Precious Stones

BY

A. H. CHURCH F.R.S.

VICTORIA AND ALBERT MUSEUM

ART HANDBOOK

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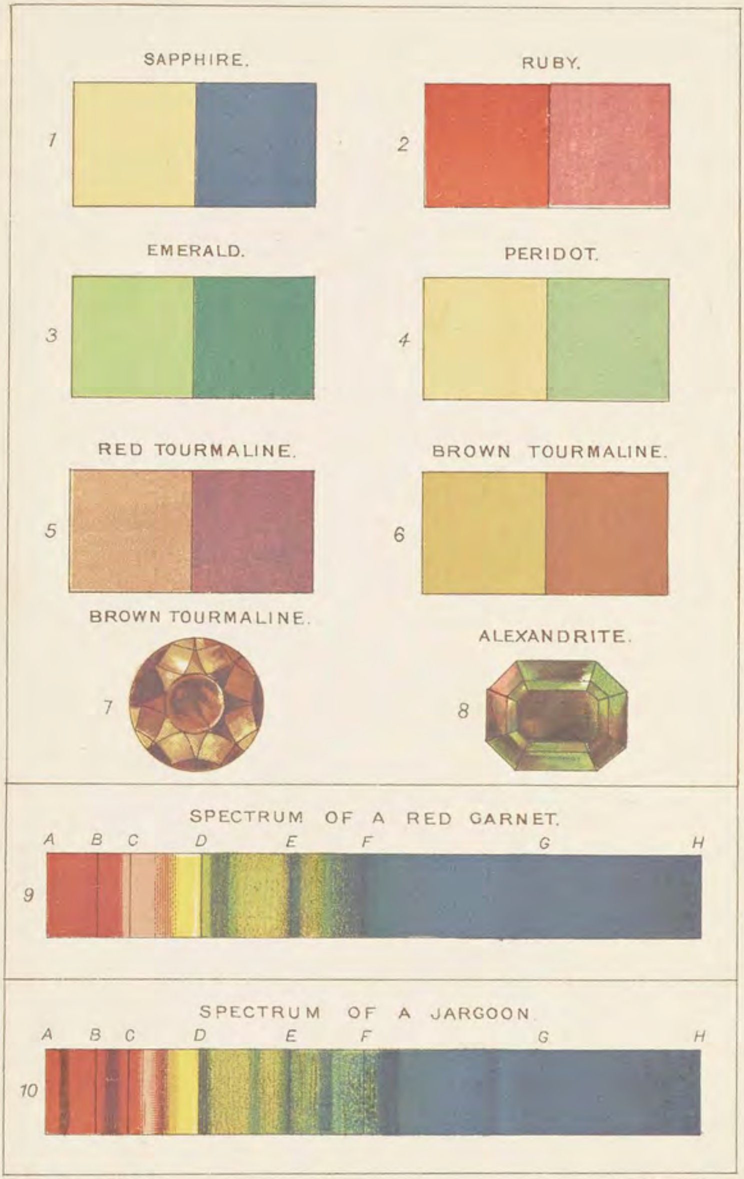
VICTORIA AND ALBERT MUSEUM ART HANDBOOKS.

PRECIOUS STONES.



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PRECIOUS STONES

CONSIDERED IN THEIR SCIENTIFIC AND ARTISTIC RELATIONS.

WITH A CATALOGUE OF THE TOWNSHEND COLLECTION IN THE VICTORIA AND ALBERT MUSEUM.

BY

A. H. CHURCH, M.A., F.R.S., F.S.A.,

Professor of Chemistry in the Royal Academy of Arts.

WITH A COLOURED PLATE AND WOODCUTS.

FOURTH THOUSAND.

Published for the Board of Education.

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1901


PERIDOT
BROWN TOURMALINE
ALEXANDRITE
SPECTRUM OF A RED GARNET

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PREFACE.

A revised Catalogue of the Townshend Collection of Precious Stones in the South Kensington Museum originated this Handbook, in which an attempt has been made to associate, if not to combine, the scientific with the artistic study of precious stones. It has been necessary to confine this work within somewhat narrow limits, and hence to omit much which might fairly find a place in a comprehensive treatise on the subject. The writer, however, trusts that what is here offered for the consideration of students and amateurs may increase the intelligent appreciation of precious stones, and further their more judicious treatment in jewellery. Notwithstanding the exquisite skill of a few modern artist-workmen, it must be affirmed that there is room for improvement in the ordinary productions of jewellers' shops, with respect to knowledge, taste, and finish. Chiefly in fault, however, are the purchasing public, who still tolerate the horseshoes, anchors, and clumsy cables of a debased time, and are not quick to appreciate refinement and originality in the selection and artistic mounting of precious stones. So a few words about these beautiful materials—their nature, variety, and employment—may prove of wider service than a mere descriptive catalogue of the specimens belonging to the South Kensington Museum.

A. H. C.

KEW, *Nov.*, 1882.

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CHAPTER VII.

ILLUSTRATIONS.

NOTES.

In the present issue of this Handbook a few corrections have been made here and there in the text. The reader is requested to refer to the following notes when studying the subjects discussed on pages 12, 16, 56, 57, 65, 68, and 77.

Page 12. Of all heavy liquids for testing the specific gravity of stones, the most convenient is probably methylen iodide, represented by the formula CH_2I_2. At the temperature of 15° C., this liquid has the specific gravity 3·327, which may be raised to 3·6 by saturating the liquid with iodoform and iodine. On the other hand, dilution with toluol serves to lower the density to any desired point. In this connection it may be mentioned that my recommendation made in 1883 to use four solutions of the several densities, 3·17, 2·9, 2·67, and 2·63, for discriminating precious stones has been appropriated (in 1899) without acknowledgment by Mr. Leopold Claremont in "The Mineral Industry," vol. vii. p. 279. The same writer has also annexed, without indicating its source, other original matter from the present Handbook, or from earlier writings by its author.

Page 16. A suitable substitute for dilute alcohol in taking the specific gravity of small specimens of minerals is found in the pure hydrocarbon toluol. This liquid possesses the great advantage over alcohol of suffering no change in density by exposure to the air. At 15° C. its specific gravity is 0·869.

Page 56. An unusually large and fine crimson spinel or spinel-ruby, weighing $49\frac{1}{64}$ carats, from India, proved to have the specific gravity 3·582, while its index of refraction was—for the red ray, 1·711; for the yellow ray, 1·714; and for the blue ray, 1·719. Its hardness scarcely exceeded that of red garnet, but the tests of specific gravity and refraction sufficed to show that it was a true spinel.

Page 57. Fine turquoises have been found in considerable abundance in New Mexico. The best specimens I have seen came from Burro Mounts, Grant County.

Page 65. In the "Intellectual Observer" for 1866 I announced for the first time the existence of a series of black absorption-bands in the spectrum of almandine. Quite recently I have found that the beautiful variety of garnet, known as rhodolite (from Cowee Creek, North Carolina), which has been conjectured to consist of two molecules of pyrope associated with one molecule of almandine, shows the characteristic spectrum of the latter variety.

Page 68. A considerable quantity of pale-green cut gem-stones have been sold in London as peridot, but proved not to be that variety of chrysolite. They were softer than peridot, and though more glittering in lustre were of poorer colour. They were not dichroic, and showed no sign of crystallized structure. On analysis they were found to contain much more silica and much less magnesia than peridot, while alumina and soda were present in distinct quantities. If the material had not been known to be a natural product, these specimens would have been called green glass. Their composition varies widely, and so does their density, the latter ranging from 2·36 to 2·63. The mineral, which occurs in several Bohemian localities, is known as moldawite, water-chrysolite, pseudo-chrysolite, and *bouteillenstein*. Dr. Bauer gives sixpence as the price of a cut specimen weighing one carat.

Page 77. Much precious opal has been obtained during recent years from Queensland and from New South Wales. At first the specimens were too thin to allow of fine gems being cut from the mineral-veins, but afterwards much more solid masses were found, vying in fire with the noble opal of Hungary, and admitting of the production of polished specimens, sumptuous in size as well as in play of colour. In consequence of these new supplies of this mineral, the old market price of the precious or noble opal has not been maintained.

PRECIOUS STONES

CONSIDERED IN THEIR SCIENTIFIC AND ARTISTIC RELATIONS.

CHAPTER I.

DEFINITION OF PRECIOUS STONES.

Beauty, durability, and rarity—such are the qualities characterising the minerals to which we apply the adjective "precious." But the term "mineral," though including all true precious stones, does not exclude some natural products of the earth (such as gold and platinum) which, though precious, are not *stones* in the ordinary acceptation of that word. Native metals, then, are outside the category of precious stones. On the other hand, at least one animal product, the pearl, is commonly ranked with such minerals as the diamond and the sapphire, associated as it is with these stones in jewellery, and partaking as it does of the characters of beauty and rarity, with a good share of durability.

After all, it is no easy matter to define a precious stone. Where can the line be drawn between stones that are precious and stones that do not merit that appellation? Is not the preciousness of one sort of stone or of another dependent in part upon caprice, upon time and place? If the fashion set in some new direction, then gem-stones now reckoned of small value might in some measure displace the diamond and the ruby; for, compared with these gems, there are doubtless several hard and beautiful stones which are found in less abundance, but which remain less costly because in less demand. Yet there is something to be said in favour of the high position commonly given to the diamond, the ruby, the emerald, the sapphire, and we may add the pearl and the opal: they all possess a very conspicuous and obvious beauty. By brilliancy and colour they force themselves upon our attention, while the spinel, the jargoon, and the tourmaline generally need to be studied, to be looked into, that their merits may be discovered. But the argument that beautiful stones ought not to be employed in the higher kinds of bijouterie unless they are costly is an unworthy one. It will not bear criticism. Why should not moonstones, even if they can be bought for a shilling apiece, be introduced into goldsmith's work of the most artistic sort? Surely they may rank at least with coloured enamels, which are of extremely small money value, but which are prized highly when employed with skill in well-designed jewels.

It has been before stated that the caprice of fashion influences and alters the market value of precious stones from time to time. The peridot, the amethyst, the cat's-eye, and the aquamarine have each had their day, and then been abandoned for new favourites. Even the emerald has suffered vicissitudes, and is now less esteemed than it was a few years ago: the fall in the value of the opal is even more marked. The causes of such changes in the popular esteem in which particular species of gems are held cannot often be traced. A new fashion is set or an old one restored, and once set is blindly followed. The introduction of a little-known gem, however beautiful it may be, is generally a most difficult matter. A jeweller who is in the first rank of artistic workers was showing a customer a bracelet beautifully set with the rich green garnets of Bobrowska. This lady admired the stones and the workmanship immensely, but spoke of the former as *emeralds*. The jeweller honestly said: "They are not emeralds, but a rare sort of garnet from the Ural Mountains." Forthwith the lady rejoined: "Well, after all, I do not think I care so very very much for this bracelet; please show me something else." Not that she knew that there did exist a real objection to these green garnets —they are not quite hard enough to stand much wear. For the ignorance that prevails about precious stones, not only among the wearers and owners of them, but also among jewellers themselves, is indeed dense. A London goldsmith had six stones to mount as rings; in returning them finished, the invoice gave to the specimens five wrong designations! A year or two ago how very few jewellers understood what was wanted when a tourmaline or a jargoon was asked for! and yet the tourmaline and the jargoon have been long known. Diamond, ruby, emerald, sapphire, pearl, opal; opal, pearl, sapphire, emerald, ruby, diamond—such is the range and variety of acknowledged gems. If a novelty has to be introduced it must be called by some modification of these well-known names, and must become a "Cape ruby" or an "Uralian emerald." In speaking further on, in reference to the artistic use of precious stones, something more will be said upon this point of the neglect of certain kinds of extremely beautiful stones.

From the statements just made it will be gathered that although a stone to be precious must have, in very good measure, the qualities of beauty, durability, and rarity, yet we cannot arrange precious stones in any fixed and definite order, by assigning them places in our list in accordance with the degrees in which they possess these three qualities. Even if all stones going under the same name were equally fine this would be impossible; much more is this the case when we learn that two specimens—say of ruby—each weighing the same, might be worth five pounds and fifty pounds respectively. In placing these three necessary qualities of beauty, durability, and rarity in this sequence the intention has been to express the pre-eminent necessity for beauty in stones deserving the name of precious; the importance of durability, which must claim the second place; and the desirability of a certain degree of rarity, especially where the quality of durability may not exist in the highest degree. How far a very beautiful and hard mineral would maintain its position as a precious stone in the event of its becoming exceedingly abundant, one cannot venture to judge; but as we have to deal with existing facts only, the problem is one which practically has not yet been presented for solution.

As precious stones have just to be looked at and worn, or used in decorative work, it will be readily understood why no occult property is of much moment in determining their value. Individual and learned amateurs may indeed value a stone according to what they know of its history, its romance, its memories, or the curiousness of its components; but in nine hundred and ninety-nine cases in a thousand any enhancement of value through such causes is out of the question. Still, from the mineralogical and chemical points of view, it is perhaps legitimate to import some elements of interest when appraising the right of a stone to be called precious, or its place in the list of gems. One need not follow those writers who speak of precious, semi-precious, and common stones; but one may reasonably arrange the different kinds in a few groups or classes, according to what we may call the average sum of their merits. To assign a precise place to each species is not possible.

CHAPTER II.

PROPERTIES AND DISCRIMINATION OF PRECIOUS STONES.

SUCH properties of precious stones as are perceptible to the eye unaided by optical apparatus, but trained to keenness of vision, afford valuable means of discriminating precious stones from one another, but do not exhaust such means. Indeed, such mechanical properties as hardness and specific gravity are of the greatest use in determining the species of a stone, and are more commonly available than the majority of optical tests. Optical properties must, however, ever hold a chief place in all artistic classifications of precious stones, so that it will not be unadvisable to begin the present chapter by a synopsis of the most obvious characters of this class. They may be arranged in the form of a tabular view, the use of which is twofold, enabling us to define the several optical properties found in gem-stones, and also to appreciate their artistic capabilities. We arrange these optical (or mainly optical) qualities under the general heads of "Surface" and "Substance:"

SURFACE.	*Form.*	1. Plane.
		2. Curved.
	Lustre.	3. Metallic.
		4. Adamantine.
		5. Resinous.
		6. Vitreous.
		7. Waxy.
		8. Pearly.
		9. Silky.

SUBSTANCE.	*Light.*	10. Transparent.
		11. Translucent.
		12. Opalescent.
		13. Chatoyant.
		14. Opaque.
	Colour.	15. Iridescent.
		16. Monochroic.
		17. Pleiochroic.
		18. Fluorescent.

The greater number of these terms will be found illustrated in the present and succeeding chapters: we now proceed to the discussion of the qualities which underlie them, and of other important physical characters of precious stones. The order which will be followed may be gathered from this scheme:

REFRACTION.
DISPERSION.
POLARIZATION.
PLEIOCHROISM.
HARDNESS.
SPECIFIC GRAVITY.
FORM.
STRUCTURE.

Refraction of Light.—The familiar experiment of plunging a stick in a vessel of water and observing the broken appearance which it assumes, serves to illustrate the action called "refraction," or bending back. This refraction of light occurs in the majority of cases where a ray of light falls upon one transparent medium from another—say from the air upon a diamond. Part of the incident light enters the diamond, and follows a different path—is refracted. The diamond, like liquids, glass, and other molten or vitreous—that is non-crystalline—matter, possesses the property of simple refraction; many precious stones, indeed the majority, are doubly refractive. A bright spot of light, say a small candle-flame, when viewed through a single refracting stone appears single; through a doubly refracting stone, double. The stone should be moved from the eye until, even when at a considerable distance, the flame seen through it appears single or double, as the case may be. All crystals belonging to the cubical system, such as diamond, spinel, and garnet, are, like glass and strass, simply refracting; ruby, beryl, topaz, and quartz are all doubly refracting. There are very precise and beautiful methods for ascertaining this quality in transparent crystals, but they are not applicable generally to cut and polished gem-stones. The results of some of these accurate measurements of the indices of refraction of transparent minerals will be found in chapter vii.; that they differ much in different species may be seen from this brief list of indices (for the yellow ray), selected from Sir D. Brewster's results:

Diamond	2·75	Beryl	1·598
Zircon	1·95	Flint glass	1·57
Ruby	1·779	Rock crystal	1·547
Tourmaline	1·668	Plate glass	1·52

Dispersion of Light.—When a ray of light passing from one medium to another is bent or refracted, the light being composite and consisting of rays having different degrees of refrangibility, it suffers dispersion as well as refraction. In this way the several component rays, differently coloured, are separated more or less widely from each other, and are said to be *dispersed.* Upon this property of gems depends that peculiar quality of "fire"—the play of prismatic hues, which is the most marked characteristic of the diamond. It is the difference between the extreme indices of refraction of the red ray and of the violet ray at the ends of the visible spectrum. It is best measured by taking as standards certain fixed lines in the solar spectrum; but for the purpose of comparing the dispersive powers of different stones the following list of approximate dispersion-coefficients will perhaps suffice:

Diamond	·044	Red garnet	·027
Borosilicate of lead	·049	Tourmaline	·019
Flint glass	·036	Crown glass	·015
Blue sapphire	·029	Rock crystal	·014

Polarization of Light.—There are several ways in which light may suffer the remarkable change known as polarization. If we assume that a beam of ordinary or natural light, freely traversing any medium, have what we may call *identical properties on all its sides,* then, should that beam encounter any obstacle, as by reflection or refraction, it exhibits to a greater or less extent different properties on different sides—is, in fact, polarized. One quality of this polarized light is that it cannot be again reflected at a certain angle, nor can it again traverse in a certain direction the crystal in which it has suffered this change. But the amateur of precious stones is mainly concerned with these two facts, that in some doubly refracting crystalline minerals the two oppositely polarized beams are of different colours; and secondly, that some transparent gem-stones are more or less opaque, in one direction at least, to one of the two oppositely polarized beams. Thus it will be clear that upon double refraction and its concomitant polarization depends that property of many gems which is known as pleiochroism, and which may be most easily recognised by that useful little instrument, the dichroiscope.

Pleiochroism.—When a precious stone is examined by means of a dichroiscope it will, if coloured, show two images of the same hue or of different hues. Should the two images of the square opening of the instrument be identical in colour, then the specimen may be a garnet, a spinel, or a diamond; it cannot be a ruby, a topaz, or a beryl, all of which show twin colours differing in a perfectly recognisable degree from each other. However, before proceeding with the description of the special applications of the dichroiscope, a word on the construction of the instrument may be introduced. It consists of a cleavage rhombohedron of Iceland spar, having one edge nearly an inch long and the other two edges about three inches each. In the original form of the instrument a small glass prism of 18° was cemented on each of the small end faces of the prism; but this may be done away with if these end faces be ground and polished so as to be perpendicular to the length of the prism. A sliding cap at one end has a square perforation of about ·12 inch; at the other end is a lens, or combination of lenses, of such focal length as to show a distinct image of the square opening when the cap is pulled out a quarter of an inch or so. With an instrument so constructed the pleiochroism of the vast majority of gem-stones may be determined at a glance. Of course this quality is so conspicuous in some species (tourmaline and chrysoberyl) that no instrument is usually needed to discern it. For it is easy to notice that the colours of some crystals, seen by transmitted light, vary with the direction in which they are viewed. If the transmitted ray be analysed by a Nicol's prism its colour will be found to vary as the prism is turned round its axis; in fact, the two differently coloured beams are polarized in opposite planes. It is of course only in doubly refracting crystals that this phenomenon of dichroism occurs. In the descriptions given further on, of the several species of stone, these twin colours, as seen by the dichroiscope, are duly recorded. Here, however, it may be useful to group a few of the most conspicuous instances of dichroism together.

NAME OF STONE.	TWIN COLOURS.	
Sapphire (blue)	Greenish straw	Blue.
Ruby (red)	Aurora red	Carmine red.
Tourmaline (red)	Salmon	Rose pink.
,, (brownish red)	Umber brown	Columbine red.
,, (brown)	Orange brown	Greenish yellow.
,, (green)	Pistachio green	Bluish green.
,, (blue)	Greenish gray	Indigo blue.
Emerald (green)	Yellowish green	Bluish green.
Topaz (sherry)	Straw yellow	Rose pink.
Peridot (pistachio)	Brown yellow	Sea green.
Aquamarine (sea green)	Straw white	Gray blue.
Beryl (pale blue)	Sea green	Azure.
Chrysoberyl (yellow)	Golden brown	Greenish yellow.
Iolite (lavender)	Pale buff	Indigo blue.
Amethyst (purple)	Reddish purple	Bluish purple.

The whole question of the colours of precious stones, including, as it does, a group of optical qualities, some of which we have already discussed, and some (such as absorption and diffraction) we have not even mentioned, will be considered in chapter iv.

Hardness.—One of the characters by which gem-stones may be distinguished from each other and from their imitations is that of the degree in which they possess the power of resisting abrasion. Many hard minerals may, however, be easily broken, fractured, or chipped, though they cannot be scratched : a very hard stone may be a very fragile one. Emeralds, zircons, and diamonds have often been ruined by a fall or a blow.

The scale of hardness adopted for minerals was devised by Mohs. Fragments of transparent minerals are applied in succession to the stone under examination, so as to attempt to scratch its surface. When the stone neither scratches nor is scratched by any member of the scale, the hardness of the two stones is the same. When it scratches the softer, and is scratched by the harder of the two test-stones, some notion of its position between them may be gained by passing all three specimens, with slight pressure, over the surface of a fine, clean, hard file, one end of which rests upon the table, and noting their different degrees of resistance to abrasion and the sounds produced. In chapter vii. of this book will be found, under the description of each kind of precious stone, numbers which nearly represent the average hardness of good specimens of the several sorts according to the common mineralogical scale, which is—

Diamond	10	Apatite	5
Sapphire	9	Fluorspar	4
Topaz	8	Calcite	3
Quartz	7	Rock salt	2
Felspar	6	Talc	1

A list of the degrees of hardness of a considerable number of different gem-stones will serve to show their relative positions with regard to this scale. Although this character of hardness cannot be extensively used in the discrimination of cut and polished gem-stones, yet it is sometimes available even in the case of such specimens when unmounted, the "girdle" of the stone offering a suitable surface for a trial of hardness.

TABLE OF HARDNESS.

Diamond	10·0	Iolite	7·3
Sapphire	9·0	Cinnamon stone	7·0
Ruby	8·8	Jadeite	7·0
Chrysoberyl	8·5	Amethyst	7·0
Spinel	8·0	Jade	6·5
Topaz	8·0	Peridot	6·3
Aquamarine	8·0	Moonstone	6·3
Emerald	7·8	Green garnet	6·0
Zircon	7·8	Turquoise	6·0
Tourmaline	7·5	Opal	6·0
Phenakite	7·5	Lapis-lazuli	5·2
Almandine	7·3	Callainite	4·0

As the property of hardness is of great value in the case of precious stones, those kinds which are scratched by quartz, and which, consequently, are below 7° of hardness, are ranked as half-hard, or "demi-dures." Stones scratched by a knife are below 5°.

Specific Gravity.—The most generally applicable of all modes of discriminating precious stones from one another is to ascertain their specific gravity—that is, the relative weights of equal bulks—the weight of a bulk or volume of distilled water (commonly taken at 60° F. or 15°6 C.) being employed as the unit with which all the others are compared. There are three modes of ascertaining the specific gravity of a stone: (1) By placing it in liquids of known specific gravity, and noting the position which it takes up. (2) By weighing it in air, and then in water (or other liquid), and thus learning the weight of water which the stone displaces—that is, the weight of an equal bulk of water. (3) By measuring or weighing, directly or by difference, the water which the stone displaces when immersed in water in a small vessel of known capacity. We will now briefly describe these three methods.

