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OF GREAT BRITAIN

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OF GREAT BRITAIN
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THE GEOLOGICAL SETTING OF THE NODULES AT DULCOTE, SOMERSET*

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Nodules and geodes from the Mendip Hills in Somerset have been known to mineral collectors for a few hundred years, but recently material of this kind from Dulcote, near Wells, has made a noticeable impact on the lapidary and gemstone market, due to the exploitation of a rich deposit in a quarry primarily worked for road and concrete aggregate. Various articles have appeared in the popular and scientific press describing the nodules and this article is an attempt to outline their geological setting and to summarize the latest ideas on their origin. Quartz nodules from the Mendips have been given different names at different times, being known variously as 'potato stones', 'Bristol Diamonds' or 'Bristol Stones', the diamond allusion having been firmly fixed in the sixteenth century. The 'diamonds' were subsequently correctly identified as quartz, but the controversy surrounding the nodules merely switched from their identification to their mode of origin.

Nodules and geodes occur in the conglomerate and marls of Keuper or Upper Triassic age (190 to 200 million years old) over an

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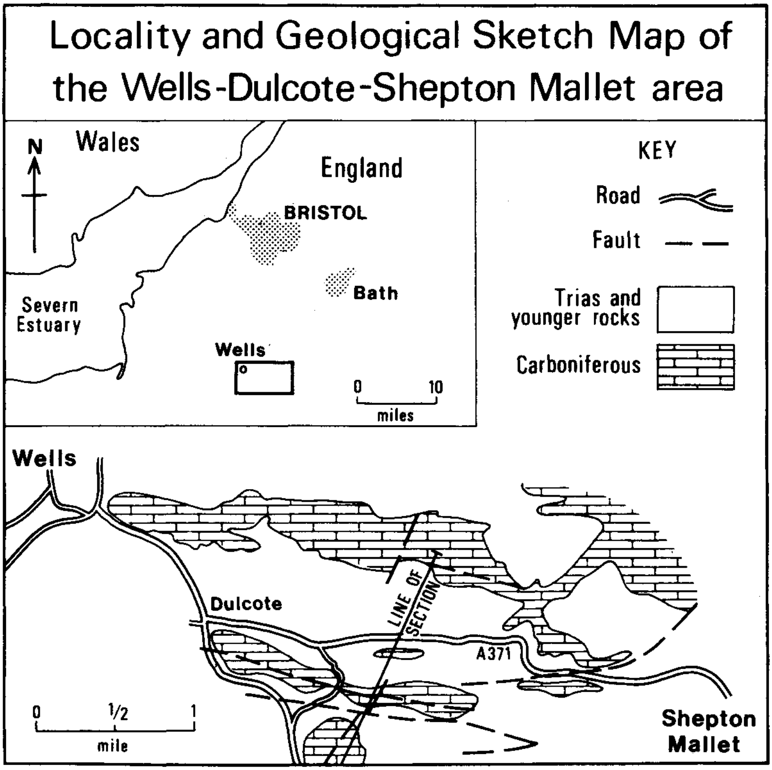

Fig. 1.

area extending from Bristol to Wells. In this region the conglomerates and marls rest unconformably on an uneven surface of folded and eroded rocks of Silurian, Devonian and Carboniferous age (i.e. on rocks formed between 420 and 280 million years ago). Figure 1 shows the areal extent of the Trias and younger rocks between Wells and Shepton Mallet, and Figure 2 shows how patchy and variable in thickness the Trias is on the limestone basement. The Keuper rocks consist mainly of red marls (calcareous and dolomitic mudstone and siltstone) with sporadic thin bands of greenish grey sandstone and marl, between 150 and 400 feet (50-130 m) thick north of the Mendips, but attaining up to 1500 feet (460 m) or more some way south of the Mendips. Between these two sedimentary areas the marls pass laterally into conglomerates and breccias (the Dolomitic Conglomerate) which are banked against the older rocks and represent a massive blanket

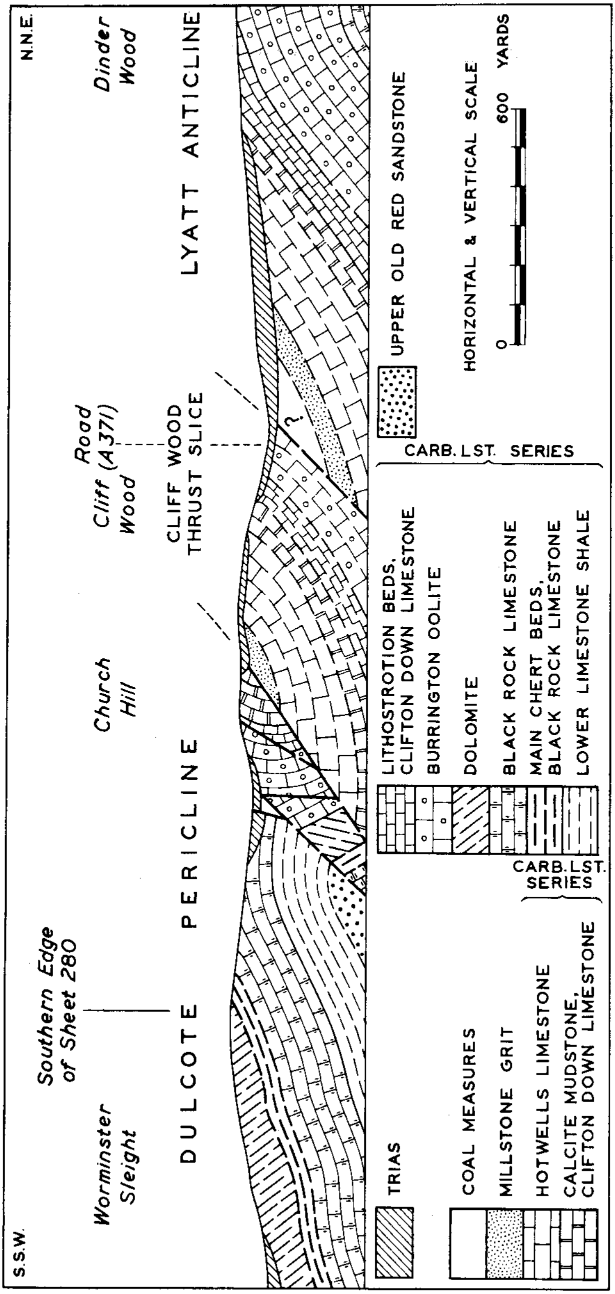

Fig. 2. Section through Carboniferous and Trias rocks near Dulcote (after Green and Welch, 1965).

of scree locally up to 350 feet (91 m) or more thick around the Mendips in a form strongly suggestive of an old shoreline or cliffline. The Dolomitic conglomerate is largely composed of ill-sorted fragments of Carboniferous limestone with some Old Red Sandstone and Quartzitic Sandstone Group (Millstone Grit) detritus set in a sandy marl or fine-grained calcareous matrix. Its calcareous nature has been modified over a large area by the introduction of magnesium and formation of dolomite, and in more localized patches it has suffered varying degrees of silicification and haematitization. The dolomitization affects both pebbles and matrix and is commonly accompanied by hydration processes, the results of which are most obvious in the hand specimen where dark red haematite (Fe_2O_3) has been converted into ochreous yellow limonite ($FeO(OH)$). Near the old shoreline of Palaeozoic rocks the conglomerate is very coarse-grained but farther away from the ancient land mass it passes into finer varieties with beds of marl intercalated with the pebble horizons until ultimately the succession consists of marl and minor fine pebbly calcareous sandstones. The local succession in the Trias below the Rhaetic is divided into the Keuper Marl (predominantly red-brown) and above it the Tea Green Marl (mainly grey-green). Both are affected, like the conglomerate, by dolomitization with $MgCa(CO_3)_2$ replacing the detrital and recrystallized calcite, and by hydrous fluids altering the iron oxides so that the rocks take on a yellow or pale brown hue. In addition to the carbonate and water components a wider variety of replacing fluids containing chloride and sulphate ions is indicated by the occurrence of halite, celestine, anhydrite and gypsum which occur both as matrix replacement minerals and as nodules.

In this wide range of sediment type and associated chemical variation occur the siliceous nodules (see Plates 1 and 2). Some are composed of medium to large quartz crystals with an inner layer of much smaller grains, while others consist of fibrous quartz with or without prismatic quartz. Both types of nodules are found with internal voids or with cores of quartz, calcite or celestine. Recent work on the structures and inclusions in the nodules by Tucker (1976) has confirmed that the silica grew from the outside inwards, but perhaps the most significant of his observations about the inclusions concerns anhydrite. This mineral is no longer found in any quantity in the hand specimen but occurs with carbonates and hydroxides as micron-sized inclusions in the milky parts of the quartz nodules and as even smaller inclusions in the chalcedonic ones. Tucker interpreted these textures (1976, p.571) to show that the siliceous nodules had formed by replacement of anhydrite—already in nodular form—and quotes examples of similar anhydrite textures in present day nodules in the Persian Gulf. Shearman (1966) has described in detail the environments in the Persian Gulf and the sediments in which anhydrite nodules are forming and suggests that ancient sulphate-bearing sedimentary rock sequences with nodular anhydrite were also formed in supratidal conditions in a desert tropical or subtropical climate. In this connexion Van der Voo and French (1974) have shown that the British Isles were also probably on the edge of the tropics in late Triassic times. A similar arid tidal-flat environment has been invoked for the formation of anhydrite concretions, subsequently silicified, in the Mississippian (about 340 million years old) of Tennessee by Chowns and Elkins (1974). They postulate that ground waters became saturated with $CaSO_4$ and deposited anhydrite in the tidal sediments, and say (op. cit., p.896) that the uncompacted nature of the nodules strongly indicates that silicification commenced before much sediment had been deposited above them. They are uncertain as to the origin of the silica but think it likely that most of it came from the breakdown of siliceous sponge spicules with perhaps later silica coming from the weathering of clay minerals. To account for both solid and hollow nodules Chowns and Elkins (op. cit.) and Tucker (op. cit.) favour the idea of different rates of solution of the anhydrite; in cases where the speed at which silica replaced the sulphate equalled the speed of sulphate solution, the resulting nodule would most likely be solid (Plate 2), but where the rate of solution exceeded that of silica growth, there would come a point when all the anhydrite had dissolved away and the silica would grow into a void (Plate 1). Solid nodules of chalcedony or jasper showing textures similar to the Dulcote stones have been described from an anhydrite bed of Upper Permian age (235 million years) by Harrison (1975). He considers that these nodules started as colloidal masses of silica, resting in anhydrite-rich groundwater, that coalesced and then solidified by rhythmic precipitation of chalcedony, incorporating varying amounts of haematite (giving colour banding) and also small amounts of fluorite and barite.

Little lead-zinc mineralization occurs either in the nodules or in the marls around Dulcote, although in the general area rocks as

PLATE 1. Four red and white geodes showing a variety of minerals in the cavities. In the upper specimen, yellowish calcite is the main cavity mineral with clear quartz and black specks of goethite evident in the top section. Pale grey-blue celestine in thin blades is well developed in two cavities in the left hand geode, providing a fine contrast with the amethystine blue of the quartz in the geode on the right. The lower specimen illustrates the transition from red silica to very clear massive quartz to discretely crystalline quartz - which gives the specular reflections in the picture.

The upper specimen is 20 cm long.

PLATE 2. The left hand nodule consists of white, grey and mauve chalcedony with crystalline quartz mantling the rounded masses of chalcedony in the core. At two spots on the bottom of the specimen and one spot on each side, black veins of galena can be seen to have penetrated up to 5 mm into the chalcedony. The right hand nodule is a beautiful example of concentric banded red and white agate. A selection of cabochons cut from mauve and from red and white material is shown.

young as the Lower Lias (about 170 million years old) are in places cut by fissures which are lined with galena (see Plate 2) and sphalerite. Again iron ore mainly in the form of limonite or goethite is widespread in pipes or fissures cutting the Carboniferous Limestone and Dolomitic Conglomerate but in the latter it also occurs as a metasomatic replacement along certain beds and is present as haematite or goethite in the nodules. It is likely that in some places at least iron mineralization predates the introduction of lead and zinc, for it lines some fissures bearing these ores, but it would be unwise to apply this conclusion to the whole mineral field as much secondary solution of the minerals has occurred.

At Dulcote the nodules occur in red and green marls above the Carboniferous Limestone, which here consists of part of the Burrington Oolite and part of the Clifton Down Limestone (see Fig. 2). Nodules are now extracted from the predominantly red marly clays from above the eroded limestones by a combined Foster Yeoman Ltd—Wessex Impex Ltd operation, and Van Moppes (of Wessex Impex Ltd) has carried out identifications of nodule types on 7100 lb (3220 kg) of material which he characterized thus:

Geodes:	red agate geodes with various minerals in the cavities:	11%
	white quartz-rimmed:	6%
Lapidary grade agate:	purple and red:	33%
Tumbling grade:	nodules containing some agate:	30%
Other grades:		20%

The general proportions are consistent with those found in a previous sample of 2400 lb (1088 kg), and it appears that from this particular area the majority of nodules are composed of red and white cryptocrystalline silica—falling into the fibrous quartz group of Tucker (1976, p.570), with only a small percentage showing good crystal terminations into central cavities. These proportions are not likely to be constant throughout the marls and conglomerates, for conditions of silicification, carbonate development and iron impregnation all vary markedly over distances of a few metres; it will be of interest to see what proportions emerge from future development of the deposits.

ACKNOWLEDGEMENTS

I am most grateful to Mr E.A. Jobbins for suggesting the topic and for his help, to Mr M. van Moppes for demonstrating the range of nodules found, to Mr Ted Airey, of Foster Yeoman Ltd, for guidance round Dulcote Quarry, to Mr G.W. Green and Mr R.F. Symes, who reviewed the text and suggested many improvements, and to Mr H.J. Evans for producing the colour plates.

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CERULEITE—A NEW GEMSTONE

By K. SCHMETZER, H. BANK, W. BERDESINSKI and E. KROUŽEK

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INTRODUCTION

Some time ago one of the authors got some rough and cut blue stones which in colour were very close to turquoise and which were offered as ceruleite. Ceruleite is not mentioned at all in some mineralogical textbooks or only with the sign '?' as a 'not exactly defined mineral' in the index; in others it is described in detail, but not in the appearance which will be described hereafter. Therefore in the beginning the authors thought that it might be a 'not exactly known mineral species'.

If one tries to determine samples of such a not exactly known or even unknown mineral, one first determines in the laboratory the chemical and physical properties and compares them with the properties of well known minerals. If one finds no satisfying congruence—naturally within the limits of error—but certain similarities with a known mineral, it is not easy to decide whether it is really a new mineral or whether there are only varying measuring properties (perhaps caused by impurities). If, furthermore, there are only few properties of the 'similar' mineral known and if the locality of the sample-material is not certain, the only possibility is a comparison with samples from the original locality of the 'similar' mineral to confirm the identity of both materials.

This was exactly the problem of our investigations with the Cu-Al-arsenate ceruleite. That the material in question indeed is the mineral ceruleite, could only be confirmed by comparison with an original sample of material from the originally described locality which we received by courtesy of the British Museum of Natural History, London, for which we acknowledge here our thanks.

H. Dufet (1900) described for the first time a Cu-Al-arsenate containing H_2O and called it ceruleite (céruléite) because of its sky-blue colour. The mineral had been discovered in several samples in Chile and came from the Emma Luisa goldmine near Huanaco in the Taltal Province. This first description by Dufet contains the only known data of ceruleite (chemical analysis, specific gravity,

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FIG. 1. Ceruleite from Bolivia—natural and cut.

solubility in acids). To our knowledge, no later supplementary investigations exist or at least are published. This fact has led to the varying position of ceruleite in the different systematic mineralogical textbooks and index tables. In some of them—Dana (1922), Doelter (1918), Fleischer (1975), Hey (1955), Hintze (1933)—the mineral is mentioned in the text part; Strunz (1970) mentions it in the index only with the sign '?' for 'not exactly defined minerals'.

The samples, which we got, come from Southern Bolivia, and it was not possible to get an exact locality though we tried our best. Since the ceruleite samples are in part at least worth cutting, the mineral is also worth describing in this *Journal*. Details have been published elsewhere (Schmetzer *et al.*, 1976).

RESULTS

The samples consist of concretions ranging up to 10 cm in diameter, macroscopically blue in colour (Fig. 1). Single individuals of the very tiny crystals, which form polycrystalline aggregates, cannot be distinguished. With a SEM micrograph, it was possible to recognize rod-shaped crystals up to 5 μm in length and up to 2 μm in thickness (Fig. 2). The concretions are coated on the surface partly by a crust of idiomorphic quartz crystals with inclusions of rutile and fine crystalline barite and goethite. On cutting the concretions, there have been found, in some pieces,

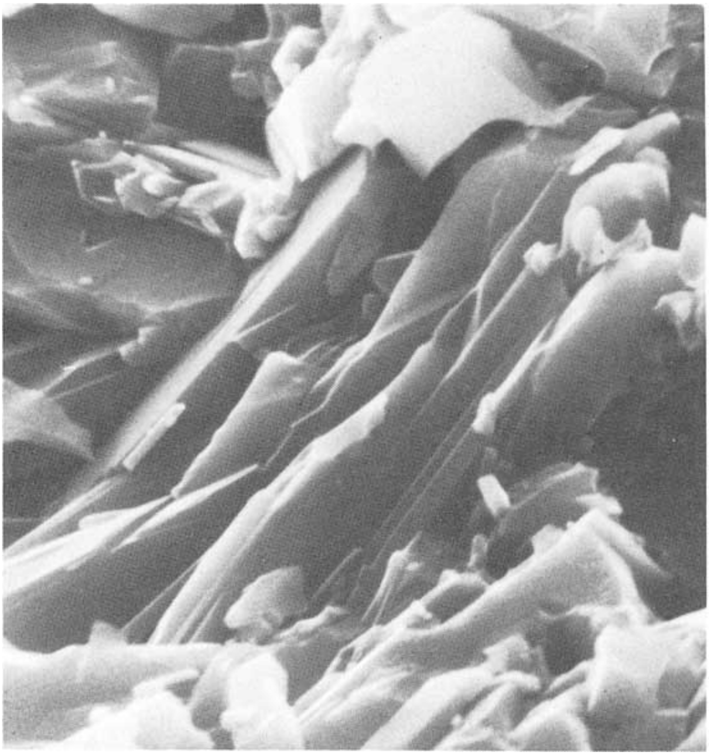

FIG. 2. Ceruleite crystals. SEM micrograph, 10 000×.

parts of white mansfieldite, which can range up to 1 cm in diameter. The specific gravity of the polycrystalline aggregates has been experimentally determined at 2.70±0.02 g/cm³. The refraction averages ≈ 1.60; more precise values could not be received either for refraction or for birefringence.

Ceruleite is not soluble in water, but it is attacked by HCl, HNO_3 and KOH. Wet chemical analysis of seven different samples show an average composition of:

CuO	11.8%
Al_2O_3	26.9%
As_2O_5	38.0%
H_2O	23.3%
	100.0%

This furnishes the crystal chemical formula

$$Cu_2Al_7\left[(OH)_{13}\middle|(AsO_4)_4\right].11.5\ H_2O$$

which differs from the formula and the analysis of Dufet (1900) by a lower content of Al_2O_3. We cannot exclude a small impurity perhaps of mansfieldite in our samples.

Since no single crystals of sufficient size have been available, the x-ray investigations were done by powder diffraction analysis. The strongest d-values are:

7.296	(75)
5.926	(70)
5.650	(100)
4.760	(70)
3.545	(60)
2.650	(60)

They can be indexed (supposing a triclinic unit cell) with the lattice parameters:

$$a_o = 14.36\text{Å}; \qquad b_o = 14.69\text{Å}; \qquad c_o = 7.44\text{Å}$$

$$\alpha = 96.1°; \qquad \beta = 93.2°; \qquad \gamma = 91.6°$$

A comparison of this blue investigation material from Bolivia with the ceruleite of the original locality in Chile has furnished an identical x-ray diffraction pattern for the blue, greenish-blue and colourless parts of the sample available. Thus the identity of the mineral from Bolivia with ceruleite has been confirmed.

Ceruleite is stable up to ≈ 230°C and at ≈ 250°C inverts to a blue-green crystalline phase losing 14.7% H_2O. This arsenate is stable up to ≈ 290°C. At higher temperature, there is formed a green substance, amorphous to x-rays.

For the commercial evaluation of a gemstone there are of importance colour, colour intensity or colour optimum. So far, ceruleite could be regarded, with its colour shades similar to those of turquoise, as a gemstone. Since it is similar to turquoise in hardness also, ceruleite may reach an important position on the world market if the occurrence furnishes enough material.

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GEMMOLOGICAL NOTES

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THE STAR OF INDEPENDENCE

The Smithsonian Institution was recently given the opportunity to have on loan, for a period of two weeks, a new and superbly cut diamond, named 'The Star of Independence'. The gem was exhibited in the Hall of Gems at the Smithsonian from 17th to 30th November, 1976.

