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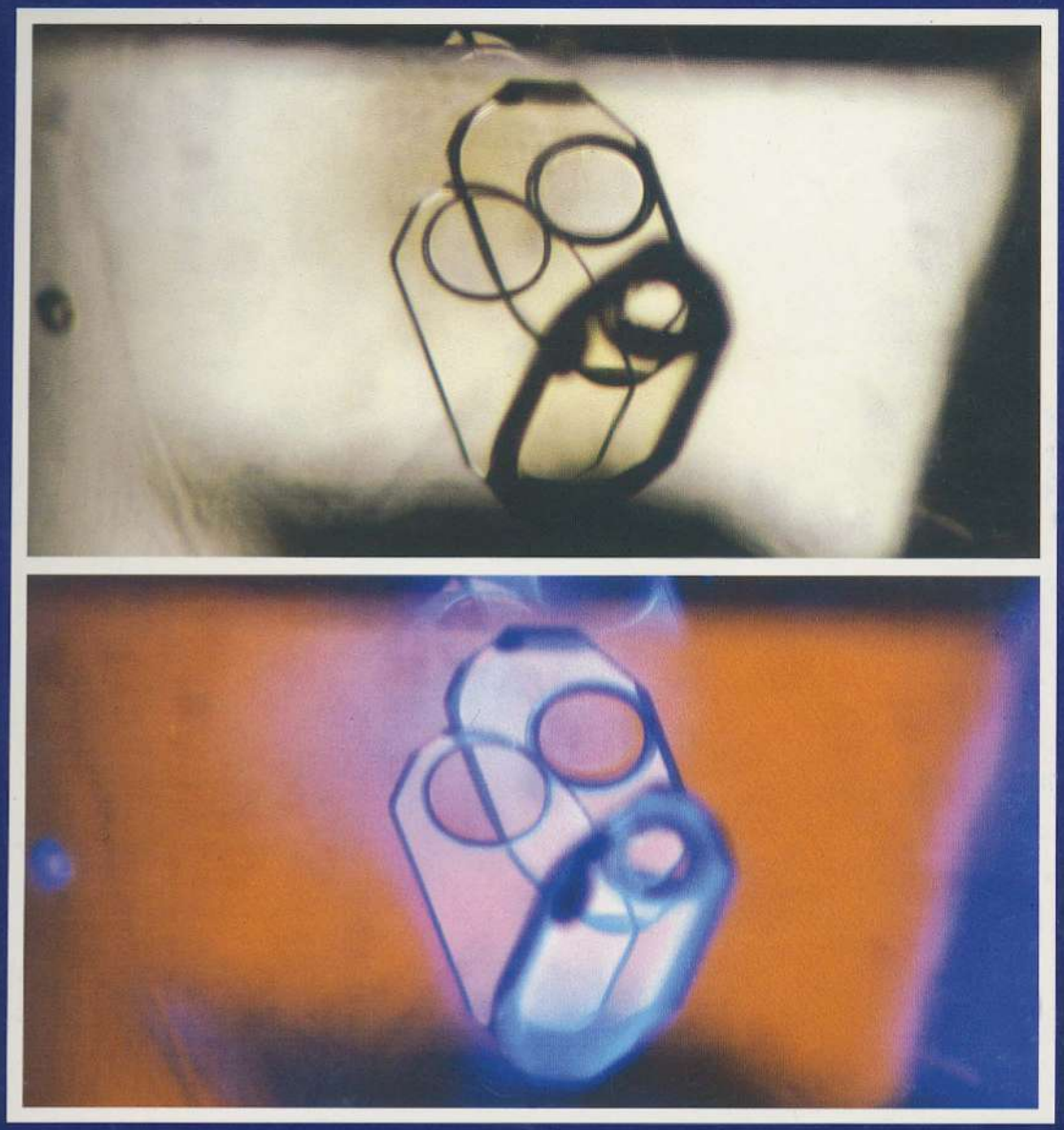

The Gemmological Association and
Gem Testing Laboratory of Great Britain

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Cover Picture

Three-phase inclusions in quartz consisting of oil, a gas bubble and a small black particle of bitumen. Transmitted light (top) and long-wave ultraviolet light plus low intensity transmitted illumination below. 14x.
(See 'Fluorescent oil inclusions in quartz' pp. 84-5)
Photo by Anthony de Goutière

ISSN: 0022-1252

Alan Jobbins
Editor 1986-93

Alan Jobbins resigned from the editorship of the *Journal* at the end of 1993. The Council of Management has appointed Dr Roger Harding to succeed him.

In 1985 Alan became joint Editor of the *Journal* with J.R.H. Chisholm and took over completely in 1986. In that year he launched a new design, of increased size, which incorporated more colour illustrations of better quality and enhanced the already world-wide reputation of the *Journal*.

Gemmology is a constantly changing and expanding subject, and we intend that the *Journal* should develop to reflect, record and be part of these changes. To this end, an editorial structure including Assistant and Associate Editors is planned and will involve a wide range of expertise. This will enable a thoroughly professional assessment of new manuscripts describing the latest gemmological developments.

The *Journal* will continue to be a major magazine for original papers on topics of significance for gemmologists whether they be in production, manufacturing, distribution, testing or research sectors of the profession. We invite accounts of new gemstone research and stimulating reviews of recent advances for publication. We aim to achieve publication in twelve months or less from date of reception of a satisfactory manuscript.

For many years and throughout his editorship Alan supplied a constant stream of colour illustrations for the *Journal* - they were superb and have been a major feature in his articles and lectures on gemmology. We hope that Alan will continue to delight us all with his pictures and with the fruits of his gemmological travels throughout the world. We would also like to wish him good health and many more years of enjoyment in his gemmological activities.

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Four hessonite occurrences in Orissa, India

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Abstract

Hessonite garnets from the villages of Ghatpara, Dahikbala, Budhido and Burubura in Orissa, India, are located in the high-grade metamorphic khondalite suite and occur either in calc-silicate lenses or in quartzite-amphibolite contact zones. The paragenesis of Orissa's hessonite is linked to regional metamorphic processes, probably during Middle Proterozoic times. The colours of the stones are pale yellowish, orange to brown and the ranges of the refractive index and density from each locality are:

Ghatpara:	n=1.738-1.752	D=3.56-3.64 g/cm^3
Dahikbala:	n=1.750-1.756	D=3.58-3.64 g/cm^3
Budhido:	n=1.751-1.758	D=3.60-3.63 g/cm^3
Burubura:	n=1.759-1.763	D=3.60-3.66 g/cm^3

In addition to calcium, aluminium and silicon, the chemical analyses also show a distinct content of iron and traces of both manganese and titanium.

Microscopical study shows that the hessonite from Ghatpara is characterized by mineral inclusions, healing cracks with two- or three-phase inclusions and growth marks which sometimes show strong interference colours under crossed polarizers. The inclusions in the stones from Burubura are mainly healing cracks with two- or three-phase inclusions and growth marks. The hessonite from Budhido shows a strong oily appearance and mineral inclusions, and the stones from Dahikbala are characterized by needle-like inclusions, growth marks and some mineral inclusions.

Introduction

India is an important producer of gemstones and rare collectors' specimens, and well known for its abundant gemstone occurrences. There are many valuable garnet occurrences, not only of very fine rhodolite, almandine and pyrope-almandine but also of the hessonite variety of grossular.

Indian hessonite has been found near Madras in the Coimbatore district; in the State of Orissa, near Boirani in the Genjam district and near Daolathgarh in Rajasthan (Rouse, 1986).

During a United Nations Development Programme (UNDP) exploration mission in Orissa (India) recently one of the authors (J.K.) collected light yellowish to brownish hessonite samples from the Ghatpara deposit, south of the Tel river. Later, in November 1992, hessonite samples in yellowish-brown and orange to brownish colours were collected from three other occurrences near Dahikbala, Budhido and Burubura, all in the State of Orissa.

The physical, chemical and microscopic characteristics of hessonites from these four different occurrences are interesting to compare. Grossular is chemically a calcium aluminium silicate ($Ca_3Al_2(SiO_4)_3$) and forms with andradite and uvarovite the ugrandite series (Deer *et al.*, 1982). Two kinds of decorative grossular can be distinguished: a transparent and an opaque type. Opaque green grossular variety, which is known in the trade as 'Transvaal Jade', is a mixture of grossular with vesuvianite. The green colour depends on the chromium (Cr^{3+}) content (Bank, 1982). Opaque pink grossular is a mixture of grossular and hydrogrossular, now know as hibschite where SiO_4 is partly replaced by $(OH)_4$, and the colour is caused by manganese (Bank, 1982).

Transparent grossular is known in colourless, green, yellowish and orange to brown colours. It is the vanadium (V^{3+}) and/or chromium (Cr^{3+}) content which is responsible for the green colour, and this green grossular is well known under the name tsavorite, from East Africa. The yellowish and orange to brownish colour is caused by iron (Fe^{3+}) and this grossular variety is known as hes-

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Table I. Refractive indices and densities of transparent grossular from previous literature

Literature	*Colour*	*Refractive index*	*Density: g/cm³*
Eppler (1984)	pure synthetic grossular	1.734	3.594
Bank, H. (1971)	colourless	1.732	3.65
Bank, H. and Henn, U. (1988)	yellowish-green - dark green (contains vanadium)	1.735-1.759	3.55-3.64
Eppler (1984)	light green	1.734-1.738	
Eppler (1984)	tsavorite (green)	1.739-1.744	3.61 (mostly)
Bank, H. *et al.* (1969)	yellow	1.745	3.60
Bank, H. *et al.* (1969)	brown	1.749	3.73
Webster (1983)	hessonite	1.728-1.748	3.65
Eppler (1984)	hessonite	1.742-1.748	3.65 (mostly)
Manson and Stockton (1982)	hessonite	1.733-1.760	3.59-3.66

sonite. The refractive indices and density in the transparent varieties vary considerably, depending on the contents of different elements. For instance, in the green vanadian grossular the aluminium (Al^{3+}) is partly replaced by vanadium (V^{3+}) and chromium (Cr^{3+}). The higher the percentage of vanadium (V^{3+}), the more intense is the green colour and the higher are the refractive indices and the density (Bank and Henn, 1988). In the yellowish to brown grossulars there is a partial replacement of aluminium (Al^{3+}) by iron (Fe^{3+}). Similarly, the refractive indices and the density are higher with increased iron content.

Strongly corroded apatite and calcite have been found as inclusions in hessonite, as well as diopside and zircon. Typical internal features in hessonite are oily-looking streaks, often called 'treacle'. According to Gübelin and Koivula (1986) this is due to a colloid separation of calcite in the hessonite from Sri Lanka. Also lamellar growth marks are observed.

During the International Gemmological Conference meeting in Rio de Janeiro (1987) Gübelin reported inclusions in the orange, brownish-orange to brownish-yellow grossular from Orissa. These inclusions are orthoclase crystals with twinning, small prismatic apatite crystals and well formed quartz crystals. Gübelin also mentioned three-phase inclusions (watery fluid, gas bubbles and halite crystals) and multiphase inclusions (watery fluid, drops of oil, gas bubbles, halite crystals and a not yet identified black amorphous substance, which could be bitumen).

Federal State of Orissa

Geography

The State of Orissa is situated on the east coast of India, along the Gulf of Bengal and south-west of Calcutta.

The Mahanadi river flows through the Eastern Ghats and has a length of 885km. This mighty river has been known for the occurrence of alluvial diamonds for more than 200 years. The hills and mountains of the Eastern Ghats dominate the morphology of Orissa; the average elevation is about 750m, but a few peaks rise to over 1500m.

Geology

Geologically the Eastern Ghats consist largely of high grade Precambrian metamorphic rocks with a distinct structural-geomorphological trend parallel to the north-north-east to south-south-west elongation of the Eastern Ghats. The principal lithologies are khondalite, charnockite, leptynite and gneiss, with a very complex structure, indicating a zone of intense deformation (Figure 1).

The high degree of regional metamorphism (granulite and amphibolite facies) in the western part of Orissa has been responsible for developments of garnets, rubies, sapphires and

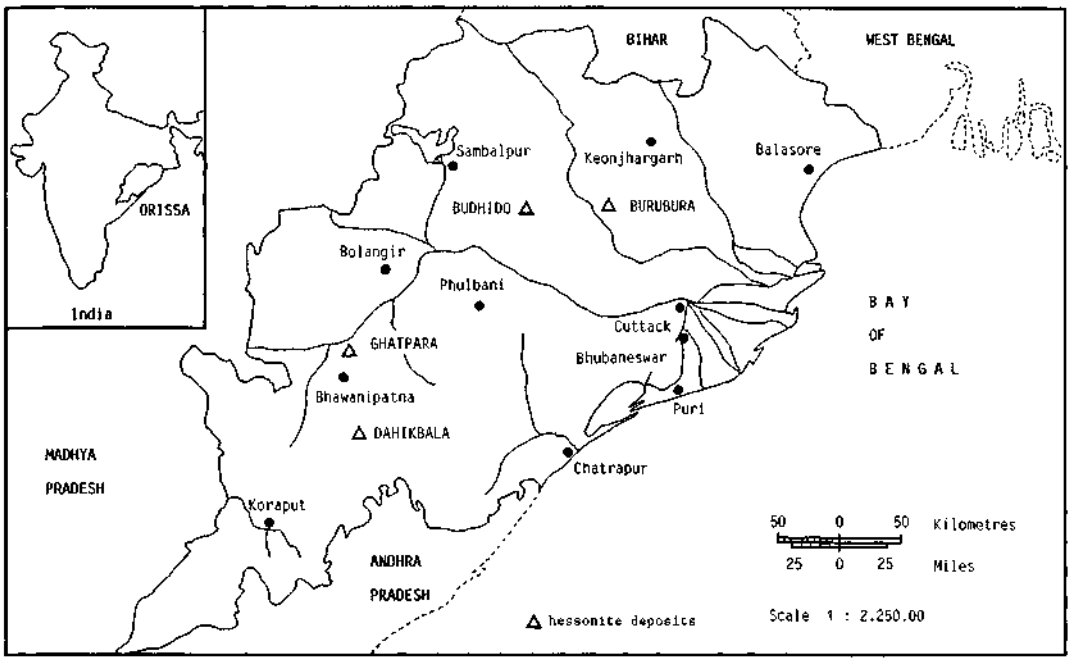


Fig. 1. Geographical location of Orissa hessonite occurrences.

cordierite, whilst younger granite intrusions and their related granitic pegmatites are the source for gemstones like aquamarine, chrysoberyl cat's-eye and tourmaline. These occur in a number of extensive pegmatite belts throughout western Orissa. The two principal rock suites of the Eastern Ghats are:

Khondalites and related rocks, which consist of calc-silicates, a metamorphosed sequence of sediments and limestones. In addition to sillimanite and garnet, other minerals indicative of the high metamorphic grade are cordierite and sapphirine.

Charnockites are silica-rich, quartzo-feldspathic assemblages containing hypersthene.

Khondalites and charnockites were first recognized in India in the Khalahandi district of Orissa (khondalite) and near Pallavaram in Tamilnadu (charnockite). Subsequently, these rocks were identified in other parts of India and Sri Lanka.

The khondalites are intimately interbedded with calc-silicate rocks and represent a series of argillaceous sediments formed in an environment that also permitted the deposition of

Fig. 2. Erratic hessonite 'pockets' in calc-silicate formation (khondalite). (*Photo J. Kanis*)

Fig. 3. Illegal hessonite mining near the village of Singjharan in calc-silicate formation (khondalite). (*Photo J. Kanis*)

carbonate rocks. These calc-silicates form lenticular bodies 50 to 800m long and 5 to 200m wide, often associated with manganese-bearing rocks. These interbedded lenses always contain K-feldspar, wollastonite, calcite and quartz. Other characteristic minerals are grossular, scapolite, diopside and sphene.

The mineralogy is largely a result of prograde metamorphism, but some retrogressive effects have been found, e.g. Choudhuri and Banerji (1974) described an assemblage of grossular and quartz formed by retrogressive reaction of anorthite and wollastonite. Cordierite is present in areas of a lower metamorphic grade than the common sillimanite-garnet rocks which do not contain cordierite. Naqvi and Rogers (1987) mention that an inverse correlation between the abundance of orthopyroxene and garnet implies a reaction relationship. The garnets in khondalite are generally high in grossular and low in pyrope components, in contrast with the almandine-pyrope garnets of associated charnockites. Garnets tend to be paragenetically young, showing inclusions of all other surrounding minerals.

The ages of deformation of the Eastern Ghats granulite suites are unknown, but they may have coincided with emplacement of granites in the Middle Proterozoic, or perhaps a collisional event might have been a principal cause.

Table II. Refractive indices and densities of Orissa hessonites

Locality	*Refractive indices*	*Density: g/cm³*
Ghatpara	1.738-1.752	3.56-3.64
Dahikbala	1.750-1.756	3.58-3.64*
Budhido	1.751-1.758	3.60-3.63
Burubura	1.759-1.763	3.60-3.66

* Some samples were too small to justify more precise density values.

Hessonite occurrences in Orissa and their localities

It is unusual that the exact location and geological source of gemstones examined in the laboratory are known to the gemmologist. It is fortunate, therefore, that the four hessonite localities, mentioned below, were visited by one of the authors (J.K.) during field trips as consultant for the current UNDP gemstone project in Orissa.

Ghatpara

North-east of the railway town of Kesinga in the Bolangir District is the village of Ghatpara, near the south bank of the Tel river. Between Ghatpara and the small village Singjhran, about 3km south-east of Ghatpara, are various calc-silicate lenses embedded in khondalite rocks. These

Table III. Chemical analyses (in wt.%) of hessonite from Ghatpara and Burubura in Orissa, India

	Gh 01	*Gh 02*	*Gh 03*	*Bu 01*	*Bu 02*	*Bu 03*
SiO_2	38.15	38.31	37.48	37.32	38.50	37.14
Al_2O_3	20.43	19.55	18.46	17.12	17.78	17.20
CaO	39.59	37.53	37.10	38.12	36.24	36.15
Fe_2O_{3tot}*	1.10	4.17	6.15	6.75	6.93	8.20
MnO	0.37	0.44	0.66	0.26	0.22	0.80
TiO_2	-	-	0.15	0.44	0.33	0.51
Total	100.00	100.00	100.00	100.00	100.00	100.00
n:	1.738	1.746	1.752	1.759	1.760	1.763
D g/cm³	3.56	3.60	3.64	3.60	3.61	3.66

* total iron content measured as Fe_2O_3

NB The Edax programme processes these oxide values to total 100%.

Gh 01: hessonite, light yellowish Ghatpara, Orissa
Gh 02: hessonite, yellowish-brown Ghatpara, Orissa
Gh 03: hessonite, yellowish-brown Ghatpara, Orissa
Bu 01: hessonite, yellowish-brown Burubura, Orissa
Bu 02: hessonite, yellowish-brown Burubura, Orissa
Bu 03: hessonite, brown Burubura, Orissa

Table IV. Chemical analyses (in wt.%) of hessonite from Budhido and Dahikbala in Orissa, India

	Bh 01	*Bh 02*	*Bh 03*	*Di 01*	*Di 02*	*Di 03*
SiO_2	36.75	34.63	35.97	35.97	36.39	36.17
Al_2O_3	18.95	17.59	17.64	18.84	18.85	18.62
CaO	37.82	39.81	38.73	37.62	36.45	36.12
Fe_2O_{3tot}*	5.54	6.38	6.67	5.89	6.68	7.09
MnO	0.67	1.26	0.73	1.30	1.21	1.60
TiO_2	0.27	0.33	0.26	0.37	0.42	0.41
Total	100.00	100.00	100.00	100.00	100.00	100.00
n:	1.751	1.756	1.758	1.750	1.753	1.756
D g/cm³	3.60	3.60	3.63	3.58	3.61	3.64

* total iron content measured as Fe_2O_3

NB The Edax programme processes these oxide values to total 100%.

Bh 01: hessonite, light yellowish — Budhido, Orissa
Bh 02: hessonite, yellowish-brown — Budhido, Orissa
Bh 03: hessonite, yellowish-brown — Budhido, Orissa
Di 01: hessonite, yellowish-brown — Dahikbala, Orissa
Di 02: hessonite, yellowish-brown — Dahikbala, Orissa
Di 03: hessonite, brown — Dahikbala, Orissa

lenses contain concentrations of hessonite crystals in 'pockets', together with calcite and small diopside crystals (Figures 2 and 3). The lenses are between 60 and 250m long and about 20m wide. Wollastonite is another important constituent and, due to its hardness, it shows pronounced bands within these lenses. The markings of deformation patterns in wollastonite bands are clearly visible. A significant percentage of hessonite from Ghatpara is of gem quality and from some crystals stones of 5 to 6ct can be cut. The coordinates of this occurrence are lat. 20°16′N and long. 83°16′E.

Dahikbala

A hessonite occurrence was recently discovered by digging foundations for a power line 9km from Ambadola in the direction of Mumiguda in the Koraput District. Shallow pits expose khondalite quartzites with small fractured crystals of transparent orange-brown coloured hessonite. The coordinates are lat. 19°45′N and long. 83°29′E.

Budhido

This relatively large hessonite occurrence was discovered in 1991. Local villagers dug (illegally) many pits over an area of about 300m long and 50m wide. The hessonite crystals occur in a garnetiferous gneiss, in contact with amphibolite.

Although the hessonite crystals found on the dumps are large and show a strong brownish-orange colour, the crystals are translucent rather than transparent and the interior appears 'treacly', a common feature in hessonite garnets. At the time Budhido was visited, local villagers had abandoned the occurrence, probably due to the fact that not sufficient gem quality hessonite crystals were found.

The coordinates are lat. 21°15′42″N and long. 84°55′E. Budhido is about 2km north-east of the village Riamal in the Sambalpur District.

