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and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

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Vol. VIII No. 7 JULY 1962

THREE-PHASE INCLUSIONS IN EMERALD, AQUAMARINE AND TOPAZ

By W. F. EPPLER

THREE-phase inclusions are a reliable diagnostic feature of genuine emeralds, particularly for those from Colombia. They exhibit different forms according to their position within the host crystal. If they are parallel to a face of the prism zone, they are characterized by jagged forms, the points of which indicate the direction of the c-axis of the emerald crystal (Fig. 1). This kind of inclusion is originated by disturbances during the crystal growth. The peaks of the inclusions can be described as negative planes of steep pyramids, sometimes elongated into prong-like forms.

The other kind of three-phase inclusion in emerald is found parallel to the basal plane of the host crystal (Fig. 2). They also develop irregular forms but they exhibit a more complex shape. Not seldom, they are more or less elongated and rounded. These inclusions represent the remains of a healed fracture originally generated as a cleavage plane during the growth of the emerald crystal.

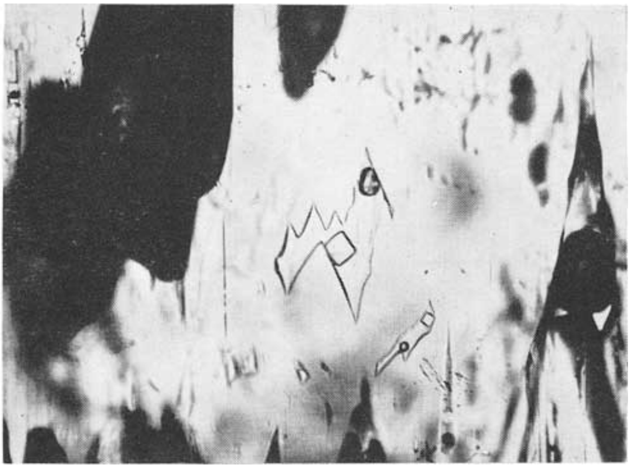

FIG. 1. *Three-phase inclusions parallel to a face of the prism zone of a Colombian emerald. 120X*

Both kinds of inclusions are identical with regard to their contents. A rounded gas bubble indicates the presence of a liquid, and a regularly developed crystal of rectangular shape represents the solid phase. The crystals are said to be cubes of rock-salt (or halite, NaCl), an explanation which sometimes has been doubted.

As early as 1870, F. Zirkel gave a convincing proof about the nature of the solid component of three-phase inclusions, not in emerald but in quartz (Fig. 3). By microscopic examination he made it plausible that the isotropic cube could be nothing else than a rock-salt crystal. But he found other reasons to confirm his assumption. He crushed to a fine powder some quartz rich in these inclusions and boiled it in distilled water absolutely free of chlorine. Then he added a solution of silver nitrate and obtained a milky precipitation from which follows, that by the boiling water the rock-salt was dissolved and its part of chlorine identified by the precipitation of the indissoluble silver chloride.

Next he held with platinum-tipped tweezers a coarser piece of the quartz in the colourless flame of a bunsen burner. Some moments later, the little piece of quartz started to crackle and to break up whereby each time a sudden yellow colouring of the flame occurred. A very simple and reliable proof for the presence of sodium.

Now, after these convincing tests for the presence of sodium chloride or rock-salt in quartz, it seems to be obvious that the little cubes within the three-phase inclusions in emerald are also rock-salt, not only on account of their cubic crystal form but also with regard to their isotropic character. Additionally, the pegmatitic origin of the emerald makes it very likely that the similar three-phase inclusions in quartz and emerald respectively are of the same nature.

Besides this, it has been confirmed in modern times that rock-salt and sylvite (KCl) occur as a solid phase not only in liquid inclusions in quartz, but in beryl and topaz also. A very interesting publication of Lemmlejn and Klewzow (among many others) mentions this particular fact. So we can be sure that the little cubic crystals in liquid inclusions in emeralds are rock-salt, which mineral can sometimes be accompanied by the rarer sylvite.

The method used by the Russian scientists consists in cooling the material in question until the liquid of the inclusion congeals. They cooled, for instance, a quartz with a three-phase inclusion down to minus 26·8-27·8°C., at which temperature the liquid became frozen. By calculation they found that this freezing point is characteristic for a saturated solution of NaCl and KCl with 2-3% $MgCl_2$.

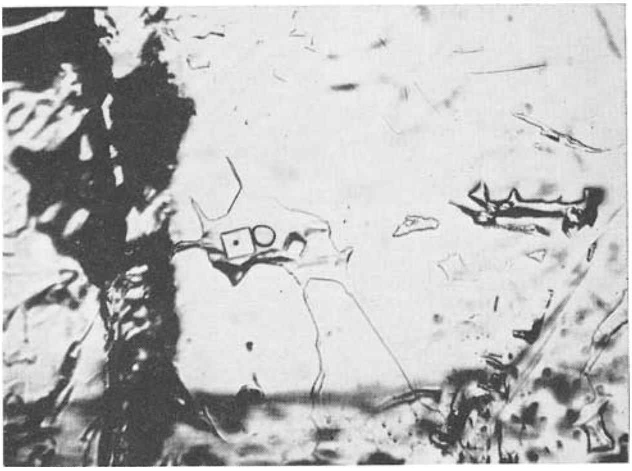

FIG. 2. *Emerald from Burbar, Colombia, with three-phase inclusions parallel to the base plane. 65X*

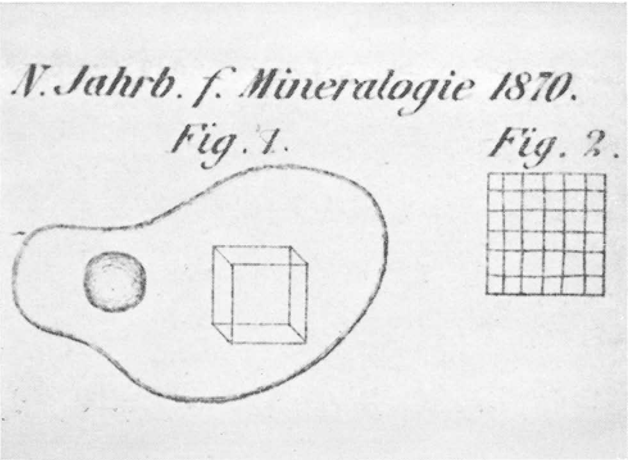

FIG. 3. *Copy of an original drawing of F. Zirkel* (1870). *A three-phase inclusion with a cube of rock-salt in quartz.*

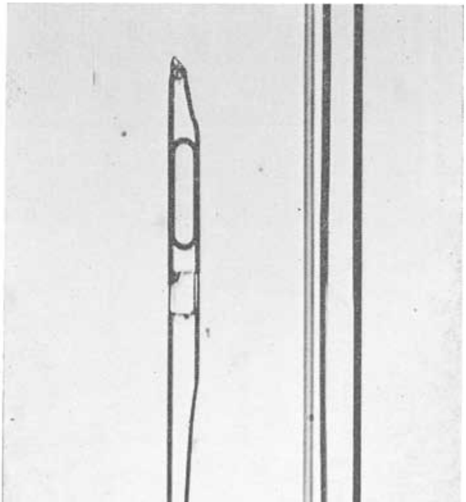

FIG. 4. *Three-phase inclusion in an aquamarine from Bom Jesus das Meiras, Bahia, Brazil. 240X*

The author often tried to detect similar inclusions in beryls other than emerald, especially in aquamarine. Until now, they could not be found in gem material. Only in a poorly coloured but well developed slender crystal of aquamarine from Brazil, tube-like three-phase inclusions could be observed, of which Fig. 4 gives an example. Obviously, this inclusion represents a tube of growth, so common and well known in aquamarines. It follows, naturally, the direction of the host's c-axis. The little cube, most probably of rock-salt, is colourless, singly refractive, and it bears in its upper left corner a minute dark dot, such as can often be seen on the cube face of the rock-salt crystal in this particular kind of inclusion (see also Fig. 2). It could not be determined if this dot is an additional micro-bubble or a tiny particle of solid material.

