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THE GEMMOLOGICAL ASSOCIATION
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DIAGNOSTIC IMPORTANCE OF INCLUSIONS IN GEMSTONES

By EDWARD GUBELIN, Ph.D., F.G.A., C.G.

IN the previous paper on gemstone inclusions, published in the " Journal of Gemmology," Vol. 1, No. 7, a general survey on inclusions was presented ; the exquisite beauty of the fairylike landscape scenery, sunlit garden corners, bizarre forms and fantastic shapes appeared to consist of foreign particles of matter which could be solid, liquid or gaseous ; they could consist of cavities filled with liquid or crystals within crystals of the same gem species ; and the veracity and significance of Pliny's assertion that in gems we admire nature's majesty in miniature was substantiated and will remain unchallenged.

An intensive study of gemstone inclusions is as essential to any gemmologist as a thorough knowledge of the other properties of gemstones, such as refractive index, density and absorption spectrum, since this study enables him to become capable of determining any gemstone by its inclusions as quickly and as accurately as by its spectrum or refractive index. The identification of gemstones by their inclusions as a means of revelation and as a field of scientific investigation therefore ranks on a par with the two other principal examinations, that of the refractive index and that of the absorption spectrum.

Apart from the ordinary observation of inclusions for their splendour, or as a means of distinction from synthetic stones, plastics and pastes, they are of greatest value in the discernment and classification of genuine stones. Inclusions are beginning to attain increased significance in crystallography, and are also receiving close attention in genetic mineralogy and stratigraphy.

It may certainly be taken as a merit of the youngest branch of mineralogical science, namely gemmology, that, out of the need to evolve new identification methods for its objects of study, since the standard methods are often not sufficient for identifying a gemstone, it has made a considerable contribution to the increase of knowledge about inclusions and their use in identification, at any rate, of gemstones. The invention of a new type of dark field illumination for binocular microscopes in connexion with a new rotation device has enabled considerable progress to be made. This apparatus makes it possible in a practical way to examine gemstones and their inclusions in dry condition from all angles, and proves especially advantageous for investigating the crystallization form of enclosed crystals. Systematic studies have shown that the inclusions of the different kinds of gemstones differ to such an extent that they offer a reliable means of separating them.

Rightly recognizing that the differing chemical and physical conditions during crystallization of different species of minerals in separated deposits have left their unmistakable traces in most gemstones, the diagnostician turns mainly to the phenomenological picture of the inner paragenesis. (Phenomenology is used in the sense of the science of the visible, and a phenomenological picture is one which characterizes a stone and leads to its identification.)

The diagnostic value of inclusions lies not so much in the single occurrence of the various kinds in the various species of gemstones, but rather in their regular appearance in a certain species of crystal (byssolite fibres in demantoids), in their manner of arrangement and distribution (" silk " in corundums, or amphibole needles in almandines), their phenomenological pictures in conjunction with peculiarities of structure (diopside crystals in the streaky distribution of colours in hessonites), their unique appearance or development (jagged liquid inclusions in beryls, three-phase inclusions in emeralds, tetrahedron cavities in fluorites), or the typical relationship of the inner paragenesis with a known exterior association (metamict zircons in Ceylon stones, enstatites and garnets in diamonds, spinels in Burma rubies, etc.). The inclusions specific for many kinds of minerals are just as characteristic as oak leaves for the oak trees ; indeed, in their profusion of forms individuals are just as different from one another as two oak leaves are never exactly identical.

The knowledge about the diagnostic value of inclusions in gemstones so far obtained from gemmological research already is so extensive and is confirmed with certainty by numerous examples, that the time seems to have come to give the gemmologist a comprehensive summary.

Diamond. Although the diamond is often considered as a gemstone free from inclusions, and although exaggerated ideas of the common occurrence of pure diamonds are widely held, its inclusions are extraordinarily characteristic. A diamond with inclusions can easily be distinguished from other gemstones which may appear similar. An interesting abundance of different, but always typical, pictures of inclusions presents itself to the person through whose hands numerous diamonds pass. As the diamond owes its formation to unique conditions, a peculiar type of formation characteristics may be expected.

Among the solid inclusions we find more or less well-developed zircons, varieties of pyropes (Fig. 1), quartz (Fig. 3), haematites (as single tablets or grouped into " iron roses "), enstatites, diopsides, graphite and other less important minerals. These inclusions may be pre-temporary or con-temporary. Furthermore, crystal splinters, rarely particles of coal, and earth-like substances have been found to be included. Some of the fissures that sometimes occur in diamond are caused by included zircon crystals (Fig. 4) whose thermal expansion coefficient is higher than the diamond's. Many of the inclusions are minerals of the outer paragenesis of the diamond. Especially the occurrence of enclosed, usually distinctly euhedral crystals of diamond, frequently octahedral, may be regarded as an unequivocal recognition characteristic (Fig. 2). Not merely the presence of these microlites but often quite as much the type of distribution and arrangement are equally of diagnostic importance. " Carbon spots " is a favourite term in the jewellery trade for the dismissal of any apparently dark-coloured inclusions within a diamond, though in my opinion carbon is very rarely present.

Liquid inclusions occur as filling of cavities with or without libellas or as a kind of foggy cloudiness, caused by a microscopically dense accumulation of the finest droplets of liquid. Liquid inclusions are none the less very rare ; the well-known feathers of other gemstones, which will be discussed later, appear to be entirely absent from diamonds.

On the other hand, gaseous inclusions, usually microscopic bubbles, which as a rule are accumulated in dense clouds and as such often assume interesting shapes, are very frequent, and can serve as an instructive source of information about the crystal form of the host crystal which has been lost in cutting. Thus a cloud of octahedron shape displays the original position of the natural crystal faces and their angular relation to the cut stone (Fig. 5). Cross-shaped clouds are sometimes found enclosed in Golconda diamonds, clouds which are surrounded by one or several foggy frames (Fig. 6). Such structures were formed by dense clouds of gas bubbles settling during the growth of the diamond on its temporary surface. The present cross shape of the cloud indicates that these bubbles settled on the crossing edges and on the surfaces forming the re-entrant angles of interpenetrating twin cubes. On approaching the surfaces of the crystal the cloud was parted by the edges and assumed the shape of a cross above the re-entrant angles. In addition to these genuine inclusions there are straight-running clefts, which offer a less interesting picture, and which must be distinguished from the conchoidal, stepped-up fissures through breakage and the jagged cracks. Both these and the rather frequent fissures through tension may also be considered handy characteristics for recognizing diamond.

It is quite impossible to give an even approximately exact description of the profusion of forms and of the multiplicity of distinctive inclusions in diamonds and all other gemstones. The present account has therefore been illustrated by as large a selection as possible of typical pictures of inclusions, from which can be read what cannot be expressed in words.

Corundums are to the student of inclusions an inexhaustible source of charmingly beautiful pictures of inclusions with manifold types of inclusions and a hardly imaginable wealth of forms. Usually the expert gemmologist can at once recognize the species of corundum under the microscope on account of their characteristic inclusions. In addition to the always distinctive peculiarity of the inclusions of all corundums, a differentiation according to their occurrence is obvious. Thus the corundums from the three main deposits, Burma, Ceylon and Siam, differ markedly from one another.

Well known and often described is the type of inclusions called " silk " by the gemmologist, which in Burma corundum consists of fine rutile needles (Fig. 7) and in Ceylon corundum of a loose accumulation of tubes which permeate the whole gemstone (Fig. 9). Here the group-wise arrangement of the short, black, rutile needles in Burma corundum is distinctive as compared with the penetration of colourless capillaries through the whole stone in Ceylon corundum. Rutile needles and canals are orientated according to the direction of the edges of faces $(0001)/(10\bar{1}1)$ and $(10\bar{1}1)/(11\bar{2}0)$; thus they are, so to speak, " two-dimensionally " embedded in sagenite arrangement parallel with the basal plane, and they are contemporaneous coalescence-inclusions. In Burma corundums together with the " silk " there occur a host of crystal inclusions, inter alia normal zircons, coarse rutile crystals (frequently in knee-shaped twins), spinels (usually as euhedral octahedra), corundum crystals, and glassy melted drops (Fig. 8). In Ceylon corundums, on the contrary, one finds calcite plates, either single or in packets, muscovite lamellae, garnets, and metamict radio-active zircons. The latter are typical guests not only of the corundums but also of numerous other minerals of the Ceylon deposits, and the radio-halo which always surrounds them is to be considered as a distinctive character of the locality. These halos are formed by the destructive radiation of alpha rays by the radio-active element uranium, which is contained in metamict zircons (Fig. 14).

Liquid inclusions are seldom found singly, and then in Ceylon sapphires only. They fill up hose-like cavities with step-like grooves, the shape of which cavities is so distinctive that one can always recognize them if one has observed them once (Fig. 10).

Much more numerous are the so-called feathers of liquid, which consist of a host of microscopic liquid droplets and the whole of which may be compared with wings of insects (Fig. 12). This type of inclusion, too, is typical of Ceylon corundums (Fig. 13). If strong magnifications are used, the microscopist is always surprised by the most magnificent patterns formed by the droplets of these clouds (Fig. 11). Clouds of liquid of the type and aspect found in the corundums have so far not been discovered in any other gemstone.

The inclusions of Siam corundums differ entirely from those so far discussed. In Siam rubies are found opaque, brown-black to black, hexagonal crystals, surrounded by flat liquid halos with concentric structure (Fig. 15). The nature of the hexagonal crystals has not yet been established with certainty ; preliminary examinations suggest opaque corundum crystals. Feathers of liquid, which occur singly and are not tied to the opaque crystals, show a hieroglyphic pattern (Fig. 16).

In Siam sapphires the picture of the inclusions is characterized by opaque black prismatic crystals, which are accompanied by films of a brownish liquid containing iron (Figs. 17 and 18). As the colouration of the Siam sapphires is almost always very dark, the study of their endogenesis is rendered so difficult that the nature of the prismatic crystals could not be determined.

The milky or foggy opaque appearance of the Kashmir sapphires is caused by microscopically small, short cracks or channels, which often occupy the whole crystal.

Beryls. Among the beryls the emeralds and aquamarines can be recognized and distinguished from similar different gemstones by their inclusions.

In **emeralds** the liquid inclusions are of the first importance ; they as a whole make up the so-called " jardin." True, not the narrow, sinuate or crumpled feathers, but the individual droplets of liquid, and especially their shape and contents are decisive for the diagnosis. These single droplets of liquid have an irregularly jagged shape with acutely pointed extensions (Fig. 19), and their contents have reached the highest stage of liquid inclusions, as the three phases of matter are represented in them side by side (Fig. 20). The liquid in the cavity surrounds a gas-libella and one or several small crystals. Because of these contents such inclusions, typical of emeralds, are called three-phase inclusions (Fig. 21).

It is interesting that the emeralds from the two most important localities, the Urals and Colombia, can be separated by the diversity in the general appearance of the enclosed small crystals, the crystals in Colombian emeralds being always cubic, those in Ural emeralds of rhombic crystal shape. Nobody has yet succeeded in determining the nature of these small crystals beyond dispute, although in several small cubical crystals blue spots have been observed similar to those in rock-salt containing a surplus of Na. In addition to the three-phase inclusions Colombian emeralds frequently contain calcite inclusions, which either take up the whole stone or part of it as more or less massed separation inclusions or occur as single distinctly rhombohedral crystals. Well developed pyrite crystals are not seldom present as single loosely dispersed microlites or assembled into aggregates. In contrast to typical Colombian endogenesis, in Ural emeralds single mica scales, or whole bundles of them, are found. Mica has also been found in Transvaal emeralds.

