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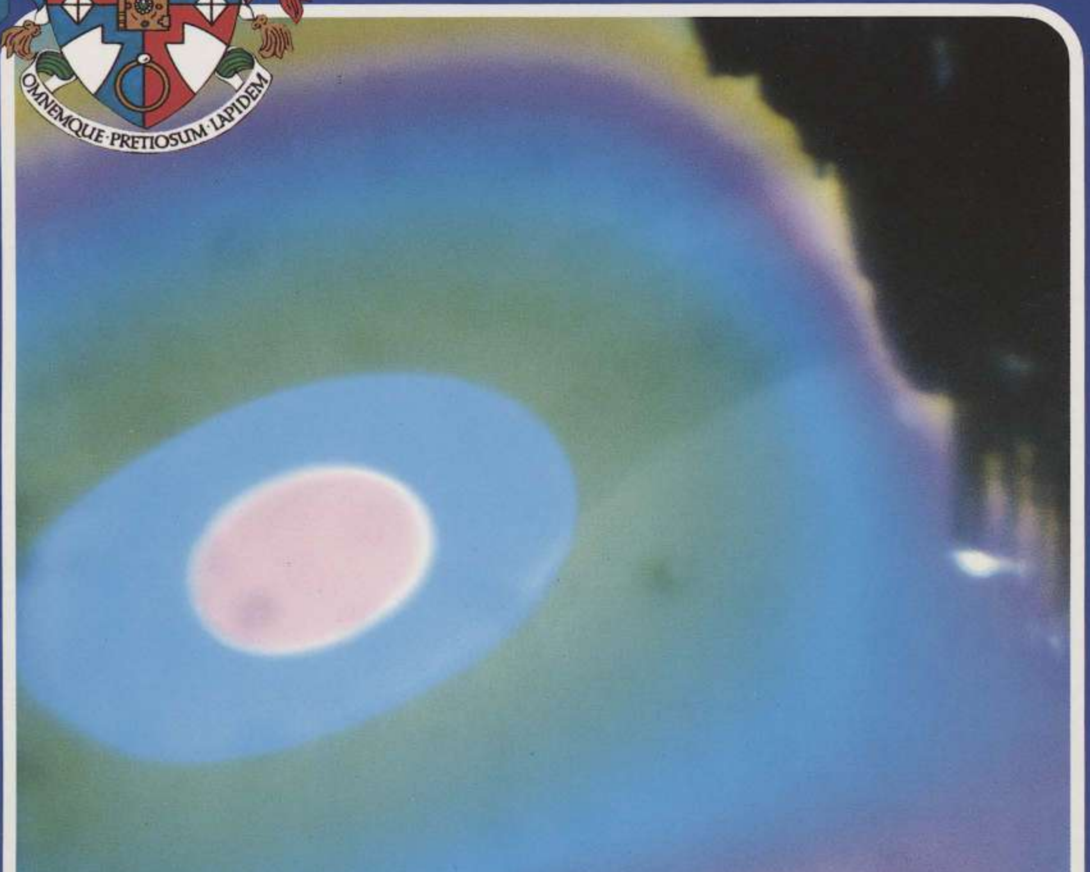

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Cover Picture

A thin film inclusion in an aquamarine from Pakistan. x22.
(See 'Unusual inclusion in an aquamarine' pp. 286)

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A notable red-brown diamond

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Abstract

A 5.03 ct red-brown diamond in the Smithsonian Institution in Washington DC, USA (referred to as the 'DeYoung Red'), has attracted public and media attention as one of the only diamonds of its kind on museum display. Faceted diamonds having the hue term 'red' as any part of their colour description are extremely rare. Gemmological examination of this round-brilliant cut stone reveals it has internal features and a visible absorption spectrum typical of both brown and other pink-to-red diamonds. This correspondence supports the belief of a similar cause of pink and some brown colours that is thought to be related to deformation of the structure of these diamonds while they were still in the earth. The 5.03 ct stone described here is an example of a relationship in colour origin among brown and pink diamonds.

