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and

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TOURMALINE CHATOYANCY

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ABSTRACT

Various laminae and cabochon-cut tourmaline samples were examined to represent all the elongated inclusions which may occur in this mineral with respect to the type, colour and site of the embedding crystal.

The specimens were characterized by means of x-ray powder patterns, being attributed essentially to elbaites and, in a few cases, to dravites. The elongated inclusions which may cause the cat's-eye effect are growth-tubes and needles, which microchemical analyses proved to be mainly constituted of tourmaline, the former sporadically by prosopite and cookeite, the latter by epidote. It has been noted that the growth-tubes most frequently occur in green samples, while the needles occur in red and blue ones.

INTRODUCTION

A great number of minerals show the chatoyancy effect when a multitude of relatively short needles or microscopic tubes traverse the embedding crystal in a strictly parallel manner along its main direction of growth. The intensity of such a phenomenon is due to the thinness and density of the elongated inclusions which cause the *scattering* of light.

Various types of elongated inclusions occur in tourmaline, and may be classified as (a) unorientated capillaries—thread-like

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cavities, called trichites, which often contain two-phase contents (Figure 1), and (b) strictly parallel inclusions, which may produce chatoyancy (Figure 2).

However, the trichites are not responsible for producing the chatoyant effect, since they are mainly gathered on bent planes referable to fractures which trapped residual drops of mother-fluid during their healing. Moreover, such thread-like capillaries are unorientated, trending irregularly and crossing one another at random. Usually the capillaries spread from a central nucleus which makes the generation of the cat's-eye effect more difficult, and in which two-phase inclusions occur. Tourmalines are occasionally characterized by other elongated fibrous inclusions which could be differentiated into growth-tubes and needles (Figure 3).

The former are primary cavities which may be caused both by evident strains generated by the embedding of an inclusion in the lattice of the crystal, and by irregularities in growth-modalities, as well as conditions of rapid growth of the host tourmaline (Bradley *et al.*, 1953). Such channels may be filled by two-phase inclusions as well as by birefringent (and rarely by opaque) materials. On the other hand, the needles are elongated thin fibrous crystals which, during the tourmaline's growth, aligned themselves strictly parallel to the main growth direction of the crystal. However, sometimes these are bent or curved at their extremities (Figure 4).

The chatoyant effect was suggested to be induced also by bundles of included mineral fibres, possibly members of the amphibole family (Eppler, 1973; Gübelin, 1974). Occasionally columnar assemblages with sub-hexagonal habit may yield a large and ill-defined cat's-eye effect.

Since the aim of this research is the study and determination of the cause of the cat's-eye effect, a considerable number of tourmaline specimens were examined in order to represent significantly all the elongated inclusions which may occur in this mineral with respect to the colour, type and site of the embedding crystal (Table I). Such samples were kindly made available from the collections of Professors Eppler and Gübelin. The specimens from the former's collection, nos 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, and 16, are made up of polished slabs (max. sizes: approx. 10 × 5 × 2 mm) orientated parallel to the optical axis of the mineral. The other samples from Gübelin's collection, nos 13, 14, 15, 17, 18, 19, 20, 21

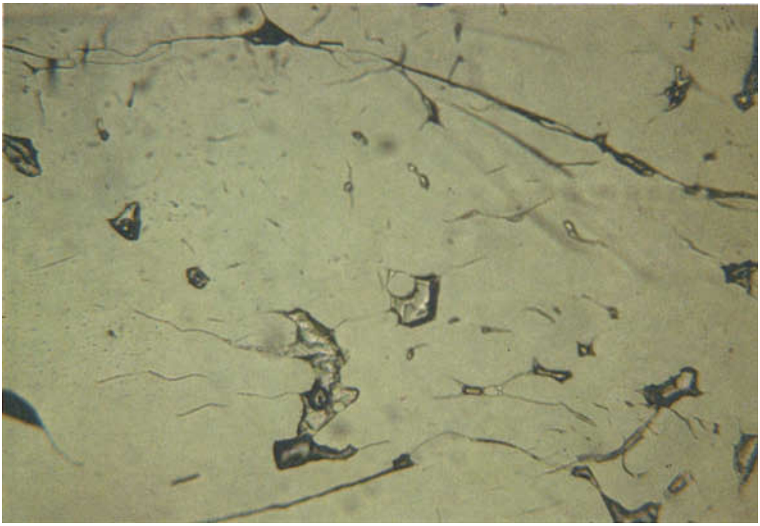

FIG. 1. Tourmaline chatoyancy: Sample 1. Green-yellowish tourmaline from Minas Gerais (Brazil). Capillary thread-like trichites, typically unorientated, with two-phase contents. × 80.

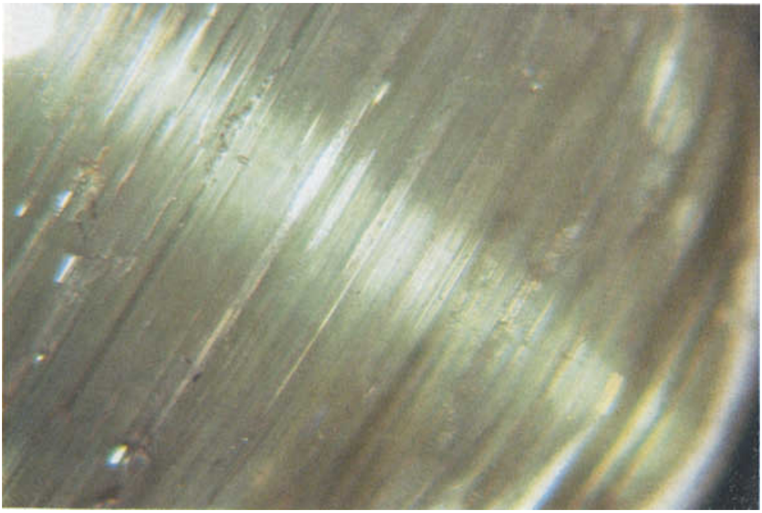

FIG. 2. Tourmaline chatoyancy: Sample 14. Green tourmaline from Himalaya mine, Pala (U.S.A.). Cat's-eye streak running over the curvature of the cabochon. × 30.

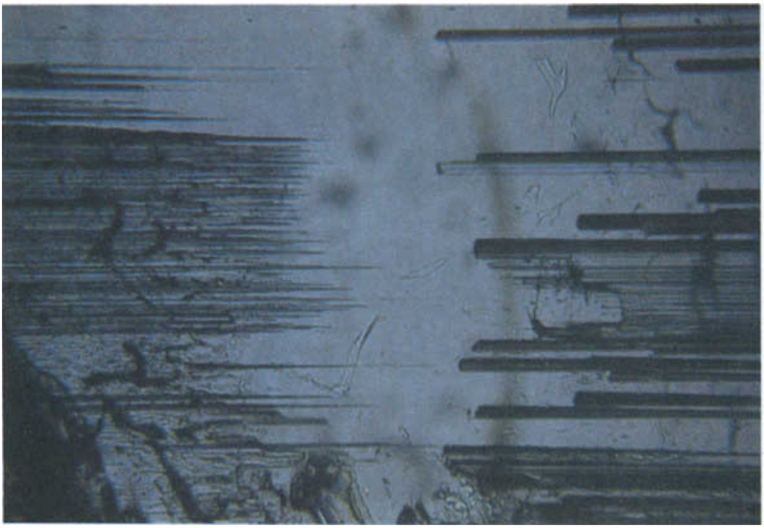

FIG. 3. Tourmaline chatoyancy: Sample 5. Light-green tourmaline from Pala, San Diego (U.S.A.). The various growth stages of the embedding crystal are evidenced by the presence of growth-tubes and needles. ×20.

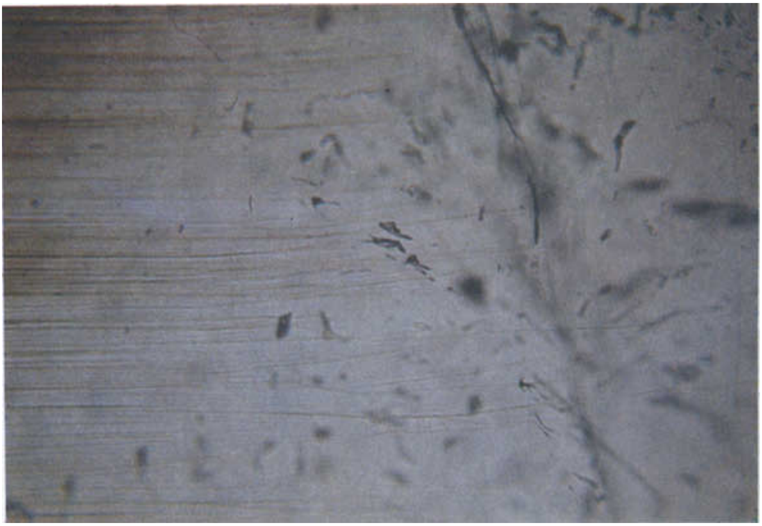

FIG. 4. Tourmaline chatoyancy: Sample 9. Green tourmaline from Minas Gerais (Brazil). Needles with sporadically bent or curved endings. ×25.

TABLE I. Selected tourmaline samples.

Sample number	Colour	Type of inclusions	Locality	Varieties of tourmaline
1 ☐	Green-yellowish	Trichites	Minas Gerais	Dravite
2 ☐	Blue-green	,,	,,	Elbaite
3 ☐	Light-green	,,	,,	,,
4 ☐	Pink	,,	Pala, S. Diego	Dravite
5 ☐	Light-green	Growth tubes	,,	Elbaite
6 ☐	Pink	,,	,,	,,
7 ☐	Blue-green	,,	Minas Gerais	,,
8 ☐	Green	,,	,,	,,
9 ☐	,,	,,	,,	,,
10 ☐	Light-green	,,	,,	,,
11 ☐	Green	,,	,,	,,
12 ☐	,,	,,	,,	,,
13 ○	,,	,,	Himalaya Mine, Pala	,,
14 ○	,,	Needles and growth-tubes	,,	,,
15 ○	Pinkish	,,	Minas-Gerais	Schorl-dravite
16 ☐	Blue	Needles	,,	Elbaite
17 ○	,,	,,	,,	,,
18 ○	,,	,,	,,	,,
19 ○	Grey-bluish	,,	,,	Dravite
20 ○	Green	,,	Newry	Elbaite
21 ○	Pink-white	Needles and Laminae	,,	,,
22 ○	Green/pink	Needles and laminae/granular	Alto Ligonha, Mozambique	,,

☐ Eppler's collection.
○ Gübelin's collection.

and 22, are fine, cabochon-cut tourmalines all showing a conspicuous cat's-eye effect.

The specimens were first sorted with respect to their colour, and an attempt was made to evaluate the refractive indices, while the density was determined by means of the Berman balance. However, the data collected proved to be unreliable due to the peculiar characteristics of these tourmalines rich in fibres. It was thus not possible to define a clear correlation between these data and the total weight-percentage of the Fe, Mn, and Cr oxides content (Quensel, 1957).

Hence, the tourmalines were characterized by means of x-ray diffraction powder patterns, evaluating the unit cell parameters and using the assignation method suggested by Epprecht (1953). X-ray powder diffractograms were obtained with Ni-filter CuKα radiation from 10° to 70° 2θ per minute, with semiconductor grade silicon metal as an internal standard (Jarrel Ash J. M., spectroscopy impurity $<$ 300 ppm). Unit cell parameters were established by the least-squares refinement of the collected data (Appleman & Evans, 1973) indexed by comparison with the reflections listed by the Joint Committee of Powder Diffractions Ståndards, Card nos 14-76, 19-1372 and 26-964.

Electron microprobe analyses have been carried out to clarify the chemical composition of the matrix and to identify the elongated inclusions. At first, optical observations were accomplished with the purpose of determining the areas most suitable for each sample, both on the bulk crystal and on the inclusions, to carry out the microprobe analyses.

The micro-analyses of the fibres embedded in the cabochons were performed on the protruding terminations of such inclusions; it was thus necessary to operate on the curved sides of the samples, resulting in a larger experimental uncertainty. Such analyses were performed using an E.D.S. system from Link, on a Jeol JXA-50A probe with on-line matrix corrections, Zaf-4 program. Boron, lithium and both H_2O^+ and H_2O^- were not determined because of their failure to respond in the microprobe, and also because of the impossibility of utilizing destructive methods of analysis. Eight-spot analyses were carried out on each selected area for every sample, averaging the collected data.

The two-phase inclusions have been studied by means of a heating plate Leitz 1350, utilizing both transmitted and reflected light with a dry nitrogen current of 2 ml/min. The homogenizing temperatures have thus been determined using a chromelalumel thermocouple, with an experimental uncertainty of about ± 1 °C.

RESULTS AND DISCUSSIONS

The experimental measurement of the refractive indices proved to be extremely difficult, due to the characteristics of the samples. In addition, it proved extremely difficult to determine the total weight-percentage of the oxides of the heavy elements, since the data obtained from the diagrams happened to be excessively sporadic. Moreover, since chemical composition does not always

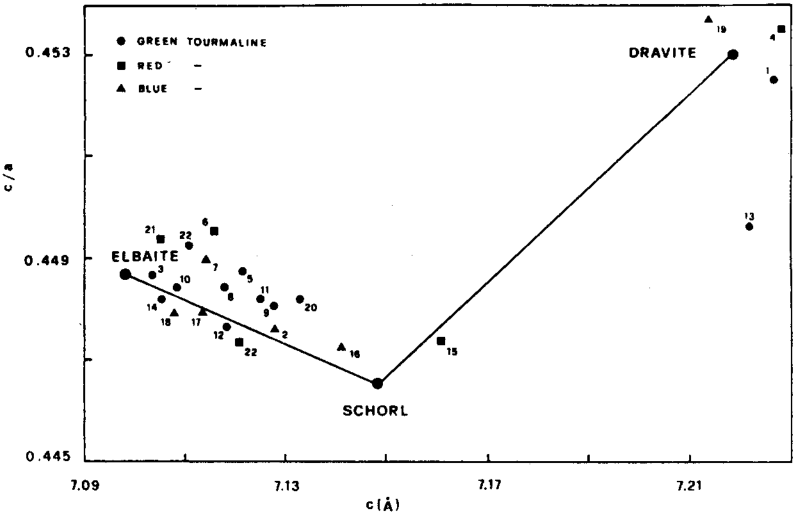

FIG. 5. Tourmaline chatoyancy: Interdependence between *c/a* ratio and *a* parameter.

succeed in discriminating the percentage content of dravite, schorl and elbaite of a sample with sufficient accuracy, it was necessary to make use of the relation existing betwen the lattice constants, attributing the examined samples mainly to elbaites and, in a few cases only, to dravites (Figure 5). However, it should be noted that no close relationship between such structural classification and colour has been recognized, and consequently a noticeable dispersion of the specimens in the whole diagram is evident.

All the different elongated inclusions shown by the samples were then grouped according to the colour of the embedding tourmaline, disclosing a peculiar preference of each inclusion for one or another of the various colours (Figure 6). These inclusions were roughly classified into three groups: trichites, growth-tubes and needles. The trichites particularly seem to be generally distributed and not linked to the colours, while the growth-tubes are remarkably characteristic of the green samples (Figure 7). Inversely the needles are most abundant in the pink-red and blue tourmalines. Two-phase inclusions, which occur both as trichites and growth-tubes, were examined by means of a hot plate and the homogenizing temperatures were determined, suggesting in this way the presence of CO_2 and H_2O as main constituents, indicating typically hydrothermal environments (Figure 8).

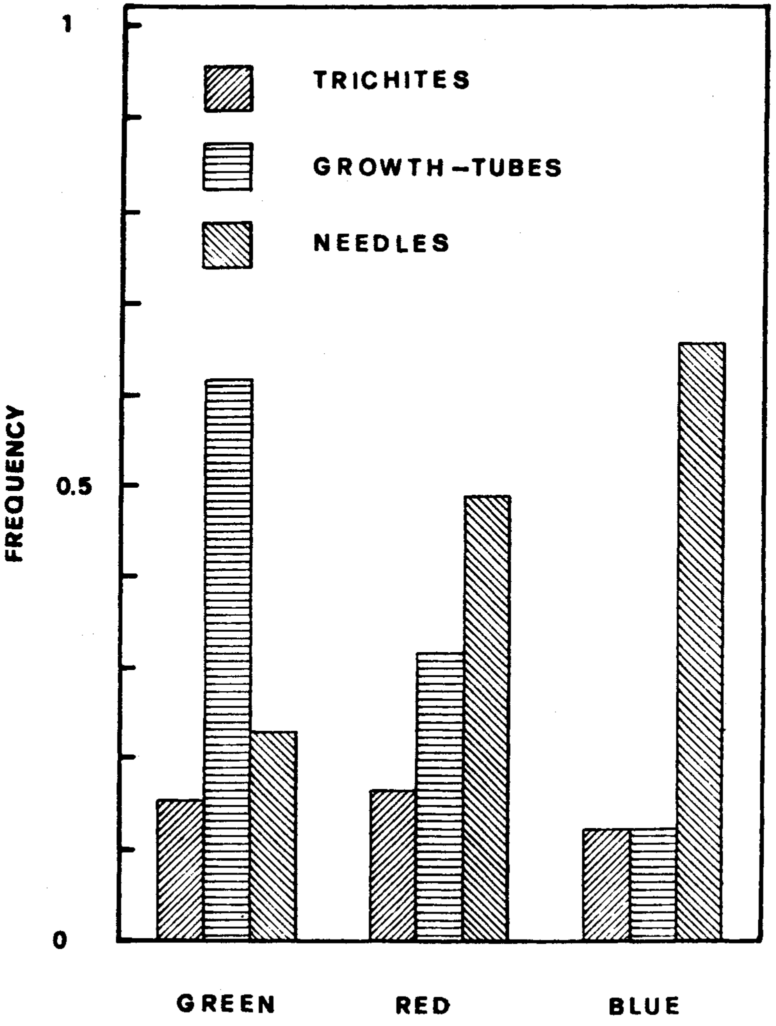

FIG. 6. Tourmaline chatoyancy: Inclusions frequency with respect to the colour of the embedding crystal.

Most frequently however, the growth-tubes are filled with birefringent material, which at times appears powdery. Microchemical determinations have been carried out with the purpose of defining the nature of such material, which was found to be mainly made up of silica aluminates whose chemical

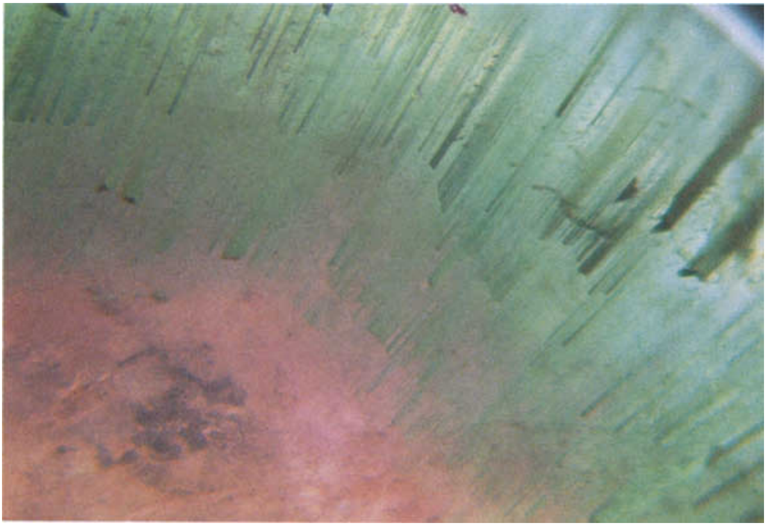

FIG. 7. Tourmaline chatoyancy: Sample 22. Green/pink tourmaline from Alto Ligonha (Mozambique). The growth-tubes are evidently gathered in the green area. × 60.

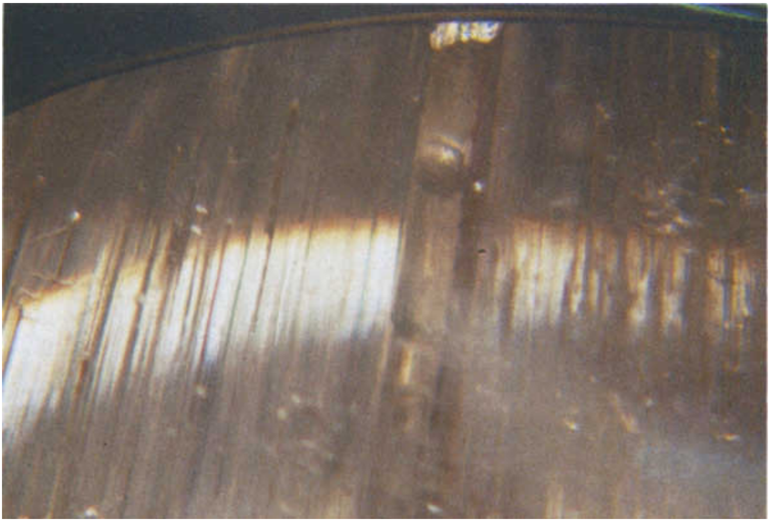

FIG. 8. Tourmaline chatoyancy: Sample 15. Pinkish tourmaline from Minas Gerais (Brazil). Two-phase inclusions evident in the growth-tubes. × 30.

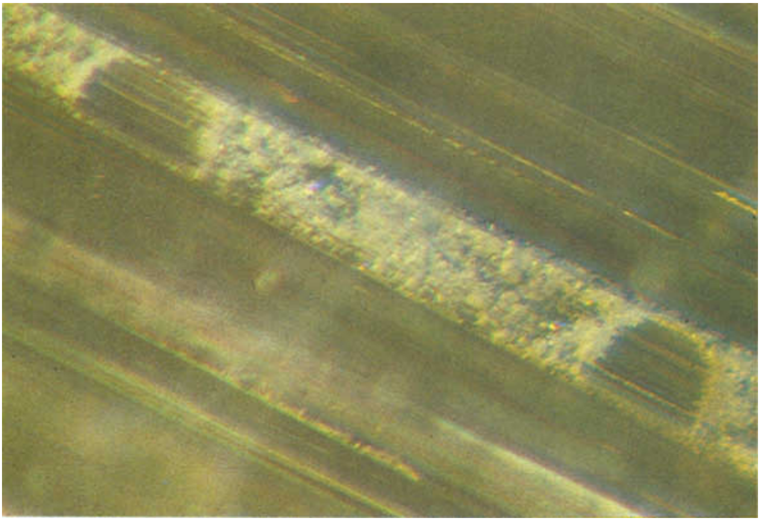

FIG. 9. Tourmaline chatoyancy: Sample 20. Green tourmaline from Newry, Maine (U.S.A.). Growth-tubes filled with powdery crystal material of prosopite. × 250.

