NEW SOUTH WALES.

DEPARTMENT OF MINES,

GEOLOGICAL SURVEY.

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GEM STONES.

BY

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GEM STONES.

E. C. ANDREWS.

General.

The gem stone industry of the State has been important, and various official reports* have been published thereon.

Opal, exceeding £1,500,000 in value, has been won. The various opal fields have not been at all thoroughly prospected, and the industry is likely to become a flourishing one again, as the opal of the State is comparable with the best the world produces.

Following are the gem stones considered in this article:—

i. Diamond.
ii. Sapphire.
iii. Opal.
iv. Other gem stones.

I. DIAMOND.

General.

The diamond is composed of pure carbon, and is found crystallised generally in eight-sided figures. Crystals with twelve faces also occur. The faces of the diamond crystals, especially in New South Wales, are commonly curved. Diamonds are usually transparent or translucent, and they may be colourless. Opaque forms, however, are common, for example, bort or black diamonds.

Blue, brown, green, orange, red, and yellow tints, both in light and deep shades are not uncommon. The lustre is generally brilliant. No other mineral appears to be as hard. The specific gravity of crystals slightly exceeds 3.5, that of bort is about 3.5 also, and of carbonado 3.15 to 3.29.

Mode of Occurrence—Origin.

Diamonds occur generally as—

(1) Crystals, fragments, or waterworn pebbles in stream wash.
(2) Pebbles in "cement" or hardened sediment.
(3) Inclusions within "volcanic pipes" or "breccias."

The origin of diamonds in New South Wales has received considerable attention from miners and geologists.

After many years of unsuccessful search by the mining community for diamonds *in situ*, a prospector named A. Pike found a diamond at Copeton (New England), occurring as a portion of a dark-coloured igneous rock of the dyke type. It is highly probable that other diamonds occur in the dyke, but no commercial deposit of them has been found as yet. It is probable that the diamonds of New England were formed within igneous rocks at moderate depths below the surface, and that these have been much

* "The Mineral Resources of New South Wales," E. F. Pittman, 1901, pp. 373–414.
"Diamonds, Their Occurrence in New South Wales." D. C. McLachlan, Dept. Mines and Agriculture, 1899.
"Gem Stones of New South Wales." G. W. Card, British Ass. Adv. Science, 1914, Handbook of N. S. Wales, pp. 562–566.
The above publications are out of print.
"Report on Tintenbar Opal Discovery." M. Morrison, Ann. Rept. Dept. of Mines, 1919, p. 173.

denuded, the diamonds themselves being preserved and gathered into the later stream courses by reason of their hardness and resistance to decay. This is suggested by a study of the tin deposits of New England. The tin "leads" of this large district have been extremely rich, but lode tin-mining has never been conducted commercially, owing to the lack of size of the individual deposits. The tin appears to have been deposited around the margins of "sandy" granites of closing Palaeozoic age, especially the upper margins. The deposits so formed appear to have been denuded in great measure.

Although diamonds are widely-distributed in the State, nevertheless, in nearly every instance discoveries have been made by miners engaged in the washing of alluvial gravels for gold. The principal deposits occur in outliers of Tertiary stream drifts and "cement," together with the more recent stream drifts derived from them.

Sources of Supply.

i. *The Cudgegong Diamond Field.*

The occurrence of diamonds in an ancient river drift, close to the Cudgegong River, and about 4 miles west of Gulgong, has been known for many years.

"In 1867 the Australian Diamond Mines Company began operations here and at first the ground yielded at the rate of four to five diamonds and 4 dwt. of gold to the load, but afterwards fell off to one diamond in two loads.

The total number of diamonds obtained by the company while operations lasted was 1,765, ranging in weight to 1¼ carats."*

"In 1916 the New Caledonia Mining Company commenced operations on the eastern bank of the Cudgegong River, about one and a quarter miles above its junction with Reedy Creek, and in twelve months had recovered 150 diamonds, ranging individually in weight to 2 carats, and totalling 32¼ carats.

