ISSN: 0022-1252 XIX (1) 1-96 (1984)

Vol. XIX No. 1 January, 1984

THE JOURNAL OF GEMMOLOGY

and

PROCEEDINGS OF THE
GEMMOLOGICAL
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Vol. XIX No. 1 January 1984

A BRIEF DESCRIPTION OF A SPECTACULAR 56.71 CARAT TABULAR DIAMOND

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In June 1983 a large, flat diamond of octagonal outline was shown to Miss Anna Somers-Cocks, of the Victoria and Albert Museum, London, who suggested that it should be taken to the Geological Museum for further examination; the owner had wondered if it might be part of the 'Great Table' shown to the explorer Tavernier at Golconda, India, in 1642. We quickly assured him that this was unlikely in view of the convincing study carried out by Meen, Tushingham & Waite (1967) in Teheran in 1967. The study showed

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beyond reasonable doubt that the Darya-i-Nur diamond and a pink brilliant, both among the Iranian Crown Jewels, were derived from and comprise the major part of the Great Table shown to Tavernier. The history of the present important stone is not known before 1893, when the father of the present owner is reported to have had it in his possession during a visit to Paris.

The diamond is attached to a recent Indian-style necklet of braided gold wire with faceted pyrope-almandine beads by means of two holes drilled near one edge of the diamond (see Figure 1).

FIG. 1 Front view of 56.71 ct diamond showing large rectangular table facet.

The corners by the drill holes appear to have been 'ground' away, and there is some evidence from marks along the edge of the diamond of earlier drill holes (see Figure 9). Thus there may have been attempts to drill more widely spaced holes which failed because of fracturing, and the stone may have weighed considerably more before the present set of holes was drilled. The necklet prevented accurate weighing of the diamond, but the owner assures us that its weight is 56.71 carats. The weight of the stone with the necklet is 104.95 carats. The diamond could not be

FIG. 2 and FIG. 3 Views of diamond showing large rear facets.

FIG. 4 Edge view of diamond with 1.33 ct diamond for scale. The plan view is an inclined mirror reflection.

removed from the necklet and it was not possible to determine its specific gravity. The dimensions of the diamond are 44.6 × 33.0 × 3.6 mm and the exact shape is shown by the (water) immersion contact prints (Figures 5 and 6), which also show the facet arrangements of crown and pavilion. The upper surface (see Figure 5) is step cut, and the very large table facet (approx. 27.5 × 19.0 mm) is extraordinarily smooth and well polished with an adamantine lustre. However, it is not plane, but slightly curved as shown by the slightly distorted reflections of window frames. The rear facets (Figures 2, 3, 6) are very irregular with interfacial angles of only a few degrees, and it was not possible to measure these angles in the short time available for study. The large rear facet adjacent to the drill holes shows particularly prominent curved ridges (Figure 1), which have possibly resulted from the polishing of a stepped cleavage face; other rear facets also show polishing marks. The cutting of the rear facets especially may appear crude, but when the stone is viewed in subdued lighting it displays an extraordinary ability to pick up any available light and reflect it brilliantly. The girdle is polished (in planes essentially at right

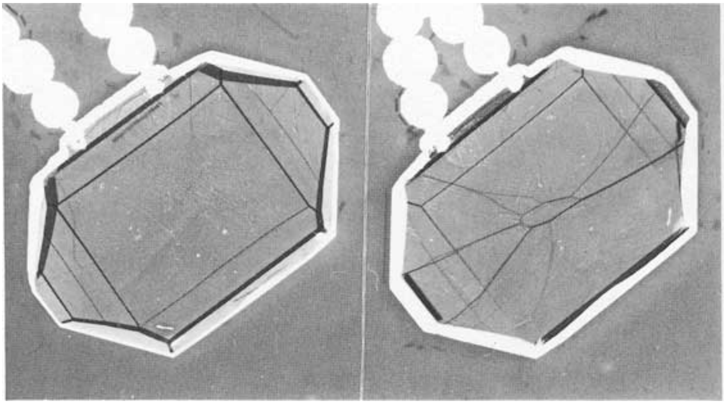

FIG. 5 and FIG. 6 Immersion contact prints showing outlines of front (left) and rear facets (natural size).

angles to the table facet) and a 'natural' showing three cleavage directions is retained on one corner of the stone (see Figure 7).

The stone obviously draws colour to some extent and this was, perhaps, best demonstrated by the owner, who inserted it between layers of white cleaning tissue and held it to the daylight; the stone showed a distinct pale pink colour. A grading colour might be 'fancy light pink', but the stone was not examined under ideal grading conditions.

Careful search by all three authors failed to reveal any absorption spectrum; it was not possible (or prudent!) to examine the stone for a spectrum at liquid nitrogen temperatures. The diamond shows no fluorescence under long-wave (365 nm) ultraviolet light, but under short-wave (253.7 nm) radiation a very faint pale blue fluorescence was seen. A (water) immersion contact print using short-wave ultraviolet light shows the outline only of the stone which is, therefore, transparent to this radiation to a considerable degree. Between crossed polars the stone shows notable strain birefringence. In most areas the strain pattern resembles albite feldspar twinning (Figure 10) or the cross-hatching typical of microcline twinning, but in addition there are a few points or nodes of radial strain around minute inclusions.

The stone contains no prominent inclusions, but iron staining is present in cracks near one corner. Cleavage traces are present in several areas, and these were carefully noted with a view to attempting to orientate the stone in an octahedral framework. Near one corner of the stone one cleavage trace (see Figure 8) was seen to be essentially parallel to the table facet, and it was then possible to orientate the tiny cleavage traces within the stone and those visible on the girdle of the stone with the theoretical cleavage traces of the octahedron. The diagram (Figure 11) shows one possible orientation which is consistent with the cleavages seen at three edges of the diamond, but there may be others!

The origin of this stone is intriguing: Miss Sue Stronge, of the Victoria and Albert Museum, has drawn our attention to paintings of Shah Jahangir (reigned 1605-27) in the Freer Gallery, Washington, in which he is wearing flat 'table-cut' stones as wrist bracelets; they are not dissimilar to the present stone. Diamond

FIG. 7. 'Natural' on corner of diamond showing cleavage traces in three directions.

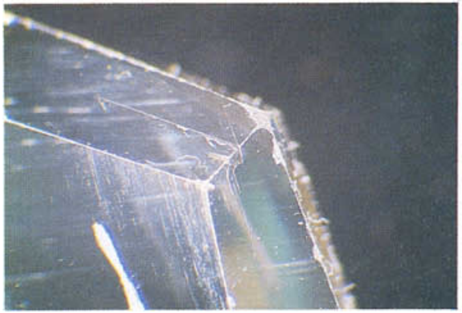

FIG. 8. Part of 56.71 ct diamond showing cleavage traces in two directions and scratch 2.5 mm long.

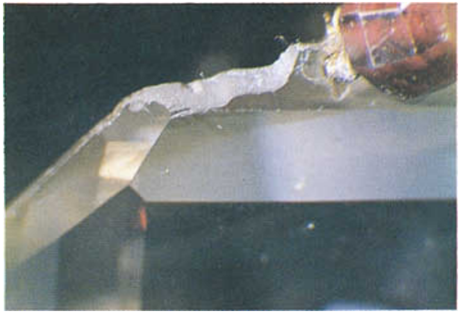

FIG. 9. Corner of diamond showing re-drilled support hole and traces of former hole.

FIG. 10. Part of diamond viewed between crossed polars and showing strain birefringence resembling albite (feldspar) twinning.

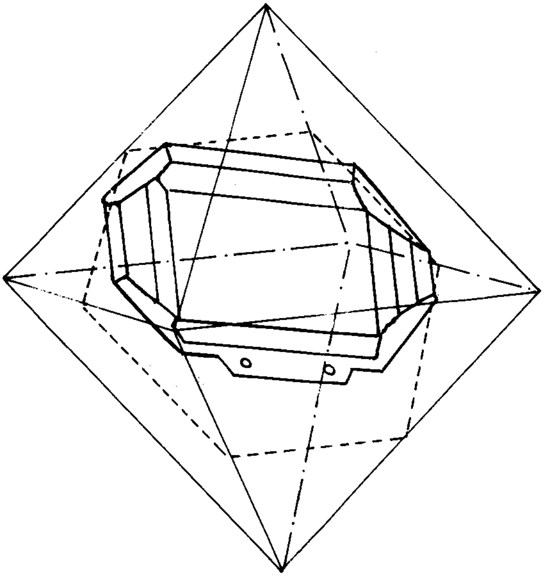

FIG. 11 Approximate orientation of 56.71 ct flat diamond with table facet coplanar with octahedral cleavage direction.

cleavages and lasques have been known for centuries in India, and the size and style of cutting of the present stone are consistent with its being of Indian origin and cutting, possibly from the seventeenth century.

REFERENCE

Meen, V. B., A. D. Tushingham and G. G. Waite. 1967. Long-lost Darya-i-Nur—largest pink diamond rediscovered. *Lapidary Journal*, **XXI**, 11, 1000-9.

[*Manuscript received 10th October, 1983.*]

A REMARKABLE SPHALERITE WITH AN INTENSE GREEN COLOUR

By IVO QUINTENS and THEO MULLER

Secretary and Chairman respectively of the Belgian Foundation for Gemmology
(Belgische Stichtung voor Gemmologie)

ABSTRACT

Gemstones made of a rare specimen of sphalerite*, having a deep green colour, coming from Kipushi, Zaire, are described.

A sample of a deep green sphalerite was found in a collection of Zairian minerals. It was reported by a previous mine engineer to be a curious specimen of which only a few were found. In old mine documents the existence of green sphalerite was mentioned in only two different analysis reports. Neither geological nor mineralogical information could be obtained, even from the best specialist on the Zaire mines.

The sphalerite is found in paragenesis with other copper-, gallium- and germanium-containing minerals. In clear green crystals small inclusions of chalcopyrite can be detected at magnifications of 300-1250 with a reflecting polarizing microscope. More sophisticated investigations have been started. An x-ray powder diffractogram showed a typical sphalerite pattern.

The absorption spectrum is characterized by three bands:

- the red is absorbed to 625nm;
- in the yellow a band from 595 to 580 nm;
- the blue is absorbed starting from 470 nm.

The specific gravity was found to be 4.18 (for a 0.825 ct stone) and 3.98 (for a 0.260 ct stone). The largest cut stone weighed 0.98 ct and 23 stones were obtained having a total weight of 6.28 ct.

During cutting and polishing no particular unusual behaviour was observed compared with common sphalerite. Further investigations to determine the colour mechanism will be carried out.

We thank Mr H. W. Lorenz, of Idar-Oberstein, for his information about the cutting and polishing properties and Dr N. Blaton, of the Catholic University of Louvain, for the diffractograms.

[*Manuscript received 2nd April, 1983.*]

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*Sphalerite (ZnS) is perhaps more commonly known as 'blende'—Ed.

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A RECENT FIND OF TAAFFEITE

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ABSTRACT

Several taaffeites have been found recently in spinel gravels. Identification is simple with the use of the hand spectroscope. The article details the observations made of one recently discovered stone.

INTRODUCTION

In October 1982, it was my good fortune to have an opportunity to examine a taaffeite. I was told that the stone was found in spinel gravels, in Sri Lanka, during 1982. No more information on origin was available, except that several other taaffeites were found in the same location at about the same time.

CHARACTERISTICS

This particular taaffeite weighs 1.65 ct, after having a spot on one side polished to allow the RI to be taken and to allow internal observation. The shape of the stone is a somewhat triangular water-worn pebble. One edge of the stone has a notch in it suggestive of possible twinning (see Figure 1). There is also a slight ridge running lengthwise along the top of the stone.

The external appearance is slightly frosty with occasional pin-points of glitter suggesting a fairly high dispersion. The over-all colour is a light greyish lavender, becoming a pale lavender, without much greyish component, when polished.

No colour zones or growth lines were observed, either externally or internally. But there are some external and internal black specks, at first glance similar to those encountered in zircon rough. Under 30× magnification, these black specks are blocky to flat and/or slightly fibrous (or perhaps acicular) shiny crystals.

Other inclusions are small white breadcrumb-like crystals, most occurring as part of an irregular underside of the pebble surface. In the area polished, most of these inclusions were removed, but what remained were a couple of oval areas where the inclusions extended to a slightly greater depth.

There is also an area containing a fingerprint pattern located well within the stone, at least partly composed of moderately long,

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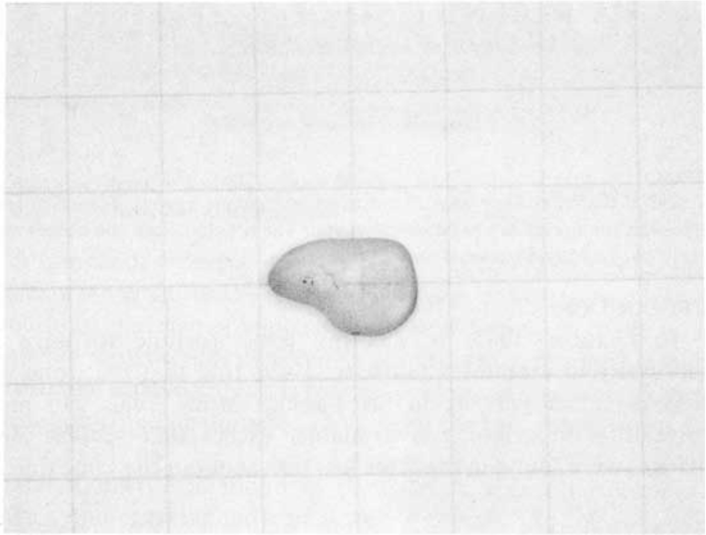

FIG. 1 Taaffeite pebble—external shape on ¼" squared graph paper. *(Photo A. C. Bonnano)*

flat, shiny crystal inclusions. I have observed a similar set of fingerprint inclusions in the only other taaffeite I have seen. This, therefore, may be a diagnostic inclusion. Figure 2 shows this rather distinctive inclusion, which includes several circularly arranged groups of the fingerprint crystals. There are actually three sets of fingerprints, along with some larger crystals and an inclusion with an outline shaped like a shoulder of lamb, shown in Figure 3. Finally Figure 4 shows the crystals within one of the fingerprints at 70 ×, revealing an apparent two-phase structure for some of them.

No fractures or negative crystals were observed. There were no stains. In general, the stone was quite clean and, in this respect, quite similar to spinel. With appropriate polishing, the taaffeite is also very transparent and would make a very nice cut gem that is eye-clean.

The taaffeite is faintly dichroic with a calcite dichroscope (but dichroism was not observable with a plastic polars-type dichroscope). The colours are light pink (with a possible yellowish cast) and light lavender, which is slightly darker than the pink ray.

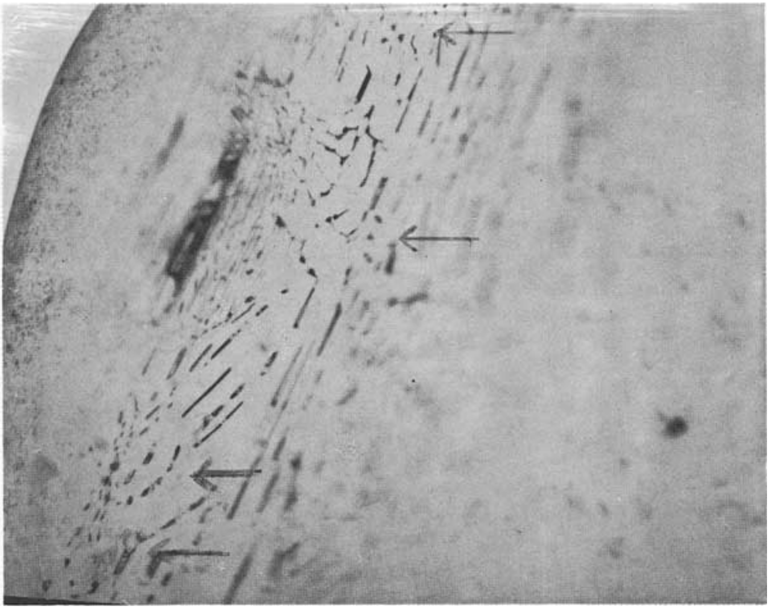

FIG. 2 Fingerprint inclusion with circularly arranged groups (arrowed). 50× *(Photo A. C. Bonnano)*

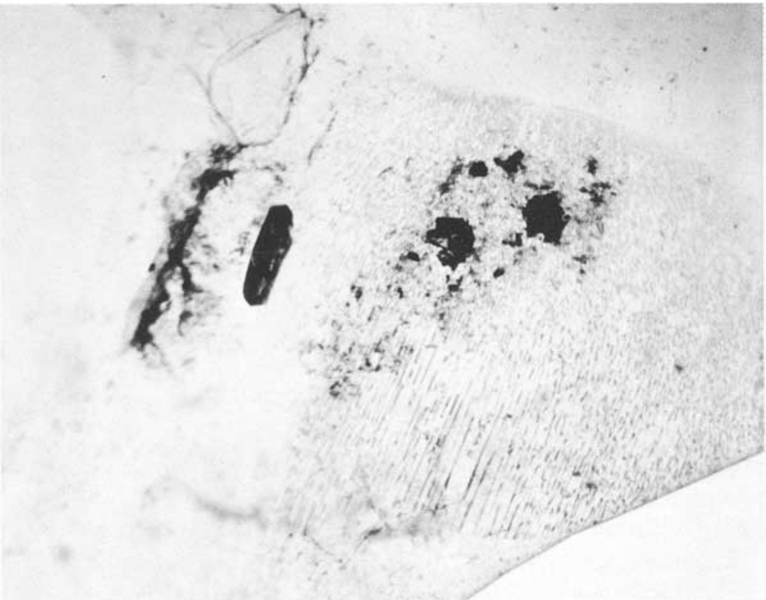

FIG. 3 Fingerprint inclusion with larger crystals and an inclusion with outline shaped like a shoulder of lamb. 30×. *(Photo A. C. Bonnano)*

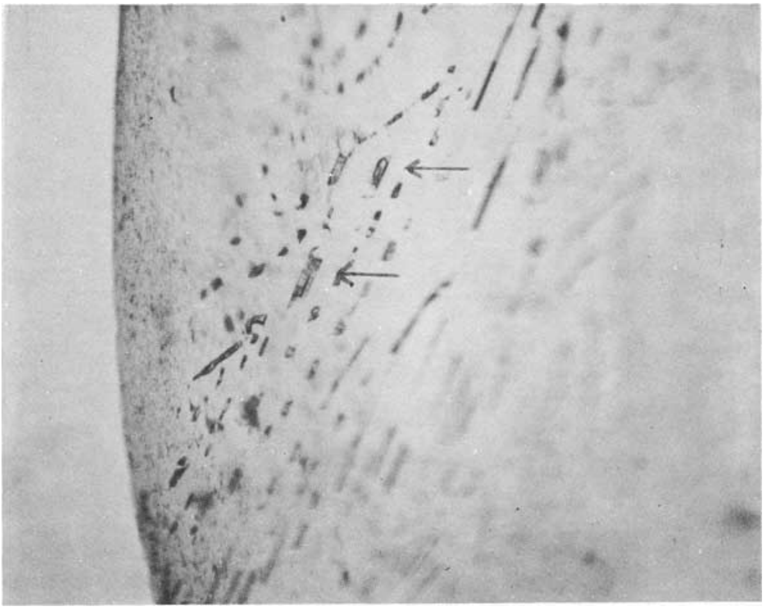

FIG. 4 Fingerprint inclusion with some two-phase structures (two are arrowed). 70×. *(Photo A. C. Bonnano)*

Examination with a hand spectroscope showed a general absorption above approximately 670 nm. Otherwise, no lines and no significant attenuation of the visible spectrum was observed. It was a little surprising that the violet wavelengths were not attenuated, since many stones restrict this end of the spectrum: in particular, spinel in all colours greatly attenuates the blue and the violet.

The spectroscope, therefore, may be the easiest way to separate spinel and taaffeite, though a polariscope or refractometer may also be used.

Through the Chelsea filter the taaffeite showed virtually no colour, even in quite strong lighting. At most there may be a slight pink tint. Using a so-called beryl filter made in Austria and sold by Advance Electric in the U.S.A., the stone, in strong white light, is a bright pink. In long-wave ultraviolet the stone fluoresces weakly with a dull green colour. The stone is inert under short-wave UV.

TABLE I. Taaffeite Constants

RI	DR	Disp.	SG	Optics
1.717-1.721	0.004	0.018 est.	3.60	Uniax. (-)

Table I gives the list of constants measured by the author. The value for dispersion was estimated from taking the RI reading for the ordinary ray (in this case, the 1.721 reading) using a sodium lamp (589 nm) and then a green lamp (546 nm).* The difference between these two RI readings was then multiplied by the ratio of the differences in wavelength between the Fraunhofer B and G lines and the yellow and green lines noted above. Assuming a linear relationship for taaffeite between RI readings at different wavelengths across the spectrum between B and G, the dispersion should be about .018. The following formula describes these calculations:

$$(RIg\text{-}RIy)\,\frac{\lambda B\text{-}\lambda G}{\lambda y\text{-}\lambda g} = \text{Dispersion}$$

ACKNOWLEDGEMENT

My thanks are due to Mr A. C. Bonanno, F.G.A., of Columbia School of Gemology, Silver Spring, Md, U.S.A., for the photographs, which were taken by transmission lighting from a quartz-halogen lamp with the stone immersed in methylene iodide.

[*Manuscript received 28th November, 1982.*]

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*These were the only two calibrated light sources available to the author.

X-RAY UNIT FOR GEMMOLOGICAL USE

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São Carlos, SP, Brazil.

THE USE OF X-RAYS IN GEMMOLOGY

There are many references to the use of x-rays as a means of gem diagnosis by transparency or by luminescence excitation.(1, 2) Most of the references to transparency are related to diamonds and pearls.(2, 3, 4) Webster(5) describes the value of luminescence under ultraviolet radiation at 3650 Å and 2537 Å. He emphasizes, however, the limitation of the use of UV radiation in diamonds and the more significant response to x-rays.(5, 7) This means of diagnosis is also useful for other gemstones and particularly in the case of mounted gemstones when other tests cannot be used for identification. The phosphorescence and fluorescence exhibited by diamonds and some synthetic gems under x-rays can be a guide to their classification and identification.

THE TRANSPARENCY OF GEMS TO X-RAYS

Brown *et al.*(1) and Moule & Brown(2) considered the transparency of gems to x-rays. According to these authors the transparency of a gem can be evaluated by radiographers observing the films or measuring its optical density. In the present work the transparency is related to the electronic density and the atomic number of the atoms in the gem composition. This approach allows the transparency calculation of gems of any thickness.

Diamond is a form of carbon and has atomic number 6 and a low electronic density. Its imitations are made of materials containing heavy atoms with high atomic numbers and electronic density. Their transparency to x-rays is very low. This property can be used to provide a quick identification by using a fluorescent screen or a radiographic film.(2, 5, 6, 8) This method can also be used for other gems, requiring in this case an exact adjustment of the voltage and the current in the x-ray tube. A close control of the time of exposure related to the gem and its thickness may also be necessary.

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THE DIAMOND AND ITS IMITATIONS

Optical properties only allow a differentiation between the diamond and its imitations in the cases when these properties are observable in a quantitative way.(9) Specific gravity is useful under the same conditions. The radiograph is independent of mounting, size and other difficulties in performing an accurate gem analysis, especially in the case of the diamond.

The absorption of x-rays by the materials follows the equation:(10)

$$\frac{I_x}{I_o} = e^{-\mu x} \qquad (1)$$

In this equation the relation I_x/I_o is the fraction of the incident radiation passing through the material of thickness x. The parameter μ is the linear absorption coefficient equivalent to the product $(\mu/\varrho)\ \varrho$ of the mass absorption coefficient μ/ϱ and the density ϱ of the material. If this material is a compound μ/ϱ is calculated by the formula

$$\left(\frac{\mu}{\varrho}\right)_c = w_1\left(\frac{\mu}{\varrho}\right)_1 + w_2\left(\frac{\mu}{\varrho}\right)_2 + \ldots w_n\left(\frac{\mu}{\varrho}\right)_n \qquad (2)$$

where the indexes c, 1, 2, . . .n are related to the compound and the elements forming the compound, respectively. The values w_1, w_2, . . . w_n are the weight fractions of these elements. The mass absorption coefficient μ/ϱ of each element can be calculated by this formula:

$$\frac{\mu}{\varrho} = k\lambda^3 Z^3 \qquad (3)$$

where λ is the wavelength of the x-rays, Z is the atomic number of the element and k is a constant of each element varying discontinuously as λ varies. The discontinuities of the mass absorption coefficient lead to the absorption edges.(10) From the formulae above and the mass absorption coefficients of the elements⁽¹¹⁾ the μ/ϱ of the gems at a radiation with a maximum of intensity corresponding to $\lambda = 0.5$ Å approximately can be calculated. This radiation is obtained from a tungsten tube.