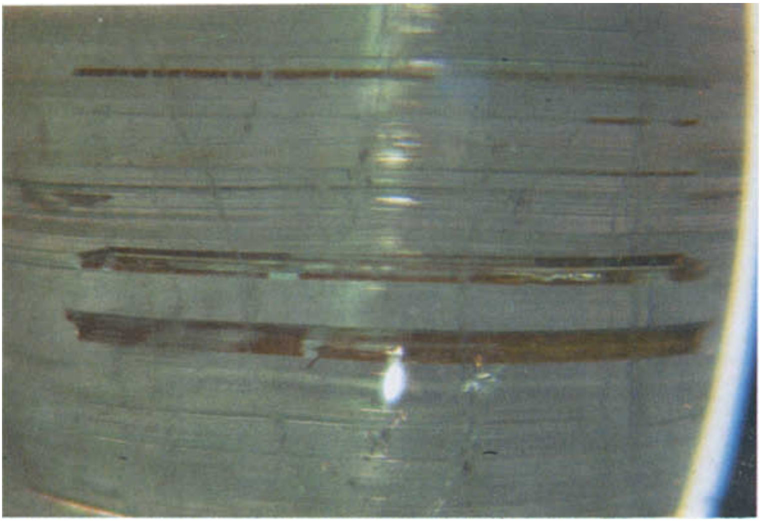

FIG. 10. Tourmaline chatoyancy: Sample 22. Green/pink tourmaline from Alto Ligonha (Mozambique). Laminae of iron oxides and hydroxides filling the growth-tubes. × 60.

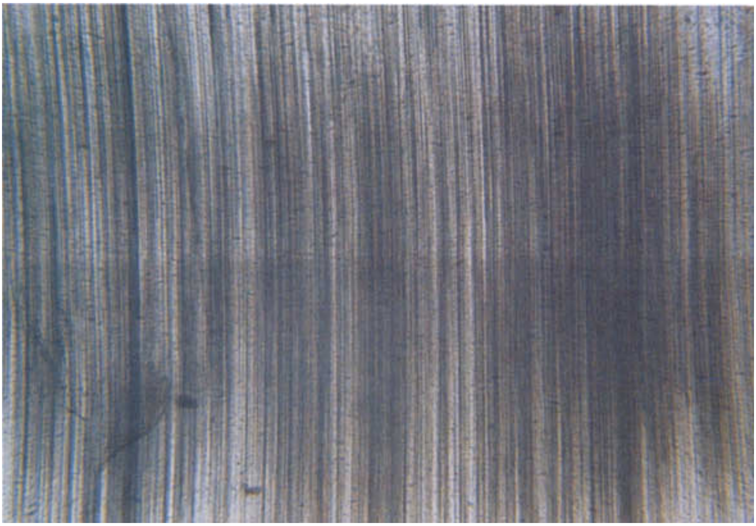

FIG. 11. Tourmaline chatoyancy: Sample 11. Green tourmaline from Minas Gerais (Brazil). The needles are rigorously iso-orientated parallel to the *c* axis of the embedding crystal. × 20.

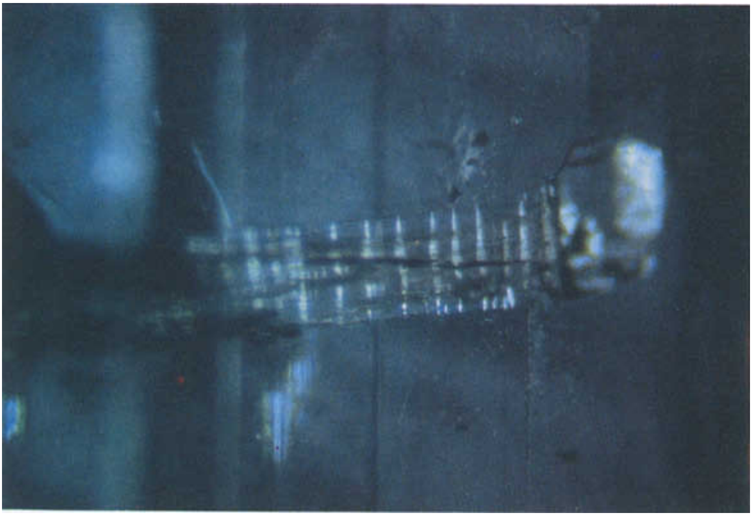

FIG. 12. Tourmaline chatoyancy: Sample 16. Blue tourmaline from Minas Gerais (Brazil). Columnar assemblages referable to muscovite laminae. × 40.

composition did not differ from that of the host crystal. It may therefore be concluded that the most usual filling of the growth-tubes is tourmaline showing a chemical composition as well as a pattern of minor elements similar to that of the embedding crystal.

The other materials recognized in the growth-tubes are prosopite and cookeite (Figure 9). Prosopite usually occurs in veins and greisen associated with quartz, fluorite, mica and caolin as well as tourmaline, and formed apparently as an alteration product of topaz-bearing porphyries. Prosopite can easily be found both in the channels, associated and mixed with tourmaline, and sometimes in the healed fractures as powdery material. Cookeite is also a characteristic of pegmatitic and hydrothermal environments, forming in the last stages of the replacement process developing after early lithium minerals: mainly rubellite and lepidolite, tourmaline and microcline. The opaque material which occurs in the channels was found to be pyrrhotite owing to its iron-sulphur ratio and its appearance.

Laminae of iron oxides can usually be found on the inside surfaces of the growth channels. Their colour varying from red to brownish would suggest their attribution to haematite-maghemite or lepidocrocite respectively (Figure 10). Yellowish haloes have also been noted surrounding some of the channels; the electron microprobe analyses indicated enrichment of iron which would suggest the presence of various iron oxides, related to the previously described ones.

The needles, which are also responsible for setting up the phenomenon of chatoyancy, are both consituted by birefringent long thin crystalline fibres and by straight elongated birefringent rods (Figure 11).

The former sometimes appear slightly undulating, though strictly parallel among themselves, and their ends often deviate from a strictly linear direction. Microanalyses show in this case also no difference between the chemical composition of the inclusions and that of the embedding tourmaline. Small fragments and laminae of opaque material, presumably sulphides, are frequently interbedded with such fibres.

The birefringent rods turned out to be made up of epidote, whose chemical composition was close to that of the calcium end-member clinozoisite. This mineral, which is characteristic of medium grade regionally metamorphosed igneous and sedimentary rocks, can be found also in metasomatic environments, sometimes crystallizing from hydrothermal liquids in vugs and fissures extremely poor in iron as clinozoisite.

The columnar assemblage which was found in a few green elbaite samples consists of a succession of subhexagonal muscovite laminae (Figure 12). This mineral is characterized of the same late magmatic stage as tourmaline, being found in a pegmatitic and hydrothermal environment. Its low sodium content suggests crystallization temperatures below 400 °C for all samples.

CONCLUSION

The data collected from the numerous tourmaline samples examined suggest that, among the various inclusions which may be found in this mineral, the trichites are not linked to the colour of the embedding crystal, the growth-tubes seem more frequent in the green specimens, while the needles are more often found in the blue and red ones.

As far as the cat's-eye effect is concerned, it may be stated that it is mainly caused by growth-tubes, filled primarily with tourmaline and secondly with prosopite, cookeite, iron-oxides and sulphides, as well as by needles also consisting of tourmaline and, in a few cases, of epidote.

ACKNOWLEDGEMENTS

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AN UNUSUAL GARNET FROM UMBA VALLEY, TANZANIA

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ABSTRACT

A yellowish-brown garnet from Umba Valley, Tanzania, is described. The unit cell dimension, refractive index and density were found as $a_0 = 11.627$ Å, $n = 1.762$, and $D = 3.68$ g/cm^3, respectively. The garnet is a member of the pyrope-spessartite solid solution series with an extremely high grossularite component and has a composition of 28.5% pyrope, 24.0% grossularite, 43.6% spessartite, 3.3% almandine, and 0.6% goldmanite. The absorption spectrum shows bands of Fe^{2+} and Mn^{2+} on X-sites, and of Fe^{3+} and V^{3+} on Y-sites of the garnet lattice. Because of the low vanadium content of only 0.2% V_2O_3, the intensity of the V^{3+}-absorption band is too weak to produce an alexandrite effect, as described in other vanadium-bearing garnets.

Garnets are nesosilicates with the general formula $X_3Y_2[SiO_4]_3$. In nature different garnet solid solution series are observed, e.g., between the end members pyrope, $Mg_3Al_2[SiO_4]_3$, almandine, $Fe_3Al_2[SiO_4]_3$, and spessartite, $Mn_3Al_2[SiO_4]_3$. In the members of the solid solution series mentioned, the Y-position of the garnet structure is occupied by Al^{3+} while the X-position is occupied by different amounts of Mg^{2+}, Fe^{2+}, and Mn^{2+} as well as to a certain extent by Ca^{2+}. The members of the solid solution series pyrope, almandine, and spessartite, which may also contain distinct amounts of CaO, i.e., distinct amounts of the grossularite end member, are called pyralspite garnets.

The variously coloured pyralspite garnets from Umba Valley, Tanzania, are members of the solid solution series pyrope-almandine and pyrope-spessartite (Schmetzer & Bank, 1981a). Chemical investigations by the electron microprobe showed the members of the solid solution series pyrope-almandine to have a composition between 26% and 73% pyrope, between 15% and 61% almandine, between 1% and 11% as well as between 0% and 20% spessartite and grossularite. The garnets of the solid solution series pyrope-spessartite from this locality were found to contain between 5% and 51% pyrope, between 38% and 86% spessartite and minor amounts of almandine (between 1% and 10%) and grossularite (between 4% and 11%). In garnets of this second solid solution series, containing additional, but small, amounts of V_2O_3 and/or Cr_2O_3, a distinct alexandrite effect is observed. Crystals of

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this composition are described from Umba Valley, Tanzania, and from Ratnapura, Sri Lanka (Zwaan, 1974; Jobbins *et al.*, 1978; Schmetzer & Ottemann, 1979; Schmetzer & Bank, 1981b).

The investigations, described in this paper, were undertaken because of the unusual yellowish-brown colour of a garnet from Umba, which was not observed before in a member of the different garnet solid solution series from this locality (Figure 1). Chemical investigations showed the composition of the sample to be outside of the known solid solution field for Umba garnets. Therefore, the chemical and physical data of the garnet and the cause of its unusual colour are discussed in this paper.

FIG. 1. Yellowish-brown member of the pyrope-spessartite-grossularite solid solution series, Umba Valley, Tanzania; size of the sample approx. 6×9 mm.

The results of the chemical and physical investigations of the yellowish-brown garnet from Umba are given in Table 1. The sample is a member of the solid solution series pyrope-spessartite with an extremely high content of 24.0% of the grossularite molecule. The pyrope-spessartite garnets, described by different authors, show a maximum content of 6.85% CaO (17.7% of the grossularite end member), which was found in a greyish/orange brown crystal by Jobbins *et al.* (1978).

The parameter of the unit cell, determined to be $a_o = 11.627$ Å is larger than for other members of the pyrope-spessartite solid solution which contain smaller amounts of CaO. The refractive index ($n = 1.762$) is distinctly higher, while the density ($D = 3.86$ g/cm^3) shows only a small increase compared with other garnets of the pyrope-spessartite solid solution series with similar MnO contents (e.g., sample E, Schmetzer & Bank, 1981b). These differences in the physical data are explained by an isomorphic replacement of Mg^{2+} and Ca^{2+} on X-positions of the garnet lattice.

TABLE 1

Chemical and physical data of pyrope-spessartite-grossularite garnet, Umba Valley, Tanzania.

Microprobe analysis, in weight-%		cations calculated to $\Sigma O = 12$	
MgO	7.41	Mg	0.842
CaO	8.88	Ca	0.725
MnO	19.94	Mn	1.288
FeO^{+}	1.53	Fe	0.098
Al_2O_3	22.03	Al	1.980
V_2O_3	0.18	V	0.011
Cr_2O_3	———$^{+++}$	Cr	———
SiO_2	39.56	Si	3.017
TiO_2^{++}	0.24	Ti	0.014
Σ	99.77	Σ	7.975

$^{+}$total iron as FeO

$^{++}$total titanium as TiO_2

$^{+++}Cr_2O_3 < 0.05$

Composition of end members, in wt%		Physical data
pyrope	28.5	$a_o = 11.6267(2)$ Å
grossularite	24.0	$n_D = 1.762(1)$
spessartite	43.6	$D = 3.86(1)$ g/cm^3
almandine	3.3	colour after DIN 6164
goldmanite	0.6	between 2:5:3 and 2:5:4
Σ	100.0	

The chemical composition of pyrope-spessartite-grossularite garnets from Umba Valley, Tanzania, and Ratnapura, Sri Lanka, is shown in Figure 2. The garnets of both localities have similar chemical compositions; therefore, a single garnet crystal cannot be assigned to either of these localities because of its composition and physical properties (refractive index, density, parameter of the unit cell). The pyrope-spessartite-garnets from Sri Lanka are, up to now, very rare, whereas great quantities of the orange brown coloured pyralspites from Umba are available in the gemstone market.

According to Novak & Gibbs (1971), all garnets of the system pyrope-almandine-spessartite-grossularite are situated in one stability field because of the ionic radii of the X- and Y-cations. The stability of garnets in the quaternary system has been calculated by Ganguly & Kennedy (1974). The members of the solid solution series mentioned above are found to be stable at 600 °C for all compositions. Therefore, it has to be clarified by further

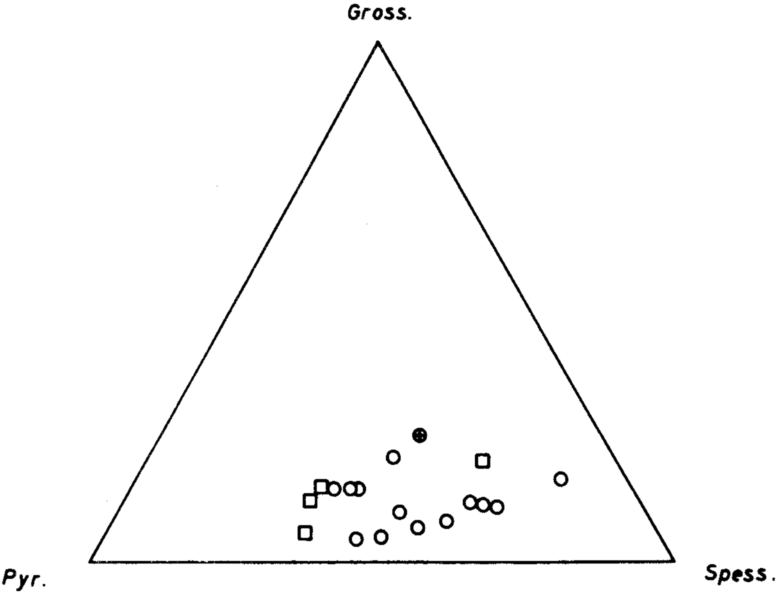

FIG. 2. The pyrope-spessartite-grossularite ratio of members of the pyrope-spessartite solid solution series from Umba, Tanzania (○), and Ratnapura, Sri Lanka (□); chemical data from Jobbins *et al.* (1978), Schmetzer & Ottemann (1979), Schmetzer & Bank (1981a, b). The crystal with a content of the grossularite end member of 24.0% is individually marked (⊕).

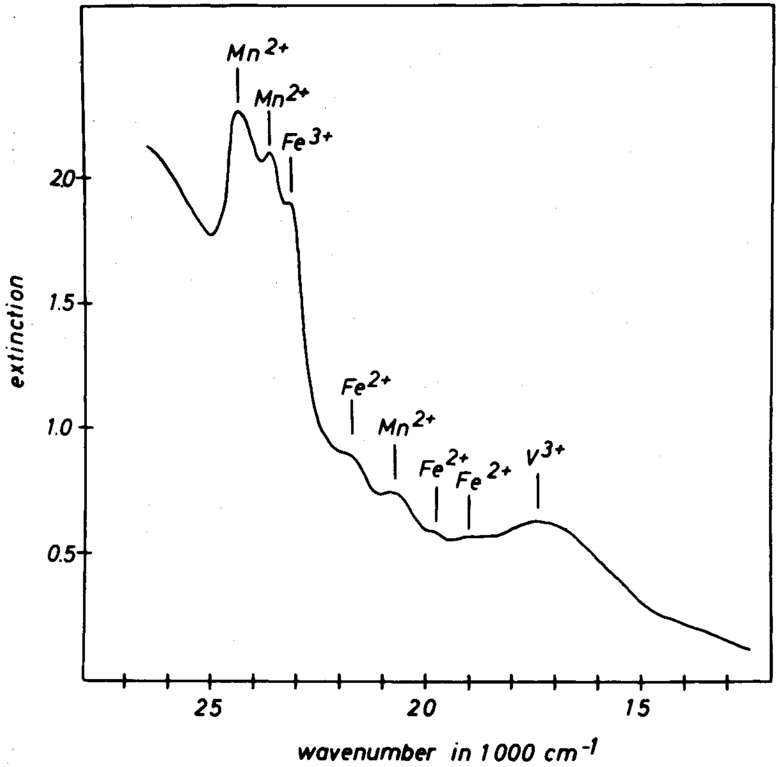

FIG. 3. Absorption spectrum of a pyrope-spessartite-grossularite garnet, Umba Valley, Tanzania.

chemical investigations and not by theoretical considerations as to whether the solid solution field shown in Figure 2 can be enlarged for other garnets of different chemical composition. Only little information is available on the metamorphic p-t-conditions of the wall rocks of the Umba garnets; therefore, the exact pressure and temperature of formation are still unknown.

The absorption spectrum of the pyrope-spessartite-grossularite crystal described in this paper, shows absorption bands, whose positions are identical with those known for pyralspite garnets (Moore & White, 1972; Loh, 1975; Schmetzer & Ottemann, 1979). The absorption bands are assigned to Fe^{2+} and Mn^{2+} on cubic X-sites and to V^{3+} and Fe^{3+} on octahedral Y-sites in the garnet lattice (Table 2). The spectrum of the garnet shows an absorption band of V^{3+} at 17 500 cm^{-1}, which is not observed in the spectra of orange-

TABLE 2
Spectroscopic data of pyrope-spessartite-grossularite garnet, Umba Valley, Tanzania.

Absorption maxima $[cm^{-1}]$	Assignment cation	lattice site
17 500	V^{3+}	Y (oct.)
19 000	Fe^{2+}	X (cub.)
19 800	Fe^{2+}	X (cub.)
20 800	Mn^{2+}	X (cub.)
21 800	Fe^{2+}	X (cub.)
23 200	Fe^{3+}	Y (oct.)
23 700	Mn^{2+}	X (cub.)
24 450	Mn^{2+}	X (cub.)

coloured pyralspite garnets from Umba. This absorption band, however, is known from the spectra of alexandrite-like garnets from the same locality (Schmetzer & Ottemann, 1979). These alexandrite-like garnets, in general, contain distinctly higher amounts of V_2O_3 and/or Cr_2O_3 compared with the garnet described in this paper. The absorption at 17 500 cm^{-1} (yellow region of the visible area) in those alexandrite-like pyralspites is stronger and therefore produces a distinct minimum in the bluish-green area, which is also observed in other solids showing an alexandrite effect (Schmetzer *et al.,* 1980). The bluish-green minimum, however, is not found in the spectrum of the yellowish-brown garnet and, therefore, an alexandrite-effect is not observed in this crystal. Due to its colour, the sample is the connecting link between the V- and/or Cr-containing alexandrite-like pyralspites from Umba and the orange-coloured members of this solid solution series, in which, generally, no V- or Cr-contents are observed.

The author is grateful to Dr H. Krupp, of Heidelberg, for the sample and to Dr H.-J. Bernhardt, of Hamburg, for the microprobe analysis.

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A STRANGE REPORT ON GOLDSTONE

By R. KEITH MITCHELL, F.G.A.

A recent gemmological study report published in the *Australian Gemmologist* (1981, 14, 6, 139) and entitled 'Some observations on goldstone' draws some extraordinary conclusions which cannot be accepted. Predictably the investigation found the material to be crown glass with the constants and physical characters expected of that material, and to contain angular flakes of metallic copper. It is in the nature of the copper particles that the investigation appears to be at loggerheads with the established facts. The conclusions in question are: 'The reflective flakes in goldstone are *not* the product of crystallization; the flat *machined* flakes being added to the molten glass before it is cooled.' 'Included reflective flakes appear to possess a *preferred orientation*—sub-parallel sheets parallel to the surface of the glass.'* This preferred orientation seems to be advanced as justification for the first conclusion.

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*The italics are mine.

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Now each piece of 'goldstone' is crowded with thousands, possibly millions, of these microscopic specks, varying in size from about 0.2 mm down to invisibility at 50× magnification. They are by no means always oriented in the way described. I have a three-sided seal stone of this material which has faceted edges and ends. There is no apparent difference in the spangling of any of the surfaces thus exposed. Further, as the angle of the surface is changed under a fixed light source some flakes extinguish and others start to reflect without any real diminution of the over-all effect.

The suggestion that these millions of ultra-thin plates could be machined, presumably shaped, cut and polished, before inclusion in the molten glass (the fact that this is before it is cooled is rather obvious) is economically quite unsound. Even if it were feasible costwise, such admixture could not be achieved without oxidation of the copper and would almost certainly show swirls and concentrations of flakes which are not usually present. A few old pieces have shown swirls suggesting that the glass was stirred, probably as a deliberate decorative effect, or pressed into moulds, while in a viscous state.

The vast majority of the flakes are equilateral triangles, although they can photograph to look isosceles or even scalene when they are inclined to the film plane of the camera. Some have their corners truncated by other faces of the octahedron, some to the extent that they become hexagonal. But the angles are always precisely 60° or 120°, which argues beyond doubt that they are the product of crystallization.

Copper crystallizes in the cubic system, and one of its common habits is that of octahedral plates, i.e. equilateral triangles. In the circumstances a cooling glass containing a labile (super-saturated) solution of copper could be expected to give an even distribution of ultra-thin microscopic octahedral plates in the essential form of equilateral triangles or truncated forms derived therefrom. It may also be noted that a few flakes examined in the course of my own work have shown surface markings paralleling crystal edges, which again suggest crystals rather than artificially shaped particles. Under greater magnification I have been able to get reflection from angled edges on some triangular flakes, which suggest truncation by a neighbouring octahedral face.

A letter from Dr Michael Cable, of the University of Sheffield Department of Ceramics, Glasses and Polymers, gives the following information: 'Aventurine glass is made in the usual way and the crystals precipitated out and grown by very slow cooling (e.g. 4 days to cool to annealing temperature). It is not made by stirring copper filings in glass merely to get a physical mixture. . . . . According to Peligot* the copper is always added to the original glass batch and will therefore either all dissolve in the melt or, possibly, form a pool of molten metal at the bottom of the pot: I have done this myself many times.'

Now this information that the glass is cooled over a long period suggests a reason for the apparently preferred orientation of the copper crystals. This feature is certainly seen in flat pieces of goldstone intended for use in seal rings or other articles needing a thin flat stone. Obviously a preformed flat sheet represents a saving in manufacturing costs and I would suggest that it is probably a practice to pour the saturated molten glass on to a smooth horizontal surface, where it is maintained at high temperature for the required cooling period. With the glass completely molten the embryo copper crystallites, being some four times as dense as the host glass, would gravitate to the bottom and, like leaves falling from a tree, would tend to lie flat. This, I submit, deals adequately with the matter of the 'preferred orientation'.