"A few diamonds, ranging to half a carat in weight, were recovered in 1918 by W. J. Lerroo from the sluicing of the old tailings at the No. 44 shaft, about 2 miles north of Gulgong."†

ii. *The Bingara Diamond Field.*

The Bingara Diamond Field was discovered shortly after the finding of the Cudgegong deposit. The field lies about 5 miles west-south-west of the township of Bingara in water-worn gravels capping the foothills of a high basalt-covered range. The basalt occurs in two distinct flows, overlying thick stream gravels. The basalt-covered gravels are not known to contain diamonds.

The area of the diamond-bearing ground, as proved, has been estimated at 200 acres. The "wash" has a maximum thickness of 60 feet, but the diamond-bearing portions vary from a few inches to 8 or 9 feet in thickness.

The total value of the diamonds won from the Bingara district exceeds £24,000.

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* *See* Taylor, H., Geol. Mag., London, Vol. VI, 1879, pp. 403-404.
† Information supplied by Mr. L. J. Jones.

iii. *The Cope's Creek, or Boggy Camp, Diamond Field.*

"After the discovery of the alluvial tin deposits of the Inverell district, diamonds were found from time to time by the miners who were working the tin-bearing gravels in the bed, and along the banks of Cope's Creek, from Tingha to the junction of the Gwydir River. . . . Ten years later the diamonds were traced to an older formation, similar to those . . . containing diamonds at Bingara and Cudgegong."*

Mr. Pittman reported that a number of isolated hills capped by basalt occur in the neighbourhod of Boggy Camp, about 15 miles south-west of Inverell, and that sands and gravels of later Tertiary age underlie these basalt caps. Diamonds, stream tin, and gold occur in these ancient stream deposits.

The average thickness of "wash" in these deposits varies from 3 to 4 feet, and the maximum thickness recorded is 14 feet.

The total value of diamonds won from Inverell and Cope's Creek workings is £97,000, approximately.

iv. *The Mittagong Diamond Mine.*

Diamonds have been recorded from an isolated patch of stream alluvium, about 300 feet in diameter, and 7 miles south-easterly, from Mittagong.

v. *Other Localities.*

Diamonds have been reported from the Tingha, Emmaville, Bathurst, Hill End, Turon, Berrima, Shoalhaven River, Crookwell, and other districts.

Production.

The following Table shows approximately the quantity and value of diamonds won in this State to the end of 1927 :—

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Carats.	£		Carats.	£
1867-85†	2,856	2,952	1908	2,205	1,358
1886	5,151	5,151	1909	5,474	3,959
1887	42‡	26	1910	3,606	2,881
1888††	...	...	1911	5,771	4,064
1889	2,196§	878	1912	2,240	2,001
1890	732	335	1913	5,573	5,141
1891	1,200	1,050	1914	1,580	1,440
1892	458‖	460	1915	839	707
1893	15,000¶	15,375	1916	1,901	1,375
1894	1,772¶	859	1917	2,991	2,006
1895	1,313**	492	1918	1,784	1,204
1896	8,000	2,625	1919	1,774	1,706
1897	9,189	3,250	1920	3,523	6,282
1898	16,493	6,060	1921	1,563	1,915
1899	25,874	10,350	1922	1,000	1,300
1900	9,828	5,663	1923	175	230
1901	9,322	9,756	1924	284	498
1902	11,995	11,326	1925	210	240
1903	12,239	9,987	1926	64	77
1904	14,296	11,620	1927	199	227
1905	6,354	3,745			
1906	2,827	2,120	Totals	202,431	£144,756
1907	2,539	2,056			

NOTE.—This table is compiled from such information as is available, but is believed to considerably understate the actual output.

* Pittman, E F., Mineral Resources, 1901, pp. 388-390.

† Estimated. ‡ Result only of 19½ loads washed in January (Cope's Creek).

§ Output of Malacca Co. (Inverell) only. ‖ From "Monte Christo" Mine (Bingara) only.

¶ Output from Bingara only. ** From Boggy Camp (Tingha) only. †† No information obtainable.

II. SAPPHIRE.

General.