The transparency was evaluated in Table I (for Tables I and II see insert between pp. 16 and 17) as the radiation fraction passing through 1 mm of the material. This fraction is recorded as a factor I_x/I_o and in the % form. The 89% value in the diamond indicates an x-ray transmission through the gem of 89% of the incident radiation. The % values of transmitted x-radiation for a material of thickness 2 mm and 3 mm respectively corresponding to expression 100 (I_x/I_o) are in the last two columns of Table I. From these values the % of transmitted radiation for other thicknesses can be computed. In the case of diamond, for example, the % for 5 mm of thickness can be computed approximately:

$$\begin{array}{lclcl} 2\text{ mm} & + & 3\text{ mm} & = & 5\text{ mm} \\ (I_x/I_o)_{2\text{ mm}} & \times & (I_x/I_o)_{3\text{ mm}} & = & (I_x/I_o)_{5\text{ mm}} \\ 79/100 & \times & 70/100 & = & 0.553 \end{array}$$

Thus, the % of x-rays transmitted is

$$100 \times 0.553 = 55.3\% \text{ for 5 mm thickness.}$$

The transparency of diamond to x-rays is closer to that of beryl, quartz, spinel, topaz, and corundum in decreasing order.

Taking the diamond as reference, the transparency of the remaining gemstones can be compared to its transparency, for the various thicknesses of the material. Table II serves as an example of this comparison. In each column headed by the corresponding thickness (1 mm, 2 mm, 3 mm) the values of the last three columns of Table I were placed on the left and the transmitted radiation on the right, considering the diamond as equal to 100.

It should be observed that not all of the gems of Table I and Table II would be adequate as diamond imitations, which depends on the values of the refractive index, of the birefringence and of the dispersion.

From the values of Table II it is clear that on increasing the material thickness, the differentiation of the various gems by the x-rays is increased. With 1 mm of thickness beryl transmits 80% of the radiation which the diamond would. The distinction between both gems is clearer with 3 mm of thickness in which the beryl

TABLE I

Gem	Chemical Formula	Refr. Index	Birefr.	Disp.	Density ϱ g/cm³	M.A.C. μ/ϱ	I_x/I_o for x = 0.1 cm	% X-rays passing through a thickness of		
								x = 0.1 cm	x = 0.2 cm	x = 0.3 cm
Barium titanate	$BaTiO_3$	2.40	0		5.90	12.57	6.01×10^{-4}	0.06	3.62×10^{-5}	2.17×10^{-8}
Beryl	$Be_3Al_2Si_6O_{18}$	1.577-1.583	0.006	0.014	2.65-2.75	1.26	0.71	71	51	36
Calcium titanate	$CaTiO_3$	2.40	0		4.05	5.31	0.12	12	1.4	0.16
Corundum	Al_2O_3	1.76	0.008	0.018	3.90-4.00	1.31	0.62	62	38	24
Cubic Stab.Zirconia	$Zr_{0.90}Y_{0.10}O_{1.95}$ $Zr_{0.85}Ca_{0.15}O_{1.85}$	2.17-2.18	0	0.060	~5.65	31.43 29.83	3.05×10^{-8}	3.05×10^{-6}	9.29×10^{-14}	2.83×10^{-21}
Demantoid	$Ca_3Fe_2(SiO_4)_3$	1.89	0	0.057	3.82-3.85	5.52	0.12	12	1.4	0.17
Diamond	C	2.42	0	0.044	3.52	0.34	0.89	89	79	70
Flint glass (Beryl imit.)		1.567	0		3.0	8.33	0.082	8.2	0.68	0.06
Fluorite	CaF_2	1.434	0	0.007	3.18	3.97	0.28	28	8	2.3
Gadolinium Gallium Garnet (GGG)	$Gd_3Ga_5O_{12}$	1.970	0	0.045	7.05	19.98	7.63×10^{-7}	7.63×10^{-5}	5.82×10^{-11}	4.44×10^{-17}
Lithium niobate	$LiNbO_3$	2.21-2.30	0.09	0.13	4.64	28.77	1.59×10^{-6}	1.59×10^{-4}	2.54×10^{-10}	4.04×10^{-16}
Lithium tantalate	$LiTaO_3$	2.22	0	0.087	7.45	29.38	3.12×10^{-10}	3.12×10^{-8}	9.73×10^{-18}	3.04×10^{-27}
Quartz	SiO_2	1.544-1.553	0.009	0.013	2.65	1.44	0.68	68	47	32
Rutile	TiO_2	2.63-2.90	0.287	0.28	4.2	5.45	0.10	10	1	0.1
Scheelite	$CaWO_4$	1.918-1.937	0.016		5.9-5.61	26.72	2.10×10^{-7}	2.10×10^{-5}	4.40×10^{-12}	9.23×10^{-19}
Sphalerite	ZnS	2.37		0.156	4.08-4.10	15.59	1.70×10^{-3}	0.17	2.89×10^{-4}	4.93×10^{-7}
Spinel	$MgAl_2O_4$	1.714-1.736	0	0.020	3.58-3.65	1.27	0.63	63	40	25
Strontium titanate (Fabulite)	$Sr\,TiO_3$	2.41	0	0.19	5.13	20.46	2.76×10^{-5}	2.76×10^{-3}	7.64×10^{-8}	2.11×10^{-12}
Topaz	$Al_2SiO_4(F,OH)_2$	1.630-1.638	0.008 0.010	0.014	3.53-3.56	1.27	0.63	63	40	25
Yttrium aluminate	$YAlO_3$	1.938-1.955	0.017	0.039	5.35	22.08	7.41×10^{-6}	7.41×10^{-4}	5.49×10^{-9}	4.07×10^{-14}
Yttrium Aluminium Garnet (YAG)	$Y_3Al_5O_{12}$	1.83	0	0.026	4.57-4.60	18.63	1.95×10^{-4}	0.02	3.81×10^{-6}	7.43×10^{-10}
Yttrium oxide (Yttria)	Y_2O_3	1.92	0	0.050	4.84-4.90	31.72	2.00×10^{-7}	2.00×10^{-5}	3.82×10^{-12}	7.47×10^{-19}
Zircon	$ZrSiO_4$	1.925-1.984	0.059	0.039	4.67-4.70	21.81	3.65×10^{-5}	3.65×10^{-3}	1.33×10^{-7}	4.87×10^{-12}

TABLE II

gem	thickness 1 mm		thickness 2 mm		thickness 3 mm	
	% transparency		% transparency		% transparency	
	measured	relative to diamond	measured	relative to diamond	measured	relative to diamond
diamond	89	100	79	100	70	100
beryl	71	80	51	65	36	51
quartz	68	76	47	59	32	46
spinel	63	71	40	51	25	36
topaz	63	71	40	51	25	36
corundum	62	70	38	48	24	34

transmits only 51% of the corresponding value of the diamond. In corundum the differentiation is even larger, going from 70% at 1 mm to 34% at 3 mm.

As for the remaining gems of Table I, it is not necessary to compare the values since they are truly opaque to x-rays.

In addition to the measurements of gemstones described above, the equipment can be used to obtain radiographs of pearls, but it is not suitable for Laue photography, because its x-ray tube can work only for short periods.

THE PROPOSED X-RAY UNIT

On the x-ray equipment proposed here, fluorescence and gem phosphorescence can be seen directly(12) and transparency can be seen on a fluorescent screen(13) or on a radiographic film. The price of the whole unit is in the region of US$1000, and its components are available in virtually any country.

The components of the x-ray camera are indicated by letters corresponding to those in Figure 1:

A. The x-ray tube generator is used in dentistry. This tube works in a continuous range to 70 kV and to 10 mA with a maximum power of 700 W. The voltage, the current and the time exposure are controlled electronically. The installation requirements are very simple and do not require a cooling circuit.

B, C. This is a box internally covered with lead foil of 1 to 2 mm thickness and divided into two parts with a rectangular window between them to accommodate the fluorescent screen H. This screen allows the observation of gem transparency on the mirror F, through the lens L_2 in the adjustable tube E. Covering the screen H with an opaque plate G, the fluorescence and the phosphorescence can be observed through the lens L_1. In both tubes, E and D, the screw threads K and L in the draw tubes I and J can be adjusted to accommodate a photographic camera with the lenses L_1 and L_2 working as approximation lenses. These lenses must be protected with lead glass equivalent to 1 mm of lead foil.

THE UNIT USE

The radiographs of Figures 2 to 4 and 7 to 10 were made with the described unit on radiographic film. They show the aspect which would be observable on the fluorescent screen with the opaque materials shown dark. The observation on an original

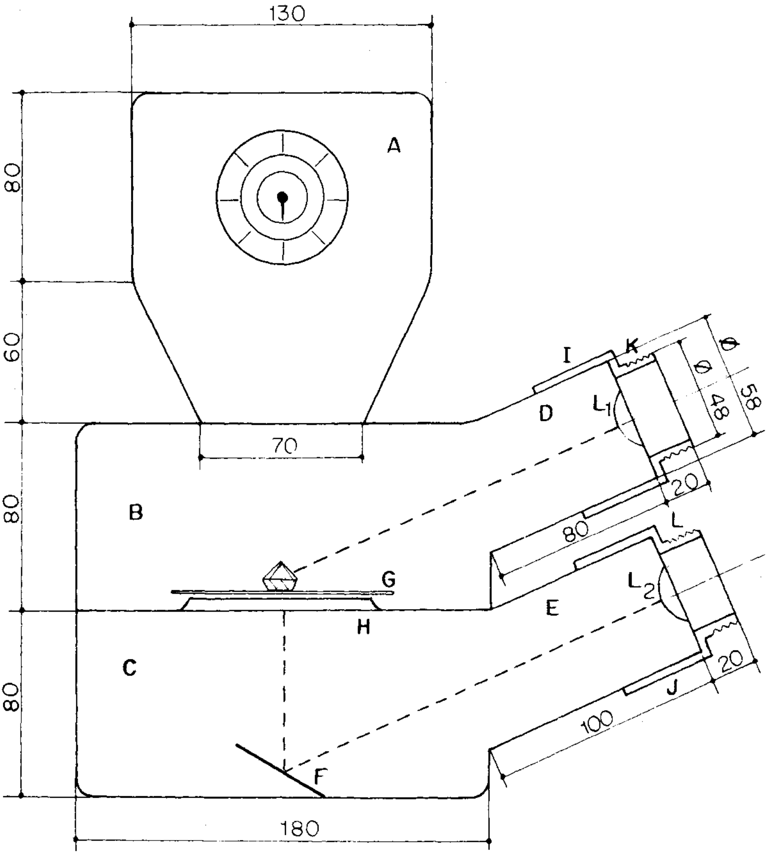

FIG. 1. Gemmological x-ray unit.
A: X-ray tube generator. B, C: Box with intermediate fluorescent screen. D, E: Adjustable tubes. F: Mirror. G: Opaque plate. H: Fluorescent screen. I, J: Draw-tubes. K, L: Screw threads. L_1, L_2: Lenses.
(The numbers indicate the length in millimetres).

radiograph would be the reverse of this with the opaque material shown light.

Figure 2 shows a comparison of a diamond mounted with three synthetic spinels of several sizes. In Figure 3 the comparison is with cubic zirconia. In Figure 4 three series of gemstones are compared: from left to right, beryl, cubic zirconia and synthetic spinel. Figure 5 shows a view of the fluorescent screen of the x-ray unit with a mounted diamond and two cubic zirconias. This photograph was taken with the photographic camera attached to the unit (Figure 6).

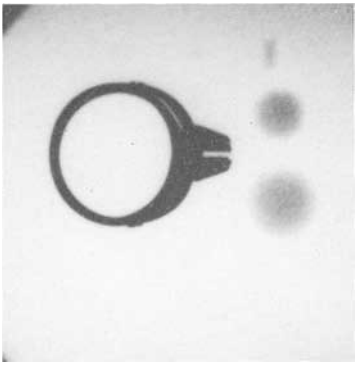

FIG. 2 Mounted diamond and synthetic spinels.

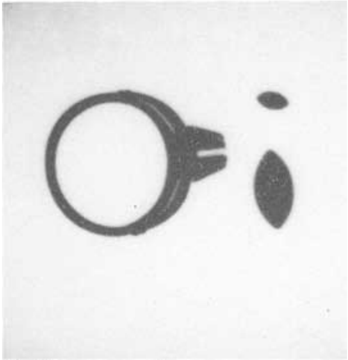

FIG. 3. Mounted diamond and cubic zirconias.

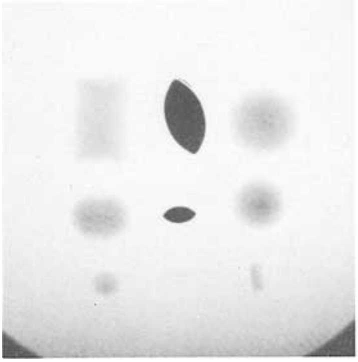

FIG. 4. Left to right, beryls, cubic zirconias and synthetic spinels.

FIG. 5. Photograph of the fluorescent screen of the x-ray unit with a mounted diamond and two cubic zirconias.

The three radiographs and the photograph of the screen were obtained with an x-ray unit of 220 volts, but connected to only 165 volts, the tube operating around 26 kV with a time exposure of 1 second.

The influence of the input voltage of the unit can be evaluated by the continuous radiation intensity emitted each second by an x-ray tube which can be expressed thus:(10)

$$I = AiZV^m \quad (4)$$

where A is a constant, i the tube current, Z the atomic number of the element used in the tube ($Z=74$ for tungsten), and V is the voltage applied to the tube in a constant approximately equal to 2.

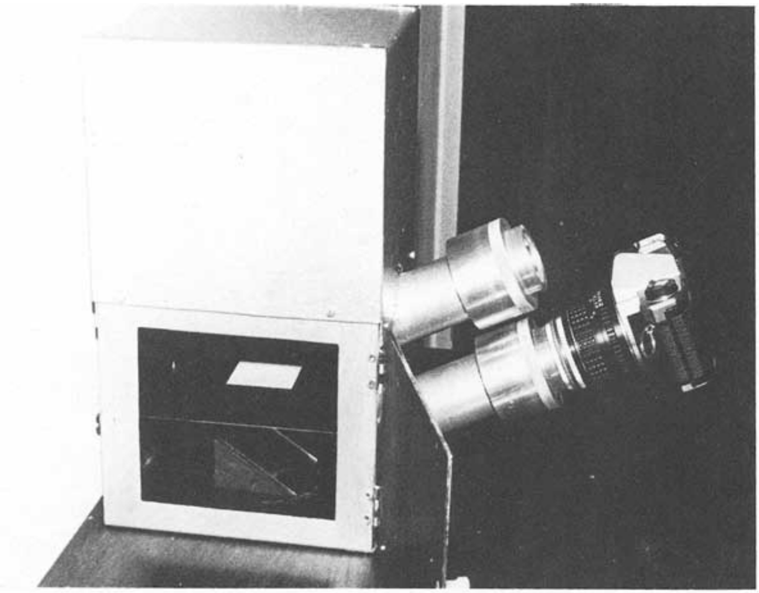

FIG. 6. Photographic camera attached to the unit.

Using an x-ray unit capable of 220 V of input, and a tube regulated for 35 kV, its working power can be controlled by the input voltage.

In the radiographs of the Figures 7, 8 and 9, quartz gems were used with the following conditions of the unit respectively:

Input voltage	tube voltage	intensity (I)
220 V	35 kV	1
165 V	26 kV	0.42
145 V	23 kV	0.29

In the 3rd column the variation of the energy irradiated by the tube was calculated from the equation (4) and presuming that i varies in a way nearly proportional to the input voltage. The advantage which can be observed in the photographs is that of differentiating or equalizing the transparencies according to the thickness or to the nature of the material when that is the case. There is also the advantage of the x-ray tube lasting longer when the equipment is used with a voltage lower than the nominal one.

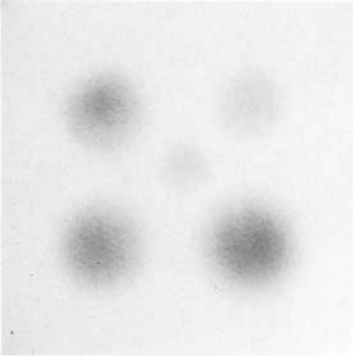

FIG. 7.

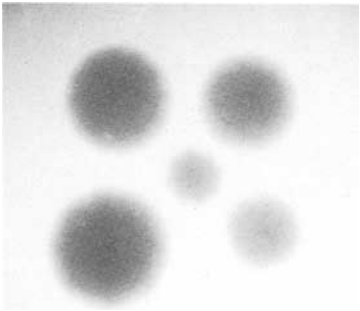

FIG. 8.

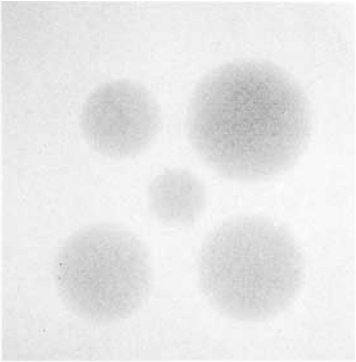

FIG. 9. Quartz gems at 35 kV, 26 kV and 23 kV.

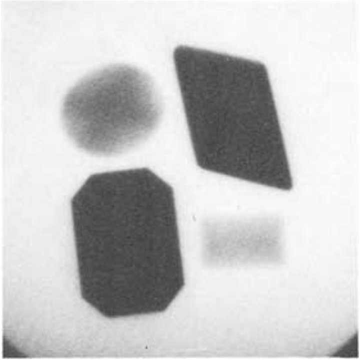

FIG. 10. Above-synthetic sapphire and fluorite.
Below-glass and beryl.

The radiograph in Figure 10 shows four gems. The oval one, in the upper left corner, is a synthetic sapphire with pavilion showing two crossed edges which appear in the photograph. On the right is a fluorite. The octagonal gem is an imitation beryl, made in flint glass, and the smallest, rectangular, stone is a natural beryl. The radiography conditions were the same as those of Figures 2, 3 and 4.

Figure 11 shows the unit being used in the observation of gem luminescence.

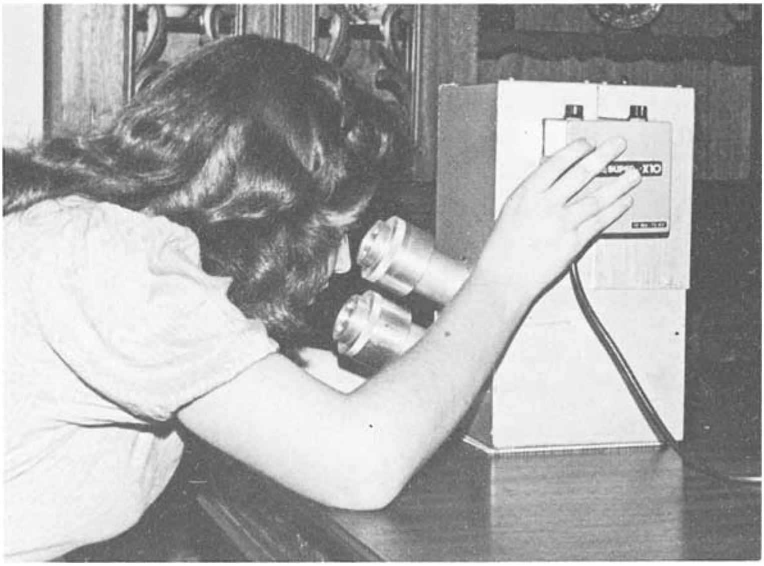

FIG. 11. Use of the unit in the observation of gem luminescence.

SPECIAL CARE

The x-ray gemmological unit proposed in this work generates a radiation which can be harmful to the operator if no special care is taken. The generating unit and the box where the gems are placed must be adequately shielded.

This shielding should be sufficient to prevent the transmission of direct radiation from the tube. The final test of shielding should be made with a detector with a scale of mR/h units or with solid state dosimeters. Assistance may be requested from some radiological safety department or from universities working on irradiation or x-ray diffraction.

In any case, with the indicated shielding, the equipment should be quite safe, mainly because the observations are made over periods of only 1 second. If it is used with radiographs only it is even safer, and a red plastic transparent box allows working in a normal environment without the necessity of a darkroom. This box is commonly used in dentistry.

Concerning the gemstones, a brief x-irradiation is insufficient to stimulate any kind of colour or transparency change. To generate any change in a gemstone would require an intensity of irradiation several times greater and applied over a longer time than the conditions described here.

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[*Manuscript received 8th July 1982; revised May 1983.*]

PARTICOLOUR IN TOURMALINES

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

In 1981 Mr Philip Jerome raised the matter of particoloured tourmalines in connexion with the report of the Geological Museum robbery in 1933, which mentioned a five-coloured tourmaline.* At the time I was able to ascertain that this was almost certainly a case of erroneous reporting in the press of the day, and that what had actually been stolen were five differently coloured tourmalines.†

However, particolour in tourmaline is so much a feature of that mineral that it deserves some further comment.

This is a mineral in which chemical composition is unusually complex, and isomorphous replacement can occur at the same time in more than one part of the unit cell structure and can involve any two or more of three alkali elements and any two or more of six metallic elements. No wonder tourmaline covers a greater colour-range than any other gem mineral.

Compositional changes can and apparently often did occur during the growth of a crystal and, in the best known examples, resulted in crystals which are yellow-green on the outside and reddish pink at their core. This coloration has given rise to the generally used name 'water-melon tourmaline'. Crystals can vary in colour concentrically around the *c* axis, or can vary in colour along the length of the crystal.

The possible colours are far from being limited to red and green. In recent years some blue and pink material, originating from SW. Africa, has appeared on the market. This was usually so heavily flawed as to make it hardly suitable for faceting, although much of it was in fact cut this way and sold at quite high prices.

In my own collection I have several green and red particoloured stones covering a range of shades; a yellow and green; a grey and red, a blue and pale yellow; and a red and green cat's-eye in which the division between colours is so sharp as to give

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**J.Gemm.*, 1981, XVII(7), 452.—Ed.

†*J.Gemm.*, 1982, XVIII(1), 107.—Ed.

ISSN: 0022-1252 XIX (1) 24 (1984)

the impression of two separate stones cemented together. It is, however, a completely natural stone apart from the fact that it has been cut as a cabochon.

I also have a number of sections cut across the prisms of Madagascan tourmalines in which multicoloured banding can be seen quite clearly, and even more so when a lens is used. In one such section a sequence of narrow pink, yellow, green and orange zones followed by broader areas of pink and purple-red may be seen. Another is black, colourless, blue, pink and red. Yet another is opaque black, transparent blue with a green centre.

FIG. 1. Particoloured cabochon tourmaline of 57 ct (with millimetre scale).

Perhaps the most extraordinary example of particoloration in tourmaline that I have seen was a large cabochon which I bought and sold about seven years ago. This is illustrated in Figure 1.

This 57 carat stone can be seen to consist of a very large number of colour-bands. In fact there are 23 distinct colour-zones. The dark lines are a very dark green, while all the lighter areas, except one which is pink, are a pale straw yellow. But with a lens further variations are to be seen where each dark green line has a very narrow region of light green on one or both sides of it. If these are taken into account there are some 35 changes of colour along the length of this stone.

The millimeter scale at the bottom of the illustration gives some idea of its size. The stone was heavily marked by cracks and almost certainly would not have been cut if it had not been so uniquely zoned.

Such colour-zoning in tourmalines generally seems to give fairly sharp edges between the colours, but a few stones show a very gradual change from one colour to another or, in some instances, two less well defined colours fading into and out of a central colourless area.

Although it is best known in tourmaline, colour-zoning is by no means restricted to that species. Corundum is quite commonly zoned in this way although the colours involved are less varied. Emerald may also have colourless areas adjacent to areas of very fine colour. Here the dividing surface between the two contrasting colours is often strangely 'roiled' and the division is an abrupt one. Green diopside, among the rarer stones, may also have this same particoloration between green and almost colourless areas.

Perhaps the rarest example of the phenomenon which has come my way was a zircon with one end green and the other end orange. Again this was a heavily cracked stone, but my friend, the late C. J. Payne, of the London Chamber of Commerce Gem Laboratory, used a diamond refractometer to obtain RI values of 1.853 and 1.863 for the green end and 1.866 and 1.876 for the orange end of the stone. I still have this specimen which was described in this *Journal* as long ago as January 1952.* It poses some problems when it is realized that both colours have to be the result of the metamict process, which seems to have developed to a different extent at either end.

[*Manuscript received 9th March, 1983.*]

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*Some speculations on an unusual zircon, *J.Gemm.*, 1952, III(5), 202-3.—Ed.

J.Gemm., 1984, XIX, 1

AN INVESTIGATION OF THE SYNTHETIC PRODUCTS OF GILSON SHOWING A PLAY OF COLOURS

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ABSTRACT

A characterization of five man-made products of Gilson showing a play of colours is given. In all five man-made products investigated, the play of colours is caused by a close-packed array of uniformly sized amorphous silica spheres. Three of Gilson's man-made products with white, grey and yellowish-brown body colours have a chemical composition which is distinctly different from that of natural opals: all three products contain only small amounts of water ($< 1\%$); in one sample an admixture of crystalline ZrO_2 ($\approx 0.5\%$) was observed. In the sample with a yellowish-brown body colour, a great amount of organic compounds ($\approx 16\%$) was detected. According to the results mentioned, these products have to be designated as opal imitations, rather than synthetic opals. In two of the synthetic products investigated with a black body colour, only small amounts of water ($< 2\%$) were detected, and admixtures of organic compounds (≈ 0.5 - 1.0%) were also found. Using the nomenclature proposed, and the criteria for a distinction of synthetic and imitation gemstones given by Nassau (1976) in a strict sense, these two products also do not deserve the synthetic label, and have to be designated as black opal imitations.

