PRECIOUS AND SEMI-PRECIOUS STONES

MICHAEL WEINSTEIN

R. H. B. Bolton
1929.

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SPECIMENS OF PRECIOUS AND SEMI-PRECIOUS STONES

(*Left to right*) 1. Emerald; 2. Rough diamond crystal; 3. Sapphire; 4. Garnet (carbuncle), mounted as brooch; 5. Blue zircon; 6 (below 5). Red spinel; 7. Rough emerald crystal; 8. Peridot; 9. Chrysoberyl cat's-eye; 10. Opal; 11. Ruby; 12. Aquamarine; 13. Tourmaline; 14. Topaz.

Frontispiece.

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BY

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FOREWORD

THE aim of this work is to present the salient facts in a readable and comprehensible manner to the person who, though interested in precious stones, will not, or cannot, read and enjoy the larger scientific books already written on this interesting subject.

The continued vogue of gem stones in jewellery, with the increasing use of some of the lesser known semi-precious stones, demands some knowledge if appreciation is expected from "the man (or woman) in the street." In addition, modern imitations are so frequently encountered, and in many cases they are so well conceived, that blind faith, without knowledge, is, in our days, no longer a correct guide.

That people are interested, in any case superficially, in precious and semi-precious stones is obvious from the fact that so many of them are worn in all types of mounted jewellery of to-day. This book should be, therefore, of general interest, and it will have served its purpose if to some it has given a little pleasure and to others an incentive to pursue further a subject of absorbing interest.

The writer wishes to express his thanks to the authorities at the Museum of Practical Geology, Jermyn Street, London, S.W., for their kind assistance and permission given to use the stones reproduced on the coloured frontispiece.

Thanks are also due to the High Commissioner for Australia, the Agent-General for Western Australia, Mr. Leo Weinthal, C.B.E., Messrs. Giovanni Luise & Sons, and the Staatliche Bernstein Manufactur G.m.b.H, who

readily placed at my disposal photographs and blocks, thus enabling the following illustrations to be made—

Opening Pearl Shells.
An Assorted Collection of Fine Pearls.
Blister Pearl on Shell.
Various Illustrations on Diamond Mining.
The Working of Coral.
Amber Mining and Dredging.

Also I owe special thanks to Mr. Edmund Jacobson, who has kindly read through the proofs and has made several valuable suggestions.

MICHAEL WEINSTEIN

June, 1929

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PRECIOUS AND SEMI-PRECIOUS STONES

PART I

CHAPTER I

REAL, SYNTHETIC, AND IMITATION STONES

THE appreciation of gem stones is not a result of the development of civilization. Many of the precious stones we know to-day were regarded with high esteem in the earliest days. Even in the Bible frequent mention is made of different stones, though in those days many were known under different names from those by which we recognize them to-day. For instance, the ancient sapphire is our lapis lazuli, and the topaz our peridot, whilst diamond was probably not known. The softer stones, such as rock crystal and amethyst, were naturally the first to be appreciated, since they could be easily cut and polished and their beauty made evident. The polishing was carried out by the use of emery powder, and diamonds, even if known, could not be held as being very attractive, since the fact that diamond alone will cut diamond was not discovered till the fifteenth century, and in its natural state a diamond is an uninteresting stone as a rule. Amber, coral and pearls were also regarded from the earliest days as being of great value, and when lack of knowledge and consequently superstition abounded, many legends were attached to various precious stones, both concerning their mode of formation and also their so-called virtues.

The art of engraving on hard stones was also known from the earliest times, and no doubt the Israelites learnt this art from the Egyptians. Both are known to have used emery powder for polishing. At different times, certain stones became very fashionable, as in our days, and Pliny wrote that in his time there was a general demand by the wealthy Romans for all precious stones and engraved gems. To Pliny and Theophrastus our early knowledge of stones is indebted, though much of their information, in the light of present-day knowledge, is incorrect. Since those days, much has been done to elucidate the mysteries of the mode of occurrence, the physical and the chemical properties of the different precious and semi-precious stones, so that to-day they may be more correctly classified and understood than was formerly the case. Amongst the great men who were collectors of gem stones in olden days may be mentioned Alexander the Great, Mithradates, Pompey, Julius Caesar, Augustus, Maecenas and Hadrian. Although knowledge was little, tools primitive, and material difficult to obtain, many fine specimens of early work in stones still exist. To-day much has been discovered, but there is also much that is still not understood. Before describing the varieties of gem stones most known to us, it is necessary to understand certain terms which must be used in their description, otherwise their characteristics and individual beauty will not be appreciated.

In the first place, it must be understood that, with very few exceptions, precious and semi-precious stones are natural minerals. They are, therefore, the product of an inorganic process, and are composed of the same substances throughout. All have a definite chemical composition which may be expressed by a chemical formula.

Of the vast number of natural stones known, however, very few are suitable for purposes of adornment, and it is with these that we are particularly concerned. The necessary qualities to make a stone *precious* are beauty, rarity, and durability, and for these reasons the only five stones recognized to-day as being precious are diamond, ruby, sapphire, emerald, and precious opal. Pearls, being of organic origin, are not stones, although they are usually considered with precious stones on account of their beauty and rarity.

Semi-precious stones are those natural stones used in jewellery other than the precious varieties, and under this heading are included several beautiful species, such as zircon, spinel, topaz, jade, chrysoberyl, tourmaline, amethyst, etc. All these stones are sufficiently attractive for ornamental purposes when suitably cut and polished; they have depth of intrinsic colour and they are sufficiently hard to withstand ordinary wear.

Synthetic stones are those manufactured by an artificial process in which the constituent elements of the stone are combined so that the resulting material has the same composition and physical characters of the genuine stone simulated. Synthetic stones are frequently used in moderately expensive jewellery, and they have several advantages over the purely imitation stone. The latter is the product of an artificial process in which the material used is other than that of the stone imitated. In most cases the material is a glass, coloured when necessary, and this form of an imitation stone is generally known as "paste" or "strass."

There are other types of stones met with which are not wholly imitation. These may be *doublets*, which are a combination of two stones joined together to look like a single stone. The upper half, known as the crown, is generally of real stone, but the lower portion, the base, is usually an imitation stone of a similar or deeper colour. By this means, the colour of the doublet is improved, and the cost of the stone lessened, since most stones are sold by weight and quality.

Triplets are also made after this manner, and in these the centre of the three different sections is generally the imitation layer. Emeralds, sapphires, rubies, and opals are some of the stones which are frequently seen in the form of doublets and triplets.

Synthetic stones of most of the varieties of precious stones have been produced (emerald is as yet an exception), and naturally the manufacture of synthetic diamonds on a commercial scale has been the aim of many chemists. These stones have been produced, but the expense has always been very high, and only small crystals have been obtained. Moisson, a French chemist, was one of the first to produce synthetic diamonds. He mixed pure carbon and iron and subjected the mixture to the heat of an electric furnace. After being kept at a temperature of about 4,000° C. for a short time, the solution was plunged into cold water. This sudden cooling resulted in the formation of a crust of iron round the liquid and expanding exterior, since iron expands when passing from the liquid to the solid state. The pressure so produced was enormous, and some of the carbon thrown out assumed the form of diamonds. The separation of the iron and the carbon from the small diamond crystals was a tedious process, and the experiment, though of scientific interest, was of no commercial importance. Synthetic diamonds were produced by Hannay and Friedländer, among other chemists, by different methods, but such stones are not, as yet, to be found in mounted jewellery.

The synthetic stones that require most notice are rubies and sapphires, as many are produced and used to-day in all kinds of jewellery. Both of these stones are identical in chemical composition, alumina, and in their natural state are classified as corundum. Their well-known difference in colour is due solely to naturally included metallic oxides.

It was not until the year 1904 that synthetic stones became of importance. But in that year the French chemist, Verneuil, succeeded in producing synthetic rubies and sapphires by a laboratory process, and the stones which he produced and marketed had a definite effect on the prices and sale of the natural stones. Verneuil fused a number of small natural rubies of no value by means of an oxy-hydrogen blowpipe, allowing the resulting mass to cool and crystallize. These *reconstructed* rubies possessed all the characteristics of the natural stones, though they were naturally larger and apparently free from faults. The only exception was that they contained very small internal air bubbles.

Fragments of natural stones are not now used for this purpose, but pure ammonium alum and a little chrome alum are fused together by means of a blowpipe. Under suitable conditions, and with certain precautions, pear-shaped crystals are produced, and from these stones are cut. In order to obtain the sapphire blue small quantities of magnetic oxide of iron and of titanic acid are added to the alumina.

Although the introduction and marketing of these *synthetic* stones caused a considerable fall in the value of sapphires and rubies during a period of some years, the certain means of detecting these stones and the increasing confidence of the public have restored both sapphires and rubies to their previous level. Indeed, these stones are now in demand, and good specimens command higher prices than ever before.

The success obtained in the manufacture of synthetic corundum was naturally followed up, and many other stones, the most important of which are alexandrite and spinel, were produced. These are quite often seen in jewellery of to-day. However, a competent jeweller or stone dealer is always able to differentiate between a natural and a synthetic stone, and with the aid of a good microscope and a little practice he can note the following differences—

(*a*) In synthetic stones there are small air *bubbles*, which are generally perfectly round. In natural crystals, if bubbles occur, they are always irregular in shape, and often resemble the original form of the crystal.

(*b*) If included particles of matter are to be seen, they are arranged in curve formation in synthetics. In natural stones the inclusions would vary in size and would be irregularly distributed.

(*c*) If striae are present, they consist of straight lines in natural stones. In synthetics they are generally curved.

(*d*) The peculiar internal optical effect shown by many natural rubies and sapphires, known as "silk," is never seen in synthetic stones.

(*e*) The colour of synthetic stones is generally wrong. It is frequently too uniform and looks "glassy." Colour in natural rubies and sapphires frequently varies in different parts of each stone, and if bands of colour occur, they are either parallel or irregular and never curved.

One or more of the above characteristics may be always seen, though patience is frequently required, as the faults are often very minute. In the case of doublets and triplets, the naked eye is alone generally sufficient to detect these stones. The edges of the different sections may be seen, but if any doubt exists the stone should be placed in water, or in oil. The difference in colour in various parts of the stone may then be seen on viewing it from an oblique angle. If the stone is not a whole one, the parts may be separated on boiling in water, or by soaking in alcohol.

Stones which are wholly imitation, "pastes," consist of various kinds of glass, generally foiled or backed with quicksilver. The better qualities contain a large proportion of lead oxide, which increases the lustre of the glass. This addition, however, makes the "paste" very soft, and it also tarnishes more quickly, so that although paste jewellery has quite a brilliant effect when new, it loses its brilliance in a very short time. Real stones, of course, never lose their original effect in this way. The different colours in "pastes" are produced by adding metallic oxides, and in general the colour is never the same as that of the natural stone imitated.

Nearly all synthetic stones are made in Germany and France, though the cheapest varieties are produced in Czecho-Slovakia.

The finest imitation pearls are made in France. The method used is to fill blown glass beads with a prepared wax and then the outer surface is coated with a solution. Another method is to use a solid glass bead, which is sometimes slightly coloured, and this is coated with a prepared solution known as "essence d'orient." This solution is derived from certain fish found in the Baltic Sea, and is fairly expensive. In the best qualities of imitation pearls, several coatings are applied, and each is allowed to dry before being polished. The Japanese sometimes use a round mother-of-pearl bead for the centre. In all cases no difficulty should be experienced in differentiating the natural from the imitation. The solid variety is smooth to the touch, while the natural pearls give a gritty sensation. The application of one's teeth to the surface of a pearl is the best test for this. Also a sharp point applied to the outer covering of a solid imitation pearl will slightly depress it. Real pearls would not, of course, be affected in this way. The artificial coatings generally show at the stringing hole, whilst those filled with wax may be tested for their softness by a needle. *Cultured pearls* are more difficult to detect, and these are considered in the chapter on pearls.

In general, it must be emphasized that it is impossible definitely to identify a stone by its colour alone. Price, name, or place of origin is also no guide, and the only sure means is to establish certain of its physical properties which differ characteristically with each different species, and this is discussed in the next chapter.

CHAPTER II

SOME PHYSICAL PROPERTIES OF GEM STONES

1. Occurrence. As a rule, gem stones occur either in the earth's crust where they were formed or in secondary deposits away from their original place of formation. In the first case, they are often a constituent of the rock itself and were formed at the same time as the other component minerals. Gem stones found in secondary deposits have been subjected to the weather and the action of transporting agencies. The action of the sun and rain, alternate heat and cold, all tend to break up rocks in time, and the presence of a stream or river results in the transporting of the broken constituents some distance from their place of formation. The constant friction during this process generally causes wearing of the minerals; consequently most stones found in secondary deposits, such as river beds, or ancient river beds, are round or oval in form, and are thus known as "water worn." Their faces are worn smooth, and all traces of sharp faces which they may have had originally have been obliterated by the action of the water and the constant rubbing. Gem gravels, of which several occur in Ceylon, often contain many different kinds of stones, and they are naturally more easily found and dissociated from surrounding material than those stones found as integral parts of rocks. These, if not completely embedded in the rock mass, are sometimes attached to the walls of cavities in the rock. These cavities, known as *druses*, are of a more recent date than the parent rock, and the gem stone lining the cavity has generally assumed a definite shape in its formation, that is, it appears as a crystal.

As it is necessary to understand clearly what is meant by a crystal, we may here define a crystal as a naturally produced solid of a definite form, bounded by smooth surfaces, and possessing definite internal

Characteristic Crystallographic Forms

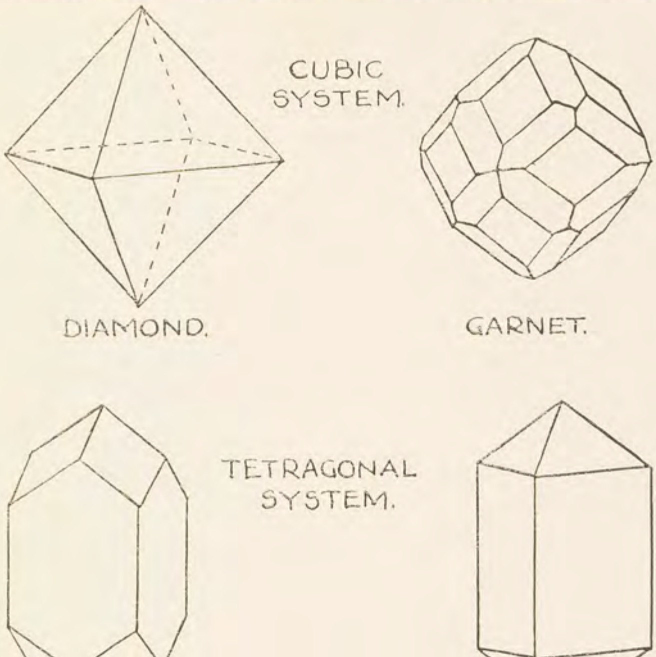


Fig. 1

structure. Its external form is really an expression of its internal form, and here we see the chief difference between a natural mineral and an artificially produced glass. The latter has no definite internal structure, it has not developed from a smaller to a larger form, and its internal particles are irregularly arranged and are in no way connected with each other. A natural crystal may be imagined to be built up of an innumerable number of small crystals of the same shape as the whole, The natural shape of a crystal is of great importance. as on this so many physical characters depend. For this reason crystals have been classified, and each may be assigned to one of six great systems—Cubic, Tetragonal, Hexagonal, Rhombic, Monoclinic, and Triclinic. Each system refers to a constant number of planes of symmetry, and a study of Crystallography is necessary to understand gem stones thoroughly. It is interesting to note that stones occurring in crystal formation always occur in the same definite form, even when found in different parts of the world. Thus emeralds always occur as hexagonal prisms even if found in South America or in Egypt. Moreover, the angles between like faces of crystals of the same species are always the same, wherever found. Many crystals are, however, found broken or even distorted, as development is often irregular. Others have been formed on a common plane, and are known as *twinned* crystals.

As has already been remarked, many physical characters of a stone depend upon its crystalline form, and amongst these properties may be noted hardness, cleavage, optical characters, heat and electrical effects, all of which are considered later.

Localities where gem stones are formed will be noted under the different stones discussed, though it is interesting to note that certain stones are frequently found together. Thus rubies are often associated with spinels, diamonds with garnets, and the discovery of the one stone generally leads to the assumption that the other is present in the vicinity. This is curious, in so far as

Characteristic Crystallographic Forms

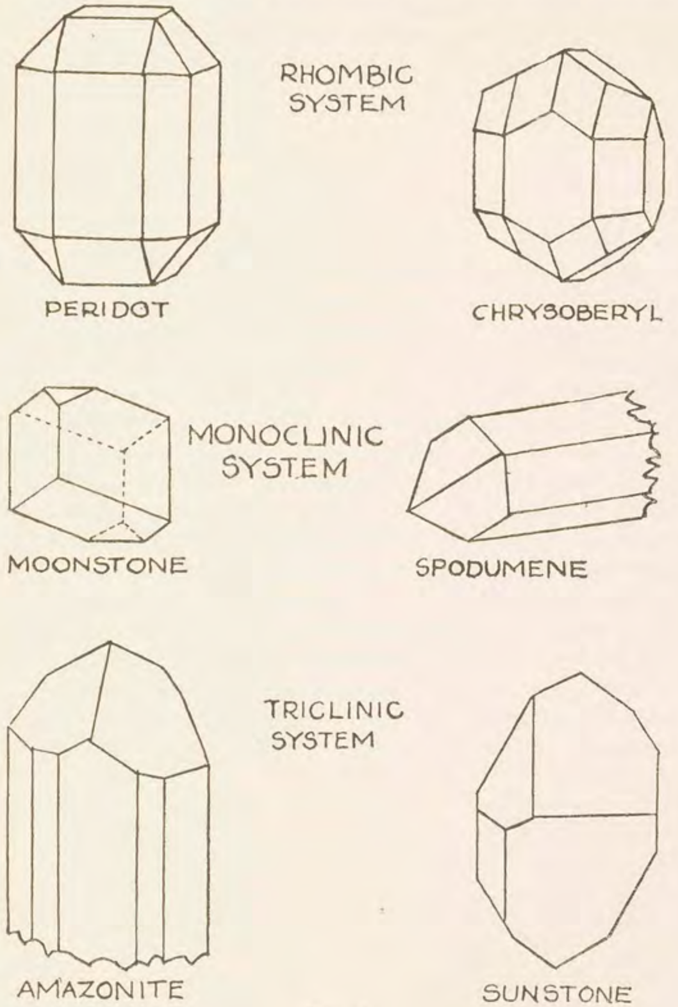


Fig. 2

the associated stones are generally unlike in chemical composition.

2. Chemical Composition. If all gem stones were to be analysed, it would be found that the following elements play the most important parts—

Silicon, aluminium, iron, carbon, oxygen, hydrogen, copper, calcium, magnesium, sodium, zirconium, beryllium and phosphorus.

With the exception of diamond, which is almost pure carbon, most of the gem stones known are a natural combination of two or more of the above elements. Thus, rock crystal is oxide of silicon, a combination of oxygen and silicon in certain definite proportions. It should be observed that the colour of a stone does not figure in the chemical composition, as it is nearly always due to a mere trace of some organic or inorganic matter.

3. Hardness and Cleavage. It is common knowledge that most stones used in jewellery are hard, since they must be sufficiently durable to withstand ordinary wear. By *hardness* we really mean the resistance which a stone offers to the separation of its particles, and the degree of hardness may be measured relatively by scratching the mineral with some harder substance. Thus each stone can be graded by its hardness, and this serves as a rough test in the case of rough specimens.

The following table, known as Mohs's Scale of Hardness, is still used, and the table on page 129 shows the hardness of the well-known gem stones in relation to each other.

10. Diamond.	5. Apatite.
9. Corundum (ruby and sapphire).	4. Fluor Spar.
8. Topaz.	3. Calcite.
7. Quartz.	2. Gypsum.
6. Orthoclase (felspar).	1. Talc.

Each of the above may be scratched by the mineral which precedes it, but it must be clearly understood that this scale has no quantitative significance. Diamond is not twice as hard as apatite, but the difference in hardness between diamond and ruby is far greater than the difference in hardness between ruby and talc. As a rough test, it may be remembered that a file will have no effect on quartz or stones of a greater hardness, but it will easily scratch glass. The hardness of ordinary glass and "pastes" is about five and a half. A finger-nail will scratch gypsum. Hardness may vary slightly with locality, as, for example, in the case of diamonds. In some cases, different faces of the same crystal vary in hardness, and some faces may differ if scratched in different directions. This property is due to the internal molecular structure of the stone.

A stone may be hard and yet may be easily cleaved. By *cleavage* is meant the tendency many stones have to break in certain directions producing more or less smooth surfaces. This property is also directly connected with crystallographic form, as the cleavage plane is always parallel to some possible face of the crystal. Cleavage is an important property in the working of some stones, especially in the case of diamond, which, though extremely hard, may be easily cleaved.

4. Specific Gravity. By specific gravity is meant the weight of a body compared with the weight of an equal volume of pure water at 4° C. All solids are compared with the weight of 1 c.c. of water, which weighs one gram. Thus, 1 c.c. of carnelian would weigh 2·66 grams, and its specific gravity is therefore designated as 2·66. Each stone has a different specific gravity (see table on page 129), and this property is a good method of identification.

There are many methods of finding the specific gravity of a stone. A comparative method, which is very useful in the case of small stones, is to immerse the stone in a liquid of known specific gravity. If the stone floats, it must have a lower specific gravity than the liquid; if it sinks, a higher one.

The most frequently used liquids are bromoform (specific gravity 2·9), methylene iodide (specific gravity 3·32), Klein's solution (a saturated solution of cadmium-boro-tungstate with water, specific gravity at 15° C.

3·28), Sonstadt's solution (a saturated solution of potassium mercuric iodide in water, specific gravity at 15° C. 3·18), and Retger's solution (a double nitrate of thallium and silver, specific gravity at 15° C. 4·6). The first and second mentioned are the most convenient liquids to use, and results may be quickly obtained.

Another method of determining the specific gravity of a stone is to weigh it first in air and then when totally immersed in water. The difference in weight (apparent loss) gives the weight of the water displaced, and this divided into the weight in air gives the specific gravity of the stone. This method is based on the principle that, when a body is totally immersed in water, the loss in weight is equal to the weight of the water displaced. In practice, any delicate balance may be adapted; if a piece of silk or thin wire is used to suspend the stone and enable it to be immersed in the beaker of water, the weight of this "cage" must be taken into consideration. For example—

		Carats
Weight of wire	=	·80
Weight of wire and stone	=	13·65
Weight of stone	=	12·85
Weight of wire partly immersed	=	·72
Weight of wire and stone partly immersed	=	10·38
Weight of stone in water	=	9·66
Loss of weight of stone in water	=	3·19
Specific gravity of stone	$= \frac{12·85}{3·19} =$	4·02

If possible, porous stones, such as opal and turquoise, should not be tested in liquids other than water. Also in weighing, accuracy is most important, and corrections should really be made for temperature and surface tension which tend to produce small errors.

5. Electrical Properties of Gem Stones. These are not very important and cannot be used as a distinguishing feature of any particular stone. The following develop electricity when heated—topaz, quartz, diamond, and tourmaline. Amber becomes negatively charged when rubbed. Stones generally exhibit positive electricity only when polished, and negative electricity when unpolished. Diamond is an exception.

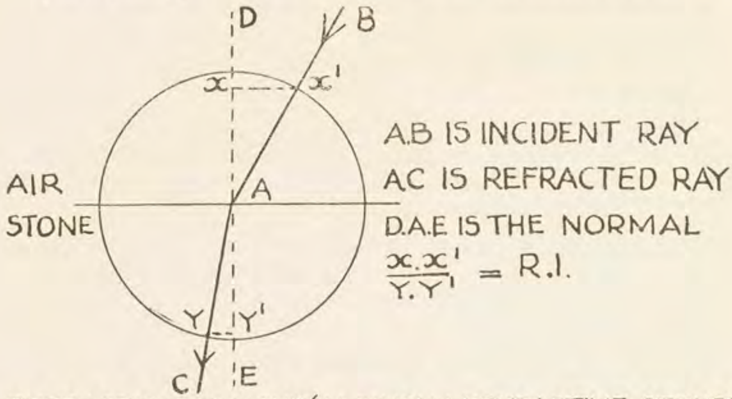
6. Effect of Heat on Gem Stones. In the case of one or two stones, such as topaz and zircon, the application of heat, with certain precautions, is used to improve the existing colour, and this is noted under the individual stones described later. But in general most stones are entirely spoilt when subjected to high temperatures.

Opal cracks and loses its opalescence; turquoise fades in colour; tourmaline becomes electrically charged; amethyst turns to yellow citrine, whilst smoky quartz turns brown or yellow in colour. Some sards turn to carnelian, whilst some zircons become white and increase in lustre. Diamond is reduced to a black carbon if a very high temperature is reached. Some sherry coloured topaz lose their colour, but become pink on cooling. Rubies and some other stones change colour, but on cooling the original colour returns. Pearls turn brown and split, whilst amber burns with a camphor smell, and gives off black fumes.

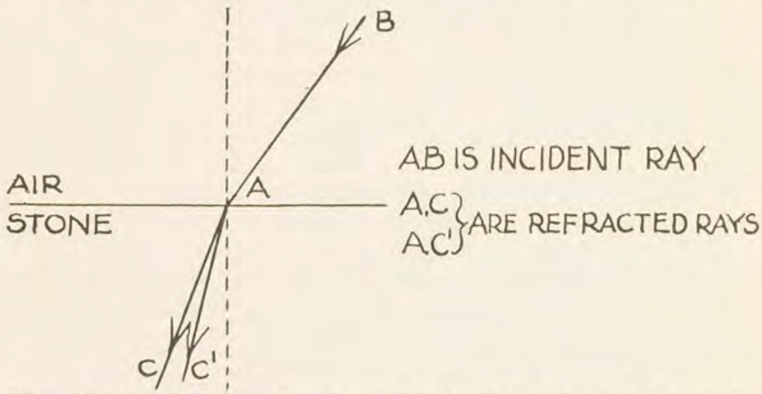
It is thought that, when the colour of a stone is due to included organic matter, heat permanently destroys the original colour. When due to inorganic matter, the colour may return on cooling, or it may change altogether.

7. Optical Properties of Stones. These are most important, as they serve as the chief tests of the different stones. A good knowledge of the subject of Light is essential, but here the chief points only will be considered. It will also be seen that crystal formation has a great bearing on the optical properties of stones.

Colour is considered by many to be sufficient to identify a stone, but the more experience one has the more unreliable does this test prove itself. White light is composed of the following seven colours in varying proportions—red, orange, yellow, green, blue, indigo, and violet, and this may be seen on splitting up rays by passing white light through a prism of glass and allowing the refracted rays to fall on to a sheet of white paper. The different series of colours, called a *spectrum*, may be easily recognized. When white light is brought into contact with any medium, such as a stone, part of the light is absorbed at the surface and part during transmission. The fundamental colour of



REFRACTION OF LIGHT (IN SINGLY REFRACTIVE STONES)



REFRACTION OF LIGHT (IN DOUBLY REFRACTIVE STONES)

FIG. 3

the stone depends upon this. Generally some colours of the spectrum are more strongly absorbed than others, the absorption being *selective*. Certain minerals absorb certain colours, and the transmitted colours therefore vary. The selective absorption may vary in certain directions within the same stone, and for this reason some species appear differently coloured when viewed along certain directions, e.g. tourmaline. This property is definitely connected with the molecular structure of the crystal.

When an incident ray meets the face of a medium, such as a gem stone, it is *refracted*, that is, bent away from its normal course. Further, the refracted ray makes a definite angle with the normal plane, and this angle is found to be constant in the case of each stone, so that the measurement of the angle of refraction gives a means of identifying the stone, and this is the best and surest means. In practice, the sine of the angle of incidence is compared with the sine of the angle of refraction, and this constant is known as the *refractive index* (R.I.). See the two diagrams on page 16. The constant can be measured and immediately read off on an instrument known as the refractometer.