Recently, some three-phase inclusions could be observed in a bluish-coloured topaz of gem quality from Brazil. Sometimes, the inclusions are very similar to those found in emerald parallel to its base plane (Fig. 5). In other cases, they cover a relatively large area. They are always parallel to the basal plane of topaz, a direction which represents the perfect cleavage of this crystal. Therefore, they can be regarded as the indigestible remnants of a cleavage crack which healed during the further growth of the topaz crystal.

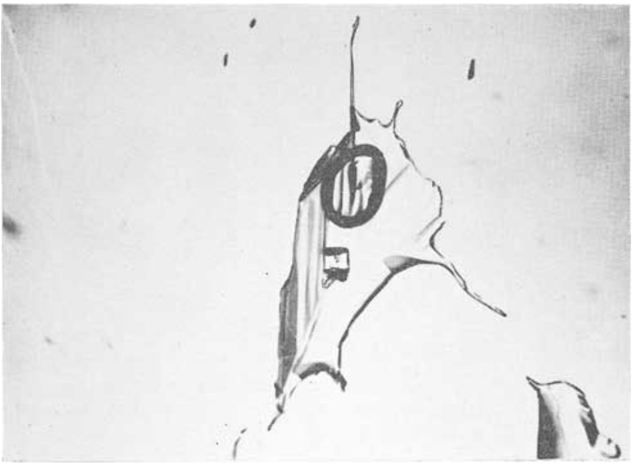

FIG. 5. *Topaz of gem quality from Brazil, exhibiting a three-phase inclusion of irregular shape parallel to the basal plane. 120X*

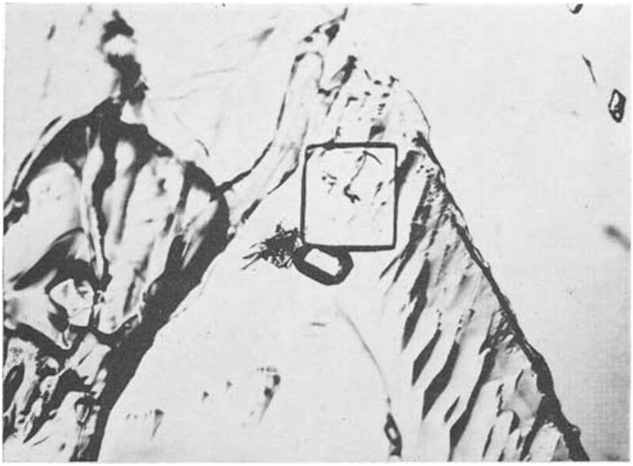

FIG. 6. *Part of a large three-phase inclusion in topaz. 120X*

Fig. 6 shows a part of a large three-phase inclusion in the same topaz. The left part of the picture with its darker appearance is a section of the large gas bubble. The square in the upper middle represents a cube of rock-salt. It overlays a dark-rimmed smaller and doubly refractive crystal of unknown nature. In 1955, M. M. Iwantischin reported the presence of rock-salt and sylvite as primary inclusions in topaz. So, this little contribution offers no new discovery, but another confirmation for the long-known nature of the solid component of these particular three-phase inclusions.

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G. G. Lemmlejn and P. W. Klewzow, Physikalisch-chemische Analyse flüssiger Einschlüsse im Quarz, die Halit- und Sylvinkristalle enthalten. Sapiski Wsesojusn. min. Obsc. (Report of the USSR Mineralogical Society), (in Russian), 84, 1955, 47-52. Abstracted in: Zentralblatt für Mineralogie I, 1957, 82.

M. M. Iwantischin, Topase aus den Pegmatitgängen von Korostenj., Geol. Shurnal (Ukrainian and Russian), 15, 1955, No. 4, 58-73. Abstracted in: Zentralblatt für Mineralogie, 1958 1, 132.

PEARL TESTING THROUGH ONLY ONE X-RAY DIFFRACTION PATTERN

By JORGE ANGUS

It is known that in a determined position a cultured pearl can produce a diffraction pattern like a natural pearl. This makes necessary a second X-ray of the pearl, turned to a 90° angle according to the first position each time, if the first result was of a hexagonal diffraction pattern. If the second testing gives the same hexagonal symmetry, then this means that the pearl is a natural one. But if the symmetry shows a rectangular form it indicates that the pearl is cultured.

In the " Laboratorio de Gemologia Y Ensayo de Materiales del Banco Municipal de la Ciudad de Buenos Aires " a Rich Seifert X-ray diffraction equipment has been installed with its corresponding Laüe's chamber. The classical method is used with satisfactory results.

However, due to internal demands at the Bank for quick testing, it has been necessary to reduce the time involved. The procedure is as follows.—A special device, as indicated in Fig. 1, was installed to obtain a rotation movement of the pearl during exposure to the X-rays. This rotation is obtained with the help of Debye-Scherrer's chamber motor (Fig. 2). A one minute revolution of the pearl is sufficient. The film was placed as Laüe's technique requires and the method is only a combination of the techniques of crystal rotation and Laüe's. By this method the natural pearl shows a hexagonal symmetry pattern (Fig. 3). The cultured pearl shows a rectangular symmetry, as shown in Fig. 4.

The best results were obtained by working with 0·6 mm diaphragm, 20 mA 53 Kv and 4 cm from the pearl to the film. The X-rays film used was Kodak KK, with 6-8 minutes exposure time according to the pearl size. An intensifying screen was not used. After the first attempts it was very easy to centre the pearls correctly. It was also possible to do this by hand, mounting the pearl on a little wax cone. The method described has been a great saving in time and costs, and has been extremely useful in cases of pearls which were irregular in shape.

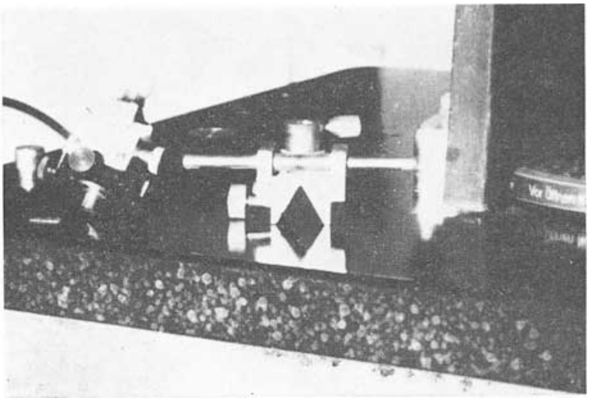

FIG. 1

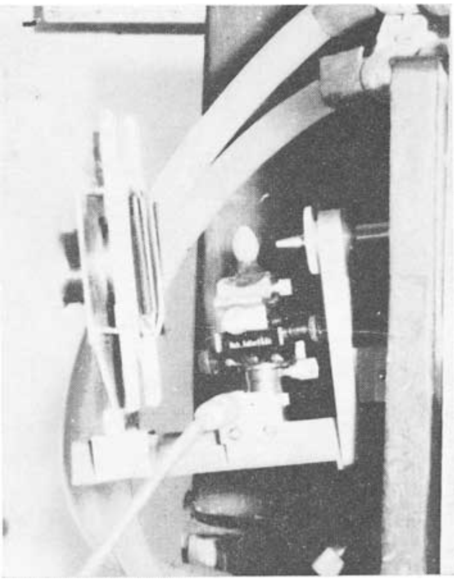

FIG. 2

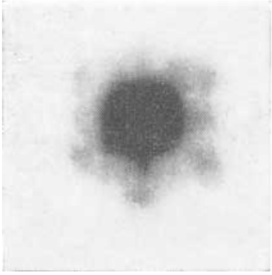

FIG. 3

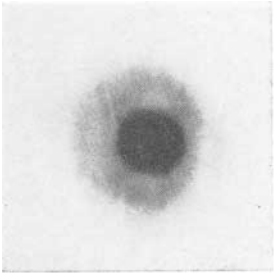

FIG. 4

Gemmological Abstracts

TOLANSKY (S.). *Folklore & history of diamond.* Gemmologist, Vol. XXX, Nos. 361, 362, 364, 365, pp. 155-158; 167-170; 205-210; 232-235, August, September, November and December 1961.