Introduction

In May 1989, we had the opportunity to examine a faceted red-brown diamond that had been donated to the Smithsonian Institution of Washington DC, USA in 1987 (Figure 1). Very little is known of the prior history of this 5.03 ct diamond, except that it had been owned by the late S. Sydney DeYoung, a well-known Boston gem dealer, who reportedly acquired it about 50 years ago and subsequently kept it locked in a vault. Gill (1978) suggested that this diamond may have come from India, but provided no further details. On Mr. DeYoung's death in 1986, the diamond was given to the Smithsonian as a bequest from his estate by the firm J. and S.S. DeYoung, Inc. It was delivered to the Smithsonian in November 1987, and was placed on public display in February 1988 in the National Museum of Natural History (Moser, 1987; Andrews, 1988; Federman, 1988).

Although the terminology used by the GIA Gem Trade Laboratory on reports describes this particular natural-colour diamond as a 'fancy, very dark, orangy red-brown', it has commonly but incorrectly been referred to as simply a 'red' diamond by the public and the press (Moser, 1987; Andrews, 1988; Federman, 1988). Diamonds that can be described as actually being 'pure red', or containing red as a principal (e.g. red-brown) or significant modifying (e.g. reddish-brown, reddish-purple) colour hue, are extremely rare in nature. Few diamonds of this colour have ever been examined or described in the gemmological literature; whatever information is available is often incomplete, or is included along with descriptions of other coloured diamonds. The GIA Gem Trade Laboratory has never issued a report on a diamond whose colour falls in the pure 'red' category, although recently a 0.95 ct diamond was described on the report as being purplish-red (Kane, 1987).

As part of our ongoing study of the gemmological properties of coloured diamonds, GIA Research staff examined this 5.03 ct stone to learn more about its coloration and other features. In this article, we briefly describe the gemmological properties and origin of colour of this notable coloured diamond (News Release, Smithsonian Institution, February 2, 1988, 'Colored Diamonds at the Smithsonian').

Instrumentation and Methods

Our examination was conducted using standard gemmological testing equipment, as well as more sophisticated instruments to record both the visible and infrared absorption spectra. The former included a GIA Gem Instruments binocular gemmological microscope, a Beck prism hand spectroscope, and a DISCAN digital-scanning, diffraction-grating hand spectroscope. The latter included a PYE-UNICAM Model 8800 ultraviolet-visible spectrophotometer, and a NICOLET Model 60SX Fourier-Transform spectrometer to record infrared spectra.

Results

Gemmological properties

Some quality-grading characteristics of this coloured diamond are summarized in Table 1. When examined under overhead fluorescent lighting, the diamond appears a very dark orangy-brown with a few bright red-brown reflections; the primary impression, however, is that of a brown diamond.

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Fig. 1. This 5.03 ct diamond, now on display at the National Museum of Natural History, Smithsonian Institution, is a very dark, orangy-red brown. *Photo by Robert Weldon, copyright by the Gemological Institute of America.*

When examined using directional lighting from, for example, a fibre-optic light source, the orangy red-brown bodycolour is more apparent. The overall appearance of this diamond has been described as similar to that of a red-brown garnet (Federman, 1988).

Because of its size and dark colour, it was difficult to transmit sufficient light through the diamond to observe some of its internal features with a microscope. Nonetheless, the bodycolour appears to be uniformly distributed when the diamond is viewed face-up with overhead fluorescent or incandescent lighting. The presence of red-brown coloured graining of moderately strong intensity could be seen when the stone was viewed through the pavilion (Figure 2). Such graining is evident throughout the diamond along octahedral planes of red-brown colour. Considering the orientation of this graining relative to that of polished table of the stone, the table appears to be approximately parallel to the cube {100} crystallographic plane. Such a stone is called in the trade a 'four-point diamond' (Gaal, 1977, p.109). This suggests the stone was fashioned from a primarily octahedral rough crystal.

When observed with a microscope using cross-polarized light, the diamond also displays strong anomalous birefringence ('strain') in the form of interference colours in either a banded or mottled pattern (depending upon the stone's orientation). This birefringence is seen throughout the diamond, and exactly replicates the pattern of graining. Both of these visual features – internal graining and anomalous birefringence – are typical of a number of natural yellow-to-brown, pink-to-red, and purple diamonds that we have examined during the past several years.