It must be noted, however, that some stones have more than one refractive index. All stones of the cubic system and all non-crystalline material, e.g. opal, garnet, "paste," are singly refractive, that is, the refracted ray emerges as a single ray. Light falling on all stones of the other crystallographic systems is split up into at least two refracted rays, which take different paths, and have different refractive indices. It will be seen, therefore, that these optical properties depend upon the crystalline formation of a stone. The indices of doubly refractive stones can be read off directly by means of the refractometer in most cases.

It has already been mentioned that some stones, such as tourmaline, give two different colour effects when viewed from different angles. This effect, known as *dichroism*, is a characteristic of certain stones; an instrument devised to show the effect clearly and quickly is known as the dichroscope. Naturally, stones of the cubic system cannot be dichroic, nor can any imitations. Thus garnets may be distinguished from red tourmalines by this property alone. Not many stones show strong dichroism, and reference to the table on page 130 will show that most stones show no effect at all. No colourless stone can be dichroic.

The breaking up of white light by a stone and the production of a visible spectrum is known as *dispersion*, and this power determines the "fire" of a stone. It is strongly seen in diamond, demantoid garnet, sphene and zircon, when these stones are properly cut. Colour tends to mask the dispersive power of a stone, and though one would say that diamond shows the strongest dispersion of all stones, both demantoid garnet and sphene are really stronger in this respect.

Other phenomena, such as "play of colour" in the case of opal, sheen on pearls, chatoyancy, iridescence and asterism are all due to peculiar internal structure which causes interference of light. These effects will be explained under the headings of the different stones.

CHAPTER III

THE CUTTING OF STONES, ARTIFICIAL STAINING, WEIGHTS AND PRICES

HARDLY any precious stone is used in mounted jewellery in the same form as it is naturally found. The natural shape is often irregular; sometimes stones occur as pebbles, or sometimes as broken crystals or slabs. Time and weather have flawed their surfaces, and their beauty and interior colour have to be brought out by artificial shaping and polishing. As the whole aim of the lapidary is to produce the most beautiful gem from the given piece of unattractive rough stone, considerable skill and experience are required. Badly flawed pieces are not, as a rule, cut as jewel stones. Cleavage and optical properties, as well as hardness, all have to be considered, and the advancement of understanding of these properties has led to the cutting of stones in definite shapes and proportions.

Unfortunately, lapidary work is a craft little understood in this country, and practically all the gem stones we see have been cut in Holland, Belgium, Germany or France. Native cut stones, many of which emanate from India, Ceylon and China, are for the most part crudely worked, with the exception of jade, and nearly all are re-cut before being put on the European market. Antwerp and Amsterdam are the chief centres of diamond cutting, and this is quite a separate industry from the working of other precious and semi-precious stones. The latter are fashioned chiefly in Idar and Oberstein (Germany), and neighbouring villages. Here, also, many stones are stained and "synthetics" manufactured. Some lapidary work is done in London, but it is chiefly in connection with good quality stones. Other districts in Germany and France carry on a small industry in the cutting of stones, and arrangements have recently been made to start this work in South Africa. An attempt to cut diamonds in Brighton within recent years failed chiefly through lack of experience. The work demands great skill and accuracy, as stones are easily spoilt, and since they are valued chiefly by weight and quality, the best results from the rough stone must always be obtained.

Originally precious stones were kept in the form as found in the matrix, but when the abrasive use of the diamond was discovered (not till the fifteenth century) stones were cut and polished, but only to improve the natural facets. Flaws, also, were covered by small facets. Many of the old Indian diamonds remained like this for centuries. Later, the cleavage property of diamonds being known and more modern appliances being employed, the cutting of stones was further developed, and the "brilliant" cut of to-day is a direct development from the more simple forms of former times. Louis van Berguen, a citizen of Bruges, was the first to discover the art of cutting and polishing diamonds. This was in the year 1456.

Modern cutting is based on the knowledge of the physical properties of the individual stone, and its refraction and dichroic effects are so well understood by the skilled cutter that faceting and cutting are checked by the eye only, and no actual angular measurement is taken. In the case of most semi-precious stones the finished faceted stone is only about one-sixth the size of the original rough piece. The waste material from diamonds is used for industrial purposes, such as drills, polishing material, etc., but faulty material from other stones is practically useless.

To-day cutting is done by electrical power, though hand power is still used in delicate work. Stones are first slit by revolving vertical wheels, or laps, and they are then ground by laps set horizontally. In the case of diamond polishing, the laps are of soft iron. Various polishing and lubricating materials are used, and a hard form of diamond, known as boart, is used for grinding and polishing the harder stones. Facets are not so exact in coloured stones, that is, stones other than diamond, as here the chief aim is to bring out the fundamental colour of the stone to the best advantage, at the same time retaining weight.

The cutting of agates is of special interest, and this is described in the chapter on quartz.

Forms of Cutting. The chief forms now used are—

1. The Brilliant cut.
2. The Step cut.
3. The Cabochon cuts.
4. The Rose cut. (See Figs. on page 22.)

Transparent stones are usually faceted, but translucent and opaque stones are generally cut *en cabochon*, as this form of cutting gives the best effect as a rule.

1. *Brilliant Cut* is so characteristic of diamond that this stone is often referred to as a "brilliant." In a perfectly cut stone of brilliant form there are fifty-eight facets. The girdle divides the crown from the base, and the upper part contains thirty-three facets. The base, or culasse, contains twenty-five facets. The girdle, which is used as the setting edge when the stone is mounted in jewellery, is usually circular, otherwise the arrangement of the facets is distorted. Certain proportions are also necessary to obtain the maximum amount of brilliancy and "fire" in the diamond. The thickness of the crown should be one-third the total thickness of the stone, while the table should be about four-ninths the breadth of the stone. The girdle should be as thin as is practical, and the light falling on the table should be refracted and then reflected from the base facets, ultimately emerging from the crown. The correct inclination of the facets requires a knowledge of the optical properties of diamond, and in addition to skill a considerable amount of patience and time is required in cutting valuable stones in this form.

The optical characters of other stones when cut in brilliant form are individually studied, and the inclination of the facets is modified accordingly.

2. *Step Cut*, sometimes known as trap cut, is often seen in emeralds and topaz. The facets above and below the girdle are parallel and horizontal, but there are no strict rules of proportion. Dark stones are made

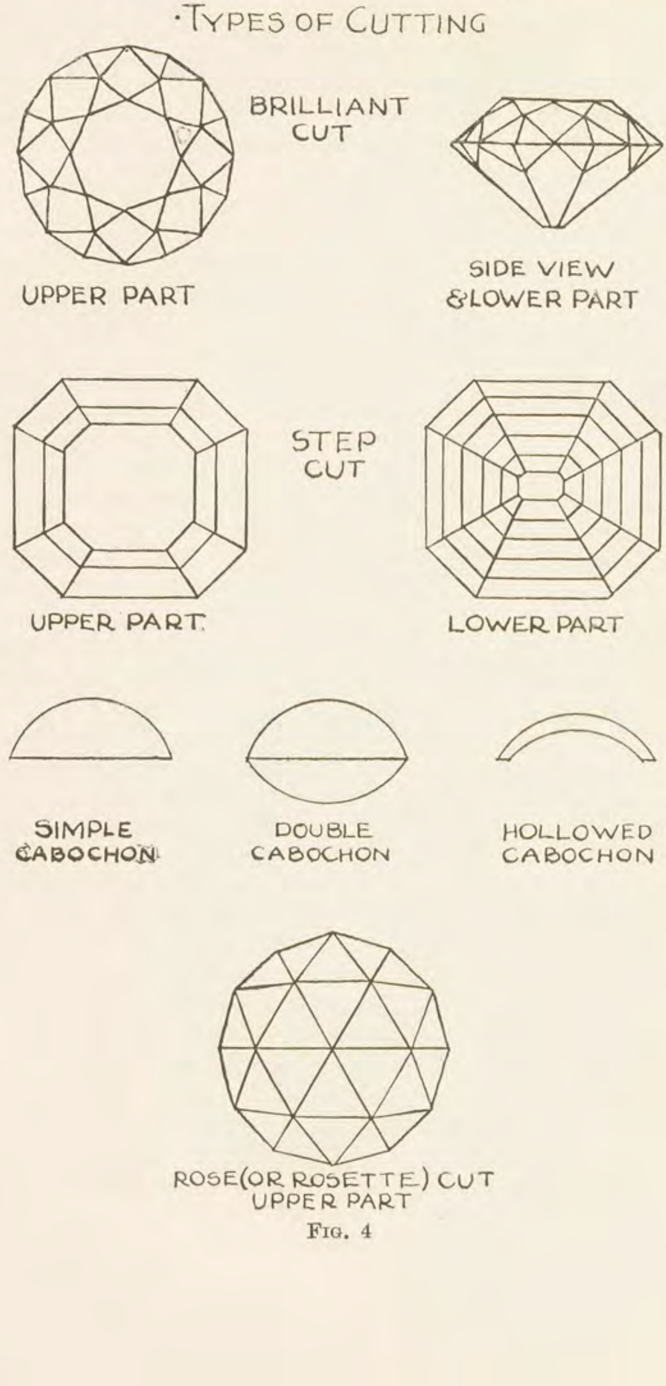

·TYPES OF CUTTING
BRILLIANT CUT
UPPER PART
SIDE VIEW &LOWER PART
STEP CUT
UPPER PART
LOWER PART
SIMPLE CABOCHON
DOUBLE CABOCHON
HOLLOWED CABOCHON
ROSE(OR ROSETTE) CUT
UPPER PART

FIG. 4

to appear paler by having a greater "spread," and absorption effects must be considered.

There is a form of cutting known as the **mixed cut,** in which the upper part of the stone is brilliant cut, and the lower part is step cut. Amethysts are characteristically cut in this fashion.

3. *Cabochon* cutting may be in the form of a simple cabochon, in which the top of the stone is curved and the base is flat, or it may be double cabochon in which the upper and lower portions are both curved. There are no flat facets. Opals, moonstones, and cat's-eyes are frequently seen in cabochon forms. Occasionally one sees hollow cabochons. These are curved above the girdle and hollowed out below. Carbuncles (garnets) are sometimes cut in this form, as the colour is lightened thereby.

4. *Rose Cut* is now used in very small diamonds only, and these are sometimes called "roses." The form is really a simple cabochon, but the curved surface is faceted. In most cases there are twenty-four facets, and the flat base is the cleavage plane. Double "roses" are very seldom seen. The rose cut is generally used for stones intended to encircle a larger stone in moderately valuable jewellery.

The present forms of cutting can hardly be improved upon, since they are all based on the actual known properties of the individual stones. Also, since diamond is the hardest material known as yet, its use as an abrasive agent cannot be bettered. The actual *methods* of drilling and polishing may be further simplified in the future, but the present means seem sufficiently efficient to meet market conditions.

The Artificial Colouring of Stones. The artificial colouring of stones to improve their original appearance and value is quite a general and recognized practice in the case of many varieties. The idea is not new, as indeed the writings of Pliny show that the Ancients were conversant with many processes in this direction, some of which have been forgotten and others greatly improved upon.

In general, all porous stones may be treated successfully, though the resultant colour is not always permanent. Time and care are needed, and a considerable amount of experience is necessary in order that stones be not spoilt. The application of heat is often required, and a correct temperature must be obtained. Similarly, when direct staining by soaking in a solution is essayed, the correct period of saturation must be given, and this frequently varies with the individual stone.

Amongst the cheapest semi-precious stones, chalcedony, of which there are various types, is the frequent victim of human enterprise. Heating alone accentuates the colour of many agates, and the bright red carnelians one often sees are the result of applied artificial heat, except the Indian stones, which generally come from the East untouched. Before heating, the red stones are sometimes impregnated with a solution of iron vitriol. The so-called green and blue agates (the former being often misnamed "chrysoprase") never occur in such vivid colours in their natural state. The blue colour is obtained by soaking first in a solution of ferric oxide, and then in a solution of potassium ferrocyanide. By this means, a deposit of Prussian blue is formed in the pores. The green colour is produced by soaking either in a solution of a nickel salt or in a solution of chromic acid and subsequently heating.

Certain portions of the natural agate are not porous, and consequently will not take the dye. Thus white streaks may be apparent throughout the stone, with intermediate brightly coloured portions. Natural stones do not have such distinctive white zones, nor are the coloured portions so deep. This staining is, in many cases, permanent in effect, and certainly makes the stone more attractive than when presented in the original state.

In like manner, the white and black stripes in onyx are generally accentuated by heat and chemical action. The stone is first immersed in a solution of sugar or honey, which is kept at a certain temperature for several days, the temperature and the time depending upon the porosity of the stone. It is then taken out, washed, and soaked in warm sulphuric acid. In this way, the honey or sugar absorbed from the first soaking is converted into carbon, and this gives the required black colour. In the case of the mauve-coloured stones, referred to as "chalcedony," an ammonia compound is used, and as this is subject to evaporation, the colour is not permanent. The staining of jasper has produced the stone known as Swiss Lapis, or German Lapis. Different processes are used to obtain the blue colour, but none is permanent in effect. Nor is the resultant colour the same as that of lapis lazuli, with which it is sometimes confused. The paler and cheaper varieties of this more valuable stone are often stained to appear deeper in colour, as are also turquoises, since the deeper blue colours are preferred. The effect is superficial only, and soon reveals itself in wear, though it must be remembered that natural turquoise often loses its colour also, not, however, so quickly as the artificially stained stones.

White jade is often stained green, but exposure to light quickly reveals the uninteresting "mutton fat" colour of the least expensive forms of jade. Quartz cat's-eye is sometimes seen with vivid greenish and bluish effects, which are quite unnatural.

The demand for "antique" amber has resulted in the staining of modern pieces to simulate the dark brown or clear red varieties so much sought after. Suitably cut pieces are immersed in oil together with a dyestuff, and a slow heat is applied for a considerable period. The pieces are then dried, cleaned, and repolished, and if the resultant colour is suitable, they are marketed in the form of necklaces or pendants. As amber is very brittle, much material is spoilt by this process, and though colours are rarely natural and never permanent, such pieces are often sold at high prices. A recent process by which amber is heated and a darker colour obtained is said to have a permanent effect.

A considerable improvement is sometimes effected in the case of certain zircons. These, when heated, become colourless and their lustre improves. In fact, many such stones have been passed off as diamonds, but lower hardness and higher specific gravity distinguish the inferior stone.

Many types of quartz, as well as topaz and other stones, are the subject of alteration by heating and chemical action, and these will be dealt with under their respective headings. In all cases, a gradual heat and gentle cooling are necessary, and even so, much material is inevitably spoilt. In many cases improved effects have been obtained, though as a general rule they are only temporary, and to the trained eye are obvious.

Weights and Prices. Weight and price are directly connected in the case of all stones of commercial value. How often have we regarded beautiful pieces of mounted jewellery and marvelled at the brilliant stones, the exquisite design and workmanship! Yet a dealer in precious stones would not be primarily concerned with the effect of the article. He would immediately try to calculate the weights of the mounted stones, and then, having regard to their quality, would estimate the total worth. The unit of weight used in relation to all precious stones is the *carat*, and this small weight is a development of the ancient use of seeds as weights. The modern carat, however, is one-fifth of a metric gram, and the metric system is now universally used in weighing stones. The only exception is pearl, for which the *grain* is used, the grain being equivalent to a quarter of a carat. Rough material, such as opal, etc., is generally bought by the ounce, and cheaper rough stones, such as rock crystal, are bought by the kilogram or hundredweight.

Prices of all gem stones, including the cheaper varieties, vary so much that no guide of any practical value can be given. Fashion and demand are the chief causes of varying prices; supply is quite a secondary cause. Prices may vary from pence per carat to hundreds of pounds per carat. As an example, fine emeralds are now realizing as much as £3,000 per carat, and these stones are to-day the most expensive gems.

Long ago the Persians regarded emeralds and rubies as more precious than diamonds, and even in the sixteenth century Cellini records that rubies were worth eight times the price of diamonds. To-day the Chinese regard jade as the most precious stone, and this is the reason that the finest pieces realize such high prices. Indeed, the best examples of this stone are never marketed in Europe.

The popularity of a stone is sometimes influenced by its being worn and favoured by a member of a royal family. Thus the Duke of Connaught gave the Princess Louise of Prussia a ring which contained a chrysoberyl cat's-eye. This made the stone fashionable for a time, and consequently increased the price considerably. In like manner, Princess Mary has helped to popularize the emerald, and the Duchess of York, by favouring sapphires, has increased the demand for this stone.

But apart from fashion, the economic state of a country has some bearing on the price of gem stones. Immediately before the French Revolution, when the European courts vied with each other in extravagance, the prices of all precious stones rose considerably. During and after the Revolution they fell in price again. Similarly, in the year 1914, prices of all stones dropped, and their recovery was effected in 1917 and onwards. At present, the finest stones realize prices that could not be imagined in former days. Much of this is due to the prosperity of the United States, where most of the finest specimens are sold to-day.

As previously mentioned, the introduction of synthetic rubies and sapphires some years ago affected the prices of these stones, but the realization that there is a difference between a synthetic and a real stone, a difference, moreover, which may be quickly recognized, has restored the natural stone to its former place. In fact, fine specimens of the natural stones command even higher prices to-day than formerly. In addition, these stones have certain industrial uses, so they must of necessity be of some value always. This is also the case as regards diamond, though the supply of this stone is largely controlled, and is, therefore, kept at a fairly steady price.

Prices of semi-precious stones fluctuate considerably, as supply is seldom limited. Certain varieties, such as alexandrites, command good prices, but the majority of other stones, such as garnets, amethysts and moonstones have all been victims of fashion in late years, and prices have fluctuated considerably within a very short period.

The price of pearls is based on a method not used in the case of any gem stones. The pearl is first weighed in grains, and this weight is squared. The resultant figure, called the "base," or "shilling base," is regarded as shillings. The "base" value of the pearl is then ascertained (this depends upon market fluctuations) and the shilling base is multiplied by the base assigned to the pearl. Thus a ten-grain pearl valued at 15s. base is worth a total sum of £75. Prices of pearls in the trade are always referred to by "base," except the very cheapest qualities, which are priced by carat, like other stones. The actual value of pearls varies considerably, according to quality, colour, size, etc., and the smallest imperfection makes a great difference to their worth. The introduction of the cultured pearl has not affected the price of natural pearls; in fact, large fine pearls are to-day realizing higher prices than ever. In addition, the total production of pearls from each year's fishery is comparatively small, and apparently is not sufficient for the demand.

It will therefore be seen that, whilst it is possible to appreciate the beauty of gem stones by recognizing their individual properties, their value is largely influenced by a variety of conditions which only those actively and constantly engaged in the buying and selling of stones can appreciate.

As the reader will now be acquainted with the various terms used in the description of gem stones, we can proceed with a few observations on individual stones.

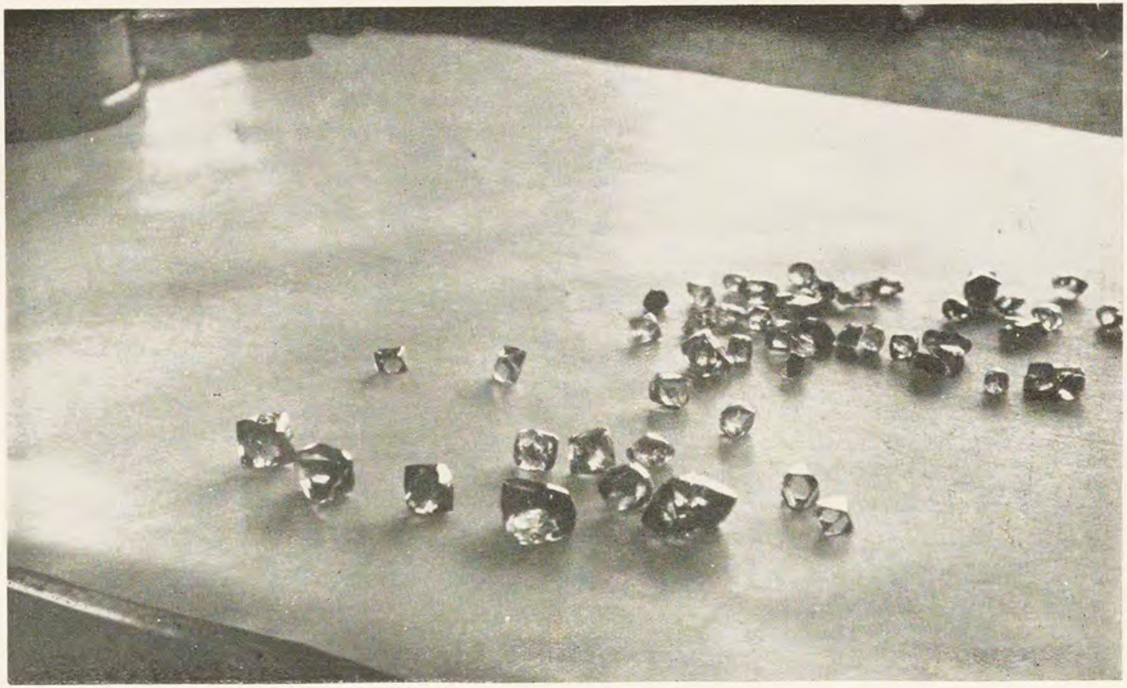


PLATE I

ROUGH DIAMONDS (KIMBERLEY, SOUTH AFRICA)
Note the crystal formation

PART II

CHAPTER IV

DIAMOND

(Hardness, 10; specific gravity, 3·52; refractive index, 2·4175)

DIAMOND is probably the most widely known precious stone, and it justly holds its position of esteem on account of its several remarkable properties. Yet chemically it is much the same as ordinary lampblack —nothing more than carbon, but in a very pure state. When found, rough pieces look decidedly unattractive, though crystals sometimes occur that are remarkably symmetrical. The crystal forms may be classified under the cubic system, although the crystal faces are often curved and distorted owing to the tremendous pressure to which they have been subjected during their formation.

The variety used in jewellery is almost colourless and practically free from flaws, though many faint shades of colour occur. "Fancy" colours are rare, and are nearly all characteristic of certain districts. Other varieties include boart and carbonado, the former being a minutely grey to black species, and the latter being quite black. Boart is very hard, and when powdered is used for cutting and polishing stones. Carbonado is used as an abrasive, and although both are important industrially, they are not used as gem stones.

Diamond is the hardest substance known, although it is quite brittle, and may be injured by a fall on a floor. It is a prevalent idea that diamond is difficult to break, indeed one of the first stones found in South Africa and thought to be a diamond was given to a blacksmith to test. He put it on his anvil and smashed it to pieces, thus apparently satisfactorily proving to the owner that it was not a real diamond!

It is interesting to note that hardness in these stones varies according to place of occurrence. The stones from Borneo and Australia are harder than the South African stones. Some of the specimens from Africa harden slightly after they are exposed to the air, and many are of unequal hardness in themselves. However, all are harder than any other known mineral, and it is only the very perfect cleavage that this stone possesses which simplifies its cutting. Until this property was discovered, it was nearly impossible to get the best results from the rough stone.

Its specific gravity is remarkably constant, and the refractive index is the highest of all gem stones. Its adamantine lustre is well known, whilst the dispersion is very strong, being, in fact, the greatest of all colourless stones. This latter property is responsible for the play of colours called "fire," and the Indian stones show this property to the highest degree when properly cut.

Though diamond is infusible, it may be burned by using a lens to concentrate the sun's rays upon it when suspended in a jar of oxygen. Lavoisier was one of the first to carry out this experiment.

The finest diamonds are colourless, but many pale tints occur. Blue-white is regarded as a fine colour, though most of the stones found are of a yellowish or brownish tinge, particularly those from South Africa. These stones are called "off-coloured," and are included in the cheaper grades. Colours are difficult to judge, and flaws are not readily seen, except by those who constantly handle stones. Imperfections generally consist of black spots, due to graphite or uncrystallized carbon probably, and these spots are often found in the finest stones.

The form of cutting generally adopted is the brilliant cut, though fancy cuts, such as drop shapes, are seen sometimes. The rose cut is now used only for small stones.

Diamonds were first obtained from the Golconda mines in India, near the river Kistna. Golconda was the marketing town for the stones, though the actual fields covered a wide area, and the stones occurred in conglomerate, sandstone, or gravels in river beds. Tavernier, a French jeweller and traveller, who visited India in the seventeenth century, described the working of these fields by the natives, and also their mode of cutting the precious stone. But new fields were discovered in Brazil about the year 1725. They were noticed in the gold mining districts, and at first were not thought to be diamonds; in fact, they were used as counters in card-playing by the miners until they were seen by a person who had dealt in diamonds in the East. Stones then naturally fell in price, but this was checked by the astuteness of the controlling merchants, who stated that the stones found were really inferior Indian stones shipped to Brazil. Before long this was counterbalanced by the shipping of stones from Brazil to India, to be sold as Indian stones.

The Portuguese Government, some little time later, demanded such high royalties on stones exported from Brazil that mining became an unprofitable proposition. In 1834, when Brazil became independent, reasonable royalties were introduced, and the mines were worked again. Good small stones were found, but the high cost of living, the unhealthy climate, and lack of suitable labour did much to hinder progress.

Mining is still being carried on, and the stones occur chiefly in a river deposit, a kind of gravel known as "cascalho," over an area in the States of Minas Geraes and Bahia. Carbonado is almost exclusively found here.

India and Brazil were the only sources of supply until the year 1867, when the South African fields were discovered by a mere accident. The children of a Boer farmer found a stone, which was later tested and proved to be a rough diamond. Though this stone was sold for £500, and shown at the Paris Exhibition, it was regarded as an isolated find. Two years later, another stone was found by a shepherd boy, and this was subsequently sold for over £11,000. These discoveries now attracted attention, and prospectors began to invade the district. Various other finds were made, especially round what is now the town of Kimberley, and soon a large town sprang up, which still remains the centre of the diamond industry.

Stones were found in the loose surface deposit, and also later in the under surface. This latter, known as "yellow ground" on account of its colour, was also fairly loose and easy to work, but farther down, about fifty feet, a hard rock was encountered, known from its colour as "blue" ground. This also yielded diamonds.

Open working soon became impossible, chiefly owing to the falling rock (reef) from the sides, and the sinking of shafts and expensive machinery necessitated the formation of companies with large capital in order to make the work profitable. Cecil Rhodes was prominent in forming the De Beers Mining Company, which later became the De Beers Consolidated Mining Company, and this concern gradually incorporated the majority of the Kimberley mines. It has been the policy of the company to buy up all important mines found subsequently, so that to-day it exercises the controlling interest in the diamond market. This is becoming increasingly difficult, as new mining areas are being discovered. The most recent find, that of Dr. Marensky, a geologist, is situated in Namaqualand. Stones have been found near the surface in an area known as Alexander Bay, below the mouth of the Orange River. Mining is being strictly controlled by the South African Government, and it remains to be seen how prices of diamonds will be affected by these discoveries.