Table V. Absorption maxima of Orissa hessonites and their assignment

Orissa	*Amthauer (1975)*	*Assignment*
432-433 nm (23 148–23 094 cm^{-1})	434 nm (23 041 cm^{-1})	Fe^{3+} / oct.
408-409 nm (24 509–24 400 cm^{-1})	409 nm (24 449 cm^{-1})	Mn^{2+} / cub.
370 nm (27 027 cm^{-1})	371 nm (26 954 cm^{-1})	Fe^{3+} / oct.

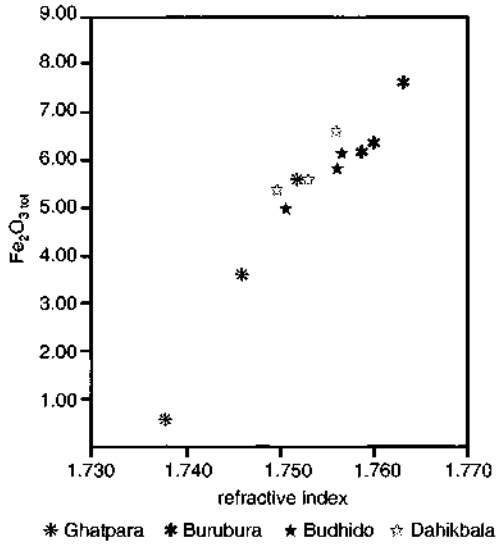


Fig. 4. Correlation diagram of iron content (Fe_2O_3) and refractive indices.

Burubura

About 1km south-south-east of the village of Burubura in the Dhenkanal District is an exposed hessonite occurrence in a contact zone between khondalite quartzite and amphibolite. The colour of the hessonite crystals is a pleasing dark orange. The coordinates are lat. 21°15'05"N and long. 85°14'50"E.

Physical properties

The values of RI and density obtained from hessonite from the four Orissa occurrences (Table II) fall in the ranges reported by previous authors.

The light yellowish hessonite from Ghatpara has the lowest refractive index, n= 1.738 (1.10 wt.% $Fe_2O_{3\,tot}$) whilst the highest value belongs to the brown hessonite from Burubura, namely n= 1.763 (8.20 wt.% $Fe_2O_{3\,tot}$).

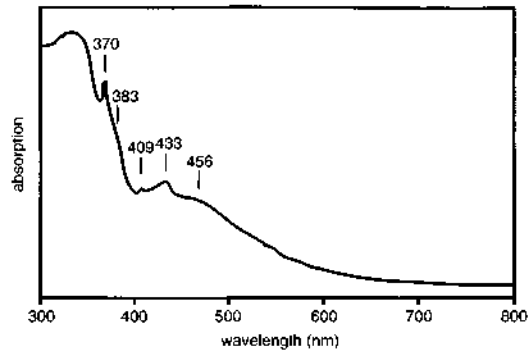


Fig. 5. Absorption spectrum of yellowish-brown Budhido hessonite (Orissa).

These figures proved that an increase in iron content is linked to a higher refractive index. Figure 4 shows the relationship between refractive indices and iron content for the four Orissa hessonite occurrences.

Chemical data

The chemical analyses of the hessonite crystals were carried out on a Philips Raster electron-microscope, type XL 30. They indicated, besides calcium, aluminium and silicon, small quantities of iron and traces of manganese and titanium.

Absorption spectra results

The spectrophotometer examination was carried out with a Perkin Elmer instrument (Lambda 9, UV/VIS/NIR) in the 800 - 300 nm range (see Figure 5). The Orissa samples showed three absorption bands at ca. 434nm (23 041 cm^{-1}),

Fig. 6. Mineral inclusions with a strongly corroded surface in Ghatpara hessonite. Immersion, 20x. (*Photo M. Redmann*)

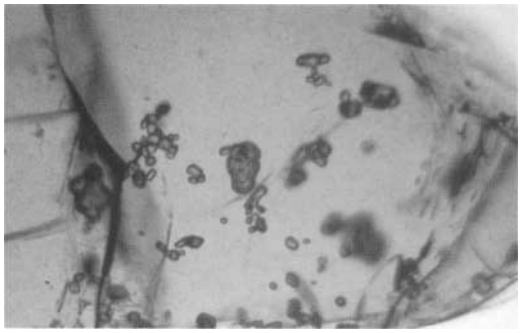
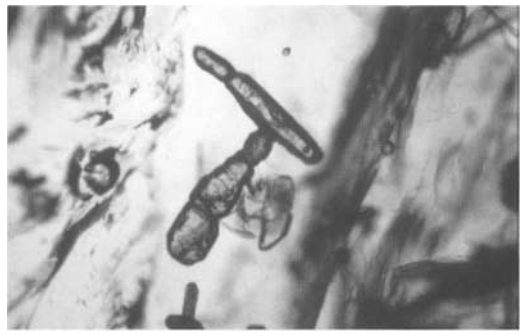


Fig. 7. Strongly corroded, long prismatic inclusions in Ghatpara hessonite. Immersion, 40x. (*Photo M. Redmann*)



409nm (24 449 cm^{-1}) and 371 nm (26 954 cm^{-1}) which are identical to the results of Amthauer (1975) for the brown grossular from Tanzania.

Other absorption bands between 383–387 nm (26 109–25 839 cm^{-1}) and 456–460 nm (21 929–21 739 cm^{-1}) have been observed which, according to Manning (1969), are also due to iron (Fe^{3+}).

Amthauer (1975) mentioned the three absorption bands of 434 nm (23 041 cm^{-1}), 409 nm (24 449 cm^{-1}) and 371 nm (26 954 cm^{-1}) as the origin for the brown colour in hessonite and in contrast to green grossular, a strong Ligandfield absorption near the UV range.

Microscopical features

The hessonite samples from Ghatpara are rich in different types of mineral inclusions. Some of the mineral inclusions are strongly corroded (Figures 6 and 7), which in parts show tension fractures and interference colours under crossed polars, indicating an optically anisotropic crystal. Other mineral inclusions are idiomorphic, hexagonal, long prismatic crystals well terminated, which also show interference colours under crossed polars and are, therefore, also optically anisotropic (Figure 8). These are probably euhedral crystals of apatite. One sample contained fibrous mineral inclusions, but their identity has not yet been established. Some of the hessonite showed healing cracks with undefined contours and two-phase inclusions (lg) in some parts. Various samples showed strong growth marks and zones. Under crossed polars a double refractive effect indicating strain is noticeable at the growth marks and some samples show an intense interference picture, also caused by the strong growth structures (Figures 9 and 10). The 'oily' internal feature typical of many hessonites was observed in only a few of the Ghatpara hessonite samples.

Compared with the Ghatpara samples the Burubura hessonite is relatively poor in inclusions. Healing cracks with two-phase (lg) and three-phase inclusions (slg) can be seen. Different mineral inclusions can also be seen in the multiphase inclusions (Figures 11 and 12). Furthermore, growth marks are visible which, under crossed polars, show patchy double refraction. All the examined Budhido samples have a strong 'oily' appearance, which, of course, influences the transparency of the hessonite (Figure 13). In addition strongly corroded mineral inclusions can be seen which, under

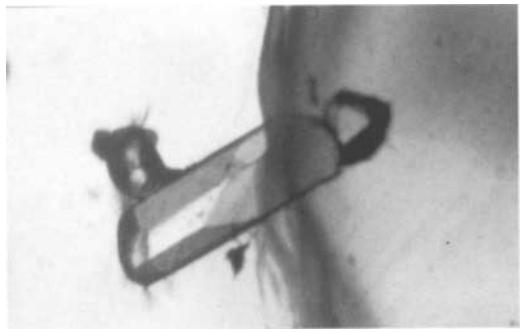
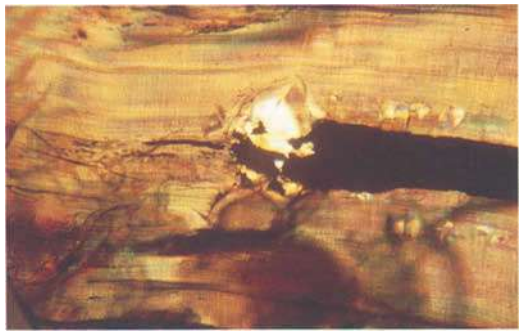


Fig. 8. Idiomorphic, long prismatic, hexagonal mineral inclusions, well terminated, in Ghatpara hessonite. Immersion, 40x. (*Photo M. Redmann*)

Fig. 9. Growth marks showing strong interference of light under crossed polars in Ghatpara hessonite. Immersion, 25x. (*Photo M. Redmann*)

Fig. 10. 'Schlieren' growth marks under crossed polars in Ghatpara hessonite. Immersion, 10x. (*Photo M. Redmann*)



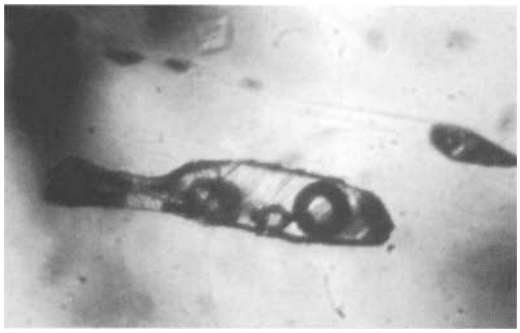


Fig. 11. Multi-phase inclusion (slg) in Burubura hessonite. Immersion, 50x. (*Photo M. Redmann*)

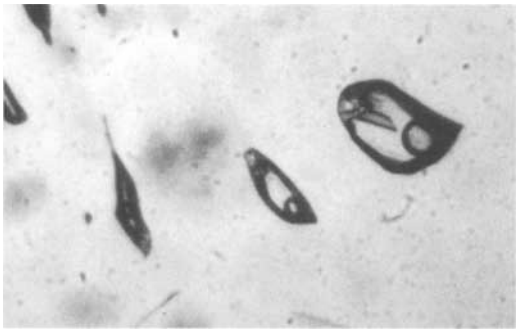


Fig. 12. Multi-phase inclusion (slg) in Burubura hessonite. Immersion, 25x. (*Photo M. Redmann*)

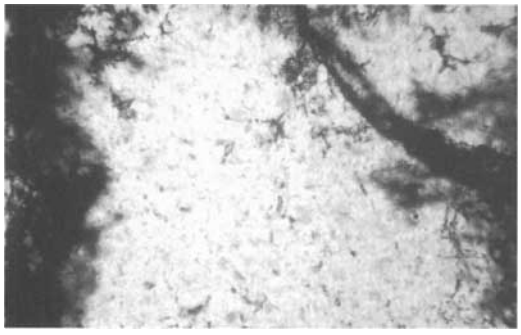


Fig. 13. 'Oily' appearance with small corroded mineral inclusions in Budhido hessonite. Immersion, 40x. (*Photo M. Redmann*)

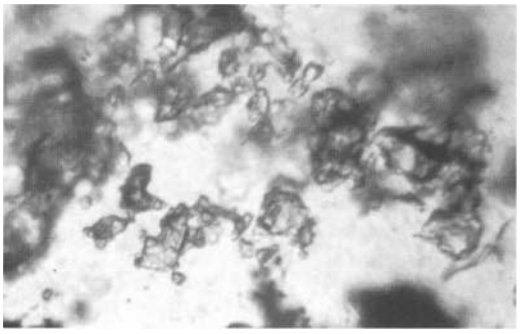


Fig. 14. Strongly corroded mineral inclusion, 'oily' appearance, in Budhido hessonite. Immersion, 10x. (*Photo M. Redmann*)

Fig. 15. Long, needle shaped mineral inclusions, which are partly bent, in Dahikbala hessonite. Immersion, 10x. (*Photo M. Redmann*)

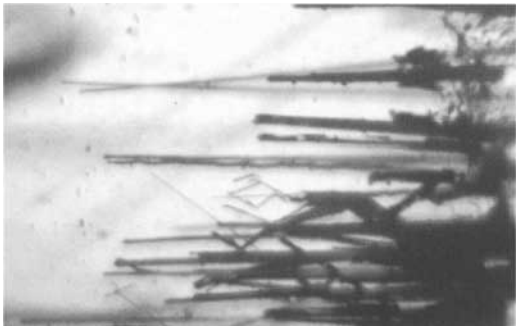
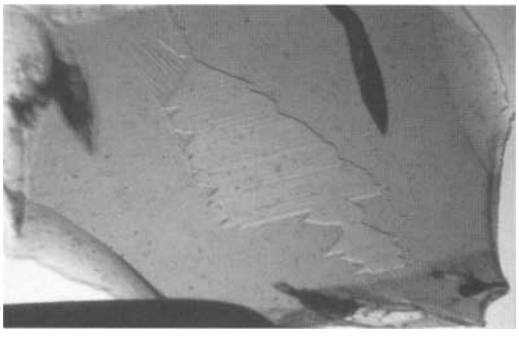


Fig. 16. Growth marks in Dahikbala hessonite. Immersion, 10x. (*Photo M. Redmann*)



crossed polars, show interference colours (Figure 14). The microscopic study of all Dahikbala samples showed long needle-like mineral inclusions, which are in part parallel and often bent (Figure 15).

Rarer are mineral inclusions with a corroded surface, which are doubly refractive. Also rare at Dahikbala are healing cracks with liquid inclusions. However, growth marks in parallel stripes, as 'schlieren' features, or in grotesque shapes are common (Figure 16). All samples with these complex growth marks show distinct double refraction.

Acknowledgement

The authors thank the UNDP and UNDESD (the New York office executing the project) for permitting the publication of this article and Mr S.K. Mohapatra, National Project Director and Director of the Department of Mining and Geology in Bhubaneswar, Orissa, India.

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Fluorescent oil inclusions in quartz

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Fig. 1. This is a photograph taken of the two crystal specimens described as they appeared in the ultraviolet light unit.

The accompanying photomicrographs are of fluorescent oil inclusions found in two quartz crystal specimens purportedly from Herkimer, New York (Figure 1). Both crystals are doubly terminated and weigh 13.06 grams and 3.54 grams respectively. I have examined quite a number of small quartz crystals from this source over the last few years but these are the first specimens containing oil inclusions that I have had the opportunity to photograph.

Figures 2, 3 and 4 show a three-phase inclusion containing a fairly large globule of petroleum, which in turn contains a gas bubble. The third phase in this inclusion is a brine solution. There is actually a fourth phase consisting of small particles of a tar-like substance (bitumen). The gas bubble moves freely about in the oil when the specimen is tilted. The oil fluoresces very strongly under long-wave ultraviolet light.

The trio of included crystals shown in the cover

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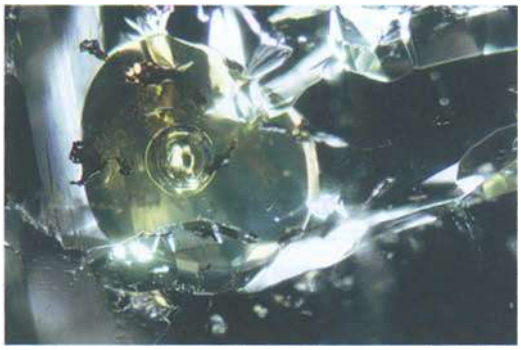

Fig. 2. Transmitted illumination. 8x

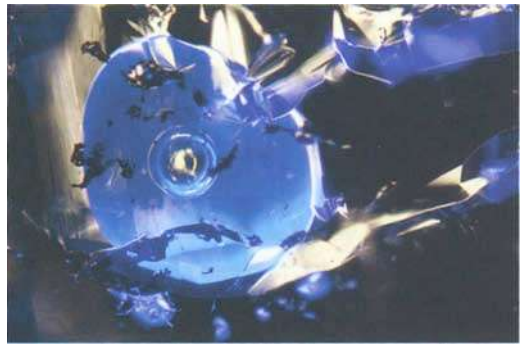

Fig. 3 Long-wave ultraviolet light plus low intensity transmitted illumination. 8x.

picture are all three-phase and consist of oil, a gas bubble and a small black particle of bitumen. The oil in these inclusions doesn't fluoresce quite as strongly as in the other inclusion, but once again the gas bubble moves about as the specimen is tilted.

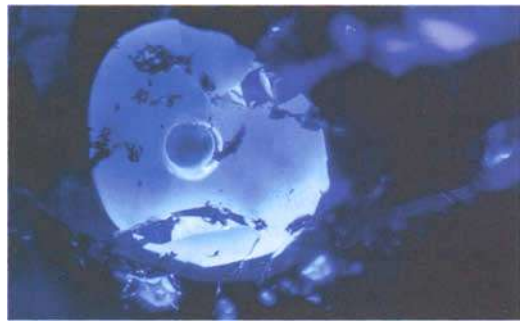

Fig. 4 Long-wave ultraviolet light only. 8x.

Twinning in Ramaura synthetic rubies

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Abstract

Twinned individuals of Ramaura synthetic rubies were examined. The crystals are penetration twins, the two components of which are symmetrically related by a 180° rotation about the *c*-axis or by a reflection across one of the first-order hexagonal prisms {10$\bar{1}$0} or across the basal pinacoid (0001). The twins are in contact along four twin boundaries which are oriented parallel to the twin planes. This form of penetration twinning has never been encountered before in either natural or synthetic corundum.

Each twin crystal reveals one planar surface which represents the contact of the ruby with the floor of the crucible in which the growth procedure was performed. These planar surfaces of the twins are subdivided into different sectors by the four twin planes, which intersect at one central point. Triangular growth structures on basal planes are related by the symmetry elements of the twin, i.e. by a two-fold axis parallel to [0001] or by mirror planes parallel to {10$\bar{1}$0}.

Introduction

Ramaura flux-grown synthetic rubies have been commercially available since early 1983 (Kane, 1983; Bosshart, 1983). Although details of the commercial growth process of these high quality synthetic rubies produced by Judith A. Osmer, J.O. Crystal Company, Long Beach, California, are kept secret, the study of morphological properties of rough crystals (Kane, 1983; Schmetzer, 1986a, 1986b) as well as the chemical examination of residual flux remnants trapped in faceted and rough crystals (Schmetzer, 1986a, 1986c), clearly indicate a perfect correlation between the Ramaura synthetic rubies and those of flux-grown synthetic rubies described by Janowski *et al.* (1965), Chase, (1966) and Chase and Osmer (1967, 1970). Consequently, it can be assumed that at least the basic principles of the commercial production process of Ramaura synthetic rubies are consistent with the processes described in the four papers just mentioned.

According to these publications, rubies are grown by spontaneous nucleation without seed crystals from solvents with Bi_2O_3 and PbF_2 as dominant and La_2O_3 as subordinate components of the flux material. Slow programmed cooling of the flux from 1250°C to 1000°C with constant cooling intervals between 2°C and 8°C per hour is applied during the growth process. Perfect crystals of high transparency and purity are obtained by the application of an additional temperature gradient in the growth medium by localized cooling of the platinum crucible by means of an air flow (Chase and Osmer, 1967).

The habit of the flux-grown synthetic ruby crystals varies with the content of La_2O_3 in the melt. In general, only three crystal faces are observed: the basal pinacoid *c*, the positive rhombohedron *r* and the negative rhombohedron *d**. Crystals grown from Bi_2O_3 - PbF_2 fluxes without La_2O_3 result in flat, tabular plates with dominant basal faces c and smaller positive rhombohedra *r*. If small amounts of La_2O_3 are added to the melt, the habit of the crystals changes from tabular to rhombohedral (more equidimensional), with larger positive and negative rhombohedral faces, *r* and *d*. With La_2O_3 contents of the melt up to approx. 0.5 mole %, only the positive rhombohedron *r* is present. With La_2O_3 contents between 0.6 and 1.0 mole %, the negative rhombohedron *d* begins to develop and becomes the more predominant crystal face at 1.0 mole % La_2O_3 (Chase,

* CRYSTAL FACES:

basal pinacoid	*c*	(0001)
first-order hexagonal prism		(10$\bar{1}$0)
second-order hexagonal prism	*a*	(11$\bar{2}$0)
positive rhombohedron	*r*	(10$\bar{1}$1)
negative rhombohedron	*d*	(01$\bar{1}$2)

This nomenclature is used throughout this publication.

