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VERDITE

by ROBERT WEBSTER, F.G.A

IN the useful and informative article on the employment of onyx marbles as the material for the production of small objects of art and utility, such as cigarette and clock cases, published in the Watchmaker, Jeweller and Silversmith for October 1952,[1] the use of *verdite* as an inlay is mentioned. References in the literature to this attractive green material give no data of value for testing. It is hoped that the following notes will, in part, supply some of these deficiencies.

The first account of verdite that I can trace is that written by Kunz,[2] who writes :—" During 1907 there was found on the south bank of the Nord Kaap river in South Africa, two miles above Kaap station, a stone of deep green colour. It has a hardness of 3 and is susceptible to a high polish. The colour is a rich chrome green and the stone contains a chrome muscovite and some argillaceous material. Occasionally it has yellow or red spots. The stone is obtained in blocks weighing 1 ton or more and is now sold in England at the price of £18 to £40 per ton (*1907-8*). The name verdite has been suggested for it."

Apart from references in Herbert Smith's " Gemstones "[3] where it is stated that the material is also known as " Transvaal-jade " and " African-jade " ; and in Schlossmacher's edition of

Bauer's "Edelsteinkunde,"[4] little has been written about this material in the literature on gemstones. A good account is given, without data, in the handbook of the South African Department of Mines.[5] This more modern work states :—" Verdite ; a variety of serpentine known locally as verdite has been worked for a number of years near Nord Kaap in the Barberton district, some 185 miles East by North of Johannesburg and 136 miles from the port of Lourenco Marques in Portuguese territory. It is an extremely beautiful stone of brilliant dark green colour. It has been used for all manner of small ornaments as well as for interior decorative architectural purposes. It occurs discontinuously in narrow bands in the Jamestown intrusive rocks. Sometimes it is intergrown with grey talc. The true verdite is soft and easily worked but it varies greatly in quality. It is sometimes intergrown with hard corundum-bearing rock of equally good colour but which is very difficult to work. The stone is obtainable only in comparatively small sizes, but pieces varying in weight from 25 lbs. to 100 lbs. or 200 lbs. and in exceptional cases up to 500 lbs. have been recovered. Pieces down to 4 square inches being saleable. It has been used in the interior decoration of prominent buildings such as the Bank of England and South Africa House in London."

The reference to the material being a serpentine calls for some comment. Bauer and Herbert Smith do not mention the term serpentine in their references to this material, whereas DuToit[6] states :—" The beautiful green variety of serpentine cut under the name of ' verdite ' is mined in Barberton " ; and Watson[7] notes that verdite is " an example of Sericite, a fibrous aggregate of Muscovite belonging to the Mica group of rocks, which occurs in the Barberton series of Swaziland " and that it " is deeply stained with green, owing probably to the presence of copper. It also possesses a silky lustre, a characteristic which has given rise to the name Sericite (from σηρικσς, silky). It takes a fairly good polish, and is known commercially as Green Verdite Marble." It must be pointed out that the specimen Watson refers to, in the Sedgwick Museum at Cambridge, is not from the Transvaal, but from the Piggs Peak Mines, Swaziland, and may be quite different from the original verdite of the Barberton district, Transvaal.

In order to obtain a more satisfactory understanding of the nature of the substance, Dr. W. Campbell Smith, the then Keeper of Minerals in the British Museum (Natural History), was approached. His reply is reproduced below.

" I have examined thin sections of our specimens of verdite, checked up on the X-ray photograph and spectograph taken in 1937, and had the density determined.

As far as thin sections show the rock consists of minute flakes and radiating groups of flakes of muscovite. The green colour is barely perceptible in thin section. I failed to detect any clay. The pale-yellow flecks are pseudomorphs of some mineral, but I cannot guess at its nature. The material of these patches is mostly opaque, but associated with it is a highly refracting birefringent mineral which may be epidote.

The X-ray photograph taken by Bannister showed muscovite and the spectrograph indicated chromium and a trace of copper, hence his identification of the main constituent as muscovite (var : fuchsite). The density is 2.82 as determined by Mr. S. E. Ellis.

As far as our evidence goes the rock can be described as a massive muscovite-rock coloured green by the chromiferous variety, fuchsite. Density 2.82. The description given in Mineral Industry for 1907, vol. 16, p. 108, is, " . . . contains a chrome-muscovite and some argillaceous material ; occasionally has yellow or red spots." That description, and Herbert Smith's in Gemstones, seems to be fairly satisfactory, but I have not proved the presence or absence of clay. I should ignore J. Watson's description ; except for the stress laid on colouring by copper his agrees with mine, i.e. is a massive muscovite-rock."

In order to obtain data of specific gravity, determinations of 23 specimens were recorded, and these are shown in the following table.

No.	*Weight.*	*Density.*	*Determined by.*
1.	7.30 carats	2.81	A. E. Farn.
2.	17.77 carats	2.82	R. Webster.
3.	?	2.82	S. E. Ellis.
4.	Large rough piece.	2.83	Chelsea students.
5.	4.95 carats	2.84	R. Webster.
6.	1.641 grams	2.840	,,
7.	1.6125 grams	2.841	,,

No.	*Weight.*	*Density*	*Determined by.*
8.	166.39 grams	2.86	R. Webster
9.	11.640 grams*	2.85	,,
10.	20.698 grams*	2.87	,,
11.	1.225 grams	2.902	,,
12.	1.457 grams	2.903	,,
13.	1.448 grams	2.904	,,
14.	1.571 grams	2.906	,,
15.	1.204 grams	2.907	,,
16.	1.117 grams	2.908	,,
17.	1.496 grams.	2.911	,,
18.	1.231 grams	2.912	,,
19.	0.968 gram	2.915	,,
20.	1.940 grams	2.921	,,
21.	1.203 grams	2.925	,,
22.	1.661 grams	2.953	,,
23.	1.876 grams	2.956	,,

* No. 8 was later sawn into two pieces and determinations made on each of the two pieces. No. 9 and 10 are the determinations on the two pieces.

The wide variation in density found is what would be expected in the case of a material which is essentially a rock and not a homogeneous mineral. The refractive index approximates to 1.58, but only a vague shadow edge can be seen on the refractometer. As a matter of interest the constants for muscovite mica are, according to values given in Larsen and Berman (1934), p. 237, refractive indices α 1.558–1.579 ; β 1.593–1.611 ; γ 1.598–1.615 ; and specific gravity 2.86–2.89. Examination by reflected light, and by transmitted light through fairly thin plates, showed the absorption spectrum to consist of three lines in the red, with the strongest near 7000 Å and a vague band in the blue about 4550 Å. The material does not luminesce when in the beam of an ultra-violet lamp, or under X-rays.

Perusal of the literature has shown that there are at least three other green materials of somewhat similar characters. Watson[8] mentions a fuchsite-schist from Shrewsbury, Vermont in the United States. Known as the Green Marble of Shrewsbury, it is a chrome-mica-schist found on the western slopes of the Green Mountain Range where the deposit, of Lower Cambrian age,[9] is about 100 feet thick. The material when polished displays a brilliant dark emerald-green colour, varied with veins and patches of a lighter green colour. It is reported[10] that an attractive ornamental stone of serpentinised dolomite very beautifully coloured in wavy streaks of dark and light green and brown, and veined with white, is being obtained on the farm Bergendal near Belfast in the Transvaal. Kunz[11] refers to a deep green chromiferous syenite found at the jadeite mine at Bhamo, Burma, to which material he suggested the name "jadeolite." No opportunity has been found to examine these materials.

From the information obtained, the characters of verdite may be given as under.

VERDITE.

Composition.	A massive muscovite-rock coloured green by fuchsite.
Density.	2.80 to 2.96.
Refractive index.	About 1.58.
Hardness.	3 (Mohs's scale).
Absorption spectrum.	Three lines in the deep red and a vague line in the blue.
Luminescence.	None.

In conclusion I have to thank Dr. W. Campbell Smith for his ready help ; Mr. A. E. Farn for collecting a number of the specimens worked upon, and Messrs. Grant, of Torquay (per Miss J. Banister) for presenting the specimen No. 8.

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8. Watson (ibid), p. 445.
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LIQUID INCLUSIONS in GEMS

In 1835 the English physicist, Sir David Brewster, distinguished two types of liquid inclusions. This was referred to by Dr. E. Gübelin in his article (Journal Gemmology, January 1946, page 24), and the full text of Sir David Brewster's letter to Sir Walter Scott, in which he detailed his observations is given below.

GRAND as the chemical operations are which are going on in the great laboratory of Nature, and alarming as their effects appear when they are displayed in the terrors of the earthquake and the volcano, yet they are not more wonderful to the philosopher than the minute though analogous operations which are often at work near our own persons, unseen and unheeded. It is not merely in the bowels of the earth that highly-expansive elements are imprisoned and restrained, and occasionally called into tremendous action by the excitation of heat and other causes. Fluids and vapours of similar character exist in the very gems and precious stones which science has contributed to luxury and to the arts.

In examining with the microscope the structure of mineral bodies, I discovered in the interior of many of the gems thousands of cavities of various forms and sizes. Some had the shape of hollow and regularly-formed crystals : others possessed the most irregular outline, and consisted of many cavities and branches united without order, but all communicating with each other. These cavities sometimes occurred singly, but most frequently in groups forming strata of cavities, at one time perfectly flat and at another time curved. Several such strata were often found in the same specimen, sometimes parallel to each other, at other times inclined, and forming all varieties of angles with the faces of the original crystal.

These cavities, which occurred in sapphire, chrysoberyl, topaz, beryl, quartz, amethyst, peridot, and other substances, were sometimes sufficiently large to be distinctly seen by the naked eye, but most frequently they were so small as to require a high magnifying power to be well seen, and often they were so exceedingly minute that the highest magnifying powers were unable to exhibit their outline.

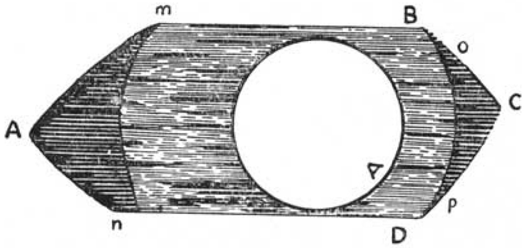

Fig. 1. The highly expansible fluid in the cavity of a gemstone. At low temperatures there is always a vacuity like an air bubble.

The greater number of these cavities, whether large or small, contain two new fluids different from any hitherto known, and possessing remarkable physical properties. These two fluids are in general perfectly transparent and colourless, and they exist in the same cavity in actual contact, without mixing together in the slightest degree. One of them expands thirty times more than water ; and at a temperature of about 80 deg. F. it expands so as to fill up the vacuity in the cavity. This will be understood from the above Fig. 1, where ABCD is the cavity, mnpo the highly expansible fluid in which at low temperatures there is always a vacuity V, like an air-bubble in common fluids, and Amn, Cop the second fluid occupying the angles A and C. When heat such as that of the hand is applied to the specimen, the vacuity V gradually contracts in size, and wholly vanishes at a temperature of about 80 deg., as shown in Fig. 2. The fluids are shaded, as in these two figures, when they are seen by light reflected from their surfaces.

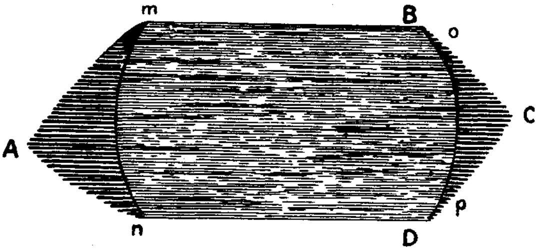

Fig. 2. When the specimen was heated the vacuity gradually contracted in size and wholly vanished at a temperature of about 80 degrees F.

When cavities are large, as in Fig. 3, compared with the quantity of expansible fluid m n o p, the heat converts the fluid into vapour, an effect which is shown by the circular cavity V becoming larger and larger till it fills the whole space mnop.

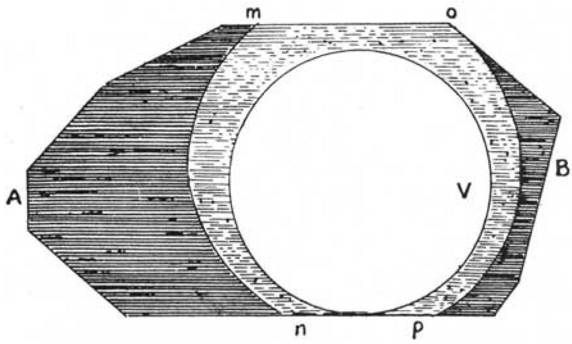

Fig. 3. In a large cavity containing a small quantity of expansible fluid the heat converts the fluid into vapour until it finally fills the whole space.

When any of these cavities, whether they are filled with fluid or with vapour, is allowed to cool, the vacuity V re-appears at a certain temperature. In the fluid cavities the fluid contracts, and the small vacuity appears, which grows larger and larger till it resumes its original size. When the cavities are large several small vacuities make their appearance and gradually unite into one, though they sometimes remain separate. In deep cavities a very remarkable phenomenon accompanies the reappearance of the vacuity. At the instant that the fluid has acquired the temperature at which it quits the sides of the cavity, an effervescence or rapid ebullition takes place, and the transparent cavity is for a moment opaque, with an infinite number of minute vacuities, which instantly unite into one that goes on enlarging as the temperature diminishes. In the vapour cavities the vapour is reconverted by the cold into fluid, and the vacuity V, Fig. 3, gradually contracts till all the vapour has been precipitated. It is curious to observe, when a great number of cavities are seen at once in the field of the microscope, that the vacuities all disappear and reappear at the same instant.

While all these changes are going on in the expansible fluid the other denser fluid as A and C, Figs. 1, 2, remains unchanged either in its form or magnitude. On this account I experienced considerable difficulty in proving that it was a fluid. The improbability of two fluids existing in a transparent state in absolute contact, without mixing in the slightest degree, or acting upon each other, induced many persons to whom I showed the phenomenon to consider the lines mnop, Figs. 1, 2, as a partition in the cavity, or the spaces Amn, Cop, either as filled with solid matter, or as corners into which the expanding fluid would not penetrate. The regular curvature, however, of the boundary line mnop, and other facts, rendered these suppositions untenable.