The rough diamond weighed 204.10 carats and was found early in 1976 in Sierra Leone. It was then purchased by Harry Winston, the noted New York diamond merchant. The diamond was cut by Winston's diamond cutters and as the cutting progressed, it became apparent that the largest stone to be cut from the rough would weigh about 76 carats. The actual weight of the finished gem is 75.52 carats. However, rounding this figure gives an approximate weight of 76 carats and hence the gem was named 'The Star of Independence' in honour of the United States Bicentenary (1776-1976).

The author had an opportunity to briefly examine the gem. It

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is cut as a superb pendeloque with a faceted girdle. The most striking feature of the stone is the placement of 8-10 extra facets on the pavilion which does away with the 'black bow-tie' so common in pendeloque-cut diamonds. The finished product is a strikingly brilliant pendeloque worthy of its name. The gem has now been sold to an anonymous owner at an undisclosed price.

PHOSPHOPHYLLITE FROM BOLIVIA

Gem phosphophyllite was found in the Krause vein, Potosi, Bolivia, in the late 1950s. Little of the material has been cut. Owing to its softness 3-3½ and three cleavages on $\{100\}$, $\{010\}$, and $\{\bar{1}02\}$, this is a gem material more suited to museum care than to street wear. Bank (1975) noted the refractive indices of the material to be $\alpha = 1.599$, $\beta = 1.621$ with a density of 3.09 g/cm^3. Subsequent analysis of this material has shown that the Bolivian phosphophyllite, unlike the material from Hagendorf, Germany, is manganese-free and approaches the end-member composition of $Zn_2Fe(PO_4)_2.4H_2O$.

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ZEKTZERITE

A new mineral, zektzerite, has been found in a granite in Washington, U.S.A. The mineral was described by Dunn *et al.* (1977) as an orthorhombic lithium sodium zirconium silicate, $LiNaZrSi_6O_{15}$. The gem potential of the material is quite low, although gems up to 5-10 carats might be cut. Since several stones have been cut, it seems useful to set down the constants for the files of the practising gemmologist.

Zektzerite is orthorhombic, with a density of 2.79 g/cm^3 (±0.02). Refractive indices, in sodium light, for this biaxial negative gem are: $\alpha = 1.582$, $\beta = 1.584$, and $\gamma = 1.585$ (±0.003). The material is colourless to very light pink and has very low dispersion. It fluoresces a light yellow colour in short-wave ultraviolet radiation. There is no response to long wave ultraviolet and no phosphorescence. The Mohs hardness is about 6, and there are two perfect cleavages, at right angles to each other, which are parallel to

{100} and {010}. The material takes a good polish and, due to the two perfect cleavages, is best suited to rectangular cuts. It will probably only be encountered by the connoisseur of rare gems and museum curators.

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BLUE-GREEN GEM DRAVITE FROM EAST AFRICA

A stream-worn pebble of tourmaline was found in East Africa and is quite notable in that its colour, bluish-green, is unlike any of the hues normally associated with the common gem tourmaline, elbaite.

A small section of the waterworn single crystal was removed for analysis and the sample was analysed with an electron microprobe operating at 15 kV and utilizing a sample current of 0.15 μA. The resultant partial analysis is presented as Table I. The material is obviously dravite, a sodium magnesium tourmaline. Iron is present as a minor constituent, perhaps in substitution for magnesium. The dravite is uniaxial negative with $\varepsilon = 1.616$, $\omega = 1.637$, birefringence 0.021. The absorption is $\omega > \varepsilon$, ω = bluish-green, ε = light yellowish-green. No inclusions were observed.

The author is indebted to John Saul for calling his attention to the material.

TABLE I

PARTIAL ANALYSIS OF DRAVITE FROM EAST AFRICA

SiO_2	36.27
TiO_2	0.04
Al_2O_3	31.12
Na_2O	2.74
K_2O	0.02
MgO	11.89
CaO	1.43
FeO*	0.39
MnO	0.00
total	83.90

*total iron calculated as FeO

BLUE PECTOLITE FROM SANTO DOMINGO

Many tourists returning from Santo Domingo have purchased a gem called *'larimar'*. This gem material is comprised of radiating spherules of a fibrous mineral. The mineral has been x-rayed and found to be pectolite, $NaCa_2Si_3O_8(OH)$. The spherules vary from 2 to 8 mm in diameter. They are light blue at their centres and the colour changes to white at the exterior of the spherules. Due to the extreme toughness of the material and its attractiveness to tourists, it is likely to prevail as a gem material, but should be labelled pectolite, its true mineral name.

[*Manuscript received 17th May, 1977.*]

A STUDY OF EMERALDS FROM AN UNSUBSTANTIATED AFRICAN SOURCE OF ORIGIN

By I.C.C. CAMPBELL, F.G.A.

Upon one of my recent visits to Johannesburg to visit a personal friend of mine, Michael Sutherland, F.G.A. (who is also a practising gemmologist), I had the opportunity of seeing for the first time two comparatively large faceted emeralds of a fine deep bluish-green colour. One was temporarily made available to me after I had indicated my interest in its origin. Mr Sutherland and I spent some time examining this stone. The inclusions, apparent clarity, and hue of colour appeared initially to have some similarity to recorded data in relation to some synthetics—particularly modern ones. Such suspicions were not altogether unfounded because the colour and quality also appeared to be exceptional and the cut unusually good. Initially there were no, or very little, aspects of the inclusions in this particular stone which seemed clearly to indicate natural origin—other than perhaps the physical

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and optical constants which were high and at the top bracket of a few other varieties of natural emeralds. The other large stone was also eventually examined and found to have similar characteristics. Although the inclusions appeared similar to those in Indian emeralds, there were basic differences. A number of smaller stones which were said to be from the same source of origin were then obtained, and in fact covered a colour range from almost that of the two large stones mentioned above down to what may be described as medium shades and qualities. At a later date some additional medium to pale shades were also made available. All these, with a few variations, contained similar inclusions to the two above-mentioned large stones—however, other solid mineral inclusions were also observed in some of the smaller stones *together* with these types originally seen in the two large ones. These additional internal features confirmed that the stones were of natural origin, with the result that I decided to make the following study of the stones. This necessitated a number of visits to Johannesburg over the period concerned, as I did not have any similar emeralds at my disposal in Rhodesia at the time. A limited number of crystals in the rough were also seen which were of various qualities. They also contained similar inclusions to those seen in the other cut stones constituting this study. The uncut crystals were suitably immersed, thus making the internal examination much easier.

REGARDING POSSIBLE ORIGIN

Questions regarding origin were rather vaguely answered (maybe for trade reasons) and it would appear at this stage that a reliable answer is not to hand. All that could be finally learned was that they were from 'an African country somewhere to the north of Rhodesia and South Africa'. Rumours of Tanzania being the origin were also heard, but I think this is unlikely. Zambia should not be ruled out and may well be the source of origin. Other than limited mica flakes and some inclusions with the appearance of biotite, inclusions in these stones are *not* typical of emeralds from the Miku claims in Zambia. However, the refractive indices and specific gravity range are in part similar. I do not think Moçambique should be ruled out either, although (from a consideration of the circumstances) Zambia seems the probable source. Three emeralds from the Maria Mine (approximately 17 miles north-west of Marvë—in the north Quelimane district of Moçambique) were examined by me. They were of a poor colour although a good bluish-green is in fact mined. They do not fluoresce. The Refractive Indices were 1.577-1.584 (DR 0.007) and the SG was 2.70 to 2.71. Some inclusions were two-phase, but the general picture did not, in my opinion, reconcile with those seen in the test stones used in this study.

Finally, there is a possibilty that Zaire could also be the source of origin—information has been heard to this effect. The two serious choices are in my opinion either Zambia or Zaire. (I have since received several unconnected statements that Zambia is in fact the source, the new claims apparently being in the district in which the Miku claims are situated).

COLOUR

From what was seen, the colour appears somewhat similar to some good quality bluish-green stones from Zambia (Miku claims), but with what appears to be more brilliance (no doubt due to good cutting). This obviously grades down through the colour range to an insipid, almost slightly tinted bluish-green colour of ordinary beryl. Another comparison of some of the deeper coloured stones can be made to that of better quality Lechleitner synthetic emerald-coated beryl, except that the test stones are much brighter, coupled with a more full-bodied hue than the Lechleitner. Yet again, stones half the size of the two large ones appeared a slightly more grass green, although still having the bluish tinge to them. Possibly the differences in physical size had at least something to do with this. (In any case, a variation of shades has also been seen in most other emeralds from one source or another.) One could even say that the large spectrum of green shades that were seen were welcomed from a scientific point of view, especially when initially we had doubts as to the identity of the two fine coloured stones. One does not expect to see synthetics with this sort of colour range—not on the market, anyway.

MARKETING ASPECTS AND THE REQUIREMENT OF ADDITIONAL RESEARCH

These stones are apparently being cut in a number of Western countries. This has apparently been initiated only relatively recently. Just to what extent the stones have been released on to the market to date is a matter of conjecture, but the writer has not as yet seen anything in print about them—at least from a gemmological point of view. It is for this reason that the following details are given. It would, however, be of obvious advantage if other gemmologists were in a position to obtain similar stones (which must happen in due course) and enlarge upon what is reported here. Whatever additional results are achieved, such a contribution would benefit all concerned with gemmology. This was amply demonstrated by my original article 'Emeralds Reputed to be of Zambian Origin' (1973)(1) being followed up by the report 'The Emerald Occurrence of Miku, Zambia,' by Professor Dr Hermann Bank, F.G.A., (1974),(2) in which the source of origin was confirmed.

REGARDING THE COMPUTATION OF SPECIFIC GRAVITY

These were computed hydrostatically with the use of a Mettler H 800C balance. The liquid medium used was absolute alcohol, the SG of which was determined with a Westphal balance at the time of the exercise. Thereafter, the stones were re-tested against the computed figures with the aid of specially mixed heavy liquids on a comparative basis. As a result of this, one SG was found to be incorrect and re-computed after another weighing. The second figure proved correct.

SHORT-WAVE ULTRAVIOLET TRANSMISSION TESTS

Short-wave ultraviolet light was used (253.7 nm being the main activating radiation) with the two large test stones and some control stones together resting table facet down on photographic paper, the UV light being situated approximately 24 cm above. The exposure was for a duration of 2 seconds and another of 3 seconds. The former one gave better results. The two stones appeared to be opaque, or nearly so, to these rays, whereas two Zambian emeralds and a Lechleitner (except around the area designated by the crown facets) transmitted quite freely. It is also interesting to note that a Gilson synthetic was also opaque to these waves, and slightly more so than the two test stones which were much larger. It is acknowledged that this type of test no longer applies from a diagnostic point of view due to the incorporation of iron into the formula of more recent synthetic emeralds(3) and some natural ones as well.

Test Specimen Reference Number	*Wt Cts*	*Whether Faceted or Rough*	*Colour*	*Refractive Index & Birefringence*	*Specific Gravity*	*Photomicrograph Reference*
1	2.61	Faceted (emerald cut)	Fine deep bluish green	1.583—1.590 0.007	2.76	Figs 1-6 inclusive
2	2.48	Faceted (baguette)	Fine deep bluish green Bright	1.583—1.590 0.007	2.76	Figs 7-12 inclusive
3	1.12	Faceted	Fine moderately deep bluish green Bright	1.584—1.591 0.007	2.76	—
4	1.31	Faceted	Deep bluish green Somewhat dull Moderately heavily included	1.583—1.590 0.007	2.74	Figures 13, 14 and 15
5	0.68	Faceted	Very good moderately deep bluish green Fairly bright	1.583—1.590 0.007	2.75	—
6	0.46	Faceted	Very good moderately deep bluish green Suggestion of leaf green Bright	1.583—1.590 0.007	2.76	Figures 16, 17 and 18
7	0.31	Faceted	As per 6 above	1.583—1.590 0.007	2.76	Figures 19 and 20
8	0.61	Semi-faceted Part-crystal	A good medium bluish green	1.582—1.589 0.007	2.73	—
9	0.648	Small uncut crystal	Somewhat pale bluish green	—	2.73	—
10	0.919	Faceted	Moderately deep bluish green Bright	1.583—1.590 0.007	2.73	Figure 21
11	0.538	Faceted	Pale bluish green More like ordinary beryl than emerald	1.582—1.589 0.007	2.73	—

Refractive Index:	1 stone—1.584—1.591
	7 stones—1.583—1.590
	2 stones—1.582—1.589
Birefringence:	All stones—0.007
Specific Gravity:	From 2.73 to 2.76

FLUORESCENCE

The fluorescence, under the Chelsea colour filter, of the two largest stones (Nos 1 and 2) was in the first instance not noticed. However, after paying more attention to this it was noticed that there was a visible darkening of the stones. This applied to specimens referenced 3, 4 and 10 in the above schedule as well. Specimen No. 11 did not react at all and stayed a yellowish-green colour under the filter. However, the others, numbered 5 to 8 inclusive, showed a very slight tinge of reddish colour coupled with a similar dark appearance as described above. The remaining specimen (the uncut crystal of a somewhat pale bluish-green colour) showed a very slight darkening affect. The iron content (see

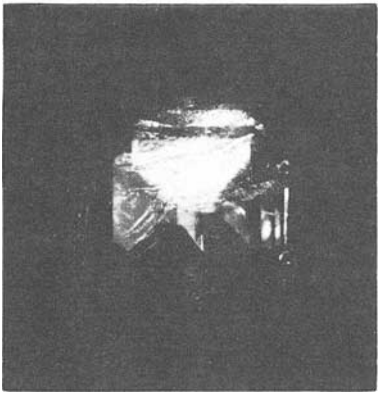

FIG. 1

FIG. 2

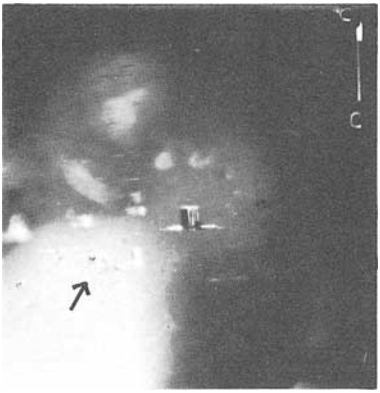

FIG. 3

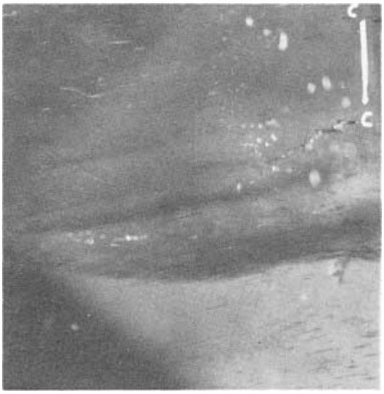

FIG. 4

FIG. 5

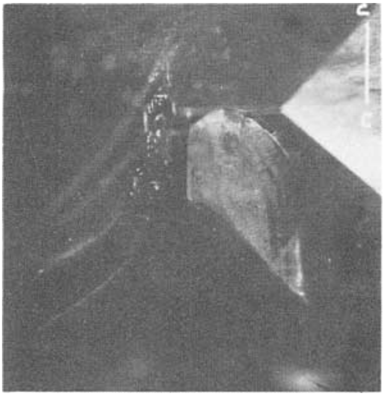

FIG. 6

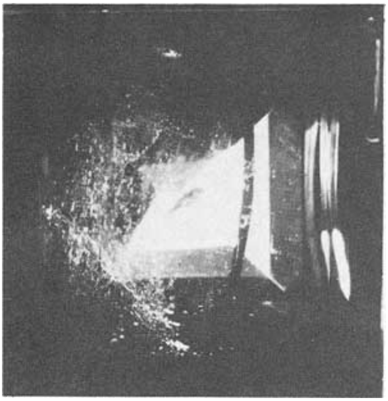

FIG. 7

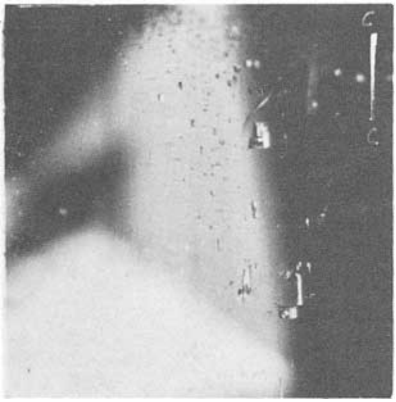

FIG. 8

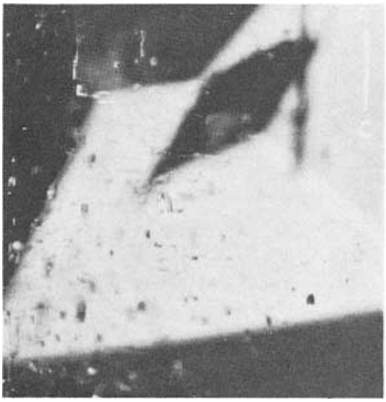

FIG. 9

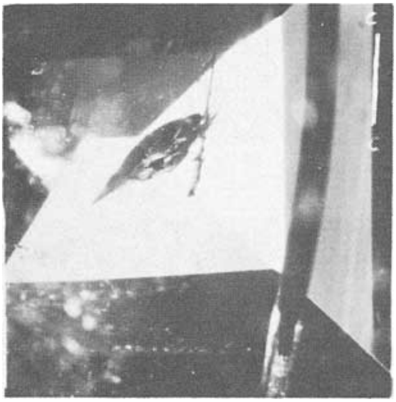

FIG. 10

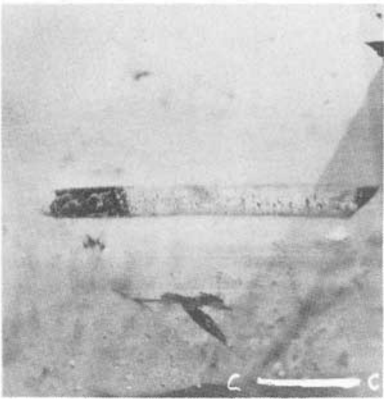

FIG. 11

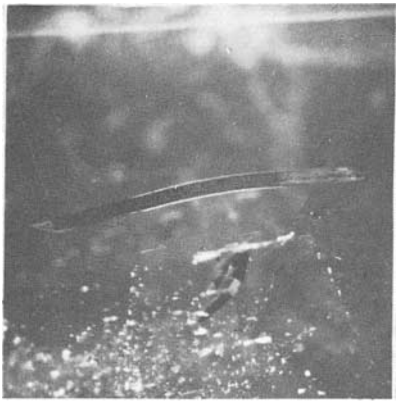

FIG. 12

FIG. 13

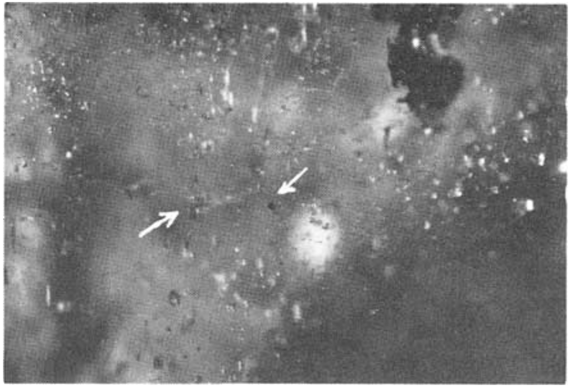

FIG. 14

FIG. 15

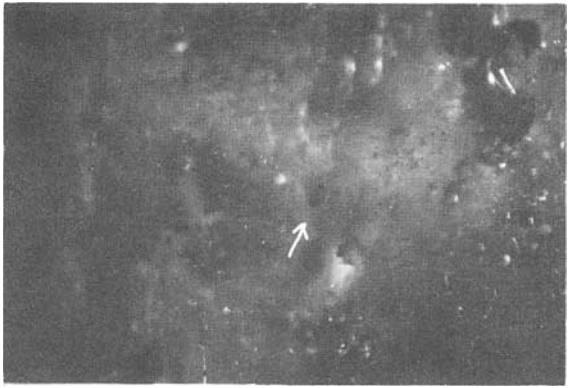

FIG. 16

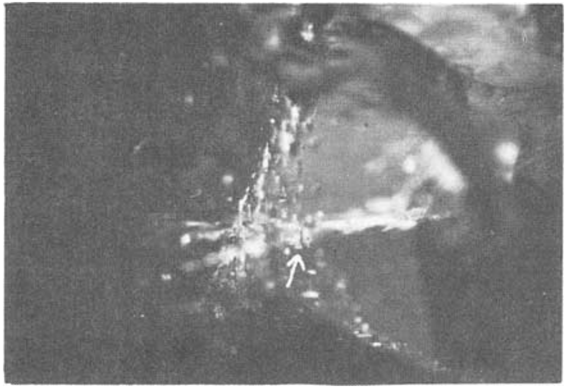

FIG. 17

FIG. 18

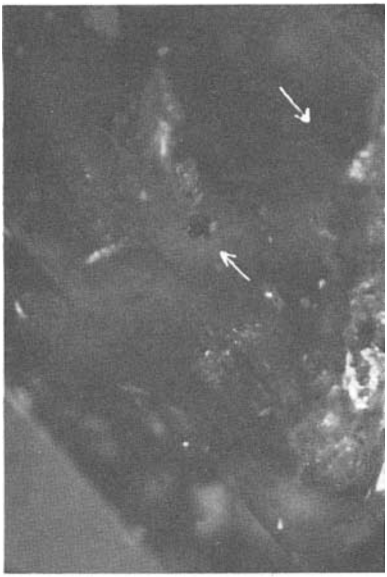

FIG. 19

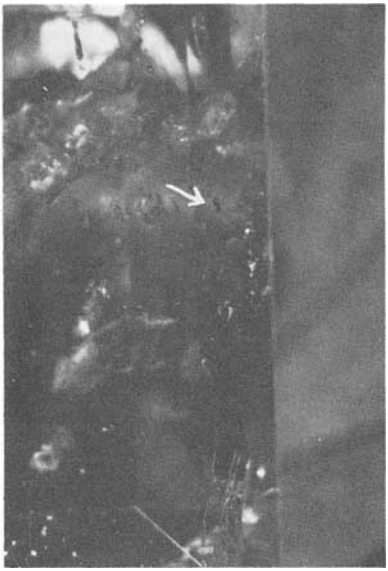

FIG. 20

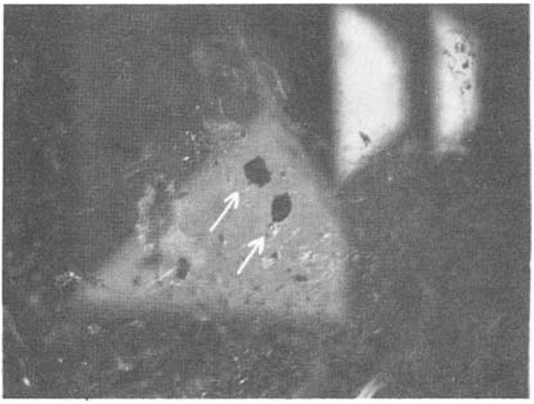

FIG. 21

under paragraph re absorption spectrum) has obviously had an effect on this property.