An article based on a paper presented to the Royal Society of Arts. The early references to diamond are discussed and particular regard is had to the early engraving of diamonds. Some of the curious myths applied to diamonds in the early days are mentioned, with special note of the notions of the indestructability of diamond. The historical aspects of cleavage are discussed and the fabulous ideas on diamond which were current in medieval times are given. The history of the techniques for polishing diamonds from the 15th century to the present day is given and there is discussion on the origin of the carat weight. A number of the famous diamonds are referred to and their histories mentioned. There is a note on the modern diamond mining methods.
9 illus.

R.W.

AREND (R.). *Austrian synthetic emerald examined.* Gemmologist, Vol. XXX, No. 362, pp. 161-164, September 1961.

Reports the examination of 31½ carats of synthetic emerald-coated beryls (Lechleitner synthetic emeralds). The density was found to average 2·738 (2·725 to 2·752). The overgrowth on the cut beryl core is only about 0·3 mm. The refractive indices were found to lie between 1·565 to 1·568 for ε and 1·570 to 1·573 for ω. These are values lower than those given by other workers. The absorption spectra, fluorescence, colour filter and microscopic observations were made and recorded.

R.W.

TISDALL (F. S. H.). *Synthetic red spinel.* Gemmologist, Vol. XXX, No. 362, pp. 165-166. September 1961.

A synthetic red spinel had a refractive index of 1·722, and the density 3·66—taken by flotation and refractive index method.

The stone showed curved structure lines which had an effect rather like a Venetian blind. The fluorescence spectrum is compared with that of ruby and natural red spinel.
2 illus.

R.W,

SPRIGG (R. C.). *The Burma jade mines.* Gemmologist, Vol. XXX, No. 364, pp. 211-212, November 1961.

The jadeite is found in a remote area of the northern provinces and at the time of writing the article this area was in insurgent hands so that the author could not visit the mine personally. The mines are at Tawmaw in the Myitkyina district. The jadeite occurs in dykes of jadeite-albite rock bounded on the margins with amphibolite and chlorite in a country rock consisting of serpentine. The rocks are said to be of cretaceous age. The various Burmese names for the different colours and qualities of jadeite are given. Some historical aspects and something of the mining methods are discussed.

R.W.

LEE (H.): WEBSTER (R.). *A pearl encysted crab.* Gemmologist, Vol. XXX, No. 365, p. 231, December 1961.

A small crab was found to be the nucleus of a blister pearl.
1 illus.

R.W.

KOMKOMMER (J.). *The great blue diamond.* Gemmologist, Vol. XXX, No. 365, pp. 224-226, December 1961.

Tells the story of the Wittelsbach blue diamond which weighs 35·56 carats, not 35·32 carats as usually reported.

R.W.

TRUMPER (L. C.). *Stibiotantalite.* Gemmologist, Vol. XXX, No. 361, pp. 141-142 and 146, August 1961.

A report on the examination of two small specimens of pale yellow stibiotantalite, presumably from Madagascar. The refractive index, found by using the author's design of reflectometer, was 2·45 and determinations of density gave values approximate to 7·63. The cause of the increase in density is discussed. The stones were doubly refractive, had an adamantine lustre, and the inclusions seen in the stones were short rods and liquid filled feathers. Dichroism was distinct and the absorption spectrum showed only a general absorption below 5200Å. There was no fluorescence. Stibiotantalite is a double oxide of antimony and tantalum with some columbium (Sb (Ta, Cb) O_4) and crystallizes in the orthorhombic system. It has a hardness of $5\frac{1}{2}$; a double refraction varying between 0·060 and 0·083 and the dispersion is about 0·060. Stibiotantalite is also found in the Himalaya mine, San Diego, California.

R.W.

Zaveri (C. K.). *Gemstones of India.* Gemmologist, Vol. XXX, Nos. 356 and 361, pp. 46-52 and 143-146, March and August 1961.

Emeralds and garnets are found in Rajasthan; diamonds at Panna and blue sapphire in Kashmir. These comprise the stones found in the northern half of India. These are mostly mined by organized operation for the Government or for private companies. Many other species, mostly the less precious stones, are found in the southern half of the country. Here the stones are mined by individuals rather than by organized groups. The gemstones found are diamond, emerald, chrysoberyl, garnet, aquamarine, amethyst, moonstone, green aventurine, moss agate, bloodstone and star-corundums. Apatite, beryl, apophyllite, euclase, iolite, kyanite, rhodonite, tourmaline, spinel and calcite are also found. Famous Indian diamonds are referred to and the early methods used to recover diamonds (taken from Streeter's book) are given. Mention is made of the diamond mines at Panna and those of the Kristna River. There are notes on the sapphire from Kashmir, the emeralds from Ajmir and Jaipur and the garnets from the latter district. A brown tourmaline from Rajasthan and a blue aventurine quartz are mentioned. In southern India, Mysore and Madras are the major gem producing states, Kangayam being the main locality for most of the stones. Aquamarine is the costliest material found in this area. Amethyst is found here also. Iolite is an important mineral and is known as Kaka Nilam (uncle of sapphire). There are moonstones of white, milky-white, pink, green, grey, chocolate, and black colours from this area. Star-ruby and sapphire, the latter in various colours, come from Mysore, which state is also the supplier of green aventurine. Near Trivandrum chrysoberyl cat's-eye is found. Agate, particularly moss agate, cornelian, bloodstone and jasper are found in the state of Bombay.

1 map.

R.W.

WALTER (D. R.). *A star-beryl find.* Gemmologist, Vol. XXX, No. 361, pp. 159-160, August 1961.

Describes two specimens of star-beryl from Brazil, one being a golden bronze colour and the other in silver tones. The asterism is said to be due to inclusions of oriented crystal plates of ilmenite. The stones resemble the Australian black star-sapphire. There is a note on the polishing of such stones.

R.W.

OSTWALD (J.). *An introduction to the optics of gemstones.* Australian Gemmologist, No. 10, pp. 8-14, December 1961.

This is part of a series. Reflection, refraction, total internal reflection and double refraction are discussed. Some historical detail is included.

6 illus.

R.W.

TUFFLEY (J. R.). *Cleavage.* Australian Gemmologist, No. 9, pp. 5-7, September 1961.

The structure of the atom and the formation of compounds are discussed in order to give an outline of atomic bonding relevant to cleavage. The silicate minerals forsterite and mica are given as examples of bonding giving little and perfect cleavage. The types of cleavage and their value or otherwise in the case of gemstones, are mentioned, as well as the reasons why some minerals show no cleavage. There is a note on parting.

5 illus.

R.W.

ANON. *G.J.'s quick course in gemmology.* Goldsmiths' Journal, pp. 204-208 (May 1961); 252-256 (June 1961); 304-307 (July 1961); 348-351 (August 1961); 396-399 (September 1961); 446-449 (October 1961); 542-543 (December 1961); 10-12 (January 1962); 58-61 (February 1962); 115-116 (March 1962).

The first ten instalments of a series of articles on practical gemmology. The series does not follow the accepted pattern of progression used by the normal text books, each section being a unit in itself. Some unexpected but useful sections are included, such as the best colours of paper to be used in stone packets. The series has eye-catching sub-headings and is profusely illustrated with unusual line drawings.

80 illus. R.W.

Walter (D. R.). *Chiastolites from the Olary Province of South Australia.* Australian Gemmologist, No. 6, pp. 5-9, June 1961.

The chiastolite variety of andalusite was first found in Australia in 1901. Specimens come from Bimbowrie, Alconie and Mount Howden. A description of the crystals is given. There is a discussion of the reasons for the cross-like inclusions and the effects of subsequent metamorphic geological strains on such crystals.

10 illus. R.W.

Chalmers (R. O.). *Gemstones of Australia.* Australian Gemmologist, No. 10, pp. 15-17, December 1961.