Sapphires and rubies are the forms which corundum assumes when "precious." The chemical composition is that of alumina.

The occurrence* of sapphires in recent and Tertiary alluvial deposits in the State is fairly common, but in most instances the colour of the stones is not such as to render them valuable as gems.

The discovery of sapphires in Australia was first recorded on the 18th October, 1851, by the late S. Stutchbury, in a report by him to the Colonial Secretary.

Sources of Supply.

(With notes on Mode of Occurrence.)

The only locality in the State where any serious attempt has been made to win the gem on a commercial basis is the Inverell district, where it occurs in considerable quantities in the shallow alluvial deposits lying about 17 miles easterly from the township of Inverell itself. The name Sapphire has been given to the locality. Although the occurrence of sapphire has been known in the locality for many years, it was not until 1918 that systematic mining for the gem commenced. Since then sapphires to the value of £28,365 have been produced from the field. The output has, however, been somewhat restricted owing to the inability of the producers to obtain a remunerative price for their product.

Sapphires are distributed over a fairly wide area to the eastward of Inverell. They occur in the recent alluvial deposits along several watercourses, and in the surface soil over certain limited areas. Mining operations have been confined to the shallow alluvial ground in Horse Gully and Frazer's Creek, in the parishes of Swamp Oak and Nullamanna, county of Arrawatta.† The rocks of the district consist, in the main, of sediments and lavas of Carboniferous age, capped in places by basaltic lavas of Tertiary age. The alluvial deposits along the watercourse are composed largely of black clayey material with pebbles and boulders of basalt and other igneous and sedimentary rocks. The wash-dirt averages from 2 feet to 4 feet in thickness, and has an overburden of 2 feet to 8 feet of clayey black soil. Fifty per cent. of the wash consists of pebbles and boulders of basalt and felsites mainly. The wash-dirt is treated in puddling machines and then passed through several sieves, and the final product is obtained by hand sieving. Sapphires 40 carats in weight have been obtained, and about 10 per cent. of the marketable gems won exceed 1 carat each in weight. The prices obtained for fair to good blue sapphires weighing over 1 carat each ranges from £3 to £13 per oz., while small stones have realised from 15s. to 30s. per ounce. Twenty per cent., approximately, of the material won is corundum, of a greyish-green colour, for which there is no market. Pleonaste, which occurs in the basalt at the head of Horse Gully, is present in the wash-dirt, and specimens of weathered basalt containing crystals of sapphire embedded in it have been obtained from the wash. Some of the specimens are on exhibition at the Mining Museum of this Department. There is no record of sapphires having been found in the basalt of the district, although a search has been made therein. Streams such as Horse Gully, Frazer's Creek, Swan Brook, and Swamp Oak Creek,

* Information supplied by Mr. M. Morrison.

† Small sapphires have been obtained on the surface in several stream gullies which flow from the higher basaltic areas in the locality.

along which sapphires are known to occur, have cut their channels through the basalt cappings, and into the older Palaeozoic rocks, and sapphires weighing from ¼ to over 1 carat have been obtained by "specking" in several of the tributary gullies of those streams.

In some cases the sapphires, together with fine water-worn material, have been found in the gullies within a few feet of the base of the basaltic flows. Crystal forms, almost perfect in outline, are not uncommon among the sapphires found in these positions; others, again, have the angles of the crystal faces rounded. There appears to be little doubt that a bed of alluvial material occurs either at the base of the basalt or between two lava flows. The occurrence of alluvial material between basaltic flows in the district is recorded. It is therefore probable that some of the sapphires in the gullies have been shed from a Tertiary lead either beneath or between the basalt flows. No prospecting for the gem appears to have been done in the older gravels. The fact, however, that crystals of sapphire, embedded in weathered basalt and showing no sign of corrosion, occur in the recent drift, and that pleonaste is fairly abundant in the basalt in places, suggests that the basalt in this locality is probably the matrix of some of the sapphires at least which have been shed from the parent rock into the present watercourse.

Production.