This difficulty was at last entirely removed by the discovery of a cavity of the form shown in Fig. 4, below, when A, B and C are three portions of the expansible fluid separated by the interposition of the second fluid D E F. The first portion A of the expansible fluid had four vacuities V, X, Y, Z, while the other two portions, B, C, had no vacuity. In order to determine if the vacuities of the portions B, C, had passed over to A, I took an accurate drawing of the appearances at a temperature of 50 deg. as shown in the figure, and I watched the changes which took place in raising the temperature to 83 deg. The portion A gradually expanded itself till it filled up all the four vacuities V, X, Y and Z ; but as the portions B, C, had no vacuities, they could expand themselves only by pushing back the supposed second fluid E E F. This effect actually took place. The dense fluid quitted the side of the cavity at F. The two portions B, C, of the expansible fluid instantly united, and the dense fluid having retreated to the limit m n o, its other limit advanced to p q r, thus proving it to be a real fluid. This experiment, which I have often shown to others, involves one of those rare combinations of circumstances which nature sometimes presents to us in order to illustrate her most mysterious operations. Had the portions B, C, been accompanied, as is usual, with their vacuities, the interposed fluid would have remained immovable between the two equal and opposite expansions ; but owing to the accidental circumstance of these vacuities having passed over into the other branch A of the cavity, the fluid yielded to the difference of the expansive forces between which it lay, and thus exhibited its fluid character to the eye.

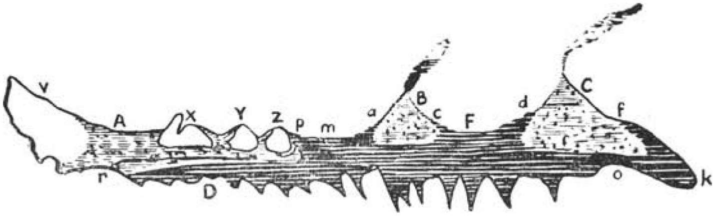

Fig. 4. Three portions, A, B, C, of the expansible fluid separated by the interposition of a second fluid.

When we examine these cavities narrowly, we find that they are actually little laboratories, in which chemical operations are constantly going on, and beautiful optical phenomena continually displaying themselves. Let ABDC, in Fig. 5, be the summit of a crystallized cavity in topaz, S S, representing the dense, N N, the expansive fluid, bounded by a circular line abcd, and V V, the vacuity in the new fluid, bounded by the circle efgh. If the face ABDC, is placed under a compound microscope, so that light may be reflected at an angle less than that of total reflection, and if the observer now looks through the microscope, the temperature of the room being 50 deg., he will see the second fluid S S, shining with a very feeble reflected light, the dense fluid N N, with a light perceptibly brighter, and the vacuity V V, with a light of considerable brilliancy. The boundaries abcd, efgh, are marked by a well-defined outline, and also by the concentric coloured rings of thin plates produced by the extreme thinness of each of the fluids at their edges.

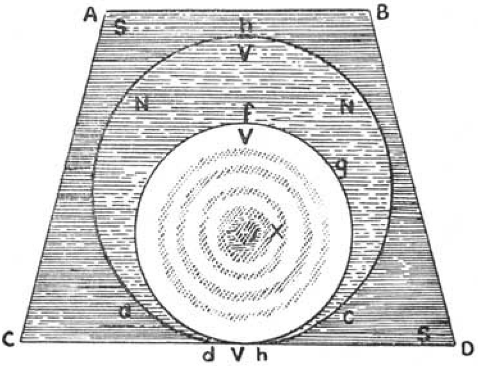

Fig. 5. When the temperature is perfectly uniform, the vapour rings are stationary. The first ring produced has swollen out to meet the first ring at the margin of the fluid.

If the temperature of the room is raised slowly to 58 deg., a brown spot will appear at x in the centre of the vacuity V V. This spot indicates the commencement of evaporation from the expansible fluid below, and arises from the partial precipitation of the vapour in the roof of the cavity. As the heat increases, the brown spot enlarges and becomes very dark. It is then succeeded by a white spot, and one or more coloured rings rise in the centre of the vacuity. The vapour then seems to form a drop and all the rings disappear by retiring to the centre, but only to reappear with new lustre. During the application of heat, the circle efgh, contracts and dilates like the pupil of the eye. When the vaporization is so feeble as to produce only a single ring of one or two tints of the second order, they vanish instantly by breathing upon the crystal, but when the slight heat of the breath reaches the fluid, it throws off fresh vapour, and the rings again appear.

If a drop of ether is put upon the crystal when the rings are in a state of rapid play, the cold produced by its evaporation causes them to disappear, till the temperature again rises. When the temperature is perfectly uniform, the rings are stationary, as shown between V and V in Fig. 5 ; and it is interesting to observe the first ring produced by the vapour swelling out to meet the first ring at the margin of the fluid, and sometimes coming so near it that the darkest parts of both form a broad black band. As the heat increases, the vacuity V V, diminishes, and disappears at 79 deg., exhibiting many curious phenomena which we have not room to describe.

Having fallen upon a method of opening the cavities, and looking at the fluids, I was able to examine their properties with more attention. When the expansible fluid first rises from the cavity upon the surface of the topaz, it neither remains still like the fixed oils, nor disappears like evaporable fluids. Under the influence, no doubt, of heat and moisture it is in a state of constant motion, now spreading itself on a thin plate over a large surface, and now contracting itself into a deeper and much less extended drop. These contractions and extensions are marked by very beautiful optical phenomena. When the fluid has stretched itself out into a thin plate, it ceases to reflect light like the thinnest part of the soap-bubble, and when it is again accumulated into a thicker drop, it is covered with the coloured rings of thin plates.

Effect of Hand Humidity

After performing these motions, which sometimes last for ten minutes, the fluid suddenly disappears, and leaves behind it a sort of granular residue. When examining this with a single microscope, it again started into a fluid state, and extended and contracted itself as before. This was owing to the humidity of the hand which held the microscope, and I have been able to restore by moisture the fluidity of these grains twenty days after they were formed from the fluid. This portion was shown to the Reverend Dr. Fleming, who remarked that, had he observed it accidentally, he would have ascribed its apparent vitality to the movements of some of the animals of the genus Planaria.

After the cavity has remained open for a day or two, the dense fluid comes out and quickly hardens into a transparent and yellowish resinous-looking substance, which absorbs moisture, though with less avidity than the other. It is not volatilized by heat, and is insoluble in water and alcohol. It readily dissolves, however, with effervescence in the sulphuric, nitric, and muriatic acids. The residue of the expansible fluid is volatilized by heat, and is dissolved but without effervescence, in the above-mentioned acids. The refractive power of the dense fluid is about 1.295, and of the expansible one 1.131.

The particles of the dense fluid have a very powerful attraction for each other and for the mineral which contains them, while those of the expansible fluid have a very slight attraction for one another, and also for the substance of the mineral. Hence, the two fluids never mix, the dense fluid being attracted to the angles of angular cavities, or filling the narrow necks by which two cavities communicate. The expansible fluid, on the other hand, fills the wide parts of the cavities, and in deep and round cavities it lies above the dense fluid.

When the dense fluid occupies the necks which join two cavities, it performs the singular function of a fluid valve, opening and shutting itself according to the expansions or contractions of the other fluid. The fluid valves thus exhibited in action may suggest some useful hints to the mechanic and the philosopher, while they afford ground of curious speculation in reference to the functions of animal and vegetable bodies. In the larger organizations of ordinary animals, where gravity must in general, overpower, or at least modify, the influence of capillary attraction, such a mechanism is neither necessary nor appropriate ; but, in the lesser functions of the same animals, and in almost all the microscopic structures of the lower world, where the force of gravity is entirely subjected to the more powerful energy of capillary forces, it is extremely probable that the mechanism of immiscible fluids and fluid valves is generally adopted.

In several cavities in minerals I have found crystallized and other bodies, sometimes transparent crystals, sometimes black spicular crystals, and sometimes black spheres, all of which are movable within the cavity. In some cavities the two new fluids occur in an indurated state, and others I have found to be lined with a powdery matter. This last class of cavities occurred in topaz, and they were distinguished from all others by the extraordinary beauty and symmetry of their form. One of these cavities represented a finely-ornamented sceptre, and, what is still more singular, the different parts of which it is composed lay in different planes.

Explosion Experiences

When the gem which contains the highly-expansive fluid is strong, and the cavity not near the surface, heat may be applied to it without danger ; but in the course of my experiments on this subject, the mineral has often burst with a tremendous explosion, and in one case wounded me on the brow. An accident of the same kind occurred to a gentleman, who put a crystal into his mouth for the purpose of expanding the fluid. The specimen burst with great force and cut his mouth, and the fluid which was discharged from the cavity had a very disagreeable taste.

In the gems which are peculiarly appropriated for female ornaments, cavities containing the expansible fluid frequently occur, and if these cavities should happen to be very near the surface or the edge of the stone, the fever heat of the body might be sufficient to burst them with an alarming and even dangerous explosion. I have never heard of any such accident having occurred ; but if it has, or if it ever shall occur, and if its naturally marvellous character shall be heightened by any calamitous results, the phenomena described in the preceding pages will strip it of its wonder.

A SPECIFIC GRAVITY VOLUMETER

by S. J. Everett and Sir James Walton

IN March 1950 one of us (J.W.) published an account of a balance which would give a direct reading of the specific gravity of a mineral.* At that time it was pointed out that the instrumental readings were not very reliable for small specimens having a weight of less than one carat.

Since then attempts have been made to devise an instrument which would give reliable results for small specimens. In a well-equipped laboratory very accurate results can be obtained by the use of heavy fluids but a considerable number of these fluids is required to cover a wide range and if great accuracy is required, as in the case of a rare or new mineral, a fluid has to be carefully mixed of such a density that the specimen is accurately suspended within it. The specific gravity of the fluid has then to be determined by the rather prolonged and tedious use of a pycnometer. Moreover a sufficiently large battery of fluids is not easily portable and the individual fluids have to be rather frequently controlled to make certain that their densities have remained constant. For accurate work corrections have also to be made for the temperature of the fluid. The method therefore has drawbacks for use in the field and for those who have no well-equipped laboratories.

It is a somewhat curious fact that although the basic formula for obtaining the specific gravity is Sp. gr. $= \frac{W}{V}$ in nearly all the other methods the volume is not directly estimated but is calculated from an estimate of the weight of fluid displaced by the specimen. It is true that with relatively large specimens the density may be estimated by dropping them into fluid contained in a graduated cylinder and observing the rise in the level of the fluid. The cylinder has, however, to be wide enough to admit the specimen and the scale cannot therefore be sufficiently delicate to give more than approximate results.

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* "A New Type of Specific Gravity Balance." Mineralogical Magazine. Sept., 1950. Vol. xxix, No. 210, pp. 200–205.

The fact that capillary tubes are widely used in pathological and bacteriological laboratories to give very accurate determinations of the volume of small quantities of fluid led to the view that some adaptation of this method might be used to determine the volume of relatively small mineral specimens.

The first model made consisted of a syringe on the piston stem of which (Fig. 1) a screw thread had been cut and a knurled nut fitted to it. It was found however that most syringes on the market had much too inaccurately fitting a piston so that with only slight pressure the fluid readily passed from one side of the piston to the other. One of us (S.E.) was producing, however, syringes for other purposes which had pistons fitting so accurately that this difficulty was entirely overcome. The needle fitting was removed from such a syringe and into it was fitted one of two glass capillary tubes about 25 cms. long having a lumen of 1 and 1.5mm., which was fixed in a perspex support having a flat surface to take a scale and a carefully turned lower end with a taper of 1° so as to fit firmly and snugly into the cylinder. In use the syringe was half filled with any fluid, the syringe held vertically, the piston fully retracted, the capillary tube unit inserted and the piston advanced

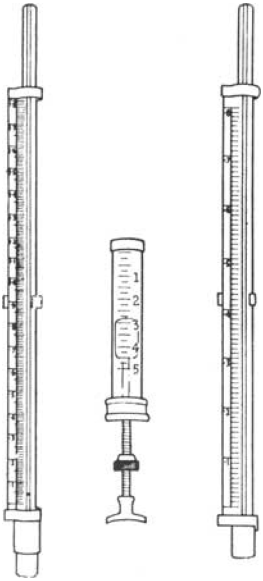


Fig. 1
Specific Gravity Syringe.

From James Walton's "Physical Gemmology" by kind permission of Sir Isaac Pitman and Son, Ltd.

Tube 1.5*mm. diameter.*

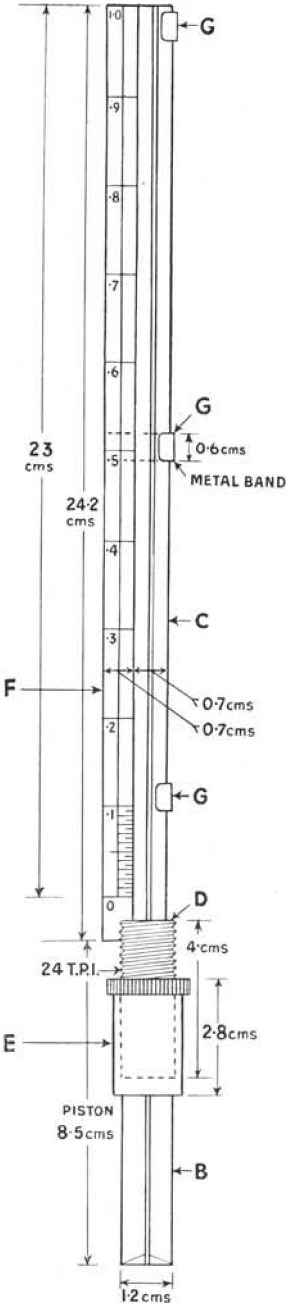
Tube 1*mm. diameter.*

until the fluid passed a little above the zero mark. On slowly screwing up the knurled nut the fluid could be easily and evenly withdrawn to the zero mark. The screw was left untouched, the piston fully withdrawn, the capillary tube unit extracted, the specimen inserted, the capillary tube unit replaced and the piston pushed up until its progress was stopped by the nut, i.e., it was in the identical position it occupied before the specimen was inserted. The volume of the fluid was however increased in amount by the volume of the inserted mineral and hence rose higher up in the capillary tube. The scale having been carefully calibrated this increase of volume was at once visible.