ABSORPTION SPECTRUM

Absorption for chromic oxide was noticed in all cases, with the intensity appearing to increase in step with the intensity of colour. It was strong in specimens 1 to 7 inclusive, less intense but still obvious in 8 and 10. However, the lines in the red were not at all obvious in the pale stone and could only be seen with difficulty. In all cases an absorption occurred for iron in the medium to lower part of the blue wavelengths when the stones were examined in direct lighting from below the microscope stage (with the spectroscope fitted in place of one ocular). In the paler stones transmitted light was used, which high-lighted the iron absorption bands more clearly. In some cases it appeared as though part of the violet was absorbed as well. In all cases the bands in the blue appeared somewhat diffuse without an obvious demarcation on either side. As the spectroscope (Rayner prism type) was not calibrated, it is not possible to write in terms of wavelengths.

ORIENTATION OF THE TWO LARGE STONES IN RELATION TO THE INCLUSIONS SHOWN IN THE PHOTOMICROGRAPHS, AND THE INCLUSIONS IN THE OTHER STONES

As was inferred earlier in this study, the general picture presented by the inclusions in the two (first seen) larger stones gave one the impression that perhaps they were of synthetic manufacture. Not until the other stones were examined did it become apparent that they were of, in my opinion, natural origin. The first two seen, really beautiful gems, contained what could be misleading inclusions to the average gemmologist. There were no other inclusions in either of these stones except the two-phase ones (and a rudder-like inclusion in each) which when coupled with other doubtful aspects gave food for thought. However, when the other stones were obtained and tested for similar properties the same type of inclusions were evident in all the stones (except the rudder-like inclusions), with the addition of other foreign crystals (which do not appear to have been seen in synthetics to date, as far as I am aware), thus bridging the gap between the two 'unsure' stones and what are now taken by the writer to be the other natural stones. (The writer has since been told that limited quantities have been obtained to date in South Africa as virtually 'mine-run' material. It has apparently been from these parcels that a limited number of good to fine quality stones have been sorted out, resulting in a good financial return on the amount paid for the parcel. This can, of course, only be accepted at face value until it is actually established that this is so). Another interesting thing about the rough material is that it appears to be abnormally difficult to orientate in relation to obtaining the best cuts from the material.

As the two larger stones gave some problems initially (in spite of the high RI and SG) the results of the photomicrography are given in detail. The remaining photomicrographs of the inclusions in the other stones, much more limited in this context, serve as visual evidence of the common association of all the stones and an indication of their natural origin. The photomicrographs of the larger stones are numbered 1 to 12 inclusive. In numerous cases considerably enlarged prints from the negatives give much clearer indications in relation to the comments below. The optic axis (hence the *C*-axis) of each of the two large stones was orientated with the combined aid of a polariscope and refractometer. Each photomicrograph is marked accordingly where applicable. Magnifications are listed in the schedule as well as under each photomicrograph. Attention is drawn to the following features:

Figure No.	*Magnification (Contact prints)*	*COMMENTS* *Relating to Specimen No. 1* *(Wt—2.61 ct)*
1	6 ×	Overall view of stone with table up. Note curved feathers. (As opposed to 'twisted' veils generally seen in the majority of synthetics.) For large inclusion near culet (or wedge) see No. 6
2 and 3	Both 60 ×	*TABLE FACET UP* These two views are exactly the same in all respects but for one exception. It was noted that the bubble in the left hand inclusion behaved somewhat strangely, while the test specimen remained untouched. It moved 'up' and 'down' with the change of temperature as a result of the substage illumination being reduced or increased—introducing an obvious temperature change. It was difficult to substantiate whether or not the inclusion was actually slightly tilted to the horizontal plane; however, tilted or not, it looked odd to see a bubble with a reciprocating action when its host remained stationary. In order to maintain the light intensity for the purpose of photography, the test specimen was fanned until the bubble moved 'downwards' and the negative thus exposed—(Fig. 2). The fanning was stopped, the bubble travelled 'upwards' (Fig. 3), and the next negative then exposed. It would seem to indicate a critical balance between gas and liquid.
4	40 ×	*TABLE FACET UP* Brush-stroke type inclusions. Other coarser inclusions are also apparent and are approx. parallel to and at right angles to the main *C*-axis (two directions).
5	40 ×	*TABLE FACET DOWN* A clear view of 2-phase inclusions accompanied by other inclusions butting up to one extremity in each case and at right angles to them. Again, one will be seen to have a vaguely striated appearance which is parallel to the length of the inclusion.
6	24 ×	*TABLE FACET UP* A clear view of a rudder-like inclusion protruding into the stone near the culet (or wedge). An interesting observation here is that this inclusion is similar in appearance to that in the other test stone shown in Figs 7, 9, 10 and 12—and also similarly positioned in the host. Nothing like this was observed in specimens examined later. (There is the possibility that the two gems could have been cut from the same piece of rough.) As can be clearly seen in this view, this internal 'protrudence' exhibits curved 'striations', is basically curved at its extremity, and has what appears to be possible external faces along the curved edge. It is more or less aligned to the *C*-axis of the host. Note curved feathers again.

Figure No.	*Magnification*	*COMMENTS* *relating to Specimen No. 2* *(Wt—2.48 ct)*
7	10 ×	*TABLE FACET UP* The concentration of feathers at the right—particularly the upper right—have a curved appearance, not entirely unlike those seen in most synthetic emeralds—although more recently made synthetics show curved veils much less than their older counterparts. See relative photomicrographs below in relation to the two obviously large features shown here—the internal 'protrudence' near the culet (or wedge) and the 'black' curved one across the stone.
8	40 ×	*TABLE FACET UP* A clear view of more two-phase inclusions under higher magnification. There appears to be a tapering affect in some. Note again, the striations on the one two-phase inclusion which gives it the appearance of a piston (the bubble inclusion giving the illusion of the hole that accommodates the gudgeon pin). The orientation in two planes is still obvious. An interesting aspect of this view is the obvious zoning, parallel to the *C*-axis. In fact, both stones showed a broad, slightly paler, colour zone more or less through the centre of the stones and visible end on—i.e. when observing the stone from the side in the direction of the optic axis. The one large stone (the emerald-cut one) showed a similar band—which was less visible than the one in this specimen and at a slight oblique angle to the table facet. This zoning was *not* accommodated with demarcation lines when the stone was examined with the unaided eye under suitable lighting.

9	40 ×	*TABLE FACET UP* Larger inclusion at centre of photomicrograph (which was much clearer when viewed under the microscope) appears to have an irregular (negative?) crystal form. The existence of this particular inclusion as being a two-phase one was not at all apparent.
10	24 ×	*TABLE FACET UP* View of a rudder-like inclusion similar to that in Fig. 6 (in the other stone). The surprising thing about this is the remarkable similarity not only in overall shape but in their position in each stone. It is not known what the ragged 'inclusion' near it is. The curved, dark inclusion (seen obliquely here) is shown in Figs 11 and 12.
11 and 12	Both 16 ×	*STONE RESTING ON A PAVILION FACET AND IMMERSED.* (Fig. 11) The first reaction here is that this inclusion is a seed plate, which it is not. The inclusion itself takes the form of a 'ribbon' which is comparatively thin in section and curved. The view shown here is an oblique end one (i.e. this is not its thickness). The angled end corresponds to the surface of a pavilion facet. Also note the zoning parallel to the *C*-axis. In this view demarcation lines are obvious. This type of zoning was noticed in numerous other stones as well.
		STONE AGAIN IMMERSED: TABLE FACET DOWN. (Fig. 12) Another oblique view (other way round) of the curved inclusion. Curvature even more obvious. This looks very much like a fracture. *NOTE:* Both these exposures were taken in overhead transmitted light. In substage lighting (see other prints) this inclusion showed as black.

NO OTHER FOREIGN MINERAL INCLUSIONS WERE SEEN, OTHER THAN TWO RUDDER-LIKE (SOLID?) ONES IN THESE TWO LARGEST STONES.

Figure No.	*Specimen No. Magnification*	*SOME OF THE OTHER STONES* (Specimens 4, 6, 7 &10)
13 and 14	*SPECIMEN No. 4* 40 × 60 ×	Fig. 13 shows similar inclusions to the two largest specimens, except in greater abundance. Also a 'black' looking crystal (Fig. 14) of unknown identity at the centre of the view. What appeared to be yellowish-brown iron stains were present in flaws well within the stone. Although appearing like part of a mica flake, this is not so. ('Terminated' both ends). Another view, which prevented successful photography, showed this to have the appearance of a terminated (black) crystal. Another, similar in colour, inclusion seen (which could not be successfully recorded because of its location) looked very much like a well terminated magnetite of octahedron form but this could well be another mineral species.
15	*SPECIMEN No. 4* 40 ×	Lozenge shaped, flat inclusion. Transparent. Rounded corners. Slightly deeper green in colour than body colour of stone. Location close to black inclusion mentioned above.
16	*SPECIMEN No. 6* 40 ×	Showing two-phase inclusions typical of all the specimens. Diagonally opposite this are fractures a little out of focus, but re-focused as shown below in Fig. 17.
17 and 18	*SPECIMEN No. 6* 40 × 60 ×	Iron stained fracture with hair-like inclusions orientated at approximately right angles to the fracture planes. Also (Fig. 18) ragged, apparently tapered, hollow inclusion.
19	*SPECIMEN No. 7* 60 ×	An oblique view of an inclusion which appears to be similar in appearance to the striated ones clearly shown in Fig. 2 and Fig. 8. Also irregular, black (biotite?) inclusions (bottom right).
20	*SPECIMEN No. 7* 40 ×	Black, geometric shaped, inclusion near edge of specimen and just below the surface. Other black inclusions of irregular shape also present. (Transmitted light). In substage light the inclusion of geometric shape reflects light, giving the inclusion a transparent quality as noticed in mica under similar conditions. Other black, thin (some partly geometric, others irregular shaped) inclusions also seen but not shown here. (Black in both transmitted and substage lighting). Not seen in this photograph, were also numerous hair-like inclusions in circumstances similar to those described in Specimen No. 6 (Fig. 17) above.
21	*SPECIMEN No. 10* 40 ×	Thin, irregular and geometric shaped inclusions of a pale brownish colour. Appear to be limited in quantity. Only a few were seen in three stones. Possibly a form of mica (similar to that seen in Zambian emeralds from the Miku claims).

IN CORRELATION OF THE FOREGOING FINDINGS (INCLUSIONS)

(i) As already stated, before the other specimens were seen the writer's thoughts were that a possibility existed that the two initially examined largest specimens were synthetics. This was in spite of the high physical and optical constants. This view was also held by Michael Sutherland who, as I said, examined one of them with me in the initial stages. (He also examined others later). Only Indian emeralds bear any resemblance to the type of inclusions seen in these test stones—and then Indian stones at least have some indication of biotite or fuchsite in them. The 'comma' type negative twin crystals of Indian emeralds have been reported as negative twin crystallites that have grown on one side of a mica flake.(4) Pakistan emeralds contain two-phase inclusions and thin films, of the details of which not a great deal appears to have been printed.(5) The constants of Pakistan emeralds are similar to these test stones. However, in view of unconnected sources of information that the test stones are of African origin, it is considered reasonable to accept that they are not of Pakistan origin. Other than the similar physical and optical constants (and colour in many cases) of Zambian stones of Miku origin, there is no relationship with presently known facts insofar as the inclusions are concerned. This does not of course, rule out the possibility of a new Zambian discovery. One thing seems apparent—these stones are from a newly discovered source of origin in or about central Africa.

(ii) Notwithstanding stones of this species which contain the additional type of inclusions as found later in the smaller test stones, future ones of a rich bluish-green colour which contain *only* the inclusions seen in the two larger test stones could, in the writer's opinion, be somewhat misleading—resulting in a possible misidentification. Inclusions and descriptions given by Gübelin (including photomicrographs) appear to have, in part, a similarity to the two large test specimens.(4) The high constants of the original two test stones did, however, give food for thought at the time—although it has been reported that recent synthetics have constants well into the natural range (many being quoted, but none as high as these test stones). The addition of larger quantities of iron into the basic formula in recent synthetics is responsible for this. The test stones also have a significant iron content. Quite apart from this, the curved nature of the feathers in the test stones—many being of a coarse nature, however—can lead to a possible misinterpretation of origin if this is not accompanied by other mineral inclusions.

(iii) The additional inclusions in the smaller stones gave a different outlook and, in the opinion of the writer, support the view that these are natural stones. The identity of the inclusions is not known. Mr Sutherland, who also saw thin rounded 'flake-like' inclusions of a pale brownish hue of colour, wondered if perhaps they were oil. Fluorescent tests conducted under the microscope showed no fluorescence—then again, as the stones have a significant iron content this may have affected the results. Having seen similar flakes, though sparsely situated, which have definite geometric outlines (hexagonal in some cases, or part of a hexagonal form) the writer is of the opinion that it is one of the micas. (Since then, a similar type of flake of a rounded nature was noticed in another similar variety of emerald to that of these test stones by both Sutherland and myself. It was at the crown surface and, with the aid of a probe, we established it as one of the micas.)

(iv) A summary of the inclusions found in the test stones is as follows:

(a) Two-phase, comprising two parts, orientated at right angles to each other with the main component parallel to the *C*-axis. These inclusions appear to be part of curved feathers.

(b) Both coarse and fine feathers. Many of a curved nature.

(c) Brush-stroke type formation of what appear to be densely packed thin tubes more or less orientated in the same direction to each other.

(d) One component of the double inclusion (the bubble-included one) often of a striated nature and orientated parallel to the *C*-axis of the test stone.

(e) An odd rudder-shaped internal growth in the two largest stones but not appearing in any of the others.

(f) Colour zoning parallel to the *C*-axis of the host stone.

(g) Tubular, two-phase inclusions parallel to the *C*-axis of the host stone and other tubular inclusions at right angles to this.

(h) Flat, 'plate-like' inclusions upon which stand the principal two-phase ones.

(i) Crystals, limited in quantity, which resemble black or blackish solid crystals. One *looked* like an octahedron of magnetite. Others did not.

(j) Lozenge shaped, thin transparent 'flakes', which are almost certainly one of the micas.

(k) Yellowish-brownish stained internal fractures (iron stains?) and coarse-looking cotton-wool type clouds in one stone with the same stains in and around the localized area well within the stone.

(l) Black geometric and irregular shaped inclusions. (Biotite and/or some iron compounds).

(m) Hair-like growths extending from fractures within two stones.

CONCLUSION

From the foregoing data, it appears that these stones are in fact from a new unconfirmed source—probably Zambia. The information given here should help to identify them from other varieties. There is an overlap or coincidence of refractive indices and specific gravities in relation to limited numbers of emeralds from other origins, but the inclusions are distinctive and coupled with the physical and optical constants they should serve their purpose as a means of identification of this species—of whatever origin they turn out to be.

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[*Manuscript received 17th May, revised December, 1977.*]

J. Gemm., 1978, XVI, 2

THE ROLE OF REFLECTIVITY IN GEMMOLOGY

By W. WILLIAM HANNEMAN, Ph.D.

PART I. FRESNEL REFRACTOMETERS

A Fresnel refractometer operates on the principle that the quantity of light reflected from the polished surface of a gem can be related to the Refractive Index (RI) of that gem. The equation developed by Fresnel in the early 19th century is shown in the Appendix (on page 113).

The index of refraction, n, by definition equals the ratio of the velocity of light in air to the velocity through the medium.

However, the velocity of a light ray through a gem varies with the wavelength of the ray. It therefore follows that for any gem, the value of n is different for each different wavelength of light. Indeed, the magnitude of the change in n between two selected wavelengths is, by definition, the gemmologist's dispersion.

Because of this variation of n, confusion would be sure to reign, if some standard wavelength were not agreed upon for making measurements of n. As a result, 589 nm was chosen, because essentially monochromatic light of this wavelength can be readily created in the laboratory. This corresponds to the D line of Fraunhofer in the spectrum of the sun and is due to sodium. These values were designated by the symbol n_D and it is these values which are now known to gemmologists by the term Refractive Index (RI).

Although it has been known since the time of Fresnel that one could construct a refractometer if one could only devise a means of determining the fraction of light reflected from the surface, it is only recently that technology has made this feasible.* Does this mean that the Fresnel Refractometer will now become a significant gemmological instrument? For the reasons set out below, I do not think so.

Long ago, scientists recognized the usefulness of RI (n_D) values and the critical angle refractometer was developed and has become an indispensable tool of the gemmologist. Using sodium light, he

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*It should be acknowledged that a great deal of work has been done on this principle in the past and can be found referenced in any text on optical mineralogy. While useful for characterizing ore samples, the difficulty of making accurate absolute measurements precluded the development of a practical gemmological instrument.

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can easily measure the refractive index or indices of a gem to three decimal places. The value of double refraction (birefringence) can also be determined as well as optic character. He can even make a good estimate of dispersion by using white light. As a laboratory tool, the critical angle refractometer leaves little to be desired except that its range is limited so that it cannot be used to differentiate the high RI gems, including the modern simulated diamonds.

The Fresnel Refractometer is not so limited and now such a 'universal' instrument can be, and in fact has been, constructed. However, the practical question is whether such an instrument will be useful enough to justify the expense of its construction. The answer to this question would undoubtedly be 'Yes', if the Fresnel Refractometer could duplicate all the functions of the critical angle refractometer and replace it: but it cannot. In spite of its 'unlimited' range, the Fresnel Refractometer cannot either (1) detect double refraction (much less measure its value), or (2) determine optic character, or (3) indicate dispersion. Therefore the only really useful function it can perform is to determine the RI of gems above 1.8, and it really cannot do this too well, as explained below.

The operation of the critical angle refractometer is based on determining the point of total internal reflection of a beam passing from a medium of higher n (the prism) into one of lower n (the gem). This manifests itself in the instrument as a discrete division between a light and dark area. It is easy to observe, easy to measure accurately and if a reading can be made at all (i.e. if the specimen is within the instrument's range) it will be the correct value. Small scratches or imperfections on the gem surface are of no consequence.

The Fresnel Refractometer operates by determining the percentage of light reflected when a beam passing through a medium of lower n (air) strikes the polished surface of a material of higher n (the gem). There is a gradual change in the quantity reflected as the angle of incidence changes and there is a different quantity reflected by different gems at the same angle. The Fresnel Refractometer must be constructed to record these differences and this can only be done, practically, by electronic means.* The only

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*The late L.C. Trumper, B.Sc., F.G.A., using visible light and no electronics, constructed an optical Fresnel-principle reflectometer (claimed to provide direct readings of refractive index between 1.40 and 3.20), which he described in *The Measurement of Refractive Index by Reflection,* J.Gemm., 1959, **VII**, 4, 129-38: but there appears to have been no follow-up.

observation by the operator is merely that of reading an electronic meter.

