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SYNTHETIC RUBY MADE BY KNISCHKA

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ABSTRACT

This paper deals with the newly created Knischka synthetic rubies in respect to their identification by gemmological methods. The growth of extra crystal faces is briefly discussed and the different crystal forms are compared with those made by Knischka. Further, the typical inclusions are presented to make the identification procedure as easy as possible.

INTRODUCTION

Quite recently Professor Paul Otto Knischka, of Steyr, Austria, announced the production of a new synthetic ruby under the name 'Knischka Synthetic Ruby' (PK-ruby after **P**aul **K**nischka). The growth has been achieved by using a modification of the gradient transport technique involving supercooling and

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supersaturation. The crystals are characterized by many resulting modified lustrous faces. This higher number of faces has not yet been reported from any other synthetic corundum crystal manufacturers. These new synthetic rubies have been grown as single crystals (Figure 1), twins, triplets and other multiple crystals including cluster formations.

FIG. 1. Single crystal of synthetic ruby made by Knischka showing the pseudohexagonal bipyramidal form with horizontal striations.

CRYSTALLOGRAPHY

Different corundum manufacturing processes are known, and gem quality material has already been introduced by various manufacturers (Nassau 1980). 𝒦-rubies are rather dissimilar to synthetics reported previously in relation to their crystallization phenomena. Gradient transportation is achieved by high-pressure-solution growth with the influence of melt-diffusion method or using both methods together.

Different synthetic growth techniques are reported. It has also been reported that by doping of Mn and Mg with slight temperature changes like 10 °C to 20 °C from the crystallization point, the number of faces can be increased even up to 20 (Siesmayer *et al.* 1975). Such increased numbers of faces in synthetic corundum crystals are illustrated in Figures 2 to 9.

In their crystallization process 𝒦-rubies have shown even more faces than illustrated in Figures 2 to 9. By modification of the parameter the number of faces is influenced in this new product by Professor Knischka as reported in 1980. They often showed the five different faces of $d\,\{01\bar{1}2\}$, $y\,\{01\bar{1}5\}$, $r\,\{10\bar{1}1\}$, $n\,\{22\bar{4}3\}$ and $c\,\{0001\}$ in a single crystal. Some of them even presented the sixth face $\cdot\{10\bar{1}9\}$. Further development of $a\,\{11\bar{2}0\}$ is possible.

With the explanations given above 𝒦-rubies have shown higher numbers of faces often amounting to 32 or 38 or occasionally 44 in a single crystal. The type with 38 faces is illustrated in Figure 10.

The new synthetic rubies were analysed in the crystallographic section of the district museum *Joanneum* in Graz, Austria, for crystallographic investigations. The results were reported by Professor Knischka in his paper (1980) and are detailed below:

The crystal class was *Ditrigonal Scalenohedron* $D^{6}_{3d}-R_{\bar{3}c}$
Typical forms possible to occur with 𝒦-rubies are:

$c = \{0001\}$
$n = \{22\bar{4}3\}$
$r = \{10\bar{1}1\}$
$\cdot = \{10\bar{1}9\}$

$d = \{01\bar{1}2\}$
$?y' = \{03\bar{3}.16\}$
$a = \{11\bar{2}0\}$*
* for $𝒦_6$-rubies.

Different forms of single crystals with indices are shown in Figures 11 to 14. As mentioned, apart from single crystals, twins, triplets, multiple crystals and cluster formations may occur through

(a) temperature variations (possibly by lowering the temperature), or
(b) inherent chemical process, or
(c) evaporation in an oxidization process.

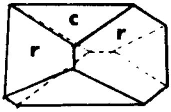

FIG. 2. Remeika (1963) corundum crystal with 8 faces.

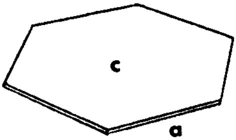

FIG. 3. Remeika (1963) corundum crystal with 8 faces.

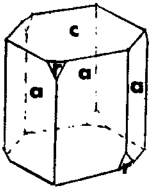

FIG. 4. Neuhaus *et al.* (1962) corundum crystal with 14 faces formed at high-pressure.

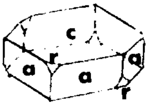

FIG. 5. Neuhaus *et al.* (1962) corundum crystal with 14 faces formed at low-pressure.

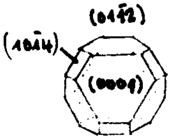

FIG. 6. White *et al.* (1965) corundum crystal with 14 faces.

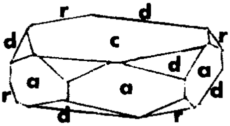

FIG. 7. Chase (1966) corundum crystal with 20 faces.

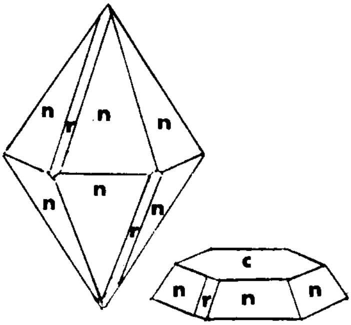

FIG. 8. Yanovskii *et al.* (1970) corundum crystal consisting of 20 faces (bi-pyramid with or without basal pinacoid).

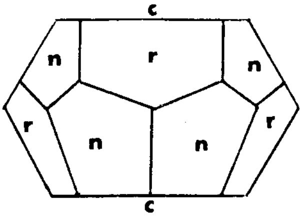

FIG. 9. Watanabe *et al.* (1976) corundum crystal consisting of 20 faces (bi-pyramid with basal pinacoids).

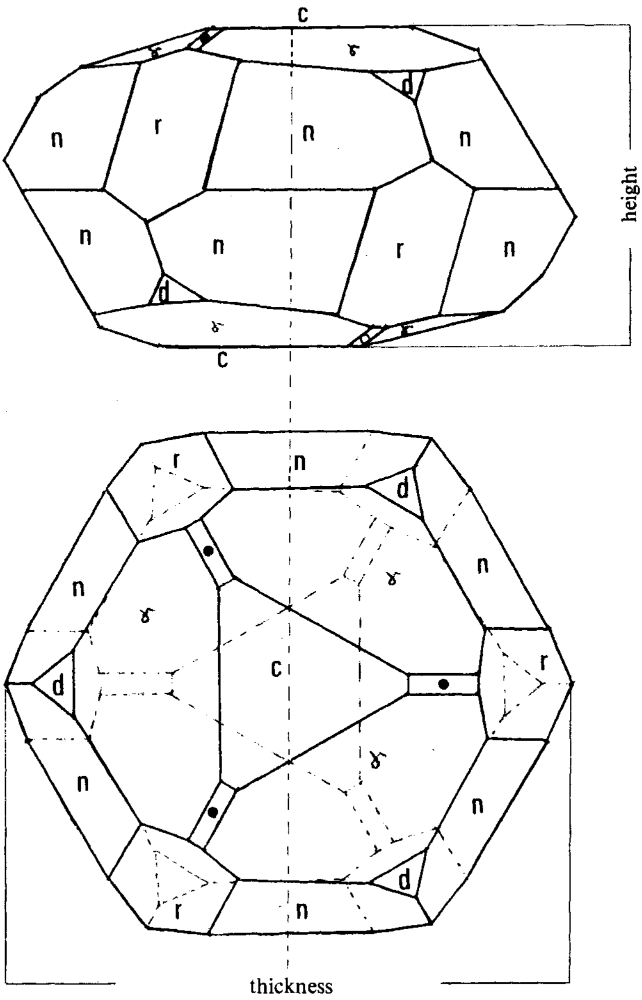

FIG. 10. Knischka (1980) Synthetic corundum crystal consisting of 38 faces.
above = side view below = top view

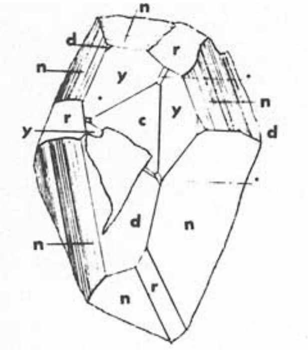

FIG. 11. K-ruby of 1.029 carat showing the face nomenclature.

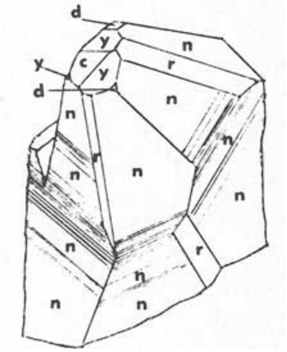

FIG. 12. K-ruby of 1.710 carat showing the face nomenclature.

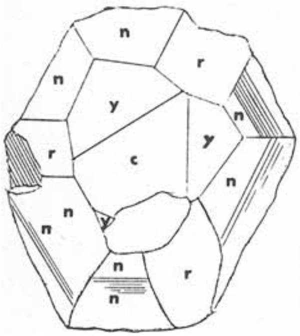

FIG. 13. K-ruby of 0.59 carat showing the face nomenclature.

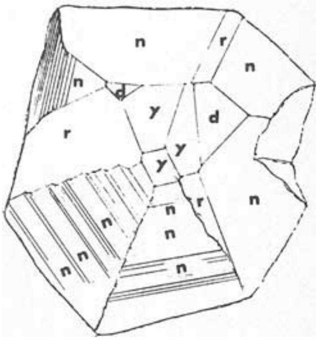

FIG. 14. K-ruby of 1.825 carat showing the face nomenclature.

All the Knischka examples showed striations according to $22\bar{4}3$

CHEMISTRY

Chemical investigations have shown that these new rubies contained less Fe than naturals. On the other hand Cr percentage is much higher as in some Chatham or Verneuil synthetic rubies. Such chemical analysis does not really differentiate the new synthetics from other natural or synthetic rubies. Powdered ruby samples including three 𝔎-rubies, one natural and one Verneuil were analysed and reported by Knischka & Gübelin (1980). Further the relative foreign element percentages were given by Bosshart (1981). The analytical reports of these two investigations are given in Table 1 and Table 2 respectively.

TABLE 1. Foreign element percentages comparison (after Knischka & Gübelin 1980)

Powdered rubies (weight in mg)	42.6 mg	12.2 mg	102.6 mg	100.7 mg	102.2 mg
selected samples	𝔎-1 ruby	𝔎-2 ruby	𝔎-3 ruby	nat. ruby	Vern. ruby
Elements %					
Fe	0.073	0.13	0.065	0.241	0.073
Zn	0.013	0.041	0.0068	0.022	0.047
Ni	0.031	0.126	0.034	0.028	0.017
Ti	lower than 0.3% in all samples			0.99	present
Au	0.03	0.08	0.02	0.01	0.011
Co	0.025	0.073	0.016	0.01	0.008
Pb	0.199	0.776	0.076	0.034	0.044
Cr	1.585	0.796	0.558	0.305	0.841

elements like Bi, W, Pt, V, Ba, Si, Rh, Cu, Ag, etc., were not detected.

TABLE 2. Relative foreign element content in K-rubies compared with other natural and synthetic rubies (after Bosshart 1981)

	Cr	Fe	Ti	V
Knischka	***	**	**	*
Verneuil	**	*	*	*
Chatham	***	*	*	*
Kashan	*	**	***	*
Burma	**	**	**	**
Thailand	***	***	*	**
Sri Lanka	**	***	***	*
Kenya	**	**	**	*

Element content major *** medium ** minor *

GEMMOLOGICAL INVESTIGATIONS

The production developments may, perhaps, reach the market in quantities. In 1980 Knischka & Gübelin have already reported the possible identification criteria of these new synthetics. The author analysed 12 K-rubies at the gem testing laboratory of Deutsche Gemmologische Gesellschaft which are reported below.

In dealing with the identification of these new K-rubies the following were taken into consideration, their appearance and colour, pleochroism, absorption, luminescence, refractive indices and inclusions.

Where the colour is concerned there was not much difference from other natural or man-made rubies. Most of them were reddish-violet in colour similar to those from Thailand or Kashan synthetics. Some of them appeared pinkish with many internal imperfections lowering the degree of transparency. By comparing the colours with the DIN 6164 colour chart they were between 10:7:3 from red to 10: 5:6/5:4 violet red. The dichroism was not of much importance and showed purple-red and orange-red of varying intensities.

Absorption spectroscopy was determined by using a Krüss prism-type KL 10 spectroscope, and the following lines were noted. The chromium emission doublet was at 694.2 and 692.8 nm with other lines at 668, 659.2, 476.5, 475 and 468.5 nm, as with other comparison stones. Available stones were visually inspected under both long- and short-wave ultraviolet radiations. K-rubies behaved rather differently under UV radiations. Some of them showed an inert centre with a crimson glow on the coating (Figure 15). This is probably due to the natural seed used which contained some iron. Private communication between Dr Lenzen and Professor Knischka (1980) revealed the use of seeds of natural Indian (Montgomery) rubies.

The refractive indices were measured using a Topcon critical-angle refractometer with Na_D light. The results were:

$n_e = 1.760\text{-}1.761$

$n_e\text{-}n_w = -0.008$

$n_w = 1.768\text{-}1.769$

The specific gravity determinations under controlled conditions gave values between 3.940 to 3.982 g $cm^{-3}/4$ °C. It was noted that those with natural seeds gave higher values than the ones with synthetic (Verneuil) seeds.

INCLUSIONS

With the above mentioned gemmological means it was difficult to confirm the origin of these new synthetic rubies. Inclusions had always been a necessary criterion in terms of ruby separations. Under the microscope these rubies revealed some interesting inclusions which are shown in Figures 16 to 26. Some inclusions were not encountered previously with other synthetic rubies. In most cases the overgrowth was evident.

CONCLUSION

K-rubies need to be treated with care. It is clear that with the above mentioned properties there is a possibility of confusion with their natural counterparts. Therefore much care must be taken in dealing with these stones either in the rough state or as a fashioned gem.

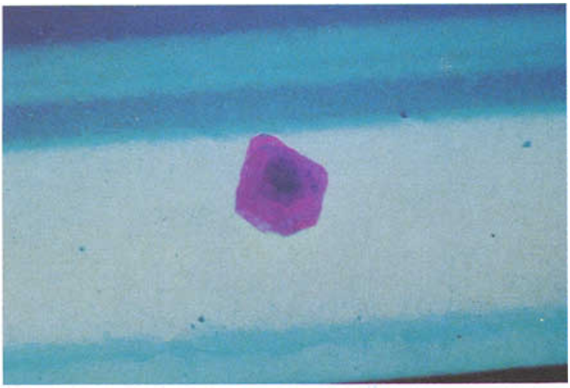

FIG. 15. A K-ruby under short-wave ultraviolet radiations showing the inert inner seed with the glowing coating.

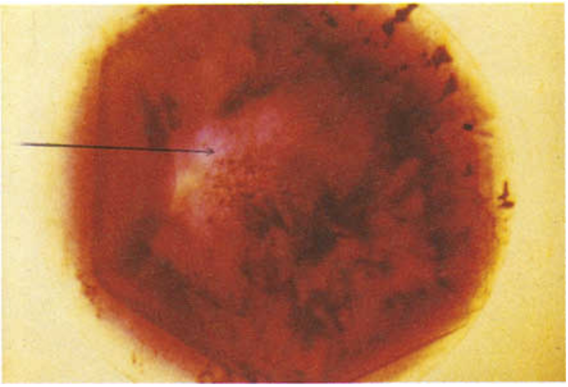

FIG.16. Overgrowth of a natural seed. At first appearance this may look like a natural ruby. Upon further examination the patchy colour of the natural seed (arrowed) was noted. Black particles were detected as flux remainings. 25 ×

FIG. 17. K-rubies contained flux inclusions, which appeared with a metallic lustre under reflected lighting conditions. It was clear that the growth conformed to a pseudohexagonal structure. 25 ×

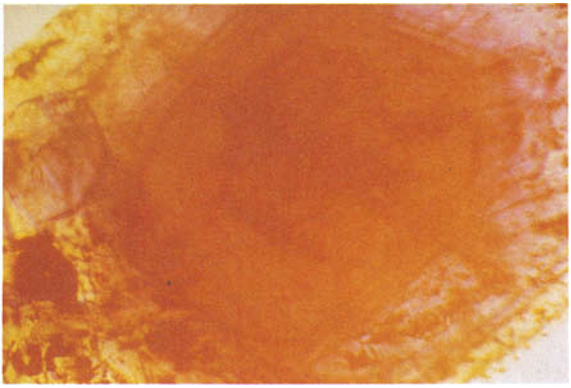

FIG. 18. Overgrowth on a natural seed which appeared darker than the synthetic coating. This was very distinct under ultraviolet radiations (see Figure 15). 30 ×

FIG. 19. 'K-rubies contained not only natural seeds, but also synthetic seeds. Characteristic curved growth lines are visible in this picture. 45 ×

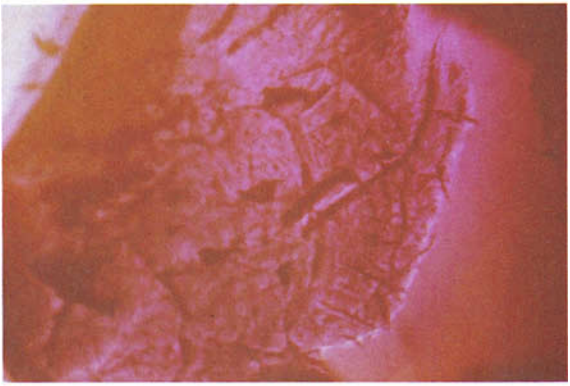

FIG. 20. This type showed a feather rather similar to that of natural ruby with some flux particles. 25 ×

FIG. 21. Wispy veil-like inclusions were presented on one plane of the stone. 25×

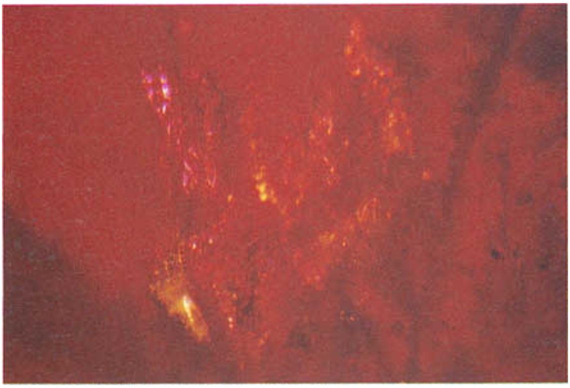

FIG. 22. Metallic appearance of the flux under reflected light. 45×

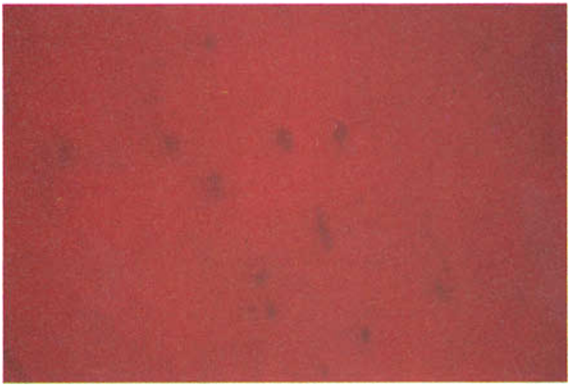

FIG. 23. 𝒦-rubies showed two-phase inclusions as a common feature. Much care must be taken in this connexion. 60×

FIG. 24. Two-phase inclusions were present rather characteristically here. The cavity showed irregular edges. 60×

FIG. 25. Veil-like feathers and a group of two-phase inclusions (arrowed) in a K-ruby. 30×

FIG. 26. Triangular flux particles were confirmed as a typical inclusion of these synthetic rubies. 60×

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OBSERVATIONS ON SOME SCAPOLITES OF CENTRAL TANZANIA: FURTHER INVESTIGATIONS

By Prof. Dr GIORGIO GRAZIANI,*
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Among various scapolite crystals of gem quality, those from Tanzania are of particular interest because of their high birefringence, homogeneity and, at times, evident chatoyancy. In the Umba deposit, North-East Tanzania, such mineral can be found both in contact zones referable to calcareous metasediments and in pegmatite intrusions related to basic and ultrabasic rocks (Solesbury, 1967), and in secondary deposits (Zwaan, 1971).

The scapolite chatoyancy effect has recently been attributed to iso-orientated needle-like channels of reddish colour, which were revealed to be due to iron oxides or hydroxides (Schmetzer *et al.*, 1977). Further investigations of this material indicated that the growth tubes, which were often filled with brownish-red or yellow laminae, had the same chemical composition, when examined with the electron microprobe, as the bulk crystals. They were thus considered to be filled by scapolite, while the laminae were found to be of a different mineralogical species (Figure 1).

The yellow laminae might be more or less hydrated iron oxides—i.e. lepidocrocite, according to appearance, colour and idiomorphous habit. The tabular reddish scales were more difficult to identify, since they might be either haematite or maghemite. It was assumed that they were produced by a dehydration of lepidocrocite; maghemite would have been obtained at temperatures not higher than 500°C, while if this limit was exceeded, haematite would have segregated (Graziani & Gübelin, 1981).

Recent studies carried out on some idiomorphous transparent scapolite samples of various geneses and geological settings, gave evidence that their refractive indices increase during heating (Graziani & Lucchesi, in press).

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FIG. 1. Scapolite from Central Tanzania. Sample 1: two typical laminae. Top left: with partially dehydrated lepidocrocite. Bottom right: shows irregular shape and complete alteration of lepidocrocite. In both laminae the dark brown scales consist of maghemite. 110×.

Optical observations were carried out for each sample at high temperatures, and then, at room temperature, after cooling.

The former measurements continued up to a maximum of 450 °C, since beyond this temperature the radiating energy of the heated scapolite prisms made it impossible to discern the emission doublet of sodium clearly. The measurements at room temperature were made after the sample had been heated to a maximum of 800 °C, a limit slightly below the temperature at which scapolite exsolves into plagioclase, sodium and potassium chloride. The heating experiments indicated that rising temperature leads to a linear increase in the values of the refractive indices from 350 to 375 °C, at a slightly higher rate in the case of ε than in that of ω. To a first approximation, this increase was proportional to the meionite content of the sample. At higher temperatures, a sudden increase was recognized for both refractive indices, referable to loss of H_2O (Figure 2).

Measurements carried out at room temperature after cooling showed almost constant values for each sample over the whole temperature range investigated. Colour too was affected by heating. There was a progressive fall in colour intensity until the

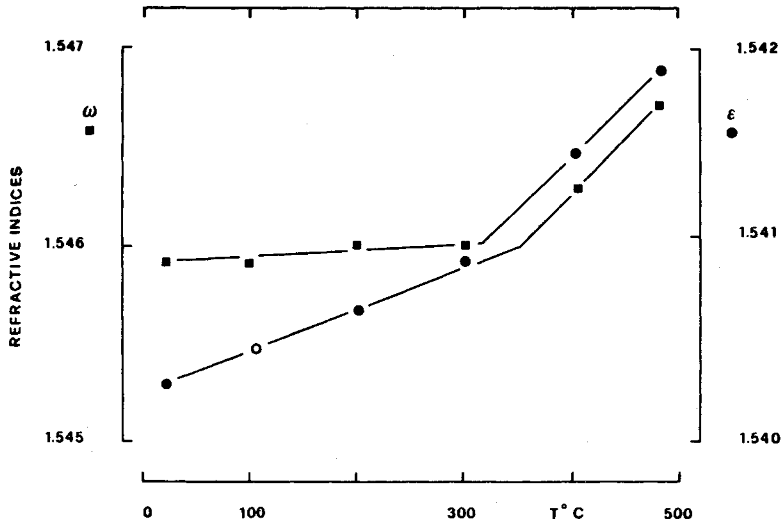

FIG. 2. Increase in value of refractive indices during heating.

sample became completely colourless at temperatures between 350 and 400 °C.

Thus it was possible to define the environmental conditions of this scapolite sample from Tanzania better considering the previously described results (Graziani & Gübelin, 1981). Particularly since this sample showed a faint yellow colour which would have been lost after heating up to temperatures beyond 350 to 450 °C, it was possible to conclude that this crystal never reached such a high temperature after its formation. Thus the reddish laminae which fill the growth channels are more likely made up of maghemite than haematite.

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THE OUGHTON SPECTRA

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

In 1976 the obituary of John H. Oughton, F.G.A.A., editor of the *Australian Gemmologist* and a gem expert of considerable distinction, mentioned a seemingly impossible feat which he had performed many times.

Faced with a sapphire, Jack Oughton would hold it close to his eye 'at a certain angle' and look through it at a suitable light source, and would say 'I can see a strong absorption line in the blue,' or 'The iron band at 4500Å is missing', and would identify the stone as natural or synthetic accordingly.

My own first reaction to this was that it was not possible—an absorption spectrum seen without a spectroscope, with its essential slit and collimating lens—it couldn't be done. Most rainbow effects seen in ordinary life are not sequences of discrete wavelengths but are overlapping images due to the breadth of the original light-source. Even the spectroscope version suffers from overlap, which is the reason why we work with as narrow a light slit as possible. Seriously overlapped images such as those seen without a spectroscope are usually far too confused to permit absorption lines to be seen.

Later a paper on 'Visual Optics', which went against my own experience of 'look through' testing, caused me to re-examine the facts and to do again the many experiments I had first tried in the mid-Thirties, before writing on the subject.

The bright multiple images of the light source seen through a stone tested in this way always consist of spectra, either discrete or in associated pairs, the double ones indicating that the stone is birefringent.

Since a clear electric light bulb is used, the spectra will be C shaped, for they are images of the C filament of the bulb.

The light source will be several feet away, so there is no need for a collimating lens. The eye can focus the light image quite

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normally at a distance equivalent to the actual light-to-eye distance divided by the refractive index of the stone. At such a distance the filament is equivalent to a very narrow slit of light. Thus we have effectively disposed of the need for both slit and collimator.

While repeating my own experiments of many years before, and being now aware of the claim made for Jack Oughton's powers of observation, I suddenly noticed that a faceted red stone was giving bright spectra in each of which, despite their extreme shortness, the highly characteristic three band absorption of almandine could be seen. Using a straight filament bulb it was even easier to see this.

Mr Oughton was dealing with Australian sapphires which are iron rich and have a dark broad band centred at 4500Å. This would be easily visible in this 'look through' technique. Its absence in synthetics would also be quite obvious. The procedure is extremely simple provided the light is not diffused by a 'pearl' bulb, and involves little more than just looking through the table facet of the stone and adjusting it to give the longest possible spectrum, which will still be extremely short.

It must be noted, however, that this method works only when we are dealing with gem species which give broad and strong absorption bands. The observed spectra are minute by comparison with those beautifully spread ones seen through a spectroscope and cannot possibly allow us to distinguish very fine lines.

In this type of testing the facets of a stone are acting as a series of prisms and give dispersion depending on their angles to each other, on the position of the optic axis or axes, and the positions of the prisms relative to the light source and to the eye and, finally, upon the actual dispersive power of the stone. It has to be accepted that only the latter is a fixed factor and that the visual manifestation of this can be varied by the other three factors. These remarks apply equally to the determination of the actual birefringence by this method.

We can say that the 'look through' technique can be used safely to detect birefringence, or its lack, and, where a broad emphatic absorption occurs in a gem this will probably be seen. The determination of the amount of birefringence and the dispersion by this method involves calculation which is extremely difficult to achieve visually, although with practice some degree of approximation may be obtained.

Although Jack Oughton was probably using a method which he himself had found, and should have every credit for the acute observation that was involved, it has to be pointed out that Robert Crowningshield saw and identified absorption in this way as early as 1951.*

Dr W. W. Hanneman† has told me, in a personal communication, that paired spectra may be seen through quartz crystals and through calcite cleavage rhombs. I have seen them myself in quartz, but in my experience uncut calcite rhombs do not allow both the widely separated spectra to be seen at one time. The method might be useful in field work in the rather unlikely case where a mineralogist is not able to recognise transparent quartz crystals on sight.

[*Manuscript received 25th November, 1981.*]

Gems Gemol.*, 1951, **VII, 4, 120-4.

†Mr Mitchell complained to me that Dr Hanneman had misrepresented him in his 'Understanding the Hodgkinson Method' (*J.Gemm.*, 1982 XVII (3) 221-8): but these two writers are in broad agreement that interesting phenomena may be seen by this method. Basically they disagree only on the ease with which an observer can interpret observed phenomena with reliable accuracy. Enough space, however, has now been devoted to this subject in this *Journal*, and readers must be left to draw their own conclusions.—Ed.

A DIAMOND DOUBLET AND THE INFRARED REFLECTOMETER

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

While writing a report on diamond testing instruments recently it occurred to me to try them out on a diamond doublet. This was one with diamond top and white synthetic sapphire base.

Not surprisingly the four different diamond heat probes, which are said to assess the heat conductivity of diamond, but which, Dr D. B. Hoover suggests,* are more likely to be responding to the thermal inertia of stones tested, were completely fooled by this fake. Only when, knowing what the stone was, I tested the base did I get a reject signal from these instruments. Normally one would not expect to have to test the base of a diamond.

