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and

PROCEEDINGS OF THE
GEMMOLOGICAL
ASSOCIATION
OF GREAT BRITAIN



GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
SAINT DUNSTAN'S HOUSE, CAREY LANE
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A NEW IMMERSION LIQUID

By HAROLD LEE

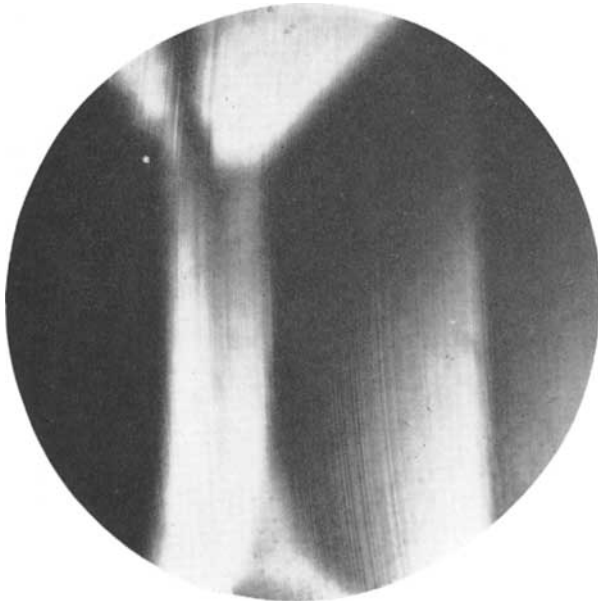
HAVING decided the mineral of which a stone is composed the gemmologist usually asks, "Is it natural, synthetic or artificial?" and, sometimes, "What is its source?" To answer these questions he must examine the interior. The inclusions he sees there are the most rewarding source of information enabling him in many cases to answer any or all of the above questions—hence the time devoted to this work in the training classes.

It has been postulated that the inclusions of a stone can best be seen when the stone is immersed in a liquid having a refractive index fairly near to that of the stone itself. Most of the liquids usually recommended have very undesirable characteristics especially when used in such quantities as are required by a number of students in a training establishment.

What is probably the most efficient liquid, especially for the corundum gemstones and others of high refractive index, is methylene iodide. This is a fairly pleasant liquid to use and has a R.I. of 1.74, but it darkens on ageing and has the disadvantage of being expensive. The liquid most commonly used is mono-bromonaphthalene, which has a R.I. of 1.66. This is a greasy type of liquid and has an unpleasant odour which is extremely persistent.



"Veiled" feathers in a Gilson (French) synthetic emerald



Curved striae in synthetic ruby

Furthermore its vapour is very irritating to the eyes, particularly when after a short time the liquid becomes warm from the heat of the microscope lamp. It also has the minor drawback of attacking certain plastics and if inadvertently transferred by the fingers to a fountain pen, ball-point pen or slide rule, soon renders the surface rough and sticky. For stones of a lower refractive index, in particular the beryls, a number of liquids have been proposed and used. Such liquids include bromo-benzene of R.I. 1.56 and benzyl benzoate of R.I. 1.59. The latter was proposed by Professor K. Schlossmacher, who suggested its use in particular relation to the identification of the synthetic emeralds and the emerald-coated beryls.

Is it always necessary to use a highly refracting liquid to "get into" the stone? One instructor who finds mono-bromonaphthalene obnoxious uses water (R.I. 1.33). The writer, who has over many years in a chemical laboratory developed a natural aversion to many of the halogenated organic chemicals, set out to find an immersion liquid which while being effective was at the same time pleasant to use and considerably less toxic. For some time a variety of solvents have been used, mainly in the examination of stones of lower refractive index and on occasions for the higher refracting stones, where they proved fairly successful, certainly so far as visual use was concerned. Another feature sought for was that the stone on removal from the immersion cell should be quite clean or at most require only a quick rinse in water or methylated spirit. Amongst the substances tried were ethane diol (ethylene glycol) (R.I. 1.42) and di-methyl-phthalate (R.I. 1.51). These liquids appeared to do quite well, are colourless and practically odourless. It was however discovered that on occasions they tended to form small air-bells which adhered to the surface of the stone. This while probably of little importance to the experienced worker may lead to errors of interpretation in the case of students. One of the liquids tried was ethylene-glycol-mono-ethyl-ether, of which the technical product is marketed under the names Cellosolve and Oxitol. This appeared to have the qualities desired without any of the disadvantages. It is water-white, practically odourless and even on violently shaking does not form any air-bells. It leaves the stone in a perfectly clean condition but if desired can be entirely removed by a quick rinse in water, in which it is soluble in all proportions. The refractive index of this liquid is somewhat



Feathers in dark blue Australian sapphire



Typical cracks and unpolished facet showing crystal surface, typical of a synthetic emerald-coated beryl

lower than the others mentioned, and the questions were, would this detract from its usefulness in the examination and more particularly in the photography of the highly refracting stones and also how would it behave in the examination of the beryls, with particular thought to the separation of natural and synthetic emerald and the emerald-coated beryl? This called for more exhaustive tests with a variety of these stones and Mr. Robert Webster kindly undertook to do these. He went into this with enthusiasm and thoroughness and the following details of the results are in the main his own conclusions.

Although the index of refraction is lower than that of the liquids usually used (R.I. 1.408) experiment has shown that one can "get into" the stone without difficulty, even corundums with their high refractive index. True, not all of the stone can be examined in any one position but by turning the stone into different positions a worker will be able to inspect the greater portion of it. As will be seen by the photomicrographs the stones of comparative high refractive index tend to show the facet edges but this is sometimes a good thing as it allows the inclusions to be "pin-pointed", thus acting as a reference. For training students this is often valuable and in fact saves the use of an indicating eyepiece. This is well illustrated in the photograph of the feathers in a dark blue Australian sapphire. The photograph of the synthetic ruby shows how well the fine curved striae can be recorded. Regarding the use of this liquid in the examination of emeralds and beryls the photograph of the "veiled" feathers in a Gilson (French) synthetic emerald and in particular the one showing the typical cracks and the unpolished facet showing the crystal surface typical of a synthetic emerald-coated beryl indicate that this liquid may safely be used in the testing of a wide variety of stones.

Still not being satisfied that his own work was sufficiently searching in the application of this liquid for general use, particularly by students, and to obtain a better evaluation of its use in the classroom, Mr. Webster made use of the liquid at three different classes of practical gemmology at the Sir John Cass College, and sought the opinion of the students on its efficiency. The general impression was that the liquid, being colourless, allowed a clearer view of the inside of the stone. There was a comment on the odour, mainly because it was strange after using the customary immersion liquid, but there were no adverse comments, nor was

there any difficulty found in observing the various inclusions.