INTRODUCTION

Since 1974, different synthetic products showing a play of colours were manufactured, and sold by P. Gilson, of Saint-Sulpice, Switzerland. For all synthetic products designated as synthetic opals, a formula of $SiO_2.nH_2O$ is given, which corresponds to the composition of natural opals; additional admixtures are not mentioned (advertisement brochure of P. Gilson). Synthetic products with white and black body-colour corresponding in appearance to white and black opals have been available on the gemstone market since 1974. Recently, a new product with a yellowish-brown body-colour, corresponding to fire opal with a play of colours, was also offered under the designation 'created fire opal', or 'created honey opal'.

Different possibilities for the production of opals have been discussed by several authors (e.g., Iler, 1965; Darragh & Perdrix, 1975; Darragh *et al.,* 1977; Falter & Liebertz, 1978; Liebertz &

ISSN: 0022-1252 XIX (1) 27 (1984)

Falter, 1979). A first step for the production of opaline materials is the growth of uniformly sized silica spheres, with diameters in the range of 170-380 nm. A method suitable for such a process was developed by Stöber *et al.,* (1968). This method is based on hydrolysis of tetraesters of silicic acid, e.g., in a solution of tetraethyl silicate, methanol and ammonia. The silica particles were allowed to settle in close-packed arrays by sedimentation over a period of several weeks; in the next step, the liquid is removed. The play of colours of the opaline body in a dry state is distinctly diminished compared to the wet state; in addition, the body without liquid-filled voids is of high porosity and brittleness. In order to use the product for gem purposes, an impregnation of the open voids with opaline silica is necessary. In general, this last step in the production process of synthetic opal is noted to be highly problematic, and a method satisfactory for this purpose is not described in detail (e.g., sintering or hydrothermal treatment). Though similar effects (hardening and improvement of a play of colours) are also caused by plastic impregnation, the result of such a procedure is the production of an opal imitation and not of a synthetic opal (Darragh & Perdrix, 1975). Due to the great difficulties with an impregnation process of amorphous, hydrous silica, the patents held by CSIRO, of Melbourne, Australia, since 1968, are not at present applied for commercial production of synthetic opal for gem purposes.

Up to now, the process used by P. Gilson for the synthesis of materials showing a play of colours has been kept secret. The investigation of one single sample by infrared spectroscopy showed the synthetic product of Gilson to contain smaller amounts of water compared to the water content of natural opals (Darragh & Perdrix, 1975). By investigations with the electron microscope, the internal structure of Gilson's products was found to consist of uniformly sized silica spheres, which are arranged in close-packed aggregates (Darragh & Perdrix, 1975; Falter & Liebertz, 1978). The gemmological distinction of the synthetic products of Gilson from natural opals is based on a microscopic investigation (columnar structure, lizard skin effect). The observations of microscopic investigations are described by various authors; for details see Eppler (1974, 1975), Jobbins *et al.,* (1976), Scarratt (1976), Mertens (1977), Darragh *et al.,* (1977), Ball (1977, 1978, 1979), Jamieson (1978), and Robertson (1979). The gemmological properties and

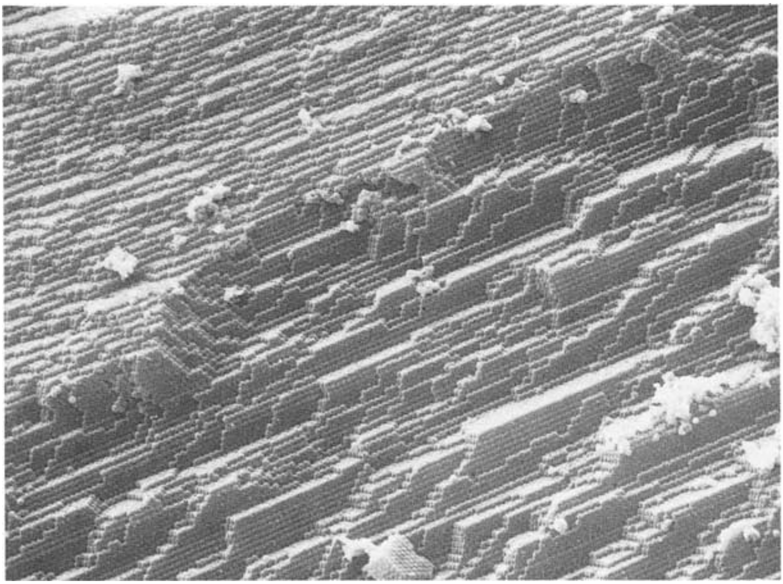

FIG 1. Fire opal imitation of Gilson.—SEM micrograph, 3000 × .

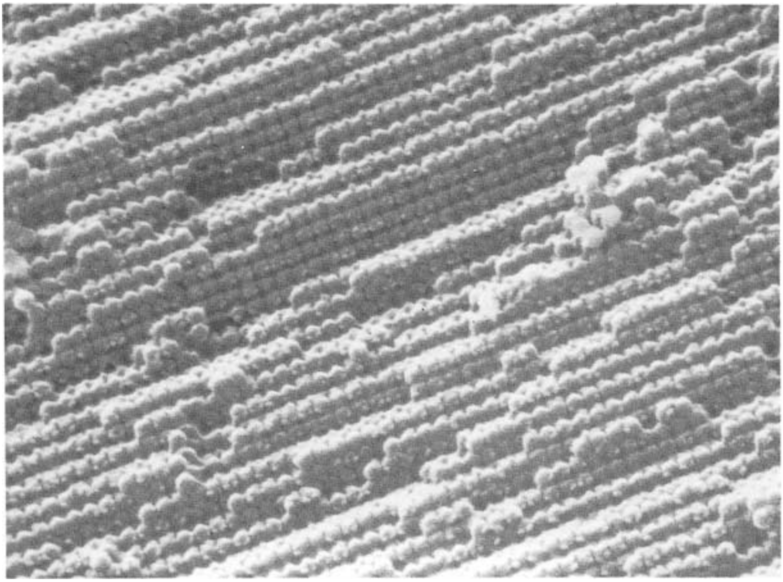

FIG. 2. Fire opal imitation of Gilson.—SEM micrograh, 10 000 × .

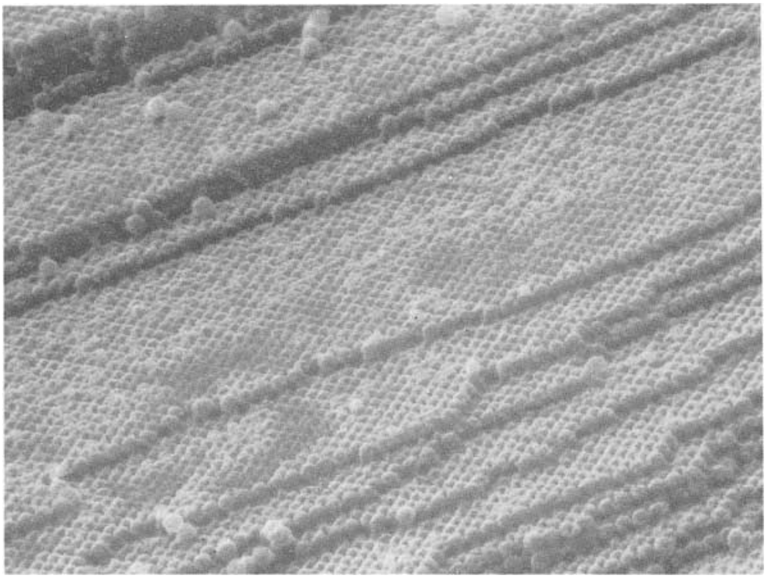

FIG. 3. Fire opal imitation of Gilson.—SEM micrograph, 10 000 ×.

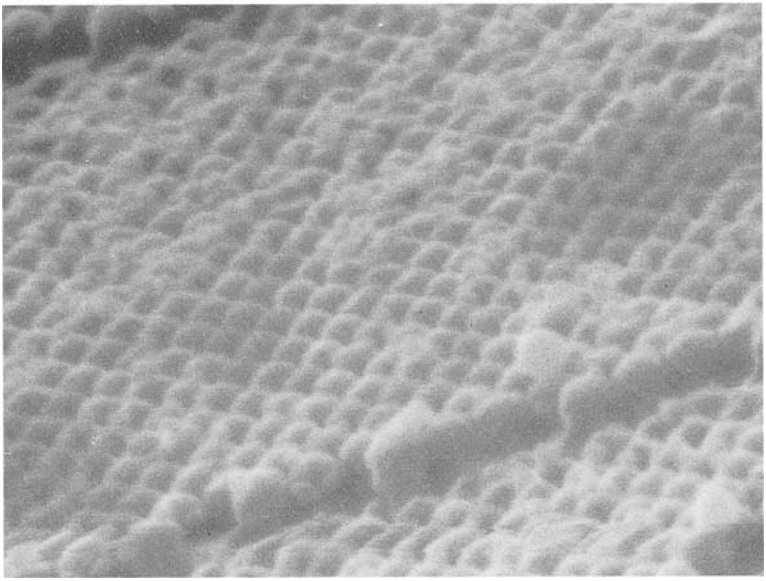

FIG. 4. Fire opal imitation of Gilson.—SEM micrograph, 30 000 ×.

the results of microscopic investigations of the new Gilson product imitating fire opal with a play of colours are described in detail by Gunawardene & Mertens (1984).

A systematic investigation of the synthetic products of Gilson was initiated by the appearance of the new substance with a play of colours, having a yellowish-brown body colour, the so-called 'synthetic fire opal'. A thermogravimetric analysis of this new product showed a loss of weight of about 16% between 300 and 400 °C, a result which was highly unusual compared with data from the literature on natural opals. Though an investigation of the new product by the electron microscope showed an internal structure consisting of uniformly sized silica spheres (Figures 1-4), a detailed investigation of the unusual reaction of heat on this sample seemed necessary. For comparison, additional synthetic products of Gilson as well as some natural opals of different localities were investigated.

MATERIALS AND EXPERIMENTAL DETAILS

For the investigations cited in this paper, five different types of synthetic products of Gilson were available:

Sample 1: several identical pieces, body-colour white with a play of colours violet to green (Figures 5, 6)

Sample 2: body-colour grey with a play of colours violet to red (Figure 7).

Sample 3: body-colour black (opaque) with a play of colours violet to blue (Figure 8).

Sample 4: body-colour black (opaque) with a play of colours violet to red (Figure 9).

Sample 5: several identical pieces, body-colour yellowish-brown, with a play of colours violet to red (Figure 10).

Investigations of the x-ray powder diffraction pattern of the samples were conducted with a powder diffractometer or with Debye-Scherrer cameras. For thermogravimetry between 20 and 1000 °C, a 1090 Du Pont thermal analyser with TGA 951 thermobalance was available; heating rate: 10 °C/min. in 50 ml air/min. Qualitative chemical analyses were done with the energy dispersive systems of an electron microprobe and a scanning electron microscope. The quantitative contents of SiO_2 and ZrO_2 were evaluated by classical chemical methods. SiO_2 was determined

FIG. 5. Opal imitation of Gilson with white body colour, sample 1.—Size 12 × 5 mm.

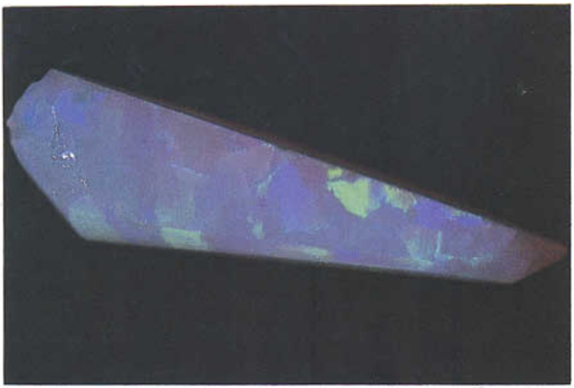

FIG. 6. Opal imitation of Gilson with white body colour, sample 1.—Size 12 × 3mm.

FIG. 7. Opal imitation of Gilson with grey body colour, sample 2.—Size 7 × 4 mm.

FIG. 8. Opal imitation of Gilson with black body colour, sample 3.—Size 3 × 4 mm.

FIG. 9. Opal imitation of Gilson with black body colour, sample 4.—Size 18 × 11 mm.

FIG. 10. Opal imitation of Gilson with yellowish-brown body colour, sample 5.—Size 8 × 7 mm.

by atomic absorption spectroscopy, after fusion of the samples with Na_2CO_3/K_2CO_3. Five samples of synthetic quartz, heated to 1100 °C, were used as standards, which were analysed parallel to the unknown samples. ZrO_2 was precipitated in H_2SO_4 as a phosphate and determined as pyrophosphate. A standard sample with a known content of 3.3% ZrO_2 was investigated parallel to sample 1 of Gilson. The water contents of the samples were chemically determined by means of Karl-Fischer-titration, after decomposition of the samples by heating to 1200 °C. Organic compounds, which were also found to be present in the synthetic products of Gilson, were characterized by flame ionization (rock-eval-analysis) and mass spectrometry. A method of high temperature pyrolysis in connexion with flame ionization, commonly used in petroleum geochemistry, is called rock-eval-analysis: the samples were first heated for 3 min. in a helium atmosphere at 250 °C. Parallel to further heating at a rate of 30 °C/min. up to 500 °C, the organic compounds released by cracking processes were analysed by a flame ionization detector. Investigations by mass spectrometry were conducted with a ZAB mass spectrometer from Vakuum Instruments, attached to a VG data system with a direct inlet, sample temperature of 20-400 °C, and source temperature of 240 °C, with dynamical 6000 resolution. As a reference substance, perfluorkerosene was used. Taking an investigation of the empty sample holder under conditions identical to those for investigation of the unknowns, no background reading for the mass spectrometer was found.

RESULTS

The experimental results of the investigations described in this paper are summarized in concise form in Table 1.

Sample 1 (white): The thermogravimetric investigation shows a loss of weight $<0.1\%$ up to 1000 °C. The water determination by means of Karl-Fischer method was conducted to a water content of 0.07% H_2O. By qualitative chemical analysis with energy dispersive systems only Si and Zr were found. The quantitative determinations by classical chemical methods yielded up to 99.2% SiO_2 and 0.56% ZrO_2. The investigation of the x-ray powder pattern of the sample showed the diffuse diffraction line at about 4.1 Å, which is typical for opal-A, or silica glass, along with some additional weak diffraction lines. Using exposure times up to 12 h

TABLE 1

Physical and chemical properties of man-made products of Gilson showing a play of colours.

	X-ray powder diffraction pattern	Thermogravimetry	Chemical analysis			Flame ionization rock-eval-analysis	Mass spectrometry
			SiO_2	ZrO_2	H_2O		
Sample 1 (white)	4.1 Å (diffuse) and lines of tetragonal ZrO_2	no loss of weight	99.2%	0.56%	0.07%		
Sample 2 (grey)	4.1 Å (diffuse)	no loss of weight	100.0%				
Sample 3 (black)	4.1 Å (diffuse)	1.6% between 20 and 1000 °C continuous	99.2%		0.75%		butylphtalester and fragments between 240 and 400 °C
Sample 4 (black)	4.1 Å (diffuse)	2.9% between 20 and 1000 °C continuous			1.86%	0.4% organic compounds between 250 and 500 °C, 0.06% CO_2	
Sample 5 (yellowish-brown)	4.1 Å (diffuse)	a) 16.6% b) 16.0% between 300 and 400 °C	85.0%		0.53%	16% organic compounds between 250 and 400 °C, 0.1% CO_2	at least two organic compounds and their fragments between 240 and 400 °C

for Debye-Scherrer films, these weak diffraction lines become stronger; the d-values of these lines are assigned to the tetragonal modification of ZrO_2 (ASTM 24-1164). As a result, sample 1 consists of SiO_2, amorphous to x-rays, and small admixtures of tetragonal ZrO_2. The water content of the sample is extremely low.

Sample 2 (grey): This specimen is similar to sample 1, but without a distinct Zr content. TGA of sample 2 proved the loss of weight to be $< 0.1\%$. The sample consists of SiO_2, without distinct admixtures; the x-ray powder pattern revealed only the diffuse diffraction line at 4.1 Å.

Sample 3 (black): TGA shows a continuous loss of weight of 1.6% between 20 and 1000 °C. Only the diffuse diffraction line at 4.1 Å was observed. SiO_2 determination: 99.2%; a water content of 0.75% was found. From these results, a distinct difference between the loss of weight of 1.6%, measured by TGA, and the Karl-Fischer water determination of 0.75% becomes evident. Therefore, additional admixtures are present, which are released by heat treatment up to 1000 °C. By means of mass spectrometry, the presence of butylphtalesters were established as the main components of the organic compounds released between 240 and 400 °C. The determination of masses showed at least four fragment compounds:

m/z	223,0951	$C_{12}H_{15}O_4$
m/z	205,0878	$C_{12}H_{13}O_3$
m/z	149,0250	$C_8H_5O_3$
m/z	57,0712	C_4H_9

Sample 3 therefore consists of amorphous SiO_2, 0.75% H_2O and at least one organic compound of butylphtalester.

Sample 4 (black): Similarly, as above, TGA shows a continuous loss of weight of 2.9%, up to 1000 °C (Figure 11). The water content was established to be 1.86%, i.e., the amount of water in this sample is distinctly higher compared to sample 3. Again, a significant difference between the loss of weight and the value of the chemical water determination was found. By means of flame ionization (rock-eval-analysis), the release of about 0.4% of organic compounds occurred between 250 and 500 °C. According

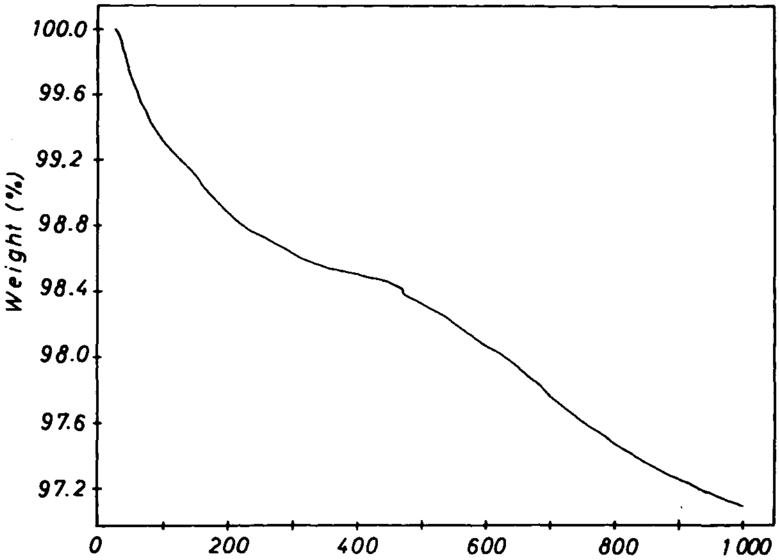

FIG. 11. TG curve of opal imitation of Gilson with black body colour, sample 4.

to these investigations, part of these substances (T>350 °C) have to be regarded as cracking products of complex organic compounds. In sample 4, a CO_2 content of 0.06% was also determined. Sample 4 consists of SiO_2 as a main component, with admixtures of water, and at least of one organic compound.

Consequently, samples 3 and 4 should come from an identical type of manufacturing process, but from different generations or steps in the synthesis.

Sample 5 (yellowish-brown): These specimens are also amorphous to x-rays, but show significant differences toward heat treatment. Between 300 and 400 °C, a loss of weight of about 16% was observed (Figure 12). The water content of the sample (0.53%) is distinctly lower than the loss of weight; the SiO_2 content was established to be 85.0%. By means of flame ionization (rock-eval-analysis), about 16% in organic compounds were detected in this sample, and are released between 250 and 400 °C. A CO_2 content

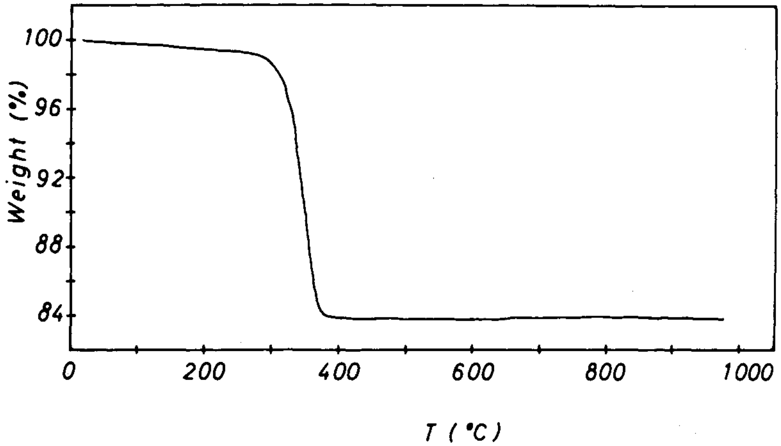

FIG. 12. TG curve of opal imitation of Gilson with yellowish-brown body colour, sample 5.

of 0.1% was found. The investigation by mass spectrometry showed fragments of organic compounds, which are assigned to at least two substances due to their genetic relationship; only C-H-O containing compounds were taken into consideration:

m/z	198.0668	$C_{13}H_{10}O_2$
m/z	154.0758	$C_{12}H_{10}$
m/z	122.0353	$C_7H_6O_2$
m/z	105.0334	C_7H_5O

Substance B:

m/z	100.0521	$C_5H_8O_2$
m/z	99.0448	$C_5H_7O_2$
m/z	69.0375	C_4H_5O
m/z	41.0332	C_3H_5
m/z	39.0176	C_3H_3

Consequently, sample 5 consists of about 85% SiO_2, amorphous to x-rays, of 0.5% H_2O and of 16% organic compounds. The presence of at least two different organic compounds was proven.

DESIGNATION OF THE SAMPLES INVESTIGATED

It was not the intention of the investigations described in this paper to clarify production processes. However, significant differences in chemical composition between natural gem opals and synthetic products of Gilson were established. Therefore, the correct designation of these substances is debatable. A proposal for a distinction between non-single-crystal synthetics and imitations is given by Nassau (1976, 1977). The author suggests five levels of investigation:

(a) chemical composition (analysis)
(b) crystal structure (x-ray diffraction)
(c) sub-micro-structure (electron microscope)
(d) micro-structure (optical microscope)
(e) visible appearance (unaided eye)

According to Nassau, the only way in which synthetic material is permitted to differ from natural material is at the microscopic level of investigation. At the levels of crystal structure, sub-micro-structure and visible appearance of man-made gem materials, the properties of a synthetic gemstone have to meet exactly the properties of natural material. In chemical composition only those components which are variable in natural material are allowed to vary within the limits found in natural samples too. No foreign binder, filler or colouring matter may be present in material which deserves or claims the label 'synthetic'. An examination of the criteria suggested by Nassau with respect to the man-made materials of Gilson leads to the conclusions given below:

(a) At the level of chemical composition all samples investigated have significant differences as compared to natural gem opals.* All five samples fail to duplicate the natural substances. In samples 1, 2 and 5, distinct water contents, which are always present in natural opals (Bayliss & Males, 1965; Jones & Segnit, 1971; Langer & Flörke, 1974; Darragh & Perdrix, 1975), were not found. In samples 3 and 4, the water contents are lower than in natural opals (≈ 3-10%). A limit of 1% H_2O for the designation opal was suggested by Jones & Segnit (1971). This limit is extremely important for the distinction of hyalite and silica glass (compare Flörke *et al.*,

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*Contrary to opaline silica formed by geologic processes, plant opal separated from soil may contain a distinct amount of organic matter which was protected by the opal from oxidation (Jones & Beavers, 1963).

1973; Langer & Flörke, 1974). Comparing this limit with the H_2O contents in samples 3 and 4, only sample 4 meets the compositional range of opals.

In sample 1, an amount of crystalline ZrO_2 was observed which may not be present in natural opals. This admixture is supposed to be added in order to produce the white body colour of the samples. In samples 3 and 4, admixtures of organic compounds were detected. These compounds may be regarded as residues of the production procedures. Sample 5 even contains great quantities of organic material (≈16%).

(b) By means of x-ray powder diffraction, congruency is observed between samples 2, 3, 4 and 5, and natural opaline material of the amorphous type (Jones *et al.*, 1964; Jones & Segnit, 1971). In addition to the diffuse diffraction line at 4.1 Å in the diffraction pattern of sample 1, the lines of tetragonal ZrO_2 were observed. A diffraction pattern similar to the pattern of opal-CT was not observed during the investigations of Gilson's products (the Mexican fire opals are assigned to this group; compare Sanders, 1975).

(c) In the electron microscope, close-packed aggregates of silica spheres were observed (Figures 1-4; compare Darragh & Perdrix, 1975; Falter & Liebertz, 1978; Liebertz & Falter, 1979). However, no internal structure of shells within the silica spheres was observed in Gilson's products (Darragh & Perdrix, 1975; Ball, 1977; Darragh *et al.*, 1977; Jamieson, 1978), as it was described for natural opals of the amorphous type (Darragh *et al.*, 1966; Cole & Monroe, 1967; Jones & Segnit, 1969; Monroe *et al.*, 1969; Sanders & Darragh, 1971).

(d) As mentioned before, the man-made products of Gilson show distinct differences against natural opals at the level of microscopic observations (compare Gunawardene & Mertens, 1984).