I then tried the doublet on three different infrared reflectometers, and in each case it gave a needle deflection far greater than for normal diamond and so rejected the stone as a fake. This was evidently due to reflection from the parallel junction layer between the diamond crown and the sapphire base. It was a high enough reading to be confused with that for synthetic rutile, but the stone did not have the gaudy play of colour of the latter species.

Diamond doublets are quite rare, so the tests were perhaps academic to some extent, but it is nice to know that a comparatively simple instrument is now available which will cope with them should the need arise. Formerly the diamond doublet was checked principally by close observation with a lens or microscope, looking for reflections from the junction layer, which were not always easy to see. The 'new' test is far more positive.

[*Manuscript received 20th February, 1982.*]

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*The Thermal Properties of Gemstones and their Application to Thermal Diamond Probes, *J.Gemm.*, 1982, XVIII (3), 232.

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THE INFLUENCE OF THE INTERNAL STRUCTURE OF PEARLS ON LAUEGRAMS

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Switzerland.

INTRODUCTION

Among other possibilities, two types of x-ray methods are used for the examination of pearls. They are direct radiography (the shadow method) and the Laue method (x-ray diffraction). Both methods are of restricted use if applied exclusively, since each of them gives specific information which may not be conclusive for certain types of pearl. Thus in each case of a pearl test one has to decide on which method to place the greater reliance when deciding upon whether a pearl is natural or cultured. This study deals with the factors which influence the patterns of lauegrams.

Doing authenticity tests for the trade, we often found that lauegrams resulted in which neither a clear pseudohexagonal pattern nor a two-fold symmetry pattern showed, which is what an unprejudiced observer would expect from the pictures shown in textbooks. Most of these pearls deviated more or less from the ideal shape of a sphere. It is the purpose of this study to investigate any correlation of pearl shape and direction of the primary beam in respect of the resulting laue pattern. Furthermore it is of interest to evaluate the effects produced by a relatively thick overgrowth on the bead of a cultured pearl. To understand the pseudohexagonal spot patterns, the questions of the presence and type of aragonite twins and the arrangement of aragonite tablets are investigated.

DIRECT RADIOGRAPHY

The direct radiography method utilizes the fact that x-rays are weakened to varying degrees by the differing forms of matter they penetrate. The extent of the weakening depends on the thickness, the density and the chemical composition of the object being investigated. When x-raying a pearl, a shadow image is produced behind it on a photographic film. This image indicates the conditions of thickness and density as an effect of this absorption. In pearls, the relatively darker areas deriving from the conchyolin-rich parts are considered valuable in respect of diagnosis. These

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zones enriched with organic matter have a lower x-ray density than the surrounding calcium carbonate, and are thus weakening the radiation to a lower degree. Such zones may be situated in the centre of the pearl or in the form of single or repeated arcs or circles approximately concentric to it. In most cases, direct radiographs of natural pearls show such features. In addition to this, a typical, discontinuous course of darkness from the centre to the rim may be observed. In cultured pearls with a bead, usually one dark ring near the periphery is seen, which represents the conchyolin-rich shell around the bead. In non-nucleated cultured pearls, besides the mostly irregular external shape, an irregular shaped cavity lined with conchyolin is resolved in the radiograph as a quite striking dark irregular area at or near the centre of the pearl.

In some cases it is unfortunately not possible to make visible such fine growth inhomogeneities. These pearls show us the limitations of direct radiography. References for the technique and interpretation of this method are Webster (1975), Brown (1979), Anderson (1980) and Farn (1980).

TECHNICAL DETAILS

The lauegrams needed for his investigation were produced by the author in the x-ray laboratory of the Institute of Mineralogy and Petrology of Basel University. Since there is no specialized Laue camera, a precession camera with a 0.7 mm diaphragm was used instead. The molybdenum tube was operated with a Philips generator (40 kV/20 mA). The radiation was used unfiltered, for a continuum is required. The pearls were placed directly on the diaphragm, leaving an interspace of 4.5-6 cm to the film (plastic wrapped dental film). Exposure time, according to the thickness of the pearl, ranged between 4 to 10 hours.

The photographs of pearl surfaces were made by means of scanning electron microscopy (SEM) with a Stereoscan mark IIA instrument (Cambridge). It was operated with an acceleration voltage of 20 kV. The samples were coated with an approximately 20 nm thick gold layer.

LAUEGRAMS (X-RAY DIFFRACTION)

The German physicist Max von Laue succeeded in 1912, with his colleagues, in proving the wave character of x-ray radiation and the lattice character of crystalline matter. With this knowledge,

W. H. Bragg and his son, W. L. Bragg* started to investigate crystal structures. Since at latest 1924 the Laue method has been applied in pearl testing (Galibourg & Ryziger, 1927; B. W. Anderson, pers. com., 1982). The Laue method is used to show the intrinsic symmetry of a crystal. If a narrow beam travels through a crystal parallel to a symmetry axis, it will deviate from this primary direction. It is diffracted (i.e. it will follow all directions in which the conditions of Bragg's law, $n.\lambda = 2d.\sin\theta$, are fulfilled). In total these diffracted rays will form a spot pattern on the film behind the crystal. This spot pattern or lauegram exhibits the symmetry which the crystal possesses in the selected direction.

Natural pearls are more or less good ordered aggregates of microscopic crystals. Their regulation follows a concentric or radial structure respectively. This is also evident from cross sections (Alexander, 1977). The tiny tabular crystals consist of Aragonite ($CaCO_3$, orthorhombic), but in some cases, (after Alexander, 1977), Calcite ($CaCO_3$, trigonal) is also found involved as a pearl material. The dominant faces of aragonite tablets or platelets are always set tangentially to the surface of the sphere. Their main symmetry axes (*c*-axes) point towards the centre of the pearl. Therefore, from whichever direction the x-ray beam passes through the centre of a spherical pearl, it will meet the same conditions. It will follow the symmetry axes of thousands of crystallites. Because of the pseudohexagonal symmetry pattern, Webster (1975) supposed the crystals to be twinned repeatedly (cyclic twinning). For orthorhombic minerals in the untwinned state, the resulting spot pattern should exhibit at the most two-fold symmetry. Other orthorhombic minerals show a tendency to form cyclic twins (e.g. chrysoberyl, cerussite) and thereby obtain a higher state of symmetry.

Thus, if a spherical natural pearl is struck centrally by an x-ray beam, an apparently hexagonal pattern or a ring (halo) will appear on the film.

Cultured pearls with nacreous beads are well ordered aggregates of microscopic crystals, too. But the type of arrangement is different. The cultivated layer consists of a skin with considerably varying thickness from pearl to pearl, from less than 10% up to possibly more than 70% (Scarratt, pers. com.,

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*Respectively Presidents of the Gemmological Association from 1937 to 1942 (Sir William Bragg) and from 1954 to 1972 (Sir Lawrence Bragg).—Ed.

1982). This outer skin has the same built up structure as described for natural pearls. If cultured pearls have a core of mother-of-pearl, as they do in most cases, the aragonite platelets of this core are arranged in more or less even, parallel layers. Their main symmetry axes are all oriented approximately parallel to each other. The resulting lauegram is produced mainly by the set of crystals forming the core, since this inner bead normally represents the main part of the pearl. It now depends upon the angle at which the x-ray beam hits the layered structure of the bead. Oriented lauegrams of a cultured pearl with a thin skin illustrate this directional dependence (Figures 1a-d). If the beam direction coincides with the main symmetry axes (*c*-axes), i.e. is perpendicular to the layers of tablets, the well known six spot pattern arises. In all other directions patterns with a lower symmetry appear, since the crystallites are struck obliquely or perpendicular to their *c*-axes. Such a pattern shows at most two-fold symmetry and has been used to prove the presence of a nucleated cultured pearl (Webster, 1975; Anderson, 1980), (Figures 1b-d, 17).

INVESTIGATIONS BY SCANNING ELECTRON MICROSCOPY (SEM)

With a 10× lens lines are already visible on the surface of pearls which resemble contour lines. They bound relatively extended aragonite tablets or scales which overlie each other in a terrace or tile-like manner. To obtain more information on these structures, we produced photographs by means of a SEM. The advantage of this instrument lies in the high degree of sharpness and the better resolution compared with the conventional light microscope, even at low magnification. Figure 2 shows the structure in cross section of a broken piece of the cultivated layer of a cultured pearl. In this strictly speaking authentic part the aragonite tablets follow the curved surface of the sphere (see also Figure 5). The surface of this cultivated layer is illustrated in Figure 4. The tile-like and displaced aragonite tablets are clearly seen. Less clearly visible is a polygonal honeycomb-like pattern within these platelets. In Figure 3 a cross section of the spherical bead of a nucleated pearl is shown. Most beads are worked out of mother-of-pearl from the shell of an American river mussel. The beads are implanted into the mantle tissue of a pearl oyster to induce pearl

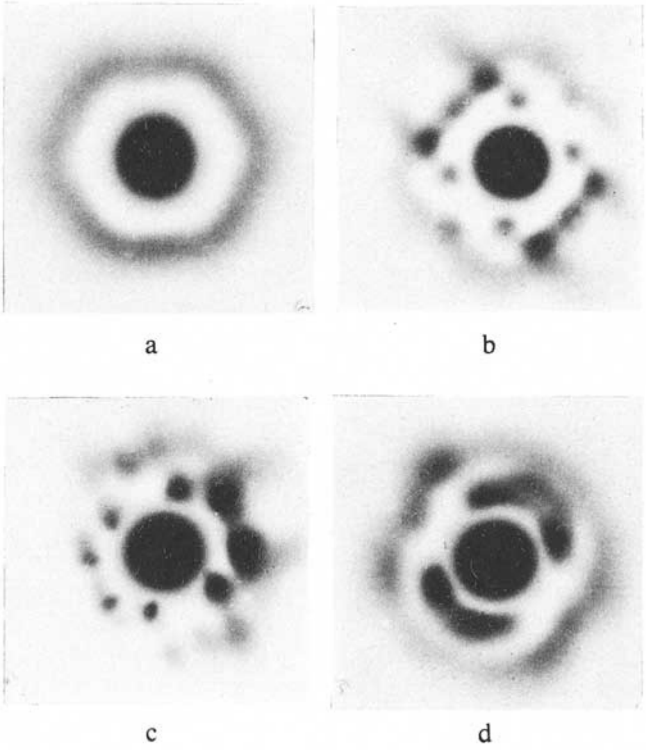


FIG. 1. Lauegram of a cultured pearl with bead, round, Ø 7 mm, with a thin overgrowth.
a: perpendicular to the aragonite layers of the core.
b: parallel to the aragonite layers of the core and perpendicular to the direction of a.
c: perpendicular to the directions in a and b.
d: oblique to the three preceding directions.

Scanning Electron Microscopic pictures of structures in pearls.

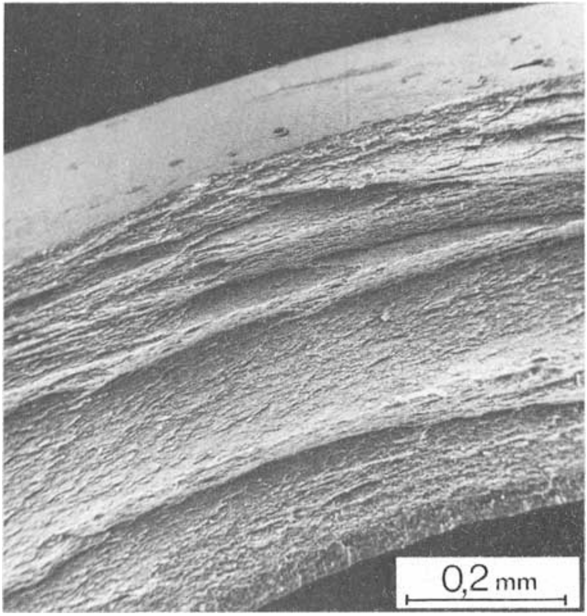


FIG. 2. Broken surface of a cultivated layer of a marine cultured pearl, with bow-structures. (SEM photograph)

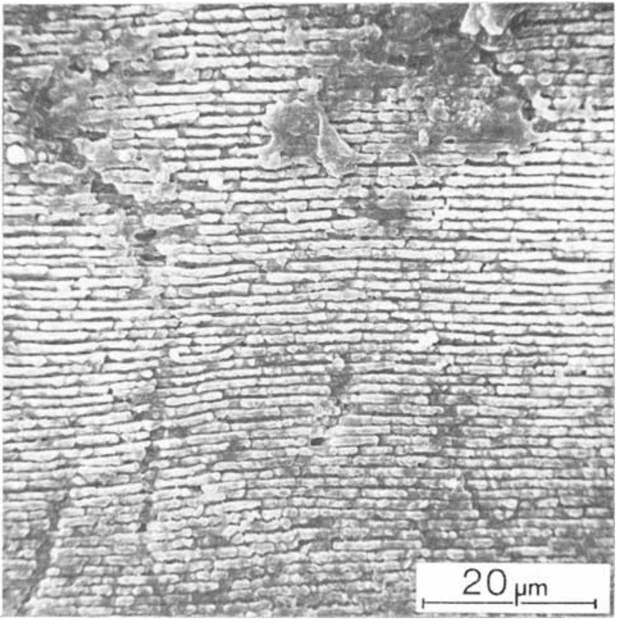


FIG. 3. Cross section through an etched bead of a cultured pearl, with brick-wall-like arrangement of the aragonite platelets. (SEM photograph)

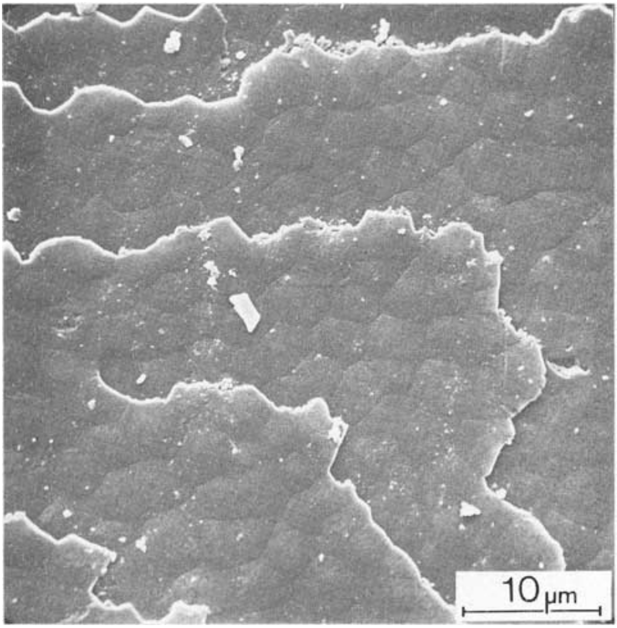


FIG. 4. Terrace or tile-like arrangement of aragonite platelets at the surface of a pearl. Honeycomb structures are visible. (SEM photograph)

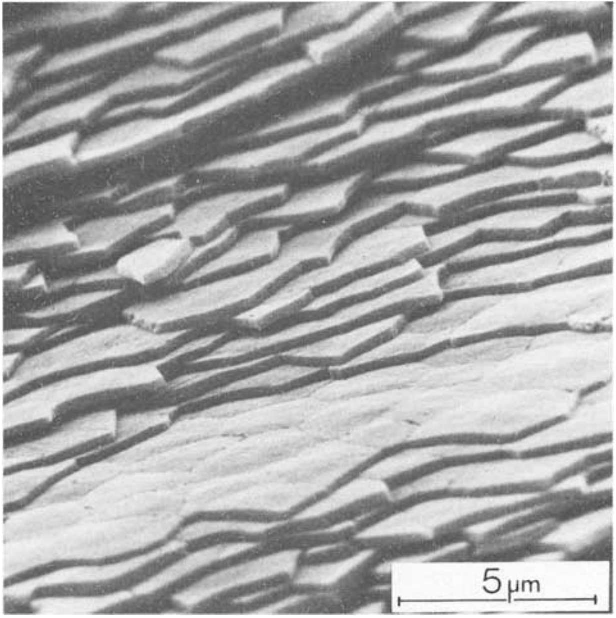


FIG. 5. Section out of Figure 2, with stacked aragonite platelets which show a polygonal split-up. (SEM photograph)

growth, i.e. to be overgrown by a pearly substance. These cores of mother-of-pearl have an even, layered structure, in contrast to the natural overgrowth which has a concentric build up. Figure 3 shows clearly the brick-wall-like arrangement of the plates which do not follow any curves of the pearl surface.

The honeycomb structure on the individual tiles of pearls deserves special attention (Figure 4). In search of twin structures which might prove the expected cyclic twinning, the surface was etched with dilute formic acid before inspection with the SEM, but no boundary lines between any twin individuals became visible, as expected according to the results of Mutvei (1977). He investigated different shells of moluscs, which showed after treatment with acid a strange type of regular intergrowth of aragonite. In Figure 6 different possibilities for twin formation are presented (Ramdohr & Strunz, 1967; Mutvei, 1977). The individual plates of the pearls are composed of a mosaic of polygons (honeycombs). In some places they are nearly regular hexagons; in other places, which are less ordered, distorted squares or pentagons are recognized.

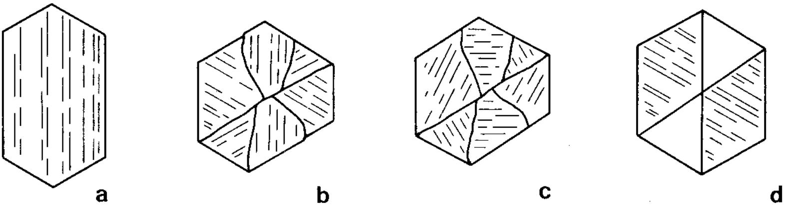


FIG. 6. Twin formations of aragonite. a: untwinned crystal. b&c: penetration-twins and repetition-twins respectively. d: twins according to Mutvei (1977). The *c*-axes of all individuals are perpendicular to the paper. The marked areas correspond to identically oriented individuals.

THE ARRANGEMENT OF ARAGONITE AGGREGATES IN PEARLS

To investigate the mutual crystallographic orientation of the polygons in the plates, the boundary angles were measured. The assumption that three preferred orientations existed, each being rotated 120° to the next, could not be confirmed for the time being. The verification of such a rule failed at the impossibility to orientate the individual polygons or domains with respect to the others. Such a statistical order within a plate would yield the effects of juxtaposition twinning and triplet-forming (Figure 7). The triplet state is also reached if, instead of an ordered arrangement embracing an entire plate, an arrangement between different 'floors' or in stacking is present. The 'honeycombs' which overlie each other and belong to different plates, i.e. different levels, may be rotated 120° from one to another (or a whole number of times of 120°). This arrangement would yield the effects of twinning in superimposition and triplet-forming (Figure 8). Both the first model of juxtaposition-triplets as well as the model of superimposition give an explanation for the pseudohexagonal Laue symmetry pattern. But it is not clear if, in the strict mineralogical sense, such formations are allowed to be named triplets, since the individual plates are separated from each other by organic membranes. They are thus not intergrown directly.

A pearl aggregate of aragonite plates possesses a maximum of regulation, if both principles of ordering are fulfilled. It is interesting to note that in our SEM investigations no prismatic layers became visible. Former authors (Smith, 1972; Eppler, 1973; Hurlbut & Switzer, 1979) may have interpreted stacked plates as prisms.

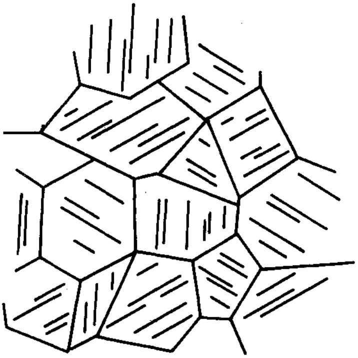


FIG. 7. A statistically ordered planar triplet aggregate, regulated after three directions (Triplet in juxtaposition).

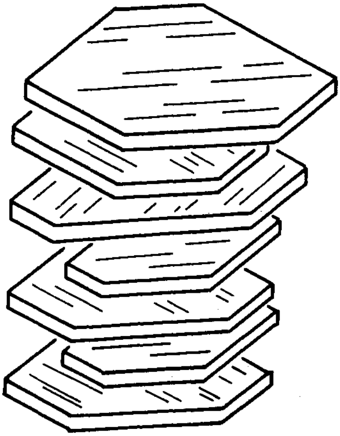


FIG. 8. A statistically ordered vertical triple aggregate, regulated after three directions (Triplet i superimposition).

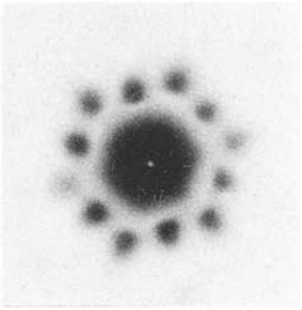
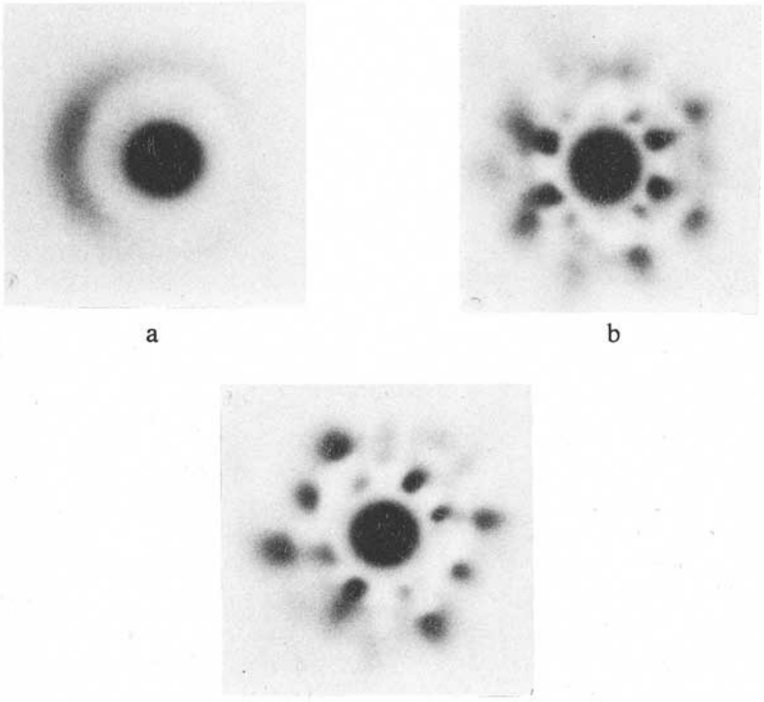


FIG. 9. Lauegram of a natural pearl, round, Ø 10 mm.

FIG. 10. Lauegram of a natural pearl, drop shape, 21 × 11 mm, taken through the short axis.



a

b

c

FIG. 11. Lauediagrams of a natural pearl, bouton shape, 8 × 9 mm.
a: perpendicular to the flat region.
b: through the thickest place, perpendicular to a.
c: 2 mm eccentric, parallel to b.

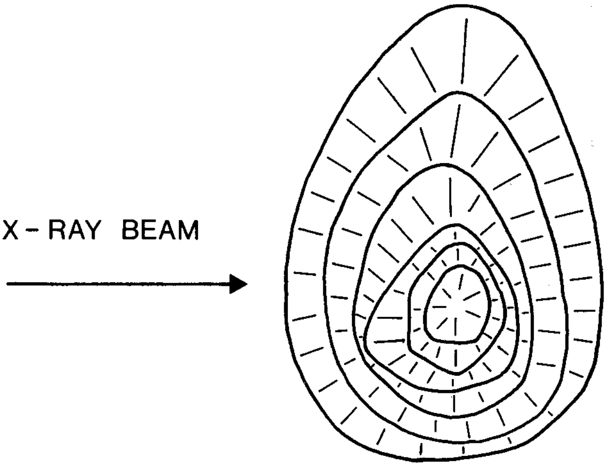


FIG. 12. Schematic built-up of an unround pearl. The small lines indicate the directions of the *c*-axes, which are at right angles to the platelets. The x-ray beam hits the crystallites under various angles, depending on how the pearl is situated/placed.

PRACTICAL EXAMPLES OF LAUEGRAMS

The author supposes that in pearls producing lauegrams like Figure 9 both principles of orderly arranged aragonite plates are relatively well realized. With a poor observance of the 120° angle to which one domain may be rotated in respect to another, we would expect lauegrams with diffuse hexagons (Figure 10) or even haloes (Figure 11a). So far only spherical pearls, in which the speed of growth has been equal in all directions, have been cited. If one direction accumulates the pearl substance more rapidly than another, button-, pear- or drop-shaped deviations from the sphere develop. In the course of the development of a pearl such growth inhomogeneities may occur several times and at different places on the then surface. Occasionally a formerly deformed pearl may grow on to become rounded.

The addition of unequally thick layers of shell which lead to an onion-like build-up has an important meaning in lauegraphy. In this way formations originate, which offer differing circumstances to a fixed x-ray beam (Figure 12). Frequently the beam will meet many crystals obliquely to their main symmetry axes. It will pass along a direction of two-fold symmetry. The resulting lauegrams

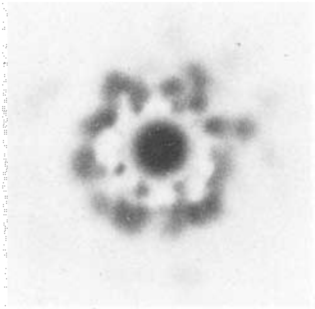
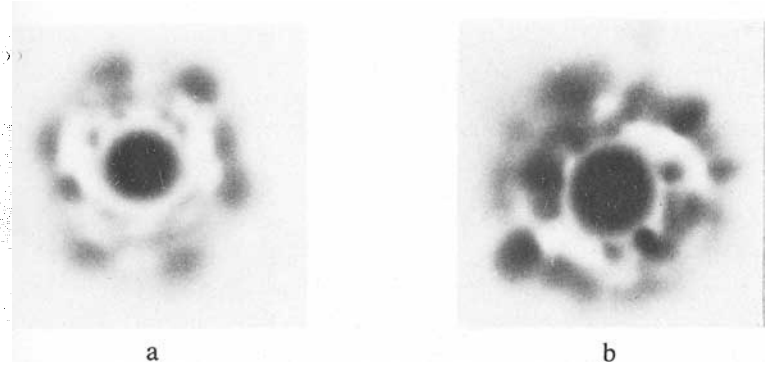


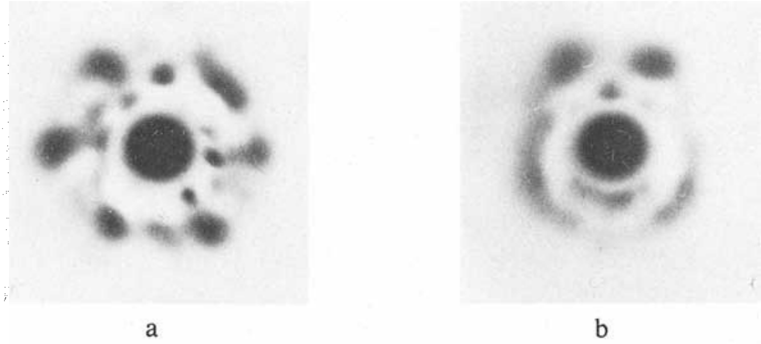
FIG. 13. Lauegram of a natural pearl, drop shape, 19 × 12 mm, in the direction of the short axis.



a

b

FIG. 14. Lauegram of a natural pearl, pear shape, 12 × 9 mm. a: through the short axis. b: obliquely, on the thin side.



a

b

FIG. 15. Lauegram of a Natural pearl, drop shape, 20 × 11 mm. a: through the short axis. b: 2 mm above the short axis.

from such examples show a multitude of spots among which the six 'real' refections are not resolved (Figures 13, 14b). Sometimes even mixed pictures arise, where the four spot pattern which is typical for nucleated cultured pearls may get through quite strongly (Figures 11b, 15b).

The most intriguing pictures arise from button- or drop-shaped pearls. In both shapes, from the outside it is not clear in which position the possibly displaced nucleus is located, and for a decisive lauegram the beam should pass through the centre of the nucleus. Depending on the direction of the primary beam, mostly very complex lauegrams are produced (Figure 14). A directly misleading picture occurs if the beam strikes a drop pearl at the neck, somewhat displaced from the long axis (Figures 14b, 15a). In such cases it is best to produce several lauegrams from differing directions. A direct radiograph produced in advance may reveal some of the internal particularities and may recommend a direction for a lauegram, but, if direct radiography is informative in its characteristics, in most cases no further lauegrams are needed except for scientific curiosity. They then help us to understand the influence of a complex internal situation in such pearls.

When seedless (non-nucleated) cultured pearls are investigated by x-ray methods, direct radiography yields the most reliable information. Lauegrams of such formations show the pseudohexagonal symmetry of natural pearls, or a halo. These lauegrams are somewhat diffuse and characterized by fine radiating lines (Figures 16a, 16b) which are not yet explained. Thus in the case of a seedless cultured pearl it would be most imprudent to rely on the lauegram only, as the 'spot patterns' produced would be the same as for natural pearl.