Some stones occur in river diggings, chiefly in the Vaal river district, but the majority come from the dry diggings. There they occur in the contents of what seem to be pipes which pierce the local strata for thousands of feet in a vertical direction. Many believe that these pipes are evidence of old volcanoes; they are filled with "blue" ground, really a periodotite, an ultra basic rock, and this is very much broken up. It is sometimes called Kimberlite, and in addition to diamond it

PLATE II

DE BEERS MINE, KIMBERLEY, SOUTH AFRICA
The depth of the mine may be judged from the buildings above

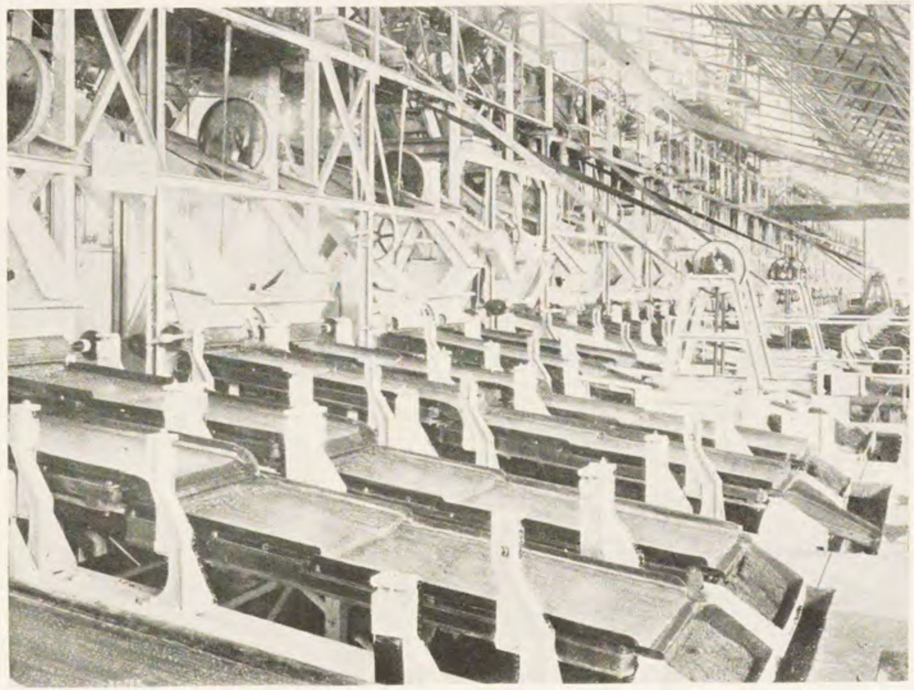


Plate III

Dissociating Diamonds from the Blue Earth

The tables, a series of greased moving trays, at Pulsator House, Kimberley, South Africa contains pyrope garnet, zircon, mica, magnetite, and other minerals. The "yellow" ground is really the "blue" ground which has been exposed to the air and the influence of the weather. The colour is probably due to oxidization of the iron present in the original blue material.

The method of gaining the precious stone from the surrounding material is first to raise the "blue" ground and spread it over "floors" on the open veldt. There it is allowed to remain for a considerable time exposed to the weather, which breaks it up. Then it is taken to washing and concentrating machines, where the heavier materials are separated from the lighter. Those left are then placed in a series of enclosed iron trays, covered with a thick coating of grease. Diamond has the peculiar property of adhering to grease while other stones pass over; by this method all hand work is obviated and consequently possible theft. The grease is periodically boiled to remove the stones, which are handled at this point for the first time. They are then passed to sorters, who separate them into parcels according to size and quality. Afterwards they are rearranged with a view to market conditions and sent to London, where a syndicate of merchants handles the rough stones and disposes of them to cutters. After being cut, the stones are sorted once again according to quality, and sold to manufacturing jewellers and others, from whom they appear in the market in the form of mounted jewellery. Blue-white, white, silvery Cape, and fine Cape stones are considered the best, and brown and dark brown stones the cheapest. Experts can tell not only from which country a cut stone originated, but in many cases the mine of origin as well. South African stones are generally "off-coloured," except the Jagersfontein mine stones, which are usually white in colour.

New South Wales produces small stones of great hardness, but commercially the fields are not important. Borneo also produces very hard stones. These are found near the surface, and are of good colour as a rule. In South-West Africa (formerly German) stones are found within a foot of the surface, and are picked up by hand by the natives. Stones are small and yellowish, and not of great value. Rhodesia, the Belgian Congo and British Guiana, all furnish stones, and the last is becoming a commercially important area.

The mode of origin of the diamond is still unsolved. That enormous pressure has been used is evident, but there are no signs of excessive temperature. The successful production of diamond by artificial means on a larger scale may, in the future, throw more light on this subject.

Since diamond has, from time immemorial, been considered a stone of great value, it is not surprising that certain large stones exist whose past history can be traced for a considerable time.

The weights of many of these stones are inexact, since some have been recut at different dates, whilst others have disappeared for a number of years, and on reappearing they have been confused with other large stones. The largest and most valuable stones have been found in India, with the exception of the Cullinan diamond, which is of South African origin.

The stone called the Koh-i-noor (Mount of Light) has been known since the fourteenth century, when it was in the hands of the Mogul Emperors. Nadir Shah took it, together with other spoils, from Delhi in the year 1739, and on his death the stone passed successively into the possession of several different Indian princes. Ultimately it came into the hands of Runjit Singh, whose descendants kept it until the East India Company acquired it. Later it was presented to Queen Victoria. In 1862 the stone was recut, and its weight was reduced to one hundred and six carats. This stone is now the private property of the English Royal Family, and is valued at about £100,000. A model of the stone may be seen in the Tower of London.

Another well-known stone, the Pitt or Regent diamond, was discovered in India about the year 1700.

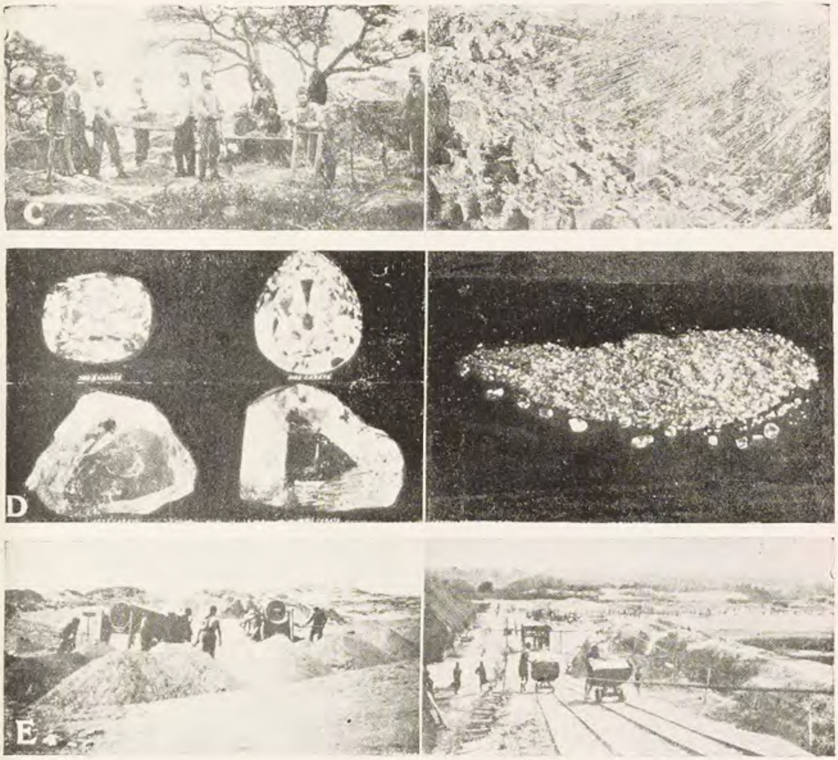


PLATE IV

C (*a*). DISCOVERY OF THE KIMBERLEY MINE, 1870

C (*b*). EARLY DAYS IN THE KIMBERLEY MINES: HAULING GROUND FROM THE CLAIMS BY WIRE ROPES

D (*a*). THE CULLINAN DIAMOND, 3,032 CARATS, AS FOUND, ABOVE: THE STARS OF AFRICA CUT FROM IT

D (*b*). A DAY'S WASH AT DE BEERS MINE

E (*a*). DIAMOND MINING IN SOUTH-WEST AFRICA, NEAR LUDERITZ BAY

E (*b*). ALLUVIAL DIAMOND MINING IN THE KASAI VALLEY, BELGIAN CONGO

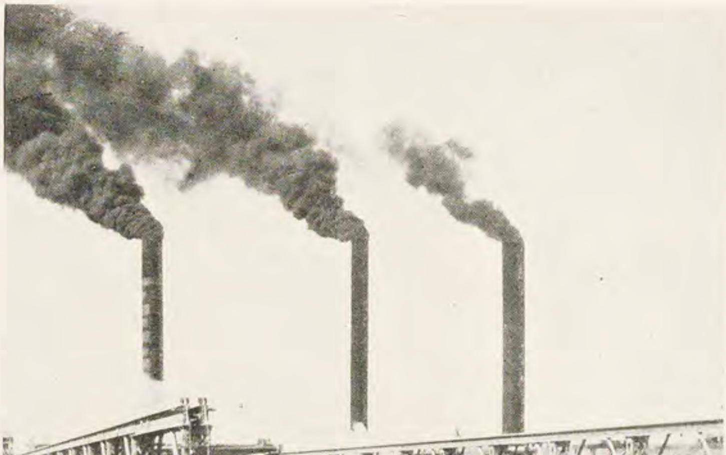


PLATE V

STEAM CRUSHING AND WASHING GEAR AT THE PREMIER DIAMOND MINE, NEAR PRETORIA

It was purchased by Pitt, Governor of Fort St. George, Madras, who had it cut into a perfect brilliant. The actual cutting took about two years, and cost about £5,000, the resulting stone weighing about one hundred and sixty-three carats. Pitt sold the stone to the Regent of France in 1717 for £135,000, but it was stolen with other French jewels in 1792 during the French Revolution. It was recovered from the thieves, and is now exhibited in the Louvre. The stone is valued at about £480,000.

The largest known Indian stone is the Great Mogul. This was found in the year 1650, and on being cut it was reduced to two hundred and forty carats. It has disappeared from all view for some years.

Another historical stone is the Orloff, which once formed the top of the royal sceptre of the Russian royal family. It is rose cut, weighs about one hundred and ninety-three carats, and is of very fine quality. It is supposed to have come originally from a temple in India, from which a French soldier stole it. After changing hands several times, it was bought by Prince Orloff, who presented it to Catherine II of Russia.

The Savoy diamond once belonged to Queen Elizabeth, and later James II sold it to Louis XIV. It was shown at the Paris Exhibition in 1867. Several other large and fine stones are owned by Indian princes, and some of the finest found their way to the Russian Crown jewels in the past.

Since the expansion of the South African fields, several large stones have been found, but these were all surpassed in 1905 by the finding of a huge stone near Pretoria. This stone, now known as the Cullinan, was named after the Chairman of the Premier Diamond Mining Company, and when found it weighed about three thousand and twenty-five carats. It was quite transparent, colourless, and showed only one flaw near the surface. The Transvaal Government purchased this stone for £150,000, and presented it to King Edward VII. The stone was later cut into several brilliants and fancy shaped stones by an Amsterdam firm, and two of the largest stones have been set in the English Crown jewels.

The largest coloured diamond is the Hope, which weighs about forty-four carats, and is of a greenish-blue shade. Originally a larger stone, Tavernier purchased this in India in 1642, and sold it to Louis XIV. During the French Revolution it was stolen. In 1830 the stone reappeared in another form, and was bought by Thomas Hope, a banker, for £18,000. On the sale of Hope's collection of gem stones, this went to America, and later an Indian purchased it for £80,000. It was subsequently sold by auction in Paris for a smaller sum. This stone is supposed to bring ill-luck to its possessor, but the stories associated with it are mostly fables.

The Dresden diamond is of a beautiful apple green, and the Tiffany is an orange-coloured brilliant of one hundred and twenty-five carats. A ruby-red stone, known as Paul I, was in the Russian Crown jewels, but the fate of most of the Russian stones since 1917 is a matter of conjecture.

CHAPTER V

RUBY AND SAPPHIRE

(Hardness, 9; specific gravity, 4·03;
refractive indices, 1·76–1·77)

THESE stones may be described together, since they are both corundum, an oxide of aluminium. The impure granular variety of common corundum is known as emery, and this is used as an abrasive on account of its hardness.

Ruby and sapphire are both popular and costly gem stones, the former being of a beautiful red colour, and the latter an attractive blue. Ruby generally occurs in crystals of six-sided prisms and sapphire as twelve-sided prisms. Both are therefore of the hexagonal system. Other finely coloured varieties of pure corundum occur, and these are named according to colour. All are either transparent or translucent, and are both attractive and suitable for jewellery on account of their wide range of colours and their hardness.

Yellow stones are known as yellow sapphire, or Oriental topaz (King Topaz in Ceylon).

Colourless stones—white sapphire.

Green stones—green sapphire or Oriental emerald.

Purple stones—purple sapphire or Oriental amethyst.

Pink stones are also found, and all the colours are due to different metallic oxides. The coloured varieties, with the exception of ruby and sapphire, are known as "fancy sapphires." Star rubies and sapphires are sometimes seen, and these, when cut *en cabochon*, display a six-rayed star of light on the summit of the stone. This is due to the stone's containing cavities regularly arranged parallel to the six sides of the prism, and on being suitably cut light is reflected from the interior, which produces the star effect known as "asterism." Layers of different colours are often seen in one stone, and frequently the colour of a cut stone is the result of the reflection of light from a small spot of colour near the base of the stone. Parti-coloured stones are frequently seen, and most stones contain flaws in the form of cracks or spots.

The rarest and most expensive shades are the "pigeon-blood" red in rubies, and the "cornflower" blue in sapphires. Large and perfect stones are very scarce, and command a high price. The majority have faults, and sometimes silky-looking internal patches. This "silk" is also due to a number of parallel minute canals from which light is reflected.

All coloured varieties show strong dichroism, and this must be taken into consideration when cutting. Although very hard, crystals break fairly easily along the parting planes, so care should be taken when handling cut stones. The hardness is not constant, and rubies are generally softer than sapphires. Similarly, Ceylon sapphires are harder than Cashmere sapphires. The specific gravity is fairly constant for all varieties of corundum, and the dichroism is so well-marked that it may be seen frequently with the naked eye. Colour dispersion is small, so not much "fire" is shown. This property alone would distinguish white sapphire from diamonds, apart from its higher specific gravity and double refraction.

Cut stones are seen in brilliant, mixed, and step forms, whilst "star" stones are cut *en cabochon*. Ceylon sapphires are generally cut steeply, so that all emerging light passes through the deep blue-coloured spot in the base of the stone.

The colour of ruby varies with locality. Siamese rubies are generally darker than the Burmese, and the Ceylon stones are, as a rule, pale and parti-coloured. Cashmere produces the best sapphires, and Montana (U.S.A.) supplies the market with the metallic bluish stones. The Australian sapphire is a deep blue to almost black. Ceylon and Australia produce nearly all the "fancy sapphires." The best rubies are found in the Mogok district in Upper Burma. Here crystals occur in a metamorphic limestone, which weathers to

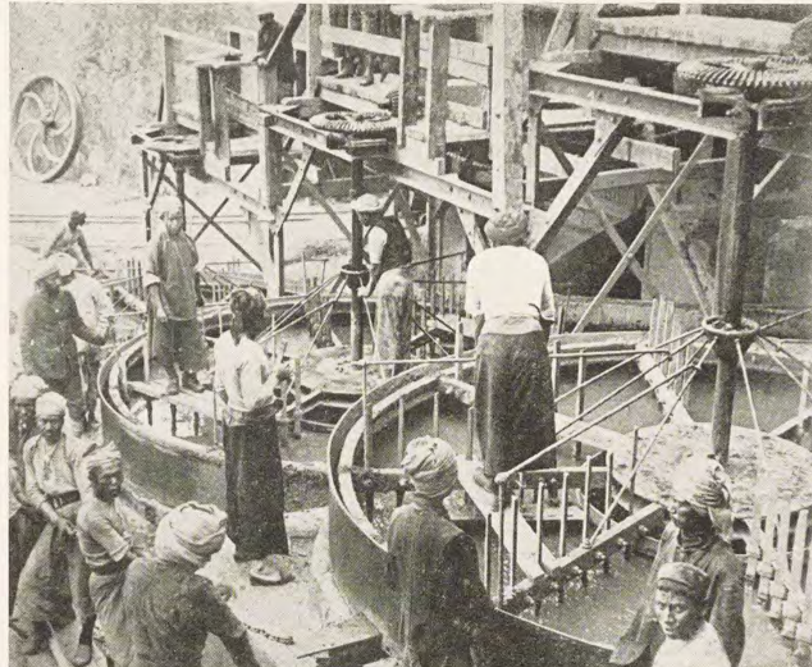


Plate VI

Washing Plant in a Ruby Mine, Burma
Gem-bearing gravel being washed, the power being supplied by hand

Plate VII

Open Ruby Market, Mogok, Burma

a yellowish clay. In Siam the locality of Battambang produces sapphires, and rubies are found at Chantabun, near Bangkok, both in a sandy clay. But the Burmese mines, which are of a great age, have yielded all the finest large rubies. Two of the finest stones from these mines have been sold for £10,000 and £20,000, and their weights were only thirty-two and thirty-eight carats respectively. Until comparatively recent times the ruby mines were unapproachable by Europeans, as the locality was very carefully guarded by the natives, but since the occupation by the British, in 1885, the mines have been exploited by modern methods. In 1889 a company was formed, known as the "Burma Ruby Mining Company, Ltd." Modern apparatus for pumping the water from the mines was installed, and other improvements made, but on account of the high taxes payable to the Government the results were not profitable, and for some time a yearly loss was incurred. In addition, mostly small stones were found, and those of medium size contained many faults that rendered them of very little value. Stones were cut in Mandalay, and mining continued until the introduction of synthetic stones. This entirely spoilt the market for some years, and mining has been carried on only in a spasmodic fashion since that time.

Siam produces splendid sapphires, but the largest and most valuable have come from Cashmere (India). These stones are also found in Queensland and Rhodesia, whilst Ceylon, the most prolific gem-bearing area known, produces both rubies and sapphires of all colours, though not in large quantities.

In the former Russian Crown jewels there was a ruby of considerable size. This was presented to Catherine of Russia in 1777. A large stone in the English Crown jewels, which was for a long time regarded as a ruby, is really a red spinel. The Duke of Devonshire possesses a fine sapphire of one hundred carats, and an image of Buddha, carved from one sapphire, is shown in the Mineral Gallery of the British Museum at South Kensington. There, one may also see a fine crystal of ruby, one hundred and sixty-three carats in weight, whilst beautiful specimens of sapphire may be seen in collections at Paris and Vienna.

The largest brown sapphire weighs about one hundred and thirty-two carats, and is in the Mineral Museum, Paris. It has been called the "Wooden-Spoon Seller," from the occupation of the man who found it in Bengal. Many sapphires are of historical interest, and amongst these is one of a heart shape, dating from about 1575, which was once owned by Darnley, the husband of Mary, Queen of Scots. It is now in the Crown jewels. Another sapphire, mounted in a ring, was used as a token to confirm the death of Queen Elizabeth. It was thrown out of a window by Lady Scrope to the Earl of Monmouth, who took horse to Scotland and presented the ring to James VI. Two large sapphires, once the talisman of Charlemagne, were presented to Napoleon by the clergy of Aix-la-Chapelle. These afterwards came into the possession of Emperor Louis Napoleon III.

The term "corundum" must not be confused with the abrasive material carborundum, which is corundum mixed with heavy minerals, such as magnetite and haematite, all of lower hardness. Ordinary corundum is used in watch parts and for abrasive and polishing purposes. The name of this species is derived from an Hindu word, and all the original stones came to Europe via India. Hence "oriental" distinguishes the varieties of corundum. "Ruby" is derived from the Latin "ruber," meaning red, and this is the root word for other red stones, such as rubicelle and rubellite. "Sapphire" occurs in the Hebrew and Persian languages, and means "blue." Originally it was applied to lapis lazuli, a stone which was apparently known and appreciated before the blue sapphire. The term "yellow sapphire" is therefore rather incongruous in view of the real meaning of "sapphire."

Plate VIII

Ruby Cutting in Mogok, Burma
Note the primitive tools and methods which are still used

CHAPTER VI

EMERALD

(Hardness, $7\frac{3}{4}$; specific gravity, 2·74; refractive indices, 1·57–1·58)

This stone, the most costly of all gem stones at present on the market, is the beautiful velvety green variety of beryl, a silicate of aluminium and beryllium. Aquamarine, golden beryl, and morganite (the pink variety) are all beryls also, and are chemically of the same composition as emerald, though they differ in colour. The green in emerald is probably due to a small percentage of chromic oxide, as heat does not affect the colour.

Crystals frequently occur in the form of hexagonal prisms (hexagonal system), and are nearly always found flawed. This, in contrast to aquamarine, which is usually found in comparatively large and flawless pieces, is one reason why fine emeralds are so expensive. Most emeralds are marred by cracks and inclusions, which greatly lessen their value. Pale shades are not so valuable, and the best colours range from a deep velvet green to a grass green. The vitreous lustre of a good stone gives a beautiful velvety appearance.

Emerald shows little cleavage, and its degree of hardness is rather low for such an expensive stone. It has a low specific gravity, so it is comparatively light in weight. Stones are very brittle, and great care must be taken when setting into jewellery. For this reason the girdle should never be cut too thinly. Dichroism is distinct in well-coloured specimens. Emerald is usually step cut, and ring and brooch stones are nearly always seen in this form. Acids have no effect on this stone, though it may be fused by means of a blow pipe.

Emeralds are rarely, if ever, found in gravels, but usually in the parent rock, which is often a mica schist.

The chief localities are Colombia (South America), Egypt, the Urals, and New South Wales. It is interesting to note that some crystals from the Columbian mines appear to be clear and transparent when taken from the mine, but flaw immediately on exposure to the air. Some stones even splinter into fragments.

The word "emerald" is derived from a Persian word, though originally it was applied to a different green stone (chrysocolla). It was not discovered that emerald was a beryl until about a century ago. The emeralds known to the Ancients all came from the mines in Upper Egypt, situated in the range of mountains running parallel to the western side of the Red Sea. These mines are still worked, although they produce rather poor stones. The ruins of these mines were re-discovered by the French explorer Caillaud about one hundred years ago. He found tools and plant there which showed that the mines dated many centuries back. Many of the ancient emerald scarabs came from here, as also did the famous engraved stone which was presented to Cleopatra. This area was also the source of supply of all emeralds mentioned in the Bible.

The Uralian mines were accidentally discovered by a Russian peasant in the year 1830. Though some large stones have been found, they are not so fine as those from Colombia, where they have been mined for many centuries. The fine emeralds which Cortez presented to his wife were of extraordinary size and quality. These stones, which were carved and inscribed, were unfortunately lost at sea in the year 1529. Some of the best stones were no doubt carried off by the Spaniards amongst other spoils from South America. However, it was some time before they discovered the actual mines, as the natives persistently refused to disclose the secret of their situation. In 1558 they were discovered by accident, and they were subsequently actively worked.

From time to time the working of the mines has been continued in a spasmodic way owing to difficulties with the local government, with labour, and with climatic conditions. Lately the mining rights were leased to a syndicate by the Colombian Government. Disagreement about details led to litigation between the government and the syndicate, and for some time working was suspended. Meanwhile, demand for good stones increased, and prices rose considerably. The rough stones mined during the law proceedings accumulated and were lodged for safety with a bank in London. On the settlement of the case, the rough was offered for sale, but owing to the enormous sum involved, it was possible for only a limited number of firms to consider the purchase. The stones were eventually bought by a French firm, who had them cut and then mounted in the most suitable forms of jewellery. By ingenious methods, demand for emeralds was further stimulated, and now enormous prices are being obtained for good stones.

Actual rarity is the chief cause of the value of emeralds, though no doubt fine stones are really beautiful, and of all the green stones that exist none can approach the beauty of the velvety-green emerald. Also, unlike most green stones, emeralds retain their colour in artificial light. Even in the days of Pliny this stone was highly esteemed, for he wrote of emeralds, "Neither dim nor shade, nor yet the light of a candle, causes them to lose their lustre."

The largest single crystal of emerald known belongs to the Duke of Devonshire. It is nearly a regular hexagon, and is about two inches in diameter and length. It weighs about one thousand three hundred and forty-seven carats, but though of good colour it is badly flawed. The stone was given to the Duke by Dom Pedro of Brazil.

The finest cut stone belonged to the late Czar of Russia. This weighed about thirty carats.

A fine crystal and also a cut stone may be seen in the British Museum (Mineral Gallery).

CHAPTER VII

OPAL

(Hardness, 6; specific gravity, 2·15; refractive index, 1·45)

THIS beautiful stone is definitely different, even superficially, from all other gem stones. It is difficult to imitate, and impossible to manufacture synthetically. Its ever changing colours make it the most remarkable of precious stones, and fine specimens merit the prices they command.

The chemical composition of opal is silica (oxide of silicon), with a varying amount of water (6 per cent to 10 per cent). Impurities consisting of various metallic oxides are also often present, but these are not responsible for the remarkable play of colours usually seen in most opals. This is caused by its structure. Opal is not a crystalline body, but may be regarded as having been, in its original form, a jelly-like mass of silica which cooled and, in so doing, cracked in many places. These minute cracks later became filled with more recent opal substance containing a different proportion of water. Masses having different refractive indices were thus solidified into one mass, and the resultant opal in this way possesses that characteristic play of colour known as "opalescence." The thinner and more regular the cracks, the finer is the chromatic effect when the stone is moved. The cracks in some opals contain air and no solid matter; these show no opalescence unless immersed in water. This variety is known as *Hydrophane*.

There are two varieties of precious opal—black and white. Both give a beautiful display of colours, but those showing a predominance of red flashes are the most sought after and consequently the most expensive. Some black opals are almost opaque, whilst pieces showing greyish and bluish patches are fairly common. The purer stones are nearly colourless, but these pale milky varieties are uninteresting and not much in demand.

A transparent variety of opal, which does not show any opalescence, is known as *Fire Opal.* Its colour ranges from a yellow to a reddish yellow, and when brilliant cut, this stone makes a good centre piece in mounted forms of jewellery. The term *opal matrix* is assigned to those pieces of opal which cannot be freed from the parent rock because they are too small. Pieces are, therefore, cut and polished together with the parent stone.

Opal is not a hard stone, and it is easily damaged and scratched. Moreover, being porous, it should never be immersed in any liquid. Heat also has a detrimental effect on the colour. In order to show its characteristic beauty of colour, opal is always cut *en cabochon*, with flattened forms for pendants, and steeper sides for rings. Fire opal is generally cut in brilliant or mixed forms.

The oldest known opal mines are in Hungary, and the stones known to the Romans probably came from this district. That they were highly appreciated in those days is evident, since Pliny describes opals in a vivid manner. In the past the mines have been worked both by means of private enterprise, subject to certain taxes, and also by the Hungarian Government. To-day the industry employs not more than sixty men, as the mines are practically exhausted, and are commercially unimportant. The chief sources of supply are now New South Wales and Queensland. These were accidentally discovered by a hunter in 1889. It is said that whilst he was tracking a wounded kangaroo he picked up an interesting stone. Further stones were found, and the mines were subsequently opened. The chief mines are Lightning Ridge and White Cliffs, and from these most of the present-day opals originate. The Hungarian mines are little worked, and produce only small stones.

In Queensland and New South Wales, opal is found in a sandstone rich in iron. These sandstones are of a considerable age. Other stones are found in seams and cavities of rocks, and even in cracks in wood. In the last case, the wood is occasionally replaced by opal, and wood opal is formed. Similarly opal agate, in which layers of differently coloured opal occur, and jasper opal (opal with colour of jasper), are also occasionally met with. In Hungary, opal is found filling cavities and fissures of a decomposed lava, and it is often found associated with iron pyrites. Czerwenitza is the centre of the Hungarian opal mines. Honduras (in the neighbourhood of Gracios à Dios) and the United States of America (New Jersey) also produce a few stones, and fire opal is almost exclusively found in Mexico, near Zimapan. Fire opal was first introduced into Europe by the explorer Humboldt at the beginning of the eighteenth century.

Mention has already been made that opal doublets and triplets are frequently encountered. Thin slices of good stones are "backed" on to inferior quality pieces, or on to onyx. When set in the form of a ring or brooch, the two edges are not always discernible, and such stones are found in all types of mounted jewellery. They are, however, of moderate value only.

Good pieces of opal are exceedingly valuable, and command "fancy" prices, notwithstanding the superstition that opals bring ill-luck to the wearer. How this idea originated it is impossible to imagine, but it has had a definite effect on the sale of opals. Demand for a time declined and prices consequently fell. Of late years the superstition has been dispelled, or perhaps it has been passed on to another stone. In any case, opal has regained its former place as a valuable gem stone.

The finest opal of modern times belonged to the Empress Josephine. It was called the "Burning of Troy," from the number of red flashes which its surface displayed. The largest known stone was probably the one that could be seen in the Imperial Cabinet of Vienna. This was about seventeen ounces in weight, and as large as a man's fist, though it was full of flaws.