This might be perfectly acceptable if the index of refraction (n) were the only factor which determined the quantity of light reflected. However, any imperfection in the gem surface in the form of poor polish, scratches, dirt, etc., may drastically affect that value and the resulting meter-reading will be low. Also, 90% or more of the incident beam actually passes into the gem and may be reflected again from a back facet. This could lead to high meter-readings.

All of the identification schemes of gemmology depending on the index of refraction are based on the premise that the RI value obtained from a refractometer is indeed the correct value. Consequently, any refractometer capable of providing an erroneous value must be looked upon as an instrument capable of doing more harm than good. The Fresnel Refractometer is such an instrument. The Fresnel Refractometer is not inherently limited by its own design: it is limited by the condition of the gem.

In order to build a Fresnel Refractometer, one must construct an electronic instrument containing a light source, a focusing system, a light detector and a read-out meter. Let us examine these components separately.

Light Source: Since this is going to be a gemmological refractometer, it is imperative that the value it determines is n_D and this means that a sodium light source is required. This is a relatively expensive component and I have yet to see anyone attempting to make a commercial instrument of this design. However, by using a white light source, one can obtain values approximating n_D. Such an instrument has been patented by Long.(1) It is a very complex and expensive instrument and is not currently available commercially.

However, from a practical gemmological viewpoint, there is another insurmountable problem facing the Fresnel refractometer. Diamond and strontium titanate have n_D values which are so close together that they cannot be differentiated on an electronic meter scale. This severely limits the usefulness of the instrument for differentiating the simulated diamonds.

Several commercial instruments (Gemeter and Redex)* have been constructed using infrared light sources. These can indeed

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*Redex is understood to be no longer commercially available and Gemeter is now spelt with a J.

separate diamond from strontium titanate, because in this energy range the values of n for these two substances are significantly different from each other (and also from their n_D values). It would appear that the manufacturers of these infrared instruments either did not appreciate the fact that the instruments were not determining n_D or else ignored it in an attempt to create a 'Fresnel Gem Refractometer'. In any event, diamond reads 2.41 on their RI scales and this left R. Webster(2) and other gemmologists wondering whatever had happened to the RI of strontium titanate which appeared on the scale at about 2.2 to 2.3. It seems, also, that these instruments were plagued with detector linearity problems which created calibration difficulties. As a result, they were not widely acclaimed by the critics.

Focusing System: Fresnel's equation relates n to the ratio of the reflected light to the incident light. Therefore, in order to determine this ratio, one must accomplish one of two things, namely either (1) devise a system to measure the total light impinging on the gem surface and another system to measure the total light reflected from the gem surface, or (2) devise a means of focusing and shielding, so that all the light falls only on the gem surface or that only light reflected from the gem surface strikes the detector. Either approach results in a complex instrument with the associated high manufacturing costs.

Detector and Read-out Systems: If Fresnel's equation is to be used, the detector response must be linear with respect to the amount of light striking it. This response is then displayed on a meter. Being a manufactured item, each meter has a specification as to its accuracy. The more accurate the meter, the more costly it is and the best meters are usually no better than ±0.5% of full scale. This can result in a variation of about ±0.01 in the RI value and this is due solely to the meter. When the other sources of error are considered, it is readily apparent that the determination of RI with a Fresnel refractometer can be a very risky business.

Tatsumi(3) also acknowledged the shortcomings of the Fresnel Refractometer when he wrote, 'Measurements on several gemstones with higher refractive index by this instrument showed that we could identify them, provided that stones have a refractive index of over 1.81'. A key word in that sentence is 'several': as the data in Table I which lists some gemstones having RI values between 1.9 and 2 indicates, identification is impossible with a refractometer which cannot determine double refraction. Unfortunately, the practising gemmologist does not have the luxury of specifying which gems he is going to accept for identification.

TABLE I

	Expected RI Range of Fresnel Refractometer Reading
Zircon	1.92—1.98
Scheelite	1.92—1.94
Sphene	1.88—2.05
Yttrium Aluminate	1.93—1.96

All the preceding may leave the reader with the idea that reflectivity has no significant role to play in gemmology. This is not at all true and I shall explain just what that role is in Part II—Relative Reflectivity.

Appendix

Reflection of light by a transparent medium in air (Fresnel's formulae). If i is the angle of incidence, r the angle of refraction, n_1 *the index of refraction for air (nearly equal to unity),* n_2 *index of refraction for a medium, than the ratio of the reflected light to the incident light is,*

$$R = \tfrac{1}{2}\left(\frac{\sin^2(i-r)}{\sin^2(i+r)} + \frac{\tan^2(i-r)}{\tan^2(i+r)}\right)$$

If $i = 0$ *(normal incidence), and* $n_1 = 1$ *(approximate for air),*

$$R = \left(\frac{n_2 - 1}{n_2 + 1}\right)^2$$

PART II. RELATIVE REFLECTIVITY—THE JEWELER'S EYE AND LUSTERMETER

Anyone having the slightest association with gems is well aware that some gems have a greater lustre (i.e. reflect more light) than others. In Part I it was shown that Fresnel mathematically related the fraction of light reflected to the index of refraction of the substance (providing the surface was clean and well polished). As a consequence, today many believe that it is the RI of a gem which *determines* its lustre. This is not true. The RI is nothing more than a pure number expressing the ratio of the speed of light through air to its speed through a material. It is true that the RI value may be used to calculate the reflecting *potential* of a gem; however, it is the *chemical composition* and the *atomic structure* of that gem which govern the stone's optical and physical characteristics and consequently control its *theoretical* potential reflectivity and in addition its maximum degree of polish and therefore its *practical* potential reflectivity.

It follows, therefore, that one should be able to construct an instrument which relates the quantity of light reflected by a gem surface (i.e. the meter-reading of a reflectometer) to the chemical composition and atomic structure of a gem, which in combination are adequately defined by its name.

Such an instrument, the *relative* reflectometer, has been developed and is marketed under the name 'The Jeweler's Eye'. The late Robert Webster, F.G.A., has previously discussed the mechanics of this instrument in this *Journal*(4).

The relative reflectometer differs from a Fresnel reflectometer in that all of the reflected energy striking the sensor is not reflected from the gem surface. Some comes from the back of the plate on which the gem rests. This configuration simplifies construction to some extent, allows for the use of a smaller hole and makes possible the examination of smaller gems. However, it precludes the use of a standard precalibrated scale for all instruments.

In recognition of the effects of different components comprising each instrument and of the fact that there will be a spread in readings due to birefringence, strain and isomorphous substitution, each instrument is individually calibrated to show a series of regions of expected response for different gems (Figure 1).

The Jeweler's Eye was conceived and designed as a tool to help confirm the identity of gemstones offered for sale in circumstances where there is no access to the full array of gemmological instruments. The philosophy behind the successful operation of 'The Eye' can be summed up as follows. Given a gem which appears to be well polished and clean, and is indeed what the seller claims it to be, then the response on the Jeweler's Eye should fall in the region designated for that gem. If it doesn't, there is something amiss—the gem may not be what the seller claims it is or the surface may

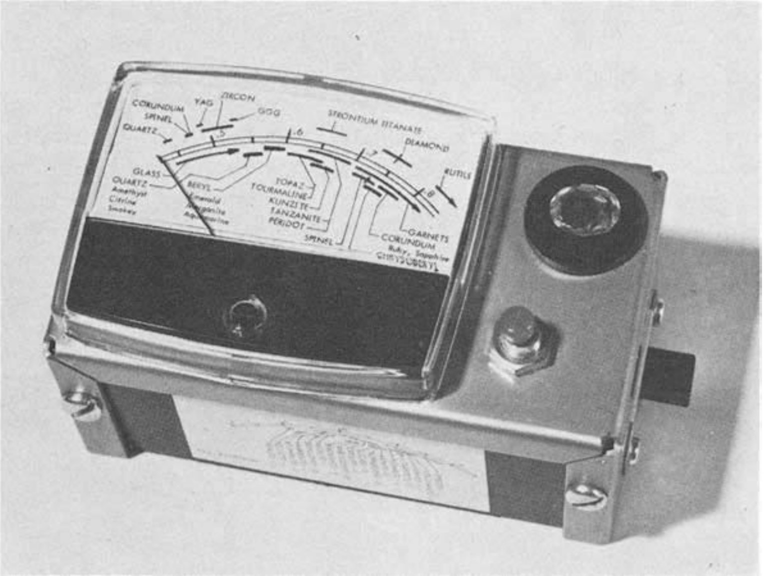

FIG. 1. The Jeweler's Eye, calibrated to show regions of expected response for different gems.

actually be flawed or dirty. Find out before you purchase it. Consider yourself warned!

The Jeweler's Eye can only be understood, appreciated and properly utilized when the user completely removes the concept of RI from his mind and does not try to impose on the Jeweler's Eye any of the attributes, capabilities or functions of a refractometer. This may be a very difficult thing for a G.G. or F.G.A. to accomplish. However, it is a very simple thing for many untrained individuals to do. Consequently, this instrument has found wide acceptance and is proving to be a most useful tool in their hands.

The Jeweler's Eye does nothing more than measure the quantity of energy reflected from the surface of a gem relative to the quantity reflected from a reference gem. The Jeweler's Eye represents a type of instrument which, like the microscope but not like the refractometer, provides information but does not produce a number. Consequently, useful as it is, some gemmologists find it difficult to accept the Jeweler's Eye.

Historically, determinative gemmology has been largely based upon using an instrument to determine a value for one of the intrinsic physical properties (e.g. RI, SG, etc.) of a gem and then comparing that value with a table of reference values. Repetition of the test on similar gems will always produce the same results. This is not necessarily true with the Jeweler's Eye, for this instrument does not measure an intrinsic property. The Jeweler's Eye measures reflectivity, and reflectivity depends partly upon the condition of the surface. If the surface condition and cleanliness of the stone to be tested and that of a reference gem of the same type are significantly different then neither will they give the same meter response nor should they be expected to do so. Although the Jeweler's Eye is admirably suited for confirming the identity of gems for which it is has been calibrated, reflectivity instruments must provide useful numerical values, if reflectivity is to play an important role in determinative gemmology: and here I may quote Lord Kelvin—'When you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind'.

However, before useful numerical values could be obtained, it was necessary to determine exactly what it was that a reflectometer measured. If one accepts as a definition of lustre—'the appearance of a surface by reflected energy'—then the Jeweler's Eye, using an infrared energy source, actually senses the infrared lustre of the gem surface. Now, by placing a numerical scale on a relative reflectometer, an entirely new gemmological instrument, 'The Lustermeter' was created, which is capable of producing relative numerical values of infrared lustre. Since relative numerical values of infrared lustre had never been determined before, it was necessary to devise a suitable scale. Values are designated by the term L_H indicating the use of a gallium arsenide LED energy source. A thorough treatment of the concept L_H, a table of L_H values and the application of this approach to the characterization of simulated diamonds have been published in American Journals.(5, 6)

The scale is an arbitrary one reflecting relative differences in energy reflecting properties. The overall scale is not linear and is similar in concept to the Mohs scale of hardness, i.e. L_H5 is more reflective than L_H4, L_H4 than L_H3, etc.

Since surface condition is a dominant factor in determining the lustre of a gem, the values on the scale represent the maximum

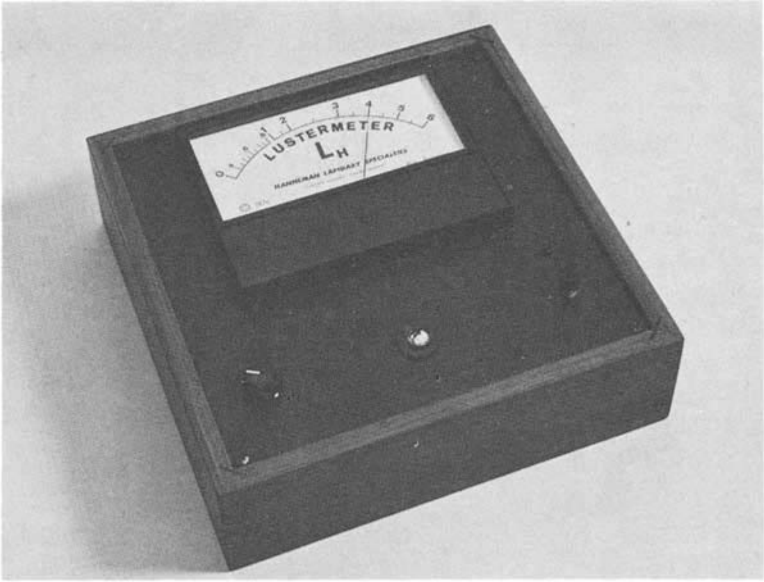

FIG. 2. The Lustermeter, showing a typical scale.

responses shown by the following reference gems: Diamond = 4, Strontium titanate = 3, GGG = 2, and YAG = 1. The positions of 5 and 6 are determined by extrapolation. The scale below 1 is discontinuous from that above and a typical Lustermeter scale is shown in Figure 2.

To use, the numerical L_H value is determined for the unknown gem and compared with a Table of L_H values in the same manner as RI, SG, or hardness values. A higher-than-expected measured lustre value would indicate that an assumed identification was incorrect. A lower value would not positively rule out the purported identity unless it could be shown that the surface condition was not significantly lowering the reading.

I firmly believe that the true role of reflectivity in determinative gemmology is that of measuring the lustre of gems which are above the range of the critical angle refractometer. To be sure, the lustre of the lower RI gems can be measured, but for these gems the ability of the refractometer to determine birefringence values makes it a far more useful instrument.

In order to utilize reflectivity measurements properly, it is imperative that one understands the limitations of this technique. The Lustermeter is by no means the ultimate instrument for the identification of the high RI gems. That instrument is, of course, a refractometer capable of determining their RI values to three or more decimal places as well as birefringence. However, until the day when such an instrument is developed, the Lustermeter appears to represent the best alternative.

Fortunately, there are few scratch-resistant natural high RI gems and a trained gemmologist can easily identify them if he is given but a crude RI value. The Lustermeter can provide a value which, although it is not the same, is equivalent in usefulness to that crude RI value. The Table of L_H values in effect substitutes for the Table of RI values for gems above 1.80.

However, there are problems associated with determining the 'true' L_H value of a specimen. A properly operating and calibrated Lustermeter will always give a steady reading for a gem placed upon it. If the gem is moved slightly, the reading may or may not change. If it changes, it is because the quantity of reflected energy (lustre) changes. This may be a result of a change in surface polish or cleanliness of the new area or it may be due to the effect of energy reflected from within the gem. The Lustermeter is giving the *correct* value for L_H of the *area exposed* over the hole in the examination disc. However, this value may or may not represent the 'true' value of L_H for the specimen and it is this 'true' value which must be compared with the values in the L_H Table.

This concept is illustrated in the example below. Since meaningful L_H values cannot be obtained on poorly polished gems or those with chipped tables, we shall assume the gem surface appears well polished and is clean. If the gem is placed on the examination disc but not over the hole, the Lustermeter will show a small reading representing the background reflection. As the gem is moved across the hole, the readings will change. Figure 3 shows a plot of the different readings obtained related to the position of the area exposed over the hole. The initial low readings are due to the hole not being completely covered. At the edge of the table (and sometimes in other unique spots) high readings will result from internal reflections from the pavilion facets. Across the centre of the table the gem gives relatively stable readings, but the presence of a small scratch or speck of dirt will produce a low reading.

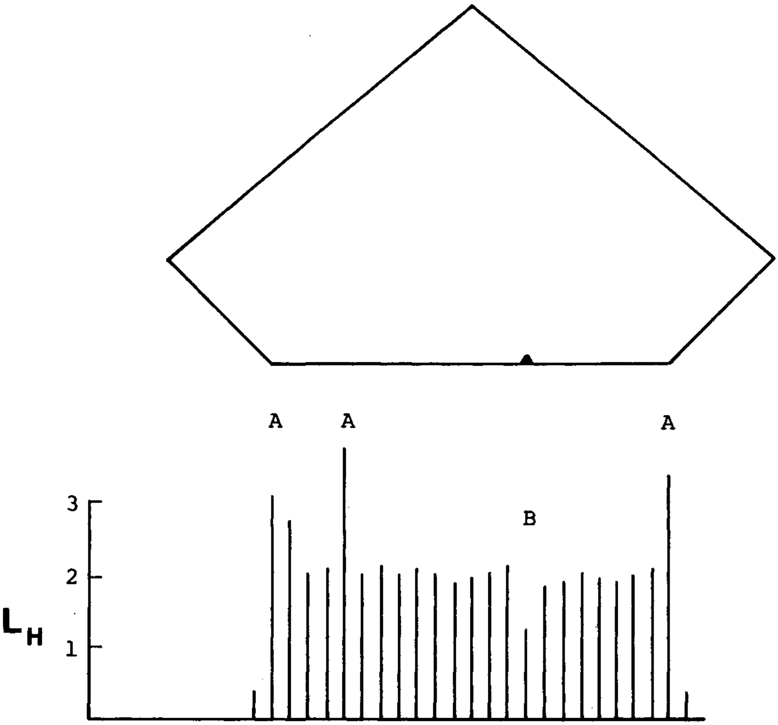

FIG. 3. Typical L_H values measured relative to position of exposed area. A = internal reflections. B = scratch or dirt.

This points out the danger of taking a single measurement. An overall view of Figure 3 indicates that most readings are relatively 'constant' and fall between 1.9 and a shade over 2.0. The 'true' value of L_H to be used for that gem should be 2.0. One must take several readings of different areas in order to determine that 'constant' value. One must also recognize that it is folly to attempt to attach any significance to the second decimal place of any L_H value above 1. The technique of reflectivity is simply not that precise and there is nothing to be gained by lamenting that fact. Nevertheless gemmologists have recognized that while L_H values cannot always tell what a gem *is*, it quite often is the easiest method of telling what it *is not*.

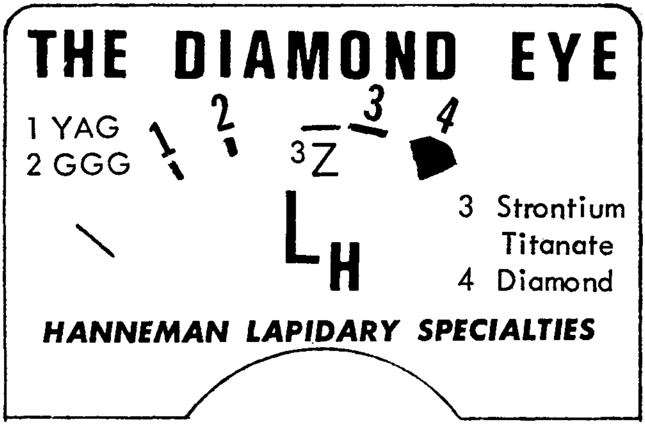

FIG. 4. Typical scale of the Diamond Eye, showing ^{3}Z = cubic zirconia. (× 2)

Epilogue—The Diamond Eye

The manufacturers of simulated diamonds are continually creating more realistic products. While synthetic spinel could be detected by the refractometer, YAG, GGG and strontium titanate progressively taxed the skills of the diamond merchants.

Now cubic zirconia has emerged and without a doubt it is going to cause problems in the jewellery trade. Fortunately diamond has a unique L_H value of 4 and can be easily separated from its simulants (L_H of cubic zirconia is $\sim$2.7).

In recognition of this, a new instrument—The Diamond Eye—has been developed. It can serve not only as a tool of determinative gemmology but also as an inexpensive form of insurance for the diamond merchant and/or jeweller. It is smaller in size even than The Jeweler's Eye. A typical scale of this instrument is shown in Figure 4 and is recognizable as being a combination of that of the Jeweler's Eye and the Lustermeter. The use of bands of response serves to mask to some extent the imprecision of reflectivity measurements and the L_H calibration allows for obtaining determinative information on unknowns of all types.

The author would like to express his appreciation for the assistance of Mr J.R.H. Chisholm in the preparation of this article.

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   This is the instrument described by R.M. Wilkins in the Lapidary Journal, **26**, 432-4, (1972).
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ON COLOUR

By R.M. YU, B.Sc., Ph.D., M.Inst.P.
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Recently a clear and concise account of some of the causes of colour in gemstones was published.(1) In that paper the author explained that 'our eyes perceive the frequency or oscillations of light and not the wavelength, as has been customarily regarded'. The fact that the colour of our flesh remained the same whether observed in air or under water was quoted as evidence. He argued that since the wavelength of light in water was equal to that in air divided by the refractive index of water (1.33), our flesh would appear to have a different colour when observed under water if our colour sensations were associated with the wavelength of light. This happens to be an ambiguous example if we probe deeper into the problem.