In cultured pearls with a thick cultivated layer the signals from the kernel pierce the mantle and are able to put the four diagnostic spots on the lauegram. For example, in the cultured pearl of Figure 17 the outer layer (37% of the diameter) cannot produce a pseudohexagonal pattern (in spite of its identical structure to natural pearls), while the cultured pearl of Figure 18 (with an outer layer of 59% of the diameter) shows a superimposition of both patterns. It is remarkable that the smaller proportion of the mother-of-pearl bead in this latter pearl gives a more prominent pattern than the very thick overgrowth. It is thus reassuring that the diagnostically valuable information is able to penetrate the

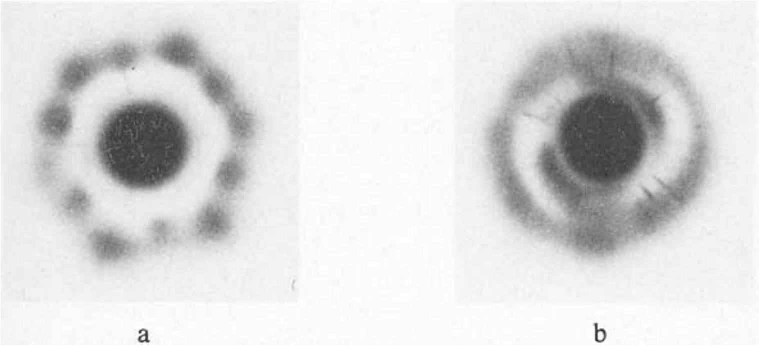


FIG. 16. Lauegram of a non-nucleated cultured pearl, baroque shape, 14 × 6 × 4 mm, a and b: two directions, at right angles to each other.

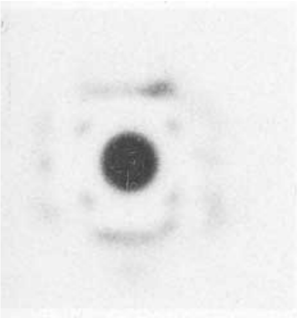


FIG. 17. Lauegram of a cultured pearl with nacreous bead, round, ø 13 mm, thickness of the cultured layer 2 × 2.4 mm.

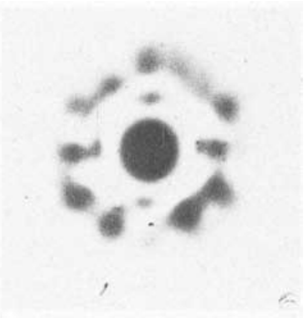


FIG. 18. Lauegram of a cultured pearl with nacreous bead, oval, 16 × 13 mm, thickness of the cultured layer 2 × 3.9 mm.

cultivation layers even if the coatings are very thick. It is therefore important to observe the central part of the lauegram (Figures 17, 18), looking for a strong four spot pattern.

CONCLUSIONS

Lauegraphy therefore yields indications for answering the question whether a pearl contains a mother-of-pearl bead or not. Lauegraphy is not the appropriate means to prove the authenticity of a pearl in general (e.g., seedless cultured pearls). Normally two lauegrams taken at 90° to each other are sufficient to demonstrate a possible two-fold symmetry pattern. But the technique has to be used with skill, since with a disadvantageous conduction of the primary beam on unround natural pearls two-fold symmetry patterns may be produced too.

ACKNOWLEDGEMENTS

Thanks are due to Professor Dr S. Graeser (Mineralogical Institute of Basel University) and Dr R. Guggenheim (Laboratory for Scanning Electron Microscopy, Basel University) for valuable discussions. I am also grateful to Mr M. Düggelin from the SEM-Laboratory for preparation of the samples and supplying the SEM-pictures. Furthermore my thanks go to Mr K. Scarratt (The Gem Testing Laboratory of the London Chamber of Commerce and Industry) for his important professional advice and critical reading of the manuscript.

The author was recently informed by Dr E. Gübelin of the existence of a thorough investigation, similar to the one presented here, carried out by Dr William H. Barnes in 1944 in Montreal, Canada. This research was done for the Gemmological Laboratory of Mappins Limited, Montreal, Canada. The report, entitled 'Pearl Identification: The Diffraction of X-rays by Pearls', was never published; however a small number of typed copies for local distribution were produced. The interest of Dr Gübelin is gratefully acknowledged here both for mentioning the existence of this report to me and for giving me access to his copy. Barnes treated both natural pearls and mother-of-pearl as being similar to fibrous aggregates. His results with respect to identification however are more or less identical to the results presented in this paper.

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NATURAL CORAL AND SOME SUBSTITUTES

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INTRODUCTION

It is well known that varieties of coral—*rubrum, japonicum* and *secundum** (Brown, 1980)—nowadays on the market are sometimes replaced by synthetic products and natural coral treated by different methods.

One of the best man-made imitations, Gilson's 'Imitation Coral' (Nassau, 1979) has been widely investigated and its properties published. Not so well known are treated coral substitutes. The first type of coral we are going to mention is the so called resin epoxy-esters type treated coral (Aliprandi and Butini, 1981). The material consists of poor quality coral, very rich in cavities, produced by action of polyps. This coral is very little valued because of lack of compactness, posing some problems for the shaping and polishing.

Cavities are filled with some colourless organic resins, of the epoxy-esters type, presumably using vacuum techniques or embedding the specimens in the mould chamber of a hydraulic press. This treatment imparts a high degree of compactness which will render this material, otherwise considered valueless, more suitable for cutting and using in jewellery. The external appearance, once treated, is very similar to the natural coral, causing some difficulties in identification.

The second type of treated coral could be classified as dyed coral. This material becomes pigment-treated by the employment of various techniques which are not yet completely understood. In some cases the treatment is easily detected, in some others the dye-stuff penetrates the porous coral completely, and detection of the treatment in this case turns out to be more problematical.

EXPERIMENTAL

The following samples have been tested: (a) natural coral bead, (b) dyed coral bead, (c) resin treated coral bead, and (d)

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*See *J.Gemm.*, 1981, XVII (8), 600 for H. S. Pienaar's proposed classification.—Ed.

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TABLE 1.

Optical and physical properties of the corals

Specimen reference	Colour	Weight ct.	D	RI*	Additional diagnostic data
(a) Natural coral	dark red	4.71	2.62	1.55	Striped structure, colourless streak, good polish, translucency.
(b) Stained coral	pink-white	5.21	2.62	1.56	Weak fluorescence UV 365 nm.
(c) Resin treated coral	pink-white in patches	6.51	2.42	1.56	Poor polish, waxy lustre.
(d) Gilson imitation coral	ox blood red	5.52	2.50	1.58	Coloured streak, grainy texture, very good polish.

*mean values

Gilson 'Imitation coral' bead. A summary of the tested specimens is shown in Table 1.

The hardness of all specimens tested proved to be 3½ on the Mohs scale, while the density differed notably in the Gilson product and in resin-treated coral. Our test reported a value of 2.50 g/cm^3 for Gilson's and 2.42 g/cm^3 for the resin-bonded specimen, both lower than the natural, which lies between 2.6 and 2.7 g/cm^3.

Refractive indices on all specimens were measured on a Krüss ER 60 refractometer. Only one mean value could be taken on the round surface of the bead, using the distant vision method. The RI values obtained were 1.55 for the natural and 1.56 for the stained material, 1.56 for the organic resin-treated bead and 1.58 for the Gilson substitute.

The chemical reaction of the beads to diluted hydrochloric acid was examined. Effervescence was noted and some small residual red pigments were seen in the Gilson material. The attack of acid on the resin-bonded coral slowly produced total reaction on the calcium carbonate composition, leaving at the end a porous spongy semitransparent round aggregate, which further investigation proved to be epichlorhydrin.

A comparative streak test of the four specimens gave no valuable information, except that the Gilson material produced a dark red streak, compared with the colourless streak of the other specimens.

We found fluorescence under both long- and short-wave UV light of no diagnostic value, except only that in testing the colour-stained bead we found, along certain minute veins hiding almost invisible fractures, a weak purplish red fluorescence when bathed by a beam of long-wave UV. The effect is due, most probably, to the presence of small amounts of the colouring agent, supposed to be an organic aniline dye, concentrated in surface cracking. Immersing the coral in ether or acetone causes the dye to be deposited in the liquid, which becomes slightly coloured, leaving behind a bleached specimen.

What we found to be a very diagnostic feature for the identification of natural coral, was the degree of translucency of all *Corallium* when tested with a transmitted concentrated beam from an optic fibre. Synthetic products consisting of pressed calcite or resin-impregnated material on the contrary appear opaque.

Furthermore this technique will clearly render visible those straight lines parallel to the skeleton of the coral tree considered important features for the positive identification of the natural coral (Cavenago-Bignami, 1972).

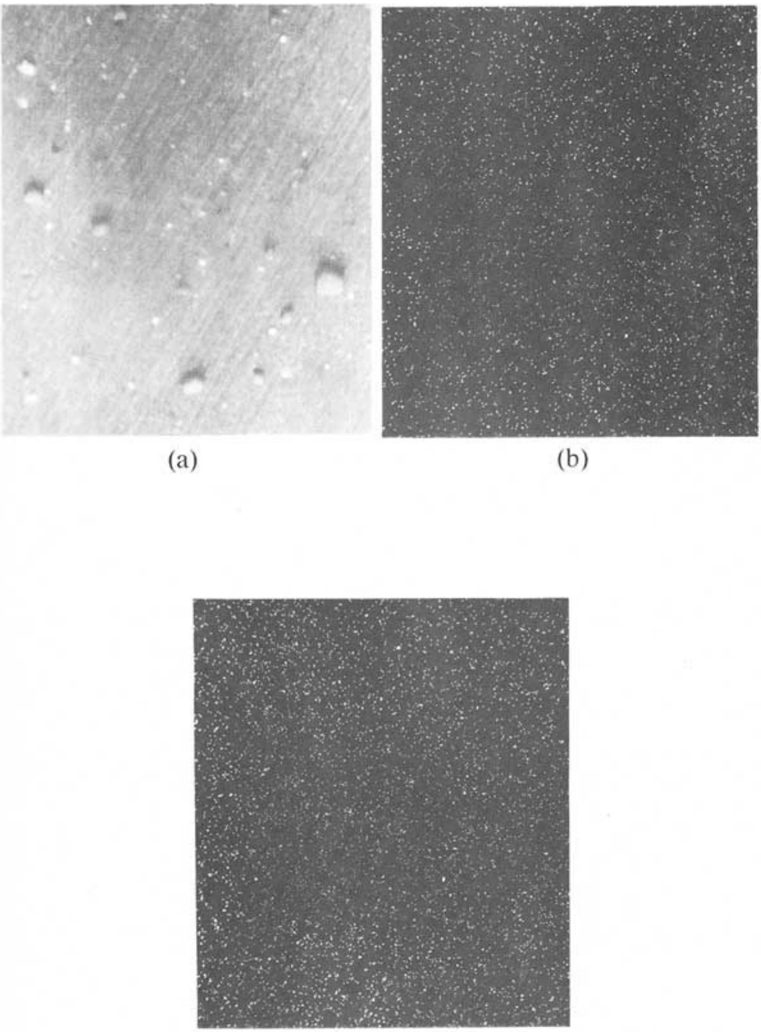
Micrographs of surfaces, both polished and rough were taken of all specimens, using SEM techniques (Figures 1-6). The analysis of polished surfaces has clearly shown the porous structure of the resin-treated coral (Figure 3a). The specks of resins were here easily and clearly identified as spots of different consistency, breaking the homogeneity of the surface. The Gilson coral has a grainy structure and is made up of particles of different shape and size (Figure 4a). Microscopical examination and further SEM determinations gave no clues which would enable one to distinguish stained from natural coloured coral (Figures 1 and 2). Figure 6 shows two spicules produced by the action of polyps in the solidified structure. The same polished surfaces were subsequently investigated for Ca, Si and Fe concentration patterns. Comparative tests on all specimens have demonstrated uniform distribution of Ca and Si in natural (Figures 1b and 1c) and stained coral (Figures 2b and 2c).

On the contrary the patterns found in the specimen treated with epoxy resins appear quite different. Ca is absent in some areas of the surface (Figures 3c and 5c). The arrangement of Ca and Si is different in Gilson imitation coral; Ca seems evenly spaced (Figure 4c), while Si is distributed in an irregular way (Figure 4b). Figure 5a shows the surface of resin-treated coral after the attack of a drop of diluted hydrochloric acid.

CONCLUSION

The samples investigated in this paper have demonstrated that separation with traditional gemmological instruments of natural coral from treated or substitute material always presents different grades of difficulty. However it is possible without using destructive tests to discriminate between natural coral and simulated or treated coral.

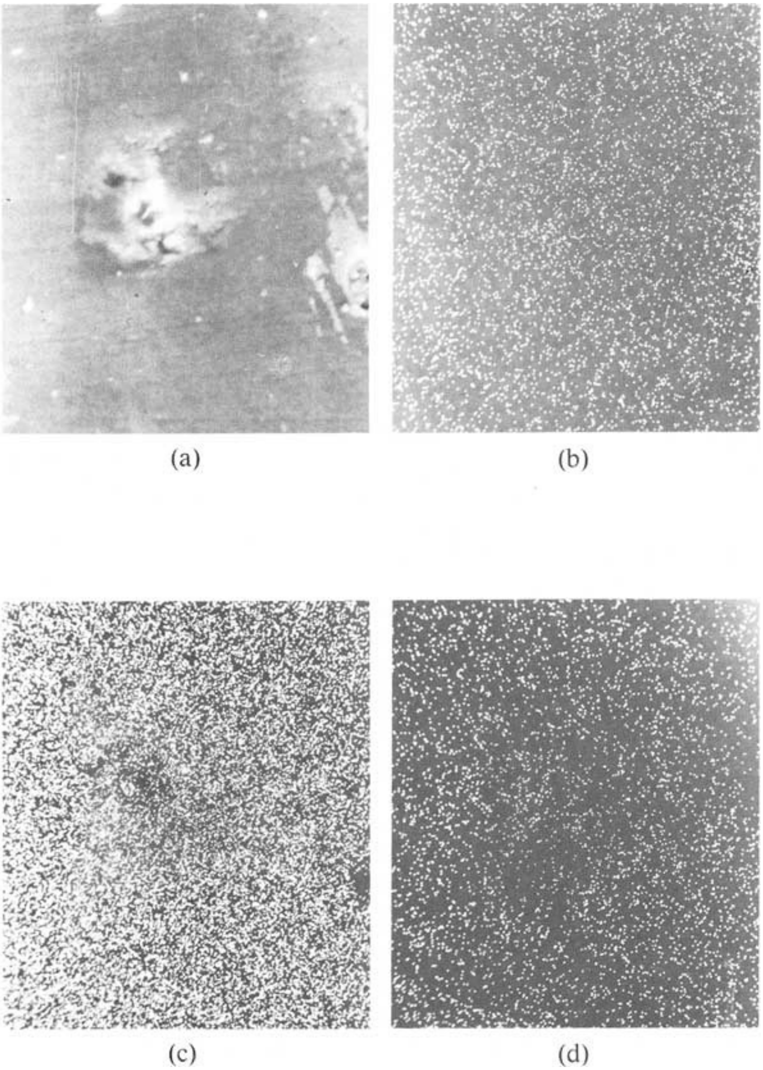
The only test which produced colour alteration, performed in separating stained from naturally coloured material, was that of immersing the bead in a solution of ether or acetone. Such a test, which is always left to the discretion of the operator, in any case needs the approval of the owner of the sample, since in this case a colour-destructive technique is being applied.



(a) (b)

(c)

FIG. 1. Natural Coral. (a) Polished surface, × 1200. (b) Polished surface, elemental distribution, Si $K\alpha$. (c) Polished surface, elemental distribution, Ca $K\alpha$. (Fe absent).



(a) (b)

(c) (d)

FIG. 2. Stained Natural Coral. (a) Polished surface, × 1200. (b) Polished surface, elemental distribution, Si $K\alpha$. (c) Polished surface, elemental distribution, Ca $K\alpha$. (d) Polished surface, elemental distribution, Fe $K\alpha$.

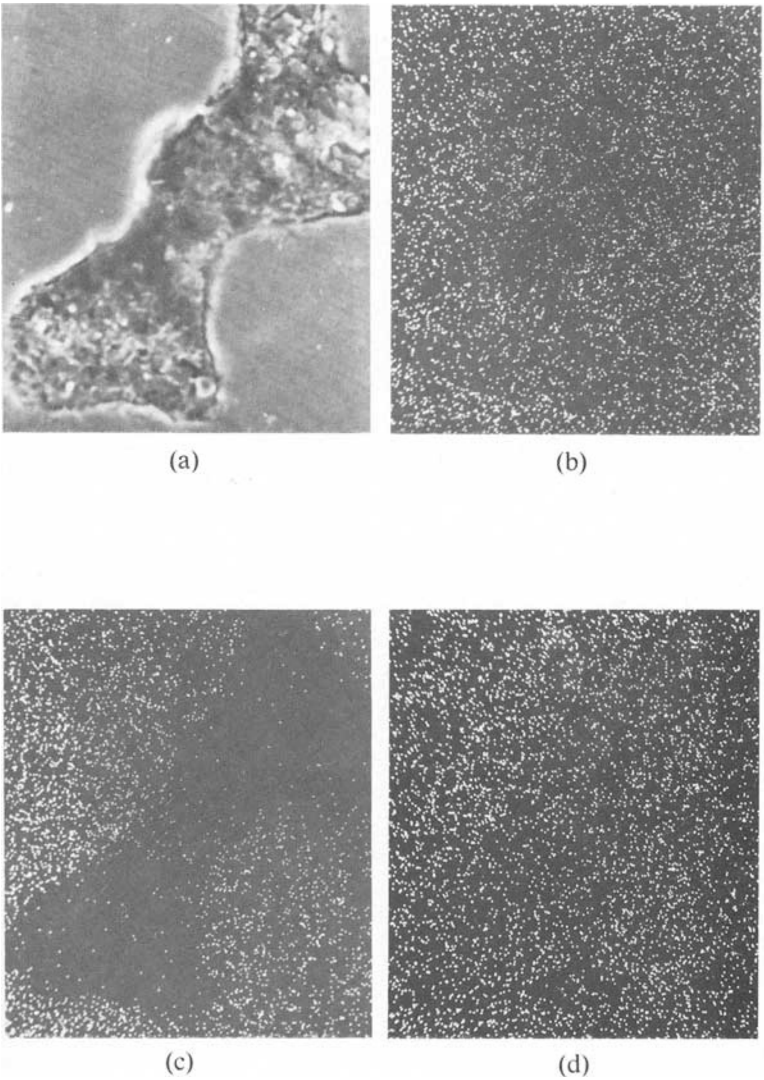
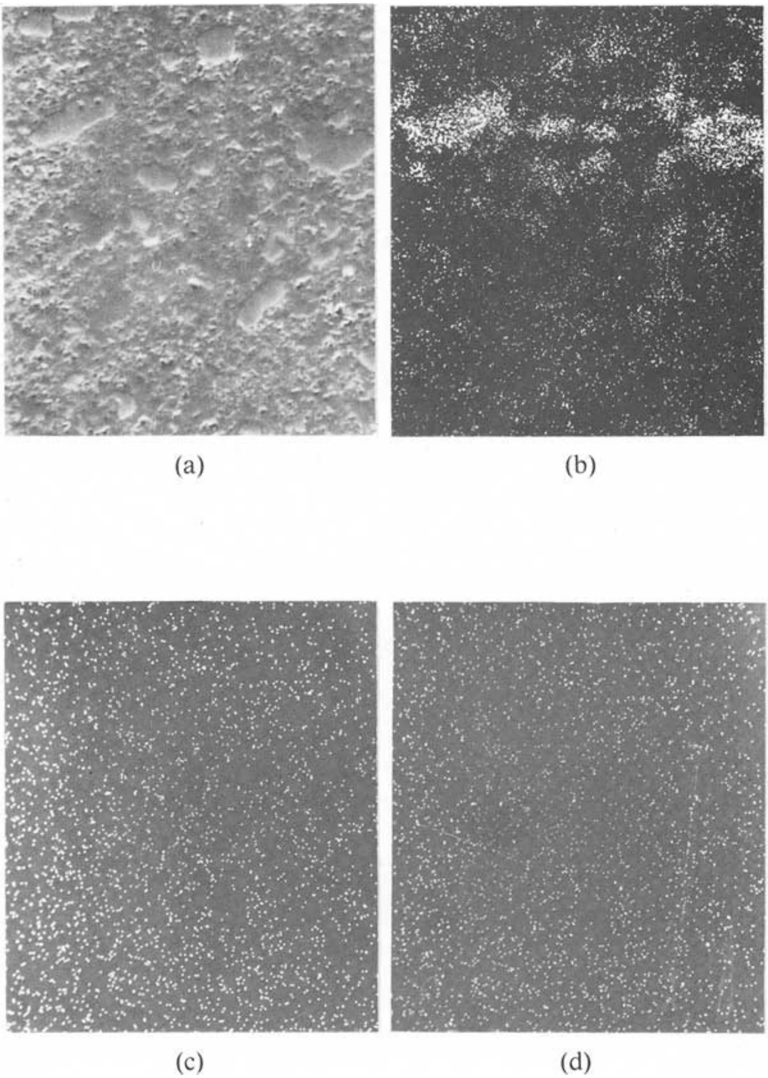


FIG. 3. Resin-treated Coral. (a) Polished surface, × 1200. (b) Polished surface, elemental distribution, Si $K\alpha$. (c) Polished surface, elemental distribution, Ca $K\alpha$. (d) Polished surface, elemental distribution, Fe $K\alpha$.


(a) (b)

(c) (d)

FIG. 4. 'Gilson Coral'. (a) Polished surface, × 1200. (b) Polished surface, elemental distribution, Si $K\alpha$. (c) Polished surface, elemental distribution, Ca $K\alpha$. (d) Polished surface, elemental distribution, Fe $K\alpha$.

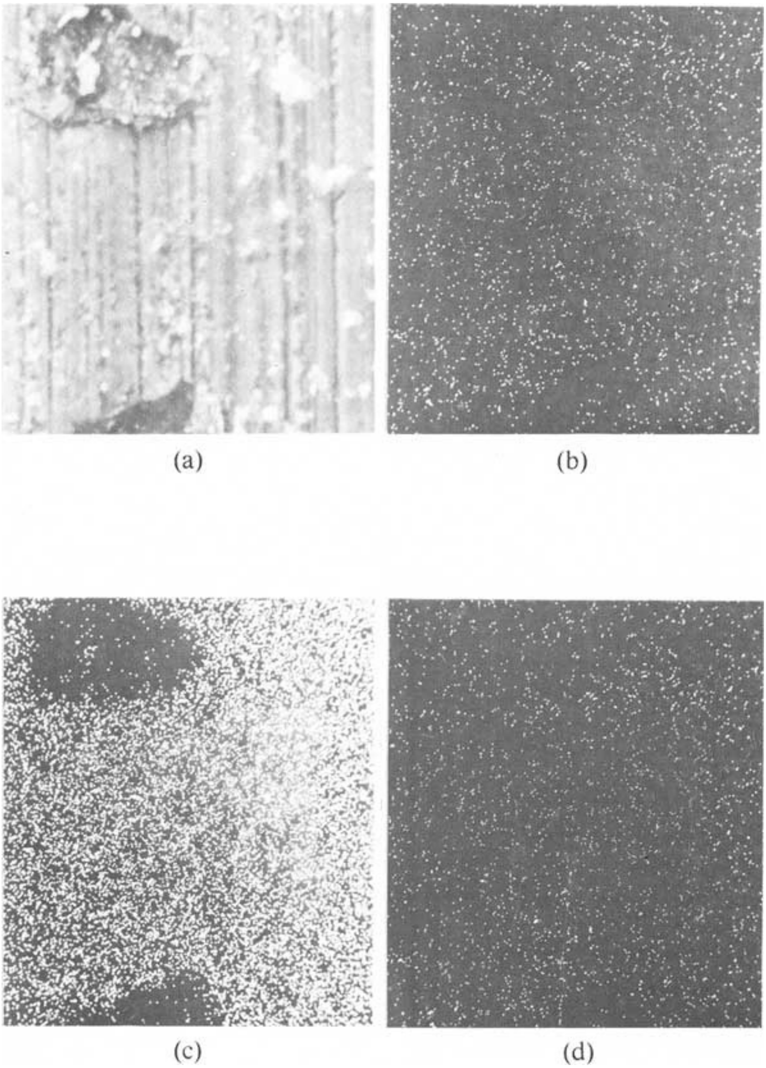


FIG. 5. Resin-treated Coral after treatment with HCl. (a) Polished surface, × 1200. (b) Polished surface, elemental distribution, Si Kα. (c) Polished surface, elemental distribution, Ca Kα. (d) Polished surface, elemental distribution, Fe Kα.

FIG. 6. Natural Coral. Rough surface, × 1000, evidencing spicules fused into the skeleton.

ACKNOWLEDGEMENTS

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A METHOD FOR MEASURING THE INFRARED SPECTRA OF FACETED GEMS SUCH AS NATURAL AND SYNTHETIC AMETHYSTS

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ABSTRACT

A method which allows infrared measurements of faceted gems in transmission is described. This method enables distinction of synthetic amethysts of Russian production from natural stones. Effects caused by dispersion are minimized by immersion in liquid paraffin (nujol) (RI = 1.484 at 589 nm). The volume of immersion liquid traversed by the infrared light is much reduced by using a variable cell which was specially constructed. The influence of the immersion liquid on the infrared spectra can be compensated for, if necessary, by placing a second, identical cell, into the reference beam. In the manner described, it is possible to record infrared spectra of faceted stones, which have about the same quality as the spectra of plane-parallel plates.

The principal function of gemmology is acquiring criteria for identification of gems and for distinguishing them from their imitations in the widest sense. As a matter of fact, the distinction of natural gems from the corresponding synthetic stones by means of conventional gemmological techniques is getting more and more difficult, because progress in the science of materials during recent decades has led to exact knowledge of the conditions of growing ultra-pure single crystals—especially in laser, maser and communication engineering. Today, several producers offer synthetic gems whose attributes are very similar to those of natural ones. Permanent improvement of growing conditions has even led to synthetic stones which cannot be identified by measuring physical properties easily available to the gemmologist, such as density, hardness and refractive indices, and which have no diagnostic inclusions. The trained gemmologist accordingly will still be able to make a decision in most of the relevant cases just by means of using a gem microscope, but the quota of synthetic gems which cannot be identified in this way is increasing. To avoid upsetting the gemstone market in view of this fact, new detection methods have to be worked out and provided, so that one can fall back on them if necessary.

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Different growing conditions of synthetic and natural crystals lead to differences in structural properties, such as the number and types of displacement in the lattice, and incorporation of foreign atoms. One of the methods which can be used to detect such structural differences is infrared spectroscopy. With this method, one can investigate the absorption or the transmission of electromagnetic radiation by the sample in the infrared region of the spectrum (4000-100 cm^{-1}). Electromagnetic radiation in the infrared region has frequencies which correspond to molecular vibrations or to lattice modes of solids. These vibrations can be excited by electromagnetic radiation of the same frequency, if the vibration is coupled with the change of the corresponding dipole moment. The energy of the radiation is then absorbed and transformed into vibrational energy of the molecules or the solid. Modern infrared spectrometers record continuously the absorption of a sample which is brought into the radiation path. The spectrometer is scanned through the complete frequency range of interest. From the position and the intensity of the absorption bands one can draw conclusions concerning the composition of the sample (certain molecular groups exhibit so-called 'characteristic frequencies') and the way certain molecules are incorporated into the substance.

Infrared spectroscopical investigation on crystals is done either by reflection spectroscopy (for measuring surface effects, as, for example, adsorption, or for measuring the lattice modes), by the use of KBr-pellets (1-2 mg substance pressed together with about 200 mg KBr to a glassy pellet), by the use of nujol mull* or by thin, plane-parallel plates. The application of infrared spectroscopy for distinguishing natural from synthetic gems has been pointed out for emeralds (Wood & Nassau, 1968; Nassau, 1976, 1980), turquoise (Arnould & Poirot, 1975) and quartz, especially amethyst (Zecchini, 1979; Zecchini & Mérigoux, 1980; Schmetzer & Bank, 1980). With this method it is also possible to identify treated turquoises, which show additional bands induced by plastic (Banerjee, 1972). Whereas emerald and quartz are normally investigated as single crystals, natural or treated turquoise can be investigated as KBr-pellets or by reflection spectroscopy.

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*According to the O.E.D. Supplement (H-N, 1976), 'nujol' is a preparation of paraffin oil used for making mulls in infrared spectroscopy, and 'mull' is a preparation of finely ground material suspended in oil for the purpose of studying the infrared spectrum.—Ed.

Natural and synthetic emeralds show different mechanisms of incorporation of H_2O molecules into the channels of the beryl structure, as was shown by Wood & Nassau (1968). The infrared absorption bands of natural and synthetic emeralds, which are induced by incorporated H_2O molecules therefore differ in frequency and intensity.