The diamond fluoresces a weak yellow to both long-wave and short-wave ultraviolet radiation. The fluorescence is chalky or turbid, and is evenly distributed except for one area under the table facet about 3mm in diameter which is inert. There is no phosphorescence after either ultraviolet lamp is turned off.

Spectroscopy

When viewed with a hand-held spectroscope, the spectrum of the diamond exhibits a broad region of absorption up to about 480 nm and a pair of weak but sharp lines at 496 and 503 nm. The diamond luminesces a moderately strong, turbid or chalky green colour when exposed to the intense transmitted light on the stage of the spectroscope unit (Figure 3). The luminescence to visible light (referred to by gemmologists as a 'green transmission' or 'transmission luminescence') is zoned, with some of the emission of green light observed to come specifically from the planes of coloured graining. This type of luminescence is common in natural brown to orangy-brown diamonds, and is believed to be associated with the H3 centre (503 nm; see Collins, 1982).

It was difficult to record absorption spectra obtained with the ultraviolet-visible spectrophotometer and the Fourier-Transform infrared spectrometer, again because of the strong absorption of the diamond due to its size and dark colour. The visible-range spectrum curve exhibits a continuously increasing absorption toward the violet (Figure 4, spectrum A). The curve levels off at wavelengths below 500 nm because the amount of absorption reaches the upper detection limit of our spectrophotometer (this is also the reason for the absence of the 496 nm absorption band in this curve that could be seen with a hand spectroscope). This kind of absorption curve gives rise to the 'brown' component of the colour of this diamond (Collins,

TABLE 1. Quality-grading characteristics

Dimensions	11.55 – 11.84 x 6.36 mm
Cut	Round brilliant with horizontally-split bezel facets
Weight	5.03 ct
Proportions	Table width percentage (54%), depth percentage (54.4%), medium culet size, and thin girdle width
Finish	Good symmetry and polish
Clarity	(VS2) with several small chips in the girdle, and a small needle-shaped inclusion under the table

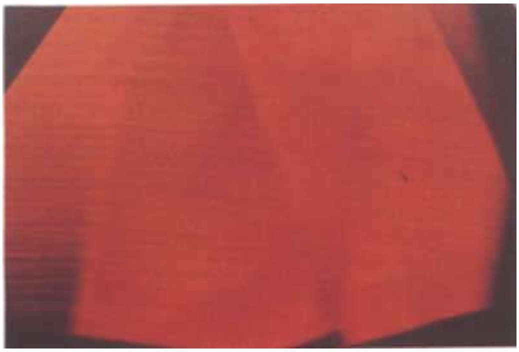

Fig. 2. When examined with 20X magnification through the pavilion, the strong red-brown graining that occurs throughout the diamond can be seen. *Photo by John Koivula, copyright by the Gemological Institute of America.*

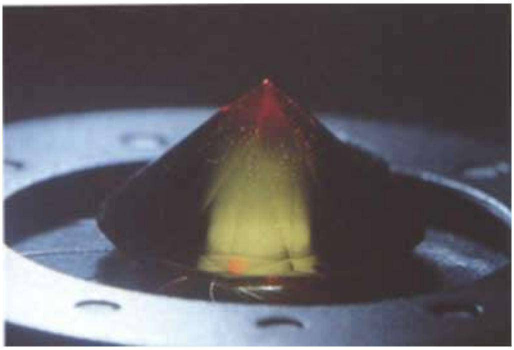

Fig. 3. When placed over a strong visible light source (such as from the hand spectroscope unit shown here), the diamond exhibits green luminescence. The numerous bright specks on the pavilion facets are dust particles on the surface. *Photo by John Koivula, magnified 2X, copyright by the Gemological Institute of America.*

1982). Superimposed upon this rising curve is a broad region of moderate-strength absorption between 500 and 600 nm that is centred at about 550 nm (that cannot be seen with a hand spectroscope). This broad-band absorption is characteristic of natural pink or purple diamonds (Collins, 1982), and its presence explains the 'red' component of the colour of this particular diamond. This can be seen by the comparison of the visible absorption spectra of this diamond with those for the 0.95 ct purplish-red and a 0.59 ct purple-pink diamonds (Figure 4, spectra B and C, respectively). The possible origin of these several absorption features is discussed below in the section entitled 'Cause of Colour'.