Let us consider the anatomy of the human eye, a schematic diagram of which is shown in Figure 1. The reader is referred to any

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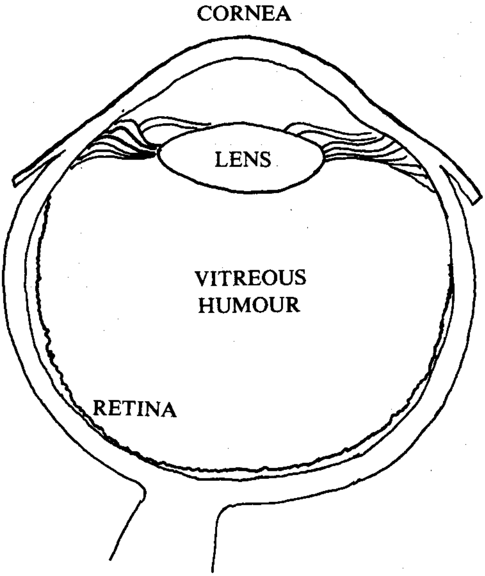

Fig. 1. Cross-section of human eye.

standard textbook on visual optics(2, 3, 4) for a detailed description of the structures and functions of the eye. For the present discussion we are concerned with the light-receiving part known as the retina. It contains two kinds of photo-sensitive cells, the rods and cones. The rods are highly sensitive to light, but are unable to distinguish colour. Thus they give us high speed black and white pictures. The cones are less sensitive, yet they are able to give a coloured view of the object. The rods and cones are always immersed in the transparent gelatinous substance called vitreous humour. The light received by the cones will have a wavelength determined by the refractive index of vitreous humour (about 1.336). Whether the light has passed through air or water does not matter, since eventually it must pass through the vitreous humour before arriving at the retina. In other words, the wavelength of light detected by the cones is independent of the refractive index of the medium in which the object is immersed. The fact that an object appears to have the same colour in water as in air does not prove that the sensations of colours are associated with the frequency of light rather than the wavelength. However, from a conceptual point of view frequency does have more physical meaning than wavelength, since the latter changes with the refractive index of the propagating medium while the former does not.

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[*Manuscript received 29th July, 1977*]

GEMMOLOGICAL ABSTRACTS

Amstutz (G.C.), Bank (H.). *Geologische, petrographische und mineralogische Beobachtungen in einigen Minen von Smaragd, Tansanit, Tsavorit und Rubin in Tansania und Kenya.* (Geological, petrographic and mineralogical notes on some emerald, tanzanite, tsavorite and ruby mines in Tanzania and Kenya.) Z. Dt. Gemmol. Ges., **26**, 3, 118-27, 12 illus., bibl., 1977.

The authors describe the tectonic structure, the petrographic-stratigraphic position and construction as well as the content of usable gem material from six mines, (1) the emerald-alexandrite mine near Lake Manyara in Tanzania, (2) the Merelani zoisite finds in Tanzania, (3) the grossularite and zoisite finds in Komolo, also in Tanzania, (4) Ol Bill, which is an alluvial find of tanzanite, (5) the vanadium and grossular finds in Mgama in Kenya, and (6) the ruby mines in the Tsavo national park. E.S.

Andeen (C.), Fontanella (J.). *The dielectric spectrum of Europium doped* CaF_2. Journal of the Physics and Chemistry of Solids, **38**, 237-41, 1977.

The dielectric constant has been measured at 5 audio-frequencies over the temperature range 4.2-400 K for europium-doped CaF_2. Three strong relaxations are noted which indicate large amounts of the Eu^{3+} ion. M.O'D.

Arbuniés Andreu (M.). *Estudio físico y óptico de variedades gemológicas del granate.* (Physical and optical study of the gem varieties of garnet.) Gemmologia, **6**, 23/24, 23-54, 1974.

Reviews the gem varieties of the garnet group with tables of constants, diagrams and a bibliography. M.O'D.

Arbuniés Andreu (M.). *Estudio bibliografico y análisis crítico de los trabajos sobre relaciones entre color y composicion quimica de los granates, aparecidos en la última década.* (Biblographical study and analysis of work on the relationship between colour and chemical composition of garnets appearing in the last 10 years.) Gemmologia, **6**, 23/24, 60-63, 1974.

Illustrates absorption spectra, colour figures and relevant publications. M.O'D.

Bank (H.). *Sinhalit und Diopsid aus Ceylon.* (Sinhalite and diopside from Ceylon.) Z.Dt.Gemmol.Ges., **26**, 2, 78-9, 1 graph, bibl., 1977.

The author looked through a parcel of 12 sinhalites and took their RI and found one diopside among them. He shows the difference in the RI of two stones in graph form. E.S.

Bank (H.). *Mit dem Schmelzdiffusionsverfahren hergestellte synthetische Korunde (Rubine und Saphire nach Chatham).* (Synthetic corundums produced by the melt-diffusion method (rubies and sapphires according to Chatham.)) Z. Dt. Gemmol. Ges., **26**, 3, 170-2, 3 illus., bibl., 1977.

Short survey of corundum synthesis with illustration of typical Chatham inclusion and rough crystals grown by Chatham (one ruby and one sapphire). The author describes a group of synthetic sapphires recently received, but does not know whether these will be commercially available in the near future. E.S.

BANK (H.). *Schleifwürdiger gelbbrauner Coelestin.* (Cuttable yellow-brown celestine.) Z. Dt. Gemmol. Ges., **26**, 3, 168-9, bibl., 1977.

Celestine is chemically $SrSO_4$ and named after *coelestis* (i.e. blue). The author had previously described colourless or light blue celestine from Madagascar; this browny material comes from Namibia. Physical properties are given. E.S.

BANK (H.). BECKER (G.). *Klar durchsichtiger Schleifwürdiger Rhodochrosit aus Hotazell in Süd-Afrika.* (Clear transparent cuttable rhodochrosite from Hotazell in South Africa.) Z. Dt. Gemmol. Ges., **26**, 3, 157-60, 4 illus., bibl, 1977.

The crystals from the manganese district Hotazell in South Africa are exceptionally clear, partly macrocrystalline, partly corroded crystals and partly botryoidal and reniform. Physical properties are given. E.S.

BANK (H.), BECKER (G.). *Blauer schleifwürdiger Jeremejewit aus S. W. Afrika.* (Blue cuttable jeremejevite from South West Africa.) Z. Dt. Gemmol. Ges., **26**, 3, 161-5, 7 illus., bibl., 1977.

The mine is near Swakopmund and belongs to the Val-Tourmaline-Mines Company. The original finds were in Transbaikalia in U.S.S.R. The crystals vary from colourless to cornflower blue, even dark blue; some are completely transparent and a few cuttable. The composition is $AlBO_3$, hexagonal or pseudohexagonal, density 3.33, RI 1.653-1.640, DR -0.008. E.S.

BANK (H.), BECKER (G.). *Farbloser und Blau-violetter schleifwürdiger Herderit aus Brasilien.* (Colourless and blue-violet cuttable herderite from Brazil.) Z. Dt. Gemmol. Ges., **26**, 3, 166-7, 1 illus., bibl., 1977.

Physical properties are given. E.S.

BANK (H.), MAES (J.). *Über farblose Spodumene und Farbveränderungen bei Spodumenen.* (About colourless spodumenes and colour changes in spodumenes.) Z.Dt.Gemmol.Ges., **26**, 2, 76-7, bibl., 1977.

Pleochroic spodumene is found as hiddenite and kunzite, but also in yellow and colourless. The colours can be altered by heat treatment and bombardment, the latter being usually reversible. Spodumene made colourless by heating can easily be confused with sillimanite. E.S.

BARIĆ (L.). *Im weissen Marmor.* (In white marble.) Lapis, **2**, 8, 10-12, 1977.

Describes the pink to reddish rubies found at Prilep, Yugoslavia, where the occurrence is in a dolomitic marble. Crystal diagrams and coloured illustrations are given. M.O'D.

BERKOWITZ (R.). *Gem characterized by refractive index.* Canadian Gemmologist, **2**, 1, 9-12, 1977.

Describes the spinel and garnet families, chrysoberyl, corundum, kyanite, rhodonite, azurite, epidote and benitoite. M.O'D.

BIANCONI (F.). *Campolungo, Tessin.* (Campolungo, Ticino.) Lapis, **2**, 8, 14-18, 1977.

Small rubies and sapphires have been found in the dolomite of the Campolungo region of Canton Ticino, southern Switzerland. The dolomite is a marble type and associated minerals include grammatite, scapolite, green tourmaline, chrysoberyl and fluorite. Coloured illustrations, a map and crystal diagrams are given. M.O'D.

Boscardin (M.), Michele (V. de), Mattioli (V.). *Lo smeraldo della Val Vigezzo (Ossola).* (The emeralds of the Val Vigezzo, Ossola.) La Gemmologia, **2**, 1, 21-6, 1976.

Val Vigezzo runs from Domodossola on the Swiss-Italian border towards Locarno. Emerald is found with albitite and is semi-transparent with inclusions of some albite, chlorite, scheelite and other minerals. Cr^{3+} is found as 0.05% of weight. Refractive index is calculated as 1.5834 and 1.5905 for the extraordinary and ordinary rays respectively. The infrared spectrum was measured, but no absorption bands were seen in the visible spectrum. M.O'D.

Brown (G.). *Black coral - true or false.* Australian Gemmologist, **13**, 2, 35-41, 9 figs, 1977.

A detailed study of 'true', Antipatharian or thorny black coral and of the 'false', Gorgonian or horny black coral. They are identical in appearance when polished but are readily differentiated when the surfaces are in their natural state, the 'true' coral having an abrasive surface of short black spines while the 'false' black coral is smooth and horn-like. Both are non-calcareous. The 'true' material is a protein, while the 'false' is a collagen. Gemmological testing constants are identical, but the 'false' material softens below 150 °C while 'true' black coral needs temperatures above that figure to become pliable.

Abstractor feels that the use of the 'false' and 'true' prefixes is misleading. Author is dealing with two different species of coral, both of which produce black axial skeletons which are indistinguishable when worked. To designate them in this way only panders to commercial interests. R.K.M.

Brown (G.), Moule (A.J.). *The structural characteristics of elephant ivory.* Australian Gemmologist, **13**, 1, 13-17, 13 figs, 1977.

An authoritative account of the structure of ivory of the elephant, mammoth and mastodon. 'Engine-turned' appearance of polished lateral sections of ivory, incorrectly called 'Striae of Retzius', is due to reflection from minute fibres of a dental protein called collagen, not to reflection from dentinal tubes as had been previously thought. The effect is seen only in the three types of elephant ivory, including all fossil forms. Several of the excellent photo-micrographs are lettered but the lettering is not explained in the text. This paper is free from the misprints which usually plague this otherwise excellent journal. R.K.M.

Brown (G.), Moule (A.W.). *The structural characteristics of various ivories.* Australian Gemmologist, **13**, 2, 47-60, 9 figs, 1977.

Part two to authors' paper on elephant ivory abstracted above. This deals with less common ivories of wild boar, hippopotamus, walrus and the even rarer ivories of the sperm whale and the long spiral horn of the narwhal. The latter beast is on the verge of extinction. (In fact almost no ivory is obtained from any animal without killing it first, so there are several cases for conservationists here.) Distinction between ivories is difficult in solid pieces (apart from the 'engine-turned' appearance of elephant ivory in cross section and the obvious spiral of the narwhal tusk), but authors show that in thin section micro-differences are distinct. R.K.M.

CECCUZZI (B.). *Il metodo della misurazione diretta dell'indice di rifrazione.* (The direct measurement method of obtaining refractive index.) La Gemmologia, **2,** 3/4, 31-6, 1976.

Describes the real and apparent depth method of obtaining refractive index.
M.O'D.

CHERMETTE (A.). *Bresil 1976 - le Minas Gerais.* (Brazil 1976 - Minas Gerais.) Revue de Gemmologie, **51,** 2-4, 1977.

A general geographical and economic survey of the state of Minas Gerais with some reference to its gemstones. M.O'D.

CHESTERMAN (C.W.). *California jade; a collection of reprints.* Special Publ., Calif. Divn. Mines & Geol., **49,** 53pp, 1976. Price $2.00.

Five earlier reports are here reprinted: R.A. Crippen, *Nephrite jade and associated rocks of the Cape San Martin region, Monterey County, California,* 14 figs., 1951; C.W. Chesterman, *Nephrite in Marin County, California,* 11 figs., 1951; H.S. Yoder & C.W. Chesterman, *Jadeite of San Benito County, California,* 6 figs., 1951; C.W. Chesterman, *Intrusive ultrabasic rocks and their metamorphic relationships at Leech Lake Mountain, Mendocino County, California,* 4 figs., 1963; J.R. Evans, *Nephrite jade in Mariposa County,* 9 figs., 1966. A.P.

CROWNINGSHIELD (R.). *Developments and highlights at GIA's Lab in New York.* Gems and Gemology, **XV,** 8, 245-52, 20 figs, 1976.

Colour banding in natural brown diamond and a single inclusion reflected in almost every facet of another are illustrated. Writer says early irradiated diamonds also showed banding. Another diamond graded flawless but faulted on bad shape after a girdle flaw detected in an earlier grading had been removed. Brilliants cut with crown angles of 30 ° or less noted adversely in reports. Such angles combined with thin girdles account for 75% of damaged stones examined. Natural green diamonds are rare but crystals have brownish skin which may remain if a natural surface is left on the girdle. Laser beam finger-printing of diamonds mentioned and criticized. Strain patterns between crossed polaroids suggested as another fingerprint procedure. Coated diamonds not often seen today but are still about. Cloud-like central inclusion in an orange diamond said to be characteristic. Ethics of describing clean diamonds as internally flawless when marked surface graining is present are raised.

A natural ruby with marked strain (shatter) cracks at facet edges due to rapid polishing and another in which apparent bubbles proved to be haloed are described and illustrated. A third one had angular metallic crystals and was a flux synthetic. Indian carved 'rubies' proved to be dyed quartz. 'Venetian blind' banding in Gilson synthetic emerald is well illustrated and mention of similar banding in synthetic alexandrite is made. Insects in amber and in modern plastic are shown. Gift of fibre-glass cat's-eyes acknowledged. R.K.M.

DE CAMARGO (W.G.R.), BRUDER (J.). *Random layer structure of autunite by grinding.* An.Acad.Brasil.Ciênc., **48,** 2, 249-53, 1976.

Grinding may precipitate disorders such as stacking faults, which are naturally found in minerals with preferential cleavage. This has been observed in autunite.
M.O'D.

De Camargo (W.G.R.), Filho (J.B. de Madureira). *New diagrams for physical determination of garnets.* An.Acad.Brasil.Ciênc., **48**, 1, 57-68, 1976.

A means of identification of individual members of the garnet group is proposed. Triangle diagrams given an approximate idea of the chemical composition and the properties $\Delta\ 2\ \theta$, n and D are all that are needed to identify the species. Since the linearity of $\Delta\ 2\ \theta$ is a function of chemical composition the use of triangle charts is valid. M.O'D.

De Camargo (W.G.R.), Leite (C.R.). *Olivine epitaxy in Brazilian diamonds.* An.Acad.Brasil.Ciênc., **48**, 2, 240-4, 1976.

Olivine has been identified as an inclusion in Brazilian diamond and the crystals have been shown to be oriented specifically with respect to the host. The diamonds examined came from secondary deposits at Abadia dos Dourados, Minas Gerais. It is thought that the inclusions might show a relationship between diamonds and basic or ultrabasic magmas. M.O'D.

Diehl (R.). *Neues zum Thema 'Synthetischer Smaragd': Besuch bei Pierre Gilson.* (New additions to the subject of synthetic emerald: visit to Pierre Gilson.) Z.Dt.Gemmol.Ges., **26**, 2, 61-75, 17 illus., bibl., 1977.

Pierre Gilson lives about 40 km south-west of Calais in a village called Campagne-lez-Wardrecques manufacturing ceramics and for many years synthetic emeralds. Single crystals of beryl are not only used as gem material but also in scientific research to study the channelling of ions in crystals. In beryls the Si_6O_{18}-rings are stacked along the c-axis forming wide channels into which accelerated ions can penetrate. Natural beryls are unsuitable for this purpose because the channels contain water and carbon dioxide, but the Gilson synthetic beryls are useful for these experiments. They are produced by a flux fusion (rather than flux reaction) technique. Therefore the Gilson material is being investigated thoroughly using microscopy, x-ray topography and infrared spectroscopy. These unusual methods may produce interesting results also for the gemmologist. The author closes with remarks on P. Gilson as crystal grower. E.S.

Diehl (R.). *Diamantsynthese bei Temperaturen unter 1300°C und Drucken unter einer Atmosphäre.* (Synthesis of diamond with temperatures under 1300°C and pressure under one atmosphere.) Z. Dt. Gemmol. Ges., **26**, 3, 128-34, 1977.

This deals not with a synthesis in its strictest sense, but with a crystal growth based on the idea of a metastable synthesis. It is mainly a laboratory method, not suitable for larger commercial output, using diamond powder or small diamonds as starting material. It might be of interest in healing fissures or growing together of canals in diamonds caused by laser beams. The growth rate seems to be 3% in four hours. E.S.

Dunn (P.J.). *Observations on the Slocum stone.* Gems and Gemology, **XV**, 8, 252-6, 7 figs., 1 table, 1976.

A careful examination of a comparatively new glass imitation of opal. Colours change with angle of viewing as in natural opal. SG 2.47, RI 1.514, H 5-5½. Between crossed polaroids colour effect is kaleidoscopic. X-ray diffraction pattern is incoherent, proving it to be glass. Composition is sodium calcium magnesium potassium aluminium silicate. Very tough, fractures with difficulty. Opalescence possibly due to textural dissimilarity of adjacent layers. No intergranular material, organic or otherwise, was found. R.K.M.

DUNN (P.J.). *Chromium in dravite.* Mineralogical Magazine, **41**, 408-10, 1977.

Shows that chromium can substitute for both aluminium and magnesium in dravite. These dravites have Na>Ca; high chromian dravite is compositionally zoned as light and dark green material, the depth of colour varying with Cr content. The name chrome tourmaline should be abandoned in favour of chromian dravite. M.O'D.

EPPLER (W.F.): *Amazonit.* (Amazonite,) Z. Dt. Gemmol. Ges., **26**, 3, 109-10, 3 illus., 1977.

Amazonite is an opaque, triclinic potash feldspar, a microcline. The green colour is caused by a trace of copper. The author describes a 'green feldspar' which was found to be amazonite and came from Broken Hill, New South Wales. This stone is found in rock consisting mainly of quartz, garnet and various ores, mainly copper. The quartz contains some rutile needles. In section this amazonite shows a definite perthite (exclusion) structure, more finely developed than usual in amazonite. E.S.

FISCHER (K.). *Edelstein Epidot.* (Epidote the gemstone.) Lapis, **2**, 7, 10-13, 1977.

Reviews and illustrates in colour the gem varieties of the mineral epidote. Details are given of the occurrences in Europe, particularly those in Austria. M.O'D.

FISCHER (K.). *Die Zweifache Kraft Fundorte und Verarbeitung von Cyanit (Disthen).* (Two-fold hardness, origin and working of kyanite.) Lapis, **2**, 8, 31-5, 1977.

Reviews the properties and occurrences of kyanite, especially those found in the Ticino area of Switzerland and other parts of Europe. Crystal diagrams and coloured illustrations are provided. M.O'D.

GAAL (R.A.P.) *Cathodoluminescence of gem materials.* Gems and Gemology, **XV**, 8, 238-41 (240 = 5pp), 4 figs, 16 colour figs, 1 table, 1976.

Describes results obtained with an 'inexpensive' Nuclide Luminoscope ELM-2A, recently acquired by the GIA, when attached to an ordinary binocular microscope or to a scanning micro-spectrophotometer. The effect is analogous to the luminosity of a television screen. A stream of high velocity electrons bombards the specimen in a vacuum chamber on the stage of the microscope. Impurities, defects, distortions or intrinsic elements cause the specimen to emit visible light. Spectrophotometry provides further identifying features. Cathodoluminescence (CL) in gemmology is only in its early stages and should be regarded as a further sophistication of the fluorescence under UV light or x-rays type of test. Irradiation for 10 seconds or more was found to change the colour of the luminescence in some cases, probably due to heating. It is not stated whether this form of radiation causes temporary or permanent changes in the intrinsic colour of the material examined: cf. corundum temporarily yellowed by x-rays, zircons faded by UV. A helium gas supply is shown in one figure but is not explained in the text. R.K.M.

Gleadow (A.J.W.). *The geology of the moon.* Australian Gemmologist, **13,** 1, 22-7, 5 figs., 1977.

A brief account of the fascinating lunar geology as revealed by examination of rock samples brought back from the several Apollo landings. Most are basalts or breccias of very great age. Some new minerals, unknown on Earth, were found. Lack of atmosphere and of water has meant that almost all geological evolution on the moon ceased more than 3000 million years ago. By contrast the Earth is still geologically extremely active. Most rocks were fine grained with minute crystals. No gem minerals reported. R.K.M.

Gramaccioli (C.M.). *Lo zircone: una pietra interessante.* (Zircon, an interesting stone.) La Gemmologia, **2,** 1, 16-20, 1976.

Describes and illustrates in colour the members of the zircon family with particular attention to crystals found in Alpine regions. M.O'D.

Gübelin (E.). *Im Tal der Rubine.* (In the valley of Rubies.) Lapis, **2,** 8, 19-26, 1977.

Describes with a coloured geological map and other illustrations the Mogok area of Burma with notes on the occurrence and mining of the rubies found there. Typical inclusions are illustrated in colour. M.O'D.