The total production of sapphires amounts to 19,417 ounces, valued at £28,365, all of which have been obtained in the Inverell Mining Division. The following table, compiled from the Annual Reports of the Department of Mines, gives the quantity and value of sapphires won in the State from 1919 to the end of 1927:—

Year.	Quantity.	Value.	Year.	Quantity.	Value.
	Ozs.	£		Ozs.	£
1919	1,150	76	1925	1,490	7,772
1920	3,084	840	1926	1,808	2,418
1921	1,583	2,876	1927	3,118	2,612
1922	3,437	2,830			
1923	1,034	3,282	Total	19,417	28,365
1924	2,713	5,659			

III. OPAL.

General.

Opal consists of silica, with which a proportion of water is chemically associated. It differs from quartz in several particulars. For example, it is neither as hard nor as heavy as quartz; moreover, it does not crystallise in any definite form. It has a glassy lustre, in some cases inclining to a resinous, in others to a pearly appearance. In colour it is blue, brown, grey, green, red and yellow. It is translucent to opaque. In rare instances it possesses a brilliant play of vivid colours, the stone then being known as precious or noble opal. Other varieties are known as common, milk, and wood opal.

"Common" opal occurs in many localities within the State, particularly in the neighbourhood of Orange.

Precious opal is found in the State in two distinct geological formations, namely, in vesicular basalt and in sandy sediments of Cretaceous age.

History.

"The first discovery was made on the western side of Rocky Bridge Creek, and above the junction of that creek with the Abercrombie River. The deposit was examined, in 1877, by the late C. S. Wilkinson. . . .*"

The opal occurred in vesicles and small cavities in basalt. The opal contained in the cavities was both common and precious, the latter being semi-transparent, and displaying fine colours of green, blue, and red shades.

The most important discoveries of precious opal, however, have been made at White Cliffs, Lightning Ridge (including Grawin and Angledool), and Tintenbar.

In the Tintenbar locality, precious opal, occurs in association with decomposed volcanic rock.

Mode of Occurrence—Origin.

(*a*) *In Tertiary Basalt.*—Tintenbar district.

Although the precious opal has not been found in the solid rock, it is evident that it occurs as amygdales, or "fillings" in cavities in the basaltic rock. "Similar occurrences are known in the State at Abercrombie River. Warrumbungle Mountains, and Bingara, but they have not been worked commercially."†

(*b*) *In Cretaceous Sediments.*—White Cliffs district, Lightning Ridge district.

The main deposits of precious opal occur in sandstone and shale of Cretaceous age.

Cretaceous rocks are distributed widely in the low plateaux of the White Cliffs and Lightning Ridge districts. An intense silicification of the surface layers of pudding-stone and sandstone has taken place over the plateau area, but not in the valleys separating the plateaux. The nature of this surface layer suggests, upon cursory inspection, a sedimentary origin, but a closer examination indicates its origin in secondary processes. In every case the layer is arranged sub-horizontally. Many of the individual "pebbles" and "boulders" of the "gibber" layers of White Cliffs are peculiar in that they are composed of flint and are of the same composition as the cementing material between them. The "gibber" plains and plateaux extending, discontinuously, from White Cliffs to the north-western corner of the State represent the weathering and denudation of the "quartzite" surface layers. The pebbles of the surface conglomerates or grits of Lightning Ridge represent pebbles of quartz and other material derived from bedded rocks of Cretaceous age. The cementing material of these pebbles is a secondary quartzite. The action of silicification has not been as marked at Lightning Ridge as at White Cliffs.

The loose forms, littering the surface, are darker in colour than those forming the compact surface layers, indicating the action of arid weathering, with a tendency to deposit iron oxide in thin films upon the detached fragments. The thickness of this secondary mass varies from a few inches to 25 feet, according to the amount of denudation the surface has suffered. In certain arid areas, for example, those lying to the west of Milparinka, a surface layer, 5 to 6 feet in thickness, is rudely columnar in appearance, somewhat reminiscent of the crude prisms or columns which rice starch assumes in drying from the manufacturing solution.

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* Pittman, E. F., Mineral Resources, 1901, p. 398.

† Morrison, M., Ann. Rept., Dept. of Mines, 1919, p 173.