The differentiation of natural amethysts from synthetic ones, which are produced in the U.S.S.R. and can be found on the gem market in growing quantities, is possible by examining the infrared spectra in the range from 3800-3000 cm^{-1}. Infrared investigations on α-quartz have been done long since (e.g. Saksena, 1958; Kats, 1962; Dodd & Fraser, 1965; Chakraborty & Lehmann, 1978), and the absorption measurement of synthetic quartz is done as a routine procedure for quality control. The relationship between trace element concentrations and intensities of the infrared absorption bands, especially the origin of infrared bands of amethysts, has not yet been clarified completely. Infrared reflection measurements of emeralds and amethysts are, however, not suitable for investigating the incorporated H_2O and OH^-, because the depth of penetration of the radiation is too low, so that only surface effects can be measured. The application of the KBr-pellet or the nujol mull method is also impossible, because the relevant concentrations and, accordingly, the infrared band intensities are too small.

Wood & Nassau as well as Schmetzer & Bank used plane-parallel plates, which were mounted perpendicular to the incident beam, so that no refraction and no variation of the symmetry of the radiation path took place. This method is well suited for working out criteria for distinguishing synthetic from natural stones, but less suitable for gemmological routine investigations, because the principal requirement of investigation without damage is not fulfilled. Faceted gems are cut in such a way, that a radiation path like the one through a plane parallel plate is avoided; light should be totally reflected by the pavilion facets and come out again through the table facet (Figure 1). As the refractive index is changing continuously with the wavelength of the incident radiation (dispersion), the symmetry of the radiation path is also varied continuously with the wavelength. A symmetrical path of radiation between the reference beam and the beam through the sample is, therefore, not guaranteed if a faceted stone is mounted into a spectrophotometer. Furthermore, only a small part of the

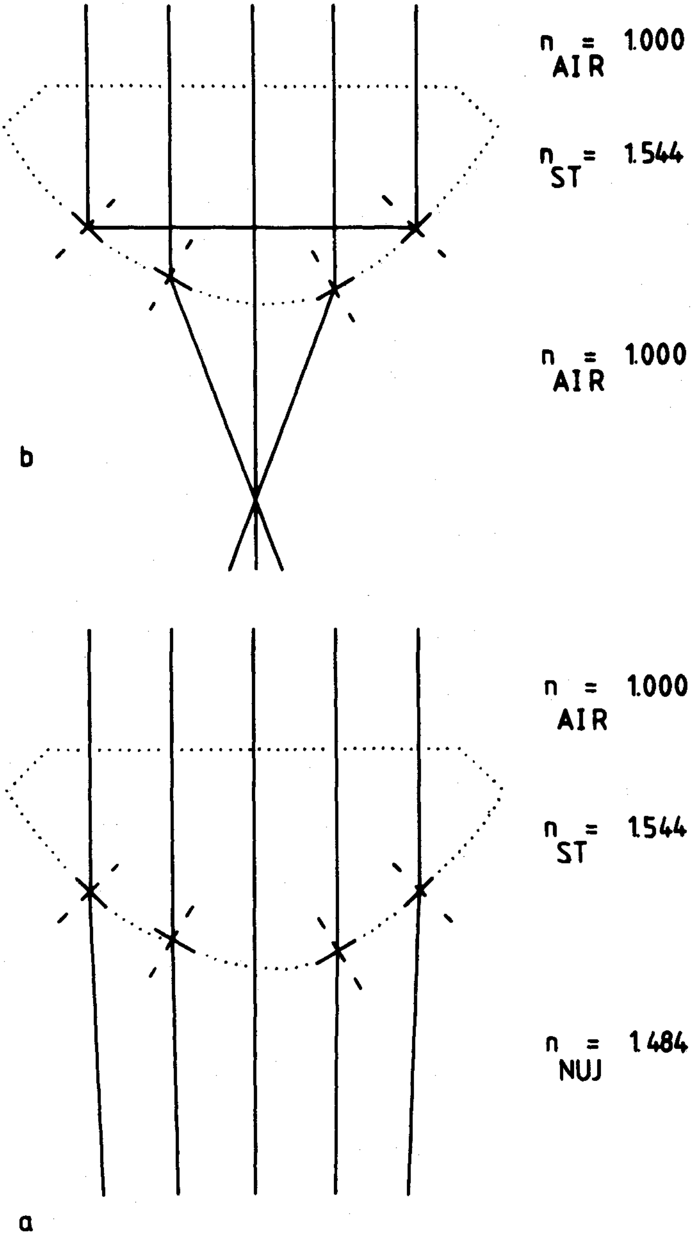

FIG. 1. Radiation paths through a faceted amethyst, when using nujol as immersion liquid (a) and in air (b).

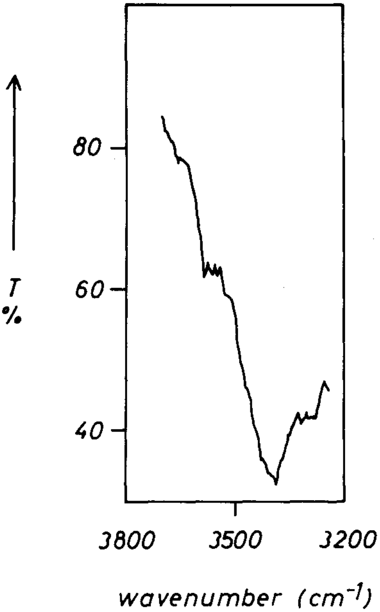

FIG. 2. Infrared spectrum of synthetic amethyst of Russian production; faceted stone, spectrum recorded without using an immersion liquid.

incident radiation will be registered by the detector after having passed through the stone (Figure 1). The forementioned facts are the reasons for the spectra of faceted gems (Figure 2) being of a much poorer quality than those of plane-parallel plates (Figure 3), when they have been mounted without further precautions. Only a few, suitably cut stones will allow the recording of a somewhat characteristic spectrum, after a skilful and time-consuming orientation has been done. This method is not suitable for routine investigations.

Zecchini (1979) pointed out the disturbing influence of refraction and dispersion when infrared spectra of faceted gems have to be recorded. He therefore investigated faceted quartz crystals in an open, constant path-length cell which was filled with CCl_4 as an immersion liquid. This liquid has a refractive index of 1.4607 at a wavelength (of the incident radiation) of 589 nm. The

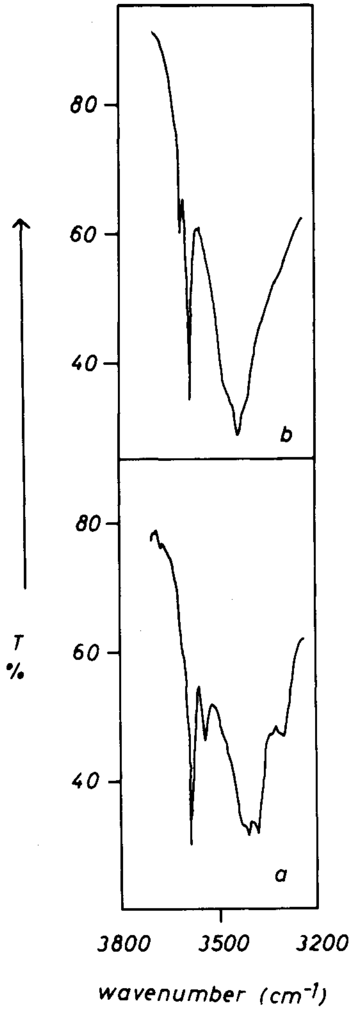

FIG. 3. Infrared spectra of synthetic amethyst of Russian production (a) and natural amethyst from Africa (b); plane-parallel plates; spectra recorded without using an immersion liquid.

above mentioned effects can be clearly reduced by using this immersion liquid, and a better interpretation of the spectra is possible.

When using halogenated hydrocarbons in an open cell, there is the danger, that the mirrors of the optical systems of customary infrared spectrophotometers are damaged by halogen hydrides, which are produced at the radiation source. CCl_4 should therefore not be used routinely in open cells. As a liquid that does not contain any halogens and which has no absorption bands in the range of 3800-3000 cm^{-1} and a refractive index near that of quartz, we have chosen liquid paraffin (nujol, $n = 1.480$-1.484 at 589 nm). This liquid is used as a suspension medium in infrared spectroscopy and can be handled without problems. The only disadvantage is the relatively low transmission which makes it impossible to use a constant path-length cell. Therefore, a cell was constructed the path-length of which is variable. For gemmological routine investigations, this cell has to be open, so that the gems can easily be mounted. To provide a great range of application, the windows can be exchanged. In the range of 3800-3000 cm^{-1} polished KBr windows have been used. By using such a cell (Figure 4), it is possible to minimize the variation of the symmetry of the radiation path through the stone and to minimize the immersion layer thickness. After the stone has been brought into the cell by the sample holder, the cell is closed until the table facet touches one of the windows and the back of the stone touches the other one. A diaphragm, the diameter of which should be nearly the same as that of the table facet of the stone, is installed in front of the first window. The radiation path through the cell is shown in Figure 1. The greatest part of the beam enters the stone without being refracted. The difference between the refractive indices of the stone and the immersion liquid being very small, the beam will leave the stone with very little refraction and pass through only a small layer of liquid. If a second, identical cell is brought into the reference beam for compensation, it is possible to gain infrared spectra of faceted stones which are of about the same quality as those of plane-parallel plates (Figure 5). The method described is easy to handle and makes it possible to record infrared spectra of faceted amethysts in a routine manner.

It stands to reason that other gems can also be investigated with the described cell. If gems with a higher refractive index are to

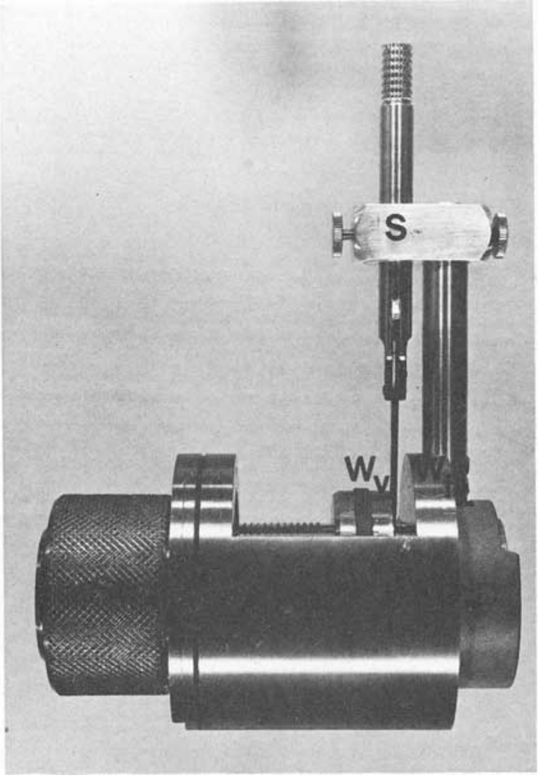

FIG. 4. Liquid cell for measuring infrared spectra of faceted gems; S sample holder; W_f fixed window; W_v variable window; Sc adjusting screw for variable window; D diaphragm.

be measured, it is impossible to avoid the use of halogenated hydrocarbons, which makes the handling of this method more difficult. The cell has to be welded into plastic foils which have no bands in the spectral range that is under investigation. Very suitable for this purpose is polyethylene, which has a very good transmission in almost the whole infrared range.

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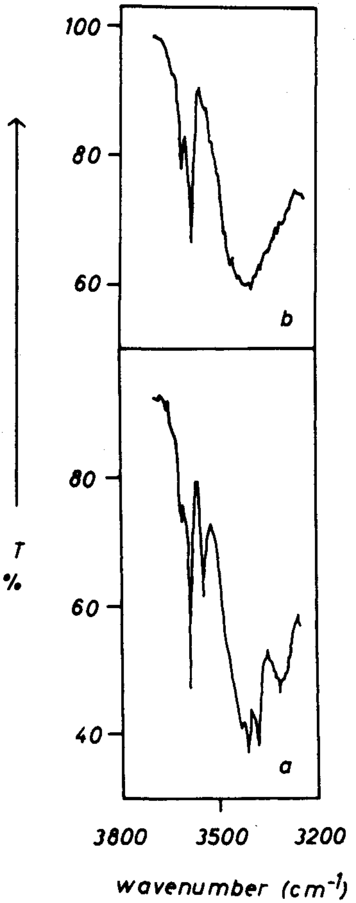

FIG. 5. Infrared spectra of synthetic amethyst of Russian production (a), and natural amethyst from Zambia (b); faceted stones; spectra recorded using nujol as immersion liquid in variable cell (see Figure 4).

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The measurements have been done in the Inorganic Chemical Institute of the University of Heidelberg by kind permission of Prof. H. Siebert and Prof. H.-H. Eysel.

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THE USE OF ELECTRON SPIN RESONANCE SPECTROSCOPY TO DISTINGUISH SYNTHETIC FROM NATURAL GEMSTONES

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INTRODUCTION

In a previous article (Hutton, 1979) for this *Journal,* one of us described the use of magnetic resonance spectroscopy (known either as electron spin resonance, ESR, or electron paramagnetic resonance, EPR) in gemmology. In this article, it is proposed to review briefly an exciting recent development in the application of ESR spectroscopy at about 3 cm wavelength to gemmology—the ability to distinguish synthetic from natural gemstones, and even, in some cases, to say by which process the synthetic stones were made.

The theory and apparatus associated with ESR spectroscopy as applied to gemmology have been described previously (Troup, 1969, Hutton, 1979), and therefore we will not present them again here. Rather, we will present the spectra for the natural and the synthetic stones, discuss the features of difference and the reasons for them, and show why the identification of (say) the synthetic stone is very secure.

EXPECTED DIFFERENCES BETWEEN NATURALS AND SYNTHETICS

It is convenient to list here some quite general differences we might expect between natural and synthetic stones, so that we can to some extent predict the differences to be expected in the ESR spectra.

Particularly with modern crystal growing techniques and modern technology, we would expect that, in many crystal species, the synthetic lattice would be more perfect than the natural one, because of the lack of inclusions, and of 'impurities' other than those required (these comments do *not* apply in the unusual but well known case of spinel). Immediately, we are given two differences in the spectra: the lines for the synthetic will be

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narrower, because the environment of the paramagnetic ions will be more uniform, and certain lines appearing in the natural crystals from various impurities there will not appear in the synthetic. The reverse can also be true, since it may be easier to substitute a certain impurity in a synthetic in order to colour it, than to incorporate the naturally occurring impurity.

The narrower lines will mean that certain small but important features of the spectrum of the (single) common impurity will be more evident in the synthetic spectrum. For example, lines due to neighbouring pairs of impurity atoms will show up more clearly, because they will be narrower. All these features discussed will be described below.

APPARATUS AND TECHNIQUE

The apparatus used in all investigations was either that described in Hutton (1979), or standard commercial apparatus (e.g. the Varian system) operating at wavelengths in the 3 cm region. Magnetic fields of up to 10 kilogauss (1 tesla) were required. The specimens were oriented so that the magnetic field lay along principal magnetic axes for the spectra, and the spectra along each such axis recorded. The 3 cm wavelength resonant cavity allows the use of fairly large specimens (about the size of a little-finger nail in perimeter), which has proved convenient when identification has been required for commercial reasons.

RESULTS AND DISCUSSION

(a) Golden Sapphire

We choose to begin with yellow sapphire, since this was the first system to be established historically (Scala & Hutton, 1975). Figure 1(a) shows the typical spectrum (ESR) of a natural golden sapphire with the steady magnetic field perpendicular to the trigonal axis, and 1(b) shows the ESR spectrum of a synthetic golden sapphire under the same conditions. It will be seen that there is very little or no Cr^{3+} in the natural stone, while the Fe^{3+} lines are broad and prominent: in the synthetic stone, there is very little Fe^{3+} present, but considerable Cr^{3+}. The spectrum of synthetic brown sapphire is also shown, in Figure 1(c); here, the percentage of Fe^{3+} has increased with respect to that of Cr^{3+}.

The multiplicity of small lines on either side of the middle Fe^{3+} line in the natural stone is also a feature of the spectrum. They are

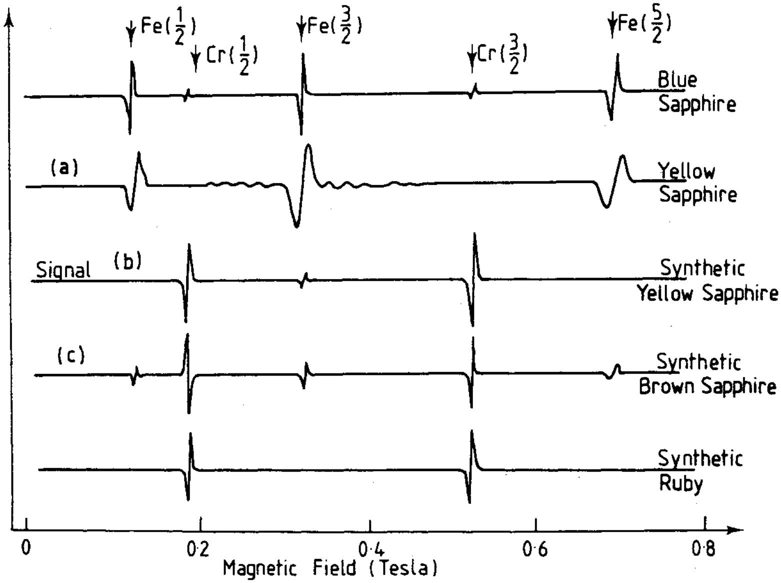

FIG. 1. ESR spectra of various sapphires at ∿3 cm wavelength taken with the steady magnetic field perpendicular to the trigonal axis.

absent in the synthetic stones. Their origin is not known at this stage: pair spectra, or Mn^{2+}, or radiation damage are possibilities.

(b) Blue Sapphire

The ESR spectra for various natural blue sapphires, taken with the steady magnetic field perpendicular to the trigonal axis, are shown in Figure 2(2)-(6). The multiplicity of small lines about the middle Fe^{3+} line (labelled B) are clearly seen in all natural stones, except perhaps the Ceylon blue. They are effectively absent in the boule fragment (synthetic), whose Fe^{3+} lines are also very much narrower than those of the naturals. The linewidth is effectively the distance between the peak and the trough of the signal denoting the line.

It may be argued that this case is not as conclusive as that for the golden sapphire. It is really necessary to pass to the spectra with the magnetic field parallel to the trigonal axis, as shown in Figure 3(1)-(4). In this case, even the Ceylon blue clearly shows the many

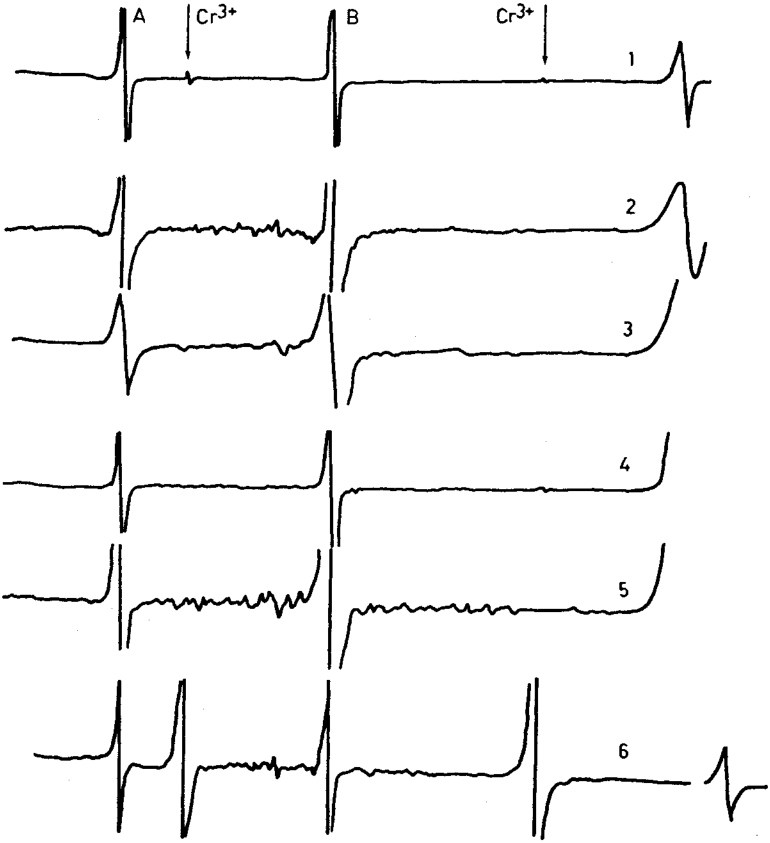

FIG. 2. ESR spectra of various blue sapphires, taken under the same conditions as Figure (1). 1: Boule fragment. 2: Certain natural, origin unknown. 3: Australian blue. 4: Ceylon blue. 5: Cambodian pale blue. 6: Montana blue.

small lines about the middle Fe^{3+} line (B), but the most important feature of the spectrum of the synthetic is the appearance of the lines labelled F. These are identified as the so-called 'forbidden' lines, arising from transitions not between neighbouring energy levels (see, e.g., Hutton 1979) but between levels and their next nearest neighbour. When the magnetic field lies parallel to the trigonal axis, these transitions have a low probability: hence the name 'forbidden'.

They are very narrow because next-to-nearest neighbouring levels will converge or diverge more rapidly as the magnetic field is

FIG. 3. ∿3 cm wavelength ESR spectra of various blue sapphires: steady magnetic field parallel to trigonal axis. 1: Boule fragment. 2: Ceylon blue. 3: Australian blue. 4: Cambodian pale blue.

increased than the nearest neighbouring levels. Any imperfections in the lattice will broaden these lines and hence their peak-to-peak height will decrease. Their clear presence and *narrowness* is an indication of the perfection of the lattice. They are just visible in the Ceylon blue, perhaps the most perfect of the natural specimens we used. However, they are clearly present, and narrower, in the synthetic.

The combination of 'perpendicular' and 'parallel' spectra, then, makes the test very nearly conclusive for blue sapphire (Anderson, Hutton & Troup 1981). To make the test fully conclusive, what is needed is a statistical study of the linewidths of synthetic and Ceylon sapphires, and a further investigation of the possible effects on ESR spectra of the heat-treatment of natural

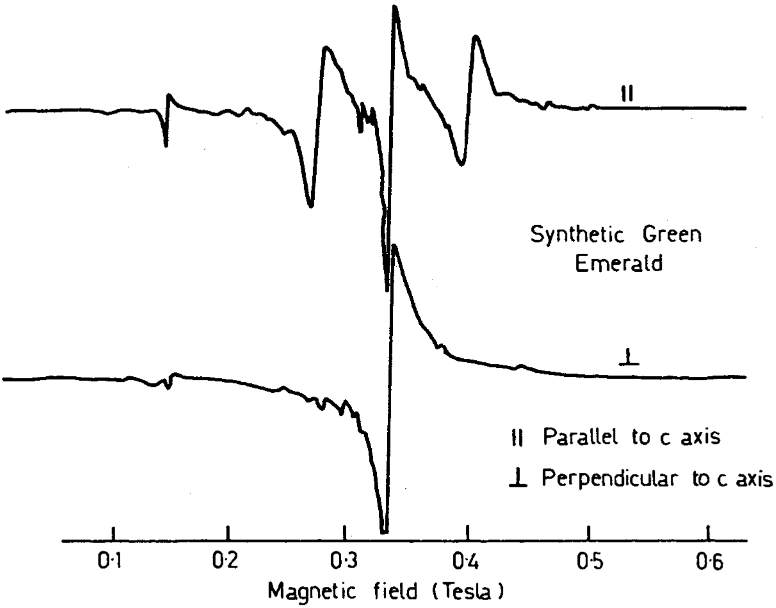

FIG. 4. ∿3 cm wavelength ESR spectrum of synthetic green 'emerald' coloured by V^{3+}.

sapphires. However, at this stage, it would be fair to say that there is a very good case for considering blue sapphires having pronounced and narrow forbidden transitions as synthetic, unless they can be proven natural by other means.

(c) Emerald

There have been (Campbell, 1974; Farn, 1975) arguments about how to define emerald. For example, *to the eye,* beryl containing V^{3+} can have the same 'characteristic' colour of emerald which is, in general, beryl coloured by the presence of Cr^{3+} (with little Fe^{3+} in comparison).

The spectra of the synthetic beryl containing V^{3+}, taken at room temperature, are shown in Figure 4. V^{3+} does not show up at room temperature, but the Fe^{3+} spectrum does. Such a stone also remains green under a Chelsea filter.

The spectra of natural emeralds from various sources are shown in Figure 5(a)-(b). The Rio Tinto specimen shows chromium but no iron, but others show spectra characteristic of both. Differences in the parallel spectra satellite lines are quite marked.

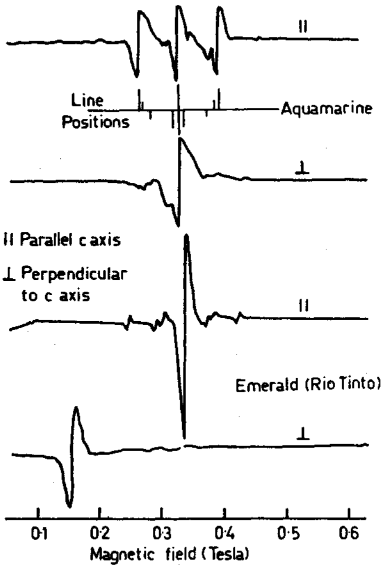

FIG. 5(a). ESR spectrum of Rio Tinto emerald, with Aquamarine spectrum for comparison.

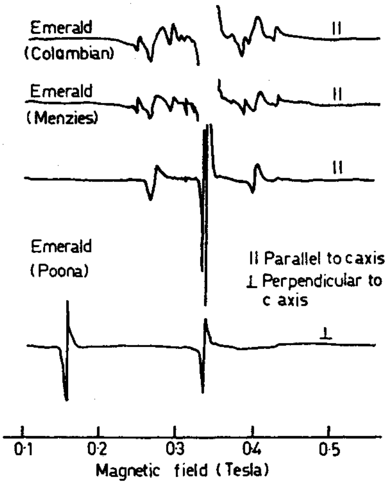

FIG. 5(b). ESR spectra of Colombian, Menzies, and Poona emeralds.

The Poona sample has well resolved iron lines and the spectra are characteristic of low concentrations in a well-ordered crystal. The Colombian and Menzies samples have higher chromium concentrations and are not as well ordered.

Spectra for Gilson and Chatham synthetic emeralds are shown in Figure 6(a)-(b). The many sharp satellite lines clearly distinguish these synthetics from the naturals. In addition, the Gilson, but not the Chatham, shows a pronounced iron spectrum, which explains why the line at 4270 Å is seen in the optical region (Liddicoat, 1971). The satellite lines which distinguish these synthetics from the naturals have been shown to be due to Cr-Cr pairs (Edgar & Hutton, 1978).

(d) Alexandrite

Very good quality synthetic alexandrite, made for laser purposes, has recently become available (Walling & Peterson, 1980). Since the crystal is orthorhombic, three spectra, with the steady magnetic field parallel to each of the principal magnetic axes, are required for specification. One of these is shown in

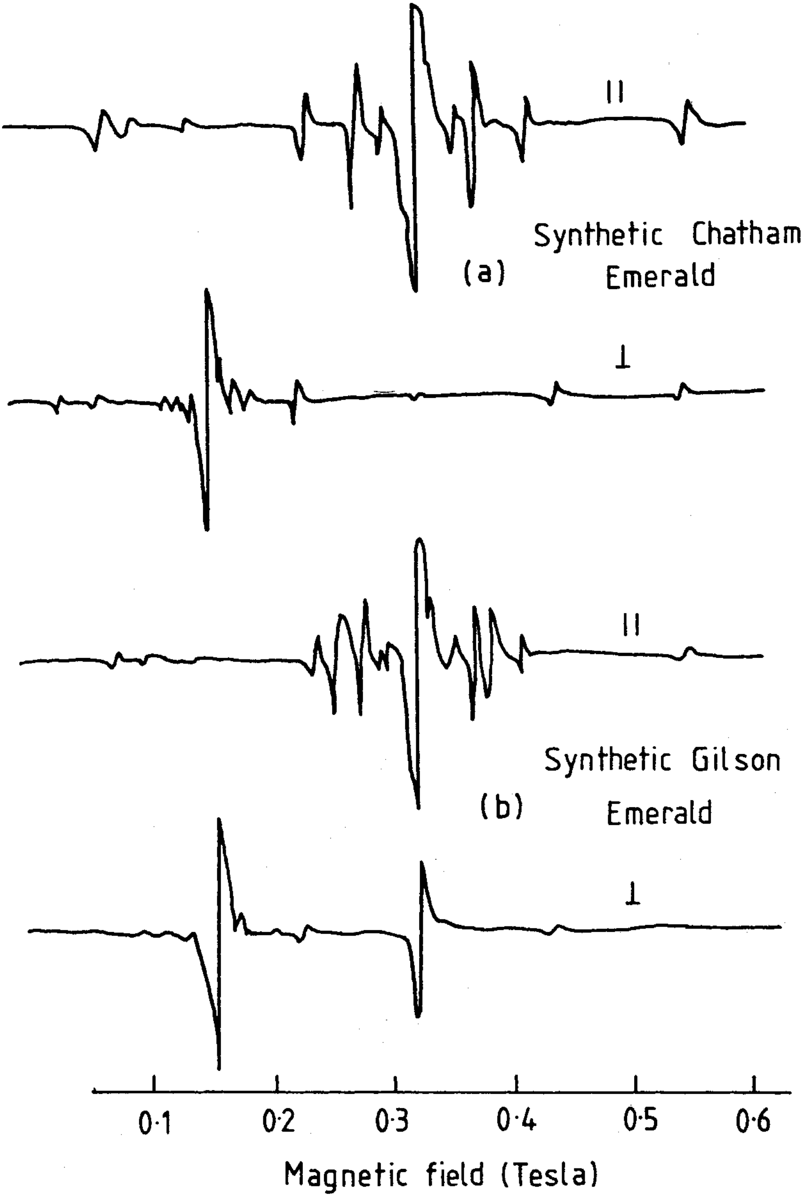

FIG. 6. ESR spectra of (a) synthetic Chatham emerald (b) synthetic Gilson emerald.