A reliable article (reprinted from the Australian Museum Magazine) giving the locations where Australian gemstones may be found. The opal localities are first discussed. In recent years the opal production of New South Wales has fallen off and the two South Australian localities at Coober Pedy and Andamooka are the principal sources. Sapphire in blue, golden and green colours is obtained mainly from Anakie. Ruby is not found in Australia. Aquamarines are occasionally found in the Emmaville and Torrington district of New South Wales. Emerald is found near Emmaville in the same state and at Poona in Western Australia. Topaz, with tints of blue and green, is found in New South Wales. Zircons, deep red to golden yellow in colour, are found in New South Wales and Queensland, and some pale straw-yellow to colourless crystals have been found in the Strangeways Ranges of Central Australia. These have been cut at Alice Springs. Almandine garnets are widely distributed. Rock crystal, cairngorm, citrine and amethyst are found in the Australian Highlands. Green and pink tourmaline is found in Kangaroo Island off the South Australian coast. Diamond is found in every State except in the Northern Territory. The diamond crystals are small and are generally considered to be harder than those from other sources.

R.W.

WEBSTER (R.). *Diamond cuts and colours; Detecting diamond simulants.* Watchmaker, Jeweller & Silversmith, pp. 60-65 (April 1961); 74-77 and 102 (May 1961).

The first two parts of a sub-series on gemstones for the series " Salesmen need facts ". The characteristics of a diamond points to look for in identifying a diamond are given. The effects of artificially altering the colour are discussed. Diamond doublets and how they may be detected are described together with such simulants as white zircon, fabulite, synthetic rutile, white sapphire and spinel, and lustrous pastes. Mention is made of those natural gemstones which may resemble coloured diamonds.
12 illus.

P.B.

WEBSTER (R.). *Pearls; Cultured and imitation pearls.* Watchmaker, Jeweller & Silversmith, 78-83 (June 1961); 70-75 (July 1961).

Describes the formation and structure of pearl and the methods used in fishing for the pearl oysters. The shapes and colours of pearls are mentioned and notes are given on the care of pearls. The difference in structure of the real pearl and the cultured pearl is shown. Non-nucleated cultured pearls are mentioned and details are given of the ways cultured pearls are detected, both by visual observation and by the use of instruments. The article covers imitation pearls and other objects resembling pearls such as hematite, " cave pearls" and " coco-nut pearls ".
16 illus.

P.B.

WEBSTER (R.). *Ruby and sapphire: Emerald and aquamarine: Alexandrite, cat's-eyes and topaz; Tourmaline, zircon and peridot; Garnet and sphene.* Watchmaker, Jeweller & Silversmith, pp. 62-67 (August 1961); 104-109 (September 1961); 102-107 (October 1961); 98-103 (November 1961); 68-73 (December 1961).

Describes each of the stones in so far as the salesman needs to know them so as to be sufficiently conversant with them to answer a customer's questions. The synthetic counterparts and simulating stones are discussed in each case.
42 illus.

P.B·

ANDERSON (B. W.). *An orange metamict zircon.* Gemmologist, Vol. XXX, No. 365, pp. 221-223, December 1961.

Reports the examination of an orange-coloured zircon of low type. The density was found to be 4·008 and the refractive index 1·823. The stone had an absorption band at 5200Å. Most metamict stones are green. A table of density and refractive indices of a number of all types of zircons is appended. The unusual absorption spectrum of the stone and other anomalous absorption spectra in zircon are discussed.

R.W.

SPRIGG (R. C.). *A flying visit to opal country.* Gemmologist, Vol. XXXI, No. 366, pp. 11-13, January 1962.

A popular account of a visit to the Queensland opal area near Canaway Downs; and of the Hayricks opal mine.
2 illus.

R.W.

CRIBB (H. G. S.). *The Hayricks opal mine.* Gemmologist, Vol. XXXI, No. 366, pp. 7-11, January 1962.

A sandstone boulder type of opal is found as irregularly distributed elongated concretions. The article is a geologist's report on the nature of the rock formations and the opal boulders. Mining operations and the quality of the opal are discussed.
1 map.

R.W.

ANDERSON (B. W.). *Alteration in absorption spectra and properties of metamict zircons induced by heat treatment.* Gemmologist, Vol XXXI, No. 367, pp. 19-23 and 36. February 1962.

Experiments made to study the effect of heat treatment on metamict zircons showing the anomalous 5200Å band and other metamict and near metamict zircons are described. Careful measurements of density and refractive index before and after each experiment were made. A zircon showing the 5200Å band was heated to 600°C for three hours and found not to alter. After a further two hours heating at 800°C a strong and clearly defined series of about twelve bands were seen in the absorption spectrum. They were not in the normal positions of the zircon bands in the spectrum, but the arrangement was similar. The density and refractive index were found to have lowered from 4·04 to 3·89 and

1·819 to 1·785 respectively. Further heating to 900°C caused a further decrease in refractive index to 1·778. Experiments were repeated with other metamict zircons with similar results. The author has attempted to discover the " watershed ", that is the point below which heating produces a decrease in constants and above which the stone will increase in density and refractive index when heated. From these experiments it was found that this " watershed " lies virtually as the dividing line between Stevanovic's " a " and " c " classification. During the latter series of experiments one stone was found to be anomalous in this respect.
1 illus.

R.W.

Webster (R.). *Quartz varieties; Chalcedony, agate and jasper; Opal.* Watchmaker, Jeweller & Silversmith, 62-67 (January 1962); 74-79 (February 1962); 70-75 (March 1962).

Descriptions of the various types of quartz and quartzite are given and the inclusions seen in rock crystal, amethyst and Venus hair-stone are illustrated by photomicrographs. Quartz cat's-eyes, crocidolite and the many forms of agate are mentioned. The staining of agate and the various types of jasper, including the dyed blue jasper called " Swiss lapis", are described. Localities for opal are given. Opal doublets and the rock-crystal-topped triplet are used as substitutes for opal.
24 illus.

P.B.

VanLandingham (S.L.). *Unakite.* Gems & Minerals, 1962, 297, p. 28.

Unakite is a variety of granite containing green epidote, quartz and pink feldspar. Epidote must always be present for this ornamental rock to be called unakite.

S.P.

BOOK REVIEWS

Selwyn (A.). *Retail Jewellers' Handbook.* Seventh edn. revised by J. J. Adler and G. F. Andrews. 42s. Heywood, London, 1962.

The revised edition of this standard work has gained by elimination of unnecessary text and the additions made in the light of changes which have occurred in the trade. Some of the illustrations are not as clear as in earlier editions and the chapter on watches could have been more complete. In spite of these minor blemishes Selwyn's book, which was first published over sixteen years ago, is still the leading work of its kind. The National Association of Goldsmiths continue to use it as a textbook for their courses for retail jewellers in Britain.

S.P.

Neumann (R. von). *The design and creation of jewelry.* 45s. Pitman, London, 1962 (Amer. edn. Chilton Co. 1961).

A useful book for the designer-craftsman, the section upon manufacturing techniques being particularly well written. Although the setting of faceted gems is clearly described, the illustrations showing modern design are mostly in metal devoid of gemstone embellishment.

The author has aimed at stimulating interest in creating beautiful articles of adornment, which can give so much pleasure and pride in achievement, and he has succeeded admirably.

S.P.

Webster (R.). *Gems: Their sources, descriptions and identification.* Two vols. (476 pp. Vol. 1; 328 pp. Vol. 2). 20 colour plates. £9 10s. Butterworths, London, 1962

A review of this important new work on gemstones will appear in the October issue of the Journal.

J.R.H.C.

ON THE REFLECTION AND ABSORPTION OF NORMALLY INCIDENT PLANE-POLARIZED LIGHT BY POLISHED GEMSTONES

By J. OSTWALD
B.Sc., F.G.A.A., A.M.Aus.I.M.M.