Dr Cable goes on to say that he has encountered aventurine glass with green spangles. These are due to the addition of chromium in the form of chromic oxide. Also, some coppery crystals seen in other examples are possibly cuprous oxide rather than the pure copper crystals seen in most examples of this decorative paste. In the latter case it is recorded by Peligot that iron filings are stirred in to reduce and to cause the copper to precipitate out.

But I think the case for the spangles being crystalline is beyond all doubt. Regrettably, I feel that the Australian Study Club have been hasty in arriving at conclusions without due thought and consideration. This is unusual. Their work in the past has made some interesting contributions to gemmology.

[*Manuscript received 15th September 1981.*]

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*Eugene Peligot, *Le Verre; son histoire, sa fabrication*, Paris, 1877.

AN INTERESTING GREEN CABOCHON

By R. KEITH MITCHELL, F.G.A.

My old friend and former student, Henry Whitehead, the Correspondence Instructor whose untimely death was reported in 1980,[*] was a travelled man and twice in his retirement he visited Sri Lanka. Inevitably he collected various gems but, unfortunately, did not always record their provenance.

Christopher Cavey bought some of these stones and I helped Dr Colin Whitehead, the son, by buying the remainder. Among Mr Cavey's selection is a small green cabochon of 1.60 carats, closely resembling very fine jadeite, or possibly Australian chrysoprase, in colour. But its most puzzling features are the masses of acicular inclusions which radiate from a number of centres in the stone (see Figure 1). These needle-like crystals appear to be isotropic, but between crossed polars something resembling a uniaxial interference figure is to be seen over the points of origin of the groups.

A careful RI was taken, giving 1.523, and the SG was found to be below 2.86 (Anderson, 2.64). Under the Chelsea filter the stone remained green. There was no observable absorption spectrum. Mr Anderson found that the gem scratched glass and it was apparently harder than 5. It was, however, warm to the tongue, although no bubbles or swirls were detected.

No other similar stone had been seen by any of us and I was sufficiently intrigued to enlist the aid of Mr Alan Jobbins and Dr Roger Harding, of the Institute of Geological Sciences. The former confirmed the findings and observations so far made and the stone was passed to Dr Harding for analysis by electron microprobe, with the following results.

The needle-like inclusions were positively identified as apatite, while the host material, which apparently provided the fine green colour, was identified as a glass with a composition essentially that of a sodium calcium silicate ($Na_{19}K_1Ca_{10}Mg_2Si_{38}O_{100}$), plus about 10% of some other unidentified constituent, possibly boron, lithium or even water. Colour may have been due to iron or

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[*] J.Gemm., 1980, XVI, 3, 201 and 5, 345.—Ed.

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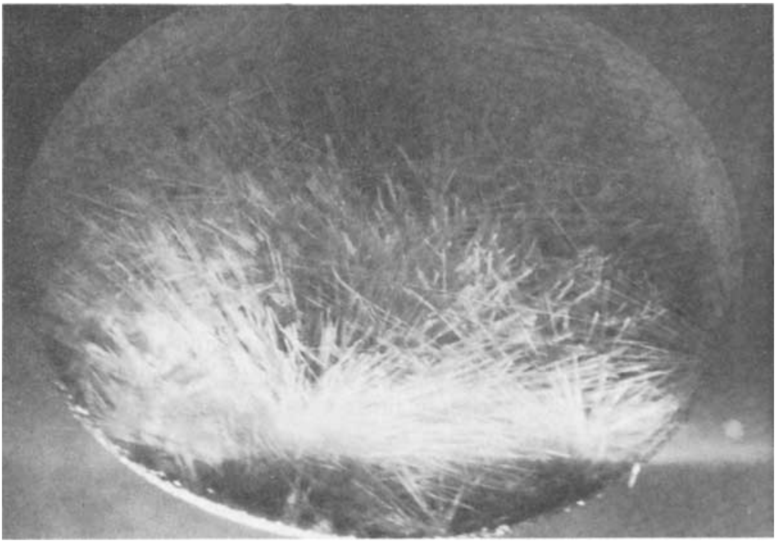

FIG. 1 Radiating needle-like crystals of apatite in a matrix of fine green glass.

chromium in the glass, but this was not evident in the absorption spectrum.

No indication whatsoever has been found of how the stone came into Henry Whitehead's possession. It could possibly be a natural glass, but a fortuitous slag seems more likely. There is always the possibility that it has been made deliberately to imitate fine jadeite. It would not be the first time that has been done, especially by the Chinese. But the resemblance is superficial and in colour only, the inclusions being quite incompatible with natural jadeite. Perhaps a reader somewhere has more information on this interesting material. There must be more than this single specimen around. One thing is certain, and that is that even a glass can provide some surprises!

I record with considerable appreciation and gratitude the work done by Dr Harding and Mr Jobbins in this investigation, and at the same time thank Mr Cavey for permission to publish the details.

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BLUE COLOUR-CHANGING KYANITE FROM EAST AFRICA

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ABSTRACT

The chromophore pairs Fe + (Ti) and Cr + Fe are shown to produce the various blue colorations of Kyanites rather than titanium traces, claimed in earlier reports to be the only cause for the blue hues. Vanadium and manganese have no apparent influence on the blue when present at trace levels.

As a novelty, Cr + Fe or Cr alone has been found to be responsible for an alexandrite effect displayed by a kyanite crystal from East Africa.

INTRODUCTION

Kyanite is rarely encountered as a faceted gem because it is difficult to cut. This is due to its perfect cleavage and marked anisotropy in hardness. The mineral commonly occurs in blue to bluish green hues. The intensely blue kyanites from Kenya and Tanzania are especially attractive, some resembling sapphire in colour and transparency. Three years ago, one of the authors was shown a crystal of this colour by a gemstone dealer in Nairobi. During a recent visit, the authors were presented with another unusual crystal specimen of kyanite. It exhibited a strong pleochroism and, in one direction, was definitely light green in daylight and changed to reddish in incandescent light. The term 'alexandrite-like' arose in the discussion with the dealer. It was decided to analyse this kyanite sample, together with three other collection stones from East Africa.

CHEMICAL COMPOSITION

Detailed analyses were performed on four kyanite samples (Table 1) using an ARL-SEMQ microprobe combined with an energy-dispersive detector system (Tracor-Northern). The microprobe was operated at an accelerating voltage of 15 kV and a sample current of 15 nanoamperes. To minimize drift effects,

ISSN: 0022-1252 XVIII (3) 205 (1982)

TABLE 1. Microprobe analyses of East African Kyanites

sample	(1) colour-changing kyanite	(2) dark blue kyanite	(3) blue kyanite	(4) brown kyanite	blue kyanite (Kenya)	blue kyanite (India)
SiO_2	37.08 ± 0.30	37.00 ± 0.29	37.44 ± 0.32	36.85 ± 0.31	—	—
Al_2O_3	62.10 ± 0.18	62.20 ± 0.20	61.83 ± 0.17	61.30 ± 0.19	—	—
TiO_2	$\lesssim$.04*	<.05	<.05	<.05	.07	.01
Fe_2O_3	.35 ± 0.04	.87 ± 0.05	1.20 ± 0.10	1.15 ± 0.09	.04	.11
Mn_2O_3	$\lesssim$.04*	<.05	<.05	.30 ± 0.06	—	—
Cr_2O_3	.50 ± 0.07	<.05	<.05	.10 ± 0.05	.23	.01
V_2O_3	$\lesssim$.04*	<.05	<.05	<.05	.60	.03
total	100.03	100.07	100.50	99.70		
	cations on the basis of 20 oxygens					
Si	4.01	4.00	4.03	4.01		
Al	7.92 } 7.99	7.92 } 7.99	7.86 } 7.96	7.86 } 7.98		
Fe^{3+}	.03	.07	.10	.09		
Mn^{3+}	—	—	—	.02	References	
Cr^{3+}	.04	—	—	.01	Schmetzer (1978)	White (1967)

no. 1 intense greenish blue kyanite crystal from Kenya/Tanzania, 10 × 5 × 3 mm
no. 2 dark blue kyanite, cut gem, 0.31ct, from Kenya/Tanzania, 4.2 × 3.9 × 2.1 mm
no. 3 blue kyanite crystal, Machakos District, Kenya, 30 × 10 × 8 mm
no. 4 translucent brown kyanite crystal, Emali (?), Tanzania, 14 × 5 × 3 mm
*EDS-XRF data

counting time was controlled by means of beam current integration. For standardization, natural and synthetic compounds were used. Data reduction was accomplished with a ZAF-type correction program. Analytical details are described by Schwander & Gloor (1980).

Kyanite, the high pressure polymorph of Al_2SiO_5, usually contains only minor amounts of impurities such as Ti, Fe, Mn, Cr, or V. White & White (1967) reported that the characteristic blue colour of kyanite is caused by the presence of very small Ti^{3+} contents. Smith & Strens (1976) and Schmetzer (1978) related it to the charge transfer pair Fe^{2+}/Ti^{4+} and to the variable chromophore contents. Chromium-bearing kyanites are typically found in high-pressure rocks, as, e.g., eclogite or glaucophane schist, and show a blue or green colour. The presence of transition elements causes different colours. This has been summarized by Ribbe (1980):

substitution of Al^{3+} on octahedral sites in synthetic kyanites by	resulting colour
Fe^{3+}	yellow-green
Mn^{3+}	orange-yellow
V^{3+}	greyish-green
Cr^{3+}	green

The analyses of East African kyanites represented in Table 1 reveal considerable amounts of Fe, Cr and, in one case, Mn, whereas Ti as well as V are below the detection limit of the microprobe ($\leqslant 0.05\%$). It should be stressed that V is common in East African kyanites and often exceeds the Cr concentration (Schmetzer, 1978). Variable amounts of Fe can be observed in our four samples. They range up to 1.20 weight-% Fe_2O_3 in sample no.3. Specimen no.4 exhibits a brown colour which is due to the combination of Mn with Fe and Cr.

Of special interest is the composition of sample no.1. It shows a distinct colour-change effect. This sample contains a substantial amount of chromium which clearly exceeds the iron content. An additional XRF analysis of this specimen by an energy-dispersive detector system showed concentrations of Ti, Mn, and V, each of them being < 300 ppm. From this it may be concluded that the special colour effect observable in no.1 is mainly due to Cr, in the relative absence of V.

ABSORPTION SPECTRA OF BLUE KYANITES

White & White (1967) postulated that the characteristic blue colour of kyanites is generated by Ti^{3+} concentrations of as little as 50 ppm (0.005%), while considerably higher ferric iron contents could vary widely without affecting the colour. No clear correlation to minor contents of chromium, vanadium or manganese was detected either.

The first three samples of Table 1 seem to contradict the statement that Ti is the only cause for the blue coloration. The UV-VIS spectra of samples no. 2 and 3 are dominated by a very broad absorption band between approximately 540 and 800 nm. According to Schmetzer (1978) it has to be attributed to the charge transfer pair Fe^{2+}/Ti^{4+} and to eventual traces of Cr. Titanium, however, being supposed to produce a very strong and sharp peak at 600 nm in the gamma ray spectrum at trace level already, does not clearly show up in the absorption of the two iron-bearing samples. In contrast, Fe^{3+} underlines its presence by a triplet in the violet region (431 > 446 > 452 nm) and a slightly stronger one in the near ultraviolet (379 > 369 > 374 nm). The alpha and gamma ray spectra of no. 2 and 3 are strikingly similar to the extraordinary and ordinary ray absorption of blue sapphire, with a corresponding pleochroism of light bluish green and intense blue.

The alexandrite-like sample no. 1, strongly deviating in its chromophore content, is bound to exhibit a different optical spectrum and pleochroism but not necessarily another colour than blue. Bank (1980), though, described a kyanite from Tanzania with Cr, Fe, V, and Ti impurities to be 'emerald green' (but not colour-changing). The absorption of all three rays in Figure 1 essentially is characterized by the bands and absorption lines of chromium, the strongest of which appear in the red region as in many other chromic solids (e.g. in aluminates and aluminosilicates). The alpha ray of no. 1 displays the purest chromium spectrum while only the gamma vibration shows a clear but comparatively weak iron interference in the violet portion and around 620 nm as described above for samples no. 2 and 3. Gamma is almost the same greenish blue as beta but more saturated. Both are intense colours visible through the planes of the cleavage platelets. As is common in blue kyanites, the alpha ray is the weakest. It is seen in the direction parallel to the planes of the perfect cleavage (100) and perpendicular to the length of the crystal as a light green colour in daylight, changing to an obvious purple in incandescent light.

References to blue kyanites in recent mineralogical literature are numerous, but reference to specimens of kyanite with an elevated chromium content in gemmological journals is scarce. Liddicoat (1973) pictured a fine drawing of a spectroscope observation, however not giving any description or interpretation. As shown in Table 1, the chromium concentration of sample no. 1 is unusually high for cuttable material from East Africa, and exceeds the iron (and vanadium) contents. Line and band centre positions therefore are listed briefly, the relative intensities being left away for the sake of clarity:

Alpha 706, 688, 668, 657, 648, 578, 482, 475, 466, 461, 417 nm (± 1 nm)
Beta 704D, 688D, 663, 657, 651, 643, 582, 482, 475, 466, 461, 415 nm
Gamma 707, 688, 668, 660, 652, 616, 486, 476, 461, 443, 428, 415 nm

At liquid nitrogen temperature (LNT) the bands (underlined figures) shift to lower wavelengths and the lines sharpen up and become stronger. A number of new weak lines appear and the beta doublet at 704 nm (D) resolves into a triplet. The absorption edge moves from approximately 320 nm (RT) to 310 nm (LNT).

The chromium containing specimen no. 1 weakly fluoresces red under the stimulus of long-wave ultraviolet radiation as opposed to the iron-rich samples no. 2 and 3 which are inert.

THE ALEXANDRITE EFFECT IN BLUE KYANITE

Purity and depth of a colour depend on the steepness and strength of the absorption bands and on the degree of transparency between the bands. If the positions and depths of these transmitting areas (absorption minima) are appropriate, the alexandrite effect may become visible. It follows that the strength of this colour change phenomenon also depends on the position, steepness and intensity of the absorption minima, i.e. on the composition of the colouring transition metal impurities (substituting aluminium on the sites of certain distorted coordination octahedra). This phenomenon has been explained and the conditions for it to be observable have been derived by White *et al.* (1967) and Schmetzer *et al.* (1980). The prediction that a greater number of minerals could theoretically show the colour-change is supported by recent reports on alexandrite-like garnet, corundum, spinel, fluorite and, as a latest addition to the list, kyanite.

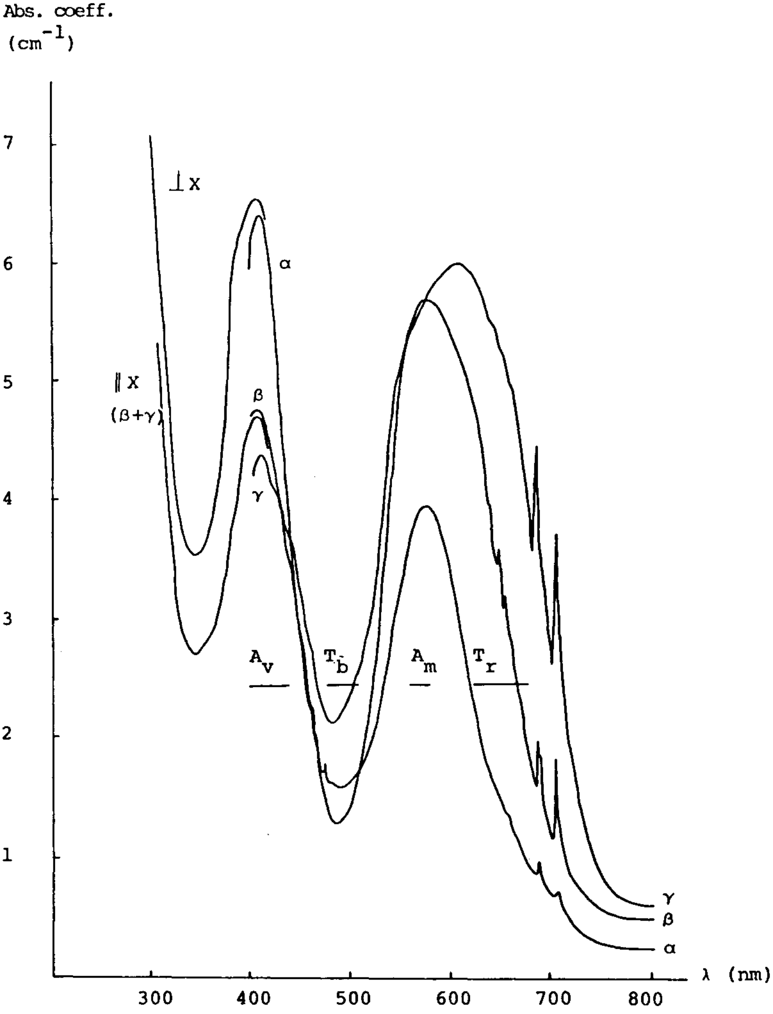

FIG. 1. Optical absorption spectra of chromium in a transparent blue colour-changing kyanite crystal from East Africa, polarized in the range of 400 to 800 nanometres and recorded at room temperature on a PYE Unicam SP8-100 UV-VIS spectrophotometer. Absorption coefficient is approximate.

The conditions for the alexandrite effect to become visible are (according to Schmetzer *et al.*, 1980):

—transmission in the red region above approximately 625 nm (T_r in Figure 1),

—strong absorption in the yellow-green part with a maximum between approx. 580 and 560 nm (A_m),

—transmission in the green to green-blue region (T_b) with an absorption minimum between approx. 510 and 475 nm,

—continuous absorption in the violet part from about 460 nm to the end of the visible (A_v),

—appropriate spectral composition of the two illuminants (White *et al.*, 1967).

The phenomenon in sample no. 1 is caused by one vibration only (Figure 1). The pure chromium spectrum of the alpha ray fulfils the conditions and accordingly presents light green in daylight and purple in incandescent light. The beta ray does not transmit enough of the red wavelengths and gamma absorbs them almost totally. As a result of their strong transmission around 485 nm, the hue of beta and gamma is an intense greenish blue.

At present there are no criteria how to classify colour changes differing from the alexandrite effect *sensu stricto* (green/red).

PHYSICAL DATA

Refractive indices of specimen no. 1 were determined as:

$$n_\alpha = 1.714 \qquad n_\beta = 1.724 \qquad n_\gamma = 1.731$$

The birefringence is −0.017 and the optical axial angle $2V_x$ was determined as being 82° (universal stage with immersion). These figures are slightly on the high side, but typical for gem material and reflecting the minor element contents it possesses. The specific gravity was found to be 3.676 ± 0.004.

The alexandrite-like kyanite yields a variety of inclusions; the most frequent and interesting ones are oriented exsolutions of what appears to be rutile (Deer *et al.*, 1962). These reflective inclusions are long and short acicular when parallel to the platelet faces but more platy when perpendicular to them. Long growth tubes are parallel to the long direction of the crystal. In the same direction there are planar healing fissures consisting of mainly small negative crystals filled with a liquid and little gas. Other inclusions are fissures encrusted with goethite or haematite and colourless resorbed crystal prisms with tension haloes.

ACKNOWLEDGEMENTS

Thanks are due to Dr W. B. Stern for the analysis of trace element contents by EDS-XRF, and Mr U. Näf for assistance in drawing Figure 1, both of the Mineralogical Institute, University of Basel, Switzerland.

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NEAR-COLOURLESS ENSTATITE FROM SRI LANKA

By R. R. HARDING, B.Sc., D.Phil., F.G.A.,
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A roughly faceted gemstone obtained in Sri Lanka in 1981 was submitted for examination to the Institute by one author (C.H.W.). The stone was broken during postal transit when the facile cleavage became only too apparent; several pieces resulted from the impact, the largest weighing 8.08 carats and measuring 14 × 5 × 7 mm. The large fragment is almost colourless, but shows a faint brownish-pink colour when viewed along its length. Pleochroism is not apparent in sections 1 mm thick and barely visible at 2 mm; above 7 mm faint tints of brownish-pink and greyish-green are visible in the adjacent windows of a calcite dichroscope. The material is inert under ultraviolet light and between crossed filters (copper sulphate solution and red glass); it shows green through the Chelsea filter.

The refractive indices, determined in sodium light using a Rayner Dialdex refractometer, were α 1.658, β 1.661, γ 1.668 (all ± 0.001). The material is optically biaxial positive. The density, determined by hydrostatic weighing in toluene, is 3.250.

The absorption spectrum is notable with the typical strong narrow band in the green at 506 nm, which appears to be a doublet but is not quite resolvable. This band is flanked on either side by very faint lines at 510 nm and 502.5 nm. A further broad weak band is centred around 543 nm; no bands were seen in the red or blue. This spectrum, usually attributed to ferrous iron in enstatite, is very prominent despite the virtual absence of colour and the low percentage (2.92% FeO) of iron (see Table 1).

Chemical analyses of a polished section of the enstatite were made using a Link Systems energy-dispersive (E.D.) x-ray analyser on a Cambridge Instruments Geoscan electron microprobe. An

ISSN: 0022-1252 XVIII (3) 213 (1982)

accelerating voltage of 15 kV, a specimen current of 5×10^{-9} amps and an electron beam focused to approximately 5 μm were used. The microprobe can measure elements of atomic number 11 (Na) and above, and the limits of detection for each of the oxides measured are about 0.2 wt%. Analyses of seven spots on the enstatite were made and the range, mean and atomic proportions are given in Table 1. The analyses indicate that the enstatite is relatively homogeneous and that the composition lies close to the magnesium end-member of the enstatite-ferrosilite series of pyroxenes. In addition to the elements listed in Table 1, Ti, Mn, Cr, Ni, Ca and Na were sought but not found, and they are below the detection limit of 0.2 wt% oxide. On the basis of 6 oxygen atoms the enstatite formula is $(Mg_{1\cdot84}Fe_{0\cdot08}Al_{0\cdot06})\ (Al_{0\cdot02}Si_{1\cdot98})O_6$.

TABLE 1.
Electron microprobe analysis of enstatite

Wt%	Range (7 analyses)	Mean	Atomic ratio		
SiO_2	57.97– 58.78	58.23	Si	1.980	2.000
Al_2O_3	1.71– 2.11	1.91	Al	0.020	
FeO*	2.86– 3.03	2.92	Al	0.057	1.982
MgO	36.13– 36.70	36.34	Fe	0.083	
Total	99.21–100.34	99.40	Mg	1.842	
			O	6.000	

*Total iron given as FeO.

The Sri Lankan gem is more magnesian than any igneous orthopyroxene quoted by Deer, Howie & Zussman (1978, p.35), but it is closely comparable to a metamorphic enstatite described from the Pamirs, U.S.S.R. (op. cit., p.41). However, it would be rash to infer a metamorphic origin for the Sri Lankan stone merely on a compositional basis. Very tiny colourless inclusions with low relief and high birefringence were examined near the gemstone surface and although microprobe analyses indicated the presence of forsterite (olivine) or another enstatite inclusion there was some overlap into the host mineral and the results were not conclusive. If further stones come to light however, determination of the inclusions would give the best indication as to the geological origin of the gem.