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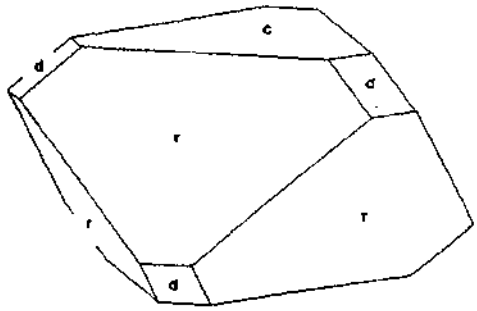
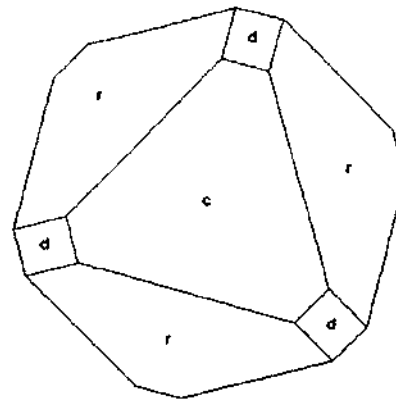
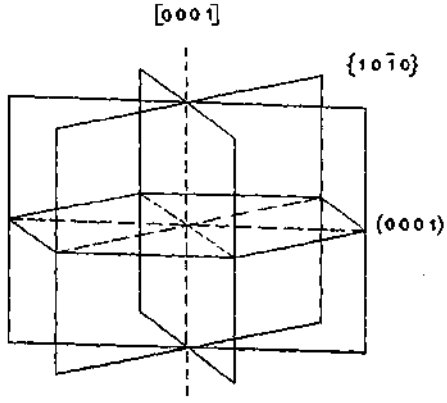


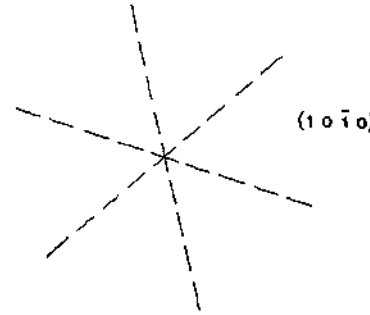
a) clinographic projection of an untwinned crystal with basal pinacoid *c* (0001), positive rhombohedron *r* (10$\bar{1}$1) and negative rhombohedron *d* (01$\bar{1}$2)



b) *c*-axis projection of an untwinned crystal with *c*, *r* and *d* faces



c) clinographic projection of equivalent symmetry elements in crystal class $\bar{3}2/m$, a two-fold axis parallel to [0001] as twin axis is equivalent to three mirror planes parallel to {10$\bar{1}$0} and one mirror plane parallel to (0001) as twin planes



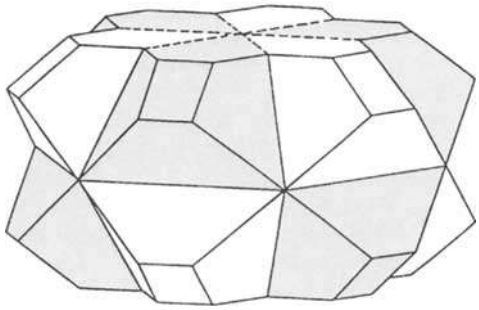
d) *c*-axis projection of mirror planes parallel to {10$\bar{1}$0} as twin planes

Fig. 1. Twinning in Ramaura synthetic ruby

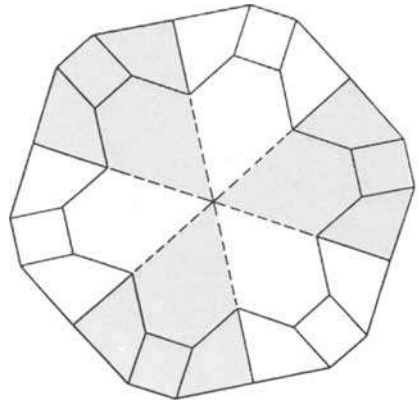
1966). Equidimensional Ramaura synthetic ruby crystals with such rhombohedral habits are described in Kane (1983). In Figure 1 of that paper, a rough Ramaura synthetic ruby crystal is shown with predominant *r* and more subordinate *d* rhombohedral faces, whereas Figure 2 of the same paper portrays a clinographic projection of a Ramaura synthetic ruby with dominant *d* and more subordinate *r* faces.

Twinning in synthetic ruby crystals grown from Bi_2O_3 - PbF_2 fluxes was described by Janowski *et al.* (1965). After etching the rubies in molten potassium bisulphate, the study of the resulting etch pits located on basal *c* faces indicated that the composition planes between twinned individuals were approximately normal to the same basal faces. The traces of composition planes between twinned individuals did not strictly follow any particular plane, but tended to favour the (11$\bar{2}$0) and (10$\bar{1}$0) prism planes. In general, only a single straight line was found as trace of the twin boundary between twinned individuals, but more complex twin structures were also rarely observed.

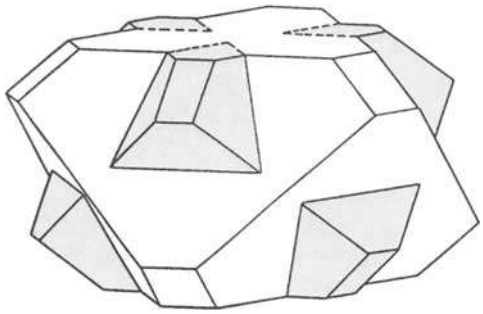
Up to now, twinning characteristics have been described in Ramaura synthetic rubies only according to microscopic observations of faceted samples (Schmetzer, 1986a, 1986b, 1987). Consequently, no description of macroscopic twinning characteristics is available in the litera-



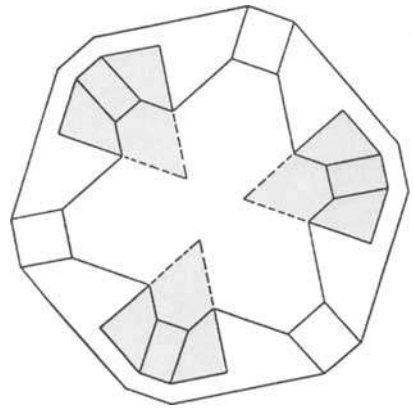
e) clinographic projection of a penetration twin consisting of two equally sized twin components, dashed lines are traces of twin planes and twin boundaries parallel to {10$\bar{1}$0}



f) *c*-axis projection of a penetration twin consisting of two equally sized twin components, dashed lines are traces of twin planes and twin boundaries parallel to {10$\bar{1}$0}



g) clinographic projection of a penetration twin consisting of two differently sized twin components, dashed lines are traces of twin planes and twin boundaries parallel to {10$\bar{1}$0}



h) *c*-axis projection of a penetration twin consisting of two differently sized twin components, dashed lines are traces of twin planes and twin boundaries parallel to {10$\bar{1}$0}.

Fig. 1. Twinning in Ramaura synthetic ruby

ture to date. It is, therefore, the aim of the present study to complete this information and to compare these twinning features with flux-grown synthetic rubies from various other producers and those observed in natural ruby crystals.

Materials and methods

The present study is based upon the examination of five macroscopically twinned Ramaura synthetic rubies (Figures 2, 3, 4). Two crystals (6.03 and 4.41 ct) were submitted by Judith A. Osmer of J.O. Crystal Company, Long Beach, California, producer of Ramaura synthetic rubies, while three of the twinned individuals (59.14, 8.00 and 3.69 ct) were available from the reference stone collection of the Gübelin Gemmological Laboratory, Lucerne, Switzerland. Several single crystal, non-twinned Ramaura synthetic ruby crystals were also used for comparison purposes. The rubies were examined using conventional gemmological and mineralogical methods. The identification of crystal faces and growth structures were performed using a standard goniometer and by immersion microscopy using the techniques described by Schmetzer (1986b) and Kiefert and Schmetzer (1991).

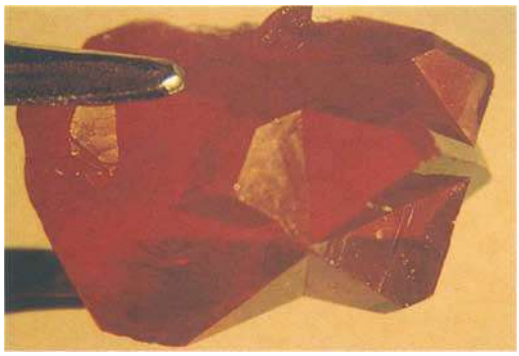


Fig. 2. Penetration twin viewed in a direction almost identical to that of the clinographic projection of Fig. 1, 18x.

Gemmological properties

The standard gemmological properties of the five Ramaura synthetic rubies examined were determined to be consistent with those observed during previous studies (Kane, 1983; Bosshart, 1983; Schmetzer, 1986a). These include refractive indices (e = 1.760, o = 1.768), birefringence (0.008), optic character (uniaxial negative), pleochroism (e = orange-red, o = purplish-red), spectral characteristics through the UV-VISIBLE-NIR regions, fluorescence (LW-UV strong red, SW-UV weak to medium red), density (3.99 g/cm^3) and inclusion features consisting of white and 'golden' coloured flux remnants occurring isolated or in fingerprint patterns of various sizes, along with transparent internal growth structures reflecting the external crystal morphology.

Twinning characteristics

The crystal faces identified in both twinned and untwinned individuals of Ramaura synthetic rubies (Figure 1), were the basal pinacoid *c*, the positive rhombohedron *r* and the negative rhombohedron *d*. The habit of all the crystals examined consisted of dominant *c* and *r* faces with subordinate d faces (Figure 1 a, b). Synthetic ruby crystals consisting of dominant *d* and subordinate *r* faces, as pictured in Kane (1983), were not observed.

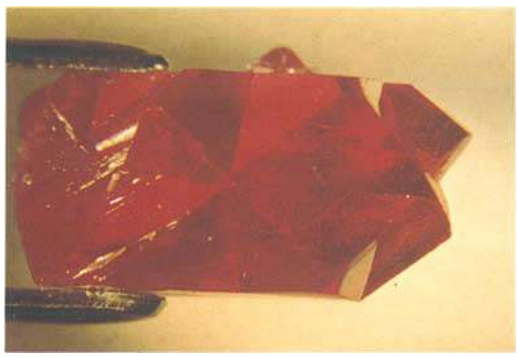
Corundum crystallizes in the trigonal/rhombohedral system and belongs to crystal class $\bar{3}2/m$. In this crystal class, the three following symmetry operations are equivalent:

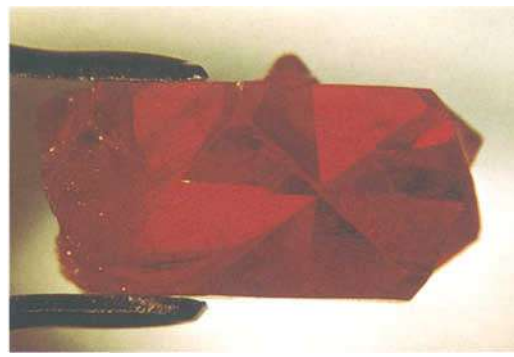
- 180° rotation about the *c*-axis [0001],
- reflection across the first-order hexagonal prism $\{10\bar{1}0\}$, and
- reflection across the basal pinacoid *c* (0001).

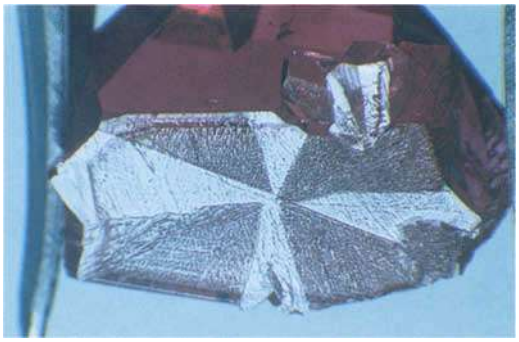
The orientation of the symmetry elements characterizing these symmetry operations, i.e. the two-fold twin axis and the four $\{10\bar{1}0\}$ and (0001) twin planes (mirror planes), is shown in Figure 1 c,d. It is important to mention that these symmetry operations do not occur in untwinned ruby crystals. By the application of one of these symmetry operations to a single crystal of an untwinned ruby, a twinned crystal is formed (Figure 1 e-h).

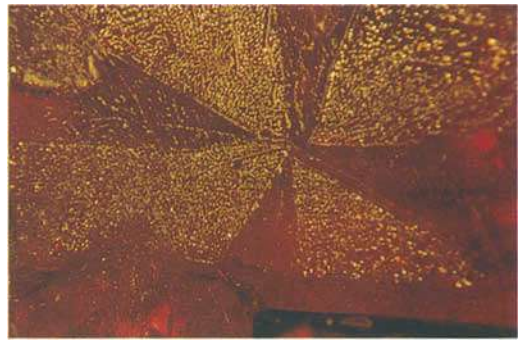
These theoretical considerations are consistent with the observations on the twinned Ramaura synthetic rubies. All five twins in this study (Figure 1 e-h, Figures 2-4) are penetration twins formed from a single, untwinned ruby crystal (Figure 1 a, b) by a rotation about the twin axis or by a reflection across one of the four twin planes. Each Ramaura penetration twin was found to reveal four contact surfaces as twin boundaries. Three of these contact surfaces are planes parallel to the first-order hexagonal prism. The

Figs 3, 4. Penetration twin viewed in a direction perpendicular to the *c*-axis: the two figures are related by a small rotation about the *c*-axis, 18x.









Figs 5, 6. Planar surface of a penetration twin confined to the floor of the crucible, with two groups of four growth sectors subdivided by traces of three twin planes parallel to $\{10\bar{1}0\}$ prism faces and one twin plane parallel to the (0001) basal face. Portrayed here is a nearly undistorted twin consisting of two almost equally sized twin components. View nearly perpendicular to the *c*-axis. Fig. 5, 16x; Fig. 6, 32x.

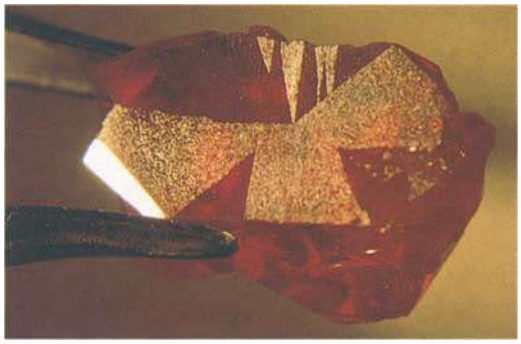
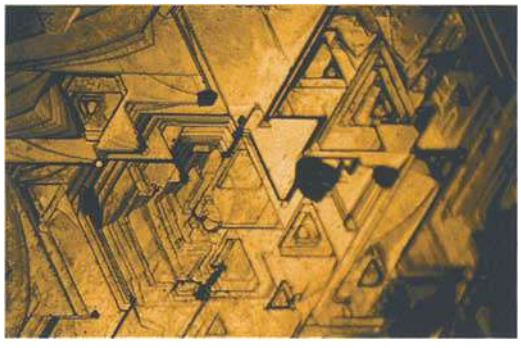


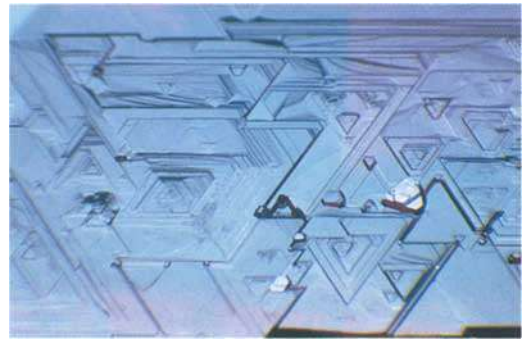
Fig. 7. Planar surface of a penetration twin confined to the floor of the crucible, with two groups of three dominant sectors subdivided by traces of three twin planes parallel to $\{10\bar{1}0\}$ prism faces and one twin plane parallel to the (0001) basal face. Portrayed here is a distorted twin with four subordinate sectors within one of the dominant sectors. View nearly perpendicular to the *c*-axis, 16x.

remaining fourth twin boundary is a slightly irregular plane which tends to run more or less parallel to the basal pinacoid *c* (Figure 1 e-h). The two components of the penetration twin may be of equal size (Figure 1 e, f) or of different sizes, with one being dominant and the other subordinate (Figure 1 g, h). The observed re-entrant angles are formed by the meeting of two positive rhombohedral faces, *r* and *r'*, of the two twin components (refer to Figure 1 e-h, Figures 2-4).

All of the twinned crystals revealed one planar surface which did not follow any of the crystal faces *c*, *r* or *d*. It was felt that this plane represented the 'contact surface' of the growing crystal with the floor of the crucible. This interpretation was confirmed by the producer. The planar surface of each twin is subdivided into two groups of growth sectors, with all the related sectors within one individual group displaying optical reflectivity in the same orientation.

Figs 8, 9. Triangular growth structures parallel to traces of the twin planes $\{10\bar{1}0\}$ on the basal pinacoid *c* (0001) of a penetration twin.
Fig. 8: A twin boundary extends from the lower middle to the upper right of the photograph, 20x.
Fig. 9: A twin boundary extends from the lower right to the upper middle of the photograph, 30x.





Collectively, the sectors belonging to different groups of growth sectors displayed optical reflectivity in differing orientations (Figures 5-7). The traces of the boundaries between these sectors correspond to the four composition planes of the two twin components (Figure 1 c, d) and intersect at one central point. Ideally, in twins such as these, each group consists of four essentially equal sectors (Figures 5, 6). In twinned crystals which are distorted to varying degrees, different numbers of dominant sectors with additional subordinate sectors can also be observed (Figure 7).

The different sectors of the twin can also be seen in the subtle surface topography characteristics of the basal faces (Figures 8, 9). These trigonal growth structures located on basal faces were observed on two of the five Ramaura synthetic twins examined. Within one of the two components of the twin, these growth triangles have the same orientation. Different orientations of the triangles within different sectors located on the basal planes *c* and *c'* of the twin components (again refer to Figure 1 f, h), are the result of twinning, i.e. the result of a 180° rotation about the *c*-axis or of a reflection across the first-order hexagonal prism. The three sides composing these growth triangles were found to follow the traces of the three twin boundaries $\{10\bar{1}0\}$. These observations in Ramaura synthetic rubies are consistent with the previous results obtained from the study of etch pits in twinned flux-grown synthetic corundum (Stephens and Alford, 1964; Janowski *et al.*, 1965; Champion and Clemence, 1967; Lillicrap and White, 1976).

Discussion

The rough Ramaura synthetic ruby crystals examined by the authors in the past several years were found to be single crystals without any indication of interpenetrant twinning. The five Ramaura synthetic rubies examined in this study are penetration twins, involving the three equivalent symmetry operations described previously, with three twin boundaries along first-order hexagonal prism planes and one slightly irregular twin boundary essentially parallel to the basal pinacoid *c*. These crystals were grown by a process of spontaneous nucleation in a flux environment, possessing a single planar surface which was in contact with the floor of the surrounding crucible. This form of interpenetrant twinning in corundum has never been observed by the authors or reported in the literature before.

In the various papers mentioned previously, twinning was described in flux-grown synthetic corundum (both rubies and sapphires) according to the examination of etch pits, which in most cases were intentionally created by etching the basal faces of the crystals involved. For all these corundums, the twinning was described as a 180° rotation about the *c*-axis or as a reflection on the first-order hexagonal prism, which is also consistent with the twinning observed here in Ramaura synthetic rubies. According to the references cited above, the twin boundaries were found to run along the first-order hexagonal prism or along the second-order prism *a*. It is important to mention that in the crystal class of corundum $\bar{3}2/m$, the prism *a* is parallel to a mirror plane and therefore cannot be a twin plane but rather a composition plane of two twinned individuals.

In flux-grown synthetic rubies and sapphires produced by Chatham, the typical twinning observed consists of a $(10\bar{1}0)$ face as twin plane (mirror plane) and a $(11\bar{2}0)$ face as contact plane (twin boundary) (Schmetzer, 1986a, b, 1987; Kiefert and Schmetzer, 1987). Simple contact twins consisting of two twin components are known, which are related by a reflection across the first-order hexagonal prism and intergrown along the second-order hexagonal prism *a*, and cyclic twinning has also been observed (Kiefert and Schmetzer, 1987).

In natural rubies and sapphires, contact or penetration twins possessing one of the prism faces $(10\bar{1}0)$ or $(11\bar{2}0)$ as twin boundaries have never been described. In extremely rare cases, contact twins consisting of two twin components which are twinned by a reflection across the basal pinacoid *c*, with the *c* face as twin plane and composition plane, have been identified (cf. Goldschmidt, 1918; Schmetzer, 1986a, 1987). The most common form of twinning observed in natural rubies and sapphires, however, consists of rhombohedral twinning along the positive rhombohedron *r*, commonly referred to as 'laminated' twinning in gemmology. This type of twinning has not been observed in Ramaura synthetic rubies to date. For a more detailed description of rhombohedral twinning in natural and synthetic rubies, the reader is referred to the detailed descriptions of Schmetzer (1987).

Acknowledgement

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The glass filling of diamonds Part 2: a possible filling process

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Abstract

Diamonds are now appearing in the market place with a greatly enhanced appearance caused by fissure-filling glass. No patent disclosures have been made on the filling method or glass composition, but much useful information has now been published on the nature of the glass.

A possible practical process is outlined for the filling of outcropping cleavages, fractures and fissures in cut diamonds. This scheme is based on reports in the gemmological literature since 1987, describing the characterization and identification of filled diamonds. It embodies all the requirements which would have to be met for successful batch productions.

Introduction

Diamonds and coloured gemstones often have fractures and cleavage fissures which outcrop on the polished surfaces. These optical discontinuities lower a stone's brilliance and sparkliness. To improve the appearance of poor quality, or even unsaleable gemstones, various impregnation techniques have been used in attempts to conceal the defects.

If the refractive indices of the filling materials approach or match those of the host stone, they are usually quite successful in helping to mask the original optical discontinuities. However, this apparent improvement in the stone's clarity also results in unwanted 'colour flashes'. These appear as streaks or patches of high intensity spectral colours of fairly fixed hues and are seen only at particular orientations of the stone. While these flashes are not obvious in stones having strong body colours, such as rubies, sapphires and emeralds, they can be very visible in diamonds of the Cape Series. Here, significant enhancements in the degree of perceived clarity from say, SI to VS, could be accompanied by reductions in the colour grade, by as much as one point (for example from E to F, H to I or L to M).

The existence of the colour flashes has been treated at some length in the current gemmological literature, but no account has been given of the basic cause of this phenomenon.

Part 1 of this article (*J. Gemm.*, **23**, 8, 461-72) now offers an explanation of the optical mechanism responsible for the flashes. However, the nature of this explanation obliges one to speculate on the physical mechanisms of the clarity enhancement process for diamonds and on the physico-chemical properties of their fillings. This is mainly the substance of Part 2.

Emerald clarity enhancement

Emeralds are notoriously prone to show surfacing fissures and cracks and were probably the first stones to be subject to improvements in clarity. Very early on, it was found that these arrived in the form of low viscosity oils chosen to have a refractive index which matched the mean refractive index of the emerald as closely as possible. Liquids having also low surface tensions enabled them to penetrate almost to the very roots of the fissures (Ringsrud [1]).

The colour flashes seen when the refractive indices were matched did not present any great problem as the strong green colour of the stone tended to obscure them. If the emerald possessed only a pale green colour, then the use of oils tinctured with an intense, green, oil-soluble dyestuff also served to dampen the non-green colour flashes.

This remedy was often short-lived. In time, the liquid tended to seep out or even evaporate and the stone reverted to its original state. The treatment had then to be repeated.