1. Several different liquids have been used for the purpose of

ascertaining the density of minerals, and even for separating species having different densities one from another. There are two of great service for this work. One is a solution of mercuric iodide in potassium iodide; the other is the boro-tungstate of cadmium. The former is very poisonous and corrosive, and must be manipulated with the greatest caution. It is prepared in the following manner: Dissolve in a very small quantity of distilled water the utmost amount of potassium iodide that it will take up. Then add mercuric iodide in small portions at a time, till no more of this compound will dissolve. Some powdered potassium iodide is again introduced, and will be found to dissolve. When this ceases to disappear, add a little more mercuric iodide; and so on, alternately, until neither salt is further affected. Constant stirring and gentle warming aid the process of solution. The honey-yellow heavy liquid finally produced is called, after the discoverer, "Sonstadt's Solution." The highest specific gravity attainable at the ordinary temperature is 3·18. If cloudy, it may be filtered through a bit of asbestos cloth: it is well to keep a drop or so of metallic mercury in the bottle holding the solution. For the purpose of discriminating precious stones there should be kept three or four solutions of different specific gravities, as under: they are made by adding small quantities of water to the original saturated solution:

SOLUTION	A,	of specific	gravity	. 3·17
,,	B,	,,	,,	. 2·9
,,	C,	,,	,,	. 2·67
,,	D,	,,	,,	. 2·63

IN SOLUTION A:

Spodumene Diopside Diamond Topaz Peridot Spinel Chrysoberyl Corundum Garnet Zircon	sink;	Tourmaline Phenakite Turquoise Labradorite Beryl Quartz Iolite Moonstone	float.

In solution B, tourmaline, phenakite, and turquoise, which float in A, sink; in solution C, labradorite and beryl sink; and in solution D, quartz and iolite sink, but moonstone floats. With intermediate strengths further separations may be made. Steel pincers should be used in placing stones in Sonstadt's Solution or in removing them; brass is instantly amalgamated. The liquid drained from the stones and the distilled water used in washing them after immersion should be preserved and concentrated by evaporation for subsequent use.

Mixtures of chloride of lead and chloride of zinc when in a state of fusion (at 400° C. or thereabouts) afford liquids having densities ranging from 2·4 to 5·0; the application of such liquids to the separation of minerals of higher specific gravity than 3 was made by M. Revé Bréon, in March, 1880. The subsequent application of tungsto-borate of cadmium to the same purpose possesses many advantages; it was suggested by M. Daniel Klein, in 1881.* The crystals of this salt (to which the chemical formula $9WO_3, B_2O_3, 2CdO, 2H_2O + 16$ aq. is assigned), when fused in a water bath in their own water of crystallization, yield a liquid which at 75° C. has the specific gravity 3·55, and upon which some of the crystals sinking in Sonstadt's Solution will float. At 22° C. the tungsto-borate of cadmium in crystals requires but 1-10th its weight of water for solution, yielding a dense liquid, which may be advantageously substituted for that of Sonstadt.

2. By weighing a stone in air and then in some liquid of known density, the weight of the bulk of the latter displaced by the stone is ascertained. If, for example, a sapphire weighing 4 grains in air weighs but 3 grains in water, it has evidently displaced 1 grain of water, becoming lighter by that amount. So the number 4 represents the specific gravity of sapphire, showing, as it does, the number of times that the weight of any bulk of that stone contains

* Bulletin Soc. Min. de France, iv. pp. 149–155.

the weight of an equal bulk of water. An example of an actual experiment of this kind will serve to illustrate this, the ordinary method of taking specific gravities, better than any further explanation of the principle involved.

A yellow sapphire weighed in air . .	12·896 grams.
" " water . .	9·677 "
Difference, that is, weight of water displaced	3·219 "

The proportion will be:

Wt. water displaced.		Sp. gr. water.		Wt. sapphire.		Sp. gr. sapphire.
3·219	:	1	=	12·896	:	x

$$x = 4{\cdot}006$$

There are several corrections which are needed before an exact result can be reached. They are these: Firstly, the stone and the water must be compared at the same temperature, usually that of 60° F. or 15·6 C. This is the most important correction, and the only one usually applied; it is well to avoid the necessity of introducing it, by conducting the experiment at the standard temperature. The second correction originates in the fact that the stone is weighed in air, and consequently is buoyed up to some extent by that fluid, appearing lighter than it would be if weighed *in vacuo.* The third correction depends upon the material of the weights. These, if of brass, displace from one-half to one-third of the amount of air displaced by the stone in the other pan of the balance, and consequently involve another error. The several corrections we have named may be learned with sufficient accuracy by the following methods: The correction for temperature may be applied by multiplying the difference between the weight in air and the weight in water, not by unity, but by the actual specific gravity of water at the observed temperature,* then proceed with the calculation as before. The correction, on account of the air and the brass weights is given by the formula:

$$y = w \cdot 0012 \left(\frac{1}{d} - 0{\cdot}12\right)$$

where w is the observed weight in air of a given substance; d its approximate specific gravity; ·0012 the mean density of atmospheric air; ·12 the reciprocal of the specific gravity of brass, and y the weight by which the substance when weighed with brass weights will appear too light. The true weight, W, *in vacuo* will then be:

$$W = w + y$$

Now, with the true weight, W, *in vacuo*, the specific gravity may be calculated according to the equation previously given. To furnish a notion of the value of this correction, it may be stated that a fragment of rock crystal weighing 10 grams will become 10·0031 grams, a gain of 3 parts in 10,000.

When the specific gravity of a small gem is to be taken, an assay balance of great accuracy may be advantageously employed.† In this case the full advantage of the delicacy of the instrument cannot be secured if water be the liquid in which the stone is weighed, the friction between it and the stone and immersed pan being too great. Alcohol considerably diluted with water answers

* If the specific gravity of water at 4° C. be taken as 1, then the specific gravities at higher and lower temperatures will be:

0°	·99987	7°	·99993	14°	·99930
1	·99993	8	·99989	15	·99916
2	·99997	9	·99982	16	·99900
3	·99999	10	·99975	17	·99884
4	1·00000	11	·99966	18	·99865
5	·99999	12	·99955	19	·99846
6	·99997	13	·99943	20	·99826

† M. Jolly's spring balance, as modified by Mr. C. F. Cross, is another useful form of instrument for this purpose.

well. A fair quantity is prepared and preserved in a well-stoppered and capped bottle. Its specific gravity is best ascertained by means of Dr. Sprengel's tube. In the following example of an experiment a dilute alcohol of sp. gr. ·8488 at 15° C., and containing about 80 per cent. by weight of absolute alcohol, was used :

Specific gravity of brilliant-cut specimen of phenakite.

Weight in air	1·1294	gram.
„ „ alcohol at 15° C.	0·8064	„
Alcohol displaced	0·3230	„

The equation will be:

$$\frac{1·1294 \times ·8488}{·323} = 2·9676 = \text{sp. gr. of phenakite.}$$

3. The third method of taking specific gravities does not admit of great exactness. A small wide-mouth bottle or beaker, with a ground rim and ground glass cover, both truly plane, is filled with water, the cover placed in position, avoiding air-bubbles and wiping off any water outside the vessel, and then weighing it and its contents. Let this weight be x. Now introduce the gem and replace the lid as before ; let the present weight be y, and that of the gem in air w ; then approximately,

$$\frac{w}{w + x - y} = \text{sp. gr.}$$

In employing this method the vessel used should be no larger than will contain the specimen.

Specific gravities may be ascertained by means of contrivances dependent upon the measurement of the liquid the objects displace from a vessel of known capacity or carefully graduated. The space at our disposal will not allow of any further details on this subject. But a caution as to the necessity in all specific gravity experiments of getting rid of air-bubbles may not be out of place. To attain this end boiled water should be used, and if mechanical contrivances fail (a feather or sable pencil) then the liquid and stone should be placed under the receiver of an air-pump and the air exhausted.

Details concerning the specific gravity of each kind of precious stone will be found in chapter vi. The following table gives a fair number of average densities arranged in regular sequence:

FOUR AND ABOVE.		THREE AND ABOVE.		TWO AND ABOVE.	
Hæmatite . .	5·3	Green garnet .	3·85	Phenakite . .	2·97
Pyrites . . .	5·2	Chrysoberyl .	3·76	Turquoise . .	2·75
Zircon . . .	4·6	Pyrope . .	3·75	Labradorite . .	2·72
Almandine . .	4·2	Essonite . .	3·66	Beryl . . .	2·70
Sapphire . .	4·0	Spinel . .	3·65	Amethyst . .	2·66
		Topaz . .	3·55	Rock crystal .	2·65
		Diamond . .	3·52	Iolite . . .	2·63
		Peridot . .	3·38	Moonstone . .	2·58
		Spodumene . .	3·20	Opal . . .	2·20
		Tourmaline . .	3·10		

The following brief notes as to the physical or mechanical properties of minerals not already discussed or described must suffice:

Form.—The forms of crystals are all referable to one or other of these six crystallographic systems. (1) The cubic or monometric; (2) the pyramidal, dimetric, or tetragonal; (3) the rhombohedral or hexagonal; (4) the prismatic, trimetric, or orthorhombic; (5) the oblique or monoclinic; (6) the triclinic or anorthic.

Structure.—The mode of mechanical aggregation or intimate texture of minerals may often be learnt by disruption of the mass, or by splitting or cleaving it. Structure is often crystalline, laminar, fibrous, or columnar. Fractured, not cleaved, surfaces are less instructive—they may be conchoidal, uneven, splintery, or hackly

Transparency.—For want of a more comprehensive term, the various degrees of resistance to the transmission of light through minerals are included under this title. The degrees are five:

> Transparent—when objects can be seen distinctly.
> Semitransparent—when objects can be seen dimly.
> Translucent—when light, not objects, can be seen.
> Subtranslucent—when light is transmitted through thin splinters.
> Opaque—when light is not transmitted.

Lustre.—This character, although it needs some practice to discern it accurately, is of importance as an element not merely of the beauty but also in the discrimination of precious stones. The terms employed to designate its various qualities are these:

Metallic,	as on	pyrites.
Adamantine,	,,	diamond.
Resinous,	,,	garnet.
Vitreous,	,,	emerald.
Waxy,	,,	turquoise.
Pearly,	,,	moonstone.
Silky,	,,	crocidolite.

Metallic and adamantine lustres are connected with high refractive indices. The colours of precious stones are discussed in chapter iv.

CHAPTER III.

CUTTING AND FASHIONING PRECIOUS STONES.

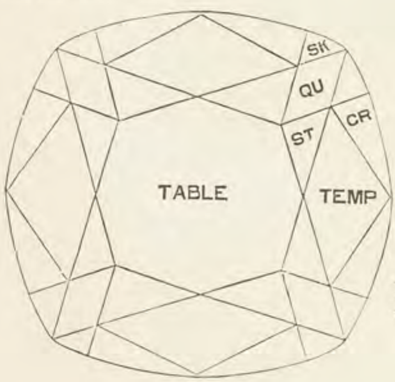
VERY few precious stones, as we receive them from the hands of nature, present the beautiful qualities for which we look in these concentrated treasures of the earth. Often they are waterworn pebbles, roughened by attrition and blows during years or even centuries of wanderings in the beds of streams and rivers. If we find them intact in their rocky homes, they are ofttimes obscured with flaws and intruding matters which mar their beauty. If transparent and without speck or fracture, yet the natural forms in which crystallized gem-stones occur are but rarely adapted for direct employment in objects of jewellery. In shape or size they are awkward for such use, while many of those marvellous optical qualities which distinguish them from the crowd of commoner materials are brought into prominence only by the artificial processes of cutting and polishing. These processes convert rough crystals into shapely gems, having fine qualities of surface lustre and interior colour, and, withal, much less liable to fracture than the original stone. Now and then a perfect natural octohedron of flawless diamond or rosy spinel may be set in a ring or jewel; but such instances are exceptional, and gem-stones, in order that all their elements of beauty may be developed to the uttermost, must be cut and polished according to rule.

All the different forms into which precious stones are cut may be arranged into the two groups—(1) those having plane surfaces; (2) those having curved surfaces: but, under special circumstances, facets or plane surfaces are occasionally associated with curved surfaces in the same specimen. The further subdivision of the two groups of forms may be tabulated thus:

Group 1.	Plane surfaces	Brilliant-cut. Step or trap-cut. Table-cut. Rose-cut.
Group 2.	Curved surfaces	Single cabochon. Double cabochon. Hollowed cabochon. Tallow top.

A few words descriptive of each of these modes of cutting stones may now be given.

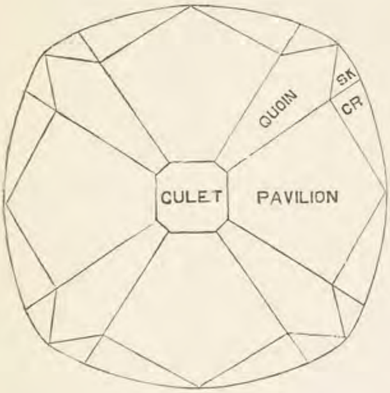
The old brilliant-cut, though susceptible of many small modifications as to the size of the facets, their mutual proportions and inclinations, and even their number, requires, when perfect, 58 facets thus arranged:



1 Table 8 Star facets 4 Templets or bezils 4 Quoins or lozenges 8 Cross or skew facets* 8 Skill facets* — 33	= The "Crown," or upper part of the brilliant.

Fig. 11.

* The cross and skill facets are sometimes called half-facets; the former are known as clôtures by the French lapidaries.



1 Culet or collet
4 Pavilion facets
4 Quoins
8 Cross facets
8 Skill facets
—
25

= The "Pavilion," or base, or under part of the brilliant.

Fig. 12.

There are thus 58 facets in a brilliant, while the "girdle" or edge bounding the widest part of the stone, divides the crown from the base, and is concealed, in part at least, by the mounting or setting. This girdle must not be very thin (it is liable to be so in what are called "spread," that is, shallow, stones), for then it may become chipped and break away during mounting. If it be thick, on the other hand, the brilliancy of the stone is lessened, and its material wasted by the concealment of a good deal of it in the mount. This form of cutting is reserved particularly for the diamond—so much so, that the word "brilliant" used alone signifies a diamond cut after this fashion. Of late years the girdle of brilliants has been made to approach a circular outline; the templets and quoins are nearly of the same size, and eight star facets are cut round the culet, thus making a stone of 66 facets. Certain rules have been laid down for the relative proportions, not only of the several classes of facets in a brilliant-cut diamond, but also for the thickness of the finished stone in each and all its diameters. Thus 1-3rd of the total thickness should be occupied by the crown or upper portion above the girdle, 2-3rds being below. The table should be 4-9ths of the breadth of the stone, and the culet 1-6th to 1-5th of the table;

but according to some modern experts, both these facets, but chiefly the former, may be reduced with advantage below these proportions. Two of the most famous diamonds of the world show large departures from the typical proportions of a brilliant: The Koh-i-nûr in its present form is far too broad for its depth or thickness; the Regent is a good deal too thick for its breadth. But the same rule of proportion, although it may hold good for such diamonds as admit of being subjected to it without extravagant loss of weight, must be modified with stones of other species, and especially with coloured stones. With colourless topazes, sapphires, etc., the surfaces and inclinations of the facets must be modified to suit the refractive indices and other optical constants of these minerals; with coloured stones, if pale (certain alexandrites for example), greater depth must be secured; if dark in hue, then greater "spread" and less depth (deep red garnets furnish instances).

The style of cutting known as the step-cut or trap-cut is adopted for the emerald and many coloured stones. It is subject to rules of proportion far less strict than those devised for the cutting of the diamond in the brilliant form. Each species of stone needs special study, that the typical step-cut may be so modified as to bring out the full beauty of the gem. The fault most common with step-cut stones is the too great breadth of the table, for the internal reflections from the lower facets are best seen through the sloping bezils of the crown, not through the flat surface of the table. In the step-cut (fig. 13) we have then a table, two or more sloping step facets, and then the girdle, while the lower part of the stone (fig. 14) is cut

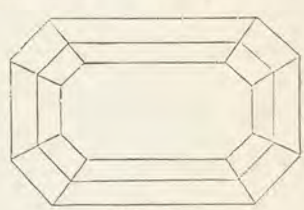


Fig. 13.

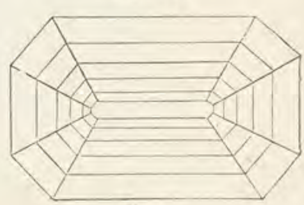


Fig. 14.

into three or more sets or zones of diminishing steps, with an oblong square or hexagonal or octagonal culet as termination. Some trap-cut stones are brilliant cut below the girdle, or *vice versâ*.

The table-cut needs little description: it has a very largely developed table with bevelled edge, or a border of small facets. It is employed for covering fine gold-work and miniatures; in the sixteenth century and later it was used in Europe for much diamond-work.

The rose-cut (fig. 15) shares with the table-cut a much greater antiquity than the brilliant-cut. It may be compared with the latter by supposing the table to be replaced by six triangular or star facets, and the crown to be represented by eighteen triangular cross and skill facets which together constitute what the French call *la dentelle*. The base is either flat or a duplicate of the upper part.

Fig. 15.

The other forms given to faceted stones are not of sufficient importance to need description; the star-cut and the pendeloque may just be named as patterns sometimes followed in the cutting of diamonds.

Translucent and opaque stones are commonly cut *en cabochon* (fig. 16); the opal and the turquoise are characteristic examples. The moonstone, avanturine, cat's-eye, and star sapphire, too, would not show their peculiar properties were the confusing reflected lights from facets to be mingled with the white sheen, the brilliant spangles, the silver thread, or the six-rayed star which these stones respectively present when properly fashioned. The one transparent stone which is frequently cabochon-cut is the garnet, which is then called a carbuncle. A variety of cabochon

Fig. 16.

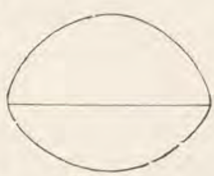


Fig. 17.

used for this gem is somewhat hollowed behind (fig. 18), to receive a piece of foil as well as to lessen the depth of colour in very dark stones. Our figures represent the simple cabochon (fig. 16), the double cabochon (fig. 17), the hollowed (*évidé*) cabochon (fig. 18), and the flattened form much used for opals, and called tallow-topped (fig. 19). The double cabochon is usually cut with the base of lesser curvature than the crown; but with many stones a more brilliant play of coloured light within the stone may be secured by reversing these proportions. Although the cabochon form is almost essential to many precious stones, and is useful to hide the poverty and flaws of others, and also is convenient in the case of stones to be used in the decoration of vases and other objects to be handled, yet it ought not to be allowed to displace the various faceted forms. Doubtless there is a quiet beauty and richness in a good cabochon ruby, sapphire, emerald, or jargoon, but we lose some of the most striking characteristics of these gems when we so cut them as not to admit of the display of their dichroism, and their dispersive and reflective powers. The narrow view that all faceted stones are vulgar is based on caprice and ignorance; it is the mere unintelligent whim of a clique of artists and amateur writers on art. For the faceting of the great majority of transparent stones is an operation necessary for the development of those optical qualities upon which the beauty of precious stones mainly depends. It should be performed in strict accordance with certain rules of proportion, which may be deduced from the optical constants of each species of stone.

Fig. 18.

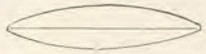


Fig. 19.

Information as to the mechanical processes and the materials employed in the cutting and polishing of precious stones may be found in the works of Jannettaz and Dieulafait. Horizontal wheels of steel, gun metal, lead, and wood, charged with diamond dust (from boart, an imperfectly crystallized variety), emery, tripoli, etc. are employed for different stones and in different stages of the work; the subject, however, is one which cannot be discussed here, involving, as it does, a large number of minute technical details of no interest from an artistic standpoint.

CHAPTER IV.

ARTISTIC EMPLOYMENT OF PRECIOUS STONES.

Some acquaintance with the less obvious characters and qualities of precious stones, and especially with the distinctive properties of those kinds which remain practically unrecognised and unappreciated, may serve more than one good purpose. Not only may the jeweller's art receive new impetus and suggestion, but the buyers and connoisseurs of bijouterie may learn to appreciate more highly well-conceived design, new combinations, and exquisite workmanship. Most admirable and pleasant colour-combinations may be attained by the aid of materials which in many instances are now by no means costly. Curious and delicate hues of luminous and refined quality, preserved in enduring substance, may be arranged and grouped in forms of endless beauty and variety. Neither silks, nor paints, nor even enamels can ever equal the colours of precious stones in durability, or in brilliancy and pulsating variety of hue. And it cannot be doubted that when knowledge of the true nature of any art material (such as precious stones) becomes more intimate, exact, and diffused, a more intelligent and lively interest will be created in examples of good work wrought in the substance in question. Every connoisseur or collector of artistic objects must have shared in experiences of this kind. He may have been once quite dead to the peculiar merits of certain works, say in bronze, not even glancing at any specimens falling in his way. Then some casual circumstance, perhaps an exciting contest for a fine piece of work at a sale between two enthusiastic collectors, or perhaps the gift of a choice specimen, may have drawn attention, not perhaps to the merits of such specimens, but at least to the esteem in which they may be held. Curiosity—it may be an intelligent curiosity—is excited. Investigation, more or less searching, follows. The hardness of the metal, its *provenance*, its designer, its age, the mode of manufacture, whether by casting or hammering; the manner of decoration, whether by chasing, engraving, or inlaying; the colour and texture of the surface, the presence or absence of *patina*; and not a few other points of interest, constitute the materials of complex study. Study provokes observation, and observation study, so that before long the neglected group of artistic bronzes exerts a kind of fascination upon the new votary. If his knowledge be superficial and inaccurate, or if he be merely an amateur or collector just because it is a fashionable pursuit to gather together or to admire certain classes of artistic objects, well then, he does not really know what and why he admires. Forgeries delight him just as much as genuine works, so long as he is not sure that they are forgeries; but he has not sufficient patience for the mastery of, or sufficient insight into, the characteristics of true productions to discriminate them from those that are false. It often happens thus with the amateur of precious stones. He knows nothing of the optical elements, say of surface lustre, and the pleiochroism which go to make up the *tout ensemble* of any particular gem, and is quite satisfied with a well-cut bit of paste, or a cleverly contrived doublet. No doubt, in some cases, even an educated keenness of vision does not suffice to distinguish the true stone from the false, although the durability of the genuine specimens will ultimately prove their superiority. But it is not difficult to learn to appreciate the peculiar and essential characters of the majority of the species of precious stones. The few simple pieces of apparatus and the appliances described in the last chapter, will serve to supplement and correct the deductions of a trained eye and touch. And with a spectroscope, a polariscope, in addition to a good hand magnifier or pocket lens, such an array of evidence may be marshalled that there can remain but few cases in which the identity of a stone shall continue doubtful. But for the purpose of the artistic employment or appreciation of precious stones such a table as that given on pages 5 and 6 will prove more useful than any recondite method of inquiry. Some of the uses of that tabular arrangement of conspicuous optical qualities may be gathered from the following examples. Referring to the shape of stones we note that their boundaries are either *plane* or *curved.* Now if we have to use, in any piece of personal ornament, stones having curved surfaces, it will not answer in general to associate with them other curved surfaces, like those of the *en cabochon* moonstone; and especially is this the case where the size of the stone, as well as the character of the curved surface, is nearly identical; but a happier result will be attained by combining a step-cut stone with one having a curved surface. Again, citing an example from the series of adjectives expressing qualities of surface, it will be found that gems having an adamantine lustre assort better with those which present the less brilliant surface known as waxy, than they do with those which show a nearer approach to the adamantine surface, and which are called resinous. The diamond and the jargoon do not improve or bring out each other's qualities, for they have too many points in common; but the diamond accords well with the pearl, and the jargoon with the turquoise, that is, the adamantine with the pearly, and the resinous with the waxy. Looking, now, into the substance of stones, rather than on their surface, their relations to the transmission of colourless light furnish many illustrations of wise and unwise, or effective and defective combinations. For example, chatoyant stones, like cat's-eyes, do not associate well with translucent stones, like the chrysoprase and the chalcedony—the translucency of the latter confuses, because it resembles too closely, the chatoyancy of the former. But transparent stones accord well with all those which interrupt the passage of light by such internal reflections. The diamond, on this account, combines admirably with the cat's-eye and the pearl, but it affords too strong a contrast, especially when of large size, with the turquoise, to associate pleasantly with this nearly opaque stone. From amongst the qualities pertaining to the colour of stones, examples of the utility of the table may be cited. When a stone has much "fire" in it—that is, when its refractive and dispersive actions upon light are high—and it shows prismatic hues, then it looks best if associated with gems in which this property is less developed. Again, monochroic stones, which in all directions transmit beams of the same colour, should be associated with pleiochroic stones, which exhibit two or more hues, while the latter should not be mixed together.