TABLE 2

Observed and calculated x-ray powder diffraction data for gem enstatite from Sri Lanka

I/I_1	d_{obs}	d_{calc}	*hkl*
2	6.33Å	6.334Å	210
10	4.403	4.404	020
1	4.335	4.337	111
1	4.044	4.048	410
1	4.013	4.010	211
14	3.300	3.300	121
90	3.166	3.167	420
35	3.149	3.149	221
1	3.039	3.039	600
16	2.938	2.937	321
100	2.874	2.873	610
8	2.825	2.824	511
3	2.795	2.795	230
10	2.703	2.702	421
30	2.531	2.530	131
1	2.512	2.512	611
10	2.492	2.492	202
18	2.468	2.469 2.468	521 430
2	2.382	2.383	302
4	2.356	2.355	331
<1	2.300	2.300	312
4	2.279	2.279	800
3	2.250	2.252 2.250	402 711
2	2.228	2.228	431
<1	2.183	2.182	412
<1	2.141	2.1404	240
12	2.112	2.1114	630
10	2.092	2.0920	531
5	2.057	2.0574	721
5	2.053	2.0534	512
5	2.024	2.0240	820
4	2.014	2.0141	141
7	1.982	1.9827	440
7	1.978	1.9782	241
12	1.955	1.9552	631
2	1.923	1.9236 1.9224	612 341
3	1.885	1.8852	821
1	1.852	1.8517	441
1	1.850	1.8501	332
1	1.837	1.8365	702
1	1.800	1.8003 1.7991	830 622
8	1.7856	1.7854	10.1.0
5	1.7717	1.7713	541
10	1.7296	1.7296	250
4	1.7004	1.7005	831
4*	1.6952	1.6951	722
2	1.6797Å	1.6796Å	812
1	1.6498	1.6499	242
2	1.6408	1.6406	251
3	1.6077	1.6075	023
2	1.6019	1.6020	10.2.1
2	1.5958	1.5957	902
5	1.5873	1.5872	931
5*	1.5833	1.5836 1.5831	840 223
<1	1.5700	1.5701	912
1	1.5661	1.5662	451
6	1.5236	1.5240	650
8	1.5194	1.5193	12.0.0
1	1.5004	1.5002	922
16	1.4836	1.4839	10.3.1
12	1.4683	1.4687 1.4680	642 060
2	1.4164	1.4165	352
1	1.4044	1.4045 1.4043	751 10.4.0
4	1.3959	1.3961 1.3957	11.0.2 261
9	1.3903	1.3904	11.3.1
<1	1.3782	1.3780	533
<1	1.3592	1.3598 1.3588	813 043
<1	1.3553	1.3554	10.4.1
1	1.3368	1.3366	633
<1	1.3260	1.3260	343
7	1.3056	1.3058	12.3.1
4*	1.3022	1.3023	14.0.0
3	1.2959	1.2962	12.1.2
2	1.2883	1.2883	14.1.0
<1	1.2783	1.2781	114
4	1.2666	1.2669 1.2666	10.5.0 304
4	1.2646	1.2648	262
2	1.2494	1.2498 1.2488	362 14.2.0
1	1.2272	1.2273	852
2	1.1823	1.1824	134
1	1.1396	1.1395	16.0.0
2	1.0704	1.0702	480
2	1.0604	1.0604	381
2	1.0558	1.0558 1.0557	10.0.4 12.6.0
4	1.0470	1.0472 1.0468	14.5.0 971
2	1.0204	1.0205	11.0.4
4	0.9115	0.9116	20.0.0

The intensities are relative peak heights

*Intensity enhanced by overlapping α_2 peak

X-ray powder diffraction data for the gem enstatite were determined from diffractometer charts taken with CuKα radiation at room temperature (around 22 °C) and a scanning speed of 1/8 ° 2θ/min. Silicon ($a = 5.43088$Å at 25 °C) was used as an internal standard. The *d*-spacings, which are listed in Table 2, were provisionally indexed by comparison with data for synthetic enstatite (Stephenson *et al.*, 1966) and were refined using the U.S. Naval Laboratory least squares program for refining cell parameters, giving cell dimensions $a = 18.232 \pm 0.002$Å, $b = 8.808 \pm 0.001$Å, $c = 5.180 \pm 0.001$Å, ($V = 831.9$Å^3), space group *Pbca*. The density corresponding to these cell dimensions and the formula is 3.243 gm cm^{-3} (cf. 3.250 measured density).

In the past most gem enstatites (in yellowish, reddish and greenish-browns) have come from Burma, Sri Lanka and southern India, with bright green chromian stones from the kimberlites of southern Africa. It remains to be seen whether further examples of virtually colourless material are found in the gravels of Sri Lanka or elsewhere.

We acknowledge with thanks helpful discussions with colleagues in the Petrology Unit of the Institute and we are especially indebted to Mr J. E. Rouse for making available the computer program for the refinement of the x-ray data and to Mr D. J. Bland for processing the data. This paper is published by permission of the Director, Institute of Geological Sciences, (NERC).

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THERMOLUMINESCENCE IN ELBAITE

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Tourmaline crystallizes in the trigonal system with the symmetry of space group R3m. Chemically, tourmaline shows a complex formula which may be written as:

$$RY_3Z_6(BO_3)_3Si_6O_{18}(OH,F)_4$$

where R = Na,Ca; Y = Mg,Li,Al,Mn,Cr,V; Z = Al,Fe,Ti.

As is well known, there are three end members in the tourmaline solid-solution series: the magnesian tourmaline or dravite, the iron tourmaline or schorl and the alkali tourmaline or elbaite. An alkali cation-deficient series has also been reported(1).

Extensive crystal structure analyses have been carried out on all members of the tourmaline group(2,3,4,5,6,7).

Group theory predicts the following lattice phonons in tourmaline:

$$\tau = 28\ A_1 + 21\ A_2 + 49\ E$$

Only modes A_1 and E are both IR and Raman active optical phonons. It has been shown elsewhere(8) that all Wyckoff sites present in tourmaline contribute without discrimination to both of the resulting A_1 and E Raman active phonons. Accordingly, it is better to regard tourmaline structure as a framework silicate than as a ring silicate, contrary to what is currently assumed in some structural classifications of minerals.

Diverse nearest neighbour cation interactions in tourmaline have been studied at some extent over the past fifteen years using NMR spectroscopy(11), Mössbauer spectroscopy(14,15,16,17,18,19) and EPR spectroscopy(20,21).*

Tourmaline occurs in a wide range of colours and hues which can be related to its composition. Generally, iron-bearing tourmalines are black, green or blue, while elbaites are pink (rubellite) or colourless (achroite) and dravites are dark brown, yellow or colourless. In addition, some colour changes have been reported on heating(16,18) and gamma irradiation(22a).

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*See D. R. Hutton. *Magnetic Resonance—a Non-destructive Probe of Gemstones,* J.Gemm., 1979, XVI (6), 372-85.—Ed.

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Thermoluminescence (TL) phenomenon in solids often appears to be associated with radiation-induced coloration. As discussed by Nassau(22b) the trap concept contributes to understanding the varying stability of electron and colour centres in minerals with respect to heat bleaching and thermoluminescence.

Under short wave ultraviolet radiation colourless elbaite shows a bright violet emission while crystals with shades of pink and green show a weaker violet fluorescence(23). However, as far as we are aware, no basic research has been devoted to the luminescent behaviour of tourmaline. We report here new data on the thermoluminescence of a single crystal of elbaite before and after x-ray irradiation.

Cell parameters, as well as optical constants and density data belonging to this elbaite, are included in Table I. By means of the electron microprobe a Mn content lower than 0.1% and nil Mg content have been detected in it. Differential scanning calorimetry (DSC) was performed within the 300-750 K temperature range. Our elbaite shows an endothermic peak at 636 K ($\Delta H = 0.1$ cal/g). The above temperature range was also covered in search for thermoluminescence. Further details of experimental set used may be seen in Reference 24.

TABLE I—Physical constants of our elbaite.

Cell Parameters	a_0	15.99 ± 0.01
	c_0	7.06 ± 0.01
Optical constants	ω	1.640
	ε	1.618
Density	D	3.07

Before x-ray irradiation, our elbaite shows at least four TL peaks at 510, 572, 670 and 714 K. After irradiation, the TL maxima appear at 338, 350, 450, 520, 670 and 714 K. In addition, some particular features regarding the intensity, broadening and sift temperature of glow peaks can be seen (Figure 1).

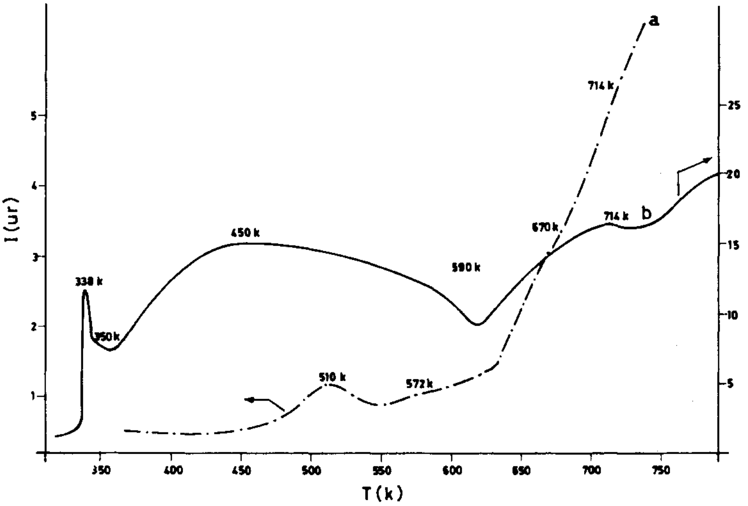

FIG. 1. TL spectrum of elbaite: (a) before and (b) after, x-ray irradiation.

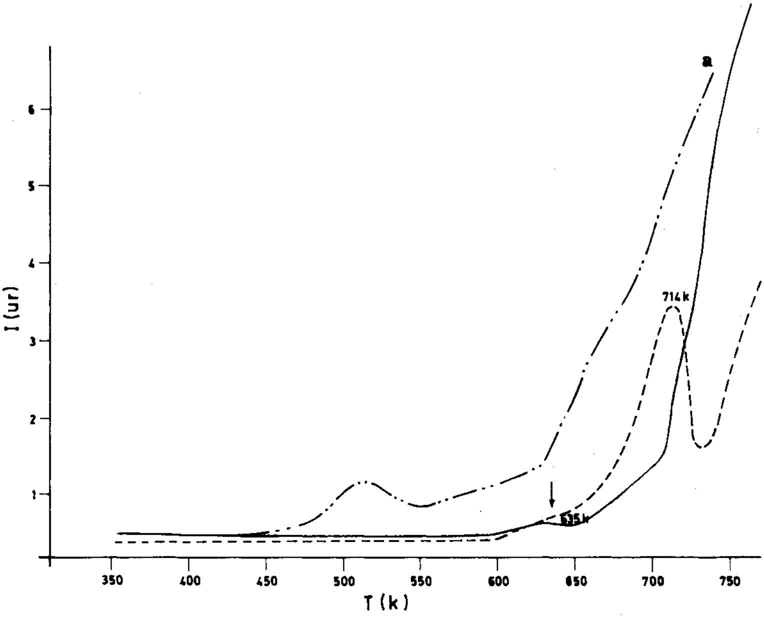

FIG. 2. TL spectra of elbaite before x-ray irradiation separated by standard cleaning technique.

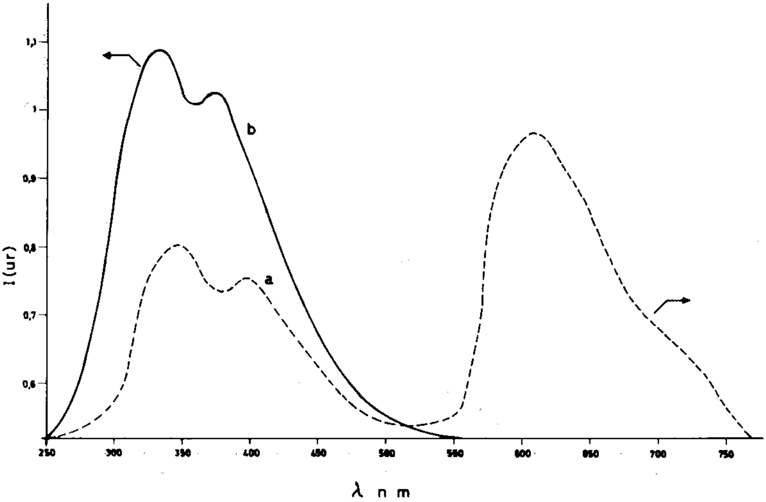

FIG. 3. Emission spectrum of elbaite: (a) before and (b) after, x-ray irradiation.

We were unsuccessful in our attempts to obtain some quantitative information about the TL peaks kinetics because wide overlappings exist among glow peaks. This source of complication has been studied by means of the standard cleaning technique (Figure 2). A salient fact can then be observed: the 636 K TL peak coincides with the temperature at which we have detected a DSC minimum.

All recorded TL peaks show the same emission spectrum. Figure 3 shows the emission spectrum of our elbaite before and after x-ray irradiation. The former consists of three emission bands at 350, 400 and 620 nm. The latter only shows two emission bands at 330 and 375 nm. Tentatively, we believe that the 620 nm emission band could be related to the well known $^4G-^6S$ transition of Mn^{2+} in octahedral coordination(25,26).

At present, no evidence is yet available to us to be able to assume a mechanism by which the experimental observations shown here can be explained, namely the annihilation with radiation of the 620 nm emission band. We hope, however, that additional luminescence studies in connexion with EPR spectroscopy will further provide a more reliable basis to understand the thermal annihilation of colour centres in tourmaline.

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UNDERSTANDING THE HODGKINSON METHOD

By W. WILLIAM HANNEMAN, Ph.D.

Hodgkinson(1) described a technique (visual optics) for deriving, without the aid of instruments, information concerning the RI, birefringence, dispersion, and spectral absorption of a gemstone. In response, Mitchell(2) submitted a 'Letter to the Editor' expressing the opinion that this approach did not produce valid

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results and had not warranted publication. Meanwhile, in America, Hanneman(3) published an article extolling Hodgkinson's approach. This article was abstracted by O'Donoghue(4) with the admonition to 'see' Mitchell's letter. By such action, O'Donoghue raised this letter to the status of a formal scientific report and implied his support of its contents. This indeed represents formidable opposition to an idea.

Gemmologists must be wary to avoid the trap of judging an idea on the basis of its proponents or opponents rather than its intrinsic merits. Science progresses through the resolution of differences of opinions among investigators. To that end, I would like to offer a rebuttal to the Mitchell letter.

Hodgkinson's Method, in its simplest form for a round brilliant-cut gem, consists of three steps.

1. Look through the table of the gem towards a distant light source. Keeping the table perpendicular to the direct line to the light, choose a circle of images formed by light passing through facets having pavilion angles of about 40 degrees. Mentally calculate the diameter of that circle and compare it to what you have observed for known reference gems. On this basis, estimate the RI.

2. Considering the diameter of the circle and the 'spread' of each image, estimate the dispersion of the unknown. This estimate is based on experience gathered from examining known specimens of similar RI (circle diameter). At this point merely deciding whether the dispersion is high, medium or low is usually sufficient.

3. Determine the maximum Birefringence:Dispersion (B:D) ratio as will be described below. It will be necessary to make estimates through several sets of facets to insure obtaining the highest possible value.

In many instances sufficient information may be obtained to positively identify the gem. This is especially true if the impact of colour is also considered.

According to Mitchell, there are four variables militating against the Hodgkinson Method. 1. The unknown RI of the stone. 2. The angle of incident light relative to the pavilion facet. 3. The effects of optic axes. 4. The size of the stone.

I would first like to respond to Mitchell's fourth point concerning the size of the gem as a variable. The size of the gem is not a variable. Exactly the same results are obtained with a 2 mm stone as are obtained with a 100 mm stone cut with the same angles. The inclusion of this point indicates that Mitchell, himself, does not fully understand the optical principles involved. Such being the case, it is understandable why he discarded the idea 45 years ago. However, the fact that Bauer, Dieulafait, Kluge and Mitchell could use the technique only for determining the presence of birefringence is less of an indictment of the technique than of their limitations.

The laws of optics are well founded. Consequently, it is reasonable to expect to be able to provide a physical explanation for every image seen by the eye. Conversely, it is reasonable to expect that effects associated, not only birefringence, but also dispersion, absorption and RI, should be manifested.

Attempts at rationalizing the observed images have been made by Hodgkinson,(1) and Crowningshield & Ellison.(5) In both cases, the explanations were faulty. However, a faulty explanation does not in any way change the fact that differences do indeed exist and they have an origin related to the laws of optics. An explanation is presented below which the author believes is more nearly correct.

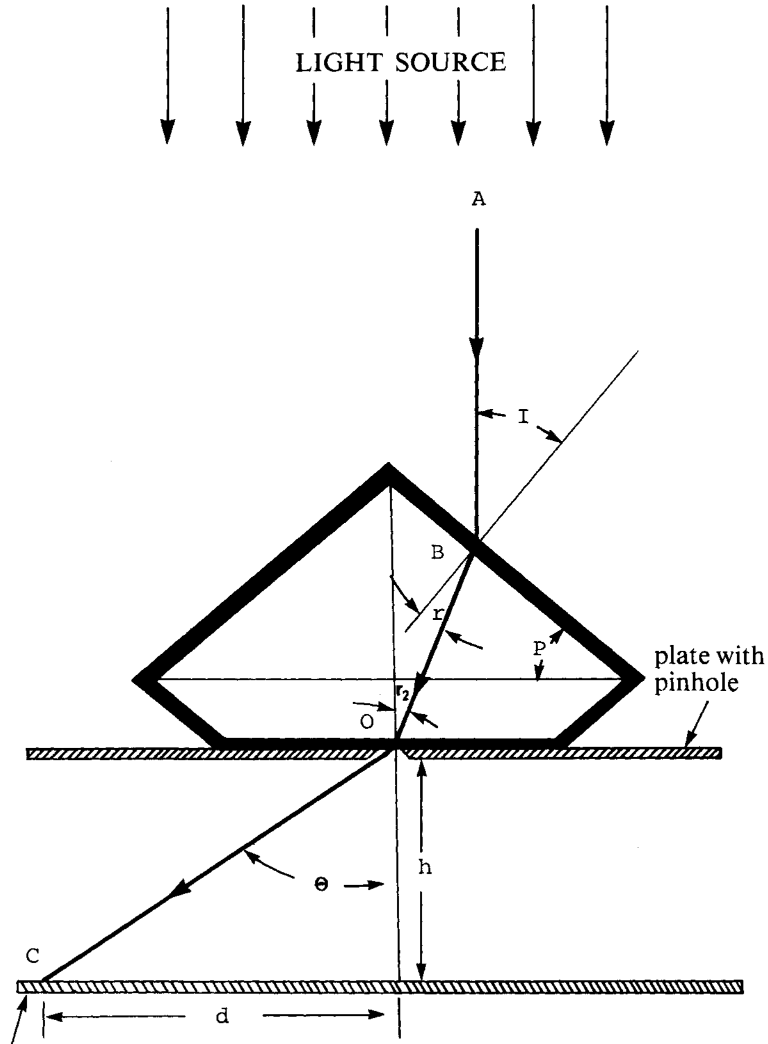
PINHOLE REFRACTOMETER

The eye, a camera and a pinhole can be optically related. One can create a pinhole refractometer in the following manner. Support a flat plate having a pinhole in its centre above a white card, the surface of which has been scribed with a series of concentric circles. Place a round brilliant cut gem over the hole and illuminate it from above. Circles of images of the light will be seen on the card. If the light source is a narrow slit,(3) the images will appear as small spectra (rainbows). This is precisely what one observes in the Hodgkinson Method.

All concepts relating to the pinhole refractometer can also be related to Hodgkinson's visual optics. If the gem is singly refractive, a single image is projected through each facet of the pavilion. If the gem is doubly refractive then two images are seen. This is the point at which Mitchell would have gemmologists stop. However, it is just the beginning.

REFRACTIVE INDEX (nD)

Figure 1 shows the path of a ray of monochromatic sodium light through a single facet of a gem placed on the pinhole



Card scribed with
concentric circles

When ray AB is ⊥ to table of
gem then $\angle P = \angle I$

$P = 40.75°$
$I = 40.75°$
$r = 17.59°$
$r_2 = 23.16°$
$\Theta = 58.16°$
$\frac{d}{h} = \tan \Theta$

FIG. 1. Pinhole Refractometer

refractometer. This is related to Mitchell's first variable. Utilizing the laws of optics, one can derive the formula relating the pavilion angle P of the gem, angles I and θ, and the index of refraction (n) of the gem. One form of the expression is

$$RI = n_D = \sqrt{\sin^2 I + \left[\frac{\sin\theta + \sin I \cos I}{\sin I}\right]^2}$$

The complexity of this expression is why the early investigators, who had no computers, carried the approach no further.

For the moment, let's assume a constant pavilion angle (ca. 40 degrees) for a well cut brilliant gem. By designating a value for h in Figure 1, it is possible to calibrate the distance d in units of nD. The length d is equal to the radius of the circle of images of a light source whose rays are initially travelling parallel to each other, perpendicularly to the table, and transmitted through facets cut at angle P. The diameter of the circle of images seen in the Hodgkinson Method is thus a function of the RI of the gem.

Gross changes in pavilion angles as found in fish-eye gems of course produce gross variations which can, with practice, be accommodated by an agile mind. The Hodgkinson Method has never been promoted as a tool for robots. The average gemmologist can, with a little practice, easily learn to estimate the refractive index of round brilliant cut gems to ±0.05.

DISPERSION

In a pinhole refractometer utilizing white light, each image appears as a spectrum. This is due to the dispersion of the gemstone. If the pinhole refractometer scale were calibrated (constant P) in units of n it would be a simple matter to determine the numerical dispersion ($\frac{\Delta n}{\Delta\lambda}$) value of the gem. Incidentally, dispersion cannot be measured directly by means of a critical angle refractometer. This is one reason why very few gemmologists routinely utilize dispersion as an aid to identification.

When examining images originating through facets cut at steeper angles, the spectra will appear to be broader. However, the numerical value of dispersion measured with a properly calibrated pinhole refractometer scale would be identical. It is just that altering P (or I) alters the value of d for the same value of n and calls for a different calibration scale. In order to estimate dispersion numerically for an irregularly cut gem, one should choose an image which passed through a facet cut at about 40 degrees. This will coincide with round brilliants with which one should have become familiar.

BIREFRINGENCE

In the case of doubly refractive gems two images (spectra) will be seen. For quartz, the two spectra will appear overlapped. For peridot, the spectra will usually appear widely separated.

Using a 'calibrated' scale of n of a pinhole refractometer, one can, as previously described determine the dispersion. Using the position of the yellow of a spectrum, it is possible to determine nD (RI). With doubly refractive gems, two values of nD can be determined. The difference between these values is the birefringence.

In the Hodgkinson Method, in cases where the spectra overlap, the positions of the yellows are often difficult to ascertain precisely. Equivalent results will be obtained by measuring between the positions of the red at the begining of each spectrum. This is akin to the use of a red filter for refractometer readings obtained from a white light source. The absolute n values differ slightly from nD, but the more important birefringence value is correct.