The distinctive inclusions in **aquamarines** consist of straight tubes, which are filled with a liquid containing iron. They always run parallel to the *c* axis (Figs. 23 and 24). Inclusions which under low magnification are reminiscent of snow stars, and which therefore are called " snow-star inclusions," furnish magnificent pictures (Fig. 22). In every instance they are arranged parallel to the prism surfaces of the host crystals. Under high magnification it is seen that these inclusions consist of a microlite, which is surrounded by a halo of single small droplets of liquid. It is very obvious to assume that extraneous melted drops, not soluble in the mother liquor of the aquamarine, have joined as a consequence of positive adsorption the growth surfaces of the aquamarine, and that the microlites now visible have very quickly separated from the melted drops by ex-solution, leaving residue droplets in their closer proximity.

It has been impossible so far to discover distinctive inclusions in yellow, green and pink beryls.

Garnets. Green andradite contains typical inclusions, which occur again and again, and which can be discovered in 99 per cent. of all demantoids. These are hair-fine brown or colourless byssolite crystals, which are arranged in wavy bundles or which radiate from a common centre (Fig. 28) ; in many demantoids, however, they intersect each other in confused irregular tangles. It is a peculiar and interesting fact in the occurrence of these byssolite fibres that the fine fibres are not by any means enclosed in a compressed and bent condition, but extend freely, being obviously unaffected by the substance of the crystal, as though they projected freely into the air like free fibres (Fig. 27).

Red Pyrandine garnets, comprising **Pyrope, Almandine** and the mixed crystal **Rhodolite,** which is intermediate between them, cannot easily be separated from each other by means of their inclusions (nor is this of great importance, as they belong to the same isomorphous series). Nevertheless, they too contain quite characteristic interior parageneses, which form a decisive criterion for distinguishing them from other red, brownish-red, or purple-red gemstones. The best-known kind of inclusions in these three closely related red garnets are black needle-like amphibole crystals, which permeate the host crystal in accordance with the edges of the rhombic-dodecahedron (Fig. 25). The feature discriminating between these needles and the small rutile needles called " silk " in rubies is their arrangement. In garnet these fine needles are distributed in a distinctly three-dimensional order, often occupying all the interior of the stone ; the silk in rubies, on the other hand, is arranged bi-dimensionally, i.e. the needle-shaped crystals have been deposited in a sagenite-like way on the growth surfaces of the rubies. In red garnets, however, they lie apparently in promiscuous disorder (Fig. 26), and only after careful examination the way in which their directions are governed by crystallographic laws can be recognized. The expert is hardly surprised to find that the typical locality characters of Ceylon gemstones, namely metamict zircons with radio-halos, occur also in almandines from Ceylon. Here, too, these black-margined, usually xenomorphous zircon inclusions with their halos supply the unequivocal proof of provenence. The halos are not always circular, even less spherical, but frequently they are developed on one side only or in star-like rays.

Every expert is familiar with the somewhat granular appearance of the **hessonites.** Herein lies to hand a distinguishing character though it is as a rule not so distinct that with the unaided eye one could rely on it alone. If this granular appearance be in-

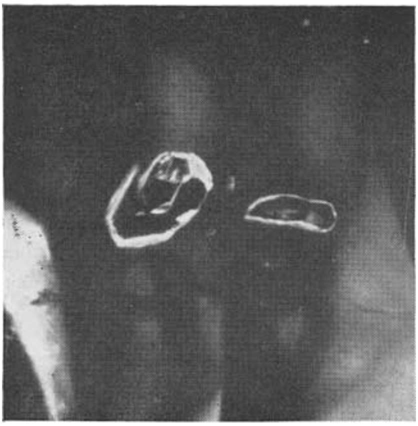


FIG. 1.
Garnet crystals in diamond. 150 ×

FIG. 2.
Diamond octahedron in diamond. 150 ×

FIG. 3.
Resorbed crystal inclusions in diamond. 75 ×

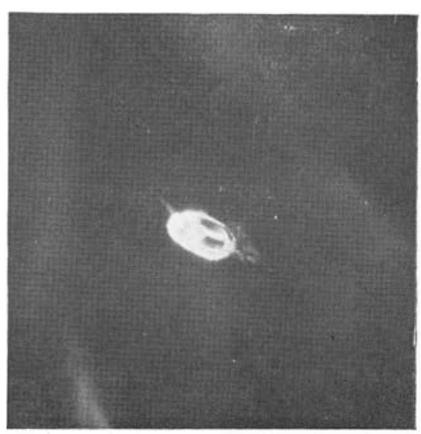


FIG. 4.
Zircon crystal in a diamond form. 20 ×

vestigated more closely with the aid of a microscope, it will be found that inclusions again play an interesting part in it. They consist of a multitude of diopside crystals, which are irregularly distributed over the whole of the stone, and are often very distinctly idiomorphous. Diopside often accompanies the hessonite during formation, which means that it also shares the exterior paragenesis with it. Moreover, hessonite is permeated by peculiar streaks, which give its interior an oily appearance (Fig. 29).

A pretty but rare occurrence is **spessartite,** a manganese-alumina garnet, rarely of gem quality, and which also shows characteristic inclusions. These consist of irregularly arranged feathers of fine, bizarre liquid droplets (Fig. 30). Such feathers are embedded singly in the spessartites, or, aggregated in bundles, spread over them in various directions. This special type of feathers of liquid does not occur in any other garnet or any other gemstone resembling spessartite.

In the species of gemstones not so far mentioned the inclusions and their appearances are less complicated, and only one type of inclusion is characteristic of each species. In many cases even some experience is needed for recognizing the distinguishing features of apparently similar inclusions in different kinds of gemstones. The similarity in appearance of the liquid inclusions with libellae in aquamarines, topazes, kunzites, and beryllonites is confusing, and only a detailed knowledge of their specific appearance will permit of their differentiation.

In **tourmalines,** no matter what variety, irregularly arranged threadlike capillaries, the so-called trichites supply a reliable character for identification. Strong magnification reveals them to be canals, which may run in any direction, and which are filled with a liquid and contain a libella (Figs. 31, 32 and 35). They occur singly or amalgamated into nets. Trichites occur in all varieties of tourmalines, but the red tourmalines are, in addition, almost always permeated by long, perfectly straight phases, which occur singly or united into dense bundles.

The **spinels** contain innumerable well-developed small spinel octahedra, which as contemporaneous crystallizations are merged with the growth surfaces of the host crystals. They are grouped densely in parallel rows, which run in wavy directions (Figs. 33 and 34). Sometimes also they are grouped in nests. From Ceylon

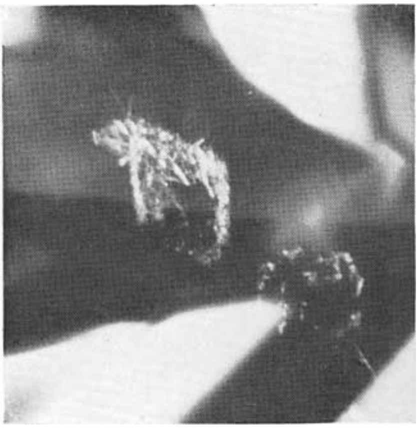


FIG. 5.

Cloud of small gas bubbles in a diamond, oriented according to (110). 150 ×

FIG. 6.

Cloud of gas bubbles according to (110) in a diamond twin. 250 ×

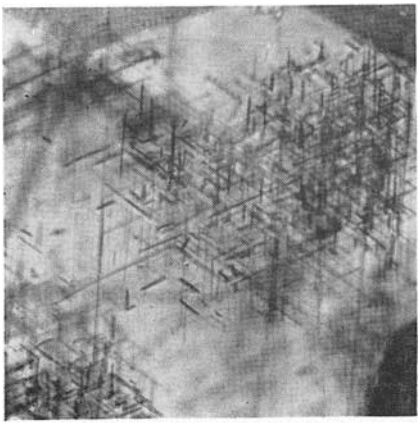


FIG. 7.

Patches of short, oriented rutile crystals in a Burma ruby. 250 ×

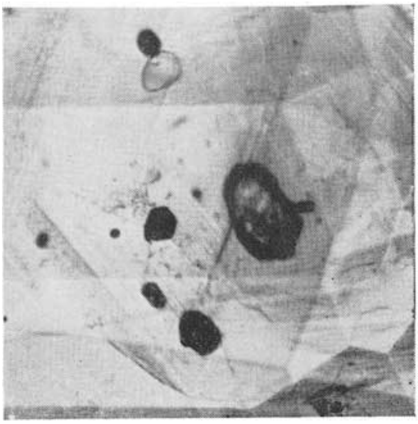


FIG. 8.

Characteristic inclusion picture of Burma ruby. 150 ×

spinels the locality character, radio-active zircons with radio halos, is seldom absent.

In **moonstones,** fine figures of stress-fissures develop along the twin planes of polysynthetic twin lamellae. As a rule these figures, which may suggest incipient albitization, consist of a more or less straight-running principal cleft from which short fissures branch off on both sides (Figs. 38 and 39). These systems of stress fissures usually occur singly, though sometimes they are amalgamated into more complicated combinations. In spite of individual diversity their appearance is always so unmistakably distinctive that in every case it can be regarded as a valuable characteristic of moonstones.

Andalusite. There does not appear to be any inclusion which may be regarded as occurring typically in andalusite. Stones from Ceylon have revealed minute rod-like crystals of varying crystal habit and in some instances it has not been possible to determine their nature. In andalusites from Brazil inclusions frequently take the form of dense clouds of extremely minute particles which (Fig. 47), under very strong magnification, have proved to be liquid drops of an elongated kind and fissures. These densely massed, though extremely fine, inclusions are typical of andalusites mined in Brazil, and thus provide a clue to their origin which andalusites from Ceylon do not do. In addition to these useful diagnostic inclusions, Brazilian andalusites sometimes show narrow parallel striations which, but for their straightness, are not unlike the striations seen in some synthetic rubies (Fig. 48).

Green Metamict Zircons. It has often been remarked that green zircons sometimes have their colour slightly marked by an internal sheen-like effect. The cause of this phenomenon appears to be due to the edges and corners of isomorphous layers which are present in the stones. The phenomenon is quite characteristic of this type of green zircon (Figs. 40 and 41).

Kyanite. This mineral is rarely cut as a gemstone and the many tubular or flat fissures seen may perhaps not interest the gemmologist quite so much. These inclusions are highly characteristic and correspond to the crystal's two cleavage directions (Figs. 42 and 43).

One of the finest examples of diagnostically important inclusions is furnished by the **fluorites,** which contain, no matter whence

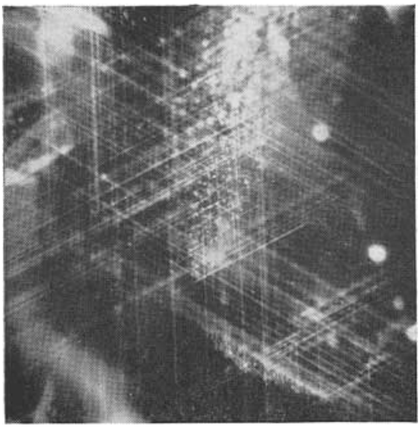


FIG. 9.