Gübelin (E.), Weibel (M.), Girgis (K.), Wessicken (R.). *Die Struktur der Sterne.* (The structure of stars.) Lapis, **2,** 8, 27-30, 1977.

Illustrates, with the aid of electron microscope photographs, the way in which asterism forms in minerals; special attention is given to a very dark form of star-sapphire from Bang-kha-cha, south-east Thailand. M.O'D.

Harding (B.L.). *Crazy corundum.* Rocks & Min., **51,** 180-2, 2 figs, 1976.

This paper discussed the cutting of gem corundum, and the ways polysynthetic twinning and parting affect this. R.S.M.

Hassib (A.), Beckman (O.), Annersten (H.). *Photochromic properties of natural sodalite.* Journal of Physics D:Applied Physics, **10,** 771-7, 1977.

The authors postulate the presence of colloidal metal clusters as the cause of the blue colour of sodalite. A pink colour can be obtained by the production of F-centres by ionizing radiations. It is thought that these centres can be eliminated by visible light and that this process may be the cause of the establishment of the colloidal clusters. A number of colour and bleach cycles will impart a deep blue colour to the material. M.O'D.

Hogarth (D.D.), Griffin (W.L.). *New data on lazurite.* Lithos, **9,** 39-54, 1976.

Non-cubic lazurite was found to be common and may be caused by S_3^- ions in parallel orientation. Dark lazurite contains more S_3^- than pale varieties. M.O'D.

Ito (J.). *High temperature solvent growth of orthoenstatite, $MgSiO_3$, in air.* Geophysical Research Letters, **2,** 533-6, 1975.

Crystals up to 5 × 2 × 1 mm size were obtained by the primary crystallization of a melt in the system MgO-SiO_2-lithium vanado-molybdate. Crystals are stoichiometric, transparent and often euhedral. M.O'D.

ITO (J.). *Crystal synthesis of a new cesium aluminosilicate, $CsAlSi_5O_{12}$*. American Mineralogist, **61**, 170-1, 1976.

Crystals of a substance ideally $CsAlSi_5O_{12}$ have been grown by slow cooling of the melt containing Ba-, Cs-vanadate flux. It is orthorhombic, space group Bbm2. M.O'D.

ITO (J.). *Crystal synthesis of a new olivine, $LiScSiO_4$*. American Mineralogist, **62**, 356-61, 1977.

$LiScSiO_4$ has been synthesized by both oxide mixes in air and by high-temperature solvent growth with lithium molybdo-vanadate. It is orthorhombic, space group Pbnm. M.O'D.

JAHNS (R.H.). *Gem materials.* Industrial minerals and rocks (ed. S.J. Lefond *et al.*), American Institute of Mining, Metallurgical and Petroleum Engineers Inc., New York, 271-326, bibl., 1975.

Gives market prices for rough gem material together with comparative retail values. Short scientific summaries of the different materials are included. M.O'D.

KOLOMITSEV (A.I.), YAKUBOVA (S.A.). *Columnar mechanism of growth of natural diamond crystals of cubic habit.* (In Russian.) Zapiski Vsesoyuznyi Mineral. Obshchestva, **105**, 469-72, 1976.

Columnar growth of natural diamond crystals with a cubic habit proceeds along the [111] axis. This results in the development of coherent single crystals and is proved by Laue patterns. M.O'D.

KRESTEN (P.). *Chrome pyrope from the Alnö complex.* Geologisk Föreningen Förhandlinger, **98**, 179-80, 1976.

This example shows 64.8% of the pyrope molecule and is similar to garnets found with diamonds and in ultrabasic nodules in kimberlite. M.O'D.

KUSTOV (E.F.), PETROV (V.P.), PETROV (D.S.), UDALOV (J.P.). *Absorption and luminescence spectra of Nd^{3+} and Er^{3+} ions in monocrystals of $CaYAlO_4$*. Physica Status Solidi, **41**, 379-83, 1977.

Crystals are grown by the optical melting method; the absorption and luminescence spectra were investigated at 77 and 300 K. M.O'D.

LEHMANN (G.). *Über die Färbungsursachen natürlicher Citrine.* (About the causes of colour in natural citrines.) Z.Dt.Gemmol.Ges., **26**, 2, 53-60, 5 graphs, bibl., 1977.

Citrine has been chosen as gem for 1977 and the author shows that the gem chosen is not the natural citrine but the burnt amethyst, as this has a much more attractive colour than the natural citrine. Natural citrines often contain smoky quartz 'centres' in varying degrees - these centres are conductor defects in non-conductors. The author compares the absorption spectra of smoky quartz, citrines and burnt amethysts, the spectrum of the latter being isotropic. It is shown that it is easy to differentiate between natural citrines and the burnt amethysts. E.S.

LIDDICOAT (R.T.). *Developments and highlights at GIA's Lab in Santa Monica.* Gems and Gemology, **XV**, 8, 233-7, 13 figs., 1976.

A diamond with up to thirty laser-drilled holes, a paste imitation bloodstone cameo (writer suggests it is carved but it looks moulded) and plastic repairs to jades are mentioned and illustrated. A canary yellow diamond lacking 'normal' Cape spectrum (note: a yellow *with* a Cape spectrum is *not* a canary stone), a 6ct sinhalite, blue and colourless jeremejevite crystals described and a possible new diamond simulant (SG 5.57, singly refractive, H 6-6½, inert to UV) structurally close to dysprosium gallium oxide recognized as a rare-earth garnet-structured synthetic. Gilson opal used in triplet had glass top. Various inclusions in diamond are described, while a 'spherical' bubble in natural sapphire proved to be a drumshaped inclusion. R.K.M.

LIEBER (W.). *Peridot—Arizonas Staatsjuwel.* (Peridot, state gem of Arizona.) Lapis, **1**, 1, 14-17, 7 figs, 1976.

Describes and illustrates the occurrence of gem-quality peridot in the State of Arizona; most of it is mined by Indians of the Apache tribe and used in Indian-style jewellery. M.O'D.

LOEFFLER (B.M.), BURNS (R.G.). *Shedding light on the color of gems and minerals.* Amer. Scientist, **64**, 636-47, 11 figs (2 in colour), 1976.

Colours in minerals depend upon the selective absorption of light according to wavelength. The responsible electronic processes fall into four main categories: crystal field transitions, molecular orbital transitions - e.g. oxygen→metal charge transfer or metal→metal charge transfer, colour centres, and band gap transitions. Several examples of each type are given. R.V.D.

LOUGHLIN (John). *Australian opals.* Rocks & Minerals, **52**, 139-40, 1 fig, 1977.

A general review is given of the mining and marketing of opal. The mine fields are at Coober Pedy and Andamooka, in far inland South Australia, and Lightning Ridge, in western New South Wales. R.S.M.

MEIXNER (H.). *Rubin von Longido Tansania.* (Rubies from Longido, Tanzania.) Lapis, **2**, 8, 12, 1977.

Describes the occurrence of ruby in the Longido region of Tanzania, lying approximately 100 km north-west of Kilimanjaro. The rubies are found in a zoisite-bearing amphibolite and are associated with hornblende, the bytownite variety of plagioclase, a greenish zoisite and tremolite. Refractive index is measured at 1.764, 1.772, with a birefringence of 0.008; specific gravity is 3.99 g/cm^3. M.O'D.

MICHELE (V.de). *Ametista di Osilo.* (Amethyst from Osilo.) La Gemmologia, **2**, 3/4, 5-8, 1976.

Osilo is a commune in Sassari province, north Sardinia. Crystals are heavily striated and some contain two-phase inclusions. Colour occurs in typical bands. Heating to 400°C drives the colour off temporarily, heating to 1000°C permanently. Some Brazilian twins have been noted. Specific gravity, somewhat low at 2.63, is probably affected by small voids. M.O'D.

MITCHELL (R.S.). *A turquoise-like mixture of chalcedony and celadonite from Conejos County, Colorado.* Rocks & Min., **51**, 394-5, 1976.

Specimens resembling turquoise, from the Blue Sky mine, Conejos Canyon, Conejos County, Colorado, are actually a mixture of chalcedony and celadonite. The material is bluish-green to emerald green, waxy to dull, and has a conchoidal fracture. The veins and masses of chalcedony-celadonite occur in a fine-grained, brownish-grey basalt porphyry. Natrojarosite and clays are also present. R.S.M.

MOMOI (H.). *Hydrothermal crystallization of $MnSiO_3$ polymorphs.* Mineralogical Journal of Japan, **7**, 359-73, 1974.

Pyroxmangite was synthesized at temperatures lower than 700 °C and rhodonite above this figure. M.O'D.

MONES ROBERDEAU (L.). *Estudio cuantitativo de la fluorescencia provocadas por la radiación ultravioleta en diamantes tallados en estilo brillante.* (Quantitative study of fluorescence stimulated by ultraviolet radiation in brilliant-cut diamonds.) Gemmologia, **6**, 23/24, 5-12, 1974.

Surveys the fluorescence emitted by cut diamonds on irradiation and gives tables and diagrams. M.O'D.

NASSAU (K.). *Cubic zirconia, the latest diamond imitation and skull melting.* Lapidary Journal, **31**, 4, 900-26, 1977.

This material is the cubic modification of ZrO_2, whose monoclinic form is known as baddeleyite. Constants are refractive index 2.15-2.18, dispersion 0.060-0.063 and hardness 7½ to 8½ (these are provisional figures).The material has been grown by the skull-melting technique in which a skull-shaped container holds the melt in a crust of its own powder. RF energy passes through the skull to heat the contents. Small bubbles, cloudiness and striations have been noted in the material, but good quality stones should not show them. The absence of typical diamond features forms a reasonable test. M.O'D.

NASSAU (K.), PRESCOTT (B.E.). *Smoky, blue, greenish-yellow and other irradiation-related colors in quartz.* Mineralogical Magazine, **41**, 302-12, 1977.

Blue was found to originate from absorption by the A_1 and A_2 bands at 1.85 and 2.55 eV. The cause of the colour in smoky quartz is now believed to be a previously unreported absorption band at 2.90 eV. Greenish-yellow colours were seen after irradiation with gamma rays both in natural and synthetic quartz, the colour originating from the tail of an absorption band in the ultraviolet. The variation in colour of natural and irradiated smoky quartz is attributed to the combination of the A_3 (smoky) with the A_1 and A_2 (blue) and the greenish-yellow absorption features. M.O'D.

NASSAU (K.), PRESCOTT (B.E.). *A unique green quartz.* American Mineralogist, **62**, 589-90, 1977.

Green quartz collected in Brazil by Dana was found to be coloured by a broad absorption band at 2 eV and a strong band extending from 2.5 eV into the ultraviolet. This is lost by heating to 500 °C and cannot be recovered by heating under reducing conditions or by irradiation. Some amethyst colour is also present with the green. The origin of the green is so far unestablished. M.O'D.

NICHOL (D.) *Opal occurrences near Granite Downs Homestead.* Min. Resrcs Rev., South Australia, **139**, 99-101, 2 figs, 1975.

A brief inspection of workings in the vicinity of Granite Downs homestead showed that both precious and common opal occur in deeply weathered gneiss of the Precambrian crystalline basement at one group of workings, 4 km east of Mount Chandler. At a second group of workings, also in weathered gneiss, 3 km south-east of Granite Downs homestead no evidence of the occurrence of opal was found.

D.C.W.

NICHOL (D.). *Amethyst deposit, hundred of Kelly.* Min. Resrcs Rev., South Australia, **138**, 99-102, 1975.

Semi-precious amethystine quartz fills fractures and cavities in a discordant quartzite development which cuts Cleve Metamorphics of Lower Proterozoic age. The amethyst is purple in colour and ranges from light to dusky tones. Crystal form is poor due to deformation during crystal growth. The portion of gem quality material is less than 5%. It is estimated that over 250 m^3 of amethyst are available in the deposit. D.C.W.

O'LEARY (B.). *Black opal.* Australian Gemmologist, **13**, 1, 3-11, 1977.

A largely historical account of this gem, including theories that earlier black opals were treated stones. Writer suggests, incorrectly, that play of colour is due to micro-faulting of opal structure. Explanation of black body-colour is inadequate and P.J. Darragh is credited with saying that it is due to carbon (this surely referred to *stained* blacks and not to the natural stones). Named large opals are listed, and a further list suggests that the practice has been extended *ad absurdum* to quite small stones (e.g. 'Eros', 2.31 carats). R.K.M.

PELLÉ (F.), DENIS (J.-P.), BLANZAT (B.). *Crystallographic and spectroscopic studies of europium trivalent doped garnet type germanates.* Materials Research Bulletin, **12**, 511-17, 1977.

Polycrystalline calcium-yttrium germanate doped with trivalent europium at different concentrations has been prepared for research purposes which include study of the spectroscopic properties of the trivalent europium ion. M.O'D.

PETROV (I.), BERDESINSKI (W.), BANK (H.). *Bestrahlte gelbe und rotbraune Topase und ihre Erkennung.* (Treated yellow and red-brown topazes and their identification.) Z. Dt. Gemmol. Ges., **26**, 3, 148-51, 3 graphs, bibl., 1977.

Topaz colours based on a colour centre (blue, red-brown, yellow and orange) can easily be caused by radiation treatment; the colour can be deepened or altered. Also the more stable violet caused by chrome can be altered to yellow or red. All topazes where the colour has been formed by radiation cannot be distinguished from naturally coloured topazes by the absorption spectra; the only method of differentiation is thermoluminescence. E.S.

PETROV (I.), SCHMETZER (K.), BANK (H.). *Chromhaltige violette und orangefarbige Topase—Ein Vergleich.* (Chrome-containing violet and orange-coloured topazes—a comparison.) Z. Dt. Gemmol. Ges., **26**, 3, 152-6, 5 illus., bibl., 1977.

Orange-coloured topazes are found near Ouro Preto in Minas Gerais, Brazil. When heated these topazes turn violet and are similar to those natural topazes found in Sanarka in the Soviet Union. There is very little cuttable material available from these Russian sources, but recently violet topazes have been found in Pakistan, the colour apparently being caused by traces of chrome in the crystal lattice. The orange colour is shown to be a mixture of yellow and violet. E.S.

POIROT (J.-P.). *Quelques aspects de l'oxyde de zirconium cubique synthétique: fabrication de la 'djévalite', apparence de cette probable zirkelite synthétique.* (Some aspects of synthetic cubic zirconium oxide: manufacture of 'djevalite' and appearance of this probable synthetic zirkelite.) Revue de Gemmologie, **51**, 11-12, 1977.

Constants agree with those of Schiffmann (p.56 above) and some notes on the preparation of the substance are given. The material is made by the Bridgman process and the zirconium oxide is stabilized by the addition of calcium and yttrium oxides. M.O'D.

RISLING (M.). *The diagnostic inclusions of beryl and topaz.* Canadian Gemmologist, **2**, 1, 2-8, 1977.

Describes and illustrates the typical inclusions in topaz and in the beryl family. Parisite is misspelt throughout. M.O'D.

SCHIFFMANN (C.A.). *Gemmologische Studie an einem Original Maxixe Beryll.* (Gemmological study of an original maxixe beryl.) Z. Dt. Gemmol. Ges., **26**, 3, 135-41, 7 illus., bibl., 1977.

The original maxixe beryls were mined in the Maxixe mine in the west of the Minas Gerais in Brazil about 1917 and described during the thirties by Schlossmacher, Klang and Wild. The beryls had an intensely blue colour, which was somewhat unstable when exposed to light and production was stopped. Beryl of similar colour and behaviour came onto the market about 1972 and interest was aroused again. Strong pleochroism, density and RI as for heavy beryl (2.801 and 1.594-1.596). Microscopic examination shows layered phases of growth and resolution. E.S.

SCHMELTZER (H.). *Katzeldonien und gut Rötelstein.* (Katzeldonia and good red stones.) Lapis, **2**, 6, 6-10, 1977.

Lists and illustrates the minerals of the Rhineland-Pfalz. M.O'D.

SCHMETZER (K.). *Chrom, Eisen & Titan: Ursachen für die Farben von Rubin und Saphir.* (Chromium, iron and titanium: cause of the colour of ruby and sapphire.) Lapis, **2**, 8, 8-9, 1977.

Explains, with coloured illustrations and a diagram in the text, the work of the colouring elements in ruby and sapphire. M.O'D.

SCHMETZER (K.), MEDENBACH (O.), BANK (H.), KRUPP (H.). *Kristalle mit aussergewöhnlichen Einschlussen—Turmalin aus Tansania und Beryll aus Brasilien.* (Crystals with exceptional inclusions—tourmaline from Tanzania and beryl from Brazil.) Z. Dt. Gemmol. Ges., **26**, 3, 145-7, 4 illus., bibl., 1977.

Well illustrated note on two different crystals. The brown tourmaline from Tanzania shows a spiral inclusion consisting of 18 regular spirals parallel to the c-axis with a distance between each spiral of about 0.5 mm. The 5.7 kg aquamarine from Brazil also shows a spiral inclusion, but not of the same regularity. E.S.

SCHREIBER (H.D.). *On the nature of synthetic blue diopside crystals: the stabilization of tetravalent chromium.* American Mineralogist, **62**, 522-7, 1977.

Crystals were synthesized in air from silicate melts and some were found to be blue rather than green. This is attributed to the stabilization of a small portion of the total Cr as Cr(IV). This is not present initially in the melts but forms from the reduction of Cr(VI) during crystallization. M.O'D.

STOCK (H.D.), LEHMANN (G.). *Phenomena associated with diffusion of trivalent iron in amethyst quartz.* Journal of the Physics and Chemistry of Solids, **38**, 243-6, 1977.

Changes in the EPR, optical and infrared spectra were measured as a function of annealing temperature in natural amethyst crystals from different locations. After heating to 650 °C for two hours the concentration of Fe(III) on substitutional sites with alkali ions as charge compensators is equal in all crystals irrespective of initial concentration. M.O'D.

STRUNZ (H.). *Dichroskop, Polariskop, Kristall-Refraktometer—Drei vereinfachte bzw. verbesserte Hilfsmittel zur Edelsteinbestimmung.* (Dichroscope, polariscope, crystal-refractometer—three simplified, i.e. improved, instruments for gem identification.) Z. Dt. Gemmol.Ges., **26**, 3, 111-17, 7 illus., bibl., 1977.

The author suggests the use of a filter-dichroscope, polarization tweezers and a semi-cylindrical crystal refractometer. E.S.

SUHNER (B.). *Zur Messung der Dispersion an geschliffenen Steinen.* (Measuring dispersion of cut stones.) Z. Dt. Gemmol. Ges., **26**, 3, 142-4, bibl., 1977.

The author compares results obtained with refractometer and goniometer, naming some feldspars, tanzanite, vesuvianite, grossularite and hessonite. E.S.

TROSSARELLI (C.). *Il polariscopio-conoscopio.* (The polariscope-conoscope.) La Gemmologia, **2**, 3/4, 9-24, 1976.

Introduces and illustrates the use of polarized light in gem testing with photographs and diagrams. Interference figures are explained. M.O'D.

VILLEDIEU (M.), DEVISMES (N.), DE GOER (A.M.). *A study of valency changes of vanadium ions in Al_2O_3 by γ-irradiation.* Journal of the Physics and Chemistry of Solids, **38**, 1063-70, 1977.

The effect of γ-irradiation at 300 K on the concentration of V^{3+}, V^{4+} and V^{2+} in Al_2O_3 is studied quantitatively. M.O'D.

VOLOSHIN (A.V.), DAVIDENKO (I.V.). *Andalusite in granite pegmatites of the Kola peninsula.* (Translated into English.) Doklady Acad. Sci. USSR, Earth Sci. Section, **203**, 116-17, 1972.

Prismatic crystals up to 3 cm long and 0.5 mm across and coloured orange, pink or brownish-pink with a faint pink to lilac-pink pleochroism are found in granite pegmatites in gneisses of the Kola series. Some of the andalusite is replaced in the pegmatite by sillimanite. M.O'D.

WILLIAMS (J.D.), NASSAU (K.). *A critical examination of synthetic turquoise.* Gems and Gemology, **XV**, 8, 226-32, 6 figs, 1976.

A detailed report of the sophisticated scientific examination of Gilson synthetic turquoise and Adco, Syntho and Turquite simulations, with natural Nevada turquoise. Scanning electron microscope, x-ray diffraction and tests for possible binding substances, together with conventional gemmological tests were used. This established the Gilson product as a true synthetic and the other three manufactured substances as simulants or imitations. This determined, the important comment was that normal gemmological procedures should clearly distinguish the imitations; while the Gilson synthetic was identifiable under magnification. R.K.M.

Gemmologische Kurzinformation. (Short Gemmological Notes.) Z.Dt.Gemmol.Ges., **26**, 2, 82-5, 1977.