(e) The visual appearance of the synthetic products of Gilson showing a play of colours is in good congruency with its natural counterparts.

Between natural opals and all five of the man-made products of Gilson investigated in this paper, significant differences were detected. The main differences are in sample 1: no water, ZrO_2; in sample 2: no water; and in sample 5: no water, 16% organic compounds. As a result of these observations, the three products mentioned do not deserve the synthetic label. An application of the criteria of Nassau (1976, 1977), in a strict sense, to the results obtained during the investigation of samples 3 and 4, does not allow the designation of these two products as synthetic opals. Due to their contents of organic compounds, they too have to be assigned to the group of imitations.

A clear decision by an International Commission on Gemstone Nomenclature (CIBJO or Commission on Gem Materials of IMA) concerning the distinction of synthetics and imitations is highly desirable in the opinion of the author.

ACKNOWLEDGEMENTS

The samples investigated in this paper were supplied by the firms of Gebr. Bank and R. Litzenberger, of Idar-Oberstein; R. Mertens, of the German Gemmological Society, Idar-Oberstein, was also helpful. The investigation of the new fire-opal imitation, initiating a systematic characterization of Gilson's products, was stimulated by M. Gunawardene, of the German Gemmological Society, of Idar-Oberstein. The author is grateful to H.-G. Röpert, of TÜV Rheinland, Köln, for investigations by the scanning electron microscope, and to Dr O. Medenbach, of Bochum University, for the photographs of the samples. Thermogravimetry was done by Dipl.-Min. K.-H. Breuer, of Heidelberg University, and mass spectrometry was conducted by Dr D. Krauss, of Heidelberg University.

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[*Manuscript received 18th June, 1983.*]

GILSON CREATED FIRE OPAL IMITATION WITH PLAY OF COLOURS

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ABSTRACT

In the chain of opal simulants made by Gilson, the new-comer is the 'Mexican opal synthetic' (according to the manufacturer). Compared with natural opals, this simulant behaved unnaturally and was proved to be an imitation rather than a synthetic (Schmetzer, 1984). Upon this the chemical and physical properties are compared with those opals of natural origin. Gemmological identifications are presented with intensive microscopic studies.

INTRODUCTION

Synthesis of gem materials is a well understood process to the solid state chemist and ceramist. Thus deep knowledge of chemistry has taken up a notable position in present day gemmology. However, considering opal, chemistry alone does not help to bring out the 'play of colour' effect. The cause for this magnificent splendour phenomenon was explained by Sanders (1964) during early days of investigations on natural opals. In the late 1960s scientific organizations in U.S.A. and Australia proceeded further and patented the synthesizing of opals. The commercial aspects of these patents were employed by Gilson, who announced the availability of black and white laboratory-made opals (Jobbins *et al.*, 1976). His product contained (according to Gilson) $SiO_2.nH_2O$, indicating a similarity to that of natural opal. However, Kose & Hachisu (1976) proved that 'play of colour' effect can be achieved by using dissimilar chemical ingredients (see also Gunawardene, 1983).

New developments achieved by the Swiss scientist were shown to the authors during October 1982 by courtesy of the Litzenberger firm in Idar-Oberstein. The samples were introduced by the producer under such names as 'Mexican fire opal type synthetic' or 'synthetic honey opal'. Visually, they resembled the appearance of honey opal (after Ball, 1982), having 'play of colours' like those found in Australia or Mexico.

ISSN: 0022-1252 XIX (1) 43 (1984)

Fire opal imitations consisting of one slab weighing 12.07, one cabochon of 3.62 carats, and a parcel of chipped pieces, six natural gem-quality fire opals (also called honey opals) and four black and white (two from each colour variety) opal simulants of the manufacturer were used in this investigation.

CHEMISTRY

It is known that gem opal is chemically a hydrous silica. Certain colour varieties are caused by the presence of transition elements—for instance, the iron coloration in natural fire opal. The chemical analysis according to Schmetzer (1984) in this new simulant measured contents of 85.0% SiO_2, 0.53% H_2O and 16.0% organic componds. Investigated by thermogravimetry (TGA) the samples gave a loss of weight of 16.0% at a temperature range between 320 °C and 370 °C and then remained constant upon the increase of heat. A Mexican fire opal, on the other hand, showed a loss of weight of 9.5% between 20 °C and 1000 °C (Figure 1).

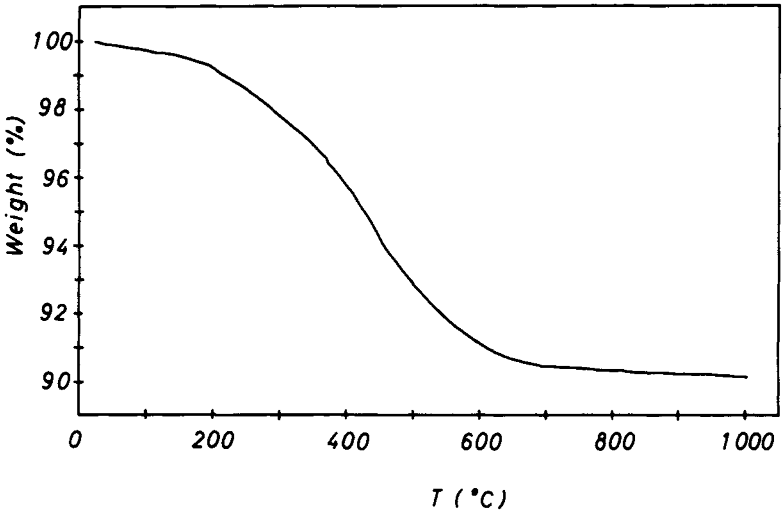

FIG. 1. TG curve of Mexican fire opal showing the continuous loss of weight between 20 °C and 1000 °C.

STRUCTURE

As reported by Sanders (1964) the sedimentation of spheres should take an ordered array in a three-dimensional network in the formation of opals of gem quality. Similar structural appearance of the new product was evident under the scanning electron microscope. The approximate diameter size of the spheres was about 200 nm (Schmetzer, 1984). The careful observations made on the available slab indicated that the colour columns were at right angles to the base of the container used during the growth. Examination of the other samples showed no such effects. This may have been due to some influence of periodic gentle disturbance caused to the sedimentation of the structure.

BODY COLOUR

The newly made opal stimulant is of distinct yellowish-brown body colour having notable 'play of colour' effect. It is much better in appearance than the natural samples of high grade with which it was compared. The unpolished part of the slab showed an unnatural nature much more clearly than the cabochon cut samples of the imitation, in that the reddish flashes of colour were more prominent than those of other colour segments such as green, blue and violet.

PHYSICAL PROPERTIES

The measured refractive indices and specific gravity values were not very different from those of natural or previous varieties of man-made opals. Both distilled water and toluene were used in determining the specific gravity. The physical properties are given in Table 1 along with those of comparision stones.

The noted affinity for water, after a 30 minutes soak, was much less than that reported previously for imitations (Jobbins *et al.*, 1976). The porosity of those simulating black and white varieties revealed a propensity for sticking to the tongue. However, this porosity was absent in the new fire-opal imitation. The cause is probably due to the impregnation of a synthetic material which hardens and influences the 'play of colour' effect (see Schmetzer, 1984). Polished surfaces of the new product and the natural honey opal felt rough and smooth respectively to the moistened thumb. This 'feeling' test may be used as an additional method of descrimination by an experienced dealer.

TABLE 1. Summary of the characteristics of the fire opal imitation made by Gilson and natural fire opals.

		Gilson fire opal imitation with ‘play of colours’	Natural fire opal with or without ‘play of colours’
Chemistry*		SiO_2 85.0% H_2O 0.53% organic compounds 16.0%	
X-ray powder pattern*		Amorphous	CT—opal
Thermogravimetry*		loss of weight about 16% between 300 °C and 400 °C	loss of weight about 8-9% between 20 °C and 1000 °C
Refractive index		1.41±0.001	$1.44^{+0.003}_{-0.007}$
Specific gravity (g/cm³)		1.91±0.001	$2.15^{+0.007}_{-0.009}$
Affinity for water		hydrophilic**	hydrophilic
‘feeling’ test		cool feeling; rough to the thumb	cool feeling; smooth to the thumb
UV Luminescence	Long-wave	strong bluish-white	weak orange
	Short-wave	weak bluish-white	none
Thermoluminescence at 30 °C to 40 °C		strong chalky bluish-white	none

*after Schmetzer (1984)

**affinity less due to impregnated synthetic material

LUMINESCENCE

The stones were examined under both long- and short-wave ultraviolet radiations. The cabochon cut sample of the new imitation and all the natural opals were inert to both radiations. However, the remaining samples of new and previous products showed a distinct fluorescence with a chalky bluish-white body glow and a much stronger surface glow of the same colour. A phosphorescence effect was noted after switching off the ultraviolet radiations. The fluorescence and phosphorescence effects were stronger under the long-wave than under the short-wave ultraviolet. The experiments were repeated with different distances between the radiation source and the object, and with different exposure times. Stronger and more distinct glows and afterglows were evident when the radiation was nearer to the object and exposed for longer periods.

Further, a thermoluminescence was noted on those samples which reacted under ultraviolet radiations. The heat was induced by using the microscope light source and the amount of heat induced produced a fluorescence and an afterglow which also depended on the length of time of heating. The gemmologist is warned about heating opals in repeating such experiments —extreme heating may result in cracking the material.

MICROSCOPIC EXAMINATIONS

Examinations were done on both *horizontal* and *vertical* microscopes. Under high intensity fibre-glass optic light coupled with the *horizontal* gem microscope, the new Gilson product revealed a structural effect similar to the 'chicken wire' in appearance (Figure 2). Individual colour segments, made visible under oblique orientation of the fibre-glass tube, showed structural patterns similar to those reported by Scarratt (1976). However this effect was absent in the natural stones used for comparisons (Figure 3).

Since most of the microscopic examinations are done on low intensity lighting conditions, the investigations were then turned to usual gemmological procedure with the light sources supplied by the manufacturers of both types of microscope (Read, 1979; Lenzen *et al.*, 1983). The transmitted light was directed at different angles and the visibility of the red colour segments was noted (Figure 4). Apart from a few healed fractures, perhaps due to

FIG. 2. Gem microscopic examination using high intensity fibre-glass optic light showing 'chicken wire' appearance. (transmitted light. 20 ×)

temperature increase after the growth (we do not know whether these samples were examined under intensity lighting conditions—causing some heat—by the supplier beforehand?), dendritic patterns similar to those seen in moss agate were apparent (Figure 5). On the other hand the colour patches in the natural gem-quality fire opal with colour flashes showed striations (Figure 6). In further examinations the new imitation opal variety showed the characteristic 'lizard skin' or 'fish-scale' effect (Figure 7) similar to those reported by Jobbins *et al.,* (1976) on the black and white imitations of the manufacturer. In oblique directions a characteristic dangling stalactitic colour-distribution was noted (Figure 8). The stones viewed from the side showed the substructural boundaries of colour patches rising in columns (Figure 9). The possible cause for this is discussed in the section on body colour. Similar colour boundaries were noted in early black and white varieties of the imitations and are reported by the previous investigators in this *Journal* (Jobbins *et al.,* 1976) and elsewhere (Mertens, 1977).

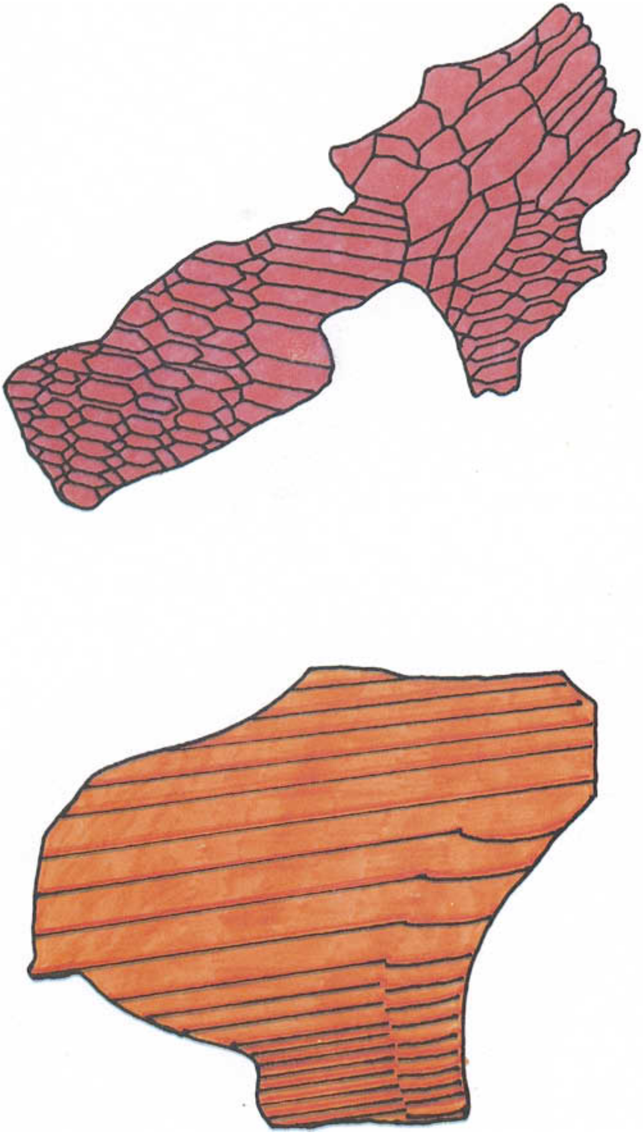

FIG. 3. Drawings of red and orange colour-segments in new opal imitation *(above)* and Mexican fire opal *(below)* respectively.

FIG. 4. Often visible red colour-patches and typical dendritic patterns seen in the Gilson imitation. (transmitted light. 20 ×)

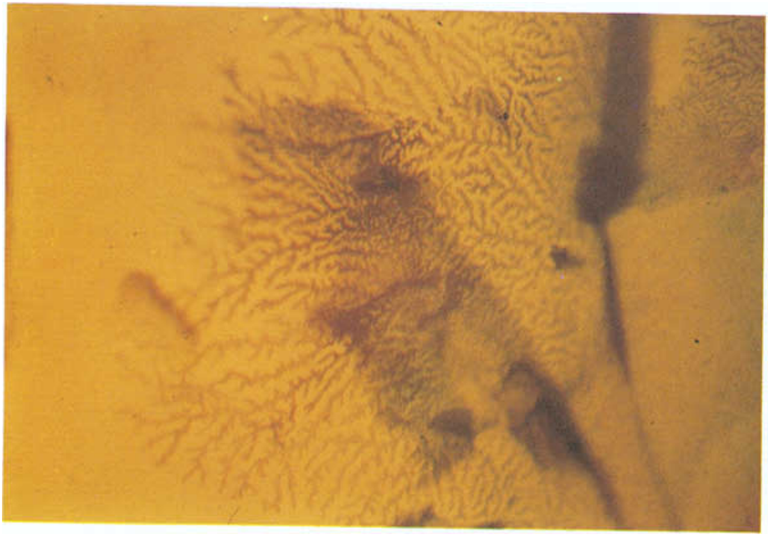

FIG. 5. Enlarged dendritic pattern in fire opal imitation of Gilson. (transmitted light. 100 ×)

FIG. 6. The structural pattern seen in most of the colour segments of natural honey opal. (transmitted light. 40 ×)

FIG. 7. Typical 'lizard skin' structure in fire-opal-like Gilson imitation. (reflected light. 25 ×)

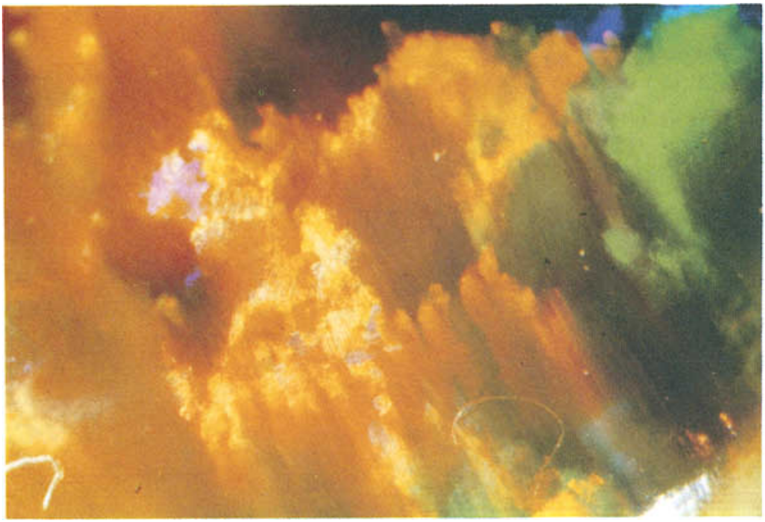

FIG. 8. Characteristic 'dangling stalactitic' colour distribution in the new fire opal imitation. (oblique light. 40 ×)

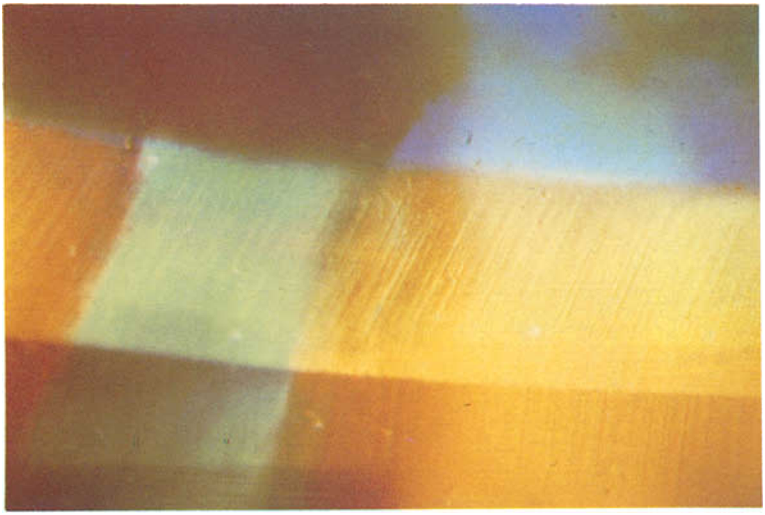

FIG. 9. Substructural boundaries of colour columns in side-view observations in fire opal imitation of Gilson. (reflected light. 25 ×)

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the following contributors:

Dr K. Schmetzer, Heidelberg, for permitting us to use his analytical results obtained on the new imitation and critical discussions made; K. Arnold (firm R. Litzenberger, Idar-Oberstein), W. Roos (firm Hugo Roos & Sons, Kirschweiler), Professor Dr H. Bank and Dr G. Lenzen (Deutsche Gemmologische Gesellschaft, Idar-Oberstein) for the supply of the samples of the new product, natural gem opals of both Australian and Mexican origin and previous simulants of Gilson respectively.

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[*Manuscript received 18th June, 1983.*]

SOME OBSERVATIONS ON A KASHAN SYNTHETIC RUBY

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ABSTRACT

Three visually distinct types of inclusions observed in a flux-grown Kashan synthetic ruby are illustrated and described and some speculations are presented on their possible origins. It is tentatively suggested that all of the inclusions in the stone consist essentially of trapped flux which may occur either in a crystalline or vitreous state depending on factors such as size, cooling rate and amount of alumina dissolved. None of the inclusions appear to contain any liquid phases.

1. INTRODUCTION

In recent years flux-grown synthetic rubies have become increasingly important in the gemstone markets of the world. The major producers are Chatham and Kashan, both of the United States, but the recently introduced Knischka ruby of European origin is likely to be marketed in the near future. Although research laboratories, equipped with sophisticated instrumentation, can usually distinguish the flux-grown stones from each other and from natural rubies, the average gemmologist will have to rely heavily on inclusion characteristics if he hopes to confidently separate these deceptive synthetics from genuine rubies. Several excellent papers on flux-grown rubies have appeared in the gemmological literature in the last few years, the most recent being the magnificently illustrated summary by Dr E. J. Gübelin in the April 1983 issue of this *Journal.*

In recent months the author had the opportunity of examining a particularly interesting Kashan ruby, kindly loaned to him by Alan Hodgkinson. The paper describes and illustrates the inclusions observed in this stone and speculates on their possible origin. As only one stone is under discussion, and no analytical work was undertaken by the author, the article is not intended to serve as a guide to the identification of Kashan rubies in general nor is it implied that the inclusions described will necessarily be found in other Kashan stones. It is hoped, however, that the photographs and descriptions will be useful, for comparative purposes, for those seeking evidence of flux growth in other specimens.

ISSN: 0022-1252 XIX (1) 54 (1984)

2. DESCRIPTION

Three distinct kinds of inclusion were noted in the stone—'metallic' solid inclusions, 'crazed' solid inclusions and 'fingerprints'.

Type I—'Metallic' Solid Inclusions

These inclusions were the most conspicuous internal features present. Their general shape was irregular in the larger examples and elliptical, rod-like or even spherical in the smaller ones.

In transmitted light only the structures were completely opaque, but using a combination of transmitted and oblique overhead illumination they were revealed as strongly reflecting inclusions with a distinctly 'metallic' lustre. Precise determination of their colour was difficult, as this varied according to the angle at which the oblique overhead lighting was directed into the stone; colours recorded were dark red, bronze, greenish and 'white'. Most of these inclusions appeared to be solid, homogeneous bodies.

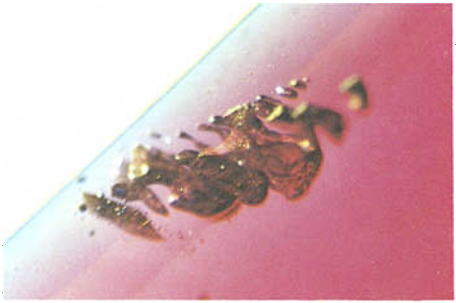

FIG. 1. Type I. Coarse crystalline flux inclusions. Kashan ruby 6.3 ×.

FIG. 2. Type I. Elliptical flux inclusion with a bubble-like structure (top right). Kashan ruby 6.3 ×.

Figure 1 shows a typical grouping of Type I inclusions. In Figure 2 some of these 'metallic' inclusions are seen to possess an approximately elliptical shape. The elongate inclusion towards the top right of Figure 2 is of particular interest. The usual metallic appearance is evident but in addition this inclusion contains a black oval structure resembling a bubble.

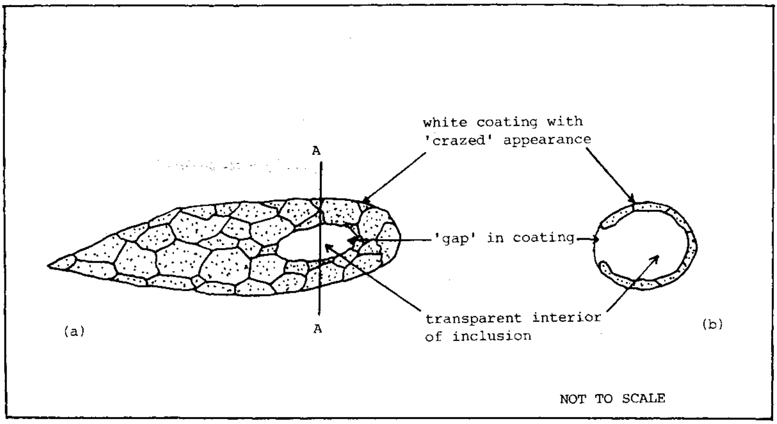

FIG. 3. Probable structure of a Type II inclusion. (a) Lateral view of inclusion. (b) Vertical section along line A-A.

Type II—'Crazed' Solid Inclusions

Most of these inclusions occurred in elongate, well shaped forms with angular to sub-angular terminations (negative crystals?). All of the Type II inclusions observed contained an opaque or translucent substance with a granular, sugary or 'crazed' appearance (resembling 'crazy' paving) which was dazzling white in oblique overhead lighting. Interestingly none of the inclusions seemed to be completely filled with this white material, the latter occurring rather as a thin outer coating or layer. Moreover numerous 'gaps' or breaks in the white coatings enabled the observer to examine the insides of the structures in some cases. Where this was possible the interiors always consisted of a homogeneous, transparent material which in fact comprised the main bulk of the individual inclusions. These observations indicated that Type II inclusions were composite bodies. Their presumed structure is shown diagrammatically in Figure 3.

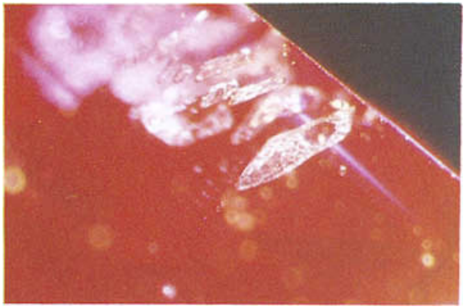

FIG. 4. Type II. Elongate, well shaped inclusions with 'crazed' surface coatings of flux. Kashan ruby 10 ×

FIG. 5. Type II. Note large bubble-like 'gap' in flux coating in uppermost inclusion. Kashan ruby 10 × .

FIG. 6. Type III. 'Fingerprint' inclusion (upper part of photograph). Kashan ruby 6.3 × .