We are led from the study of these examples of associations of gem-stones to inquire into the principles which underlie artistic combinations. Probably we are satisfied with arrangements of precious stones in which the leading *motif* is either identity, or seriation, or contrast. When stones match, when they are graduated, or when they offer a distinct but not startling contrast, the resulting effect is at least capable of being made satisfactory. When we speak of identity, seriation, and contrast, as expressing the elements of decorative association in the mounting of precious stones, we use words into which we are compelled to import special meanings. By identity, we mean that very close resemblance which selected specimens of choice stones of the same kind will exhibit; seriation expresses the orderly sequence of tones or colours with the presence of a pervading and dominant element; contrast implies an effect of change rather than of passage, and may include contrast of tone and of lustre as well as contrast of colour. Instead of further discussing the question of the artistic employment of precious stones in precise accordance with the three principles of association before laid down, a more useful and generally available plan will be to follow a classification according to *colour*. For as the ornamental or artistic employment of precious stones conveys primarily, if not wholly and ultimately, an appeal to the eye, it is clear that such optical properties as can be comprised in the terms lustre, light, and especially colour, should be our first consideration. After all, as, on the whole, the prominent feature of precious stones is their colour, so the easiest way of considering their colour is to adopt the order of succession of the colours in the ordinary rainbow or prismatic spectrum, beginning with the white light, which contains them all, and originates them all.

White Stones.—The diamond naturally takes the first position if we consider its hardness, its remarkable composition, and its strong refraction and dispersion of light. Its properties, so far as they appeal to the eye, differ much from those belonging to the majority of other stones, and it forms, partly in consequence of this peculiarity, as good a border or setting to other gems as a gold frame generally does to a picture. Of course much depends upon the quality of the diamond, and much upon the shape which is given to it by the lapidary. The flat plates of *lasque* diamonds, and, in less degree, the step-cut stones with broad tables, exhibit the unique and splendid lustre which is peculiar to the polished surface of this stone; these forms also permit the transparency and the total internal reflection of light to be well seen. Even the form of the diamond crystal, the regular octohedron, when its surfaces are really planes, well exhibits the transparency and reflection of the stone. Next to the diamond we may place the colourless zircon or jargoon, then the phenakite, then the white sapphire, the white topaz, and the white beryl. Rock crystal will come below these in point of beauty and brilliancy. The colourless zircon (of which a fine specimen set in a ring may be seen in the British Museum Mineral Gallery, now at South Kensington) approaches very near in prismatic brilliancy to a diamond; so, at night especially, does the rare and curious mineral phenakite. There is, however, always a sort of difficulty in finding an appropriate use for colourless, yet lustrous, stones in any article of jewellery intended for personal adornment. The more lustrous and prismatic they are—the more they resemble the diamond, in fact—the less available are they for the usual purpose to which gems are put. Still, there are peculiar qualities in these stones which need not be lost to artistic employment, if the white stones in question were judiciously associated with materials which would prevent their being mistaken for diamonds. A white diamond should rarely or never be bordered by green tourmalines, but these stones would form an agreeable combination with a white zircon, a phenakite, or a white topaz. In the sapphire there is usually a faint suspicion of milkiness, and in the white beryl a cool greenish tint, which prevent these stones from resembling the diamond so closely as to be taken for imitations of that gem. But many of these colourless stones, notably the topaz and rock crystal, in all probability are most appropriately used when set as bosses in vessels and other large pieces of metal work, or employed in the form of plaques for engraving or etching. It is scarcely necessary to justify such uses of these minerals, and this is not the place to enter upon the question, particularly as it is only by a rather wide use of the term precious that I am able to include these materials, and some others of which I shall have to speak presently, amongst precious stones. Of two other white materials employed in jewellery, the moonstone and the pearl, a few words may be introduced here. The moonstone forms an excellent substitute in many combinations for the pearl, but it does not associate so well as the latter with the diamond. With deep-coloured amethysts, spinels, and tourmalines, few colourless gems look more refined than the moonstone. But these stones, which fetch a shilling or so apiece only, should always be accurately recut and highly repolished before being used. Their forms are too irregular and their surfaces too imperfect, as imported from Ceylon, to show off their moonlight sheen with half its intensity, unless they are passed again under a careful lapidary's hands. The improvement thus effected is marvellous. The value of the pearl, whether its "orient" be luminous with prismatic hues, or whether it be a warm soft white merely, is too well known to be more than named in this connection. But we may be permitted to say one word in deprecation of the extravagant expenditure of time, of ingenuity, and of costly materials, which the attempt to convert large irregular pearls into structures resembling figures has so often caused. The result is nearly always most unhappy.

Red Stones.—The ruby may fitly be considered before other coloured stones. It, with the sapphire, and all the transparent varieties of corundum, ranks next to the diamond in hardness. It is, moreover, a stone of great beauty. Probably the experts in jewels are right in assigning the highest value to those rubies which possess a "pigeon's blood" colour—this is the orthodox hue. But the paler colours, and those which verge upon pink and crimson, and even violet, are capable of being so treated by means of association with white and black enamel or with dark stones, like olive-green tourmalines, as to lend themselves to the production of very beautiful decorative effects. The great mistake commonly made in the treatment of the paler rubies lies in the attempt to treat them in the same way as the deeper coloured stones.

It is difficult to describe the peculiar colour quality of the ruby in words. In fact, our nomenclature of colours is neither ample nor accurate. Our appreciation of delicate differences between colours is growing, but the language by which we endeavour to describe the hues which we have learned to appreciate is either stationary, or else receives additions from time to time of unsatisfactory words, derived from the caprices of French fashions. The time has really arrived when a standard series of hues of all sorts should be constructed and appropriately named ; but, in the case of the ruby, the question of pleiochroism comes in, and renders the difficulty of describing the colour quality of this stone greater.

There is also some prismatic "fire" in the stone, and much internal reflection of light, while its surface lustre lies between resinous and vitreous. These four properties give to the red of the ruby a peculiar richness, which the two other species of precious stones—the spinel and the garnet—which come nearest to it in colour, do not equally possess. The two reds which make up the colour transmitted by the ruby do not differ much, but yet they help to impart, to a properly cut stone, a delicate variation of hue which is not present in any other red stone, nor in any imitative substance. The dichroiscope, consequently, never fails to discriminate between a ruby on the one hand and a spinel or a garnet on the other. The two latter stones are, of course, softer than the ruby, and the former is always lighter, that is, of less specific gravity. For the ruby, and the whole of the corundum family of stones, have the specific gravity of 4, and a hardness which is nearly, and in some cases quite, 9 on the mineralogical scale.

One of the happiest uses of the ruby is in the form of an inlay, in certain gold vessels of Indian origin. The external surface of these vessels is covered with a system of interlacing ridges and furrows. The rubies, generally small, oval, and cut *en cabochon*, are set along the furrows. Thus they are much protected from the chance of dislodgment, while the effect they produce, of a rich deep crimson groundwork over which a gold netting has been thrown, is in perfect harmony with the materials and their workmanship. For, naturally, the metal gold, when pure, or nearly pure, throws a ruddy tint when light is reflected from surface to surface; witness the interior of gilt vessels. The same thing occurs in the golden furrows of which we have spoken, where the rubies seem to rest in a golden sheen, of a hue in which the yellow, and orange, and red elements, now one and now another, appear to prevail. The gold should not be burnished where much contrast between the metallic surfaces and the rubies is desired, but the stones themselves should be as brightly polished as possible, in order not only to develop the full beauty and variety of their colour, but also the very considerable surface lustre which the ruby possesses. There is another kind of Indian jeweller's work to which most of the remarks I have just made apply. A perforated plate or disc of delicate arabesque or radiated work is found decorated with ruby beads, round or oval, attached to the circumference of the ornament, or else introduced into its midst in concentric circles. Here dull dead or "matt" gold is particularly appropriate, as affording a pleasant contrast to the rich, smooth, and soft transparency of the rubies, which, from the manner of their mounting, may be looked through. The refinement of the slender gold-work, which, in this class of jewellery, approaches the delicacy of filagree, sets off by its minuteness of detail the simpler and bolder forms of the plain, smooth, rounded stones, which give it colour and warmth. We must dwell for a moment or two upon another Eastern method of dealing with the ruby—the use of this stone as an inlay or onlay—that is, an incrustation—upon jade, both white and green. It is not so much here a beautiful contrast of colour that is attained, although the greenish gray, or olive green of the jade, enhances the redness of the ruby; but it is a contrast of textures, a contrast of surfaces, a contrast of translucencies. You see but a little way into the jade, though it is illuminated by a soft diffused light; but you see through the clear deep-toned rubies, with their flashing beams of crimson.

Now compare with these examples of the artistic employment of the ruby, the ordinary mode in which this stone is set by English jewellers. Look at the half-hoop ruby ring, with five rubies well matched in colour, and graduated exactly in size, set close together in a regular row. You see, perhaps, a little speck of gold appearing here and there at each end of each stone, but nothing is made of these pieces of gold. You accept them because you know they are necessary to hold the stones in their places, but you find neither invention nor beauty in these little bits of gold claws. In fact, they are frequently prepared by the gross, ready for the mounting of any stones, provided the shape of the latter be suitable. Rubies, sapphires, diamonds, garnets, and emeralds are all set in the same way, not an attempt being made to adapt the amount of gold surface or its form to the specific nature of each gem. But why should not some variety and some appropriateness of mounting be secured for all stones? How exquisite, and yet how strong, were the gold and enamel settings of precious stones in the cinque-cento time in Italy! Let those patrons who desire the rather barbaric splendour of masses of rubies gratify their taste by means of jewels in which the setting is not seen at all. But surely a fine stone is worthy of a fine and originally designed setting—proportioning the latter in form, in amount of work and surface, and also in colour, whether red, or green, or yellow gold, or enamel, to the shape and the hue of the stone to be set. And even small stones become quite beautiful when arranged with taste and judgment, in accordance with the conditions just named, and with the further condition as to collocation of individual stones in accordance with their size and shape. In pendants, and necklets, and lockets, and brooches there is room for the expression of some definite and intelligible design. The mere alternation of rubies with diamonds in rows or chequer work may, in some instances, achieve all that is needed. But a design of more definite form may often be preferable, especially where the stones at one's disposal are of differing colours and sizes. Then one may construct a suitable bit of leafage or flowerage, duly conventionalized, in accordance with the nature of the available materials, into forms of more or less geometrical severity. It should be noted that moonstones and white sapphires, in which there often lurks a faint opalescence, accord well with rubies; but it must be kept in mind that the size of the colourless stones which are to be associated with rubies in such designs as those named is a matter of much moment. It is a mistake to attempt to match the colourless and the coloured stones in respect of size, and generally of shape also. One should be smaller than the other. Large rubies with small moonstones, or small rubies with large moonstones, and similarly, square stones with round, and oblong stones with round, generally produce happier effects than square with square, and oblong with oblong. Pearls accord with rubies, not only by reason of their colour relations, but also on account of their shape. In the case of rubies cut *en cabochon*, brilliant-cut or square step-cut diamonds will be found to yield very satisfactory combinations. A border of small brilliants or roses is a usual and a useful mode of setting off the qualities of a ruby. The colour of the pale stone is heightened by contrast with the colourlessness of the diamonds; the richness of a rich stone is enriched, and a small stone, if surrounded by stones still smaller, becomes magnified in proportion.

Next to the ruby, amongst the red stones, comes the spinel, or balas ruby, an entirely different mineral species, without any pleiochroism, and inferior in hardness to the true ruby. The scarlet, aurora-red, and flame-coloured spinels are the most beautiful; those which verge upon crimson, purple, and violet, looking dull and black at night, but showing very delicate and often rare hues by day. Red spinels accord well with small brilliants, or with larger pearls or moonstones. A fine aurora-red spinel looks well when surrounded with delicate foliage of white, orange, and black enamels. Step-cutting, similar to that employed for emeralds, accords best with the optical qualities of this stone. A biconvex lenticular form may be so adapted to this stone as to throw a good deal of soft and rich colour into a specimen which would otherwise have had little beauty to recommend it. What richness of hue the finer examples of red spinel may show is to be studied in two specimens in the Townshend collection, Victoria and Albert Museum, Nos. 1326 and 1327.

From spinels the passage to garnets is easy. But it is not really difficult to discriminate between the two species, even when the colours seem the same. If you have a ruby, a spinel, and a garnet together, the first will scratch the second and the second the third. The ruby will show two colours in the dichroiscope, the spinel and the garnet only one. The spinel will exhibit no black bands like those belonging to the red garnet, when viewed with the spectroscope. And there is a blackness, due to much absorption of light, in many of the facets of a garnet, as seen from the "table" of the stone, which will not be observed in the spinel. The garnet, unless of remarkable size or quality, will hardly be deemed worthy of being mounted in the same costly way as the ruby or the red spinel, but it may be said that the same general treatment suits all these red stones. Yet there are two ways in which garnets have for long and in many places been treated, to which I may legitimately refer here. The plates of garnet so largely found in Anglo-Saxon and Celtic jewels have remained, in the majority of cases, intact to the present day. They afford, in their breadths of soft rich colour, a pleasing contrast to the minute filagree, granulated, and enamel work with which they are generally associated. The other employment of the red garnet (and it may be traced back to a far earlier date than that just cited) is as a carbuncle—not necessarily foiled at the back. Cut *en cabochon*, slightly hollowed behind, and laid on a plain gold surface, the light, as of a glowing coal, quivers in the midst of a good stone. There is a lovely disc of antique gold set with five carbuncles in the Gold Ornaments room at the British Museum. In the centre is a round carbuncle boss; then four long pointed arms, much like elongated pears, radiate from this centre, alternately with a somewhat similar series of *repoussé* arms, beaten up from the disc of gold, and bordered with knurled wires onlaid. There is not much work in the piece; the intrinsic value of gold and garnets is quite small, but the effect is delightful; simple, yet rich; solid, yet elegant. Can the same praise be honestly given to modern garnet-work? Can we feel a genuine satisfaction either in the design, the execution, or the effect of a compound big carbuncle of eight lobes, with an eight-rayed star riveted into the midst of it, the aforesaid star being of hard, poor, glittering, much alloyed gold, and containing a number of irregular fragments of defective diamonds? The star soon gets loose, and later on the diamonds begin dropping out. But we will not pursue the history of the piece any further, and will refrain from calling attention to other obnoxious modes of using carbuncles, as in a ring with a sham gold knot on either side.

Orange and Yellow Stones.—Amongst orange and yellow stones we may assign the first place to the yellow zircon—a stone which is sometimes found of a hue which may be aptly described as that of transparent gold. Next to this comes the cinnamon stone, or essonite; and then we may place the rich sherry-coloured Brazilian topaz—that kind which yields when heated the finest rose-pink stones. Yellow sapphires take an almost equal rank with the best topazes, and then the chrysoberyl follows, and, at some distance, the yellow beryl. Few colour combinations have been attempted with these yellow stones; puce-coloured spinels associate with the yellow sapphire very happily, but there are some enamels which answer equally well. Generally a design of pale bluish-gray enamel, with minor details wrought in buff and white, develops the richness of gold-coloured stones.

Green Stones.—There are three green stones about which something ought to be said—the emerald, the tourmaline, and the peridot. Some persons regard the green of the emerald as vulgar. It is too easy to construct a vulgar coarse ornament out of emeralds, even if they be of fine quality. But the emerald, step-cut, and judiciously and quietly mounted, possesses a rich and refreshing colour, just sufficiently dichroic to show passages of bluish-green with the green. Green tourmalines are much more markedly dichroic, and it is much to be regretted that, with rare exceptions, the patrons of the jeweller's art still remain ignorant, not only of the peculiarly rich and varied qualities of the colour of the tourmaline, but even of the existence of this gem-stone. With moonstones, or with gray and ivory-white enamel, long prismatic tourmalines, carefully cut, afford a delightful colour-combination peculiarly fitted for larger pieces of personal adornment, such as pendants and brooches. The so-called green garnets of the Urals, especially those which are of an olive or pistachio green, are lustrous and fiery stones, but their softness precludes their use in rings. The same objection holds good with regard to that lovely stone the peridot; but this species occurs frequently of large size, and so is well adapted for employment in jewels not subject to much attrition. It is a dichroic stone; it accords well with small puce, violet, or indigo spinels, also with black and white enamel; small dark-coloured almandine garnets may sometimes be associated with peridots of fair size advantageously.

The aquamarine and other pale varieties of the beryl are stones which lose nothing of their brilliancy at night. Their beauty may generally be greatly enhanced by the judicious use of creamy white enamel, with delicate arabesques of black or indigo blue. It is not often that the hue of the beryl is such as to bear the juxtaposition of other coloured stones.

Blue Stones.—Of these there are four that claim notice in this place—sapphire, blue spinel, iolite, and lapis-lazuli. Rich yellow dead-gold settings suggest themselves for most of these materials. Pearls or diamonds enhance the colour of the paler sorts of sapphire, spinel, and tourmaline, but afford too striking a contrast with very richly and deeply tinted stones. A fine indicolite, step or cabochon cut, accords well with pearls or moonstones arranged as a bordering or in some conventional form: the gold work may well receive an enrichment in the form of gray or olive green enamel. In the case of the sapphire, the twin beams of diversely-coloured light which this stone transmits—the one azure blue, the other greenish straw—contribute to produce the peculiarly rich quality of its velvety softness. There is a glittering coldness in all the imitations of the sapphire —the *timbre* of their colour, to borrow a word from music, is harsh and unsatisfactory. So a recent imitation, a kind of lime-spinel made artificially, exhibits apparently the right colour, but it is flat and uninteresting. To my eye, the difference between a true sapphire and a false one is the analogue of the difference between a piece of leafage in wrought iron, and the same piece in cast iron. As to the arrangement of the sapphire in jewellery, so much depends upon its depth of colour and its precise hue, that a general rule would be fallacious. Unless it be pale, when certain green tourmalines go well with it, the sapphire may be most safely associated with pearls, diamonds, moonstones, or white topazes, the cutting and size of the stones being carefully studied.

Violet and Purple Stones.—The amethyst, the oriental amethyst, and the almandine garnet cannot, as a general rule, be safely associated with stones having strongly marked contrasting hues. The paler sorts of peridot may however be combined with deep-coloured amethysts or almandines, provided the latter be small in comparison. The use of opaque fawn-coloured, olive green, and brown enamel with violet and purple stones sometimes yields happy effects.

In devising arrangements of coloured stones a mere water-colour sketch will not suffice. It is always desirable to study with the aid of the actual materials themselves—stones, gold, silver, enamel—the sum of the effects due to lustre, texture, form, size, etc., as well as the balance and distribution of colour.

CHAPTER V.

ARTIFICIAL FORMATION OF PRECIOUS STONES.

A CLEAR distinction must be made between the imitation of a precious stone and its actual reproduction or formation by artificial methods. In the former case we simulate the appearance of the natural substance by means of some product or preparation, which may be (and generally is) widely different in chemical composition and even in many physical properties. In the latter case we form the very mineral which Nature has formed, endowed with all its chemical and physical characters, but not necessarily produced by processes identical with those of Nature. A few examples of the true reproduction of precious stones will serve to explain the distinction pointed out with sufficient exactitude.

Take the case of the ruby and sapphire, varieties of crystallized alumina or corundum. If, by the aid of the intense heat of the oxyhydrogen blowpipe pure alumina, with traces of chromium oxide or other colouring oxide, be fused, we get a sapphire or ruby glass, having a hardness and density much less than those belonging to crystals of alumina. But by prolonging the time of cooling or by producing the alumina from some of its compounds during the heating, a portion of the product will crystallise in forms identical with those of the natural stone, and having the density of 4 and the hardness 9. Until lately the specimens made have been small in size and poor in colour and brilliancy, but the product was identical with native corundum. Now the spinel, a compound of alumina and magnesia, has furnished better results. By the aid of a substance such as boracic acid, which acts as a solvent for the constituents of spinel, but which volatilizes at very high temperatures, crystals of spinel having considerable dimensions, good colours, and the hardness of 8, have been obtained by several chemists. These stones, having been cut and polished, could not be distinguished by any test from the natural gems. Another method of operating, by which rock crystal and a considerable number of hard transparent and beautiful compounds of silica have been made, consists in causing two substances to act upon each other when both are in the state of vapour, sometimes with the aid of the vapour of water as a decomposing agent, and sometimes without. By the reaction of fluoride of aluminium and boracic acid, fluoride of boron and alumina are produced, the latter crystallizing in colourless rhombohedra of white sapphire, or even, when chromium is added, taking the colours of ruby and blue sapphire. Similarly treated at a very high temperature in a lime crucible, the fluorides of aluminium and glucinum have been made to yield distinct crystals of chrysoberyl. It is probable that in Nature the formation of gem-stones has been in the presence of water, and under very great pressure continued for a long time. Indeed, it may be concluded that the agency of a very high temperature has not been generally at work, but that the important elements in the production of natural crystals have been time, mass, and pressure.

CHAPTER VI.

IMITATIONS OF PRECIOUS STONES.

THE one point in which all artificial imitations of precious stones fail is hardness. Practically they all yield to the file, and many are scratched even by a bit of common glass. Indeed, with the exception of some of the recent productions of M. Feil, of Paris, they consist of flint glass containing an unusually large proportion of lead, and tinctured by the addition of certain colouring oxides, such as cobalt for blue, manganese for violet, as well as nickel, copper, iron, chromium, or mixtures of these, for other hues. Colourless strass commonly contains 38 per cent. of silica, 53 oxide of lead, 8 potash, and traces of boracic and arsenious acid, with some alumina and soda. There are three other points in which these coloured glasses differ from true stones. Besides their softness already named, they tarnish in impure air, the lead becoming sulphided, and therefore brown; they are heavier than any of the stones having specific gravity under 3·3, which they represent, and they are all destitute of pleiochroism. Under the microscope, or even a hand magnifier, the majority of them show many lines, and specks, and air-bubbles, which betray their origin and nature —their origin, at a high temperature rapidly reduced; their nature, as fused, glassy non-crystalline masses. The lines and striæ are signs of layers of unequal density and of strain; the bubbles are rounded cavities, quite different from those cavities, with angular and crystalline walls, which some gem-stones, such as amethyst, beryl, topaz, frequently present. This is true not only of the many varieties of coloured paste or "strass," which form the usual materials for imitative gems, but also of the fused compounds having the precise (or at least analogous) chemical composition of various gem-stones which have been prepared by Mr. Greville Williams and M. Feil. The green beryl glass of the former, and the blue lime spinel of the latter, afford cases in point.

Instead of substituting a wholly imitative preparation for a true stone, a doublet or triplet is constructed, in which a colourless or pale stone, of no value, is made to appear possessed of a fine deep colour. The doublet sapphire has a table and crown—all the stone down to the girdle—of colourless or pale blue sapphire, then the lower part of the combination, attached by cement, is made from blue glass or strass. If then the upper part of the stone be tested for hardness it answers to that of the sapphire, but if the base be examined, it immediately betrays its softness. To avoid this the triplet has been devised. Here we have pale sapphire for crown and base, but a thin layer of deep blue glass at the girdle—a part generally hid by the mount. To detect this imposture immersion in water generally suffices, for then the three layers will become visible; and if a doublet or triplet be boiled in water, or soaked in a small bottle of chloroform, it usually betrays its composite nature by falling to pieces. We should add that some false stones of this sort are coloured by means of a layer of coloured varnish or cement.

Imitation pearls claim a word of description. They are small spheres blown on tubes of slightly opalescent glass, and coated internally with a preparation made from the scales of a certain fish (as the bleak), and called Essence d'Orient. The little opalescent glass globe first receives, while still soft, a few very slight dents, then a coating of parchment size is introduced, and then a film of the pearl essence. Lastly, when the essence is dry, the bead is filled with wax.

Some remarks on the artificial colouring of natural stones will be found in chapter vii.; the different varieties of silica—agate, onyx, cornelian, and even opal—are frequently subjected to processes of heating and saturation with chemical reagents in order to change their hue or to introduce foreign colouring matters.

CHAPTER VII.

DESCRIPTION OF PRECIOUS STONES.

DIAMOND.

THERE are three characters which unite to place the diamond in a unique position amongst precious stones. It is the only gem which is combustible; it is the hardest of all minerals; it exerts upon light the most energetic refractive and dispersive power.

The diamond belongs to the cubic or isometric system, and usually occurs in the form of an octahedron, or in combinations in which the cube, the dodecahedron, and the tetrahedron are involved. The faces of these forms are commonly curved: macled and hemitropic associations of crystals are of frequent occurrence.

The diamond is easily cleaved in directions parallel to its octahedral faces. Its fracture is conchoidal. Its hardness is 10.