H. Bank examined a parcel of sinhalites and found a peridot amongst them—the RI and DR being very similar, but the peridot having a lower density was separated from the denser sinhalites. H. Bank also contributes a small article on the colour changes of topaz, and mentions the following: (1) heating from brown or yellow to pink, (2) bombardment from colourless to brown, (3) bombardment and subsequent heating from colourless to blue (low RI), and (4) bombardment from yellow to intensive yellow (high RI): he heated yellow-brown topazes which became salmon-brown at about 420 °C and colourless at a higher temperature without obtaining the desired pink colour. Lastly, G. Lenzen mentions the fact that Gilson's synthetic opals also are used in opal triplets. E.S.

Materials of electrical and magnetic interest. One-day meeting of the Crystallography Group of the Institute of Physics, 22 November 1974.

Reviews the electrical and magnetic properties of spinel, lithium tantalate, corundum and other crystals. M.O'D.

Tsumeb. Mineralogical Record, **8**, 3, pp. 128, illus. in colour, 1977.

Although not separate from the numeration of the series, this issue ranks as a special item, since it is devoted completely to the mineralogy of Tsumeb in south-west Africa. Chapters cover the history and the individual mines of the area and a particularly noteworthy feature is the number of new minerals mentioned (they are not fully described). A good general bibliography is provided. M.O'D.

BOOK REVIEWS

ANTHONY (J.W.), WILLIAMS (S.A.), BIDEAUX (R.A.). *Mineralogy of Arizona.* University of Arizona Press, Tucson, 1977. pp.255. Some coloured illustrations. $22.50 (hardback).

A major work in which the minerals to be found in the state of Arizona are listed alphabetically. The bulk of each descriptive entry is given over to an account of the various localities in which the mineral is found, details of the mineral itself being restricted to chemical composition. Some crystals are shown in diagrammatic form, but there is no description accompanying them nor is there a table which could be consulted. This is the deliberate policy of the authors as stated in the introduction; serious students of mineralogy will possess Roberts *et al.*, 'Enclyclopedia of Minerals' (see J. Gemm., 1977, XV, 7, 401) and 'Dana's System of Mineralogy', 7th edition, or at least have access to them. This book does provide detailed descriptions of the mode of occurrence of the minerals to be encountered in the State and also good-quality maps. Arizona contains uranium and vanadium deposits as well as the perhaps better-known copper ones, such as Bisbee and Tiger;

48 minerals were first found in the State; over 200 have been discovered since 1959, which pays tribute to the amount and depth of mineralogical study taking place in the area.

The quality of printing and of the coloured illustrations is very high; the authors have included an extensive bibliography and also, where applicable and desirable, catalogue numbers denoting important type materials in museum and other collections. At the price, this is well worth buying, even if a trip to Arizona is not imminent. M.O'D.

BLAKEY (G.G.). *The diamond.* Paddington Press, New York and London, 1977. pp.280. Illus. in black-and-white and in colour. £10.95.

This large and handsome book is not aimed at the specialist though he will be pleased to acquire such obscure scraps of information as the whereabouts of celebrated stones and illustrations of contemporary scenes obtained during the early years of diamond mining in South Africa. Notes on the properties of diamond are given; there is a very short bibliography and a glossary in which the description of kimberlite is inadequate. M.O'D.

EVANS (J.). *Magical jewels of the Middle Ages and the Renaissance.* Dover Books, New York, 1977. pp. 264. £2.15.

Reprint of a classic of the genre; first published in 1922. Its greatest value lies in its treatment of original manuscript and early printed material. M.O'D.

GREG (R.P.), LETTSOM (W.G.). (1858). *Manual of the Mineralogy of Great Britain and Ireland.* A Facsimile Reprint with Supplementary Lists of British Minerals by L.J. Spencer, F.R.S. and a Fourth Supplementary List (1977) together with a Foreword by Peter G. Embrey. Lapidary Publications, Broadstairs, Kent, 1977. pp. lxvii, 483. £10.

For many years now and particularly since the expansion in interest in all aspects of mineralogy since World War II, curators of mineral collections have been inundated with requests for information on British mineral localities. The Mineral Resources Memoirs of the Geological Survey have been available in specialized libraries or could sometimes be bought from the Stationery Office, but they were confined, in general, to the somewhat specialized treatment of limited areas and with mineral deposits of economic or potential strategic importance. There has been no *general* British mineralogy since Greg and Lettsom was published in 1858 and it has long been out of print. In recent years a number of articles on British regional mineralogy have appeared in magazines catering for the amateur, and it seems wholly appropriate that this reprinting of Greg & Lettsom should be carried out by publishers catering mainly for the amateur fraternity who have contributed so much to British mineralogy.

It has been argued that the ideal would be a *new* British Mineralogy, but this is a truly mammoth task and those few individuals with the expertise and necessary encyclopedic knowledge are often burdened with administrative and/or teaching duties. The late Sir Arthur Russell, a gifted amateur, planned such a mineralogy as did L.J. Spencer, formerly Keeper of Minerals of the British Museum (Natural History), but neither had the time to attack the problem in the necessary single-minded manner.

For this reprint, Peter Embrey has persuaded the publisher that this volume would be so much more valuable if the lists of minerals new to Britain since 1858 produced by L.J. Spencer in 1898 and 1931 (combined in this volume) and in 1958 were to be appended. Spencer's 1958 list went further than listing the mineral name with the reporter and date (as in the first and second lists) and included the chemical formula, crystal system, locality, and the reference to the original paper. Embrey has followed the latter arrangement in his 4th supplementary list which was specially compiled for this reprint edition, and mentions all additional species new to Britain and Ireland that had come to his notice by late summer 1977.

The new Foreword to the reprint by Peter Embrey gives much detail on the history of mineral collecting and of some of its personalities during the 'classical era' of its development during the late 18th and 19th centuries. References are freely appended and the amateur mineralogist will find this section of more than passing interest and even an inspiration for the future.

In the original work the primary classification is into *metallic* and *non-metallic* minerals, and these are then divided into chemical and element groupings with further chemical sub-divisions. This arrangement seems to have no modern counterpart, but it is not difficult to find one's way around the book—there is a useful alphabetical index, but no locality index. The principal merit of the book is the reasonably detailed locality information which is provided for each species, and this will be its main appeal to the amateur mineralogist.

With its lucid, plump foreword and biographical notes, supplementary lists and good locality information in the original manual this *new* Greg and Lettsom is a volume which no enthusiastic British or visiting mineralogist, amateur or professional, can afford to ignore, more especially since the binding and photolithography are well executed and the price reasonable. Criticisms are few; the modern type face and the layout of the title page appear out of sympathy with the original 1858 printing and the facsimile of the entry in the Allan-Greg catalogue is placed too high on the page. On the other hand the dust jacket shows an excellent colour reproduction of Weardale fluorite fluorescing. E.A.J.

POYNDER (M.). *The price guide to jewellery, 3000 B.C. to 1950 A.D.* Antique Collectors' Club, Woodbridge, 1976. pp. 385. Illus. in black-and-white and in colour. £15.00.

This large and expensive book attempts to give an indication of the price range of a variety of jewellery types. Many of these are illustrated in colour quite adequately and black-and-white photographs depict the more commonplace pieces. Prices are based on those obtaining in the saleroom and in some of the more important specialist shops. It is hoped to provide an annual updating service for a small extra cost. There is a bibliography, some notes on cutting, a glossary and a small section on gemstone identification. By and large the material is well chosen and accurate, although one or two undesirable names (which this reviewer will not perpetuate by quoting) have crept in. Though everyone has his own idea of price, this book will be invaluable for those who do not see antique jewellery every day and for the student. M.O'D.

RYKART (R.). *Bergkristall.* (Rock-crystal.) 2nd edn. Ott Verlag, Thun, Switzerland, 1977. pp. 248. Illus. in black-and-white and in colour. Fr 39.

This is the second edition of a work first published in 1971. The previous edition was not illustrated in colour, as this one is, and the later bibliography is much more extensive. M.O'D.

SCHNEER (C.J.). *Crystal form and structure.* (Benchmark papers in geology, no. 34.) Dowden, Hutchinson & Ross, Stroudsburg, Pa, 1977. pp.xiii, 368. $33.50.

The Benchmark papers are collections of major papers on a variety of scientific subjects edited by an acknowledged authority in the field. They cover the subject back to early papers (in this instance the 17th century) and endeavour to present the landmarks in the subject with some connecting editorial comment. This volume begins with some papers on the conception of internal periodicity and also includes items on vectorial surface energy, Bravais's rule and its extensions, the applicability of thermodynamics, periodic bond chains and surface energy as a function of structure. Since it is now quite difficult either to obtain the earlier papers or to separate basic theory from its applications with which most current papers are concerned, this book will prove invaluable to students of crystallography and crystal growth. M.O'D.

SCHUMANN (W.). *Gemstones of the world.* English trans. by Evelyne Stern. N.A.G. Press, London,1977. pp. 256. Illus. in colour. £8.95.

This is a concise, almost pocket-sized survey of gems, chiefly notable for its 70 pages of quite superb colour plates illustrating some 1500 specimens. Mrs Evelyne Stern has used her own very considerable gemmological knowledge to good purpose in preparing this careful translation.

Exhaustive tables are provided, but gemmological facts and methods are glossed over, or totally omitted, in the cause of brevity. Crystallography is dealt with inadequately in a couple of pages. Synthetics are dismissed in less than a page, imitations in half a page, doublets in seven lines, and no procedure for the recognition of any of these is given. The microscope, polariscope and dichroscope are not mentioned.

The main part of the book consists of brief descriptions of gem species divided into five sections: traditional trade gems, usable collectors' gems, rare gems for collectors, rocks (decorative minerals), and organic gems. Gem minerals are arranged in order of decreasing hardness in each group and one is surprised to find beryl between sapphire and chrysoberyl and to be told that it is a trigonal mineral. (I have been asked to point out that this error does not occur in the original German version, nor was it in Mrs Stern's translation. However, the joint publishers in New York, with an eye to the American sales, employed Professor Anthony C. Tennisen, of Lamar University, as a consultant and the unconventional classification seems to have crept in at this point. Is this another divergence between American mineralogy and that of the rest of the world?). Each description has its own superb coloured illustration on the opposite page. A few rarer gems are named but described by colour and hardness only and are not illustrated. In most cases, but not all, the deficient physical constants can be found in the tables. RIs and SGs are generally quoted only as overall ranges.

One is surprised to find sulphur included as a gem. Gaylussite, also in the third section, tends to lose water and become opaque.

Final tables combine hardness, refractive indices and specific gravities and suggest a gemmological procedure for testing individual stones. One of the tests postulated is hardness. Professor Schumann is a mineralogist, and this is evident in his approach to gem testing.

The book is called a complete survey of gemstones. A survey is not necessarily a detailed study. This one is aimed at the lay public rather than at the gemmologist. Its chief merit must be in its fine colour plates. R.K.M.

SCHUMANN (Walter). *Mineralien und Gesteine.* (Minerals and stones.) 5th edn. BLV Verlagsgesellschaft, Munich, 1977. pp.256. Illus. in colour. DM 25.

Available in both hard- and flexi-cover copies, this forms a companion to the author's *Edelsteine und Schmucksteine* (reviewed in J.Gemm., 1977, XV, 6, 337). Some Hartmann photographs appear, but the majority are new and welcome on that account as well as for their general excellence. Some rocks are included, but the space devoted to them is only about one quarter of the book. There is no bibliography, though (in the flexicover copy) advertisements from the publisher suggest further reading in the subject. Each specimen is described opposite its illustration and the quality of reproduction is high. An English edition is promised. M.O'D.

STERN (Evelyne). See SCHUMANN (W.). *Gemstones of the world,* above.

STONE (D.M.), BUTT (R.A.). *Australian precious opal.* (Revised edn.) Periwinkle books, Dee Why West, N.S.W., 1977. pp. 110. Illus. in colour. $2.95.

A well-illustrated book which gives some good shots of various opal mines, together with good quality colour-plates illustrating the types of material associated with different areas. Hints on prospecting and maps make this a promising guide for the collector in the field. M.O'D.

STRÜBEL (G.). *Mineralogie. Grundlagen und Methoden.* (Mineralogy: foundations and methods.) Ferdinand Enke, Stuttgart, 1977. pp. viii, 472. DM 24.80.

This pocket-size book presents an exhaustive survey of mineralogy with a good deal of reference to modern techniques. Up-to-date instruments are illustrated by photographs and the results obtained from them by clear diagrams. Each chapter includes its own bibliography and there is also a general list of relevant periodicals. Knowing this author's particular interests, it is not surprising to find particularly good treatment of crystallography and crystal-growth techniques. A feature which makes the book particularly suitable for student use is the section of question and answer accompanying each chapter. M.O'D.

VARGAS (G.), VARGAS (M.). *Faceting for amateurs.* 2nd edn. Vargas, Thermal, Ca. 92274, U.S.A., 1977. pp.xii, 345. 122 figs (black-and-white). Price on application.

This large book contains much more than instructions for faceting techniques, though these form the major part and are very well done. The rest is devoted to descriptions of gem materials, both natural and synthetic, and the range of materials included is very wide (painite is there, together with villiaumite, wardite and mellite). Among the synthetic materials are bromellite and tellurium oxide, both of which produce toxic dust, and tourmaline, which has only been manufactured in minute sizes. Natural zirconium oxide (baddeleyite) is wrongly stated to be hexagonal (it is monoclinic). These are, however, small points in an otherwise excellent work. Especially valuable to the student of gemmology are the directions given to the faceter when examining rough material with a view to fashioning it; diagrams illustrate all the important styles of cutting; there is a short bibliography and an extensive glossary. The book can be highly recommended. M.O'D.

VOLLSTÄDT (H.), BAUMGÄRTEL (R.). *Einheimische Edelsteine.* (Native gemstones.) 2nd edn. Steinkopff, Dresden, 1977. pp. x, 232. Illus. in black-and-white and in colour. Price on application (about DM 19).

This is a manual of gemmology in the sense of an introduction to the world of gemstones; crystal symmetry is discussed and, unlike many (or most) gemmological textbooks, the geological origin of the gem minerals is described. The gem materials themselves are listed in traditional mineralogical order (elements, oxides, etc.) and some unlikely candidates such as painite make their appearance. Many of the listed species are shown diagrammatically in their crystalline state, though some important ones (fluorite, brazilianite) are not so treated. By now the origin of the cause of colour in precious opal is common knowledge and it is treated correctly here.

Probably the most serious omission is a detailed review of the use of the spectroscope in gem testing; although the instrument is described, there is no list of important lines and bands apart from a small list of the significant features in the absorption spectra of some red stones. The chapter on synthetic materials lacks the important illustrations of inclusions in synthetic emerald and additional discussion of this important topic would have been welcome. A fairly large section of the book is devoted to the fashioning of stones and there is a short bibliography and a table of constants. Altogether quite a workmanlike book, evidently aimed at readers in the German Democratic Republic since that country and its mineral locations are shown on the back end-paper. M.O'D.

ZUCKER (B.). *How to invest in gems.* Blandford Press, Poole, 1977. pp. 128. Illus. in colour. £3.95.

The English version of the American text already reviewed (J.Gemm., 1977, XV, 7, 401), with appropriate changes in currency. M.O'D.

Guide to Australian gemstones. Reader's Digest Services Pty, Sydney, 1976. pp. 52. Illus. in colour. $1.10.

A beautifully illustrated booklet which covers the gem materials found in Australia, this useful guide includes maps and brief lapidary information and is substantially accurate. M.O'D.

Inventaire minéralogique de la Françe. (Mineralogical inventory of France.) Bureau de Recherches Géologiques et Minières, Service Géologique National, Orléans. Price on application.

These guides are prepared for each Department of France and so far the following have been covered: Hautes-Alpes, Alpes-Maritimes, Aveyron, Cantal, Côtes-du-Nord, Finistère, Tarn. Locations are pinpointed within each area and sketch maps are provided. Indexes are included for places and minerals and there are bibliographies. M.O'D.

Mineral Fundstellen. (Mineral Sources.) Christian Weise Verlag, Munich, 1975–

This series, as yet incomplete, is highly recommended and is easily the best of its type so far seen. The volumes published up to now are as follows:

1. FRUTH (L.). *Tirol, Salzburg, Südtirol.* (Tyrol, Salzburg, South Tyrol.) 1975. 2nd edn. pp. 207. Illus. in colour. DM 28.50.

This area of Austria includes the Habachtal, where emeralds are found in a mica schist. In this volume the bibliography is very short, but the coloured illustrations are well up to standard.

3. Glas (M.), Schmeltzer (H.). *Baden-Württemberg.* (Baden-Württemberg, W. Germany.) 1977. 2nd edn. pp. 197. Illus. in black-and-white and in colour. Price on application.

Baden-Wüttemberg is rich in minerals due to its varied geology and these are illustrated in high-quality colour plates. Each mineral location is depicted by a sketch-map and there is a very comprehensive bibliography. Well-known regions included are Pforzheim and the Kaiserstuhl.

4. Wilke (H.-J.). *Skandinavien.* (Scandinavia.) 1976. pp. 370. Illus. in colour. DM 48.

There is no other guide comparable to this one which deals with the minerals of the whole of Scandinavia (i.e. Sweden, Norway, Finland). Since there are so many important locations in these countries, such a guide has long been a desideratum, but now we have a handy form of reference to such places as Outokumpu (Finland), celebrated for uvarovite and chrome-diopside, Langesundfjord (Norway) with its suites of rare minerals, and Långban and its vicinity in Sweden, also famous for rarities. As in the other guides of this series, there is a superb bibliography extending over 14 pages (of small print): this is arranged by country, locality and then alphabetically.

5. Weninger (H.). *Steiermark und Kärnten.* (Styria and Carinthia, in Austria.) 1976. pp. 231. Illus. in colour. DM 32.

This volume follows the pattern of this excellent series in listing the major mineral sources of the country or portion concerned. The bibliography contains 200 entries, which gives some guide to the depth of the work. The area around Graz is well covered, as might be expected, since there is a wide range of minerals in that region. Titanite, fire opal and fluorite are found widely in the area and are beautifully illustrated in colour.

6. Schmeltzer (H.). *Rheinland-Pfalz.* (Rhineland-Palatinate, W. Germany.) 1977. pp. 189. Illus. in black-and-white and in colour. Price on application.

This area includes Idar-Oberstein and the Hunsrück as well as the Saarland. Other features are similar to the volumes reviewed above.

8. Huber (S.), Huber (P.). *Oberösterreich, Niederösterreich und Burgenland.* (Upper and Lower Austria and Burgenland.) 1977. pp. 270. Illus. in black-and-white and in colour. Price on application.

Similar to the volumes mentioned above and of equally high quality.

M.O'D.

ASSOCIATION NOTICES

PRESENTATION OF AWARDS

The Chairman, Mr Norman Harper, presiding over the annual Reunion and Presentation of Awards, held at Goldsmiths' Hall on 24th October, 1977, described the results of the year's examinations as regrettably below those of previous years. Only 53% of those taking the Preliminary and only 24% of those taking the Diploma had passed. He described this as 'terrible'.

The Prime Warden of the Goldsmiths' Company, Mr Algernon Asprey, made the presentation of the awards to successful candidates, who had come from all over Britain as well as from Sri Lanka, Finland, Spain, the Netherlands and Belgium. In addressing the assembled students, he drew a parallel between the Worshipful Company and the Association in that they both cared for the integrity and stability of the trade. 'Your success is the stepping-stone to experience', he said, 'because to be expert in gems requires constant handling of them. People push rings under my nose and say "What are they worth?"' he added, and to illustrate that this was an impossible task he instanced as a case of experts disagreeing over value the yellow diamond which was to have been auctioned in Switzerland as naturally coloured but was then pronounced to have been artificially coloured by irradiation. He had seen such disasters happen on a smaller scale where people had bought goods abroad thinking them bargains and he had to explain to them that the knowledge of stones was world-wide—a dealer in Bangkok was just as aware of their value as was one in London. 'I have often told such people that they should have known better, and should have gone to a well-known firm to buy. An individual may or may not be honest, but a firm with a famous name cannot afford to be dishonest: the integrity of a business must be sustained.'

He quoted a passage from Samuel Pepys where the diarist had recorded that his wife had increased her stock of jewellery by getting a ring made with a turkey stone (turquoise) set with diamonds. She had chosen the gift. No one just *bought* such things, they were eventually *given,* no matter how fantastic they might appear as part of a stock: giving was a fact of life, which brought much pleasure.

As members of the Gemmological Association they were not alone, because they had a world fellowship. Mr Asprey recalled a meeting with the jeweller to the Imperial Household in Ethiopia, who said that he was not alone where diamonds were concerned because he was in touch with dealers in Hatton Garden, but he was on his own where coloured stones were concerned. That meeting led to an embarrassing experience. 'We went to the Palace to examine the gifts of a wealthy Arab ruler. Looking at the rubies, we realized that they were reconstructed.'

Mr Asprey had recently visited Teheran, where they had been holding a British Cultural Festival at which treasures from London had been an important exhibit presented by the Goldsmiths' Company after touring the U.S. and Canada. He had planned to buy turquoises there but was interested to note that the dealer had some magnificent diamonds and was backing them with a gemmological certification. So, though he was in a remote country, he was not alone.