Recently, an epoxy resin-type filling liquid having all the desired properties was introduced. After impregnation, in order to seal off this mobile, unpolymerized liquid, the stone's surface was lightly smeared with a liquid polymerizing agent. After a brief gelling period to harden the

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Fig. 1. Opticon filled emerald: 5.71ct. Before treatment. After treatment. Reproduced from the article of Reference 2, with the kind permission of the Editor of *Gems and Gemology*. © Gemological Institute of America and Tino Hammid.

resin at the outcropping surface only, the surplus polymerizing liquid was wiped away with a solvent. In this way a solid, impermeable plug of fully-polymerized resin prevented the outward flow of the totally unpolymerized liquid resin.

The most successful of these preparations is now marketed as a stone improvement kit under the trade name 'Opticon 224'. Figure 1 shows a typical 'before-and-after' treatment of an emerald upon which this kit has been used. [2]

While not readily apparent to unaided vision (i.e. 1x magnification), an examination with a 10x loupe or a compound microscope reveals the presence of muted colour flashes bordering the defects, enabling the stone to be classed as 'liquid-filled'.

The now more common use of the horizontal axis immersion microscope means that a suspect emerald must first be examined in air before being transferred to the glass immersion cell. Benzyl benzoate is a much favoured immersion liquid, partly because it has a refractive index almost identical to that of the ordinary ray of emerald. If an emerald has not been subjected to any filling treatment, this liquid will readily penetrate into any outcropping fissure networks. The stone would therefore be wrongly pronounced as 'fissure-filled' because of the resulting colour flashes.

It is clear that the Opticon emerald treatment has little effect on the body colour and that any observed colour flashes serve only as a useful diagnostic aid.

Diamond clarity enhancement

The new form of diamond enhancement was first encountered by the GIA in January 1987. Developed by Mr Zvi Yehuda of Ramat Gan, Israel, it can increase the apparent clarity of many faceted diamonds.

An exhaustive and elegant study describing the characterization and identification of some eighteen filled stones from this source was reported in 1989 by a group of six research gemmologists at the GIA.[3] This research, particularly that part touching upon their analyses of the filling material, provided much insight into the whole process. Apart from a brief reference to a note by Rapaport [4], the actual nature of the filling process was not considered. However, from the details outlined and from several subsequent articles and bulletins published since 1989, it is possible to outline some of the parameters of the filling glass and filling procedure.

A possible filling glass

A low melting-point glass would first have to be formulated. It would have to have a low contact angle with diamond (i.e. it would 'wet' diamond), a low viscosity slightly above its melting point (i.e. 'runny') and a refractive index at room temperature close to that of diamond itself. These combined requirements are quite a tall order, but Yehuda seems to have achieved them.

The GIA's scanning electron microscope with its X-ray energy-dispersive spectrometer was able to demonstrate that the major elemental ions present in the *in-situ* fillings were lead (Pb^{2+}), bismuth (Bi^{3+}) and chlorine (Cl^-). The Pb^{2+}:Bi^{3+} concentration ratio was generally around 2:1, while the Cl^- concentration consistently seemed 'to approximate the sum of the Pb^{2+} and Bi^{3+} concen-

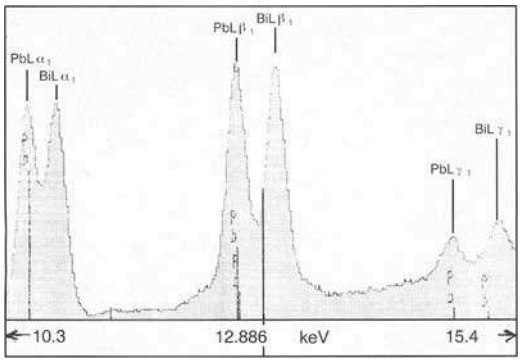


Fig. 2. Electron microprobe chart of an outcrop of a Yehuda glass filling.
Source: Scarratt[5]

trations'. A separate electron microprobe equipped with an X-ray wavelength-dispersive spectrometer showed that oxygen ions (O^{2-}) were also a major constituent. X-radiography of many filled stones confirmed that the fillings must contain one or more very heavy elemental ions, while an X-ray powder diffraction analysis of the scrapings of an adhering droplet of the filling material established it to be that of an oxide glass.

In a current study of filled diamonds by Scarratt and Jobbins [5], the high concentrations of Pb^{2+} and Bi^{3+} were confirmed for a Yehuda-filled stone. Another new diamond-filling Israeli producer, Koss by name, has followed Yehuda, but the analyses of the fillings in Koss stones have not yet been reported. Figure 2 shows an electron microprobe chart of the filling in a Yehuda-treated stone.

In the light of these studies, it is instructive to

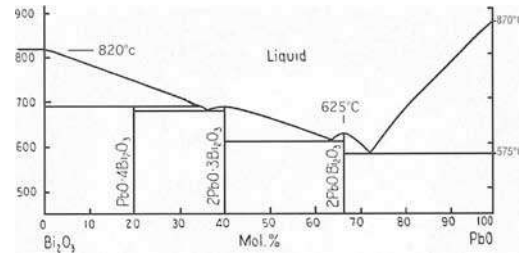


Fig. 3. The phase diagram of the Bi_2O_3-PbO system.

examine the phase equilibrium diagram of the binary component system, bismuth oxide (Bi_2O_3) and lead oxide (PbO). This is shown in Figure 3. It is a rather unusual binary diagram, having five phases, three eutectics and showing no mutual solid solubility of any of the neighbouring phases. The lowest freezing point of the system occurs at the third eutectic point at a temperature of about 575°C and at a composition of around 72 mole % PbO. This corresponds to a weight % PbO of 55.2 and a weight % Bi_2O_3 of 44.8.

If a melt of this composition was to be cooled rapidly to well below 575°C, it is highly probable that it would remain as an *extremely* viscous liquid, that is to say, a glass. If this glass phase was held at a temperature not too far below 575°C for some time, then this uniform glass phase would decompose (i.e. devitrify) into two different polycrystalline phases. It would consist of a mixture of about 82 mole % of the phase $2PbO.Bi_2O_3$ and about 18 mole % of the pure mineral phase massicot (PbO); these phases have melting points of about 625°C and 870°C respectively. Both are soluble in nitric acid, as would be

Table 1: Properties of the possible third melt component

Mineral name	*None*	*Cotunnite*	*Bismoclite*	*Mendipite*
Formula	$BiCl_3$	$PbCl_2$	BiOCl	$Pb_3O_2Cl_2$
Crystal system	Cubic	Orthorhombic	Tetragonal	Orthorhombic
Refractive indices, λ = 589nm	n = unknown	α= 2.199 β= 2.217 γ= 2.260	ω= 2.15 ε= unknown	α= 2.24 β= 2.27 γ= 2.31
Melting Point	232°C	501°C	'Red heat'	'Red heat'
Density, g/ml	3.86	5.81	7.70	7.24
Colour	Colourless	Colourless	Pale Yellow	Colourless
Soluble in dilute nitric acid	Yes	Yes	Yes	Yes

the glass phase itself.

Both crystalline phases have refractive indices for sodium light (λ = 589nm) well above that of diamond. For example, massicot has α= 2.51, β= 2.61 and γ= 2.71. No indices are available for $2PbO.Bi_2O_3$, but undoubtedly they will be higher than that of diamond (2.418). It would therefore be safe to conclude that the optically homogeneous glass phase, although having a slightly lower refractive index than that of the mean refractive indices of the mixed crystalline phases, would still have an index greater than 2.418.

It is now obvious that a third component having much lower indices than diamond will have to be added to the two-component melt to bring down the index to near that of diamond. There are many candidates for this role, but the most suitable by far are the chlorides of bismuth and lead. Their properties are given in Table 1.

It should be mentioned here that the presence of relatively large amounts of chloride ions might result in a mainly oxide mixture being more susceptible to devitrification. The photomicrographs shown in Figures 13, 14 and 15 of Reference 3 do show some evidence, not so much as incomplete fillings but as microcrystalline (devitrified) fillings.

$BiCl_3$ has probably the greatest attraction because a modest concentration of it would dramatically lower the binary eutectic point of 575°C down to a ternary eutectic point perhaps as low as 450°C.

The melting of the three components;

(1) bismite, α - Bi_2O_3, melting point 820°C
(2) massicot, PbO, melting point 870°C
(3) taking, say, $BiCl_3$ with a melting point about 230°C

in the correct proportions to make a yellow tinted but clear glass should be quite straightforward. A prolonged stirring of the melt following complete fusion would be necessary to ensure optical homogeneity and freedom from bubbles. The molten mass would then be poured directly into a large quenching bath of cold mineral oil in order to retain the solid glassy state. The shattered fragments would be recovered, cleaned with a solvent and dried, ready for the infilling step.

Measurement of the optical properties of the glass

It is necessary to ensure that the correct amount of the third component has been added to the 575°C eutectic composition. This would be most easily accomplished for exploration batches by using a gemstone infrared reflectance meter. Although the refractive index (n) is actually measured at the peak of a broad band at about 950nm and not for sodium light at 589nm, the calibration of the meter with a polished diamond should ensure sufficient accuracy.

The measurement of the dispersion of the glass would not prove so simple. The conventional method of employing several monochromatic filters in conjunction with the minimum-deviation method on a goniometer, using a cut-and-polished prism of the glass, could be troublesome. If the prism was strongly absorbing in the blue-to-green region, then accurate dispersion measurements would not be possible.

Unfortunately, there does not yet exist a total reflection refractometer capable of measuring indices higher than about 2.10 for the 589nm line, let alone for other wavelengths.

Liquids of high enough indices do not exist for use with the well-known Becke line technique for small particles. However, even if some such liquids could be found, the difficulty of ensuring even the short-term stability of the liquid dispersion calibrations, awkward as they would be, again rules out this approach.

The best course of action is to measure the optical reflectances (R), at normal incidence of a flat, scratch-free, polished surface of a quenched glass fragment using a suitable photometer. These vary in pattern from a simple selenium-cell device to the more sophisticated microphotometers equipped with a stabilized power supply, a photomultiplier photosensor and a set of monochromatizing interference filters. An example of this latter instrument is shown in Figure 4. With the aid of calibrated reflectance standards, it is capable of measuring the R values of circular areas down to a diameter of ten micrometres. An oil immersion objective on its microscope stand yields values of 'oil reflectance' at four different fixed wavelengths (λ = 470, 546, 589 and 650nm). These values are designated '$^{oil}R_\lambda$'. The procedure for translating these into refractive indices (n_λ) has been described by Galopin and Henry.[6] This makes use of the classical Fresnel optical relationship:-

$$n_\lambda = \frac{1 + \sqrt{^{oil}R_\lambda}}{1 - \sqrt{^{oil}R_\lambda}}$$

An example of the dispersion of the refractive indices (n versus λ) for four reflectance standards

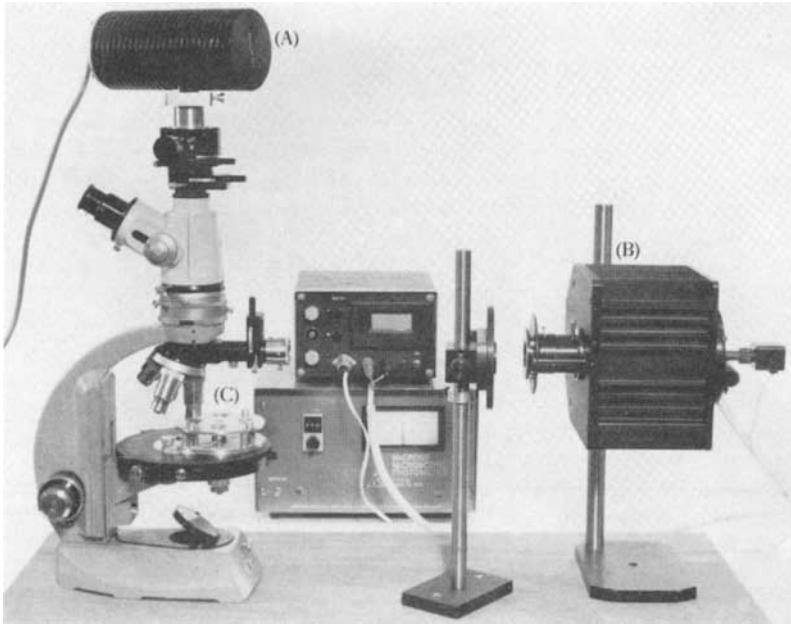


Fig. 4. The McCrone microreflectance photometer.

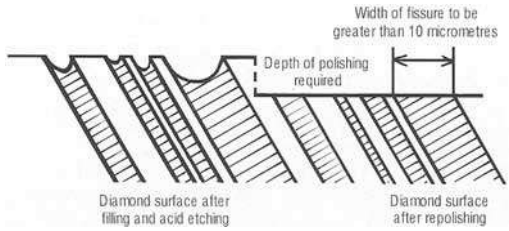
is given in Figure 5. Made, calibrated and marketed by the writer's company, they all possess flat, isotropic surfaces and are free from the smallest scratches, pits and other light-scattering centres. They are alpha-SiC (omega ray), CZ, GGG and YAG.

If the wavelength, λ, is drawn on a linear scale, the graphs are always curved lines. When drawn on a Hartmann chart the graphs always plot as straight lines, including those of immersion liquids such as methylene iodide (di-iodomethane).

In theory, it should be quite possible to measure *in situ* the actual dispersion of the infilling glass using the microphotometer of Figure 4.

Two conditions would be necessary. A substantial filled crack or 'nick' or a fissure larger than about 10 micrometres would have to be found. As the acid used to remove the surplus melt also penetrates quite deeply into the surface-reaching cracks and fissures, it would be necessary to repolish that particular facet to render the glass infilling exactly co-planar with the diamond surface. Moreover, both the new glass and diamond surfaces would require to be rigorously free from any light-scattering artefacts such as minute sleek-like defects or gas bubbles. An expert diamond polisher should have no difficulty in executing the kind of repolishing required for this measurement, so long as overheating was avoided. This could result in glass devitrification.

Fig. 6. Facet polishing required for the 'in-situ' dispersion measurement of the infilling glass.



The sketch in Figure 6 illustrates the repolishing geometry.

It is always necessary to employ an external reflectance standard to convert the photometer reflectance values into the required absolute values ($^{\infty}R_{\lambda}$). An alpha-SiC standard represented in the dispersion chart of Figure 5, would serve admirably for this purpose. However, there is an unexpected bonus in using the reflectance method for the n_{λ} dispersion measurements. It is this. It is seen in Figure 6 that a built-in standard already exists in the shape of the co-planar, juxtaposed, repolished surface of the diamond itself. The Hartmann plot for diamond is shown in Figure 7.

Other physical properties of the glass

It should be emphasized that the viscosity,

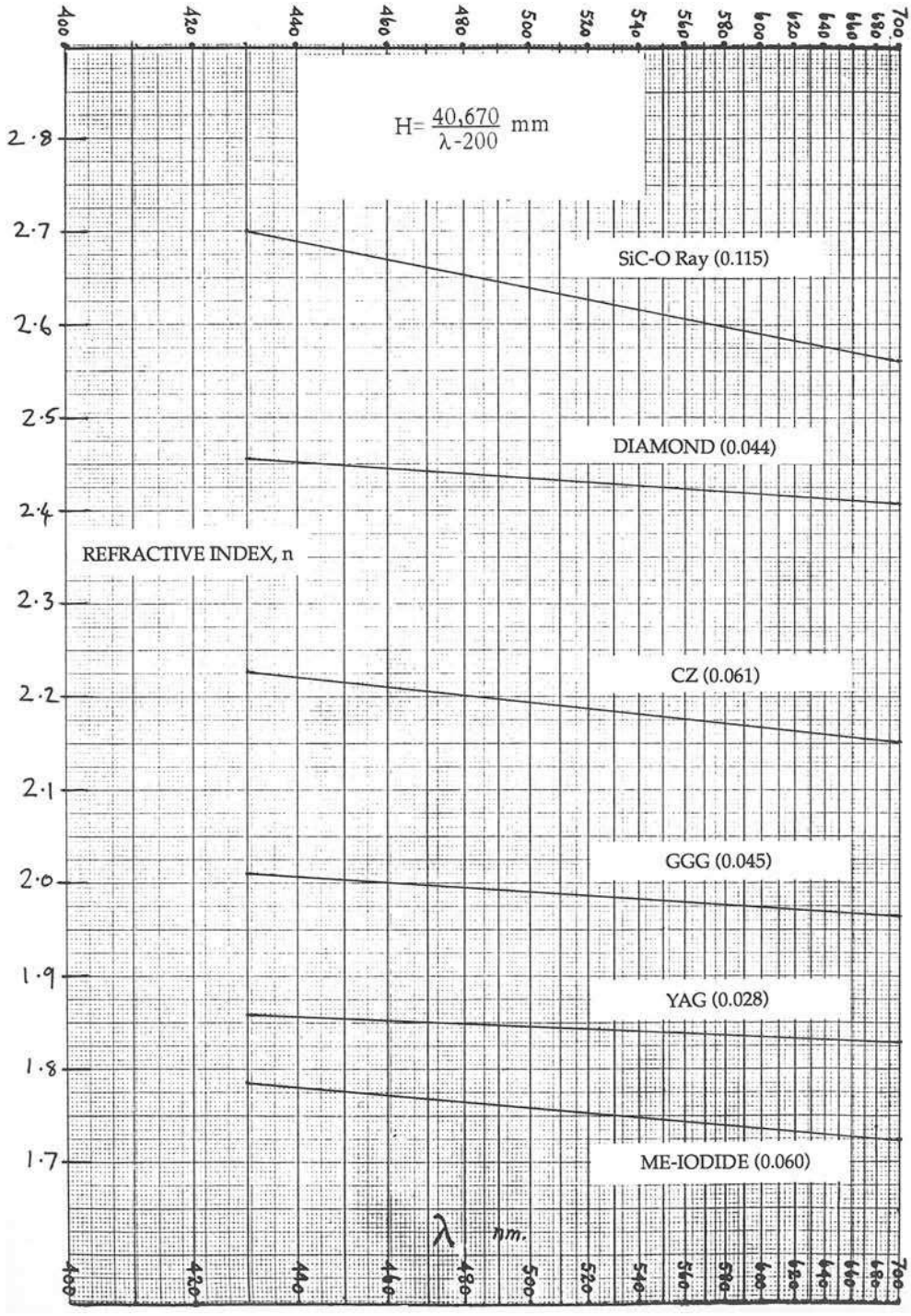


Fig. 5. Hartmann plots of the dispersions of four calibrated reflectance standards, diamond and methylene iodide. The numbers in brackets are those of the n_c - n_s dispersions.

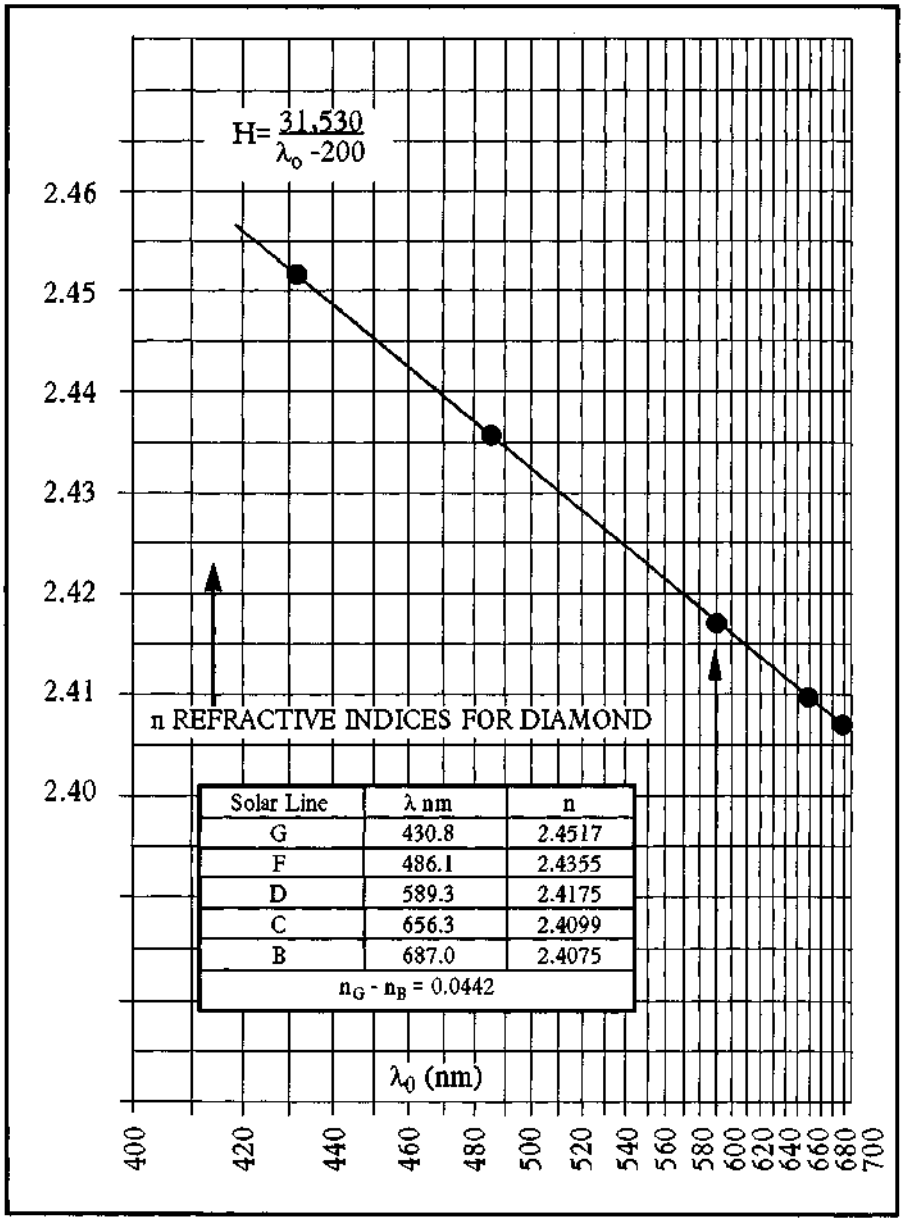


Fig. 7. The Hartmann dispersion chart for diamond.

diamond wettability and stability (resistance to devitrification) are features of the proposed glass which cannot even be guessed at. Certainly, Yehuda's glass must possess the requisite low viscosity. From the appearance of the beads of glass which had bled out from the infillings during torching (Figure 21 of Reference 3), their low profile contact angles show it to be a very good wetting agent. His glass too seems to possess the physical elastic properties which are compatible with diamond. If they were not, the resultant tensile or compressive stresses would render the filled diamond very unstable, leading to failure during any rough mechanical handling.