The lustre both of natural and artificial surfaces of diamond is peculiarly brilliant, approaching that of such a metal as silver. This characteristic lustre, which is shared to some extent by the jargoon and the garnet, is known as *adamantine*—it lies between the metallic and the resinous lustres. The peculiar brilliancy of diamonds results in part from the total reflection of light from their internal faces when the incident light strikes them at an angle greater than 24° 13′. Diamond refracts light very strongly—the index of refraction for the yellow ray being 2·419, while that of rock crystal is but 1·545; of topaz, 1·621; of white sapphire, 1·75; of phenakite, 1·675; and of white zircon, 2. In the extent to which diamond disperses the several coloured rays into which white light is split, this gem greatly surpasses all others. Its "fire," or the flashing of prismatic hues which characterises this precious stone, is mainly due to this dispersive power.

The specific gravity of the diamond, when transparent and colourless, is of remarkable constancy. When taken in the ordinary way, without the refinement of certain small corrections which are made only for scientific purposes, the best results have lain between the narrow limits of 3·52 and 3·53, at 60° Fahrenheit. The fine colourless Porter Rhodes diamond has the specific gravity 3·523: the smaller but equally fine Gor-do-norr, 3·527. The former stone was found at Kimberley, South Africa, on the 12th of February, 1881, and weighs 474 troy grains: the latter is of Indian origin, and weighs 213½ grains. The Star of the South, a Brazilian stone of 254½ carats, has the specific gravity of 3·529, according to M. Halphen.

The range of colour of the diamond is extensive; but various hues of yellow, grayish yellow, brown, and straw colour, are the most common. Strongly-coloured diamonds are very rare; but green, blue, and even red stones are known. The celebrated Hope blue diamond, of 44¼ carats, and the Brunswick blue diamond, of 6½ carats, are both of the same brilliant and steely blue, and may very likely have both been parts of the French blue diamond stolen from the Garde-Meuble, in 1792, and never since seen.

The least valuable diamonds are those which lack brilliancy, or have faint hues of gray, brown, and yellow. The most prized are those which combine brilliancy with decided tints of rose, green, or blue: cinnamon-coloured, salmon, or puce diamonds are also much esteemed. But pure diamonds, without flaw or tint of any sort, are those which are regarded as coming up to the market standard of excellence, and are spoken of as of the "first water." But even under this designation there is room for considerable diversity of quality, and consequently of price. And there are occasionally met with stones of such exceptional purity and beauty that the ordinary rules of valuation applicable to stones of the "first water" do not hold good. This observation of course refers to cut stones, that is, to well-proportioned brilliants. Such a stone, weighing but 1 carat (3·17 grains), might fetch £30 at a time when a first-water brilliant of the same weight would not realise above £20. In fact, specimen stones, like exceptionally large stones, cannot be said to be amenable to any precise rule of valuation. The value of the diamond increases in an increasing ratio with its weight up to stones of moderate size, beyond which no rule holds good. Assuming a first-water brilliant of 1 carat to be worth £20, then an equally fine 2-carat stone would fetch £60, or £30 per carat. Formerly the value of the larger brilliants increased so rapidly with their weight that a stone of 10 carats was worth over £200 per carat. But since the South African diamond fields have been extensively worked, large stones have been found in greater abundance, and have not maintained their relatively high prices.

In the preceding paragraph brilliants of the first water have been considered, but it should be added that the diamonds used in ordinary shop-jewellery, being either dull, flawed, or "off-colour," possess small market value.

For the localities where diamonds have been or are found reference may be made to the works named in the brief bibliography at the end of this manual. The story of the diamond-fields of the world is full of romantic interest. India, Brazil, Borneo, and South Africa have all furnished most curious contributions to the long list of adventures, discoveries, and disasters connected with the diamond.

The following list gives some particulars concerning a few of the best known and most important diamonds above 100 carats in weight. The figures quoted are carats, but are probably not in all cases based on an exact standard.

NAME.	ORIGIN.	WEIGHT IN THE ROUGH.	WEIGHT WHEN CUT.
De Beers of 1880	S. Africa	428½	288½
Nizam	India	—	277
Orloff	India	—	194¾
Darya-i-nur	India	—	186
Victoria	S. Africa	457½	180
Taj-i-mah	India	—	146
Regent or Pitt	India	410	136⅞
Austrian Yellow	India	—	133¼
Star of the South	Brazil	254½	125¾
Tiffany Yellow	S. Africa	—	125½
Stewart	S. Africa	288¾	120
Koh-i-nur	India	—	102¾

Full discussions of the history of these diamonds and of many others will be found in the works included in the Bibliographical Notes on page 95. Dr. Max Bauer's "Edelsteinkunde" contains a good set of figures of most of the celebrated big diamonds of the world.

Diamonds and the more valuable of precious stones generally are bought and sold by the weight called a *carat*. This carat, whatever its precise value, is always considered as divisible into 4 diamond grains, but the subdivisions of the carat are usually expressed by the vulgar fractions, one-fourth, one-eighth, one-twelfth, one-sixteenth, one-twenty-fourth, one-thirty-secondth, and one-sixty-fourth. The origin of the carat is to be sought in certain small hard leguminous seeds, which, when once dry, remain constant in weight. The brilliant, glossy, scarlet-and-black seed of *Abrus precatorius* constitutes the Indian rati, about 2 grains; the *Adenanthera pavonina* seed is about 4 grains. The seed of the locust-tree, *Ceratonia siliqua*, weighs on the average 3⅙ grains.

The carat is not of absolutely the same value in all countries.

Its weight, as used for weighing the diamond and other gemstones in different parts of the world, is given, in decimals of a gram, by the majority of the authorities, as—

Madras	·2073533	France	·2055
Vienna*	·20613	England	·205409
Frankfort	·20577	Spain	·205393
Brazil and Portugal	·20575	Holland †	·205044

Assuming the gram to correspond to 15·43235 English grains, an English diamond carat will nearly equal 3·17 grains. It is, however, spoken of as being equal to 4 grains, the grains meant being "diamond" grains, and **not** ordinary troy or avoirdupois grains. Thus a diamond grain is but ·7925 of a true grain. In an English troy ounce of 480 grains there are 151½ carats; and so it will be seen that a carat is not indeed quite 3·17 grains, but something like 3·1683168 grains, or less exactly, 3·168 grains. Further, if we accept the value in grains of one gram to be, as stated above, 15·43235, and if there be 151½ carats in a troy ounce of 480 grains, it will follow that an English diamond carat is ·205304 of a gram, not ·205409, as commonly affirmed. By recalculating the value of the diamond carat, as used in different parts of the world, into its scientific equivalents in the metric system, the weight to four places of decimals will become, according to Mr. Lowis D'A. Jackson ‡—

Turin	·2135	Holland and Russia	·2051
Persia	·2095	Turkey	·2005
Venice	·2071	Spain	·1999
Austro-Hungary	·2061	Java and Borneo	·1969
France	·2059	Florence	·1965
Portugal and Brazil	·2058	Arabia	·1944
Germany	·2055	Egypt	·1917
England and British India	·2053	Bologna	·1886

On the other hand there would appear to be an arrangement between the diamond merchants of London, Paris, and Amster-

* Schrauf gives ·2057. † Schrauf gives ·20613.

‡ Modern Metrology, p. 377.

dam, by which the uniform value for a diamond carat is fixed at ·205 of a gram. This value, which was suggested in 1871, by a syndicate of Parisian jewellers, goldsmiths, and others engaged in the commerce in precious stones, was subsequently (1877) confirmed. But, in spite of all efforts to secure uniformity in the standard by which diamonds are bought and sold, very serious discrepancies in sets of carat weights as turned out by different makers still exist. Be it remembered, to show the importance of one fixed and universal value, that even the small difference between the values of ·205304 and ·205 gram for the carat, corresponds to 15s. in each £500 worth of stones of 1 carat, and to much more when heavier stones are being sold.

CORUNDUM.

Sapphire, Ruby, and Oriental Amethyst.

Next to the diamond in hardness must be placed the many varieties of the species called corundum. This includes the sapphire, the ruby, the oriental amethyst, the oriental topaz, and a whole crowd of stones, practically identical in composition, but presenting great diversity in colour and optical properties. All these varieties belong however to the mineral species corundum, the French *corindon*, and consist of crystallised alumina, the oxide of the metal aluminium. From the mineralogical, or rather from the physical point of view, the colour of these stones is of no account, while chemistry has not as yet succeeded in discovering much concerning the causes of the variations of colour which determine the very different values set upon different specimens of corundum. That there are small quantities of magnesia, oxide of iron and silica in rubies and sapphires of all hues, has been ascertained, but this fact does not furnish the clue to the cause of the blue of the sapphire or of the red of the ruby. That certain chromium compounds impart a red hue to certain artificial preparations, both crystallised and vitreous, of alumina, will not count for much in the absence of proof that all rubies contain chromium. That iron is the cause of the dark colour of emery and impure corundum is, however, certain : indeed some specimens of emery contain half their weight of iron oxide.

Corundum always occurs in crystals, or is at least crystalline ; the forms are six-sided prisms or pyramids belonging to the hexagonal (rhombohedral) system. The lustre is vitreous except on the basal planes, which are often pearly. The six-rayed star seen in many cloudy sapphires and rubies, especially when cut *en cabochon* with the summits cutting the principal axis of the prism, is due to the peculiar intimate structure of the crystal, some of the incident light being reflected regularly from the internal surfaces of the layers which make up the crystal. When this chatoyant lustre is very marked it gives us the "asteria," or star-stones, known as star-rubies when red, and star-sapphires when blue or gray : the star-sapphire is the ceraunia of Pliny.

The specific gravity of pure transparent corundum, including the colourless and yellow varieties as well as the blue sapphire and the ruby, is as nearly as possible 4, the extremes being about 3·97 and 4·05 respectively. A fine yellow stone without flaws gave 4·006.

The hardness of the ruby is not quite so high as that of the colourless and blue sapphire; the hardness of the latter is usually stated as 9.

Coloured corundums are invariably dichroic. Rubies can thus be at once discriminated, not only from garnets, but also from spinels, by examination with the dichroiscope, which shows, with the true ruby only, two differently coloured squares. Similarly the sapphire can be known from the blue spinel, and, of course, from blue paste. The twin colours, polarized in opposite planes, are these :

Sapphire,* of rich velvety blue	Deep ultramarine blue. Greenish straw yellow.
Ruby,† of true "pigeon's-blood" red	Aurora red. Carmine red.

* Fig. 1, Frontispiece.

† Fig. 2, Frontispiece.

There can be no doubt that part, at least, of the peculiar beauty of fine rubies and sapphires is due to the play of different hues caused by their dichroism.

The ruby, when of perfect colour and fair size, is more valuable than any other precious stone. If a diamond of five carats be worth £350, a faultless ruby of the same weight would sell for £3000 at least. A fine stone of one carat may be worth as much as £100. All or nearly all the fine rubies met with in collections are believed to have come from Burma. The mines are situated in Upper Burma, north of Mandalay. Two very fine stones from this locality reached England in 1875. When recut they weighed $32\frac{5}{16}$ and $39\frac{9}{16}$ carats respectively. The rubies from Siam now in the market are not only too dark in colour, even verging on brownish red, but they are also slightly cloudy.

Sapphires, that is, blue sapphires, are not only more abundant than rubies, but they are found of larger size. In Burma and Ceylon occur the chief localities for fine sapphires, but inferior specimens are met with in many parts of the world. A perfect sapphire of one carat is worth rather more than a perfect brilliant of the same weight. The *saphir merveilleux* of the Hope collection, the sapphires of Lady Burdett-Coutts, and the fine stone ($132\frac{1}{16}$ carats) in the mineral gallery of the Jardin des Plantes at Paris, are all characteristic examples of this gem. There is also a fine rose-cut sapphire in the British Museum collection of minerals. The sapphire was engraved sometimes in the later Roman days, but more frequently in the cinque-cento time. The pendent sapphires in the votive crowns of the Guarrazar treasure (7th century) and those on the front of the Pala d'oro in the church of Sant' Ambrogio, at Milan (8th century) are of Indian origin, perforated and roughly polished but not faceted. Small polished sapphires *en cabochon*, are frequently found set in gold rings of a stirrup form, and having a projecting bezil—worn by lay persons as well as by ecclesiastics in the 13th and 14th centuries.

Amongst the rarest coloured corundums is the green or oriental emerald. The true oriental amethyst, or purple sapphire, is not quite so uncommon; it is an exquisite stone, often made up of alternate layers of ruby and sapphire.

While the ruby holds its own by candle and gas light, the sapphire becomes dull, and often acquires a somewhat purplish or amethystine hue.

The white sapphire of modern writers is, in all probability, the adamas of Pliny; the blue sapphire is the ancient hyacinthus; while the true ruby, the spinel, and certain red garnets formed the several varieties of Pliny's carbunculus, under which name the writer included several stones which were perfectly distinct from each other.

SPINEL.

No precious stone includes so wide a range of colours as the spinel. Following the order of the rainbow, we have red, orange, green, blue, and indigo-coloured spinels; and also those which show the hues known as purple, puce, and violet. Yellow spinels are not unknown; some are colourless, others black. Another character of importance which enhances the position of the spinel as a gem-stone is its hardness, which, though inferior to that of the ruby, is greater than that of the red garnet. But over against these excellences of the spinel must be set the lack of fire, due to its small refractive and dispersive power; and also the somewhat prosaic quality of its colour, attributable in part to the absence of pleiochroism. It is perhaps unfortunate for the appreciation of this species of precious stone that its red varieties seem to enter into competition with the incomparable splendour of the ruby, and its blue varieties with the velvety softness of the sapphire. But the spinel owns other hues which labour under no such disadvantages. There is a brilliant aurora red, and a whole suite of passage hues, between indigo and puce, which stand alone for curious beauty. And to these may be added steel-gray and slate, without exhausting the colours offered by the spinel.

The red varieties of the spinel are generally spoken of as "spinel ruby" and "balas ruby," those designated by the latter name being inferior in colour and brilliancy, and less like the true ruby; but, chemically and physically, there is no sharp distinction between them. "Rubicelle" is a term applied to orange and flame-coloured spinels; those that are violet and purple being called "almandine" spinels.

Spinels fit for use in jewellery come from many localities. Of these the chief are in Burma, Siam, and Ceylon; also in the United States, in New York, and New Jersey, but the fine large red spinels come exclusively from India; several of these, weighing, when properly cut, as much as 25, 72, 81 carats, have recently found their way to Europe. One rose-coloured specimen weighed as much as 150 carats, but being too pale was sold for no more than £80. A spinel ruby of rich colour is seen probably to the best advantage when step-cut; the paler hues often look well brilliant-cut. A border of small diamonds enhances the colour and beauty of a spinel.

The spinel crystallizes in the cubic or monometric system, a regular octahedron being its most common form. Some of the natural crystals of spinel are so perfect in shape and polish that they are quite fit for ornamental mounting without further preparation. The hardness of this gem is 8, while its specific gravity is about 3·65. The following determinations of the specific gravity of choice cut specimens of spinel will be useful for reference:

Rose red	3·631	Dull purple	3·637
Puce	3·592	Indigo	3·675
Aurora red	3·590	Deep indigo	3·715

Where the specific gravity of a spinel is too near that of a garnet to allow of the species being thus distinguished the superior hardness of the spinel enables the problem to be solved. It is scarcely necessary to say that the dichroiscope affords no criterion in such a case, since the spinel and garnet both belong to the monometric system and are necessarily monochroic.

Spinel is essentially composed of one molecule of alumina and one of magnesia, or in 100 parts:

Alumina	72	Magnesia . . .	28

But in the coloured varieties decided traces of other oxides occur, such as that of chromium in the spinel ruby; oxide of copper in the grass green spinel called chlorospinel; and the protoxide of iron in the darker and opaque varieties. Some specimens of pleonaste, the black spinel of Ceylon, have been found to contain over 20 per cent. of ferrous oxide, the protoxide of iron, which takes the place of its equivalent of magnesia.

Spinels in true crystals and very hard have been formed artificially, though not of fine quality and large size, by several different processes, such as heating alumina, magnesia, and boracic acid together to a very high temperature. The vapour of aluminium chloride passed over heated magnesia also produces spinel crystals, so does the strong heating together of magnesia and alumina. Some imitation blue spinels or sapphires have been made by the fusion together of alumina, lime, and a little cobalt. These ingredients have, however, given a blue glassy mass softer than true spinel, and merely inclosing here and there a few minute crystals of what may be termed a "lime spinel," the main mass being indeed the same substance, but in a vitreous or non-crystalline state. The specific gravity of this lime spinel, which has been sold for blue sapphire, is lower than that of sapphire or even than that of blue spinel.

TURQUOISE.

The turquoise acquired its name from having been imported into Western Europe by way of Turkey. The best specimens come from the neighbourhood of Nishapur, in Persia, where the gems occur in a clay slate. The hardness of the stone is nearly 6, and its specific gravity 2·75. There is a peculiar quality in the colour of the best turquoises, which is partly dependent upon the delicate hue of its blue, with which a slight infusion of green is mingled, and partly upon the faint translucency of the stone. For turquoise is indeed not opaque, thin splinters transmitting light easily.

It is very probable that turquoise was described by Pliny under the three names of *callais*, *callaina*, and *callaica*. Turquoise is often now called callaite, while an allied mineral from a Celtic grave near Morbihan, France (1864), has been called callais and callainite, but has lately been proved identical with the variscite of Breithaupt, a mineral described in 1837.

The true turquoise, which shows various hues and tones of blue, greenish blue, and bluish green, is not to be confounded with the blue fossil turquoise, or odontolite, which is in fact fossil ivory, or rather fossil bone. The true turquoise owes its colour to phosphate of copper, and its powder becomes dark blue when moistened with strong ammonia. Odontolite is coloured by phosphate of iron, is more opaque than turquoise, and much softer, and shows its bony structure under the microscope. Turquoise often becomes green by age; this change is frequently noticeable in the turquoise cameos of the Italian cinque-cento.

Turquoise is a phosphate and hydrate of alumina, associated with a hydrated phosphate of copper; it always contains small quantities of phosphate of iron and manganese. A fine Persian specimen contained in 100 parts:

Phosphorus pentoxide	32·8	Water	19·3
Alumina	40·2	Copper oxide	5·3
Iron and manganese oxides	2·5		

Turquoises of considerable size and occasionally of good colour are met with having Persian and Arabic inscriptions or ornamental designs engraved upon them. The hollows of the designs are sometimes gilt, sometimes inlaid with gold wires.

The distinction between turquoises *de la vieille roche* and those *de la nouvelle roche* has a real existence. The former, chiefly obtained from the Nishapur district, are superior in quality of colour, even when the latter belong to the same species, and are not, as is often the case, identical with odontolite, or bone turquoise, or with variscite.

CALLAINITE.

There are three minerals passing under the name of turquoise. The true turquoise is the callaite of mineralogists; then there is a fossil turquoise or odontolite; and lastly we have a pale bluish-green stone which has been described under the names callais, variscite, and callainite, and which presents a near relationship to the true turquoise. Its hardness is 4; its specific gravity 2·55; and its percentage composition:

Alumina	32·4	Phosphorus pentoxide	44·9
Water	22·7		

TOPAZ.

Although the topaz is a perfectly definite and distinct mineral species, yet three different stones are commonly called by this name. But the topaz known as "oriental topaz" is in reality the yellow sapphire, a kind of corundum; the occidental or Scotch topaz is nothing but yellow quartz; while the true topaz, sometimes spoken of as the Brazilian topaz, is the only one which in reality may properly bear the name. The hardness and specific gravity of these three stones are very different, and furnish good criteria for their discrimination:

	Hardness.	Specific Gravity.
Oriental topaz	9	4·01
Brazilian ,,	8	3·53
Scotch ,,	7	2·65

The true topaz belongs to the orthorhombic system; its crystals are prisms, usually having but one end regularly terminated. The cleavage of topaz is highly perfect and basal, that is, transverse to the length of the prism. The prismatic faces are commonly deeply channeled but brilliant. The refractive indices of topaz, in the three directions of the axes, are, for the yellow ray in a colourless crystal:

$$\alpha = 1{\cdot}622\ ;\ \beta = 1{\cdot}615\ ;\ \gamma = 1{\cdot}612.$$

The double refraction of topaz is strong, and the pleiochroism of coloured specimens very marked. A wine-yellow crystal from Brazil showed two images, one rose pink and the other brownish yellow, in the dichroiscope; after heating, the same crystal gave a stronger pink colour and a dull white. The colours of topaz are many and beautiful; the rose pink (often called burnt topaz) is commonly obtained by heating the richly coloured wine-yellow or amber-yellow crystals, but occasionally occurs in natural specimens. Blue and pale-green topazes are sometimes found of large size, and are more brilliant than similarly tinted beryls. Colourless topazes vary a good deal in purity of hue and fire; those from Brazil are often of remarkable whiteness, and show dazzling reflections of pure white light when properly cut. The polish which the topaz takes is very high, and the surface of cut specimens is exceedingly smooth and slippery to the touch.

The specific gravity of the topaz, even in perfectly flawless and transparent specimens, ranges between rather wide limits, so far as the colourless specimens from different localities are concerned. The coloured specimens show a much smaller variation.

Topaz, white	3·597	Topaz, rose pink	3·534
,, ,,	3·595	,, ,,	3·533
,, ,,	3·585	,, sherry yellow	3·539
,, ,,	3·572	,, blue	3·541

The topaz is one of the few precious stones containing the element fluorine; it may be regarded as a silicate of alumina, in which part of the oxygen of the silica is replaced by fluorine. The analysis of topazes from different localities points to a composition which may be represented in 100 parts by these figures:

Silicon . . .	15·5	Oxygen. . . .	36·8
Aluminium . . .	30.2	Fluorine . . .	17·5

When strongly heated, topaz not only changes in colour, but loses considerably in weight; hydro-fluoric acid, fluoride of silicon, and fluoride of aluminium being given off to the extent of 20 to 24 per cent. With moderate heating no loss of weight, but merely change of colour, occurs, the bulk of the stone remaining unaltered, and consequently its specific gravity suffering no increase or diminution. The sherry-coloured, the brown, and the other tinted topazes, which are susceptible of being "pinked" by heat, exhibit a very curious phenomenon during the operation. When a suitable stone is packed in magnesia or other inert material, and heated in a crucible, the specimen, if removed before it is cold and laid upon a white surface, shows scarcely any shade of colour; but after a little time, when the stone has acquired the temperature of the air, the desired pink hue makes its appearance. If the temperature reached has not been sufficiently high, a salmon tint, or a hue like that of a drop of blood mingled with much water, is obtained instead of a rose-petal pink. What the cause of these changes of colour is remains doubtful: it may be a change in the molecular or physical condition of some minute trace of a coloured constituent in the topaz, or it may be an actual chemical change. Anyhow the colour of topaz is a very unstable one, for light, or at least the solar rays, soon exert a bleaching effect on many pale-coloured specimens; so that the fine suite of wine-hued Russian crystals, collected by Colonel de Kokscharow, and now in the British (Natural History) Museum, is kept shrouded from the light of day.

Topaz occurs in several Scotch and Irish, and in some English, localities—St. Michael's Mount in Cornwall, may be named amongst the latter. Villa Rica, Novas Minas, and Minas Geraes in Brazil, Flinders Island, and many places in the United States, as well as several Siberian localities, furnish splendid specimens of colourless and coloured topaz. Good topazes come from Pegu and Ceylon, and they have been found in Australasia. The topazios of the ancients was our chrysolite and peridot, not the stone now called topaz, which was not known as a distinct stone until comparatively modern times. The topaz (pitdâh) of Aaron's breastplate was probably a peridot.

The commercial value of the topaz is small and variable. Very richly-coloured specimen stones, suitable for pendants, may be bought for a pound or a few pounds: they are commonly sold by the ounce, not by the carat.

TOURMALINE.

The tourmaline is marked out from all other precious stones by a very complex chemical constitution, and by a very interesting optical structure. Its hardness, 7·5, suffices to protect it from wear, while the range and quality of the colours which it exhibits commend it to those persons who appreciate the artistic value of jewellery in which other stones besides those which are well known and popular form dominant elements.