"Silk," fine oriented capillaries in a Ceylon sapphire. 150 ×

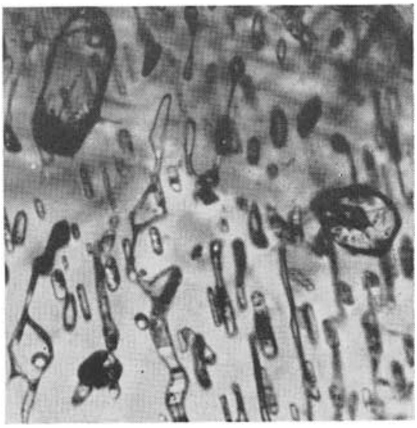


FIG. 10.

Small area, strongly enlarged, of feather consisting of liquid inclusions in a sapphire from Ceylon. 250 ×

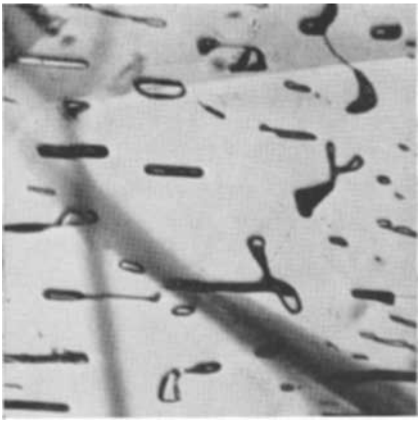


FIG. 11.

Typical liquid feather in Ceylon sapphire greatly magnified to disclose single liquid drops and their bizarre shapes. 350 ×

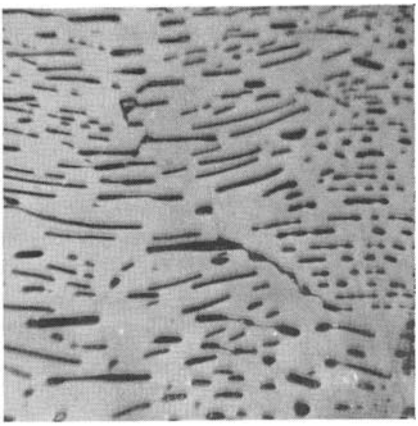


FIG. 12.

Liquid feather in sapphire from Ceylon. 150 ×

they come, a few single, or dense crowds of innumerable tetrahedral liquid inclusions. These are negative crystals in the shape of tetrahedra, filled with a liquid and a libella, which moves as the stone is being turned (Fig. 36). As natural crystals do not only occur in ideal forms, these tetrahedral cavities have not in every case assumed the geometrical ideal shape (Fig. 37). Usually they are distorted in some way or otherwise interrupted in their development. The presence of such tetrahedral cavities is so characteristic of fluorite that it can always be recognized by them.

It must not be supposed that the preceding descriptions deal with every kind of inclusion that has been observed. There are still many more which can be used less well or not at all as identification characters. An attempt has, however, been made in specific examples selected for the purpose to portray, with brief descriptions relating to the most essential characters, the distinctive inclusions of a few common species of gemstones and to point out their diagnostic significance. The study of inclusions is a young branch of gemmological and mineralogical science, and much work will have to be done by mineralogists, crystallographers and gemmologists if the numerous problems which the inclusions of the most different gemstones will present to-day are to reach an indisputable solution. An interesting field for fruitful collaboration between mineralogy and gemmology is opened up here. Out of it, thanks to possibilities presented by its objects and methods of research, gemmology can make lasting contributions of new observations to mineralogy for the use of both sciences, so that from the knowledge so gained valuable conclusions in the direction of genesis and diagnosis may be hoped for.

(EDITORIAL NOTE.—It is hoped that the two articles by Dr. E. Gubelin that have appeared in the " Journal of Gemmology " will prove a useful introduction to his comprehensive forthcoming book on Gemstone Inclusions which is shortly to be published by the Gemological Institute of America.)

(See further illustrations on pages 295 - 303)

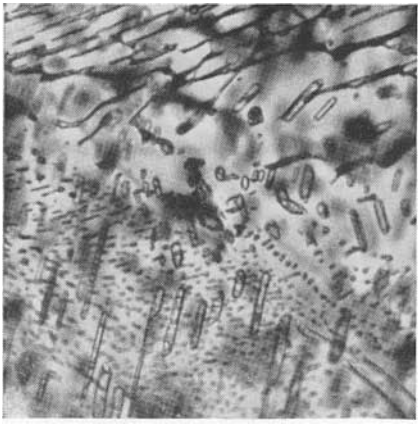


FIG. 13.
Liquid feathers in a sapphire from Ceylon. 250 ×

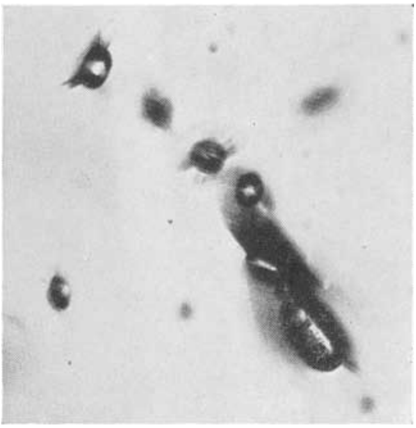


FIG. 14.
Metamict zircons surrounded by halo in Ceylon sapphire. 125 ×

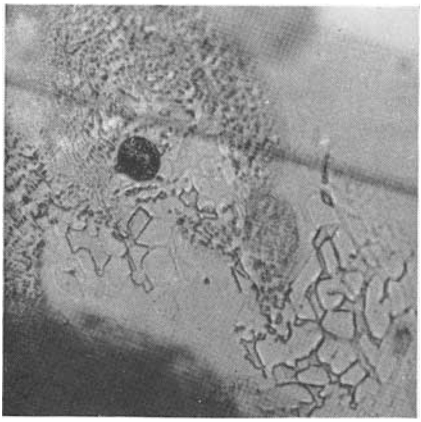


FIG. 15.
Diagnostic inclusion picture of ruby from Siam. 150 ×

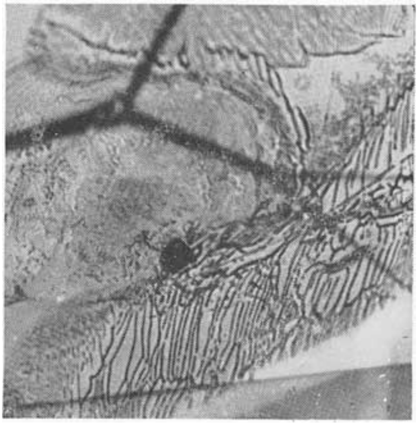


FIG. 16.
Characteristic inclusion picture of Siam ruby consisting of black crystals accompanied by large script-like liquid feather. 150 ×

FIG. 17.

Typical phenomenological picture of inclusions in Siam sapphire. 250 ×

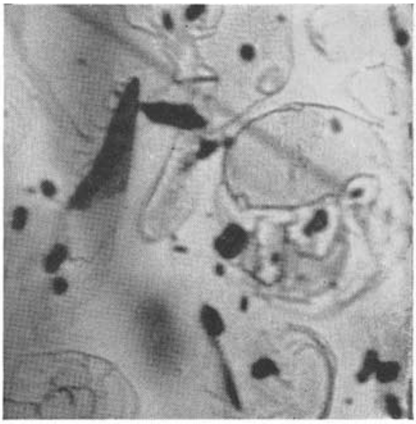


FIG. 18.

Characteristic inclusions in Siam sapphire. 250 ×

FIG. 19.

Jagged irregularly shaped liquid and three-phase inclusions in emerald. 200 × .

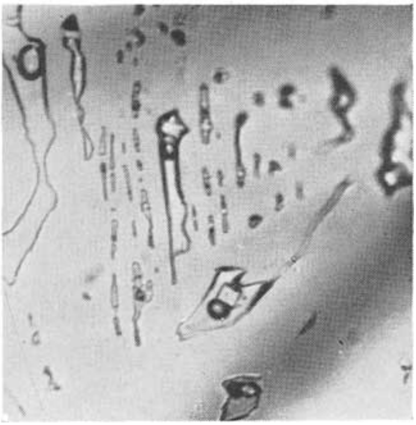


FIG. 20.

Irregular liquid and three-phase inclusions in Emerald. 200 ×

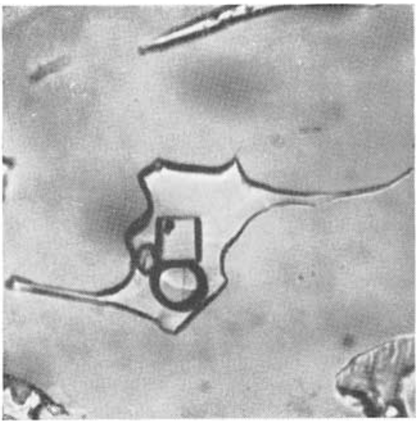


FIG. 21.

Three-phase inclusion in a Colombian emerald. 500 ×

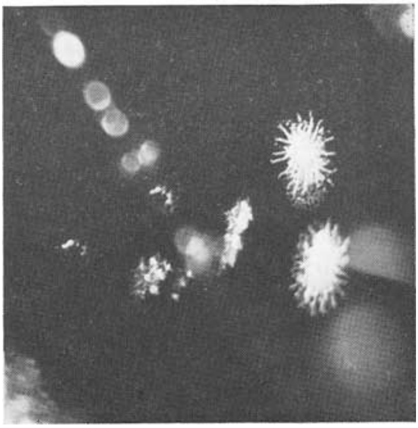


FIG. 22.

Typical "snow-star" inclusion in aquamarine. 150 ×

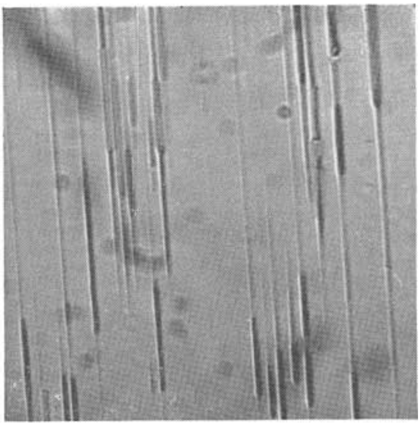


FIG. 23.

Liquid filled canals in aquamarine. 200 ×

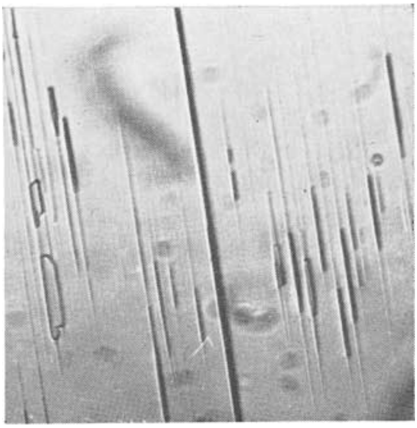


FIG. 24.

Liquid filled canals in aquamarine. 250 ×

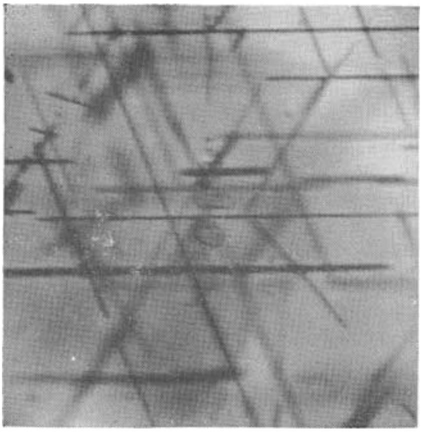


FIG. 25.