INTRODUCTION

This short paper is concerned with some of the simpler mathematical aspects of the electromagnetic theory of reflection and absorption, especially those formulae which are of use in quantitative studies. As far as the author knows, this subject has not been treated in any of the gemmological text-books. The subject may be looked upon as of theoretical importance only at the present time, but with precision apparatus for measurement with reflected light becoming more readily available it seems likely that such physical properties of gemstones as reflectivity, colour and pleochroism will become the subjects of quantitative studies. The theoretical side of the study is not without its difficulties, some of which will be indicated in the following pages.

THE NATURE OF POLISHED GEMSTONE SURFACES

Before proceeding to investigate the effects which polished crystal surfaces have on light it will be necessary to inquire into the nature of the surfaces themselves. For if we are to be concerned with the action of polished surfaces on light, it is necessary first to have a clear understanding as to what a " polish " is. The most common definition is that a polished surface is one which is specularly reflecting at normal incidence and in which the separation of surface irregularities is less than the wavelength of the light. The actual physical nature of the polished surface is still a matter of dispute.

The most widely accepted view, and the one which is described in the gemmological text-books, is that the final polish given to an already smooth surface is the direct result of local fusion of the surface, with the spreading over it of a liquid-like layer of ultramicroscopic depth, the Beilby Layer. Four possibilities are thought to exist for this layer.

1. The structure may not show fusion and thus no Beilby Layer forms. Polishing in this case is a very fine grinding, e.g. diamond.

2. The Layer recrystallizes after formation with the same atomic orientation as the crystal, e.g. quartz.
3. The Layer recrystallizes on certain atomic structure planes only (such as cleavage surfaces), e.g. calcite.
4. The Layer remains amorphous, e.g. zircon.

This theory was originally put forward by Beilby (1921), who at the time was not able to explain the mechanism of flow, although he thought it was possibly a surface tension effect. The discovery of very high local temperatures when solids are rubbed together, by Bowden and Hughes (1937), was taken as a possible point in favour of the theory, as it could lead to a fusion of the surface layer. Even more important to the theory were the experiments of Thomson (1930) and French (1933). These workers found that the electron diffraction patterns of polished metal surfaces showed two diffuse halos, similar to those obtained from the surfaces of liquids.

Recently (1959) research work at the New South Wales Branch of the Defence Standards Laboratories has brought to light a number of objections to the theory. The more important are listed as follows:—

1. By the use of phase-contrast microscopy and reflection electron microscopy, it has been found that even the most perfectly polished surfaces are covered in innumerable fine scratches.
2. Beilby's theory argued that there should be no loss of material during the final polishing. Samuels (1952) proved that material was removed at quite definite rates during final polishing.
3. Epitaxed deposits are able to grow on mechanically polished surfaces.
4. Electron diffraction studies of polished silver crystals indicate that the surface layers are crystalline but have been disorganized by plastic deformation.

Samuels and his co-workers believe that polishing is essentially a very fine grinding. The finer the abrasive used the finer the grooves produced until finally the surface is " polished " within the meaning of the definition. The surface layer is crystalline but plastically deformed, the amount of deformation decreasing with increasing fineness of polish.

BASIC PRINCIPLES OF REFLECTION AND ABSORPTION

When light is normally incident on the surface of a polished gemstone its initial intensity Io is reduced in passing into the crystal by—

1. reflection at the upper surface
2. scattering by inclusions in the crystal
3. absorption by the atomic structure of the crystal.

As gem crystals are usually perfect and free from major inclusions we can neglect (2).

We can define the reflectivity of a crystal surface (R) as the percentage of normally incident light reflected from the surface.

$$R = \frac{\textit{Total Reflected Light}}{\textit{Total Incident Light}} \times 100\%$$

If the crystal is not perfectly transparent to the incident wavelength, then the intensity of light will decrease as the wavefront passes through successive layers of equal thickness in the crystal. The following formula defines this decrease.

$$I = Io \cdot e^{-(4\pi k d/\lambda)}$$

where

Io = the initial intensity
I = the final intensity
e = the base of natural logarithms
d = the distance moved by wave
k = the Absorption Coefficient
λ = the wavelength.

It will be seen that, except in the case of perfectly transparent crystal, two constants are necessary to define completely the passage of light through a crystal (and its reflection). Thus a generalization of the concept of refractive index should include " n " (the usual refractive index) and " k " (the absorption coefficient just defined). Now as early as 1837 James MacCullagh of Trinity College, Dublin had proposed an imaginary refractive index (involving the square root of -1) for metals and absorbing substances. The real nature of the refractive index was discovered by Paul Drude as a result of an analysis of Maxwell's equations in absorbing media. Solutions of these equations in this case yielded complex dielectric constants and further analysis showed that the generalized refractive index was a complex number of the form

$$\mathcal{N} = n - i\,k$$

where

n is the ordinary refractive index
i is the square root of minus one
k is the absorption coefficient.

Both n and k are constants for a particular crystal lattice direction. Isotropic crystal can have only one value, i.e. $n - i\,k$. Anisotropic crystals, in which the atomic structure of the lattice has different patterns in different directions can have either two or three principal refractive indices. Those for uniaxials are N_E and N_O those for biaxials are N_x, N_y and N_z. This theory is well described in any good text-book on crystal optics. If these anisotropic crystals are absorbing then the principal complex refractive indices are:

$$\text{UNIAXIAL} \quad \begin{array}{l} N_O - ik_O \\ N_E - ik_E \end{array}$$

$$\text{BIAXIAL} \quad \begin{array}{l} N_x - ik_x \\ N_y - ik_y \\ N_z - ik_z \end{array}$$

Certain difficulties exist in defining the complex indices for the absorbing crystals of the orthorhombic, monoclinic and triclinic systems. It was first proved in 1880 by Laspeyres that the axes of least, intermediate and greatest absorption for these crystals do not necessarily coincide with the principal directions of the indicatrix. These crystals likewise do not possess true optic axes. These are replaced by four rotation axes, which are inclined in pairs to the optic axial plane and which become more widely inclined as the absorption increases. No simple explanation of their nature is available.

TRANSPARENT ISOTROPIC GEMSTONES

In this case we can assume there is no absorption and thus we are concerned only with reflection. The reflectivity is given by Fresnel's equation.

$$R = \frac{(n-1)^2}{(n+1)^2} \times 100\%$$

A little thought will show that the higher the refractive index of the gemstone the higher the reflectivity. No fractional phase change occurs on reflection.

If the refractive index is known then the reflectivity can be calculated from the above rule. In the same way, if one can measure the reflectivity then it is a simple matter to calculate the refractive index. Two methods are commonly used to measure R.

1. *Visual Comparison Methods using the Microphotometer*

Various types of apparatus are now available by means of which the reflectivity of a polished specimen can be compared with some standard reflecting surface. One method involves the use of a reflecting type petrological microscope (mineragraphic microscope) with the eyepiece replaced by a Berek microphotometer. This latter consists essentially of a horizontal tube near the eyepiece with a light source, the intensity of which can be varied by rotating a polaroid disc between two fixed parallel discs of polaroid. In the middle of field of view of the eyepiece is an inclined comparison surface, illuminated by the light source in the horizontal tube. The specimen is placed under the microscope, and the polaroid plate rotated in its graduated holder until the specimen and the comparison surface are equally illuminated. The same is done for the standard. Since the intensity of illumination of the comparison surface is proportional to the fourth power of the sine of the angle of rotation it is possible to measure the reflectivity of the unknown relative to the standard. For opaque ore minerals polished pyrite is the standard, with $R = 54{\cdot}5\%$. This is rather too high for transparents, and diamond, with $R = 17{\cdot}2\%$ may be used. In the case of cut stones all surfaces except the one under study should be painted black and the specimens placed in a small cavity lined with black velvet to eliminate back reflections.

2. *Photoelectric Measurements*

In this case a mineragraphic microscope is used, the ocular being replaced by some type of photocell. The technique is very similar to that employed in the previous section. Photocell readings are taken on the standard and on the specimen and the two are compared. The main source of errors lies in fluctuation in mains voltage and frequency, for the intensity of illumination of the specimen and standard must remain constant during the taking of readings. This has been overcome by the use of a stabilization circuit (Bowie, 1957).