The infrared spectrum reveals that this diamond is of type Ia with a relatively high nitrogen content (Figure 5). The spectrum is unusual, however, because it shows a rarely-seen absorption feature referred to as the 'amber centre' (DuPreez, 1965, p.83), with a principal absorption band at about 4150cm^{-1} and many smaller bands at higher energy (Figure 5). Since the DuPreez thesis, there have been no further original data published on this unusual and complex absorption system. We have observed it in six out of about 1300 diamonds that we have recorded spectra for during the course of our ongoing coloured diamond research project. These six include four type Ia and two type Ib diamonds (one of the latter laboratory-treated to a red-brown colour (Landreau, 1986)). Our observations contradict the statement made by DuPreez that this absorption system was 'very common' in diamonds with paramagnetic nitrogen (e.g. type Ib diamonds). DuPreez named this system the 'amber centre' from the colour of the diamonds in which it was first found. However, one of the four type Ia diamonds with this centre that we examined has a light greyish-pink colour, and two of the other type Ia diamonds have a pinkish or reddish component to their colour. Interestingly enough, DuPreez associated the 'amber centre' with a broad absorption band at 550 nm, similar to that giving a pink colour (Collins, 1982), but he reported that the latter band behaved differently on cooling or exposure to X-rays than has since been noted elsewhere.

Discussion

Only a small number of diamonds with 'red' as a principal hue component of their colour have ever been mentioned in the gemmological literature. With few exceptions, these reports contain little, if any, detailed information on gemmological properties. There is also little specific information on their geographic origin of these diamonds. Ball (1934) lists the following sources: India, Borneo, Brazil, and South Africa. Gill (1978) mentions these same sources, but also includes Venezuela. The Alto Paranaiba area around Uberlandia (known as the 'Triangulo Mineiro', or the miner's triangle) in western Minas Gerais, Brazil, was reportedly a source of red and pink diamonds earlier in this century (Svisero *et al.*, 1984; K. Scarratt, pers. comm., 1989; Cassedanne, 1989).

Besides the diamond described here, the GIA Gem Trade Laboratory has issued reports on only three faceted diamonds in the recent past that contain the terms 'red' or 'reddish' as part of the colour description on their report.

* 2.33 ct cushion antique brilliant, fancy brownish orange-red, known as the 'Raj Red'.

* 0.95 ct round brilliant, fancy purplish red, known as the 'Hancock Red' (Kane, 1987; Federman, 1992).

* 0.54 ct round brilliant, fancy reddish-purple (Kane, 1987).

No coloured diamonds have ever been described

TABLE 2. 'Red' diamonds reported in the gemmological literature or by our colleagues, but not examined by GIA