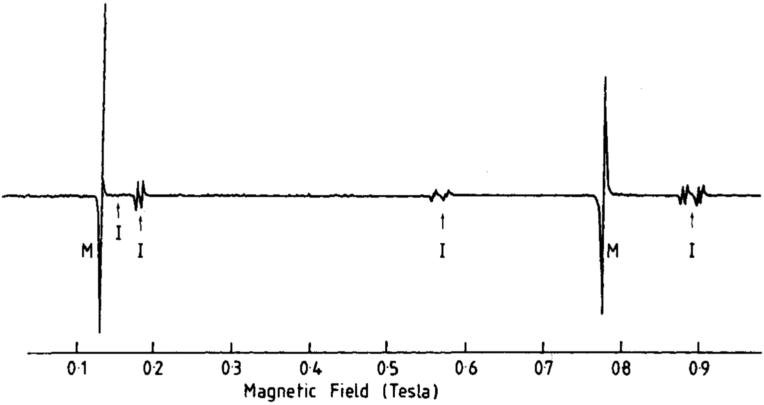

FIG. 7. ∿3 cm ESR spectrum of laser quality synthetic Alexandrite: steady magnetic field along *b* axis. The lines labelled 'M' arise from Cr^{3+} ions in sites having inversion symmetry. The steady magnetic field is slightly misaligned from the *b* axis: when it is exactly along the *b*-axis, the lines labelled 'I' become single, not doubled as shown.

Figure 7, taken on a synthetic sample kindly supplied by Dr J. C. Walling, of Allied Chemicals, New Jersey, U.S.A.

In previous work (Barry & Troup, 1969), over fifty natural alexandrite samples were studied by ESR. All contained Fe^{3+} as well as Cr^{3+}, leading to a far greater number of lines in the spectrum, and to broadening of all lines by exchange coupling. A flux-melt grown synthetic crystal, kindly supplied by Dr E. F. Farrell, of M.I.T., was also studied. This gave spectra similar to those of Figure 7, but the lines were broader: the crystal was not of good optical quality. Thus the breadth of the lines and the presence of many extra lines due to Fe^{3+} are what enable the natural alexandrite to be distinguished from the synthetic.

(e) Mg Spinel (Cr^{3+})

Naturally occurring $MgAl_2O_4$ is almost completely ordered as regards crystal structure, but the corresponding synthetic material is not.

In the natural material, the linewidth of the ESR transition does not vary very much with the angle θ made by the steady magnetic field and the [111] direction, whereas in the synthetic material, the disorder imposes a considerable variation (Atsarkin, 1963: Schindler, Gerber & Waldner, 1970). A table (after Atsarkin) is reproduced overleaf.

	Angle θ (degrees)				
Compound	0	15	70	90	
Natural Spinel (Light Pink)	24	25	27	24	Linewidth (Gauss) at half intensity
Synthetic (Stoichiometric, 0.6% wt Cr_2O_3)	32	70	90	70	Linewidth (Gauss) at half intensity

Schindler *et al.* (1970) have also performed ESR experiments on synthetic $ZnAl_2O_4$ coloured pink by the inclusion of Cr^{3+}. This material does *not* have the disorder of the synthetic $MgAl_2O_4(Cr)$.

While it is known that careful refractive index measurement can distinguish natural $MgAl_2O_4(Cr)$ from synthetic $ZnAl_2O_4$, we have a further test involving ESR, because the spectral parameters are different. Careful observation of the field strengths at which the Cr^{3+} ESR lines appear for a given frequency allows distinction between the spinels. Unfortunately, the quoted literature for this work on spinel is somewhat more specialized than that in the previous sections, and published spectra are not available for reproduction.

DISCUSSION

We believe some considerable progress has been made in using ESR to distinguish between certain natural and synthetic stones. The work needs to be extended to other stones, but more importantly, the technique needs to be made more readily available to the gemmologist. A 3 cm wavelength ESR spectrometer, and associated fairly large electromagnet, to obtain the necessary steady magnetic fields, is not portable, and hence the stones for identification must be brought to the laboratory where the spectrometer is sited. However, there is another possibility, currently being investigated in our laboratory, and that is the use of a 10 cm wavelength ESR spectrometer. This can be almost completely transistorized, the necessary transmission lines can be made very compact, and the electromagnet can be made much smaller, as one needs to go only to about 0.3 tesla instead of the 1 tesla required for 3 cm wavelength ESR. Thus, there is some hope of a fairly low-cost commercial instrument one day becoming available.

ACKNOWLEDGEMENTS

The substance of this article (up to Section (d) of the results and quoted spectra) formed the subject of a seminar at the Physik Institut der Universität Zurich, Schönbergasse 9, Zurich at the invitation of Professor Detlef Brinkmann, in late 1980. The information on spinel was most kindly and generously brought to our notice by Dr F. Waldner, of the same Institut. The Gemmological Association of Australia, especially the Victorian Branch, have been most generous always in supplying us with gemmological specimens.

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[*Manuscript received 6th November 1981, revised 17th April 1982.*]

GEMMOLOGICAL ABSTRACTS

ABRAHAM (J. D. S.). *Heat treating corundum: the Bangkok operation.* Gems & Gemology, **XVIII**, 2, 79-82, 4 figs (3 in colour), 1982.

Something over 95% of corundums exported from the Far East have been heat-treated in one way or another. Stones are first trimmed of cracked or heavily included areas, and usually coated with borax paste. Heating processes are secret, but sapphires are heated to 1600 °C for upwards of 24 hours, rubies for four to eight hours. Process is often repeated many times. Results largely a matter of luck and many stones are ruined. Hit or miss methods vary greatly, successful ones are not revealed in detail. R.K.M.

ANDERSON (A.). *Is it really a Kashan?* Jewelers' Circular Keystone, pp.54-7, 8 figs in colour, March 1982.

The report gives some notes on the Kashan synthetic ruby. Characteristics listed include solid-filled very coarse negative crystals with high reflectivity; clusters of parallel rod-like negative crystals, also solid-filled; networks of solid-filled negative crystals; wispy patterns resembling rain, sometimes resembling a tailed comet; straight growth lines. Some Kashan stones are reported to be inclusion-free up to magnifications of 126 ×. M.O'D.

ANDERSON (J. E.). *Color grading ruby with the Color Master.* Lapidary J., **36**, 3, 534-6, 1982.

The Color Master is sold by Gem Instruments Corporation and places stones according to an arbitrary table of colour. In this case ruby was the stone selected, and a table is given of the grading notation. M.O'D.

BALL (R. A.). *Common opal and potch opal.* Aust.Gemmol., **14**, 11, 305-10, 7 figs, 1982.

Discusses the difference between potch opal and common opal. The terms are often used synonymously, but this writer shows that potch is found only in association with precious opal and differs from common opal in its structure quite substantially. Common opal does not show the sphere structure. Potch does, but has spheres of mixed sizes which prevents the play of colour. An interesting and well illustrated paper despite the fact that these differences can only be seen when an electron microscope is available. R.K.M.

BALL (R. A.). *Honey opal.* Aust.Gemmol., **14**, 12, 324-5, 2 figs, 1982.

Deals with opal of this colour and outlines major sources. Mexican material may have play of colour. One reference calls it 'Bernsteinfarbener opal'—amber coloured opal. R.K.M.

BLAK (A. R.), ISOTANI (S.), WATANABE (S.). *Optical absorption and electron spin resonance in blue and green natural beryl.* Physics and Chemistry of Minerals, **8**, 4, 161-6, 13 figs, 1982.

EPR spectra taken on natural blue and green beryl from the Governador Valadares area of Minas Gerais, Brazil, show that trivalent iron in blue beryl occupies a trivalent substitutional aluminium site and that in green beryl trivalent iron is localized in the structural channels between two 0_6 planes. Infrared spectra on the other hand show that the alkali content of blue beryl is mostly at substitutional and/or interstitial sites and mostly in the structural channels in green beryl. M.O'D.

BRACEWELL (H.). *Mt Surprise to Mt Isa.* Wahroongai News, 10-11, August 1982.

A report from a former editor of this excellent little magazine who is, with her husband, on an extended 'rock-hound' trip. She writes vividly of the gem fields of North Queensland from Mt Surprise to the Gulf of Carpentaria and then south to Mt Isa. Topaz, aquamarine, rhodolite garnet, malachite, quartz, gold, amethyst, chrysocolla, staurolite and unakite were found. They are heading for the Harts Range. R.K.M.

BRACEWELL (H.). *Mt Isa—mine and minerals.* Wahroongai News, 12, August 1982.

A further report from the world's largest underground mine, producing lead and silver, zinc and copper. City boundaries encompass 40 977 square kilometres, making it the world's largest city in area. Mining and civic programmes appear to be very well organized. R.K.M.

BRIGHTMAN (R. F.). *Surface topography of gem crystals.* Aust.Gemmol., **14**, 11, 300-4, 12 figs (10 in colour), 1982.

Multibeam interferometry has been used to produce spectacular colour pictures of shallow surface features emphasizing growth patterns and symmetry. Colours obtained are due to interference and bear no relation to the colours of the crystals photographed. R.K.M.

BRIGHTMAN (R. F.). *Stones seen—viridine with low R.I.* Aust.Gemmol., **14**, 12, 322-3, 2 tables, 1982.

A green Brazilian andalusite which had lower constants than usual for this variety. R.K.M.

BROWN (G.), BRACEWELL (H.), KELLY (S. M. B.). *Mt Surprise topaz: a gemmological study.* Aust.Gemmol., **14**, 12, 326-33, 16 figs, 1982.

In depth examination of blue and colourless topaz from creeks 40 km north of the town of Mt Surprise in northern Queensland. Two figures appear to have been printed upside down, but habit of crystals is typical of (Australian!) topaz. Inclusions are discussed and illustrated in some detail. R.K.M.

BROWN (G.), SNOW (J.), LUND (D.). *Examination of an unusual item of 'native' jewellery.* Aust.Gemmol., **14**, 12, 334-7, 5 figs, 1982.

A crudely fashioned pendant made from the full thickness, including bone, of the carapace of a Central African land turtle. Not the usual hawks-bill marine turtle which yields most of the commercial shell used. R.K.M.

BROWN (G.). *How to improve the 'life' of a gemstone.* Wahroongai News, 14-16, June 1982.

An account of the effects of coating gems with such substances as magnesium fluoride which, it is suggested, significantly improves 'the "life" of the colour improved gemstone.' The method employed is not described, and there seems to be no suggestion that the practice is wide-spread. Hypothetical examples are discussed. R.K.M.

BROWN (G.). *Identifying turquoise.* Aust.Gemmol., **14**, 11, 289-99, 14 figs, 1982.

An account of this species and of its many simulants and of methods of distinguishing and identifying them from each other. An important paper on what has been described as the most difficult stone in gemmology. R.K.M.

BROWN (G.). *Malachite—Azurite.* Wahroongai News, 11-13, June 1982.

Two closely allied copper carbonate minerals. Deals principally with paragenesis, petrology and mineralogy. Basic gemmological facts and figures are given. R.K.M.

BROWN (G.). *Peridot.* Wahroongai News, 17-21, June 1982.

A monograph dealing with paragenesis, crystal structure, petrology and mineralogy and gemmological testing constants. [640 nm absorption line is not usually quoted for this gem. Is it correct?] R.K.M.

BROWN (G.). *Trapiche emeralds.* Wahroongai News, 15-16, 1 fig., August 1982.

An account of these 'gear' shaped crystals found in the Muzo and Chivor mine regions of Colombia. Chivor trapiche has a 'spindle' of emerald material, those from Muzo have a centre core of carbonaceous mineral which also occupies the prism corners. R.K.M.

BROWN (G.), SNOW (J.). *The AIGS master viewer.* Aust.Gemmol., **14**, 11, 311, 1 fig., 1982.

A very short evaluation of a new stereo viewer and slides illustrating grading standards for sapphires and rubies. R.K.M.

BURCH (C. R.). *Inclusions—an aid to the identification of gemstones—6.* Gems, **14**, 2, 26-30, 3 figs in colour, 1982.

This part of the series discusses liquid inclusions with examples. M.O'D.

BUTLER (J.). *A letter from Mt Isa.* Wahroongai News, 5-6, August 1982.

Writer reports euhedral pale yellow, yellow-green and blue beryl crystals of large size (30 cm × 100 cm plus) mined at Mica Creek, S.W. of Mt Isa. Feldspar, quartz, cassiterite, tourmaline, rutile, rhodonite, garnet, fluorite, apatite and topaz are listed among other minerals found in these pegmatites. Staurolite and massive iolite found in the vicinity. R.K.M.

BUTLER (J. N.). *The quartz minerals of the Redcliffe Peninsula.* Aust.Gemmol., **14**, 12, 338-41, 4 figs, 1982.

Various chalcedonic nodules are found along the Redcliffe Peninsula north of Brisbane. Most are altered to a greater or lesser depth to chert. R.K.M.

CASSEDANNE (J.-P.). *L'onyx de San Luis (Argentine).* (Onyx from San Luis, Argentina.) Revue de Gemmologie, 70, 11-15, 9 figs (2 in colour), 1982.

A green calcite from San Luis province, Argentina, is sold as 'green onyx'. The geological occurrence is described together with differences in chemical composition. References are given. M.O'D.

CASSEDANNE (J.-P.), SAUER (D.-A.). *Les emeraudes de Santa Terezinha (Goias).* (Emerald from Santa Terezinha (Goyaz).) Revue de Gemmologie, 71, 4-8, 8 figs (2 in colour), 1982.

Emerald has been found in the south-east part of the state of Goyaz, Brazil. The area is a large lateritic plain upon which emerald is found in talc schists; it forms well-shaped crystals, not usually more than 1 cm in length and showing prism and pinacoid forms. From 0 to 1% Fe and a much larger proportion of Cr are found. Iron and manganese oxides are found as inclusions. SG is approx. 2.70, though for crystals with pyrite inclusions the value increases to 3.05. RI is 1.588, 1.580 with a DR of 0.008. Dichroic colours are bluish-green and clear yellowish-green; sharp absorption lines are seen at 692 and 695 nm, partial absorption from 635 to 600 nm and from 445 to 400 nm. M.O'D.

COLLINS (A. T.), WOODS (G. S.). *An anomaly in the infrared absorption spectrum of synthetic diamond.* Phil.Mag., B, **46**, 1, 77-83, 2 figs, 1982.

Apparently contradictory observations have been made on the infrared spectra of synthetic diamonds. First, there is a good correlation between the strengths of nitrogen-induced absorption at 1130 cm^{-1} and the local-mode absorption peak at 1344 cm^{-1}. But the incorporation of ^{15}N into crystals shifts the 1130 cm^{-1} band to lower wavelengths while leaving the 1344 cm^{-1}unaffected. The suggestion is that N atoms do not participate in the 1344 cm^{-1} vibration. M.O'D.

COZAR (J. S.), FERNANDEZ (M.). *Inclusiones cristalinos en el rubi sintetico Chatham.* (Crystalline inclusions in Chatham synthetic ruby.) Boletín del Instituto Gemológico Espanol, 22, 11-26, 20 figs (6 in colour), 1982.

Three different types of crystalline inclusions have been detected in Chatham ruby. Platinum with tabular and prismatic habit, lithium aluminate, and matrix material have been illustrated and described. M.O'D.

DARRAGH (P. J.), WILLING (M. J.). *A new synthetic emerald.* Aust.Gemmol., **14**, 12, 344, 1982.

An Australian hydrothermal synthetic emerald with trade name Biron was examined. Remarkably clean and good colour. RI 1.570-1.577, so higher and with greater birefringence than expected in most synthetic emeralds. Preliminary report.

R.K.M.

DILLON (S.), ed. *Gem News.* Gems & Gemology, **XVIII**, 2, 120-2, 2 figs (1 in colour), 1982.

Diamonds. De Beers to handle 75% (including 10% expected gem quality) of Ashton Joint Venture output in Western Australia. Depressed market conditions are affecting diamond-oriented economy in Botswana. Only one mine producing in Ghana; a cutting industry is being considered. India is exploring in Madhua Pradesh and Andhra Pradesh for new diamond sources. Israel has removed some customs duty and the import licence requirement. Mine closures reported from Lesotho, Namibia and S. Africa. Zaire also reports very substantial drop in diamond output.

Emerald. Aga Khan mine, West Australia, is stockpiling, about 10% gem quality: all small crystals. Brazil reports emeralds of superior colour discovered recently: RIs high.

Pearl. Japan worried that China may process their own freshwater [cultured] pearls which are at present processed in Japan.

A fine pink topaz and peridot suite of jewellery is illustrated with a request for information on the unusual hall marks, also illustrated. R.K.M.

DILLON (S.), ed. *Gem News.* Gems & Gemology, **XVIII**, 3, 183, 1982.

A diamond cutting operation is starting in Sri Lanka, sponsored by Belgian interests and by Sri Lankan government.

Brazil. Report of good quality emerald cat's-eyes found near Itabira, Minas Gerais. Also fine blue-green tourmaline and brazilianite near Taquaral.

Pakistan. Dr Edward Gübelin confirms existence of aquamarine mines in Haramosh valley and that 'chrome diopside' from Hunza River is proved to be the low iron mineral pargasite.

Ruby. New Kenya mine producing cabochon material similar to Burmese ruby in colour. Dr P. Keller reports that despite the political situation in Cambodia many miners cross daily from Thailand and stones are taken back through Bo Rai. He confirms that Thai gem centres routinely heat corundum rough. R.K.M.

ELLIOTT (D. G.). *Amethyst from the Thunder Bay region, Ontario.* Mineral. Record, **13**, 2, 67-70, 8 figs, 1982.

A gem-quality amethyst occurs in the Thunder Bay region of Ontario, Canada. Some specimens contain haematite inclusions; normally the terminal rhombohedron alone is found. M.O'D.

FERGUSON (R. W.). *Sunstones by the square mile.* Lapidary J., **36**, 3, 570-8, 13 figs, 1982.

Sunstone from the southern Oregon area is described, with an account of its recovery. M.O'D.

FRYER (C.), ed., CROWNINGSHIELD (R.), HURWIT (K. N.), KANE (R. E.). *Gem Trade Lab Notes.* Gems & Gemology, **XVIII**, 2, 102-8, 21 figs in colour, 1982.

Alexandrite disfigured by scratched number on pavilion facet; yellow-green cyclotron-treated diamond; beryls painted emerald colour; a pink grossular necklace; jadeite bleached by repair heat; a kornerupine with apatite inclusions; an opal with a flow structure and a rare oolitic opal are described and illustrated. Ironstone opal was a doublet held together by cement and powdered opal to conceal join.

Blister pearls attached to shells created problem and it is still uncertain whether they are natural or induced. A baroque pearl of 26 mm diameter was exceptionally light and very smelly, suggesting that the natural nucleation was around an organic fleshy centre which was decaying.

Synthetic star ruby boule was cut to give cat's-eye effect and the pedestal end cut to give interrupted star with clear centre. A fine yellow sapphire had been altered to yellow green by careless heating in sizing. Other types of heat damage are described. A heat-induced star in a cabochon sapphire; a synthetic sapphire, which had been diffusion treated by heat to mask the curved lines, was detected by immersion examination, but not easily. Three pictures of inclusions in spinels, two of them unusual. Cat's-eye tourmalines are discussed and two are illustrated.

R.K.M.

FRYER (C.), ed., CROWNINGSHIELD (R.), HURWIT (K. N.), KANE (R. E.). *Gem Trade Lab Notes.* Gems & Gemology, **XVIII**, 3, 169-73, 17 figs in colour, 1982.

A chalcedony cameo repaired with plastic cement; a fake octahedral diamond crystal made from cubic zirconia; a colour-changing garnet inclusion in diamond and two fine rare cat's-eye emeralds are described and illustrated, as are several fake matrix emerald specimens. A Lennix synthetic emerald, described as 'new', contained opaque black inclusions. An iolite cat's-eye; a fine green glass imitation of jadeite; dyed marble 'lapis lazuli'; and a carved bird in pink opal are all discussed and pictured. A fine conch pearl; diffusion-coloured cabochon sapphire and a stone 'faceted from a meteorite' but suspected of being black spinel conclude the account of fascinating gemmological 'finds' from these laboratories. R.K.M.

GRUSSING (T.). *Carving gem-quality opal.* Gems & Gemology, **XVIII**, 2, 95-9, 6 figs (in colour), 1982.

An interesting account of the planning and execution of three carved opal ornaments. Author emphasizes the difficulties and the pitfalls of this very skilled art. R.K.M.

GÜBELIN (E.). *Die Edelsteinvorkommen Pakistans—I.* (Gemstone localities of Pakistan—I.) Lapis, **7**, 5, 19-31, 22 figs in colour, 1982.

Ruby and red spinel are found in a marble in the Hunza valley of Pakistan. Calcite and pyrite are found as inclusions in the ruby, with apatite in both the ruby and the spinel. Geological maps of the area are provided together with a table of compositions in which it can be seen that the Hunza ruby has a chromium content of 0.81 (one stone) compared with 1.30 and 1.81 in Burmese stones tested. M.O'D.

GÜBELIN (E.). *Die Edelsteinvorkommen Pakistans—II. Die Smaragdvorkommen im Swat-Teil.* (Gemstone deposits of Pakistan—II. Emerald deposits of the Swat Valley.) Lapis, **7**, 6, 19-26, 19 figs in colour, 1982.

Emerald with an SG of 2.77, RI of 1.588, 1.596 and DR of 0.007 is found in the Swat Valley near Mingora, in the region of the Hindu Kush. The stones have calcite and dolomite inclusions as well as various patterns of liquid droplets. They show orange-red through the Chelsea filter and are of a fine colour. M.O'D.

GÜBELIN (E.). *Erkennungsmerkmale der neuen synthetischen Rubine.* (Identification signs of new synthetic rubies.) Goldschmiede Zeitung, **80**, 5, 53-9, 42 figs (41 in colour), 1982.

Coloured pictures of the inclusions in Chatham and Kashan rubies show a wide variety of useful recognition signs. M.O'D.

GÜBELIN (E. J.). *Gemstones of Pakistan: emerald, ruby, and spinel.* Gems & Gemology, **XVIII**, 3, 123-39, 25 figs (23 in colour), 1982.

Dr Gübelin has visited potentially important new emerald, ruby and spinel mine sites on the Swat and Hunza rivers in remote northern Pakistan. Swat emeralds are fine in colour with high RI (1.597-1.590), mostly cabochon material. Hunza rubies also very fine in colour but largely cabochon grade. A detailed and important paper. R.K.M.

GÜBELIN (E. J.). *New synthetic rubies made by Professor P. O. Knischka.* Gems & Gemology, **XVIII**, 3, 165-8, 8 figs (6 in colour), 1982.

Description of well-developed melt-fusion multi-faceted ruby crystals, some with pseudo-cubic habit. Distinctly violet in colour. Constants, etc., similar to those for other synthetics and for natural stones. Inclusions need magnification to reveal net-like veils of healed cracks typical of melt-fusion synthetics. Not easy to prove cut stones. R.K.M.

GÜNTHER (A.). *Polyedrische Quarz-Drusen aus Brasilien.* (Quartz polyhedroids from Brazil.) Aufschluss, **33**, 147-51, 3 figs (1 in colour), 1982.

Quartz druses of polyhedroid shape have been found in Brazil. M.O'D

HÄNNI (H. A.). *Caractéristiques des corindons chauffés et traités par diffusion.* (Characteristics of heat- and diffusion-treated corundum.) Schweiz.Uhrmacher und Goldschmiede Zeitung, **104**, 9, 15-62, 10 figs in colour, 1982.

Some of the characteristics of heat- and diffusion-treated corundum are described and illustrated. M.O'D.

JENSEN (A.), PETERSEN (O. V.). *Tugtupite: a gemstone from Greenland.* Gems & Gemology, **XVIII**, 2, 90-4, 6 figs (5 in colour), 1982.

Mineral discovered at Tugtup agtakôrfia in South Greenland in 1957 is quite wide-spread in the area, but gem red material has been found in only one 25 × 5 metre spot on Kvanefjeld plateau. Red colour fades if not exposed to ultraviolet light. A pale blue variety is known but is very rare. Full gemmological details are given. Original source is now exhausted but it is hoped that more will be found when uranium mining is started. R.K.M.

KANE (R. E.). *The gemological properties of Chatham flux-grown synthetic orange sapphire and synthetic blue sapphire.* Gems & Gemology, **XVIII**, 3, 140-53, 20 figs (16 in colour), 1982.

These are now available as crystals but not as cut stones. A valuable paper giving diagnostic features with emphasis on inclusions which are illustrated and described in detail. R.K.M.

KEELEY (H. H.) *The ruby mines of Burma—1.* Gems, **14**, 2, 6-8, 1 fig., 1982.

Introduces ruby, the Mogok Stone Tract of Upper Burma and some of the legends associated with the recovery of the stone. M.O'D.

KEELEY (H. H.) *The ruby mines of Burma—2.* Gems, **14**, 3, 8-11, 1982.

Further legends are recounted, centring round the Laung Zin area. M.O'D.

Kerr (W. C.). *A report on the new Watermeyer split-facet diamond cuts.* Gems & Gemology, **XVIII**, 3, 154-9, 9 figs (4 in colour), 1982.

Basil Watermeyer, of Johannesburg, has perfected new marquise and pendeloque cuts which eliminate the objectionable 'bow-tie' effect which normally spoils these styles. Diagrams and photographs of cubic zirconia in old and new cuts prove his point. An advance important to diamond cutters. R.K.M.

Koivula (J. I.). *Shadowing: a new method of image enhancement for gemological microscopy.* Gems & Gemology, **XVIII**, 3, 160-4, 7 figs (4 in colour), 1982.

Increased contrast obtained in microscopy of inclusions by inserting laterally light-shields of various shapes between light source and object. Explained and illustrated in detail. R.K.M.

Koivula (J. I.). *Pinpoint illumination: a controllable system of lighting for gem microscopy.* Gems & Gemology, **XVIII**, 2, 83-6, 7 figs in colour, 1982.

A hand-held fibre-optic illuminator of exceptional flexibility and precision is shown to have considerable potential in the examination of inclusions. Needs clamping for photography but is expected to receive wide acceptance. Some more superb photomicrographs from the camera of this skilled G.I.A. Senior Staff Gemologist. R.K.M.

Komotauer (S. K.). *Chalcedon, SiO_2.* (Chalcedony, SiO_2.) Mineralien Magazin, **6**, 7, 315-22, 14 figs (13 in colour), 1982.

A beautifully illustrated summary of the chalcedony varieties. M.O'D.

Kozlova (O. G.), Belov (N. V.). *Twisted quartz crystals as Brazil penetration twins.* Soviet Physics Doklady, **26**, 9, 805, 3 figs, 1982.

The occurrence of Brazil twins of synthetic quartz is most marked when crystals are grown in a weakly alkaline solution with K_2CO_3 at a high degree of supersaturation. Twisted crystals are thought to be Brazil twins formed by the intergrowth of crystals along faces of the oblique $[\bar{1}11]$ band. M.O'D.

Lambert (J. B.), Frye (J. S.). *Carbon functionalities in amber.* Science, **217**, 55-7, 2 figs, 1982.

High-resolution NMR spectra of carbon nuclei in powdered amber are obtained by a technique known as magic angle spinning, which, together with cross polarization, provides information on types of carbon functionalities. Amber from the Baltic area and specimens from Sicily, Burma, Romania and Bohemia are examined and compared. M.O'D.

Maddern (D.). *A fossicking guide to the Harts Range.* Wahroongai News, 17-26, 2 sketch maps, July 1982.

A practical guide to rock-hunting in a remote and gemmy area of Northern Territory, Australia. Gives sound advice on equipment and working and underlines the aridity of the Harts Range. R.K.M.