All the minerals called by the names "indicolite" (blue), "rubellite" (red), "schorl" (black), and "achroite" (colourless), form but one species—tourmaline. These differences of colour are accompanied by differences of composition, so that we have a series of varieties of tourmaline, in which, while the proportion of silica is fairly constant, the bases consist of the oxides of iron, magnesium, sodium, manganese, and aluminium in differing proportions. To give some notion of the chemical complexity of the tourmaline we may cite an analysis by Rammelsberg of a green Brazilian stone of specific gravity 3·107 :

	In 100 parts.		In 100 parts.
Silica	38·55	Lime	1·14
Alumina	38·40	Soda	2.37
Manganic oxide	·81	Lithia	1·20
Ferric ,,	5·13	Potash	·37
Ferrous ,,	2·00	Boron trioxide	7·21
Magnesia.	·73	Fluorine	2·09

The specific gravity of tourmalines varies between 3 and 3·25. The following determinations were made with particular care:

Tourmaline, green, from Brazil	3·109
,, ,, ,, ,,	3·154
,, black, Bovey Tracey, Devon	3·120
,, rich rose pink	3·044
,, almandine coloured	3·009

The tourmaline occurs crystallised in the form of prisms belonging to the rhombohedral system; some of the faces are striated or even channeled. The hardness of perfectly flawless transparent tourmalines is about 7·5.

The optical properties of tourmaline are most striking. When a crystal is viewed along the direction of its principal axis, it is less transparent and of a different colour than when viewed across that axis. The coloured varieties, or most of them, absorb and quench to different degrees the ordinary ray, which is polarised in a plane parallel to the axis, while they allow the extraordinary ray, polarized in a plane perpendicular to this line, to pass. Examples of the marked dichroism, which is so conspicuous a feature in the majority of coloured tourmalines, may be seen in this list of twin colours of the two polarized rays passing along and across the crystal respectively:

ORDINARY RAY.	EXTRAORDINARY RAY.
Yellow brown.	Asparagus green.
Deep violet brown.	Greenish blue.
Purple.	Blue.

The following are some additional instances of the twin colours seen in tourmalines, owing to the optical peculiarity just named. These examples were observed with the aid of the dichroiscope, which serves for the study of such a phenomenon admirably, causing, as it does, a complete separation of the oppositely-polarized and differently-coloured rays, not attainable by mere inspection of a polished slice of a tourmaline crystal:

COLOUR OF STONE.	TWIN COLOURS.
Red	Salmon—Rose pink.
Brownish red . .	Columbine red—Umber brown.
Brown . . .	Orange brown—Greenish yellow.
Green	Pistachio green—Bluish green.

A few illustrations of the influence of this powerful dichroism upon the appearance of cut and faceted tourmalines will be of service, not merely in identifying doubtful specimens, but in explaining the peculiar and exquisite quality of the colours which this gem-stone shows. If we cut a green tourmaline in such a manner that the table and culet are perpendicular to the axis of the crystal, the probability is that the gem will appear, especially in its thicker parts, perfectly opaque and black. Held sideways, we may see some greenish and olive green hues, by looking across the stone from one part of the girdle to another. Now the same green tourmaline may be so cut as to present a brilliant appearance, with a fine play and interchange of two hues of green, by making the table parallel with the axis. If the crystal be a yellowish brown one, a very beautiful effect is secured by cutting it in the form of a brilliant, but with a small table parallel with the axis. The templets and other facets of the crown should be well developed, so as to display, as the stone is viewed in different positions, the different colours of the light transmitted and reflected in different directions which become visible in one after another of the facets. If one of these be at one moment greenish yellow, presently it is yellowish brown, and then russet.* With pale yellowish and greenish gray tourmalines cut in a similar manner, there will be seen other equally striking changes of hue; and if a pale crystal be so cut as to remain of considerable length in relation to its thickness, it will very likely show a deep brownish colour at each end, while apparently nearly free from colour in the middle.

GARNET.

The great group of the garnets includes several gem-stones which would not be associated, as having many characters in common, unless chemical and crystallographic properties were allowed to overbalance the more obvious peculiarities of these minerals. Garnets present almost every hue and depth of colour, and they vary greatly in hardness and specific gravity. But the crystalline forms in which they are found are all referable to the same system, the cubical or monometric, while the chemical expression which represents their constitution is identical in structure, though one or another constituent is replaced by analogous elements. All garnets are singly refractive and monochroic. The following list includes the chief varieties:

Essonite or cinnamon-stone—Lime aluminium garnet.
Almandine and carbuncle—Iron aluminium garnet.
Pyrope or Bohemian garnet—Magnesia-iron-lime aluminium garnet.
Uwarowite—Lime chromium garnet.

To these must be added, though with some doubt as to its position and constitution, the green garnet of Bobrowska, in which much protoxide of iron is found along with the same proportion of lime that occurs in the essonite, or ordinary lime-aluminium garnet. This green Bobrowska garnet has not yet been found in definite crystals. One character common to all garnets save Uwarowite is their fusibility before the blowpipe; they thus yield a vitreous mass which is of much lower density than

* Figs. 5, 6, and 7, Frontispiece.

the original garnet before fusion. As the garnets differ so widely from each other in appearance, hardness, specific gravity, etc., it will be advisable to discuss the five chief varieties used in jewellery separately.

1. Essonite, or cinnamon-stone, has long been confused with zircon of similar colour, a sort of deep golden hue with a tinge of flame red. All the engraved gems said to be cut in hyacinth or jacinth are in fact cinnamon-stones (that is, hyacinthine garnets), or else sards, not zircons. The best essonites come from Ceylon: they may be recognised by their peculiar appearance in a strong light when examined with a hand magnifier. This appearance is that of a finely granulated texture, as if made up of sand grains barely molten together.

The specific gravity of cinnamon-stone will be seen from the following determinations to be fairly constant:

(1) 3·690. (2) 3·657. (3) 3·642. (4) 3·642. (5) 3·666.

A cinnamon-stone from Ceylon gave on analysis in 100 parts:

Silica	40·0	Iron oxides	3·7
Alumina	23·0	Lime	30·6
Other substances	2·7		

Antique Roman intaglie on essonite and the darker-hued hyacinthine garnet are numerous; camei are not infrequent. The stone is more easily cut than the full red varieties of garnet; having, indeed, a hardness of less than 7, instead of 7·5.

2. Almandine and carbuncle. The range of colour in this variety of garnet, the iron-aluminium garnet, lies between a violet or purple very near that of the amethyst, and a brownish red. The pure fiery scarlet, the deep red, and the crimson are commonly cut *en cabochon*, with a hollow at the back to receive a bit of foil; such stones are called carbuncles. A delicate silvery cross is seen in some carbuncles, which may be called star carbuncles, though the star has but four rays. The red

garnets of this group generally show a very decided set of black bands* when viewed with the spectroscope; a test which serves as one distinction between red garnets and red spinels. When a garnet is faceted the table should not be large, nor the stone be left very thick, or there will result a blackish appearance which can be avoided by proper precautions. The purple garnets or almandines are said to have been so named from Pliny's adjective "alabandicus," applied to the "carbunculus" cut and polished at Alabanda. Siriam, a city in Pegu, and a mart for fine garnets, gives its name to the choicer sorts.

Transparent red garnets of very large size have been fashioned into cups and boxes. The Mayer collection at Liverpool includes a cup of this material; the Hope collection, another. Slabs of polished garnet, sometimes of considerable area, were employed as inlays in Celtic and Anglo-Saxon jewellery.

The red or precious garnets of this group or section are, like most other garnets, mixtures of two or more garnet types, but a characteristic specimen was found to contain, in 100 parts, about:

Silica	36	Manganese oxide	1
Alumina	21	Magnesia	4
Iron oxides	34	Lime	2

Nearly all the iron was in the form of protoxide. The hardness of this variety of garnet is about 7·5, and its specific gravity is seldom less than 4·1, and may be as high as 4·3.

3. The pyrope or blood-red garnet is essentially a magnesium aluminium garnet, but it always contains a good deal of iron and some chromium and manganese—these elements doubtless being the cause of its colour. This kind of garnet is commonly rose-cut, and is well known through the cheap Bohemian jewellery, of which it forms the chief part. Good specimens come from half a dozen localities in Bohemia, from Santa Fé, and from South Africa. Its hardness is 7·5, and its specific gravity lies between 3·7 and 3·8.

* Fig. 9, Frontispiece.

Two analyses of pyrope are here given, as it is well to have this means of fixing the practical identity of pyrope from different localities, and its difference from almandine :

	Bohemia.	Santa Fé.
Silica	41·4	42·1
Alumina	22·3	19·4
Iron protoxide . . .	9·9	14·9
Manganese protoxide . .	2·6	·4
Chromium sesquioxide . .	4·5	2·6
Magnesia	15·0	14·0
Lime	5·3	5·0

These analyses cannot be discussed further here ; but this at least may be said concerning them, that they do not accord exactly with the garnet formula, and that the state of oxidation of the three metals—iron, manganese, and chromium—has not been ascertained with complete accuracy.

4. Uwarowite, or lime chromium garnet, is of a beautiful emerald green colour, but has scarcely been found of sufficient size for cutting into a gem-stone, nor is it generally sufficiently transparent. Its hardness, however, is greater than that of other garnets (nearly 8), while its density is 3·45. It contains about—

Silica	37	Chromium oxide . .	23
Alumina	6	Lime	33

5. Bobrowska garnet. Some extremely beautiful but rather soft gems, of various hues of green and brownish green, have been imported for use in jewellery since the year 1878. They are found in the gold washings of the river Bobrowska, near Poldnewaja, district of Syssersk, in the Urals, and occur in nodular masses, varying in size from a pea to a chestnut. The fractured surfaces of the mineral are semi-adamantine ; the refractive and dispersive powers are high, so that the cut stones exhibit a remarkable amount of "fire," especially by artificial light. The colours vary much, ranging from a rather yellowish emerald green through pistachio, asparagus, and olive green, to a liver brown. The hard-

ness of the mineral is about 5. The specific gravity of three specimens proved to be as follows:

Green yellow	3·854	Pistachio green	3·848
Emerald green	3·849		

Although this variety of garnet (if it be really a garnet) contains silica, iron oxides, and lime, with mere traces of alumina and magnesia, the exact constitution of the mineral can scarcely be said to be placed beyond doubt.

PERIDOT.

Under the species olivine are now included both the yellow and greenish-yellow chrysolite and the pistachio green or leek green peridot, or evening emerald. The latter possesses a quieter hue than the emerald, and needs to be in rather large pieces that its colour may be properly developed. Perhaps the peculiar hue of the peridot may be best suggested by that seen on looking through a delicate green leaf. It contains more yellow and gray than the emerald. The peridot is dichroic, giving a straw yellow and a green image.* It crystallizes in the orthorhombic system. Its hardness is unfortunately rather low, about 6·5, so that polished specimens are easily scratched by wear. The peridot is, however, well suited for engraving, and forms, when set in black and white, or orange enamel, and gold, a beautiful stone for pendants. Engraved peridots are, however, with very few exceptions, of modern date. The specific gravity of the peridot is not changed by heat. A careful determination of the specific gravity of a fine rich-coloured peridot gave 3·389. A range of 3·35 to 3·44 is usually assigned to this variety of the "precious olivine." The last polish is given to the cut peridot by means of sulphuric acid.

Fine peridots come from Egypt, but the exact locality is unknown. One of the peculiarities of olivine is its occurrence in meteorites. There are some good peridots in the Hope collec-

* Fig. 4, Frontispiece.

tion, and characteristic specimens in the British Museum and in the Museum of Practical Geology.

The percentage composition of peridot, though the ferrous oxide may be more or less replaced by magnesia, is approximately:

Silica	41	Ferrous oxide	9
Magnesia	50		

Manganese, nickel, and lime have been found in small quantities in some olivines.

BERYL.

(EMERALD, AQUAMARINE.)

The emerald and the aquamarine are included by mineralogists under the species beryl. The differences of colour are due to minute traces of compounds too small to be determined with exactitude. The chemical constitution and the crystalline form of all the varieties of the mineral are the same. The form is a regular six-sided prism, belonging to the hexagonal (rhombohedral) system. This prism is often striated, both internally and externally, with delicate lines and fissures which are invariably parallel with its sides, not, as is the case with quartz crystal, at right angles with or across these sides.

The specific gravity of the different varieties of beryl, when free from flaws, cavities, and intruding minerals, is as nearly as possible 2·7. So the emerald and the aquamarine are a little heavier than rock crystal (2·66) and much lighter than green garnets (3·85) or green sapphires (4). Here are a few determinations of specific gravity made with stones of different colours:

Emerald (from Muso)	2·71	Blue beryl	2·701
,, ,,	2·704	Yellow beryl	2·697
Aquamarine (Brazil)	2·702	Brown yellow beryl	2·690

The hardness of beryl varies between 7·5 and 8, the fine emeralds of Muso being less hard than the aquamarines of Brazil and Siberia ; they are also rather brittle. The indices of refraction for the green ray are in the emerald of Muso :

$$\omega=1{\cdot}581 ; \epsilon=1{\cdot}578.$$

The dichroism of some forms of beryl is very strong ; this is particularly the case with the emerald. Viewed across the prism with the dichroiscope the two images of the emerald are seen to be of different hues of green—one verging on yellowish green, and the other being a green with a tinge of blue.* The same effect of hue may be noticed in small parcels of cut emeralds—cut, it may be, from the same stones. And it cannot be doubted that the dichroism of the emerald plays a part in producing its peculiar colour effect. The aquamarine is also dichroic, a sea green specimen showing straw white and gray blue as twin colours.

The range of colour in the beryl is not very extensive ; colourless specimens occur, but usually the palest beryls have a faint greenish or bluish tint. The most usual colours are pale green and pale blue with intermediate hues. The true deep rich green of the emerald is rare, but pale yellow, honey yellow, and yellow brown beryls are not uncommon. Sometimes this stone occurs with a rose tint.

The best emeralds occur in isolated crystals and geodes, accompanied by calc-spar, quartz, pyrites, and parisite, in a clay-slate, a rock in which are very fossiliferous limestone concretions of bituminous character. It belongs to the neocomian formation, at the Muso mine, near Bogota, in New Granada. Fine beryls occur in mica schist, on the right bank of the Takowaja river, west of Ekaterinburg, in Siberia. Emeralds seem to have been furnished by the Upper Egyptian mines, at Mount Zabara, near the Red Sea, before the discovery of the famous locality in New Granada. Besides several Siberian localities, Brazil, and Canjarum in Hindostan, must be named as important localities for the aquamarine. Common beryls, but of muddy and even opaque hues,

* Fig. 3, Frontispiece.

are sometimes found of enormous size. One from Grafton, New Hampshire, U.S., weighs 2900lb. It is 4ft. 3in. long, 32in. in one direction and 22in. in another, transverse to the last, across the crystal. A still larger crystal from the same locality was estimated to weigh nearly 2½ tons. But some of the Russian aquamarines and transparent or precious beryls are of considerable size and without flaw. An aquamarine weighing 225 troy ounces, and without a flaw, belonged to Pedro II. of Brazil. Good specimens may be seen in the Mineralogical Gallery of the British Museum. Emeralds are rarely free from flaws, even in the case of small stones. So large and finely-coloured an emerald as No. 1284 in the Townshend collection is an exceptional stone; it is nearly ½ an inch across. The emerald is usually step, that is, trap cut; the table should not be large. Perfect stones of the best colour, and without flaws, sell for £40 to £60 per carat.

The emerald and the aquamarine consist essentially of a silicate of alumina and of the rare earth glucina. In the emerald Wöhler has confirmed the presence of enough oxide of chromium to cause the green colour, for he has coloured white glass with the same proportion, –·19 per cent. Neglecting the oxide of iron, occurring in all varieties of beryl, and also the water and traces of other compounds, the composition in 100 parts of this mineral species will be:

Silica	66·8	Alumina	19·1
Glucina	14·1		

The emerald was employed in antique Roman jewellery, sometimes in the form of slices of the native prisms, sometimes in beads, and very rarely for intaglios. Antique engraved gems of beryl or aquamarine are not quite so rare.

The smaragdus of Theophrastus included with the beryl a number of quite different stones, such as the chrysocolla and dioptase. Pliny's smaragdus included besides the above the green chrysoberyl and the chrysoprase, as well as the green plasma, the prase, and green jasper.

CHRYSOBERYL.

The cymophane or true cat's-eye, the hard specimens called oriental chrysolite by jewellers, and the alexandrite are varieties of chrysoberyl. Their differences of hue and of physical appearance are not associated with any essential differences of composition. The colours of chrysoberyl range from columbine red through brownish yellow to leaf green; a golden yellow and a greenish yellow are not unusual. The coloured chrysoberyls are strongly dichroic;* some brownish specimens from this cause may present to the unassisted eye the aspect of tourmalines. The leaf green, or deep olive green variety, known as alexandrite, of which fine flawless specimens of large size have been sent from Ceylon, is remarkable for appearing of a raspberry red hue by candle or lamplight. The hardness of chrysoberyl approaches that of the sapphire: it is 8·5. Its lustre and brilliancy are considerable. Its specific gravity averages 3·7; it is but slightly lowered by strong ignition.

Golden yellow	3·84	Brownish yellow	3·734
Greenish yellow	3·76	Alexandrite	3·644

The cymophane, or true cat's-eye, owes its chatoyancy, whether of pale steely whiteness as a flash, or in a line like a silver wire, to the minute internal striations of the composite crystals of which the whole is constituted. The dark yellowish green hue is most prized; it is usually cut *en cabochon*. The chrysoberyl occurs in many localities, notably in Brazil and Ceylon, Connecticut, and the Urals. A fine specimen from the Hope collection is in the British Museum.

The chrysoberyl owes its colour chiefly to iron in the form of

* Fig. 8, Frontispiece.

ferrous oxide; but traces of chromium and of manganese oxide also occur in it. Its percentage composition is roughly:

Alumina	76	Glucina	18
Ferrous oxide	4		

PHENAKITE.

Phenakite is but rarely used as a gem-stone. The colourless transparent variety may however be easily mistaken for a diamond, especially by candlelight, when the prismatic colours, or "fire," of a brilliant-cut specimen are very conspicuous. The hardness of this stone lies between 7½ and 8, while its specific gravity is close upon 3. Crystals of phenakite usually take the form of a low obtuse rhombohedron. This mineral is sometimes perfectly colourless and transparent, but more frequently is rather clouded and milky, or of a straw, sherry, or cinnamon tint. When viewed with a dichroiscope the ordinary image is colourless, the extra-ordinary image being of a warm yellow or brown, should the specimen examined possess any colour at all.

The best specimens of phenakite known come from the emerald and chrysoberyl mines at Takowaja, eighty-five versts east of Ekaterinburg, Perm, Asiatic Russia: the matrix is a mica-schist.

In the Mineralogical Gallery of the British Natural History Museum, there are fine specimens of phenakite both in crystals and in cut forms. (Case 22.)

Phenakite is one of the four species of precious stones which contain the earth glucina as an essential constituent—the others are euclase, beryl, and chrysoberyl. Its percentage composition is represented by the numbers:

Silica	54·2	Glucina . . .	45·8

EUCLASE.

Euclase is rarely used as a gem-stone. It varies in hue from a pale straw colour through many qualities of green to indigo blue. Its hardness is 7·5, and its specific gravity about 3·1. It crystallizes in the monoclinic system, and exhibits trichroism. Fine crystals came from the neighbourhood of Villa Rica, Brazil, where it was associated with topaz in a chloritic schist. It occurs in the Urals. Its composition in 100 parts is approximately:

Silica	41·2	Glucina	17·4
Alumina	35·2	Water	6·2

ZIRCON.

The gem-stones known as jargons or jargoons, as well as the true hyacinths, belong to the mineral species zircon. There are many circumstances which unite to make the zircon a beautiful and interesting gem. For it presents a considerable range of rich and delicate hues; its surface lustre is brilliant, almost adamantine; its "fire," owing to its high dispersive power, comes next to the diamond; while its chemical composition is rendered noteworthy through the presence of the rare earth zirconia. Moreover the spectroscope reveals the presence, in many of the transparent specimens, of a series of black absorption bands* (discovered by the author), which are characteristic, and which have been attributed to small quantities of uranium compounds. Zircon crystallizes in the tetragonal system. Its hardness is about 7·5, while its specific gravity is usually near 4·7, although even in some transparent specimens it may fall as low as 4·32. The following set of determinations of the specific gravity of choice cut specimens of jargoon and hyacinth or jacinth will be useful for reference:

Red jacinth (Espaly)	4·863	Red brown	4·651
Columbine red (Mudgee)	4·705	Brownish yellow	4·620
Cinnamon (Ceylon)	4·756	Yellow	4·600
Brown	4·696	Orange yellow	4·362
Green	4·691	Dull green, opalescent	4·320

* Fig. 10, Frontispiece.

If we add indigo blue and white to the above series of colours, we may form some notion of the range of hues shown by the zircon. It should be noted that minute internal striations, and chains of small cavities, forming what are technically known as *feathers*, are not unusual in otherwise flawless zircons.

Many zircons, when pretty strongly heated, lose their original colour, wholly, or in some measure, becoming pale or colourless. This change is frequently accompanied by a contraction which results in a permanent increase in density. Colourless zircons thus prepared and set in massive gold rings have been pawned as brilliants, and not redeemed; a file will not scratch them, so that this test for "paste" is inapplicable.

The best gem-stones of this species come from Ceylon and Mudgee, New South Wales; the Espaly locality in Auvergne yields brilliant but very small stones of the true jacinth colour.

Putting on one side minor and accidental ingredients (to which, however, the colours, absorption bands, opalescence, etc., of the stone are due), the percentage composition of this mineral is:

Zirconia	67	Silica	33

SPODUMENE.

Until lately spodumene was not recognised as a stone which could be cut and polished as a gem; but a large importation from Brazil of brilliant and transparent crystals of yellow spodumene led to some specimens being cut and polished. The easy cleavage of the stone renders its working and mounting difficult matters. Spodumene crystallizes in the monoclinic system, and resembles in appearance the chrysoberyl. Its hardness is 7, and its specific gravity 3·2. It contains in 100 parts:

Silica . . .	64·2	Iron Oxide . . .	·4
Alumina . . .	29·00	Lithia	6·0

with traces of soda, lime, potash, and water.

HIDDENITE.

This beautiful green stone is transparent and of a brilliant green hue, not unlike that of a rather yellowish green emerald. It is a variety of spodumene, a mineral generally of a dull well-nigh opaque grayish or creamy colour, but sometimes of a brilliant straw yellow and transparent. Hiddenite rarely occurs in crystals sufficiently large for cutting into gem-stones. A cut stone, however, nearly perfect, weighed 2½ carats, and was sold for more than $125 a carat. It has been found as yet in but one locality, Alexander county, North Carolina. It was discovered by Mr. W. E. Hidden. Its hardness is 7, and its specific gravity 3.

OPAL.

Among the numerous forms or varieties of the mineral species called opal one kind alone is prized as a gem-stone. This is the noble or precious opal, which is distinguished by its play of brilliant rainbow colours. These are not caused by any coloured substances as constituents, but are due to a peculiar structure of this mineral. Although by transmitted light the precious opal appears milky or cloudy and yellow, by reflected light it exhibits orange, red, blue, green, and many other beautiful hues. These colours are produced by a mechanical or physical structure, which consists of a multitude of fissures, the sides of which are minutely striated, and which causes the diffraction and decomposition of the white light which falls upon them. The size of these striations and fissures influences the colour and its distribution within the stone, some specimens showing a predominance of one set of hues, say red and orange, and others exhibiting chiefly green, sea green, and blue tints. Sometimes, too, the patches of colour are of moderate and uniform size; sometimes they are large and irregular. The precious opal is moreover sometimes so milky as to be almost opaque; sometimes, as in many Queensland and Honduras specimens, it is nearly as transparent as glass. An intermediate condition, provided the fiery play of colours be well developed, is most highly prized: the best opals from Hungary and some of those from Mexico are of this kind.

The opal consists essentially of silica, but it differs from quartz—that is, rock crystal—in two important particulars: it is vitreous, not crystalline, and it contains combined water. The precious or noble opal usually contains from 9 to 12 parts of water in 100; but it may be dried so as to lose for a time a small part of this moisture without injury to its beauty; in fact, the whole of the water present is not essential to the mineral. The specific gravity of opal is lower than that of quartz or rock crystal—about 2·2. Its hardness is about 6, or even as low as 5·5. Its fragility and softness, and its liability to injury from oily or greasy matter, render the opal unfit for a ring-stone, but it may be used to advantage in pendants, bracelets, and ornaments for the head. A foolish but prevalent notion that the opal carries bad luck with it is of quite modern origin, but lowers the commercial value of the stone. Moreover, the great diversity in the quality of this gem renders it impossible to assign definite prices to opals of definite weights, though it may be said that a fine opal of 1 carat is worth about £3.