Weight (ct)	Faceting style	Reported colour	Reference
10.26	Pear brilliant	'Chinese Red'	Gem Catalogue of the Duke of Brunswick-Luneburg (1860, pp.126-7)
8.00	Not reported	'Red'	Kunz (1926, p.596)
7.44	Round brilliant	'Garnet'	Gem Catalogue of the Duke of Brunswick-Luneburg (1860, pp.108-9)
6.00	Cushion cut	'Red'	Kunz (1926, p.596); Gill (1978, p.85); reportedly from South Africa
5.05	Emerald cut	'Blood red'	Drukker (1971); Gaal (1977, p.241); Gill (1978, p.85); 'De Beers Red'; reportedly from Lichtenburg, South Africa
5	Not reported	'Ruby red'	Shepard (1934); Monnickendam (1955, p.154)
5	Round brilliant	'Port wine red'	Gill (1978, p.86)
3.98	Round brilliant	'Brownish red'	Gem Catalogue of the Duke of Brunswick-Luneburg (1860, pp.94-5)
2.50	Round brilliant	'Port wine red'	Gill (1978, p.86)
2.50	Marquise	'Deep cherry red'	Gill (1978, p.86)
2.50	Round brilliant	'Red'	Gill (1978, p.85); reportedly from Brazil (?)
2.00	Not reported	'Red'	Kunz (1926, p.596)
1.64	Not reported	'Deep red'	K. Scarratt (per. comm., 1989; Gem Testing Lab of Great Britain report)
1.28	Marquise brilliant	'Red/pink'	C. Schiffmann (per. comm., 1989)
1.15	Not reported	'Bright red'	Eclat (1984, p.119)
1.14	Not reported	'Red/brown'	K. Scarratt (per. comm., 1989; Gem Testing Lab of Great Britain report)
1.13	Round brilliant	'Purplish-red'	T. Horovitz (per. comm., 1989; Gübelin Lab and SSEF Lab reports)
1.00	Not reported	'Red'	Streeter (1884, p.141); Gill (1978, p.85); 'Halphen'; reportedly from Borneo (?)
1	Cushion cut	'Ruby red'	Gübelin (per. comm., 1989)
0.80	Not reported	'Red'	Zucker (1984, p.93)
0.60	Round brilliant	'True red'	Crowningshield (1965, p.362)
0.52	Marquise	'Purplish red'	Eclat (1984, p.117)
0.46	Cushion brilliant	'Purple red'	C. Schiffmann (per. comm., 1989)
0.46	Marquise brilliant	'Reddish-pink'	T. Horovitz (per. comm., 1989; Colored Diamond Lab Services report)
0.37	Not reported	'Red'	Kunz (1926, p.596)
0.29	Not reported	'Red'	K. Scarratt (per. comm., 1989; Gem Testing Lab of Great Britain report)
0.28	Not reported	'Rose red'	K. Scarratt (per. comm., 1989; Gem Testing Lab of Great Britain report)

Notes:

1. The colour description of these diamonds using current GIA terminology is unknown.
2. Additional diamonds with these colours are cited in Fersman and Goldschmidt (1911, crystal drawings #55, 91, 92, 105, 120), Kunz (1926, p.596; 1927, p.567, and 1929, p.515), Drukker (1971, pp.140-1), Pyplev (1896; cited in Orlov, 1977, p.121), and Gill (1978, p.85).

by them as being 'pure red'. Considering the great number of coloured diamonds seen over the years in the GIA Gem Trade Laboratory, this very small number demonstrates how extremely rare coloured diamonds that would be described by experts as being 'red' or 'reddish' actually are.

Given the widely-held perception and reported experience of professional diamond gemmologists as to the great rarity of these coloured diamonds, we thought it would be interesting to try to find references to diamonds of this colour. Table 2 presents a list of other alleged 'red-orange' (i.e. 'red-brown'), 'red' and 'red-purple' faceted diamonds that have either been reported in the gemmological literature, or by our colleagues who are involved in the gemmological study of colored diamonds. Our purpose for compiling this table was to find reports of apparent 'red', 'reddish' or 'red-brown' diamonds. We chose not to mention pink or brown diamonds because of their much greater relative abundance and corresponding wider recognition among gemmologists. Literature citations also exist for rough diamond crystals, but they are given in Table 2 only as a footnote because it was impossible for us to be certain if their reported colour is a true bodycolour or just a surface colour (due to staining, for example).

In compiling Table 2, we sought references that mentioned a polished diamond in terms of its weight, faceted shape, and colour. Anyone familiar with the gemmological and trade literature recognizes that it is often incomplete, as can be seen for some citations in Table 2 where even this basic information was not reported. Some of these references, such as the Brunswick gem catalogue (1860) and the personal communications from our colleagues, are without doubt first-hand reports of specific diamonds. Others, such as the citations from Kunz and Gill, appear to merely be repetitions of information apparently reported elsewhere, and thus, their accuracy is more doubtful. Nonetheless, we have no reason to suspect that there is not some degree of truth in all these citations of actual diamonds with some form of reddish appearance. It should be emphasized, however, that we have no accurate current colour description of the diamonds beyond what is shown in Table 2, since none have been examined by GIA. Neither can we be certain in all cases that the diamonds shown in Table 2 each represent a different diamond, nor whether or not they had been artificially colour-enhanced for the more recent references (since gemmologists have long recognized that red-brown diamonds are occasionally produced by laboratory irradiation treatment [Crowningshield, 1959, 1966]).