CHAPTER VIII

PEARL

(Hardness, $3\frac{1}{2}$–4; specific gravity, 1·5–2·86)

There is no doubt that pearls have been regarded as precious gems since the earliest days. The surprise and delight of our unclothed forefathers when they discovered a beautiful gem in a shell instead of only an oyster may be easily imagined. Their further efforts to find these gems were no doubt disappointing, since pearls are not to be found in every shell. So the rarity and beauty of these gems definitely established them as precious and valuable, and as such they are mentioned in the earliest writings.

Yet this beautiful gem is the product of a mollusc, a shell-fish, and although of organic origin, it is composed principally of mineral matter. It is therefore strictly not a gem *stone*, although it is always regarded as a precious gem.

In order to understand pearls and their formation, it is necessary to study, to some extent, the animal that first produces the pearl shell and subsequently, under certain conditions, also produces the pearl. The pearl oyster belongs to the mussel family, and somewhat resembles the scallop in shape. It possesses a byssus, similar to a bundle of tough threads, by which it is able to attach itself to rocks or other submarine objects. There are generally two spawning seasons each year, when millions of young oysters are liberated. Only those that fall on rocks reach a fishable age, though all bivalves (those oysters possessing two half shells) are capable of producing pearls.

The animal is contained in two flaps of tissue known as the "mantle," and this mantle is covered with minute cells which are able to pour out a mixture of horny materials and carbonate of lime. This mixture partially crystallizes and builds up the shell. This shell, which is formed of two pieces almost equal in size, and hinged at one end, covers and protects the animal. The oyster is able to close the shell by means of a powerful adductor muscle. When food is required this muscle is relaxed, and the shell opens itself ("gapes").

The shell consists of four separate layers. The first (outer) layer, called the periostracum, consists of a horny material known as conchyolin, and this is secreted by the cells of the mantle. The second layer is the prismatic layer, and consists of calcite or aragonite with conchyolin arranged in the form of prisms at right angles to the surface of the shell. The conchyolin forms a framework on which the calcium carbonate is deposited. This is produced by the cells of the mantle. The third layer, the nacreous layer, consists of mother-of-pearl, or calcium carbonate, which is secreted by the entire external surface of the mantle, and this is built up of delicate lamellae overlapping and parallel to the surface of the shell. The edges are zigzag, and are exposed, and this produces interference of light effects, thus giving the beautiful iridescence. The fourth layer (hypostracum) is found between the muscle of the fish and the shell. It is composed of columns of calcium carbonate built up at right angles to the surface of the shell.

These layers are naturally the result of intermittent growth, and the reflection and refraction of light from the different layers produce the wonderful lustre of pearl, known as "orient." For pearls are composed of the same material as the comparatively worthless shell that houses the oyster, and this is why the composition of the shell has been explained in some detail.

The oyster, having made its home, is satisfied to live in it peaceably and enjoy life, but occasionally a foreign body gets into the valves and irritates the soft body of the animal. The irritant may be a sand grain, a parasite, or a fragment of rock or horny material. The last is the most general. The animal tries to get rid of this irritant, and sometimes it is ejected when the flaps "gape." If it cannot be expelled, the oyster

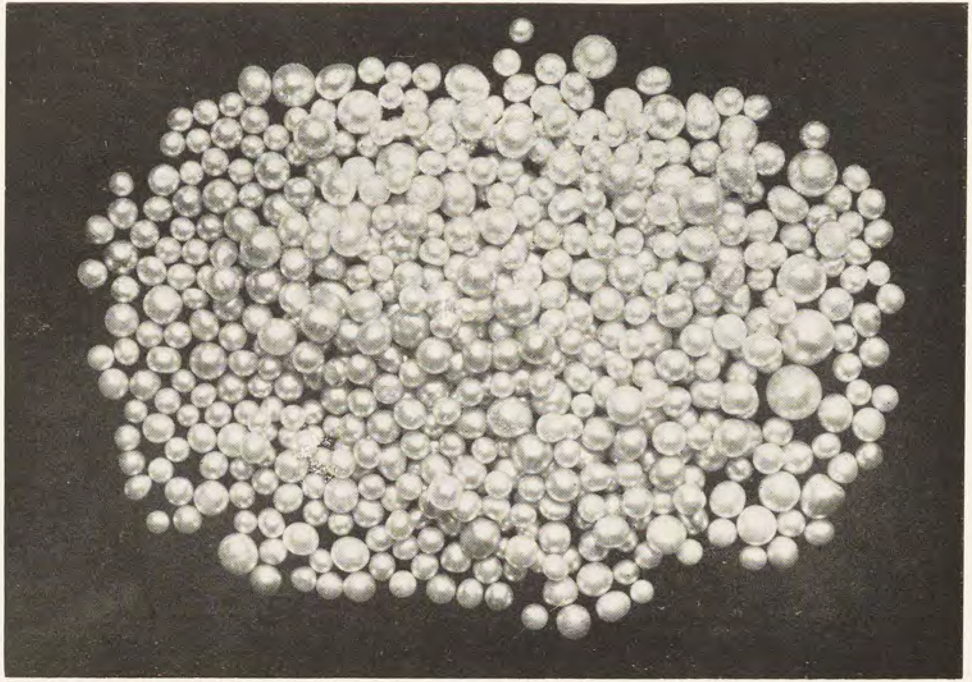


PLATE IX

AN ASSORTED COLLECTION OF FINE PEARLS

Note these include round pearls, button pearls, drop shapes, and baroque pearls

PLATE X

BLISTER PEARL ON SHELL

gradually covers it with layers of smooth shell material. The irritant is thus enclosed as a nucleus by concentric layers of the same material that has produced the shell, and this covered irritant, the result of an accident, is the gem we know as the *pearl*. A pearl may be therefore defined as a natural concretion consisting of concentric layers of conchyolin and calcium carbonate arranged around a nucleus.

Sometimes the irritant gets between the shell and the mantle, or a boring parasite pierces a hole in the shell. In this case pearls are produced which are attached to the shell, and they have to be cut away. Their shape is flat and generally irregular, and these *Blister* pearls are of little value compared with round pearls.

The *True* pearls, or *Cyst* pearls, occur embedded in the mantle or soft tissue of the animal. They are not attached to the shell, and are therefore spherical or pear shaped. Round pearls are most valuable, and good colour and absence of irregularities still further enhance their value. The pear and button shapes are not so valuable, since they cannot be used in strung necklaces. Irregularly shaped pearls are known as *Baroque* pearls, and are of the lowest grade.

The hardness of pearls varies, and may be between three and a half and four. Similarly the specific gravity may be between 1·5 and 2·86, poor pearls having the lowest constant and pink pearls the highest. The lustre varies with the nature of the layers, and different ocean beds seem to yield pearls of characteristic tints. An expert can tell from which area a pearl originated solely by the sheen. Colours may be white, black, and tinges of yellow, blue, salmon-pink, red, brown, blackish green, etc. The rosy sheen is considered the best, and is the most expensive. Pearls having this sheen come almost exclusively from the Persian Gulf, and are a product of a univalve called the Indian conch (*mileagrina margaritifera*). They are of a particularly brittle nature.

All pearls should be carefully handled as they are easily injured, and their hardness is not such as will endure hard wear. Heat affects their colour, and they are readily attacked by any acid, since their composition is largely calcium carbonate (about 90 per cent). Even perspiration from certain skins discolours them, as they are porous. There is no certain means of preserving pearls, and owing to their soft nature, wear is inevitable in the course of time.

There are many fallacious ideas connected with the preservation of pearls, such as covering them with flour, or retaining them in sea-water, but they are all equally valuable, as the organic matter is bound to decay. The holes of drilled pearls tend to become larger in wear owing to the constant fraying of the silk or thread, and the only means of repairing the damage is to plug these holes with a similarly coloured material, and then to redrill. The quill of birds' feathers is often used. The existing surface of old pearls may sometimes be improved by "skinning," but this is a risky process, as a lower layer may reveal blemishes or an inferior colour.

Pearls are not cut like real stones, neither are they polished. Sometimes they are bleached, but the majority require only drilling before being used in jewellery. The peculiar method of calculating the value of pearls has already been referred to, and it will be readily understood that large fine specimens obtain very high prices. Pearls are used in rings, pendants, brooches, earrings, studs, and other forms of jewellery, generally in conjunction with other stones. But it is in the form of necklaces that they reach their highest prices, since matching for sizes and colours is so very difficult. As shades vary so much, a well-matched necklace commands a very much higher price than the total that the pearls would realize individually.

The chief sources of supply are the Persian Gulf, Ceylon (Gulf of Manaar), Australia (off the Great Barrier Reef), Venezuela, Japan, the Red Sea, Panama, and the Pacific Isles. The area from which the finest pearls come to-day is the Persian Gulf. Here, the actual fishing is done by natives during certain months of the year, but the whole fishery is financed by private enterprise. The firms concerned supply the boats, tackle, and everything necessary to the crews, even their clothing (if any) and food. The pearls are mostly brought to Bombay, where they are classified, bleached, and drilled if necessary, and then strung in bunches, if round in shape. There they are sold to different merchants, or they may be sent direct to London or to Paris for sale. From the pearl dealers they eventually find their way into shops as necklaces or in mounted jewellery. Most of these so-called "Indian" pearls are of a yellowish tinge, though those of the finest rosy sheen come from this area.

The Ceylon coast is not a very important region now, as very few pearls have been fished from these waters in late years, and the pearls, moreover, are small in size, though good in quality. The chief mollusc producing pearls here is the *margaritifera vulgaris*, and as fishing is controlled by the Government, samples of shells are now periodically examined, and a report made as to whether a fishing is practicable. If the report is favourable, the most suitable period is between February and April, when the sea is smooth.

The divers are of mixed nationalities—Moors, Tamils, Malabars, Arabs and others. Their tools consist of a smooth stone of about twenty pounds in weight, which acts as a sinker, and a small basket in which the oyster shells are collected. The divers provide their own boats and crews. When the boat is in position, the diver simply drops over the side with his implements, at the same time holding his breath. The sinker is disengaged from the diver by a pre-arranged signal directly he touches the bottom. As many shells as possible are collected in the available time, usually about a minute. Another signal to the crew then brings the diver to the surface.

When a sufficient number of shells have been collected, the boats return to headquarters, where the shells are divided into three equal portions, one to the crew, and two to the Government. The shells are then opened, the pearls extracted (if there are any to extract), and afterwards sold by auction. It is possible that some of the best pearls do not find their way to the Government centre. In any case, the life of a diver is usually a short one owing to the terrific strain imposed, and a short life should have its consolations.

Pearls from the Gulf of Manaar have always been small in size, and since the year 1908 none have been produced in this area. The reason for the banks becoming barren of oysters and remaining so for some time has not yet been properly explained. In any case, some action has been taken to encourage the oyster to live and multiply in this region, and the prospect of a productive fishery in the near future is anticipated. During the last one hundred and twenty-eight years forty fisheries produced a revenue of over one and a half million pounds sterling from this area.

Off the Australian coast, modern methods of diving are employed, and divers are equipped with suits of the latest type. The pearls from this area are characterized by a whitish sheen, which is more appreciated on the Continent than in England and America. Pearls from the Pacific Isles are usually of a "fancy" colour, and those from Venezuela are generally black. The fine black pearls which have a greenish tinge are valuable. and are quite rare.

Pearls are also found in fresh water, though none that have been fished have been of outstanding quality. Fishing is still carried on in certain European rivers, and particularly in Scotland, June to August being the fishing months. Many pearls have been found, but the majority are of little value. The best one, from a Perthshire river, realized £100, though this was some years ago. The finest specimen from Scottish waters is the large pearl contained in the Crown Jewels of Scotland, which may be seen in Edinburgh Castle. A fine pearl from the river Conway, in North Wales, was presented to the Queen of Charles II by Sir R. Wynne. It is now in the Royal Crown.

The largest known pearl was at one time in the Hope

Plate XI

Opening Shells. (Australian Pearl Fishery)

A blister pearl may be seen on the shell being opened

Collection. It was about two inches long, weighed four hundred and fifty-four carats, and was valued at £12,000, although it was not homogeneous in colour. The Moscow Museum contained the famous Pellegrina pearl, which was twenty-eight carats in weight, and perfectly round. Other fine pearls may be seen in the Green Vaults of Dresden, whilst to-day America must possess a fairly good collection of fine pearls, though they are privately owned. Fine pearls continue to rise in price, and the appearance of cultured pearls has not affected the value in the slightest.

The Cultured Pearl. Every year brings a shock or a delight to some section of human beings wandering about on this earth. The introduction of the cultured pearl in a round form in the year 1921 provided the shock to the small community of people dealing in pearls in certain streets of London and Paris. But the effect was quite temporary, and all reliable dealers in precious stones now regard cultured pearls in the same light as other artificial or synthetic gem stones.

The idea is really very ancient, in fact the Chinese are known to have been familiar with a similar process by which small images of Buddha were coated with a nacreous substance. But they did not pursue their knowledge in this direction to any extent. Of late years, however, the Japanese investigated this ancient idea, and developed it on scientific lines, so that to-day whole cultured pearls are being produced which make it difficult to distinguish the real from the cultured to those not in the trade. A pearl dealer can always distinguish the two, however, and if any doubt exists, an instrument has been designed which infallibly shows the difference.

The half and three-quarter cultured pearl is really a blister pearl. An *artificial* irritant is inserted between the mantle and the shell, usually a small bead made of mother-of-pearl, and this stimulates the deposition of the nacre round the bead in the same way as an accidental natural irritant. The blister pearl produced is cut from the shell and "backed" by a suitably shaped piece of mother-of-pearl, so that the whole appears to be one bead. The back is ground and polished, but the line of joining is always to be seen without difficulty. These pearls are frequently seen mounted in the form of rings, scarf pins, studs, etc., as the setting hides the back.

It was not till the year 1921 that the *whole* cultured pearl was put on the market in quantity. These pearls, though of a slightly greenish tinge, were round in shape, and were not at first suspected to be anything but natural pearls. They had been produced in Japanese waters by much the same means as the half and three-quarter pearls. A round bead had evidently been inserted in the mantle of the oyster, and in course of time round beads covered with nacre were produced. This is still being carried on, though as it is now more a commercial than a scientific proposition, the nuclei are getting larger and the nacreous coatings are getting thinner.

Detection of these pearls would be always easy and certain if the pearl could be sliced, but as this is not practicable an instrument has now been perfected whereby the pearl is fixed and the nucleus can be seen in much the same way as a human bone may be seen in an X-ray apparatus. This is a certain test of a pearl, and can be resorted to should any doubt exist.

There is a large difference in the value of natural and cultured pearls. The former retain their value to a large degree, and keep their natural form and sheen for a much longer period than do the cultured variety. In the latter the space between the deposited nacre and the bead tends to dry; in time the outer nacre splits and crumbles away, as it is very thin in most cases. The price of the cultured pearl is maintained owing to the limited quantities produced and the ingenious method of distribution. That they are chemically the same as the natural pearl cannot be denied, nor do the finer specimens differ largely, from an aesthetic point of view, from natural pearls, but the fact remains that they are *not* natural gems, and they should be regarded accordingly

PART III

CHAPTER IX

TOPAZ AND SPINEL

TOPAZ

(Hardness, 8; specific gravity, 3·53;
refractive indices, 1·61–1·62)

THE term "topaz" must not be applied, as is frequently the case, to all yellow stones. As a rule, the yellow variety of quartz is known under this name, but the true topaz is a much rarer and finer stone. It is really a fluo-silicate of aluminium, and natural crystals occur commonly in a prismatic form with pyramid terminations. These are classed in the rhombic system. Topaz is one of the few gem stones that contain fluorine; water is also present in a very minute quantity.

There are many varieties of topaz, but the commonest are the colourless stones and those whose shades range from yellow to a sherry colour. Pale blue and pale green stones sometimes occur, but the natural red and pink stones are very rare. Pale green stones resemble aquamarines very closely. Most of the pink stones on the market have been produced by an artificial process known as "pinking." Suitable brownish-yellow stones are packed in an inert material, such as magnesia, and then heated carefully in a crucible. The colour is driven off, but when the stone cools, a pinkish shade appears, which is permanent. If the temperature is not high enough, a salmon tint instead of a rose pink is produced. This phenomenon is probably due to an effect on the tinctorial agent, as no change in molecular arrangement takes place. If yellow topaz are heated, they lose their colour entirely, whilst pale yellow stones from Russia lose their colour on being exposed to strong sunlight. For this reason a fine collection of Russian stones now in the British Museum is kept under cover.

Topaz is easily cleaved, so stones should be carefully handled. Incipient flaws easily arise, and stones may be split with the greatest of ease. Notwithstanding its perfect cleavage, topaz is a fairly hard stone, corundum and diamond being the only two varieties which are harder. Stones take a particularly high polish, and they can be made to possess a very fine lustre. For this reason topaz has a characteristic slippery touch. Dichroism is distinct in well coloured specimens, but it is difficult to determine in pale stones. The dichroscope must be used to see this effect. Topaz is pyroelectric, and may be strongly electrified by friction.

Stones are cut in brilliant and step forms, though large specimens frequently have additional facets, and mixed cuts are common. Many stones are cut with an oval, round, or oblong girdle. Feathers and flaws within the stone are common, and lack of colour often mars otherwise good pieces.

Stones usually occur in granatic and gneissic rocks, but sometimes also as rolled pebbles in river beds. In Saxony specimens are found in a brecciated mass of tourmaline quartz rock cemented by topaz and quartz. Cavities in these rocks are lined with topaz crystals. In Russia and Siberia, particularly in the locality of Mursinska, fine crystals, often blue in colour, are found in granite druses associated with beryl, quartz and other stones. Most of the fine brown stones come from Brazil (near Minas Geraes). Here they are found, together with quartz, in a soft, talc-like schist.

Originally the stones were confused with diamonds, and the beautiful stone known as the Braganza (one thousand six hundred and eighty carats), set in the Portuguese Crown jewels, is nothing more than a fine topaz. Colourless stones have been found in Banffshire (Scotland), Mourne Mountains (Ireland), Cornwall, and certain localities in Japan. Very fine specimens of cut stones may be seen in the Green Vaults at Dresden.

Topaz is correctly called "Brazilian Topaz," but the so-called Oriental Topaz is really yellow sapphire. Scotch Topaz is yellow quartz, whilst in Ceylon, where some stones are found, the colourless specimens are called Water Sapphire; yellow stones are incorrectly known as King Topaz, and light green topaz is frequently sold as aquamarine.

The word "Topaz" is derived from an island in the Red Sea, Topazios, from where the earliest stones originated. The term was originally also used for yellow peridots, and altogether it has been more loosely used than the name of any other gem stone. The hardness of true topaz is a good test, as quartz and inferior yellow stones are all softer, whilst its optical properties and its specific gravity will leave no doubt if any confusion should arise.

SPINEL

(Hardness, 8; specific gravity, 3·60; refractive index, 1·72)

Spinel is a double oxide of magnesium and aluminium, and under this term is included a large isomorphic group of minerals, not all of which are used in jewellery. Natural crystals occur in forms which fall under the cubic system; octahedra and twinned octahedra are very common forms.

The group of spinels used in jewellery is known as precious spinel, and these occur in a remarkably wide range of colours; in fact nearly every shade has been found. The rose-tinted stones, known as *Balas Rubies*, are most in demand, and are the most valuable to-day. But other colours are quite attractive, and the following names are generally applied to these—

Ruby spinel, ruby-red stones.

Almandine spinel, purple stones.

Pleonastes and Ceylonites, dark green to black

Sapphire spinel, sapphire blue.

Rubicelle, ruby to orange.

Pale blue spinels also occur, but colourless stones are rare. The colours are due to different metallic oxides, and many intermediate shades are seen.

Spinels show practically no cleavage, and their hardness (the same as topaz) is sufficiently high for their use in rings, etc. Nevertheless, this is one of the many semi-precious stones that are not used as much as they ought to be in mounted jewellery. As this stone is of the cubic system, it is singly refractive, and consequently no dichroism is seen. These properties distinguish it very quickly from garnets, rubies, and other stones with which it may be confused. In fact, a large number of so-called rubies are really spinels, though apart from other properties, ruby is generally more flawed and is not so clear as spinel. Stones have a vitreous lustre, though little "fire" is seen. Step, brilliant, and mixed cuts are used, and in mounting, care must be taken, as the stones are brittle.

Spinels generally occur associated with rubies. In Burma and Siam, they are found in a crystalline limestone. In other localities they occur with calcite in serpentine, and also in gneiss. Blue and green spinels are found in gem gravels in Ceylon, quite often with corundum.

Many large cut stones are known, and for some time they were regarded as rubies. The large red stone set in front of the English Crown is really a spinel, though it was formerly supposed to be a ruby. It was given to the Black Prince in 1367 by Pedro the Cruel, and was worn by Henry V at Agincourt. The British Crown jewels also contain the largest ruby spinel known (three hundred and fifty-two carats). It is known as the Timir Ruby, as Amir Timir captured it at Delhi, and it passed to the East India Company in 1850, together with other famous stones. It was presented to Queen Victoria in 1851.

Two fine specimens of red spinels may be seen in the Mineral Gallery of the British Museum.

The word "Spinel" is derived from a Greek word meaning "a spark."

CHAPTER X

GARNET AND TOURMALINE

ONE generally associates the term garnet with a dark-red transparent stone. But really garnet includes a large group of minerals, not all of which are gem stones. These all have similar crystalline properties and chemical composition, but they vary in physical properties. Chemically, there is no sharp division between the varieties, and this accounts for their varying physical constants.

All garnets consist of a double silicate, in which one of the metals may be calcium, iron, magnesium, or manganese, whilst the other may be aluminium, iron, or chromium. Crystals are of the cubic system, and are quite often found perfect in shape. Many are found in a rounded form as waterworn pebbles, especially when they occur in gem gravels. The dodecahedron is a common form, and twin crystals are also frequently found.

There are several varieties not seen in jewellery, as they are too dull and not sufficiently transparent to be attractive. Amongst these are Uvarovite, Spessartite, and Rhodolite. The four commonest varieties used in mounted jewellery are Hessonite, Pyrope, Almandine and Demantoid, and these are described hereunder in detail. These also merge into one another, and often it is difficult to assign a stone to a particular species.

HESSONITE GARNET

(Hardness, 7¼; specific gravity, 3·61–3·66; refractive index, 1·75)

These stones are of a golden yellow to a cinnamon brown in colour, and appear to the best advantage in artificial light. The lighter coloured stones are called *cinnamon* stones, and darker ones Hessonites, sometimes *Essonites*, though they are occasionally misnamed Jacinths. (The real Jacinth is a zircon.) They are a calcium-aluminium garnet, and may be easily recognized by their peculiar internal structure. They appear to be composed of granular specks which are often visible to the naked eye in the form of minute internal spots. These stones are sometimes confused with red zircons, but the latter are much heavier and are also doubly refracting.

Most of the specimens on the market come from Ceylon, where they are often confused with zircons and other stones.

PYROPE GARNET

(Hardness, 7¼; specific gravity, 3·7–3·8; refractive index, 1·75)

This is the most popular of garnets, and until a few years ago a great proportion of the cheaper pieces of mounted jewellery contained these stones. They are still worn, but in more limited quantities. Chemically, they are a magnesium-aluminium garnet, and their colour ranges from a fine deep red to a ruby red. A slight yellowish tinge often spoils the red colour. Other names for this stone are *Cape Ruby*, *Arizona Ruby* and *Bohemian Garnet*. Bohemia supplies most of the stones to-day, and here the garnet industry dates back for some hundreds of years. It has been further stimulated by the visitors to the local spas (Karlsbad, etc.), and many souvenirs containing these stones set in a variety of forms are sold annually in this locality. About three thousand people are now employed in cutting Bohemian garnets, and about ten thousand are employed in the whole industry. Stones are usually small, but large pieces have been found, and specimen stones may be seen in Vienna and Dresden. The King of Saxony had a stone weighing four hundred and sixty-eight carats, set in an Order of the Golden Fleece. The Bohemian stones are found in gravels derived from serpentine, but in the Transvaal stones are found in the "blue ground" together with diamond. Stones have also been found in Rhodesia and the United States of America (Arizona and Colorado).

Unlike ruby, pyrope garnet is usually free from flaws and of a good colour, so it is most useful as a gem stone. It is found in too great quantities, however, to be valuable, and although it has been used in jewellery for many centuries, it has never been considered a precious stone. The term pyrope is derived from a Greek word meaning "Fire-like."

ALMANDINE GARNET

(Hardness, 7½; specific gravity, 3·9–4·2; refractive index, 1·79)

This is sometimes known as *Syrian Garnet* and *Adelaide Ruby*, though it is not found in Syria, nor is it anything like a ruby. Its colour is a deep red with a purplish tinge, and it is an iron-aluminium garnet. Deep red stones, cut *en cabochon* are called *carbuncles* (from a Latin word meaning "a little spark"). The term once included all red stones such as red spinel, pyrope, and almandine garnets. This stone has a high specific gravity, and a most interesting feature is the characteristic absorption spectrum it shows when a spectroscope is used. A few carbuncles show a four-rayed star on the summit, this being due to the same cause as in the case of star rubies, though the latter show a six-rayed star effect.

Stones are widely distributed, and are often found in deposits derived from a mica schist. Crystals are often large, especially those from Brazil (Minas Geraes district), where they are generally found together with topaz. In Ceylon they are found in gem gravels, and certain localities in India, Australia, East Africa and the United States of America supply a few stones. In former days this stone was extensively worked and polished in Alabanda (Asia Minor), and slabs were frequently used as inlays in Celtic and Anglo-Saxon jewellery.

DEMANTOID GARNET

(Hardness, $6\frac{1}{2}$; specific gravity, 3·84;
refractive index, 1·88)

These stones are incorrectly though generally called *Olivines*, and must not be confused with the true olivine, the peridot. They are a calcium-iron garnet of a fine, bright green colour, though some stones are brownish-yellow to greenish-brown. Their popularity dates from about 1880, when large quantities were found near the Ural Mountains (Bobrovka River), but demand has greatly declined during the last few years. They are still sometimes referred to as Uralian emeralds. The most remarkable property of demantoid is its high dispersion. This is very strong, and is the highest of all gem stones, including diamond, though the effect is largely hidden by the green colour. Cut stones are very effective, since the lustre is adamantine, but softness renders them unsuitable for hard wear. They appear to great advantage in artificial light.

Stones are still found in the Urals, and occur as rolled pebbles in the river gravels, though sometimes they are found in the parent rock, a serpentine associated with dolomite.

In general, all garnets are too soft to be used as ring stones or in jewellery that demands constant wear. Though attractive, they have the misfortune to be too abundant to be valuable. They may be readily distinguished from similar stones, since all garnets are of the cubic system, are therefore singly refractive, and show no dichroism. A few specimens, however, show anomalous double refraction, and all varieties, except uvarovite, are fusible. Stones are cut in brilliant, mixed, and cabochon forms, but none obtain a very high price.

Garnets have been used in jewellery since the earliest days, and very ancient intaglios in this stone have been found. They have been used in the smelting of iron ores and also for polishing purposes as a substitute for emery. According to Pliny, large carbuncles used to be hollowed out and made into drinking vessels.

The term garnet is derived from a Latin word meaning " seed-like," which refers to the appearance of the small crystals when in the matrix.

TOURMALINE

(Hardness, 7½; specific gravity, 3·10; refractive indices, 1·62–1·65)

This stone occurs in a variety of colours, and although its grade of hardness is not very high, it could, if demand were greater, be more readily used in many forms of jewellery. Its composition is rather complex, and this varies slightly in different specimens, thus giving rise to the various colours. In general it is a silicate and borate of alumina, magnesia, and iron, and all crystals may be classed in the hexagonal system. Crystals generally occur in prismatic forms, often prisms of three sides, terminated with three or six faces, and marked vertical striations are often seen.

Tourmaline is sometimes grouped into three divisions—

(*a*) Alkali Tourmaline—those containing sodium, lithium, or potassium. These are generally colourless, or red and green.

(*b*) Iron Tourmaline—usually black.