He sums up: "The advantages seem to be cheapness, clarity, due to its colourless nature, and the ease of cleaning both the stones and apparatus. The liquid is less detrimental to the metal parts of instruments than the others commonly used. While in certain cases a liquid of higher refractive index may be necessary, the use of this liquid as an immersion medium for general purposes for training and maybe for routine work has many advantages".

As a matter of interest I append the following details:

Ethylene glycol mono-ethyl ether $C_2H_5O.CH_2.CH_2.OH$

The pure material has boiling point $134.5^{\circ}C$; refractive index 1.408; vapour pressure at $20^{\circ}C$ 4.5 mm; specific gravity 0.936 at $20^{\circ}C$. The present price in the catalogues of normal chemical suppliers is 7s. for 500 ccms.

I express my gratitude to Mr. Webster for the searching tests he has carried out and also for the excellent photomicrographs illustrating this article.

STAR-DIOPSIDE AND STAR-ENSTATITE

By *W. F. EPPLER*

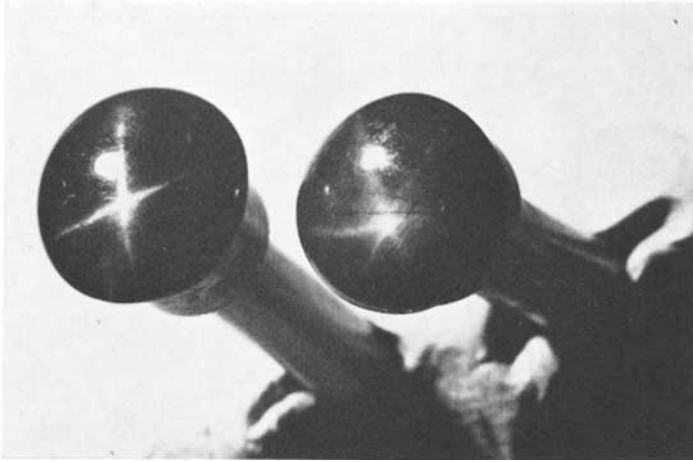
ABOUT two or three years ago, star-diopside entered the market, a gemstone which was rarely seen before. It is an opaque material of dark colour, which at its best is black with a greenish hue, and sometimes dark brown to black-brown. Diopside is a member of the so-called "monoclinic pyroxenes", a group of crystals to which, by the way, belong the gem minerals kunzite and hiddenite and jadeite likewise.

The chemical composition of the diopside is represented by the formula $\text{CaMg}(\text{SiO}_3)_2$ or $\text{CaO} \cdot \text{MgO} \cdot 2 \text{SiO}_2$, with a certain amount of iron replacing the Mg in the formula. The variable contents of iron are responsible for the differences in colour, in the optical properties, and in the specific gravity.

The values for diopside given by Webster⁽¹⁾ are $n_a = 1.670$ and $n_\gamma = 1.701$ for the refractive indices, with the remark that higher indices are caused by higher contents of iron. The specific gravity is quoted by the same author at 3.29 with the tendency to higher values with higher iron contents.

The measurement of material of dark brown colour available to the author resulted in a refractive index of 1.67 to 1.68, measured by the distant vision method and by observing the Becke-line in suitable liquids. The density was found to be near to 3.33, both by the hydrostatic and the heavy liquid method. A final identification of the material as diopside was kindly made by Professor Dr. H. Jagodzinski, of Munich University, by an X-ray analysis.

The star-diopside came from Nammakal, South India, and with its four rays it looks very attractive (Fig. 1). The asterism is caused by the reflection of light on coarser or finer or even very tiny inclusions, as shown in Fig. 2. The nature of these particular inclusions is not yet known. They must have been originated by a process of exsolution, as they are strictly orientated according to the monoclinic symmetry of the diopside. It may be that they consist of clinoenstatite, MgSiO_3 or $\text{MgO} \cdot \text{SiO}_2$, which is not soluble in diopside at lower or normal temperatures. But this speculation is not yet confirmed and further investigations are necessary to answer this question.

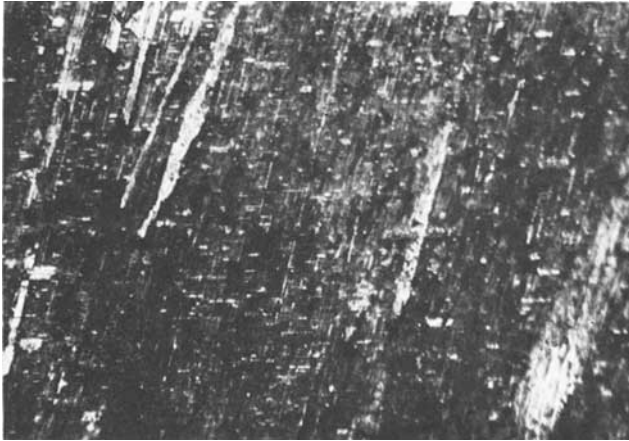


2 ×

FIG. 1. *Four-rayed star-diopside (left) and six-rayed star-enstatite (right); approx. magnification.*

Another peculiarity of the elongated crystal inclusions is the fact that they intersect each other at angles different from 90° , which is caused by the monoclinic symmetry of the diopside crystal. The deviation from the right angle is approximately 17° , as can be seen in Fig. 2. Consequently, the rays of the star deviate also from 90° and they include angles of 73° and 107° respectively. Besides this, R. T. Liddicoat, Jr.,⁽²⁾ mentions a difference of the rays from which two are said to be broader and two to be thinner. This effect could be explained by the coarser and finer development of the needle-like inclusions in different directions. With the material in question, such a variation in the brightness of the rays could not be observed.

Star-enstatite. Quite recently, a six-rayed star-enstatite was encountered, which is also said to come from South India. It looks dark brown and the star is not so strongly developed as with the diopside (Fig. 1). Enstatite is also a member of the pyroxene group but has an orthorhombic symmetry. Chemically, it is characterized by the formula MgSiO_3 or $\text{MgO} \cdot \text{SiO}_2$ with varying contents of iron. Thus the physical properties are slightly variable.



65 ×

FIG. 2. *Elongated inclusions in star-diopside are the cause of the four-rayed asterism; reflected light.*

According to Webster⁽¹⁾, the values for green enstatite of gemstone quality are $n_{\alpha} = 1.663$ and $n_{\gamma} = 1.673$ and they rise with the increase of iron. The density is given as 3.26 to 3.28. The star-enstatite, which has not so far been mentioned in the gemmological literature, has similar values to those of the star-diopside. The refractive index was measured as 1.67 to 1.68, and the specific gravity near 3.3 using the same methods as already mentioned before. The final result again was found by an X-ray analysis kindly performed by Professor Jagodzinski.