Amphibole needles in almandine. 250 ×

FIG. 26.

Three-dimensional arrangement of needles in almandine. 250 ×

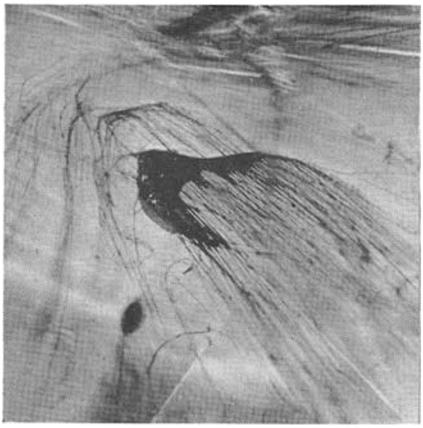


FIG. 27.

Byssolite fibres in demantoid. 75 ×

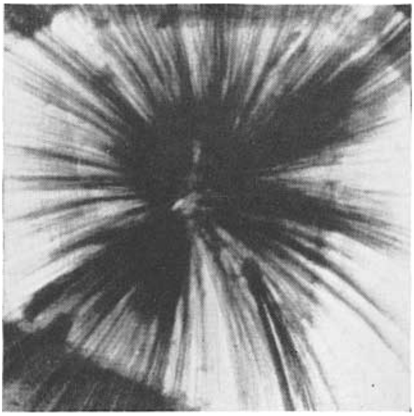


FIG. 28.

Radially arranged byssolite fibres in demantoid. 100 ×

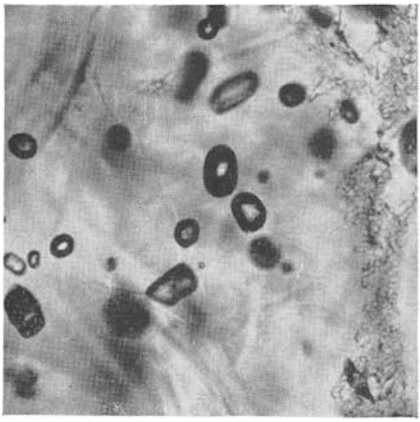


FIG. 29.

Diopside and zircon crystals embedded in swirly structure of hessonite. 250 ×

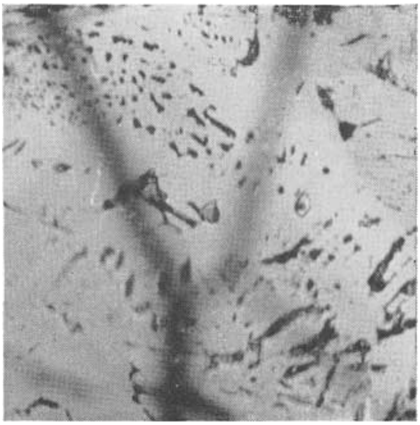


FIG. 30.

Typical cloud of liquid droplets in spessartite. 250 ×

FIG. 31.

Liquid filled trichites in green tourmaline. 250 ×

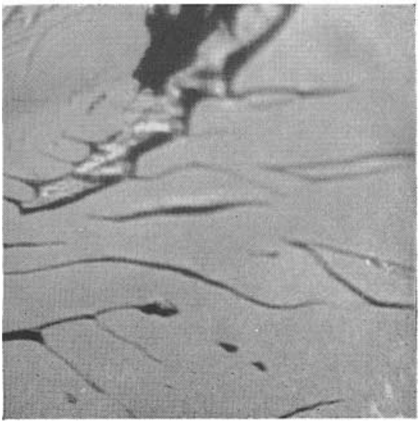


FIG. 32.

Greatly magnified capillaries (liquid filled so-called trichites) in green tourmaline. 300 ×

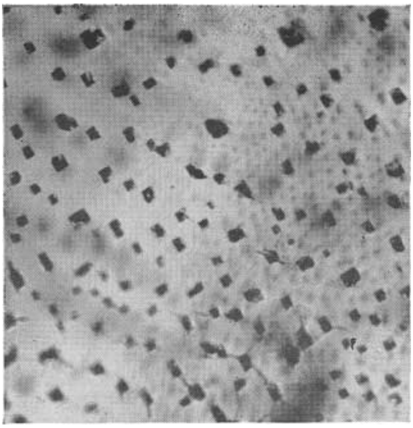


FIG. 33.

Rows of euhedral spinel octahedra in a spinel from Burma. 150 ×

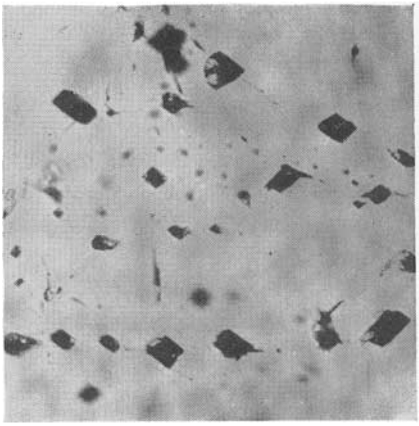


FIG. 34.

Series of spinel microlites in a spinel from Burma. 150 ×

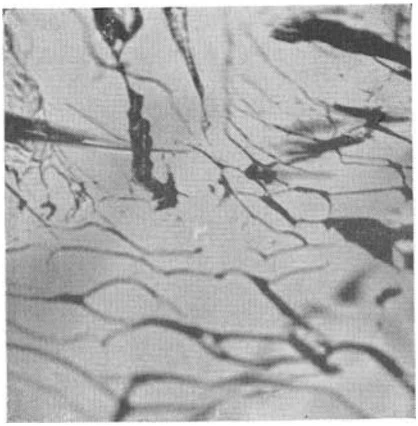


FIG. 35.

Liquid filled trichites in green tourmaline. 250 ×

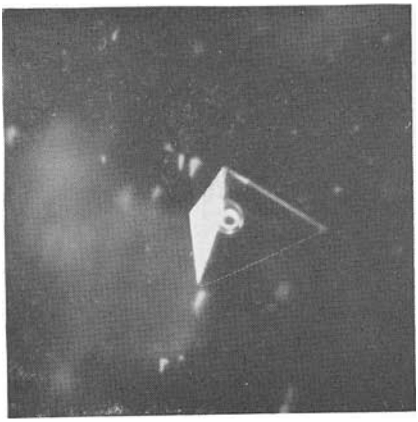


FIG. 36.

Positive diagnostic inclusion in fluorspar consisting of a cavity in the shape of a cubic bisphenoid with liquid and a movable libella. 400 ×

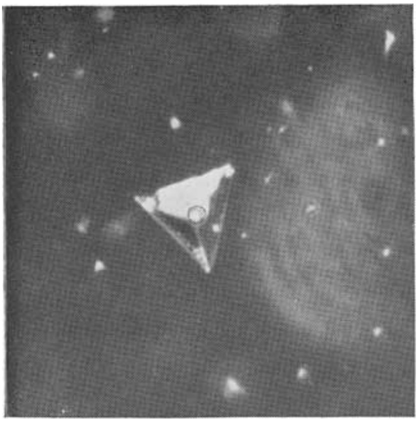


FIG. 37.

Cubic bisphenoid filled with liquid and libella in a fluorspar. 350 ×

FIG. 38.

Fissures and metamorphous deposits along polysynthetic twin-lamellae in moonstone. 250 ×

FIG. 39.

Fissures and metamorphous deposits along twin-lamellae in moonstones. 150 ×

FIG. 40.

Angular markings, which are characteristic of green metimact zircons from Ceylon. 300 ×

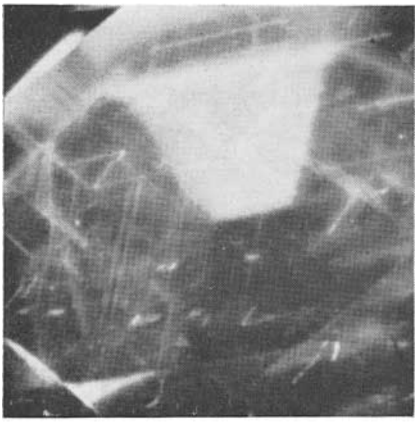


FIG. 41.
Metamict zircon with typical angular markings. 100 ×

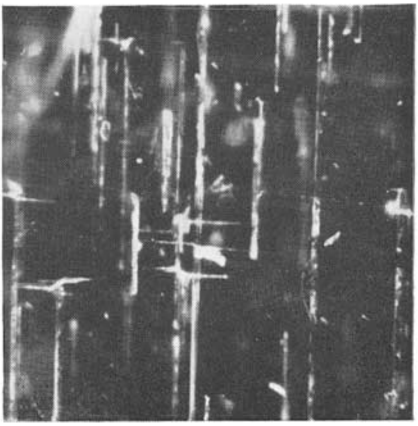


FIG. 42.
Typical fissures in kyanite. 100 ×

FIG. 43.
Greatly magnified picture of characteristic fissures in kyanite. 300 ×

FIG. 44.
Typical inclusion picture of topaz consisting of cavities filled with non-miscible liquids. 100 ×

FIG. 45.

Characteristic inclusions in topaz consisting of cavities filled with non-miscible liquids. 100 ×

FIG. 46.

Irregular cavity filled with non-miscible liquids in topaz. 150 ×

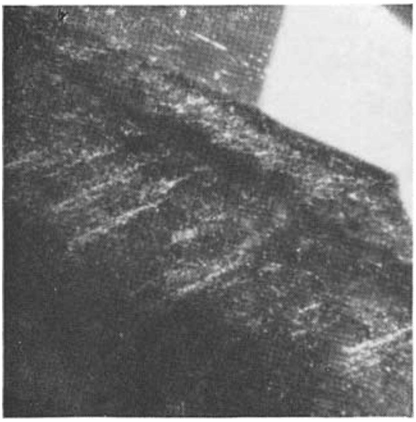


FIG. 47.

Clouds of dust-like inclusions in Brazilian andalusite.

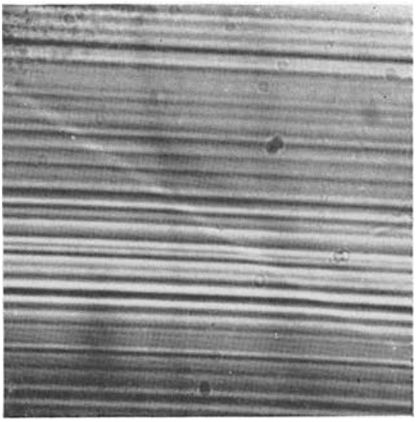


FIG. 48.

Straight and parallel striations and clouds of dust-like inclusions in Brazilian andalusite. 100 ×

OPTICAL ORIENTATION IN UNIAXIAL GEMSTONES

by

E. BURBAGE and T. G. JONES, FF.G.A.

BEING less well-informed on Platonic matters than Dr. Joad, we cannot tell whether the philosopher is correctly reported in that famous passage which credits him with regarding knowledge as " but remembrance ; intellectual acquisition but reminiscential evocation ; and new impressions but the colouring of old stamps which stood pale in the soul before." We confess that our present enquiry can pretend to no status more elevated than a refurbishment of this sort, as we have not adventured beyond an application of a law of crystal optics which has been known for a century. Curiously enough, this application appears to have escaped the attention of gemmologists. Whilst no search has been made through the literature of mineralogy and related subjects to discover whether earlier papers have been published on this subject, we are fairly confident that with the exception of a brief reference in an earlier article upon another subject by one of the present authors, nothing relevant has appeared in gemmological books and journals.