Besides the more usual form of precious opal, we have the Mexican fire opal, showing yellowish and reddish colours and flashes of fire; and the harlequin opal, in which the brilliant patches of colour are small, angular, variously tinted, and uniformly distributed. The common or non-prismatic opal is found of many hues, rose-coloured, green, milky, agatoid, and with dendritic markings. Hydrophane is a variety which becomes transparent, and sometimes even shows colours when saturated with water; hyalite is transparent; cacholong is milky and nearly opaque.

Opals are cut with a convex surface; their brilliancy is often increased by moderate warmth.

Root of opal contains veins and specks of opal in a dark-coloured ferruginous matrix, which may be still further darkened by soaking in oil of vitriol. Cameos are sometimes cut so as to show a head or figure in precious opal thrown up against a background of the dark-brown ferruginous matrix of the stone.

QUARTZ.

The purest form of quartz is represented by the colourless rock crystal so largely used for ornamental objects in the cinquecento time, and now employed extensively for optical purposes. It is silica, the oxide of silicon (SiO_2), and contains 46·7 per cent. silicon and 53·3 per cent. oxygen. The coloured varieties contain sometimes very small traces of foreign matters to which it is presumed their colours are due: but there are doubts in many cases as to the exact nature of the causes of these colorations when they are not of merely mechanical or physical origin. The presence of nickel compounds in the green chrysoprase, and of titanium in the rose quartz of Rabenstein is believed to be the cause, in these instances respectively, of the colours of these two varieties of quartz; moreover, there is no doubt that many of the red, green, and brown colours shown by members of this group are due to manganese and iron oxides. Traces of water, alumina, lime, and magnesia also occur, but these ingredients are of little importance as regards the source of the hue of different varieties of quartz.

Quartz crystallizes in the rhombohedral system, its commonest form being a six-sided prism, striated transversely, and terminated by a six-sided pyramid. In amethyst there are many fine undulatory layers, so superimposed that a slice across a crystal shows their triangular section distinctly, and reveals as it is turned round the difference of colour caused by their structure and arrangement. The alternate layers are endowed with right and left handed powers of rotatory polarization. The "rippled" fracture, and the feathery flaws of amethysts are due to these fine layers.

Quartz is doubly refractive: the coloured specimens are dichroic. The indices of refraction for the yellow ray are— $\omega = 1{\cdot}5442$ and $\epsilon = 1{\cdot}5533$. The colours of oppositely polarized rays are, in the case of the amethyst, reddish purple and bluish purple.

The hardness of pure rock crystal is 7, and its specific gravity 2·65. A list of specific gravities of some of the purest forms of quartz will be useful, but it must be remembered that the dark coloured and opaque varieties are much denser, sometimes reaching 2·8.

Milky quartz	2·642	Brown cairngorm	2·656
Pure rock crystal	2·650	Amethyst	2·659
Very dark ditto	2·662		

Quartz may be melted by the aid of the oxyhydrogen blowpipe to a limpid glass having the specific gravity 2·2 and the hardness 5.

The very numerous varieties of quartz cannot be classified accurately, for many of them owe their peculiarities to intruding minerals of many sorts. The quartz cat's-eye includes fine fibres of asbestos or crocidolite; avanturine quartz, minute spangles of iron oxide; and so on. But the pellucid varieties group themselves near rock crystal, while the translucent kinds may be arranged under chalcedony. The former group includes amethyst and cairngorm, the latter sard, chrysoprase, and plasma. We cannot here find space for more than an alphabetical list of the chief members of the great quartz family.

Agate—layers of chalcedony, jasper, rock crystal; also mottled.
Agate-jasper—a variety of agate containing jasper.
Amethyst—transparent, purple, honey yellow or greenish yellow.
Avanturine—transparent, with golden brown iridescent spangles.
Beekite—silicified corals, shells, or limestone, resembling chalcedony.
Bloodstone—translucent to opaque; green with red spots.
Cairngorm—transparent and smoke gray, yellow, or brown.
Cat's-eye—translucent gray or greenish, with chatoyancy.
Chalcedony—cloudy or translucent; white, yellow, brown, blue.

Chrysoprase—translucent; pale bluish green.

Cornelian—translucent, like horn; yellow, brown, red.

Egyptian jasper—opaque, concentric, and other layers of yellow, brown, or black.

Heliotrope—a chalcedonic base, with much green delessite and red spots of iron oxide.

Jasper—opaque; dull red, dull green, and ochre yellow.

Milky quartz—opalescent or milky, yellowish by transmitted light.

Onyx—bands or strata of white, gray, black; translucent to opaque.

Plasma—very translucent; rich leaf green.

Porcelain jasper—sub-translucent, often white and pink.

Prase—translucent but spotted; muddy olive green.

Riband jasper—opaque bands, dull red and dull green; sometimes yellow.

Rock crystal—transparent and colourless.

Rose quartz—translucent and pale pink.

Sapphirine quartz—translucent and pale grayish blue.

Sard—very translucent; red, brownish red, crimson, blood red, blackish red, golden, amber.

Sardonyx—a stratified stone, having one or more strata of sard.

Smoky quartz—transparent; of various hues of gray and brown.

But this list by no means exhausts the varieties of quartz, for of agate alone we have fortification agate, moss agate, and mocha stone, eye agate, and brecciated agate. All of these stones, and indeed the majority of those in the list just given, so far as their colours and markings are natural and not due to artificial treatment, consist of amorphous or crystalline silica, variously arranged or disposed, and associated with colouring oxides and silicates containing oxides of iron, manganese, or nickel. The claim of very few of these varieties of quartz to the rank of precious stones can be sustained. It is not merely that they are abundant, but their brilliancy and beauty are not sufficiently pronounced to entitle them to high rank amongst stones for jewels. The great merit of the artistic work executed in these materials, in Greek, Roman, and cinque-cento times has indeed ennobled the sard, the onyx, the prase, the sapphirine quartz, the jasper, etc.; but except in the forms of camei and intaglie these stones are but little esteemed. Rich deep-coloured amethysts, with the colour not quite uniformly distributed throughout their substance, are perhaps the most prized form of quartz. The colour of such amethysts gains in beauty from the dichroism of the stone and from its peculiar rippled and parquetry structure. Such amethysts are wrongly called *oriental* amethysts by jewellers (some do come from India), for the true oriental amethyst is a purple sapphire, not quartz at all, and an excessively rare stone.

The localities for choice specimens of amethyst, sard, chrysoprase, chalcedony, etc. are legion. The amethysts of Brazil and Ceylon, the agates of Uruguay, the chrysoprases of Silesia, the cornelians of Arabia, and the jaspers of Egypt are famous.

Not only have the dark-coloured onyxes of commerce been artificially dyed or stained, but a large proportion of agates, cornelians, sards, etc. have been similarly altered. A moderate heat reddens many varieties of quartz originally gray and brown, while a soaking in sugar or honey followed by treatment with strong sulphuric acid brings out black and white bands in the natural gray onyx.

LAPIS-LAZULI.

Lapis-lazuli, or azure-stone, is not a definite mineral, but a mixture of a colourless and a blue substance (Haüyne). The latter is the characteristic ingredient, but is difficult of separation from the former. Minute brass yellow specks of iron pyrites are also commonly found in lapis, and sometimes these are so largely developed as to produce a spangled appearance. The lapis was the sapphire of the ancients.

Lapis-lazuli occurs in Transylvania, Siberia, Tartary, Persia, China, and Thibet, also in Brazil. The richly-coloured varieties are used for mosaic work and inlays in bijouterie, vases, furniture, and even in the interior architectural decoration of buildings.

The hardness of lapis-lazuli lies between 5 and 5·5; its specific gravity is about 2·4.

The blue colour of this mineral is not altered by heating, nor by carbonic acid or a solution of alum. Strong acids decompose it, the colour disappearing and sulphuretted hydrogen gas being given off. Although many analyses of lapis-lazuli have been made, the composition (or rather essential constituents of its blue part) has not been precisely determined. It probably contains sulphur in more than one state of combination (as sulphide and as sulphate) about 45 per cent. of silica, 25 per cent. of alumina, with smaller quantities of soda and lime. Ground, washed, and levigated lapis-lazuli forms the permanent paint called "ultramarine" or "genuine ultramarine." This has been very successfully imitated, not only as to colour but as to chemical constituents, by chemical art.

IOLITE,

Called also dichroite and saphir d'eau, is a beautiful and curious stone, remarkable for its pleiochroism. Good specimens, such as are occasionally met with in Ceylon, show in different directions of the crystal a soft blue, a grayish white, and a straw colour. Iolite is frequently full of flaws and almost opaque: its beautiful change of colour is then very imperfectly seen. The hardness of iolite is above 7; its specific gravity is 2·6 to 2·66. One hundred parts of iolite on an average contain about:

Silica	49	Ferrous oxide . . .	7
Alumina	32	Magnesia . . .	9

CROCIDOLITE

Is one of the minerals which has been termed cat's-eye. It occurs of three distinct colours—brownish yellow or gold, indigo or greenish blue, and dull red. When cut *en cabochon* of an oval form, with a high ridge, and with the longer diameter of the oval at right angles to the direction of the fibres or filaments of which the mineral is made up, crocidolite shows a good line of light and presents a brilliant appearance. Crocidolite often contains a chalcedonic base; indeed the best specimens, which now come from Orange River, South Africa, and have a hardness of nearly 7, and specific gravity of 3, are essentially pseudomorphs after crocidolite, and not the unchanged mineral itself, which is softer and heavier. This stone is related to hornblende and asbestos, and has approximately this composition in 100 parts:

Silica	51	Soda	7
Oxides of iron	34	Magnesia	2
Water	3		

Bronzite and Hypersthene are two other minerals, resembling crocidolite in their metallic reflections, and consisting of silica, iron oxides, and magnesia.

LABRADORITE.

Labrador spar is a felspar, crystallizing in the triclinic system. It is usually translucent rather than transparent, and by transmitted light appears of a gray colour. Owing chiefly to a peculiarity in its intimate or minute structure, which resembles a complex system of gratings, labradorite often shows magnificent chatoyant reflections of brilliant blue, sea green, orange, puce, amber, and peach-blossom hues. It should be cut *en cabochon*. It occurs, associated with hypersthene and amphibole, of fine quality, in the island of St. Paul, and in large masses on the coast of Labrador. Labradorite has the hardness 6, and the specific gravity 2·7 to 2·75. In 100 parts it contains:

Silica	55·5	Iron oxides	·31
Alumina	26·5	Lime	11·0
Soda	4·0		

In some specimens there is less lime, but instead, a small percentage of potash and magnesia.

MOONSTONE OR ADULARIA.

This is a variety of felspar, or rather of that species of monoclinic felspar called orthoclase or orthose. Moonstone is found at St. Gothard, and also in Ceylon. It differs from ordinary orthoclase in the remarkable pearly reflection of light which it exhibits in certain directions. Its hardness is 6, and its specific gravity almost invariably 2·58. It contains in 100 parts:

Silica	64½	Alumina	18½
Potash	17		

with traces of soda, lime, and magnesia.

SUNSTONE, OR AVANTURINE FELSPAR,

Is usually a variety of oligoclase, or soda lime felspar, having golden yellow, reddish, or prismatic internal reflections, due to the presence of minute imbedded and scattered crystals of hæmatite, göthite, or mica. Some avanturine is, however, a mixture of albite and orthoclase, and the same name is given to quartz containing brilliant imbedded micacious crystals. The green avanturine, called amazon-stone, is microcline, a felspar.

OBSIDIAN, OR VOLCANIC GLASS,

Is often nothing more than fused or vitreous orthoclase—that is, potash felspar. But obsidian frequently contains many other minerals in small quantities, such as augite and olivine; in fact, obsidian is a melted lava, and contains the various minerals of the lava melted or else associated together. Obsidian when transparent has about the specific gravity 2·4, and is softer than crystalline felspar. Black specimens of it resemble black garnet, spinel, and tourmaline, but are much more translucent in thin splinters, as well as striated and full of bubbles.

EPIDOTE.

The various hues of olive, brownish, and pistachio green which are presented by tourmaline occur also in great measure in epidote. The latter mineral is, however, less dichroic than the former, although in some green Siberian and Brazilian specimens an emerald green image and a yellow one may be seen in the dichroiscope. The hardness of epidote is about 6·5, and its specific gravity 3·3 to 3·4. It occurs in oblique prisms, often much elongated. Green epidote presents in 100 parts about the following composition :

Silica	38	Ferric oxide	15
Alumina	22	Lime	23
Water	2		

AXINITE.

Although almost a curiosity among gem-stones, yet fine crystals of axinite have been cut for ornamental use. It belongs to the triclinic system. The hardness of axinite approaches that of rock crystal, but the brittleness of this substance almost precludes its being cut. It looks well *en cabochon*, and incurs in that form less liability to fracture. The specific gravity of transparent flawless axinite is 3·29; its colour ranges between a pale puce, a plum, and clove brown; it is generally strongly pleiochroic, showing a white or straw yellow, an olive, and a violet or purple image in different directions. The best specimens are found at St. Christophe in Oisans, Isère. The presence of boron in axinite is remarkable: tourmaline is the only other gem-stone in which the element occurs. The percentage composition of axinite approaches—

Silica	43	Manganese dioxide	3
Boron trioxide	5	Potash	1
Alumina	16	Lime	20
Ferric oxide	10	Magnesia	2

SPHENE.

Sphene, or titanite, when transparent and colourless, greenish, or yellow, presents an appearance not unlike that of the precious opal, or fire-opal. Its refractive and dispersive powers on light are strong. The hardness of sphene is about 5·5, and its specific gravity 3·5. It contains in 100 parts about:

Silica	31	Lime	27
Titanium oxide	41	Ferrous oxide	1

DIOPSIDE.

This mineral has been occasionally cut as a gem-stone; it presents a close resemblance to dull green tourmaline or epidote. Its hardness, however, does not exceed 6. The specific gravity of a fine cut diopside was 3·306. Its colour is due to ferrous oxide. It contains about—

Silica	54	Magnesia	18
Lime	24	Ferrous oxide	4

APOPHYLLITE.

Apophyllite can hardly be regarded as a gem-stone, its softness causing its rapid abrasion. The hardness of apophyllite does not exceed 5; its specific gravity is 2·335; its colour varies from nearly transparent white to gray, yellowish, greenish, and flesh red. This mineral crystallizes in the tetragonal system, the forms assumed being usually an octahedron, with the solid angles truncated; the basal planes have a decided pearly lustre, the other faces are merely vitreous.

Apophyllite is found in amygdaloid and related rocks, also in mineral veins, as at the silver mines of Andreasberg in the Hartz. Greenland, Iceland, the Faröe Islands, also Poonah, and Ahmednuggar in India yield fine crystals. It also occurs in many Swedish, Tyrolese, and Transylvanian localities.

Apophyllite is nearly related to the zeolites, and is a hydrated silicate of lime and potash, with a little fluorine. Its percentage composition is represented by the following numbers:

Silica	52	Potash	5·0
Lime	25	Water	16·5
Fluorine	1		

ANATASE.

The rather low hardness of anatase (about 5·8) unfits it for use as a gem-stone, yet its brilliant lustre, lying between the metallic and the adamantine, and the fine indigo blue tint which some specimens show by transmitted light, might suggest its employment. Very beautiful low octahedra of the tetragonal system are found among the crystals of this mineral from Brazil. The specific gravity of anatase is about 4·86; it is nearly pure titanium oxide.

PYRITES.

There are two minerals having the same two elements in the same proportions as constituents, but differing in physical and chemical characters. These two minerals are pyrite or iron pyrites, and marcasite. Both contain iron and sulphur, 46·7 per cent. of iron, and 53·3 per cent. sulphur, corresponding to 1 atom of iron and 2 atoms of sulphur. The properties of the two minerals may be compared thus:

	Pyrite.	Marcasite.
Hardness	6·5	6·0
Specific gravity . . .	5·2	4·8
Crystalline form . . .	Isometric.	Orthorhombic.
Colour	Brass yellow.	Pale or gray yellow.

Pyrites is the more abundant form of this compound of iron and sulphur. It was largely used in jewellery in the eighteenth century, and is often incorrectly spoken of as marcasite. It takes a fine polish and presents the appearance of a metal. It is of no value whatever from a commercial point of view, although a good deal of time and trouble were frequently spent in cutting specimens of it into faceted forms, such as single "roses." Pyrites was used by the ancient Mexicans along with turquoise and obsidian for their mosaic inlays and incrustations. In the Christy collection of the British Museum is a Mexican mask, in which the eyes are represented by hemispheres of pyrites.

HÆMATITE.

Black hæmatite is an oxide of iron occurring under several common names, as specular iron ore, iron glance, and micaceous iron ore. Its powder is red, though a perfectly polished artificial or natural surface presents a metallic black lustre with slight iridescence. It has been employed, cut *en cabochon*, to simulate black pearls. The hardness of the densest hæmatite is 6·5, and its specific gravity 5·3. It contains in 100 parts:

Iron	70	Oxygen	30

AMBER

Is hardly to be reckoned amongst precious materials of mineral origin, for not only is it comparatively abundant, but it is an almost unchanged vegetable product, a fossilised resin of certain conifers of tertiary age. Its specific gravity is about 1·08, and its hardness, 2·5. When traces of moisture and ash are deducted, it contains in 100 parts about:

Carbon	79	Hydrogen	10·5
Oxygen	10·5		

MALACHITE.

Malachite is never used in the higher class of jewellery; its softness, opacity, and crude hue are not in its favour. In Russia veneers of it are employed with very bad effect in the decoration of vases, furniture, and even doors. Its hardness is 4, and its specific gravity 4.

The concentric veinings and markings of malachite, showing its deposition from water, vary in depth of tint and often exhibit a satiny texture.

Malachite belongs to the hydrated carbonates, and is represented by the chemical formula $Cu\ CO_3$, $Cu\ H_2O_2$; it is therefore near chessylite or azurite $2\ Cu\ CO_3$, $Cu\ H_2O_2$. Malachite contains, in percentages, about the following proportions of its three constituents:

Copper oxide	72	Carbon dioxide	20
Water	8		

LUMACHELLA

Is a precious marble. It consists of a brown limestone, in which occur numerous fossil shells, having brilliant fiery red, green, or yellow chatoyant reflections. It comes from Bleiberg in Carinthia, and from Astrakhan. It is an impure carbonate of lime.

PEARL.

Although nearly all those bivalves which have nacreous shells do occasionally produce pearls, there are two mollusks which must be regarded as pearl-bearers *par excellence*. These are the pearl oyster and the pearl mussel: one shell out of four is said to contain a pearl.

The pearl oyster, *Meleagrina margaritifer*, yields the famous pearls of Ceylon, as well as those of the Persian Gulf, Madagascar, Panama, California, and West Australia. From the pearl mussel, *Unio margaritifer*, the pearls of Scotland, North Wales, and the English Lake District are derived. These British pearls possess generally in a very moderate degree that "orient" or iridescent sheen which constitutes the peculiar charm of this gem; but some specimens of great beauty have been found from time to time. A pearl of particular purity from the river Conway, North Wales, was presented to the queen of Charles II. by Sir R. Wynne, and is now in the crown of Queen Victoria. The somewhat clouded "orient" of the majority of Scotch pearls accords well with dead or mat gold, and with many deep-coloured stones.

Pearls are sometimes found having a decided tinge of colour: rose coloured, salmon pink, pale blue, russet brown, olive black, plumbago gray, and black pearls are highly esteemed; dull and muddy hues are less appreciated, and yellowish pearls are of the second rank. Pearls may be dyed easily, and are liable to become discoloured by wear. Pink coral, cut into suitable forms, is often made to simulate pink pearls, but its texture is entirely different, and may be readily recognised with a hand magnifier. Black hæmatite, one of the chief ores of iron, when not too highly polished, makes a passable imitation of the black pearl; but nothing is easier than to detect the imitation, for hæmatite is more than twice as heavy as the pearl.

The substance of the pearl is identical with the nacreous material, the mother-o'-pearl, which lines the interior of the shell. It consists of concentric layers having a regular structure, and made up of carbonate of lime and organic matter. But detached pearls are much harder and denser than mother-o'-pearl, which moreover has its layers superposed in a more or less distinctly rectilinear manner. Now and then a dull pearl, when peeled by mechanical means, or when its surface has been removed by the gently solvent action of a weak acid, will reveal a fine orient beneath, and be consequently greatly improved in appearance.

Pearls are secreted by the "mantle" of the mollusk, and in the same way that the shell itself is formed. The Chinese sometimes introduce small metal figures of Buddha between the shell and the mantle of a pearl mussel. After the lapse of some time the figures become completely coated with a layer of the pearly substance. Specimens of this curious artifice may be seen in the Museum of Practical Geology. But although the irritation caused by a wound, or by the introduction of a foreign substance, such as a bit of metal, a grain of sand, or a fragment of shell, undoubtedly does cause the secretion of pearl, yet there are many pearls which betray no sign of such an origin.

The value of pearls is increased greatly when a considerable number of well-matched specimens are got together. But the market value of pearls depends upon so many factors that, even for a single pearl of what may be called standard quality, and perfectly spherical form, the price can hardly be stated with exactness. Such a pearl is perhaps worth £10 if it weigh 1 carat, four times as much if it weigh 2 carats, and eight times as much if it weigh 4 carats. Button-pearls, which have one side convex and the other flat, are less valuable than round pearls, but pear-shaped pearls often fetch more. The large irregular and grotesque pearls called *baroque* acquire value when set into curious figures—busts, fruits, etc.—by the aid of gold and enamel mountings. Fantastic arrangements of this kind exercised the skill of many 16th and 17th century jewellers, but the artistic merit of these productions cannot be appraised very highly; the chief excuse for their existence must be sought in the difficulty of making any other use of the mis-shapen pearls in question. The Green Vaults of Dresden are rich in specimens of this sort. It should be mentioned that the majority of pearls used in ordinary jewellery are half-pearls, that is pearls sawn in half. Seed pearls, the small pearls attached as pendants to jewels, the pearls sown on garments, and necklace pearls, are perforated by careful drilling.

Pearls have been used in almost all parts of the world, and from very early times, for jewellery and personal adornment. The pearls set in antique Roman ornaments have rarely survived intact to the present day. Sometimes the place of a pearl in the setting is represented by a small brownish residue; sometimes the reduced form of the pearl is still to be seen, deprived of much of its lustre by the long-continued action of water charged with carbonic and vegetable solvent acids from the earth.

CORAL.

The use of coral in jewellery justifies us in adding a few words here concerning this product of animal origin. All the white pink and red coral used for objects of personal adornment is derived from a single species, *Corallium rubrum*, belonging to the family Gorgonidæ, order Alcyonaria, class Actinozoa, and sub-kingdom

Cœlenterata; the rare black coral, which is entirely horny and has but a trace of earthy matter in its composition, belongs to another order, Zoantharia. The solid compact part of the coral animal, or polypdom, in the case of *Corallium rubrum*, is mainly calcium carbonate (carbonate of lime), with small quantities of magnesium carbonate, iron oxide, and organic matter; the exact nature of the red colouring matter remains unknown.

Coral is mainly obtained from the Mediterranean, the coasts of Provence, Majorca, Minorca, and North Africa being the best localities. The coral grows on rocks at depths varying from 30 to 130 fathoms, but a depth of 80 fathoms is considered most favourable.

The price of coral varies much—from five shillings to £120 the ounce; the pale rose-pink variety is the most esteemed.

A good series of specimens of coral was bequeathed to the South Kensington Museum in 1870 by Mr. Alfred Davis; it is now in the Branch Museum at Bethnal Green.

INDEX OF NAMES OF PRECIOUS STONES.

BIBLIOGRAPHICAL NOTES.

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THE TOWNSHEND COLLECTION

OF

PRECIOUS STONES.