A possible filling process

If an engineer was asked to construct a batch production unit for filling stones, he would prob-

ably design a unit which might not be too different from that concocted on paper by the writer. The scheme is illustrated in Figures 8, 9, 10 and 11.

While seemingly rather complex, it is a proposed practical solution to the air- evacuation of the fissure roots. In a single cycle it could treat a batch of diamonds weighing up to 100 carats.

It consists of a rotatable, evacuable cylinder with internal heating units where three successive stages of operation can be carried out. One side of the cylinder supports the electrical wire resistance ovens together with their power control and temperature measuring connecting leads. It is removable and is sealed to the drum with a rubber O-ring. On the other side is a metal plate containing the vacuum pipe outlet together with a glass observation port for monitoring the various cycles. A cross-sectional sketch of the unit is shown in Figure 8.

It is vital that all open fissures are emptied completely of occluded or absorbed air. This operation is far from the simple process it appears to be. As air-filled channels in any porous solid become narrower, the rate at which air molecules can be removed from them by evacuation with even the fastest vacuum pump, becomes ever slower. Their complete removal, and particularly the multiple layers of air molecules which are strongly absorbed on the fissure walls and roots, is a very time-consuming process. It could take hours or even days of continuous pumping. If the air is not fully removed, then certainly it cannot be forced out, ferret-wise, by any liquid entering the wide mouths of the fissures, no matter how small the size of the molecules of the liquid itself. The still entrapped air cells and 'lakes' [3] will continue to behave as before the filling, as small but effective light-scattering, brilliance-robbing centres.

The reason for the long duration of the evacuation is related to the 'mean-free-path' of air molecules. These are in constant motion and they impact on each other less frequently when pressures and temperatures are low. This situation can be imagined as the average straight path distance travelled by a molecule where no collision occurs with neighbouring molecules. When the opposite-facing walls of a fissure are separated by a distance which is commensurable with the mean-free-path of the air molecules, then these are less able to move towards the vacuum pump. Heating the fissure walls enormously decreases the mean-free-paths and so accelerates the molecular drift towards the pump.

In Figure 9, the polycrystalline pure alumina refractory tube containing the batch of fissured diamonds is heated in the oven 'A', with its temperature monitored by a thermocouple. The clean glass fragments, held in oven 'B', would not be heated to above the melting point until the vacuum de-airing phase was near to completion.

The second stage is shown in Figure 10. The cylindrical evacuated drum is rotated on its axis until the melt contents of the alumina tube in oven 'B' have been emptied into the tube of oven 'A'. The drum is rocked slightly to ensure that all the stones floating in the melt have had an opportunity to be bathed in the melt. Unlike the de-airing stage, the filling stage should be almost instantaneous if the views about the melt's viscosity and wetting powers are correct.

At the end of this stage, the vacuum pump and oven 'B' are switched off. Air is admitted to the chamber and the observation port is removed. A diamond recovery metal cup with a stone-retaining drainage screen is clamped in place.

This cup is shown in Figure 11 where the diamond and melt recovery stage ends. After the cup has been released, the diamonds are removed from the screen and cooled as quickly as possible to prevent glass devitrification.

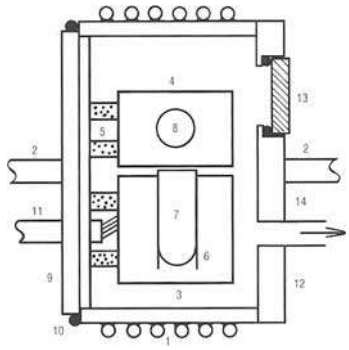
The removal of the residual frozen melt on the diamonds' facets would be accomplished by a solvent treatment with dilute hydrochloric or dilute nitric acids. Sulphuric acid must be avoided as it leads to the chalky formation of highly insoluble lead sulphate ($PbSO_4$). A strong solution of caustic soda (NaOH) might also be effective if strong acids were unacceptable.

Conclusions

This tightly-specified proposed scheme for the fissure filling of diamonds is an amalgam of what is already known and what is thought to be desirable for a repeatable working process.

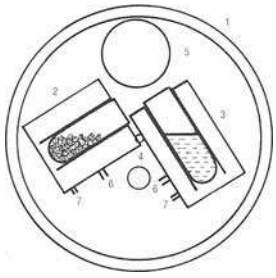
It could be argued that the filling procedure is unduly elaborate but the complexity of the apparatus arises from the need to remove the air completely from the fissure roots *before* immersing the stones in the molten glass. This longish vacuum 'baking-out' step is believed to be vital for really successful results.

One can also question the need to measure dispersion accurately, but it is likely that further improvements will be sought to preserve the



1. Cylindrical steel chamber with soldered-on water cooling tube.
2. Axial rotation spindle (V-block bearing not shown).
3. Electrically heated oven 'A'
4. Electrically heated oven 'B'
5. Heat-insulating standoff pillars.
6. Resistance heaters wound on insulated metal sleeves ('A' and 'B').
7. Sintered alumina reusable tube for holding the glass melt.
8. Sintered alumina reusable tube for holding the untreated cut diamonds.
9. Removable aluminium alloy end-plate.
10. Stretched rubber O-ring vacuum seal.
11. Vacuum-sealed electrical conduit for conducting both the independent power leads to each oven and the leads to each thermocouple temperature sensor.
12. Vacuum-tight fixed end-plate.
13. Glass-disc observation port with rubber O-ring seal.
14. Vacuum pipe showing the direction to the vacuum pump.

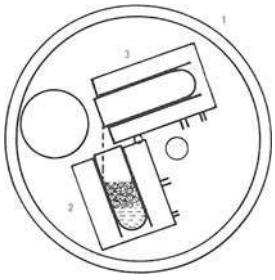
Fig.8. A cross-sectional sketch of the glass filling unit



1. Thick-walled steel chamber.
2. Oven A showing the diamond batch under the air evacuation of fissures.
3. Oven B showing the molten glass after the completion of the air evacuation.
4. Vacuum pipe.
5. Observation port.
6. Power supply terminals.
7. Thermocouple terminals.

Conditions: Oven A on. Oven B off. Vacuum pump on.

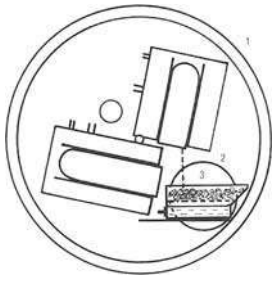
Fig.9. The first stage of filling: fissure evacuation.



1. Chamber rotated to the glass pouring position.
2. Oven A.
3. Oven B.

Conditions: Oven A on. Oven B on. Vacuum pump on.
At the end of the second stage: Oven A on. Oven B off. Vacuum pump off. Air admitted to the chamber. Observation port off. Diamond recovery cup with its integral screen clamped on in place. (see Fig. 11).

Fig.10. The second stage of filling: fissure filling.



1. Chamber rotated to the position for discharging the diamonds and melt into the recovery cup.
2. Open observation port.
3. Recovery cup with diamond retaining screen.

Conditions: Oven A on. Oven B off.
The recovery cup is unclamped and removed from the chamber. The diamonds are removed from the screen as rapidly as possible to prevent devitrification. Molten glass is recovered for recycling.

Fig.11. The last stage of filling: recovery of diamonds and melt.

original body colour and increase the brightness of the enhanced stones. These efforts would certainly require dispersion control.

In this technical and theoretical account, it has been felt inappropriate to touch upon the market aspects. These are best discussed by members of the stone trade. However, it is interesting to note that the CIBJO rules require the disclosure of the glass filling of any gemstone, and some consider (e.g. Hänni[7]) that the requirement should be mandatory.

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A device to facilitate the measurement of birefringence in gemstones

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Introduction

When discussing birefringence in gemstones, as measured on a refractometer, Anderson (1990) states:- 'for the purposes of identification maximum and minimum readings are all that are normally necessary. It can be stressed that for all stones, uniaxial or biaxial, the difference between the maximum and minimum readings obtainable on any facet must always represent the full birefringence for that stone'.

The technique which Anderson describes for obtaining birefringence is to select one edge and, using the forefingers of each hand, slowly rotate the stone on the table of the refractometer by gentle nudges. The upper shadow edge is chased to its highest limit and recorded; the lower edge is then chased to its lowest limit and also recorded. The difference between the two values is the birefringence of the stone. Anderson also describes another technique in which the stone is rotated and both lower and higher edge readings are recorded for each orientation of the stone; finally the lowest value is subtracted from the highest to give the birefringence.

This paper describes the construction of a simple device, which could be modified to suit most refractometers*. It enables a stone to be rotated by means of a 'twiddler rod' with the refractometer lid in the closed position, whilst at the same time observing the movements of the shadow edges via the eye piece[1]. First, the high reading shadow edge is selected using the polarizer and, as the stone is rotated, the edge is observed until it reaches its maximum value and begins to reverse. This peak reading is marked with the cursor (in the Dialdex) and recorded. The lower edge is dealt with in a similar fashion to obtain the point where its value is minimal. The point of reversal is obtained just as easily as when focusing a single lens reflex camera, i.e. first going beyond the point of focus in both directions and then returning to a position intermediate between the two. It is, therefore, possible to measure birefringence in just a few seconds since only two values need be recorded and both are accurate. In comparison, using a discontinuous procedure involving writing down a series of values is time-consuming and prone to error and the true value may in fact be in a position intermediate between successive stone orientations. Additionally, since the lid is in the closed position, the operator is not troubled by fumes from the contact liquid, nor does the liquid dry up so quickly.

When using the 'spot' or 'distant vision' test with cabochons, the spot of liquid may be progressively reduced in size quite easily by first retracting the twiddler-rod, so lifting the stone vertically and therefore safely off the table. The liquid remaining on the table is then removed with tissue so that on closing the lid and allowing the stone to descend, the liquid still adhering to the cabochon provides contact with the table, but now the spot has been reduced to approximately half its original size. (The rod stays in its retracted position since the Blu Tack sticks to the top of the hood.) The procedure is repeated until a suitably small image is obtained which gives greater accuracy. Optic sign determinations are also facilitated since the movement of both shadow edges related to each other may be observed directly as the stone is rotated. Mechanical rotation of the stone ensures that, provided the stone is placed at the centre of the table initially, it rotates about the same centre each time and is not laterally displaced as it would be if fingers were used to effect movement. This reduces the possibility of scratching the table and readings are accurately repeatable at any particular orientation of the stone.

Instructions for making the device are given

*A ready-made device for the Dialdex (with mounting instructions) is available from the writer's address for £20 for those who may wish to construct their own.

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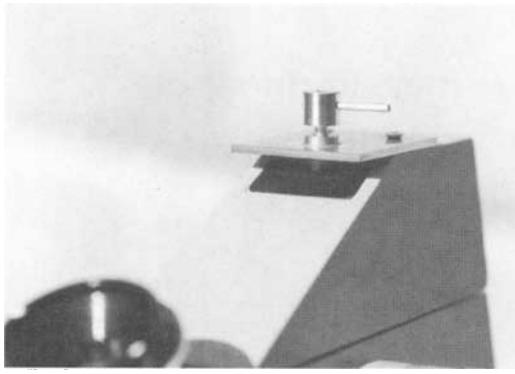


Fig. 1. The rod is shown down in its position of contact with the stone.

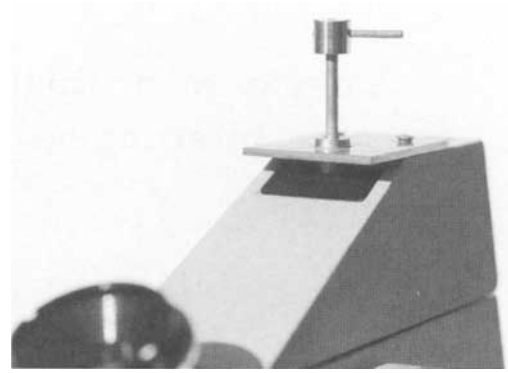


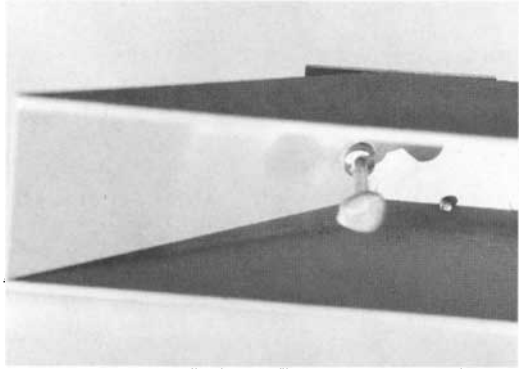
Fig. 2. The rod is shown retracted as when a ring-mounted stone is tested, or when an unmounted stone is withdrawn from contact with the table.

below for the Dialdex refractometer, but only a slight modification would be necessary to adapt it for other instruments.

Basically the device consists of a drilled bush which is inserted into the hood of the refractometer directly above the centre of the table. The bush is mounted on a brass plate which projects over the sloping part of the hood as shown in Figure 1. The bush is of such a length as to steady the rod which passes down its centre hole, but short enough to allow the rod to be retracted as shown in Figure 2. This enables ring-mounted stones to be tested. The rod has a pointer which acts as a handle on its upper end. On its lower end, inside the hood, is a blob of Blu-Tack or some similar substance (Figure 3) which contacts the stone and enables it to be rotated and also lifted from the surface of the table when necessary.

In use, no downward pressure is required once contact has been made with the stone, and the accuracy of the system is such that the same readings are obtained at the same orientation of the pointer each time. With the simple addition of a disc, calibrated in degrees, below the pointer, it would be possible to draw a continuous curve showing the RI of the stone at any specific angle of orientation.

Fig. 3. A blob of Blu-Tack is shown fixed to the end of the rod for rotation of the stone or the shank of a ring.



Construction

The plate

The first item to be made is the mounting plate for the bush. This plate in effect lengthens the top surface of the hood so that the bush, which it holds, is perpendicular to the table surface. This is necessary because the hood slopes at the point where the bush must be inserted. Cut a 27 x 30 mm plate from 1.6 mm brass sheet. Scribe the positions of the two mounting screw holes 6 mm in from the edge on a 27 mm side and drill to take the screws to be used. Mark the position of the hole for the bush on the centre line and 9 mm from the edge on the side opposite the screw mounting holes. Mount the plate in a vice in a drill press and using a centre finder (or as accurately as possible by eye) position a 5 mm drill over the mark and drill the hole.

The bush

Mount a short length of 6.5 mm diameter brass rod in a lathe chuck. Turn down a 6 mm length to a diameter of just under 5 mm so that it makes a good sliding fit in the hole in the plate. Drill through with a 2.4 mm drill (or to suit the diameter of the rod to be used). Part off to leave a flange approximately 2 mm thick and fix the

Fig. 4. Another version of the device is shown mounted on the Jemeter, with a spacer designed to accommodate ring-mounted stones.

bush into the plate, using Araldite, high-strength Loctite or solder, etc.

Marking the position for the hole in the hood

It is important to drill the hole in the hood vertically above the centre of the refractometer table. The easiest way of doing this is to mark the centre of the table by drawing diagonals across the rectangular glass area, using a sharp grease pencil which will not damage the glass. Remove the hood and mount the body of the refractometer in a drill press vice, taking care not to overtighten it. Place a centre finder (or fine drill) in the drill chuck and position it accurately above the centre-mark on the table. Now replace the hood (after backing off the drill chuck) and,using a Slocombe centre drill, make a mark on top of the hood. An ordinary drill is too flexible for this job since the mark has to be made on a sloping surface. When the centre mark has been made, remove the refractometer to a safe place and mount the hood only in the vice. Reposition it so that the drill is now directly above the mark previously made and drill a 5 mm hole through it. (It helps to start the hole first with a stiff centre drill.)

The bush in the plate made earlier should fit snugly through the hole in the hood. With the bush in position in the hood, rotate the plate until it lies with its sides parallel with the sides of the hood, then, holding it firmly in place, use a scriber to transfer the position of the screw holes onto the hood. Remove the plate and drill and tap the two holes which are to take the screws. If tapping is a problem, simply drill two holes which just clear the threaded shanks of the two screws and secure them with nuts inside the hood. Mount the plate on the hood.

The twiddler rod

A 30 mm long piece of 2.4 mm diameter aluminium tube is mounted in a brass head with about 27 mm projecting. (The diameter may be varied to suit the material available.) The handle is a clock pin or similar small-diameter rod. The finishing touch is to insert the rod into the bush and fix a pea-sized blob of Blu-Tack on the end. It was found helpful when using the device to mould the Blu-Tack on the rod so that it rotates concentrically with it. In this way, the culet of the stone seats neatly in line with the rod. A little practice is all that is needed to achieve RI and DR measurements in a fraction of the time taken previously.

Jemeter Digital 90

Figure 4 shows a similar device which has been constructed for the Jemeter Digital 90 obtainable from Gemmological Instruments Ltd.

Note

1. The device was sent to Reg Peace. a GAGTL Tutor, who reports as follows:
   'Once the lid of the refractometer has had suitable holes drilled (a relatively simple job), the stone is easily attached to the vertical rotator by Blu-Tack. This procedure avoids scratching the glass prism.
   'Observation of shadow edges while rotating the stone is easily done and repeatable. This is particularly valid in the case of biaxial stones where both shadow edges have to be observed and the maximum and minimum positions do not occur in the same position. By noting the position of the horizontal arm at these stages the refractive indices of each can be checked (a protractor in the form of an adhesive plastic disc on the top of the hood would be an advantage). The relative positions have no significance as they depend on the relationship of the table facet to the optic axes, whilst the numerical values of the refractive indices determine the double refraction.
   'I have found the "twiddler" to be an excellent addition to the refractometer and so easy to use. It can even be used where the stone is set in a ring.'

Reference

Anderson, B.W., revised by E.A. Jobbins, 1990. *Gem Testing* 10th edn. Butterworth & Co., London, p. 23.

More on the antiquity of emerald oiling

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In a recent article I pointed out that the usual 2000 year antiquity attributed to emerald oiling cannot be supported (Nassau, 1991). Pliny's description, as discussed in detail, does not apply to emerald but to the oiling of turquoise to turn it from blue to green. It is amusing that Koivula, *et al.* (1992) have recently reported that turquoise is still oiled in Luxor, Egypt, to obtain the green colour preferred by the local population, while blue material is preferred by tourists. All the usually cited sources on emerald oiling since Pliny appeared to be merely restatements of Pliny's account. Tracing emerald oiling backward from today, I was then only able to go back to about 1910.

I am very grateful to Dr John Sinkankas for drawing my attention to two sources, both in the fourteenth century, which give a definite history of at least 650 years to emerald oiling.

The first of the two is a brief mention in *The book of nature* by Konrad von Megenburg (1299-1374). This was written about 1350, widely circulated in manuscript form but not published until 1475, with a facsimile version edited by Pfeiffer (1962). In discussing emerald he says:

> '*Smaragd*... But the best is that which one finds in Scythia, and which is taken from the nest of the griffin bird, which guards the nest with great ferocity... And if one washes it and smears it with palm oil so improves its green.' (Translation by Sinkankas)

Were this the only evidence, however, one would be concerned whether this mix of myth and apparent fact might not still be merely repeated from Pliny. This is particularly likely, since many of the names Megenburg used for stones are unidentifiable because they were taken from Pliny according to Sinkankas. And was oil actually used to the same extent that emeralds were found in griffin nests?

All doubt, however, is removed by a report published by Oskar Schneider (1892) on 'The Egyptian emerald' which includes many historical citations. Among these is one taken from the report of an Arab traveller (p.68):

> 'Schehab ed-din Abul Abbas Achmed in his work "Mesa-lek-al-absar" gives the following more exact description, which he obtained from Abder-rahim, who was employed as a notary at the mine. "The emerald mine is located in the desert which borders on the town of Aswan... When an emerald is found, it is thrown into hot oil, then placed into cotton [wool], which is then wrapped in a piece of linen or other such material."' (Translation by Nassau)

Also included is a detailed description of the mine, with problems of water supply, financing by the Sultan, thieving by the workers, and the rarity of good quality emeralds.

I am greatly indebted to Dr Hedi Benaicha, Arabic Bibliographer at the Princeton University Library, for locating the following information: Abu'l-ᶜAbbās A. b. Ya. b. Fadlallāh al-ᶜOmarī Šihābaddīn was a member of a famous family of government officials. He died in 1349. The work in question was titled *Masālik al-abṣār fi mamālik al-amṣār*. This poetic sounding title can be literally translated as 'The Road of the eyes to the kingdoms of the world', being a detailed account of his wide-ranging travels. Its date is not certain, but it was already cited in 1331.

With this realistic description we can clearly accept emerald oiling early in the fourteenth century. Particularly convincing is the use of oil that is hot, since this reduces the viscosity to enable it to penetrate more readily, as well as causing air to expand in fractures and draw in the oil as the air shrinks on cooling. Whether additional convincing evidence for an even earlier occurrence of emerald oiling (not derived from Pliny) will turn up remains to be seen.

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Nassau, K., 1991. Two types of historical traps: on 'diamond softening' and the 'antiquity of emerald oiling'. *Journal of Gemmology*, **22**, 7, 399.