MEMBERS' MEETINGS

London

On the 1st February, 1978, at the Geological Museum, London, Mr E.A. Jobbins, B.Sc., F.G.A., gave a lecture on 'The Ruby and Sapphire Gem Fields, Cambodia', based on a three months' visit in late 1974. Mr Jobbins dealt with the methods of working, the gemstones and the basic geology, as well as proposals for future working; and his lecture was illustrated by maps and a large number of colour-transparencies. The lecture-theatre of the Geological Museum proved a most attractive and comfortable venue and it is hoped that the substance of the lecture will be published in a future issue of the *Journal.*

On the 4th April, 1978, at the Central Electricity Generating Board Cinema, London E.C.1., a talk was given by Mr P.H. Read, C.Eng., M.I.E.E., M.I.E.R.E., F.G.A., Head of Electronics, De Beers Central Selling Organization, entitled 'New Gemmological Instruments and Techniques'.

Midlands Branch

A meeting was held on the 26th January, 1978, at the Royal Institute of Chartered Surveyors, Birmingham, when Mr R. Punnell gave a talk on 'The Art of Stone Cutting'.

North-West Branch

On the 24th November, 1977, at the Royal Institution, Liverpool, films were shown entitled 'Aurum' and 'Its All Done with Minerals'.

On the 28th January, 1978, a Buffet Dance was held at the Shaftesbury Hotel, Liverpool.

On the 22nd February, 1978, at Church House, Liverpool 3, Mr Alan Hodgkinson, F.G.A., gave a lecture entitled 'Gemmological Insight'.

South Yorkshire and District Branch

A 'Practical Evening' was held on the 16th January, 1978, at the Sheffield City Polytechnic, when members were able to examine a selection of specimens.

The Annual General Meeting of the Branch was held on the 11th February, 1978, at Tapton Hall, Sheffield 10, followed by a dinner for members and guests.

ANNUAL GENERAL MEETING

The Association's Annual General Meeting will be held at Saint Dunstan's House, Carey Lane, London EC2V 8AB on Thursday, 11th May, 1978, at 6.00 p.m.

COUNCIL MEETING

At a meeting of the Council held on Monday, 13th February, 1978, the following were elected to membership.

FELLOWSHIP

Alexander, Frank E., London.D. 1955
Bhaskaran, G., Bombay, India. D. 1977
Bruce, James T., Transvaal, S. Africa. D. 1977
Campos de Quevedo, Juan N., Madrid, Spain. D. 1977
Cañas Carballido, Miguel, Madrid, Spain. D. 1977
Clements, Jennifer M., London. D. 1977
de Silva, Nirmali P., Ambalangoda, Sri Lanka. D. 1977
Gill, Stephen H., East Horsley. D. 1977
Goonawarna, C. L. W. P., Ratnapura, Sri Lanka. D. 1977
Gunaratna, M. S., Colombo, Sri Lanka. D. 1977
Gunawardene, Mahinda, Colombo, Sri Lanka. D. 1977
Havlik, Jan C., London. D. 1977
Innala, Harri T., Toijala, Finland. D. 1977
Lintunen, Viktor, Kuusonkoski, Finland. D. 1977
Mendis, Rowena, Colombo, Sri Lanka. D. 1977
Murga Chivite, Miguel A., Barcelona, Spain. D. 1977
Mylius, Maren-Ann, Oslo, Norway. D. 1977
Narros Martin, Gabriel, Madrid, Spain. D. 1977
Nootenboom, Poppy Z. L-B., Hong Kong. D. 1977
Perez-Alberdi Manzano, Felix, San Sebastian, Spain. D. 1977
Pethe, Dilip M., Bombay, India. D. 1977
Pounds, James R. W., Horsham. D. 1977
Rademaker, Elizabeth J. M., Soest, Holland. D. 1977
Ramchandran, K. T., Bombay, India. D. 1977
Salminen, Mirja L., Pori, Finland. D. 1977
Sayer, David J., Weston-super-Mare. D. 1977
Timonen, Esko Tapio, Hameenlinna, Finland. D. 1977
Truelove, Stephen R., Bradford. D. 1977
Uchihara, Ichiro, Osaka, Japan. D. 1977
Walker, Andrew G., Guildford. D. 1977

ORDINARY MEMBERSHIP

Abasolo, Aranguren, Ander, London.
Abeyakoon, Sudanta, London.
Abeysinghe, Pushpa K. de S., Colombo, Sri Lanka.
Akizuki, Haruo, Nairobi, Kenya.
Alidina, S. A., London.
Anderson, Charles, Va, U.S.A.
Andrews, Sheila M., Dalkeith, W. Australia.
Aresh, Gordafrid T., Tehran, Iran.
Ashra, Harish, London.
Atiqalam, Farooqi, Rawalpindi, Pakistan.
Bartram, Garry D., Perth, W. Australia.
Bass, Joan J. A., Deal.
Baxendale, John F., Shipley.
Blake, Jeannette A., London.
Blanckenberg, Antoinette, Southampton.

Bodenham, Kenneth E., Newcastle-upon-Tyne.
Bogues, Patrick M., Omagh, N. Ireland.
Bolsover, Shirley, Hong Kong.
Bonham, Frank C., Ca, U.S.A.
Borg, Stefan, Charlottenlund, Denmark.
Borthwick, George W., Klerksdorp, S. Africa.
Bradoch, Robert, Tokyo, Japan.
Bramwell, Peter, Durham.
Brierley, Hugh, Invercargill, New Zealand.
Bromwich, Graham S., Reigate.
Brownlow, Arthur H., Mass, U.S.A.
Burgan, Shirley E. M., Bristol.
Burns, Lynn D., Birmingham.
Carrel, Gerard, Geneva, Switzerland.
Chadwick, John S., Todmorden.
Chodanowicz, Janina T., Bradford.
Christensen, Curtis J., London.
Clampitt, Marjorie, Abingdon.
Curtis, Malcolm D., Fareham.
de Almeida Prado, Joao B., São Paulo, Brazil.
de Camargo, William G. R., São Paulo, Brazil.
Deeley, Peter J., Birmingham.
de Grado, Joseph, La, U.S.A.
Deuell, C. Francis, Oreg., U.S.A.
Dobb, George H., Ca, U.S.A.
Dominguez Mondelo, Segundo, Oviedo, Spain.
Donald, Robert J., Ont., Canada.
Dougan, Patricia M. S., Nairobi, Kenya.
Dups, Kennerley C., London.
Emslie, Iain A., Bromyard.
Fainzilber, Misha, Dar es Salaam, Tanzania.
Fenton, John, Dartford.
Folgueras Dominguez, Servule, Madrid, Spain.
Foster, Stephen V., Ohio, U.S.A.
Furse, Anna A., London.
Furuya, Hitomi, Tokyo, Japan.
Garson, Magnus S., Kerala, India.
Gold, Andrew D., Ilford.
Green, James E. W., Wolverhampton.
Griffiths, Geoffrey E., Grimsby.
Groenenboom, Hans K., Spykenisse, Holland.
Hameed, Abul H. M. S., Hong Kong.
Harding, Roger R., London.
Hashiguchi, Masahiro, Tokyo, Japan.
Hassen, Naufan W., Dharga Town, Sri Lanka.
Henson, Ian J. D., Hillingdon.
High, Lawrence R., Salisbury, Rhodesia.
Horvath, Elsa, Que., Canada.
Howard, David, Longridge.
Huang, C. K., Taipei, Taiwan.
Huo, Bonnie K., Hong Kong.
Ichimura, Yoshino, Aichi Pref., Japan.
Ishida, Toshio, Kyoto, Japan.
Israel, Nigel B., London.
Jealouse, Roy G., Crewe.
Jibiki, Emiko, Aichi Pref., Japan.
Johnson, Arthur George, Ill., U.S.A.
Jones, Edith W., Peppermint Grove, W. Australia.
Kasahara, Yuriko, Yokohama-City, Japan.
Kato, Takenori, Osaka, Japan.
Kayman, Shelley, London.
Kenner, George F., Ca, U.S.A.
Keydar, Susan, London.
Khan, Humayun Y., South Ruislip.
Kimura, Shinichi, Kyoto, Japan.
Klaver, G. J., Jeppestown, S. Africa.
Kojima, Mieko H., Yokohama, Japan.
Lakdawalla, Noshir J., Bombay, India.
Lam, Kenneth T. H., Hong Kong.
Lee, Richard S. K., Hong Kong.
Li, Woon So, Hong Kong.
Lurie, Joseph, Randburg, S. Africa.
McCready, Ann, London.
McNeel, Day P., Tex., U.S.A.
Mavromati, Yiota, Nicosia, Cyprus.
Minster, David, Pretoria, S. Africa.
Murphy, Mary M., New York, U.S.A.

Nakama, Toshiro, Okinawa Pref., Japan.
Nakagawa, Masateru, Hyogo Pref., Japan.
Narita, Kazuaki, Tokyo, Japan.
Nobumisto, Takagi, Kanagawa Ken, Japan.
Nosaka, Yoshiko, Tokyo, Japan.
O'Donnell, Francis X. D., Liverpool.
Ohkura, Keiko, Tokyo, Japan.
Okimoto, Yoshiyuki, Tokyo, Japan.
Okimoto, Youko, Tokyo, Japan.
Pagoulatos, Elias, Athens, Greece.
Palmer, Joanna G., Guildford.
Pattni, Pravin, London.
Pendlebury, Marguerite D., Hove, S. Australia.
Perera, G. M. Beatrice, Nivitigala, Sri Lanka.
Pierson, Robert C., Deale, Md, U.S.A.
Pillay, Subbiah V., Isipingo Hills, S. Africa.
Pollard, James F., Glen Waverley, Australia.
Pollard, Jilly, Dorking.
Qami, Kiyoshi, Tokyo, Japan.
Quinn, Robert C., Dublin, Ireland.
Raniga, Harish B., Ilford.
Richardson, Malcolm F., Cleethorpes.
Roditi, Maurice, New York, U.S.A.
Sadamatsu, Toyojiro, Nagasaki Pref., Japan.
Salgado, Eric G. A., Solihull.
Schofield, John, Leeds.
Selbey, Sheelagh F., Newcastle-upon-Tyne.
Senda, Katuniko, London.
Sever, Katherine M., Altrincham.
Shepherd, Richard B., Aylesbury.
Shirai, Saijiro, Tokyo, Japan.
Shore, Barry F., Ca, U.S.A.
Sin, Gwang S., Seoul, Korea.
Skai, Eve, Oslo, Norway.
Spivack, Hyman, Harrow.
Spooner, David J., Merstham.
Stears, Trevor W., Bromley.
Streight, Stewart G., Ont., Canada.
Sugawara, Tadashi, Tokyo, Japan.
Sugiyama, Yoshie, Yamaguchi Pref., Japan.
Suhner, Bertold, Herisau, Switzerland.
Suzuki, Takayoshi, Tokyo, Japan.
Takahashi, Ikuo, Kyoto, Japan.
Tarjan, Andrew, Toronto, Canada.
Tate, Julia F., Hong Kong.
Timms-Hackworthy, David, London.
Tollefson, Terry W., Minn., U.S.A.
Tongi, Aurora, Bouira, Algeria.
Uppard, John E., Westcliff-on-Sea.
Vale, Shelagh V., Dundee.
Vidal, Nessio V., Eastbourne.
Vollom, Paul A., Oreg., U.S.A.
Vose, James, Me, U.S.A.
Watson, Joy S., Cottingham.
Watts, Terrence J., Newcastle-upon-Tyne.
Weeresinghe, N. P. O., Ratmalana, Sri Lanka.
West, Clive G., London.
Winarto, Arief, Jabar, Indonesia.
Winn, Neelia, London.
Woodford, Trevor A., Windsor.
Worthington, Sally L., Bingley.
Yamashita, Junko, Tokyo, Japan.
Yoshikawa, Kazuhiko, Wakayama Pref., Japan.
Zahir, Sheik, Oberwil, Basel, Switzerland.
Zala, Marga, Hong Kong.
Ziff, Harold, Ariz., U.S.A.

NEWS OF FELLOWS

On the 4th December, 1977, Mr E.A. Jobbins, B.Sc., F.G.A., gave a talk entitled 'The Gentle Art of Gemstone Faking' at the Geological Museum, London.

Mr E.A. Jobbins also took part in a program entitled 'The Mountain of Light: the Story of the Koh-i-Noor Diamond', which was broadcast by the BBC on Radio

4 at 11.05 a.m. on Monday, 19th December, 1977, and repeated at 8 p.m. on Thursday, 22nd December.

On the 14th January, 1978, Mr J.A. Fleming, F.G.A., gave a talk on unusual gemstones to the Wessex Branch of the N.A.G.

The classes in gemmology started by the Gemmological Institute of India two years ago (J.Gemm., 1976, XV, 4, 224) are in charge of Shri Ravindra J. Jhaveri, B.Sc., F.G.A.

OBITUARY

Mr Norman de Berry Noakes (D.1970), Auckland, New Zealand, died on the 31st December, 1977.

GIFT TO THE ASSOCIATION

The Council of the Association is indebted to Mrs Janet Harris, F.G.A., Adelaide, Australia, for a fine oval greenish/brown sphene weighing 6.91 ct.

DIAMOND TRAINING CLASSES (INDIA)

To meet an insistent demand from the trade, the Gemmological Institute of India has now arranged for training classes in diamond grading and sorting. The first trainees started training on 12th December, 1977. The classes are in charge of Shri Sudhir Ghaswalla, B.Sc.

VIENNA NATURAL HISTORY MUSEUM

The Natural History Museum (Naturhistorisches Museum) in Vienna has opened a new room for a mineralogical-petrographic collection which includes rocks and gemstones. The gem part of the exhibition forms about one third of the collection. New safety measures have been introduced, and these enable some specimens to be exhibited which had not been on show since 1848.

Roughly 3000 gemstones are exhibited. The collection of emeralds from Colombia may be one of the best in the world; it contains a piece of rough consisting of 15 large crystals of gem quality, which was a present from Montezuma to Ferdinand Cortez.

The diamond collection is mainly from South Africa; it contains a crystal of 82.5 ct, as well as various rough pieces weighing from 10 to 40 ct each. Some coloured diamonds are set in rings. There are also some Golconda pieces, one beautiful blue of 5 ct, some pink, some yellow-green and a particularly beautiful yellow stone.

The largest European precious opal weighs 584 ct, is of finest quality, was found at the time of Maria Theresa in Czerwenica, now in Slovakia, but then in Hungary. There is also a good collection of precious metal objects and many other gemstones, such as a very fine cut alexandrite of 13 ct, many rubies, a giant precious topaz and tourmaline crystals from Pala in California.

A well produced card on sale at the Museum depicts a bunch of flowers which Maria Theresa presented to her husband in 1760. Made by the Viennese jeweller Grosser, it consists of 1500 coloured gemstones and 1200 diamonds, all of the best quality.

XVIth INTERNATIONAL GEMMOLOGICAL CONFERENCE

(Report received from Mr A.E. Farn, F.G.A.,
Manager of the London Chamber of Commerce Gem Testing Laboratory)

The Sixteenth International Gemmological Conference was held at The Hague from 9th to 13th October, 1977. Thirty-nine people, four of them women, participated, and the Conference was chaired by Dr P.C. Zwaan, F.G.A., (National Museum of Geology and Mineralogy, Leiden). At the commencement of the proceedings all stood in silence as a tribute to the late Robert Webster, F.G.A.

Mr B.W. Anderson, B.Sc., F.G.A., gave an elegant and informative talk upon 'Experiences with Industrial Diamond', speaking of carbonado, boart and industrial crystals, plus the purity-testing of powders and grits.

Dr C.E.S. Arps, F.G.A., (Leiden) demonstrated an immersion-contrast polariscope.

At an evening meeting at Oud-Wassenaar Castle, 'Fancy-colour Diamonds' were covered by Mr E. Asscher (a relative of Joseph Asscher, of Cullinan fame).

Professor Dr H. Bank, F.G.A., (Idar-Oberstein) gave a rapid resumé of some recent additions to the world of gemstones, and promised to send a complete list with properties to all participants.

Dr J.M. Bosch-Figueroa (Barcelona University) described accessories for photographing with a microscope the surface structure of diamonds.

Professor A. Chikayama, F.G.A., (Tokyo) gave a talk illustrated with colour slides of gem mines in the Far East.

Mr Robert Crowningshield, F.G.A., (GIA New York Laboratory) spoke upon the growth of diamond grading under the GIA since about 1955.

Mr A.E. Farn, F.G.A., after commenting on the wide range of gem materials encountered (from diamonds and sapphires to such materials as tortoiseshell, shagreen and even dung-beetles), spoke of the carbonates and calcium carbonate itself in its various forms, particularly of calcite—beautiful as a crystal, as a cut stone a rarity (owing to cleavage and softness), the basis of the dichroscope (now an underrated instrument) and nicol prisms, the standard 3 on the Mohs hardness scale and a useful indicator in density determination liquids—and various forms of pearl and shell, but also of bonamite (rivalling both jade and emerald in colour): his talk was illustrated by fine colour slides from the Institute of Geological Sciences and from Mr R.K. Mitchell, F.G.A.

Professor Dr M. Font-Altaba (Barcelona University) described crystallographic applications in gemmology with some wonderful slides.

Mr H.M. Forth (Toronto Gem Lab) spoke of some minute diamond finds in a Kimberlite pipe covering an area of 90 acres in Somerset Island, N.W. Territory, Canada.

Mr E.A. Jobbins, B.Sc., F.G.A, (Institute of Geological Sciences, London) gave a coloured-slide lecture on the origin of the Pailin ruby and sapphire deposits: he had actively participated in surveying the area.

Dr J. Kanis (Rhodesia) gave a potted discourse upon the various gemstones from southern Africa with informed observations upon the physical scene and its latent troubles.

Mlle Dina Level (late of the Paris Laboratory) produced a series of slides and observations which were both beautiful and practical.

Mr Richard T. Liddicoat, Jr, (President of the Gemological Institute of America) described the new headquarters of the GIA in Santa Monica, California. Briefly, they have 17 classrooms (1 research), 215 full-time resident students, 11-12 000 correspondence students, craft classes and department-store management classes. Their equipment includes instruments such as a scanning electron microscope with an energy-dispersant magnification of 5-150 000 × .

Dr H. Nairis, F.G.A., (Geological Survey, Sweden) gave a short talk on diamond substitutes.

Mr P.P.E. Paulin, B.Sc., F.G.A., (Uppsala University, Sweden) gave details of investigations into the causes of colour-centres in sodalite.

A lecture on 'The Optical Refractoid' by Mr H.S. Pienaar, F.G.A., (Stellenbosch University) described a method of teaching uniaxial and biaxial measurements on a practical refractometer extension.

M. J.-P. Poirot (Paris Laboratory) talked upon the same subject as Mr Pienaar, which caused some overlapping of ideas.

Dr F.H. Pough described cut dumortierite and a new man-made fibrous cat's-eye material.

Mr Hans Reymer (Toronto) accented the difficulties of Canadian gemmologists due to the great distances separating them.

Dr J. Saul gave an exposition on an unusual suite of garnets from the Umba River, Tanzania, which have a colour-change effect.

Mr C.A. Schiffmann, F.G.A., (Gübelin Laboratory, Lucerne) spoke of alexandrite-like garnets and mentioned the powerful influence of chromium on colour.

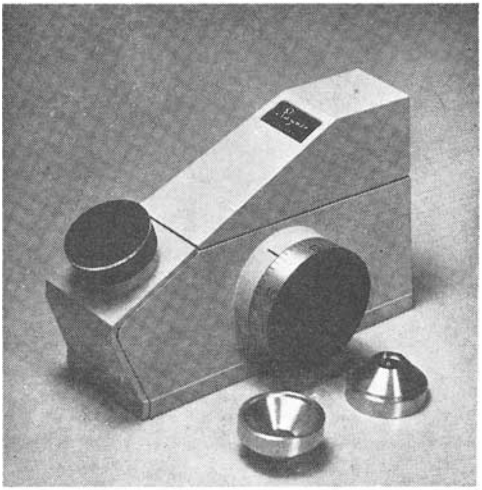
Dr H.-J. Schubnel (Paris) gave a talk on gem mining methods in Thailand with beautiful colour-slides.

Mr E.B. Tiffany (Ontario) gave a shrewd summation of the impact of gemmology (post- and pre-war effectiveness), commenting on the improvement of quality, standards, techniques and grading and the order emerging from these concepts and emphasizing the principle 'No consumer—no gemmology'.

Mr G. Tombs, F.G.A.A., (Sydney, Australia) spoke of the lack of technical information available on heat treatment and described his own experiments to lighten the colour of dark Australian sapphires.

CORRIGENDA

On page 28 *ante*, in Figure 10, (1) in the top right-hand diagram (EFG Growth) 'diet support' should read 'die support', and (2) in the middle left-hand diagram (LPE Growth) there should be no rule joining 'rotate' to 'excess ...' (viz. slow rotation for growth, fast rotation for spin-off of excess melt on withdrawal).



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