The proposed method uses extinction directions to determine the optical orientation of a gemstone. To those who are familiar with petrological techniques, it will be apparent that it is in a sense a three-dimensional generalization of the extinction criteria by which a petrologist distinguishes minerals in thin sections. With a gemstone, where one does not normally have a cleavage to employ as datum line, it is convenient to use instead a direction related to the symmetry of the cut stone. Except in cases such as the rose and cabochon cuts where another choice becomes obligatory, the obvious direction for this purpose is the normal to the table facet. Now, given two further axes forming a system such that all three are mutually at right angles, one has a sufficient framework of reference for the intended purpose.

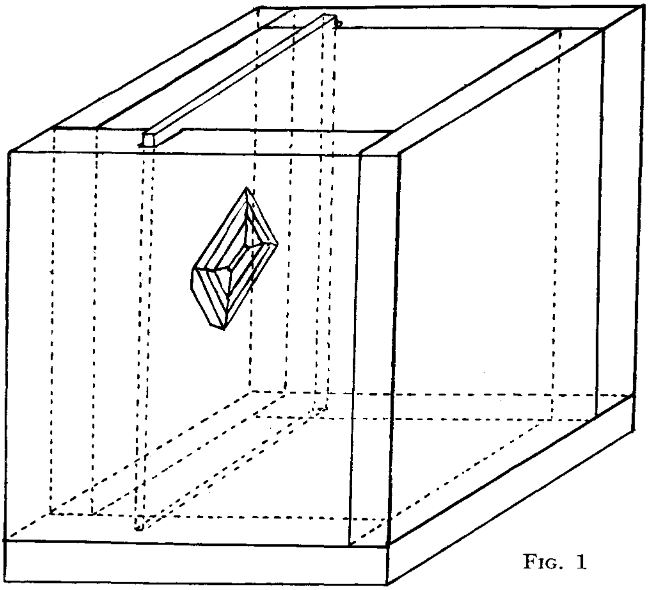


FIG. 1

To translate this project into actuality, we constructed an immersion cell of transparent plastic, having initially checked that the material was isotropic. Two sides of this cell were slotted vertically to hold a square of glass, resulting in a gadget as sketched in Fig. 1. We then related the principal directions of the glass slip to the axial conventions of three-dimensional co-ordinate geometry ; that is, we called its vertical direction in the initial position the Z-axis, the normal to its surface the Y-axis, and the direction at right angles to these two the X-axis, and postulated the usual sign conventions, as shown in Fig. 2.

It is advantageous to standardize one's working routine, and our own procedure has been as follows: The gemstone is mounted table downwards on the glass slip by means of Perspex cement, and the cell is filled with a liquid whose refractive index is a reasonably close match to that of the stone. Inserting the slip in a vertical position in the cell, the latter is placed on the revolving stage of a petrological microscope between crossed Nicols, with the stage at the zero position, the edge of the glass slip lined up in a N.S. position and with the stone on the E. side of the slip. Then, rotating the stage in a clockwise direction, the angle through which

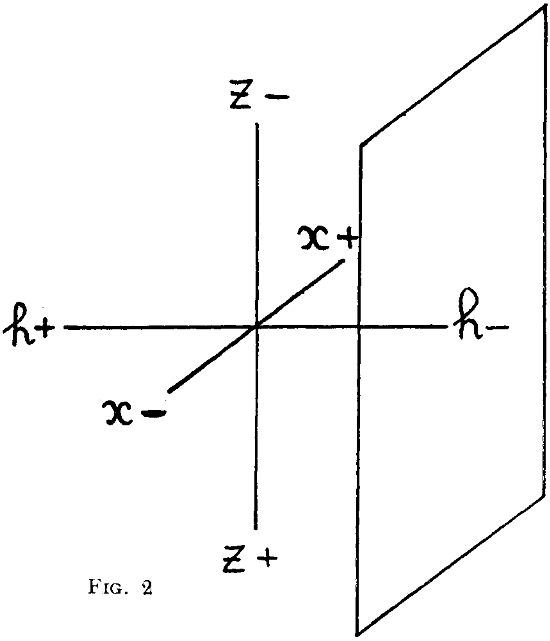


FIG. 2

one must travel before reaching the first position of extinction is noted. The slip is then lifted, rotated through a right angle in a clockwise direction, if the slip is viewed from the side at which the stone is attached. Then the stage is returned again to zero, and the edge of the slip again to the N.S. position, and the extinction angle determined as before. Lastly, the slip is rotated back to its former position, and lifted and placed in a horizontal position in another larger cell, lining up the original upper edge in a N.S. position, and a third extinction angle is determined.

In addition to each of the determined directions, there are, of course, extinctions at right angles to these, giving, in all, a set of six, and it is necessary to compare them to reject unwanted values before finding the direction components of the optic axis. We can best illustrate this process from an actual set of readings. The extinctions of a faceted gemstone (a pink beryl) were found to be as follows: First position, 79° ; second position, 26° ; and the third (horizontal) position, 68°. The relations of these angles with the planes containing the co-ordinate axes are shown in Fig. 3.

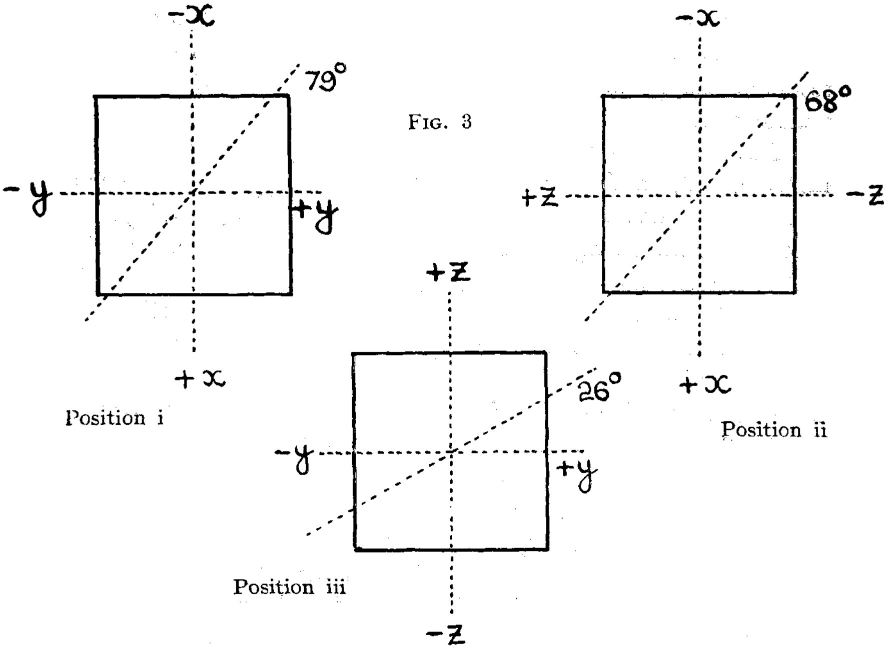


Fig. 3

Position i

Position ii

Position iii

Positions (i) and (ii) furnish a set of four possibilities for the direction components of the optic axis:—

$L:M:N = -\tan 79^\circ : 1 : \tan 26^\circ$
or $\cot 79^\circ : 1 : -\cot 26^\circ$
or $\cot 79^\circ : 1 : \tan 26^\circ$
or $\tan 79^\circ : 1 : \cot 26^\circ$
From position (iii) $L:N = \sin 68^\circ : \cos 68^\circ$
or $\cos 68^\circ : -\sin 68^\circ$

Thus the four values of the ratio $\frac{L}{N}$ derived from positions (i) and (ii) are -10.548, $-.095$, $.398$, and 2.509, and the two derived from position (iii) are 2.475 and $-.404$. The last value is clearly one which does not match any of the first four, but, allowing for experimental errors, the 2.509 and 2.475 match very well. Accepting the former value as *the* true one, the ratio of the direction components is given by $L:M:N = \tan 79^\circ : 1 : \cos 26^\circ$, and dividing these values by the normalizing factor $\sqrt{L^2 + m^2 + N^2}$, the direction cosines of the optic axis are given as $l = .915$, $m = .178$, and $n = .355$. The cosine of the angle between the normal to the table facet and the optic axis is equal to the value of m, giving this angle as about 79¾°. If one uses the other value of $\frac{L}{N}$, 2.475, the resultant change in this angle is very small, approximately one minute of arc.

Described at length, the calculations appear somewhat formidable, but, in fact, a table of the logarithms of the trigonometrical functions enables them to be performed very quickly, the process of normalizing, itself quite simple, being the most lengthy part of the calculations. Superficially, it would seem that one could shorten the work to some extent by normalizing the L:N value derived from extinctions in position (iii), as this ratio is a simple trigonometrical expression, but this is an error, for, unlike the corresponding value chosen from the first set of four, the essential proviso that M=1 has not here been observed.

In order to clinch the validity of this method, we decided to try it out in circumstances where an independent check was possible. In a uniaxial crystal having pyramid and either or both prism and pinacoid faces, the angle between the normal to a pyramid face and the optic axis can be found by this extinction method, and compared with the interfacial reading determined on a goniometer or quoted in the textbook data. For instance, a crystal of apatite was mounted on the glass slip with a pyramid face in contact, and, from direction cosines obtained from extinctions, the two values of the angle made by the normal to the pyramid face with the optic axis were 42° 24′ and 42° 10′. These were very satisfactorily close together, and about 2° removed from the value of 40° 18′ quoted by Herbert Smith as the angle between the basal pinacoid and appropriate pyramid, a disparity no doubt resulting from a somewhat imperfect cementation between stone and glass giving rise to a small amount of " play " between them. A further trial with a crystal of beryl (aquamarine) yielded the two results 44½° and 45½°, of which the mean, 45°, was coincident with the angle measured on the spectrometer and quoted in the textbooks as that between the basal pinacoid and the (1121) pyramid.

In this, as in most enquiries involving measurements of angles, lengths, physical constants, and the like, one has to consider at the outset the tolerance limits imposed by one's initial requirements. For ourselves, the purpose which we had in view required readings of the angles between normals to the tables of gemstones, and their optic axes, in which errors up to ± 3°, say, would be permissible, and it was therefore pointless to strive for an exactitude in our results of an order of minutes of arc. If this were required, one's obvious course would be to ensure that the cell construction permitted an examination in positions which were very accurately 90° apart, to check carefully that contact between stone and glass was as nearly perfect as possible, and to seek methods to define very sharply the extinction positions and to measure the angle of rotation with more precision than the graduated stage of the microscope normally affords.

The use of a petrological microscope is not essential for this work, and if the standard of accuracy required is not too great, it should be possible to assemble a polariscope for this purpose, although really accurate results would probably demand precision engineering beyond the scope of the amateur's workshop. It should be noted that in a home-made polariscope, the routine which we have described would need modification if any departure from the N.S., E.W. convention of the crossed Nicols or Polaroids were made. It is interesting to note that in his " Crystallography " (1922), Tutton, for whom extinctions had to be accurate in terms of minutes of arc, advances the claims of the Fuess stauroscope over the petrological microscope on grounds of its greater accuracy. As, however, the gemmologist is seldom likely to have either the need to work with such precision, or access to the stauroscope recommended to attain it, a good petrological microscope remains first choice for work involving extinctions.