The "Gibber" of the west is thus only the weathered and denuded "Geyser," or surface quartzite, while the "Grey Billy," or "Shin-cracker" of the prospectors of Lightning Ridge represents a less intense form of silicification than that which obtained in the more central or western regions, as at White Cliffs.

The combined depth of the conglomerate and the quartzite is variable, but at most it is only a skin, or covering of arid weathering to the underlying sandstone.

Both at White Cliffs and at Lightning Ridge layers of soft porous sandstone, somewhat resembling "biscuit-ware" are commonly found.

The biscuit sandstone is remarkably light in weight and represents a sandstone, from which a considerable portion of silica has been drawn to the surface either under conditions of arid weathering, or of alternations of arid and "pluvial" seasons in high seasonal temperatures. The ascending material has been deposited at the surface as "quartzite."

Another peculiarity of action during this upward passage of the silica is the formation of thin layers of siliceous material, known as "Hard" or "Steel" Band, in sub-horizontal layers and along inclined joints, within a depth of 100 feet from the surface. Associated with these, especially in the subjacent bands of "Opal Dirt" are the opal nodules and layers.

Sources of Supply.

Tintenbar District.

Tintenbar lies about 7 miles from Ballina, on the Richmond River, and 10 miles from Bangalow, on the Murwillumbah-Grafton railway line. Precious opal was found at Tintenbar in 1901.

The geological formations in the locality are of slate, sandstone, claystone, and other types of Lower Palaeozoic age, capped by basalt flows. Two flows at least have been detected. These are separated by a layer, 1 to 4 feet in thickness, of a hard, cherty rock, associated with siliceous material and common opal.

At Tintenbar the opal has been found as loose pieces in the soil, at depths varying from 3 to 6 feet, while at Teven, half a mile to the south-west, it occurs filling cavities in a decomposed volcanic rock. "Many of the pieces are characteristic of filled-in cavities in volcanic rock, and it is evident that, at the former localities, the opal has been loosened and detached from the volcanic rock by weathering. The opals vary in size from that of peas to large walnuts. They are of two kinds, the transparent, which resembles the Mexican opal, and a variety of black opal, which differs somewhat from the Lightning Ridge material. Both the fire opal which possesses blue, green, and yellow colours with flashes of fire, and the harlequin opal, in which small angular and variously-tinted patches of colour are distributed throughout the stone, are obtained.

Prospecting work does not seem to be sufficiently advanced to determine whether the opal is confined to one lava flow or to any particular portion of a flow.*

Mr. Morrison considers that the opal occurs mainly "in the upper portion of the first basaltic flow or the lower part of the second flow."

* Summary of report by M. Morrison, Ann. Rept., 1919, p. 173.

White Cliffs.

Mr. Pittman states that the opal of White Cliffs was discovered by accident, fragments of the gem being found on the surface by a bushman.

"The precious opal is sometimes met with in thin flat veins between the bedding planes of the rock; at other times it forms irregularly-shaped nodules, or deposits occupying joints. Occassionally, fragments of wood are found converted into common opal, while where cracks have occurred in the wood they have been filled by precious opal. Fossil . . . shells . . . entirely converted into precious opal, are not uncommon. . . . Some of the Devonian quartzite have been similarly transmuted. . . .

"The really valuable opal, however . . . is found in the irregular nodules and seams in the joints and fissures of the soft siliceous rock. . . ."*

The Lightning Ridge (Wollangulla) Opal Field.

Lightning Ridge lies 47 miles north-north-west of Walgett, the latter town being 460 miles from Sydney by rail. The country from Walgett to Lightning Ridge consists of "black soil" plains, whereas low gravelly ridges and plateaux extend from Lightning Ridge to the Queensland border by way of Weetalibah and Angledool.

Mr. J. B. Jaquet reported on the field in 1908. Opal, however, had been recorded thence at various times, probably as much as forty years ago, according to statements by residents, but the stone was not recognised as of commercial value until about 1905.