In practice the model gave satisfactory results if care was used to insert the capillary unit always with the same pressure but if greater pressure was used it was found that the perspex plug was sufficiently compressible to give an increased reading of several divisions on the scale. It was therefore unsuited for general use where varying pressure might be exerted by individual observers.

After considerable thought and experiment we have produced the present model which is free from this drawback and after very careful testing has been found to give accurate and reliable results.

It consists of a very carefully and accurately ground glass cylinder, the lower end of which is closed. It is mounted in a small wooden stand and about one half way up a horizontal line is inscribed (Fig. 2A). Into this passes a piston (B) equally accurately ground and fitting so perfectly that although sliding easily there is no leak of fluid around it. Through it passes the capillary tube (C), the lower opening being bevelled so that no air bubble collects there. Over the capillary tube and the upper end of the piston a brass tube (D) 4 cms. long and having an external screw with 24 threads to the inch is fixed with Canada balsam. Over this is fitted another brass tube (E) with a similar screw cut on its inner surface and having a knurled band so that it can be easily rotated. When the piston is inserted this outer tube rests on the glass cylinder and so determines the depth to which the piston can be inserted. To the upper end of the inner fixed screw is soldered a flat brass strip to hold the scale (F) and on it are soldered three semicircular brass bands (G) which closely embrace and hold tight the capillary tube.



In use the cylinder is fitted with fluid up to the horizontal mark. Any fluid could be used for the volume is measured directly and is not estimated from the weight of fluid displaced. The ordinary commercial methylated spirit is found to be very satisfactory for it cleans and does not stain the glass surfaces and since it has a low viscosity and surface tension the common problem of getting rid of air bubbles attached to the specimen does not seem to exist.

The outer screw is screwed down so that the piston when inserted remains about ¼in. above the level of the fluid. The outer screw is then slowly screwed upwards and the piston slowly descends and as it does so the fluid rises in the capillary tube. Its movement can be most easily regulated and its upper level is set at the zero

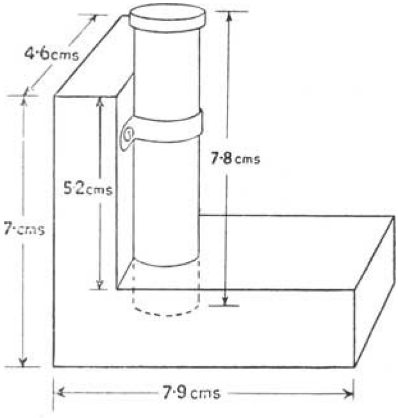


Fig. 2a.

mark on the scale. During this process the scale must be held with the left hand while the screw is rotated with the right so that the capillary tube and piston do not rotate with the screw. When the fluid is exactly at the zero mark the piston is slowly and carefully withdrawn by holding the scale. Care must be taken that the piston is drawn vertically upwards and not rotated lest the outer screw move on the inner. (In a future model the two will be fixed with a small screw).

The specimen, the weight of which has been carefully taken, is dropped into the cylinder and the piston replaced. It will fall until its progress is stopped by the tube E in exactly the same position it occupied before withdrawal but now the fluid in the tube will reach a higher level and the height of this above the zero mark will give the volume of the specimen. The weight divided by the volume will of course give the specific gravity.

The gramme as a unit of weight for all gemstones and most small mineral specimens is too large and the metric carat has been universally adopted. This is $\frac{1}{5}$ of a gramme and the volume of this weight of distilled water at 4°C is $\frac{1}{5}$ of a millilitre, that is 200 cubic mms. Unfortunately there is no name for this volume which we have therefore designated as a water carat. The capillary tube in this model is of such a length that it has a volume of exactly one water carat, and hence would record the volume of any specimen whose weight is identical with its specific gravity, but since with such a weight the fluid would be right at the top of the tube it is wise to limit the use of the instrument to specimens of a weight slightly below that of their density. The tube could, of course, be made of any length provided that the large subdivisions have a volume of exactly 0.1 of a water carat. The large sub-divisions are again divided into tenths each giving 0.01 of a water carat, and these again into two so that of the smallest divisions register 0.005.

The calibration of the scale has to be very carefully carried out. If a small piece of a mineral of a known and constant density, such as quartz with a sp. gr. of 2.651 be taken and carefully weighed, its weight divided by its sp. gr. will give its volume and the position of the level of the fluid in the capillary tube given by this mineral when the instrument is used in the usual way will show this volume. From this the volume of the whole length of the tube can be deduced. For greater accuracy the positions of the volumes of several specimens, say four of pure quartz of sp. gr. 2.651 and two of corundum of sp. gr. 4, are marked and the volume of the whole length of the tube estimated in each case. If they differ in the slightest degree an average is taken. Having obtained the volume in water carats of the whole length of the tube, the length of 0.1 carat is easily estimated, and this divided into ten equal parts.

There are two precautions that have to be taken. When the piston is first inserted it and the wall of the cylinder are dry. When the piston is withdrawn it wets the side of the cylinder with a thin film, but so delicate is the instrument that when the piston is reinserted the fluid column will be slightly lower in this model, about 0.02 of a water carat, but this film does not allow leakage for if the piston is inserted and the screw screwed up until the fluid reaches the upper end of the scale it will remain fixed and not fall as it would if there were any leakage. To overcome the faulty reading of this wetting it is wise with the first wetting to set the fluid at a given level, say 0.1, to withdraw the piston and then reinsert. If the reading is now lower, say 0.08, to reset it lower the column until it is at zero, when the piston can be removed and the specimen inserted in the usual way.

The second precaution is against allowing any wetting of the upper border of the cylinder from the lower end of the piston when it is withdrawn. This can be prevented by making the withdrawal vertically upwards. If it should accidentally wet the upper margin of the cylinder, the piston should be replaced and reset before the specimen is inserted.

The instrument is very delicate and accurate but if great accuracy is required, as in the determination of a new mineral, several determinations should be made and if there is any variation, they should be continued until three or four consecutive readings are identical, thus tending to eliminate human error.

With a little practice the investigations can be made very rapidly and the method has the great benefit that since the volume itself is measured no irksome corrections have to be made for variations in the specific gravity of the fluid due either to its nature or its temperature. It is also very compact and portable and thus should be useful in field work.

The instrument is being manufactured by Mr. S. J. Everett of S. and R. J. Everett & Co. Ltd., at the Invicta Works, 939 London Road, Thornton Heath.

LETTER TO THE EDITOR

An Interesting Experiment

DEAR SIR,

While reading the chapter on single and double refraction from Mr. B. W. Anderson's " Gem-Testing," I thought of trying the following experiment.

I placed one polaroid above the sub-stage condenser, and below the stage of my Beck microscope. The other polaroid was placed within the eyepiece. Now, I placed a ruby red glass (1 inch by 1 inch) on the stage, when the polaroids were not crossed. On this red glass was placed a very thin and small crystal of Calcite, on which the eyepiece was focused, so that the Calcite crystal stood out sharply against the red background of the glass slide. The whole system was illuminated by a 15 watt. lamp in a dark room.

The polaroid in the eyepiece was gradually rotated in a circular motion. On doing so, the red glass background began to darken gradually, until it completely vanished and became " invisible " when the polaroids were in the crossed position. Now the Calcite crystal glowed, like a red hot coal, against a totally dark background. On further turning the eyepiece, the " status quo ante " was gradually restored.

By a little trial and error one can find the most suitable orientation for the Calcite crystal to show this effect to its best advantage. The crystal may even be permanently mounted on the red glass. Glass of any other colour may be used, but red gives the most impressive effect.

Yours faithfully,

India. V. R. KIBE, B.Sc., LL.B., F.G.A.

Gemmological Abstracts

ANON. *Ivory—an ancient gem material.* Gemmologist, Vol. XXI, No. 256, pp. 201–202. November, 1952.

A short article listing the properties of ivory and some simulating materials. Apparently culled from the earlier works of R. Webster. 2 illustrations. W.B.

SCHLOSSMACHER (K.). *Die Unterscheidung von echten Perlen und Zuchtperlen mit der Rontgenschattenbildermethode.* Differentiation between genuine and cultured pearls by X-ray radiography. Zeit. Deutsh. Gesell. f. Edelsteinkunde, Autumn, 1952, No. 1, pp. 14–17.

A brief survey of the usual methods of testing. An X-ray apparatus has been installed at the Institute at Idar-Oberstein.

E.S.

——— *Synthetische Diamenten.* Synthetic diamonds. Ibid. pp. 19–20.

Short notes on official inquiry regarding experiments of Dr. H. Meincke and the Bell Telephone Corporation announcement of production of synthetic diamond in form of glossy hard balls through heating polyvinylbenzol to 1050° C.

E.S.

CHUDOBA (K.). *Durch Chrom verursachte Edelsteinfarben.* Gem colours caused through chromium. Ibid. pp. 9–13.

Chromium is the pigment in several important gems. The relevant composition is frequently chromium oxide (Cr_2O_3), itself deep green and forming rhombohedral or hexagonal crystals. Traces of 0.11% to 0.19% of Cr_2O_3 cause the colour in emerald (ideally 3 $BeO.Al_2O_3$ 6 SiO_2) when some Al. ions (ion radius Al^{3+}=O.57Å) are replaced by Cr. ions (ion radius Cr^{3+}=O.64Å). Uvarovite garnet (3 $CaO.Cr_2O_3$. 3 SiO_2) contains 6.2-30.6% Cr_2O_3 (mostly about 25%). The ideal Uvarovite would contain 32.5% Cr_2O_3 but a part of this is replaced by Al_2O_3 and in rarer cases by Fe_2O_3 (Ion radius Fe^{3+}=0.67). The striking difference in Cr_2O_3 content of Emerald and Uvarovite is due to the different capacity of the two crystal lattices when incorporating foreign ions through isomorphic replacement. Up to 1.5% of Cr_2O_3 causes green colour in demantoid ($3\ CaO.F_2O_3.\ 3\ SiO_2$) but red colour in pyrope garnet ($3\ MgO.Al_2O_3.\ 3\ SiO_3$). A similar phenomenon is observed in synthetic corundum where up to 8 atom per cent. chromium cause red colour and bigger quantities (up to 30%) green colour. The red corundums become green on heating and revert to red when cooling ; the green corundums turn red on cooling (minus 150° C) and revert to green at higher temperature. It is assumed that the green colour is caused by chromium-chromium contact in the lattice, giving the chromium partly a metallic structure. Chromium is also the pigment in red spinel ($Mg.O.Al_2O_3$). In synthetic spinel, too, red or green colour is produced by isomorphic replacement of Al_2O_3 through Cr_2O_3 the critical limit being 15 atom per cent. of chromium.

E.S.

Cox (H. H., Jr.). *Jet—the Black Beauty Gem.* Lapidary Journal. Dec., 1952, pp. 334–342, 2 illus.

Jet is used in costume jewellery and commands high prices. There is a strong possibility that much of it is not jet at all, some so-called jet being coarse grade glass. The article tells how to cut and polish jet without machinery ; files, paring knife and a jeweller's saw are the principal tools used. A.G.

Day (N. H.). *A visit to a French artificial pearl factory.* Gemmologist. Vol. XXII, No. 258, pp. 15–16. January, 1953.

A note of a visit to " La perle du lac " imitation pearl factory at St. Gingolph on Lake Geneva. Scales of the bleak taken from the waters of the lake are employed. The scales are scraped off, washed in ammonia, and treated with other chemicals before suspension in a solution of amyl alcohol and ether. The beads are dipped in this solution, which is apparently bonded in a special enamel, to give the coating. Up to 17 dips are given to best quality pearls. Coloured pearls are made by using a dye for the third dip and completing with two further dips in standard solution.

R.W.

WEBSTER (R.). *Operculum.* Gemmologist, Vol. XXII, No. 259, pp. 31–33. February, 1953.

A reprint of an earlier article (1938) on the operculum of the topshell which has been used in jewellery. The origin of these pieces, the localities where the shells abound, the appearance of the opercula and the chemical and physical properties are given. An additional note to the earlier write-up refers to an article published during the last war, on the finding of these opercula by the fighting forces operating among the Pacific islands. 1 illus.

P.B.

ANDERSON (B. W.). *Two new gemstones : Taaffeite and Sinhalite.* Gems and Gemology, Vol. VII, No. 6, pp. 171–175. Summer, 1952.

A full description, with history, of the finding of the two new species. A list of their properties is given. The subject has previously been reported in Journ. Gemmology (*Vol. III, p. 77–80 taaffeite ; pp. 315–321, sinhalite*).

R.W.

SWINDLER (K.). *Engraved gems through 6,000 years of popularity.* Gems and Gemology, Vol. VII, Nos. 6 and 7, pp. 176–185 (Summer, 1952) and 213–222 (Fall, 1952).

A very full exposition of the history of engraved gems from the earliest times. Egyptian, Greek and Roman carved gems are discussed. Mention is made of the materials used (including shell cameos). The second part details the gems of the Middle ages to those of to-day. A note is given on the tools used in gem engraving. 17 illus.

R.W.

WEBSTER (R.). *Some unusual composite stones.* Gems and Gemology, Vol. VII, No. 6, pp. 186–187. Summer, 1952.

Tells of two types of composite stones which were somewhat unusual. Three were quartz soudée type—one the ordinary green emerald imitation and the other two similarly had a rock crystal crown and base but were of unusual colour. One had an " alexandrite-like " colour change, and the other was sapphire blue in daylight and purple under artificial light. The other three stones were composed of a rock crystal crown with a coloured glass base. Their colours were sapphire blue, purple and yellow and the glass bases had refractive indices of 1.51 and the density was respectively 2.61 ; 2.56 ; and 2.55. P.B.

HARRISON (A. R.). *Occurrence—mining and recovery of diamonds. Part II.* Gems and Gemology, Vol. VII, No. 6, pp. 188–190. Summer, 1952.