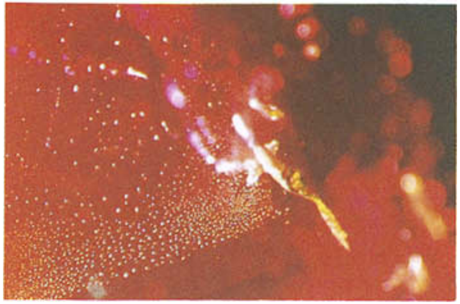

FIG. 7. Type III. 'Fingerprint' inclusion (left). Kashan ruby 6.3 × .

Some actual examples of Type II inclusions are shown in Figures 4 and 5. The elongate shape of the inclusions is apparent in the photographs and the 'crazed' appearance of the white coatings is particularly clear in the largest inclusion in focus in Figure 4. Their composite nature is indicated by the occasional presence of bubble-like structures; the latter are not bubbles but represent 'gaps' in the opaque outer layers through which the interiors of some of the inclusions can be seen.

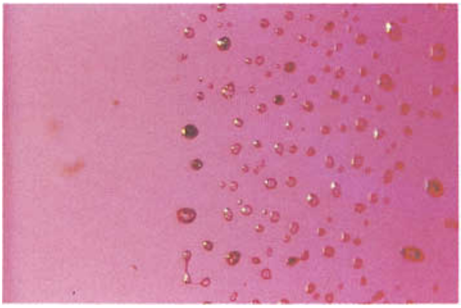

FIG. 8. Type III. Details of 'fingerprint' showing rounded to spherical two-phase inclusions. Kashan ruby 25 ×.

Type III—'Fingerprint' Inclusions

Several good 'fingerprint' inclusions, superficially resembling similar features in natural rubies, were present in the stone. Examples are shown towards the top of Figure 6 and on the left hand side of Figure 7. These inclusions were composed essentially of a large number of very small spherical or near spherical structures which appear in the low magnification photographs (Figures 6 and 7) as tiny, bright pinpoints of light separated by darker areas of corundum. When examined under higher magnification (see Figure 8) the rounded nature of the inclusions within a fingerprint become even more obvious. Many of them in fact approached perfectly spherical, bubble-like shapes; a few displayed 'dumb-bell' forms. Apart from a very small number which were opaque (black), the vast majority of these rounded inclusions showed a high degree of transparency and appeared to be two-phase bodies—individually not unlike the liquid-and-gas inclusions sometimes seen in natural rubies.

3. DISCUSSION

There seems little doubt that the metallic inclusions, designated Type I in this account, represent coarse crystalline residues of flux trapped during the growth of the host ruby. The origin of the 'bubble' in the inclusion shown in Figure 2 is unknown. It may be a genuine gas bubble (oxygen?) produced during shrinkage of the flux on cooling but the possibility that it is a solid body, differing in properties from the surrounding flux, cannot be discounted.

Alan Hodgkinson (personal communication), who has had these inclusions analysed, confirms that they contain a high proportion of zinc—indicating the use of a flux, or flux additive, of somewhat unusual composition during synthesis.

Since nothing comparable with them in every respect has ever been recorded from natural rubies, or indeed from any other types of synthetic ruby, such coarse inclusions can be regarded as valuable indicators of flux growth. Information from Kashan, however, suggests that these useful inclusions are rare or absent altogether from faceted stones currently being marketed. The nature of the other types of inclusions present in the stone is much more speculative. Type III inclusions are considered first because their origin may have a bearing on that of Type II.

Type III inclusions seemed to be typical 'fingerprints' such as are often found in many natural and synthetic gemstones. The spherical, or near spherical shape of the individual inclusions has already been mentioned but their nature is debatable. At first sight they *appeared* to be ordinary two-phase liquid-and-gas inclusions. The presence of gas bubbles is not at all surprising in flux grown gemstones—one would expect gas, probably oxygen, to be liberated during the manufacturing process, perhaps in large quantities. Attempts to persuade any of the gas bubbles to move within their spherical cavities proved fruitless, however, and suggested (but did not prove) that mobility of the bubbles may have been impossible *perhaps because no liquid was present.*

An alternative view is that these are far less common types of two-phase inclusions consisting of a gas bubble combined with a transparent *solid* phase. Without analysis of course, the nature of such a solid phase is purely conjectural. Kurt Nassau, however, in his excellent book *Gems Made by Man** has pointed out that

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*See also K. Nassau's Did Professor Nacken ever grow hydrothermal emerald? *J.Gemm.*, 1979, XVI(1) at p.47—Ed.

apparently two-phase liquid-and-gas inclusions in Nacken synthetic emeralds are in reality transparent *solid* inclusions associated with gas bubbles, the latter being liberated as a result of shrinkage during cooling. Even more surprising were the results of Nassau's analyses of the solid components of the two-phase inclusions in the Nacken material—they were found to consist of trapped flux containing the ingredients of beryl with extra chromium, but in a *vitreous* (glassy) state. It is tempting to suggest that the inclusions which make up the fingerprints in the Kashan stone studied have a similar origin. If this is true then these tiny inclusions consist essentially of spheres of flux-glass, perhaps containing some Al_2O_3 and Cr, together with small gas bubbles. The process envisaged would involve very rapid cooling of droplets of residual flux, which would prevent its crystallization, followed by contraction with the formation of a shrinkage gas bubble and ultimate solidification as glass.

The white sugary material forming the coatings to the Type II inclusions is definitely solid and is probably composed of residual flux. The 'crazed' pattern of this material suggests rapid crystallization around a large number of closely spaced nucleation centres. It is conceivable that such a process could occur around the walls of gas-filled cavities which contained small amounts of trapped flux. The general shapes of these inclusions, however, are nothing like typical gas bubbles so it is unlikely that these inclusions are gas filled. It also seems extremely doubtful that any liquid is present either. The interesting possibility remains that the interiors of these inclusions are again *solid.* Their transparency might indicate that they are also composed of flux-glass as postulated above for the Type III inclusions. A satisfactory explanation for the precise development of these unusual inclusions is difficult to give. Perhaps the amount of alumina dissolved in the flux is an important factor, coupled with cooling rate, which determines whether flux-glass or crystalline flux develops. If this is true the interiors of these inclusions are probably richer in dissolved alumina than the crystalline flux coatings. The original sizes of Type II inclusions may also be significant in determining how they subsequently develop.

4. CONCLUSION

The above observations suggest that the three types of inclusions are related to each other. Type II inclusions seem to contain a combination of the features (namely crystalline flux *and* possibly flux glass) seen independently in Types I and III, and this may indicate that a transition exists between the three types. This is certainly true on the basis of size—Type I are the largest, Type II are intermediate in size and Type III the smallest.

It is therefore possible that all of the inclusions consist essentially of solid flux—either crystalline or vitreous. The amount of alumina dissolved in the flux, original size disparities between the inclusions and differences in cooling rates, could all contribute to the totally different visual characteristics of the three types of inclusions. There is no apparent evidence for the existence of liquid in any of the inclusions examined and described.

ACKNOWLEDGEMENT

The author wishes to thank Alan Hodgkinson for the loan of the Kashan ruby which is discussed in this paper.

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Nassau, K. 1980. *Gems Made by Man.* Chilton, Radnor, Pa.

[*Manuscript received 25th July, 1983.*]

IMPROVEMENTS ON THE RAYNER REFRACTOMETER

By R. M. YU, Ph.D., F.G.A., G.G.

Physics Dept., University of Hong Kong.

In the last few years I have had the pleasure of teaching hundreds of jewellery-trade people in practical gemmology. In our laboratory both the Rayner (S model) and the Duplex refractometers are provided for students' use. Most novices find the Rayner refractometer easier to use because they can read refractive index scale by just positioning their eyes close to the refractometer eyepiece. With the Duplex refractometer they have to position their eyes at a suitable distance by trial and error before a refractive index can be read. However, by the time they progress to the distant vision method (spot test) of measuring the refractive index of cabochons, they find the Duplex refractometer much easier to use. This is because the Duplex refractometer has a wider field of view of about thirty small divisions, corresponding to a refractive index range of 0.3. In contrast the field of view in the Rayner refractometer is only about four small divisions, corresponding to a refractive index range of 0.04. If the 'spot' does not lie near to any one of the marked scale reading 1.4, 1.5, 1.6, 1.7 and 1.8, the user cannot read the refractive index of the cabochon directly. Such a situation is indicated in Figure 1 where the field of view is shown by a dotted circle and the 'spot' is represented by an ellipse. We have overcome this inconvenience by placing a divergent lens on top of the eyepiece of the Rayner refractometer whenever the 'spot test' is conducted. With a divergent plano-concave lens of focal length -148 mm (Ref.1) the field of view can be increased to about nine small divisions, corresponding to a refractive index range of 0.09. One of the marked values of the refractive index scale will then fall inside the field of view.

Although the divergent lens can be used as it is, readers who have access to a mechanical workshop may wish to make a holder for the lens. We have constructed a holder to attach the divergent lens permanently to the refractometer eyepiece (Figure 2). With this

ISSN: 0022-1252 XIX (1) 62 (1984)

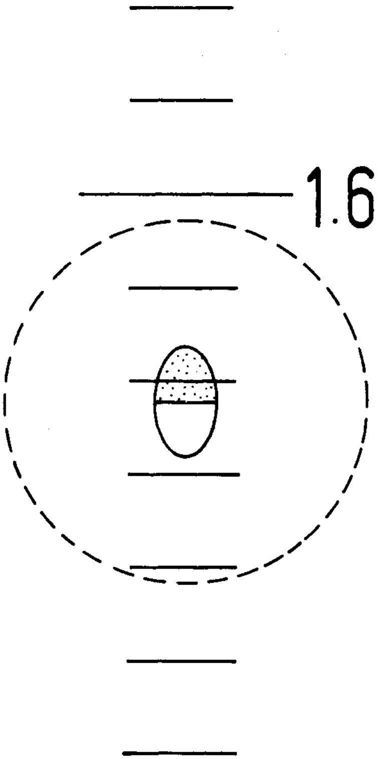

FIG. 1. Rayner refractometer 'spot test' field of view.

holder the divergent lens may be swung out of view when it is not required, thereby allowing either a polarizing or monochromatic filter to be placed on top of the refractometer eyepiece.

Another possible improvement on the Rayner refractometer concerns the yellow monochromatic filter supplied by the manufacturer. Such a filter is placed on top of the refractometer eyepiece to enable the refractive index to be read more accurately in monochromatic light. It is essential for determining the birefringence (double refraction) of faceted gems. Our experience shows that the yellow filters bought in 1978 are quite adequate but that those bought in later years are so dark as to transmit

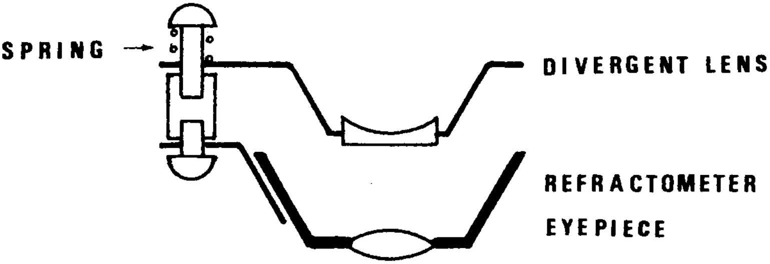

FIG. 2. Sketch of the divergent lens holder.

insufficient light for comfortable reading of refractive indices. We have now dispensed with these dark yellow monochromatic filters, and instead place a 589.6 nm interference filter (Ref.2) in front of either the ground glass window of the refractometer or the white light source, whichever is more convenient. White light from any incandescent lamp becomes a strong beam of yellow monochromatic light after passing through the 589.6 nm interference filter. The filter can be stuck on to the refractometer window with cellotape. Alternatively a holder made of aluminium sheet or even cardboard can be glued on to the refractometer to hold the interference filter. Then the filter may be installed or removed from the holder easily.

In conclusion I hope the manufacturer will incorporate the above mentioned features in their next generation of Rayner refractometers for users' convenience.

REFERENCES

1. Divergent lenses are available from Edmund Scientific Co., 101E Gloucester Pike, Barrington, N.J. 08007, U.S.A. #95,425 consists of two plano-concave lenses of focal length -148 mm and diameter 12 mm at total cost US$2.85.
2. Edmund Scientific Co. #30698 interference filter (589.6 nm) at US$16.75 each.

[*Manuscript received 4th February, 1983.*]

GEMMOLOGICAL ABSTRACTS

BANCROFT (P.). *Australia's black jade.* Lapidary J., **37**, 5, 700-14,22 figs (19 in colour), 1983.

A 'black' variety of nephrite has been found near Cowell, South Australia. Other colours, including a fine dark green, are also found in the area. General notes on the jade minerals are given. M.O'D.

BEASLEY (A. W.). *Australian topaz for faceting.* Australian Gem and Treasure Hunter, 82, 45-6, 1 fig., 1982.

A number of Australian topaz locations are described. M.O'D.

CASE (L. C.). *A lot of jadeite is an adventure in jade.* Lapidary J., **37**, 6, 840-54, 24 figs in colour, 1983.

Describes the sorting of a large quantity of jadeite and the criteria employed in selection of material for cutting. M.O'D.

CASSEDANNE (J. P.), CASSEDANNE (J. O.), VACHEY (H.). *L'axinite de la Lagoa da Tabua (District de Lagoa Real-Etat de Bahia-Brésil).* (Axinite of Lagoa da Tabua, district of Lagoa Real-Etat, Bahia, Brazil.) Anales, Academia Brasileira de Ciencias, **55**, 1, 93-103, 6 figs, 1983.

Axinite crystals said to be larger than those found at Santa Rosa (Bahia, Brazil) have recently been recovered from Lagoa da Tabua in the same state. The crystals occur in veins with andalusite, actinolite, calcite, quartz and feldspar. Some crystals exceed 20 cm in length. The iron content places the newly discovered material in the ferroaxinite category. M.O'D.

CHIRKIN (A. P.), PUSTYL'NIK (A. I.), KAPACHINSKAYA (O. G.). *The thermal field in a furnace for growing crystals by the Verneuil method.* Soviet physics—crystallography, **27**, 5, 592-5, 4 figs, 1982.

A method of studying the thermal field in a Verneuil furnace is suggested and the distribution of the particles of the charge in the burner flame in flow and temperature-rate change conditions is discussed. Changes in the charge flow rate noticeably affect temperature fluctuations at the crystallization front. M.O'D.

DALLOW (L.). *Pakistan.* Australian Gem and Treasure Hunter, 82, 26-31, 8 figs (6 in colour), 1983.

Interesting account of a recent visit to Pakistan. M.O'D.

DANIEL (P.). *Tiger eye gems machined by diamond.* Industr. Diamond Rev., 4/83, 184-5, 4 figs, 1983.

Advances in diamond tool technology and machining methods have resulted in the tiger-eye variety of quartz no longer being considered as a problem stone for cutting by the manufacturing jewellers. Fine-grade workable-quality tiger-eye is only found in South Africa, and government legislation prevents it from being exported except in the polished state. The polishing sequence now includes cutting the rough material into slabs using a diamond saw (taking careful account of the angle so as to exploit the material's chatoyancy) and then coring the slabs with a special diamond drill to produce cylindrical blanks. These blanks are next secured to dop pins and ground on a diamond-impregnated cabbing wheel to a preform shape. Finally, the preforms are tumble-polished in a vibratory lap using a conventional abrasive with water plus sawdust from a particular wood. The latter component is added as a 'cushion' to prevent stones from chipping or cracking each other. P.G.R.

DAY (E.). *Jade hunting in New Zealand.* Lapidary J., **37**, 5, 726-35, 10 figs, 1983.

Several areas of jade production in New Zealand are described. M.O'D.

GIPPIUS (A. A.), ZAITSEV (A. M.), VAVILOV (V. S.). *Formation, annealing and interaction of defects in ion-implanted layers of natural diamond.* Soviet Physics: Semiconductors. **16**, 3, 256-61, 8 figs, 1982.

Cathodoluminescence techniques were used to discover what the features of ion-implanted diamonds were. It is thought that the features could be explained using existing ideas on the properties of disordered regions created by ions. Nitrogen was found to have a specific influence on the formation of defects in ion-implanted layers. M.O'D.

HEYLMUN (E. B.). *Opal localities in west central Mexico.* Lapidary J., **37**, 4, 598-602, 1 map, 1983.

Deals with the opal-producing locality of Magdalena, west of the city of Guadalajara, Jalisco, Mexico. Some opal with blue and green coloration is found there. M.O'D.

HEYLMUN (E. B.). *Four opal localities in Mexico.* Lapidary J., **37**, 6, 880-2, 3 maps, 1983.

Two of the localities, the Jada opal district and La Curva opal district, are in the state of Nayarit; the other two, the Huanimaro and Penjamo opal districts, are in the state of Guanajuato. In all cases the opal occurs in a rhyolitic rock. M.O'D.

HUTCHINSON (J.). *Opal fever in the outback.* Reader's Digest, **123**, 737, 142-6, 2 figs in colour, 1983.

Brief and accurate account of opal mining in Australia. M.O'D.

KAMO (M.), SATO (Y.), MATSUMOTO (S.), SETAKA (N.). *Diamond synthesis from gas phase in microwave plasma.* J. Crystal Growth, **62**, 642-4, 3 figs, 1983.

Crystalline diamond has been grown on a non-diamond substrate from a gaseous mixture of hydrogen and methane. Microwave glow discharge conditions were used and the crystals showed predominantly {100} and {111} faces. M.O'D.

KOGO (K.). *Persian Gulf pearls.* Gemmological Review, **4**, 6, (English translation section) 1-5, 1982.

A brief history of pearl fishing and the Kuwait pearl market. M.O'D.

McMahon (B.). *Zircons from Lake Bullenmerri, Victoria.* Australian Mineralogist (bound with Australian Gem and Treasure Hunter No. 81, 1983), 42, 235-6, 3 figs, 1983.

Well-formed crystals of zircon showing a range of colour from pale orange-brown to straw, with some a pale greenish yellow to colourless, have been found on the shore of Lake Bullenmerri, Victoria, Australia. The crystals, many containing black inclusions of (?) allanite, occur in a heavy mineral sand layer. M.O'D.

Milledge (H. J.), Mendelssohn (M. J.), Seal (M.), Rouse (J. E.), Swart (P. K.), Pillinger (C. T.). *Carbon isotopic variation in spectral type II diamonds.* Nature, **303**, 791-2, 1 fig, 1983.

Type II diamonds measured for this study showed a carbon isotopic composition ($\delta\,^{13}$C values) of from −5 to −31.9‰. The composition for most diamonds falls in a range from −5 to −9‰. M.O'D.

Nogués Carulla (J. M.). *Obtención de gemas sinteticas.* (Obtaining of synthetic gemstones.) Gemologia, **16**, 53/54, 5-37, 5 figs, 1982.

Comprehensive survey of the synthetic gem field. M.O'D.

O'Donoghue (M.). *The dealer looks at gemstones—11.* Gems, **5**, 3, 16-17, 1983.

Price changes in ruby, emerald, sapphire, topaz, pearl and coral are discussed and notes given on the current state of the Brazilian market.

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

O'Donoghue (M.). *Some beryl minerals.* Gems, **15**, 3, 28-9, 1983.

Taaffeite, bromellite and the element beryl and its compounds are discussed.

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

O'Donoghue (M.). *Man-made gemstones.* Gems, **15**, 3, 34-5, 1983.

A previous account of the hydrothermal growth of quartz is continued and followed by discussion of the Knischka synthetic ruby, turquoise and emerald.

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

Read (P.). *Artificial enhancement of coloured gemstones.* Australian Gem and Treasure Hunter, 82, 49-50, 1 fig, 1983.

Summarizes the position in gemstone heating and irradiation. M.O'D.

Ritchie (C. I. A.). *Tortoiseshell jewellery.* Gems, **15**, 3, 8-11, 5 figs, 1983.

An introduction to the occurrence and fashioning of tortoiseshell. M.O'D.

Skalicky (J.). *Interesting opals from Czechoslovakia.* Lapidary J., **37**, 4, 578-84, 12 figs (11 in colour), 1983.

Describes opal occurrences in a number of Czech localities. In general the material is dendritic, banded or glassy rather than displaying a play of colour.

M.O'D.

Stuker (P.). *Mineralien mit seltenen Erden.* (Minerals with rare earths.) Schweizer Strahler, **6**, 7, 288-95, 6 figs, 1983.

Discusses the use of the spectroscope in identifying minerals with a rare earth content. M.O'D.

SUHNER (B.). *Bestimmung von Mineralien mit Infrarot-Spektroscopie.* (Identification of minerals with infrared spectroscopy.) Schweitzer Strahler, **6**, 7, 296-306, 8 figs, 1983.

The use of infrared identification techniques in mineral identification is discussed. M.O'D.

SWART (P. K.), PILLINGER (C. T.), MILLEDGE (H. J.), SEAL (M.). *Carbon isotopic variation within individual diamonds.* Nature, **303**, 793-5, 1 fig, 1983.

Sections of Type I diamonds were analysed to see if there was an intra-specimen variation in carbon isotopic content. In many cases a trend from the centre to the exterior was noted. Some samples showed cores enriched in ^{12}C whereas the edges became heavier. Controlled laser dissection was employed to show up the very small scale of internal structures during an effort made to pinpoint areas in individual stones which might have been formed in differing conditions. M.O'D.

TENNYSON (C.). *Granat von Bayerischen Fundstätten.* (Garnet from Bavarian localities.) Aufschluss, **34**, 275-85, 6 figs, 1983.

Analyses and crystal structure for a number of garnets from various locations in Bavaria are given. M.O'D.

THIMES (J. L.). *A simple polariscope and dichroscope combination.* Lapidary J., **37**, 4, 556-66, 14 figs, 1983.

Details are given of the method of making a combination dichroscope and polariscope at low cost. M.O'D.

ZAITSEV (A. M.), GIPPIUS (A. M.), VAVILOV (V. S.). *Luminescence of impurity-defect complexes containing nitrogen in ion-implanted layers of natural diamond.* Soviet Physics: Semiconductors, **16**,3, 252-6, 5 figs, 1983.

An examination by cathodoluminescence of diamond crystals with nitrogen impurities induced by ion implantation showed specific lines in the spectra. The lines were associated with complexes containing nitrogen atoms. M.O'D.

ZEITNER (J. C.). *Proctor's rough and cut collection.* Lapidary J., **37**, 4, 572-6, 5 figs in colour, 1983.

The Keith and Mauna Proctor collection of fine gem crystals is described. Mining anecdotes relating to some of the specimens are given. M.O'D.

ZEITNER (J. C.). *Iron in gems.* Lapidary J., **37**,5, 684-92, 11 figs, 1983.

Iron gem minerals and the role played by the element in coloration are discussed. M.O'D.

Gemstones of China. Gemmological Review, (page numbers in English translation section) (a) **4**, 7, 1-4; (b) **4**, 8, 1-4; (c) **4**, 9, 1-4; (d) **4**, 10, 1-5; 1982.

(a) The regions of China most likely to produce gemstones are listed. The original Japanese text includes a map. (b) Nephrite occurrences and uses are described. (c) Jade-like minerals and their occurrences are described. (d) Localities for fluorite, amber, pyrophyllite, andalusite, turquoise and pearl are given. M.O'D.

Indian gemstone localities. Gemmological Review, **4**, 11, (English translation section) 1-4, 1982.

General geological survey of India with reference to gem-producing areas. The original Japanese text includes a map. M.O'D.

Jewellery News Asia. Issue no. 1. Jewellery News Asia Ltd., Hong Kong, 1983. Annual subscription for U.K., £30.

A standard form journal with newspaper-type articles, brightly presented and illustrated. M.O'D.

The paradise of gems has still other surprises. Brazil Trade and Industry, **6**, 61, 23-6, 2 figs in colour, 1983.

Gives a short account of the present state of Brazilian gem production. M.O'D.

BOOK REVIEWS

ANDERSON (B. W.). See Webster (R.).

BARNETT (F.). *Opal and how to work it.* Gemcraft Publications Pty Ltd, East Malvern, Victoria, 1981. pp. iv, 60. Illus. in black-and-white. Price on application.

A practical and clearly-written booklet which would be useful to those able to buy rough and who wish to fashion it. Details of fashioning occupy the bulk of the book, but there is also a useful chapter on evaluating stones. I recommend this as a no-nonsense guide. M.O'D.

BLAKEMORE (K.). *The retail jeweller's guide.* 4th edn, Butterworths, London, 1983. pp. vii, 359. Illus. in black-and-white. £18.

It is always pleasing to see an old friend reappearing and in this case I have always regarded Blakemore as a perennial to which one could always turn when faced with the query that is just on the fringe of one's field (or completely out of it). The first edition of the *Guide* came out in 1969 and replaced Selwyn's *Retail Jeweller's Handbook,* which ran to a number of editions; I have the impression that the present work is to some extent streamlined and lacks the slightly garrulous air that the old *Handbook* used to have but I suppose that is a change for the better. In any case this is a good book; information is concisely presented and brought up to date, especially in areas where there have been changes in laws (hallmarking of platinum is an example). Some useful appendices and a good index complete a textbook which every student should have by them. M.O'D.

DIETRICH (R. V.), WICANDER (R.). *Minerals, rocks and fossils.* Wiley, New York, 1983. pp. 212. Illus. in black-and-white. £7.50.

This book forms part of the Wiley self-teaching guides series and aims to instruct the reader as he goes along. To this end each chapter closes with a set of questions (you cannot find the answers at the back of the book). Considerable assistance is given by text illustrations and the style is lucid. M.O'D.