Mr. George Smith, late Inspector of Mines, reported on the Lightning Ridge field in 1923.†

Very extensive areas of unbroken "Billy" country occur in the Lightning Ridge-Angledool district, which, probably, contain valuable opal deposits. The cost of testing these, however, is such as to discourage prospectors, who limit their operations to areas of denuded "Billy," containing precious opal in the material shed from the denuded sediments.

At Lightning Ridge itself, the even skyline of the black soil is broken by long, low, sub-horizontal ridges and plateaux, rising from the plain almost insensibly to extreme heights of 75 to 100 feet.

Ridges and slopes alike are covered with loose pebbles of quartz and ironstone gravel. In some places pudding-stone or conglomerate outcrops. A hard rock known as "Grey Billy" also occurs in loose or continuous masses, both on the plateau tops and on the slopes. The weathered forms of the "Grey Billy" are known as "Shin-cracker." This conglomerate, with the "Grey Billy," covers ridges, slopes, and flats alike between Weetalibah and Angledool, and thence north to the Queensland border. In other places the pudding-stone and the "Grey Billy" have been worn from the summits and the slopes, leaving only a loose cover of gravel, pebbles, and soil, overlying a light and porous sandstone.

Black Opal is found in the sandstone, and "Opal Dirt," underlying the Shin-cracker or Grey Billy from the 3-Mile to Queensland, a distance of 40 miles.

At Angledool and Weetalibah the quartzite and conglomerate cap is a pronounced and persistent feature; nevertheless, on the richer portions of the opal fields as worked, these hard types have been denuded in great measure, and the "Grey Billy" reduced in hardness. Beneath the weathered quartzite or "Shin-cracker," layers of soft, porous sandstone, somewhat resembling biscuitware, are commonly found. This biscuit sandstone occurs

* Pittman, E. F., Mineral Resources, p. 400–401.
† Smith, G., Ann. Rept. Dept. of Mines, 1923, pp. 43–44.

in beds which are relatively thin, and are of sub-horizontal disposition. The specific gravity of this porous sandstone is remarkably low, a cubic yard of the material weighing no more than 15 cwt. It represents sandstone a great portion of whose silica has been attracted to the surface by capillarity, and there deposited.

At Lightning Ridge, and the 3-Mile, to the south, the holes or shafts sunk to the sub-horizontal summits generally reach the upper opal layer at a depth of 40 to 50 feet, whereas on the slopes of the ridges the opal layer or layers may outcrop, or they may have been removed by erosion. At Bald Hill, about 1½ miles north of Lightning Ridge township, the upper opal level occurs at a depth of 40 to 50 feet below the surface pebbles; a second and sub-parallel layer occurs at a depth of 60 feet; while a third and fourth occur between the depths of 60 and 100 feet from the surface. (Fig. 11.) These levels are not at all persistent, nor are they necessarily horizontal. Moreover, there is a general lack of surface indication to guide the miner in his search for the opal. In many places the first or upper level is indicated by the presence of a very thin and hard band of siliceous sandstone known as the "Steel Band." Below this occurs a layer of soft material resembling clay or sandy clay. This is known as the "Opal

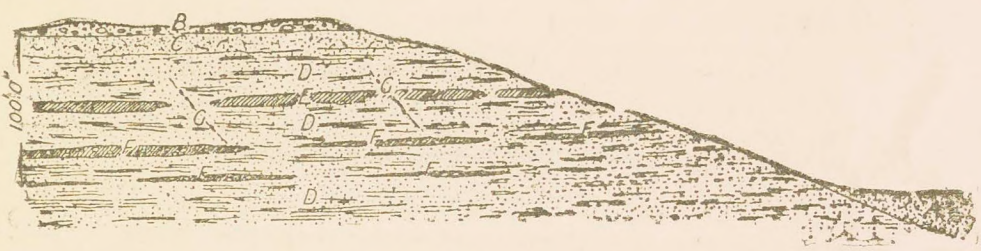

Fig. 11.

Diagrammatic Illustration of Method of Occurrence of Opal at Lightning Ridge.