Mehta (K.). *Serpentine, the pride of Jaisalmer.* Gem World, **9**, 2, 36-7, 4 figs, 1982.

Several varieties of serpentine occur in the Rajasthan area of India, including antigorite and williamsite. A brief summary of the serpentine group is given.
M.O'D.

MENZEL (M.). *Über den Pegmatitaufschluss Landsverk I bei Evje, Setestal, Südnorwegen.* (On the pegmatite workings at Landsverk by Evje, Setestal, South Norway.) Aufschluss, **33**, 129-41, 13 figs, 1982.

The pegmatites in the Evje area are rich in feldspars, some of which are of gem quality. M.O'D.

MINAKAWA (T.), MOMOI (H.). *Ruby from the Sanbagawa metamorphic belt, in the Hodono valley, Ehime Prefecture, Japan.* Mineralog.J., **11**, 2, 78-83, 3 figs, 1982.

Transparent purplish red to pink ruby up to 5 cm in diameter occurs in an amphibole-zoisite rock found as boulders in the Hodono valley, on the southern flanks of Mt Gongen. It has ε 1.761, ω 1.769, D 3.887 g/cm^3; red fluorescence is shown in both long- and short-wave UV light. Microprobe analyses for dark purplish red, light purplish red, and light purplish pink ruby show respectively Cr_2O_3 0.41–0.14, 0.16–0.07, 0.10–0.01 and Fe_2O_3 0.44–0.37, 0.41–0.33, and 0.44–0.42%, the abundance of Cr_2O_3 thus corresponding with the shade of red. R.A.H.

MOREAU (M.). *Voyage au pays des opales.* (Trip to opal country.) Revue de Gemmologie, **70**, 7-10, 11 figs (1 in colour), 1982.

A *tour d'horizon* of the Australian opal fields. M.O'D.

MORIYA (K.), OGAWA (T.). *Growth history of a synthetic quartz crystal.* J. Crystal Growth, **58**, 115-21, 6 figs, 1982.

Growth interfaces of a synthetic quartz crystal are marked by fluctuation of hydroxyl concentration. This fluctuation is thought to be caused by growth breathing in turn due to fluctuating convection of solution in the vessel. Undecorated dislocation lines and plate-like defects have been observed in synthetic quartz, using light-scattering tomography. M.O'D.

MYERS (J.). *Opal nomenclature.* Wahroongai News, 10-12, July 1982.

An intelligent listing of types, origins and factors controlling quality etc. Poses some questions by introducing such expressions as 'crystal', 'skin to skin', without clearly explaining their meanings. R.K.M.

NASSAU (K.). *Heat treating ruby and sapphire.* Lapidary J., **36**, 4, 708-19, 17 figs (16 in colour), 1982.

A reprint of a paper first published in *Gems & Gemology,* XVII, 3, 121-31, 1981 (abstracted in *J.Gemm.,* XVIII, 2, 168, 1982). M.O'D.

NOVAK (G. A.). *Verde Web variscite from Lander County, Nevada.* Lapidary J., **36**, 3, 544-52, 1 fig. in colour, 1982.

A new deposit of fine quality variscite has been found in Crescent Valley, Nevada. It is monomineralic (compared with variscite from Fairfield County, Utah, which contains up to twelve phosphate minerals). The variscite occurs as both nuggets and vein fillings in or near a shear zone which is on the flank of an Ordovician shale tending upwards in a north descending anticline. Colour of the variscite varies from pastel green to sky or pale blue. M.O'D.

O'DONOGHUE (M.). *The dealer looks at gemstones—4.* Gems, **14,** 2, 31, 1982.

Alteration of colour is discussed with special reference to topaz, beryl and kunzite. Some dark blue topaz has been shown to display some radioactivity.
(Author's abstract.) M.O'D.

O'DONOGHUE (M.). *The carbonate group of minerals—2.* Gems, **14,** 4, 34, 1982.

Dolomite is the chief mineral discussed and some notes on cerussite are given.
(Author's abstract) M.O'D.

O'DONOGHUE (M.). *The dealer looks at gemstones—5.* Gems, **14,** 3, 14-15, 1982.

The selection of rough material and its availability, varying due to political reasons as much as geological ones, is discussed. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *The carbonate group of minerals—1.* Gems, **14,** 3, 30-1, 1982.

Calcite is the first carbonate discussed after general remarks on the group as a whole. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *The dealer looks at gemstones—6.* Gems, **14,** 4, 15-18, 1982.

Star stones and business methods are discussed. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *Man-made gemstones—8.* Gems, **14,** 3, 26-7, 1 fig. in colour, 1982.

Kashan ruby and some of the coloured beryl recently made in Japan are discussed. (Author's abstract.) M.O'D.

O'DONOGHUE (M.). *Man-made gemstones.* Gems, **14,** 5, 28, 1982.

Deals with a synthetic emerald by Lechleitner, an imitation haematite, some varieties of spinel and of sodalite. (Author's abstract.) M.O'D.

PEARSON (G.). *The approximate iron content of some sapphires.* Aust.Gemmol., **14,** 12, 347-9, 1982.

An investigation by x-ray fluorescence to determine the relative iron content in various Australian sapphires and comparing this with that found in sapphire from Sri Lanka and Thailand. Sri Lanka stones were yellowed temporarily by x-rays. Thai and Australian stones of deep colour were not affected. R.K.M.

PONOMARENKO (A. I.), SPETSIUS (Z. V.). *Mineral rims on diamonds from kimberlites.* International Geology Review, **24,** 7, 829-34, 4 figs, 1982.

A wide variety of minerals can be found as coatings on diamond crystals, the thickness of the coating varying from tenths of a millimetre to 1-2 mm. It is postulated that in common with other minerals diamond was removed from different strata in the upper mantle. Rims of hydrothermal minerals were produced in the late stages of formation of the kimberlite bodies. M.O'D.

ROSSMAN (G. R.), QIU (Y.). *Radioactive irradiated spodumene.* Gems & Gemology, **XVIII,** 2, 87-9, 2 figs (1 in colour), 1982.

Report on citrine-coloured spodumene mixed in parcel of citrine from Brazil. The spodumenes were radioactive to a dangerous degree. Similar irradiation by scandium-46 had been detected earlier in topaz. Dangerous to handle in quantity and would remain so for some years. Irradiation by neutrons gives highly penetrating radioactivity and no autoradiograph could be expected, so Geiger counter test is essential. R.K.M.

ROTHSTEIN (J.). *Just what is an emerald?* Lapidary J., **36**, 4, 734-43, 1982.

Discussion of the criteria distinguishing emerald from green beryl. M.O'D.

SAHAMA (Th.G.). *Asterism in Sri Lankan corundum.* Schweiz.Mineral. Petrograph.Mitteilungen, **62**, 1, 15-20, 3 figs, 1982.

Slightly bluish and turbid, barrel-shaped corundum crystals are described from the Elahera area of Sri Lanka. They are up to 7 cm long and show a well-developed rhombohedral parting with holhmite in the seams. The inclusions of rutile which cause the asterism are almost invariably twinned, and are either of a needle-like habit with two individuals or geniculate with three or four individuals; the twin plane is {011} and the needle axis is not the *c* axis but $\langle 00\bar{1}\rangle$. The orientation of the rutile relative to the corundum host is rutile $\langle 010\rangle \| $corundum [0001], rutile $\langle 01\bar{1}\rangle \| $corundum $[11\bar{2}0]$. R.A.H.

SARMIENTO CARPINTERO (L.). *El opalo.* (Opal.) Boletín del Instituto Gemológico Espanol, 22, 27-43, 12 figs in colour, 1982.

A comprehensive account of opal with notes on its imitations and on the various kinds of synthetic opal now on the market. M.O'D.

SCARRATT (K. V. G.). *The identification of artificial coloration in diamond.* Gems & Gemology, **XVIII**, 2, 72-8, 11 figs (7 in colour), 1982.

An excellent paper on identification of irradiated diamonds which summarizes the facilities and the difficulties encountered in this specialized work. There is still some confusion between artificially and naturally irradiated stones. Stones are examined at a temperature of −160 °C to sharpen the diffuse bands. R.K.M.

SCHWARZ (D.). *Chemismus und Fluoreszenzverhalten von Zirkon ($ZrSiO_4$).* (Chemistry and fluorescence behaviour of zircon ($ZrSiO_4$).) Uhren, Juwelen, Schmuck, 3, 217-20, 10 figs, 1982; 7, 237-40, 5 figs, 1982.

Natural zircons from a variety of localities were examined by fluorescence spectrophotometry, by optical emission spectroscopy and neutron activation analysis. The main fluorescence band, found in 80-90% of specimens, lies in the yellow-green and is very strong. It is probably due to defect centres in the lattice. Some zircons show, in addition, groups of lines ascribed to Dy^{3+}. Many of these specimens were from Sri Lanka. Much more rarely seen was a weak emission in the UV region due to Gd^{3+}. All 43 stones from locations in Sri Lanka, Thailand, Norway, Liberia and Miask/Ilmengebirge showed a dominance of the heavy lanthanides (Eu-Lu). M.O'D.

SIRAKIAN (E.). *La taille du diamant.* (The cut of a diamond.) Revue de Gemmologie, **70**, 4-6, 16 figs, 1982.

The first part of a series devoted to diamond polishing, this covers crystal form and habit. M.O'D.

STOCKTON (C. M.). *Two notable color-change garnets.* Gems & Gemology, **XVIII**, 2, 100-1, 2 figs (1 in colour), 1982.

Two pieces of East African waterworn garnet rough gave different colours in fluorescent and in incandescent light. They also showed further marked differences in colour depending upon whether the light was transmitted or reflected. Colours are illustrated within the limits of photography. Chemical compositions are anomalous and both stones are principally spessartite/grossular, one with a leaning towards almandine, the other towards pyrope. R.K.M.

TOMBS (G. A.), JORIS (W. J.). *More synthetic opal.* Aust.Gemmol., **14**, 12, 345, 1982.

Half-drilled white synthetic opal beads offered as natural opal in Sydney. Surfaces heavily pitted by cut-through bubbles, colour play muted with 'rolling' pattern and 'chimney' effect as seen in some Gilson opal. 20× revealed crenelations and 'lizard skin' pattern on colour patches. Warning issued on bead opal.

VASHISHTHA (S.). *Gadolinium gallium garnet.* Gem World, **9**, 4, 27-9, 1982.

GGG is described with notes on its production. M.O'D.

VASHISHTHA (S.). *Yttrium aluminium garnet.* Gem World, **9**, 2, 28-35, 2 figs, 1982.

A comprehensive account of the growth and properties of YAG. M.O'D.

WEIBEL (M.). *Wie entsteht der Stern?* (How do stars arise?) Lapis, **7**, 10, 25-30, 10 figs (7 in colour), 1982.

The origin of chatoyancy and asterism is discussed with particular reference to the part played by rutile in the corundum gems. M.O'D.

WIGHT (W.). *Notes from the National Museums of Canada: two varieties of opal from Mexico.* Canadian Gemmologist, **3**, 3, 8-12, 4 figs, 1982.

A hyalite variey of opal weighing 0.98 ct and showing profuse swirls and striae and two small purple opals were recently obtained by the National Museum of Natural Sciences of Canada. All stones described were faceted. M.O'D.

WILD (K. E.). *Das Museum unterhalb der Felsenkirche in Idar-Oberstein.* (The museum below the Felsenkirche in Idar-Oberstein.) Aufschluss, **33**, 257-64, 5 figs (1 in colour), 1982.

The well-known museum in Oberstein celebrates its fiftieth anniversary this year. The history is summarized and the exhibits described and illustrated. M.O'D.

WILSON (A. F.). *The genesis of noble metal nuggets.* Aust.Gemmol., **14**, 11, 285-8, 1982.

Theories on the precipitation and growth of large nuggets of comparatively pure gold. Suggest that it is leached from narrow impure veins by water containing humic acid, and deposited when carbonates are encountered. Platinoid metals are also thought to accrete in a similar way. R.K.M.

ZEITNER (J. C.). *The quest for green bolts—2.* Lapidary J., **36**, 3, 558-66, 12 figs, 1982.

Emerald mining at the Rist, Crabtree and Old Plantation mines in North Carolina is described. Only the Rist mine is open at present. M.O'D.

ZEITNER (J. C.). *Spinel.* Lapidary J., **36**, 4, 684-92, 11 figs, 1982.

A general review of the spinel group of minerals with some reference to North American localities. M.O'D.

ZEITNER (J. C.). *Why agate is the favorite.* Lapidary J., **36**, 5, 842-50, 16 figs in colour, 1982.

An attractively illustrated summary of agate varieties. M.O'D.

ZWAAN (P. C.). *Sri Lanka: the gem island.* Gems & Gemology, **XVIII**, 2, 62-71, 14 figs in colour, 1982.

A short account of the gem areas, mining, cutting and marketing in this beautiful island. R.K.M.

BOOK REVIEWS

ARACIC (S.). *Fortunes in Australian opals.* Sapphire Books, Strathfield, N.S.W., 1979. pp.vii, 150. Illus. in black-and-white and in colour. $9.50.

This is an account of the author's experiences as an opal miner and is due to be followed by a second volume in which the nature and occurrence of opal will be discussed. In this book the material is mainly anecdotal, but there are some comments to interest the general as well as the specialist reader. M.O'D.

BURY (S.). *Jewellery Gallery summary catalogue.* Victoria and Albert Museum, London, 1982. pp.252. Illus. in black-and-white. £4.95.

This is a case-by-case handlist of the items in the recently re-opened Jewellery Gallery of the Victoria and Albert Museum in London. The collections of Lady Cory and Dame Joan Evans, with earlier bequests, have been amalgamated to form a continuous chronological and type sequence. It is hoped that a *catalogue raisonné* may appear in due course, but until that time this is a most useful guide and easy to use. M.O'D.

HAILL (R. G.). *Opals of the Never Never.* Horwitz Grahame Books, Cammeray, New South Wales, 1981. pp.viii, 152. Illus. in black-and-white and in colour. Price on application.

This book is about the opal fields of the Coober Pedy area of South Australia though there is a good deal about opal in general. The style is journalistic and anecdotal but the book is well produced and readable. Useful maps are provided in the text. M.O'D.

MENCHINSKAYA (T. I.). *Biryuza.* (Turquoise.) Nedra, Moscow, 1981. pp.159. Illus. in black-and-white and in colour. 85 kopecks. (In Russian.)

This is a full account of the geology and mineralogy of turquoise deposits over the world, with a full bibliography of both Russian and European works. A translation would be of the greatest interest. M.O'D.

READ (P. G.). *Dictionary of Gemmology.* Butterworths Scientific, London, 1982. pp.vi, 240. Illus. in black-and-white. £15.

This is a useful and readable book with a good deal of out-of-the-way information in it. It is marred by consistent misspelling of foreign institutional titles, which leads to misfiling in some cases (this should have been caught by the publisher's editor) but, this apart, the facts presented are accurate and relevant. This author's speciality is instrumentation and the book is specially useful in this area. At the end are some tables and some notes on grading systems. M.O'D.

STRUNZ (H.). *Mineralogische Tabellen.* (Mineralogical tables.) 8th edn. Akademische Verlag Geest & Portig K.-G., Leipzig, 1981. pp.viii, 621. Diagrams in the text. 54M.

Though described as '8 Auflage' this is not a new edition but a reprint of an earlier text. This was also the case with the previous (7th) printing (1978).* None the less the book remains a valuable standard text, though it now needs to be read in conjunction with Fleischer's Glossary of Mineral Species and Mineralogical Record.

M.O'D.

WILSON (A. N.). *Diamonds from Birth to Eternity.* Gemological Institute of America, Santa Monica, California, U.S.A., 1982. pp.xxv, 450. Illus. in black-and-white and in colour. $43.95.

This is a large book in which the various diamond-producing areas of the world are reviewed, with notes on their history and a considerable amount of material given on the presumed geological origins of diamond from particular regions. While much of this may be authoritative, the author's remarks in the preliminary matter—'the bibliography of books and scientific papers digested for the purpose of this book makes a formidable body of technical and semi-technical literature. It would serve little purpose to specify them in detail'—lead the reader to wonder whether due consideration has been paid to the value of the many theories set out. Without knowing the sources it is impossible to know whether there has been a journalistic selection of interesting speculations or whether there has been considered scientific evaluation of one paper against another. The genesis of diamond is an area where much work remains to be done and the impression given by the book, that it is a conspectus of work known to be well-founded at the time of writing, must be suspect without there being a view of the actual detailed foundations upon which it is based. It is a great pity that what is admittedly an interesting and well-compiled work should carry an aura of doubt and uncertainty with it. Naturally it is very possible and even likely that if all the details of the foundations were given we might not be very much further forward in many areas, so uncertain is the field, but the author should have set his teeth and tried and the publishers should have insisted. Then we should have had a work of immense value. So far from giving a complete bibliography, the author has given nothing at all; the pictures are pleasant but pretty much the type of thing one has come to expect as routine in this kind of book—a considerable journalistic effort, but no more.

M.O'D.

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*Reviewed *J. Gemm.*, 1980, XVII (3), 199.—Ed.

ASSOCIATION NOTICES

OBITUARY

THE LATE DR W. F. EPPLER

A Tribute by B. W. Anderson

In the death of Prof. Dr W. F. Eppler on June 5th last, the world has lost one of its greatest gemmologists, while I personally feel deep regret at the passing of an old and valued friend. Wilhelm Friedrich Eppler was born on 6th August 1902 at Detmold in N.W. Germany. His father, Dr Alfred Eppler, was well known as a mineralogist and as author of *Edelsteine und Schmucksteine,* first published in 1912, which was at that time one of the fullest and best textbooks on gemmology available. It was natural that Wilhelm should follow in his father's profession, and he benefited from an extensive education at Bonn and Hamburg Universities, in which his studies embraced not only mineralogy but also chemistry, physics and mathematics. After graduating in mineralogy at Hamburg he remained at the University for eighteen months as an assistant in the mineralogical faculty.

There followed during the next few years (1927-1931) two extensive tours in the East during which Eppler was able to study at first hand all aspects of the gem deposits and production in the world's most famous centres. These included what were then known as Ceylon, Siam, Indo-China, India and Afghanistan. As a result Eppler became probably the world's most thoroughly informed scientist in that field of study. During this period he also learned to speak excellent English with an indefinable 'colonial' accent.

The following years were largely spent in the writing of two valuable books. The first (published in 1934) was a revised and extended version of his father's *Edelsteine und Schmucksteine.* This was a major work of over 500 pages, the main part of which was taken up by a full description of 130 gemstones arranged (most unusually) in order of their increasing hardness. The book was illustrated by over 300 text figures and contained several excellent coloured plates. The other work, which appeared in the following year, formed the second part of *Lagerstätten der Edelsteine,* in which Dr O. Stutzer wrote the first section, which dealt with the sources of diamond only, while Eppler, in the second section, treated with all the other gems of commercial importance. The work was rich in geological information concerning the various mines and deposits, and additional information of a more

Dr W. F. Eppler, Lucerne, 1938.

commercial nature was provided in the form of production figures for a range of years. A full bibliography of the relevant literature was also appended, and the book still makes valuable reading.

There followed for Dr Eppler a number of appointments. In 1935 he became Director of the precious stone trade school in Idar-Oberstein: in 1938 he taught in the Mineralogical Department in Bonn University, and in 1941 was appointed a lecturer in mineralogy in the University of Frankfurt. In 1942 until after the end of the War he was an instructor in applied mineralogy in Strasbourg University. In 1946 there came a change of course from a hitherto academic teaching career to work in a commercial concern, when he accepted an appointment as works manager in the synthetic gemstone section of the giant chemical firm Weides Carbidwerk in Frankfurt. In this post, as might be expected, he acquired an intimate knowledge of the Verneuil flame-fusion process. Amongst other advances in technique Eppler enabled his firm to produce synthetic star corundums of superior quality to those pioneered by the Linde Air Products Co. in the U.S.A. shortly before. It should be mentioned that some years earlier (1943) Eppler had made the commercially

Dr W. F. Eppler (right) with Dr E. Gübelin, Munich, 1956.

important discovery that jewels used for instrument bearings if fashioned from synthetic spinel instead of corundum (thus avoiding the use of the scarce and expensive diamond powder) could be made to attain a surface hardness almost equal to that of sapphire by careful heat treatment.

In later years Dr Eppler was able to return to his true profession as a teacher and in 1955 his outstanding achievements in that sphere were rewarded by the title Honorary Professor of Mineralogy which was bestowed on him by the University of Munich. For many years Eppler enriched the journals with valuable articles on gemmology, and in 1973 his important new work *Praktische Gemmologie* was published. This outstanding book contains over 400 illustrations (mostly of inclusions photographed by the author) and concentrates entirely on accounts of the gem species. I understand from his widow, Renate, that the manuscript of a revised edition was nearly completed before his death and there is hope that this may be published in due course.

My first personal contact with Dr Eppler was in 1938, when there was an informal meeting in Lucerne between G. Gobel, Prof. K. Schlossmacher and myself, representing the precious stone laboratories of Paris, Idar-Oberstein and London. Wilhelm was staying in the same hotel, and he and I made full use of the opportunity to enjoy pleasant walks and long conversations together, resulting in a warm and lasting friendship. We met again in London shortly before the War, and in post-war years were happy to renew contact at the first International Gemmological Conference, which took place in Amsterdam in October 1953, and at many other Conferences thereafter. These early annual gatherings in different European capitals were small, friendly, and informal. Many of the talks centred round inclusions in gemstones and their synthetic counterparts, and these were illustrated by 35 mm coloured slides of high quality. Edward Gübelin and Wilhelm Eppler were the main protagonists in this field and vied with each other in the excellence of their slides. Eppler's particular skill lay in his ability to produce photomicrographs showing splendid detail at high magnification,* and these would often give rise to a spontaneous burst of applause as they appeared on the screen. He was an excellent lecturer, his slow, clear utterance making one appreciate the sonorous quality of the German tongue.

Dr W. F. Eppler, 1973.

Although he suffered considerably from ill-health in recent years, his keen interest in gemmology never flagged and he responded at once whenever I wrote asking his advice. He belonged to that happy band for whom gemmology is a lifetime addiction. The three photographs chosen show Wilhelm Eppler at intervals of some twenty years. The first was taken in Lucerne in 1938 at our first meeting. The second was taken during the Conference in Munich in 1956, and shows him conversing with his great friend Edward Gübelin, while the third was taken in 1973. I have to thank Renate Eppler for providing the last two photographs, and to her and Prof. Dr Hermann Bank I owe information concerning Dr Eppler's many professional appointments.

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*Examples of his remarkable photomicrographs may be found in *J.Gemm.*, 1976, XV (1), 2-4.—Ed.

Mr Kenneth Robert Baker, F.G.A. (D.1971), Whitehaven, died on 8th April, 1982.

Mr Robert M. Shipley, Jr, died on 10th September, 1982, in Santa Rosa, California, U.S.A. He was the son of the late Robert M. Shipley, F.G.A. (see The late Robert M. Shipley: an Appreciation, by B. W. Anderson; *J.Gemm.,* 1979, XVI(5), 285-9) and in the early 1930s assisted his father in establishing the Gemological Institute of America. He devised and/or improved a number of gem-testing instruments (see A Brief Summary of Gemmological Instrument Evolution, by Richard T. Liddicoat, Jr: *J.Gemm.,* 1981, XVII(8), 568-75), including the first Diamondscope which he patented in 1938, but, although after military service in World War II he resumed his work of developing and improving gemmological instruments and was awarded the title of Honorary Research Member of the G.I.A., he abandoned gemmological research in the early 1950s and thereafter employed his inventive talents in other fields.

Mr James W. Watts, B.Sc., M.Inst.P., F.G.A. (D.1963), Berkhampsted, died on 23rd September, 1982.

FAREWELL NOTE FROM THE RETIRING SECRETARY

I am writing this just a few days before my official retirement. The long period of service with the Association has for me been very enjoyable and culminated with the unforgettable party at Goldsmiths' Hall, when over 200 members and guests came to personally express their thanks. I now wish to thank all of those other members who have sent good wishes and also contributed to my retirement gift and cheque. I do appreciate your kindness very much, and, although I will no longer be at the office, my interest in gemmology will remain, and for a time at least I will continue as one of the proof-readers of the *Journal.*

Con Lenan, my successor, will, I am sure, carry on the good work of looking after the interests of members and gemmology in general and do everything possible to ensure that the high regard of the Association throughout the world will continue.

My very best wishes for the future of the G.A. of G.B. and all its members.—Harry Wheeler.

GIFTS TO THE ASSOCIATION

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

Mrs W. A. N. Athauda, F.G.A., London, for a collection of Sri Lankan mineral specimens showing good crystal form including corundum, feldspar, quartz, tourmaline, zircon and kyanite.

Mr Denis Bradshaw, F.G.A., Orpington, Kent, for an old-type Steward Dichroscope and a 2458 Beck Prism Spectroscope.

Mr Gary Flewelling, F.G.A., Arthur, Ontario, Canada, for a collection of quartz crystals (Herkimer County, U.S.A.).

Mrs Cynthia Mendis, F.G.A., Halifax, Nova Scotia, Canada, for one cut apatite with rutile needle inclusions, weighing 6.03 ct.

NEWS OF FELLOWS

Mr M. J. O'Donoghue, M.A., F.G.S., F.G.A., gave a talk entitled 'Identifying man-made gemstones' to the Highgate Literary and Scientific Institution on 19th October, 1982.

On 8th September, 1982, at the Post-Graduate Medical Centre, Royal Victoria Hospital, Boscombe, Dorset, Mr Peter G. Read, C.Eng., F.G.A., gave an illustrated talk to the Bournemouth and Poole Medical Society on 'Colour in Gemstones'. Mr Read also attended the Technical Meeting of the German Gemmological Association in October 1982, of which he has provided the following report.

'During the bi-annual 2-day D.Gem.G. Technical Meetings, the Saturday venue is traditionally located in the Association's Training Centre in Idar-Oberstein. This year (1982), on Saturday 2nd October, two working and discussion groups in the Centre were led by Prof. Dr H. Bank, F.G.A., who showed new gemstones and synthetics (including mellite, adamin and the Japanese plastic opal simulant), and Dr G. Lenzen, F.G.A., who described and demonstrated the Okuda DC530-A Diamond Color Checker.

'On Sunday 3rd October, in the Bourse lecture hall, D.Gem.G. diplomas were awarded to successful students, and this ceremony was followed by a series of formal lectures on gemmological themes. Among these, Dr K. Schmetzer talked on the problems of detection of synthetic and treated gemstones, Dr H. A. Hänni, F.G.A., spoke on the examination of heated and diffusion-treated corundum, Mr G. Becker gave an illustrated talk on the Tucson Mineral Fair, and Mr R. Dröschel gave a practical demonstration of optical differences he had discovered between natural and synthetic amethyst (synthetic samples had, so far, shown no characteristic lamellar growth patterns under polarized light).

'Although 1982 was the fiftieth anniversary of the founding of the German Gemmological Association, celebration of this event is being postponed until October 1983, when the extension to their Training Centre in Idar-Oberstein will be completed. This extension will approximately double the size of the Training Centre and will allow the Association to dispense with the separate use of the Gewerbehalle premises.'

MEMBERS' MEETINGS

London

On 26th October, 1982, at the Central Electricity Generating Board Theatre, Sudbury House, 15 Newgate Street, London E.C.1, the A.T.V. film 'Muzo, the emerald mine', produced by Brian Moser, was shown.

Midlands Branch

On 24th September, 1982, at the Society of Friends, Dr Johnson's House, Colmore Circus, Birmingham, Mr Roy Starkey, a founder member of the British Micromount Society, gave a talk and demonstration on micromounts and micro-crystals.

On 29th October, 1982, at the Society of Friends, the Revd S. B. Nikon Cooper, B.D., F.G.A., gave a talk on 'Gemstones of the Bible'.

On 26th November, 1982, at the Society of Friends, Mr Neal Oliver, Master Engraver and Teacher of Engraving, gave a talk and demonstration on hand engraving on precious metals and glass.

North West Branch

On 16th September, 1982, at Church House, Hanover Street, Liverpool 1, Mr Alan Williams, F.G.A., gave a talk on 'Cubic zirconia and the retailer'.

On 21st October, 1982, at Church House, Mrs H. Müller, M.Sc., F.G.A., gave a talk entitled 'All about jet'.

On 18th November, 1982, at Church House, the Annual General Meeting was held, at which Mrs I. Knight, F.G.A. and Mrs E. Cartmel were re-elected Chairman and Secretary respectively.

South Yorkshire and District Branch

On 5th October, 1982, at the Sheffield City Polytechnic, Mr A. E. Farn, F.G.A., gave a talk entitled 'Pearl and the Laboratory'.

On 2nd December, 1982, at the Sheffield City Polytechnic, a practical evening was held. Some aspects of valuation were covered, with emphasis on organic materials, coral, amber, etc., which are currently causing some problems.