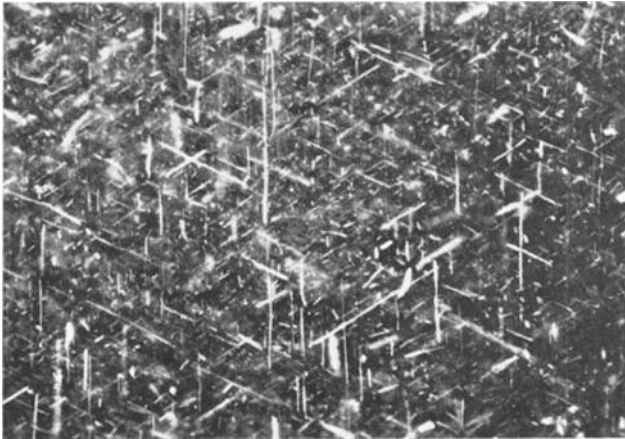
The asterism is caused by very fine and tiny inclusions of crystal needles, most probably rutile (Fig. 3), which are originated by exsolution. They have a high refractive index and look the same way as the well known rutile needles in corundum. The stone in question was first offered as a star-corundum. At first sight, the six-rayed star seems to be regularly developed, but looking nearer, the rays do not include angles of 60° exactly. Dr. S. von Gliszczynski⁽³⁾ was kind enough to calculate the possibilities for a six-rayed star in an orthorhombic crystal like enstatite. Starting from a unit cell of $a = 18.2 \text{ \AA}$ and $b = 8.8 \text{ \AA}$, he found a pseudo-hexagonal net with angles of $51^{\circ} 36.6'$ and $64^{\circ} 11.7'$ and these amounts signify the aberration from a regular star as seen in the trigonal corundum.

The star-enstatite described does not look as attractive as a star-corundum, but it is a novelty and an interesting enrichment of natural star-stones.

The author is indebted to Dr. S. von Gliszczynski, Münster (Westfalen), Germany, for the generous gift of the samples and for the calculations mentioned in the text. He is also most grateful to Professor Dr. H. Jagodzinski of Munich University for the X-ray analysis which enabled the conclusive definition of diopside and enstatite.

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1. Robert Webster. *Gems*, London 1962.
2. R. T. Liddicoat, Jr. *Gems & Gemology*, Winter 1965, 66, 370-371.
3. Dr. S. von Gliszczynski, private communication.



120 ×

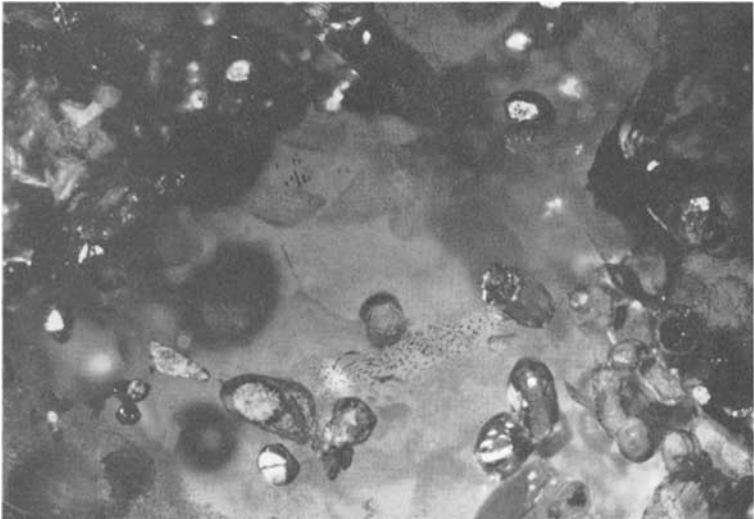
FIG. 3. *Six-rayed star-enstatite with orientated rutile needles, reflected light.*

DETERMINATION OF SOLID INCLUSIONS IN GEMSTONES

By HENRI-JEAN SCHUBNEL

THE determination of solid inclusions in gemstones is of the greatest importance in proving their natural origins and, in some cases, indicating their presumed sources. It is perhaps useful to point out the various possibilities offered for this type of complicated work by the modern equipment available in mineralogical laboratories. Of course, cut gemstones cannot usually be subjected to destructive tests, but no longer do small inclusions, approaching or being smaller than the 10th part of a millimetre, present insurmountable difficulties in the matter of identification.

Each stone poses its own problem, a problem which can be resolved by testing by different methods, although they cannot be systematized too much in a theoretical way.



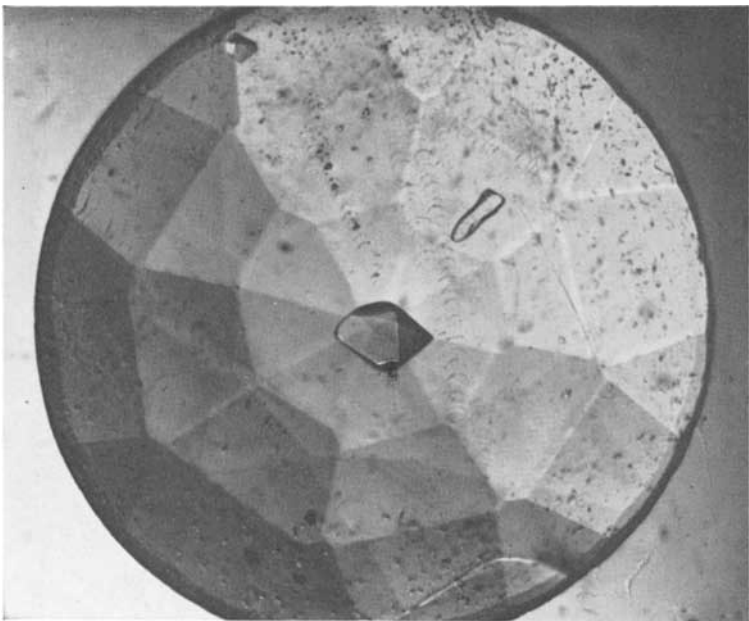
50 ×

FIG. 1. *Pyrrhotite and chlor-apatite crystals in a mauve sapphire.*

Some results of the determination of inclusions undertaken in the course of the last two years are given in this paper. Only inclusions touching the surface of cut stones can be directly determined and in some cases it was necessary to polish a face of a rough crystal in order to bring the inclusion to the surface.

Among the techniques employed, three of them were particularly interesting because they suited the problem involved very well.

1. Rapidly performed chemical analysis with an electronic Castaing microprobe which enabled, by spectrography of direct emission of X-rays, the analysis of the chemical composition of inclusions as small as 5-10 cubic microns in volume.