Our literature search encompassed many documents available in GIA's Richard T. Liddicoat Library and Information Centre, but we found citations of only 27 such faceted coloured diamonds in literature references in the last century. This small number further substantiates the great rarity of truly 'red' diamonds.

Cause of Colour

The visible absorption spectrum of a 'red' diamond has not been published before. The few natural-colour 'reddish' diamonds for which some data have been reported suggest that the red component of the colour is due to a strong, broad band centred around 550 nm ('2.2 eV band'), the same that contributes to a pink or purple colour when the band is less intense. This is illustrated by the comparison of visible spectra of the three diamonds (Figure 4) which each exhibit the 550 nm broad band of varying intensity. Preliminary work has shown this broad band to be a vibronic band (Raal, 1958;, Collins, 1982). This hypothesis has been confirmed by our ongoing study of coloured diamonds. In Figure 4, three weak oscillations (sidebands) on the low-energy side of the 550nm broad band at approximately 590, 605, and 610 nm, are seen in the spectrum (C) of the purple-pink diamond, and two of them (590 and 600 nm) are seen in the spectrum (B) of the purplish-red diamond. It has been speculated that the origin of this 550 nm broad-band absorption, as well as the absorption rising toward the violet that gives rise to the brown coloration, is plastic deformation (a small displacement of atoms) along gliding planes in the diamond crystal structure (Harris *et al.*, 1984).

Other causes of pink-to-red colour in diamond have been suggested. The early idea that the pink colour is related to traces of manganese was totally discredited as long ago as 1965 (DuPreez, 1965, p.79). Neither does there appear to be any correlation between a pink or red coloration and the nitrogen content of the diamond as is sometimes suggested (e.g. Christie's auction catalogue, 28 April 1987, p.292). It has been our experience that the nitrogen content of pink-to-red diamonds can vary. In some instances, the amount of nitrogen seems to be quite high, as evidenced by the mid-infrared spectrum of the 5.03 ct diamond (Figure 5). In fact, the 0.95 ct purplish-red diamond (described by Kane, 1987) and the 5.03 ct stone are both type Ia diamonds containing relatively large amounts of nitrogen. Research is currently being carried out to better understand the exact nature of the atomic-level plastic deformation that is now generally thought to produce the pink-to-red coloration in diamonds.

The visible spectrum of the 5.03 ct diamond in Figure 4 (spectrum A) also displays a weak, sharp band at 503 nm (the H3 centre). As mentioned above, this band is responsible for the green luminescence seen when the diamond is exposed to intense visible light, as well as the yellow ultraviolet fluorescence.

Summary

This 5.03 ct red-brown diamond exhibits gemmological features that we find are characteristic of a number of natural-colour yellow-to-brown and pink-to-red or purple diamonds. These include prominent red-brown graining, green luminescence in visible light, and a visible spectrum with an increasing absorption toward the violet and a broad band located at about 550 nm. This particular diamond also displays the rare 'amber centre' in its infrared spectrum.

Some individuals consider this diamond unattractive due to its dark colour (which is further compounded by its large size). However, it sometimes happens that much can be learned from the study of such a diamond where certain features are more prominently developed than is normally the case in a lighter-coloured stone. In this diamond, the unusual feature is the hue and intensity of the colour. We propose that the colour – mainly brown and some red – can be explained in terms of the visible absorption spectrum where the causes of both colour components are evident. Furthermore, visual examination indicates that the red-brown colour is concentrated along planar octahedral graining. When considered with the reported occurrence of some pink-brown diamonds from the Argyle mine (see Hofer, 1985), the presence of red (or pink) and brown in the same diamond suggests a