Pfeiffer, F. (Ed.), 1962. *Das Buch der Natur Von Konrad Von Megenburg*. 1861 Stuttgart, Facsimile reprint, Olms, Hildsheim.

Schneider, O., 1892. Der Aegyptische Smaragd. *Zeitschrift für Ethnologie*, **24**, 41.

Gemmological Abstracts

ARROUAS, S., 1993. Rubis du Vietnam, mythe ou réalité. *Revue de Gemmologie*, 115, 7-8, 6 photos (3 in colour).

A brief survey and statistical report on ruby from the Luc Yen area of Vietnam.

Average size of cut stones ranges from 0.15-1.80ct and the largest stone found so far weighed 57.6ct. Only 6 per cent of the production is suitable for faceting. M.O'D.

ARTIOLI, G., RINALDI, R., STÅHL, K., ZANAZZI, P.F., 1993. Structure refinements of beryl by single-crystal neutron and X-ray diffraction. *American Mineralogist*, **78**, 7/8, 762-8, 3 figs.

Single-crystal neutron and X-ray data of two samples of beryl with different alkali and water contents (gem varieties morganite and aquamarine) confirm existing theories of site occupancy. M.O'D.

ASTRIC, B., MERIGOUX, H., ZECCHINI, P., 1993. Studio della variazione dell'aspetto delle gemme con l'aiuto di immagini di sintesi. *La gemmologia*, **16**, 7-31, **4** photos, 11 figs.

Computer-aided image synthesis is used to build up a picture of various possible shapes for a faceted brilliant-cut diamond. The part played by the source and type of light used for illumination is also studied. M.O'D.

BEDOGNÉ, F., SCIESA, E., 1993. Die Demantoide vom Val Malenco, Sandrio/Italien. *Mineralien Welt*, **4**, 6, 25-8, 8 photos in colour, 1 map.

Well-shaped crystals of demantoid are described from the classic location of Val Malenco, Italy. From the photographs the colour is the expected yellow to brownish- green. Some material is of faceting quality and size. M.O'D.

BOVENKERK, H.P., BUNDY, F.P., CHRENKO, R.M., CODELLA, P.J., STRONG, H.M., WENTORF, R.H.Jr., 1993. Errors in diamond synthesis. *Nature*, **365**, 19, 1 fig.

A natural diamond is reported to have got into the diamond synthesis run 151 carried out in 1955 by some of the present authors while working on diamond synthesis at General Electric. The pressure attained is now believed to have been not much above 42kbar, insufficient to synthesize diamond. Examination of the run 151 specimen to obtain an IR absorption spectrum showed coincidences with a natural N-containing Type Ia diamond. M.O'D.

BROWN, G., 1993. Value enhanced jadeite. *South African Gemmologist*, **7**, 2, 27-32, 5 photos in colour.

A brief survey of the various methods used to enhance the colour of jadeite with notes on identification. M.O'D.

BROWN, G., 1993. Vietnamese ruby. *South African Gemmologist*, **7**, 2, 14-20, 6 photos

A description of ruby from Vietnam is combined with a warning on the presence of Verneuil-type synthetic ruby in parcels of natural stones. M.O'D.

BROWN, G., 1993. Lapis lazuli – a long used gemstone. *South African Gemmologist*, **7**, 3, 12-18, 7 figs in colour.

A brief account of lapis lazuli and its main imitations with notes on simple identification methods. M.O'D.

CUIF, J-P., DAUPHIN, Y., STOPPA, C., BEECK, S., 1993. Forme, structure et couleurs des perles de Polynésie (suite). *Revue de gemmologie*, 115, 9-11, 3 figs.

Spectral analysis of dark pearls from Polynesia is reviewed as part of a general programme to improve the appearance of cultured material from the region. M.O'D.

DE JENLIS, M., 1993. Les mines de rubis de Bolaï. *Revue de gemmologie*, 116, 10-11, 2 photos.

Ruby mines at Bolaï in the former Cambodia are now closed but this brief account describes the method of working that took place. M.O'D.

DEREPPE, J.-M., MOREAUX, C., 1993. Application gemmologique de la résonance magnétique nucléaire. *Revue de gemmologie*, **117**, 8-10, 4 figs.

NMR techniques have a number of gemmological applications including identification of some synthetic emeralds and resolution of diamond types. M.O'D.

DUCHAMP, M., 1993. Les richesses du cristal de roche. *Revue de gemmologie*, 116, 2- 5, 7 photos (1 in colour).

An account of the various uses to which rock crystal has been put in the manufacture of historical artefacts. Objects discussed come from different named museums. M.O'D.

DUCHAMP, M., 1993. Les intailles en cristal de roche et en agates. (Part 1) *Revue de gemmologie*, 117, 4-7, 7 photos (2 in colour).

The use of rock crystal as a medium for engraving is described with reference to a number of artefacts of the sixteenth and seventeenth centuries held in the Karlsruhe Museum and in Vienna. M.O'D.

ENDERS, J., KEJM, T., NOHL, U., 1993. Farbwechselnder Hackmanit aus Kanada-ein überraschender Edelstein. *Lapis*, **18**, 7/8, 26, 5 photos in colour.

A variety of hackmanite showing distinct photochroism is reported from Canada. A variety of sodalite, this type of transparent hackmanite may be found near-colourless, turn purplish during UV-irradiation and remain reddish-orange for a while after the irradiation before reverting to the original near-colourless state. The nature of the colour centre responsible is discussed. M.O'D.

FOLIE, K., 1993. 150 Jahre Burgum-eine klassische Fundstelle für Zirkon in Südtirol. *Mineralien Welt*, **4**, 6, 29-38, 15 photos and 1 map in colour, 2 figs.

Zircon, sphene and vesuvianite are among the minerals found at Burgum in the southern Tirol, Austria. Crystals of all three minerals are well-formed though small. M.O'D.

FORD, T.D., 1992. Postscript to the largest Blue John vases ever made. *Bulletin of the Peak District Mines Historical Society*, **11**, 6, 282.

A large Blue John vase is reported from Renishaw Hall near Sheffield, the home of the Sitwell family. The vase measures 22 inches from base (excluding the plinth) to the top of the handles, thus making it one inch taller than a similar Blue John vase at Chatsworth. Notes on other pieces are given; some of them appear to have been lost. M.O'D.

FORD, T.D., SARJEANT, W.A.S., SMITH, M.E., 1993. The minerals of the Peak District of Derbyshire. *UK Journal of Mines and Minerals*, 13 [jointly with] *Bulletin of the Peak District Mines Historical Society*, **12**, 1, 68pp., illus. in black-and-white and in colour.

The full description of all minerals so far recorded from the Peak District of Derbyshire includes an account of fluorite covering occurrence, production, varieties and properties. The paper, in which the minerals are listed in chemical order, concludes with an excellent bibliography. M.O'D.

GAUTHIER, J-P., 1993. Une mission à Takapoto, 'l'Ile des perles'. *Revue de gemmologie*, 115, 2-6, 4 photos (3 in colour).

Pinctada margaritifera and the smaller *P. maculata* are used for the culture of pearls on the island of Takapoto, situated east of Tahiti in the southern Pacific. M.O'D.

GRIFFIN, W.L., SOBOLEV, N.V., RYAN, C.G., POKHILENKO, N.P., WIN, T.T., YEFIMOVA, E.S., 1993. Trace elements in garnets and chromites: diamond formation in the Siberian lithosphere. *Lithos*, **29**, 235-56.

Trace elements in garnet and chromite inclusions in diamonds from some Siberian kimberlites are studied by proton-microprobe analysis. The kimberlites studied are the Mir, Udachnaya, Aikhal and Sytykanskaya mines in the Yakutia area of the CIS. Examinations of garnet and chromite concentrates from the same pipes have provided information on the thermal state and chemical stratification of the Siberian lithosphere. Diamonds from the peridotite-suite have formed over a temperature interval of about 600°C (Yakutia specimens), this information being obtained from Ni and Zn thermometry. Similar data from other diamond pipes are given. M.O'D.

GRUNDMANN, G., MORTEANI, G., 1993. 'Smaragdminen der Cleopatra': Zabara, Sikait und Umm Kabo in Ägypten. *Lapis*, **18**,

7/8, 27-39, 22 photos (17 in colour), 5 maps, 6 figs.

Several emerald mines in the south-east of Egypt are reviewed. Some may have produced emerald crystals used in the jewellery from the time of the Pharaohs and intermittent work is carried on today though on a very small scale. The three main emerald-producing areas are Wadi Sikait, Zabara and Umm Kabo; the emerald is found in a variety of assemblages: at Sikait it occurs with biotite, plagioclase, muscovite and other minerals and at Zabara, the source of the finest crystals, with biotite schists. At Umm Kabo the emerald is found with carbonate-chlorite schists in association with quartz. An inclusion of columbite is reported in an emerald crystal from Sikait. M.O'D.

HENN, J., LIEBER, W., 1993. Amethyst vom Brandberg, Namibia. *Lapis*, **18**, 10, 44-8, 11 photos (6 in colour), 3 maps.

Sceptre and phantom varieties of amethyst are found at Brandberg, Namibia. General details of the location are given. M.O'D.

JERDE, E.A., TAYLOR, L.A., CROZAZ, G., SOBOLEV, N.V., SOBOLEV, V.N., 1993. Diamondiferous eclogites from Yakutia, Siberia: evidence for a diversity of protoliths. *Contributions to Mineralogy and Petrology*, **114**, 2, 189-2-2, 9 figs.

The compositions of 14 diamondiferous eclogites from the Udachnaya kimberlite, Yakutia, Siberia are examined with particular reference to major-element and rare earth element factors. Tests involving the electron microprobe and secondary ion mass spectrometer were used in the determination of compositions. While these Siberian eclogites have roughly similar compositions to those in southern Africa there are significant differences which are extensively discussed. M.O'D.

JONES, G.C., 1993. Amber. *Mineralogical Society Bulletin*, **100**, 3.

Short and authoritative account of the formation, distribution, properties and care of amber. M.O'D.

KAMMERLING, R.C., KANE, R.E., 1993. Die Rubine- und Saphir-Abbaue von Mogok. *Lapis*, **18**, 7/8, 40-56, 27 photos (22 in colour), 2 maps.

The paper, a revised and updated version of that appearing in *Gems & Gemology*, **28**, 3, 152-74, 1992, describes the traditional and more up-to-date methods of mining for ruby and sapphire in the area. Details of some of the geology and mineralization are given and a full list of gem-quality minerals appended. M.O'D.

KAMMERLING, R.C., KOIVULA, J.I., 1993. The role of fashioning in effective gemstone substitutes. *South African Gemmologist*, **7**, 3, 19-29, 7 figs in colour.

Cutting styles used for synthetic and imitation gemstones are discussed with reference to such features as colour distribution, pleochroism and inclusions, as well as to the cutting itself. M.O'D.

KANEKO, K., LANG, A.R., 1993. CL and optical microtopographic studies of Argyle diamonds. *Industrial Diamond Review*, **53**, 6, 334-7, 6 photomicrographs, bibl.

External surfaces and polished sections of Argyle stones have been examined by cathodoluminescence (CL) topography and optical microtopographic techniques, revealing radiation damage on natural surfaces, complex growth histories and post-growth plastic deformation. Spatially fine-scale variations in nitrogen impurity content correlate closely with differences in abrasion resistance. E.S.

KAZACHENKO, V.T., BUTSIK, L.A., SAPIN, V.I., KITAEV, I.V., BARINOV, N.N., NARNOV, G.A., 1993. Vanadian-chromian tourmaline and vanadian muscovite in contact-metamorphosed carbonaceous rocks, Primorye, Russia. *Canadian Mineralogist*, **31**, 347-56, 7 photos, 1 map, 5 figs.

Vanadian-chromian tourmaline with up to 4.06wt% V_2O_3 and 2.38wt% Cr_2O_3 is reported from contact-metamorphosed carbonaceous metasediments of the Pribrezhnaya anticlinal zone in Primorye, Russia. Crystals show compositional zoning with depletion in Cr and V and enrichment in Al, Mg and Fe from core to rim. The Cr and V enter via the mechanisms $Cr^{3+} \leftrightarrow Al^{3+}$ and $V^{3+} \leftrightarrow (Mg^{2+}, Fe^{2+}, Mn^{2+})$. The second exchange necessitates a charge increase and this is thought to be resolved via substitution of ^{IV}Al for Si and by the appearance of vacancies in the X site. M.O'D.

KOSHIL, I.M., VASILISHIN, I.S., PANCHENKO, V.I., 1993. Bernstein aus der Ukraine. *Lapis*, **18**, 10, 34-7, 4 photos in colour, 1 map, 1 fig.

Ukrainian amber has been known for at least 1200 years. Artefacts are described and there are notes on characteristic inclusions. M.O'D.

KRAPPMANN, M., DREES, H-H., 1993. Mineraliensuche im Süden Afrikas. *Lapis*, **18**, 10, 41-3, 5 photos (4 in colour).

Particular reference to amethyst, beryl and tourmaline is made in a general survey of South African minerals. M.O'D.

MAGNORI, L., 1993. Brevi osservazioni sull'anfibolite zoisitica a corindone della Tanzania. *La gemmologia*, **16**, 33-5, 4 figs in colour.

Ruby in zoisite from Tanzania is briefly reported with notes on some petrographic characteristics. M.O'D.

MATHEZ, E.A., BLACIC, J.D., MAGGIORE, C., MITCHELL, T.E., FOGEL, R.A., 1993. The determination of the O content of diamond by microactivation. *American Mineralogist*, **78**, 7/8, 753-61, 4 figs.

Microactivation techniques have been used to determine the oxygen content of diamond. The specimen is bombarded with an energetic beam of $^{3}H^{2+}$ from a tandem accelerator giving the reaction $^{16}O(^{3}He,p)^{18}F$. The ^{18}F decays to ^{18}O (half life of 109.8 min) by positron emission and the decay activity is measured by coincidence counting. In 28 diamond samples most showed 10-100ppm O (atomic) in spots. These were later found to be inclusion-, crack- and defect-free. It is not thought that the O is present in submicroscopic mineral inclusions. Samples tested came from some unknown locations and also from the Monastery and Finsch kimberlites, South Africa, from Orapa, Botswana and from Muji Mayi, Zaire. M.O'D.

MITCHELL, A.H.G., 1993. Cretaceous-Cenozoic tectonic events in the western Myanmar (Burma)-Assam region. *Journal of the Geological Society, London*, **150**, 1089-102, 11 figs.

Late Mesozoic mafic and ophiolitic rocks when correlated may imply that a NE-facing mafic arc was emplaced on to SE Borneo, western Sumatra, western Myanmar (then 1100 km S of its position today), the Mogok belt and the Denquen-Bangong Co-ophiolite zone in Tibet in the late Lower Cretaceous. These sites were at that time situated on the SW margin of Asia. Subsequent reversal of tectonic polarity and other events were implicated in the mineralization of several important gem-bearing areas, including the Mogok Stone Tract. M.O'D.

MONAT, P., MERIGOUX, H., 1993. Marbode. Poème des pierres précieuses. (part 1) *Revue de gemmologie*, 117, 2-3.

Prologue, diamond, agate, amber, jasper, sapphire and chalcedony are reviewed in this first part of a commentary on Marbodius, *Libellus de lapidibus*, a poem tentatively dated between 1067 and 1101. M.O'D.

MUNTYAN, B.L., 1993. 10 interessante Mineralienfundstellen in Colorado, USA. *Mineralien Welt*, **4**, 4, 17-23, 10 photos (8 in colour), 1 map.

Among the ten sites are the Sweet Home mine, celebrated for gem-quality rhodochrosite and Crystal Peak where good quality amazonite is found. M.O'D.

NEUBAUER, D., 1993. Olivinkristalle aus Hawaii. *Aufschluss*, **44**, 347-8, 1 fig., 1 photo in colour.

A near gem-quality green olivine crystal found at Mauna-Lani on the west coast of Hawaii measured approximately 2 x 1.5mm and 1mm in height. Predominating faces were (001), (102), (011), (012) and (110): SG was 3.35. M.O'D.

NIEDERMAYR, G., 1993. Saphir. *Mineralien Welt*, 4, 4, 29, 3 photos (2 in colour).

Characteristic inclusions in Sri Lanka blue sapphire are illustrated and described. M.O'D.

NIEDERMAYR, G., 1993. Diffusions-behandelte Korunde. *Mineralien Welt*, 4, 5, 15, 1 photo in colour.

Brief review of diffusion-treated corundum with notes on identification. M.O'D.

NOVAGA, M., 1993. La vesuviana di Bellecombe e Montjovet (AO) come materiale di interesse gemmologico. *La gemmologia*, **16**, 36-40, 6 photos in colour, 1 map.

Gem quality vesuvianite is reported from Bellecombe and Montjovet in the province of Aosta, northern Italy. SG and RI ranges are given. M.O'D.

O'DONOGHUE, M., 1993. Gemmology towards the 21st century. *Mineralogical Society Bulletin*, **191**, 3-4.

A survey of some of the problems facing gemmologists towards the end of the twentieth century includes alteration of colour by various means and the related question of disclosure; new gem species and varieties and changes in mining, supply and marketing methods. Gem-quality synthetic diamond bids to occupy gemmological attention very soon.

(Author's abstract) M.O'D.

PICKER, H., 1993. Granite International. *International Diamond Review*, **53**, 557, 4, 218-22, 3 tables, 4 photographs.

Reprint of a lecture by H. Picker at the international seminar *Dimension Stone Afrika 1993* earlier this year in Johannesburg. He surveyed the growth of the granite industry, which covers the use of granite in memorials and tombstones; in construction for wall cladding, flooring, in pedestrian areas and as tiles and veneer tiles and for technical application as surface plates and basins for acids and as pillars. The main producing countries are India, South Africa, China, Spain, Brazil, Norway, Korea and Finland, although sizeable quantities are also produced in Sweden, Italy, Portugal, France, Germany, the former Eastern bloc, USA and Canada. The industry is growing rapidly in China as well as in Taiwan and a big diamond sawing capacity is being built up in Thailand, Malaysia, Singapore and Indonesia. E.S.

RENDELL, H.M., KHANLARY, M-R., TOWNSEND, P.D., CALDERON, T., LUFF, B.J., 1993. Thermoluminescence spectra of minerals. *Mineralogical Magazine*, **57**, 2, 217-22, 6 figs.

Though most TL measurements are obtained by examining light emission during heating, using broad-band optical filters and blue-sensitive photomultiplier tubes, more useful information can be gained by an examination of the emission spectrum displayed during the time that the TL is occurring. Crystal purity, radiation dose, dose rate and thermal history all affect the TL spectra of minerals. The paper describes TL spectra of calcite, fluorite, zircon and feldspars. M.O'D.

RIZZI, F., WEISS, S., 1993. Grösster Apatitkristall aus einer Schweizer Zerrkluft. *Lapis*, **18**, 12, 21-6, 11 photos (7 in colour), 1 fig.

Large crystals of apatite, some with a moonstone-like sheen and others apparently with sections sufficiently transparent to be faceted, are found in Alpine clefts in the area of Naret, Ticino, Switzerland. The colour is predominantly pale yellow. M.O'D.

ROBERT, D., 1993. Gemmes irradiées et radioactivité, *Revue de gemmologie*, 116, 6-9, 1 photo in colour.

The irradiation of gemstones and the problems associated with radio-activity are briefly discussed with particular reference to topaz. M.O'D.

ROBINSON, G.W., KING, V.T., 1993. What's new in minerals? *Mineralogical Record*, **24**, 5, 381-95, 18 photos in colour.

The paper includes the annual world summary of mineral discoveries covering April 1992 through April 1993. Gem-quality and ornamental species described include: rhodochrosite from the Sweet Home mine, Alma, Colorado; fluorite from the classic locality of the Minerva no. 1 mine, Cave-in-Rock, Illinois; purple fluorapatite and variously coloured tourmalines from several different sites in Maine; very fine opal from Opal Butte, Morrow County, Oregon. Outside the United States there are reports of kunzite and lazurite from Afghanistan, brazilianite from Minas Gerais, Brazil, a state also producing fine-coloured tourmaline of different colours, chrysoberyl from Medeiros Neto, Bahia, Brazil. Spectacular crystals of red spinel in white quartz are reported from Burma and bluish-green fluorite crystals from Shang Bao, Leiyang County, Hunan, China. Fine emerald crystals from Colombia have been on the market as have gem-quality golden beryl crystals from Wolodarsk-Wolynski, Wolhynien, Ukraine. Large red elbaite crystals have come from the Otjua mine near Karibib, Namibia and transparent green gem-quality zoisite from the Northern Areas of Pakistan. M.O'D.

SCHÄFFER, W., 1993. 'Tsavorite', der grüne Grossular aus Kenya. *Lapis*, **18**, 7/8, 57-66, 23 photos (18 in colour), 3 maps, 1 fig.

Transparent gem-quality green grossular is found in the Taita Hills near Voi, Kenya. Details of the occurrence and of the sporadic mining operations are given. The garnet occurs in a graphitic gneiss. M.O'D.

SCHELLHORN, S., 1993. Bitterfeld: Sächsischer Bernstein aus dem Braunkohlen- Tagebau, *Lapis*, **18**, 10, 32-3, 3 photos in colour.

Amber is found in brown coal measures at Bitterfeld, Saxony, Germany. The current working site, Gute Hoffnung I, is described. M.O'D.

SCHRAUDER, M., NAVON, O., 1993. Solid carbon dioxide in a natural diamond. *Nature*, 365, 42-4, 1 photo., 2 figs.