50 ×

FIG. 2. *A spinel crystal containing 3% of zinc in a cut ruby.*

2. Microscope using polarized reflected light, which is more often used to observe and measure optical characteristics in opaque minerals.

3. Measurement of X-ray diffraction powder-diagrams of crystalline dust taken from inclusions of rough crystals and subsequently the measurement of hardness with the Leitz "microdurimeter" apparatus, which only leaves square marks a few microns wide on the samples tested.

Using microprobe technique, the nature of various inclusions could be established. The three illustrations show some of the results.

It is probable that distinguishing between natural and synthetic stones will become more difficult as the years go by but by the use of microprobe techniques it should be possible to make a systematic study of inclusions in gemstones that will enable the gemmologist and mineralogist to distinguish various types of inclusions more confidently.

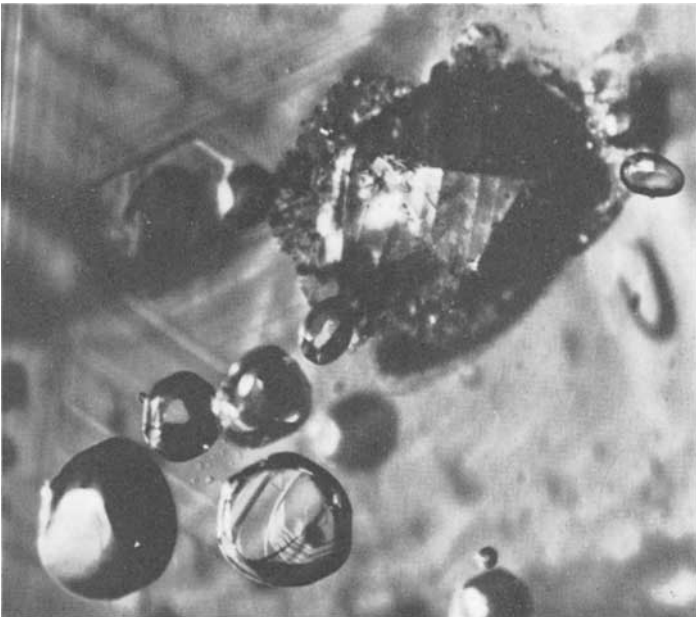
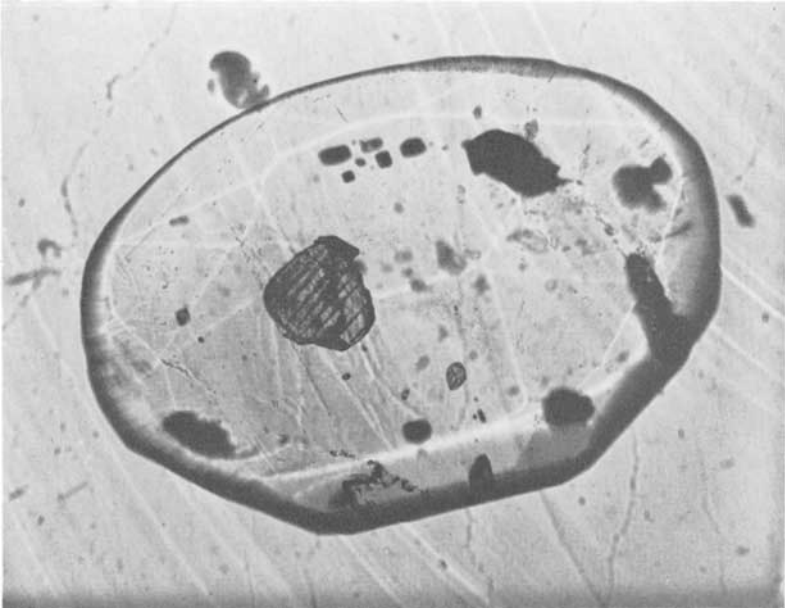


FIG. 3. *Calcite crystal in a ruby.*

100 ×

Inclusions in a faceted ruby

A tri-lingual presentation of details of an inclusion in a faceted ruby, which the author suggests might be a suitable technique for specialists in the study of inclusions to use.



35 ×

Rubis taillé avec inclusions

Inclusion de calcite⁽¹⁾, le rubis est immergé dans l'iode de méthylène; lumière transmise.

Le faciès de la grande inclusion rappelle “La tête de clou”.

Les plans de clivages sont nettement reconnaissables.

La grande inclusion atteint la surface et a été déterminée: à la microsonde de Castaing, au microscope en lumière réfléchiée et au microdurimètre.

Origine présumée: Birmanie.

Inclusions in a ruby

Inclusion of calcite⁽¹⁾. The ruby was immersed in methylene iodide and transmitted light used.

The faces of the large inclusion look like the head of a nail and cleavage planes can be distinctly seen.

The large inclusion reaches the surface and has been determined using the Castaing microprobe, with the microscope using reflected light and by micro-hardness test.

Presumed origin: Burma.

Geschliffener Rubin mit Einschlüssen

Einschlüsse von Calcit⁽¹⁾. Der Rubin ist in Methylenjodid eingettet; durchfallendes. Der grosse Einschluss erinnert an einen Nagelkopf.

Die Spaltrisse sind deutlich zu erkennen.

Der grosse Calcit-Einschluss reicht bis an die Oberfläche und wurde mit der Castaing-Mikrosonde mikroskopisch in reflektierten Licht und auf die Mikrohärtigkeit untersucht.

Vermutlicher Fundort: Birma.

(1) Calcite CaCO_3
Hexagonal-rhombohedral $D_{3d}^6 - R_{3c}$
Density = 2.71 Hardness = 3 $\omega = 1.658$ $\epsilon = 1.486$

These notes have been adapted from an article which appeared in the *Bulletin de l' Association Francaise de Gemmologie*, 1967, No. 9.

REFRACTION ANOMALIES IN TOURMALINES

By R. KEITH MITCHELL

TWO dark green gem-quality tourmalines acquired recently from Brazil showed unusual optical properties.

To all outward appearances they are quite normal stones. Refractometer readings, however, reveal the inexplicable fact that the stones each give *four* distinct shadow edges in sodium light; two lower ones for the extraordinary ray at 1.620 and 1.624 and two for the ordinary ray at 1.646 and 1.653. Birefringence is high, whether one takes it as 0.026 or 0.029, or even 0.033, but is within the extreme range for the species.

The shadow edges on the instrument cancel out quite nicely in pairs when polaroid is used to segregate them. Both pairs behave exactly as one would expect, the twin ordinary ray readings remain stationary while the other two move as the stone is rotated.