BIREFRINGENCE:DISPERSION RATIO (B:D)

Two facts are apparent from the preceding paragraphs:

1. RI (nD) is related to the size of the circle of images.
2. Dispersion and Birefringence both are measured as Δn.

In regards to Mitchell's second variable, irrespective of angle, one can examine any pair of images from a doubly refractive gem and derive a value for B:D. B is proportional to the distance between reds of two spectra while D is proportional to the distance between the red and the blue* of the inner spectrum. For the purpose of this estimation, one can assume that the n scale is linear over that range. Actually it isn't. B:D ratios will be found to vary from zero in the case of singly refractive gems and glass to 2.6 for sphene.

At this point we shall consider Mitchell's third variable. All gemmologists should be aware that the 'apparent birefringence' seen by critical angle refractometers and/or the Hodgkinson Method varies with the orientation of the facet, the gem, the optic axis or axes and the light source. The 'true birefringence' of course

*i.e. Fraunhofer B line (687 nm) to G line (430.8 nm).

is the maximum value. Dispersion, on the other hand, is virtually unaffected by orientation.

It is imperative that one try to observe the maximum B:D ratio. Ruby or pale tourmaline cut along its *c* axis, at first, appears to be singly refractive. To observe the birefringence it may even be necessary to look across the stone through the crown facets. All that is necessary is two non-parallel polished faces and the patience to orient the light properly. The apparent B:D ratio can be observed in any position. Since D is a constant (although the apparent width may vary due to the effective change in the angle P and the position of the light) the B:D ratio can be determined. You just have to satisfy yourself that you have found the maximum value.

CUBIC ZIRCONIA AND DIAMOND

Mitchell's final objection was that diamond and cubic zirconia were not fairly compared. He believed that it was necessary to tilt the cubic zirconia to see the spectrum. He also believed that doing likewise with diamond would produce similar results. Reply to this provides a good opportunity to point out some of the 'finer points' of the method.

We are speaking now of well cut round brilliant gems cut with about a 40 degree pavilion angle. With quartz (RI 1.54), one should line up the pupil of the eye perpendicular to the table of the gem and in direct line with the culet and the light source. One or more circles of images of the light will be readily visible. What the eye is actually assessing is the path of the ray forming the angle θ (Figure 1).

With topaz (RI 1.62), the diameter of the circle is noticeably larger than with quartz. As the RI of the gem increases, angle θ gets larger and it is necessary to put your eye closer to the gem to see the full circle. At an RI about equivalent to spinel, the size of the circle reaches the limit of the field of view of the eye. No longer can the complete circle be observed. Because of the large size of the angle θ, it becomes necessary to move the eyeball and/or the head in a circular motion to see the complete circle. One can, however, see several images at once. From this arc of images, the diameter of the circle can be estimated.

Another approach which can be used for high RI gems is to assume the original fixed position of eye, gem, and light. Nothing, of course, will be seen. However, as one bends forward at the waist the angle of incidence (angle I in Figure 1) is increased and the image comes into view from below. An astute student can, with experience, learn to relate the degree of forward bend to the RI of the gem.

As with all good things, there comes an end. The case of cubic zirconia is shown in Figure 1. The angle θ approaches 60 degrees and one must move the eye above the level of the stone. This gives the impression that one is looking almost parallel to the table of the gem. However, contrary to Mitchell's belief, one cannot do this with a diamond. The cut off point is a RI of about 2.37. The recent article by Wong(6) dealing with the dot-ring test provides the mathematical proof. This test is a very basic form of the pinhole refractometer in reverse. The spot corresponds with the pinhole. Its appearance indicates light travels from that point through the stone and out of the pavilion. Since light travels equally well in both directions, the absence of the spot, as in the case of diamond, indicates no image is formed in a pinhole refractometer or in the Hodgkinson Method.

EPILOGUE

A trained gemmologist has the numerical values for RI, birefringence and dispersion committed to memory. It is a simple matter to calculate the B:D ratio.

Since the visual images seen in the Hodgkinson Method are subject to the laws of optics, a trained gemmologist ought to be able to explain the reason for the appearance of any image he might see. Mastering this technique should be considered a required postgraduate course in gemmology.

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THE THERMAL PROPERTIES OF GEMSTONES AND THEIR APPLICATION TO THERMAL DIAMOND PROBES

By DONALD B. HOOVER, D.Sc., F.G.A.

Mr P. G. Read in the April 1980 issue of this *Journal** presented an evaluation of the Ceres Diamond Probe which, like the similar G.I.A. instrument, is described as a thermal conductivity comparator. Due to the completeness of Read's evaluation two anomalous points became apparent. Read noted that diamond's thermal conductivity is greater than any other material, yet aluminium foil and silver gave higher readings on the Ceres Probe. Also, the range of thermal conductivities from glass to diamond covers a range of over 1000 to 1, while the Ceres probe gives a range of about 25 to 1 on these materials. This paper examines the measurement of thermal properties and attempts to explain the above anomalies.

Read describes the Ceres Probe as using a pulsed thermistor heat source with a second thermistor measuring the temperature of the probe tip at the interface of the gem under test. The reading is taken when a steady value is obtained. This suggests that the probe is measuring thermal inertia and not thermal conductivity of the gem. Because thermal properties are not well discussed in gemmological texts, a brief discussion should help to make concepts of the various thermal properties clearer.

Thermal conductivity (K) is an intrinsic material property which relates the heat flux (F) transferred by conduction through an object to the temperature difference across the object. In the c.g.s. system of units, which will be used throughout this paper, F has units of calories per sec cm^2, and K units of calories per sec cm °C. Thermal conductivities are normally measured by what are called steady-state methods (Carslaw & Jaeger, p.25, 1959), which merely means that the measurements are made after all parts of the measuring apparatus have reached thermal equilibrium after a constant temperature difference is established across the test sample. A simple schematic diagram of a one-dimensional thermal

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ISSN: 0022-1252 XVIII (3) 229 (1982)

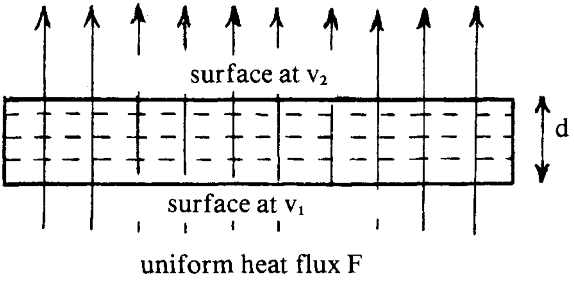

FIG. 1. Diagram illustrating a common means of measuring thermal conductivity by measuring the temperature difference across two surfaces normal to a uniform heat flux. Dashed lines are isothermal surfaces.

conductivity experiment is shown in Figure 1. If one knows the heat flux (F), the temperature difference across the slab (v_2-v_1) and its thickness (d), then the thermal conductivity may be calculated.*

In conductive processes thermal energy is transferred by quantized elastic wave vibrations of the atoms of the material called photons by analogy with the photon in electromagnetic radiation, and by electrons as well in metallic materials. This transfer of thermal energy constitutes a thermal wave similar to the more familiar wave motion of light. The idea of a thermal wave is important, and will be developed more fully later.

The thermal conductivity of any material is not a fixed constant. For most materials at room temperature it increases slightly as the temperature decreases. For example, the thermal conductivity of spinel at 35 °C is 0.033, decreasing to 0.026 at 68 °C (Clark, 1966). However for the small temperature change, as used in the Ceres Probe, K may be considered a constant. For most materials the thermal conductivity continues to increase to close to absolute zero (−273 °C) and then abrubtly decreases. Corundum has a maximum value of 15 cal/sec cm °C at −223 °C while diamond only reaches a maximum of 7 cal/sec cm °C (Kittel, 1956). For reference, silver the best metallic conductor at room temperature has a value of 1 cal/sec cm °C.

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*The equation relating these properties for the one-dimensional case illustrated is

$$F = \frac{-K(v_2 - v_1)}{d}$$

For the convenience of the reader who wishes to consult Carslaw and Jaeger (1959), their nomenclature will be followed as closely as possible.

To further complicate the picture, thermal conductivity is a function of direction in non-homogeneous or non-isometric crystalline solids just as the optical properties are. The thermal ellipsoid which describes the variation of K with crystallographic orientation will in general have the same symmetry properties, for a given crystal, as the optical properties (Washburn, 1929). Unfortunately the directional thermal properties of gem minerals are poorly known. A few values may be found in Washburn (1929) and Clark (1966). The difference with direction can be significant, for quartz is given as 0.030 parallel to the *c* axis and 0.016 normal to *c* (Washburn, 1929).

Another intrinsic thermal property we need to consider is the specific heat or heat capacity (c) of a gem. This is defined as the amount of heat in calories required to raise one gram of a substance one degree Celsius.* The specific heat also is a slowly varying function of temperature, increasing with increasing temperature. As with thermal conductivity it is usually considered a constant for experiments involving small temperature excursions. It also is quite uniform for most gem materials differing little from 0.2 cal/g °C at room temperature, so is not of practical diagnostic value. The specific heat is dependent on the experimental situation, whether conducted under constant pressure or constant volume conditions. For solids the difference is small and will be ignored in what follows.

Now consider what happens to the slab in Figure 1 if initially it is at room temperature and then we suddenly bring a source of heat near one side. The side nearest the source increases most rapidly in temperature as the heat flows into it. Some of the heat is used in raising the temperature of the slab as required by the specific heat property. This heat may be thought of as being stored temporarily in the slab. The rest flows into and through the slab governed by the physical principals discussed under thermal conductivity. Because there are not heat sources or sinks in the slab, the total heat must sum to zero; i.e. the heat flowing into the slab must equal that flowing out plus that stored by the increase of temperature. When this relationship is expressed mathematically it is called the heat conduction equation and a new thermal constant (k) is introduced.

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*Mathematically this is expressed as

$$F = c\varrho V(v_2 - v_1)$$

where ϱ is the density of the material, and V is its volume.

It is called the thermal diffusivity with units of cm^2/sec.* Thermal diffusivity k is related to thermal conductivity by

$$k = K/\varrho c.$$

Thermal diffusivity is normally measured by transient heat conduction experiments (Carslaw and Jaeger, 1959).

If in Figure 1 a sinusoidal heat flux, $F = F_0 \sin \omega t$, is substituted for the steady flux, and the thickness extended to infinity, solution of the heat conduction equation shows that after an initial transient disturbance is over the surface temperature also varies sinusoidally at the same frequency. However the amplitude of the sinusoidally varying temperature is not a function of K or k, but of $1/\sqrt{K\varrho c}$. The quantity $\sqrt{K\varrho c}$ is called the thermal inertia, (I), and is usually measured by experiments using a periodic heat source (Carslaw and Jaeger, 1959). A classic example of the use of a periodic heat source to measure thermal inertia occurs in geophysical exploration. The diurnal or annual solar flux constitutes the periodic source. Measurement of the surface or subsurface temperatures then gives a measure of the thermal inertia of the near-surface material of the earth (Carslaw and Jaeger, 1959; Watson, 1975). Surface temperature measurements obtained from aircraft have even been used to map variations in the earth's thermal inertia so as to infer variations in rock type.

While many details of the Ceres Probe and similar instruments are not known, it seems reasonable from the above discussion that such probes are measuring thermal inertia. If this assumption is correct then the probe response should be proportional to thermal inertia and not thermal conductivity. In order to verify this prediction, I looked up available data on the thermal constants of gem materials and calculated their thermal inertia. Some problems were encountered in making the compilation due to the scarcity of adequate thermal conductivity measurements on single-crystal gem materials. Values of K reported in the literature have varied by as much as 2 to 1 (Horai, 1971), and often the orientation is not given for measurements on anisotropic material. Diamonds represented a special case with recent references showing a range of over 10 to 1 for the value of K. Examination of the literature however showed that most of the lower values (0.29) of K originate with the

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*The classic heat conduction equation may be found in most texts on mathematical physics. For the one-dimensional case illustrated in Figure 1 it is given by

$$\frac{\partial v}{\partial t} = \frac{K}{\varrho c}\frac{\partial^2 v}{\partial x^2} = k\frac{\partial^2 v}{\partial x^2}$$

TABLE 1

Thermal properties of some gem minerals and metals at room temperature

Material	Thermal Conductivity cal per cm sec °C	Specific Heat cal per g °C	Density g per cm^3	Thermal Diffusivity cm^2 per sec	Thermal Inertia cal per cm^2 °C sec$^{1/2}$
diamond	1.6 to 4.8	0.12	3.52	3.79 to 11.36	0.822 to 1.42
copper	0.92	0.092	8.89	1.125	0.867
silver	1.0	0.056	10.5	1.701	0.767
gold 24 carat	0.70	0.031	19.3	1.170	0.647
aluminium	0.49	0.214	2.70	0.848	0.532
platinum	0.166	0.032	21.37	0.243	0.337
platinum-10% iridium	0.074	0.032	21.62	0.107	0.226
corundum	0.060	0.206	4.0	0.0728	0.222
pyrite	0.0459	0.136	4.91	0.0687	0.175
kyanite	0.0338	0.201	3.66	0.0460	0.158
haematite	0.0269	0.169	5.14	0.031	0.153
topaz	0.0269	0.2*	3.53	0.0381	0.138
spinel	0.0226	0.216	3.63	0.0288	0.133
fluorite	0.0227	0.220	3.19	0.0324	0.126
quartz (mean)	0.0184	0.196	2.65	0.0354	0.0978
quartz ∥ c axis	0.030	”	”	0.0578	0.125
quartz ⊥ c axis	0.016	”	”	0.0308	0.0912
andalusite	0.0181	0.202	3.10	0.0289	0.106
jadeite	0.0159	0.206	3.20	0.0241	0.102
magnesite	0.0139	0.236	2.99	0.0197	0.0990
rutile	0.0122	0.189	4.24	0.0152	0.0989
grossular	0.0131	0.196	3.49	0.0192	0.0947
peridot	0.0115	0.210	3.47	0.0158	0.0915
elbaite	0.0126	0.2*	3.13	0.020	0.089
zircon	0.0108	0.140	4.63	0.0167	0.0837
beryl	0.00953	0.2*	2.7	0.018	0.072
rhodochrosite	0.00731	0.184	3.58	0.0111	0.0694
sphene	0.00558	0.187	3.52	0.00848	0.0606
fluor-apatite	0.00328	0.195	3.22	0.00522	0.0454
barite	0.00319	0.113	4.41	0.00640	0.0399
silica glass	0.00325	0.201	2.20	0.00735	0.0379
hyalite	0.0029	0.2*	2.08	0.00697	0.0347
flint glass	0.002	0.117	3.5	0.0049	0.029

*estimated values

measurements of Euken in 1911. These low values I believe are in error. The most thorough modern study I have found is that of Burgemeister (1978) who reports measurements on 100 natural diamonds and a few synthetic stones. He finds that Type II diamonds, at room temperature, have a constant K of 4.8 cal/cm sec °C, but that Type I diamonds vary downwards to a low of 1.6 cal/cm sec °C. The variance is dependent on the nitrogen content. The limits reported by Burgemeister are used in my compilation.

Table 1 gives the results of the compilation showing values of K, c, ϱ, k, and I for some metals and a variety of gem materials. For the gem minerals most values of K are taken from Horai (1971) who gives an extensive list of mean values because his measurements were on powdered samples. The specific heats were calculated from the tables of Robie and Waldbaum (1968). The densities are from Horai (1971) or Webster (1975). Examination of Table 1 shows that the Ceres Probe is approximately measuring

TABLE 2

Comparison of the relative values of thermal conductivity and thermal inertia to the relative measured response of diamond thermal probes referenced to spinel.

Material	Thermal Conductivity	Thermal Inertia	Measured Read	Measured G.I.A.*
silver	44.2	5.8	3.1	n.d.*
aluminium	21.7	4.0	3.1	n.d.
gold 24 carat	31.0	4.9	2.7	n.d.
diamond	70.7 to 212.	6.2 to 10.7	3.0 (0.75ct)	2.1
corundum	2.65	1.6	1.75	1.5
zircon	0.48	0.63	1.4	1.2
spinel	1.0	1.0	1.0	1.0
quartz	0.81	0.74	0.63	n.d.
rutile	0.54	0.74	0.63	n.d.
glass	0.088	0.22	0.13	0.27

*from G.I.A. advertising literature; n.d. = no data.

thermal inertia rather than thermal conductivity. This is more clearly shown by Table 2 where the relative responses of the Ceres Probe and the G.I.A. probe, both referenced to spinel, are compared to the ratios K/K spinel or I/I spinel. Table 2 shows that the predicted response I/I spinel, correlated reasonably well with the relative measured values and much better than K/K spinel. Some discrepancy however occurs for diamond, metals, and zircon. The discrepancy noted for zircon is probably due to a wide range in thermal inertia for this mineral. The computed value is for metamict Australian material while Read's measurement was made on high zircon. An increase in the disorder of the crystal lattice due to the metamict state would be expected to decrease the thermal inertia, and this is what is observed. To understand the cause of the discrepancy between measured and predicted values for metals and diamond requires that the thermal wave in the gem be better understood.

The solution for the one-dimensional heat conduction equation with periodic heat flux is given in the Appendix for those interested. Examination of this solution shows that the thermal

TABLE 3

Thermal wave propagation velocity and wavelength for selected materials at 1 and 60 hertz.

	1.0 hertz		60 hertz	
Material	Velocity cm/sec.	Wavelength cm.	Velocity cm/sec.	Wavelength cm.
silver	4.66	4.66	35.8	0.60
diamond	6.9 to 11.9	6.9 to 11.9	53.5 to 92.5	0.89 to 1.54
spinel	0.73	0.73	4.66	0.78
beryl	0.47	0.47	3.64	0.060
flint glass	0.25	0.25	1.92	0.032

wave has a very low velocity and short wavelength.* At a frequency of one hertz the velocity ranges from 10.3 cm/sec for diamond to 0.25 cm/sec for flint glass. At this frequency the wavelength is equal to the velocity. Table 3 gives the propagation velocity at 1 hertz and 60 hertz for several gem materials. Combined with a slow velocity is a rapid attenuation rate.† After only one wavelength of travel in the gem the amplitude of the sinusoidal temperature wave has decreased to 0.0019 of its surface value! We assumed in solving the one-dimensional equation that the gem was semi-infinite in extent, but the rapid attenuation means that, if the back of the slab, or gem, is more than 1/2 wavelength from the surface, then its effect will hardly be noticed. From Table 3 it is evident that, except for diamond, the Ceres Probe with its 1 hertz operating frequency should give accurate measurements of thermal inertia for gems of about 1 ct and above.

Figure 2a shows the relative magnitude of the thermal wave and its attenuation for glass, spinel and diamond. The amplitude of the surface heat flux is assumed the same for all materials. The graph shows that glass has a high surface temperature, but that the thermal wave penetrates only a short distance. Diamond on the other hand has a much smaller surface temperature, but the wave penetrates much farther before suffering significant attenuation.

Figure 2b shows the thermal wave as it would appear in a probe tip and gem under test. The figure has been scaled to a 10 mm diameter zircon. The large size was chosen for illustrative purposes to avoid having to show reflections from the pavilion. Crown reflections also are not shown. It should now be clear why Read's measurements on diamonds and metal are lower than predicted. The wavelength in these materials was long enough that reflections of the thermal wave returned to the measuring surface causing the surface temperature to be too high thus making the thermal inertia appear too low. It would take a very large diamond for the Ceres Probe to give an accurate measure of thermal inertia. It should be obvious also from Figure 2b that the thermal wave falls off faster in the gem than predicted by the one-dimensional solution due to geometrical spreading of the wave front.

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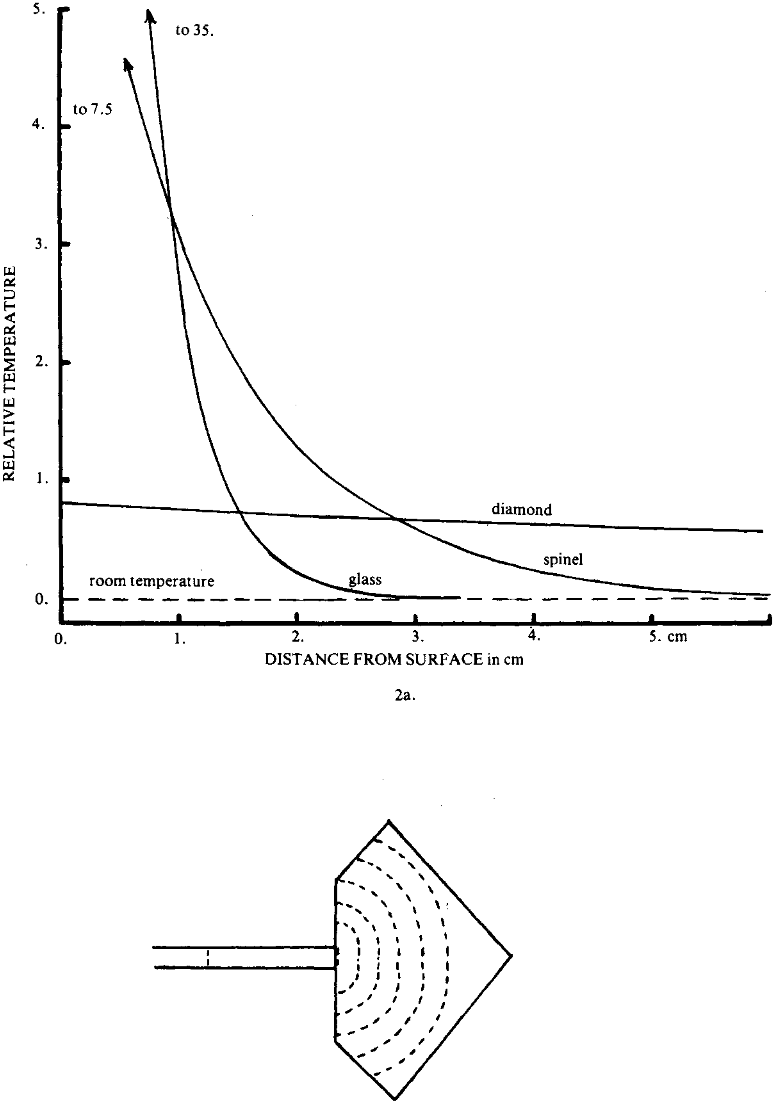
*The velocity is given by $V = \sqrt{2\omega k}$

†The attenuation for this one-dimensional case is given by $\varepsilon^{-x\sqrt{\omega/2k}}$



2a.

2b.

FIG. 2. Illustration of the fall-off of the thermal wave in various materials for a sinusoidal heat flux at 1 Hz. (a) The variation of amplitude with distance from the surface for glass, spinel and diamond. (b) Isothermal contours every 0.1 wavelength in a gem zircon of 10 mm diameter.

The question of how small a diamond can be reliably distinguished is difficult to answer theoretically because of problems in solving the heat conduction equation subject to the actual boundary conditions. The question is best answered by experiment with the instrument. The simple theory presented here, however, does suggest that loose melee should be tested by placing them on a plate of copper or silver. A recessed tip, such as supplied with the Kashan probe, can then be placed over the pavilion. Under these conditions a diamond should give a reading essentially the same as would be obtained on the metal while a simulant would give a lower value.