In the year 1869 the South Kensington Museum became possessed of a valuable collection of precious stones, under the provisions of the will (dated 6 August, 1863) of the Rev. Chauncy Hare Townshend. The following extract from the will refers to this bequest:

I, Chauncy Hare Townshend, late of Down Hill, in the parish of Tottenham High Cross, in the county of Middlesex, and now of Norfolk Street, Park Lane, in the Parish of Saint George, Hanover Square, in the said county, Clerk, do hereby revoke all Wills and other Testamentary Dispositions heretofore made by me, and declare this to be my last Will and Testament. I appoint my friends Burdett Coutts of Stratton Street, Piccadilly, in the said county of Middlesex, spinster, and the Reverend Thomas Helmore, Master of Her Majesty's Choir at the Chapel Royal, St. James's, trustees and executors of this my will. I give and bequeath to the Right Honourable Granville George Leveson Gower, Earl Granville, or other the President of Her Majesty's Council on Education for the time being charged with the promotion of Art Education, now undertaken by the Department of Science and Art, such of my pictures and water-colour drawings, and engravings and books containing engravings, as his Lordship, or other the President aforesaid, may think fit to select; and my collection of Swiss coins, and my box of precious stones (including such as are generally kept therein, but which in my absence from England may be with me on the Continent); and my box of cameos (which boxes, for the sake of identity, I declare to be those which in my absence from England are always deposited for safe custody with my bankers); and the ancient gold watch formerly belonging to my father, which, being stolen by the celebrated Barrington, was the cause of his transportation, together with the chain, seal, and keys thereunto attached; and also the looking-glass and frame over the dining-room chimney-piece, which frame was carved by Grinling Gibbon, on condition that the said several articles be never sold or exchanged, but to the intent that the same may be deposited and kept in the South Kensington Museum, or any other suitable place which may be provided in substitution for that Museum, and exhibited to the public with the other Works of Art which now are or may be therein.

The Townshend collection of precious stones contains 154 specimens, nearly all of them mounted in gold, as rings. A considerable number of these specimens once formed part of the famous "Hope collection," and appear in the "Catalogue of the Collection of Pearls and Precious Stones formed by H. P. Hope," described by B. Hertz, 1839. Two copies of this catalogue are in the Art Library, Victoria and Albert Museum. One of these copies contains MS. additions, and belonged to Mr. H. Hope, and then to Mr. Townshend: in it are entries giving the prices paid for many of the specimens. Many of the specimens are figured in Hertz's "Catalogue"; fifty of these illustrations, representing stones now in the Victoria and Albert Museum, have been reproduced for the present volume. Mr. Townshend's bequest to the Museum included, besides the above precious stones, 41 other specimens (Nos. 1791—'69, to 1831—'69). These are engraved gems, some antique and some modern, chiefly in onyx, cornelian, and sard. One example, however, is on turquoise, and is remarkable for its size; it is an irregular octagon, 2 inches long by rather more than 1½ inch broad.

A catalogue of the Townshend gems was written by the late Professor Tennant, and published by the Science and Art Department in 1870. The author of the present Handbook of Precious Stones has submitted each specimen to such an examination as could be managed with cut and mounted stones, and has been enabled to correct some of the attributions. These corrections were first made by him in "The Spectator" of July 9th, 1870; they were reproduced in "The Quarterly Journal of Science" for January, 1871, and were adopted by Mr. Hodder M. Westropp in his "Manual of Precious Stones," published in 1874.

No strictly scientific classification of precious stones is possible. Those in the Townshend collection have been described in the same order as that adopted in chapter vii. It so happens that the diamond, as consisting of the pure element *carbon*, takes for every reason the first place; while the sapphire and ruby, as varieties of corundum, the oxide of aluminium, naturally fall into the second position. Other species are grouped roughly in accordance with some prominent constituent:

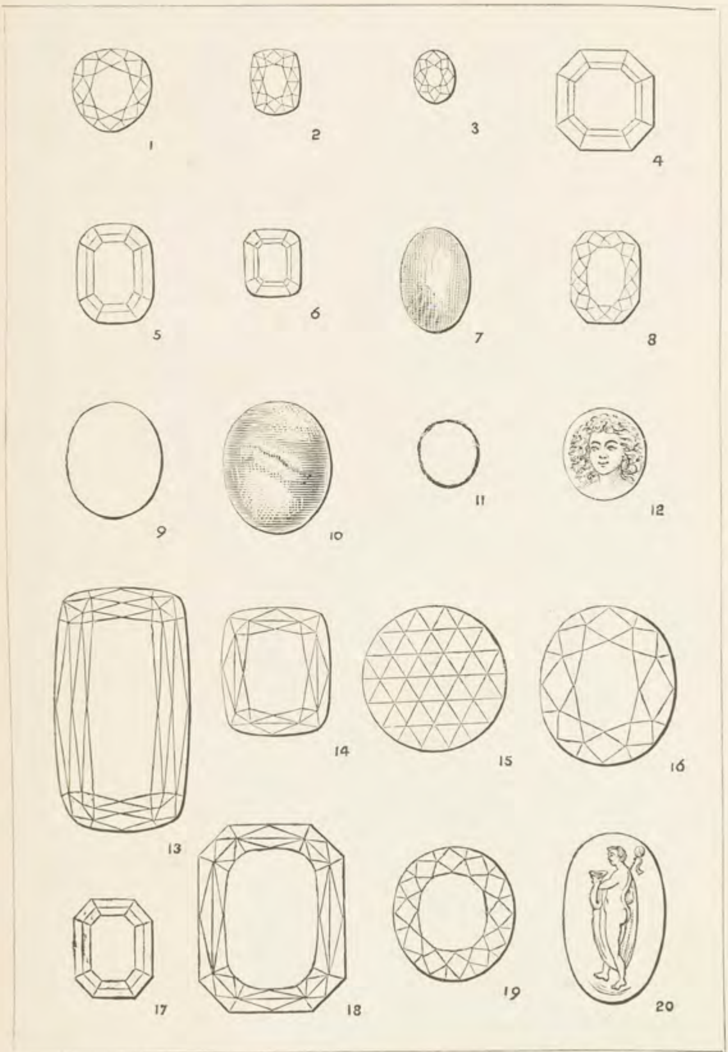
Characteristic element.	
CARBON . .	Diamond.
ALUMINIUM .	Corundum, spinel, turquoise, topaz, tourmaline, garnet.
MAGNESIUM .	Peridot.
GLUCINUM .	Beryl, chrysoberyl, phenakite, euclase.
ZIRCONIUM .	Zircon.
SILICON . .	Opal, quartz, iolite, moonstone.

INDEX OF SPECIMENS IN THE TOWNSHEND COLLECTION.

CHIEF SPECIES AND VARIETIES NOT REPRESENTED IN THE TOWNSHEND COLLECTION.

Alexandrite. Axinite. Fossil Turquoise. Green Garnet. Phenakite. Sphene. Spodumene.

PLATE I.—Diamonds, Corundums, Turquoise, Topazes, Tourmalines, Garnets.



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CATALOGUE OF
THE TOWNSHEND COLLECTION.

DIAMOND.

DIAMOND. A natural crystal of octahedral form, having curved faces, and with its edges replaced, and so passing into a dodecahedron ; $\frac{1}{3}$ in. diam. ; claw setting on swing mount. 1172—'69.

DIAMOND. Black, brilliant-cut, nearly circular ; $\frac{1}{4}$ in. diam. ; bordered with 14 small roses ; coronet mount. 1173—'69.

DIAMOND. Colourless, brilliant-cut, nearly circular ; $\frac{5}{12}$ in. diam. ; silver claw setting, on chased gold shank. 1174—'69.

DIAMOND. Honey yellow. brilliant-cut, circular ; $\frac{5}{12}$ in. diam. ; with 8 roses, one on each point of the coronet mount. (Hope catalogue, p. 27, No. 19.) Plate I. fig. 1. 1177—'69.

DIAMOND. Pale grayish green, brilliant-cut ; $\frac{5}{16}$ by $\frac{1}{4}$ in. ; with 6 roses, one on each point of the coronet mount. (Hope catalogue, p. 28, No. 24.) Plate I. fig. 2. 1176–'69.

DIAMOND. Bluish gray, brilliant-cut, circular ; $\frac{1}{4}$ in. diam. ; bordered with 12 brilliants set in silver, on gold mount. 1175—'69.

DIAMOND. Pale indigo blue, brilliant-cut ; $\frac{9}{16}$ in. by $\frac{7}{16}$ in. ; bordered with 12+6=18 brilliants. 1179—'69.

DIAMOND. Pale pinky cinnamon hue, brilliant-cut ; $\frac{3}{16}$ in. by $\frac{1}{8}$ in. ; bordered with 12 small brilliants set in silver, on the openwork mount. (Hope catalogue, p. 27, No. 15.) Plate I. fig. 3. 1178—'69.

CORUNDUM (*including Sapphire and Ruby*).

SAPPHIRE. White, with very pale bluish gray hue, faceted, octagonal, diam. $\frac{17}{32}$ in. ; coronet mount. (Hope catalogue, p. 40, No. 19.) Plate I. fig. 4. 1257—'69.

SAPPHIRE. Straw yellow at the ends, and pale gray in the middle, oval oblong; $\frac{1}{2}$ in. by $\frac{6}{16}$ in. and $\frac{6}{16}$ in.; thick coronet mount. (Hope catalogue, p. 40, No. 13.) Plate I. fig. 5. 1256—'69.

SAPPHIRE. Yellow, faceted, oval, $\frac{2}{3}$ in. by $\frac{1}{2}$ in.; coronet mount. 1312—'69.

SAPPHIRE. Apricot colour, octagonal oblong, step-cut; $\frac{7}{16}$ in. by $\frac{5}{16}$ in.; bordered with 34 roses, openwork mount. (Hope catalogue, p. 36, No. 13.) Plate I. fig. 6. 1260—'69.

SAPPHIRE. Pale lavender blue, *en cabochon*, prismatic by reason of a flaw, long oval; $\frac{13}{24}$ in. by $\frac{6}{16}$ in.; coronet mount. (Hope catalogue, p. 42, No. 31.) Plate I. fig. 7. 1238—'69.

SAPPHIRE. Deep blue, oblong; $\frac{5}{12}$ in. by $\frac{5}{16}$ in.; with 3 brilliants on each shoulder of the ring, and 4 small roses on the claws of the setting. 1239—'69.

SAPPHIRE. Deep blue, nearly circular; $\frac{7}{16}$ in. diam.; with 2 pear-shaped brilliants ($\frac{1}{3}$ in. by $\frac{1}{4}$ in.) on the shoulders, and 10 small brilliants in the setting. 1240—'69.

SAPPHIRE. Blue, *en cabochon*, oval; $\frac{9}{16}$ in. by $\frac{7}{16}$ in.; claw mount. 1241—'69.

SAPPHIRE. Blue, faceted, egg-shaped; $\frac{3}{4}$ in. by $\frac{1}{2}$ in. and $\frac{9}{16}$ in. thick; coronet mount. 1242—'69.

STAR SAPPHIRE. Pale gray blue, *en cabochon*, oval; $\frac{1}{2}$ in. by $\frac{9}{16}$ in.; plain mount. 1243—'69.

STAR SAPPHIRE. Blue, octagonal, *en cabochon*; $\frac{25}{32}$ in. by $\frac{21}{32}$ in.; bordered with 47 small brilliants and a socket for another; in silver setting on openwork mount. 1244—'69.

STAR SAPPHIRE. Pale blue, hemispherical; $\frac{1}{2}$ in. diam.; bordered with 2 circles of diamonds (26 + 24), and with 27 diamonds on each shoulder of the ring. 1245—'69.

STAR SAPPHIRE. Pale blue, squarish, with corners rounded; $\frac{9}{16}$ in. diam.; coronet mount. 1246—'69.

SAPPHIRE. Violet or amethystine—the oriental amethyst; faceted oval; $\frac{7}{16}$ in. by $\frac{3}{8}$ in.; bordered with 24 roses set in silver, and bearing 6 brilliants and 2 roses on each shoulder. (Hope catalogue, p. 39, No. 10.) Plate I. fig. 8. 1247—'69.

SAPPHIRE. Violet or amethystine—the oriental amethyst; oblong, faceted; $\frac{11}{24}$ in. by $\frac{8}{24}$ in.; bordered by 44 roses set in silver on openwork mount. 1277—'69.

SAPPHIRE. Lavender, faceted, rounded oblong; $\frac{5}{12}$ in. by $\frac{6}{16}$ in.; coronet mount. 1248—'69.

RUBY. Pale claret colour, faceted, oblong; $\frac{1}{2}$ in. by $\frac{9}{32}$ in.; coronet mount. 1280—'69.

RUBY. Fine red, faceted; $\frac{1}{4}$ in. by $\frac{3}{16}$ in.; bordered with 12 brilliants; solid mount. 1249—'69.

RUBY. Rich red, Indian polished, subovate; $\frac{3}{8}$ in. by $\frac{3}{8}$ in.; set with 2 brilliants and 10 small roses; coronet mount. 1252—'69.

RUBY. Rich red, faceted, oblong, with corners rounded; $\frac{1}{2}$ in. by $\frac{7}{16}$ in.; bordered with 22 brilliants and 2 roses; openwork mount. 1253—'69.

RUBY. Red, faceted, with rounded ends; $\frac{7}{16}$ in. by $\frac{5}{16}$ in. (flaw at one corner); with 14+8 brilliants and 2 roses as border, and on shank openwork mount. 1254—'69.

RUBY. Rich red, faceted, circular; $\frac{5}{16}$ in. diam.; with 12+6 brilliants and 2 roses on edge and shank; openwork mount. 1255—'69.

STAR RUBY. Pink, *en cabochon*, hemispherical; $\frac{13}{16}$ in diam.; claw mount. 1250—'69.

STAR RUBY. Rich colour, *en cabochon*, oval; $\frac{13}{24}$ in. by $\frac{1}{2}$ in.; bordered with 35 brilliants; openwork mount. (Hope catalogue, p. 34, No. 14.) Plate I. fig. 9. 1251—'69.

CORUNDUM. Translucent clove brown, with gray chatoyancy, and with iridescence through a flaw; *en cabochon*, oval; $\frac{8}{12}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 42, No. 27.) Plate I. fig. 10. 1258—'69.

CORUNDUM. Translucent, wine coloured, *en cabochon*, oval; $\frac{3}{8}$ in. by $\frac{5}{16}$ in.; bordered with 16 roses set in silver on a swing mount. (Hope catalogue, p. 37, No. 15.) Plate I. fig. 11. 1259—'69.

SPINEL.

SPINEL. Ruby red, faceted; $\frac{7}{16}$ in. by $\frac{3}{8}$ in.; surrounded on edge and shank by 14 + 8 brilliants + 14 + 31 roses—altogether 67 diamonds; openwork mount. 1326—'69.

SPINEL. Ruby red, square, step-cut; $\frac{5}{8}$ in.; surrounded on edge and shank by 20 + 16 = 36 brilliants; set lozenge-wise on a plain mount. 1327—'69.

SPINEL. Pale purple, faceted, back step-cut; $\frac{1}{2}$ in. by $\frac{1}{4}$ in.; bordered with 37 rose diamonds in openwork mount. 1192—'69.

SPINEL. Indigo blue, faceted; $\frac{3}{8}$ in. by $\frac{5}{16}$ in.; bordered with 18 rose diamonds set in silver on openwork mount. 1325—'69.

TURQUOISE.

TURQUOISE. Greenish blue, cut with a female head in relief, nearly circular; $\frac{5}{12}$ in. diam.; solid mount. (Hope catalogue, p. 91, No. 7.) Plate I. fig. 12. 1261—'69.

TURQUOISE. Dark rich blue, somewhat mottled and dull, oval, cut *en cabochon*; $\frac{1}{2}$ in. by $\frac{9}{24}$ in.; bordered with 14 rose-cut diamonds, each in a little floret, and with an outer oval of 14 brilliant-cut diamonds, 3 brilliants on each shoulder of the openwork ring—altogether 34 diamonds. 1262—'69.

TURQUOISE. Blue, somewhat earthy, oval, cut *en cabochon*; $\frac{1}{3}$ in. by $\frac{1}{4}$ in.; bordered with 14 brilliants; openwork mount. 1263—'69.

TURQUOISE. Fine blue, oval, cut *en cabochon*; $\frac{5}{12}$ in. by $\frac{7}{24}$ in.; broad and thick gold ring. 1264—'69.

TURQUOISE. Deep blue, oval, nearly flat; $\frac{1}{2}$ in. by $\frac{9}{24}$ in.; solid mount. 1265—'69.

TURQUOISE. Rather pale and somewhat greenish blue, heart-shaped, inlaid with gold wires; Persian; $\frac{3}{4}$ in. by $\frac{1}{2}$ in.; coronet mount. 1266—'62.

TOPAZ.

TOPAZ. Colourless, brilliant-cut, nearly square, rounded corners; $\frac{7}{12}$ in. diam.; coronet mount. 1308—'69.

TOPAZ. Sherry yellow, faceted oval; $\frac{13}{16}$ in. by $\frac{5}{8}$ in.; bordered with 36 diamonds set in silver on an openwork mount. 1310—'69.

TOPAZ. Yellow, faceted oblong; 1 $\frac{3}{12}$ in. by $\frac{8}{12}$ in., and $\frac{5}{12}$ in. thick; coronet mount. (Hope catalogue, p. 65, No. 5.) Plate I. fig. 13. 1311—'69.

TOPAZ. Rich yellow, faceted oblong, with slightly convex sides; 1 $\frac{1}{12}$ in. by $\frac{11}{12}$ in., and $\frac{7}{12}$ in. thick; coronet mount. 1313—'69.

TOPAZ. Yellow, with flaws along cleavage planes, step-cut, octagonal oblong; $\frac{9}{16}$ in. by $\frac{6}{16}$ in.; solid mount, with four claws. 1314—'69.

TOPAZ. Light brown, brilliant-cut; $\frac{1}{2}$ in. by $\frac{9}{24}$ in.; coronet mount. 1315—'69.

TOPAZ. Deep wine yellow, faceted oval; $\frac{11}{12}$ in. by $\frac{8}{12}$ in., and $\frac{5}{12}$ in. thick; coronet mount. 1195—'69.

TOPAZ. Rose pink, faceted oblong; $\frac{15}{24}$ in. by $\frac{11}{24}$ in.; coronet mount. 1188—'69.

TOPAZ. Deep rose pink or light claret, faceted oblong; $\frac{15}{24}$ in. by $\frac{13}{24}$ in.; bordered by 34 roses set in silver on openwork mount. (Hope catalogue, p. 67, No. 16.) Plate I. fig. 14. 1309—'69.

TOPAZ. Pink, oblong; $\frac{5}{8}$ in. by $\frac{1}{2}$ in.; bordered by 36 roses set in silver on openwork mount. 1317—'69.

TOPAZ. Sea blue, faceted oval; $\frac{18}{24}$ in. by $\frac{15}{24}$ in., and $\frac{11}{24}$ in. thick; coronet mount. 1316—'69.

TOURMALINE.

TOURMALINE. Rubellite, cloudy red, rose cut, flat at back; $\frac{3}{4}$ in. diam.; coronet mount. (Hope catalogue, p. 72, No. 27.) Plate I. fig. 15. 1320—'69.

TOURMALINE. Rich brown, faceted; $\frac{19}{24}$ in. by $\frac{14}{24}$ in.; coronet mount. (Hope catalogue, p. 71, No. 19.) Plate I. fig. 16. 1275—'69.

TOURMALINE. Deep green, oblong faceted; $\frac{13}{24}$ in. by $\frac{5}{12}$ in.; coronet mount. (Hope catalogue, p. 52, No. 2.) Plate I. fig. 17. 1321—'69.

TOURMALINE. Deep green, oblong table, with step-cut bezil, back step-cut; 1 in. by $\frac{3}{4}$ in., and $\frac{5}{12}$ in. thick; coronet mount. (Hope catalogue, p. 70, No. 3.) Plate I. fig. 18. 1323—'69.

TOURMALINE. Indicolite, indigo blue, oval faceted; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. 1319—'69.

TOURMALINE. Nearly black, large table, faceted, almost square; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. 1294—'69.

GARNET.

GARNET. Pyrope of blood-red colour, round, rose-cut; $\frac{1}{4}$ in. diam., with border of 9 brilliants set in the broad edge of the plain solid ring. 1269—'69.

GARNET. Seven pyropes of blood-red colour set in a cluster on a plain mount. 1276—'69.

GARNET. Carbuncle cut *en cabochon* and set on foil, oval; $\frac{11}{12}$ in. by $\frac{8}{12}$ in.; solid claw mount. 1270—'69.

GARNET. Almandine, of crimson colour, faceted, nearly circular; $\frac{17}{24}$ in. by $\frac{15}{24}$ in.; coronet mount. (Hope catalogue, p. 61, No. 13.) Plate I. fig. 19. 1271—'69.

GARNET. Almandine, cut *en cabochon*, with hollowed back, engraved with a faun; $\frac{5}{8}$ in. by $\frac{1}{2}$ in.; plain mount. (Hope catalogue, p. 62, No. 24.) Plate I. fig. 20. 1272—'69.

GARNET. Almandine, flat, escutcheon-shaped; $\frac{4}{12}$ in. by $\frac{3}{12}$ in.; claw mount. 1278—'69.

GARNET. Deep red, faceted, octagonal; $\frac{7}{12}$ in. diam.; openwork claw mount. 1273—'69.

GARNET. Brownish red, faceted, oblong; $\frac{13}{24}$ in. by $\frac{5}{12}$ in.; bordered with 47 rose diamonds, set in silver on openwork mount. (Hope catalogue, p. 62, No. 23.) Plate II. fig. 21. 1274—'69.

GARNET. Essonite, or cinnamon-stone, of aurora red hue, faceted; $\frac{7}{8}$ in. by $\frac{23}{32}$ in.; coronet mount. 1279—'69.

GARNET. Essonite, or cinnamon-stone, of aurora red hue, carved in high relief with a bust; plain mount. 1306—'69.

GARNET. Essonite, or cinnamon-stone, of aurora red hue, oblong; $\frac{6}{16}$ in. by $\frac{1}{3}$ in.; light coronet mount. 1307—'69.

GARNET. Essonite, or cinnamon-stone, of aurora red hue, oblong with rounded corners, faceted; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. (Hope catalogue, p. 53, No. 6.) Plate II. fig. 22. 1318—'69.

PERIDOT.

PERIDOT. Leaf green, engraved with hermaphrodite, tree, and Greek inscription: nearly circular; $\frac{8}{12}$ in. diam.; plain mount. (Hope catalogue, p. 84, No. 7.) 1300—'69.

PERIDOT. Leaf green, octagonal oblong, step-cut, $1\frac{1}{4}$ in. by $1\frac{1}{8}$ in.; coronet mount. 1301—'69.

PERIDOT. Leaf green, rounded oblong, faceted; $\frac{10}{12}$ in. by $\frac{9}{12}$ in.; and $\frac{5}{12}$ in. thick; solid mount. 1302—'69.

PERIDOT. Rich leaf green, table slightly convex, back, barrel-shaped, with faceted ends; 1 1/4 in. by 11/12 in. and 8/12 in. thick; coronet mount. 1303—'69.

BERYL (*including Emerald and Aquamarine*).

EMERALD. Fine colour, polished flat, engraved with Persian characters, oval; 27/32 in. by 21/32 in.; coronet mount. (Hope catalogue, p. 45, No. 7.) Plate II. fig. 23. 1283—'69.

EMERALD. Perfect colour, step-cut, square, set lozenge-wise; 7/16 in. diam.; bordered with 24 single-cut brilliants, and having on each shoulder of the ring 4 brilliants and 2 roses. 1284—'69.

EMERALD. With six-rayed black star, subglobular, with face and back centrally flattened, circular, 1/2 in. diam.; plain swing mount. (Hope catalogue, p. 46, No. 9.) Plate II. fig. 24. 1285—'69.

AQUAMARINE. Sea green, faceted, large table, round; 1 10/12 in. diam., and 1 1/6 in. thick; coronet-mounted handle. (Hope catalogue, p. 49, No. 6.) Plate II. fig. 25. 1286—'69.

AQUAMARINE. Yellowish green, faceted, large table, oval; 1 7/12 in. by 1 1/3 in., and 11/12 in. thick; coronet-mounted handle. (Hope catalogue, p. 49, No. 4.) Plate II. fig. 26. 1287—'69.

AQUAMARINE. Perfect sea green, faceted, large table, oval, 1 10/12 in. by 1 1/2 in. and 1 in. thick; coronet-mounted handle. (Hope catalogue, p. 48, No. 3.) Plate II. fig. 27. 1288—'69.