The stones do not back up their strange behaviour by exhibiting a quadrupling of the back facet edges but, like so many dark-coloured tourmalines, the ordinary ray is almost totally absorbed, and any facet edge image due to this ray is swamped by the much brighter image due to the extraordinary ray. The difference between the two ϵ rays is too small to be seen with a lens. With strong lighting and using polaroid it is probable that each ray would show doubling under the microscope.

The reason for this very strange duplication of shadow edges is not at all clear, although it seems probable that the stones have been subjected to heat treatment. One possibility is that this may have caused the formation of two types of tourmaline which are existing in close association in the crystal. I have encountered something similar in a tourmaline cat's-eye, which was investigated by X-ray diffraction at the Natural History Museum and found to be an intimate mixture of tourmaline and diopside. But in that stone clear-cut R.I. readings were not obtainable. The present stones behaved normally under this test.

I understand that double reading tourmalines have been reported before by a gemmologist in Denmark. Since I found these two stones another has been found by Dr. G. F. Claringbull, Keeper of Minerals at the Natural History Museum. It seems certain that such specimens are extremely rare and that the full reason for such strange optical behaviour is not yet understood.

TWO CULS-DE-SAC

By E. BURBAGE and T. G. JONES

THE *Journal of Gemmology* shows commendable hospitality in chronicling the successful conclusions of any research, however modest, but understandably, its pages seldom or never record the null results—the stone one could not identify, or the correlation of physical constants which remained obdurately indeterminate. However, we feel the two enquiries to be described are worth recording, for diametrically opposed reasons. In what we might call The Case of the Ingenious Nobleman, we may claim to have assembled a sufficient dossier to write “finis” to the matter, and thus save other gemmologists the chore of duplicating our enquiries, whilst, contrariwise (as Tweedledee would say), in The Case of the Gallic Crystallographer, we have to admit defeat whilst leaving open the possibility that another worker may succeed where we failed.

Item the first stems from a paper which one of us contributed to an early issue of this *Journal*, collecting and commenting on the scattered references to gemmological matters in the writings of Sir Thomas Browne (1605-1682)⁽¹⁾. It was there noted that, in a communication sent to the Royal Society, a reference was made to a technique for staining agates, practised by Sir Thomas Browne’s friend Sir Edmund Bacon, who died in 1649. Such an anticipation of Idar/Oberstein techniques at so early a date seemed worth following up, and a hope was expressed that from Norfolk topographical records or elsewhere, further details might come to light. This hope was not realized, and further enquiries in recent months have led us reluctantly to conclude that no further information exists. By courtesy of the Secretary of the Royal Society, a photostat of Sir Thomas Browne’s original communication was secured, which established the correctness of transcripts by Wilkins and Keynes. The City Librarian of Norwich was good enough to search his records, but without success, although he was able to bring to our notice an interesting paper on an allied subject by Kircher in the *Philosophical Transactions* of 1665. Finally, an approach was made to the present Sir Edmund Bacon to ascertain whether his family records contained anything of relevance. In a most cordial reply, Sir Edmund expressed his interest, but regretted that owing

to the dispersal of family papers in earlier years he was not in possession of any supplementary information. There, unfortunately, the matter must rest, with little hope of further pursuing the enquiry.

The background of the second problem is as follows: you are investigating the behaviour, optical or otherwise, of a gemstone, with especial reference to the optical and/or crystallographic directions. Your experimental material consists of cut stones with usual skew orientation to such directions. You can (i) recut the stones—an expensive form of destructive testing unpalatable to most gemmologists, or, (ii) extrapolate calculated data from those which the original cutting permits—not too satisfactory, presenting experimental and theoretical problems which may be difficult or impossible to resolve. This is indeed an impasse, but if the quest is directed toward investigating an optical or physical phenomenon without especial reference to its embodiment in a particular gemstone, there is much to be said for following the excellent example of Dr. A. E. H. Tutton and employing expendable crystalline material grown from aqueous solutions. Similarly, for demonstrations to the lay public, this plan is capable of application, as was shown by Tutton himself in his brilliant demonstrations before the British Association and elsewhere. Unfortunately, our frustrations over Problem No. 2 arose from an attempted use of a technique described in one of Tutton's books. He quotes some work by the mid-nineteenth-century scientist de Senarmont, on the crystallization of strontium nitrate, using water containing a pigmenting dye, logwood, and yielding crystals which were strikingly pleochroic. Unlike many of Tutton's more esoteric brews, the components described are inexpensive and readily obtainable, and, as we were engaged on some work on pleochroism, some tentative experimentation was ventured upon, but without success. Following this setback, reference was made to de Senarmont's original (1854) paper,⁽²⁾ which, unfortunately, is vague on the technique of crystallization employed, the relevant passage being as follows—*“Lorsqu'on fait cristalliser l'azotate de strontiane, dans une dissolution concentrée de campêche, amenée au pourpre par quelques gouttes d'ammoniaque, on obtient des cristaux volumineux dont la couleur rappelle tout à fait celle de l'alum de chrome”*.

A great deal of further work was then undertaken, in the hope of achieving a like success to that of de Senarmont, but with complete

lack of success. All possible permutations of temperature, pressure, concentration and composition were tried, but our end product usually proved to be a sludgy brown syrup, and, when crystals were obtained, none showed any pleochroism. We succeeded in interesting some extremely distinguished and highly competent chemists in our quest, but they were equally unsuccessful.

What, then, is the explanation? Frankly, we do not know, and hope some *Journal of Gemmology* reader can provide it. A fake or leg-pull could be remotely possible, although the stakes would appear to be unrewardingly low! A more subtle explanation has been put forward, analogous to that which has been employed to explain the vanished scent of musk, to the effect that the success of the operation hinges on the presence as catalyst of an impurity in one of the components, which was present in the reagents of a century ago, but not today. Certainly logwood chips can be ruled out, and we have no information on any changes in the preparation of strontium nitrate; certainly ammonia comes by a different route today, but one would not expect a minor variation in "quelques gouttes" to have any significant influence. We hope some ingenious "Journal" reader can resolve the dilemma for us.

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2. H. de Senarmont. *Experiences sur la Production Artificielle de Polychroisme dans les Substances Cristallisees*. *Annales de Chemie et de Physique*, 1854 Series III, vol. 14 pp. 319 to 339.

NOTES AND NEWS

By B. W. ANDERSON

AN EXCEPTIONAL PASTE

The oldest of all forms of imitation gemstone, glass, can still have a nuisance value for the jeweller or the gemmologist. Unlike synthetic stones, which can only be used to represent a certain number of species, glass in its almost infinite gamut of colours and degrees of transparency or opacity, knows no limit to the range of natural gem materials it can represent with at least a degree of plausibility.

Another trouble with "pastes" is the wide range in refractive index and density encompassed by the different types of glass used: moreover there is often a difficulty in obtaining a refractometer reading on account of some sort of tarnish on the surface of the specimen.