Although the probes are designed as go, no-go instruments, Table 1 suggests that they may have value if used in a more quantitative manner. For example the Table shows a difference of about 2 to 1 in thermal inertia between topaz and beryl. If the variation of K with direction of these two minerals is not extreme, then the probe might provide a simple means of distinguishing blue topaz from aquamarine when an index of refraction is not easily measured. To test this prediction a Ceres Probe was used to measure the response of six beryl and six topaz gems, all above 1 ct. For the gems tested the Ceres Probe gave distinctive results for both materials. Measured along the lower edge of the red coloured zone, and referenced to the 'zero' value in air, beryl gave a range of 5-9 mm and topaz a range of 14-17 mm. Several surfaces of the gem were tested to make sure that differing crystallographic orientations were taken into account. While not conclusive, it appears that the new thermal probes could have a much broader range of application then previously recognized. Nassau (1978-79) reported on tests with a prototype Ceres Probe in which he states the speed with which the thermistor temperature falls is measured following the application of a short pulse of current. This may imply that the prototype was measuring thermal diffusivity. Nassau mentions that production models will be somewhat different in appearance but will function in the same manner as the prototype. The calculations presented in this paper however show that the response of production models is proportional to thermal inertia.

It is hoped that this brief review of the operation of the thermal diamond probes not only has provided a better understanding of their operation, but will stimulate users to investigate more fully the potential application of these devices.

APPENDIX

The one-dimensional heat flow equation is given by equation 1

$$\frac{\partial v}{\partial t} = k\frac{\partial^2 v}{\partial x^2} \tag{1}$$

The general solution and means of solving it are given in most texts on differential equations to which the interested reader is referred. The general solution may have many forms. For convenience I will take it in the form given in 2, with two constants for satisfying the boundary conditions.

$$v = A\varepsilon^{-x\sqrt{\omega/2k}}\cos\omega(t - x/\sqrt{2k\omega}) + B\varepsilon^{-x\sqrt{\omega/2k}}\sin\omega\,(t - x/\sqrt{2k\omega}) \tag{2}$$

This solution represents a wave travelling in the positive x direction with velocity $\sqrt{2k\omega}$ and attenuated by the factor $\varepsilon^{-x\sqrt{\omega/2k}}$. What is now required is to solve equation 2 for A and B subject to any boundary conditions we choose to apply. If we assume the surface temperature is given by 3,

$$v = A_0\cos\omega t \tag{3}$$

then evaluating 2 at the surface, $x = 0$, gives

$$v = A_0\varepsilon^{-x\sqrt{\omega/2k}}\cos\omega\,(t - x/\sqrt{2k\omega}) \tag{4}$$

However, we assumed the Ceres Probe gave a constant heat flux at the surface of the stone. The heat flux is given by

$$F = -K\frac{\partial v}{\partial x} \tag{5}$$

Evaluating 5 and assuming a constant heat flux in the form, $F_0\cos\omega t$, gives the solution

$$v = \frac{F_0}{K\sqrt{\omega/k}}\cos(\omega t - \pi/4) = \frac{F_0}{I\sqrt{\omega}}\cos(\omega t - \pi/4) \tag{6}$$

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GEMMOLOGICAL ABSTRACTS

AMSTUTZ (G. C.), WANG (N.). *Ein 'Schneeflocken-Obsidian' aus dem Cascadengebirge von Oregon, Nordamerika.* (A 'snow-flake obsidian' from the Cascade Mountains of Oregon, North America.) Z.Dt.Gemmol.Ges., **30**, 3/4, 226-9, 4 figs in colour, bibl., 1981.

An occurrence (possibly new) of snow-flake obsidian from the west face of the Three Sisters in the Cascade Mountains of Oregon is described, including description of the outcrop and examination under the microscope and by x-rays: and a genetic interpretation is offered. It is suggested that during the lava flow the pressure decreased and that then gas pressure distributed the fluid phases into all directions. These phases are now frozen and visible as white isolated spots, i.e. snow-flakes. E.S.

BALL (R. A.), HENNESSY (L.). *Stones Seen: 'White Nephrite'.* Aust.Gemmol., **14**, 9, 228-9, 1 fig, 1982.

Cabochon of 'white nephrite' is thought to be xonotlite. RI 1.583 and SG 2.73 both far too low for nephrite. R.K.M.

BANK (H.). (a) *Smaragde aus Sambia mit relativ hoher Lichtbrechung und Doppelbrechung und starkem Eisengehalt.* (Emerald from Zambia with relatively high refractive index and double refraction and high iron content.) Z.Dt.Gemmol.Ges., **30**, 3/4, 230-1, 1981; (b) *Natürlicher Smaragd aus Sambia mit ausgeprägtem Zonarwachstum als Smaragd-Beryll Dublette angesehen.* (Natural emerald from Zambia with definite zonal growth mistaken for emerald-beryl doublets.) Id., 232-3, 2 figs in colour, 1981; (c) *Über die Variation des Brechungsindex von Ekanit.* (About the variation of refractive indices in ekanite.) Id., 234-5, 2 figs in colour, 1981; (d) *Farbloser Andalusit aus Brasilien.* (Colourless andalusite from Brazil.) Id., 236-7, 1 fig. in colour, 1981; (e) *Viridinartige Andalusite aus Brasilien.* (Viridine-like andalusite from Brazil.) Id., 238-9, 1 fig. in colour, 1981; (f) *Kunstprodukt als Hämatit ausgegeben.* (Artificial product mistaken for haematite.) Id., 242, 1981; (g) *Grün überzogene Quarzkristalle in einer Partie Rohsmaragde aus Sambia.* (Quartz coated by green material found amongst rough emerald from Zambia.) Id., 242-3, 1981; (h) *Glas für Opal ausgegeben.* (Glass offered as opal.) Id., 244, 1981.

(a) Emeralds from Zambia have a high Fe content and the highest known RI of natural emeralds, up to 1.602, while generally they remain at 1.590. Crystals have recently been observed with a value n_o of between 1.590 and 1.600, closing the open space of until now known Zambian emeralds. (b) Zambian emeralds are described which show very distinct zonal growth, the core being colourless with low RI, the edge intensely green with high RI. Stones cut from these crystals may be taken for doublets, especially as upper and lower part show different RIs. (c) Ekanites have until now been described as dark green but have recently been observed also light brown and emerald green with RI varying from 1.590 to 1.597. (d) A colourless andalusite as one part of a cut bi-coloured stone is described originating from Brazil with low RI, free of or poor in Fe. (e) Fe-rich andalusites with high RI and containing Mn_2O_3 can be regarded as viridine-like. (f) Haematite beads were found to be imitations. Suspicion was first aroused when the beads were re-strung and the string was found to be green instead of red. The RI could not be read, but x-ray diffraction showed the beads to be imitations. (g) Quartz crystals covered with a green substance found in a lot of rough emeralds from Zambia. Suspicion was aroused by the matt faces and quartz-like crystals. (h) Glass was substituted for opal—this was finally proved by the presence of bubbles and by an RI of 1.495. E.S.

BANK (H.) and (F. H.). *Das Phänomen 'multiplier' Brechungsindizes bei rohen Turmalinen aus Tansania.* (The phenomenon of multiple refractive indices of rough tourmalines from Tanzania.). Z.Dt.Gemmol.Ges., **30**, 3/4, 240-1, 1 fig. in colour, 1981.

The phenomenon of multiple RIs so far described in dark-green tourmalines (heat treated to high temperature) and in coated beryls (after Lechleitner) have now been observed in several rough crystals of uvites (tourmalines) from Tanzania (due to vicinal faces). E.S.

BARIAND (P.). *The Sorbonne collection.* Mineral. Record, **13**, 1, 31-4, 7 figs in colour, 1982.

The mineral exhibition room which houses the mineral collection of the Faculty of Sciences, University of Paris, contains some fine gem-quality materials including tourmalines. Some details of architectural and technical features of the collection room are given. M.O'D.

BARRINGTON (E. N.). *Computers and Gemmology.* Aust. Gemmol., **14**, 7, 166-8.

A feasibility study of the computerization of gemmological data. R.K.M.

BELSHER (D. O.). *Pink octahedral fluorite from Peru.* Mineral. Record, **13**, 1, 29-38, 1 fig in colour, 1982.

Fine quality pink fluorite has been found at the Huanzala mine, approximately 240 km north of Lima, Peru. The occurrence is in a working mine producing lead and zinc. Although green fluorite is also found, the pink is exceptionally fine; it occurs as simple octahedra. There is some doubt as to the stability of the colour.

M.O'D.

BERNHARDT (H.-J.), SCHMETZER (K.), MEDENBACH (O.). *Berdesinskiit, V_2TiO_5, ein neues Mineral.* (Berdesinskiite, V_2TiO_5, a new mineral.) Z.Dt.Gemmol.Ges., **30**, 3/4, 143-5, 3 figs (2 in colour), 1981.

The new mineral was named berdesinskiite in honour of Prof. Dr W. Berdesinski, who is celebrating his 70th birthday. It was discovered in a vanadium-bearing kornerupine mine six miles south-east of Lamsamba Hill in the Kwale district of Kenya. A similar material, schreyerite, $V_2Ti_3O_9$ was found in 1978. The new material is black with metallic lustre. Optical, chemical and x-ray data are given. E.S.

BOSSHART (G.). *Die Unterscheidung von echten und synthetischen Rubinen mit UV-Spektralphotometrie.* (The differentiation between natural and synthetic rubies with the help of UV spectrophotometry.) Z.Dt.Gemmol.Ges., **30**, 3/4, 157-69, 5 figs, 1 table, bibl., 1981.

This paper, as slightly revised, was published in English in *J.Gemm.,* 1982, **XVIII**, 2, 145-60.

BROWN (G.). *The Biwa pearl.* Aust.Gemmol., **14**, 7, 153-6, 6 figs, 1981.

A detailed account of a subject on which the Japanese Cultured Pearl industry is reticent. Describes flesh culturing procedure and 1st and 2nd crops harvested from the same long-lived mussels. First crop is cultured in 6 to 7 year old bivalves and needs up to three years to develop. These have cavity centres. They are removed and the mussels returned to the water for a further three years when a second crop of rather larger and rounder pearls is obtained which have slit-like cavity centres. A third crop is possible but is uneconomic. A map (Figure 2) has the Kaizu and Kasumiga-ura localities transposed. R.K.M.

BROWN (G.). *The Biwa pearl: Part 2.* Aust.Gemmol., **14**, 8, 186-93, 11 figs, 1981.

A second part to the paper in the previous issue (**14**, 7) of this journal. Gives identification criteria. Some experimental bead nucleation of freshwater cultured pearls may still be going on but is difficult in this mussel. Structures of pearls and of Biwa pearls, on which original investigation has been done, are discussed at length and a sequence of events in their formation is suggested. The two parts of this paper make an important contribution to literature on pearl cultivation. R.K.M.

BROWN (G.). *SWUV diaphany of ruby.* Aust.Gemmol., **14**, 8, 200-3, 1 fig., 1981.

Mr Brown has found that a dark purplish-red Kashan ruby (which showed traces of iron in its absorption) is, as might be expected, opaque to short UV light; rather more so than natural Siam rubies. R.K.M.

BROWN (G.). *Golden corals: a brief note.* Aust. Gemmol., **14**, 8, 204-8, 3 figs, 1981.

Distinction between natural golden coral and the cheaper smooth golden coral which seems to be produced by bleaching black gorgonian and antipatharian corals in hydrogen peroxide. R.K.M.

BROWN (G.), SNOW (J.). *Three brief evaluations.* Aust.Gemmol., **14**, 9, 223-8, 6 figs, 1982.

A Report of the Instrument Evaluation Committee of the G.A.A.

Kashan diamond detector. A heat probe detector with a 'red light for diamond' facility, functioning very much as other examples of this instrument. An adaptor is described, but not evaluated, which is said to aid testing of loose stones below 0.1 ct.

The Winter diffraction grating spectroscope. A pocket instrument with fixed slit, giving high resolution spectra similar to those expected in a prism instrument, probably because a silvered plastic diffraction grating is used.

The Discrimagem filter. Yet another attempt to improve on the Chelsea filter. Committee quotes Webster's reservations in respect of all colour filter tests. R.K.M.

BROWN (G.), TAYLOR (B.), SNOW (J.). *An evaluation of the Presidium gem tester.* Aust.Gemmol., **14,** 7, 169-76, 3 figs, 1981.

Report of the Instrument Evaluation Committee of the G.A.A. on an Australian heat-probe instrument which includes diamond and simulant test discs for calibration purposes. In use the probe worked well, defining diamond by needle deflection to a green area of a scale and all simulants by lesser deflection to a red area. R.K.M.

CASSEDANNE (J.-P.), LOWELL (J.). *The Virgem da Lapa pegmatites.* Mineral. Record, **13,** 1, 19-28, 23 figs (3 in colour), 1982.

This pegmatite, north-west of the town of Virgem da Lapa in north-eastern Minas Gerais, Brazil, has produced high quality crystals of topaz, elbaite tourmaline and hydroxyl-herderite. The topaz in this locality is blue, the tourmaline green, pink, blue or multi-coloured. Maps of the occurrences and references are given.

M.O'D.

COLLINS (A. T.), MOHAMMED (K.). *Optical studies of vibronic bands in yellow luminescing natural diamonds.* J.Phys.C: Solid St.Phys., **15,** 147-58, 7 figs, 1982.

Absorption and luminescence measurements are described for a large number of gem-quality brown diamonds. The stones were examined under long wave ultraviolet light (365 nm) where a bright yellow luminescence was observed. A vibronic band with a peak near 2.6 eV (488 nm) could be detected in all stones giving the bright yellow luminescence. Evidence that the electron-phonon coupling is strong is suggested by the absence of vibronic structure on the 2.6 eV band. Absorption in this band gives red luminescence. Yellow luminescence is associated with a second strongly coupled vibronic system with a zero-phonon line at 2.721 eV. In the infrared absorption spectrum a minor peak at 1240 cm^{-1} was observed in the spectra of all diamonds studied which appeared to correlate with the 2.6 eV band.

M.O'D.

CROWNINGSHIELD (R.). *Irradiated topaz and radioactivity.* Gems & Gemology, **XVII,** 4, 215-17, 1 fig. in colour, 1981.

Parcel of blue irradiated topaz found to be radioactive, thought to have been colourless material treated by neutrons in a reactor. Degree of radioactivity is considered dangerous. Other gems known to be being similarly irradiated, and author advises checking all stone parcels for dangerous radiation levels. R.K.M.

DAWKINS (J. C. F.). *The application of diamond tools.* Gems, **14,** 1, 9-13, 1 fig., 1982.

Diamond particles used as an abrasive have been developed in recent years and now are extensively used in the lapidary industry. A diamond mesh or cloth, which is embedded with diamond particles, is capable of being cut to any desired shape and can be used to polish almost any shape of rough gem material. M.O'D.

EYSEL (W.), BREUER (K.-H.). *Dioptas: Kristallstruktur, Entwässerung und Farbänderungen.* (Dioptase: crystal structure, dehydration and colour changes.) Z.Dt.Gemmol.Ges., **30,** 3/4, 219-23, 6 figs (2 in colour), bibl., 1981.

When heated dioptase ($CuSiO_3 \,.\, H_2O$) shows two types of colour changes depending on whether the stone has been heated in air or hydrothermally. There is a continuous change from green to bluish green to greyish black or green to blue, the first includes a loss of crystal water, the second does not. In both cases the basic structure is preserved, but volume shrinkage occurs. E.S.

FISCHER (K.). *Cabochonschleifen.* (Cabochon cutting.) Lapis, **7**, 2, 20-40, 10 figs (5 in colour), 1982.

Chatoyancy and asterism are described from the point of view of the lapidary and illustrations are given of gem materials showing these effects. M.O'D.

FISCHER (R.). *Der Elfenbeinhandel in der Bundesrepublik Deutschland unter Beachtung des Washingtoner Artenschutzübereinkommens.* (The trade in ivory in the Federal German Republic in relation to the Washington Convention on Endangered Species.) Z.Dt.Gemmol.Ges., **30**, 3/4, 146-51, 2 tables, 1981.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) came into force in the Federal Republic of Germany on 20th June, 1976. The import of ivory from Indian elephants is prohibited, ivory from African elephants can be imported and re-exported on presentation of the relevant documentation. The import of rough ivory had decreased since 1980, while the import of ivory products has increased slightly. Prices have risen sharply. E.S.

FRANCO (R. R.). *Brazilian gemstones.* Earth Science Reviews, **17**, 207-19, 1 map, 1981.

Most Brazilian states and territories produce gemstones, the state of Minas Gerais being the most important producer both in volume and number of species. Diamonds are chiefly derived by panning alluvial deposits in Minas Gerais, Mato Grosso, and Goias. Among other gemstones, the most important are aquamarine, beryl, chrysoberyl, topaz, amethyst, tourmaline, emerald, and agate. The occurrences of these gemstones and a great number of others are described for each state in which they are found. P.Br.

FRYER (C.) ed., CROWNINGSHIELD (R.), HURWIT (K. N.), KANE (R. E.). *Gem Trade Lab Notes.* Gems & Gemology, **XVII**, 4, 226-30, 18 figs in colour, 1981.

Dyed marble coral substitute, angular grooves in cut diamond, badly burned treated yellow diamond, diamonds with photosynthetic colour change and various other coloured diamonds, natural or otherwise, are illustrated. Dyed beryls to imitate emerald, a natural emerald with very large three phase inclusion, totally worn pearls in a necklace, 'pearls' of lacquered M.O.P., crackled quartz in green and red, a light bluish-grey quartz showing a good star and a parcel of over 50 yellow-orange sapphires, which were shown to have been heat-treated by their weak fluorescence in LWUV, stress fractures and multi-plane repolished girdles, all described and illustrated. R.K.M.

GÜBELIN (E. J.). *Einschlüsse im Granat aus dem Umba-Tal.* (Inclusions in garnets from the Umba Valley.) Z.Dt.Gemmol.Ges., **30**, 3/4, 182-93, 21 photomicrographs in colour, bibl., 1981.

Fourteen specimens with representative scenes of inclusions were selected from a large number of new garnets from the Umba Valley. The gems were cut so that the mineral inclusions became exposed at the surface and could be analysed by electron microprobe. The properties and mineral inclusions of the 14 garnets are described. It is emphasized that on account of mutual overlapping the various properties are (except a special constellation of absorption lines and the presence of large pyrite crystals) hardly diagnostic with regard to occurrence and species. Amongst the inclusions the following were found: quartz, apatite, zircon, rutile (needles and prisms), pyrrhotite, monazite and pyrites. The author also expresses his appreciation to K. Schmetzer and H. Bank for suggesting that this type of garnet should be called pyralspite.* E.S.

GÜBELIN (E.), MOOR (R.), OBERHOLZER (W. F.). *Taprobanit -ein neuer Edelstein aus Sri Lanka.* (Taprobanite—a new gemstone from Sri Lanka.) Z.Dt.Gemmol.Ges., **30**, 3/4, 197-206, 3 figs (2 in colour), 3 tables, bibl., 1981.

Taprobane is the old Greek name for Sri Lanka, 'tapa' meaning meditation and 'bove' garden. The stone was originally offered on the market in Ratnapura by a gem digger as spinel, then as ruby, then acquired by A. G. B. Amarasinghe (who had just qualified as an F.G.A.) as a taaffeite. The stone was found to have an idealized formula of $BeMg_3Al_8O_{16}$. RI 1.717-1.721; DR −0.004. Observed density 3.605 g/cm^3, calc. density 3.588 g/cm^3. Strong dichroism, absorption and emission lines at 685.2. Weak UV luminescence. Hardness 8 +, no cleavage. It is a hexagonal crystal, x-ray diffraction pattern given. Taprobanite seems to fill a missing link between spinel and chrysoberyl; because of its space grouping it was found to be a mineral species in its own right.† E.S.

HÄNNI (H. A.). *Chemischer Vergleich zwischen natürlichen und synthetischen Smaragden.* (Chemical comparison between natural and synthetic emeralds.) Z.Dt.Gemmol.Ges., **30**, 3/4, 214-18, 1 fig., 2 tables, 1981.

Synthetic emeralds show a low concentration of Na and Mg while natural emeralds show these elements in a percentage range. E.S.

HÄNNI (H. A.). *Energiedispersive Röntgenfluoreszenz-Analyse in der gemmologischen Diagnostik.* (Energy-dispersive x-ray fluorescence in diagnostic gemmology.) Z.Dt.Gemmol.Ges., **30**, 3/4, 207-9, 2 figs, 1981.

EDS-XRF is a non-destructive physical method for qualitative or quantitative determination of chemical constituents, which can also contribute towards information as to the gemstone's nature. E.S.

HORIUCHI (N.). *New synthetic opal made of plastics.* Aust.Gemmol., **14**, 9, 213-18, 9 figs, 1 table, 1982.

A translation of a paper which appeared first in The Journal of the Gemmological Society of Japan‡ this describes an imitation of opal rather than a synthetic opal. Polystyrene spheres of 200 nm diameter close-packed by gravity

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*See *J.Gemm.*, 1981, **XVII** (8), 527.—Ed.

†But see '"Taprobanite" is Taaffeite', *J.Gemm.*, 1982, **XVIII** (2), 112-13.—Ed.

‡Briefly abstracted in *J.Gemm.*, 1979, **XVI** (8), 547.—Ed.

sedimentation process lasting three to six months. Sediment lacks strength so is enclosed in acrylic coating. Latter visible from side of stone. Water beads on plastic but not on opal, real or synthetic. Some conclusions may have been drawn on insufficient data when comparing with Gilson synthetics. R.K.M.

HUMBLE (P.). *"Star" diamond.* Aust.Gemmol., **14**, 9, 219-20, 1982.

A paper based on a photograph of a star in a diamond crystal which is reproduced on the front cover of this greatly improved journal. Dr Humble has gone to a lot of needless trouble to find and prove an optical explanation of the star. [My own paper on *Star Inclusions in Diamond* (J.Gemm., 1981, XVII, 8, 584-8) deals with the same crystal and with one about ten times the size, and in both the formation is of dust-like particles giving a complex eight-armed star, seen as six-armed through each of the octahedral faces.] R.K.M.

KOIVULA (J. I.). *San Carlos Peridot.* Gems & Gemology, **XVII**, 4, 205-14, 17 figs in colour, 1981.

Mr Koivula obtained the necessary permission to visit Peridot Mesa in the San Carlos Apache Reservation and describes it in detail; a volcanic 'table' capped by dark grey basalt in which the peridot is found. Mining by hand using pick, pry bars and hammer and chisel to avoid too much blasting, which shatters peridot nodules. Excellent pictures of typical inclusions, most of which are known in peridot from other localities, but chrome diopside and smoke-like veiling, due probably to exsolution of impurities, seem unique to San Carlos. R.K.M.

KRAUS (P. D.). *Korite from Alberta, Canada.* Lapidary J., **35**, 10, 1994-6, 11 figs in colour, 1982.

Korite [a somewhat undesirable name] is the aragonite portion of the fossilized shell of the ammonite *Placenticeras*. The play of colour seen is thought to be a diffraction effect. The material had disappeared from the market for a while, though when it first appeared it had the name ammolite, which is, in fact, a name to be preferred. M.O'D.