Corresponding to the law of Malus, which we have employed in this method, there is that of Biot for biaxial media, which could be used similarly in dealing with orientation of biaxial stones. Unfortunately, one's requirements when dealing with the latter are seldom satisfied with the mere knowledge of the bisectrices and Biot does not help one to go beyond this to ascertain the value of 2V, in which one is more likely to be interested.

It is hoped in a later paper to describe an enquiry in which this method has been employed. We wish gratefully to acknowledge the advice and encouragement of Mr. B. W. Anderson in connexion with this work.

NEW BOOKS REVIEWED

"*An Easy Guide to Stones in Jewellery.*" By G. M. Sprague, A.M.I.Mech.E., F.G.A. Cairo, 1949. 77 pp., illustrated.

An elementary book on gem identification for the jeweller, with special reference to the use of simple apparatus. Explanation of the three main types of stones is given. The use of the dichroscope, hand lens and the Chelsea colour filter is discussed, and how to correlate the information obtained from their use in a possible identification. The microscope and refractometer are adequately treated, but, perhaps wisely in such an elementary book, the spectroscope is not mentioned. The list of suggested heavy liquids could be improved by the inclusion of a tube of undiluted bromoform, especially as its use is specifically mentioned in subsequent pages. Discussion of the species is divided into colour groups, a method which is having an increasingly greater vogue, and, indeed, for such an elementary work, is more or less essential. A short but clearly expressed chapter on synthetic stones, pastes and doublets concludes the first part of the book. Part 2 contains chapters on non-transparent stones and how they may be detected. Specific gravity, hardness and surface structure as seen by the lens are emphasized as useful tests, which, in conjunction with the description given in the text, should give identification. The book concludes with a set of useful tables as appendices and a good index. No rare stones are mentioned ; there are a few typographical errors. Also goldstone might have been included in the text rather than in the index only. The description of the curved lines seen in synthetic ruby as " gramophone record lines " is most expressive. The note on imitation pearls, in the section on organic gems, is ambiguous ; a clear description of the solid glass bead type which is the type now commonly employed would have been more useful.

The book is a simply expressed introduction to gem testing and may well inspire the jeweller to a better understanding of the different gemstones.

P. B.

"*Chinese Jade Carving.*" By S. Howard Hansford. Lund, Humphries & Co., Ltd., London. Illustrated. 132 pp. 32 pls.

" Chinese Jade Carving " could, so easily, have added to the endless controversy of Chinese symbolism. It does not. It is a direct contribution to gemmology. Its theme, as the title indicates, is the work of the lapidary. And not only is much of the given information a result of close contact, the author has, in certain instances, carried out his own experiments—that of testing a particular abrasive, for instance, or drilling nephrite by means of a short stick of bamboo and ordinary builder's sand. In trying to arrive at a common abrasive used in early jade carving, Mr. Hansford develops the sand theme and mentions in particular corundum and garnet sands which he believes would have been too painstaking, as a rule, to crush fine enough for abrasive purposes. It may be of interest, therefore, to mention certain " ruby sands " in a little place called Crepuke in Southland, New Zealand. These sands are minute garnet crystals and, though there is no evidence that the Maoris made use of this as an abrasive for jade work, it would suggest that some similar natural product, requiring no processing, may have been available in early Chinese times.

The student of jade will find himself frequently comparing this book with Dr. Laufer's " Jade." The author, too, compares and pays tribute to Dr. Laufer. Nevertheless, at times he is at considerable variance with him. And whereas Dr. Laufer's large volume was more or less a series of notes on his findings—for which he apologized—the more literary quality of Mr. Hansford's book makes for pleasant reading.

To all but the specialist, Chinese jade may be divided roughly into four sections. One, the Neolithic. Two, the creative, and perhaps tradition-bound, Han to Sung dynasties (though Mr. Hansford gives this a slightly earlier date). Three, the highly ornamental Ch'ien-lung period that would seem to be the Eastern counterpart of our gilded Louis XIV. And, like Louis XIV, of course, masterpieces in craftsmanship. Mr. Hansford points out here that despite the drawbacks of this period, speaking aesthetically, it was freer of tradition and willing to decorate almost any piece of jade for almost any purpose. One thinks of it in relation to the renaissance of Europe, when the artist began to break with the traditions of the Christian church and found a world full of possibilities beyond. To quote the author: " The rugged workmanship of the jade carver of over two thousand years ago shows none of the refinement to which we are accustomed in the sophisticated productions of the Ch'ien-lung period and of the present day. Yet, as regards tools and tactics the craft had reached its maturity by the end of the Chou Dynasty." To illustrate sections two and three, one may study, among the beautiful plates at the end of this book, a vase of the Sung Dynasty (No. XXVI b). It is cylindrical in shape, 6¼ inches high, and with an elongated animal that creeps almost to the top of the vase and forms a handle. It is a piece one could contemplate without satiety, a vastly different proposition from the rather " heady " efforts of the Ch'ien-lung. Plate XXVI (a) must be of extraordinary interest to any collector. Here is another Sung piece in grey jade, a two-handled bowl, for all the world like an old silver fluted sugar bowl. Perhaps it is prejudice, but the Sung period gives us, surely, far better design, even if limited—by tools or technique or tradition—than the florid let's make-money insincerity of the Ch'ien-lung. Section four brings us to the present day—as far as the jade worker is permitted to operate—and here Mr. Hansford, perhaps influenced by the graciousness with which he was admitted into this inner circle, has more than a kind word to say.

Mr. Hansford begins his exposition with a list, not only of the Principal Chinese Dynasties, always a help, but, with what is still more valuable to the occidental placing these periods, the comparative dates in world events.

Chapter Two is pure gemmology. It covers colour, structure, chemical composition, hardness, specific gravity, refractive index, and, of absorbing interest, the associations and ramifications of the word Yü, including jade as part of medicine. There is also a reference to industrial diamonds, which, Mr. Hansford believes, were used by the Chinese as early as the 4th and 3rd centuries B.C.

In the final chapter of this work—actually the last page but one—the author mentions the fascination of the *feel* of certain jades that are usually carved from suitable nephrite pebbles. He describes it thus: " It must be held in the hand, viewed from every angle, and then *fondled.*" Since nearly every writer on jade mentions this point, one is left wondering whether each has experienced it for himself or whether it is referred to as part of the build-up of the Chinese jade picture. In Western psychology this is something permissible perhaps only to women still subconsciously regarded as a lower form of the species. To a man, and a Britisher, capable of a well-documented investigation, it reads a little like sudden exposure and stamps him a man of courage. In the last paragraph but one, however, is another psychological point with which one feels inclined to take issue. " Yet no account . . . could close," writes Mr. Hansford, " without a tribute of admiration to those humble perfectionists for whom, it seems, the only reward of a thing well done was to have done it." Surely it should read " in the doing of it." No job, however well done, satisfies for long, certainly not in proportion to the amount of time and work involved. Mr. Hansford may find that his own book, not long off the press, is already of the past and in the back of his mind he is writing another. Then, perhaps, we may be treated to a phase of the subject that was the only disappointment of " Chinese Jade Carving "—some light on the " missing link " of jade. This link will unite Stone Age tools wrought by a race that Dr. Laufer and others feel were not Chinese (or Mongol even) at all, and the Chinese who are supposed later to have occupied the land. The Maoris of New Zealand travelled in their amazing canoes. This race—Chinese possibly—scaled mountains, the Pamirs it is thought. Yet neither travelled light. Wrought jade was part of their equipment.

E. R.

"*The Art of the Lapidary.*" By Francis J. Sperisen. The Bruce Publishing Co., Milwaukee, 1950. 382 pp., 406 illustrations.

From the very nature of his craft, the lapidary has a peculiarly intimate knowledge of gemstones. His judgment must be brought to bear on each stone, first as a rough crystal or pebble, and then through all the stages of its shaping and polishing. Such matters as hardness, brittleness, cleavage, flaws, inclusions, colour distribution, dichroism, reaction to heat, are all of vital concern to him. An error of judgment before beginning operations hardly less than a fracture during cutting may rob him of profit or reputation.

Small wonder, then, that before (and even after) the advent of the trained gemmologist it was to the lapidary that dealers and jewellers turned for expert advice on the nature of any stone that was in doubt. The lapidary, of course, was usually right in his judgments ; but sometimes he was rather surprisingly and disastrously wrong—relying too much on empirical knowledge and on the way in which the stone reacted " on the wheel " and scorning the quite simple scientific tests which would have saved him from error.

Things are slowly changing. The modern lapidary has probably no more empirical knowledge than his fathers, and no greater manual skill. But he has better apparatus for his craft and, if not himself a gemmologist, he is at least aware of the possibilities of the science in matters which are outside his ken. Manual dexterity, skilled judgment, and " touch " can be better taught by apprenticeship to a master craftsman than by means of the printed word, and the small but important details of technique which have been learned from experience or handed down from father to son are regarded as " secrets of the trade," and as such not to be lightly imparted to the amateur or general public. For these reasons the lapidary is usually reticent in matters affecting his craft.

In many ways, then, " The Art of the Lapidary " forms an unusual and welome addition to the literature of precious stones. Francis J. Sperisen is a successful lapidary of some 35 years' standing, who can speak with an authority based on personal experience on all the techniques of cutting gemstones. In his work he has handled rare and unusual gem materials in addition to the usual commercial stones, and is able to suggest the special treatment necessary in the case of some of the more " difficult " minerals. Mr. Sperisen has also interested himself in gemmology and in the history of lapidary work and jewellery in past ages, which gives his book a greater richness and depth than would be found in a mere technical manual. Moreover, the book is very well written and plentifully illustrated.

The first three chapters give a brief introduction to the nature of gemstones and to the characters by which they may be identified. The treatment is unconventional, full of original observations, and given from the lapidary's point of view ; it thus makes refreshing reading for the gemmologist who has become too familiar with the usual type of text-book. Since the lapidary deals largely with rough and always with unset stones, there is a natural emphasis on density tests, particularly on those which are suitable for large specimens. The reviewer has seldom seen the measurement of displaced water from what is sometimes amusingly known as an " Eureka Can " recommended as a density method for gem materials. However, though crude in appearance, there is no reason why such a simple contrivance should not yield good results on large specimens.

Optical properties, on the other hand, are dismissed far too briefly, since these, too, should serve the lapidary well on occasion. Less than a page, for instance, is devoted to the refractometer, and the enormously important phenomenon of double refraction receives four lines. The third chapter, entitled " Classification of Gems," is, for the gemmologist, the strongest and most interesting in the book. It deals largely with characteristic inclusions (including those in synthetic stones) and is illustrated with some thirty carefully selected photomicrographs taken by the author. Mr. Sperisen has special knowledge of the Chatham synthetic emeralds, as he has cut so many, so that his observations on these stones are well worth reading. Synthetic rutile, rather strangely, is not included in the book.

With Chapter IV, " Tools and Equipment," we come to grips with the main subject of the book, a subject on which the reviewer is hardly competent to comment. Thereafter are chapters dealing with all aspects of cutting, including diamond cutting, and engraving, carving and sculpturing. The illustrations help the reader to form a very clear picture of the processes involved. Chapter XIII, with which the book ends, would be better named an appendix, since it contains a medley of reference lists, tables, glossary, etc. One of the lists, headed " Stones Requiring Special Care in Handling, Cementing and Working," indicates the wide range of materials used for cutting by the author. Naturally, the easily cleaved minerals, euclase, spodumene and fluorite, are in this list (though not fibrolite) but also brazilianite, benitoite, and the rare mineral augelite, which is better left as a charming crystal than cut as a gem, having no colour to commend it. Other lists useful to the lapidary or would-be lapidary are those of stones having granular texture, coarse or uneven grain, and stones difficult to polish.