A further instalment of the series on the world occurrence of diamond. The localities dealt with are the Gold Coast ; French West Africa ; the alluvial deposits in South Africa and those of South West Africa. The production and mining methods of each of these localities are discussed. It is mentioned that the South West African deposits, and in fact most alluvial deposits, are not water-repellent because the diamonds are coated with a microscopic film of salts and it is necessary to first " condition " the diamonds by immersing and light milling the concentrate in a dilute solution of whale acid, or fish oil, and caustic soda before grease table recovery. The story that diamonds can easily be picked up on the beaches of South West Africa is shown to be false. A table is given of the relative yield of various diamond mines.

R.W.

SMALL (J.). *Weight estimation of cabochons.* Gems and Gemology. Vol. VII, No. 6, pp. 191–194. Summer, 1952.

By the use of a millimetre screw gauge or a dial gauge, such as the Leveridge or similar type, and employing the formula weight equals length in mm. multiplied by width in mm. x depth in mm. x .0026 x specific gravity of the stone, it is possible to arrive at an estimated weight with a low probability of error. The method may be simplified by the use of a graph (an example being shown). Working examples given and the derivation of the formula fully explained.

R.W.

PLATO (W.). *Oriented lines in synthetic corundum.* Gems and Gemology, Vol. VII, No. 7, pp. 223–224. Fall, 1953.

The existence of zonal lines in synthetic corundums is discussed. These are not " twinning lines." They are best seen in parallel polarised light when viewed down the optic axis—the direction being first found by the use of convergent polarized light. These lines, which show angles of 60° or 120°, are only with difficulty seen at any time and only along this one direction. They are suggested as an added sign of synthesis in difficult stones, as they differ from the effect seen in natural stones.

R.W.

BENSON (L. B.). *Los Angeles collector owns large specimen of new gem mineral.* Gemological digests. Gems and Gemology, Vol. VII, No. 7, p. 225. Fall, 1953.

A 158 carat sinhalite is reported to be in the possession of Los Angeles collector W. E. Phillips. The stone was originally purchased as a tourmaline, but its identity was questioned by Dr. George Switzer—possibly this stone is the one which initiated the work which produced evidence of the existence of the new gem species. Full data and photograph of the stone are included.

R.W.

TRUMPER (L. C.). *Iolite.* Gemmologist, Vol. XXI, No. 257, pp. 217–218. December 1952.

A discussion of the properties of three specimens of iolite in the author's collection, and on iolite generally. No new data produced. The author's measurement of the double refraction is given as 0.011, which he points out is slightly higher than the values 0.008 to 0.010 usually given in gemstone literature.

R.W.

ANON. *Joseph Strasser.* Gemmologist, Vol. XXI, No. 257, p. 224. December, 1952.

A story of the inventor of the brilliant lead glass known as "strass." It further tells that the inventor's daughter married John Dolland, the well-known English optician. *In a letter to the Editor, M. D. S. Lewis criticises many of the statements made in this article see p. 18, Vol. XXI, No. 258. January, 1953. This letter suggests that Strass (G. F.) is the rightful inventor of " strass."*

R.W.

KISCH (T. B.). *Suoth Africa's first diamonds.* Gemmologist, Vol. XXI, No. 257, pp. 226–232. December, 1952. (*Reprinted from OPTIMA*). Second instalment Vol. XXII, No. 258, pp. 9–13. January, 1953.

An original story of the early days of the South African diamond discoveries. It is taken from hitherto unpublished notes of Kisch, one of the forgotten pioneers of pre-Kimberley days. The introduction is by E. Rosenthal who obtained the papers. 2 maps, 1 illus.

R.W.

WEBSTER (R.). *Fish scales or silver ?* Gemmologist, Vol. XXII, No. 258, pp. 1–4. January, 1953.

An article printed in a trade journal of the paints industry casts doubt as to the truth that fish scales are used in the production of pearl essence, and suggests that finely divided silver is employed. Webster attempts to clarify the position by giving as full as possible the history of the use of pearl essence (guanine scales), and by the results of some experiments carried out to detect silver in pearl coatings. The results were negative for silver.

P.B.

PARKINSON (K.). *Ceylon : The island of gems.* Gemmologist, Vol. XXII, No. 258, pp. 5–6. January, 1953.

Further notes on the mining and marketing of gems in Ceylon. The method of bidding by code with the fingers while the hands are covered by a handkerchief is mentioned. Three per cent. commission is deducted by the buyer to be generally distributed one half to his mosque and one half to those who attend the sale—including lookers on. Of the 97% left 20% goes to the landowner ; 8% to the licensee and the remainder divided between the miners and labourers.

R.W.

ANON. *The beauty of star stones.* Gemmologist, Vol. XXII, No. 259, pp. 34–37. February, 1953.

A short article outlining the reasons for the effect known as chatoyancy and that known as asterism. Notes are given on the types of stones in which the effect may be seen. Chrysoberyl, corundum, garnet, quartz, beryl, tiger's eye, scapolite, calcite and tourmaline are mentioned. A silicified hematite from Minnesota, called locally *binghamite*, seems not to have penetrated gem literature.

P.B.

GRODZINSKI (P.). *A statue with diamond eyes.* Gemmologist, Vol. XXII, No. 259, pp. 24–25. February, 1953.

A small statuette in the British Museum is credited to the first century B.C. or A.D. Doubt is cast on the authenticity of the diamonds set in the eyes as being contemporary with the figure itself. Results of an investigation and general deductions seem to prove that the diamonds were inserted later. Illustrated.

R.W.

HEYNE (K. N.) and NICOL (H. Q.). *Japanese Gem Cutting Industry.* Lapidary Journal, February, 1953, pp. 420–432, 5 photos.

The centre of this industry is Kofu, comprising about 150 cottage establishments. The Kofu industry is concerned with cutting and carving of mass-production items, primarily from rock crystal, coloured stones being cut but rarely. As a result of employing much juvenile labour, the average age of workpeople employed is about 30. The various processes used in cutting rock crystal, amethyst, rose quartz and agate are adequately described. Most of the rough material is imported from Brazil, and the industry, which produces among other things the well-known crystal spheres, is aiming to capture the market which Chinese jade formerly occupied. The industry has its own research laboratory maintained by the local government.

A.G.

GÜBELIN (E. J.). *More notes of synthetic red spinel.* Gems and Gemology. Vol. VII. No. 8. pp. 236-247. Winter 1952-53.

The author states that synthetic red spinel is now commercially possible and may have to be reckoned with in the near future. Six specimens of this new synthetic, which are made by the Verneuil flame fusion process, were examined and the results fully reported. The colour is purple-red to ruby-red and approximates to that of ruby rather than to natural red spinel. X-ray Debye-Scherrer diagrams showed the stones to be identical with natural spinel, and to have unit cell $A_w = 8.084 \pm 0.001$ Å (natural spinel $8.086 \pm 0,001$ Å). The specific gravity was found to be 3.579-3.598 (3.595 in table); the refractive index 1.7191 to 1.7198, and the absorption spectrum to conform to natural red spinel. The fluorescence was found to be a dull red under short wave ultra-violet light and a bright red under the long wave radiation. The fluorescence spectrum exhibited a single broad red band (6850 to 6900Å) rather than the group of lines seen in natural red spinels. The composition of the stones is equi-molecular unlike the normal synthetic spinel with $Mg0: 3.5\ Al_20_3$. The included gas bubbles take the shape more commonly seen in synthetic corundum and curved striae are present. Between crossed nicols anomalous double refraction may be seen, or in clear stones, complete extinction. 12 illus. 2 tables.

R.W.

BOOK REVIEWS

LANG (H.). *Das kleine Buch der Edelsteine.* Little book on precious stones. Coloured pictures by H. Lang, comments by F. Schnack. List of tables, 40 pp. Insel-Book No. 54. Published by Inselverlag, Leipzig, Germany.

The booklet consists essentially of 24 handsomely executed coloured tables, with a carefully prepared descriptive list of the depicted individual precious stones in the rough and cut. Ten pages commenting on the magic and the power of precious stones are hardly of interest to the gemmologist but may appeal to the romantic lover of folk-lore and the student of superstitions.

E.S.

GÜBELIN (E. J.). *Inclusions as a means of gemstone identification.* pp. 220. 258 illustrations with coloured frontispiece. Gemological Institute of America. Los Angeles, Calif. Dollars 6.75.

The many varied patterns, often so beautiful, seen in the interior of gemstones through the magnifying eye of the microscope, have always been a source of wonder to the gemmologist. That these patterns tell more than just that the stone is either natural, synthetic, or just a glass, has long been known in a scrappy sort of way : scrappy that is, because those workers who have interested themselves in such studies have published them in divers journals, and no full correlation has been made.

Dr. Gübelin, in " Inclusions as a means of gemstone identification " has in one volume told the major part of the story. A story mainly of his own observations, his own painstaking work which he clearly has enjoyed doing. The result is a book the like of which there is none other.

In his introduction, the author mentions and honours the workers who have gone over some of the ground before him, like Michel who at one time was his tutor. The importance of these inclusions in minerals as indication of the condition of the surrounding magma at the time of the host minerals formation is stressed. The value of the modern gemmological microscope with ordinary or dark ground illumination is discussed and also what is meant by the term " inclusion." The time of formation of the inclusions in relation to the host are explained when pre-existing ; contemporary and post-formed inclusions are discussed.

“ Solid inclusions ” are discussed in the first chapter. The various types of such inclusions are given and also is the method of identifying them. The next chapter is given over to “ Liquid and gaseous inclusions ” which include not only liquid-filled cavities but also the gas bubbles seen in synthetic stones and pastes. The difference in relief shown by these two types of inclusions are explained. Cracks, fissures and such growth phenomena as twinning and zoning complete the series on inclusion types.

The chapter on inclusions seen in synthetic stones is most complete. An interesting feature is the illustration—by line drawing—of the cause of the larger bright centre seen in bubbles in paste than seen in the case of bubbles in synthetic stones. Mention is made of a synthetic star corundum in which the star is produced by ruling fine lines on the base of the cabochon and then backing with foil. The following two chapters discuss the reconstructed ruby ; inclusions in glass and in doublets. The reviewer takes exception to the comment that goldstone is glass in which copper crystals or filings have been added in large quantities. The real fact is that copper is not added, but copper compounds are incorporated in the melt which subsequently crystallize as triangular (or hexagonal) platy crystals in the glass.

The following several chapters deal with the inclusions seen in diamond, in which the controversy of its genesis is commented upon. The inclusions in ruby are discussed from the angle of the different types seen in stones from such localities as Burma, Siam and Ceylon. Sapphire is similarly treated, stones from Cashmere, Ceylon, Burma, Siam and Montana are discussed. It is noted that Australian sapphires are omitted.

A very full exposition is given of the inclusions seen in natural emerald, with particular attention to the stones from the major localities : Colombia, Brazil, Russia, India and South Africa. The synthetic emerald having been fully dealt with in the chapter on synthetics. Discussion of the inclusions seen in aquamarine ; the garnets ; topaz ; tourmaline ; quartz ; peridot ; moonstone ; andalusite ; kyanite ; zircon and fluorspar complete the species covered. The final chapter gives the author’s concluding remarks.

Such a subject would be lost if in script only and without some pictorial representation. The reader is treated to over 250 of Dr. Gübelin’s incomparable photomicrographs, which alone are worth the price of the book.

There are very few errors in the printing, which is in an exceptionally clear fount. The illustrations appear to have been printed slightly too heavily and have masked the fine detail of some of the photographs. Incidentally, the picture of crystals of Ceylon sapphire (Fig. 19) on page 134 has crept in again as " emerald inclusions " (Fig. 5) page 148 ; and Figures 3 and 4 seem to have been transposed. The paper used is of a durable nature, but it is considered that the use of an art paper and half-tones might well have reproduced the pictures better. The book has no index (there is, of course, a table of contents at the beginning), the volume being concluded with an extremely comprehensive bibliography.

No discerning gemmologist can afford to be without a copy of this important work. R.W.

CHUDOBA (K. F.) and GÜBELIN (E. J.). *Schmuck- und edelsteinkundliches Taschenbuch.* (Gemmological Pocket Book.) Published by Bonner Universitaets-Buchdruckerei, Gebr. Scheur G.m.b.H. Germany 1953. 158 pp., 150 illustr., 27 tables, 2 colour plates.

This well-produced publication by two outstanding gemmologists corresponds largely to Webster's " Gemmologists' Compendium " and like it will be an invaluable help to gemmologists, jewellers, goldsmiths, collectors and those dealers and cutters who have more than a commercial interest in precious stones. The " glossary " is sub-divided in several respects. The glossary proper is preceded by two alphabetical lists of the names of gems and gem materials, with clear indications of internationally and nationally permissible denominations. The most important materials are marked in heavy type. The etymological derivations are given in most instances thus adding to interest and understanding. The second name-list groups the gem families together and confronts usual, correct and wrong designations. Four appendices to the glossary deal with styles of gem cutting, formation cycles of gem materials, geological terminology, and occurrence of the economically important precious stones. These sub-divisions, though no doubt increasing the clarity of presentation, can be irritating to the casual user of the " pocket book," because, for instance, he will not find the occurance of Diamond under " D " in the glossary, but only in the fourth appendix to it. The remarks introducing the tables in the section on " constants and data " are masterly, short and precise. Under the optical properties twenty-seven diagrams of absorption spectra are given, paying tribute to the work of British gemmologists under B. W. Anderson. Two tables list precious stones which display fluorescence and those which do not respond under ultra-violet light (over 2000 Å). Diamond, for instance, is listed in both tables. The first table seems to suggest, that there is a connection between the colour of diamond in ordinary light and that displayed in fluorescence and phosphorescence. No such connection could be established in tests made in this country. An important section of the pocket book deals on 24 pages with inclusions, roughly half of this section being devoted to general considerations, the rest to diagnostical characteristics of individual species. The text together with 124 excellent photomicrographs in a separate appendix forms a concise and most valuable entity which is far more than a mere introduction into the exciting art of determining precious stones by the fingerprints of nature.

A summary of relevant physical properties of the most important gem materials is given in three tables. The first table, a most useful arrangement, corresponds roughly to the summary in Kraus and Slawson's " Gems and Gem Materials." The two other tables list the stones in colour groups with their density and Mohs hardness values. A small chapter describes Schlossmacher's precious stone microscope, a horizontally arranged polarizing microscope allowing rotation of the stone under observation in a liquid containing cell. Surprisingly, reference to the dispersion of gemstones has been omitted and it is also regrettable that the authors have given so much space to obsolete misleading names of gems.