LAPWORTH (P. B.). *The Golden Jubilee of the Gemmological Association of Great Britain,* Aust.Gemmol., **14**, 9, 220-1, 1982.

An account of the Jubilee celebrations in October 1981, mentioning some Australians who were present and others who had obtained their (British) Diplomas in Gemmology (including the Tully Medallist of 1956). J.R.H.C.

MacFALL (R. P.). *Historic Blue John and other fluorites.* Lapidary J., **35**, 10, 1998-2018, 9 figs (3 in colour), 1982.

A full account of the history and occurrence of the Derbyshire form of fluorite known as Blue John is given. Other fluorite deposits are reviewed. M.O'D.

MANSON (D. V.), STOCKTON (C. M.). *Gem garnets in the red-to-violet color range.* Gems & Gemology, **XVII**, 4, 191-204, 3 tables, 11 figs (1 in colour), 1981.

First of a series of papers which will investigate scientifically relationship between chemical composition and colour in garnets. After much erudite scientific work conclusion is reached that colour does not depend on proportions of end-members, e.g. pyrope/ almandine/ spessartine, but is influenced by trace impurities. R.K.M.

MEYER (I.). *Roter Beryll.* (Red beryl.) Lapis, **7**, 1, 31, 1 fig. in colour, 1982.

Red transparent beryl from Thomas Range and the Wah Wah Mountains of Utah is described and illustrated. One example contained 0.24% Cs compared to 0.05% from a Madagascan specimen. A Cs-content of 0.90% is reported from a specimen from the Thomas Range. M.O'D.

MITCHELL (J. R.). *Fossils and a variety of agate near Green River, Wyoming.* Lapidary J., **35**, 10, 2110-12, 9 figs, 1982.

Moss agate, various colours of jasper and a turritella agate are found in the Green River of Wyoming. M.O'D.

MITCHELL (R. K.). *Letter to the Editor—Birefringence,* Aust.Gemmol., **14**, 9, 221-2, 1982.

Emphasizes that the full birefringence of a gemstone can be obtained from a single polished flat facet: only to determine optic sign is it sometimes necessary to test again on a second facet. J.R.H.C

MOOR (R.). OBERHOLZER (W. F.), GÜBELIN (E.). *Taprobanite, a new mineral of the taaffeite group.* Schweiz. Min. Petr. Mn, **61**, 1, 13-21, 1981.

A new red hexagonal-prismatic crystal cut as a 204 mg gemstone and sold as taaffeite is shown to be a new species. It is named after the old Greek name for the island of Sri Lanka, Taprobane, and has Mohs's hardness ~ 8; D 3.605 g/cm^3; no cleavage; weak red fluorescence in UV radiation. It is optically uniaxial, ε (yellow-rose) 1.717, ω (carmine red) 1.721. Chemical analyses lead to the formula $BeMg_3Al_8O_{16}$. X-ray powder data are given; a crystal structure determination is reported and shows that taprobanite is related to taaffeite. It has *a* 5.684, *c* 18.322 Å; space group $P6_3mc$.* R.A.H.

MUNTZ (S. R.). *Oregon diamond find has been verified.* Oregon Geology, **43**, 26, 1981.

A clear white flattened hexoctahedron of 0.6 ct was found near Wedderburn, Curry County, prior to 1938, and is now in the Smithsonian Natural History Museum (R7826). W.T.H.

NASSAU (K.), PRESCOTT (B. E.). *Non-fading Maxixe-type beryl?* Gems & Gemology, **XVII**, 4, 217-19, 2 figs (1 in colour), 1981.

Non-fading Maxixe-type beryl reported but was 'ordinary' fading material which had probably been kept in poor light so that fade was unnoticed. No authentic instance of non-fading Maxixe-type material has yet been proved. R.K.M.

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*But see ' "Taprobanite" is Taafeite', *J.Gemm.*, 1982, **XVII** (2), 112-3.—Ed.

NICKEL (E. H.). *So you think you have a new mineral!* Aust.Gemmol., **14**, 8, 181-4, 1981.

Outlines the steps in confirming a mineral as new, and naming it. Appendix gives a case history of one such new mineral. Interesting paper. R.K.M.

NUBER (B.), SCHMETZER (K.). *Strukturverfeinerung von Liddicoatit.* (Structural refinement of liddicoatite.) N.J. Miner. Mnh., 5, 215-19, 1981.

A continuous solid solution between liddicoatite (Ca-Li-Al tourmaline and elbaite, its sodium analogue, is predicted. The structure of liddicoatite was refined to an R-value of 3.3%. M.O'D.

O'DONOGHUE (M.). *The dealer looks at gemstones—2.* Gems, **13**, 6, 33, 1981.

The second piece in this series deals with asterism, chatoyancy, inclusions in emerald and the part they play in identifying origin. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *The dealer looks at gemstones—3.* Gems, **14**, 1, 29-30, 1982.

The various colours of tourmaline are reviewed with their commercial potential in mind. Pakistan and Afghanistan have recently provided fine quality material. (Author's abstract.) M.O'D.

PEARSON (G. M.). *Reflections on the use of the hand spectroscope.* Aust.Gemmol., **14**, 7, 157-9, 1981.

A general summary of methods of use. Author is mistaken in his interpretation of the term 'reflected light' when used in absorption spectroscopy. This is light which passes through a stone and reflects at an inside surface giving a longer light path and light undiluted by stray illumination from the original source. He also advocates using a wide open slit to facilitate the location of an absorption line or band. This is contrary to normal practice and will swamp fine lines completely. R.K.M.

PFAFFL (F.). *Der Edelstein des Zaren Alexandrit.* (Alexandrite, gemstone of the Czars.) Mineralien Magazin, **6**, 2, 73-7, 7 figs (5 in colour), 1982.

The occurrence of alexandrite in the Urals is interestingly located on a sketch map and the crystal form usefully described. M.O'D.

POUGH (F. H.). *Japanese manmades.* Lapidary J., **35**, 10, 2004-8, 7 figs (4 in colour), 1982.

Opal made from monodisperse latex, beryl and alexandrite made in Japan are described. References would have been welcome. M.O'D.

RAMSEY (J. R.). *The cutting properties of kunzite.* Gems & Gemology, **XVII**, 4, 220-5, 6 figs in colour, 1981.

The cutter, Tom Carleton, undertook to cut with tables normal to the *c* axis, (something commercial cutters are usually not keen to do because of the facile and perfect prismatic cleavage). The one kilo fine quality crystal was sawn into four pieces to give stones of 703.5, 725, 514, and 145 carats respectively. First stone took 2½ hours to saw and 14 days to cut and polish. Illustrations vary in colour and final shade is difficult to assess. Problems and difficulties in cutting are explained. R.K.M.

ROBERTSON (A. D.). *Letter to the Editor—Gem Sphene in Australia,* Aust.Gemmol., **14,** 9, 222, 1 fig, 1982.

Gem quality sphene has been known from Australia for a number of years. Deposits in the Harts Range, found before 1977, yielded crystals capable of cutting as gems of over 20 ct: colour ranged from honey-brown to yellowish green with a high degree of transparency. J.R.H.C.

SANDERS (J. V.). *Jelly opal from White Cliffs.* Aust.Gemmol., **14,** 7, 161-5, 5 figs, 1981.

A valuable paper which adds to the knowledge of opal structure. Electron-photomicrographs reveal that this type of opal often has a lattice of larger opal spheres regularly arranged among the smaller spheres. These are probably responsible for the flashes of monochrome colour which characterize this kind of opal. The optics of this are complex. R.K.M.

SCHMETZER (K.). *Zur Mineralogie ternärer Oxide im System BeO-MgO-Al_2O_3.* (The mineralogy of ternary oxides in the system BeO-MgO-Al_2O_3.) Naturwissenschaften, 67, 471, 1981.

The system BeO-MgO-Al_2O_3 is discussed with particular reference to taaffeite and taprobanite. M.O'D.

SCHMETZER (K.), BANK (H.). *The colour of natural corundum.* N.J. Miner. Mnh., 2, 59-68, 1 fig, 1981.

The colour of natural corundum is ascribed to various trace elements and in some cases to lattice defects. Colours other than the basic ones are attributed to the superimposition of absorption bands of trace elements or pairs of elements. Lattice imperfections, together with trivalent chromium, are responsible for the colour of orange (padparadschah) sapphire. M.O'D.

SCHMETZER (K.), BANK (H.). *Garnets from Umba Valley, Tanzania—members of the solid solution series pyrope-spessartine.* N.J. Miner. Mnh., 8, 349-54, 1981.

A number of garnets from the Umba Valley area of Tanzania were examined and found to belong to a series with end members pyrope and spessartine. The range of specific gravity was 3.95-3.84 and of refractive index 1.768-1.751. M.O'D.

SCHMETZER (K.), BANK (H.). *Die Farbursachen und Farben der Mineralart Korund.* (Causes of colour and colour of the mineral corundum.) Z.Dt.Gemmol.Ges., **30,** 3/4, 152-6, 2 tables, bibl., 1981.

The colour of corundum and its gemstone varieties ruby, sapphire and padparadschah is caused by ions of the transition metals iron, titanium, chromium, and vanadium as well as by lattice imperfections. Crystals whose colour is due to only one transition metal ion or one pair of transition metal ions are not often found in nature. Most natural corundum crystals have different causes for their specific colours. By adding several basic colours a great number of mixed colours can be produced in natural corundums. The absorption spectra of such crystals are interpreted as a superposition of several basic types of spectra. E.S

Schmetzer (K.), Bank (H.). *Granate aus dem Umba-Tal, Tansania: Ist ein neuer Varietätsname erforderlich?* (Garnets from the Umba Valley, Tanzania: is a new name needed for this variety?) Z.Dt.Gemmol.Ges., **30**, 3/4, 177-81, 1 fig. in colour, 1 graph, 2 tables, bibl., 1981.

An English version of this paper was published in *J.Gemm.*, 1981, **XVII**, 8, 522-7.

Schmetzer (K.), Bank (H.), Stähle (V.). *Zum Chromgehalt in synthetischen Smaragdüberzügen von Beryllkernen ('Synthetische Smaragde' der Herstellung Lechleitner).* (The chrome content of synthetic emerald skin over beryl ('synthetic emeralds' as produced by the Lechleitner method.)) Z.Dt.Gemmol.Ges., **30**, 3/4, 210-13, 1 table, 1 graph, bibl., 1981.

The RIs of the synthetic skin over the beryl seed of the Lechleitner synthetic emerald show a linear correlation with the chromium content of the coating. In a sample with RIs n_o1.580, n_e1.572, a Cr_2O_3 content of 3.99% was found; a stone with n_o1.610, n_e1.601, contained 10.01% Cr_2O_3. Very broad, faint shadow edges on the refractometer in one sample were caused by an unhomogeneous distribution of Cr_2O_3 between 7.64 and 13.20% in the synthetic emerald overgrowth. It seems that the higher the chromium content in the coating, the darker the coating, i.e. the darker the stone. E.S

Schmetzer (K.), Krupp (H.). *Enstatit vom Mairimba Hill, Kenia.* (Enstatite from Mairimba Hill, Kenya.) Z.Dt.Gemmol.Ges., **30**, 3/4, 194-6, 2 tables, 1981.

An English version of this paper was published in *J.Gemm.*, 1982, **XVIII**, 2, 118-20.

Snow (J.), Bracewell (H.), Brown (G.). *An examination of the Cathaystone cat's-eye.* Aust.Gemmol., **14**, 9, 230-2, 4 figs, 1 table, 1982.

A well illustrated paper on this artificial cat's-eye apparently made from fibre-optics material. Use of scattered or patterned inserts of coloured fibres imparts colour to the latest examples seen. R.K.M.

Snow (J. J.). *The hand lens—its usefulness to the jewellery trade.* Aust. Gemmol., **14**, 9, 233-7, 14 figs, 1982.

An excellent and valuable paper dealing very fully with this indispensable optical aid and explaining diagrammatically spherical and chromatic aberration, and the virtues or otherwise of various compound lenses from simple to aplanatic triplet. Good instructive paper full of excellent advice. R.K.M.

Taylor (B.), Brown (G.), Snow (J.). *An evaluation of the Gemlusta reflectometer.* Aust. Gemmol., **14**, 8, 196-9, 1 fig, 1981.

Report of the Instrument Evaluation Committee of the G.A.A. A thorough testing assessment of an updated and improved infrared reflectometer for which high claims are made. This has a digital read-out and a remote probe which can be brought to a stone in a setting. Readings were not readily reproducible with the latter. Lower values, those for gems which can be readily tested by ordinary refractometer, had many overlapping ranges and corroborative test by other instruments would be needed. R.K.M.

WANG (N.). *The superstructural pattern of lapis lazuli.* Z.Dt.Gemmol.Ges., **30**, 3/4, 224-5, 1 table, 1981.

The very weak satellite peaks observed in the powder pattern of a pure lapis lazuli can be accounted for by a supercell with edge length $a_o = 4 \times 9.07$Å. E.S

WEIBEL (M.), WESSICKEN (R.). *Hämatit als Einschluss im schwarzen Sternsaphir.* (Haematite as inclusion in black star sapphire.) Z.Dt.Gemmol.Ges., **30**, 3/4, 170-6, 7 figs (3 in colour), 1981.

Asterism in black star sapphires from Bang-kha-cha in south-east Thailand is caused by perfectly orientated intergrowth of elongated haematite lamellae in the [100] directions of corumdum. The interphase between the two minerals produces a periodic contrast pattern which can be recognized as narrow-spaced additional intensities in electron diffraction patterns. E.S.

WICKETT (H. C.). *Determination of refractive indices.* Aust.Gemmol., **14**, 8, 194.

Author suggests that full birefringence cannot always be obtained from one facet of a cut stone because of small size and bad polish of specimens. Advocates using distant vision method on such stones, but that would not give birefringence. R.K.M.

WYART (J.), BARIAND (P.), FILIPPI (J.). *Lapis lazuli from Sar-e-Sang, Badakshan, Afghanistan.* Gems & Gemology, **XVII**, 4, 184-90, 8 figs (7 in colour).

An excellent account of the ancient historic, and still the only, source of fine lapis lazuli, investigated ten years ago. Blue colour depends on sulphur content. Sar-e-Sang, considered difficult of access, is almost incredibly so, a fact brought home by the illustrations. Access to the camp at 2500 m is over high passes. The mines are then even higher and very difficult to reach. Annual output approximately one ton of usable rock, only 16% is fine enough for jewellery, rest used ornamentally. Mined by blasting. Rock carried by men to a point where donkeys can carry it to a jeep track. Region is strongly metamorphic and lazurite is found in grey skarns through a white micaceous marble. Pyrite almost always included. Mines now in hands of Afghan Nationalists. Not worked officially since Russian invasion. Some material still smuggled to Pakistan. R.K.M.

Index to Volume 17, Numbers 1-4, Gems & Gemology, **XVII**, 4, 245-8, 1981.

Previously two years to the volume, this four issue volume is a new departure as, of course, is the whole format of this now important magazine. Index is excellent but might be improved by including abstracted papers, which in this volume form an important section of the journal for the first time. R.K.M.

Stones Seen. Aust.Gemmol., **14**, 7, 160, 1 fig, 1981.

A fly in Baltic amber was probably of an Oligocene type about 40 million years old. R.K.M.

BOOK REVIEWS

ROBINS (B.). *An A-Z of gems and jewellery.* David & Charles, Newton Abbot, 1982. pp.96. £3.95.

A completely unnecessary and derivative book which contains a large number of errors undoubtedly based on ignorance of the subjects surveyed. Tanzania and Tasmania, beryl and chrysoberyl, East Germany and Bohemia are confused; reconstructed ruby makes yet another tedious appearance and there is no bibliography. M.O'D.

SINKANKAS (J.). *Emerald and other Beryls.* Chilton Book Company, Radnor, Pa, U.S.A., 1981. pp.xvi, 665; figs 196 black & white, 24 colour; tables 88. £30.00.

This a monumental work of encyclopaedic proportions and conception, and represents the results of 15 years of painstaking research and compilation. It is divided into three parts; some 150 pages are devoted to History and Lore, 200 pages to optical and physical properties and 350 pages to Beryl deposits.

Part I goes back to 3500 BC and traces the history of beryl in Ancient Egypt through antiquity, mediaeval and modern Europe and in other continents. The author goes on to describe beryl in magic, mystery and medicine, and in art and ornament. A notable feature of this part (and indeed of the whole work) is the citing of important historical works dealing with gems and lapidary work. References in the text are augmented by carefully verified bibliographies which terminate chapters: they represent one of the most desirable features of the book.

In Part II the crystal structure and chemical composition, the physical and optical properties, colour and luminescence, crystallography, inclusions, artificial and synthetic beryls and the cutting and polishing of beryl are described, the section concluding with the geological classification of beryl deposits. Despite the extraordinary volume of facts gathered together in this part it is, nevertheless, very readable both by the amateur and professional. Well annotated diagrams abound and the numerous tables succinctly present a series of facts culled from widespread sources.

Part III forms the real 'meat' of the book. The arrangement of the deposits is alphabetical by countries. It abounds with good locality maps and black-and-white photographs; many of the latter were taken decades ago and some lack definition and contrast, but they *are* records. The treatment is comprehensive and includes details of the geological setting and the production history of the various mines, chemical analyses and other properties of the various beryls. Emphasis is placed on deposits outside N. America and upon those described in languages other than English.

An appendix (with its own bibliography) traces the nomenclature of beryl and its derivation, and includes a glossary of the various terms which have been applied to beryl and its varieties.

This fat monograph owes its inspiration to Joseph E. Pogue's (1915) work on 'The Turquoise'. The present work covers a comparatively wider field and will, it is hoped, inspire its author to yet further 'instant classics' on other gem minerals. For its size, scope and erudition the book is not expensive at £30.00, and it will appeal to a wide readership in the gemmological, mineralogical, geological and mining fields.

E.A.J.

Sweat of the sun, tears of the moon—gold and emerald treasures of Colombia. Natural History Museum of Los Angeles County, Los Angeles, Ca, U.S.A., 1981. pp.96. Illus. in black-and-white and in colour. Price on application.

Though the gemmologist will turn at once to the superb colour pictures of rough and cut emeralds, the remainder of this outstanding book gives some idea of the richness of the collections of the Museo del Oro in Bogota, Colombia, and of the civilizations which those collections represent. The photographs of emerald include some of the largest known emerald crystals as well as cut examples; a separate chapter of the catalogue is devoted to emerald and the writer is optimistic about the possibility of further deposits being located.

M.O'D.

ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to the following for their gifts:

Mrs N. Goulandris, Kifissa, Greece, for two pieces of branch coral from Greek waters.

Miss M. A. Lapworth, F.G.A.A., Guildford, Surrey, for a copy of *Edelsteine,* the German version of *Gemstones,* by Eduard Gübelin, C.G., F.G.A., Silva-Verlag, Zurich, 1969.

Mr Peter van Blommestein, Kimberley, S.A., for one piece of rough sugilite (wesselite) from Wessel's Manganese Mine, Hotazel, Northern Cape, South Africa, and also for a polished piece of rough stichtite from South Africa.

OBITUARY

Major Joe D. Hanna, Jr, G.G., F.G.A. (D.1965), St Louis, Mo., U.S.A., died on 16th December, 1981.

Mr Kenneth Parkinson, F.G.A. (D.1939), Hull, died on 15th December, 1981.

Mr Jack Raymond Shaw, F.G.A. (D.1950), Birmingham, died on 21st March, 1982.

NEWS OF FELLOWS

During the First International Coloured-Gemstones Conference, held from 1st to 3rd February, 1982 in the Bandaranaike Memorial Conference Hall, Colombo, Sri Lanka, the following Fellows spoke or presented papers: Dr Joel Arem on 'The Future Role of Collector Stones', Professor Dr E. Gübelin on 'The significance of mineral inclusions in coloured gemstones', Mr Herbert Gunaratne (chief valuer of the State Gem Corporation) and Mrs Barbara Edrisinghe (president of the Gemmologists Association of Sri Lanka) jointly on 'Sri Lankan Gemstones', and Mr Peter G. Read, C.Eng., on 'Grading Systems for Coloured Stones—their Problems and Remedies'.

Mr Ian C. C. Campbell, F.G.A., has been appointed to be the head of a new coloured-stones laboratory opened by The Jewellery Council of South Africa.

In January 1982 Mr N. H. Harding, F.G.A., was elected Chief Commoner (of the City of London) for 1982 and Chairman of the City Lands and Bridge House Estates Committee. He is First Warden of the Worshipful Company of Gold and Silver Wyre Drawers and in January 1983 he becomes their Master.

H.R.H. The Duke of Gloucester with the Chairman, Mr David Callaghan, at Goldsmiths' Hall, on Monday 5th October 1981, before the opening of the Association's exhibition, 'Fifty Years of Gemmology'.

MEMBERS' MEETINGS

London

On 17th March, 1982, in the Flett Theatre at the Geological Museum, Exhibition Road, South Kensington, Mr E. Alan Jobbins, B.Sc., F.G.A., presented 'New Zealand Jade' by Russell J. Beck, F.G.A. The talk was illustrated by superb colour slides, and almost 200 members attended the meeting.

On 20th April, 1982, in the Central Electricity Generating Board Theatre, Sudbury House, 15 Newgate Street, London E.C.1., Mr Peter G. Read, C.Eng., F.G.A., gave an illustrated talk on 'New Gemmological Instruments, 1980-1982'. A selection of equipment was available for inspection.

Midlands Branch

On 26th March, 1982, at the Society of Friends, Dr Johnson's House, Colmore Circus, Birmingham, Mr Harry Wheeler, F.G.A., gave a talk entitled 'History and growth of the Gemmological Association and overseas visits.'.

On 30th April, 1982, also at the Society of Friends, Mr Peter G. Read, C.Eng., F.G.A., gave a talk on 'More new and exciting gemmological instruments'. Mr Read's talk was followed by the Annual General Meeting at which Mr Douglas Morgan, F.G.A., was elected Chairman and Mrs Janet Leek, was re-elected Secretary.

North-West Branch

On 25th March, 1982, at the Royal Institute, Colquitt Street, Liverpool, Mr A. E. Farn, F.G.A., gave a talk on 'Pearls, cultured pearls and non-nucleated pearls'.

On 5th May, 1982, at Church House, Hanover Street, Liverpool, Mr E. Alan Jobbins, B.Sc., F.G.A., gave an illustrated talk entitled 'The occurrences of nephrite in New Zealand and its fashioning by the Maori and modern man'.

South Yorkshire and District Branch

On 18th March, 1982, at the Sheffield Polytechnic, Pond Street, Sheffield, a practical evening was held, when gem-testing equipment, specimens and books were available for members' use.