One may disagree with Mr. Sperisen on certain points of detail, but on the whole the book is remarkably free from error for a first edition, and a most valuable volume for those interested in the theory and practice of the lapidary's art. It is gracefully dedicated " To the Amateur—may his tribe increase." In America the tribe *is* on the increase, and has already reached what to us seem very large proportions. This book should serve still further to swell their number.

B. W. A.

"*The Jewelers' Dictionary.*" Second Edition. Jewelers' Circular-Keystone (Chilton Co.), New York, 1950. 262 pp., illustrated.

This very useful dictionary contains definitions of over 5,000 terms used in the jewellery trade, and covers not only gemmology (contributor Dr. F. H. Pough) but also watches, clocks and jewellery manufacture (John J. Bowman) and metals (Miss C. M. Hoke). The three contributors are all authorities on their subjects, and the result is far more than a mere compilation derived from other people's work.

The gemmological entries are naturally those which concern us most here, and in these Dr. Pough's forthright style often brings entertainment as well as enlightenment. He scores some shrewd hits against trade nomenclature where this is at fault, and since this work is likely to be consulted widely by American jewellers at least, his strictures should exert considerable influence on the right side. Of the misuse of the term " olivine " to mean demantoid garnet, Dr. Pough remarks that this is " probably the only instance in gemology where the jewelers have perpetuated an error to their disadvantage."

Authoritative information on the localities of gemstones is also to be found in the dictionary. For instance, under Mexican turquoise, where the entry reads " A misnomer ; no important turquoise occurrence is known in Mexico. . . ." Dr. Pough is also able to correct certain misconceptions as to colour ; thus under phenakite we find " Usually colorless or slightly yellow ; never rose-red, brown or yellow."

The constants of the gem materials are usually, but not always, given as part of their description in the text. The reason for their occasional omission is not very clear ; it would certainly be more convenient for the reader for the figures to be given in every case. There is a table of " Gemstone Characteristics " in an appendix at the end of the book, but this is limited to a single page, giving room only for sixteen species. A mysterious feature of this table is that two adjacent columns are each headed " gem hardness."

Amongst other valuable features of the appendix section are diagrams of various styles of cutting, and " exploded " views of all the parts of a watch.

All in all, this is a very useful work of reference which well deserves a place on every jeweller's bookshelf alongside Shipley's " Dictionary of Gems and Gemology " and Webster's " Gemmologists' Compendium."

B. W. ANDERSON.

"*A Roman Book of Precious Stones.*" By Sidney H. Ball. The Gemological Institute of America. Los Angeles, 1950. 338 pp.

Caius Plinius Secundus, better known as Pliny the Elder, was born at Novum Comum (Como) in that part of Northern Italy then known as Transpadane Gaul, in the year A.D. 23. Author of many works, only one of which, the celebrated " Historiae Naturalis " in 37 books, is extant to-day. Dedicated to Titus, son of Vespasian and his successor as Emperor, the Natural History comprehends a greater variety of subjects than we now regard as included under that title—the 37th book treating with precious stones. Pliny's work is often criticised as having little philosophical arrangement or scientific merit and that the observations are nearly all taken second-hand and show small discrimination in selecting the true from the false. But it cannot be denied that the work is a great monument of industry and research and most valuable in supplying us with details on a great variety of subjects as to which we have no other means of information. This is particularly true in respect to precious stones as they played such an important part in the life of the Roman Empire of the 1st century. This is the background of the present volume.

Pliny's Natural History has been translated into almost all European languages, and one of the best in English is that by Philemon Holland, published in London in 1601. It is on this translation that Dr. Ball's book is based. Pliny's original, and Holland's translation, are not easily available, and, further, one requires a knowledge of Latin, while the other, printed in the Old English style, is not too easily read. That is only part of the difficulty ; much of Pliny's meaning is obscure, the names of gems and localities are different, and much of the original material requires, as far as may be possible, some clarification and explanation. This is what Dr. Ball has set out to do. The result is a volume full of interest.

" A Roman Book of Precious Stones " is divided into three parts. The twelve chapters of Section 1 being a description of Pliny's career, the credibility of the authorities he quotes and the story of gems and jewellery of his day. Roman jewellers, Roman commerce and Roman taxes are discussed in this section as well as gem occurrences, known and surmised. Information on the mining of gems, on imitation and treated stones and on the industrial uses of gems is given. The section concludes with a general survey, complete with two excellent tables, of the attempts to correlate the stones described by Pliny with those of to-day.

The second section is a modernized version of Philemon Holland's translation of the 37th book of " Historiae Naturalis," with the one difference that the chapter headings have been changed to the more numerous and logical headings used in the Latin edition of Jean Hardouin. In this section the " foreign " mineral names are printed in italics and marginal notes are made of the probable modern name of the gemstone. The third section contains notes and additional information explaining and elaborating those details in the translation which are ambiguous. These are referenced by the use of superior numbers in the text.

The book is extremely well printed and is handsomely bound in linen cloth. The text is thoroughly annotated with the references placed in the wide margin in preference to the more usual positions at the foot of the page or at the end of the chapter. With the great number of references involved this method has much to commend it. In imitation of old parchment the second section—the translation—is printed on yellow India paper and each page of text is panelled with a border of a rolled scroll design. The text is often overprinted on this design and it is doubtful whether the scroll effect adds to the appearance of this section. The book concludes with an excellent index containing over 450 entries.

" A Roman Book of Precious Stones " is a volume that should be on every discerning gemmologist's bookshelf for Pliny's work is quoted by many writers on gemstones. The 37th book, indeed, gives the earliest collected knowledge of gem materials and has at last been edited by a lover of gemstones and one who knew the subject. The great pity is that Dr. Ball did not survive to see the completion of his great work, which was finally completed and launched by Kay Swindler. The Gemological Institute of America is to be congratulated in making available this splendid work to all English-speaking people.

R. W.

"***Jade of the Maori.***" By Elsie Ruff. Gemmological Association of Great Britain, London, 1950.

A review of this work, which deals with New Zealand Jade used by the Maori, will be given in the October, 1950, issue of the Journal.

Gemmological Abstracts

" New Process of Artificially Beautifying Gemstones." By E. J. Gubelin. " Gems and Gemology," Vol. VI, No. 8, pp. 243-248. Winter, 1949/50.

A survey of the surface treatment (coating) of gemstones in order to reduce surface reflection. The optical reasons underlying the effect are explained and the reason why the refractometer will give a false reading, or none at all, with such coated stones. A number of spot chemical tests for the detection of the films are given. P. B.

" Diamond Mining in Brazil." By T. Draper. " Gems and Gemology," Vol. VI, No. 8, pp. 241-242. Winter, 1949/50.

The first instalment of a series to be published on this subject. This instalment tells of the history of the Brazilian mining ; of the " garimpeiros "—the nomad miners ; their habits and their methods of mining. An interesting and informative article profusely illustrated with photographs. It seems to be the prelude to the most comprehensive survey of the Brazilian diamond fields yet written. P. B.

" New Data on Brazilianite." By B. W. Anderson. " The Gemmologist," Vol. XIX, No. 226, pp. 89-90, May, 1950.

A slightly higher value of specific gravity for material from the original source and from the new-found occurrence at Grafton Co., New Hampshire, U.S.A., has been determined by Frondel and Lindberg, Anderson and by Trumper. The new values are tabled:

AUTHOR	S.G.	REFRACTIVE INDICES		
Frondel and Lindberg:				
U.S.A.	2,985	1.602	1.609	1.623
Brazil	2.980	1.602	1.609	1.621
Anderson:				
Brazil	2.990	—	—	—
Brazil	2.994	1.6019	1.6117	1.6228
Trumper:				
Brazil	2.994	1.598	—	1.619

Pleochroism is feeble, liquid-filled " feathers " a common inclusion and the mineral does not fluoresce and has no distinctive absorption spectrum.

" Identifying Synthetic Sapphires." By G. O. Wild. " The Gemmologist," Vol. XIX, No. 226, p. 102, May, 1950.

Experiment showed that the colour induced by irradiation of colourless sapphire by X-rays from a tube with a molybdenum target and run at 40 kV. and 20 mA., to be different for natural sapphire to synthetic colourless sapphire. Natural white sapphires quickly turn to a canary yellow colour, while, after five minutes' irradiation, no colour appeared in the case of the synthetic white sapphire. Fluorescence colours induced by X-rays were found to be of little diagnostic value. Suggestion is made that the synthetic stones are under some strain, for the interference figure shown by natural stones is perfect ; that of synthetic stones is distorted. R. W.

" Neutron Treatment of Precious Stones." "Atomics," 1950, *1*, 79, 83.

Changing the properties of diamonds. Extract from recent patent by N. E. Nahmias, of Chatenay-Malabry, France (Engl. Pat. 13986/1949). The method consists in the use of neutrons to produce permanent colour change by reaching the pigments in the nuclear structure, modifying permanently physical and chemical properties, thus achieving transmutation *in situ*. (The method is based on theoretical deductions, not on practical experiments.—Ed.) The speculation is that by neutron radiation more valuable colours may be secured in gems, and that the hardness in industrials may be improved, following the determination of the nature of the impurities and their modification. Existing piles would have to be used. E. S.

" Die Bedingungen der Edelsteinentstehung." (Conditions of gem formation.) By Prof. Dr. Schlossmacher. " Schmuck," 1950, 87-88 ((No. 3).

Geographically, the most important gem occurrences will be found in a wide belt on both sides of the equator. The beauty of a gem depends on its optical properties, its purity and size. The question is, what conditions are favourable for the formation of such pure crystals of sufficient size? A table shows that most gems are formed in the pegmatitic phase of Sial, the next important is the pneumatolytic, then the hydrothermal phase. The cause is found in the volatile constituents and mineralizers of these magmas and solutions. E. S.

" Der rumänische Bernstein." (Rumanian amber.) By A. Lenard. " Schmuck," 1950, 89 (No. 3).

Enumeration of occurrences of amber in Rumania, and description of physical properties.

" Another Test for Pearls." By G. O. Wild. " The Gemmologist," Vol. XIX, No. 223, p. 23, February, 1950.

Report on a test for drilled pearls based on the X-ray induced fluorescence of the mother-of-pearl bead in cultured pearls. Oblique examination is made, by a suitably placed low-power microscope, of the inner wall of the string canal of the pearl under test. The pearl being in the beam of X-rays. In the case of a cultured pearl the bead nucleus will be seen to fluoresce, while the non-luminous shell will remain dark. The line of demarcation of the core and nacreous shell is said to be in most cases very distinct.
E. S.

" Titania now Made as Doublet." " Gems and Gemology " (Gemological digest), Vol. VI, No. 8, p. 257. Winter, 1949/50.

Report that composite stones having a crown of coloured corundum and a base of titania (synthetic rutile) have been made. All colours of synthetic corundum have been used and very little loss of brilliancy or " fire " is reported. The notion behind their manufacture is to provide a better wearing face, but the practicability of the method has not yet been proved.

" Progress in Diamond Synthesis." By K. F. Chudoba. " The Gemmologist, Vol. XIX, No. 224, pp. 62-65, March, 1950.