EPSTEIN (E. J.). *The death of the diamond.* [Previously published under the title *Diamond invention.*] Sphere Books, London, 1983. pp. 270. £1.95.

The author summarizes the history of diamond mining and distribution with an attempt at a breakdown of the interlocking companies in which De Beers have an interest. It is not possible to say how accurate this breakdown is, nor to come to any conclusion about an argument put forward that a number of factors will eventually cause the breakdown of the system by which diamond prices are controlled. An index and chapter notes are provided. M.O'D.

MACINTOSH (E. K.). *Rocks, minerals and gemstones of Southern Africa.* 2nd edn, C. Struik, Cape Town, 1983. pp.120. Illus. in colour. £7.00.

Minerals from southern Africa (widely interpreted) are classed by their properties, rock types, and economic importance in this handy-sized guide. Colour reproduction is good and factual information reliable. It is good to see illustrations of specimens from Namibia as well as from the Republic. M.O'D.

READ (P. G.). *Gemmological instruments.* 2nd edn, Butterworths, London, 1983. pp. 328. Illus. in black-and-white. £20.

The main difference between the first and second editions of this excellent book is that the instruments reviewed are evaluated in this later volume. There are, too, many more of them. A comparative value guide to the instruments is another useful departure from previous practice. Experimental equipment and microphotography are covered and the author's own computer system for the identification of gemstones is outlined. A great deal of the equipment described is shown in photographs which have reproduced quite well; each chapter has a most useful bibliography, and there are tables and lists of suppliers at the end of the book. This work is now essential for all who need to test stones and is also a most enjoyable experience to read casually. M.O'D.

VOLLSTÄDT (H.), BAUMGARTEL (R.). *Edelsteine.* (Gemstones.) 2nd (revised) edn. VEB Deutscher Verlag für Grundstoffindustrie, Leipzig, 1982. pp. 260. Illus. in black-and-white and in colour. M32.80.

An extensive bibliography, good quality coloured pictures and an informative text make this an excellent introduction to the study of gemstones. A good deal of time has been spent on chasing up references, and the material is up to date. M.O'D.

WEBSTER (R.). *Gems, their sources, descriptions and identification.* 4th edn, revised by B. W. Anderson. Butterworths, London, 1983. pp. xxii, 1006. Illus. in black-and-white, with 17 coloured plates. £40.

This new edition of Webster's *magnum opus* has been brought up to date by B. W. Anderson, who, as was to be expected, has done his work well.

The general arrangement and a substantial amount of the text remains unchanged, though names of newly found occurrences are added and new discoveries are recorded at appropriate places throughout. Among new additions may be mentioned descriptions of Brazilian opal, charoite, crystalline (non-metamict) ekanite, diaspore, 'elephant pearls', 'Gilson created' coral and lapis lazuli, plastic imitation opal, prosopite, slocum stone, sogdianite, sugilite, synthetic opal and 'synthetic turquoise' (this list is far from exhaustive, and I regret that the wrongly formed name of one new gemstone has been given further currency as 'tsavorite'—backed up by the mis-spelling of 'Tsavo' as 'Tsavor'—despite the decision of C.I.B.J.O. in favour of the correctly formed 'tsavolite'.* Another addition is a lively account of de Boimenu's pre-1914 apparently successful and inexplicably ignored manufacture of diamonds (one of them large enough to be cut in Amsterdam as a tiny brilliant with 32 facets). Several methods of diamond growth other than that of the G.E.C. are described, and the present state of knowledge regarding both heat-treated sapphires and the absorption spectra and fluorescence of bombarded colour-changed diamonds is clearly summarized.

The Australian Kimberley (Ashton Joint Venture) diamond story is brought up to the end of 1982, which is remarkable in a book published early in 1983. The chapter on RI measurement has a re-written and extended section on refractometers and also includes 'relative reflectivity meters': these are followed by clear descriptions of thermal conductivity probes and the Gem Diamond Pen, in the same chapter since the prime use of these is likewise to distinguish diamond from its modern imitations. As Mr Anderson emphasizes in his Preface, these new instruments were the direct reply to the challenges of strontium titanate, of GGG and in particular of cubic zirconia as increasingly credible imitations of diamond: 'a full description of CZ and of these new instruments was obviously a foremost concern of this new edition.'

The publishers too have done their work well, so far as appearance and ease of handling are concerned. The text, now printed in clearer type, is much easier on the eye, and, although now 1028 pages in all as against the third edition's 949, the weight in the hand has been reduced by about 5 oz. (*ca.* 142g) without—it would seem—impairing in any way the strength of the volume. But even for these days they have permitted a quite unusually large number of misprints, mainly new misprints introduced into the parts copied verbatim from the previous edition, where there is least excuse for them: *per contra* some of the third edition's misprints are corrected, but it is sad that the misprinted 'parasite' (3rd edn, p. 671) having been corrected to 'parisite' (4th edn, p.771) the third edition's correct 'parisite' (p. 88) should have been misprinted 'parasite' in this fourth edition (p. 104).

The colour plates have been reduced from twenty-three to seventeen without loss of value. The five quite unsuitable and unhelpful photographs in the third edition adversely criticized by this *Journal's* reviewer† have been omitted, and for some of the good gemstone photographs, whose rather 'wooden arrangement' he also criticized, even better ones have been substituted. It is, however, a pity that in the captions of five of the retained plates the weights of the stones illustrated, given in the previous edition, have now been left out.

When I reviewed the first edition of Webster's *Gems* twenty-one years ago,‡ my main criticisms concerned matters of literary rather than gemmological

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J. Gemm.*, 1979, **XVI (8), 554.

†*J. Gemm.*, 1975, **XIV** (7), 350.

‡*J. Gemm.*, 1962, **VIII** (8), 306-8.

interest—lapses in style, misuse of words, misprints, etc.—and the only gemmological error to which I called attention was the inaccurate description of the monoclinic crystallographic axes: despite frequent reminders to the author this remained in his second and third editions, and I am sorry to see that it has survived unchanged into this fourth.

Nearly all the failings in this important work, however, are either matters of the original author's style of writing (Mr Anderson's contributions are recognizable as limpid pools of clarity amidst Mr Webster's sometimes rather turbid prose) or such as could and should have been eliminated in this or previous editions by knowledgeable and conscientious publishers' editors. Echoing what I wrote of the first, I can confidently say of this fourth edition that to the serious gemmologist it will be—like his microscope, his spectroscope and his refractometer—an indispensable tool and a valued possession. J.R.H.C.

Cristaux géants. (Giant crystals.) Hachette, Paris, 1983. pp. 77. Illus. in black-and-white and in colour. Fr45.

This attractive book summarizes a project conducted under the aegis of the Muséum National d'Histoire Naturelle in Paris, the aim being to preserve a representative collection of crystals of great size. Since so many very large crystals are cut up or ground down for a variety of purposes the acquisition by the Muséum of the Ilia Deleff collection was timely, since it contains 78 Brazilian specimens of sizes ranging from 200-400 kg, with other pieces of smaller size. The book discusses crystal formation and the setting up of the exhibition now at the Muséum. M.O'D.

ASSOCIATION NOTICES

OBITUARY

Mr Leslie Thomas Boxall, F.G.A. (D.1954), Kingston-upon-Thames, died on 30th August, 1983.

Mr David Lewis Jones, M.A., F.G.A. (D.1972 with Distinction), Kew, Richmond, died on 12th September, 1983.

GIFT TO THE ASSOCIATION

The Council of the Association is indebted to Dr Masahiro Hosaka, Yamanashi, Japan, for a scroll depicting a postal scene.

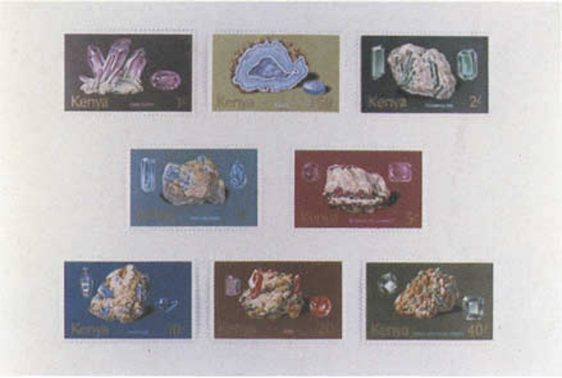
NEWS OF FELLOWS

At the First European Conference on Precious Stones, which took place in Antwerp, Belgium, on 21st-22nd October, 1983, Mr Peter G. Read, C.Eng., F.G.A., gave a talk on 'Diagnostic methods of distinguishing between natural and synthetic gemstones'.

MEMBERS' MEETINGS

London

On 19th October, 1983, at the Central Electricity Generating Board Theatre, Sudbury House, Newgate Street, London E.C.1., Mr Roy Huddlestone gave an illustrated lecture on Siberian diamonds. It is hoped that the substance of the lecture will be published in a future issue of the *Journal.* Before the lecture Mr Peter G. Read, C.Eng., F.G.A., presented to Mr Noel Deeks, F.G.A., the Vice-Chairman, on behalf of the Association, the thematic gem, mineral, mining and jewellery collection of postage stamps made by the late Mrs (Doreen) Read, and Mr Deeks expressed the thanks of the Association for this generous gift. A small cross-section of the collection is illustrated on p.74.



1. Part of a set of 15 stamps from Kenya (1978), illustrating amethyst, agate, tourmaline, aquamarine, rhodolite garnet, sapphire, ruby and green grossular garnet.

2. Set of six stamps from the U.S.S.R. (1963) with topaz, jasper, amethyst, emerald, ruby and malachite.

3. (Top) set of four stamps from Sri Lanka (1976) showing sapphire, cat's eye, star sapphire, ruby.; (Centre) three stamps from Brazil (1977)—emerald, topaz, and aquamarine.; (Bottom) Four stamps from Thailand (1972)—ruby, yellow sapphire, zircon, star sapphire.

Midlands Branch

On 28th October, 1983, at the Society of Friends, Dr Johnson's House, Bull Street, Birmingham, an illustrated talk was given by Mr Eric Bruton, F.G.A., entitled 'The wonder of diamonds'.

On 25th November, 1983, at the Society of Friends, a talk was given by Mr J. I. Reynolds, F.G.A., and Mr R. M. Wood, F.G.A., on the firm A. Ruppenthal, the well-known gem merchants.

North-West Branch

On 20th October, 1983, at Church House, 1 Hanover Street, Liverpool, the Annual General Meeting was held at which Dr John W. Franks, F.G.A., was elected Chairman and Mrs Edna Cartmel re-elected Secretary. The meeting was followed by a cheese and wine supper.

On 17th November, 1983, at Church House, Mr Alec Farn, F.G.A., gave a talk entitled 'Jade and jade-like minerals'.

South Yorkshire & District Branch

On 18th October, 1983, at the Sheffield City Polytechnic, Detective Inspector Wilde of the South Yorkshire Police gave a talk on crime prevention.

COUNCIL MEETING

At the meeting of Council held on Thursday, 29th September, 1983, at the Royal Automobile Club, London, S.W.1, the business transacted included the election to membership of the following:

FELLOWSHIP

Aburrow, Michael B., Wimborne. 1983
Alva, Shyamala J., Bombay, India. 1982
Askew, Mark A., Bristol. 1983
Axon, Martin W., London. 1983
Barnard, Stephen J., Theydon Bois. 1983
Bercott, David S., Glasgow. 1983
Bienert Albaladejo, Rosario, Barcelona, Spain. 1977
Bird, Nigel G. D., Epsom. 1983
Bishop, Ian C., London. 1983
Bisset, Ross, London. 1983
Bugg, John R., Wolverhampton. 1983
Chow, Herman K. M., Hong Kong. 1983
Cloke, Debbie H. N., Hong Kong. 1983
Collins, Glen M., Glasgow. 1983
Condrup, Jonathan R., London. 1983
Darmudas, Nat, London. 1983
Davies, Stephen, Wallsend. 1983
Doughty, Michelle S., Wembley. 1983
Eadie, John, Glasgow. 1983
Firth, Barbara, London. 1983
Fitzgerald, Leslie E., Stanmore. 1983
Flower, Jonathan S., Knutsford. 1983
Fonseka, Ruwan K. M., Colombo, Sri Lanka. 1982
Garrod, Douglas J., Exeter. 1983
Gavin, Sandra R., Thornton Heath. 1983
Gilliland, Hilary L., Newtownabbey, N. Ireland. 1983
Gilmour, Kevin D., Sheffield. 1983
Goodland, John R., Gstaad, Switzerland. 1983

Greatwood, John, Mitcham.	1983
Groom, Peter J., Luton.	1983
Hayes, Anne-Maria, London.	1983
Holness, Neil P., London.	1983
Houghton, Mark W., Poynton.	1983
Hu, Shirley S., Oxford.	1983
Huddy, William R. H., Newton Abbot.	1983
Hurst, Patricia H., Carradale.	1983
Konrath, Anthony M., Richmond.	1983
Krot, Johannes H., Amstelveen, Netherlands.	1983
Lumley, John S. P., London.	1983
McFarlane, Patricia A., London.	1983
McNair, George A., Newcastle upon Tyne.	1983
Ma, Chi Wing C., Hong Kong.	1983
Matthys, Nigel J., Ickenham.	1983
Mehta, Anoop K., London.	1983
Mizrahi, David A. S., Frankfurt, W. Germany.	1983
Mok, Dominic W. K., Hong Kong.	1982
Morling, Anthony J. D., St Mary, Jersey, C.I.	1983
Munster, Sarah H., London.	1983
Nash, Isobel M., Watford.	1983
Orchant, Lewis, Glasgow.	1983
Park, Stephen W., Romford.	1983
Pedersen, Julie, Liverpool.	1983
Purcell, Ian R., Dunstable.	1983
Rennie, Margaret M., Bothwell.	1983
Richardson, William F., Northwich.	1983
Roberts, Kassandra M., Bromborough.	1983
Schurch, Marie-Louise, Geneva, Switzerland.	1983
Sealey, Ralf E., London.	1983
Shapland, Leonora A., London.	1983
Shotton, Dominic E. J., Tring.	1983
Smith, Ian J., Rochdale.	1983
Styles, Suzanne S., Christchurch.	1983
Sutton, Janine R., Birmingham.	1983
Tam, David C. C., Hong Kong.	1982
Taub, Giselle-Karen, London.	1983
Tong, Ka-Shing, Hong Kong.	1983
van den Arend, Willem A., Rotterdam, Netherlands.	1983
Vaughan, Malcolm J., London.	1983
Wells, Bruce I., Glasgow.	1983
Wiesauer, Georg, Graz, Austria.	1983

TRANSFERS FROM ORDINARY MEMBERSHIP TO FELLOWSHIP

Abrami, Aurelio G., Milan, Italy.	1983
Amoroso, Robert E., Boston, Mass, U.S.A.	1983
Ashworth, Ian E., Bristol.	1983
Attwell, William G., Toronto, Ont., Canada.	1983
Balderston, Catriona I., London.	1983
Baxter, Gordon E., Whangarei, N.Z.	1983
Berthelsen, Lawrence J., Townsville, Qld, Australia.	1983
Carvey, Robyn, Hong Kong.	1983
Chow, Lorraine M., Hong Kong.	1983
Clark, Patricia M., Hong Kong.	1983
Clarke, Norman V., Blandford Forum.	1983
Cottafavi, Aliette, Geneva, Switzerland.	1983
Deer, Georgina, Salford.	1983
Demoray, Scott B., Grand Rapids, Mich., U.S.A.	1983
Denney, Shane S., Jacksonville, Ill., U.S.A.	1983
Eckley, Gareth D., Brecon.	1983
Eisenburger, Sabine F., Vienna, Austria.	1983
Elias, Abdul H., London.	1983
Gimpel, Remy F., London.	1983
Glaholm, Janice A., Paris, France.	1983
Greig, Edward S., London.	1983
Harre, Hendrik, Berchem, Belgium.	1983

Hee, Vincent Kim San, Singapore. 1983
Hegarty, Kathleen M., New York, N.Y., U.S.A. 1983
Hills, Gavin A., Moonah, Tas., Australia. 1983
Horne, Allan R., Brighton. 1983
Iber, Beverley A., Peoria, Ill., U.S.A. 1983
Imai, Seiichi, Fukuoka-Shi, Japan. 1983
Imazawa, Satoru, Ichikawa City, Japan. 1983
Itoh, Yasuhiro, Osaka, Japan. 1983
John, Bryan C., Carmarthen. 1983
Kanô, Mieko, Fukuoka City, Japan. 1983
Karpelowsky, Raymond, London. 1983
Kennedy, Muriel D., Toronto, Ont., Canada. 1983
Khanna, Atul, Birmingham. 1983
King, Clive H. M., Tsumeb, Namibia. 1983
Klauda, Frank P., Rochester, Minn., U.S.A. 1983
Kok-Visser, Astrid S., Nairobi, Kenya. 1983
Kwan, Ng Yue Yuk I., Hong Kong. 1983
Lee, Robert C. S., Hong Kong. 1983
Lemen, John R., Long Beach, Ca, U.S.A. 1983
Liggett, Sonia A. M., Cardiff. 1983
Lu, Milton R. K., Taipei, Taiwan. 1983
Ma, Lisa L. H., Hong Kong. 1983
Mainwaring-Burton, Jeremy J., Johannesburg, S. Africa. 1983
Marczycha, Michael J., Leeds. 1983
Mayer, Anton S., St Saviour, Jersey, C.I. 1983
Maynard, Mavis A., Sturminster Newton. 1983
Miyata, Takeshi, Yamanashi, Japan. 1983
Monnas, Maria L., Mombasa, Kenya. 1983
Mouzannar, Nabil I., Beirut, Lebanon. 1983
Munday, John J., Eltham, Vict, Australia. 1983
Nakamura, Midori, Ichikawa City, Japan. 1983
Nawaz, Rab, Belfast, N. Ireland. 1983
Ninomiya, Mutsuko, Yamanashi-Ken, Japan. 1983
Nitta, Hisako, Tokyo, Japan. 1983
Nomura, Shoji, Kyoto City, Japan. 1983
Poon, Eileen O. W., Hong Kong. 1983
Pritchard, Janet M., London. 1983
Quinn, Patrick Damian, Sacramento, Ca, U.S.A. 1983
Raney, Gerard E., Redwood City, Ca, U.S.A. 1983
Risbridger, Anne, Redhill. 1983
Rouse, Kenneth A., Newton Abbot. 1983
Segreti, Adolfo F., Reggio Emilia, Italy. 1983
Sivarajasingham, T. S., Ipoh, Perak, W. Malaysia. 1983
Soanes, Stuart E., Oakville, Ont., Canada. 1983
Soni, Anu, London. 1983
Stroud, Louise M., Harrogate. 1983
Subramaniam, Manoharan, Farnborough. 1983
Tai, Joyce C. S., Hong Kong. 1983
Tazaki, Noriko, Tokyo, Japan. 1983
Tazaki, Yasuko, Tokyo, Japan. 1983
Terauchi, Toshihiro, Kyoto, Japan. 1983
Termier, Jean-Pierre, London. 1983
Toughlouian, Grégoire, Chaville, France. 1983
Tsui, Sunny K., Hong Kong. 1983
Unwin, Christine, Greenford. 1983
Van Haaren, Mariette M., Hong Kong. 1983
Verheij, Elizabeth C. M., Vlaardingen, Netherlands. 1983
Ward, Edmund, Thirsk. 1983
Watson, Pauline E. A., Dorking. 1983

Weir, Juliet C. E., Dublin, Ireland. 1983
Wetten, Veronica F. K., Hong Kong. 1983
Williams, Kevin G., Cowbridge. 1983
Worden, Robert J., Blackpool. 1983
Wykoff, Dale E., Frederick, Md, U.S.A. 1983
Yamaguchi, Maki, Fukuoka City, Japan. 1983
Yamazaki, Hideki, Shimizu City, Japan. 1983
Young, William R., London. 1983

ORDINARY MEMBERSHIP

Ambrose, Ella P., London.
Ambrose, Thomas A., London.
Babnik, Frenk, Ndola, Zambia.
Barr, Norma E., Toronto, Ont., Canada.
Beldan, John G., Rotherham.
Bell, Rhonda S., Leavenworth, Kans., U.S.A.
Benedict, Patrick F., Seattle, Wash., U.S.A.
Bonn, Marc A., Kenosha, Wis., U.S.A.
Brown, Delmer L., Lakewood, Colo, U.S.A.
Burda, John S., Unionville, Conn., U.S.A.
Burman-Roy, Kumar, Glasgow.
Butland, Peter S., Pietermaritzburg, S. Africa.
Bydairk, Walter J., Ballston Spa, N.Y., U.S.A.
Carle, Alison E., Strathaven.
Carpenter, Dawn, Fleet.
Carthy, Patrick C., Dublin, Ireland.
Cattermole, Mavis E., Nairobi, Kenya.
Clench, Terry A., Mevagissey.
Cogswell, Jill D., Taupo, N.Z.
Conde Casado, Juan M., Sevilla, Spain.
Credland, Earl D., San Diego, Ca, U.S.A.
Digioia, Lisa M., Murrysville, Pa, U.S.A.
Dodson, Michael J., Plymouth.
Donnelly, Catherine B., Brighton, Mass, U.S.A.
Durrant, Roger W., Portsmouth.
Dyson, Esme C., Bangor.
Fitzgerald, Jennifer, London.
Franklin, June H., San Diego, Ca, U.S.A.
Fry, Kate E., Bath.
Furuya, Kimiko, Yamanashi-Ken, Japan.
Goldschmidt, Marina V., Charl, Denmark.
Gray, William D., Bangkok, Thailand.
Grinberg-Rabow, Andrew, Beverley Hills, Ca, U.S.A.
Gruys, Lorraine G., Santa Monica, Ca, U.S.A.
Guinand, François, Neuchatel, Switzerland.
Halford, James T., Northampton.
Harding, Keith J., Worcester, Mass, U.S.A.
Hardy, Joan A., London.
Heller, E. Michael, West Babylon, N.Y., U.S.A.
Higgins, Bruce I., Santa Monica, Ca, U.S.A.
Hishinuma, Mary, Chicago, Ill., U.S.A.
Hughes, Lyn, Angmering on Sea.
Hunt, John L., Lima, Peru.
Jefferies, Ahmed D., Mombasa, Kenya.
Jewell, Norman E., Sydney, Australia.
Johnstone, Frank E., Vienna, Md, U.S.A.
Jones, Michael H., Northampton.
Kahn, Stanley B., Pine Bluff, Ark., U.S.A.

Kawamoto, Midori, Hong Kong.
Kochhar, Narinder J., London.
Lance, Kay C., London.
Larson, Len, Thornton, Colo, U.S.A.
Leiberg, Cara B., Bordentown, N.J., U.S.A.
Ly, Khai, Cabramatta, N.S.W., Australia.
McKee, Marjie, Harrogate.
Malmstrom, Georgina, Upplandsvasby, Sweden.
Mealey, Clive J., Brixham.
Melvyn-Taylor, Michael, Bath.
Metcalfe, Audrey M., Tewkesbury.
Middleton, John C., Bath.
Minehan, Robyn G., Rooty Hill, N.S.W., Australia.
Miyayake, Toyoko, Osaka, Japan.
Mizobata, Kazumi, Gobo City, Japan.
Moore, Elaine P., Oslo, Norway.
Nootenboom, Rosanna L., Hong Kong.
Nuntapanish, Luz, London.
Oh, Wilhelmina, Hong Kong.
Paul, Joseph V., Tacoma, Wash., U.S.A.
Puig-Doria Pala, Jose M., Barcelona, Spain.
Rawson, Anthony, Bristol.
Reddy, James J., Carlow.
Reed, Paul R., Hamilton, N.Z.
Reyman, Mark E., Mount Vernon, N.Y., U.S.A.
Richards, Colleen H., Hong Kong.
Rockwell, Alan M., Southfield, Mich., U.S.A.
Sambandan, Vedagiri T., Singapore, Singapore.
Sauer, Daniel A., Rio de Janeiro, Brazil.
Shearer, John D., Toronto, Ont., Canada.
Shyrock, Charles L., Malvern, Ark., U.S.A.
Stather, Memory H., Hong Kong.
Steil, Patricia, Hong Kong.
Strogen, Charles E., Dover, N.H., U.S.A.
Sweeney, Noel V., Sydney, N.S.W., Australia.
Szeto, Raymond, Hong Kong.
Tailor, Jay, Gillingham.
Tankosic, M., St Catharines, Ont., Canada.
Taylor, Caroline H., Ripley.
Tolani, Nandlal P., London.
Toledo, Suzanne, Hong Kong.
Troilett, Esther L., Harare, Zimbabwe.
Watson, Charles E., Kimberley, S. Africa.
Watts, Peter J., St Austell.
Weatherley, Julie L., Sandhurst.
Welsh, Joseph C., London.
Wildi, Miranda J., London.
Winckler, Patricia J., Lakewood, Colo, U.S.A.
Young, Patrick P., Hong Kong.
Yuo, Toshio, Tokyo, Japan.
Zavahir, Izmeth A., Dehiwela, Sri Lanka.

GEM DIAMOND EXAMINATION, 1983

In the Post-Diploma Gem Diamond Examination fifty-four candidates sat and all succeeded in passing, four with Distinction. The following is a list of the successful candidates arranged alphabetically.