Very interesting graphs showing the spread of colour, density and refractive indices in the individual species conclude the pocket book. The colour plates are excellently executed.

Any book relying mainly on tables to present its information suffers necessarily from inherent disadvantages. Apart from this reservation, however, the publication is extremely clear and useful and will soon be one of the most important and handy aids for the German speaking practical gemmologist.

W.S.

GEM MINERALS of the BRITISH ISLES

by Nigel W. Kennedy

BRITAIN is not and never has been a producer of gemstones in any large quantity or of high value commercially, nor is there any indication that the United Kingdom will make any really significant contribution to the gem markets of the world. In spite of this it is not generally realized that many representatives of gem species in many colour varieties are to be found in Britain.

Most text books which go so far as to mention the presence of gem material give a strong impression that it is of inferior grade or microscopic size, of interest only to the student of geology or mineralogy.

By a dispensation of Providence, which has resulted in the accumulation of a very complete sequence of geological formations between John o' Groats and Land's End, Britian is actually a rich hunting ground for the mineralogist, and strong evidence has been advanced that the rocks of which part of the Hebrides are formed were a part of the original crust of the earth, dating back possibly some two thousand million years ago. In view of this it is not so surprising that such a variety of minerals is to be found in so small an area, but what may surprise most of us is the fact that many gem minerals previously believed only to exist in minute form and dismal tones, are now known to occur in gem quality of cuttable size and often of fine colour.

Unfortunately no concise record of the occurrence of gem material in the British Isles as a whole, and particularly of the region covered by England, Wales, and Ireland, appears to have been written up to the present time, probably because comparatively few geologists have been sufficiently interested in gemstones. This is not so in the case of Scotland, where the Scottish Geological Survey seems to have taken the trouble to indicate the occurrence of gem material on many of their maps.

The reason for this, as will shortly be seen, is probably that Scotland as a whole is more prolific in gem material than the other countries in the Union. Of course many articles on gemstones have been published in the literature of various scientific organizations from time to time, but an enormous amount of research would be required to trace and correlate them into a single account.

In the case of Scotland, at least three competent authorities have been inspired to write detailed accounts of the occurrence of gem minerals, and the subject has been very ably dealt with by Heddle in " Mineralogy of Scotland," 2 vols. (1901) ; Smith, in " Semi-precious Stones of Carrick " (1910) ; and more recently by MacCallien in his " Scottish Gem Stones " (1937), and it seems likely that these will be followed by other equally interesting works.

I felt rather handicapped owing to this lack of data on gem minerals other than Scottish, and have tried to fill the gap by a careful inspection of the splendid collections on view at South Kensington. My notes must be necessarily incomplete as, while I have been able to examine the whole collection in the Geological Survey Museum, only about half of its collection is as yet displayed in the Natural History Museum, but even as it stands, the list I have been able to compile is a very interesting one and includes many unusual minerals.

Perhaps at this point I should recall that gem material may be classified according to two entirely different modes of origin, namely those which are purely mineral, and form the greater portion, and those produced by the agency of living matter, animal and vegetable. Both may be modified or completely changed in composition, form and properties, the fresh re-arrangement being due to the effect of pressure and heat, usually in the presence of water ; that is, by dynamic and hydro-thermal metamorphism. Intrusion of molten mineral material in each case also alters the nature of the rocks in immediate contact with the intrusion, resulting in the production of many new minerals often of gemmological value and interest.

ORGANIC MATERIALS

Since the number of *organic* minerals and other material used as gems, is relatively small, we can dispose of this section before proceeding to the more detailed discussion of gem minerals.

In the organic section we include pearls, corals, incised shells, mother-of-pearl, polished sections of calcitized ammonites and belemnites, fossil bones and teeth, fossil sponges, petrified (silicified, jasperized, and opalized) wood and bone, as well as amber, jet, and surely, bog-oak. We should also remember the many beautiful marbles quarried in many parts of the United Kingdom, including

White from Antrim ; Purbeck Marbles ; Coralline Marbles from Ludlow ; Oölitic Limestones from Bristol ; as well as shelly, ammonite, and crinoidal limestones from many other localities. British Marbles are found in an astonishing variety of colours—white, cream, yellow, grey, pink, greenish, brown, and black and compare favourably with any foreign marbles, as may be verified by anyone who visits the Geological Survey Museum.

British waters are no longer warm enough for either the pearl oyster or coral polyp, although some corals are found in the south, but the quite lovely Fresh Water Pearl secreted by the mussel, which still persists in some of our rivers and lakes, in spite of pollution, may be found in Western Scotland, North-west England, North Wales and Ireland.

Amber is still washed up on the East Coast, particularly after storms, and is of course, the resinous secretion of coniferous trees which in bygone days flourished in the forests of the wide Rhine Valley which owing to depression of the continental shelf is now inundated by the waters of the voracious North Sea. The fossilized teeth of sharks and wolves, and other creatures were used by our pre-historic predecessors as gemstones and are often found in burial sites. In medieval times they were frequently mounted as charms and amulets and worn in rings to ward off the Evil Eye, not as *teeth*, but in the belief (real or simulated) that they were gems secreted in the brains of reptiles, and known variously as " Toad Stones " and " Lizard Stones " and referred to as such by Shakespeare. Several examples of such rings are displayed in the jewellery section of the Victoria and Albert Museum. Belemnites are slender pointed cylindrical objects also sometimes polished and worn as charms from an early age, in the belief that they were darts or thunderbolts dropped by mythical beings during thunderstorms, and believed to be endowed with occult powers. They are really the casts of the bony guard, or pragmacone, and ink-bag of the cuttle-fish (or sepia, squid or octopus) which at one time inhabited the waters of former seas that covered Britain.

Ammonites are species of shell-fish of the nautilus family, that is, coiled in a flat spiral like the horns of Ammon, or of a ram, and are found in large quantities in some limestone formations. Ancestors of present species have left their casts in some limestones bearing their name, in which calcite and quartz have sometimes crystallized in these shells, which when cut and polished form interesting mineral discs which when small enough were sometimes used as jewellery in Victorian times.

Jet, the precise origin of which is still a matter of conjecture, has been esteemed as an article of jewellery in Britain since prehistoric days, and beads and other artefacts in jet are found in many burial sites throughout the United Kingdom. Whitby has long been the centre of the Jet industry, which in Victorian days was very prosperous, but the discovery of ebonite, which may simulate jet closely, enabled the mass production of spurious moulded and cut trinkets and other objects to flood the market. During the recent War the industry revived somewhat owing to a demand from Americans in Britain, but now few persons are actually engaged in this craft.

The above seems to cover the organic minerals found in Britain and fabricated as gemstones, and we are now free to review the features of the inorganic minerals of gemmological interest which also occur here.

MINERALS

The gem minerals differ from each other very considerably, not merely by reason of variation in composition, but also owing to their very different circumstances of origin. Probably most gemstones are either primary accessory minerals, that is, were evolved during the formation of the granitic rock in which they are found associated with much larger proportions of the essential mineral constituents, or as secondary minerals in sedimentary and other formations penetrated by igneous intrusions, or were formed by the slow percolation of saturated mineral waters or gases.

For example, when molten material is intruded into limestone, it is converted into crystalline *marble* (Calcite or Dolomite) and in the presence of clays and other minerals, a re-arrangement takes place and *contact* minerals of an entirely different kind are produced in the area of metamorphism surrounding the intrusion. These include Corundum, Garnet, Spinel, Idocrase, Kyanite, Staurolite, Cordierite, Andalusite, Chiastolite and others. Minerals such as Azurite and Malachite, Barytes, and Blue John (Fluorite) which are stalagmitic in form, are of course, the result of percolation of saturated mineral solutions.

After reading " Scottish Gem Stones " one might expect that the rest of Britain would be equally rich in gem material, but this is not the case, and a study of a geological map of the British Isles helps to explain why. It is seen that while Scotland consists almost entirely of ancient formations exposed at the surface, and extensively folded and intruded by igneous masses, and was the scene of most violent volcanic activity in past ages, we find that except for the north-west, Wales, and south-west, the remainder of Britain is covered by later formations which are only penetrated in a few isolated areas by ingeous intrusions, as at The Wrekin, in Shropshire, or Charnwood Forest, Leicestershire. Hence any minerals which may have been formed in the older rocks are likely to be buried beneath thousands of feet of later accumulations.

SCOTLAND.

Intense folding, like that which runs diagonally from N.E. to S.W. of Scotland, producing parallel mountain ranges and long narrow lochs and fiords, such as Loch Ness, are conducive to the formation of stress minerals like Garnet, Kyanite, Staurolite, Cordierite, which are alteration products, as are the gneisses in which they arise. These minerals are in fact found in quantity, but not always in gem quality; for example Cordierite is anything but perfect as found.

No doubt the most famous gemstones of Scottish origin are those of the quartz family, particularly from the Cairn Gorm area of the Grampians, namely, Rock Crystal (found all over Scotland), brown quartz, or Cairngorm, Citrine, Smoky Quartz or Morion, and Amethyst, which at one time were to be picked up easily on the hillsides. Formerly Scottish gems were obtainable at quite low cost, mined and cut in Scotland, but during the War American troops became more familiar with these stones whose beauty appealed to them so much that supplies appear to have been dried up, and the cost has soared.

Sections cut from many Scottish rocks show the presence of many interesting gem minerals, such as Olivine, Sphene, Enstatite, which give their names to rock types, but they are usually of small dimensions unsuitable for cutting. Many of them have, however, been found of cuttable size.

A few visits to our local museums will reveal the fact that British minerals are to be found in an astonishing variety of lovely stones in many colour variations and forms, comparable with anything from abroad ; some indeed possess an almost incredible loveliness of form and colour. Among such minerals one might mention Goëthite its truly amazing variations in form, texture, colour and lustre ; Azurite and Violane of exquisite deep blue ; and purple Riebeckite. Yet although we are so fortunate as to have such a galaxy of magnificent specimens at hand to study, it is clear from such writers as Heddle, that these celebrated collections have in most cases still to be enriched by unusual colour varieties of relatively common minerals from Scotland, in shades one has never imagined.

For example blue Quartz, and really red Quartz, and even green Quartz ; and red and yellow Prehnite, as well as the elusive green Topaz of which no one seems to have a cut specimen.

IRELAND

There seems to be even less information available in literature in relation to the occurrence of gem minerals in Ireland, yet, the few specimens to be seen in our museums at South Kensington indicate that Ireland could contribute her quota of beautiful minerals but so far I have not had any opportunity to visit any Irish museums.

Probably the best known examples come from the Mourne mountains of County Down, where blue and green Beryl, and blue Topaz are found in the local granite, and similar crystals also come from County Donegal. Colourless Analsime and Kyanite are found in the Giant's Causeway, at Antrim, while brown Idocrase is found in County Donegal. Ireland also produces the well-known " Sceptre " crystals of quartz (rock crystal) which are found near Dublin, and some of the most beautiful marbles, in many shades, are quarried in many parts of the country. Bog-oak, which may be included as a gem material if jet is admitted, is produced in many parts of Ireland and fashioned into many cunning little trinkets, often beautifully carved. Fresh water pearls are still to be found in the mussel shells in many Irish rivers, and I have a fine specimen in pink, white and pale blue, which was recently found near Dublin.

WALES

This principality is certainly the richest source of native Gold in Britain, and in addition, quite a number of gem minerals are found there, probably more than have actually been recorded.

ENGLAND

A glance at a summary of minerals from English localities tells us that they may be roughly divided into two main areas, namely, Cumberland, Durham, Westmorland, with North Lancashire and Yorkshire as one, and Devon and Cornwall as the other : few gem minerals are found in most other localities, in which, however, many delightful ornamental and building stones abound in many shades of colour.

A complete list of English gem minerals would probably show that most of them occur in Devon and Cornwall. Turquoise is not a mineral that one would expect to find in England, but it has definitely been located by Sir Arthur Russell in a vein near St. Austell recently. It is interesting that both Rhodonite and Rhodochrösite, as well as Phenakite, are found in the Duchy, and our London museums contain many lovely specimens of unusual minerals from this area which are or could be cut as gemstones, and whose colour and lustre are of a high order. Cassiterite is of course relatively common as a mineral but gem quality is very rare and cut specimens quite exceptional.

I am sure that a question that most of us would like to be answered is not merely what gem minerals have so far been located in the British Isles, but also where are they situated, and in what quantity and grade, and what is the possibility of tapping such resources as may be present ? Unfortunately I am not yet able to answer these queries, but I do sincerely trust that the day is not far distant when more information of a practical nature will be available.

In America where anything which takes on with the public does so with great enthusiasm, I am informed that the energetic Rock Hounds now number over three million, and it is clear that through their activities many new localities have been discovered in which beautiful and often new minerals are found. If they are controlled and guided by experts in their perambulations this should be a good thing, and I should like to see it followed here, but otherwise great crowds of people armed with picks and hammers may do untold damage and ruin valuable and interesting specimens which should be placed in museums for all to see.

I have been able to see several collections in Scotland recently and hope to do some considerable research there in the hope of unearthing many of the specimens described by Heddle in his amazing monograph of 1900. Unfortunately interesting specimens are not always clearly labelled in museums and it is therefore difficult to trace many minerals. Also, some collections are still in a state of flux owing to taking over new galleries, but I have seen enough to believe that Heddle and other writers were justified in their descriptions of Scottish minerals, and I have made a short summary of the gem minerals included in his list.

Space does not permit more than brief references to some of the outstanding examples of gem minerals described by Heddle, and which excite one's imagination with anticipation, but I will quote a few :—

QUARTZ

" *Hyaline Quartz.*" A variety of Cairngorm, of a claret colour, but surpassing it in brilliancy, colour and pelucidity." Occurrence, Ben Lawers, Perthshire ; Lock Eck, Argyll.

Amethyst. " Occurs in Inverness in crystals usually capped, being alternately purple and colourless." Amethyst, with *red* quartz found at Scurdy Ness, Fifeshire. Amethyst associated with *blue* Barytes at Kintel, Forfar, etc.