A. "Black soil" Plain (Post-Tertiary).
B. Weathered secondary Conglomerate (Tertiary).
C. "Shin-cracker," weathered secondary quartzite.
D. Cretaceous sandstone and shale beds.
E. "Steelband"—discontinuous.
F. "Opal dirt," with opal in places.
G. Slides or joints containing opal in places.

Dirt," and is of variable thickness, but rarely exceeds 3 feet. Both in the Steel Band and just below it, and in the Opal Dirt, opal may be found. It may occur in thin seams, but generally occurs as nodules. The latter are tested carefuly by snips or pliers to test the quality of the stone inside. Opal may also occur along inclined joints or slight faults in the soft sandstone or opal dirt.

Beneath the "Opal Dirt" layer other beds of a light biscuit sandstone occur, and these in turn terminate downwards in places against a lower or second level, with "Opal Dirt" containing opal.

The existence of opal at any particular place appears to depend upon the general character of the sandstone and sandy clay bands with which it is associated, and it may be seen thus that prospecting for the opal is a very difficult process, inasmuch as the texture and composition of the sandstone and clay bands vary considerably from point to point within relatively short distances, and such variations are not necessarily indicated at the surface.

Grawin.

In the latter part of 1926 and in 1927 about eighty men have found employment at the newly-opened field at Grawin, 30 miles southerly from Lightning Ridge. The occurrence is essentially similar to that of Lightning Ridge. The value of the production amounted to £4,948 in 1926 and £4,870 in 1927.

Prospecting for Opal.

The accompanying notes are fairly applicable to the White Cliffs area as well as to the extensive Lightning Ridge area, which includes Lightning Ridge itself, the Three, Four, Six and Nine Miles, Grawin, Angledool, and the area thence to Queensland.

The whole region may be divided into two main portions, namely, "Black Soil" plains and gravel ridges, underlain by Cretaceous sandstone and shale.

The Cretaceous sandstone covered by "Grey Billy" in various stages of denudation admits generally of a threefold division, namely:—

(1) A very dense capping of secondary pudding-stone and quartzite. This occupies by far the greater portion of the area.

(2) An area covered with weathered quartzite or "Shin-cracker," not nearly so expensive to prospect as No. (1). This is underlain by discontinuous opal levels. This area is also of considerable extent.

(3.) An area, also considerable, from which the secondary quartzite capping has been removed by denudation, and from which also the upper opal level has been removed in great measure.

Valuation of Opals.

The following notes on the valuation of opals have been prepared by Mr. L. J. Jones:—

"Skill and experience are needed in the art of grading and valuing opals, as many factors have to be taken into consideration.

"The weight of a large piece of rough opal is not necessarily an indication of its value; on the other hand, it is necessary to be able to estimate roughly the number, size, and quality of the stones that could be cut from such a piece.

"The precious opals of New South Wales admit of ready separation into two classes—the "Light" opal of White Cliffs, and the "Black" opal of Lightning Ridge.

"Each of these classes is divisible in turn into many grades ranging from "potch," worth perhaps a few pence to half a crown per ounce, to the highest-quality gem worth many pounds per carat.

"Generally, it may be said that the value of an opal depends upon the following characteristics:—(1) Colour, (2) pattern, (3) fire, and (4) soundness.

(1) *Colour.*—A high-grade opal should show a perfect blending of colours; no shade should predominate to the exclusion of all others. The colour should be "true," that is, it should not run in streaks or patches alternating with colourless opal of an inferior quality.

(2) *Pattern.*—While there is a marked variation in the "pattern" of opals, the "Harlequin" and "Pinfire" types characterise the high-grade gems. The term "Harlequin" is applied to those opals whose colours are arranged in small squares—the more regular the better, and the term "Pinfire" to those resembling pin-points.

(3) *"Fire or Flash."*—Upon the character, variety, and intensity of the "flash," the value of the stone largely depends. Red fire or red in combination with yellow, blue and green is the best, blue by itself is almost valueless, while green flash opal is not of much value unless the colour is very vivid and the pattern good. Milky opal devoid of pattern and with little fire has but small value.

(4) *"Soundness."*—It is essential that the opal should be free from cracks and flaws of all kinds.