TRANSPARENT ANISOTROPIC GEMSTONES

The optics of these crystals are best described by means of the theory of indicating surfaces. The Fletcher indicatrix is a three dimensional geometric figure, which has a definite orientation inside each crystal for each wavelength of light, and which shows the variation in the refractive indices of light waves in their directions of vibration. Any radius vector from the centre of the figure to its surface shows a vibration direction in the crystal whose length measures the refractive index of a wave vibrating parallel to it.

The Fletcher indicatrix has two basic shapes. In the case of tetragonal and hexagonal crystals it is either a prolate or oblate spheroid of rotation about the vertical crystal axis. This direction is termed an optic axis and it is a direction of isotropism. A little thought will show that light moving in this direction is vibrating at right angles, in a plane which cuts the indicatrix always in a circle. In the case of orthorhombic, monoclinic and triclinic crystals the indicatrix is a triaxial ellipsoid, with three planes of symmetry so that the three principal refractive indices of light in their directions of vibration are equal to its three mutually perpendicular semi-axes. A mathematical analysis of the equations of this figure reveals the fact that there are two, and only two, possible circular sections and thus two optic axes inclined at an angle to each other. A full description of this most interesting theory is to be found in any of the advanced texts on crystal optics.

But one point is essential to what follows and this is the definition of the principal directions of a crystal section. If a ray of light is propagated in a direction defined by its wave normal, then a plane section through the Indicatrix is, in general, an ellipse. The dimensions of this ellipse completely define the nature of the transmitted light. It moves in the form of two plane-polarized waves, vibrating parallel to the two principal axes of the ellipse (the principal directions of the section).

Now, for any polished gemstone surface each principal direction has its own refractive index, and, by Fresnel's equation for isotropics, its own Reflectivity; using visual or photoelectric methods it is easy to measure the maximum and minimum values of reflectivity of the surface. The numerical difference in these readings is the bireflection of the surface studied. The bireflection of the crystal is the maximum bireflection for all possible sections of the crystal.

Let $\mathcal{N}_1$ and $\mathcal{N}_2$ be the refractive indices for the principal directions of the section. Then their reflectivities R_1 and R_2 are defined by—

$$R_1 = \frac{(\mathcal{N}_1 - 1)^2}{(\mathcal{N}_1 + 1)^2} \times 100\%$$

$$R_2 = \frac{(\mathcal{N}_2 - 1)^2}{(\mathcal{N}_2 + 1)^2} \times 100\%$$

The reflectivity for a normally incident plane-polarized wave making an angle of x with a principal direction is defined by

$$R = R_1 \cos^2 x + R_2 \sin^2 x$$

In general, if plane-polarized light is incident at an angle (azimuth) of x with a principal direction, then it can be shown, by an analysis of Maxwell's equations, that the reflected light is still plane-polarized, but has been rotated in azimuth through a small angle.

If x is the incident azimuth ($x = 45°$) and y is the reflected azimuth then—

$$\tan (x - y) = \frac{\mathcal{N}_1 \mathcal{N}_2 - 1}{\mathcal{N}_2 - \mathcal{N}_1}$$

(*Wright, p.420*)

The rotation angle of the section is defined as the rotation in azimuth of the reflected beam when the incident beam is at 45° to the principal directions. It is possible to measure this rotation angle using the reflecting polarizing microscope. Accurate measurement of this angle requires a microscope with rotating analyser, and some type of bi-quartz accessory plate, such as a Nakamura plate which is sensitive to small rotations, and thus can be used to get the correct analyzer setting.

ABSORBING ISOTROPIC GEMSTONES

Those isotropic gemstones which are not perfectly transparent to white light are termed absorbing. The amount of absorption varies widely. If the absorption is strong over the whole spectrum the material may be called opaque. This latter term requires some definition. Many crystals, opaque in large pieces become transparent (and coloured) when cut down into thin slices for petrological study. Other, notably the ore, minerals are opaque even at this thinness. It has been found that the human eye can detect a light intensity as low as 10^{-6} of the bright field of a microscope. Any crystal which transmits less than this intensity is termed opaque to the incident wavelength. It is possible for a crystal to be quite opaque to white light and yet be quite transparent to, say, infra-red. Stibnite, antimony sulphide, a steely gray metallic mineral, is extremely transparent to infra-red radiation.

Coloured gemstones owe their colour to selective absorption of various wavelengths of white light by the crystal structure. This absorption can readily be studied in a qualitative way using a direct-vision spectroscope.

The Reflectivity of an absorbing isotropic gemstone of complex refractive index $n - ik$ is

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2} \times 100\%$$

If we consider the case of the black garnet (perhaps a black variety of andradite) with index $1{\cdot}94 - 0{\cdot}058i$, substituting 1·94 and 0·058 in the above formula R for black garnet is found to be 10·2%. (Note: the above values are constants for mercury yellow light, not sodium yellow.) Yellow sphalerite, a mineral sometimes used as a gemstone, has a complex refractive index of $2{\cdot}38 - 0{\cdot}01i$ for sodium light. For comparison gold, the precious metal, has a complex index $0{\cdot}366 - 2{\cdot}82i$ and silver $0{\cdot}18 - 3{\cdot}65i$.

These metals have reflectivities (observed) of 73·4% and 93·8%. The high values of R are the result of the extreme values of k for these metals, the real part of the index in each case being quite small.

As to the nature of the reflected light, if the incident light is plane-polarized the reflected light is also plane polarized. No rotation effects occur. Various methods have been devised to measure n and k for these crystals. If the value of k is small (as it often is for gem crystals) the absorption can be measured using a thin piece of the material of known thickness. The decrease in intensity of the transmitted light when the thin sheet is placed under the microphotometer is measured and the absorption calculated by a formula given by Hallimond.

If k is not very small the above method cannot be used, for a plate of measurable thickness will be completely opaque. One excellent method exists by which n and k can be calculated (that of W. A. Wooster, 1949) but as it involves the use of oblique incident light it is outside the scope of this paper.

ABSORBING ANISOTROPIC GEMSTONES

In this section we include all non-cubic gemstones which are either coloured (pleochroic and non-pleochroic) or opaque. The optics of these crystals are best described by means of the complex indicatrix, a double shelled surface in space with similar properties to the Fletcher indicatrix. It is used to give the principal vibration directions, refractive indices and absorption co-efficients for any section of a crystal. But owing to the fact that in many of these crystals the directions of absorption (the absorption axes) do not necessarily coincide with the principal directions of the indicatrix, and because the vibrations inside the orthorhombic, monoclinic and triclinic crystals are in general elliptic, it is only possible to plot sections of the complex indicatrix for planes of crystal symmetry.

We will first concern ourselves with the non-pleochroic crystals. For uniaxial crystals, those belonging to the tetragonal and hexagonal systems, if the normal to the reflecting surface coincides with the optic axis of the crystal, then the surface can be considered to be isotropic. For other orientations the surfaces are anisotropic. Plane-polarized incident light with vibrations parallel to the two principal directions are reflected as plane polarized waves, but if the incident vibrations are at an angle to these directions then there will be a rotation effect (due to different absorption in the two components) together with a phase difference (between the components). Thus elliptically polarized light is reflected, the ellipse being in general long and narrow, and its long axis inclined to the azimuth of the incident light.

A fuller treatment is as follows. In general, the normally incident beam is resolved at the surface into a plane containing the optic axis and another plane at right angles. Let these directions have complex refractive indices $N_1 - ik_1$ and $N_2 - ik_2$ and reflectivities R_1 and R_2. Then

$$R_1 = \frac{(N_1 - 1)^2 + k_1{}^2}{(N_1 + 1)^2 + k_1{}^2} \times 100\%$$

$$R_2 = \frac{(N_2 - 1)^2 + k_2{}^2}{(N_2 + 1)^2 + k_2{}^2} \times 100$$

If the incident azimuth is x, then the intensity of reflection is—

$$R = R_1 \cos^2 x + R_2 \sin^2 x$$

The two reflected components have phase shifts

$$\tan d_1 = \frac{2\,k_1}{\mathcal{N}_1^2 + k_1^2 - 1}$$

$$\tan d_2 = \frac{2\,k_2}{\mathcal{N}_2^2 + k_2^2 - 1}$$

There is in general a phase difference $(d_1 - d_2)$ and the reflected light is elliptic.