COUNCIL MEETING

At the meeting of Council held on Wednesday, 29th September, 1982, at the Charing Cross Hotel, London, W.C.2, the business transacted included the following:

(1) it was agreed that the rate of subscription for Fellows [see *J.Gemm.,* 1982, XVIII (4), 357] should apply to our one remaining Associate;

(2) the resignation as an Examiner in Gemmology of Mr John Chisholm, who had been an Examiner for 27 years, was accepted with regret.

(3) the appointment of Mr Philip Sadler, B.Sc., F.G.S., F.G.A., as an Examiner in Gemmology was approved;

(4) the resignation as an Examiner of Dr Judith Milledge, who had been the Gem Diamond Theory Examiner for 10 years, was accepted with regret;

(5) the appointment of Mr Eric Bruton, F.G.A., as Gem Diamond Theory as well as Practical Examiner was approved;

(6) the following were elected to membership:

FELLOWSHIP

Amos, Gillian L., Enniscorthy, Ireland. 1982
Anderton, Duncan MacG., Glasgow. 1982
Ansell, Martin F., Epping. 1982
Armstrong, Gillian, Preston. 1982
Astridge, Elaine, London. 1982
Bannerman, John M., Weybridge. 1982
Blackshaw, Cheryl K., Alderley Edge. 1982
Bonanno, Kenneth E., Fredericksburg, Va, U.S.A. 1982
Bond, Gerald S., Maidstone. 1982
Christou, Christos G., Limassol, Cyprus. 1982
Courtliff, Steven Paul, Liverpool. 1982

Cousins, Jonathan, Deal. 1982
Dawson, Jane, London. 1982
Dougherty, William C., Alexandria, Va, U.S.A. 1982
Douthwaite, Elaine M., Bradford. 1982
Forshaw, Edward D. J., Newcastle upon Tyne. 1982
Fuller, Maris E., Church Crookham. 1982
Gandhy, Uday P., Bombay, India. 1982
Goeritz, Louise C., London. 1982
Gould Michael A., McLean, Va, U.S.A. 1982
Hadfield, Margit E., Canterbury. 1982
Hannedouche, Bérangére M., Paris, France. 1982
Hawkins, Sandra C., Toronto, Ont., Canada. 1982
Honse, Dennis R., Portland, Oreg., U.S.A. 1981
Hopkinson, Barbara J., Newark. 1982
Horn, Graeme F., Glasgow. 1982
Housley, John G., Sheffield. 1982
Hughes, Richard W., Bangkok, Thailand. 1982
Hurlbert, Kim E., Cayucos, Ca, U.S.A. 1982
Hutchinson, Leslie B., London. 1982
Jackson, Christopher P., London. 1982
Jeng, Jiin Hwa, Kaohsiung, Taiwan. 1982
Key, Roger M., Nairobi, Kenya. 1982
Kierkels, Johannes Jan P. E., Belfeld, Netherlands. 1982
Kothari, Harsukh N., Bombay, India. 1982
Laframboise, Michel E., Bangkok, Thailand. 1982
Lam, Alan Wah Ching, Bangkok, Thailand. 1982
Lietwiler, Christian W., Springfield, Va, U.S.A. 1982
Malpas, Robert F., Leeds. 1982
May, Brian H., Camberley. 1982
May, Brian J., Stellenbosch, S.Africa. 1982
Moore, Roscelyn M., Camberley. 1982
Newing, Robin J. T., London. 1982
Olson, A. Richard, Manzini, Swaziland. 1982
Ottaway, Terri L., Toronto, Ont., Canada. 1981
Oxley, Peter J. M., Chichester. 1982
Paradise, Thomas R., Millbrae, Ca, U.S.A. 1982
Phillips, Jean M., Hong Kong. 1982
Pickett, Diana J., Waterlooville. 1982
Rosier, Jane L., Thorpe-le-Soken. 1982
Rydfors, Anne, Brasilia, Brazil. 1978
Salloway, Nigel J., London. 1982
Snell, Keith H., Liverpool. 1982
Thomson, Pearl J., New Barnet. 1982
Tsuda, Takashi, Osaka, Japan. 1982
Voll, Aloha F., Hong Kong. 1982
Walters, Raymond J. L., London. 1982
Whittingham, Jill E. A., Farnham. 1982
Wood, Elaine, Nottingham. 1982
Woollings, Joan E., Toronto, Ont., Canada. 1982
Wright, C. John, Chorleywood. 1982
Wycherley, Megan S., Liverpool. 1982

TRANSFERS FROM ORDINARY MEMBERSHIP TO FELLOWSHIP

Adams, Myra, Huddersfield. 1982
Ainsworth, Nicola L. A., London. 1982
Andrews, Clive G., Onchan, I.O.M. 1982
Ariyaratna, Don H., Colombo, Sri Lanka. 1982
Athauda, W. A. Nanda, West Bromwich. 1982
Barlow, Peter Charles, Kidderminster. 1982

Blanckenberg, Antoinette, Durban, S.Africa. 1982
Bolton, Robert G., Ilkley. 1982
Bowman, Josephine T., London. 1982
Brom, Frederik W., Oegstgeest, Netherlands. 1982
Brown, Harold G., Glasgow. 1982
Buchanan, Vera A., Ballinamallard, N.Ireland. 1982
Buhl, Robert Anthony, West Vancouver, B.C., Canada. 1982
Cardew, Charles J. S., Thornton Heath. 1982
Cestaro, Thomas L., Cheshire, Conn., U.S.A. 1982
Chan, Cecilia P. K., Hong Kong. 1982
Cole, Jo E., Santa Monica, Ca, U.S.A. 1982
Crout, Stephen J., Christchurch, N.Z. 1982
D'Adamo, Marina, Milan, Italy. 1982
Daulatani, Shambhu L., Dubai, U.A.E. 1982
Del Rey, Mario, S. Caetano do Sul, S.P., Brazil. 1982
de Silva, G. Ranjan J., Singapore. 1982
Düblin, Theo, Arlesheim, Switzerland. 1982
Ehrenborg, Charlotte E., Gex, France. 1982
Elvidge, Caroline A., Tonbridge. 1982
Faller, Noel P., Londonderry, N.Ireland. 1982
Ford, Hermione Dolores, Hereford. 1982
Fujimoto, Naoko, Nishinomiya City, Japan. 1982
Gaw, Rossana W., Hong Kong. 1982
Gemayel, Farid V., Antelias, Lebanon. 1982
Gimpel, Beatrice L. F., London. 1982
Gobla, Michael J., Westminister, Colo, U.S.A. 1982
Golby, Nicholas G. J., London. 1982
Goss, Alan C., Welwyn Garden City. 1982
Greatwood, Sheila O., Mitcham. 1982
Griffiths, Paul A., Sutton Coldfield. 1982
Hardy, Joanna, London. 1982
Hart, Judith E., Denby. 1982
Hatenboer, Willem J., Yssel, Netherlands. 1982
Hayashi, Junji, Fukuoka City, Japan. 1982
Hayes, George R., Jr, Louisville, Ohio, U.S.A. 1982
Henwood, Glyn A., Basingstoke. 1982
Horikawa, Yoichi, Itabashi-Ku, Japan. 1982
Hutton, Andrew J., Croydon. 1982
Ikoma, Nobuo, Kobe City, Japan. 1982
Inches, Deirdre M. H., Edinburgh. 1982
Inoue, Kazuo, Yokohama-Shi, Japan. 1982
Ishii, Koji, Funabashi City, Japan. 1982
Ishiwatari, Tamotsu, Tokorozawa City, Japan. 1982
Jacques, Susan M., Santa Ana, Ca, U.S.A. 1982
Jolliff, James V., Edgewater, Md, U.S.A. 1982
Jones, Joyce M., Walsall. 1982
Jones, Sandra L., New Plymouth, N.Z. 1982
Kagita, Mayumi, Kyoto City, Japan. 1982
Kennedy, Stephen J., London. 1982
Klaver, Gerardus J., Jeppestown, S.Africa. 1982
Krementz, Richard, III, Newark, N.J., U.S.A. 1982
Kularatnam, Samuel K., Colombo, Sri Lanka. 1982
Langford, Michael Leslie, Hereford. 1982
Larsson, Alf C., Kyrkslatt, Finland. 1982
Law, Ada P. K., Hong Kong. 1982
Lum, Koke Cheong, Kuala Lumpur, Malaysia. 1982

MacDonald, Roy W., Glasgow. 1982
McDowell, Robert B., Beltsville, Md, U.S.A. 1982
McIntosh, Marsha S., Arlington, Va, U.S.A. 1982
McLeod, John W., Papakura, N.Z. 1982
Mak, Michael Man Chiu, Hong Kong. 1982
Martijnse, Christriaan-Jan, Groot-Ammers, Netherlands. 1982
Mau, Enoch C. Y., Hong Kong. 1982
Mayor, Norah, Ely. 1982
Mellows, Jacqueline M., Bexleyheath. 1982
Michaels, David B., Alexandria, Va, U.S.A. 1982
Morris, Kelsey S., Hayling Island. 1982
Nevill, Amanda J., Hong Kong. 1982
Nivera, Ma Divina G., Hong Kong. 1982
Nooten-Boom, Apollonius, II, Kingsland. 1982
Ohno, Yaeko, Tokyo, Japan. 1982
Okuya, Yukie, Tokyo, Japan. 1982
Parker, Hazel, Macclesfield. 1982
Quane, David J., Bedford. 1982
Raniga, Umesh C. G., Vancouver, B.C., Canada, 1982
Rubin, Leon, Brussels, Belgium. 1982
Schofield, Nicola J., Huddersfield. 1982
Selmon, Simon, Northwood. 1982
Shah, Chandni R., Nairobi, Kenya. 1982
Sherwin, Andrew E., Nottingham. 1982
Shiraishi, Motoko, Tokyo, Japan. 1982
Stears, Trevor W., Bromley. 1982
Steinhauer, Mary H., Adelphi, Md, U.S.A. 1982
Tanaka, Hideaki, Nagasaki City, Japan. 1982
Tether, John G. G., Lusaka, Zambia. 1982
Thavat, Paul, Auckland, N.Z. 1982
To, Matthew K. H., Hong Kong. 1982
Trickey, Sheila A., Henley-on-Thames. 1982
Tsui, Carol, Hong Kong. 1982
Tsui, Juliana Yee Wah, Hong Kong. 1982
Turk, Noriko, Hong Kong. 1982
Uesaka, Noriko, Osaka, Japan. 1982
Wake, Barry A., Sidcup. 1982
Watson, Gordon, Lanark. 1982
Yasunaga, Jun, Fukuoka City, Japan. 1982

ORDINARY MEMBERSHIP

Ahamed Humbel, Mohamed K., Colombo, Sri Lanka.
Ahmed, Zohra R., Jleeb As Shuykh, Kuwait.
Aikawa, Mitsuo, Yamanashi-Ken, Japan.
Baccan, João A., Belo Horizonte, Brazil.
Balderston, Catriona I., London.
Berger, Clark J., London.
Birchall, Steven, Stockport.
Bond, Darryl N., Brisbane, Qld, Australia.
Bonn, Marc A., Kenosha, Wis., U.S.A.
Brookman, Charles L., Walla Walla, Wash., U.S.A.
Buerki, Andreas, Geneva, Switzerland.
Chang, Julius, Hong Kong.
Chellingsworth, John M., Nottingham.
Chow, Lorraine M., Hong Kong.
Church, Susan T., New York, N.Y., U.S.A.
Coffin, Martin R., Carlisle.
Davis, Albert S., London.
de Castro Mendes, Gerson, São Paulo, Brazil.

Denney, Shane S., Jacksonville, Ill., U.S.A.
Derrick, William O., London.
de Ruyter, Gerald H., Tokoroa, N.Z.
de Rycke, Anne-Marie, Dartmouth.
de Souza, Philip F., Kobe, Japan.
Dickinson, Emelline, Hong Kong.
Douglas, Lynn, Glasgow.
Ducenne, Charles J., Brussels, Belgium.
Ehlenbach, Richard J., Newton Lower Falls, Mass, U.S.A.
Ellis, Julia L., Aylesbury.
Filliette, J. P., Lugano, Switzerland.
Foong, Yee Tuck, Kuala Lumpur, Malaysia.
Friedman, David, Los Angeles, Ca, U.S.A.
Goebel, Mayr E., Leysin, Switzerland.
Grabau Hillgarth, Antonella C., Geneva, Switzerland.
Grebitus, Robert D., Sacramento, Ca, U.S.A.
Hanakawa, Masaya, Yamanashi, Japan.
Hata, Kazunori, Yamanashi, Japan.
Henderson, Mark McA., Dundee.
Hendricks, Mogamat L., Cape Town, S.Africa.
Hennessy, Linda L., Wahroonga, N.S.W., Australia.
Hinde, Margaret A., Little Sutton.
Holdo, Nelson A., Newport Beach, Ca, U.S.A.
Hosaka, Masahiro, Yamanashi, Japan.
Hughes, Gwendoline A., Beaconsfield.
Hussain, Azher, Karachi, Pakistan.
Iino, Masato, Yamanashi, Japan.
Introna, Ilarione G., Cape Town, S.Africa.
Itoh, Yasuhiro, Osaka, Japan.
Jensen, Brenda B., Nesbru, Norway.
Kamei, Shinichi, Yamanashi, Japan.
Kamiya, Takeo, Yamanashi, Japan.
Karim, Hamza H., Colombo, Sri Lanka.
Klein, George P., Pensacola, Fla, U.S.A.
Lange, Ulf, Bremen, W.Germany.
Larsen, Robert D., Arlington, Va, U.S.A.
Lau, Hueng K., Johore, Malaysia.
Laudes, Karin, Idar-Oberstein, W.Germany.
Lee, Peng Wah, Singapore.
Leenman, Walter J., Rotorua, N.Z.
Leggett, Nancy E., London.
Lewton-Brain, Charles J., Halifax, N.S., Canada.
Littlefair, Michael J., Grantham.
Loup, Daniel, Geneva, Switzerland.
MacKay, Wilma, Nedlands, W.A., Australia.
Mann, William R., Suitland, Md, U.S.A.
Marclay, Gregory, Geneva, Switzerland.
Marsh, Lesley F., Harare City, Zimbabwe.
Martinsson, Kenton A., Colombo, Sri Lanka.
Mendelson, Myron S., Somerville, N.J., U.S.A.
Mettler, Eva, Zurich, Switzerland.
Mila de la Roca, G., Caracas, Venezuela.
Miyata, Takeshi, Yamanashi, Japan.
Moir, Richard C., Kenthurst, N.S.W., Australia.
Monnas, Maria L., Mombasa, Kenya.
Moore, Christopher S., Market Deeping.
Mortimer, Derek K., London.
Nakanishi, Kimiyo, Yamanashi, Japan.
Nakayama, Sonomi, Yamanashi, Japan.
Nelson, William L., Milan, Italy.
Ninomiya, Mutsuko, Yamanashi-Ken, Japan.
Palfreyman, William D., Civic Square, A.C.T., Australia.
Pamment, Sharon L., Letchworth.

Peshwa, Krishna V., Pune, India.
Peskett, Anthony F., Solihull.
Pornthitines, Poonsiri, Bangkok, Thailand.
Preston, Allyson B., London.
Quinn, Patrick D., Sacramento, Ca, U.S.A.
Ravenstein, Dennis M., Jackson, Miss., U.S.A.
Read, William J., Colchester.
Roach, Michael P., Howell, N.J., U.S.A.
Rowlands, Nicholas S., Weston super Mare.
Roy, Stephen B., Tucson, Ariz., U.S.A.
Sadik, Marcel, Geneva, Switzerland.
Scanlon, James G., Cavan, Ireland.
Schreier, Lawrence, Skokie, Ill., U.S.A.
Shelley, Ann M., London.
Sheppard, John F., Taos, N.Mex., U.S.A.
Sheriff, Mohamed M., Colombo, Sri Lanka.
Shiao, Leu M., Taipei, Taiwan.
Shimizu, Yoshimi, Yamanashi, Japan.
Shiratori, Yoshiko, Yamanashi, Japan.
Stimac, Ornella P., Jeddah, Saudi Arabia.
Swayne, Kenneth, Leighton Buzzard.
Takayama, Shouji, Yamanashi, Japan.
Themelis, Theodore, Rego Park, N.Y., U.S.A.
Thornley, Joan A., Green Bay, Wis., U.S.A.
Tsakiris, Theodore G., Mombasa, Kenya.
Turgis, Alison, Chesham.
Turner, Martin C., Cirencester.
Unwin, Christine, Greenford.
Valenti, Gian P., Parma, Italy.
Wackan, Susan K., Woking.
Wan, Kai-Ho, Hong Kong.
Ward, Douglas, Thirsk.
Ward, Edmund, Thirsk.
Warne, Richard A., Newbury.
Wong, Christine H., Hong Kong.
Wykoff, Dale E., Frederick, Md, U.S.A.
Yagami, Noriko, Yamanashi, Japan.
Yamada, Keiko, Yamanashi, Japan.
Young, Michael, Monroeville, Pa, U.S.A.

GEM DIAMOND EXAMINATION, 1982

In the Post-Diploma Gem Diamond Examination thirty-four candidates sat and thirty-two passed, three with Distinction. The following is a list of the successful candidates, arranged alphabetically.

QUALIFIED WITH DISTINCTION

King, Antoinette E., London.
Sadler, Philip A., London.
Woodward, Christine M., London.

QUALIFIED

Anfield, Jennifer J., Birmingham.
Ashra, Shirish, London.
Babber, Harish R., Southall.
Bardsley, John N., London.
Cooper, Roy, Disley.
Dewar, Penelope S., Stockport.

Eyre, George, Denton.
Gasco Galindo, Ignacio, Barcelona, Spain.
Gea, Lopez, Francisco José, Barcelona, Spain.
Grimston, Lady Iona C., St Albans.
Haghani, Victor J., London.
Horton, David R., London.
Jones, Owen D., Derby.
Kelly, John S., Cardiff.
Lacambra Pifarre, Carmen, Barcelona, Spain.
Law, Sheila, London.
Martuccio, Celeste, Leamington Spa.
Moody, Kenneth O., Cheltenham.
Pattni, Pravin A., London.
Podsiadly, Maria T., Birmingham.
Potter, Brian S., London.
Rigby, Ian W., Wolverhampton.
Rome, Martin L., London.
Saez Balsalobre, Lidia, Barcelona, Spain.
Smith, Catharine, Lutterworth.
Tomas Soler, Ma Rosa, Barcelona, Spain.
Tose, Christine, Oldham.
Vigo Ripoll, Leticia, Barcelona, Spain.
Zebrak, Tracy J., Hove.

EXAMINATIONS IN GEMMOLOGY, 1982

In the 1982 Examinations in Gemmology, 620 candidates sat the Diploma Examination and of these 300 succeeded in passing, 22 of them with Distinction. In the Preliminary Examination 797 candidates sat and 521 passed.

In the opinion of the Examiners, no candidate achieved the high standard required to merit the award of the Tully Medal.

The Anderson/Bank Prize for the best non-trade candidate of the year in the Diploma Examination was awarded to Mrs Sandra C. Hawkins, Toronto, Ontario, Canada.

The Rayner Diploma Prize for the best candidate whose main income is derived from activities essentially connected with the jewellery trade was awarded to Miss Susan M. Jacques, of Santa Ana, California, U.S.A.

The Anderson Medal for the best candidate of the year in the Preliminary Examination was awarded to Mr Douglas Andrew Bagnall, of Don Mills, Ontario, Canada.

The Rayner Preliminary Prize for the best candidate of the year under 21 years of age whose main income is derived from activities essentially connected with the jewellery trade was awarded to Miss Andree J. Richardson, of Eastbourne.

The following are lists of the successful candidates arranged alphabetically.

DIPLOMA EXAMINATION

Anderson/Bank Prize
Hawkins, Sandra C., Toronto, Ont., Canada.

Rayner Diploma Prize
Jacques, Susan M., Santa Ana, Ca, U.S.A.

QUALIFIED WITH DISTINCTION

Ainsworth, Nicola L. A., London.
Armstrong, Gillian, Preston.
Bolton, Robert G., Ilkley.
Buchanan, Vera A., Ballinamallard, N. Ireland.
Del Rey, Mario, S. Caetano do Sul, Brazil.

Dewendra, Rekha, Matara, Sri Lanka.
Dijkman-Vos, Christine S., Taitam, Hong Kong.
Fernandez Nuñez, Carlos Luis, Barcelona, Spain.
Garrigos Fernandez, Ma José, Barcelona, Spain.
Gould, Michael A., McLean, Va, U.S.A.
Hawkins, Sandra C., Toronto, Ont., Canada.
Hofer, Stephen C., Santa Monica, Ca, U.S.A.
Housley, John G., Sheffield.
Jacques, Susan M., Santa Ana, Ca, U.S.A.
Jolliff, James V., Edgewater, Md, U.S.A.
Kennedy, Stephen J., London
Kumaratilake, Wickramasinghe L.D.R.A., Kelaniya, Sri Lanka.
McCall, Lois G., Wooster, Ohio, U.S.A.
Matsuda, Tomoko, Tokyo, Japan.
Nevill, Amanda J., The Peak, Hong Kong.
Pellicer Beltran, Rodrigo, Barcelona, Spain.
Pike, Corinna A. W., London.

QUALIFIED

Adams, Myra, Huddersfield.
Alva, Shyamala J., Mangalore, India.
Amos, Gillian L., Enniscorthy, Ireland.
Anderton, Duncan MacG., Bearsden.
Andrews, Clive G., Onchan, I.O.M.
Ansell, Martin F., Epping.
Anwar, Abdul A. M., Beruwala, Sri Lanka.
Aoussat, Claude A., Vienna, Va, U.S.A.
Arbestain Ribas, Inmaculada, Barcelona, Spain.
Arendtsz, Natalie A., Negombo, Sri Lanka.
Ariyaratna, Don H., Colombo, Sri Lanka.
Arjalaguer Vilardell, Daniel, Barcelona, Spain.
Astridge, Elaine, London.
Athauda, W. A. Nanda, West Bromwich.
Baixauli Sanjuan, José F., Barcelona, Spain.
Baker, Judith, Ottawa, Ont., Canada.
Balas, Aranka, Budapest, Hungary.
Bambrick, Joseph E., Markham, Ont., Canada.
Bandarage, Usha Samangi, Colombo, Sri Lanka.
Bannerman, John M., Weybridge.
Barlow, Peter Charles, Kidderminster.
Bell, John A., Sevenoaks.
Bennett, A. Sirisena, Tangalle, Sri Lanka.
Berthet, William L., Jacksonville, Fla, U.S.A.
Blackshaw, Cheryl K., Knutsford.
Blanckenberg, Antoinette, Durban, S.Africa.
Bon, Maria H., Schoonhoven, Netherlands.
Bonanno, Kenneth E., Fredericksburg, Va, U.S.A.
Bond, Gerald S., Maidstone.
Bouman, Henrietta A. E., Bangkok, Thailand.
Bowman, Josephine T., London.
Braunstein, Joan, Potomac, Md, U.S.A.
Brom, Frederik W., Oegstgeest, Netherlands.
Brown, Harold G., Glasgow.
Buhl, Robert Anthony, West Vancouver, B.C., Canada.
Cabanas Casas, Terencia, Barcelona, Spain.

Capella Tomas, Ma Josefa, Barcelona, Spain.
Cardew, Charles J. S., Thornton Heath.
Cassarino, Paul R., Rochester, N.Y., U.S.A.
Castro Masaveu, Alicia, Barcelona, Spain.
Cestaro, Thomas L., Cheshire, Conn., U.S.A.
Chan, Cecilia P. K., Hong Kong.
Chao, George Y., Ottawa, Ont., Canada.
Chaturvedi, Vimal K., Jagdalpur, India.
Cheung, Cliff P. L., Toronto, Ont., Canada.
Christou, Christos G., London.
Cole, Jo E., Santa Monica, Ca, U.S.A.
Cooper, Sean, Stockport.
Cornioley, Jean-René, Fribourg, Switzerland.
Courtliff, Steven Paul, Liverpool.
Cousins, Jonathan, Deal.
Cowie, Gillian A., Liverpool.
Crout, Stephen J., Christchurch, N.Z.
D'Adamo, Marina, Milan, Italy.
Daulatani, Shambhu L., Jaipur, India.
Dawson, Jane, London.
de Beer, Christiaan T. J., Durban, S.Africa.
de Poli, Vesta, Cortina d'Ampezzo, Italy.
de Regt, Marcus N., Goes, Netherlands.
Desai, Madhav C., Hartford, Conn., U.S.A.
de Silva, G. Ranjan J., Singapore.
Dirlam, Dona M., Santa Monica, Ca, U.S.A.
Dougherty, William C., Alexandria, Va, U.S.A.
Douthwaite, Elaine M., Bradford.
Düblin, Theo, Arlesheim, Switzerland.
Ehrenborg, Charlotte E., Gex, France.
Elvidge, Caroline A., Tonbridge.
Esterhuizen, Karel F., Karoi, Zimbabwe.
Faller, Noel P., Londonderry, N.Ireland.
Fernando, Dudley L., Colombo, Sri Lanka.
Fonseka, Ruwan K. M., Colombo, Sri Lanka.
Ford, Hermione Dolores, Hereford.
Forshaw, Edward D. J., Newcastle upon Tyne.
Foster, Amanda L., Willowdale, Ont., Canada.
Fritzen, Tove, Oslo, Norway.
Fujimoto, Naoko, Nishinomiya City, Japan.
Fuller, Maris E., Kowloon, Hong Kong.
Galsterer, Maureen G., Saginaw, Mich., U.S.A.
Galt, Jessie J., Toronto, Ont., Canada.
Gandhy, Uday P., Bombay, India.
Gaw, Rossana W., Hong Kong.
Gemayel, Farid V., Antelias, Lebanon.
Geurts, Godefridus R. J. M., Heerlen, Netherlands.
Gimpel, Beatrice L. F., London.
Glover, Brian M. G., New Brighton.
Gobla, Michael J., Denver, Colo, U.S.A.
Goeritz, Louise C., London.
Golby, Nicholas G. J., London.
Goss, Alan C., Welwyn Garden City.
Greatwood, Sheila O., Mitcham.
Griffiths, Paul A., Streetly.
Grishko, Alexander, Toronto, Ont., Canada.
Gupta, Manoj B., Bombay, India.
Hadfield, Margit E., Canterbury.
Hall, Sarah Cheryl D., Toronto, Ont., Canada.
Hamer, Saskia M., Hague, Netherlands.

Hannedouche, Bérangére M., Paris, France.
Hardy, Joanna, London.
Harmer, Inge, Brisbane, Qld, Australia.
Hart, Judith E., Denby.
Hartenboer, Willem J., Krimpen a/d Yssel, Netherlands.
Hayashi, Junji, Fukuoka City, Japan.
Hayes, George R., Jr, Louisville, Ohio, U.S.A.
Heino, Tauno T. T., Eura, Finland.
Hendriks, Fransiscus R. A., Amsterdam, Netherlands.
Henwood, Glyn A., Basingstoke.
Hinduja, Anuradha, Bombay, India.
Hoogewerff, Regitse C., Diepenveen, Netherlands.
Hopkinson, Barbara J., Newark.
Horikawa, Yoichi, Tokyo, Japan.
Horn, Graeme F., Glasgow.
Hughes, Richard W., Boulder, Colo, U.S.A.
Hurlbert, Kim E., Cayucos, Ca, U.S.A.
Hutchinson, Leslie B., London.
Hutton, Andrew J., Croydon.

Ickowicz, Stephen, London.
Ifthikar, Mohamad U. M., Kandy, Sri Lanka.
Ikoma, Nobuo, Kobe City, Japan.
Illueca Domenech, Enrique, Barcelona, Spain.
Inches, Deirdre M. H., Edinburgh.
Inoue, Kazuo, Tokyo, Japan.
Ishii, Koji, Funabashi City, Japan.
Ishiwatari, Tamotsu, Tokorozawa City, Japan.

Jackson, Christopher P., London.
Jayaweera, Susil, Peradeniya, Sri Lanka.
Jeng, Jiin Hwa, Kaohsuing, Taiwan.
Jhaveri, Kalpana R., Bombay, India.
Jokela, Leena A., Helsinki, Finland.
Jones, Joyce M., Walsall.
Jones, Sandra L., New Plymouth, N.Z.
Kaersenhout, George E., Amsterdam, Netherlands.
Kegita, Mayumi, Kyoto City, Japan.
Kasagi, Nobuko, Nishinomiya City, Japan.
Kauhanen, Pentti R., Helsinki, Finland.
Kawai, Yoshito K., Utsunomiya-shi, Japan.
Kelderman, Klaas P., Alphen a/d Rijn, Netherlands.
Kesola, K. Juhani, Valkeakoski, Finland.
Ketelaar, Arend C. R., Leidsendam, Netherlands.
Key, Roger M., Cardigan.
Kierkels, Johannes J. P. E., Belfeld, Netherlands.
Klaver, Gerardus J., Hengelo, Netherlands.
Kohmura, Kyohko, Kyoto City, Japan.
Kolamunne, A. A. Susila, Kadawatte, Sri Lanka.
Korhonen, Pentti K., Hämeenlinna, Finland.
Kothari, Harsukh N., Bombay, India.
Kraan, Jan W., Amsterdam, Netherlands.
Krementz, Richard, III, New York, N.Y., U.S.A.
Krishnamoorthy, K. L. Narayanan, Trivandrum, India.
Kuittinen, Raili T., Helsinki, Finland.
Kujanpää, Asko J., Helsinki, Finland.
Kularatnam, K. Samuel, Colombo, Sri Lanka.
Kumarage, Jayantha P. R., Homagama, Sri Lanka.
Laframboise, Michel E., Cornwall, Ont., Canada.
Laine, Raimo E. L., Hämeenlinna, Finland.