At present the price of high-grade opal ranges to £5 a carat for the gem as cut and polished. It is, of course, well known that many opals command a much higher price than £5 a carat, but they must be of outstanding merit or possess special and unique features to secure such a price."

Production.

The following table shows the estimated value of precious opal won in this State to the end of 1927 :—

Year.	Value.	Year.	Value.	Year.	Value.
	£		£		£
1890	15,600	1904	57,000	1918	20,600
1891	.....	1905	59,000	1919	27,552
1892	2,000	1906	56,500	1920	23,600
1893	12,315	1907	79,000	1921	13,020
1894	5,684	1908	41,800	1922	15,150
1895	6,000	1909	61,800	1923	3,040
1896	45,000	1910	66,200	1924	10,500
1897	75,000	1911	57,300	1925	10,030
1898	80,000	1912	35,008	1926.....	11,485
1899	135,000	1913	29,493	1927.....	13,353
1900	80,000	1914	26,534		
1901	120.000	1915	6,403	Total	£1,574,762
1902	140,000	1916	21,273		
1903	100,000	1917	12,522		

IV. OTHER GEM STONES.

Beryl.—"Pebbles* of beryl are occasionally found in the alluvial gold and tin-wash dirts, but are of no particular interest. At Emmaville, in New England, beryl occurs in a granite dyke, and is sometimes of a sufficiently deep green colour to rank as a light-coloured emerald. It is associated with topaz, cassiterite, fluorite, and mispickel. Several attempts have been made to work the deposit, and a good many stones have been cut in the past.

"Massive beryl is a common gangue mineral at the Torrington wolfram mines, and some beautiful little crystals with perfect terminations have been found. The beryl seems to be always flawed, and is of very pale colour when cut."

*G. W. Card. Brit. Ass. Adv. Sci. N.S.W Handbook, 1914, p. 546.

Topaz.—Pebbles of colourless topaz are very common in the alluvial tin deposits of New England. Occasionally blue stone of good quality and colour is found, sometimes of considerable size, and from time to time are sold for good prices, but there is no regular market. Well-developed crystals are sometimes found and are of mineralogical interest.

Turquoise.—At Wagonga, on the South Coast, thin seams of green turquoise occur, and an unsuccessful attempt has been made to work it. The colour is unsatisfactory.

Zircon.—Zircon is widely distributed in gem gravels and alluvial deposits generally, but is usually of small size, and is hardly ever worth cutting. A. H. Church, in *Precious Stones,* specially refers to zircon from Mudgee, New South Wales, but the authority is not known.

Tourmaline.—Only the "schorl" variety is known.

Garnet.—Large crystals of almandine and spessartite are found in the Broken Hill district, but nothing appears to have been done with them as yet.

Spinel.—Stones suitable for cutting occur now and then, but, with the exception of opaque pleonaste, spinel is rarely found. Pleonaste is now used in jewellery.

Quartz.—Rock-crystal, smoky quartz, prase, and jasper, are all known, but, since these stones are practically unsaleable, they are seldom cut. Agate is widely distributed and is sometimes beautifully marked. A pretty variety of clear smoky quartz enclosing golden coloured needles of rutile is obtained at Tingha, and is locally known as "grass-stone." From the molybdenite mines near Glen Innes, water-clear crystals of colourless quartz enclosing spangles of molybdenite are sometimes obtained, and are very pretty when cut.

In addition to the generally recognised gem stones, other minerals found in New South Wales possess undoubted possibilities in this direction, and some of them have been cut by the Geological Survey. Among these may be instanced rhodonite, alunite, chlorite, fluorite, azurite, and jet.

Alunite is a regular article of commerce, and the pink variety looks very pretty when cut. The pseudophite variety of chlorite occurs at Nundle, and resembles New Zealand greenstone, but is, of course, much softer. Jet has been found as a great rarity in oil-shale. Mention might also be made of quartz containing free gold which can sometimes be cut with satisfactory effect."

Crystals of rhodonite and garnet of great beauty occur in the Broken Hill lode.

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