A review of the various experiments which have been carried out in the attempt to synthesize diamond. Mention is made of the two leading ideas upon which these experiments are based, i.e. high pressure (diamond having a higher density than the more stable graphite) and by quick cooling to obtain the unstable diamond modification of carbon (backed by Ostwald's grade rule). Discussion of theoretical and experimental considerations throws doubt on the validity of the assumption. R. W.

" Amethyst Colour Induced in Clear Quartz by Cyclotron." " Gems and Gemology " (Gemological digest), Vol. VI, No. 8, p. 255. Winter, 1949/50.

Extracted (by G. Switzer) from " Note on Removing the Deuteron-induced Colour from Quartz Plates " (A. A. Schulke and R. E. Nuelle) in " Review of Scientific Instruments," August, 1949. Transparent colourless quartz plates are employed in aligning the target assemblies in a cyclotron. They fluoresce a bright blue under the deuteron bombardment. These plates were found to turn a deep purple after a relatively short bombardment. The colour change is stable under normal conditions but is destroyed by heat treatment at 300° F. to 400° F. (150-200 deg. C.) with the emission of a strong blue thermoluminescence. Suggestion is made that this amethystine colour may have some bearing with the, as yet unknown, cause of the colour of amethyst. R. W.

" A Curious Polishing Effect." By M. D. S. Lewis. " The Gemmologist," Vol. XIX, No. 222, pp. 64-66, January, 1950.

The production of an anisotropic layer on isotropic solids by polishing in one direction is discussed. Experimentally polishing, in opposite directions, two halves of a glass slide and then dripping an alcoholic solution of methylene blue on the slide and igniting produced markedly different tints in the two halves when the slide was viewed through a piece of polaroid. Full references are given to the works of other authorities on this " anti-Beilby layer " and associated phenomena. R. W.

" Properties of Gem Varieties of Minerals." By Edward Wigglesworth, 1948. Gemological Inst. of America.

Published in memory of the author, this book consists of record cards listing the physical properties of varieties of minerals suitable for cutting as gemstones. The figures of optical and physical constants from works of eminent gemmologists and mineralogists are a valuable feature of the Wiggleworth tables. The loose leaf binding of the book is a useful feature.

It is a pity that some unfortunate variety names are suggested, such as " topazolite " for demantoid garnet, " padparadscha " for corundum, and " peredell " for topaz ; it is praiseworthy to note that confusion between names given to varieties of quartz and topaz has been avoided. A. G.

ASSOCIATION NOTICES

OVERSEAS VISITORS

During April, May and June the Association was honoured to receive visits from gemmologists from overseas. One of the first was Mr. Kenneth G. Mappin, F.G.A., C.G., of Mappin's, Ltd., Montreal, who is Vice-President of the American Gem Society. Mr. W. A. Catanach, President of the Victoria Branch of the Gemmological Association of Australia, brought greetings from the G.A.A. and also attended an Association meeting on May 18th. Another visitor from Australia was Mr. J. B. Lyons, President of the South Australia Branch of the Gemmological Association of Australia. Mr. D. Dresme, of Amsterdam, Treasurer of the newly formed Netherlands Gemmological Association, called to discuss problems connected with the establishment of a new organization. From Oslo came Mr. Hans Myhre, also interested in the formation of the new Norwegian Gemmological Association, and Mr. O. Modahl.

MEMBERS' MEETING

A meeting of members of the Association was held on Wednesday, May 18th, 1950, at Goldsmiths' Hall, Foster Lane, London, E.C.2, at 7 p.m. A paper by Dr. E. Gubelin, F.G.A., C.G., on the "Diagnostic Importance of Gemstone Inclusions" was read by Mr. G. F. Andrews. After the reading Mr. B. W. Anderson described a series of photomicrographs of gemstone inclusions shown on lantern slides, and emphasized some of the points made by Dr. Gubelin in his paper.

NORWEGIAN GEMMOLOGICAL ASSOCIATION

The Association is glad to record the formation on May 9th, 1950, of a Norwegian Gemmological Association (Norges Gemmologiske Selskap) with headquarters in Oslo. The Norwegian Association has been founded along similar lines to that of the Gemmological Association of Great Britain and two representatives of the newly formed organization have visited London and discussed future co-operation between the two Associations.

GEMOLOGICAL INSTITUTE OF AMERICA

Edward H. Kraus, Dean Emeritus, College of Literature, Science and the Arts, University of Michigan at Ann Arbor, has been elected President of the Gemological Institute of America. This is the fifth term as President for Dean Kraus.

H. Paul Juergens was elected for a third term as Chairman of the Board of Governors of G.I.A., and J. Lovell Baker, C.G., R.J., of Henry Birks & Sons, Ltd., Montreal, Canada, again serves as Vice-Chairman of the Board.

New members of the Board of Governors include Carleton E. Broer, C.G., R.J., of the Broer-Freeman Company, Toledo, Ohio; C. I. Josephson, Jr., C.G., R.J., of C. I. Josephson Jewelers, Moline, Illinois; and William P. Kendrick, R.J., William Kendrick Jewelers, Louisville, Kentucky.

Robert M. Shipley remains the Director of the Institute.

1950 EXAMINATIONS IN GEMMOLOGY

The Examinations of the Gemmological Association of Great Britain were held in Great Britain and Overseas as follows:—

Preliminary.—June 7th: Birmingham, Bristol, Darlington, Edinburgh, Glasgow, Harrogate, Ibsley, Liverpool, London and Plymouth.

Overseas: Cambridge (U.S.A.), Ceylon, Egypt, Holland, Indore (India), Jaipur (India), Los Angeles (U.S.A.), Ontario (Canada), Saskatchewan (Canada), Singapore, S. Africa and Toronto (Canada).

Diploma.—June 8th and 9th: London.

Overseas: Australia, Ceylon, Holland, Hong Kong, Los Angeles (U.S.A.), Northern Rhodesia, Ontario (Canada), Saskatchewan (Canada), S. Africa and Toronto (Canada).

June 8th and 12th: Edinburgh.
June 8th and 13th: Glasgow.
June 8th and 14th: Plymouth.
June 8th and 16th: Birmingham.

1950—1951 CORRESPONDENCE COURSES IN GEMMOLOGY

The 1950-1951 Correspondence Courses in Gemmology will commence in September, 1950, and will be conducted on the usual world-wide basis.

Information may be obtained from the Secretary of the Association, and the last date for receiving enrolments from United Kingdom residents is August 31st. Prospective Overseas students should send in their applications prior to August 14th.

TALKS BY FELLOWS

Mrs. Kathleen G. Warren: "'Gemstones," Townswomen's Guild, Bromley, Kent, Tuesday, June 13th.

D. J. Ewing: "Gem Testing," Edinburgh and East of Scotland Association of Goldsmiths, Silversmiths and Watchmakers, Edinburgh, March 15th.

Letter to the Editor

Dear Sir,

I have read with much interest the letters of Messrs. Jones, Burbage and Pearl regarding the latter's recent article on the broadening horizon of gemmology.

I have found from personal experience that while mineralogists in general are able to identify gems by destructive methods, usually only outstanding specialists can correctly identify all cut and polished natural and synthetic gems without injury to the stones.

This is where the knowledge possessed by the trained gemmologist exceeds that of the *average* mineralogist, who quite naturally has received training in the identification of minerals in their natural uncut state, or in thin section.

Not many years ago, before I had the opportunity to study the courses offered by the Gemmological Association of Great Britain, I had occasion to submit a parcel of cut synthetic rubies for a check test by a well-known Canadian mineralogist, at that time head of one of the departments of a Canadian University. In due course, this gentleman successfully identified the stones as red corundum, but was unable to say whether natural or synthetic. Furthermore, although aware of the curved lines in synthetic corundum, he had never been able to detect them in known synthetics he had examined.

This failure was due to no lack of mineralogical knowledge. On the contrary, the man possessed a very high University degree in geology and mineralogy, and since then he has won universal acclaim for his discoveries in the field of geology.

Prior to the establishment of the organized courses in gemmology, scientific gem testing was practically unknown, and to-day only a very few mineralogists have sufficient knowledge of modern (non-destructive) gem-testing methods to qualify them as specialists in precious stones ; for every book or course in mineralogy treats only briefly of gems, and always, of course, in the rough form, or in thin section.

The mineralogist is a great scientist who has to deal with thousands of species. The gemmologist, on the other hand, is a specialist who, ordinarily, deals with less than 90 varieties, and can therefore be much more thorough than the mineralogist.

The specialist in gems has developed the scientific study of gemstones far beyond that of mineralogy. He has conceived new instruments and new methods whereby it is now possible for him to identify any natural, synthetic or imitation gemstone, and without injury to the specimen.

Mineralogists and geologists, chemists and physicists, jewellers and laymen *who possess such knowledge* are gemmologists, whether or not they hold certificates or diplomas of the various accredited associations and institutes specializing in scientific gem study.

The great advance made in the study of gems during the last quarter of a century have been due to *specialization.* While I agree with Mr. Pearl that many unusual North American minerals and ornamental stones worked by private lapidaries should be recognized as gemstones, I feel that non-gem substances such as the plastics, bone, gold, silver, etc., have no place in gemmology, and no *intensive* study of such materials should be required of the student. These are not now and never have been gem materials, nor have they ever been effective imitations of gem materials.

The gemmologist is not necessarily a jeweller, albeit many jewellers are outstanding gemmologists. Why, then, should the student be required to study the properties of silverware, gold-plated ware, and other merchandise sold by the jeweller?

With all due respect for those who have made a special study of such material, it is surely sufficient for the gemmologist to state that a plastic is a plastic, without entering into a detailed discussion of the physical and chemical properties thereof.

If the horizons of gemmology continue to broaden at their present rate, I hazard the opinion that the time will not be far distant when the gemmologist will again be a general practitioner, or else a mental giant specializing in a dozen sciences—some of which, like plastics, are only remotely related to gemmology.

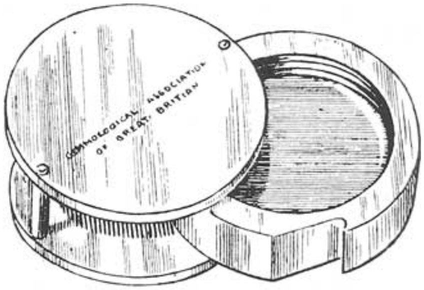
It matters little whether an imitation of turquoise is a stained beef bone or part of the fibula of an elk. It is bone. That moulded brooch in plastic ; does it matter much whether bakelite B or C or polystyrene? The latest carved cameos are being cut from wood. Must one, then, study the hundreds of varieties of wood to qualify as a gemmologist, or shall we simply state " It is a wood carving " and let it go at that?

Let us hope that the educational boards of the future will not make the specialized study of other sciences a required part of gemmological training, and let us not confuse the gemmologist with the jeweller—nor, again, with the specialists in other fields, who may or may not be gemmologists.

In short, let us stick to our wares.

Yours sincerely,
D. S. M. FIELD.

Canada.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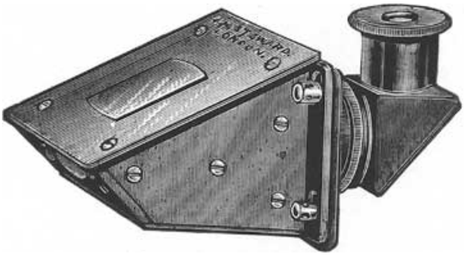
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