QUALIFIED WITH DISTINCTION

Ansell, Martin F., London.
Capella Tomas, Ma Josefa, Barcelona, Spain.
Elvidge, Caroline A., London.
Ickowicz, Steven, London.

QUALIFIED

Ainsworth, Nicola L. A., London.
Anderton, Duncan Mac G., Glasgow.
Arbestain Ribas, Inmaculada, Barcelona, Spain.
Ariyaratna, Don H., London.
Arjalaguer Vilardell, Daniel, Barcelona, Spain.
Blackshaw, Cheryl K., Alderley Edge.
Bosch Senao, Ma del Pilar, Barcelona, Spain.
Brown, Harold G., Glasgow.
Cabanas Casas, Terencia, Barcelona, Spain.
Domenech Casellas, Ma Victoria, Barcelona, Spain.
Faller, Noel P., Londonderry, N.Ireland.
Ferguson, William F., Balloch.
Fernandez Nunez, Carlos Luis, Barcelona, Spain.
Fookes, Mark H., Brentwood.
Garrigos Fernandez, Ma Jose, Barcelona, Spain.
Gettings, Barbara A., London.
Goeritz, Louise C., London.
Good, Amanda G., London.
Greatwood, Sheila O., Mitcham.
Griffiths, Paul A., Sutton Coldfield.
Hardy, Joanna, London.
Henderson, Shirley W. A., Hamilton.
Illueca Domenech, Enrique, Barcelona, Spain.
Jackson, C. P., London.
Kennedy, Stephen J., London.
Langford, Michael L., Hereford.
Little, Derek, Monifieth.
MacDonald, Roy W., Selsdon.
McEwan, Robert S., Perth.
Mantecon Burgos, Jesús, Barcelona, Spain.
Marti Beltram, José Ma, Barcelona, Spain.
Mellows, Jacqueline M., Bexleyheath.
Miralles Morey, José Luis, Barcelona, Spain.
Mora Balcells, Helena, Barcelona, Spain.
Nooten-Boom, Apollonius, II, Kingsland.
Novejarque Lopez, M. del Carmen, Barcelona, Spain.
Parker, Hazel, Macclesfield.
Perez Segarra, Montserrat, Barcelona, Spain.
Perrett, Roy, Manchester.
Schofield, Nicola J., Huddersfield.
Selmon, Simon, Northwood.
Shenker, Ian L., Edgware.
Soriano Meler, Esther, Barcelona, Spain.
Stears, Trevor W., Bromley.
Taank, Ashok P., London.
Vidal Noguera, Francisco, Barcelona, Spain.
Watson, Gordon, Lanark.
Wake, Barry A., Sidcup.
Walters, Raymond J. L., London.
Wilkie, William, Helensburgh.

EXAMINATIONS IN GEMMOLOGY, 1983

In the 1983 Examinations in Gemmology, 544 candidates sat the Diploma Examination and of these 277 succeeded in passing, 23 of them with Distinction. In the Preliminary Examination 665 sat and 400 passed.

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

The Anderson/Bank Prize for the best non-trade candidate of the year in the Diploma Examination was awarded to Mr Douglas Andrew Bagnall, of Don Mills, Ontario, Canada.

The Rayner Diploma Prize for the best candidate of the year whose main income is derived from activities essentially connected with the jewellery trade was awarded to Mr Patrick Damian Quinn, of Sacramento, California, U.S.A.

The Anderson Medal for the best candidate of the year in the Preliminary Examination was awarded to Mrs Fiona Ann Quick, of Harare, Zimbabwe.

The Rayner Preliminary Prize for the best candidate of the year under 21 years of age whose main income is derived from activities essentially connected with the jewellery trade was awarded to Mr John Paul Eldred Chieveley-Williams, of Poole, Dorset.

The following are lists of the successful candidates arranged alphabetically.

DIPLOMA EXAMINATION

Anderson/Bank Prize

Bagnall, Douglas Andrew, Don Mills, Ont., Canada.

Rayner Diploma Prize

Quinn, Patrick Damian, Sacramento, Ca, U.S.A.

QUALIFIED WITH DISTINCTION

Ashworth, Ian E., Bristol.
Bagnall, Douglas Andrew, Don Mills, Ont., Canada.
Berthelsen, Lawrence J., Townsville, Qld, Australia.
Castell Andujar, Joaquin, Barcelona, Spain.
Chow, Herman K. M., Hong Kong.
Chu, Hong-Sung, Taipei, Taiwan.
Goodland, John R. S., London.
Hegarty, Kathleen M., New York, U.S.A.
Holness, Neil P., Bath.
Lowes, Elizabeth H., Toronto, Ont., Canada.
McLean, Donald P., Toronto, Ont., Canada.
Marczycha, Michael J., Leeds.
Moreno Valero, Eloy, Barcelona, Spain.
Noguera Borel, Inés, Barcelona, Spain.
Poon, Eileen Oi-Wan, Hong Kong.
Quinn, Patrick Damian, Sacramento, Ca, U.S.A.
Rhodes, Alexandra M., London.
Soanes, Stuart E., Oakville, Ont., Canada.
Taub, Giselle-Karen, London.
Terauchi, Toshihiro, Kyoto, Japan.
van Haaren, Mariette M., Rotterdam, Netherlands.
Wetten, Veronica F. K., Hong Kong.
Worden, Robert J., Blackpool.

QUALIFIED

Abrami, Aurelio G., Milan, Italy.
Aburrow, Michael B., Wimborne.
Amoroso, Robert E., Winchester, Mass, U.S.A.
Anand, Sumedha, Bombay, India.
Askew, Mark A., Bristol.
Attwell, William G., Toronto, Ont., Canada.
Avargues Perles, Antonia, Barcelona, Spain.
Axon, Martin W., London.
Balderston, Catriona I., London.
Bank, Monika I., Idar-Oberstein, W. Germany.
Barnard, Stephen J., Theydon Bois.
Basnayake, Senarath B., Katugastota, Sri Lanka.

Baxter, Gordon E., Whangarei, N.Z.
Beattie, Roy A., Jimboomba, Qld, Australia.
Bercott, David S., Glasgow.
Berger, Nicholas H. M., Woerden, Netherlands.
Bird, Nigel G. D., Ewell.
Bishop, Ian C., Norwich.
Bisset, Ross, London.
Blankestijn, Janna G., Leersum, Netherlands.
Block, Rachel J. K., London.
Bonham, Frank C., Newport Beach, Ca, U.S.A.
Brand, Lester J., Stellenbosch, S. Africa.
Bugg, John R., Wolverhampton.
Carvey, Robyn, Hong Kong.
Chamberlain, Roger P., Belfast, N. Ireland.
Chant, Joanna K., Dorchester.
Cheong, Lai W., Hong Kong.
Chow, Lorraine M., Hong Kong.
Clark, Patricia M., Hong Kong.
Clarke, Norman V., Winterborne Kingston.
Cloke, Debbie H. N., Hong Kong.
Collado Castelles, Ma Dolores, Barcelona, Spain.
Collins, Glen M., Glasgow.
Condrup, Jonathan R., London.
Cottafavi, Aliette, Geneva, Switzerland.
Dam, Hedwig M., Nijmegen, Netherlands.
Darmudas, Nathaniel R., London.
Davies, Stephen, Wallsend.
Deer, Georgina, Manchester.
Demoray, Scott B., Grand Rapids, Mich., U.S.A.
den Hartog, Maria J. M., Baarn, Netherlands.
Denney, Shane S., Jacksonville, Ill., U.S.A.
de Swart, Johannes G. M., Wÿchen, Netherlands.
de Vries, Jacqueline A., The Hague, Netherlands.
Dings, Christianne A. M., Valkenswaard, Netherlands.
Dorren, Margot S. C., Lopik, Netherlands.
Doughty, Michelle Suzanne, London.
Dykstra, Jeannine B., Toronto, Ont., Canada.
Eadie, John, Cambuslang.
Ebert, Gabriela E., Heidelberg, W. Germany.
Eckley, Gareth D., Talgarth.
Eisenburger, Sabine F., Vienna, Austria.
Elias, Abdul H., London.
Elsten, Antonius R. M., Rucphen, Netherlands.
Emerson, Michael E., London.
Feather, Russell C., II, Fairfax, Va, U.S.A.
Firth, Barbara, London.
Fitzgerald, Leslie E., Stanmore.
Flower, Jonathan S., Plumley.
Floyd, Nancy E., Toronto, Ont., Canada.
Fretzin, Leonard H., Chicago, Ill., U.S.A.
Garcia Gisbert, Rocio, Barcelona, Spain.
Garrod, Douglas J., Exeter.
Gavin, Sandra R., Thornton Heath.
Genis Perez, Manuel, Barcelona, Spain.
Gilliland, Hilary L., Newtownabbey, N. Ireland.
Gilmour, Kevin D., Sheffield.
Gimpel, Remy F., London.
Glaholm, Janice A., Paris, France.
Gonzalez Violan, Francesc, Barcelona, Spain.
Greatwood, John, London.
Greig, Edward S., London.
Groom, Peter J., Luton.
Grootswagers, Johannes P. J., Breda, Netherlands.
Guerrero Ramon, Desamparados, Barcelona, Spain.
Harre, Hendrik, Berchem, Belgium.
Haughton, Michael, Bolton.

Hayes, Anne-Maria, London.
Hee, Vincent Kim San, Singapore.
Helton, Janet L., Toronto, Ont., Canada.
Hillgarth, Antonella C., Geneva, Switzerland.
Hills, Gavin A., Hobart, Tas., Australia.
Hindley, Angela, Bromborough.
Hiwale, Shyla H., Bombay, India.
Hollis, Patricia A., New York, U.S.A.
Horne, Allan R., Brighton.
Houghton, Mark W., Stockport.
Hu, Shirley S., Oxford.
Huddy, William R. H., Newton Abbot.
Hurst, Patricia H., Carradale.
Hutchings, Trevor J., St Peter, Jersey, C.I.
Iber, Beverly A., Peoria, Ill., U.S.A.
Imai, Seiichi, Fukuoka, Japan.
Imazawa, Satoru, Chiba, Japan.
Inoue, Yoshie, Tokyo, Japan.
Itoh, Yasuhiro, Osaka, Japan.
Jashnani, Navin B., Bombay, India.
Jennings, Joan M., Durban, S. Africa.
John, Bryan C., Carmarthen.
Jongstra, Femia E. E. M., Schoonhoven, Netherlands.
Kadota, Hiroka, Sapporo City, Japan.
Kanô, Mieko, Fukuoka Pref, Japan.
Kaper, Robert C., Washington, D.C., U.S.A.
Karmakar, Sambhunath N., Bombay, India.
Karpelowsky, Raymond, London.
Kennedy, Muriel D., Toronto, Ont., Canada.
Khanna, Atul, Birmingham.
King, Clive H. M., Tsumeb, Namibia.
Kjellin, Ewa B., Umea, Sweden.
Klauda, Frank P., Rochester, Minn., U.S.A.
Kok-Visser, Astrid S., Nairobi, Kenya.
Kong, Chor K., Hong Kong.
Konrath, Anthony M., London.
Kozen, Shigekazu, Wakayama City, Japan.
Krikos, Alexandra A., Athens, Greece.
Krot, Johannes H., Amselveen, Netherlands.
Kwan, Irene N. Y. Y., Hong Kong.
Kwok, Addy S. C., Hong Kong.
Laitinen, Mauri P., Hameenlinna, Finland.
Lam, Leung K. L. C., Hong Kong.
Lee, Jeffrey K., Don Mills, Ont., Canada.
Lee, Robert C. S., Hong Kong.
Lemen, John R., Long Beach, Ca, U.S.A.
Letros, Tony G., Scarborough, Ont., Canada.
Lette, Edward C. G., Amsterdam, Netherlands.
Liggett, Sonia A. M., Cardiff.
Lloyd, Stephen R., London.
Lu, Milton R. K., Taipei, Taiwan.
Lumley, John S. P., London.
Ma, Claudio C. W., Hong Kong.
Ma, Lisa L. H., Hong Kong.
McCornack, Constance B., Vashon, Wash., U.S.A.
McFarlane, Patricia A., London.
McGorrian-Morgan, Pauline J., Downpatrick, N. Ireland.
McNair, George A., Newcastle upon Tyne.
Mahajan, Maryada D., Bombay, India.
Mainwaring-Burton, Jeremy J., London.
Majeed, Ismath A. M. M., Colombo, Sri Lanka.
Mascetti, Daniela, Varese, Italy.
Mata, Carmen, Barcelona, Spain.
Matthys, Nigel J., Ickenham.
Mayer, Anton S., St Saviour, Jersey, C.I.
Maynard, Mavis A., Stalbridge Weston.
Mehta, Anoop K., London.

Merchant, Sandhya J., Bombay, India.
Miyata, Takeshi, Kofu, Japan.
Mizrahi, David A. S., New York, U.S.A.
Mohideen, H. M. Sultan, Madras, India.
Monnas, Maria L., Mombasa, Kenya.
Moore, Stephen S., Los Angeles, Ca, U.S.A.
Morling, Anthony J. D., St Mary, Jersey, C.I.
Mouzannar, Nabil I., Beirut, Lebanon.
Munday, John J., Eltham, Vict., Australia.
Munster, Sarah H., London.
Murakami, Kazuo, Osaka, Japan.
Nakamura, Midori, Chiba Pref., Japan.
Nash, Isobel M., Watford.
Nawaz, Rab, Belfast, N. Ireland.
Nikiforides, Constantine W., Brisbane, Qld, Australia.
Nikiforides, Tina, Brisbane, Qld, Australia.
Ninomiya, Mutsuko, Kofu, Japan.
Nitta, Hisako, Tokyo, Japan.
Nomura, Shoji, Kyoto, Japan.
Obbink, Gertrude J., Schoonhoven, Netherlands.
Orchant, Lewis, Glasgow.
Palomaki, Jukka A. J., Katinala, Finland.
Pandya, Manoj K., Bombay, India.
Park, Stephen W., Romford.
Pattani, Hitesh K., Bombay, India.
Pedersen, Julie, Formby.
Percival, Colin A., Sheffield.
Pitt, John R., Stourbridge.
Ponn, Roger E. F., Tulsa, Okla, U.S.A.
Pothof, Helga, Wageningen, Netherlands.
Pritchard, Janet M., London.
Punchihewa, Leslie J., Ratnapura, Sri Lanka.
Purcell, Ian R., Rugby.
Rajayohan, Rasiah, Colombo, Sri Lanka.
Ramaiya, Rajendra D., Bombay, India.
Raney, Gerard E., Redwood City, Ca, U.S.A.
Rennie, Margaret M., Bothwell.
Richards, David, Nottingham.
Richardson, William F., Northwich.
Rikkoert, Abraham, Schoonhoven, Netherlands.
Risbridger, Anne, Nutfield.
Roberts, Kassandra M., Bromborough.
Rouse, Kenneth A., Newton Abbot.
Ruest, Andre E., Gloucester, Ont., Canada.
Rugg-Gunn, Naomi E., Tewkesbury.
Ruiz Vazquez, Ma Cristina, Barcelona, Spain.
Rustwijk, Monique J., Zoetermeen, Netherlands.
Sakita, Yoshizo, Tokyo, Japan.
Sanchez Rodriguez, Raúl de J., Barcelona, Spain.
Sasaki, Mitsuo, Ibaragi City, Japan.
Schurch, Marie-Louise, Geneva, Switzerland.
Sealey, Ralf E., London.
Segreti, Adolfo, F., Paola, Italy.
Shapland, Leonora A., London.
Shaw, C. Helen, Toronto, Ont., Canada.
Shinoda, Keiko, Tokyo, Japan.
Shotton, Dominic E. J., Tring.
Sivarajasingham, T. S., Kelang, W. Malaysia.
Smith, Edward, Vineland, Ont., Canada.
Smith, Ian J., Whitworth.
Smith, Ronald G., Nottingham.
Soni, Anu, London.
Soni, Sara, London.
Spengler, William H., Bangkok, Thailand.
Steil, Patricia, Hong Kong.
Stroud, Louise M., Harrogate.
Styles, Suzanne S., Christchurch.

Subramanian, Manoharan, Farnborough.
Suenaga, Eiji L., Los Angeles, Ca, U.S.A.
Sutton, Janine R., Birmingham.
Swaders, Leonardus A. S., Enschede, Netherlands.
Tai, Joyce C. S., Hong Kong.
Tazaki, Noriko, Tokyo, Japan.
Tazaki, Yasuko, Tokyo, Japan.
Termier, Françoise, London.
Termier, Jean-Pierre, London.
Tong, Ka-Shing, Hong Kong.
Topitz, Ursula A., Colombo, Sri Lanka.
Toughlouian, Grégoire, Chaville, France.
Triantaphyllides, Zoe M., Athens, Greece.
Tsui, Sunny K., Hong Kong.
Unwin, Christine, Greenford.
Valls Bascu, Joaquin, Barcelona, Spain.
van den Arend, Willem A., Rotterdam, Netherlands.
van Loenen, Willem J., Lopik, Netherlands.
van Soest, Wilhelmina N. M., Wychen, Netherlands.
van Stokkom, Francis A. J. A., Dongen, Netherlands.
Vaughan, Malcolm J., London.
Vedeler, Nina, Baerum, Norway.
Verheij, Elizabeth C. M., Vlaardingen, Netherlands.
Virani, Nilesh A., Bombay, India.
Ward, Edmund, Thirsk.
Watson, Pauline E. A., Dorking.
Weir, Juliet C. E., London.
Wells, Bruce I., Glasgow.
Wennberg, Mats T., Stockholm, Sweden.
Weyn Banningh, Thomas F. M., Groenlo, Netherlands.
White, J. Marlene, Minneapolis, Minn., U.S.A.
Wiesauer, Georg, Graz, Austria.
Wiggin, Richard C., Midland, Tex., U.S.A.
Williams, Kevin G., Cowbridge.
Wykoff, Dale E., Frederick, Md, U.S.A.
Yamaguchi, Maki, Fukuoka Pref., Japan.
Yamazaki, Hideki, Shizuoka Pref., Japan.
Young, William R., London.
Zawacki, Charles G., Anchorage, Alaska, U.S.A.
Ziogos, Georgios, Thessaloniki, Greece.
Zorzanello, Giancarlo, Barcelona, Spain.
Zunz, Laura A., London.

PRELIMINARY EXAMINATION

Anderson Medal
Quick, Fiona A., Harare, Zimbabwe.

Rayner Preliminary Prize
Chieveley-Williams, John P. E., Poole.

QUALIFIED

Aherne, Elizabeth, South Amboy, N.J., U.S.A.
Akel, Eugenia, Athens, Greece.
Alavi, Mohammed A. M., Colombo, Sri Lanka.
Alexander, Jean, Wantage.
Alford, Donald H., Huntsville, Ala, U.S.A.
Aloupas, Phivos, London.
Apland, Ken A., Oregon, U.S.A.
Arulanantham, Rohini P., Colombo, Sri Lanka.
Asagai, Toshiki, Osaka, Japan.
Au-Yeung, Siu M., Hong Kong.
Aziz, Khalid, Karachi, Pakistan.
Baker, Carolyne J., Godalming.
Balakrishnan, Kanapathippillai, Salford.
Bandara, Sunil P. M. M., Kelaniya, Sri Lanka.

Barker, Stephen J., Norwich.
Barlow, Alice M., Appleton, Wis., U.S.A.
Barnard, Julie A., Nottingham.
Bartlett, Lynne, London.
Bastiaanse, Paul A., Eindhoven, Netherlands.
Bauer, Gunilla M., Uppsala, Sweden.
Baxendale, John F., Widnes.
Belda Selva, Fernando, Barcelona, Spain.
Berger, Clark J., London.
Beringen, Johannes J. G., Utrecht, Netherlands.
Bernal Garcia, Jose E., Barcelona, Spain.
Biosca Bas, Ma de los Angeles, Barcelona, Spain.
Bjørge, Eli, Lierfoss, Norway.
Blankestijn, Janna G., Leersum, Netherlands.
Bliss, Stephen J., Liverpool.
Bodifee, Brigitte K., Schoonhoven, Netherlands.
Boermans, Antoon P. E. M., Venlo, Netherlands.
Bolton, Janet M., Bolton.
Bonham, Frank C., Newport Beach, Ca, U.S.A.
Bonnema, Menno, Heerenveen, Netherlands.
Bonvehi Sola, Joan, Barcelona, Spain.
Bosch, Coert E., Hoevelaken, Netherlands.
Bourner, Anne, Manchester.
Brand, Lester J., Stellenbosch, S. Africa.
Brattan, David, Wakefield.
Brown, Sandra J., Hong Kong.
Budi, Elisabeth A., Athens, Greece.
Buis, Jan D. B., Lopik, Netherlands.
Burns, Brian, Huddersfield.
Bushby, Christine D. A., Broadstone.
Calduch Sendra, Ma Esmeralda, Barcelona, Spain.
Calje, Nicoline, Schiedam, Netherlands.
Callan, Frank, Liverpool.
Canas Aguilar, Jose V., Barcelona, Spain.
Cannon, Mark F., Stockport.
Caracciolo, Marie E., McLean, Va, U.S.A.
Cartana Martinez, Jorge, Barcelona, Spain.
Caruthers, Peter M. A., Manchester.
Casanovas Ramon, Ma Rosa, Barcelona, Spain.
Cass, Laurence, London.
Castello Costa, Antonia, Barcelona, Spain.
Chamberlain, Roger P., Newtownards, N. Ireland.
Chan, Hung C., Hong Kong.
Chan, Kai C. M., Hong Kong.
Chan, Yau-Lap, Santa Monica, Ca, U.S.A.
Chang, Julius, Hong Kong.
Cheshire, Sam J., Droitwich.
Chib, Phillip D., London.
Chieveley-Williams, John P. E., Poole.
Chinn, Jeffrey, St Helier, Jersey, C.I.
Chu, Hong-Sung, Taipei, Taiwan.
Clare, Caroline L., Chorley.
Clewer, Patricia A., Nottingham.
Cody, Carol J., London.
Coffin, Martin R., Carlisle.
Cohen, Gilbert, Montreal, Canada.
Comber, Takako K., Hong Kong.
Corbett, Timothy M., London.
Courtenay, Jutta W., Hong Kong.
Cox, Nicholas P., Warley.
Cox, Steven G., London.
Cragg, Deborah A., Knutsford.
Crolly, Sharon J., Scarborough, Ont., Canada.
Crowder, Michael J., Camberley.
Cuijpers, Heleen M., Schoonhoven, Netherlands.
Currie, John S., Manurewa, Auck., N.Z.
Curtis, Ranjana G., Colombo, Sri Lanka.
Curtis, William R., Sheffield.

Dagli, Yogeshkumar, Bombay, India.
Dale, Marlene L., Hong Kong.
Dathi, Kaniz F., Riyadh, Saudi Arabia.
Davies, Neil R., Chester.
Davis, Lisa M., Sale.
Davis, Meriel, London.
De Cunha, Kevin I. G., Portsmouth.
de Lacombe, Aliette, London.
Denney, Shane S., Jacksonville, Ill., U.S.A.
Dent, Peter J., Guildford.
De Ruyter, Gerrit H. G., Tokoroa, N.Z.
de Silva, John I. C., Trier, W. Germany.
de Silva, Neelamanee P., Leeds.
Dewan, Shobha, Deherdun, India.
Dey, Madeleine R. L., Wirral.
Dhont, Eddy C. H., Gent, Belgium.
Dicks, Graham J., London.
Dixon Phillip, John G., Wallasey.
Donoghue, Martin D., Glasgow.
Duckett, Karen L., Skipton.
Duguid, Keith B., Eiffel Flats, Zimbabwe.
Dunn, Nigel P., Brierley Hill.
Ebert, Gabriela E., Heidelberg, W. Germany.
Edirisuriya, Anura S., Dickwella, Sri Lanka.
Ehlenbach, Richard J., Winchester, Mass, U.S.A.
Feather, Russell C., II, Fairfax, Va, U.S.A.
Fein, Murray, Whitestone, N.Y. U.S.A.
Felstead, Kevin R., Brentwood.
Ferguson, Brian, Ottawa, Ont., Canada.
Ferran Estrada, Alejandro, Barcelona, Spain.
Fitzgerald, Jennifer G., Hong Kong.
Floriach Devant, Ma Teresa, Barcelona, Spain.
Foote, Lisa A., Brisbane, Qld, Australia.
Fournier-Laroque, Maryse M. J., Geneva, Switzerland.
Francis, Shirley J., Frinton-on-Sea.
Franks, Karen M., Manchester.
Freeman, Glen H., Winnipeg, Man., Canada.
Fussell, Louise, London.
Galindo Merino, Ma del Carmen, Barcelona, Spain.
Gambin Forne, Ma Neus, Barcelona, Spain.
Gibson, Dorothy, Chatham, N.J., U.S.A.
Giel, Caroline, Schoonhoven, Netherlands.
Glenn, Helen H., Darwen.
Goad, Jane F. C., London.
Gonzalez De Las Heras, Benito, Barcelona, Spain.
Goodchild, Gordon E., Colchester.
Goonatilake, Manique M., Colombo, Sri Lanka.
Goossens, Xavier A., London.
Gormley, Brendan M., Belfast, N. Ireland.
Gottlier, Kristoffer, Stockholm, Sweden.
Gould, Lewis, London.
Gresham, Catherine A., Chloorkop, S. Africa.
Griffiths, Raymond J., London.
Grotenhuis, Ingrid, Winterswijk, Netherlands.
Groves, Lesley C., Eastbourne.
Groves, Patricia, Brisbane, Qld, Australia.
Guinand, François, Neuchatel, Switzerland.
Halford, Bridget A., Hong Kong.
Hall, Michael J. B., Oxshott.
Hardman, Christopher D., Ipswich.
Harrington, Christina M., Seattle, Wash., U.S.A.
Harwood, Bruce R., London.
Hay, Scott, Rothesay.
Heikkila, Tero P. V., Tampere, Finland.
Hellman, Ulla M., Stockholm, Sweden.
Hendricks, Mogamat L., Cape Town, S. Africa.