Lam, Alan Wah Ching,
Kuala Lumpur, Malaysia.
Lam, Yat Hoong, Singapore.
Langford, Michael Leslie, Hereford.
Larsson, Alf C., Kyrkslätt, Finland.
Law, Ada P. K., Hong Kong.
Lietwiler, Christian W., Springfield,
Va, U.S.A.
Love, John, Jersey, C.I.
Lum, Koke Cheong, Kuala Lumpur,
Malaysia.
McClain, Robert J., Washington,
D.C., U.S.A.
Macdonald, Roy W., Glasgow.
McDowell, Robert B., Beltsville, Md,
U.S.A.
McIntosh, Marsha S., Arlington, Va,
U.S.A.
McLeod, John W., Papakura, N.Z.
McQueen, B. Young, Jacksonville,
Fla, U.S.A.
Mak, Michael Man Chiu,
Hong Kong.
Mallawarchchi, Gayani N.,
Kadawata, Sri Lanka.
Malpas, Robert F., Leeds.
Mantecon Burgos, Jesús, Barcelona,
Spain.
Marti Beltran, José Ma, Barcelona,
Spain.
Martijnse, Christiaan-Jan,
Groot-Ammers, Netherlands.
Mau, Enoch C. Y., Hong Kong.
May, Brian H., Camberley.
May, Brian J., Stellenbosch,
S.Africa.
Mayor, Norah, Ely.
Medniuk, Melanie A., Witham.
Mellows, Jacqueline M.,
Bexleyheath.
Michaels, David B., Alexandria, Va,
U.S.A.
Miralles Morey, José L., Barcelona,
Spain.
Mok, Dominic W. K., Hong Kong.
Moore, Roscelyn M., Camberley.
Mora Balcells, Helena, Barcelona,
Spain.
Morishita, Kentaro, Tokyo, Japan.
Morishita, Yuzuru, Tokyo, Japan.
Morris, Kelsey S., Hayling Island.
Nevalainen, Aarne E., Hämeenlinna,
Finland.
Newing, Robin J. T., London.
Nicholas, Christopher E., Colombo,
Sri Lanka.
Nieuwenhuys, Erik F. T. M.,
Bloemendaal, Netherlands.
Nilam, Mohamed C. M., Weligama,
Sri Lanka.
Nivera, Ma Divina G., Philippines.
Nooten-Boom, Apollonius, II,
Kingsland.
Novejarque Lopez, Ma del Carmen,
Barcelona, Spain.
Ohno, Yaeko, Tokyo, Japan.
Okada, Mari, Utsunomiya, Japan.
Okuya, Yukie, Tokyo, Japan.
Olson, A. Richard, Manzini,
Swaziland.
Oxley, Peter J. M., Birdham.
Paradise, Thomas R., Millbrae, Ca,
U.S.A.
Parker, Hazel, Macclesfield.
Perez Segarra, Montserrat,
Barcelona, Spain.
Phillips, Jean M., Hong Kong.
Pickett, Diana J., Waterlooville.
Piziura, Irene T., Nottingham.
Quane, David J., Bedford.
Ralls, Elizabeth L. W., Spokane,
Wash., U.S.A.
Ranabahu, Millakage K. T. S.,
Ratnapura, Sri Lanka.
Raniga, Umesh C. G., Vancouver,
B.C., Canada.
Rosier, Jane L., Thorpe-le-Soken.
Rubera, Anthony N., Dehiwela,
Sri Lanka.
Rubin, Leon P. J., Brussels,
Belgium.
St Amand, Mary J., Mill Valley, Ca,
U.S.A.
Salloway, Nigel J., London.
Schofield, Nicola J., Huddersfield.

Schutt, Karl Robert, Manotick, Ont., Canada.
Schyllander, Anna M., Lidingö, Sweden.
Selmon, Simon, Northwood.
Senanayake, Nimalka R., Homagama, Sri Lanka.
Senanayake, Sripathi P. A. M. A., Gampaha, Sri Lanka.
Shah, Chandni R., Nairobi, Kenya.
Shah, Sanjay S., Bombay, India.
Shenker, Ian L., Edgware.
Sherwin, Andrew E., Nottingham.
Shiraishi, Motoko, Tokyo, Japan.
Smiley, Laurianne, Clondalkin, Ireland.
Snell, Keith H., Maghull.
Soriano Meler, Esther, Barcelona, Spain.
Staley, Nancy C., Potomac, Md, U.S.A.
Stears, Trevor W., Bromley.
Steert, Ineke, Amsterdam, Netherlands.
Steinhauer, Mary H., Adelphi, Md, U.S.A.
Stratton, Victoria J., Toronto, Ont., Canada.
Takakura, Momoyo, Tokyo, Japan.
Tam, David C. C., Hong Kong.
Tanaka, Hideaki, Nagasaki City, Japan.
Tether, John G. G., Lusaka, Zambia.
Thavat, Paul, Auckland, N.Z.
Thomson, Ian C., Dumfries.
Thomson, Pearl J., New Barnet.
To, Matthew K. H.,, Hong Kong.
Toivainen, Heidi S., Helsinki, Finland.
Torode, Carl F., Gillingham.
Trickey, Sheila A., Henley-on-Thames.
Tsuda, Takashi, Osaka, Japan.
Tsui, Carol, Hong Kong.
Tsui, Juliana Yee Wah, Hong Kong.
Turk, Noriko, Hong Kong.
Uesaka, Noriko, Osaka, Japan.
van Andel-Wierda, Catharina J., The Hague, Netherlands.
van Bork, Margaretha A. C., Leiden, Netherlands.
van Velzen-Ritmeÿer, Elisabeth T. H., Rotterdam, Netherlands.
van Zeijst, Raymond M. E., Nieuwegein, Netherlands.
Vaughan, Susan E., Nottingham.
Venemans, Anne C., Schoonhoven, Netherlands.
Verjee, Nasim K., Nairobi, Kenya.
Vidal Noguera, Francisco, Barcelona, Spain.
Voll, Aloha F., Tokyo, Japan.
Vuorinen, Jorma T., Hämeenlinna, Finland.
Waghela, Mahesh R., Bombay, India.
Wake, Barry A., Welling.
Walsh, Francine, Dundas, Ont., Canada.
Walters, Raymond J. L., London
Watson, Gordon, Lanark.
Weber, Leo, Breda, Netherlands.
Whittingham, Jill E. A., Farnham.
Wols, René P., Rotterdam, Netherlands.
Wood, Elaine, Brinsley.
Woollings, Joan E., Toronto, Ont., Canada.
Wright, C. John, Chorleywood.
Wycherley, Megan S., Formby.
Yacub, Rafiq, Erode, India.
Yamasaki, Kazutaka, Kochi-shi, Japan.
Yasunaga, Jun, Fukuoka City, Japan.
Ypyä, Teuvo H., Kemi, Finland.
Zylstra, Christine, Schoonhoven, Netherlands.

PRELIMINARY EXAMINATION

Anderson Medal
Bagnall, Douglas A., Don Mills, Ont., Canada.

Rayner Prize
Richardson, Andree J., Eastbourne.

QUALIFIED

Aarskov, Ann, Hong Kong.
Abrami, Aurelio, Milan, Italy.
Addison, Helen, Auchenflower, Australia.
Adlam, Raymond J., Uddingston.
Aguado Roca, Fernando J., Barcelona, Spain.
Ahamed Marzook, Mohamed N., Colombo, Sri Lanka.
Aked, Francis J., Leeds.
Aldworth, Pamela M., Liskeard.
Altenloh, Jacques P. C. J., Brussels, Belgium.
Anderton, Brian G., Bearsden.
Anselot, François J. R., Canterbury.
Arandle, Christine A., East Looe.
Aroos, Mohamed A. M., Colombo, Sri Lanka.
Arzem, Frances, Willowdale, Ont., Canada.
Ashworth, Ian E., Bristol.
Athauda, Premalatha, Gonapola Junction, Sri Lanka.
Atkinson, Paul C., Weston super Mare.
Attwell, William G., Toronto, Ont., Canada.
Avargues Perles, Antonia, Barcelona, Spain.
Axon, Martin W., London.
Bach, Michelle M., Bangkok, Thailand.
Bae, Sang K., Seoul, Korea.
Bagnall, Douglas A., Don Mills, Ont., Canada.
Balasch Borras, Ma Mercé, Barcelona, Spain.
Baldellou Celma, Juan, Barcelona, Spain.
Balderston, Catriona I., London.
Ball, Andrew J., Loughton.
Banks Lyon, Rodney, Lancaster.
Barnard, Stephen J., Leigh-on-Sea.
Baxter, Gordon E., Whangarei, N.Z.
Beasley, Rosemary E., Toronto, Ont., Canada.
Beattie, Roy A., Jimboomba, Qld, Australia.
Beckett, Michael J., London.
Bell, William A., Prudhoe.
Benford, Rosemary S., London.
Bengali, Malcolm, London.
Bengali, Neville K., London.
Benham, Robert M., Great Bend, Kans., U.S.A.
Benham, Thomas R., Great Bend, Kans., U.S.A.
Beresford, Martin P., Ashford.
Berger, Nicolaas H. M., Woerden, Netherlands.
Bernad Soria, Pedro J., Barcelona, Spain.
Berthelsen, Lawrence J., Townsville, Qld, Australia.
Berthet, William L., Jacksonville, Fla, U.S.A.
Bickley, Kerry B., Pretoria, S.Africa.
Bielby, Robert W., Leicester.
Birkin, Paul M., Stoke on Trent.
Bisset, Ross, London.
Blackshaw, Cheryl K., Alderley Edge.
Bloodworth, Roy N., Stanley.

Boek, Gerriedina J., Baarn, Netherlands.
Boldova Sanchez, Pilar, Barcelona, Spain.
Bonanno, Kenneth E., Fredericksburg, Va, U.S.A.
Boreham, Kevin M., Truro.
Bouman, Henrietta A. E., Bangkok, Thailand.
Braunstein, Joan, Potomac, Md, U.S.A.
Broad, Arline E., Thames, N.Z.
Brom, Frederik W., Oegstgeest, Netherlands.
Bucy, Rodger Dale, Ellicott City, Md, U.S.A.
Budd, Lesley H., Exeter.
Buddington, Jeffrey P., Hayannis, Mass, U.S.A.
Bugg, John R., Wolverhampton.
Burbidge, Norma P., New Plymouth, N.Z.
Burman-Roy, Kumar H.,, Glasgow.
Canêlhas, Maria da G. P. S. A., Lisbon, Portugal.
Cartmell, Fiona A., Manchester.
Cassarino, Paul R., Rochester, N.Y., U.S.A.
Castell Andujar, Joaquín, Barcelona, Spain.
Catchon, Tuan J. A., Ratmalana, Sri Lanka.
Chan, Kum Bun M., Quarry Bay, Hong Kong.
Chan, Lai Kuen R., Kowloon, Hong Kong.
Chan, Lye Keng, Barking.
Chan, Yuet Mei, Kowloon, Hong Kong.
Chant, Joanna K., Dorchester.
Chanter, James E., Newton Abbot.
Chaturvedi, Vimal K., Jagdalpur, India.
Cheung, Yiu Wai D., Kowloon, Hong Kong.
Chow, Kam Ming H,. Kowloon, Hong Kong.
Chow, Lorraine M., Kowloon, Hong Kong.
Chu, Kit-Chun Q., Central, Hong Kong.
Chung, Yuk Wah C., Kowloon, Hong Kong.
Cirone, Monica A., Campbell, Ca, U.S.A.
Citron, Marc R., London.
Clappison, Diana J., Hull.
Clark, Patricia M., Pokfulam, Hong Kong.
Clarke, Julia, Aylesbury.
Cloke, Ho Ning D., Headland, Hong Kong.
Cole, Jo E., Santa Monica, Ca, U.S.A.
Collado Castelles, Ma Dolores, Barcelona, Spain.
Comas Andres, Juan, Barcelona, Spain.
Condrup, Jonathan R., Haslemere.
Conway, Jeremy P. M., Toronto, Ont., Canada.
Corbin, Janet R., Liverpool.
Cotton, Pamela D., Chorlton-cum-Hardy.
Courage, Belinda J., Truro.
Cowell, Gawin, Salisbury, Zimbabwe.
Cowell, Kenneth, Robertson, S.Africa.
Cunningham, Colin D., Townsville, Qld, Australia.
Danku, James E., London.
Dart, Nigel E., Newquay.
Daulatani, Shambhu L., Dubai, U.A.E.
Davey, Frances V., Invercargill, N.Z.
Davies, Karen, North Harrow.
Davies, Stephen, Wallsend.
Demoray, Scott B., Grand Rapids, Mich., U.S.A.
den Hartog, Maria J. M., Baarn, Netherlands.
Denton, Gary M., London.
Deogun, Surinder S., Milton Keynes.

de Poli, Vesta, Cortina d'Ampezzo, Italy.
Desai, Madhav C., Hertford, Conn., U.S.A.
de Silva, Uyanage D. N., Singapore.
de Swart, Johan, Wÿchen, Netherlands.
de Vries, Jacqueline A., Gouda, Netherlands.
Dewever, Jan A., Sittard, Netherlands.
Dings, Christianne A. M., Valkenswaard, Netherlands.
Dobson, John D., Glasgow.
Dormer, Joseph L., Corringham.
Dorren, Margot S. C., Lopik, Netherlands.
Dowie, Richard S., Christchurch, N.Z.
Dunga, Kiran D., Birmingham.
Dunn, Andrew C., Reading.
Durafourg, Isabelle. F. A., Lausanne, Switzerland.
Dykstra, Jeannine B., Toronto, Ont., Canada.
Eisenburger, Sabine F., Thalheim, Austria.
Elsten, Antonius R. M., Rucphen, Netherlands.
Emerson, Michael E., London.
Euwema, Jos, Schoonhoven, Netherlands.
Fache, Frank E. A. M., Edegem, Belgium.
Faridi, Waris J., Karachi, Pakistan.
Fernando, M. Preethi, Panadura, Sri Lanka.
Fernando, Ramani S. F., Enfield.
Finkelman, Steven L., London.
Flacks, Naomi, Sale.
Flower, Jonathan S., Plumley.
Floyd, Nancy E., Toronto, Ont., Canada.
Fonseka, S. D. H. R. Franklin, Enfield.
Ford, John P., London.
Fox, Kathleen P., Townsville, Qld, Australia.
Fretzin, Leonard H., Chicago, Ill., U.S.A.
Froehlich, Adam, Willowdale, Ont., Canada.
Fujimoto, Naoko, Nishinomiya City, Japan.
Gandhy, Uday P., Bombay, India.
Garcia Gisbert, Rocio, Barcelona, Spain.
Garcia-Elias Cos, Montserrat, Barcelona, Spain.
Gardner, Mary R., Toronto, Ont., Canada.
Gardner, Robert J., Manchester.
Garrod, Douglas J., Exeter.
Gascon Cuello, Fernando, Barcelona, Spain.
Gavin, Sandra R., Thornton Heath.
Genis Perez, Manuel, Barcelona, Spain.
Gent, Rosemary J., Tonbridge.
Gilliland, Hilary L., Newtownabbey, N.Ireland.
Glaholm, Janice A., Paris, France.
Goad, Jane B., Toronto, Ont., Canada.
Gonzalez Violan, Francesc, Barcelona, Spain.
Goodden, Rick K., Kansas City, Mo., U.S.A.
Goodland, John R. S., Gstaad, Switzerland.
Gould, Michael A., McLean, Va, U.S.A.
Graham, Kimberley E., Toronto, Ont., Canada.
Grant, Noeline L., Pietermaritzburg, S.Africa.
Greatwood, John, Mitcham.
Greig, Edward S., Kingston Hill.
Guerin Tarafa, Antonio, Barcelona, Spain.
Guerrero Ramon, Desamparados, Barcelona, Spain.
Gunter, Margaretha E., Schoonhoven, Netherlands.
Gupta, Manoj B., Bombay, India.

Gwizdala, Elzbieta M., Toronto, Ont., Canada.
Hakanen, Veikko T., Karvia, Finland.
Hall, Suzie N., London.
Hamada, Ritsuko, Tokyo, Japan.
Hannedouche, Bérangére, Paris, France.
Hansen, Joanne, Corvallis, Oreg., U.S.A.
Hapangama, Janaka P., Colombo, Sri Lanka.
Harriman, Allen L., Cue, W.Australia.
Haththotuwa, Chandrasiri, Kamburugamuwa, Sri Lanka.
Haughton, Michael, Bolton.
Hayashi, Junji, Fukuoka City, Japan.
Hayashi, Toshiko, Fukuoka City, Japan.
Hayes, Anne-Maria, London.
Hearsum, Paul A., Godalming.
Hee, Kim San V., Singapore.
Hegarty, Kathleen M., New York, N.Y, U.S.A.
Helton, Janet L., Toronto, Ont., Canada.
Hempshall, George H., Sheffield.
Hendriks, Fransiscus R. A., Amsterdam, Netherlands.
Herrero Romeu, Susana, Barcelona, Spain.
Hewitt, Georgina F., London.
Hill, Stephen E., St Albans.
Hills, Gavin A., Moonah, Tas., Australia.
Hindley, Angela, Bromborough.
Hollis, Patricia A., New York, N.Y., U.S.A.
Horikawa, Yoichi, Tokyo, Japan.
Horne, Allan R., Brighton.
Houghton, Mark W., Stockport.
Howe, John A., Huddersfield.
Howell, Stephen Q., San Francisco, Ca, U.S.A.
Hu, Shirley, Oxford.
Huddy, William R. H., Newton Abbot.
Hughes, Keith W., Liverpool.
Hurst, Patricia H., Carradale.
Hutchings, Trevor J., Bellewstown, Ireland.
Ikoma, Nubuo, Kobe City, Japan.
Inoue, Satomi, Sakai City, Japan.
Inoue, Yoshie, Tokyo, Japan.
Isowa, Keiko, Shima-gun, Japan.
Issadeen, Abdul M., Colombo, Sri Lanka.
Ito, Yasuo, Nagoya City, Japan.
Iyer, Sundaram V., Bombay, India.
Jacques, Susan M., Santa Ana, Ca, U.S.A.
Jane Riera, Inmaculada, Barcelona, Spain.
Jayasundara, Mudiyanselage A. S., Idar-Oberstein, W.Germany.
Jayawardana, Sisira L., Gampaha, Sri Lanka.
Jayaweera, Sumana, Kandy, Sri Lanka.
Jeng, Jiin Hwa, Kaohsuing, Taiwan.
Jennings, Joan M., Verulam, S.Africa.
John, Bryan C., Carmarthen.
Jones, Brenda C., Liverpool.
Jones, Deborah G., Sale.
Jones, Sandra L., New Plymouth, N.Z.
Jongstra, Femia E. M., Schoonhoven, Netherlands.
Kaga, Mari, Tokyo, Japan.
Kamara, Moulai M., London.
Kanoh, Mieko, Fukuoka City, Japan.
Karmakar, Sambhunath, Bombay, India.
Karmokar, Tapan, Bombay, India.
Kawamura, Yasuki, London.
Keast, Edmund J., Sanderstead.
Kennedy, Muriel D., Toronto, Ont., Canada.
Kerr, Marian, Busby.
Kimura, Mariko, Tokyo, Japan.
King, Barry J., Bury St Edmunds.

King, Clive H. M., Tsumeb, Namibia.
Kirkwood, Alan D., Liverpool.
Kiuipuro, Antti P., Pori, Finland.
Klauda, Frank P., Rochester, Minn., U.S.A.
Koff, Laurence R., Chicago, Ill., U.S.A.
Kor, Wai Yin, Shatin, Hong Kong.
Kong, Chor Ki, Kowloon, Hong Kong.
Konrath, Anthony M., Richmond.
Koshilka, Mike, Collingwood, Ont., Canada.
Koutsicas, Constantine, Athens, Greece.
Kowitz, Leslie B., Albany, Ca, U.S.A.
Krieger, Christine, Norfolk, Va, U.S.A.
Krikos, Alexandra, London.
Krishnamoorthy, Karana L. Narayanan, Trivandrum, India.
Kunzle, Andree-Evelyne, Geneva, Switzerland.
Kwan, Irene N. Y. Y., Hong Kong.
Kwok, Addy S. C., Kowloon, Hong Kong.
Kwok, Pui Chung, North Point, Hong Kong.
Ladell, Peter, St Albans.
Laframboise, Michel E., Bangkok, Thailand.
Lai, Wai Kwan, Pokfulam, Hong Kong.
Lai, Wing Cheong, Hong Kong.
Lal, Vispi R., Bombay, India.
Lam, Alan W. C., Bangkok, Thailand.
Lam, Leung Kim Lan C., Kowloon, Hong Kong.
Lam, Yat Hoong, Singapore.
Laso Nuñez, Ma Concepción, Barcelona, Spain.
Lau, Paul C. Y., London.
Lauer, Deborah J., Springfield, Ill., U.S.A.
Lawton, Christine A., Bolton.
Lee, Andy S. K., Hong Kong.
Lee, Jeffrey K., Don Mills, Ont., Canada.
Lemen, John R., Torrance, Ca, U.S.A.
Letros, Tony G., Scarborough, Ont., Canada.
Lette, Edward C. G., Amsterdam, Netherlands.
Leung, Kwok Tung F., Kowloon, Hong Kong.
Li, Chi Chung K., Kowloon, Hong Kong.
Liggett, Sonia A. M., Cardiff.
Liu, Kam Ham, Shatin, Hong Kong.
Liu, Wun Shian, Den Bosch, Netherlands.
Lloyd, Stephen R., London.
Llucia Aguilera, Rosa, Barcelona, Spain.
Logan, Margaret M., Toronto, Ont., Canada.
Lok, Kwun-Ling, Kowloon, Hong Kong.
Lopez Galobardes, Ramón, Barcelona, Spain.
Lopezzo, Lorraine V., London.
Love, Jane, Bowdon.
Lowes, Elizabeth H., Toronto, Ont., Canada.
Lumley, John S. P., London.
Lynden, Melody J., Richmond Hill, Ont., Canada.
McCall, Lois G., Wooster, Ohio, U.S.A.
McClain, Robert J., Morningside, Md, U.S.A.
McCornack, Constance B., Seattle, Wash., U.S.A.
McDonald, Shirley I., Salisbury, Zimbabwe.
McFarlane, Patricia A., London.
McGorrian, Pauline J., Downpatrick, N.Ireland.
McGregor, Marilyn K., Toronto, Ont., Canada.
MacLennan, David J., Glasgow.

McNair, George A.,
Newcastle upon Tyne.
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NEW CANADIAN GEMMOLOGY COURSE

Carleton University launches a new credit course in gemmology for its third year geology students during the 1983 winter semester. Carleton is the first university in Canada to include the study of gemmology in its bachelor of science degree programme. The course will involve 24 hours of lectures and 36 hours of laboratory work. It will teach the crystallographic, optical, physical and chemical properties of individual gemstones; their genesis, occurrences, synthesis and identification; quality determination. The prerequisites are two second year courses: Mineralogy (67-222) and Crystallography and Optical Mineralogy (67-221).

This will be the University's second involvement in the study of gemmology. The first was in 1980, when its Continuing Education Department introduced a 10-session non-credit gemmology course in its evening division. This general interest course will continue to be offered. The lecturer for both courses is A. P. Sabina, F.G.A., G.G., mineralogist with the Geological Survey of Canada. For more information contact the Geology Department, Carleton University, Ottawa, Ontario K1S 5B6.

LETTERS TO THE EDITOR

From Mr J. R. Eason, F.G.A.

Dear Sir,

I am writing to aquaint you of the fact that the Gemmological Association of New Zealand has been born, and in the hope that you will publish a short note to that effect. At the moment we have a membership of 40. There are two classes of membership. Full members must hold a recognized fellowship of an approved Gemmological Association (that is to say, a fellowship by examination). Associate members must have undertaken, or be undertaking, a formal study of gemmology. The Gemmological Association of New Zealand was formed, at the instigation of Mr S. Currie, F.G.A., by fellows of the G.A. of G.B. resident in New Zealand, who felt the need for closer contact with other gemmologists in N.Z. to share items of interest and ideas, and to keep up to date with the latest developments in gemmology.

Gemmologists wishing to contact the G.A.N.Z. may do so c/o Easons Pharmacy, Cnr. Lodge and Edinburgh Sts, Pukekohe, New Zealand.

Yours faithfully,
J. R. Eason.

9th November, 1982.
Pukekohe, New Zealand.

From Mr S. A. Price

Dear Sir,

I have recently acquired a copy of *The Boy's Playbook of Science* by that Mr Pepper famed for his demonstrations of Pepper's ghost, and I take the liberty of sending you a small extract from this work. I do this, firstly because of the urge to share at least one nugget from so rich a mine and secondly in case you should feel that De Beers and G.E.C. should at least be apprised of the possibility of their being overtaken by some obscure researches at Kew.

Referring to the extract, I am unable to decide whether the conclusions drawn from Brewster's examination of the Koh-i-Noor are his own or those of Mr Pepper.

With regard to the book in general, the liberal use of phosphorus, ether, heated mercury, potassium, etc., in the suggested experiments in the first section on chemistry, seems to make it problematical whether its readers would have survived to enjoy Mr Goddard's splendid oxy-hydrogen (lime-light?) polariscope or learn which tourmalines are unsuited for making tongs (because of their colour) in the optical section.

Yours faithfully,
S. A. Price

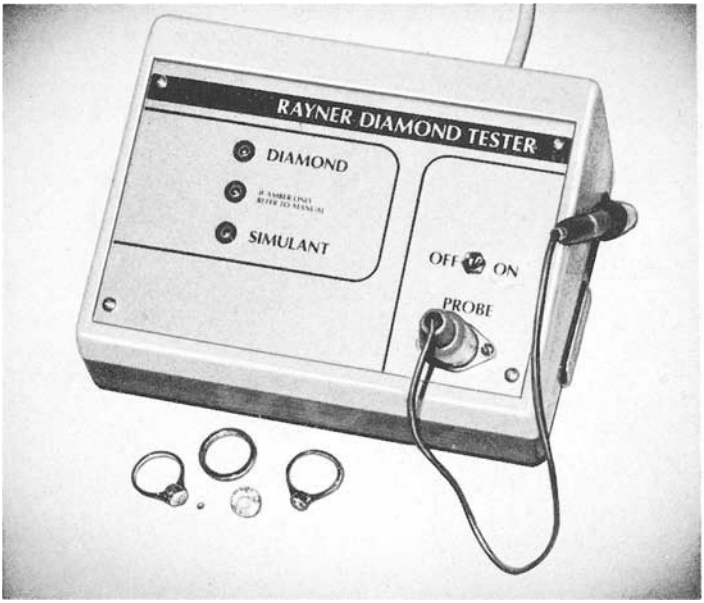
5th August, 1982.
Ipswich, Suffolk.

The extract from *The Boy's Playbook of Science* (J. H. Pepper, 1860) enclosed by Mr Price is reproduced below:

CARBON

A piece of carbon, in the shape of the Koh-i-Noor, was one of the chief attractions at the first Exhibition in Hyde Park. The diamond is the hardest and most beautiful form of charcoal; how it was made in the great laboratory of nature, or how its particles came together, seems to be a mystery which up to the present time has not yet been solved . . . . Sir D. Brewster, speaking of the Koh-i-Noor, remarks that on placing it under a microscope, he observed several minute cavities surrounded with sectors of polarized light, which could only have been produced by the expansive action of a compressed gas or fluid, that had existed in the cavities when the diamond was in the soft state.

Now it is known that bamboo, which is of a highly silicious nature, has the property of depositing in its joints a peculiar form of silica, called tabasheer. Silicon is one of the triad with carbon—i.e. it is allied to carbon on account of certain analogies; may it not then be supposed that, in times gone by, ages past, when the atmosphere was known to be highly charged with carbonic acid gas, there might possibly have existed some peculiar tree which had not only the power of decomposing carbonic acid (possessed by all plants of the present period), but was enabled, like the bamboo, to deposit, not silica, which is the oxide of silicium, but carbon, the purest form of charcoal—viz. the diamond? Speculation in these matters is ever more rife than stern proof . . . .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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 a minimum of 25 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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C O N T E N T S

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