Experience with the many thousands of glass "gemstones" encountered over the years has shown that in at least 99% of instances the refractive index lies between 1.50 and 1.70. Within this region, of course, lie the indices of a great number of gemstones, but, as it so happens, there are no stones in jewellery which have a *single* refractive index within these limits: a useful fact to remember for those engaged in practical testing.

Until recently, I had only encountered one outstanding exception to this rule-of-thumb, in the shape of a magnificent yellow paste, housed in a special leather case, which was being offered for sale as a specimen topaz. This was made from a heavy lead glass, quite unsuited to withstand any wear and tear in jewellery, and had refractive index 1.77 and density 4.98.

This was thirty years ago, and I never expected to meet another example at all resembling this. Then, some months ago, an oval yellow specimen weighing 15 carats was submitted for test which proved to be a "super-paste" of a very similar kind, in which the density and refractive index actually achieved a new record. Because of this, careful measurements were taken: the density by hydrostatic weighing in ethylene dibromide, giving a figure of 5.116, while C. J. Payne measured the refractive index on an Abbé-Pulfrich refractometer, and found it to be 1.775. The stone was not well enough cut to promise accurate results by the minimum deviation method, so the undoubtedly formidable figure for the dispersion of this freak specimen can only be guessed at.

CURVED STRIAE UNDER SHORT-WAVE ULTRA-VIOLET

Practising gemmologists will agree that ultra-violet lamps form a very valuable aid in the detection of certain types of synthetic and imitation stones. They will also agree that results under such lamps must always be treated with a certain amount of caution, and as an accessory rather than as a main test for identification.

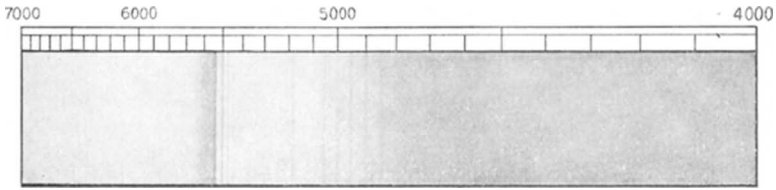
There are several types of "short-wave" lamps available, making use of the strong mercury line at 2537 in conjunction with a suitable filter which absorbs most, but not all, of the strong visible light emitted by the mercury vapour, and these lamps are particularly useful in certain cases, notably in the detection of synthetic rubies and synthetic sapphires. Synthetic sapphires commonly show a curious greenish glow or "bloom" under such lamps, which can best be detected by allowing the rays to impinge upon the stone from the side. Unfortunately every now and then an undoubtedly natural sapphire will show a very similar effect: hence the special need for caution, as suggested above.

My purpose in the present note is to draw attention to the appearance of curved structure lines in some synthetic sapphires when fluorescing under the short-wave rays. When seen, the effect naturally provides a complete proof that the stone concerned is indeed a synthetic sapphire. One would expect that such a stone would in any case reveal the striae when examined over white paper with a lens, but I have found cases where this is not so, so that one must give credit to the lamp for occasionally revealing the invisible.

Someone with time to spare might do well to investigate this curious green fluorescence with a view to establishing the chemical nature of the "phosphor".

MANGANESE LINES IN ANDALUSITE

One of the several interesting stones bequeathed to the London Chamber of Commerce Laboratory by the late Mr. Edward Hopkins was a green pebble of andalusite, polished on one side only, which revealed a striking absorption spectrum, quite unlike that seen in any other gemstone, or indeed in any of the andalusites normally cut as gems. There is an absorption band in the green, shading to a knife-sharp edge at 5535Å which is followed by fine lines at 5505 and 5475Å and a fainter line at 5440: there are further narrow lines in the blue-green at 5180 and 4950Å.



ABSORPTION SPECTRUM OF GREEN ANDALUSITE after a drawing by T. H. Smith

We first measured these bands in 1933, and assumed them at that time to be due to some form of rare earth element or elements because of the extreme narrowness of the lines. Since that time, three small cut specimens of this bright green andalusite have been found in a parcel of demantoids sent in for routine testing (1942), and further samples in the form of rough pebbles have been given me from time to time. The locality is said to be "Brazil" but that is true also of most other andalusites of the more normal kind, in which the only absorption band measurable is one in the blue at 4550Å.

Unfortunately the study of rare earth minerals and salts, and of the descriptions of absorption lines found in these materials failed to reveal any likely cause for the narrow lines, and appeals to one or two workers in the rare earth field also failed to bring forth any likely suggestions.

A paper by John W. Adams, in the *American Mineralogist* for March-April 1965 on "The visible region absorption spectra of rare-earth minerals", led me to put the problem to him, sending a sample of the andalusite concerned for study and analysis. Mr. Adams showed a most kindly interest in the matter, and before long was able to provide me with the long-sought information—not from his own experiments but from the literature. In a paper by F. Corin "Spectre d'absorption de viridine", which appeared in the *Bulletin of the Belgian Geological Society* for 1934, a description is given of absorption bands observed in viridine, a rare form of manganiferous andalusite which, together with an accompanying drawing, firmly identifies it with the spectrum described above. Corin writes "Ce spectre d'absorption est caractérisé par trois bandes sombres, dont deux étroites, accolées vers le milieu du vert du spectre visible, et la troisième, plus large, à la limite du vert et du bleu".

Corin also gives details of the variations in the strength of the bands in the three main vibration-directions of this very dichroic mineral, and includes a line drawing of the spectrum as seen through a prism spectroscope, together with the spectra of monazite and xenotime for comparison. The latter, of course, are rare-earth spectra, and clearly Corin also was impressed with the general similarity between these and the narrow bands in viridine.

It is hardly surprising that manganese should not have been suspected as a possible cause for an absorption spectrum of so delicate a nature by gemmologists familiar with the very characteristic absorption bands to be seen in the gem materials spessartite (which the pundits would prefer us to call spessartine), rhodonite and rhodochrosite. Being commonly transparent, it is in the garnet that the fullest series of bands can be seen, gaining strength, so to speak, as they stride down into the violet and near ultra-violet. Rhodonite and rhodochrosite are virtually indistinguishable in their peculiar rose-pink colour, which is chiefly influenced by a broad absorption band in the green centred near 5500\AA . In these crystals manganese is in its most stable, divalent, form. Confirmation that the divalent manganous ion is pink in colour comes from a study of the salts, in which the formate, acetate, sulphate, fluoride, chloride, bromide and iodide are all of this hue.