Hendriks, Cornelius A., Eindhoven, Netherlands.
Hennessy, Linda L., Sydney, N.S.W., Australia.
Hirons, Glen W., Liverpool.
Ho, Hay-Ming J., Hong Kong.
Ho, Ka K., Hong Kong.
Ho, Wai K., Hong Kong.
Holemans, Thierry J. N., Brussels, Belgium.
Hollins, Peter A., Birmingham.
Holmes, Irene V., Tadworth.
Holness, Neil P., London.
Hookins, Gary C., Thames Ditton.
Horton, Julie A., Wolverhampton.
Hosaka, Masahiro, Kofu, Japan.
Hughes, John M., Netherton.
Humphreys, Deborah M., Liverpool.
Hunt, Jill M., Hong Kong.
Hunter, Anne L., Oregon, U.S.A.
Hunter, Dugald C., Glasgow.
Ichinose, Atsuko, Tokyo, Japan.
Imazawa, Satoru, Chiba Pref., Japan.
Introna, Ilarione G., Cape Town, S. Africa.
Itoh, Yasuhiro, Osaka, Japan.
Iversen, Bodil, Eidsvoll, Norway.
Jaffery, Zulfiquar A., Machakos, Kenya.
Jakob, Beatrice, London.
Jashnani, Navin B., Bombay, India.
Jayasekera, Palitha R. J., Colombo, Sri Lanka.
Jerndell, Bo E. O., Stockhlom, Sweden.
Johanns, Pieter G. J., Veghel, Netherlands.
Johnson, Benjamin C., Bilston.
Jones, Julia D., Wolverhampton.
Kalubanda, Hitihamillage, Ratnapura, Sri Lanka.
Kaper, Robert C., Washington, D.C., U.S.A.
Kasliwal, Deepak, Bombay, India.
Khanna, Atul, Birmingham.
Kikano, Margo M., London.
Kinnvnen, Juha P., Espoo, Finland.
Klinberg, Baltzar H., Stockholm, Sweden.
Kodaka, Katuyoshi, Tokyo, Japan.
Kort, Karin J., Hellevoetsluis, Netherlands.
Koseki, Norio, Tokyo, Japan.
Kothari, Prajesh R., Madras, India.
Kranz, Kurt B., Woodridge, Qld, Australia.
Kumarasuriar, Geetha K. K., Colombo, Sri Lanka.
Lam, Hiu C. O., Hong Kong.
Lam, Jeremiah T. K., Hong Kong.
Lange, Ulf, Bremen, W. Germany.
Laurikainen, Markku J., Helsinki, Finland.
Law, Bik W., Hong Kong.
Lee, Cheung, Hong Kong.
Leung, Pui F., Hong Kong.
Lewton-Brain, Charles J., Halifax, N.S., Canada.
Lim, Pauline, Worcester.
Lin, Chorn-Yu, Santa Monica, Ca, U.S.A.
Lintunen, Eva E., Finland.
Lippelt, Ulrich W., Karachi, Pakistan.
Lo, Siu-Man B., Hong Kong.
London, Jan, Colombo, Sri Lanka.
Loup, Daniel L., Geneva, Switzerland.
Loveday, Elsje, St Martin, Guernsey, C.I.
Lui, Elizabeth S. H., Hong Kong.
McAleese, Daniel, Newtownabbey, N. Ireland.
McCallum, Andrew, Croydon.
McCloskey, William P., London.
McDermott, Bernard A., Manchester.
MacFadyen, Donald A., Scarborough, Ont., Canada.
McKearney, Michael C., London.
McKinney, Shona, London.
McLean, Donald P., Ottawa, Ont., Canada.
Mainwaring-Burton, Jeremy J., Johannesburg, S. Africa.
Major, Christine B., Hong Kong.
Malkani, Monica, Bombay, India.
Malmstrom, Bridget K. M., Vasby, Sweden.

Malmstrom, Georgina M. F., Vasby, Sweden.
Mann, William R., Suitland, Md, U.S.A.
Mantere, Juha M., Rauma, Finland.
Marikar Bawa, Mohamed S. R., Colombo, Sri Lanka.
Marlow, Joseph S., Birmingham.
Massey, Steven M., Altrincham.
Meguro, Sadayuki, Tokyo, Japan.
Mercer, Francis G. J., Welwyn Garden City.
Michener, John, Raybrook, N.Y., U.S.A.
Mohideen, H. M. Sultan, Madras, India.
Moir, Richard C., Kenthurst, N.S.W., Australia.
Monnas, Edith S., Mombasa, Kenya.
Montanni, Claire, Newarthill:
Monzonis Garcia-Correcher, Alejandro, Barcelona, Spain.
Moore, Elaine C., Oslo, Norway.
Moore, Fiona, Londonderry, N. Ireland.
Moore, Stephen S., Los Angeles, Ca, U.S.A.
Morgan, Leon D., Aylesham.
Morin Reyes, Luisa M., Tenerife, Canary Is, Spain.
Mousavi, Morteza, Bombay, India.
Muchlinski, Michael, Clacton-on-Sea.
Munster, Sarah H., London.
Murakami, Ryutaro, Osaka, Japan.
Murray, Jacqueline K., Morpeth.
Nadim, M. S. M., Colombo, Sri Lanka.
Nakamura, Midori, Chiba Pref., Japan.
Nakanishi, Kimiyo, Yamanashi, Japan.
Nancarrow, Peter H. A., West Horsley.
Navarrete Navarrete, Fernando, Barcelona, Spain.
Nawaz, Rab, Belfast, N. Ireland.
Nelson, William L., Ogdensburg, N.Y., U.S.A.
Ng, Fen S., Singapore.
Nial, Brian L., Southport, Qld, Australia.
Nikiforides, Constantine W., Brisbane, Qld, Australia.
Nikiforides, Tina, Brisbane, Qld, Australia.
Nitta, Hisako, Tokyo, Japan.
Noakes, Karen, J., Dudley.
North, Michael, Matlock.
Nystrom, Erik, Stockholm, Sweden.
Nystrom, Louise, Stockholm, Sweden.
Oh, Wilhelmina A. P. C., Hong Kong.
O'Keeffe, Ursula M., Sale.
O'Riordan, Sylvia, Epsom.
Palwankar, Balwant B., Bombay, India.
Papadopoulou, Daphni-Marina, Athens, Greece.
Parker, Claire E., Worthing.
Payne, James F., Minsterworth.
Pearson, Susan, Chorley.
Pease, Orville H., Burbank, Ca, U.S.A.
Peeris, Malwattege R. L., Kotte, Sri Lanka.
Pellicer Garcia, Miguel Angel, Barcelona, Spain.
Peltonen, Stella P., Handen, Sweden.
Pemadasa, Tawalama G., Colombo, Sri Lanka.
Perera, Cabandugamage L., Nugegoda, Sri Lanka.
Perera, Dewamullage J. P., Colombo, Sri Lanka.
Pescod, Ian S., Whitley Bay.
Peshwa, Krishna V., Pune, India.
Phillips, Carol S., Bridgend.
Posthuma, Sandra M., Schoonhoven, Netherlands.
Poulis, Johannes A. M., Roosendaal, Netherlands.
Prescott, Philip, Wigan.
Preston, Mitchell R., Morpeth.
Pritchard, Nichola E., Worsley.
Puddy, Patricia J., Market Harborough.

Quam, Maurice D., St Paul, Minn., U.S.A.
Quick, Fiona, A., Harare, Zimbabwe.
Quy, Caroline E., Chalfont St Giles.
Raniga, Dhiraj L., Richmond, B.C., Canada.
Ravn, Christine K., London.
Rawson, Anthony, Bristol.
Redgrave, Martin, Hessle.
Reed, Donna L., Manchester.
Reid, John E., III, Rex, Ga, U.S.A.
Rens, Gerald J., Johannesburg, S. Africa.
Rich, Frederick S., London.
Rigby, Martin P., Ashton-under-Lyne.
Rikkoert, Jasper D., Schoonhoven, Netherlands.
Roach, Michael P., Howell, N.J., U.S.A.
Robertson, Anne N., Gerrards Cross.
Robertson, Neil, Kangaroo Point, Qld, Australia.
Robinson, Christopher G., Preston.
Rodrigo Alonso, Jose L., Barcelona, Spain.
Rojals Garcia, Montserrat, Barcelona, Spain.
Ronning, Magne, Oslo, Norway.
Rooijmans, Frederik T. W. L., Eindhoven, Netherlands.
Root, Jerrold B., Bethesda, Md, U.S.A.
Rosenbaum, Stephen M., Manchester.
Rosenblatt, Robert L., Salt Lake City, Utah, U.S.A.
Ros Hernandez, Julio, Barcelona, Spain.
Round, Karen L., Wolverhampton.
Rowley, Phillip L., Vienna, Va, U.S.A.
Ruest, Andre E., Gloucester, Ont., Canada.
Rundgren, Mats E., Hagersten, Sweden.
Sadik, Marcel, Geneva, Switzerland.
Sagatun, Mari-Anne B., Sandefjord, Norway.
Sakita, Yoshizo, Tokyo, Japan.
Salas Alonso, Jose V., Barcelona, Spain.
Sane, Hemant S., Bombay, India.
Santiago Gonzalez, Antonia, Tenerife, Canary Is, Spain.
Sasaki, Mitsuo, Osaka, Japan.
Satoh, Toshiko, Osaka, Japan.
Sayegh, Michele K., London.
Seeger, Peter R., Wirral.
Seiz Ortiz, Vicente J., Barcelona, Spain.
Shah, Syed-Sibat-A-Hussian, Manchester.
Shankar, Sangeeta, Luton.
Shimada, Takanori, Tokyo, Japan.
Shimmi, Yoko, Tokyo, Japan.
Shum, Chan H., Kuala Lumpur, W. Malaysia.
Skytta, Martti V., Kouvola, Finland.
Slade, Philip M., Manchester.
Soleiman, Joseph, London.
Sorgen, Irving D., Fargo, N. Dak., U.S.A.
Spengler, William H., Bangkok, Thailand.
Spreckley, Vaughan G. M., Thundridge.
Stead, William A., London.
Stembo, Kithsiri N., Angoda, Sri Lanka.
Stoecklein, Patricia A., Trafalgar, Ind., U.S.A.
Stroom, Mirjam A., Harmelen, Netherlands.
Suzuki, Satsuko, Yamanashi, Japan.
Swaine, Christine M., Poole.
Taylor, Anne R. E., Poole.
Taylor, Caroline H. B., Ripley.
Tazaki, Noriko, Tokyo, Japan.
Tazaki, Yasuko, Tokyo, Japan.
Terauchi, Toshihiro, Tokyo, Japan.
Tetteroo, Caroline C. B. O., Nootdorp, Netherlands.
Thilesen, Georg, Fredrikstad, Norway.
Thomassen, Melanie H. E., Eindhoven, Netherlands.

Tiainen, Olli J., Espoo, Finland.
Toledo, Suzanne P., Hong Kong.
Tomlin, Karen A., Nottingham.
Tomren, Jan I., Notodden, Norway.
Tsukakoshi, Hiroko, Tokyo, Japan.
Turner, Starla E., Hillsborough, Ca, U.S.A.
Tynas, Richard M. W., Macclesfield.
Uesugi, Tohru, Osaka, Japan.
Valvis, Vassilis, Sawbridgeworth.
van den Berg, Willem P., Pretoria, S. Africa.
van der Meulen, Michael J. T., Schoonhoven, Netherlands.
van der Sloot, Annelies P., Rotterdam, Netherlands.
van Oene, Lambertus M., Schoonhoven, Netherlands.
van Wenum, Elbertha G., Amsterdam, Netherlands.
Vogler, Karl, Basel, Switzerland.
von Schlabrendorff, Beate, Hong Kong.
Vuorinen, Paivi T., Hameenlinna, Finland.
Wackan, Susan K., Woking.
Wagstaff, Edith H. C., Bury.
Wahlberg, Pirjo H., Tampere, Finland.
Walmsley, David K., Ribchester.
Wang, Kwan K. L. E., Hong Kong.
Warne, Richard A., Newbury.
Weyn Banningh, Thomas F. M., Groenlo, Netherlands.
White, Vanessa C., Colchester.
Wickramasinha, Tudor, London.
Widmer, Thomas, Aarau, Switzerland.
Wiesauer, Georg, Graz, Austria.
Wijetunga, Hemadasa, Colombo, Sri Lanka.
Wijnen, Franciscus A. P., Schoonhoven, Netherlands.
Williams, Dawn L., Stockport.
Wilson, Christopher D., Kilifi, Kenya.
Winton, Donald N., London.
Witjes de Vaal, Geertje, Oisterwijk, Netherlands.
Wong, Che K., Hong Kong.
Wong, Christine H., Hong Kong.
Woolf, Tania, London.
Woolley, Joseph G., Nelson, N.Z.
Wright, Doris A, Riverside, Ca, U.S.A.
Wurm, Lise A., San Francisco, Ca, U.S.A.
Yap, Ching-Siew, London.
Yin, Wei W. Y. A., Hong Kong.
Yip, Ki F., Hong Kong.
Ylatalo, Juha E., Riihimaki, Finland.
Yoshikawa, Kanako, Tokyo, Japan.
Yu, Fuk K. D., Hong Kong.
Yuen, Jenny L. C., Hong Kong.
Zainuddin, Nisreen A., Bombay, India.
Zandvoort, Christine J. M., Rotterdam, Netherlands.
Ziff, Ivan M., London.

GERMAN GEMMOLOGICAL ASSOCIATION FIFTIETH ANNIVERSARY

(Report by Mr Peter Read, C.Eng., F.G.A.)

Although the German Gemmological Association (Deutsche Gemmologische Gesellschaft) was founded in 1932, the official celebration of its fiftieth anniversary was postponed until 1983, so that it could coincide with the opening of the extension to the Association's training centre in Idar-Oberstein.

Each year, the Association holds two 'Working Conference' week-ends, one in the spring and one in the autumn. These gemmological week-ends consist of a series of discussion groups in the class-rooms of the training centre, demonstrations and talks in the town's trade hall, and the awarding of certificates and the presentation of formal lectures in the auditorium of the Diamond and Gemstone Bourse. This year, the autumn week-end of 7th-9th October, was chosen for the Fiftieth

Anniversary celebrations, and the invited guests included Professor Dr E. Gübelin, F.G.A., Mr J. E. Roux (of De Beers), Mr E. A. Jobbins, F.G.A., and the Secretary of our own Association, Mr Con Lenan, F.G.A.

The celebrations began on the Friday evening with a welcoming speech by the German Gemmological Association's Director, Professor Dr Hermann Bank, F.G.A. This was followed by a tour of the new class-rooms and facilities of the training centre, and a visit to the re-sited and enlarged cafeteria, where the refreshments included local wine and the traditional *spiessbraten.*

On the Saturday and throughout the rest of the week-end, three class-rooms in the centre were used to display and demonstrate various gem test instruments from the range of the Eickhorst, Krüss and Günter-Schneider companies. The Association's well-stocked bookstore was also open for inspection during this period. Added interest was provided by the De Beers coloured diamond collection and the gem collection of August Wild, which were on view in the Diamond and Gemstone Bourse. For those wishing to purchase gem specimens there was also the annual gemstone exhibition and fair in a hotel in the nearby village of Veitsrodt, where the products of the local cutters were on display.

During a celebratory buffet given in the Bourse on Saturday evening, a series of slides were shown which traced the history of the German Association through its meetings and attendant personalities up to the present day.

The formal lectures presented in the auditorium of the Bourse included a talk on 'Synthetic Diamonds' by Professor Dr Recker, of the University of Bonn. This covered the many commercial and experimental synthesis techniques ranging from the molten solvent-catalyst method to the more recent metastable process using carbon dioxide gas and a diamond seed crystal, the relationships between these being displayed by means of an expanded phase diagram. Definitive examples of gemstone inclusion photographs were shown during the lectures of Professor Dr Gübelin ('Examination of Fluid Inclusions in Gemstones'), and Mr Koivula ('Inclusions in a Better Light'), the latter speaker reminding us of the continuing diagnostic value of inclusions now that synthetic gem manufacturers are introducing trace elements such as gallium (normally found only in natural stones) into the melt.

The final lecture of the week-end was given by Dr Keller, whose talk ('A recent Update on Worldwide Gem Sources') dealt mainly with the emerald mines of Chivor and Muzo in Colombia. His talk was illustrated by slides taken during the filming of the G.I.A. production 'Gems of the Americas'.

By doubling the size of its training centre, the German Gemmological Association has become one of Europe's leading full-time teaching centres for the science of gemstones, and now offers a multiplicity of courses on gemmology and diamond grading throughout the academic year.

19TH INTERNATIONAL GEMMOLOGICAL CONFERENCE

The 19th International Gemmological Conference was held in Beruwala in Sri Lanka from the 31st October to 4th November, 1983.

Prior to the formal opening of the Conference the delegates were escorted to the Conference centre by a drummer party and on arrival at the centre entered into the traditional Sri Lankan custom of lighting the lamps, in which each delegate lit a wick.

Delegates from the U.K. were Mr Kenneth Scarratt, F.G.A., Director of the London Gem Testing Laboratory, Mr Alan Jobbins, F.G.A., Keeper of Minerals and Gemstones, Institute of Geological Sciences, London, and a senior Examiner of the Association, and Mr Con Lenan, F.G.A., the Secretary. Mr Harry Wheeler, F.G.A. attended as an observer. Delegates from the following countries attended: Australia, Brazil, Denmark, France, Italy, Japan, the Netherlands, South Africa, Spain, Sri Lanka, Switzerland, the U.K., the U.S.A. and West Germany.

At the commencement of the proceedings the delegates stood in silence as a tribute to the late Dr W. F. Eppler.*

A number of papers were presented to the Conference and a wide range of subjects with many interesting elements from the fields of mineralogy and geology complemented the gemmological presentations.

An interesting visit to the gemstone mines and cutting centres at Ratnapura was rewarding and illuminating.

Prof. Dr E. Gübelin, C.G., F.G.A., invited Mr Lenan to become 'postmaster', to which Mr Lenan agreed, and the Conference concluded with a spectacular cultural show and a dinner hosted by the Gemmologists' Association of Sri Lanka.

The papers presented at the Conference are listed below:

'Geology and occurrence of gems in Sri Lanka', Dr M. M. J. W. Herath.

'Worldwide distribution of coloured gemstones', Dr John M. Saul.

'Gemstones of Victoria, Australia', Dr E. R. Segnit.

'Investigation on fluid inclusions', Prof. Dr E. Gübelin, C.G., F.G.A.

'New emerald mines at Santa Terzinha do Goias', R. T. Liddicoat, Jr., Hon. F.G.A.

'News about Ole Roemer', O. Dragsted, F.G.A.

'Additional data on gem minerals from Kataragama area (Sri Lanka)', Prof. P. C. Zwaan, F.G.A.

'Verdite and ruby verdite from Zimbabwe', E. A. Jobbins, F.G.A.

'Gemstones from Nepal', A. Chikayama, F.G.A.

'Gemstones from Indonesia (diamonds from Kalimantan and quartz varieties and opal from Java)', Dr C. E. S. Arps, F.G.A.

'Pink topaz of natural colour from Pakistan', Prof. Dr E. Gübelin, C.G., F.G.A.

'Identification by use of the spectroscope of Kashan synthetic rubies', 'Pearls from Bangladesh', C. A. Schiffmann, F.G.A.

'Recent gemmological observations', Prof. Dr H. Bank, F.G.A.

'A new versatile lamp using standard illuminants C & D for precise colour matching of gemstones', Dr J. Ponahlo, F.G.A.

'Interdependence among chemical composition, optical properties and structural data on natural and synthetic beryl', Prof. Dr G. Graziani.

'A few interesting issues and recent findings', K. Scarratt, F.G.A.

'New observation technique for gem testing', K. Sato.

'Orthopyroxenes of Sri Lanka', G. Zoysa, F.G.A.

'Surface microtopographical studies of diamond crystals from Thailand', Prof. I. Sunagawa.

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*See *J.Gemm.*, 1983, XVIII (5), 446-9.—Ed.

'Theory and application of microprobe analysis in gemmology', Dr S. Vochten.
'Some comments on natural pearl', M. Masso.
'Emeralds produced in Brazil', Mrs E. MacGregor.
Mr C. A. Schiffmann also read a paper entitled 'Lennix Emeralds', by J. P. Poirot.

DENVER GEMOLOGICAL ASSOCIATION

The Denver Gemological Association has recently been formed to provide a forum for all professional gemmologists in the greater Denver area. Membership is limited to qualified gemmologists such as F.G.A.s and Graduate Gemologists of the Gemological Institute of America (G.G.). Meetings are bi-monthly with formal presentations given on subjects of current gemmological interest. Further information may be obtained from The Denver Gemological Association (Ms Patricia Winckler, G.G., or Dr D. Hoover, F.G.A.), P.O. Box 27541, Bear Valley Station, Denver, Colo 80227, U.S.A.

FORUM OF INDIAN GEMMOLOGISTS

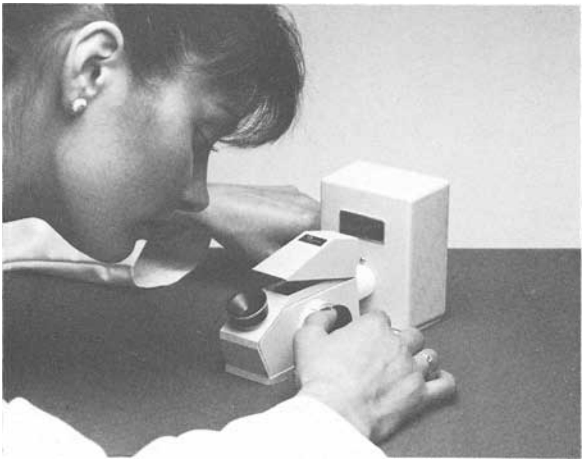
The recently formed Forum of Indian Gemmologists is a non-profit-making educational organization, whose basic objectives are to popularize gemmology and educate the members and the general public in the study of gemstones. Membership is restricted to F.G.A.s and G.G.s (Graduate Gemologists of the Gemological Institute of America). Plans include the organization of seminars, conferences and study-groups, and gemmologists passing through India will be welcomed. Meetings are held on the first Friday of each month. For further information, apply to the Forum, c/o Gemmological Association of India, 29 Gurukul Chambers, 187/189 Mumbadevi Road, Bombay, 400 002, India (telephone 32 0039).

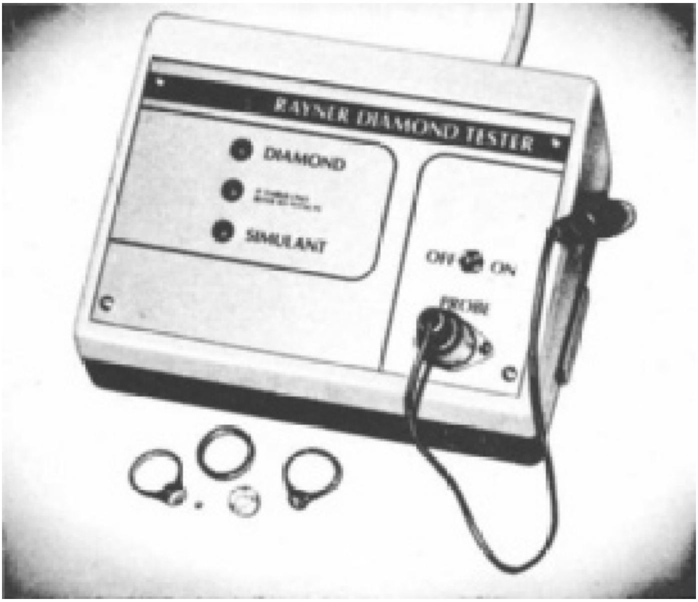
JOURNAL OF GEMMOLOGY—BOUND SET FOR SALE

A member has a set of bound *Journals* for sale at the price of £125. Anyone interested in purchasing this set should write to Box No. SC3, G.A. of G.B., Saint Dunstan's House, Carey Lane, London EC2V 8AB.

INDEX FOR VOLUME XVIII

It is regretted that the Index is not quite ready for distribution. It will be sent with the April issue of the *Journal,* if not before.

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Historical Note

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

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

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

Notes for Contributors

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

Articles published are paid for, and a minimum of 25 prints of individual articles may be supplied to authors provided application is made on or before approval of proofs. Applications for prints should be made to the Secretary of the Association—not to the Editor—and current rates of payment for articles and terms for the supply of prints may be obtained also from the Secretary.

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

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No. 1
January, 1984

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