COUNCIL MEETING

At the meeting of Council held on Tuesday, 2nd March, 1982, at Saint Dunstan's House, the following were elected to membership:

FELLOWSHIP

Adlestone, Mark I., St Annes-on-Sea. 1981
Advani, Vinod, Bombay, India. 1981
Allyn, Dale F., Eugene, Oreg., U.S.A. 1981
Alvis, Alayne G. D., Ashfield, N.S.W., Australia. 1981
Andre, Andre, London. 1981
Anfield, Jennifer J., Birmingham. 1981
Ashra, Shirish, London. 1981
Ashworth, Marie C., Toronto, Ont., Canada. 1981
Babber, Harish R., Southall. 1981
Bana, Habibullah, San Clemente, Ca, U.S.A. 1981

Barber, Anjali, Nairobi, Kenya. 1981
Bardsley, John N., London. 1981
Batycki, Charlene G., Toronto, Ont., Canada. 1981
Bekesch, Nicholas, Oshawa, Ont., Canada. 1981
Bell, Keith, Ottawa, Ont., Canada. 1981
Boyd, Robert T., Toronto, Ont., Canada. 1981
Breau, Karen L. J., Toronto, Ont., Canada. 1981
Chandrasena, Kalutantrige N. R., Panadura, Sri Lanka. 1975
Chavan, Umesh, Bombay, India. 1981
Chawla, Gulzari, Downsview, Ont., Canada. 1981
Chouiki-Doorn, Jacqueline, Spykenisse, Netherlands. 1981
Clarke, Francis B., Upminster. 1981
Cowing, Michael D., Glen Burnie, Md, U.S.A. 1981
Culpin, Ivor D., Weston-Super-Mare. 1980
Dayasagara, Kalupahana L. D., Colombo, Sri Lanka. 1981
de Hayes, Cecil, London. 1937
Dewar, Penelope S., Stockport. 1981
Ebata, Taiichiro, Takaoka City, Japan. 1981
Endean, Christine H., Auckland, N.Z. 1981
Fell-Smith, Simon A., Brisbane, Qld, Australia. 1981
Francey, Donald T., Christchurch, N.Z. 1981
Fujihara, Shigeru, Tokyo, Japan. 1980
Gasco Galindo, Ignacio, Valencia, Spain. 1981
Gettings, Barbara A., London. 1981
Girling, Matthew D., London. 1981
Grimston, Lady Iona C., London. 1981
Haghani, Victor J., London. 1981
Haniffa, Ahamed I., Urdorf, Switzerland. 1981
Hawker, Robin W. A., Kempton, Tas., Australia. 1981
Henderson, Shirley W. A., Hamilton. 1981
Hogarth, Graeme R., Kendal. 1981
Iwata, Kazuyoshi, Gifu Shi, Japan. 1981
Jones, Jeffrey M., London. 1981
Jones, Maureen D., Wellington, N.Z. 1981
Kelly, John S., Cardiff. 1981
Kelly, Susan M. B., Brisbane, Qld, Australia. 1981
Kettley, Helen M., London. 1981
King, Antoinette E., Rye. 1981
Krstic, Jovanka, Beograd, Yugoslavia. 1981
Lal, Daulet R. B., Bombay, India. 1981
Law, Sheila, London. 1981
Lindlau, Gisela, Aichwald, W. Germany. 1981
Litchfield, Anne-Marie, Northampton. 1981
McAteer, Alice M., London. 1981
McEwan, Robert S., Perth. 1981
McPherson, Heather, Leicester. 1981
Malkani, Sunil C., Bombay, India. 1981
Mansfield, Stephen McL., Burton. 1981
Mariathasan, Loganayagi, Colombo, Sri Lanka. 1981
Marikar Bawa, M. S. N., Colombo, Sri Lanka. 1981
Martin, Paul, Nuneaton. 1981
Martuccio, Celeste, Leamington Spa. 1981
Mater, Louise H., Laren, Netherlands. 1981
Meckoni, Prafulla H., Bombay, India. 1981
Mitchell, Peter J., London. 1957
Molagoda, Tikiri B. P., Kandy, Sri Lanka. 1981
Nakamura, Takeshi, Ishikawa, Japan. 1981

Nelischer-Millar, Anita I. A., Toronto, Ont., Canada. 1981
Pietroboni, Carlo, Forch, Switzerland. 1981
Postma, Renate E., Breda, Netherlands. 1981
Preston, Stephen P., Birmingham. 1981
Protopopoff, Monica, Beecroft, N.S.W., Australia. 1981
Raymond, Robert S., Brentwood. 1981
Rigby, Ian W., Wolverhampton. 1981
Rome, Martin L., London. 1981
Sadler, Philip A., London. 1981
Sastrowidjojo, Hendro, Surabaya, Indonesia. 1981
Shimada, Nobuo, Chiba-Ken, Japan. 1981
Smith, Catharine, Lutterworth. 1981
Sneddon, Katherine E., Hong Kong. 1981
Steward, Annelies, Calgary, Alta, Canada. 1981
Suguro, Norio, Tokyo, Japan. 1981
Taylor, Ernest B., Middlewich. 1981
Trinkl, André A., Johannesburg, S.Africa. 1981
van den Berge, Tania, A. P., St Amandsberg, Belgium. 1981
van der Zwaag, Hemko, Zeist, Netherlands. 1981
Venning, Ronald O., Toronto, Ont., Canada. 1981
Vermaas, Franciska J. M., Rotterdam, Netherlands. 1981
Vietti, Stuart, Penrith. 1981
Vikamsey, Indira J., Bombay, India. 1981
Warrenberg, Jonathan M., Ilkley. 1981
Wescott, H. Marjatta, Tokyo, Japan. 1981
Wijeratne, Chakrawarthige H. R., Colombo, Sri Lanka. 1981
Zanoon, Norfel W., Colombo, Sri Lanka. 1981
Zebrak, Tracy J., Hove. 1981
Zipf, William T., Bethel Park, Pa, U.S.A. 1981
Zwikker, Marijke, Nijmegen, Netherlands. 1981

ORDINARY MEMBERSHIP

Adams, Myra, Huddersfield.
Akasah, Khairuddin Bin, Selangor, Malaysia.
Alexander, Anthony P., Port St Mary.
Amedeo, James R., New York, N.Y., U.S.A.
Andrews, George C., London.
Aoki, Hisashi, Yamanashi, Japan.
Ariizumi, Keiji, Tokyo, Japan.
Attwell, William G., Toronto, Ont., Canada.
Banks, Derek R., Surabaya, Java, Indonesia.
Barnaby, Harold, Lincoln.
Bechtol, Lauren L., Bryan, Ohio, U.S.A.
Benham, Thomas R., Richardson, Tex., U.S.A.
Bhatt, Bharat K., London.
Bowman, Josephine T., London.
Breckenridge, Ian T., St Louis, Mo., U.S.A.
Bruce, H. Elizabeth, Hessle.
Buchan, David R., Nelson, N.Z.
Cardew, Charles J., Thornton Heath.

Carr, William A., New York, N.Y., U.S.A.
Carvey, Robyn, Hong Kong.
Castro, Ronaldo M., Rio de Janeiro, Brazil.
Chan Kai Chung, Marcus, Hong Kong.
Chan, Wing L., Hong Kong.
Chow, Yvonne Y., Hong Kong.
Chung, Penelopie, Hong Kong.
Clark, Margaret E., Royston.
Clark, Patricia M., Hong Kong.
Clarke, Norman V., Blandford Forum.
Cotogno, Romano, Borgomanero, Italy.
Cowell, Kenneth, Mahalarye, Botswana.
Cruickshank, Mary, Nairobi, Kenya.

Daulatani, Shambhu L., Dubai, U.A.E.
Dayawathie, Pinatuwa H., Kurawita, Sri Lanka.
Deeley, Peter J., Birmingham.
de Graaff, Martinus, Cambrils, Spain.
Demoray, Scott B., Grand Rapids, Mich., U.S.A.
Dodhia, Rohit K., Harrow.
Düblin, Theo, Arlesheim, Switzerland.
Duguid, Keith B., Salisbury, Zimbabwe.
Dunga, Kiran, Birmingham.

Edmondes, Eleanor, Bridgend.
Egeland, George S., Quaker Hill, Conn., U.S.A.
Elmer, Bruce L., St Peters, Mo., U.S.A.
Elvidge, Caroline A., Tonbridge.
Evert, Janice A., Townsville, Qld, Australia.

Fache, Frank, Edegem, Belgium.
Fancourt, Mavis J., Lilyfield, N.S.W., Australia.
Fernando, Devapurage P., Moratuwa, Sri Lanka.
Flanders, Katherine J., London.
Fordham, Robert J., Gidea Park
Frame, Olive, Nassau, Bahamas.
Fujimoto, Naoko, Hyogo Pref., Japan.
Fukazawa, Masaho, Shizuoka Pref., Japan.
Fukushima, Yasuo, Nagasaki Pref., Japan.
Fuller, Millie D., Point Richmond, Ca, U.S.A.

Gallagher, Gerard J., New Paltz, N.Y., U.S.A.
Gilbert, Leslie, Chessington.
Giodano, Sandra L., West Chester, Pa, U.S.A.
Gonggryp, Hendrik S., The Hague, Netherlands.
Goss, Alan C., Welwyn Garden City.
Graefin Grote, Isabelle E., London.
Grant, Milton G., Burlington, N.C., U.S.A.
Greatwood, Sheila, Mitcham.
Greig, Edward S., London.
Guinn, Betty R., Houston, Tex., U.S.A.
Gupta, Madan L., Kitwe, Zambia.

Hahmann, Bruno, Guatemala.
Hamachi, Heiji, Fukuoka Pref., Japan.
Hamada, Masatoshi, Shimoniikawa Gun, Japan.
Hamann, W. Richard, Lincoln, Neb., U.S.A.
Hansteen-Fossum, Bjørn, Oslo, Norway.
Hardy, Joanna, London.
Harris, Caroline A., Sutton Coldfield.
Hayashi, Junju, Fukuoka City, Japan.
Hayashi, Toshiko, Fukuoka City, Japan.
Heaton, Sally J., Dorchester.
Hegarty, Kathleen M., New York, N.Y., U.S.A.
Hickel, Stephen M., Sewell, N.J., U.S.A.
Hirokawa, Hideki, Tokyo, Japan.

Horikawa, Yoichi, Tokyo, Japan.
Horne, Allan R., Brighton.
Hurley, Christopher P., Caerphilly.

Ibara, Koichi, Tokyo, Japan.
Ichinose, Chie, Nishiyatsushiro Gun, Japan.
Ikoma, Nobuo, Kobe City, Japan.
Issadeen, Abdul M., Colombo, Sri Lanka.
Ito, Hitoshi, Yamanashi, Japan.

Jacques, Susan M., Santa Ana, Ca, U.S.A.
James, Sarah D., East Horsley.
John, Bryan C., Carmarthen.
Johnson, Mark R., Omaha, Neb., U.S.A.
Jones, Sandra L., New Plymouth, N.Z.

Kan, Michael S., Aruba, Netherlands Antilles.
Kano, Mieko, Fukuoka City, Japan.
Kasai, Reiko, Yamanashi, Japan.
Kearny-Kibble, Mathilde F., Lindfield, Australia.
Kibayashi, Misuzu, Paris, France.
Kirby, Paul A., Southport.
Knight, Barry, Bergen-op-Zoom, Netherlands.
Kobayashi, Shigeki, Ishikawa-Ken, Japan.
Kocziczka, Michael R., Vienna, Austria.
Koh, Yim F., Pahang, W.Malaysia.
Kuruppu, D. Edward, Pelmadulla, Sri Lanka.
Kyellin, Ewa, San Clemente, Ca, U.S.A.

Lane, Richard J., Townsville, Qld, Australia.
Lau, Paul C., London.
Lauer, Deborah J., Springfield, Ill., U.S.A.
Lavender, James G., Uckfield.
Law, Ada, Hong Kong.
Leolini, Franco, Florence, Italy.
Leong, Choy Y., Kuala Lumpur, Malaysia.
Levinson, Michael, Burnaby, B.C., Canada.
Lieberum, William R., Philadelphia, Pa, U.S.A.
Lim, Pauline, Hong Kong.
Lin, Chin S., Taipei, Taiwan.
McGeorge, Robyn L., Eleebana, N.S.W., Australia.
McKendrick, Stewart W., London.
McLeod, John W., Papakura, N.Z.
McPherson, George L., Speers Point, N.S.W., Australia.
Mak, Michael M., Hong Kong.
Marcus, Alec, Jerusalem, Israel.
Marsh, Brian, Keynsham.
Matongo, Winner M., Lusaka, Zambia.
Maynard, Mavis A., Sturminster Newton.
Mellows, Jacqueline M., Bexleyheath.
Millard, David A., New Orleans, La, U.S.A.
Mirza, Kaleem U., Peshawar, Pakistan.
Miyata, Takeshi, Yamanashi, Japan.
Moore, Stephen A., Leicester.
More, Barbara E., Toronto, Ont., Canada.
Morita, Yutaka, Yamanashi Pref., Japan.
Morrissey, William H., Fairfield, Conn., U.S.A.
Motegi, Hiroshi, Yamanashi, Japan.
Motozawa, Masuki, Yamanashi, Japan.
Mughal, Abdul M., Abu Dhabi, U.A.E.
Muraoka, Yasuyuki, Yanai City, Japan.

Nagasaka, Yuji, Kofu City, Japan.
Nakamura, Yasuhisa, Kitakyusho City, Japan.
Nakazawa, Akira, Yamanashi, Japan.
Nanayakkara, Vivian I., Maharagama, Sri Lanka.
Nevill, Amanda J., Hong Kong.
Ninomiya, Mutsuko, Yamanashi, Japan.

Obadia, Ménaché, Antwerp, Belgium.
Ohkawa, Minoru, Tokyo, Japan.
Ohno, Yaeko, Tokyo, Japan.
Okuya, Yukie, Tokyo, Japan.
Pancher, Sukhdev S., Hounslow West.
Patel, Makki, Bombay, India.
Patel, Shirish, London.
Pettersson, June C., Midhurst.
Pharaoh, Martin, Halifax.
Pierre, Robert E., La Jolla, Ca, U.S.A.
Pritchard, Janet M., London.
Quane, David, Bradford.
Rahman, Aman U., Singapore.
Ramamoorthy, Narayanan, Hong Kong.
Reed, Ronald W., Augusta, Ga, U.S.A.
Rerolle, Jean-Claude, London.
Retty, A. T., Singapore.
Richards, James, Saugerties, N.Y., U.S.A.
Sakita, Yoshizo, Sumoto City, Japan.
Saunders, Corinne M., Florida, S.Africa.
Saunders, Geoffrey P., Florida, S.Africa.
Sayers, Ronald J., Dhahran, Saudi Arabia.
Segreti, Adolfo, Reggio Emilia, Italy.
Selby, Gerald, Chorleywood.
Selmon, Simon, Northwood.
Setsuda, Yasuko, Tokyo, Japan.
Shariff, Amir G., Nairobi, Kenya.
Sheen, Alison M., Ossett.
Shimmi, Yoko, Tokyo, Japan.
Shinoka, Keiko, Tokyo, Japan.
Shiraishi, Motoko, Tokyo, Japan.
Shiroya, Yoshie, Funabashi City, Japan.
Siriyananda, J. Subasinghe, Pelmadulla, Sri Lanka.
Silver, Richard, Ft Lauderdale, Fla, U.S.A.
Smith, Michael P., Whitley Bay.
Steinhauer, Mary H., Adelphi, Md, U.S.A.
Stevens, Julie M., London.
Sulaiman, Zahari Z., Birmingham.
Suzuki, Setsuko, Yamanashi, Japan.
Tachikawa, Toshiaki, Yamanashi, Japan.
Tagawa, Koji, Tokyo, Japan.
Tanaka, Hideaki, Nagasaki City, Japan.
Tangkathach, Siriwan, Bangkok, Thailand.
Tanuwidjaja, D., Jakarta-Timur, Indonesia.
Theophilis, Maria U., London.
Toda, Taketoshi, Yokohama City, Japan.
Tsuchiya, Manabu, Yamanashi, Japan.
Tsunoda, Koki, Yamanashi, Japan.
Turk, Noriko, Hong Kong.
Turkel, Howard, London.
Turner, Starla E., Hillsborough, Ca, U.S.A.
Uesaka, Noriko, Osaka, Japan.
Uetake, Yasunao, Kashiwa-shi, Japan.
van Doren, Jean-Paul, Bognor Regis.
Walker, Mary C., Toronto, Ont., Canada.
Wallach, Edward M., New York, N.Y., U.S.A.
Warriner, Elizabeth R., Solihull.
Watanabe, Yuichi, Hokkaido, Japan.
Waterhouse, Winifred C., Auckland, N.Z.
Weerasuria, Ajith H., St Albans.
Weir, Juliet C., Dublin, Ireland.
White, Gerald A., Fareham.
Wolfe, Brian W., Calgary, Alta, Canada.
Yamaguchi, Maki, Fukuoka City, Japan.
Yamazaki, Hideki, Shimizu City, Japan.
Yanagisawa, Natsuko, Yamanashi, Japan.
Yasunaga, Jun, Fukuoka City, Japan.
Younger, June E., Bangkok, Thailand.
Yung, Joanna C., Hong Kong.

G.I.A.—INTERNATIONAL GEMOLOGICAL SYMPOSIUM

The First International Gemological Symposium organized by the Gemological Institute of America as part of its 50th Anniversary celebrations was held at the Century Plaza Hotel, Los Angeles, from 12th to 15th February, 1982. About 700 persons attended, many of them from outside the U.S.A.

The G.I.A. President, Mr Richard T. Liddicoat, Jr, Hon. F.G.A., started with a talk entitled 'The Development of Gemological Training in America by the G.I.A.', which was an historical survey of the G.I.A.'s foundation by Mr Robert M. Shipley, F.G.A., in 1931 and its growth and activities to the present time. Mr Shipley had obtained his F.G.A. in London in 1929. In the last session, Mr Harry Wheeler, F.G.A., gave a talk on the 'History of Gemmology in the U.K.' This covered the period from 1908 to the present day.

In addition there were over sixty talks which covered:

Diamonds—origin, sources and properties, marketing and grading.
Coloured Stones—properties, sources, supplies and marketing.
Synthetics and Simulants—growth and properties.
Pearls—sources, supplies and properties.
Selling Gemmology to the public.
Reports on Gem and Gem Occurrences.
Inclusions.
Advances in Gemmology.
Gemmology and the Market.
An Appreciation of Gems.

Although a very wide coverage was obtained by having so many talks and speakers, there was the problem of deciding which session to attend, because at times there were four different talks being given at the same time in different rooms. There was also an audio-visual programme including films by De Beers and Multimedia and talks on *Gem Carving in Idar-Oberstein, Opal Mining in Australia,* and *Colour Art and Fashion in Gemmology.*

The social programme was first class, starting with the Saturday evening when a Gala Evening with buffet supper was held in the Hotel. On the Sunday there was 'Open House' at the G.I.A. Headquarters in Santa Monica, with a complete tour of the educational facilities, the Bookstore and Instruments Factory, and a buffet luncheon in the grounds. On Monday evening there was a dinner/dance at the Los Angeles Museum of Natural History, with the opportunity of seeing some impressive mineral specimens and the superb cut-stone collection in the F. C. Hixon Gem Vault.

The Symposium was an excellent way to celebrate the 50th Anniversary and it is intended to hold further events every second or third year.

A copy of the *Proceedings* of the Symposium, containing a copy of the talks that were presented, is available from the G.I.A. Bookstore, 1735, Stewart Street, Santa Monica, California 90404, U.S.A., price (US)$43.95 plus $3.25 postage.

IRISH BRANCH

Mr Gabriel O'Grady, F.G.A., of 7 Rathfarnham Road, Terenure, Dublin 6, is desirous of forming a branch of the Association in Ireland. Will any member who is interested please communicate with him direct.

DATE FOR YOUR DIARY

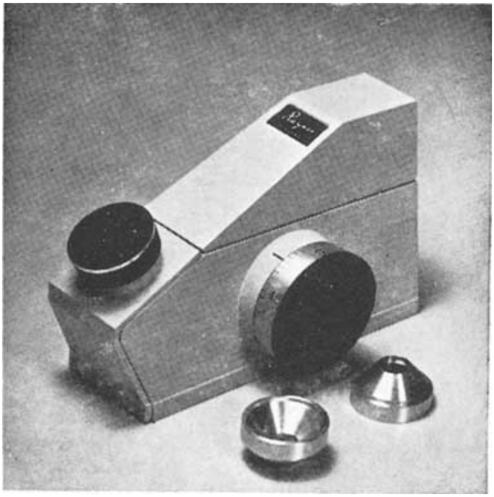
The Reunion of Members and Presentation of Awards is to be held on Monday, 15th November, 1982, at Goldsmiths' Hall, Foster Lane, London E.C.2.

RIPLUS CONTACT PASTE SUPPLIED WITH KRÜSS ER602 REFRACTOMETERS

The test report on the Krüss ER602 refractometer by Peter Read (J.Gemm., 1981, XVII (5), 321-4) contained the manufacturer's claim that the *'new "Riplus Kleber" contact fluid is a viscous non-toxic brown paste'.* Recently it has been revealed that the Kleber material consists of a Cargille high refractive index 'melt' which contains arsenic tribromide, a toxic and corrosive chemical. Anyone using the Kleber contact fluid is therefore advised to avoid contact with it and to remove any material on the body immediately by thorough scrubbing with water. The greatest danger is from ingestion, and the possibility of this is greatly reduced by avoiding eating and smoking when using the material.

JOURNAL OF GEMMOLOGY AND *GEMMOLOGIST*—BACK NUMBERS

A member has a complete set of the *Journal of Gemmology* from Volume 1 to date (some are bound) and a set of the *Gemmologist* from 1949 to 1963 (April 1962 missing). Anyone interested in purchasing these should write to Box 82, G.A. of G.B., Saint Dunstan's House, Carey Lane, London, EC2V 8AB.



Historical Note

The Gemmological Association of Great Britain was originally founded in 1908 as the Education Committee of the National Association of Goldsmiths and reconstituted in 1931 as the Gemmological Association. Its name was extended to Gemmological Association of Great Britain in 1938, and finally in 1944 it was incorporated in that name under the Companies Acts as a company limited by guarantee (registered in England, no. 433063).

Affiliated Associations are the Gemmological Association of Australia, the Canadian Gemmological Association, the Gem and Mineral Society of Zimbabwe and the Gemmological Association of Hong Kong.

The *Journal of Gemmology* was first published by the Association in 1947. It is a quarterly, published in January, April, July, and October each year, and is issued free to Fellows and Members of the Association. Opinions expressed by authors are not necessarily endorsed by the Association.

Notes for Contributors

The Editor is glad to consider original articles shedding new light on subjects of gemmological interest for publication in the *Journal*. Articles are not normally accepted which have already been published elsewhere in English, and an article is accepted only on the understanding that (1) full information as to any previous publication (whether in English or another language) has been given, (2) it is not under consideration for publication elsewhere and (3) it will not be published elsewhere without the consent of the Editor.

Articles published are paid for, and any number of prints of individual articles may be supplied to authors provided application is made on or before approval of proofs. Applications for prints should be made to the Secretary of the Association—not to the Editor—and current rates of payment for articles and terms for the supply of prints may be obtained also from the Secretary.

Although not a mandatory requirement, it is most helpful if articles are typed (together with a carbon copy) in double spacing on one side of the paper, with good margins at sides, top and foot of each page. Articles may be of any length, but it should be borne in mind that long articles are more difficult to fit in than short ones: in practice, an article of much more than 10 000 words (unless capable of division into parts or of exceptional importance) is unlikely to be acceptable, while a short note of 400 or 500 words may achieve early publication.

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CONTENTS

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