Orthorhombic crystals have only three planes of crystal symmetry. If the normal to the reflecting surface and the plane of polarization of the incident light be in one of these planes then the reflected light is plane-polarized. In general, the above is not the case. When a plane-polarized wave enters the crystal, due to absorption, etc., it can be resolved into two principal elliptically polarized beams with semi-major axes at right angles, travelling with different velocities. In the same way, two plane polarized beams are reflected, differing in amplitude and phase, and thus these can be looked upon as one elliptically polarized reflected wave.

While, in general, two elliptical waves are transmitted there are four directions, termed rotation axes, along which only one circularly polarized ray is transmitted. These are closely related to the two optic axes of low-symmetry transparent crystals. Their position in space depends on the strength of the absorption and the

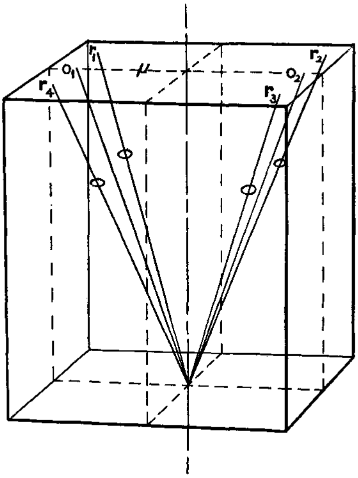

Fig. I

wavelength of light. Figure 1 shows the four axes r_1 r_2 r_3 r_4 in an orthorhombic crystal.

Monoclinic crystals have one plane of crystal symmetry, and triclinic have none. It is still possible to obtain plane polarized light by reflection at certain crystal orientations but in general both the transmitted and reflected light is elliptic. Directions which govern the production of plane polarized light are directions lying in a conical surface in the crystal termed the plane polarization cone (Woodrow, 1950).

Pleochroic crystals, those in which the absorption of wavelengths of white light is different in different directions are perhaps of more practical importance to the gemmologist than the opaques just studied. In the case of uniaxials, the strength of the pleochroism (dichroism) is termed the biabsorption, and this can be defined as $k_E - k_O$ where k_E and k_O are the absorption coefficients for the extraordinary and ordinary rays. For pleochroic "biaxials", the three main values of the absorption coefficients are k_x, k_y, and k_z and the difference between the maximum and minimum values is the biabsorption.

We will finally consider, in a general manner and without any of the experimental details, a method by which the optical properties of a pleochroic sheet or an opaque polished surface may be ascertained. If the material is transparent a petrological microscope may be used, but if it is opaque then the situation requires a mineragraphic microscope. We will deal with the latter case first as it is the most fundamental.

The polished opaque surface, normal to the axis of the microscope (with nicols accurately crossed), is rotated on the microscope stage to find the four extinction positions. It is then rotated 45° from extinction. To return the mineral (as near as possible) to extinction the analyzer is rotated through an angle known as the apparent rotation angle (Ar).

The accurate position of extinction is obtained with the use of a Nakamura plate, a thin bi-quartz accessory sensitive to small rotations, which is placed in the slot of the rotating Wright eyepiece. In Figure 2, if OP and OA_0 are the polarizer and analyzer directions, OE_1 and OE_2 are the resolved components of the incident light parallel to the vibration directions of the mineral. Owing to differential absorption these are reduced to OR_1 and OR_2, the components of the reflected light. Since there is a phase difference, the reflected light is elliptic, the ellipse being inside the rectangle p^1 *NML*. OA_1 is the position of the analyzer at extinction.

If there was no phase difference between the reflected components then there would be no ellipticity and the apparent rotation angle would be the true rotation angle. As there is a phase difference of " *d* " between the components OR_1 and OR_2, "*d*" must be measured, and also the ellipticity of the ellipse, " *e* " the angle whose tangent is the semi-minor axis " *b* " divided by the semi-major " *a* ". This ellipticity is measured using an elliptic mica compensator.

It is thus possible to measure

1. The apparent rotation angle " *Ar* "
2. The phase difference " *d* " between the two reflected components
3. The ellipticity of the ellipse.

For transparent non-pleochroic crystals, on the stage of a petrological microscope, if the vibration directions are at 45 degrees to the analyzer-polarizer directions, then two rays are transmitted with a phase difference. This is the same as an elliptical vibration, the axis of the ellipse at 45° to the analyzer. If the crystal is pleochroic the transmitted light is still elliptic, but the ellipse is of a different shape and no longer at 45° to the analyzer. The angle of rotation of this ellipse is related to the intensities of the

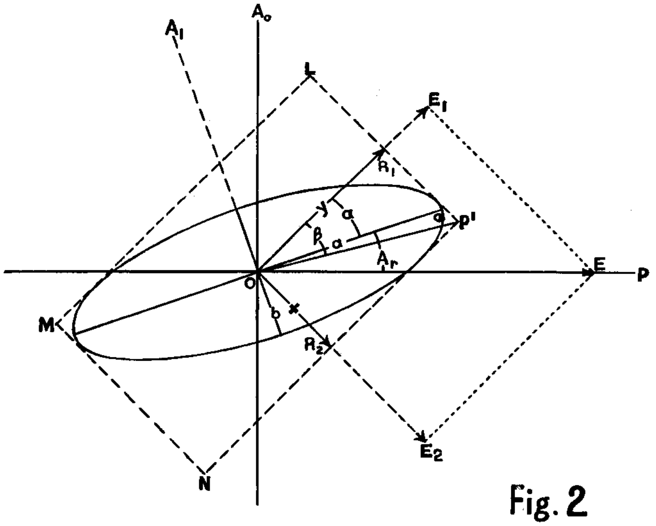

Fig. 2

two transmitted rays, and thus to the biabsorption. Using Figure 2 to indicate the measurements, it is necessary to measure the angle " alpha ", between one vibration direction and the long axis of the ellipse, and also the ellipticity.

A rotating Wright analyzer and elliptic mica compensator are used. The apparent rotation angle *Ar* and the phase difference for the ellipse can then be measured.

Now " alpha " is 45° − *Ar* and from the phase difference the ellipticity and thus the ratio of the two semi-axes of the ellipse may be measured. From these values the ratio of the intensities of the two transmitted rays can be calculated. If we consider uniaxials we can find the ratio of I_O to I_E and thus

$$I_O = I_E \cdot e^{(4\pi d/\lambda)(k_E - k_0)}$$

where $k_E - k_0$ is the biabsorption.

For the experimental details, mathematical formulae, etc., reference should be made to the original papers.

It might be well to mention another constant for opaque anisotropic surfaces. This is the " characteristic angle " of Berek. It is defined as the phase shift imparted by reflection at the specimen, between light vibrating parallel and perpendicular to the vibration directions of the polarizer. If the reflected ellipse is long and narrow (as it usually is) it is possible to measure " *e* ", the tangent of the azimuth referred to the polarizer direction and " *d* " the ratio of minor to major axes of the ellipse.

Then

$$\tan T = \frac{d}{e}$$

where *d* is the Phase Coefficient

e is the Polarization Coefficient

T is the Characteristic Angle.

T is found to be a constant for all sections of tetragonal and hexagonal crystals, and it varies between −90° and +90° for crystals of lower symmetry. Finally, *T* is found to vary with amount of polishing.

CONCLUSIONS

Though there are still some outstanding difficulties, theory has now reached a stage where it can be of use to the laboratory experimenter in gemmology. The necessary apparatus is costly, involving such items as research petrological and mineragraphic microscopes and accessories, visual and photo-electric photometers and a spectrophotometer, but if the gemmological laboratory has this apparatus then quantitative studies of absorption and reflection by gemstones are now possible. Such measurements will not necessarily revolutionize determinative gemmology but will rather be in the way of an addition and a refinement to pre-existing methods.