He mentions that crystalline varieties of quartz occur in various colour varieties, as well as Rock Crystal with a general distribution, and cites Rose (Pink) Quartz (which is most unusual as a crystal), Scarlet, Red, Dark Red, Yellow, Brown-red and Purple Quartz, and also speaks of massive Quartz in blue, yellow, rose, yellowish-green, and green.

CHALCEDONY

Occurs in many forms all over Scotland, and includes Prase (leek-green), Blood stone, Cornelian (red, and yellowish) and Blue Chalcedony.

AGATES

There is a large collection of Scottish Agates in the Royal Scottish Museum at Edinburgh, in which many hundreds of specimens are exhibited in groups from respective areas, and it is clear that in many cases they form definite locality types by which many could be identified. They are usually very beautiful and some possess the most amazing groups of colour bands ; which make them worthy of comparison with the finest artificially-coloured stones from Idar-Oberstein. Here is a description of several which should excuse my enthusiasm :—

Blue, from Luthrie, Heather Hill, et cetera. Brilliant ink-blue and white, and wax yellow, from Blue Hole, Usan. Lilac, flesh-red, rose, grey, with blue chalcedony, often with layers of

Girasol opal, found at Agate Knowe, Perthshire. Dark blue, brown, black, white, grey and lavender, with violet chalcedony, cornelian, and vermilion jasper, from Midlothian. The most beautiful Scottish Agates are stated to occur at Agate Knowe, Tinkle Top, Perthshire.

OTHER MINERALS

As a gemmologist possibly I should not associate any particular colour with any specific mineral of gem interest, but I certainly had some rather fixed conceptions regarding some mineral species. For example, Kyanite and Prehnite, the former being named after its predominant blue colour, sometimes it is true, rather blue-green, but Heddle states that " Scottish Kyanite may be green, red, yellow, or colourless, most usually blue, and is found in association with Tourmaline at Unst, Shetland, and with Garnet at Glen Clovas, Forfarshire. Prehnite I have always thought of as a dirty-greenish mineral occurring rather sparingly in some lavas as a secondary zeolitic mineral, but Heddle writes of it as being found in white, dark green, pale green, brown, bright yellow, orange, and sometimes pink, as at Edinburgh. Likewise I had not realized that pink Fluorite was found to any extent outside Switzerland and France, yet apparently it is relatively common in occurrence in Scotland.

Microcline is another " surprise " mineral and is most familiar to us as a blue-green mineral found at Pike's Peak, Colorado.

In his description of this mineral Heddle scarcely mentions the occurrence of green or blue-green, but he has located red and brick-red Microcline at Cape Wrath and Shetlands respectively, and brown in the Hebrides, with purple at Tiree ; grey to cherry-red occurs in Nairnshire, and white to blue in Harris, blue also occurring (with Garnet, Tourmaline, Beryl and Orthoclase) at Struy Bridge, Ross.

Garnet. This seems to be very abundant, and has been found in fine gem quality, Pyrope having been worked as " Elie Ruby " at Elie Ness, Fife. Almandine occurs in many places, as well as Hessonite and Grossular, and an interesting reference is made to " Water Garnet," a colourless variety found in Aberdeen and Banff.

Beryl is found in blue, yellow, white and nearly colourless, and in Banffshire is usually banded in pink, white, green and colourless.

Topaz. In Aberdeenshire this mineral occurs in pale blue, red-brown, amber, and green, in crystals sometimes a pound in weight, and in banded crystals of many colours. Colourless Topaz also found in Bute and Argyll, sometimes honey-yellow.

Corundum is recorded by Heddle as occurring in pale and dark blue *asteriated* small crystals at Clova, Aberdeen.

Tourmaline he also mentions as being found in indigo-blue and brownish green at Kirkcudbright as well as black at Ross, and among other gem stones found in Scotland he records " perfectly transparent ruby red Zircon crystals from Ben Hope " as well as colourless from Ross ; yellow-brown from Fife ; pink from the Hebrides, and blue-black from Inverness. He also remarks that " Large numbers of fine spinel crystals were collected by Teall and presented to Edinburgh Museum."

In addition to the foregoing gem minerals Heddle also alludes to the occurrence of Nephrite, pale green stones, in Shetland, the Hebrides, and Banff and other places. Staurolite is stated to occur in orange-yellow crystals " as large as in Brittany " in Inverness, while Enstatite occurs at Banff " In large lustrous pale green crystals." Sphene of yellow colour associated with Fluorite, and Datolite with green Prehnite, Scapolite (Wehnerite) and Idocrase are also recorded.

This gives some conception of the gem mineral interest of the Scottish area, but it is one thing to know that something exists, and quite another matter to locate it and determine in what quantity and quality it occurs, and its general availability.

Since commencing my investigations I have been able to pay several visits to Scotland and have located many of the museum specimens referred to above, and indeed have handled some of them by courtesy of the museum authorities, but owing to the usual changes of staff and in display of specimens, I have not succeeded in tracing many interesting stones. The several museums in Scotland amply repay a visit, and the staffs are very helpful and interested in genuine students. The Royal Scottish Museum, Edinburgh, houses a very fine selection of Scottish and other gem minerals, including many cut stones, and its collection of Scottish Agates from various localities, consisting of many hundreds of polished stones, gives some idea of their beauty and variety, and it is clear that local differences sometimes provide a clue to identity, the collections being conveniently arranged in batches from definite areas. It is a very lovely display.

Some of the gem minerals of Scotland are of very ancient formation, and time and the effect of dynamic metamorphism have in many instances altered the type of mineral, so that some are crushed and contorted beyond recognition and useless as gems. It is of interest, however, that they do occur, for in other places they may have been preserved for us. Corundum was recorded by Heddle in 1901, but since then it has been confirmed at Ardnamurchan Point, and on the Ross of Mull, by MacCallien, who states that blue crystals occur at Carsdig Bay, some over half-inch across, and deep blue crystals 2-3 mm. are found at Glebe Hill. I have handled these—about 2 cubic inches of them, and found them to be a lovely deep violet-blue. The occurrence appears to resemble that of Kashmir and Burma, where dykes penetrate limestone.

There is surprisingly little information as to activity in the working of gems in Scotland, and I was only able to learn that at present only one craftsman is actually engaged in cutting even in Edinburgh, where there is a constant demand for Scottish Gemstones (mainly cairngorms) by tourists. A shop in Oban has a good display of mounted stones, which from their general appearance seem to be genuine Scottish stones, slightly cloudy. The same shop has trinkets made from Iona Stone, guaranteed to be produced at that place, and I was informed that a lapidary still carries on at Arran, where Topaz, Beryl and other stones are sometimes found. I was told that during the recent War Mica was mined in a remote place in the West of Scotland, and that large crystals of Beryl had been discovered there, but no one had been interested between 1940-46. My informant was hoping to visit the locality this summer and to find beryls 12″ long, and according to him the quarry is situated some 2,000 feet up a remote mountain. The spot cannot be reached by road or rail, and it is only possible to take a bi-weekly steamer, or charter a private motorboat, and a week's stay is unavoidable. Few people realize that some spots in Scotland are very inaccessible owing to intervening mountain ranges, and that, for example, the Mull of Galloway is about 75 miles from the nearest railway station at Oban. Roads are good in most places, but in others local traffic does not justify them, and the gradients are often high, so that sea transport is usual in such cases. This has doubtless much in connection with lack of precise data on occurrence of gem and other minerals in Scotland.

Another important feature has to be constantly born in mind, and that is the psychology of salesmanship in relation to gemstones. In Cornwall, and many other places, gemstones are known to occur on the beaches and other places, tourists find odd stones and take them to local " lapidaries " and are told that the stones can be polished for them in a few weeks. In due course the mounted stones are received and in an attractive form, but in actual fact the originals may have been worthless and uncuttable—but what finder is prepared to believe it ? There was a constant trade in such goods between Idar-Oberstein and Cornwall and Scotland before the War, and this may be revived in due course. In Victorian days Elie Ness, Fifeshire, was the centre where " Elie Rubies " were found and became very popular. They are quite pretty Pyropes, and entered into the making of Scottish jewellery, but I cannot discover as yet whether there is now any trade in this stone.

I am still carrying on my researches into the question of gem resources of the British Isles and hope in due course to prove that under present conditions we have sufficient material to provide tourists and others with interesting specimens of British Gemstones at a remunerative rate. The general information that I have so far been able to collect on the subject seems to indicate that I am not wasting my time, and I trust that my gemmological and mineralogical colleagues will find similar interest in this record.

LOCATION OF GEMSTONE MINERALS

APPENDIX

The following is not a complete list of all gem minerals discovered in Britain, and those mentioned are in many instances found in other localities, but the purpose of this list is to indicate the great variety and wide distribution of the minerals included.

SCOTLAND		
Beryl	Colourless, yellow, green, blue	Banff, Montrose, Arran, &c.
Corundum	Deep blue, and asterias	Mull
Garnet	Colourless, Almandine, Pyrope, Hessonite, Grossular	Banff, Montrose, &c.
Heulandite	Red	Dumbarton
Jasper	Red, orange, mottled	Montrose, &c.
Kyanite	Colourless, red yellow, green and blue	Eigg, Unst, Forfar, &c.
Idocrase	Brown	Banff
Opal	Girasol	Argyll
Piedmontite	Red	Glencoe

SCOTLAND *(continued)*

Prehnite	Green, red, yellow	Dumbarton, Edinburgh, &c.
Quartz	Rock Crystal, red, citrine, green, Amethyst, blue, Morion, Cairngorm Rose and Milky, and asteriated	Wide spread occurrence
Topaz	Colourless, blue, red, yellow, green	Banff, &c.
Tourmaline	Black, indigo-blue, pink, &c.	Ross, Kirkcudbright, &c.
Zircon	Red, colourless, red-brown, pink and black	In many areas
Agates	Chalcedony (black, grey, blue, brown, yellow) Mochas	Many places

Serpentine, Nephrite, Apatite, Andalusite, Sillimanite, Staurolite, Spinel, Cordierite, Sphene, Scapolite, Epidote, Enstatite, Olivine, Microcline, Obsidian.

IRELAND

Idocrase, Analcime, Obsidian and Kyanite, are found at the Giant's Causeway, Antrim ; Blue Topaz, and Blue Beryl, located in the Mourne Mountains, County Down ; Green Beryl, County Donegal. Rock Crystal from County Down; Gold—County Wicklow ; Irish Marbles of great beauty are quarried at Galway, County Down, County Kilkenny, &c. Fresh water Pearls are still found in river mussels.

Isle of Man : Agates, Cornelian and Onyx from Peel.

WALES

Yellow Fluorite and Yellow Calcite obtained in Flint, also Blende ; Brookite from Tremadoc ; Marcasite occurs at Cardigan, and Milky Quartz on Snowdon. Gold has been mined in Cardigan, Caernarvon, Flint and Merioneth.

ENGLAND.

Cumberland : Yellow and Green—Carrock Fell ; Barytes, Rich yellow, Frizington, Blue, Mowbray Mine ; Calcite, Green—Alston Moor ; Purple—Patterdale. Scheelite—Carrock Fell ; Smithsonite, Alston Moor ; Fluorite—Various colour varieties ; Blende, Haematite, Pyrites, Gold (Keswick), Smoky Quartz, &c.

Durham : Calcite and Fluorite in various colours.

Westmorland : Fluorite found in many colour varieties, also Grossular Garnet. Fresh water pearls in Derwentwater.

Cornwall : Apatite, Axinite, Goëthite, and Rhodonite, &c., from St. Just. Azurite, Olivenite, Phenakite, Malachite from Redruth ; Epidote, Serpentine, and Datolite from The Lizard ; Epidote and Chrysocolla, Pink and Black Tourmaline from Luxulian. Turquoise from St. Austell, and Rhodochrösite from Wheel Coates St. Agnes. Rock Crystal, Blende, Cassiterite, Rutile, Haematite, Barytes, Grossular Garnet are found in various localities, and Gold in some.

Devonshire : Blue Apatite and Tourmaline come from Bovey Tracey ; Colophone (Garnet) from Okehampton, and Scheelite from Marytavey, while Axinite and other minerals, including Gold ore, have been found in other places.

Derbyshire : The most famous mineral from this area is of course Blue John, a stalagmite variety of purple Fluorite, found at Castleton, and Satin Spar

(Gypsum, or Alabaster) and Heavy Spar, stalagmitic, are also occurrent in this country.

Extract from list of Minerals occurring in Scotland, according to Heddle.

Ores.

Gold	Cassiterite	Haematite	Pyrites
Blende	Marcasite	Magnetite	Rutile
Chromite			

Gem Minerals, &c.

Acmite	Analcime	Andalusite	Apatite
Axinite	Azurite	Aventurine	Apophyllite
Agates	Barytes	Beryl	Chalcedony
Chrysocolla	Corundum (Sapphire)	Datolite	Delessite
Diamond (?)	Epidote	Enstatite	Fluorite
Forsterite (Olivine)	Fibrolite	Garnet (Various)	Goëthite
Heulandite	Iölite (Dichröite Cordierite)	Kyanite (Disthene)	(*Linarite*)
Labradorite		Malachite	Microcline
Orthoclase	Opal	Oligoclase	Nephrite
Prehnite	Quartz	(*Riebeckite*)	Rhodonite (?)
Sodalite	Sphene	Spodumene	Scapolite (Wernerite)
Staurolite	Sillimanite	Spinel	
Serpentine	Thompsonite	Tourmaline	(*Vivianite*)
Topaz	Zircon	Zöisite	Mochas
Girasol	Crocidolite	Jasper	
Amber	Jet	Fresh water pearls.	

Other Minerals occurring in Britain

Obsidian is found in the Giant's Causeway according to Hatch. Brookite has been located at Tremadoc, North Wales, while rich yellow crystals of Barytes come from Frizington Mine, Cumberland. Analcime is also found at the Giant's Causeway. Yellowish, Green and Purple Calcite are found in Derbyshire, Cumberland and at Patterdale, respectively. The rocks of St. Just and Redruth, Cornwall, are rich in many unusual minerals as well as ores, and amongst these we find Azurite, Axinite, Cassiterite, Blende, coloured varieties of Fluor, dark green Goëthite, Olivenite, Phenakite, blue Chalcedony, Turquoise, Vivianite, Rubellite and others. Idocrase and Kyanite as well as blue Beryl, and Topaz, are also found in good form and quality at times, in Ireland.