(*c*) Magnesium Tourmaline—colourless, yellowish-brown, or brownish-black.

Different varieties are known under different names, according to colour.

Thus, red and pink stones are called Rubellite.

Black—Schorl.

Green—Brazilian emerald.

Blue—Indicolite or Brazilian sapphire.

Violet red—Siberite.

Yellow to yellow-green—Ceylonese peridot or Ceylon chrysolite.

Colourless stones are called Achroite, and there are also other intermediate tints. Stones are often particoloured; some specimens show green externally and red internally, and vice versa, whilst others are red at one end and green or black at the other. Thus tints range from nearly colourless to black. Schorl, the black variety, is quite opaque, and is not used as a gem stone.

All stones have a vitreous lustre, and are pyro-electric. If the stone is rubbed, or heat is applied, it will readily attract small pieces of paper; in fact, early Dutch voyagers made use of this property for drawing tobacco ash from the bowls of their long pipes. But its most remarkable property is its strong dichroism. This is so marked that each stone must be considered from this point of view when cutting. Brilliant, step, and mixed cuts are used, and many stones are very effective when brilliant cut, with a small table and small side facets. On account of the variety of colours obtainable, tourmalines make good centre stones for large pieces of jewellery.

The brightest stones are those free from iron, and the heaviest stones are the darker ones. In many stones, dichroism is visible with the naked eye.

Stones are found in granite rock and gneisses, which are the result of mineralizing gases in the fluid magma. California supplies most of the rubellites, and Brazil (Novas Geraes and Minas Geraes) and the Urals (Ekaterinburg) most of the red and green stones. Yellow and brown stones are found in the Ceylon gem gravels, and dark brown specimens come from Saxony. Maine (U.S.A.) supplies red, green and blue stones, and these have also been found in Elba, Madagascar, and Switzerland. Red and black tourmalines have also been found in Burma, not far from Mogok, the ruby mining centre. These stones are found in the river bed (River Nampai), and mostly go to China, where they are cut and largely used as buttons for mandarins' hats. This district is a very old source of supply.

Tourmaline is often confused with other stones, but its strong dichroism and low specific gravity are generally sufficient to distinguish it from similarly coloured stones. When the green stones were first introduced into Europe, in the seventeenth century, they were mistaken for emeralds, although the colour is quite different. To-day, tourmaline is quite moderate in price and within the reach of all. Green tourmalines are often worn and used as signet stones by the Roman Catholic Bishops of South America.

CHAPTER XI

AQUAMARINE, PERIDOT, ZIRCON AND CHRYSOBERYL

AQUAMARINE

(Hardness, $7\frac{3}{4}$; specific gravity, 2·74;
refractive indices, 1·57–1·58)

Aquamarine is a variety of beryl, and consequently has, to a large extent, the same properties as emerald. This stone is found in large crystals, generally fairly flawless, and as a result prices of stones are considerably lower than those of emeralds, though the chemical composition is exactly the same (aluminium and beryllium silicate).

Colours range from a pale blue to a greenish blue. Pale shades are very cheap, but deep bluish coloured stones command good prices. These latter stones, generally from Madagascar, are strongly dichroic and twin colours are easily seen. Yellow varieties are known as *Golden Beryl*, and the rose pink as *Morganite*. The common beryl is dull and opaque, and is not used in jewellery.

Stones are cut in step, brilliant, and mixed forms, and they are frequently seen in large pieces of jewellery. The shades in aquamarine are due to alkaline earths influenced by ferric or chromic oxides. The natural colour is retained in artificial light, and stones are generally homogeneous in colour.

Crystals occur in geodes in granites, and Siberia, the Urals, Brazil and Madagascar all supply stones. Crystals are so large that they have been used as handles for daggers in the days when people used these more frequently. Old engraved aquamarines have been found, and no doubt the comparative softness of this stone made it easily worked by the Ancients. Pale aquamarines were used by them in the form of spectacles, though now we use glass or rock crystal.

Many large crystals have been found, and one of the largest and finest was unearthed by a miner in 1910 at a depth of only fifteen feet. The locality was Minas Geraes (Brazil), and the stone measured 19 in. by 16 in., weighed two hundred and forty-three pounds, and was so transparent that it could be seen through from one end to the other. This crystal was sold for over £1,000. A fine specimen of a cut aquamarine may be seen in the Mineral Gallery of the British Museum. This weighs about 8·15 carats.

PERIDOT

(Hardness, $6\frac{1}{2}$; specific gravity, 3·40; refractive indices, 1·65–1·69)

Peridot constitutes a group of minerals not all of which are used in jewellery, only the olivine varieties being used as gem stones. Chemically, these are a silicate of magnesium and iron, and they occur in prismatic crystals of the rhombic system, which are rarely of a good or perfect shape. The stones used in jewellery are of a greenish colour, and, owing to their pleasing appearance, they are being more extensively used. The darker green stones are called *Olivines*, whilst the paler varieties, varying from a yellowish green to a bottle green, are known as *Chrysolites*. The terms olivine and chrysolite are frequently incorrectly applied to other stones. Demantoid garnet is often called olivine, whilst green corundum and tourmaline are also sometimes known as chrysolite. The specific gravity alone will differentiate between these species.

The hardness of peridot does not render it suitable for use as a ring stone, but it is often used as such owing to its attractive body-colour. Stones often have an oily appearance, though the lustre is vitreous, and the dispersion weak. The specific gravity of stones varies considerably owing to the different amounts of magnesium and iron which they contain; those possessing more iron are the heavier, and they are also of a deeper colour.

The double refraction is very strong, but dichroism is distinct only in the darker specimens. Stones are cut in brilliant, step, and mixed forms, but the step cut is considered the most suitable for peridot.

Stones are widely distributed in various rocks, but the crystals are so small that they cannot be cut into gem stones. The Isle of St. John, off the west coast of the Red Sea, is the only locality which produces stones of sufficient size to make them of value. Here they occur as well-defined crystals in certain basic eruptive rocks, known as "dunite," and large stones are rarely found. In former times, the Isle of St. John was strictly guarded on account of the supply of peridots, since the stones were the monopoly of the Khedive of Egypt. The best stones are to be found in ecclesiastical jewellery. Recently some fine peridots in the rough were discovered in the foundations of a house in Alexandria. It is not certain how they came to be there, but it is likely that they were connected with some ancient superstition or possibly a theft. A few small, pale green stones have also been found in Queensland, Upper Burma, and North America.

ZIRCON

(Hardness, 7½; specific gravity, 4·2–4·7; refractive indices, 1·81 and 1·93–1·98)

This attractive stone occurs in nearly every colour, and is one of the many semi-precious stones that ought to be more extensively used in jewellery. Chemically, it is a silicate of zirconium, and crystals commonly occur either as four-sided prisms terminated by four-sided pyramids, or as water-worn pebbles. In the latter case the crystal faces are generally obliterated, but nevertheless the stone may be assigned to the tetragonal system.

There is a considerable range of colours, and green, blue, yellow, orange, brown, and other shades are often seen. Red to reddish-brown stones are called *Hyacinths* or *Jacinths*, whilst those having a pale yellow shade are known as *Jargoons*. The colourless zircons sometimes seen on the market are the result of heating certain yellow or brown stones. These white zircons show considerable "fire," especially in a dim light, and in fact they approach diamond in brilliance of lustre more than any other stone. The "fire" is evident even though the coloured varieties are sometimes cloudy and non-transparent. Zircons may be distinguished from other stones, as a rule, by their specific gravity. This is very high, and varies from 4·20 to 4·69 according to the variety of the stone. Refraction also varies; some stones are singly refractive, whilst others show double refraction. Dichroism is discernible only in the blue stones.

A definite characteristic of zircon is the absorption bands seen on examining with a spectroscope when light has been passed through this stone. Other characteristics are still not fully understood, and zircon is, therefore, of considerable interest from a scientific point of view.

There appear to be three types of zircons—

(*a*) Those of low specific gravity, generally green and yellow in colour, and usually singly refractive.

(*b*) Those of high specific gravity, generally red, high refractive index, and doubly refractive.

(*c*) An intermediate type. This is affected by heating, which increases the refractive index and specific gravity.

Stones are cut in various styles, though the brilliant form is the most common. The best specimens are found in Ceylon, together with other gem stones, in the form of pebbles in the gem gravels. They were originally thought to be diamonds, and are still locally known as "Matura" diamonds, from the mining area Matura in Ceylon. Other stones, particularly the red varieties, are found in New South Wales (Mudgee), France (Expailly), and Russia (Orenburg).

The name "Zircon" is probably derived from the Arabic, meaning "Vermilion," or a Persian word meaning "Gold-coloured."

CHRYSOBERYL

(Hardness, 8½; specific gravity, 3·75; refractive indices, 1·74–1·75)

This stone is one of the more valuable semi-precious stones, and is seldom met with in jewellery, except in the form of *Alexandrite*. This variety is in much demand owing to its attractive qualities, and as good specimens are rare they command a high price; in addition, cut stones of over five carats are seldom seen.

Chrysoberyl is an aluminate of beryllium, and occurs in flattened crystals, often twinned, of the rhombic system. Dark green stones are called *Alexandrites*, and pale yellow to greenish-yellow stones are often called *Chrysolites*, though this latter term should strictly be applied only to pale green peridots. Other specimens of a cloudy-yellow to a brownish-green colour, which show a chatoyant effect, are known as *Cymophane* or *Oriental Cat's-eye*. These must not be confused with the Quartz Cat's-eye. The latter, a much inferior stone, does not show the opalescence of the chrysoberyl cat's-eye. It also has a greenish tinge as a rule, and is much softer. Chrysoberyl is a comparatively hard stone, and is, therefore, suitable for all types of jewellery. Cleavage is distinct in one direction only, whilst only weak dichroism is shown, except by alexandrites. These are strongly dichroic.

The yellowish-green shades are probably due to ferrous oxide, but all colours in this stone are unaffected by heat, nor does the application of acids have any effect.

The paler stones are frequently mounted with diamond in rings, and the stone makes a good contrast, since chrysoberyl has a vitreous lustre. Stones are generally cut in brilliant form, except cymophane, which is always cut *en cabochon* to show the best effect. Alexandrites possess the peculiar property of changing their colour from a leaf-green by day to a raspberry-red in artificial light. This is due to the stone's absorbing more of the red part of the spectrum, which is stronger in the case of artificial light. The chatoyant effect of cat's-eyes is due to a vast number of internal microscopic hollow channels within the stone, arranged in parallel order, from which light is reflected. Stones cut *en cabochon* with the rounded surface parallel to the channels give a broad band of light running across the stone, the effect being similar to that of a cat's eye.

Alexandrites are found in the Ural Mountains, generally associated with emeralds in a mica schist; they are also found in Ceylon. These stones were always highly prized by the Russians, firstly because they were discovered near Ekaterinburg on the birthday of Czar Nicholas II, after whom they were named, and secondly because they displayed the colours of the old Russian Empire. Very few stones come from this source now, but the few that do come on the market are of good colour, though small in size. They are consequently of more value than the stones from Ceylon, which is now the chief source of supply. Most of the cymophanes also come from this island, the most prolific of all gem-bearing localities, "Chrysolites" are found in Brazil (Minas Novas and Minas Geraes), Ceylon, Rhodesia, and the United States of America. In Brazil and Ceylon, they are found as waterworn pebbles. The finest known cut stone is the one to be seen in the British Museum. It is perfect in quality, and weighs 43¼ carats. It was formerly in the Hope Collection, as was also a fine cat's-eye. The latter was known in Ceylon for some hundreds of years before it was placed in this collection of gems.

The term "Chrysoberyl" comes from the Greek, and means "Golden beryl."

CHAPTER XII

QUARTZ

(Hardness, 7; specific gravity, 2·65–2·66;
refractive indices, 1·54–1·55)

QUARTZ, a word of German provincial origin, is the term applied to the most widely distributed of all gem stones. It contains a very large number of semi-precious varieties known under different names. Many are quite familiar, since they are frequently seen in the cheapest forms of real stone jewellery, and although of comparatively small commercial value, they are of great interest. Moreover, certain species, such as amethyst and rock crystal, have been known and recognized as gem stones from the earliest days. Theophrastus wrote that "amethyst was used for engraving and was pellucid and resembled red wine in colour," whilst Pliny advised that "the best cautery for the human body is a ball of crystal, acted on by the sun."

Though so varied in type and colour, quartz is simple in composition, being silica (oxide of silicon), and all varieties are of the same composition. Hardness, specific gravity, and double refraction vary very little also. The large group of minerals known as quartz, however, may be conveniently divided into two classes—

(*a*) The crystalline, or vitreous type, which occurs as crystalline material with or without crystal faces.

(*b*) the crypto-crystalline type.

The latter type is composed of a vast number of microscopically small crystalline individuals whose boundaries cannot be determined. The general name for this second type is *chalcedony*.

1. **Crystalline Type.** The crystals occur in hexagonal prisms as a rule, terminated at one end, or both ends, by hexagonal pyramids. Twinning is common, and in some varieties, particularly in the case of rock

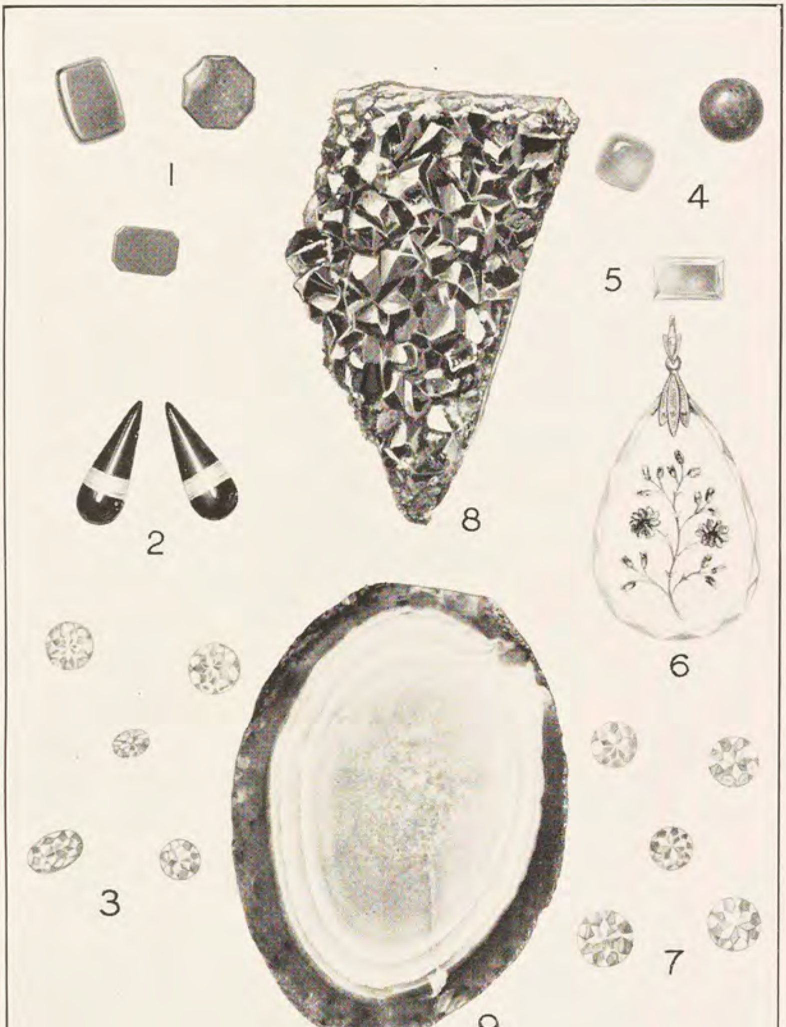


PLATE XII

SPECIMENS OF ROUGH AND CUT VARIETIES OF QUARTZ

1. Three cut carnelians; 2. Pair of onyx eardrops; 3. Five cut amethysts; 4. Cabochons of Swiss lapis; 5. Piece of cut rose quartz; 6. Engraved rock crystal pendant; 7. Five cut quartz topaz; 8. Rough piece of amethyst quartz showing crystal formation; 9. Agate (Brazil)

crystal, they occur in very large sizes. Sometimes the stones occur as lumps or as pebbles. Crystals belong to the hexagonal system, and varieties will be described separately. Under this type may be mentioned.

(*a*) The transparent stones—

Rock crystal, smoky quartz, citrine, and amethyst.

(*b*) Chatoyant stones—

Quartz cat's-eye, tiger-eye;

(*c*) Stones found in a massive form—

Rose quartz and aventurine.

2. **Chalcedony.** The varieties of chalcedony are very numerous, and amongst these are Carnelian, Chrysoprase, Sard, Jasper, Plasma, Bloodstone and Agate.

ROCK CRYSTAL

This is the only colourless semi-precious stone found in quantity. When cut and polished, it is a beautiful limpid stone, though it lacks "fire." It may, therefore, be said to lack "life," but, when faceted and polished carefully, it is very attractive in the form of necklaces and eardrops. As supply of the rough material is abundant, faulty pieces are not cut. In addition to its use in all forms of jewellery, the stone is used for spectacle lenses and parts of optical instruments. Lenses made from rock crystal retain their polish for a considerable time, whereas glass soon becomes scratched in use. Rock crystal jewellery is periodically in demand and prices, therefore, vary considerably. Articles sometimes realize very little more than the cost of cutting when this stone is not in fashion, and imitations in the form of cut glass seem to satisfy the taste of most people. A comparison between rock crystal and glass will soon show the superiority of the natural stone. It is colder to the touch, harder, and faceted edges are sharper and more clearly cut. It will also never become dull and lifeless, as will "paste" or glass in course of time.

Many fine specimens in the form of large ornaments, bowls, etc., cut out of rock crystal may be seen in various collections and museums, and it has been used as a seal stone from the earliest times. The manufacture of glass led to the decline of carving in rock crystal, and very little fine work is now executed in this stone. At one time it was used for the manufacture of drinking vessels for the wealthy, and Pliny wrote that this exemplified the considerable extravagance of the times. Rock crystal balls are still cut, chiefly from Brazilian and Japanese stones. Medium sized "gazers" cost about £100, so the majority of the so-called "crystal" gazers on the market are of glass. It is therefore important to insist that rock crystal is called by its proper name, and not merely "crystal," as manufactured glass is frequently called "crystal," "cut crystal," "hand cut crystal," "lead cut crystal," etc.

The rough crystals sometimes occur in very large sizes, which are frequently of perfect shape. They are an essential constituent of acid igneous rocks, and are found very widely distributed in limestones, cavities of granite, and gneiss, etc. Brazil, Madagascar, Japan, U.S.A., the Swiss Alps, France, and Hungary are the chief sources of supply. Some wonderful crystals have been found in the Alps at various times, but the largest quantities of rough material more recently discovered in South America and Madagascar have made the Alps commercially an unimportant district. Rock crystal has been mined in Madagascar since the seventh century, and in this island crystals have been found which measured twenty-four feet in length. Many of those unearthed have weighed between fifty and one hundred pounds. Some specimens are found in Somerset, Wales, Cornwall, Derbyshire, and the Isle of Wight, where they are locally referred to as "diamonds," e.g. Bristol diamonds, Cornish diamonds, Buxton diamonds, etc.

Inclusions of other minerals in rock crystal are fairly common, and some peculiar and interesting pieces are often seen. Sometimes pieces contain minute cavities filled with gases or liquids, while other pieces that display a chromatic effect when viewed from certain angles are known as *Iris Quartz*, or *Rainbow Quartz*. The effect is an optical phenomenon due to the interference of light by the internal faults, which contain thin films of air from which light is reflected. Many specimens of iris quartz on the market have been artificially created by heating pieces of rock crystal and then suddenly cooling by dropping into water, or into a cold liquid. The resulting cracks give the required iridescent effect, though to accentuate this a dyestuff is sometimes added to the liquid. Many stones are spoilt during this process, and in most cases specimens may be distinguished from the natural stones by the nature of the cracks.

SMOKY QUARTZ

This is really smoky-brown rock crystal, and colours vary from brown to almost black. The dark stones are known as *Morion*, the brownish-yellow and reddish-brown stones as *Cairngorm*, or *Scotch Topaz*, and the lighter yellow material as *Quartz Topaz*, *False Topaz*, *Spanish Topaz*, and incorrectly as "*Topaz*." Most of these stones lack beauty, but they are often seen in jewellery to-day. The smoky colour of this variety may be due to the presence of sodium, as colours may be sometimes changed by the application of heat. A certain amount of heating may drive off the colour completely, or it may be considerably lightened. Other stones change to a reddish or yellowish-brown in colour according to the quantity of heat used. The effect is permanent, and for this reason it is difficult to distinguish natural cairngorms from those that are the result of heating. These stones show dichroism, and this is distinct in deeply-coloured specimens.

Cairngorm is found in Scotland (Banffshire), and smoky quartz of other kinds mostly comes from Spain (Cordova). Some extraordinarily large crystals were discovered in 1868 in the neighbourhood of a Swiss glacier, and these may be seen in the museum at Berne.

CITRINE

This is really a yellow quartz with a peculiar internal structure, the colour being due probably to a trace of ferric oxide. Natural stones are not very common, and most of the "citrine" on the market is the result of heating smoky quartz. In many instances this cannot be ascertained with certainty, but in any case the value of these stones does not make the question a matter of great importance. Colour alone decides the name, and there is no strict line of demarcation. Thus yellow quartz, "topaz," citrine, and occidental topaz are terms used rather loosely, but so long as it is understood that the quartz topaz is an altogether different stone from the Brazilian topaz no one will be disappointed. Some people incorrectly refer to all yellow stones as "topaz," but besides differing in optical qualities quartz topaz is much softer and has a lower specific gravity than the real (Brazilian) topaz. Naturally, only the best pieces are cut and polished, and these are flawless and transparent. They are frequently mounted in the cheaper rings, brooches, ear-rings, etc., and also as drilled bead necklaces.

The rough stone is found in Brazil, Uruguay, the Urals, and France.

AMETHYST

This is the beautiful violet-coloured variety of quartz, and probably the most valuable of the different species. Shades vary from a transparent purple-red to violet, but stones are not often homogeneous in colour. They are frequently flawed, parti-coloured, or feathered, and fade after exposure to strong sunlight. This is not due to artificial staining, as is generally supposed, but is quite a natural change. Moreover, by strongly heating, stones become colourless, whilst some turn a brownish-yellow. Many of the yellow "topazes" on the market are really "burnt" amethysts.

Light coloured and faulty stones are of little value, but those deep in colour and free from internal faults command a good price. The deeper stones show dichroism, and the purple colour is probably due to manganese oxide. The internal structure of amethyst is much the same as that of citrine, and it appears to be composed of layers of lamellae in twin positions. Stones should be differentiated from purple corundum (purple sapphire). The latter is much harder, heavier, and does not appear grey in artificial light. When stones are faceted, the step and mixed forms of cutting are adopted, with a girdle varying in size and shape. Siberian stones are usually very deeply cut, and in addition have a characteristic metallic brilliance that distinguishes them from other amethysts. Finer pieces are mounted in rings, brooches, pendants, necklaces, etc., whilst rougher pieces are made into snuff boxes, umbrella handles, ink-stands, etc. When the stone is cut with the parent rock it is known as *amethyst quartz*, and these pieces, which are non-transparent, are of little value, and used only in the making of large ornaments. In former days engraved amethysts in the form of seals and pendants were very fashionable and highly prized. Many fine examples of this work still exist, but fashion has changed, and there is now little demand for fine work. Skilled craftsmen who are able to execute this fine work also do not exist to-day. The fall is value of amethyst is largely due to the discovery of huge quantities of rough material in South America during the last century. Before then, amethysts were of some value. At the beginning of the nineteenth century £2,000 was paid for an amethyst necklace belonging to Queen Charlotte of England. To-day this would scarcely realize £100. Even in Biblical days we read that amethysts were highly regarded as gem stones, and there are frequent references to this stone. It is also connected with several very old superstitions. (See page 119.)

The natural stones occur as crystals in druses in certain igneous rocks, such as granites and gneiss. Most of the stones to-day come from Brazil and Uruguay, but the United States of America, Mexico, the

Urals, Ceylon, Burma, and Nova Scotia also supply rough material. Stones found in the State mines in the Ural Mountains are cut mostly in Ekaterinburg, and they formerly found their way via Nijni Novgorod to Western Europe. A small quantity was once found in Sark (Channel Islands), but the " Sark Stones" sold there now are not native to that island. Moreover, the term is now indiscriminately applied to both real amethyst and purple glass.

CAT'S-EYE

This type of quartz, when cut *en cabochon*, gives a cat's-eye effect known as chatoyancy. This is due to its fibrous internal structure, which includes parallel fibres of asbestos, and reflected light gives the moving luminous band of light. Many stones are artificially stained, but these colours are not permanent. The natural colour is greenish or brownish-green, and cut stones may be seen in many kinds of cheap jewellery, as well as in the form of caskets, umbrella handles, seals, etc.

Stones are found in India and Ceylon, and in the latter district cat's-eyes are very highly esteemed. Inferior stones are found in Bavaria, and these are put on the market as "Hungarian" cat's-eyes. No cat's-eyes are found in Hungary. The oriental cat's-eye, a variety of chrysoberyl, may be distinguished from quartz cat's-eye by its superior hardness and higher specific gravity.

TIGER-EYE

This is a fibrous quartz of golden yellow to bluish colour which gives a beautiful chatoyant effect when suitably cut and polished. In this stone the original mineral was crocidolite, or blue asbestos. This mineral was replaced, particle by particle, by silica; finally a compact mass of silicon dioxide resulted, which retained the original fibrous nature of crocidolite, but the colour was changed from blue to a golden yellow. The fibres are generally wavy in character, and when stones are cut *en cabochon* a fine chatoyant effect is given. Like cat's-eyes, these stones are not now of much value, though not many years ago, when found with garnets in South Africa, they were comparatively expensive. Competition resulted in the lowering of the price, and consequently demand fell, and now supply of such material is so plentiful in Griqualand West (South Africa) that the stone is scarcely used in jewellery at all. It is often referred to as "crocidolite."

ROSE QUARTZ

Although not found in large quantities, this delicate rose-pink or rose-red variety of quartz is not commercially of much value, since demand is limited. It is always found in masses, and never in crystal formation. The deeper shades are the most valuable, and these are scarce in perfect pieces. Unfortunately, this stone fades in colour on exposure to light and also when heated. The cause of this is unknown.

Bavaria, the Urals, and Maine (U.S.A.) are the chief sources of supply.

AVENTURINE

This stone is sometimes confused with jade, though its composition and colour are quite different. It is generally dark green, impregnated with dark specks (really naturally included mica and haematite). Light reflected from these inclusions produces a spangled effect, and if inspected with a microscope each speck would show a metallic lustre. Colours may be green, yellow, or a reddish-brown, but large pieces of good quality are not often found. Nevertheless, prices are moderate and much lower than jade. Aventurine is often known as *Indian Jade*, probably because many of the cut stones come from India. There it is often cut by natives into irregularly shaped beads and pendants, and bought by Europeans as valuable jade. Some of the rough is sold to China, where it is highly prized and carved into all kinds of images, etc. Some of the poorer specimens are sent to Europe.

Stones are found in Russia (Altai Mountains) as well as in India and China.

An imitation of aventurine, known as *Goldstone*, is frequently seen. This is of a reddish-brown colour, and is made of molten glass into which copper filings have been mixed. The spangled appearance of this artificial product has a much finer effect than that of real aventurine, but apart from the appearance, a file is all that is necessary to distinguish the two. The stone is made up in blocks exclusively in Italy, where its method of production is a secret. It is cut and fashioned both in Italy and in Germany, and one sees specimens of this stone mounted as "seaside jewellery" at most coastal resorts.

THE CHALCEDONY GROUP

This is the crypto-crystalline variety of quartz, and is, as a rule, either translucent or transparent. The material is made up of an aggregate of very small doubly refracting individual crystals which have a fibrous structure. This may be seen by means of a microscope. Colours vary, but as chalcedony is porous, many stones have been stained, and natural colours are to-day more the exception than the rule. Hardness is about 7, and specific gravity 2·62 to 2·64.