Solid CO_2 is reported from a natural diamond. The specimen was a brownish- yellow diamond composed of two intergrown crystals with the larger crystal displaying a zoning with slight colour in the centre and a more intense colour at the outer zone. The smaller crystal is colourless. IR spectra for the different zones show the common type IaA bands with low N and H content, (1282 and 3107cm^{-1}). Four additional bands (at 650, 2376, 3620 and 3752cm^{-1}) can be observed in the coloured zones. The bands at 2376 and 650cm^{-1} dominate the remainder of the spectrum and show an intensity exceeding that of the diamond absorption bands. These dominating bands are the v_3 and v_2 bands of CO_2; the bands at 3620 and 3752cm^{-1} correspond to the combination bands (v_3+2v_2 and v_3+v1) of CO_2. The lines are shifted from the positions where they occur at one atmosphere pressure and comparison with high-pressure spectral data of CO_2 shows that the position of three of the peaks in the spectrum of the diamond closely fit the spectrum of solid CO_2 at a pressure of 5±0.5GPa. M.O'D.

SCHUBNEL, H-J., 1993. Les collections de synthèses anciennes du Muséum National d'Histoire Naturelle. *Revue de gemmologie*, 117, 11-14, 9 photos (5 in colour).

A number of early syntheses of gem materials, particularly corundum, spinel and emerald, are held in the collections of the Muséum National d'Histoire Naturelle, Paris. M.O'D.

SEIFERT, T., RIEDRICH, G., 1993. Die Achate im Melaphyr von Gröppendorf bei Hubertusberg in Sachsen. *Mineralien Welt*, 4, 4, 15-16, 5 photos (3 in colour), 1 map.

Ornamental agate is described from the area of the Huberstusberg near Gröppendorf, Saxony. The agate occurs in a melaphyre. M.O'D.

SIRAKIAN, D., 1993. Gemmes en lumière. *Revue de gemmologie*, 115, 12.

A pink stone with an RI of 1.732 and weighing less than one carat was tentatively identified as a garnet in the pyrope-almandine series despite the low RI which suggested spinel in the first instance. Semi-quantatitive chemical analysis was used to establish the identity of the Sri Lankan specimen. M.O'D.

SKOBEL, L.S., NEKHANENKO, I.I., POPOVA, N.P., 1993. Axinitfunde in der Lagerstätte Puiva, Polarural. *Mineralien Welt*, 4, 5, 33-7, 5 photos (4 in colour), 1 fig.

Axinite, some crystals of gem quality, are reported from the area of Puiva in the extreme north of the Urals in Russia. Occurring with and on quartz, the axinite shows strong pleochroism with predominantly violet and cinnamon colours and has RI 1.688, 1.685, 1.678. M.O'D.

SOUZA, J.L., MENDES, J.C., BELLO, R.M.S., SVISERO, D.P., VALARELLI, J.V., 1992. Petrographic and microthermometrical studies of emeralds in the 'Garimpo' of Capoeirana, Nova Era, Minas Gerais State, Brazil. *Mineralium Deposita*, 27, 2, 161-8.

Studies in this area have revealed two main lithostructural units. The first consists of gneissic rocks of granitic composition belonging to the basement complex and the second of a highly weathered metasedimentary-metavolcanic sequence represented by metapelitic schists, amphibolites, schists derived from ultramafic rocks, and quartzites. Quartz and pegmatitic veins appear near the contacts between the gneissic rocks and the mineralized metasedimentary-metavolcanic sequence. The emerald mineralization is mainly concentrated within the intercalations of meta-ultramafic schists near the contact with the pegmatitic veins. Microthermometric studies of the fluid inclusions in the emerald grains indicate that crystallization occurred in the P-T range 2000 - 2750 bar and 450 - 650°C. The data suggest that the mineralizing solutions had a late hydrothermal-pneumatolytic origin characterized by low P, suggestive of the paragenesis talc + tremolite + carbonate + biotite-phlogopite + chlorite in the emerald wall rocks. R.A.H.

SURY, E., 1993. Wie der Schein doch trügen: Edelsteine aus Glas und Klebstoff. *Lapis*, **18**,

7/8, 71-6, 7 photos (6 in colour).

A review of synthetic and imitation gemstones with notes on their manufacture. M.O'D

THOMAS, A., 1993. The emerald mines of Madagascar. *South African Gemmologist*, 7, 3, 3-11, 3 photos in colour.

Emeralds from the Mananjary mine are compared with specimens from other world localities, but with no conclusive evidence to distinguish them. The crystals occur in a biotite schist and although predominating inclusions of tremolite and actinolite are reported from this area in the literature stones recovered on the occasion of the visit of the author did not show these minerals. The solid inclusions are not identified. Most of the article is devoted to travel reminiscences. M.O'D.

VAN PRAAGH, G., 1993. Growing crystals of quartz. *Mineralogical Society Bulletin*, **101**, 7-9, 2 figs.

The writer recalls his work in investigating German crystal growth activities immediately after the Second World War. In particular he recalls meetings with Professor Richard Nacken and discussing hydrothermal growth of quartz. Details of methods used at the time are given. M.O'D.

WEERTH, A., 1993. Neuheiten aus Asiens Schatzkammer. *Lapis*, **18**, 9, 28-30, 5 photos in colour.

Gem-quality mineral finds from Asia over the past few years are reviewed. Particular attention is paid to the northern Pakistan pegmatites with spessartine, green transparent zoisite, aquamarine, scheelite and epidote. M.O'D.

WEERTH, A., 1993. Milarit und Danburit aus Südtirol. *Lapis*, **18**, 10, 26-31, 15 photos (14 in colour).

Danburite, some of good gem quality, is found with milarite in clefts at various places in the southern Tirol, Austria. Crystals are fairly small, however. M.O'D.

WEISS, S., 1993. Schörl, Rubellit und Mohrenköpfe aus Sachsen. *Lapis*, **18**, 7/8, 13-17, 12 photos (11 in colour), 2 figs, 2 maps.

Gem quality red tourmaline and specimen-quality schorl, with some characteristic dark-topped crystals, occur in the Granulitgebirge in Saxony, Germany. The nearest town to the major deposits is Penig. Other minerals reported from the area include apatite, quartz, dark red garnet and amblygonite. M.O'D.

JADES IMPÉRIAUX. *Revue de gemmologie*, 1993, 116, 12-16, 5 photos in colour.

Photographs illustrate some jade artefacts to be shown at an exhibition in Paris in late 1993. M.O'D.

A unique diamond exhibition. *Industrial Diamond Review*, 1993, **53**, 557, 4, 204-5, 7 photographs.

Short description of the *From the Treasury* exhibition in June 1993 organized by the HRD (Diamond High Council) to commemorate Antwerp's selection as the cultural capital of Europe. The exhibits included the Eureka diamond, the first diamond ever found in South Africa, and jewellery and stones from the Romanov Tsars, the Thurn and Taxis, the Duchess of Windsor and many other celebrities. De Beers loaned their Rainbow collection and Argyle diamonds the Argyle Library Egg by Kutchinsky, 70cm high and studded with 20 000 pink and white diamonds. E.S.

Book Reviews

ASSELBORN, E., FOLIE, K., GEIPEL, R., GRAMACCIOLI, C.M., GRUNDMANN, G., HOCHLEITNER, R., MAISSEN, F., MULLIS, J., NIEDERMAYR, G., STRUNZ, H., WEISS, S., 1993. *Kristall alpin.* Christian Weise Verlag, Munich. pp. 95, illus. in black-and-white and in colour (*extraLapis* 5). ISBN 3 921656 28 1.

A multi-author survey of the Alpine environment and its minerals forms the fifth in the *extraLapis* series. Though the series is not covered by a subscription to *Lapis* itself, those issues so far published are well worth the attention of gemmologists. In this number each of the major minerals is extensively described with some crystal drawings and high-quality colour photography. Rarities get similar but shorter treatment. Early chapters describe geology, inclusions, mineral formation and tectonics. A more comprehensive bibliography would have been welcome but, to be fair, this area has been well covered by other works. M.O'D.

AYERS, J., 1993. *A jade menagerie: creatures real and imaginary from the Worrell collection.* Azimuth Editions, London. pp. 72, illus. in colour. Price on application.

Jade animals, few later than the Ming dynasty, form the nucleus of the collection formed by T. Eugene Worrell of Charlottesville, Virginia. The book has chosen 41 items for description but the text takes second place to the photographs, all in colour and all showing the subtle yellow, brown and cream colours characteristic of nephrite. The text is more narrative than scientific but loses nothing by this. Items are succinctly dealt with in catalogue style at the end of the book while the main section describes the real and mythical creatures, their styles and dates. M.O'D.

BURNS, R.G., 1993. *Mineralogical applications of crystal field theory.* 2nd edn. Cambridge University Press, Cambridge. pp. xxiii, 551, £50.00.

Forming volume 5 of the series *Cambridge topics in mineral physics and chemistry*, this book first began life as a series of lectures given at Cambridge and Oxford during 1966, the lectures themselves being based on material collected for a thesis submitted to the University of California at Berkeley. Since the publication of the first edition the amount of data relating to visible to near-IR spectroscopic measurements of minerals containing cations of the first-series transition elements has greatly increased and this edition, while reviewing the data, also introduces newer applications of them, particularly in the context of the occurrence of transition metal-bearing minerals on planetary surfaces and of the applications of remote-sensed reflectance spectra in their identification.

For the mineralogist and gemmologist the chapters on measurements of absorption spectra of minerals and crystal field spectra of transition metal ions in minerals will be turned to first although other sections of the book are just as absorbing. Apart from the explanations and observations provided, the extensive reviews of work covered not only by the text but also by end-of-chapter references and a 43-page bibliography at the end of the book are just as useful. Read in conjunction with *The physics and chemistry of colour* (Nassau, 1983) the combined texts provide the best possible introduction and explanation of some of the problems faced by mineralogists and gemmologists and those persisting with the text will admire the lucidity of style excellently complementing the elegance of the conceptions.

For the price this is a most valuable bargain; the text appears to have been set and in any case is not camera-ready copy. I had been looking forward to this edition since I first saw its announcement at the beginning of 1993. M.O'D.

CHRONIC, H., 1990. *Roadside geology of Utah.* Mountain Press, Missoula, MT. pp. x, 326, illus. in black-and-white; maps in 2 colours. US$14.00.

As usual with the *Roadside geology* series, the geological features of a particular region are discussed from the point of view of those travelling along major US highways. Preliminary chapters

give general geological details of the whole area covered. Similar treatment is given to Montana (1991), US$14.95; Idaho (1991), US$15.00 and Colorado (1991) US$11.95. All are recommended to those with interest in field work. M.O'D.

De CERVAL, M., 1992. *Mauboussin*. Editions du Regard, Paris. pp. 274, illus. in black-and-white and in colour. £98.00.

The celebrated Paris firm of Mauboussin grew from a business established by M. Rocher in 1827. Six generations on the firm has branches outside France, most notably in New York. This account, well-presented in a large and heavy volume without an index, relates the story of the firm's development and describes the most celebrated pieces with photographs and some designers' drawings. A section at the end of the book covers automata and there is a useful bibliography. This is an expensive book but invaluable for students of jewellery history. M.O'D.

ENTREMONT, P., 1992. *Chasseur de pierres*. Robert Laffont, Paris. pp. 212, illus. in colour. [Series *L'aventure continue*]. Price on application.

Excellent and cheerful account of the author's travels world-wide in search of gemstones. Several classic localities are described, together with good-quality colour photographs and the author's reported dialogue is lively and full of useful information. From the accounts given, he has a notable gemstone collection. I can recommend the book which does not need high-level French to understand. M.O'D.

FALK, F., 1985. *Europäischer Schmuck*. Verlag Hans Schöner, Königsbach-Stein. pp. 201, illus in colour. Price on application.

205 items from the Pforzheim jewellery museum are well illustrated in colour with notes in German and English. A short introduction by the museum curator opens the text. M.O'D.

FRONLICH, F., SCHUBNEL, H-J., 1991. *L'Age du silicium*. Muséum National d'Histoire Naturelle, Paris. pp. 92, 115 figs. Price on application.

The catalogue to an exhibition of the same title. A series of 36 papers follows silicon from its atomic structure, its mineralogical and petrological associations through its role in stained glass to silicon chips, silica glass fibres and amorphous silica layers. The role of silicon in contemporary society is examined and it is suggested that we are now in the middle of the Silicon Age. E.A.J.

GERE, C., CULME, J., SUMMERS, W., 1993. *Garrard: the Crown Jewellers for 150 years*. Quartet Books, London. pp. 216, illus. in black-and-white and in colour. £50.00. ISBN 0 7043 7055 7.

Many people know that when the crown jewels are cleaned or from time to time altered it is the London firm of Garrard which carries out the work. This well-produced survey begins with the first Royal Appointment in 1843. Very fortunately the archives of the firm are preserved and the book draws freely on them in its description of the wide variety of artefacts produced over 150 years.

Coronations, the personal jewellery of sovereigns and the care of important pieces, all form separate sections which follow an introduction giving the history of the firm. There is free use of anecdotal material and several pages from the archives are reproduced together with photographs of plate, presentation objects, pieces of jewellery and the crown jewels. Of particular interest to many readers will be the description of the care of the crowns and regalia, and the section describing the crown jewels and their situation in the Tower of London. There is a short bibliography and the standard of illustration is excellent. Altogether there must be a great deal in Garrard's archives which has yet to be revealed and a further book, once a theme has been found, would be welcome. M.O'D.

GRIFFEN, D.T., 1992. *Silicate crystal chemistry*. Oxford University Press, New York. pp. ix, 442, illus. in black-and-white. £45.00.

Some of the main groups of silicate minerals are discussed in the context of undergraduate one-semester courses. The groups covered are arranged in decreasing order of tetrahedral polymerization; thus framework silicates come first and orthosilicates last. A single chapter covering amphiboles and non-classical biopyriboles (this word is a coinage from biotites, pyroxenes and amphiboles) is placed out of sequence to emphasize some important points made by the author. Readers with an interest in gem minerals will find some of the chapters particularly valuable, especially those discussing the garnet group, the pyroxenes, the amphiboles, the aluminium silicate polymorphs and the olivines. The chapter on the feldspars should also be consulted. The main trend of the book is the relationship between

chemical composition and structure and many useful concepts are brought out. Each chapter has its own list of references (there are, for example, 54 for the garnet chapter) and a careful reading will greatly increase the size and depth of the intellectual base on which gemmological studies are founded. M.O'D.

HURLE, D.T.J., 1993. *Crystal pulling from the melt.* Springer-Verlag, Berlin. pp. ix, 148, illus. in black-and-white. DM 78.00. ISBN 3 540 56676 7.

Donald Hurle is the *doyen* of crystal pulling techniques and it is good to see much if not most of the work so long pursued at Bell Labs, New Jersey, and elsewhere appear as a monograph. Naturally gemmologists will be interested in trying the book out as so many important materials with ornamental application are grown in this way (notably ruby and synthetic garnets). The method originated at the beginning of the present century, Czochralski's paper appearing in 1918, but it took the growth of the semi-conductor industry after the Second World War to underline its importance: the invention of the laser meant that ruby rods of exceptional purity were needed and this method was the only way in which they could be grown (though very recent work on tight temperature control with the Verneuil method has greatly enhanced the purity of materials grown by it).

Treatment of the subject is largely mathematical since the author's aim is to help the grower to improve the process and also to enhance the system modelling capabilities of the applied mathematician, rather than to give a guide to crystal pulling technology.

The first chapter summarizes the advantages of the method which are that the crystal is unconstrained as it cools so that a high degree of structural perfection can be obtained, the rotation of the crystal ensures an even distribution of solute and the growing crystal can be observed at all stages of growth. The remainder of the book examines all parts of the process in detail and provides a 268-entry list of references. M.O'D.

KELLER, A.S. (ed.), 1992. *International Gemological Symposium, Los Angeles, 1991. Proceedings of the International Gemological Symposium 1991.* Gemological Institute of America, Santa Monica. pp. xvi, 192, illus. in colour. Price on application.

Under the title Facing the future 70 full presentations and 90 poster sessions, with panel discussions and exhibitions made up a useful conference at which developments were rounded up and set out in a pleasingly-produced volume. Though most of what was contributed can be found elsewhere, the book provides a useful starting point for discussion and is also very suitable for counter display as the text is fairly general in tone. As always the colour photographs are excellent. M.O'D.

LIDDICOAT, R.T., KELLER, A.S. (eds.), 1990. *Gems & Gemology: a retrospective of the '80's.* Gemological Institute of America, Santa Monica. pp. 110, illus. in colour. Price on application.

This beautiful volume described as 'limited edition' reproduces in hardback form the contents and illustrations of Gems & Gemology, 26, 1, Spring 1990. This is a very good idea since the book is more portable and easier to display than the flimsier journal issue and in any case most gemmologists will want to keep their journal sets together. Few books and few periods show a greater range of gemmological developments and techniques and this item is particularly suitable as an introduction to our science for the student and customer. As always with GIA, quite first-rate production. M.O'D.

MARKEL, S. (ed.), 1992. *The world of jade.* Marg Publications, Bombay. pp. 124, illus. in black-and-white and in colour. £45.00

A multi-author book with chapters on early Chinese jades; the working of jade in the Ming and Qing dynasties; jades from the Islamic world; inception and maturation in Mogul jades; jades in the treasuries and palaces of Europe; historical implications of the jade trade between the Maya lowlands and Costa Rica during the early classic period; jades of the New Zealand Maori and scientific description and technical analysis.

Each chapter is well illustrated and has extensive lists of references. The colour photographs are generally quite good; some are excellent. With a large page size helping the illustrations, this is a useful and wide-ranging treatment of the jades. M.O'D.

MATLINS, A.L., BONANNO, A.C., 1993. *Jewelry and gems: the buying guide.* 3rd edn. Gemstone Press, Woodstock, Vermont. pp. xx, 26,. illus.

in black-and-white and in colour. US$16.95. ISBN 0 943763 11 8.

With a sprightly text and two sections of colour photographs showing gemstones and set jewellery respectively, it is easy to see why this simple book appeals to all connected with gemstones. While the text is aimed at the customer and dealer there is plenty for the gemmologist to praise: an excellent common-sense approach to tricky sales situations, a useful table of prices with plenty of comments advising the reader to use it with caution, usually up-to-date information on gem species currently used in jewellery and a section covering mounting, metals, buying and selling, appraising and insuring. On the debit side is the odd way in which some of the stones have come out in the colour section (look at Paraiba tourmaline and a very red topaz), the too-short list of references and the use of both 'red emerald' and bixbite for red beryl from Utah. Yes, these are pretty small criticisms and the book is recommended, especially for the student who needs a commercial source as well as a scientific one. M.O.D.

NEWMAN, R., 1992. *The pearl buying guide.* International Jewelry Publications, Los Angeles. pp 186. Illus. in black-and-white and in colour. US$18.95. ISBN 0 929975 17 0.

The greatest weakness in the literature of gemmology is the lack of even an adequate coverage of pearl in English. This comes close to being the ideal although, like other books from this publisher, it is aimed primarily at the customer. Even so, there is a sound treatment of the gemmological and zoological aspects of pearl with questions following each chapter and a good bibliography. This book makes a timely appearance and will be welcomed by students as well as by a wide range of the jewellery-buying public. M.O'D.

NEWMAN, R., 1993. *The diamond ring buying guide.* 4th edn. International Jewelry Publications, Los Angeles. pp. 151, illus. in black-and-white. US$12.95. ISBN 0 929975 20 0.

This excellent text makes a welcome reappearance as a fourth edition, though 'reprint' would perhaps be more accurate. Nevertheless, anyone connected with gemstones or jewellery should have the book – by far the best coverage of the subject around. M.O'D.

NEWMAN, R., 1994. *The ruby and sapphire buying guide.* 2nd edn. International Jewelry Publications, Los Angeles. pp. 204, illus. in black-and-white and in colour. US$19.95. ISBN 0 929975 21 9.

This useful book, accurately written, well-produced and illustrated, contains 14 additional pages of colour photographs. It also describes the present role of the GAGTL, depicting one of its certificates (as a sample only). While the pictures are very good indeed, there is little coverage as yet of ruby from Vietnam and no reference is made to the now routine heating of Montana sapphires (other than Yogo material). Nevertheless, the book can be highly recommended and at the price should be in the library of every gemmologist as well as in jewellery shops. M.O'D.

PETRUSSENKO, S.I., KOSTOV, R.I., 1992. *Gem and decorative minerals of Bulgaria.* Sofia (publishing house of the Bulgarian Academy of Sciences). pp. 90, 2 maps, Leva 17.00. [Bulgarian with Russian and English summaries]

The first part of this booklet gives an historical account of the use of precious stones and carvings in Bulgaria. Enhanced activity since 1944 led to the discovery of gemmological materials such as emerald, garnet, amethyst, jasper, turquoise, etc. In the second part some details are given of chrysoberyl, spinel, ruby and sapphire, fluorite, rose quartz, citrine, agate, amethyst, opal, amazonite, scapolite, actinolite, rhodonite, heliodor, emerald, aquamarine, kyanite, topaz, zircon, zoisite, garnet, tourmaline, apatite, turquoise and malachite. In the final part, genetic types of gem materials are discussed. The Rhodope region is the most important area for the size of deposits and their variety. R.A.H.

VOYNICK, S., 1992. *Colorado gold.* Mountain Press, Missoula, MT. pp. ix, 206, illus. in black-and-white and in colour. US$12.00.

The author of books on hard rock mining and on Yogo sapphires gives an equally readable and accurate survey of gold mining in the state of Colorado, beginning with the gold rush at Pike's Peak in 1859 to present day working. While the stories of the various enterprises are most interesting there are also many technical and mineralogical details of the mining itself which make the book useful to a wide variety of readers. There are many good black-and-white pictures and a colour section with photographs of gold specimens. Much more information will

be obtainable from the large number of sources listed at the end of the main text. M.O'D.

WARD, F., 1993. *Diamonds*. Gem Book Publishers, Bethesda, MD. pp. 64, illus. in colour. Price on application.

Another welcome book in the *Gem Books* series, this gives an excellent introduction to diamonds, covering every aspect of diamond mining, grading, sale and synthesis in a very compact text. There is also room for photographs and brief accounts of famous diamonds and jewellery. This series should be in every store; no other books that I know give a better overview of the gem world. It is good to see that the pictures are fresh and well-reproduced. M. O'D.