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ASSOCIATION NOTICES

GEMMOLOGICAL ASSOCIATION OF AUSTRALIA

The following are the Members who have qualified for Fellowship in the 1952 Examinations.

The first three positions in Australia were filled by :—

1. I. L. Thomas (Victorian Branch)
2. R. Dove (New South Wales Branch)
3. S. E. Terrill (West Australian Branch)
R. H. Hocking (New South Wales Branch)

The best student in each State was :—

New South Wales	*Victoria*	*Western Australia*	*South Australia*	*Queensland*
R. Dove	I. L. Thomas	S. E. Terrill	O. J. Cowlishaw	W. J. R. Frost

The Australian Prize has been awarded to I. L. Thomas of Victoria, and the Stevenson Award for the South Australia student to W. J. R. Frost.

The complete results are as follows :—

Out of 62 candidates who sat for the examination, 46 qualified.

NEW SOUTH WALES

I. P. J. Bloom.
R. Dove.
G. Freiberg.
R. H. Hocking.
Dolores Johnson.
K. J. Mansergh.
H. G. Milham.
Julia Myers.
K. Ramsden.
J. L. Shaw.
Livia Viola.

VICTORIA

W. Bennett.
B. Bowles.
W. Brown.
K. Chiffins.
D. Cook.
H. Crawcour.
J. R. Holdsworth.
P. G. Hoskings.
C. Manning.
D. O. McRae.
B. Schillmoller.
I. L. Thomas.
K. P. Vanderkelen.
M. Walker.

QUEENSLAND

O. J. Cowlishaw.
K. Halliday.
W. R. G. Knowles.
W. von Ploennies.
D. A. Robinson.
O. R. C. Runge.

SOUTH AUSTRALIA

I. P. Campbell.
G. T. Chambers.
W. J. R. Frost.

WESTERN AUSTRALIA

C. Brown.
I. R. Campbell.
R. Campbell.
E. Dunkerton.
R. Harper.
L. C. Hedge.
A. V. Kerr.
R. Levinson.
M. Pound.
S. E. Terrill.
Lindsay Wilson.
John D. Wyatt.

BRANCH MEETINGS

East of Scotland

A meeting of the East of Scotland Branch of the Association was held on Wednesday, 28th January, 1953, at the Heriot Watt College, Edinburgh. Mr. David L. Meek presided. The principal speaker of the evening was Professor W. H. J. Childs, Ph.D., D.Sc., F.Inst.P., F.R.C.E., whose subject was "Physics of Colour." Guests of the Association at the meeting, and at an informal dinner later, included Mr. Ian Reid, President of the Edinburgh and East of Scotland Goldsmiths' Association and Mr. S. Wood, Honorary Secretary of the West of Scotland Branch.

West of Scotland Branch

A meeting of the Branch was held on February 5th at the Y.M.C.A. Club.

The speaker for the evening was Mr. J. M. B. McWilliam, F.G.A., who opened a discussion on the Valuation of Jewellery.

Mr. McWilliam gave an outline of his methods in dealing with valuations and then invited questions and discussion. Later he gave a demonstration in the use of the American Leveridge Gauge.

COUNCIL MEETING

A meeting of the Council was held at 19/25 Gutter Lane, London, E.C.2, on Wednesday, 4th February, 1953, at 4.30 p.m. Mr. F. H. Knowles-Brown (Chairman) presided.

The Honorary Treasurer submitted the audited accounts for the year ended 31st December, 1952, which were approved for presentation to the twenty-third annual general meeting to be held on 1st April at Goldsmiths' Hall. The Council gave consideration to the future finances of the Association and decided that, with effect from 1st January, 1954, the Fellowship subscription, which had remained unchanged since 1947 in spite of increased costs of postage, stationery and the publication of the Journal, should be thirty shillings a year. Even at the new rate the subscription payable will be much lower than that asked by associations of comparable status. The rate of subscription could well be levied at two guineas, but the Council considered that this would be imposing too heavy a burden upon the younger members of the Association. It was further decided that Probationary Membership should be limited to persons under twenty-five years of age (for the previous maximum period of three years) and that the future annual subscription should be fifteen shillings. A small increase in the cost of the correspondence courses was also authorised.

The following were elected to membership :

Fellows

Ann Kochel, Alpine.

Kenneth John Lardeur, London.

Ordinary

William Arden Crosbee, Birmingham.

Sydney J. M. Latimer, Edinburgh.

Margaret Middleton, Birmingham.

William J. Webb, Leamington Spa.

Robert A. G. Struthers, Portobello.

PROBATIONARY

Trevor Martin Brook, Lincoln.
Beatrice B. Brooks, Birmingham.
Eric William Brooks, Wallasey.
Josephus L. G. Candel, Groningen.
Arthur Dennis Collinge, Birkenhead.
Joseph Dean, Newport.
Walter R. Dibben, Birkenhead.
Eric B. Forrest, Edinburgh.
Robert Cecil Fox, London.
Elmer Grey, London.
Ronald Albert Hall, Lingfield.
John Hart, Glasgow.
Scott, C. Henderson, Dundee.
Allan W. Henn, Bridgnorth.
Frederick E. J. Hewitt, Ormskirk.
Ann Holmes, Edinburgh.
Anthony L. Kemp, Bristol.
David G. Lennie, West Kilbride.

PROBATIONARY

Eric Levy, Glasgow.
Frederick E. Martin, Edinburgh.
Shirley J. Messenger, St. Albans.
Niven T. P. Mitchell, Clarkston.
Daniel McAllister, Glasgow.
Barbara J. Nilsen, Birkenhead.
George Paterson, Glasgow.
Ivan Alan Piper, Mitcham.
Eileen Bridget Pyne, South Woodford
Raphael I. Roth, London.
Moira E. Samson, Glasgow.
Noel J. Sutton, London.
Alan E. Taylor, Wallasey.
Edna May Taylor, Birmingham.
Ronald Frank Tugwell, Thornton Heath.
Sidney F. Watts, Birmingham.
Frederick A. Welch, Bebington.
Colin S. Wickens, London.

The Council made the following nominations for Officers for the ensuing year :—President, Dr. G. F. Herbert Smith ; Chairman, Mr. F. H. Knowles-Brown ; Vice-Chairman, Sir James Walton ; Honorary Treasurer, Mr. F. E. Lawson Clarke. It was reported that according to the Articles of Association Messrs. A. R. Popley, W. Stern and R. Webster retired from the Council and were eligible to seek re-election.

MEMBERSHIP

FELLOWS transferred from Probationary membership :

Austin, Leslie Frank, London.
Boudreau, Guy Armand, Canada.
Caudell, Peter Miller, London.
Chisholm, Marie-Louise Ann, Leverstock Green.
Crouchley, David, London.
Denham, Francis John, Harrow.
Drury, Ernest George Henry, Rio de Janeiro, Brazil.
Edwards, John, Manchester.
Fifield, Lawrence John, St. Albans.
Light, Donald Ashton, Sutton Coldfield.
Mason, Stanley, Harrogate.
Siedle, Louis Cochrane, Colombo, Ceylon.
Silver, Bernard, London.
Yaghobi, Hadi, London.

CORRECTION

In Vol. 4, No. 1, in Mr. F. Hessling's article " Absolute and Relative refractive index " an error occurred in the last line at the foot of p. 12. It should have read " Sine of critical angle 70° 25′ ". In the illustration the hemisphere absolute R.I. is 1.90.

INDUSTRIAL DIAMOND BUREAU LIBRARY

The Industrial Diamond Information Bureau, 32–34 Holborn Viaduct, London, E.C.1, established in 1943, has collected from its initiation a large amount of publications falling into the fields of diamond occurrence and mining, diamond tools, diamond polishing, gemstones, crystallography and all related mechanical, physical and technological sciences. It was felt that this library could be more usefully employed internally, as well as externally, if a classified list of these publications were available. This has been done in this List which is classified according to the Universal Decimal Classification (UDC).

Whilst the group headings correspond to the abridged English edition of the UDC the titles are occasionally shortened and some special groups are formed referring to special subjects not yet covered by the UDC. In two appendices in numerical order, Reports of Investigations and Information Circulars of the U.S. Bureau of Mines are listed, and Government Reports on foreign industries published after the war. The present List includes all accessions up to September 1952. Further accessions are listed in the monthly *Bibliography of Industrial Diamond Applications* issued by the same Bureau.

It is intended to publish annual supplements towards the end of each succeeding year. Publications contained in this List could be made available in general on loan for a period of 14 days, in England. The list comprises 214 pages and about 4,000 titles. A limited number of copies is for free distribution and applications should be sent as soon as possible.

TALKS BY MEMBERS

Cutts (Miss P. E.) : " Jewellery and Gemstones." Ladies' Circle, Walsall, 14th January, 1953.

Anderson (B. W.) : " Gem-testing without Instruments." Midlands Branch of the Gemmological Association, Birmingham, 13th February, 1953.

Webster (R.) : " Luminescence—its practical application in Gemmology." Members' meeting, London, 26th February, 1953.

Leak, F. E. : " Pearls." Victoria Park Contact Club, Bedminster, Bristol, 6th January. *ibid.* St. John's Fellowship, Fishponds, Bristol, 13th January. " The Science of Jewellery." Science Society of Sidcot School, Winscombe, Som. 27th January.

Armstrong, A. H. G. : " Gemstones of the Bible." Women's Guild of St. Andrew's Church, Stirling, 10th February.

Penney, W. J. : " Gemstones." Matheron Women's Institute, 18th February, 1953.

Blythe, G. : " Gems and Jewellery." Southend Business Men's Club, 19th February, 1953.

Parkinson, K. : " Gemmology." East Riding Branch of the National Association of Goldsmiths. Illustrated by films, 4th March, 1953.

Warren, F. W. : " Coronation Use of Crown Jewels." Bristol, West Young Conservatives, 25th February, also to Colston Girls' School, Old Girls' Society, 6th March, and Bristol Rotary Club, 30th March.

Parry, Mrs. G. I. : " Gemstones." The Llandaff Citizens' Association, 13th February. Ibid. The University Women, Cardiff, 13th March.

Rossiter, J. R. : " Gemstones," Catholic Women's League, Weston-super-Mare, 23rd March.

LUMINESCENCE IN THE SERVICE OF GEMMOLOGY

Mr. Robert Webster gave a talk to members of the Association at Goldsmiths' Hall, London, on Thursday, 26th February, 1953. Over 100 Fellows and Members were present. A summary of Mr. Webster's talk, which was profusely demonstrated, is set out below.

One normally couples light with incandescence, the burning faggot, the oil lamp, the gas flame and the white-hot filament of the electric lamp, all depend upon extreme heat for their luminosity. Luminescence is a light that is cold.

This light, which in general has only a weak intensity, may be induced by several different means. Cold light is not new, for the luminescence of living things has charmed and mystified mankind from the earliest times. This *bioluminescence*, as it is called, is common in sea organisms and is responsible for the so-called " phosphorescence " of the sea. Saprophytic bacteria are the cause of the " phosphorescence " of decomposing fish and meat, a light which so astonished Robert Boyle in 1672. Among terrestrial manifestations, the glow-worm and the firefly are powerful illustrations. Indeed in these insects we can approach our own sphere of interest, for in some parts of the world these luminous insects are used for adornment. For those who fear the broadening horizons of gemmology they may take heart that there is not the slightest intention of including entymology in the syllabus. Bioluminescence is actually a modification of *chemiluminescence* which is exemplified by the luminous glow given off by slowly oxidising phosphorus ; being due in the case of fireflies by oxidisation of the chemical compound *luciferin* activated by the enzyme *lucifrase.*

The luminescent glows which I want to stress are those due to *photoluminescence*, which depend upon the absorption of energy by a substance from some part of the electro-magnetic spectrum. This absorption of energy may then be re-emitted by the substance, but the re-emission is, according to Stokes, generally of a longer wavelength. Thus in the case of the absorption in the yellow green of ruby any re-emission should occur in the orange, red or infra-red regions, and this is known to occur. Accepting Stoke's Law as a generalization, it would therefore require absorption in the violet and ultra-violet in order to produce re-emision in the visible region—that is for it to be seen as light.

It may be well to consider the electro-magnetic spectrum. The waves above the visible red do not interest us to-night. The visible rays—those between 7000 and 4000Å are those which affect the eye and are seen as light, and those between 4000 and 3000 are termed the near (or long) ultra-violet rays ; those between 3000 and reaching down to about 100Å are the far (or short) ultra-violet rays, the lower end of these rays overlap the longer X-rays which have a mean of 1Å.

In modern terminology when the re-emitted luminescence is in the visible region and only occurs when the exciting radiations are impinging the substance, the glow is termed *fluorescence.* Should the glow persist after the exciting radiations are turned off, this after-glow, which can be of quite long duration, is termed *phosphorescence.* These phenomena may be briefly explained by a simple diagram. What happens is that the energy absorbed raises an electron—those unit charges of negative electricity which are planetary around the nucleus of all atoms—

from a stable orbit (the ground state) to one of higher energy level (the excited state) from which it returns immediately giving up its extra energy in the form of light—this is fluorescence.

In the case of phosphorescence some of the excited electrons do not immediately return to ground level but pass into a " metastable " level of somewhat smaller energy where it is trapped until further energy is imparted to it from the surrounding medium in order to bring it back to excited state from where it can return to ground level with emission of light. Pure substances rarely luminesce, but the inclusion of a trace of some other substance may cause it to do so. The main substance is termed the " *phosphor* " and the impurity the " *activator*."

There are two other types of luminescence which may be shown although they have little application to our science. *Thermoluminescence* is produced when certain substances are heated below incandescence. *Triboluminescence* is produced by rubbing or scratching. The reasons for these types of luminescence are not fully understood, but it has been suggested that the substance has somehow been pre-charged (pre-excited).

Fluorescence can also be excited by corpuscular bombardment. The most important is *cathodoluminescence*, which is generated by cathode rays (better known as the electron stream). Crookes showed this phenomena in the case of minerals including diamond and work on rubies was carried out by Coolidge during the '30s. The elaborate apparatus required precludes much work on these lines.