As already mentioned, the term chalcedony includes a large number of stones, the following being the most important—

CARNELIAN

On account of its pleasing red colour, this stone is very popular. Milky-white and light-yellow stones also occur, but these, unless of unusually fine quality, are unattractive though uncommon. Faint stripes are often seen in the red stones, also ruddy-looking patches.

Most of the rough material now comes from Brazil and Uruguay, but quantities also occur in India, Queensland, Japan, etc. Carnelian is usually found together with agate.

Most of the South American stones are fashioned in Germany, where modern methods are used, and excellent results are obtained. Many stones are improved in colour, as, owing to their porosity, colours may be accentuated or deepened by various means. The usual method is to apply heat and then ferrous sulphate. Rough slabs of stone are treated as a whole before being cut into beads, etc. Some stones will not stand this treatment, and often split. If heated too intensely, carnelian crumbles to a white powder. The change of colour depends upon the percentage of iron oxide contained in the particular stone, and considerable skill and experience are necessary before success may be obtained in this direction. Indian carnelian is generally unstained, and stones are, as a rule, native cut and polished. Primitive methods are used, and primitive results are obtained. Chinese carvings in the stone are often wonderful, even if meaningless to the European mind.

CHRYSOPRASE

This stone is of a fine apple-green colour, though it is generally marked by imperfections, such as cracks or brown marks. The colour is never a deep green, and is not so dark as aventurine. It has a slightly duller appearance than jade, and it does not possess the sheen of amazonite. The green colour is due to a small percentage of nickel oxide.

In good qualities this stone is rare, and it is, therefore, one of the most valuable varieties of quartz. It has, however, certain drawbacks which render it unpopular with the dealer in stones. It bleaches when exposed to the sun's rays, and heat tends to discolour the stone completely. It is, therefore, difficult to work, as a certain amount of heat is always generated in polishing. Moreover, stones crack very easily, so that large pieces in jewellery are seldom seen.

The rough stone is comparatively scarce, but enough to meet the demand comes from Silesia (Poland), the Ural Mountains, and the United States of America (California, Arizona, etc.). The Silesian mines date from the fourteenth century, but they have not been worked consistently. They were re-discovered in 1740 by a Prussian officer, and Frederick the Great interested himself in these mines. Consequently there are some fine specimens of chrysoprase in Sans Souci. This stone has always been regarded as a precious gem stone, however, and it has been found in many old works of art, mosaics, and pieces of inlaid work.

Artificially stained agate of a green colour is generally incorrectly called chrysoprase. It is of a bright colour and more translucent than the natural stone.

SARD

This is really a deep brown carnelian, and there is no sharp distinction between the two stones. The colour sometimes merges nearly into a black, and occasionally small specks are seen within the stone. Heating sometimes improves sard, but it is never very attractive. Good specimens are found in India, but the stone is widely distributed, and is found associated with carnelian. In former times it was largely used by the Greeks and Romans as engraved intaglios and seals.

JASPER

This is one of the least interesting stones in the chalcedony group. It is opaque, and dark red in colour. It is seldom cut and sold in its natural state, but on account of its porosity it is generally stained blue, and is then known under the name of *Swiss Lapis*, or *German Lapis*. The blue colour is obtained by several different processes, though the resultant colour is fugitive, and quickly fades on exposure to the light. Colours are always quite different from the genuine lapis lazuli, and the specks of iron pyrites, generally seen in the latter, are quite absent.

The structure of jasper is so intimate that constituents can be recognized only by analysis. The material is not pure quartz, but is mixed with ferric oxides and other compounds. Jasper is widely distributed, and much comes from North America, Germany, Sicily, etc.

BLOODSTONE

This is another uninteresting variety, frequently seen mounted in rings, sometimes carved. It is an opaque stone, dark green in colour, spotted with red.

PLASMA

This is a dull, opaque, green stone, without red spots, though sometimes white or yellow marks are seen. It is now seldom used in cut forms, but occasionally pieces are mounted in very cheap jewellery. Rough material is found in the eastern parts of India and in Germany.

AGATE

This is the most important species of chalcedony, as it is the most worked and used. It is essentially *striped*, sometimes distinctly, sometimes indistinctly, but the stripes may always be distinguished under the microscope, however faint. A stone examined by Sir David Brewster was found to have over 17,000 definitely marked bands in an inch. The colour varies; milk-white, yellowish, brownish, and reddish shades are the most usual. Bluish and greenish shades are unusual. The colour is often irregular, and this is due to impurities which are sometimes visible. In the case of *Moss Agate*, the visible impurity is due to an oxide of a green mineral (and not to included moss, as is generally supposed).

The bands are often in parallel lines, sometimes straight, sometimes wavy or zig-zag, but they are always more or less concentric. Agates of alternate black and white bands are known as *Onyx*, those of brown and white, *Sardonyx*, and red and white, *Red Agate* or *Carnelian Agate*. Other names are applied to other combinations of colours, and the beauty of agate depends upon the contrasting colours of the bands.

The structure of agate is due to its peculiar formation. It is found deposited in irregular cavities, often in steam holes in old lavas, so that its usual home is in old or recent volcanic districts. It is the result of deposits of silica from solution, and the shape of the curved bands depends upon the shape of the cavity being filled. The layers sometimes suggest the shape of an almond, and many beautiful natural designs are often seen in the rough stone. The layers differ in degree of porosity, and for this reason unnatural combinations of colours are seen in artificially stained stones. Deep green and blue shades are often obtained by chemical treatment of suitable stones. These bright colours, which are a distinct improvement on the natural paler shades, are generally permanent. In fact, rough material which is most suitable for staining obtains the highest price to-day. (See page 24.)

The staining of agates has been practised in Germany for many years, though the originators were the Italians. It is said that the secret of staining onyx was given to a German by an Italian whilst both were in prison in Paris. The Germans developed the process of staining very largely, and Oberstein, the centre of stone cutting, is now also the centre for staining agates. In this locality, carnelians and agates were mined for a considerable time, but the supply gradually became exhausted, and the industry was in danger of dying out when new fields were discovered in Brazil. Now the rough stones are shipped direct to Germany, and sold by auction. In Oberstein and Idar they are bought by the stone merchants, who arrange for the rough to be cut as market conditions require. Much of the drilling and smaller work is done by workers in their own homes, and they are paid by the merchants according to the work done. The actual workers seldom market the finished article. This is done by the merchants, who finance the whole process of production and distribution. Such methods are characteristic of many branches of industry in Germany ("Hausindustrie") and have proved to be the cheapest means of production. The finest agates now come from Brazil and Uruguay. India (the Deccan region), U.S.A., and Saxony are other sources.

The cutting of most of these stones is done by means of steel laps, the surface of which is coated with boart.

They are finished by the use of large sandstone wheels, some of which reach the size of a mill-wheel. These wheels revolve in water at the rate of about three revolutions a second, and the stone is held firmly against the surface. This necessitates the workman lying in a horizontal position, and the occupation is consequently not a healthy one. The work is carried on mainly in the neighbourhood of Idar and Oberstein (Germany), and the neighbouring river, the Nahe, supplies the required power for the large wheels, though electricity is now used to a larger extent than before. The more expensive stones are finished on laps driven by electrical power, but fine work cannot be done by wheels revolving at a high rate. The polishing is done on a hard, wooden lap on to which certain polishing materials have been applied.

Onyx and sardonyx are both used in the making of cameos of the better qualities, and in the past much beautiful work was done in these stones. Ancient seals, boxes, and other articles have been found, which show that these stones were always regarded as of some value. A predynastic tomb recently discovered at El Gerzeh contained a necklace consisting of beads of agate, carnelian, etc. Pliny wrote that Sicilian agates were good for wounds inflicted by spiders and scorpions, and the Indian stones "are possessed of similar properties and of other great and marvellous properties as well." In those days patent medicines did not exist.

Onyx was used extensively by the Ancients in the fashioning of vases, cups, etc., and fragments of ornaments in this stone are frequently found in Roman ruins. The earliest notice extant of onyx vases occurs in the writings of Appian, where he tells of 2,000 vessels of onyx that were captured at Talaura amongst the treasures of Mithradates. Epiphanius also writes of the oriental princesses who took delight in drinking from cups made from onyx. Besides being extensively used in jewellery, agate is used in delicate balances for supporting the steel knife-edges of the balance and of the pan holders.

The term "agate" is derived from the river Achates in Sicily, where Theophrastus says specimens were first found. "Onyx" is derived from a Greek word meaning the human nail.

A stone occasionally seen in old pieces of jewellery is *Mocha Stone*. This is similar in appearance to moss agate, and it contains inclusions of manganese oxide. It comes chiefly from India, and the name is derived from Mocha, near the Red Sea, which was an ancient source of supply.

CHAPTER XIII

TURQUOISE, FELSPAR, JADE AND LAPIS LAZULI

TURQUOISE

(Hardness, 6; specific gravity, 2·60–2·82;
refractive index, 1·61–1·65)

Turquoise is one of the few opaque stones that are of appreciable value, as its most sought-after colour, a sky blue, is comparatively scarce. Stones are generally blue-green to apple-green, and evidence of the parent rock is frequently seen in otherwise good pieces. It retains its colour in artificial light, whereas its imitations fail in this respect.

Turquoise is of a very complex composition, being a hydrous phosphate of alumina coloured by a copper compound. Small amounts of iron are also frequently present, and, on account of its containing a certain percentage of water, it is a stone that requires care in handling and use. All stones fade in colour in course of time and wear, and heat is particularly detrimental. Neither should stones be immersed in water or in any other liquid. Many pieces pale in colour immediately after being mined, and thus never reach the market. The original colours may be temporarily restored by burying the stones in damp earth, or by staining with a solution of ammonia, or Berlin blue. Many stones are affected by perspiration, and blue pieces frequently change to a greenish colour. Altogether, it is not a suitable stone for use in jewellery, as, in addition to being porous, it is also soft. Quartz scratches turquoise very easily, as will also a file.

The natural structure of this stone is not crystalline, but amorphous, or perhaps crypto-crystalline. The microscope often shows an aggregate of apparently doubly refractive fibres or grains, and in this respect it resembles chalcedony. The lustre is waxy, and a high polish cannot be obtained. If this is attempted, the heat developed during friction by the polishing lap affects the colour, and in nearly every case of a well polished stone the colour has been the result of artificial restoration.

The finest stones, those of a blue colour, come from Persia, where they are found in an acid volcanic rock, and often in cracks and cavities. Nishapur is the mining centre, and the mines are of a great age. The mines in the Sinai Peninsula have also been worked for many centuries. It is known that the Egyptians knew of their existence as early as 4000 B.C. Major Macdonald re-discovered some of the old mines and brought from them several fine specimens of turquoises to the Exhibition of 1857. The Egyptian stones are generally green and often glassy looking. Mexican stones are pale blue to green in colour, and these have been apparently bleached and mineralized by the influence of volcanic vapours. Other sources of supply are New Mexico, California, and other parts of the United States.

Most stones are cut *en cabochon*, and when they are cut to include the brownish limonite with which they are naturally found, pieces are called *turquoise matrix* Many of the Persian stones come to Europe via India, and none are found in India, as is often thought. In the East turquoise is very highly valued, especially the blue stones, large pieces of which are rare. The stone is supposed to bring good luck to the wearer, and it is commonly seen in Egypt, Arabia, Turkey, and Persia, mounted in rings, daggers, sword sheaths, and saddles, often engraved. The finest stone is said to be in the possession of the Shah of Persia. It is about three and a half inches long, and flawless.

Imitations of turquoise are frequently encountered, and many of these emanate from the East. A clever imitation is the one made from clay into which matrix has been introduced; other imitations in coloured glass and china are easily distinguished. Many so-called turquoises are really odontolite, or bone turquoise. These may be recognized by their bone structure, and if touched with hydrochloric acid, effervescence takes place on account of the calcium carbonate present.

Natural turquoise dissolves in hydrochloric acid, but without effervescence. Odontolite also has a higher specific gravity (3·0 – 3·5), but lower hardness (5).

Variscite, a hydrated phosphate of aluminium, somewhat resembles greenish turquoise. It is softer (hardness is 4), and specific gravity is 2·55. It is found in Utah (U.S.A.) in large masses.

FELSPAR

(Hardness, 6; specific gravity, 2·57; refractive indices, 1·51–1·52)

Felspar is an important group of minerals, of which only a few are used as gem stones. These are well known in jewellery under different names, but none is of any great value. Amongst these are *Moonstone, Sunstone, Labradorite,* and *Amazonite.* They are all silicates of aluminium and another metal—potassium, sodium, or calcium. The potassium felspars are known as Orthoclase, and the others Plagioclase. The former crystallizes in the monoclinic system and the latter in the triclinic.

Moonstone is a transparent, colourless orthoclase, usually found in good crystals of the monoclinic system. Stones generally have a milky sheen, and the bluish opalescence is caused by the reflection of light from the very thin layers of which the stone is composed. The bluer the stones the more expensive they are. Pale stones are cheap, and the whitish stones are quite valueless. The sheen appears in certain directions only, and to get the best effect, stones are always cut in cabochon forms and are never faceted.

The hardness is rather low, and the lustre is vitreous and pearly. Stones are thus easily cut, in addition to which cleavage is good, the main directions being almost at right angles to each other. Ceylon is the chief source of supply, and here they are found in quantity as pebbles in the gem gravels, or as rough fragments in clay which has resulted from the decomposition of an igneous rock. Other stones have been found in Switzerland, in the Mount St. Gothard district.

Notwithstanding the cheapness of this stone, it is frequently imitated, but as moonstone is doubly refractive, it may be easily distinguished from glass. Its hardness is also slightly lower than milky quartz, which somewhat resembles it in colour.

Sunstone (or Aventurine Felspar), is a reddish spangled stone, the spangles being due to included flakes of haematite. It is a sodium calcium plagioclase, occurring in crystals of the triclinic system, though it is commonly found in a massive form. Twinned crystals are common, and cleavage is perfect.

Norway is the chief source of supply, but stones are also found in Finland and Bohemia. Sunstone may be distinguished from aventurine quartz by its lower hardness.

Labradorite, or Labrador Stone, is a triclinic felspar of the plagioclase group. It is often found massive, and in colour is greyish-blue with a play of colour in patches. Greenish, reddish, and yellowish flashes are seen when the stone is moved, and this is due either to inclusions, or to interference of light caused by the reflection of twin lamellae, of which the stone is composed.

When polished and cut with a flat surface, this stone is particularly attractive, and in some respects resembles black opal, though the sheen is rather different. As a rule, however, it is too opaque and dull to be pleasing.

The rough material is found in blocks in large quantities off the coast of Labrador, and is an essential constituent of certain basic igneous rocks. This, for some time, was the only known locality where the stone was found, and it was first introduced into Europe by missionaries who had visited the Eskimos. But later discoveries of large deposits in North Russia and other districts have tended to cheapen this stone considerably, and now it is seldom seen in mounted jewellery. Labradorite is sometimes confused with Blue John, a variety of fluor spar. The latter is much softer and is also singly refractive.

Amazonite, or Amazon Stone, is a potassium felspar, and occurs in well formed crystals of the triclinic system. When cut and polished, the opaque green stones are fairly attractive, though white streaks and cracks often spoil otherwise good pieces. This stone also has a moving sheen, and, like labradorite, appears to be composed of a number of layers. This property alone distinguishes it from chrysoprase, aventurine, and jade, with which it is sometimes confused.

The green colour may be the result of traces of copper and organic matter, and only the deeply coloured pieces are cut and used. Stones are cut in cabochon forms, and are seldom faceted. Large pieces are cut into vases, etc., and as ancient monuments and ornaments have been found carved in this stone it has evidently long been recognized as a stone of some value.

JADE

Jade is a general term, which includes two distinct types—

(*a*) *Jadeite*, a pyroxene.

(*b*) *Nephrite*, an amphibole.

Both are of the monoclinic system, though stones are generally found in massive form. What is generally referred to as Chinese jade is jadeite, and this is the rarer of the two jades. New Zealand jade or Green Stone is nephrite.

Jadeite is a silicate of sodium and aluminium of a fibrous crystalline structure, which makes it an extremely tough material, though its hardness is only 6½ to 7. Colours vary from an apple-green to nearly an emerald-green, and greenish-white to almost white. The stone is opaque, and its specific gravity is 3·34. It shows double refraction (refractive indices 1·66–1·68). The most expensive colour is the apple-green, free from flaws. Good pieces are sometimes spoilt by white patches, or variations in colour. Whitish pieces are uninteresting, and are consequently of little value. On the other hand, fine necklaces of even colour reach the price of £1,000. In order to improve indifferent pieces, whitish jadeite is often artificially stained a deep green colour. This is not permanent, and quickly fades.

The fine green colour is probably due to chromium, whilst iron and manganese are also present in some specimens. The lustre is inclined to be greasy, though a good polish may be obtained.

Good pieces are rare, and the best never come to Europe, as the Chinese handle nearly all the output. In China this stone is regarded as being precious; in fact, the Chinese word "Yu" means both jade and precious stone. It is also associated with various legends and superstitions in that country, and every colour of jade has a separate name and distinct price in China.

All jades are difficult to work on account of their peculiar fibrous structure, but the Chinese have, since some time past, executed some wonderful carved work in this stone. Many carved pendants and eardrops are sent to Europe, and fine quality work commands high prices. In earlier days this material was used for the fashioning of implements and ornamental objects of various kinds, and articles made in prehistoric times have been found in many different parts of the world. Carved and polished figures in jadeite have been found in ancient Mexican tombs. In 1900, thousands of jade pieces were unearthed on the site of an old temple in Mexico City. The stone was named "Chalchituitl" by the Aztecs, who held it in high esteem, and the elaborate clasp which fastened the Imperial robe of Montezuma was made from jadeite. For a long time the Spaniards thought this green stone to be a kind of inferior emerald. It is difficult to conjecture how these carved stones arrived in Mexico, since to-day the only locality in which the rough is known to occur is in the Kachin Hills, Upper Burma. Here the mineral is found in serpentine associated with other stones.

The Myitkyina mines in Burma supply nearly all the jadeite used in jewellery. Here the Chinese firms have their own buyers of the rough material, and this is sent direct to Canton, Pekin, Soochow, or Shanghai, these being the principal towns concerned with the cutting of jadeite. The rough stone is sold by auction to the different dealers, who in turn have the stones cut into various articles of jewellery by out-workers. The market for selling the imported stone is open once a year only in Canton, and the material may be inspected the day before the sale by the prospective purchasers. Each piece is numbered and also slightly cut, so that the interior colour may be judged.

Bidding is made in secret, according to the Chinese custom. The auctioneer is attired in a long robe with long sleeves, and the merchants communicate their bid to him by grasping his hand in a certain way. When a particularly fine piece is offered, the auctioneer receives frantic bids, each of which he seems to have no difficulty in remembering. Sales are subject to the reserve prices of the importing firms being reached.

Canton handles the best quality jadeite, and in that city about ten thousand people are engaged in the jade industry alone. Firms specialize in one colour jadeite as a rule, and they will handle no other quality. The actual workers are divided roughly into four classes, and those who produce intricate carvings are the most highly paid. Simple tools are still used, and a system of weighing and checking the rough and the finished stone obviates any tendency towards dishonesty. Strangers would find it difficult to purchase jade direct from the cutters. They would find it easier to get what they required from the many shops in Canton, which offer a large variety of jewellery in Chinese jade to the tourist and foreigner, though prices are often exorbitant.

Nephrite is chemically a variety of actinolite, and is a silicate of magnesium, calcium, and iron. The presence of iron is responsible for the colour, generally a dark green, though this varies to almost a white. Like jadeite, it is found in compact fibrous masses. Its lustre is glistening, its fracture splintery, and its hardness slightly lower than jadeite (hardness about $6\frac{1}{2}$). Specific gravity is about 3, and its refraction is double (refractive indices 1·60-1·63). It may thus be easily distinguished from jadeite, with which it is often confused, particularly in carved pieces.

Nephrite is more abundant than jadeite, and it is found in various localities. In New Zealand, where it is also called Maori Stone, it is found as rolled pebbles in rivers and also in schists and in serpentine. In olden days the Maoris used to fashion tomahawks and other weapons from nephrite.

Eastern Turkestan supplies only a few stones now, as the mines in the Kuen Lun Mountains are nearly exhausted. Here it is found in layers of considerable thickness associated with gneiss, and also as pebbles in adjoining river beds. All the rough is sent to China, where carved ornaments are made and then sent to Europe. Some are fine, but most are crude, and prices vary accordingly.

Siberia is another locality where the rough stone is found. There nephrite occurs in blocks of large sizes in alluvial deposits. Ancient axe heads made of this material have also been found in Mexico and in the Swiss Lake Habitations as well as in Costa Rica, Guatemala, Venezuela, New Guinea, and other districts, although no deposits of the rough material have yet been found in any of these localities. A huge mass of the rough stone may be seen in the fine collection of jade formed by Mr. H. R. Bishop, and presented to the Metropolitan Museum of New York.

LAPIS LAZULI

(Hardness, 5–5½; specific gravity, 2·40)

This is a beautiful, rich, deep blue, opaque stone, which is frequently speckled with the metallic lustre of yellow iron pyrites. It is chiefly composed of calcite, coloured by three blue minerals in varying proportions, and occurs usually in massive formation. Occasionally it is found in crystals, but these are only of a small size, and in the form of cubes. This stone, therefore, belongs to the cubic system.

The best stones are of a very rich, deep blue colour, and are practically free from iron pyrites. Cheaper stones are lighter in colour and often streaked with white and grey. Large pieces of good colour are seldom found, and these command high prices; inferior stones are of very little value.

Lapis lazuli is difficult to work and to drill, not only on account of its mixed composition, but on account of its varying hardness. Its average hardness is fairly low, as is also its specific gravity. It shows no cleavage. When heated, many stones lose their colour, but regain it in cooling. Other pieces become phosphorescent when a certain temperature is reached.

In former times this stone was fashioned into vases and bowls, but as supply has become more limited it is not now often worked into large ornaments. Brooches, necklaces, handles of knives, forks, etc., are still made from this stone, as are also parts of boxes, clock cases, etc., in the form of mosaic work. Many fine specimens of inlay and mosaic work in lapis lazuli exist, particularly in churches and former palaces in Leningrad. This stone was the original "sapphire" of the Ancients, who esteemed it very highly. In addition to its use in jewellery, it was for many years used by artists to get that deep blue colour seen only in older works. It was used in a finely powdered form before an artificial ultramarine was discovered.

The oldest mines are those in Afghanistan, near Badakshan, where the stone is found in a narrow valley associated with limestone, impregnated with an igneous rock. This was probably the original source, and Marco Polo described these mines in the year 1271. Here the stone is still mined in a primitive way. In winter fires are lighted near rocks, and then water is poured on to the warm stone. This tends to break up the material, which is then more easily split by the natives with the use of hammers. The larger part of the material found here is sent to India and to Russia. Other sources of supply are in Siberia (near Lake Baikal) and in the Andes (Chili).

As mentioned before, this stone has been known from the earliest times. In the Book of Job it is described as "having dust of gold," and in those days it was extensively cut into the form of seals, signets, etc. Even some of the royal furniture recently discovered in the tomb of Tutankhamen contained inlaid specimens. Pliny wrote that "it is refulgent with spots of gold, and not well suited for engraving upon." The erroneous belief that the metallic specks are due to included gold still exists to-day.

Lapis lazuli must not be confused with Swiss or German Lapis, which is an artificially stained jasper. The colour is always different, and the Swiss Lapis never shows the characteristic specks of iron pyrites seen in the genuine lapis. Also the latter is a softer stone, and its colour never fades.

The word "lazuli" is probably derived from the Arabic "azul," meaning "blue," lapis, of course, being the Latin for a "stone."

CHAPTER XIV

MALACHITE, SPODUMENE, OBSIDIAN, SPHENE, SOAPSTONE, SERPENTINE, MEERSCHAUM, FLUOR SPAR, HAEMATITE, MARBLE, ALABASTER AND IRON PYRITES

MALACHITE

(Hardness, $3\frac{1}{2}$–4; specific gravity, 3·9–4.
Doubly refractive. Refractive index approx. 1·88)

MALACHITE has been employed in various forms of jewellery and decorative work for a considerable time, chiefly on account of its finely figured green colour. Its other properties do not warrant its use, since it is comparatively soft, and is thus easily damaged. However, being an opaque stone, deterioration on account of wear is of no great consequence, as a polish can soon be obtained on worn surfaces.

Chemically it is a basic cupric carbonate, and crystals occur rarely in a distinct form (monoclinic system). The bright, greenish colour is generally seen in concentric layers of different shades, and pieces are often very finely figured. Cleavage is perfect, and this stone may be easily worked on a lathe, giving a brilliant polish. If heat is applied, water is driven off (it contains about 8 per cent of water), and the colour changes to a dark, uninteresting hue. Hydrochloric acid will produce an effervescence, and in case of doubt, this serves as a good test.

Although widely distributed, malachite is generally found associated with other copper-bearing minerals, so that large workable pieces are not common. Prices are not high, however, and the stone is in little demand for purposes of jewellery. Russia, Cuba, Chile, and Australia produce most of the rough material, but the Ural Mountains are the chief source of supply, although many of the older mines there are now exhausted. The stone is seen more often in old pieces of jewellery, and in clock-cases, boxes, vases, etc., as part of the inlaid work. Russia was the home of work in this stone, and there are many fine specimens of pillars, etc., containing malachite to be seen in churches in Leningrad and St. Sophia (Constantinople).

On account of its characteristic colour, this stone is seldom confused with other stones, and its hardness alone is generally sufficient to distinguish it. The name is derived from a Greek word meaning "marsh-mallow," the leaves of which plant it resembles in colour.

SPODUMENE

(Hardness, 6½–7; specific gravity, 3·20; refractive indices, 1·66–1·67)

This is a rare stone, and good specimens, when suitably cut, command a high price. The general term Spodumene includes the varieties *Hiddenite*, which is a transparent emerald green stone, *Kunzite*, a beautiful transparent lilac-red stone, and *Yellow Spodumene*, a lemon-yellow coloured stone.

Spodumene is a silicate of lithium and aluminium, and is interesting on account of its containing the rare element lithium. Crystals are of the monoclinic system, and are usually prismatic in form. Stones are very easily cleaved, and are therefore easily fractured. This is due to their perfect lamellar structure. Another interesting characteristic of this stone is its strong dichroism.

Hiddenite has, as yet, been found in one locality only, North Carolina (U.S.A.), where small crystals occur in the cavities of pegmatite.

Kunzite has been found in California only, and yellow spodumene in Brazil (Minas Novas). These stones are seldom seen in jewellery, but are eminently suited for mounting on account of their beauty, despite their comparative softness.

OBSIDIAN

(Hardness, 5; specific gravity, 2·3–2·6; refractive index, approx. 1·5)

This is really not a mineral, but a rock. It is a lava that has cooled so rapidly that crystals have not been able to form, so it may, therefore, be best described as a volcanic glass. In composition, it is variable and complicated, but it usually contains a large percentage of silica and alumina. Smaller quantities of potash, soda, and iron oxide are also generally present.

In many respects obsidian is much like manufactured glass. It breaks just as easily, its lustre is vitreous, it has no crystalline structure, and it has a low hardness and specific gravity. Its colour is, however, somewhat different, being always of a dark hue, such as black, brown, grey, red, etc., and for this reason it is not transparent in thick pieces. Some specimens found in North America are striped like mahogany; other pieces contain pores with inclusions, giving a shimmering appearance. This last type is not abundant, and is consequently of some value.

Since obsidian is easily broken, it is difficult to cut, although it is softer than any variety of quartz. Formerly it was used in articles of mourning—brooches, etc., and many old pieces of jewellery contain this stone. The use of jet and other black stones has displaced obsidian, and now it is seldom seen in modern jewellery. In ancient times, it was used largely in the form of knives, spear-heads, and other weapons, and a very sharp edge was obtained. Relics of these weapons, as well as vases and mirrors, have been found in ancient cemeteries in Mexico and elsewhere. In Pliny's time it was used as a material for plates and dishes as well as for mirrors.