In andalusite, manganese is replacing aluminium, and would thus be in its trivalent form: there are very few stable manganic salts to act as guides to colour. Manganic fluoride is red, but the sulphate is dark green, which indicates the possibility of this ion yielding a compound of this colour. In Hackh's useful "Chemical Dictionary" it is stated that manganic salts "are generally unstable and yield in aqueous solution the green Mn^{++} ion, which readily decomposes to the stable Mn^{++} (manganous) state". Unfortunately only the red manganic fluoride (used in tanning) is on the market as a chemical, thus a study of the spectral absorption of the green manganic ion is not possible without undertaking a rather tricky chemical preparation.

The solid-state physics specialists have had some success recently in describing the physical bases for absorption bands in various solids. Eventually they may explain the strange and delicate spectrum seen in green andalusite. All that the gemmologist will then need will be an explanation of their explanation.

THE DUPLEX REFRACTOMETER

THE "Duplex" refractometer devised by the Gemological Institute of America, is the "first instrument designed expressly to give readings for curved polished surfaces as well as flat facets". It is a big and handsome instrument with a broad base enabling it to stand firmly on the work bench, and tall enough to make readings possible without raising it on a block.

The refracting unit consists of a hemicylinder of high index lead glass, the flat surface of which projects slightly above the level of the table of the instrument and measures one inch in length and a quarter inch in breadth. On one side of the refractometer is a plate engraved with the refractive indices of gemstones.

There are two separate 2-element eyepieces—one fixed to the instrument, the other sliding into a collar holding the fixed lens. The light and field of view is controlled by a mirror lit through the window of the instrument and adjustable by means of a knurled knob projecting from the right-hand side. The scale reads from 1.30 to 1.85, and is thus rather "crowded". There is no cover to protect the hemicylinder surface and to exclude unwanted light, but a strong plastic dust-cover is provided. A small bottle of contact fluid (R.I. 1.80) and one of Xylene for cleaning, also a polaroid disc and red colour-filter, complete the kit.

Instructions for use of the Duplex run to 3½ pages of typescript, and merit careful study, since this refractometer must be handled differently from the "Rayner" and other refractometers to which we have become accustomed. Whether for flat surfaces or cabochons, the first eyepiece is removed, leaving the fixed eyepiece, through which the scale is in focus when the eye is some 12 inches distant.

For accurate "spot" (distant vision) readings, the tiniest possible drop of liquid is recommended to make contact. The contact disc is then centred by turning the knurled knob. The eye is then moved up and down the scale and the highest reading recorded where the contact spot is still dark and the lowest reading where it is all light. Between these lies the true R.I. reading, which should be ascertainable to ± 0.01 . This technique is recommended rather than that of using a slightly larger spot and attempting to read the position where the shadow-edge bisects the disc.

For readings on flat surfaces the scale is again viewed at a distance and the mirror adjusted until a blue-green shadow edge is seen crossing the scale. The second eyepiece is then replaced and with the eye some 2 inches distant a reading taken in the normal way, or two readings if the stone is birefringent, with the usual rotation of the stone to give maximum and minimum readings for full birefringence. Monochromatic sodium light is of course recommended for critical readings—or the red Wratten filter can be used, which registers some 0.005 higher than sodium light readings.

Comments

The refractometer glass seems unnecessarily large, and is very vulnerable to damage. The scale is accurately calibrated, but for flat surfaces only part of the scale is covered by the contact zone, which is disconcerting for one accustomed to have the whole scale covered by light or shadow. The readings are not so easily made as on a Rayner in good condition. On the model tested there are fixed lines crossing the scale at 1.59 and 1.77, giving “false” readings which on occasion might lead to error. In the “spot” method the Duplex is very sensitive in showing an abrupt change from light to dark; but even here readings as accurate can be taken on a standard “Rayner” by the “divided disc” technique.

Gemmological Abstracts

HUANG (C. K.). [*Two gemstones—blue chalcedony and nephrite—from eastern Taiwan*]. Taiwan [Formosa] Mining Industr., 17, 58-65, 1965 (Chinese with English summary).

Blue chalcedony, sp. gr. 2.581, n 1.539, occurs in cavities in andesitic agglomerate near Taitung: it consists of spherulitic aggregates of chalcedony with minor chlorite, opal, and iron hydroxides together with veins of quartz and pyrite. It has 0.002-0.035% U and 0.01-0.02% Cu. Spinach-green to yellowish green nephrite, H.6½, sp. gr. 3.007, is found in asbestos at the contact of graphite schist and serpentinite near Hualien, and consists of interfelted tufts of tremolite with minor chromite, picotite, magnetite, garnet, and chlorite, giving black spots and streaks in the nephrite: the amphibole has α 1.609, β 1.620, γ 1.631.

R.A.H.

DARRAGH (P. J.), GASKIN (A. J.), SANDERS (J. V.). *The nature and origin of opal*. Australian Gemmologist, 1966, 66, pp. 5-9.

An important article giving details of a further research into the cause of the formation of the sub-spheroids which, as these workers discovered earlier, were the cause by diffraction of the play of colour in precious opal. Some idea of the possibility of the synthesis of opal is given.

R.W.

McKAGUE (H. L.). *Hydrogrossular—a hydrogarnet from Transvaal*. Gems & Gemology, 1966, XII, 2 and 3, pp. 49-57 and 74-76 and 95.

Deals mainly with the massive grossular garnet from Transvaal which contains the OH groups and is actually belonging to the hydrogrossular series. Reference is made to the geology of the Brits (Transvaal) deposits and the mineralogy of the rocks. Information is given on the physical properties of hydrogrossular and the chemical analyses are discussed. The lower density of the pink-coloured material as compared with that of the green massive

grossular is ascribed to the pink material containing more of the OH radical. The question of the relation and the admixture of hydrogrossular and idocrase is discussed. This important and authoritative article concludes with a summing-up and gives an excellent list of references.

R.W.

CROWINGSHIELD (R.). *Developments and highlights at the Gem Trade Lab. in New York.* Gems & Gemology, 1966, XII, 2 and 3, pp. 43-47 and 62; 67-73 and 95.

Reports of interesting pieces examined in the laboratory in New York. A diamond ring, manufactured in the Middle East, consisted of a thin rose-cut diamond mounted over a bright metal back which was crimped and moulded to appear like the back facets of a brilliant-cut stone. The whole was set in a closed setting. Another diamond, which had been badly damaged at exposed edges, was found to be a three-point stone with the cleavage direction parallel to the table facet, leaving the edge of the girdle vulnerable to damage. The characteristics of a red-brown atomically-coloured diamond are given, as well as the "umbrella" effect seen in a cyclotroned diamond. Other effects noted in diamonds are "drag marks", dendritic inclusions and a textured effect resembling human skin on the surface of an emerald-cut stone. A fine coloured iolite which had originally been sold as a sapphire, a cat's-eye apatite, and a 2.12 carat uvarovite garnet crystal, as well as an opalized clam, are items mentioned. There is a concise report on solution-grown synthetic rubies, and there is a reference to a necklace of blue enamel beads sold as turquoise.