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ASSOCIATION NOTICES

NEW BOOK ON GEMS

Gems: Their sources, descriptions and identification, by Robert Webster, F.G.A. Two volumes, price £9 10s. 0d., postage 7s. 6d. Vol. I 476 pp., vol. II 328 pp. 20 colour plates.

Copies may be obtained from the Association.

COUNCIL MEETING

Mr. F. E. Lawson Clarke (Treasurer) presided at a meeting of the Council of the Association held at Saint Dunstan's House, Carey Lane, London, E.C.2, on 5th April, 1962.

The following were elected:—

Fellowship

Keller, Jean Pierre, Lucerne, Switzerland
Nuttall, John, Manchester

Ordinary Membership

Abdeen, Mohammed Maharoof Z., London
Bana, Homi R., Dadar, Bombay, India
Lwin,
Bord, Richard B. (Mrs.), W. Virginia, U.S.A.
Bruce, George A. Jr., Georgia, U.S.A.
Felsinger, Hermann H., London
Freir, David S., Pitlochry, Scotland
Godin, Peter J., Worcester Pk., Surrey
Hill, Ian, Giffnock, Scotland
Hoad, Cecil V., Richmond, Surrey
Khan M. Hamidullah, Peshawar, Pakistan
U. Thein, Rangoon, Burma
McCorquodale, Samuel, Selangor, Malaya
Major, Robert J., Wyton, Hunts.
Pearl, Mignon W., Colorado, U.S.A.
Sheriff, Hassan, London
Thain, Eric M., Shenfield, Essex
Webster, Rosslyn, London
Macpherson, Harry Gordon, Edinburgh

Probationary Membership

Pai, S. Sundaresa Eknakulam, S. India
Hathaway, Norman, Swansea, Glam.
Houghton, Michael J., London

The Council made nominations for submission to the next annual general meeting. It was reported that it had not been possible to complete arrangements for the 1962 Herbert Smith Memorial lecture.

MIDLANDS BRANCH

Mr. W. W. Bowen presided at the annual meeting of the Midlands branch of the Association held at the Imperial Hotel, Birmingham, on the 6th April, 1962. In commenting upon the work of the year the Chairman especially referred to the summer coach outing to Luton Hoo to see the Wernher Collection, the visit to the lapidary works of Shipton & Co. Ltd., where Mr. Bert Shipton had arranged for actual cutting and polishing to be in progress, and a lecture on the spectroscope and its uses in gem testing by Mr. B. W. Anderson, B.Sc. Director of the London Chamber of Commerce gem testing laboratory. Mr. Bowen mentioned that the final event of the season had been the annual dinner dance.

The following officers were elected: Chairman, Mr. W. W. Bowen; Deputy Chairman, Mr. A. E. Shipton; Vice-Chairman, Mr. J. R. Shaw; Committee: Messrs. K. Hoskyns, D. King, J. Rossiter and T. P. Solomon. Mrs. S. E. Hiscox was elected Secretary in the place of Mr. J. R. Shaw. Two short colour films were shown at the end of the meeting—" Jewels in the Sun " and " The Golden Reef ".

WEST OF SCOTLAND BRANCH

The West of Scotland Branch of the Association held their annual summer outing on Sunday, 24th June. The outing, to Dunure, Ayrshire, was arranged in conjunction with the Scottish Mineral and Lapidary Club, Edinburgh. For the autumn the following dates have been arranged:—

25th October: Film Show.
22nd November: General discussion and exhibition.

For 1963: On 24th January there will be a talk by Mr. W. C. Butler on the manufacture of synthetics; a talk and display of specimens by Mr. J. McWilliam on 28th February.

TALKS BY MEMBERS

BLYTHE, G.: " Gemstones ", Inner Wheel Clubs for Romford, Ilford, West Ham and Leigh-on-Sea at East Ham on 3rd April, 1962; " Gemstones ", Royal Institution of Chartered Surveyors, Essex Branch, 28th April, 1962.

BAGLEE, G.: " Diamonds ", Sunny Brow Women's Institute, Darlington, on 18th April, 1962; " Gemstones ", Bishop Auckland Business and Professional Women's Guild, 16th May, 1962.

DYCE, S. B.: " Gemstones " at Spalding on 17th April, 1962.

BETTS, G.: " Gemstones ", Beeston Townswomen's Guild, Leeds, 1st May, 1962.

KENT, D. G.: " Gemstones ", City of London Tradesmen's Guild, 16th May, 1962.

ROOTS, J. L.: " Gemstones ", Tanganyika Police Inspectors, Maidstone, 30th April, 1962.

CAIRNCROSS, A.: " Gemstones ", Crieff Trefoil Guild, 25th September; Crieff South Church Social Club, 4th October; Rhynd W.R.I., 18th October; Dunbarney Parent Teacher Association, 16th November; St. Leonards in the Fields Youth Fellowship, 10th December, 1961. "Gemstones", Scone New Church Youth Fellowship, 14th January; Forteviot W.R.I., 1st March; Letham Youth Club, 21st March; St. Paul's Evening Work Party of Women's Guild, 27th March; Letham Kirk Fellowship for Young Mothers, 1st February, 1962.

ANNUAL GENERAL MEETING OF THE GEMMOLOGICAL ASSOCIATION

Mr. F. H. Knowles Brown presided at the 32nd annual meeting of the Association held at Saint Dunstan's House on the 11th May, 1962. Commenting on the annual report, he spoke of the ties which existed between gemmologists throughout the world, who shared information, results and friendship. He paid a tribute to the efficient way extra work had been handled by the staff since the Association had become the sole world agency for all Rayner instruments. The agency was a fine thing for the Association he said, and one which would increase Rayner's already world-wide reputation among gemmologists.

The Chairman welcomed Mr. Dean Field, a Fellow of the Association and founder of the Canadian Gemmological Association. Mr. Field spoke of the friendship which existed between both Associations. His Association, he said, had been founded in 1958. The Association membership, now 52, was made up almost equally of members who had close ties with the British Gemmological Association and those who had ties with the American counterpart. It was hoped membership would be 100 by the end of the year.

The annual report and audited accounts for the year were adopted and the following officers were re-elected: President, Sir Lawrence Bragg; Chairman, Mr. Knowles-Brown; Vice-Chairman, Mr. N. Harper; Treasurer, Mr. F. E. Lawson Clarke. Messrs. E. J. Ewing, W. Stern and R. Webster were re-elected to the committee. Messrs. Watson Collin & Company, chartered accountants, continue as auditors to the Association.

LETTER TO EDITOR

DEAR SIR,

Having read Mr. A. E. Farn's very useful and practical article " Testing a Sapphire " (Journ. Vol. VIII No. 6), I have two comments to make.

Mr. Farn says he has never seen cutting cracks, or chatter marks (often called fire marks in Birmingham) on a natural ruby or sapphire of importance. About a year ago a fine, clean, light blue stone of (from memory) 8 to 10 carats was sent for testing to the writer, precisely for that reason, i.e. that it did have these marks. This fact, together with its almost entire freedom from internal evidence in the way of natural marks, threw suspision on the stone. The microscope, however, did reveal a small, but unmistakably natural feather, and, furthermore, the spectrum contained the well-known band at 4,500Å. True, these cutting cracks are very seldom seen in natural corundums, but their presence is not altogether unknown.

The second point I would raise is the question why short-wave (2537Å) ultra violet light is not more frequently used in testing doubtful sapphires. All synthetic sapphires I have so far tested in this way fluoresce, natural sapphires do not. It seems to me to be a test quite as valuable as the spectroscopic one—for " difficult " stones that is. Many, as Mr. Farn remarks, are quite easily identified by marks easily seen with the 10 × loupe.

It would be interesting to learn if any practical gemmologist has discovered any exceptions to this reaction (or absence of it) of sapphires to short-wave U/V. light.

Yours faithfully, F. S. H. TISDALL.

SMITHS

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