AQUAMARINE. Bluish sea green, faceted, long oblong; 1 1/6 in. by 7/12 in., and 5/12 in. thick; coronet mount. (Hope catalogue, p. 50, No. 12.) Plate II. fig. 28. 1289—'69.

AQUAMARINE. Pale greenish gray, nearly colourless, step-cut, nearly square; 12/24 in. by 11/24; coronet mount. (Hope catalogue, p. 53, No. 4.) Plate II. fig. 29. 1293—'69.

CHRYSOBERYL (*including Cymophane and true Cat's-eye*).

CHRYSOBERYL. Yellow, faceted, nearly circular; 1 in. by 15/16 in.; coronet mount. 1297—'66.

CHRYSOBERYL. Pale yellowish green, brilliant cut; 11/16 in. by 9/16 in.; coronet mount. 1304—'69.

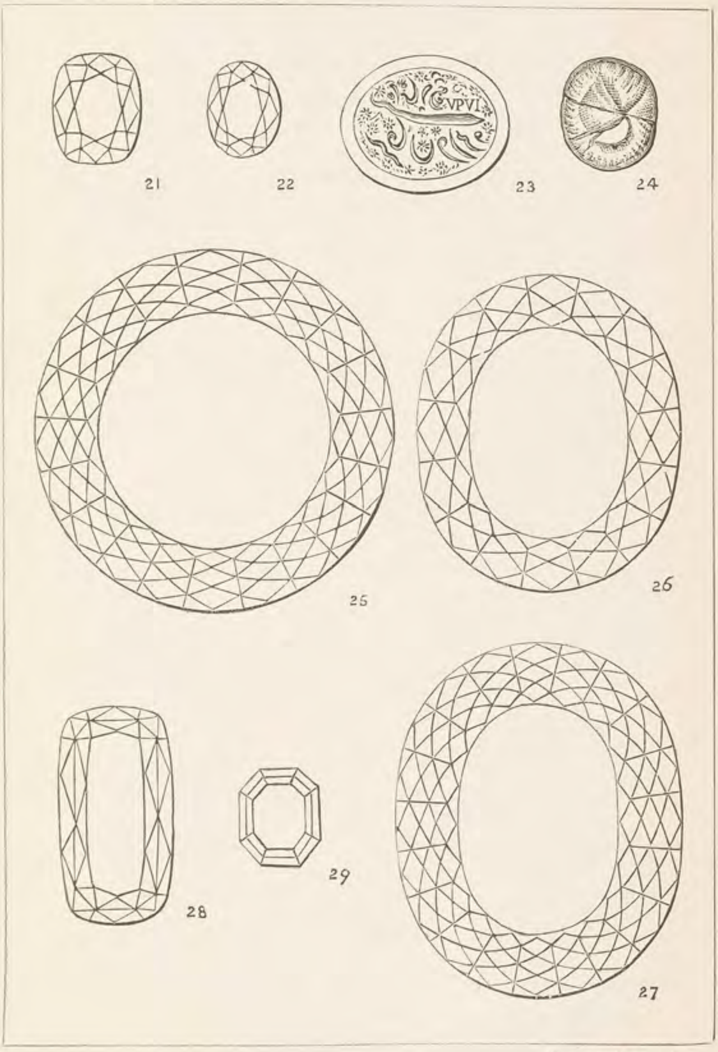
CHRYSOBERYL. Cymophane, showing band of pearly light, circular, cut *en cabochon*; 3/4 in. diam.; bordered with 16 diamonds set in silver on open-work mount. 1328—'69.

CHRYSOBERYL. Cymophane; 5/8 in. by 9/16 in.; coronet mount. 1329—'69.

CHRYSOBERYL. Cymophane; 11/16 in. by 1/2 in.; bordered with 28 small brilliants; plain claw mount. 1330—'69.

CHRYSOBERYL. Cymophane, greenish brown, oval, cut *en cabochon*; 11/16 in. diam.; coronet mount. 1331—'69.

PLATE II.—Garnets, Beryls.



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CHRYSOBERYL. Cymophane, oval, cut *en cabochon*, band of white light; $\frac{17}{24}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 57, No. 10.) Plate III. fig. 30. 1332—'69.

CHRYSOBERYL. Cymophane of dark green colour with band of bluish light, oval, cut *en cabochon*; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. (Hope cataiogue, p. 58, No. 19.) Plate III. fig. 31. 1338—'69.

ZIRCON.

ZIRCON, or JARGOON. Rich brown; $\frac{5}{8}$ in. by $\frac{4}{8}$ in.; plain mount. 1282—'69.

ZIRCON, or JARGOON. Sherry yellow, slightly opalescent, brilliant-cut; diam. $\frac{11}{24}$ in.; coronet mount. 1281—'69.

ZIRCON, or JARGOON. Pale opalescent green; $\frac{9}{24}$ in. by $\frac{8}{24}$ in.; brilliant-cut, plain mount. 1305—'69.

ZIRCON, or JARGOON. Leaf green, faceted; $\frac{7}{12}$ in. by $\frac{6}{12}$ in.; plain mount. 1322—'69.

ZIRCON, or JARGOON. Brownish green, brilliant-cut, oval; $\frac{5}{8}$ in. by $\frac{5}{8}$ in.; coronet mount. (Hope catalogue, p. 56, No. 3.) Plate III. fig. 32. 1194—'69.

ZIRCON, or JARGOON. Brownish green, long oval; $\frac{10}{16}$ in. by $\frac{7}{16}$; plain claw mount. (Hope catalogue, p. 57, No. 6.) Plate III. fig. 33. 1298—'69.

OPAL.

OPAL. Precious, with patches of brilliant colour (the *harlequin* opal), heart-shaped; $\frac{12}{16}$ in. by $\frac{9}{16}$ in.; bordered with 34 roses, and having 2 roses and 4 brilliants on each shoulder of the shank; openwork mount. 1220—'69.

OPAL. Precious, with brilliant red, yellow, and green flashes; oval; $\frac{3}{4}$ in. by $\frac{1}{2}$ in.; bordered with 34 diamonds set in silver, and having 3 diamonds on each shoulder of the shank; openwork mount. 1221—'69.

OPAL. Precious, long pear-shaped; $\frac{7}{12}$ in. by $\frac{4}{12}$ in.; open blue-enamelled coronet mount, with 6 claws, a brilliant on each claw, and 6 brilliants in the hollows between the claws. 1222—'69.

OPAL. Precious, with large colour flashes, oval; $\frac{9}{16}$ in. by $\frac{7}{16}$ in.; bordered with 24 brilliants; plain mount. 1223—'69.

OPAL. Precious, oval; $\frac{1}{3}$ in. by $\frac{5}{24}$ in.; bordered with 16 roses; openwork mount. 1224—'69.

OPAL. Precious, with broad flashes of colour, long oval; $\frac{3}{8}$ in. by $\frac{6}{16}$ in.; claw mount, with blue enamel between the claws. 1225—'69.

OPAL. Precious; Mexican; a *fire-opal* of deep amber colour, with red and green flashes, long oval; $\frac{2}{3}$ in. by $\frac{5}{12}$ in.; blue enamelled border, on gold mount. (Hope catalogue, p. 79, No. 26.) Plate III. fig. 34. 1226—'69.

OPAL. Precious; Hungarian; very brilliant *harlequin* colours; circular; $\frac{5}{12}$ in. diam.; coronet mount, on chased shank. (Hope catalogue, p. 78, No. 19.) Plate III. fig. 35. 1227—'69.

OPAL. Precious; Hungarian, oval; $\frac{11}{16}$ in. by $\frac{9}{16}$ in.; plain mount with claws. (Hope catalogue, p. 79, No. 28.) 1228—'69.

OPAL. Precious; a *fire-opal* of deep amber colour, with orange and green flashes, oval; $\frac{5}{8}$ in. by $\frac{1}{2}$ in.; plain mount. 1229—'69.

OPAL. Precious Hungarian, pinkish gray, oval; $\frac{3}{4}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 81, No. 42.) Plate III. fig. 35. 1230—'69.

OPAL. Precious Hungarian, liver colour, with purple flashes, ovate; $\frac{1}{2}$ in. by $\frac{3}{8}$ in.; plain mount. (Hope catalogue, p. 81, No. 39.) Plate III. fig. 36. 1231—'69.

OPAL. Hungarian, one-third white, with coloured flashes, two-thirds brown, oval; $\frac{1}{2}$ in. by $\frac{6}{16}$ in.; coronet mount. (Hope catalogue, p. 80, No. 34.) Plate III. fig. 37. 1232—'69.

OPAL. Mexican; deep brown, with play of green light, oval; $\frac{13}{16}$ in. by $\frac{5}{8}$ in.; coronet mount. (Hope catalogue, p. 78, No. 22.) Plate III. fig. 38. 1233—'69.

OPAL. Hungarian, gray, with black dendrites and greenish blue flashes, triangular; $\frac{1}{2}$ in. across; coronet mount. (Hope catalogue, p. 80, No. 33.) Plate III. fig. 39. 1234—'69.

OPAL. Honey yellow, with dendrites, nearly hemispherical; $\frac{3}{4}$ in. by $\frac{5}{8}$ in.; coronet mount. 1235—'69.

OPAL. Honey yellow, faceted, circular; $\frac{7}{24}$ in. diam.; coronet mount. 1236—'69.

QUARTZ (*including Cairngorm, Amethyst, Plasma, Chrysoprase, Chalcedony, Agate, and Onyx*).

ROCK CRYSTAL. Colourless, circular, brilliant cut; $\frac{1}{2}$ in. diam.; coronet mount. 1180—'69.

CAIRNGORM, OR SMOKY QUARTZ. Octagonal faceted; $\frac{10}{12}$ in. by $\frac{6}{12}$ in.; coronet mount. 1181—'69.

CAIRNGORM. Straw yellow, faceted; $\frac{5}{8}$ in. by $\frac{9}{12}$ in., and $\frac{5}{8}$ in. thick; coronet mount. (Hope catalogue, p. 86, No. 9.) Plate III. fig. 40. 1182—'69.

CAIRNGORM. Yellow, oval; 1 in. by $\frac{3}{4}$ in.; claw mount. 1183—'69.

CAIRNGORM. Yellow, with feather, consisting of many minute cavities, faceted, oblong; $1\frac{2}{12}$ in. by $1\frac{1}{12}$ in., and $\frac{1}{2}$ in. thick; coronet mounted handle. 1185—'69.

AMETHYST AND CAIRNGORM. Purple and smoky, twin stone, each half long oval, faceted, and $\frac{17}{24}$ in. by $\frac{1}{3}$ in.; plain mount. (Hope catalogue, p. 86, No. 10.) Plate III. fig. 41. 1186—69.

AMETHYST. Oval, biconvex lens, containing four large cavities, with movable liquid and bubbles; 1 in. by $\frac{3}{4}$ in.; plain swing mount. (Hope catalogue, p. 85, No. 1.) Plate III. fig. 42. 1187—69.

AMETHYST. Heart-shaped, rose-cut; $\frac{11}{12}$ in. by $\frac{11}{12}$ in.; coronet mount. (Hope catalogue, p. 89, No. 29.) 1189—'69.

Plate III.—Chrysoberyl, Zircon, Opals, Quartz.

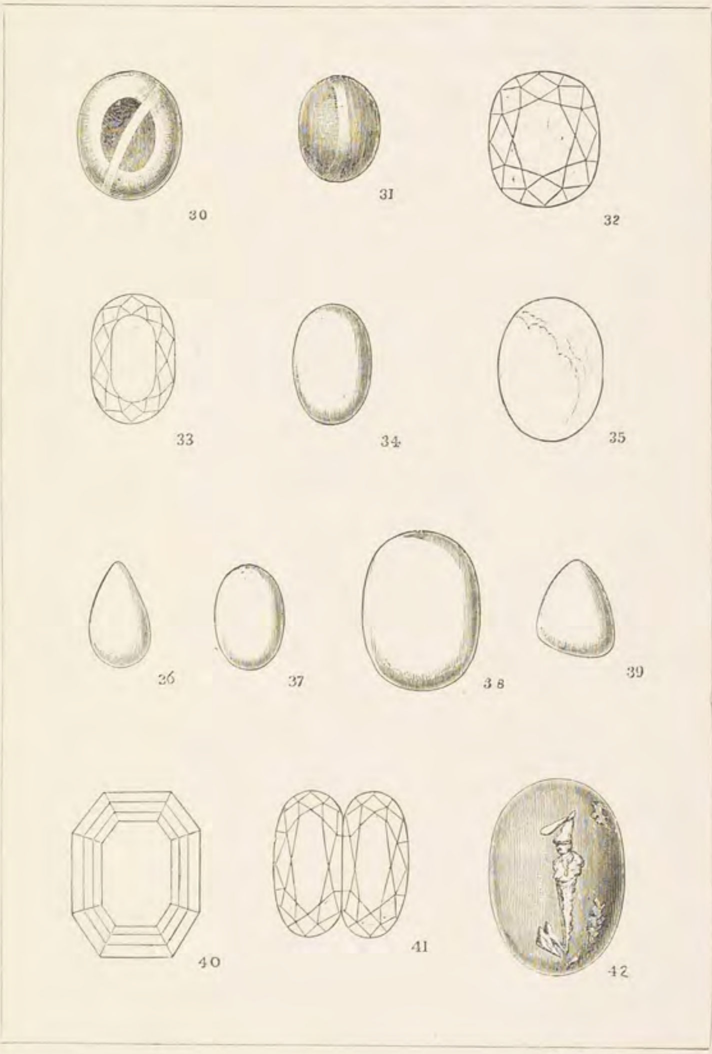

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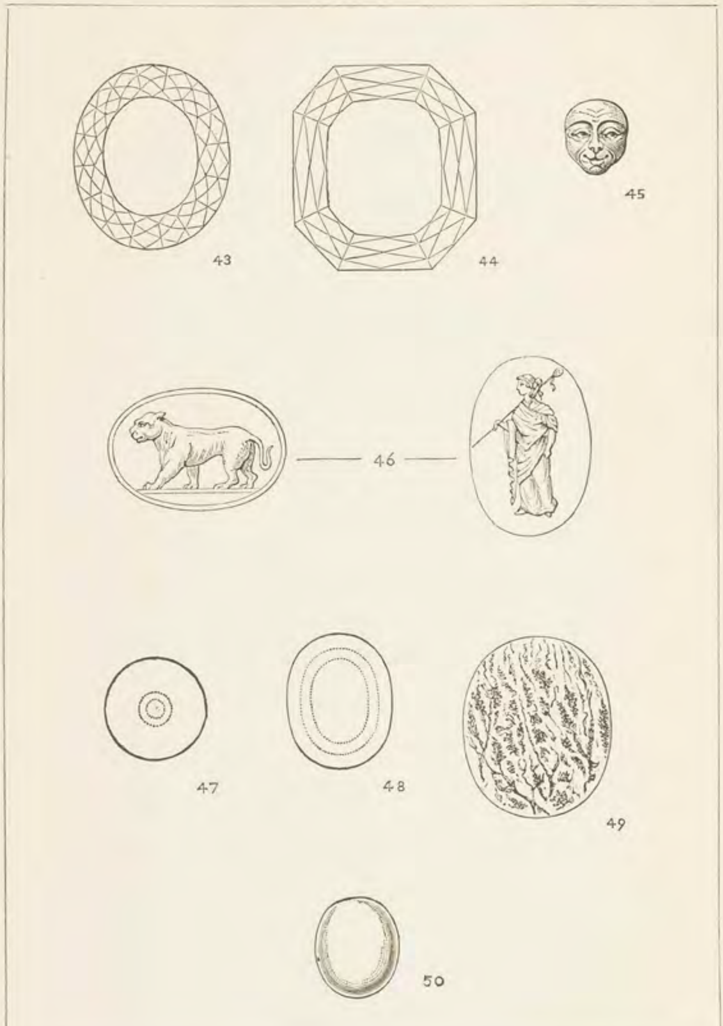
Plate IV.—Quartz, Moonstone.



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AMETHYST. Deep coloured, faceted, oval; 1 in. by $\frac{5}{8}$ in., and $\frac{1}{2}$ in. thick; coronet mount. (Hope catalogue, p. 88, No. 28.) Plate IV. fig. 43.
1190—'69.

AMETHYST. Rich colour, striped, faceted; 1$\frac{1}{12}$ in. by $\frac{23}{24}$ in. and $\frac{1}{2}$ in. thick; coronet mount. (Hope catalogue, p. 87, No. 19.) Plate IV. fig. 44.
1191—'69.

QUARTZ. Yellow and pale pink, carved as a monkey's face; $\frac{1}{3}$ in. by $\frac{7}{24}$ in.; plain mount. (Hope catalogue, p. 95, No. 5.) Plate IV. fig. 45.
1193—'69.

PLASMA. Engraved, with a Cupid holding a butterfly over a torch, oval; $\frac{5}{12}$ in. by $\frac{1}{3}$ in.; plain mount. 1196—'69.

PLASMA. Engraved, with a Cupid resting on a staff, oval; $\frac{1}{3}$ in. by $\frac{1}{4}$ in.; plain mount. 1197—'69.

PLASMA. Engraved, with two female figures, long oval; $\frac{11}{24}$ in. by $\frac{1}{3}$ in.; coronet mount. 1198—'69.

CHRYSOPRASE. Face table cut, back *en cabochon*, oval; $\frac{11}{12}$ in. by $\frac{2}{3}$ in.; solid plain mount. 1199—'69.

CHRYSOPRASE. Engraved in high relief, with laurel-wreathed head, oval; 1 $\frac{1}{12}$ in. by $\frac{9}{12}$ in.; plain mount. 1200—'69.

CHALCEDONY. Greenish yellow, nearly circular; $\frac{1}{3}$ in. diam.; plain mount.
1201—'69.

CHALCEDONY. Yellowish green, *en cabochon*, oval; $\frac{1}{4}$ in. by $\frac{5}{24}$ in.; solid chased mount. 1202—'69.

CHALCEDONY. Clouded, dull apple green, *en cabochon*, oval; $\frac{15}{24}$ in. by $\frac{7}{12}$ in; coronet mount. 1203—'69.

CHALCEDONY. Gray blue, translucent, engraved with the Olympian Zeus, convex oval; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; plain mount. 1204—'69.

AVANTURINE QUARTZ. Spangled green, oval; $\frac{3}{4}$ in. by $\frac{5}{12}$ in.; plain mount.
1205—'69.

AGATE. White chalcedony, with reddish brown patch, oval; $\frac{5}{8}$ in. by $\frac{9}{12}$ in.; coronet mount. 1206—'69.

AGATE. White chalcedony, with light-brown lines, some concentric, oval; $\frac{11}{12}$ in. by $\frac{9}{12}$ in.; two perforations; coronet mount. 1207—'69.

CHALCEDONY ON AMETHYST. The upper chalcedonic layer of brownish white cut to represent a panther, and a narrow border; the convex back of amethyst engraved with a Bacchante; oval; $\frac{10}{12}$ in. by $\frac{7}{12}$ in.; in an octagonal setting on double swivel-ring. (Hope catalogue, p. 86, No. 5.) Plate IV. fig. 46. 1208—'69.

ONYX. White and brown striped; $\frac{9}{12}$ in. by $\frac{5}{12}$ in.; plain mount. 1209—'69.

ONYX;—EYED AGATE. Hemispherical; $\frac{1}{2}$ in. diam.; coronet mount. (Hope catalogue, p. 92, No. 8.) Plate IV. fig. 47. 1210—'69.

ONYX. Three layers, brown, white, and black, oval; $\frac{2}{3}$ in. by $\frac{7}{12}$ in.; plain solid mount. (Hope catalogue, p. 92, No. 1.) Plate IV. fig. 48.
1211—'69.

CORNELIAN. Red, engraved with Persian characters and foliage, tabular; $\frac{3}{4}$ in. by $\frac{2}{3}$ in.; plain mount. 1212—'69.

MOSS AGATE. Pale purple, chalcedonic base, with jasper; oval, convex; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. 1213—'69.

MOCHA STONE. Gray, with dark-brown dendrites; oval; 1 in. by $\frac{19}{24}$ in.; coronet mount. 1214—'6ọ.

MOCHA STONE. Gray, with black dendrites, oval; 1 in. by $\frac{3}{4}$ in.; coronet mount. (Hope catalogue, p. 81, No. 40.) Plate IV. fig. 49. 1215—'69

BLOODSTONE, OR HELIOTROPE. Tabular oval; $\frac{11}{24}$ in. by $\frac{9}{24}$ in.; plain mount. 1216—'69.

CAT'S-EYE. Honey yellow, *en cabochon*, high and narrow; $\frac{3}{4}$ in. by $\frac{9}{24}$ in. and $\frac{5}{12}$ in. thick; coronet mount. 1217—'69.

CAT'S-EYE. Pale yellow gray, *en cabochon*, oval; $\frac{5}{12}$ in. by $\frac{1}{3}$ in.; plain mount. 1218—'69.

CAT'S-EYE. Brown, *en cabochon*, dished back, oval; $\frac{23}{24}$ in. by $\frac{8}{12}$ in.; bordered with 20 brilliants, and with several roses on the pierced shoulders; set in silver on gold shank. 1219—'69.

LAPIS-LAZULI.

LAPIS-LAZULI. Deep blue, with a few minute spangles of pyrites; tabular, oval; $\frac{5}{12}$ in. by $\frac{9}{24}$ in.; solid mount. 1324—'69.

IOLITE, OR DICHROITE.

IOLITE, OR DICHROITE. Pale violet, showing oblique cleavage lines, *en cabochon*, oval; $\frac{1}{2}$ in by $\frac{5}{12}$ in.; claw mount. 1267—'69.

IOLITE, OR DICHROITE. Pale blue, showing oblique cleavage lines, *en cabochon*, oblong, rounded ends; $\frac{1}{2}$ in. by $\frac{1}{4}$ in.; claw mount. 1268—'69.

CROCIDOLITE.

CROCIDOLITE. Dark bluish-green, with band of light, cut *en cabochon*; $\frac{9}{12}$ in. by $\frac{7}{12}$ in.; coronet mount. 1336—'69.

FELSPAR.

LABRADORITE. Gray, with blue, green, and orange chatoyancy, slightly convex, circular; $\frac{7}{12}$ in. diam.; claw mount. 1292--'69.

SUNSTONE. Avanturine felspar of delicate reddish-brown colour, *en cabochon*, oval; $\frac{5}{12}$ in. by $\frac{4}{12}$ in.; solid mount. 1293—'69.

MOONSTONE. Adularia, orthoclase felspar, having a bluish-white chatoyancy, *en cabochon*, oval; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; plain mount. (Hope catalogue, p. 97. No. 6.) Plate IV. fig. 50. 1294—'69.

APOPHYLLITE.

APOPHYLLITE. Translucent, white, natural crystal, prismatic octahedron, with basal planes; $\frac{5}{12}$ in. diam.; claw mount. 1296—'69.

PYRITES.

PYRITES. Brass yellow, rose-cut; $\frac{1}{2}$ in. by $\frac{1}{3}$ in.; light coronet mount. 1335—'69.

LUMACHELLA, OR FIRE MARBLE.

LUMACHELLA. Polished, nearly flat oval; 1 in. by $\frac{3}{4}$ in.; coronet mount. 1237—'69.

MALACHITE.

MALACHITE. Opaque, bluish green; $\frac{1}{2}$ in. diam.; convex top, coronet mount. 1334—'69.

PEARL.

PEARL. Whole, white, secured by a pin passing through a claw on each side; on each shoulder of the ring mount are 2 pearl-shaped brilliants, with 3 smaller brilliants; there are 4 other small brilliants, one at each corner of the setting. 1337—'69.

PEARL. White, whole, short ovate; diam. $\frac{1}{4}$ in.; mount with 4 claws. 1340—'69.

PEARL. Black, whole, round; diam. $\frac{1}{4}$ in.; plain, mount with 4 claws. 1338—'69.

PEARL. Cherry pink, whole, round; diam. $\frac{1}{3}$ in.; claw mount. (Hope catalogue, p. 10, No. 88.) 1339—'69.

There are two specimens not included in the above list. One of these has been enumerated with the peridots, but it is apparently a tourmaline; the other stone, which possesses little interest or beauty, is probably obsidian.

TOURMALINE? Dull green, *en cabochon*, oval; $\frac{1}{2}$ in. by $\frac{1}{3}$ in.; plain mount. 1299—'69.

OBSIDIAN? Dull green, step-cut; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; wire coronet mount. 1295—'69

GENERAL INDEX.

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