Of greater practical importance to the gemmologist are the glows induced by ultra-violet light and by X-rays. I will at once mention that the three types of radiation—long, short ultra-violet light, and X-rays may not give comparable results, and indeed it is my special point to-night to try to bring this out. Any source of radiation rich in ultra-violet light will produce fluorescence in a suitable substance, but to observe the glows darkness is necessary. As most of the sources give out visible light a suitable filter to cut these out but allow the ultra-violet rays to pass is necessary. Such a filter is Wood's glass, which passes the long-wave ultra-violet only. For the short-wave ultra-violet a special type of glass is used (one is known as OX7). This filter passes the short wave band down to about 2200Å, but it also passes much of the long wave band and some visible light, hence, as I shall explain later it is better used with certain types of ultra-violet sources.

The sun is rich in ultra-violet rays, but the earth's atmosphere absorbs all radiation below 3000A. Arc lamps with special carbons are excellent but are awkward to operate. A photoflood lamp in a suitable housing with filter is a cheap source for elementary long-wave work. The mercury vapour lamps are the best all round source. The high pressure lamp which has the best emission at 3560Å, with a suitable (Wood's glass) filter, is the best for long-wave ultra-violet light. The low pressure lamp being best for short-wave ultra-violet, owing to the best emission being at 2537Å (the resonance line). This, and the fact that the low pressure tube gives out far less visible light explains the better performance for short-wave ultra-violet. A new type of germicidal lamp is now being tried out. This lamp is rich in the 2537Å line and may be a useful and inexpensive addition to the gemmologist's equipment.

The generation of X-rays, produced when a greatly accelerated electron beam is made to strike a metal target, required expensive apparatus, but the rays can be more diagonistic than ultra-violet.

Luminescent phenomena have, since the last decade of the Victorian era, affected the world's of science, of industry and of art—in peace and in war. The existence of X-rays was detected by the fluorescence they caused on a mineral salt, and it is interesting to recall that Lenard, who was experimenting at the same time as Röntgen, employed a fluorescence screen made up of an organic salt which did not fluoresce under X-rays. Owing to this he may well have lost the honour of the discovery of X-rays. Advertising, decorative illumination and the stage have all turned to fluorescence for effect and novelty. Cathodoluminescence helped to give us radar in our greatest hour of need—and in peace, television. The chemist finds fluorescence of value in acidity and alkalinity and in the new study of chromatography. The circulation of percolation of fluorescent liquids along canals or fissures have use to the engineer, the geologist and the medical man. The modern fluorescent lighting depends upon the use of a low power mercury arc inducing fluorescence in powders deposited along the inside of the tube. However fascinating they are, we must not dwell too much on effects outside our own province.

Luminescent phenomena as an aid to gem testing have not been taken as seriously as well they might. A vast number of recordings have been published during the past 100 years, but their correllation does not seem to have been carried out with any completeness. A full record, and comparison, of the luminescent characters of all gemstones under the three main wavebands does not appear to have been made. The position is rather like the early days of mineralogy, when only about half the constants of the world's minerals were known. During the past years the staff of the Hatton Garden laboratory have collected a vast number of observations on the luminescent phenomena of gem materials under both wave bands in the ultra-violet and under X-rays. Some attempt has been made to correlate these and it is hoped that this compilation will be published soon.

This work, which cannot be said to have produced any surprising results, has often supplied added confirmation when the other work of testing has not been wholly conclusive. To-night I propose to mention a few important cases and some of which bring out special factors.

The fluorescence of diamond is probably due to a lattice defect rather than to activation by a foreign substance, and thus may be considered as one of the rarer group of so-called " intrinsic " phosphors. From the gemmological point of view, Anderson has given the best report on diamond fluorescence under long-wave ultra-violet light. This worker suggests that there are three groups :—blue fluorescing, green fluorescing and yellow fluorescing, groups which he coupled up with their absorption spectra. The most usual ultra-violet fluorescence of diamond is a violet blue and under X-rays a chalky white. Further the fluorescence spectrum is discrete which gives an added value to the test. As a matter of interest it has been found that diamond powder contaminated with carborundum may be investigated by ultra-violet light. The powder is spread on a slide and observed microscopically with the aid of a beam of ultra-violet light impinging on the powder.

The crimson fluorescence of chromium activated minerals, so well seen in ruby, red spinel, alexandrite and to a lesser extent in many other minerals, is particularly interesting in the case of ruby—and emerald. Both natural and synthetic ruby fluoresces under all radiations. Owing to the iron content of Siam rubies, iron being a great poisoner of fluorescence, such stones only weakly fluoresce and this lack of response has been suggested as a diagnostic test for provinence ; this is not thought by us to be wholly satisfactory. What is more useful is the fact that all the normal colours of synthetic rubies, when irradiated with X-rays show a perceptible afterglow (phosphorescence) while, again possibly through the iron which taints natural stones, natural rubies do not behave like this. There is one exception to this rule, that is in the case of the so-called " garnet colour " synthetic corundum which also does not show the afterglow. This is possibly due to over saturation with chromium. It could be noted that the ultra-violet lamp will give a quick initial separation of rubies and spinels from a parcel of mixed rough.

Despite their chromium content emeralds are feebly responsive to all the radiations. It has been suggested that the synthetic emerald can be detected by its more pronounced glow under the lamp but this has been found not to be so valuable as thought. Even the colour filter may be more useful in that direction. A method advocated to pick up weak red fluorescence is that employing crossed filters ; a bright source of light is masked by a round flask—which acts as a condenser—filled with a saturated solution of copper sulphate. This gives a blue light with no red so that if the specimen be bathed in this light and looked at with a red filter which passes no blue, any red fluorescence will be seen against a black background. This is also useful for the synthetic emerald. Some natural emeralds are known to fluoresce strongly—especially those from Chivor—so the test is not conclusive.

Despite some claims to the contrary the distinction of the synthetic blue sapphire from the natural counterpart does not seem to be possible by luminescent phenomena. On the contrary in the case of the yellow sapphire distinction is possible (with the aid of the spectroscope) ; for, Ceylon yellow sapphires show a strong apricot coloured glow under ultra-violet rays but show no 4500Å absorption band. The Siam and Australian yellow sapphires show no fluorescence but do show strongly the 4500 complex. The synthetic yellow sapphire shows neither. It is in the case of the Ceylon yellow sapphire that another factor comes in—that of photocoloration—for the pale yellow stones become a deep topaz colour after a few minutes irradiation by X-rays. This colour is not permanent, although it may keep for years if kept from light, it fades after about 3½ hours exposure to sunlight, or fairly quickly at a temperature of about 230 deg. C. Yellow sapphire is not the only stone which will colour under X-radiation. Kunzite is very spectacular in this for the " rayed " stones are green in colour in marked contrast to the lilac-pink of the untreated stones. Mostly the colour assumed by treated stones is a brownish shade. Colourless spinel is interesting in that the stones fluoresce either a strong apple-green or a bluish colour under X-rays and turn brown. They phosphoresce for quite a long time. After the glow has appeared to die out the stones are still brownish in colour and if they are dropped into boiling water they immediately glow again and partially lose their colour—completely if sufficient heat is applied.

Although initially used to detect cultured pearls ultra-violet rays are not sufficiently valuable. However under X-rays cultured pearls show a dull greenish-yellow fluorescence which seems absent from the oriental pearls. This can only be an indication as freshwater and some Australian pearls behave similarly. During the course of the experiments it was found that the massive grossular garnet, the so-called " Transvaal jade " showed an orange fluorescence under X-rays and hence can easily be distinguished from the true jades.

In the case of green fluorescing materials the use of the spectroscope will show whether the fluorescence spectrum is discrete or otherwise. A discrete spectrum indicating uranium and a continuous spectrum possibly manganese, which may give added information of a useful nature.

I hope to have shown to you to-night something of the reasons causing fluorescence ; something of the apparatus used for the the production of these fascinating effects and, albeit briefly, something of the use which may be made of these radiations in gemtesting. It is hoped that the publication of the corellated results of our observations during the past few years will materially assist the worker, but much work is still to be done in directions indicated by workers in other sciences.

Mr. Webster carried out several demonstrations during his talk and acknowledged the help received from the firms who made the following lamps available :—Hanovia long wave (Model 11), Hanovia short wave Chromatolite, American short-wave Mineralite, Bevis Smith Photo-flood lamp, Philips Black lamp, Philips germicidal lamp with filter supplied by Rayners. The Chelsea Polytechnic (Physics and Chemical Dept.), Messrs. Rayner and Keeler, and Messrs. H. Lee and A. Ramsay also provided material towards the lecture.

GEM TESTING WITHOUT INSTRUMENTS

Upwards of 70 Fellows and Members of the Birmingham branch of the Gemmological Association were present to hear a lecture by Mr. B. W. Anderson on " Gem Testing Without Instruments " at the Imperial Hotel, Birmingham, on 13th February.

Mr. T. P. Solomon, F.G.A., who was in the chair, introduced Mr. Anderson as one of the foremost gemmologists in Europe, already known to many of the audience for his book on gem testing and through his articles in the trade press.

Mr. Anderson said that gemmology might be considered a small subject, but that really it was a very large one, touching on many other sciences. " Some people," he said, " think that after a two years' course in gemmology, that they have ' done it.' But I have been at it now for 27 years, and I am sure I am nowhere near the end of it."

About 15 years ago, said Mr. Anderson, he knew a very able gemmologist who passed his examinations with distinction, but, in his business as a dealer, remained rather contemptuous of gemmology as taught at the schools, maintaining that the average student was lost when faced with an unknown stone, unless he could run to his instruments.

Mr. Anderson said that he recognised a certain amount of truth in this reproach, and had, since that time, sought to train his own eye to recognise stones without any instrument beyond a lens, and to encourage this kind of observation at least amongst the Post-Diploma students at Chelsea Polytechnic.

Every jeweller, he said, should carry with him a good pocket lens, magnifying 8 or 10 times. " If you took this out at a showing, people would not think you eccentric ; but if you whipped out a refractometer they might think it a bit peculiar."

Mr. Anderson then came to the main purpose of his talk, which was to run through some of the main properties of gemstones and show how, in many cases these could be assessed merely by careful inspection and by knowing just what to look for, with sufficient accuracy to identify the stone concerned.

First, he said, came *colour*. Despite the fact that many scientists disagreed with him, he was certain that a great deal of information could be gained from the colour of a stone. To take one example, the red of ruby was *not* the same as the red of spinel, and in testing thousands of calibré rubies under the microscope, an occasional red spinel was easily spotted by its colour, before completing the test by other means.

Next came the *distribution of colour*, which was often characteristic, as in tourmaline, amethyst, and sapphire. *Dichroism*, which was usually only thought of in connection with the dichroscope, could usually be detected in stones such as tourmaline, ruby, sapphire, and aquamarine, simply by turning the stone and noting the change in colour. A piece of polaroid would help greatly here, however.

The lecturer next mentioned *refractive index*, and said that, together with hardness, this played an important part in the *lustre* of a stone, which was one of its distinctive features. Stones of high refractive index looked shallower when viewed through the table facet than stones of similar cut but with lower index of refraction. One could note the difference here, for instance, between diamond and synthetic colourless spinel or sapphire. The adamantine lustre of diamond, so unlike that of any other gem, was due to its combination of hardness and very high refractivity.

The hardness of a cut stone, Mr. Anderson said, could often be assessed by the appearance of its edges and corners. Pastes could be detected with a lens by the blunt, moulded look of their facet edges. Chrysoberyl catseyes could be distinguished from even good quartz catseyes by their brighter lustre.

Next on the list came *double refraction*—a very important property in stone identification. The effect could be detected simply by holding a stone close to the eye and viewing some distant light-source through one of the small prisms formed by the facets. By this means, some idea of the dispersion of the stone could be gauged also by the extent of the spread of rainbow colours seen through the stone prism.

Mr. Anderson himself, however, preferred direct observation of the " doubling " of the facet edges of a doubly refractive stone when viewed through the front with a good lens. One had, of course, to turn the stone to find the position where the effect was strongest, and with practice, by taking into account the size of the stone, one could arrive at a pretty fair estimate of the extent of the double refraction. Zircon was one of the easiest stones to practise on, and could nearly always be recognised by its strong double refraction.

The lecturer showed slides showing the " doubling " to be seen of the back facets of tourmaline, zircon and synthetic rutile. He also demonstrated how one could check on the double refraction of a crystal ball by holding the corner of a card immediately behind the ball and viewing the card through the ball. If the ball were really crystal, the card had a ghostly double edge, whereas in the glass imitations of crystal balls which were far less valuable, no doubling could be detected.

Mr. Anderson then mentioned *inclusions* in stones. In certain species such as demantoid garnet, with its radiating fibres of byssolite, the inclusions were nearly always distinctive. This was also true of Burma rubies. In many other cases long experience and perhaps a microscope would be needed to come to any safe conclusions. *Surface markings* were also very important. Among these might be mentioned the " naturals " left on parts of the girdle of many faceted diamonds, the " fire marks " so typically seen on both natural and synthetic corundum—though more noticeable in synthetics—the structures of pink pearl, coral, and imitation pearls. Also the brassy specks of pyrites in genuine lapis lazuli, compared with the patches of quartz in the stained jasper known as " Swiss Lapis."

The lecturer went on to deal briefly with *cleavage cracks* and nicks as an occasional aid to identification in such stones as topaz and diamond and fluorspar, and with chatoyant and star-stone effects and with interference colours as seen in opal.

He said that the *density* of a stone could be roughly assessed by its " heft " when balanced in the hand. Though difficult to get any accuracy in this way, one should be able to distinguish, say, between aquamarine and blue topaz, or between yellow topaz and quartz.

Thermal conductivity, went on the lecturer, was the scientific basis for coldness to the touch. Crystals were better conductors than glass—hence the well-known " coldness " of a crystalling stone compared with a paste when touched with the tip of the tongue. Plastics and amber, of course, would feel " warmer " still.

Finally, said Mr. Anderson, the *size* of a stone should be taken into account when judging its nature. " It is common sense to realise that large Burma rubies priced at £30 are just not knocking around these days," he added.

At the end of his lecture, Mr. Anderson described a very simple immersion method by which the refractive index of stones could be judged with fair accuracy, and showed slides of photographs taken by one variation of this method.