33 illus.

R.W.

ANON. *The rocks bring forth beauty.* South African Panorama, 1966, 11, 2, pp. 24-29.

Well illustrated with colour and black and white pictures this popular article is concerned with the stones found in South Africa and the jewellers of that country. The text concisely covers the subject. The 24 illustrations of rough and cut stones and jewellery give importance to the article.

R.W.

TAYLOR (A. M.). *Bronzite from Anakie, Queensland*. Australian Gemmologist, 1966, 65, pp. 12-13.

Records the finding of bronzite in the Anakie gem fields. Brown in colour, the stone was found to have a density of 3.34 and refractive indices 1.675-1.687, the double refraction being 0.012. The dichroism was marked and the colours yellowish-brown to a very dark olive-green.

R.W.

ANON. *A new doublet*. Australian Gemmologist, 1966, 63, p. 10.

Reports the appearance on the market of a doublet consisting of a crown of synthetic spinel and a pavilion of strontium titanate. Square and baguette-shaped samples have been seen.

R.W.

ANDERSON (O.). *The sapphire fields of Anakie*. Australian Gemmologist, 63, pp. 5-7.

Extracts from "A prospector's guide to the Anakie sapphire fields" published in the Queensland Government Mining Journal of October, 1965. The extracts cover the types of sapphire found in the Anakie fields and their marketing. The blue colours are most favoured by overseas markets, while yellows and greens are more favoured by Australians. Some information is given on the occurrence and on the recovery.

R.W.

TOLANSKY (S.). *Birefringence of diamond*. Nature, 1966, 211, p. 158.

Some 2,000 gem quality diamonds and 3,000 clear, transparent micro-diamonds, which were recovered from tailings from South African mines, revealed that birefringence was present in all the specimens. There is therefore strong evidence to suggest that all diamonds are birefringent. The new suggestion, based upon etch patterns and polariscope examination, is that diamonds grow by successive layer formation and the proposition is made that all diamonds are layer mixtures of type 1 and type 2 material. A very small difference in thermal expansion properties, elastic strength, or lattice dimension of the two types is postulated to account for the correlation between etch pattern and birefringence in a figured position. It is suggested that the shatter observed in diamond at

1885°C could be explained in this way. Previously the explanation for birefringence in diamond was that it was caused by strain.

G.A.

SHARP (W. E.). *Pyrrhotite: a common inclusion in South African diamond*. Nature, 1966, 211 (5047), p. 402.

Examination of large batches of crushed industrial diamonds. A table is given of lattice parameters of pyrrhotites recovered from the stones. It is concluded that pyrrhotite is a common inclusion in diamond and attention is drawn to the association of pyrrhotite with diamonds in meteorites and diamonds from pipes of kimberlite.

S.P.

BOOK REVIEW

WEBSTER (R.). *Practical Gemmology*. N.A.G. Press, London, 1966. 30s.

The fourth edition of a standard introductory text to gemmology which first made its appearance in 1943. Necessary revisions have been made and there are three new chapters (but still no contents page). The new chapter on the chemistry of gemstones is a welcome and essential introduction to the study of crystals. More attention has been given to the diagnostic importance of inclusions in gemstones and the author's interest in luminescent and electrical properties of gems is shown by additional notes which have been included on these subjects.

A.G.

BOOK NOTICES

BLAKEMORE (K.) and ANDREWS (G.). *Collecting gems and ornamental stones*. W. & G. Foyle Ltd., London, 1967. 5s.

A non-technical introduction to the collecting of gemstones and gem minerals.

S.P.

McIVER (J. R.). *Gems, minerals and rocks of Southern Africa*. Macdonald, London, 1966. 40 colour plates, 80 photographs and numerous charts and illustrations. £7 10s. 0d. (U.K. only).

S.P.

ASSOCIATION NOTICES

MIDLANDS BRANCH

A meeting of the Midlands Branch of the Association was held on 7th October, 1966, at the Auctioneers' Institute, Birmingham. Mr. D. N. King, chairman, presided and introduced Mr. D. J. Ewing who spoke about his various visits to the gem-cutting district of Idar-Oberstein. The Branch Vice-chairman, Mr. P. T. Spacey thanked Mr. Ewing for his interesting talk.

MEMBERSHIP

At a meeting of the Council of the Association held at Saint Dunstan's House on Wednesday, 1st February, 1967, the following were elected:—

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Buckingham, Lionel J., Whitstable, Kent. D.1966	Fillan, Ian, Huddersfield, Yorks. D.1966
Byworth, David R., Brookmans Park, Herts. D.1966	Fournet, Bertrand P., Hong Kong. D.1966
Collier, Rowley W., Hornchurch, Essex. D.1966	Frizzell, Alan S., Motherwell, Scotland. D.1966
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Engaas, Karin, Oslo 2, Norway. D.1966	Leech, Alan G., Heywood, Lancs. D.1966
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Falcon, Lionel J., Nottingham. D.1966	Levy, Warren I. J., Kenton, Middx. D.1966

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Essex. D.1966
- Sutton, Andrew L., London,
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- Theisen, Verena, Essen-Werden,
W. Germany. D.1966
- Thompson, Peter L., Nottingham.
D.1966
- Verney, David L., London,
S.W.12. D.1966
- Widnall, Harry, Sheffield, 8. D.1966
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- Wild, Walter F., Liverpool 15,
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- Woodall, Christopher R., Streetly,
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ANNUAL MEETING

The 37th Annual General Meeting of the Association will be held on Wednesday, 3rd May, 1967, at Goldsmiths' Hall, Foster Lane, London, E.C.2. at 6.00 p.m.

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to members for the following gifts:- from Mrs. Jeanne S. Miller, Arlington, U.S.A. a donation for the purchase of books; from Mrs. C. Mendis, Colombo, a crystal of yellow sapphire; Messrs. Viktor Kämmerling have kindly given samples of their emerald-coloured beryl doublets, which are sold as "Sinaryl".

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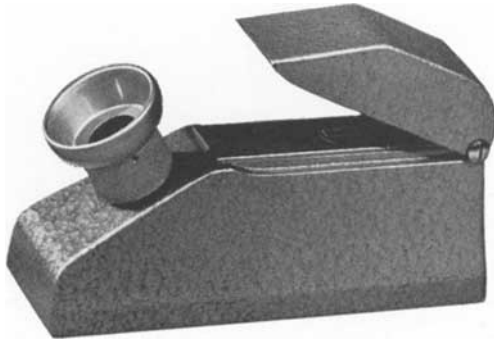


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