The stone is very widely distributed, but the island of Lipari is the chief source. Quantities also occur in Hungary, Mexico, Nevada (U.S.A.), and all volcanic areas.

SPHENE

(Hardness, $5\frac{1}{2}$; specific gravity, 3·4–3·6; refractive indices, 1·90–1·98)

This is a silicate and titinate of calcium, and for this reason it is sometimes known as *Titanite*. It occurs generally in the form of wedge-shaped flattened crystals of the monoclinic system, and the transparent stones only are cut as gem stones. These are generally green, yellow, or brown in colour, and when suitably cut are very beautiful, since dispersion is very strong, and the refractive indices are high. Unfortunately, it is a soft stone, and this is a great disadvantage to its use in jewellery, since it is not durable in wear.

This stone is also strongly dichroic, and it is easily cleaved. Brilliant cut stones are very attractive, and are sometimes seen in rings, etc. The rough stone occurs as minute crystals in many igneous rocks, associated with felspar, etc. Large crystals are not common. It is also found in crystalline limestone, and the chief sources of supply are Switzerland (St. Gothard district), and Maine (U.S.A.).

SOAPSTONE

(Hardness, 1–1½; specific gravity, 2·7–2·8.)

This is also known as *Steatite* and *Talc*, and it occurs in tabular crystals belonging either to the rhombic or monoclinic systems. The exact system is doubtful. Quite often soapstone occurs in a massive compact form, cryptocrystalline in structure.

Chemically it is a silicate of magnesium, and in colour it is greyish green to brownish grey. It is very soft, and is distinctly greasy to the touch.

Many carved and cut specimens of ornaments and images in this stone are seen. These emanate from China and India, though the rough stone comes from U.S.A. and Canada. It has no connection with white jade whatsoever, though they are sometimes confused.

SERPENTINE

(Hardness, 2·5–4; specific gravity, 2·5;
refractive index approx. 1·57.)

This stone is really a rock, and occurs in massive form. It is composed of magnesium silicate, and has, as a rule, been formed by the alteration of material very rich in olivine.

In colour, it is an oily green, and altogether it is quite uninteresting. However, it is cut into cameos, vases, clock cases, and even into small pillars; when masses are mottled in colour they are attractive. Material is found in Cornwall, and many kinds of ornaments are cut from this stone locally. Serpentine may be easily distinguished from jade by its softness.

MEERSCHAUM

(Hardness, 2–2½; specific gravity, 2)

This is a hydrated silicate of magnesium, and is an amorphous, opaque material of an earthy texture. It is very light and very soft, and in colour is white, greyish, or yellowish. It is porous, and adheres to the tongue.

Most of the material used comes from Asia Minor, where it occurs in nodular masses of irregular shapes and variable sizes distributed in alluvial deposits. Here it is systematically worked by means of pits and galleries; the earthy matrix is scraped off, and the masses are then dried and scraped again, after which they are boiled in a wax and polished. The chief use of meerschaum is in the manufacture of pipe bowls, which are turned and carved from the rough in Germany and Vienna, but the demand for this class of pipe having fallen off considerably, meerschaum is now of very little value.

Meerschaum is also found in Greece, Spain, and Morocco; in Spain it is used sometimes as a building stone, and in Morocco, when fresh and soft, as a substitute for soap.

The word "meerschaum" is the German for sea-foam, to which it has no relation whatsoever, except in appearance. It is in like manner termed *écume de mer* by the French. Several imitations of this material are used, particularly by the French, the chief being a treated form of plaster of Paris.

FLUOR SPAR

(Hardness, 4; specific gravity, 3·18;
refractive index, 1·43)

Fluor spar is calcium fluoride, and occurs in crystals of the cubic system. The crystals are often large and perfect in shape, some measuring 18 in. along one edge.

Nearly every colour has been found in fluor spar, though shades are generally faint. The only variety used for ornamental purposes is known as *Blue John*, which has a pronounced bluish colour. This used to be found in large quantities in Derbyshire, but the supply is now nearly exhausted. Vases and ornaments are cut from this stone, and colourless pieces are used in certain lenses.

Cleavage is perfect, and the hardness is low, so that the working of this stone is easy. Although singly refractive, one often sees a bluish colour in addition to green in greenish specimens. This effect is thought to be chiefly due to the action of the ultra-violet rays, and the peculiar property possessed by fluor of appearing differently coloured by reflected and transmitted light has given rise to the term *fluorescence*. The actual colour may be due to some colloidal material, since heat quickly alters the colour of specimens. It is decomposed by sulphuric acid, and hydrochloric acid is formed. Before the blowpipe, it decrepitates and fuses into an enamel.

The ordinary variety usually occurs in veins, gneiss, limestone, or sandstone. As a veinstone, it is found associated with tin ore in Saxony and Cornwall, with lead ores in Derbyshire, Cumberland, and Northumberland, and with silver ores in Germany and Norway. Pale coloured beads of fluor spar have been found in ancient ruins near Lake Titicaca (Bolivia), so its use as an ornamental stone is not recent.

This mineral has been used as a flux in various metallurgical processes, such as lead and copper smelting, hence its name, from the Latin " fluo," to flow.

HAEMATITE

(Hardness, $5\frac{1}{2}$–$6\frac{1}{2}$; specific gravity, 4·9–5·3)

Haematite is an iron sesquioxide of a glossy black colour. In former days it was considerably used in different forms of jewellery; now it is seldom faceted and mounted. Crystals are of the hexagonal system, and have an iron metallic lustre. Small, thin crystals appear by transmitted light to be transparent and of a blood-red colour. Hence the Greek name of "haematite," meaning "bloodstone," for this mineral. A streak on a piece of unglazed porcelain gives a dull, dark-red colour, which is a characteristic of this stone only. It is softer than quartz, however, and little suited for wear in jewellery.

It occurs in rocks of all ages, and material comes from the Alps, France, Norway, Spain, England (Cumberland), U.S.A., India, Elba, etc. Ring stones, brooches, and other articles are still occasionally made from haematite, but it was formerly, like jet, used in the manufacture of mourning jewellery. It is interesting to note that engraved pieces have been found in the mines of Babylon and in old Egyptian graves.

MARBLE

(Hardness, 3; specific gravity, 2·71;
refractive indices, 1·48–1·65)

This is a metamorphosed limestone, and, when pure, is white in colour. Usually it is streaked on account of impurities. Its hardness is about 3, and under the microscope a granular structure is seen; this is due to the interlocking grains of calcite, of which it is formed.

It occurs chiefly in Italy, and it is used in decorative work of many kinds. In olden days it was extensively used in sculpture, and by ancient writers was called "lychnites," as the quarries in ancient Greece were worked by the light of lamps. (Greek *lukhnos*, a lamp.)

ALABASTER

(Hardness, $1\frac{1}{2}$–2; specific gravity, 2·3)

Alabaster is a hydrous calcium sulphite (a massive form of gypsum), and is cryptocrystalline in structure. It is generally white, but often streaked with reddish impurities. It is so soft that it may be easily scratched by the finger-nail, and it is also slightly soluble in water.

It is found in Switzerland, the Tyrol, and the United States of America, and is used, like marble, in decorative work. Very ancient alabaster quarries exist in Algeria. This stone is mentioned in the Bible, and in those days it was held in very high esteem; it was then probably quarried in the neighbourhood of Thebes, which still produces some material.

The name Alabaster is said to be derived from the Arabic *al batstraton*, meaning "the whitish stone."

Florence is the present centre of the alabaster trade.

IRON PYRITES

(Hardness $6\frac{1}{2}$; specific gravity, 5 approx.)

This mineral, a disulphide of iron, is mentioned here since in the form of *marcasite* it is again being used to some extent in jewellery.

In colour it is very pale yellowish, and it has a metallic lustre, which is retained for a considerable time. It occurs in crystals of the cubic system. These are generally cut in flat rosette form, and are mounted, according to prevailing fashion, in buckles, brooches, etc. Although fairly hard, this mineral is brittle. Hydrochloric acid does not affect it in any way, although it is decomposed by nitric acid.

It is very widely distributed, and for this reason has been used since the earliest times in jewellery. Large polished pieces in the form of mirrors have been found in ancient graves in South America.

PART IV

CHAPTER XV

AMBER

AMBER, coral, and jet are all well known, and are in common use in all kinds of jewellery. Like pearls, they are, strictly speaking, not minerals, but a description of them is given here as being of interest and practical value.

AMBER

Amber was probably the first substance used for personal adornment. Necklaces used in the Bronze Age usually contained amber, and specimens have been discovered in tumuli in England—Dartmoor and elsewhere. That there was a very early and extensive traffic in amber has also been proved, and it reaches back to at least 1200 B.C.; in fact, it was probably the direct cause of the early development of civilization in the North.

During the Stone and Bronze Ages most of the amber came from the Baltic shores, and found its way to Great Britain by boat across the North Sea. Remains are frequently encountered in burial places of the Bronze Age, and during the first epoch of this age in Western Europe (900–500 B.C.) commerce in amber from the Baltic was of considerable importance. Amber was apparently very popular and worn by rich and poor, both in the form of ornaments and amulets, since its colour was considered attractive. It was easy to work, and it was connected with talismanic beliefs and superstitions. (See page 118.) As many as thirteen hundred amber beads were found in one hundred and thirteen tombs at Jezerine; ancient sepulchres all over Europe have revealed thousands of amber beads, especially those along the Adriatic coast. A remarkable amber necklace, known to date from the Bronze Age, was found with a skeleton in a tumulus in Wiltshire. This necklace may now be seen in the British Museum. Amber was also used during the Mycenaean period in Greece, as Schliemann found four hundred amber beads whilst excavating the Acropolis at Mycenae. These beads were found to be of Baltic amber, as were others found in Greece belonging to an equally remote period.

The magnetic character of amber was noticed by Thales of Miletus as early as 600 B.C., and also by Plato, Aristotle, and Theophrastus, in the fourth century B.C. Isodorus, Siculus, Strabo, and other writers mention this quality, while Virgil and Ovid speak of amber as a material for ornament. According to Pliny, the use of amber in objects of art was quite general, and Homer mentioned it in his *Odyssey*. It maintained a high value among the Romans, especially in Nero's time. The nets for protecting the podium of the amphitheatre against the wild beasts were, according to Pliny, studded with amber by Julianus, the managing director of the gladiatorial exhibitions. Also many of the weapons and articles used during the games were made of amber, or contained this material.

Not only in the West, but also in the East, was amber regarded with high esteem. The Turks, Arabs, and Persians especially favoured it, and rosaries and necklaces have been exported from there since the earliest times. No doubt the chief attraction to these people was the inexplicable power of magnetism that amber shows under certain conditions. This, to them, was mysterious, and consequently myths, legends, and magical powers were connected with it.

The earliest known races of mankind, however, were still unborn when amber was first being formed. Millions of years ago, during the Tertiary or Eocene period of our earth, there existed in what is now the Baltic Sea an area which produced plants and trees, many varieties of which are quite extinct to-day. The climate there was much warmer then than in our days, and amongst the dense vegetation grew an enormous number of

PLATE XIII

MINING FOR AMBER IN EAST PRUSSIA

The blue earth containing the amber is loaded into trucks and conveyed to the surface

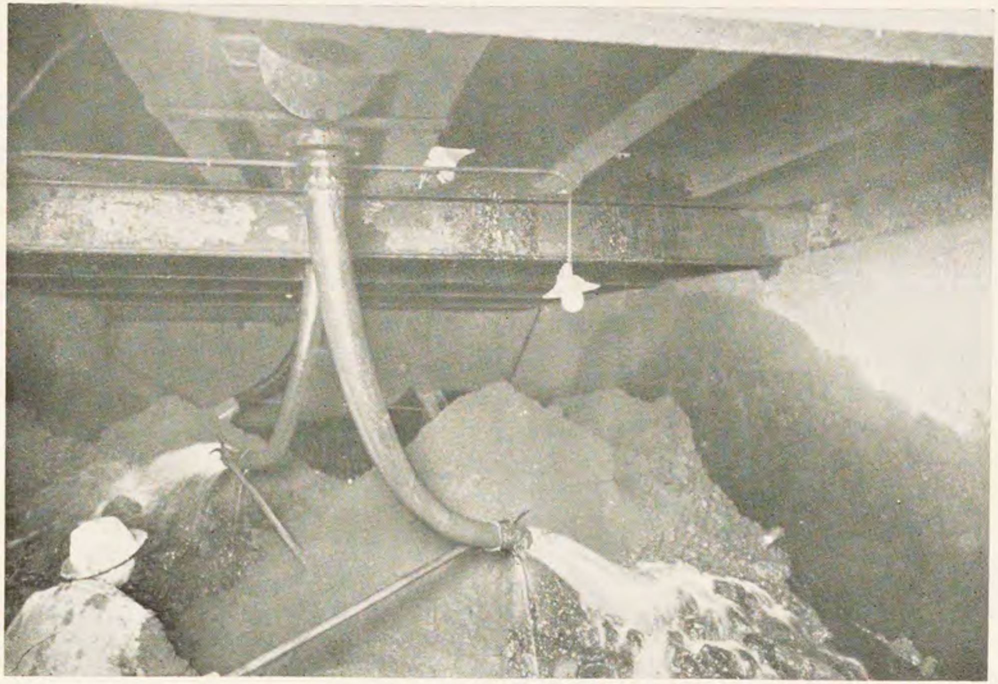


PLATE XIV

AMBER MINING IN EAST PRUSSIA

Jets of water under high pressure dissociating amber from the blue earth. The whole is passed down to a trough, where the amber is retained coniferous trees. The trunks of these trees, being subject to extreme climatic conditions, in course of time exuded resin. Later, the trunks decayed, fell to pieces, and were naturally buried in the earth. When the land sank, and the old forests were submerged, the ground with the embedded resin was subjected to the effects of the waves. The result was a formation of a blue clay, and in this blue clay amber is found. During the Ice Age, further changes in the earth's surface partly released amber from its former bed, so that much is also found in the sands of the present Baltic Sea.

Amber is, therefore, not a mineral, but an ancient vegetable product, produced from certain kinds of coniferous trees long extinct. Colours range from white to a dark brown. Reddish, bluish, brownish, and greenish tints may be present, but the usual colour is a honey-brown yellow. Amber may be transparent (clear), opaque (cloudy), or semi-clear. The clear variety is now often faceted in finished articles. In composition amber is variable, but about 78 per cent is carbon, 10·5 per cent hydrogen, and 10·5 per cent oxygen. Traces of sulphur are also sometimes found, whilst succinic acid is generally present—sometimes as much as 3 to 4 per cent in clear amber, and 4 per cent in cloudy amber. Specific gravity is about 1·10, amber thus being slightly heavier than water. Refraction is single (refractive index 1·54), and hardness is only about $2\frac{1}{2}$, and in consequence it is really quite unsuitable for jewellery subjected to hard wear. Moreover it is brittle, and is easily fractured. Experience and care are, therefore, required in working. The different methods of shaping, polishing, and carving are largely kept a secret by firms engaged in this industry, the home of which is the Baltic coast. Very little work in amber is done in England, though there are a few places on the East coast, such as Felixstowe, Southwold, and Aldeburgh, where the rough is fashioned.

As this material is a bad conductor of heat, amber is warm to the touch, and so cannot be confused with a real stone or even glass. Unlike other resins, it does not become sticky with friction. Electricity developed when rubbed, is negative, but the attraction of a piece of tissue paper on friction being applied, which is sometimes used as a " test " for genuine amber, is of not much value, since many imitations act in a similar manner.

Amber is not a simple resin; if heated, oil of amber is produced. At a temperature of about 100° C. it begins to soften, and gives off a characteristic odour. At 350° C. to 375° C. it melts. Other resins melt at a lower temperature. White fumes are given off, also a peculiar aromatic odour.

First quality amber is entirely free from flaws, cracks, and marks, and the desired colour to-day is a rich lemon or a dark yellow. As few large and perfect pieces are found, these command fair prices. Small pieces are very cheap, and to-day amber is one of the cheapest materials used in jewellery not containing "imitations." All amber darkens with age and wear as it is porous, and old amber is in demand. Good pieces fetch high prices, and the natural darkening makes the matching of pieces very difficult. Necklaces, pendants, eardrops, and brooches in amber are worn to-day just as they were centuries ago, but prices have fallen in modern times owing to increased production due to improved methods of obtaining the rough material.

This still comes, for the most part, from the shores of the Baltic. It is found in the blue earth, and in a sandstone, at a depth of about one hundred and thirty feet below the surface. The stratum containing the amber runs under the sea, and for this reason the material of former days was obtained only when violent sea storms occurred. These had the effect of breaking up the amber from the bottom of the sea and washing it ashore.

Now amber is also obtained by dredging with nets, or by actual mining. In the latter case modern dredges driven by electricity are employed. These collect the upper masses of soil, and the blue earth is then dug out and exposed. The amber is separated from the earth by water power, strong jets being directed on it.

Only about one-fifth of the material so obtained is fit for use in the manufacture of jewellery. The industry is now practically a State monopoly, and is controlled by a few German firms in much the same way as is the rough diamond by the De Beers Syndicate in South Africa.

When found, amber is covered with a gummy looking surface, which is sometimes thin, sometimes thick. This surface is thinner when found in the blue ground. Curious natural shapes often occur, and pieces of wood, insects, leaves, etc., are frequently included. These are readily seen in clear amber, and good specimens are valuable and interesting. Pope wrote—

> Pretty! in amber, to observe the forms
> Of hairs, or straws, or dirt, or grubs, or worms,
> The things, we know, are neither rich nor rare,
> But wonder how the devil they got there.
>
> (Ep. to *Arbuthnot.*)

Many of the insects found in amber are of extinct species, and some have been found in amber only. Other inclusions give a clue as to the date of formation, and in this respect amber is unique. Fine specimens of inclusions in amber are comparatively rare, though not those containing common insects. As Herrick wrote, not quite correctly—

> A drop of amber, from a poplar plant,
> Fell unexpected, and embalmed an ant;
> The little insect we so much contemn
> Is, from a worthless ant, become a gem.

On account of its softness, amber has always been easy to work. First attempts were primitive, but with the advance of civilization, workmanship made greater progress. The Assyrians and Phoenicians produced some good work, but it was the Romans who first produced artistic pieces in this material. Carved figures, bracelets, and necklets have been found which show that they considered its value equal to that of gold. Between the sixteenth and eighteenth centuries, when all arts made great strides, many beautiful pieces of work in amber were produced. Delicately worked powder-boxes, smelling-bottles, boxes, chests, altars, goblets, and mirror frames were created, often in conjunction with gold, silver, and semi-precious stones. Museums in Moscow, Berlin, and Dresden all contain fine specimens of this work. Since then, amber has been the subject of periods of fashion, like garnet, amethyst, and other semi-precious stones. To-day it is used in all forms of jewellery, and also as pipe-stems, cigarette and cigar tubes.

The Baltic coast of Germany, Lithuania and Latvia is by far the most important area in connection with amber. The largest single piece found was unearthed in East Prussia in 1860. It is of fine colour, weighs over twenty-one pounds, and has been valued at £1,500. At present, it may be seen in the Natural History Museum of Berlin. The coasts of Sicily provide a fine variety, generally tinged green or blue, and a certain amount is found off the East and South coasts of England. Germany sends amber to all corners of the world—China, Thibet, Egypt, Ceylon, South Africa, and every place where there is a demand or a likely demand for amber articles. Many pieces find their way back to Europe by means of travellers and tourists, who have listened to Eastern fables and paid heavily for their love of romance. Not only is much of the so-called Chinese, Persian, and Egyptian amber a synthetic and artificially coloured form of amber, but a great proportion is a pure imitation, generally originating from Germany. It is as well to know a little about amber before purchasing it in Cairo, Port Said, or Colombo.

There is a species of amber found in Burma. This is known as *Burmite*, or Burmese amber. It is of a dark reddish-brown colour, and is found in large masses. It is mined and worked chiefly by the Chinese, and is hence known in Europe chiefly under the name of Chinese amber. Necklaces, ropes, and carved pieces are made from this material, though much of the so-called Chinese amber is coloured compressed amber.

Block amber is the term applied to the natural amber

Plate XV

Dredging for Amber on the Baltic Coast (East Prussia)

as found, no matter what colour or variety. *Compressed* amber, also called Pressed amber and Amberoid, is reconstructed amber, that is, the product of waste and faulty pieces of block amber mixed with other substances, including in some cases colouring matter. At a temperature of about 170° C. amber becomes soft and gummy, and this property is used in the reconstruction. Hydraulic pressure is used, and the pressed amber is made up into large blocks, both in the clear and the cloudy; from these, pieces are cut and fashioned. Compressed amber cannot be sold as block amber, but it is frequently passed as "amber," "real amber," and "pure amber."

There are other natural amber-like resins, but the one that leads to most confusion is *Copal* resin. Much of this has been brought from New Zealand, and some sold as amber, though its chief use is in the manufacture of varnish. Copal takes a very poor polish, which it does not retain, and it is quickly affected by heat. It also readily softens in cold ether, whilst real amber is unaffected.

There are many imitations of amber under fancy names. Some are not easy to detect at a glance. Glass is heavier and colder to the touch than amber. The latter tends to chip when a knife is applied to it, whilst imitations, other than glass, peel under the same test. Compressed amber is generally more uniform in colour than block amber, and it also has a greenish tinge as a rule, as well as having a flaky internal appearance. Its specific gravity and hardness are, however, about the same as natural amber.

CHAPTER XVI

CORAL AND JET

The use of coral in jewellery is nearly as ancient as that of amber. The Romans were known to have worn it extensively not only in jewellery but also as amulets; it was, therefore, naturally connected with various superstitions, some of which still live to this day (see page 119).

Coral is not a mineral, but is the calcareous skeleton-like deposit of the coral polyp, and is mostly composed of calcium carbonate secreted from the sea water.

The animal responsible for what we know as coral resembles a mass of soft jelly, and by means of its tentacles it attaches itself to submerged rocks in certain seas. Under suitable conditions, it deposits a hard mass of calcium carbonate near the outer and lower part of its body. In formation red coral may be compared with very small tubes fitting into each other, and masses grow very much like branches of a tree. The masses deposited are always attached to some submerged object, a rock, stone, mussel, etc., and are only found in waters of a certain temperature. Specimens have been fished from a depth varying from nine to nine hundred feet below the surface, and the deeper they grow the less depth of colour do they possess. "Branches" are also larger when found near the surface. It is some years before the coral grows to maturity and the banks are, therefore, worked systematically so that no young coral is touched.

The variety used in jewellery is chiefly that known as *corallium rubrum*, or *corallium nobile*. Colours vary, though the different shades of red predominate. Red coral is the most common; white and yellow coral have been found, but the rose-pink and the ox-blood red colours are most sought after. It should be noted that coral is often stained to improve the natural colour, and

PLATE XVI

THE WORKING OF CORAL (NAPLES)

1. Suitable pieces of coral being cut away from the rough. A large knife is used for this purpose.
2. Drilling coral beads.
3. Carving coral.
4. Refining coral. Pieces that have already been shaped are finished on a stone lap. Hand power is used in all these operations.

this is the reason why many cheaper pieces of coral fade in time. The exact cause of the natural colours is not known, but they may be due to calcium and magnesium carbonates combined with a little iron oxide. In weight and hardness, coral is very similar to pearl—hardness being about $3\frac{1}{4}$, and specific gravity about 2·65.

All kinds of earrings are made from coral as well as necklaces, brooches, pendants, etc. Fine work is still expensive, and good quality necklaces of the rarest colours also command high prices, but at present the demand for coral is limited. Unlike pearls, it is not always fashionable, and when demand falls, prices decrease considerably.

The coasts of the Mediterranean Sea are the chief home of the coral polyp, and the Algerian and Tunisian coasts, Corsica, Sardinia, and Sicily all supply coral. The Adriatic supplies a small quantity only, and the deep red variety comes from the Spanish coast. Experts can tell from which area coral was fished by colour alone. The fishing is done nearly exclusively by Italians now, and most of the coral is taken to Naples to be fashioned. In former days the monopoly of coral fishing was held at different times by the French, Spaniards and English, and Marseilles was the centre of the industry for some time. The fishery takes place at recognized times in the year, and altogether occupies about six months in the year. The boats and crews are Italian, and mostly come from Naples, which is the home of coral and cameo work. When landed, the coral is sorted out into dead and faulty coral, black, ordinary red qualities, and picked fine qualities. In Naples over forty firms are engaged in the working of coral alone. Over three thousand people are employed, the majority being women. All kinds of jewellery are made up, particularly rosaries, necklaces, and religious articles. Considerably more coral is sent to the East than to Europe, though there is a constant demand for beads and rosaries in the Roman Catholic countries, such as Spain. In Egypt, India, Morocco, Arabia, and China, coral is extensively worn. Demand is probably greatest in India, where finely carved pieces are sought after. Large fine pieces are also used in China as buttons in mandarins' caps, whilst the natives of Central Africa use quantities in their decorative jewellery.

Many wonderful pieces of carved coral are in existence, though little of the best work is done to-day. At the International Fisheries Exhibition held at Berlin in 1880 a coral necklace valued at £6,000 was exhibited. The Italian Royal Family possesses a carved coral handle of a sunshade which is valued at £360.

A blue coral was once found off the West coast of Africa, but this is now never seen. Although a considerable proportion of the coral on the market to-day has been artificially stained, a dyestuff giving a permanent effect has not yet been discovered; many modern coral necklaces, therefore, quickly lose their colour.

Unlike its substitutes, all coral effervesces on application of an acid, and this serves as a good test, if the specimen allows. But owing to the surface colour and hardness, little confusion between the real and imitation can be made.

JET

Jet is a kind of fossilized coal, a brown lignite, which has been formed in the course of many thousands of years.

Although one of the least interesting and valuable materials used in jewellery, its use dates back to quite as far as the Bronze Age. Numerous barrows, for example, those in Dorset, have produced rings, anklets, bracelets, and other forms of jewellery in jet. To be suitable for cutting purposes, it must be pure black in colour, faultless, and homogeneous; good specimens take a high polish, and as the hardness is only about 4, the material is easily worked. Jet is a bad conductor of heat, and therefore feels warm to the touch. This is one means of identification; the specific gravity, 1·35, is another, whilst it should also be noted that electricity is developed with friction. When jet is heated, it burns, giving off dense, pungent fumes, which were once supposed to have valuable medicinal qualities.

The chief source of supply is the Yorkshire coast, near Whitby and Eskdale, but inferior material is also imported from Spain and worked in these towns. About a thousand men are still employed in this industry, though formerly, when jet was in demand, a far greater number of workers was employed. Some material is also found in France and Würtemburg, where various articles in jet jewellery are still made. It used to be largely used in mourning jewellery, but as mourning has now largely gone out of fashion, jet is little worn. In addition, various imitations have been manufactured, though very few are so light as the genuine material. Glass imitations are harder, heavier, and colder to the touch; they also have a more brilliant polish. The same qualities distinguish black tourmaline, obsidian, etc., from jet.

The word "jet" is a corruption of "Gagates," the name applied to it by ancient Greek and Roman writers. Pliny wrote that it was originally found near the river Gages (the German for jet is *gagat*), and Solinus mentions that it was found in Britain in his time.

CHAPTER XVII

SUPERSTITION AND GEM STONES

Superstition, the natural ally of ignorance, played no small part in the lives of the Ancients, and even to-day we are not entirely free from beliefs which we cannot reconcile with reason. But in olden days conditions lent themselves much more favourably to accept as facts what we to-day think absurd and know to be impossible. It is not surprising, therefore, that to many gem stones were attached fables and legends concerning their origin and mystical powers. For gem stones were not only prized as ornaments in those days but also as charms, emblems, and possessors of medicinal virtues. It is impossible to trace the origin of many of the ancient superstitions, but nevertheless they are of interest, even in these days of hard facts.

The earliest known gems were amber, coral, pearl, ruby, rock crystal, onyx, amethyst, and agate, but many others were known to the Ancients. They originally divided precious stones into male and female. They believed that all stones were dewdrops condensed and hardened by the sun. Thus, rock crystal was first believed to be frozen water, probably owing to its transparency. But when this mineral was discovered in warm climates, the idea was dispelled, and the term "crystal" was applied to all minerals occurring naturally and limited by plane surfaces. Colours were supposed to possess certain attributes, and these were no doubt passed on to stones.