WHITE, J.S., 1991. *The Smithsonian treasury: minerals and gems*. Smithsonian Institution Press, Washington DC. pp. 96, illus. in colour. £9.95.

A short and reasonably-priced guide to some of the major specimens in the National Museum of Natural History, Smithsonian Institution, with some account of the scientific work carried out there. Several named gemstones and pieces of jewellery are illustrated as well as mineral specimens; the photographs do not quite do some of them justice. M.O'D.

ZAPATA, J., 1993. The jewelry and enamels of Louis Comfort Tiffany. Thames and Hudson, London. pp. 176, illus. in black-and-white and in colour. £25.00. ISBN 0500 23664 X.

Louis Tiffany, the son of Charles, founder of the celebrated New York firm, was born in 1848. He is particularly associated with lamps, glass and ceramics, but he also produced effective and distinctive jewellery. The book opens with a history of the family and goes on to describe the early enamels. Chapter 3 describes the jewellery: it is established that Louis did not begin his jewellery production until 1902, the year of his father's death. Sadly, there are no extant record books of the earliest items up to 1907 but identified pieces show the wild flower motifs typical of the early years. Also typical is the experimenting with metals and stones; the latter include demantoid, opal (particuarly varieties from Mexico) and coral. Byzantine designs were used in some pieces.

In 1907 Tiffany & Co. began to manufacture his designs which became more stylized with, for example, platinum fashioned to resemble antique work. Early in this period the first source book was produced, the 1909 Tiffany blue book. This is an alphabetical catalogue in which the jewellery is listed under the heading Tiffany art jewelry and held separate from the Tiffany & Co. stock. In this jewellery we can note the rare use of white diamonds and the growing use of motifs taken from the impressionist-style paintings he made during his earlier life. Zircon, peridot, amethyst and tourmaline are frequently used; one early example of the period is a pink pearl brooch. Many pieces use Egyptian designs: scarab motifs were particular favourites. In general, Tiffany preferred opaque or translucent stones to transparent ones and he also preferred deeper tones in opaque materials. Since George F. Kunz and Tiffany both sat on the Tiffany & Co. board, there were many opportunities for gemmologist and designer to collaborate and it may be from this source of new gem species and varieties that Tiffany developed some of his more unusual pieces. The association of Kunz with Tiffany & Co. lasted from 1879 to his death in 1932.

The book provides many good-quality photographs both of pieces of jewellery and of pages from workbooks. There is a useful bibliography and the price is most reasonable. M.O'D.

Een Eeuw van Schittering (A sparkling age): 17th century diamond jewellery. Diamantmuseum, Antwerp, 1993. 00 223. Illus. in black-and-white and in colour. £36.00. [Text in Flemish and English]

As part of the Antwerp '93 celebrations, the Diamantmuseum put on an exhibition of diamond jewellery of the seventeenth century, featuring pieces from museums and private collectors. Opening essays introduce tendencies in seventeenth-century jewellery; seventeenth-century diamond jewellery and the ornamental print; diamond cuts in the seventeenth century and a piece describing the miniature case of Louis XIV. The catalogue entries give a description with measurements, details of provenance and citations from the literature where appropriate. In many cases the cut is illustrated by a diagram, a very useful feature as in some of the pieces the cut is obscured by the setting. M.O'D.

Proceedings of The Gemmological Association and Gem Testing Laboratory of Great Britain and Notices

OBITUARY

Mr Donald D. Baird, FGA (D.1976), London, died in 1994.

Mr Hector M. MacLeod, FGA (D.1957), Glasgow, died in May 1993.

Mr Peter G. Meakin, FGA (D.1948), London, died in 1993.

GIFTS TO THE GAGTL

The Association is most grateful for gifts of gems and gem materials for research and teaching purposes from the following:

Rod Beattie of Access Asia, Thailand, for a tourmaline crystal from Luc Yen, Vietnam.

Ing. Ludek Hubrt, M.Sc., of Gem Servis, Prague, Czech Republic, for fine moldavite pieces in six different shapes and a collection of cut pyrope garnets, all from the Czech Republic.

Mark Jobin, London, for new gem materials for research.

John Kessler, London, for a fracture filled Brazilian emerald.

Paragon Jewellery Design, for 150 rough blue sapphire crystals.

Sarah Petre, London, for sapphire rough.

Ted Themelis of Gemlab Inc., Florida, for a sapphire crystal, one half of which had been heat treated.

Professor Chen Zonghui and the staff of the Gemmological Institute, China University of Geosciences, Wuhan, for the following samples from China: pyrope garnets from Heilongjian Province, sapphire from Shandong Province, peridot from Hebei Province, zircon from Fujian Province and amethyst from Jiangxi Province.

NEWS OF FELLOWS

Norman Harding was awarded an OBE in the New Year's Honours for service to the City of London Corporation, in particular for work on the restoration of the interior of the Mansion House over the past twelve years.

Alan Hodgkinson has just returned from an extensive lecture tour. He visited Bangkok, Singapore and Tucson, giving four lectures at each location. He was also the keynote speaker at the prize giving conference weekend of the Canadian Gemmological Association, guest speaker at the Golden Jubilee of the Australian Gemmological Association and visiting speaker in all of the six Australian states.

Antonio Bonanno

A special tribute

Antonio 'Tony' Bonanno's retirement at the end of 1993 was honoured by a Gala Tribute during which he was presented with a special award from the GAGTL in recognition of his great contribution to gemmology and his long association with GAGB and GAGTL. The Award was presented by Ann Dale, GAGTL's liaison gemmologist in the United States. Ann writes:

'How do you say "Goodbye" to a master in his field, an author, admired mentor of thousands, and good friend to all? The spirit which filled Bethesda, Maryland's Positano Restaurant, seemed to answer this question, as many enthusiasts gathered to pay homage to Tony Bonanno, an outstanding leader of the nation's gemmological community, who had announced his retirement after sixty years of service. This remarkable man is credited with having personally trained over 3000 students in the field of gemmology, 1000 of whom have become professional gemmologists. His commitment to expanding knowledge and upholding the highest professional and ethical standards has been a guiding force in the industry and continues its influence through his students. I am proud to be one of these and remember fondly my student days at the National Gem Appraising Laboratory and Columbia School of Gemology, both established by Tony Bonanno as centres for specialized studies over four decades ago.

Fig. 1. Tony Bonanno listening to Ann Dale before she presented him with a Certificate of Appreciation on behalf of the GAGTL.

'It was a special pleasure for me to have been selected to represent the GAGTL as a key speaker at Tony Bonanno's retirement gala. It was an opportunity to express my appreciation for all he has done for so many for so long and proved that one needn't ever say "goodbye" to Tony, who has so generously shared time, talent and wisdom with others, because he will always be a part of them.'

DIAMOND COURSE LAUNCHED IN CHINA

In November 1993 the GAGTL launched its Gem Diamond Diploma Course in China. The course, leading to the DGA qualification, is a comprehensive study of the formation, mining, sorting, cutting, grading and trading of diamonds and was held at the GAGTL's Allied Teaching Centre at the Gemmological Institute, China University of Geosciences in Wuhan, Hubei Province.

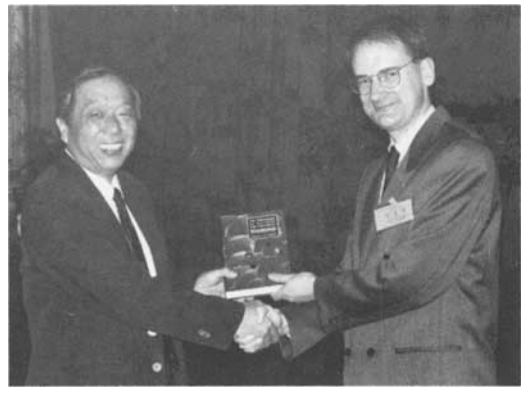
Students, mostly managers drawn from the diamond and jewellery trade, from Beijing, Shanghai, Shenzhen and Guangzhou, Changsha in Hunan Province, Harbin in Helongjian Province, Dalian in Liaoning Province and Guangxi Province, attended the intensive two-week practical part of the course and sat the examination in Wuhan.

Eric Emms travelled to Wuhan to teach the practical course which covered elementary sorting of rough; detailed grading of loose and mounted polished diamonds using the 10x loupe, microscope and colour comparison stones; detection and description of lasered and fracture-filled diamonds and identification of diamond simulants.

Mr Emms commented that the students displayed a quick grasp of grading principles and an intense desire to learn as much as possible about diamond quality.

Through its Allied Teaching Centres, the GAGTL will be offering more FGA and DGA courses throughout Asia in 1994.

Fig. 2. Professor Chen Zhonghui, Vice-President of the China University of Geosciences, receiving a gift presented by Eric Emms on behalf of the GAGTL.



MEMBERS' MEETINGS

London

The following meetings were held at the GAGTL's Gem Tutorial Centre at 27 Greville Street, London EC1N 8SU.

On 24 January 1994 Robin Walker of De Beers' Central Selling Organisation gave an illustrated lecture entitled 'Overview of world diamond producer sources'. (A full report of the lecture was published in *Gem & Jewellery News* **3**, 2, 17.)

On 7 February Patrick Daly gave a lecture entitled 'The independent gemmologist's workshop'.

On 23 February Dr Robert Symes spoke on 'Decorative and collectors' minerals from south-west England'.

On 7 March William Summers gave a lecture on 'The history of Garrards, the Crown jewellers'.

On 30 March David Lancaster spoke on 'Jewellery at auction'.

Midlands Branch

On 28 January 1994 at Dr Johnson House, Bull Street, Birmingham, James Gosling gave a lecture entitled 'The Cheapside Hoard'. The Hoard was treasure dated between 1580 and 1620, part of a Jacobean goldsmith's stock-in-trade, that was found under a cellar floor in Cheapside, London, in 1912.

On 25 February at Dr Johnson House Nigel Dunn gave a lecture entitled 'Jewellery through the ages'.

On 25 March at Dr Johnson House Dr John Wright gave a talk on 'Platinum - design and technology in the workshop'.

North West Branch

On 16 February 1994 at Church House, Hanover Street, Liverpool 1, Mr D.H. Ariyaratna gave a talk on 'Gems and gem industry of Sri Lanka'.

On 16 March at Church House Dr Roger Harding gave a talk on 'Current trends in gem testing'.

The talk on 15 September 1993 was given by Mr M. Downer of Sotheby's, London, and not Jonathan Condrup as stated previously (*Journal of Gemmology*, 1994, **24**, 1, 56).

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 15 December 1993 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Fellowship
Gao, Yan, Beijing, China. 1993
Gutierrez Martinez, Jose A., Madrid, Spain. 1993
Guo, Shouguo, Wuhan, China. 1993
Ibanez de Aldecoa, M. Angeles, Madrid, Spain. 1993
James, Cary S., Woodstock, Ont., Canada. 1993
Jun, Huang, Wuhan, China. 1993
Lanko, Jantine, Amsterdam, The Netherlands. 1993
Li, Jingzhi, Beijing, China. 1993
Molloy, Theresa A., Burnaby, BC, Canada. 1993
Sarma, Sunil, Rajasthan, India. 1993
Summanen, Sari I., Helsinki, Finland. 1993
Zhang, Xianfeng, Wuhan, China. 1993

Ordinary Membership
Blackman, Barry N., Whetston, London.
Bordat, Mark, New Southgate, London.
Briginshaw, Richard C., Hampstead, London.
Desprat, Anne-Sophie, London.
Franks, Nicola, London.
Goss, Sanya L., Aldershot.
Hardman, Joce, Preston.
Michaelides, Artemios, Athens, Greece.
Su, Bin, Wuhan, China.
Walker, Albert, New York, NY, USA.
Wang, Zhong Hui, Beijing, China.
Yu, Guimei, Wuhan, China.

Ordinary Laboratory Membership
Tim Watkins Ltd, 19 Burlington Arcade, London W1.

At a meeting of the Council of Management held on 26 January 1994 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership
Kassam, Salim Sultanali, Kensington, London. 1993

Fellowship
Chen, Meihua, Wuhan, China. 1993
Choi, Eddie Pui Ho, Hong Kong. 1993
Guo, Tao, Wuhan, China. 1993
Hui, Wing Chiu Ernest, Hong Kong. 1993
Krommenhoek, Celine, Amsterdam, The Netherlands. 1993
Sapalski Rosello, Cristina, Madrid, Spain. 1993
Stamatiadis, Nick, Athens, Greece. 1993
Tang, Yuanjun, Wuhan, China. 1993
Zhang, Xiang Dong, Hong Kong. 1993

Ordinary Membership
Agnew, Michael A., Cambridge.
Arai, Naoko, Japan.
Bennett, Shawn, Bexleyheath.
De Carvalho, Roberta, London.
Delaney, Patrick, Teresopolis, RJ, Brazil.
Ferrell, Ronald L., Deland, Fla., USA.
Fukuda, Kenji, Japan.
Fukushima, Yuko, Japan.
Ichimura, Kozue, Japan.
Imamura, Naoki, Japan.
Isaka, Masahiro, Japan.
Ives, Juleen, Shoeburyness.
Kamata, Mariko, Japan.
Karino, Masae, Japan.
Kataoka, Noriko, Japan.
Kato, Ayako, Japan.
Kawabe, Tadayuki, Japan.
Kelly, Christel E., London.
Kobayashi, Akihito, Japan.
Kukagawa, Hiroko, Japan.
Matsuoka, Satoru, Japan.
Mine, Mayumi, Japan.
Morioka, Akiko, Japan.
Nakano, Yasuyoshi, Japan.
Nii, Miwa, Japan.
Nishiyama, Fumie, Japan.
Ogino, Takashi, Japan.
Ohhara, Reiko, Japan.
Ohki, Toshie, Japan.
Ramos-Gonzalez, Stephen, Dalston, London.
Sada, Shinsaku, Japan.
Sakai, Takeo, Japan.
Sapkas, Panayatis, Larissa, Greece.
Shimakura, Toshiyuki, Japan.
Shimizu, Takayuki, Japan.
Shorter, David J., Diss.
Smith, Andrew, West Malling.
Tada, Michiko, Japan.
Toyoda, K.B.S., Weybridge.
Wakatsuki, Reiko, Japan.
Yamanaka, Kazue, Japan.
Yoshimura, Shinya, Japan.
Zhao, Rugong, Wuhan, China.

FORTHCOMING MEETINGS

London

Meetings will be held on the second floor at 27 Greville Street. Refreshments will be available from 6.00 p.m. and lectures will start at 6.30 p.m.; these will be followed by discussion and closing about 7.45 p.m. The charge for a member is £3.50 and, as places are limited to 55, entry will be by ticket only, obtainable from GAGTL.

11 May	'Spreading gem knowledge'	Ian Mercer
13 June	Annual General Meeting and Reunion of members; Bring and Buy	
19 September	'The gem materials of Zimbabwe'	Susan Anderson
28 September	'Diamonds and the retail trade'	Alan Clark
22 November	'Gem collections in the United Kingdom'	Christine Woodward
5 December	'Sapphires in the Laboratory'	Stephen Kennedy

Annual Conference and Presentation of Awards

The 1994 GAGTL Annual Conference is to be held on 23 October 1994 at the Great Western Royal Hotel, Paddington. The theme of the Conference will be 'Diamonds and modern gem developments'. A full programme of lectures and demonstrations is planned and details will be published in the July issue of the *Journal*.

The Presentation of Awards will be held on 24 October at Goldsmiths' Hall, Foster Lane, London EC2.

Midlands Branch

29 April	Annual General Meeting followed by 'The gems of Sri Lanka'	C. & N. Gems

The meeting will be held at Dr Johnson House, Bull Street, Birmingham.

A gemmological training day is to be held on 8 May, full details of which are available from Gwyn Green on 021-445 5359.

North West Branch

18 May	'Touching gold and silver'	David Callaghan
15 June	Exchange and Mart - a members and friends get together. Bring and buy, and business buzz.	
21 September	'Pearls in the Arabian Gulf'	Stephen Kennedy
19 October	A visit to the Liverpool Museum of Geology, specimen minerals and instruments.	
16 November	Annual General Meeting.	

Meetings will be held at Church House, Hanover Street, Liverpool 1. Further details from Joe Azzopardi on 0270 628251.

Ordinary Laboratory Membership
Elizabeth Gage Ltd, 20 Albemarle Street, London W1X 3HA.
Pucci of 205 King's Road, London SW3.

At a meeting of the Council of Management held on 23 February 1994 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Ordinary Membership
Adler, Allen, Geneva, Switzerland.
Austin-Kaye, Anthony M., Chester.
Barrett, Robin N., Gwynedd.
El Manawi, Abdel Hamid Wagdi Abdel Aziz, Abu Dhabi, UAE.
Farion, Jean-Christophe, London.
Fisher, Dorothy A., Tolworth, Surbiton.
Gurney, Charles R., London.
Haske, Martin D., Woburn, Mass, USA.
Johnson, Michael C., Eastbourne.
Van Goethem-Tytgadt, Anne, Johannesburg, S. Africa.
Vanson, Robert F., Bromley.
Walker, Peter L., Christchurch, New Zealand.

Gold Laboratory Membership
V. Barsamian Diamants sa, Pelikaanstraat 62, 2018 Antwerp, Belgium.
Cartier Joaillerie Internationale, 13 Rue de la Paix, 75002 Paris, France.

Ordinary Laboratory Membership
House of Antiques, 17 Prince Albert Street, Brighton.
M. Kaye Ltd, 9 St Michaels Row, Chester.
The Burlingon Jewellers Ltd, 56-57 Burlington Arcade, Piccadilly, London W1V 9AF.

Corrigenda
On p. 25 above, columns 1 and 2, and p.28 above, column 1, several of the Figure numbers given in the text are incorrect. Details are as follows:

Figure 21 should read 26
Figure 22 should read 23
Figure 23 should read 25
Figure 25 should read 32
Figure 26 should read 22
Figure 27 should read 28
Figure 28 should read 27

Letter to the Editor

From D.H. Ariyaratna, FGA, DGA, FGS

Dear Sir,

I refer to the review by Mr M.J. O'Donoghue in the October issue of the *Journal of Gemmology* (1993, **23**, 8, 494) about *Gems of Sri Lanka* (5th revised and enlarged edition). It was a surprise to read such an unfavourable review as I believe the book is well presented.

In view of the remark that 'the whole book is disordered', I would remind the reviewer that he stated that the 3rd edition is 'a pleasantly-written book whose main value is in the account of gem working in Sri Lanka' (*J. Gemm.*, 1980, **XVII**, 47).

Basically, the chapter names, line drawings, some black and white photographs and the order of the contents have remained the same from the first to the latest editions of the book.

Even though no book on gemmology can be expected to be perfect, my efforts concerning Sri Lanka's gems have been accepted by the Government of Sri Lanka (Ministry of Education) as a school library book.

Yours etc.,
D.H. Ariyaratna
London
7 February 1994

Guide to the preparation of typescripts for publication in *The Journal of Gemmology*

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

Typescripts Two copies of all papers should be submitted on A4 paper (or USA equivalent) to the Editor. Typescripts should be double spaced with margins of at least 25mm. They should be set out in the manner of recent issues of *The Journal* and in conformity with the information set out below. Papers may be of any length, but long papers of more than 10 000 words (unless capable of division into parts or of exceptional importance) are unlikely to be acceptable, whereas a short paper of 400-500 words may achieve early publication.

The abstract, references, notes, captions and tables should be typed double spaced on separate sheets.

On matters of style and rendering, please consult *The Oxford dictionary for writers and editors* (Oxford University Press, 1981).

Title page The title should be as brief as is consistent with clear indication of the content of the paper. It should be followed by the names (with initials) of the authors and by their addresses.

Abstract A short abstract of 50-100 words is required.

Key Words Up to six key words indicating the subject matter of the article should be supplied.

Headings In all headings only the first letter and proper names are capitalized.

A **This is a first level heading**

First level headings are in bold and are flush left on a separate line. The first text line following is flush left.

B *This is a second level heading*

Second level headings are in italics and are flush left on a separate line. The first text line following is flush left.

Illustrations Either transparencies or photographs of good quality can be submitted for both coloured and black-and-white illustrations. It is recommended that authors retain copies of all illustrations because of the risk of loss or damage either during the printing process or in transit.

Diagrams must be of a professional quality and prepared in *dense* black ink on a good quality surface. Original illustrations will not be returned unless specifically requested.

All illustrations (maps, diagrams and pictures) are numbered consecutively with Arabic numerals and labelled Figure 1, Figure 2, etc. All illustrations are referred to as 'Figures'.

Tables Must be typed double spaced, using few horizontal rules and no vertical rules. They are numbered consecutively with Roman numerals (Table IV, etc.). Titles should be concise, but as independently informative as possible. The approximate position of the Table in the text should be marked in the margin of the typescript.

Notes and References Authors may choose one of two systems:

(1) The Harvard system in which authors' names (no initials) and dates (and specific pages, only in the case of quotations) are given in the main body of the text, e.g. (Gübelin and Koivula, 1986, 29). References are listed alphabetically at the end of the paper under the heading References.

(2) The system in which superscript numbers are inserted in the text (e.g. ... to which Gübelin refers.[3]) and referred to in numerical order at the end of the paper under the heading Notes. Informational notes must be restricted to the minimum; usually the material can be incorporated in the text. If absolutely necessary both systems may be used.

References in both systems should be set out as follows, with *double spacing* for all lines.

Papers Hurwit, K., 1991. Gem Trade Lab notes. *Gems & Gemology*, **27**, 2, 110-11

Books Hughes, R.W., 1990. *Corundum*. Butterworth-Heinemann, London. p. 162

Abbreviations for titles of periodicals are those sanctioned by the *World List of scientific periodicals* 4th edn. The place of publication should always be given when books are referred to.

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