In later days it was believed that the sun of the tropics was necessary to form a precious stone, and all the best stones were thought to originate from the East. Consequently many were given the prefix "oriental" to distinguish them from inferior but similarly coloured stones, and to this day we have "oriental" cat's-eye, "oriental" topaz, "oriental" emerald, "oriental" amethyst, etc.

Many of the stones known to the Ancients by certain names are now known under different names. For instance, their sapphire is our lapis lazuli, and their topaz is probably our peridot. For this reason many stones mentioned in the Bible may not be the stones we know under the same names. It is improbable that diamond was known then, since the art of cutting and polishing the hardest stones was not discovered till much later days. But many other stones were known, and they are mentioned from the Book of Genesis to the Book of Revelation. The first reference is to onyx in Genesis, but the Books of Job, Ezekiel, Daniel, and even Jeremiah contain passages which show that ruby, sapphire, emerald, onyx, coral, pearl, and other gem stones were highly prized. The translated names in some cases may refer to other stones, however; for instance, ruby was probably our carbuncle. The twelve stones which the High Priest wore on his breast plate, therefore, are not definitely known. The following list is thought to be fairly accurate—

Jasper (probably carnelian).	Diamond (rock crystal).
Ruby (probably carbuncle).	Amethyst.
Topaz (probably citrine).	Onyx.
Carbuncle (garnet).	Zircon.
Emerald.	Sapphire (lapis lazuli).
Agate.	Beryl (peridot).

Similarly, the twelve stones assigned to the twelve tribes of Israel are also vague. Authorities vary in their assignments, and each points out the other's error in translation and supposition. Consequently, no list is given here.

In those days the Tyrians were the chief traders in precious stones, which came largely, according to Ezekiel, from Syria. The robes of their king were said to be covered with brilliant gems, all of which probably originated from South Arabia, India, and Ceylon. Onyx is expressly mentioned by Moses as being found in the land of Havilah. "Onyx stones, and stones to be set, glistering stones, and of divers colours, and all manner of precious stones" were among the articles said to have been collected by David for the Temple. Onyx was used in the decorative work of the Temple, and was probably inlaid in the capitals of the pillars.

Amber and rock crystal are mentioned in the Bible as being of great beauty. In the Book of Proverbs we read "Who can find a virtuous woman? For her price is far above rubies." A passage from Isaiah relates, "I will lay thy foundations with sapphires, and I will make thy windows of agates, and thy gates of carbuncles, and all thy borders of pleasant stones," and there are many other passages which show that gem stones were highly appreciated as regards their beauty and value. They were also known to have been used as signets from very early times, as ancient Egyptian scarabs are still being unearthed. We read of Jezebel using her husband's signet ring to sign false letters about Naboth's vineyard, and the ring was no doubt set with some precious stone.

But we must refer to later times in order to learn what fables people really believed about gem stones. Pliny is one of our most useful authorities, though many other writers of his age can inform us of some interesting legends. Perhaps it would be best to deal with stones separately, together with their attendant superstitions.

Amber was one of the earliest materials used for personal adornment, so it is not surprising that it was connected with a variety of superstitions. Pliny wrote, concerning its formation, that after Phaeton had been struck by lightning, his sisters were changed into poplars, which every year shed their tears upon the banks of the river Eridanus. To these tears was given the name of electrum (amber). Ovid relates another legend. He says that amber is a concretion of the tears of birds who were the sisters of Meleager, who never ceased weeping for the death of their brother. Thomas Moore evidently referred to this superstition in the "Fire Worshippers"—

> Around thee shall glisten the loveliest amber
> That ever the sorrowing sea-bird hath wept.

Even to-day amber is believed by many to be a preventive against, and even a cure for, rheumatism and like ills. In Germany small amber beads, strung as necklaces, are given to children to help them in teething, whilst the Turks believe that amber mouthpieces preserve them from inhaling pestilence when smoking. A pipe with an amber mouthpiece is often offered to a stranger in Turkey as a great mark of politeness, since amber is also believed to be incapable of transmitting infection.

The Greek name for amethyst was composed of two words meaning "not" and "to tipple," and this was connected with their belief that those who drank from goblets made from this stone could not get intoxicated. The Hebrew name for this stone comes from a root word meaning "to dream," and this apparently originated the superstition that possessors of an amethyst were sure to have pleasant dreams. The Roman women believed that this stone would preserve the affections of their husbands, and it was consequently considered the most precious stone by many. In this connection Brother Colonna, in *The Cloister and the Hearth* (Charles Reade), stated that "one stone could confer valour on its wearer, another chastity, another safety from poison, another temperance," and it is also mentioned that "sovereign qualities were universally ascribed to certain jewels, and the amethyst ranked high among these precious talismans." A German writer of the ninth century stated that if worn the amethyst prevented attacks by thieves.

Concerning coral, many legends have persisted through the ages. The Romans used to hang beads of red coral on the cradles and around the necks of infants to "preserve and fasten their teeth," and to save them from "falling sickness." It was also regarded as a charm against lightning, whirlwind, shipwreck, and fire. Paracelsus says it was worn round the necks of children as a preventive against fits, sorcery, charms, and poison. The Romans employed it as a medicine as well as an amulet. Pliny says that bunches of corals, hung around children's necks, were thought to preserve

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the wearer against danger; calcined and pulverized, and taken in water, one spoonful after each meal, it was supposed to give relief to patients suffering from griping pains and afflictions of the bladder.

Sir Hugh Platt (1594) wrote, "It will turn pale and wan if the party that wears it be sick, and it comes to the former colour again as they recover." Even to-day the Neapolitans regard coral as an amulet against the malignant influence of the evil eye, and in India it is believed to have the power of preventing evil spirits from occupying the body after death. A Norse legend says that this very useful gem is fashioned beneath the waves by Marmendill.

Rock crystal was regarded with high esteem by the Ancients, and its coldness and transparency were thought to be particularly wonderful. In Pliny's time vases and cups were made for the wealthy from this material, and Nero was supposed to have possessed two very finely carved cups in crystal, the carvings illustrating subjects from the *Iliad*. He is said to have smashed these cups in a rage when he heard that his kingdom was lost. Contemporary writers say that he did not wish anyone else to drink from these cups; in any case, it was a selfish procedure.

Both Diocorides and Pliny mention the belief that pearls are formed by drops of rain falling into the oyster shells while open, and then hardened by a secretion from the animal. Pearls were also held in great esteem by the Ancients, and it was the Asiatic conquests of Pompey that first turned the taste of the Romans towards this gem. In Pompey's triumphal procession thirty-three crowns were carried, all of which were made from pearls.

Caligula wore slippers made out of pearls, and Nero had sceptres for the actors in his theatre wrought out of them, so tradition runs. Pliny records that Clodius, son of Aesop, drew a pearl of great value from his ear, melted it in vinegar, and drank to the health of Cecilia Metalla. A similar fable is the one concerning Cleopatra, who made a costly banquet for Antony. During the banquet, she is said to have taken a pearl eardrop, dissolved it, and drunk the solution to the health of the Roman Triumvir, saying, "My draught to Antony shall far exceed it." Since vinegar does not entirely dissolve pearl, and a stronger acid would be unfit to drink, these fables are just interesting.

In more modern times Queen Elizabeth is said to have visited Sir Thomas Gresham at the Royal Exchange, when he pledged her health in a cup of wine in which a precious stone (pearl) worth £15,000 had been crushed. Heywood referred to this in his play, "If you know not me you know nobody" (1604).

That pearls were connected with tears was a very ancient superstition. Shakespeare, in *Richard III*, writes—

> The liquid drops of tears that you have shed
> Shall come again, transformed to orient pearl.

But to-day this belief no longer exists. It has perhaps been transformed to opal, which is still regarded by some as being an "unlucky" stone. Perhaps Scott's *Anne of Geierstein* fostered this idea. But Alfonso XII of Spain (1874) certainly seemed to have possessed an "unlucky" opal. On his wedding day he presented his wife with an opal ring. She died soon afterwards, so he gave the ring to his sister. She died a few days later. Then he presented it to his sister-in-law, who died within three months, whereupon he wore it himself, and he died within a very short time. The Queen Regent then suspended it from the neck of the Virgin of Almudena of Madrid. Nothing further happened. But perhaps these are a series of coincidences, not superstitions. Opals were favourite stones with Queen Victoria, and to-day it is considered to be very desirable for all people born in the month of October to possess an opal.

The Ancients considered ruby to be an antidote to poison, to preserve persons from plague, to banish grief, to repress the ill-effects of luxuries, and to divert the mind from evil thoughts. It was, therefore, a very valuable stone, even in those days. Most of the inhabitants of Burma still believe that ruby ripens in the earth; first it is colourless, and eventually when mature it becomes red.

Marco Polo wrote that the King of Ceylon had the finest ruby in existence. "It is a span long, as thick as a man's arm, and without a flaw." Kublai Khan offered the value of a city for it, but no business resulted. The King said he would not part with it "though all the treasures of the world were to be laid at his feet."

Ruby was also supposed to change colour on the approach of ill to the wearer, and it is said that the ruby worn by Catherine of Aragon changed colour when the question of her divorce was first considered.

Sapphire was regarded as a medicine, and was dedicated by the Greeks to Apollo (but not on this account). They thought that, on account of its heavenly colour, they would get an early and favourable answer from the oracle if they possessed a sapphire. It was also considered a charm against unchastity, and a scare against devils and evil powers. Pope Innocent III commanded all Bishops to wear a sapphire ring in view of these beliefs. St. Jerome also wrote that if a sapphire were worn, it would save the owner from captivity, and would make peace with foes.

Turquoise was believed by many to be a stone that should be given, not bought. "A turquoise given by a loving hand carries with it happiness and good fortune." "The colour of a turquoise pales when the well-being of the giver is in danger." These are Eastern superstitions, where turquoise is regarded as a more precious stone than we in Western Europe consider it. It was once supposed to betray the infidelity of a wife by changing colour. It was not for this reason that Shylock says in the *Merchant of Venice* that he would not lose his turquoise for a wilderness of monkeys.

Bloodstone was regarded very highly during the Byzantine period, and also by the artists of the Revival. This was chiefly due to the belief that it owes its origin to the stone lying under the Cross on Calvary, which was stained by the dripping blood of Christ. It is still known to the Italians as "bloody jasper."

Jade is connected with many superstitions, particularly in the East, where the Chinese consider it the most precious of all gems. According to them, it is the prototype of all precious stones, and the Chinese word "Yu" means both jade and precious stones. It is supposed to be a remedy for all kinds of internal disorders, if powdered and mixed with water. They believe that it prevents fatigue, prolongs life, and prevents decomposition after death. It has also long been believed to be a cure for diseases of the kidney. The French term is said to be derived from "hi-jada," the Spanish for kidney.

The flashing brilliance of diamond has been the cause of no superstition, since it was only in comparatively recent times that this beautiful property has been evinced. But its mysterious origin and peculiar hardness have always been the source of much wonder. It was known to resist fire, and the only means of breaking it was by dipping it in fresh, warm, goat's milk, according to the Ancients. They believed that, if struck with a hammer, the iron and anvil were torn asunder. Marco Polo relates—

"There is also an extensive and very deep valley; so enclosed by rocks as to be quite inaccessible; but the people throw in pieces of flesh, to which diamonds adhere. Now, there are a number of white eagles, which, when they see the flesh in the bottom of the valley, fly thither, seize and carry it to different spots. The men are on the watch, and as soon as they see the bird with the spoils in its mouth, raise loud cries, when, being terrified, it flies away and drops the meat, which they take up and find the diamonds attached."

All the largest known diamonds of early origin are connected with many legends, as well as history; they were the cause of much violence and crime, for an account of which the reader may be referred to E. W. Streeter's book on *Precious Stones and Gems.*

The diamond was for long considered a talisman in battle, and as such was worn on the finger of King John of France, who was taken prisoner by the Black Prince. A writer of the eleventh century states that it has the power of quenching the heat of certain fevers.

In Tennyson's "Lancelot and Elaine," King Arthur was supposed to have found nine diamonds in the crown of a slain knight, and he offered them to the Queen Guinevere, who flung them into a river. According to history and tradition, a diamond necklace also centres round the activities of Marie Antoinette.

The legends concerning emerald are legion, and many are very interesting. According to Eastern tradition, if a serpent fixes its eye upon an emerald, it becomes blind. This is referred to by Moore—

> Blinded like serpents when they gaze
> Upon the emerald's virgin blaze.

Nero is said to have watched the gladiatorial games in Rome through spectacles made from emeralds. This is recorded by more than one early writer. Psellus, in the ninth century, wrote: "It has power, when mixed with water, to heal leprosy and other diseases." Pliny wrote: "In the Island of Cyprus stands the sepulchre of King Hermias, on which is a lion formed of marble, but with eyes of emeralds, which used to shine so brightly on the summer sea that the fish were frightened away. The fishermen, having long observed this phenomenon, resolved to remove this disadvantage, and so have replaced the emeralds by other stones which have not this property of sparkling brightness."

Its fresh colour was supposed to be good for the eyes, and of this Pliny also writes: "There is not a gem or precious stone that so fully possesseth the eye, and yet never contenteth it with satiety. Nay, if the sight hath been wearied and dimmed by intentive poring upon anything else, the beholding of this stone doth refresh and restore it again."

In the Manta Valley, the natives are said to have worshipped an emerald the size of an ostrich's egg. The priests permitted this goddess to be seen only on high festivals, when the people were expected to bring other emeralds as an offering to their gods. A large collection of emeralds was thus made, which afterwards fell into the hands of the Spaniards when Peru was "discovered." Don Alvarado and his followers are said to have doubted the genuineness of these stones, and subjected them to the test of a hammer; as they did not resist, they were regarded as of no value.

White chalcedony was much worn as a talisman by the Greeks and Romans, and an Italian superstition regarding this stone still exists to the effect that if worn by farmers' wives, the milk of their cows is increased. Of jasper, it was written—

Auro quid melius? Jaspis.
Quid jaspis? Virtus.
Quid virtute? Deus.
Quid Deitate? Nihil.

There are many other legends connected with various stones, and they also figure largely in works of fiction. Charles Reade, Thackeray, Scott, Dumas, Rider Haggard, and many others weave diamonds or other precious stones into their novels, and no doubt gems will continue to take a part in fiction and superstition as long as they exist.

In conclusion, a list of "birthstones," with their recognized meanings, is added. This, according to ancient manuscripts, points out which stone a person should wear to withstand the bad luck of which we are all victims—

Month	Birthstone	Meaning
January .	Garnet	Constancy
February .	Amethyst	Sincerity
March. .	Bloodstone, or malachite	Courage
April . .	Diamond or rock crystal	Innocence
May . .	Emerald or chrysoprase	Success in love
June . .	Agate	Long life
July . .	Ruby or Carnelian.	Corrects mistaken friendships
August .	Sardonyx	Conjugal felicity
September .	Sapphire or moonstone	Frees from sadness
October .	Opal	Hope
November .	Topaz	Friendship
December .	Turquoise	Prosperity

In addition to the gem stones already described, the following are amongst others which are occasionally encountered—

Azurite, axinite, apatite, andalusite, beryllonite, benitoite, diopside, dioptase, enstatite, epidote, euclase, fibrolite, iolite, idocrase, kyanite, prehnite, scapolite, and willemite.

A description of the properties of these stones may be found in any modern work on minerals. If the reader is interested in this subject, a wide range of works on mineralogy, geology, crystallography, chemistry, light, and colour, all of which are connected with gemmology, may be obtained, whilst the following works, some of which have been consulted by the writer, are of especial value for more detailed information and reference—

Pliny trans. into English by P. Holland (1601).

Theophrastus' History of Stones. English version by Sir John Hill. Second Edition. (1774.)

System of Mineralogy, by James D. Dana. (1854.)

A Glossary of Mineralogy, by H. W. Bristow. (1861.)

The Natural History of Gems or Decorated Gems, by C. W. King. (1867.)

The Natural History of Precious Stones, by C. W. King. (1867.)

Great Diamonds of the World, by E. W. Streeter. (1882.)

Gems and Precious Stones of North America, by G. F. Kunz. (1890.)

Precious Stones, by H. A. Miers. (1896.)

Precious Stones and Gems, by E. W. Streeter. (1898.)

The Diamond Mines of South Africa, by G. F. Williams. (1902.)

Precious Stones, by A. H. Church. (1908.)

The Mineral Kingdom, by Dr. R. Brauns. (1908.)

Edelsteinkunde, by Max. Bauer. (1909.)

La Synthèse des Pierres Precieuses, by J. Boyer. (1909.)

Diamonds, by Sir W. Crooks. (1909.)

The Diamond, by W. R. Cattelle. (1911.)

Guide to the Gem Stones in the Museum of Practical Geology, by W. F. P. McLintock. (1912.)

Gem Stones, by G. F. H. Smith. (1912.)

Die Farben der Mineralien, by C. Dölter. (1915.)

Non-metallic Minerals, by R. B. Ladoo. (1925.)

X-rays and Crystal Structure, by W. H. and W. L. Bragg. (1925.)

Encyclopaedia Britannica—various articles.

APPENDIX

The properties of the rarer stones are not given here. The reader is referred to a larger work, such as *The Science of Precious and Semi-precious Stones*, by Max Bauer, if these are required. Many of the following constants are the average of a number of experiments, so that in the case of many stones a slight deviation from the figures given may be found.

COLOURS

Colourless and White. Diamond, white sapphire, topaz, rock crystal, jade, opal, "fired" zircon, moonstone, pearl, meerschaum. Occasionally beryl, spinel, tourmaline, spodumene.

Black. Diamond, tourmaline, obsidian, jet, haematite, pearl, amber.

Yellow. Diamond, topaz, yellow sapphire, citrine, aventurine, sphene, tourmaline, zircon, golden beryl, spodumene, amber, pearl.

Brown. Diamond, tourmaline, smoky quartz, soapstone, sphene, aventurine, agate, amber, pearl.

Green. Aquamarine, emerald, peridot, green sapphire, tourmaline, chrysoberyl (including alexandrite), zircon, demantoid garnet, turquoise, jade (jadeite and nephrite), malachite, amazonite, aventurine, chrysoprase, prase, jasper, sphene, soapstone, spodumene (hiddenite), obsidian, diamond (very rarely).

Blue. Sapphire, aquamarine, spinel, topaz, tourmaline zircon, turquoise, lapis lazuli, labradorite, fluor spar, diamond (rarely).

Violet and Purple. Oriental amethyst (purple corundum), amethyst, spinel, zircon, almandine garnet, felspar, spodumene (kunzite).

Red. Ruby, pyrope and almandine garnets, spinel, tourmaline, zircon, fire opal, topaz, jasper, felspar.

Pink and Lilac. Pink sapphire, spinel (balas ruby), tourmaline, topaz, beryl, rose quartz, zircon, felspar, spodumene (kunzite).

Multi-coloured. Opal, iris quartz, labradorite.

CHEMICAL COMPOSITION

Elements.

Diamond—carbon.

Oxides.

Corundum. Oxide of aluminium (alumina).
Quartz. Oxide of silicon (silica).
Opal. Hydrated oxide of silicon.
Haematite. Oxide of iron.

Aluminates.

Spinel. Aluminate of magnesium.
Chrysoberyl. Aluminate of beryllium.

Silicates.

Peridot. Silicate of magnesium and iron.
Zircon. Silicate of zirconium.
Nephrite. Silicate of calcium and magnesium.
Topaz. Fluo-silicate of aluminium.
Beryl. Silicate of beryllium and aluminium.
Jadeite. Silicate of sodium and aluminium.
Moonstone. Silicate of aluminium and potassium.
Tourmaline. Silicate of boron and aluminium.
Lapis lazuli. Soda aluminium silicate (with other minerals).
Serpentine. Hydrated silicate of magnesium.
Sphene. Silicate and titanate of calcium.
Spodumene. Silicate of aluminium and lithium.
Garnet (Hessonite). Silicate of calcium and aluminium.
Garnet (Pyrope). Silicate of magnesium and aluminium.
Garnet (Almandine). Silicate of iron and aluminium.
Garnet (Demantoid). Silicate of iron and calcium.
Felspar. Silicate of aluminium and one of potassium, sodium, or calcium.
Soapstone. Silicate of magnesium.
Meerschaum. Silicate of magnesium.

Fluorides.

Fluor spar. Fluoride of calcium.

Phosphates.

Turquoise. Hydrous phosphate of alumina.

Carbonates.

Malachite. Basic cupric carbonate.

HARDNESS

10. Diamond.
9. Corundum.
8½. Chrysoberyl.
8. Topaz, spinel.
7½. Beryl, almandine garnet, zircon.
7¼. Hessonite and pyrope garnets.
7. Quartz, tourmaline, jadeite.
6½. Peridot, demantoid garnet, nephrite, spodumene, haematite, iron pyrites.
6. Opal, felspar (moonstone, etc.), turquoise.
5½. Sphene.
5. Lapis lazuli, obsidian.
4. Fluor spar.
4-3½. Pearl, jet.
3¾. Coral.
3½. Malachite.
2½. Amber, serpentine.
2-2½. Meerschaum.
1-1¼. Soapstone.

SPECIFIC GRAVITIES

Amber	1·08
Jet	1·35
Meerschaum	2·00
Opal	2·15
Lapis lazuli	2·40
Obsidian	2·50
Serpentine	2·60
Felspar (moonstone, etc.)	2·57
Coral	2·65
Quartz	2·66
Pearl	2·65-2·89
Beryl	2·74
Soapstone	2·75
Turquoise	2·82
Nephrite	2·95
Tourmaline	3·10
Fluor spar	3·18
Spodumene	3·19
Jadeite	3·34
Sphene	3·40
Peridot	3·40
Diamond	3·52
Topaz	3·53
Spinel	3·60

SPECIFIC GRAVITIES—(*contd.*)

Hessonite garnet	3·61
Chrysoberyl	3·73
Pyrope garnet	3·78
Demantoid garnet	3·84
Malachite	3·90
Corundum	4·03
Almandine garnet	4·05
Zircon	4·20-4·69
Iron pyrites	5·00
Haematite	5·30

DICHROISM

Strong. Corundum, tourmaline, alexandrite, spodumene.

Distinct. Emerald, topaz, quartz, peridot, chrysoberyl, blue zircon, sphene.

Weak. Beryl.

REFRACTIVE INDICES

Singly Refractive.

Fluor spar	1·43	Hessonite garnet	1·74
Opal	1·45	Pyrope garnet	1·75
Obsidian	1·50	Almandine garnet	1·79
Amber	1·54	Zircon	1·81
Serpentine	1·57	Demantoid garnet	1·88
Spinel	1·72	Diamond	2·41

Doubly Refractive.

Felspar (moonstone, etc.)	1·53–1·54
Quartz	1·54–1·55
Beryl	1·57–1·58
Nephrite	1·60–1·63
Turquoise	1·61–1·65
Topaz	1·61–1·62
Tourmaline	1·62–1·65
Spodumene	1·65–1·68
Peridot	1·65–1·69
Jadeite	1·66–1·68
Chrysoberyl	1·74–1·75
Corundum	1·76–1·77
Malachite	1·87–1·98
Sphene	1·90–2·05
Zircon	1·92–1·98

N.B.—Glass. Specific gravity and composition varies. Hardness is 5. Singly refractive, and not dichroic.

PRINCIPAL GEM-BEARING LOCALITIES

The most important localities in which gem stones occur are given below in alphabetical order—

Afghanistan	Lapis lazuli.
Africa (South)	Diamond, pyrope garnet, tiger-eye, topaz.
Australia	Almandine garnet, carnelian, diamond, emerald, labradorite, malachite, moonstone, opal, ruby, sapphire, spinel, tiger-eye, topaz, tourmaline, turquoise, zircon. Off N. and E. coasts, pearl.
Borneo	Chrysoberyl, diamond.
Brazil	Agate, amethyst, aquamarine, carnelian, chrysoberyl, citrine, diamond, moonstone, moss agate, rock crystal, rose quartz, ruby, smoky quartz, spodumene, topaz, tourmaline.
British Guiana	Diamond.
Burma	Amber, chrysoberyl, jadeite, ruby, spinel, tourmaline.
Canada	Amethyst, labradorite, nephrite, soapstone.
Ceylon	Almandine garnet, amethyst, cat's-eye (quartz), chrysoberyl, hessonite garnet, moonstone, rose quartz, ruby, sapphire, spinel, tourmaline, zircon. Off N.W. coast, pearl.
Chile	Lapis lazuli, malachite.
China	Aventurine.
Colombia	Emerald.
Czecho-Slovakia	Almandine garnet, pyrope garnet, sunstone.
East Turkestan	Nephrite.
Egypt	Emerald, plasma, turquoise.
Elba	Haematite, tourmaline.
England	Fluor spar, haematite, jet, rock crystal, serpentine, pearls (fresh water).
Finland	Labradorite.
France	Citrine, jet, rock crystal, zircon.
Germany	Agate, amber, jasper, jet, plasma, rose quartz, topaz.
Hungary	Citrine, obsidian, opal, rock crystal.
India	Agate, almandine garnet, aventurine, carnelian, cat's-eye (quartz), chrysoberyl, chrysoprase, diamond, haematite, jasper, plasma, rock crystal, sapphire, sard, topaz, zircon.

Japan . .	. Rock crystal, topaz. Off coasts, coral, pearl.
Madagascar .	. Aquamarine, rock crystal, smoky quartz, spodumene, tourmaline.
Mexico . .	. Amethyst, obsidian, opal, turquoise. Off W. coast, pearl.
New Zealand .	. Nephrite.
Norway . .	. Haematite, sunstone, pearls (fresh water).
Persia . .	. Turquoise.
Poland . .	. Chrysoprase.
Russia (including Ural Mts.)	Amazonite, amethyst, aquamarine, aventurine, chrysoberyl (alexandrite), chrysoprase, citrine, demantoid garnet, diamond, emerald, labradorite, malachite, rose quartz, smoky quartz, topaz, tourmaline, zircon.
Scotland . .	. Cairngorm, haematite, prase, rose quartz, smoky quartz, pearls (fresh water).
Siam . .	. Ruby, spinel.
Siberia . .	. Amethyst, aquamarine, diamond, lapis lazuli, nephrite, smoky quartz, sunstone; topaz, tourmaline.
Spain . .	. Meerschaum, smoky quartz.
Switzerland .	. Alabaster, felspar, haematite, nephrite, prase, rock crystal, smoky quartz, sphene, tourmaline.
Uruguay . .	. Agate, amethyst, carnelian, citrine.
U.S.A. . .	. Alabaster, almandine garnet, amazonite, amethyst, aquamarine, chrysoberyl, chrysoprase, diamond, felspar, haematite, hessonite garnet, jasper, moonstone, moss agate, obsidian, peridot, pyrope garnet, rock crystal, rose quartz, ruby, sapphire, smoky quartz, soapstone, sphene, spinel, spodumene, sunstone, topaz, tourmaline, turquoise, zircon.
Baltic Sea .	. Amber.
Indian Ocean .	. Pearls.
Mediterranean Sea	. Amber, coral.
North Sea .	. Amber.
Pacific Ocean .	. Pearls.
Persian Gulf .	. Pearls.
Red Sea . .	. Pearls.

USEFUL WEIGHTS AND MEASURES

1 inch	= 2·539 centimetres
1 metre	= 39·370 inches
1 centimetre	= ·3937 inches
1 mile	= 1·6093 kilometres
1 litre	= ·220 gallons
1 litre	= 1·761 pints
1 pint	= ·567 litres
1 gallon	= 4·536 litres
1 metric carat	= ·200 grams = $\frac{1}{5}$ gram
1 oz. (Troy)	= 150 carats
1 oz. (Av.)	= 28·35 grams
1 oz. (Av.)	= 437·5 grains (Troy)
1 grain (Troy)	= ·0648 grams
1 kilogram	= 2·679 pounds (Av.)
1 gram	= 15·43 grains (Troy)
1 oz. (Troy)	= 30 grams

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