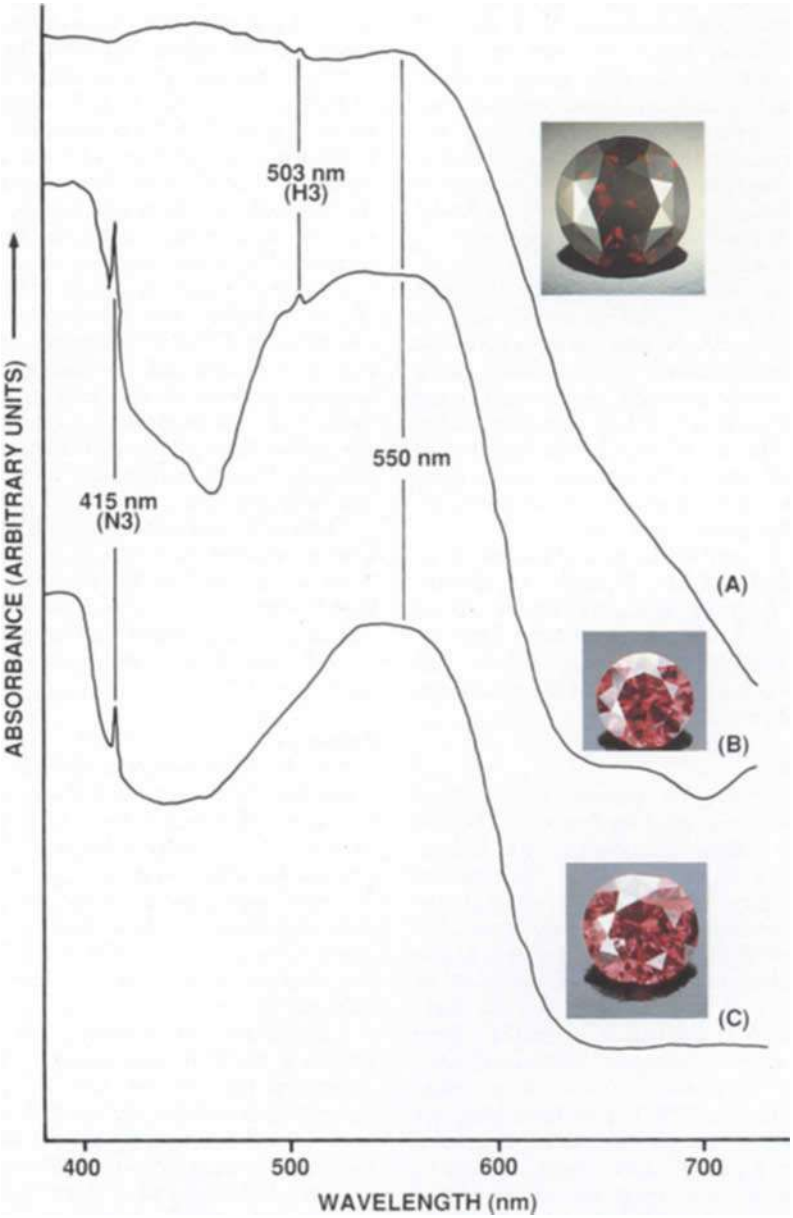

Fig. 4. These three visible absorption spectra were recorded at liquid nitrogen temperature (80 degrees K). The top spectrum (A) is that of the 5.03 ct diamond described in this article. The middle spectrum (B) is that of a 0.95 ct purplish red diamond, and the lower spectrum (C) is that of a 0.59 ct purple-pink diamond. Several features are present in these spectra;

(1) An increasing absorption toward the violet that gives rise to the brown component of the colour – this feature is only seen in (A). The 415 nm band (N3 centre), very common in type Ia diamonds as part of the 'Cape series' of absorption lines, can be seen in (B) and (C).

(2) A broad band centred at about 550 nm is responsible for the pink or red component of the colour. This band is visible in all three spectra in varying intensity. Associated weaker bands at approximately 590, 600, and 610 nm are visible in (B) and (C).

(3) The upper two spectra show a sharp band at 503 nm (the H3 centre); this band gives rise to the green luminescence of the 5.03 ct diamond. The 496 nm band observed with the hand spectroscope in the same diamond is not resolved in spectrum (A).

Acknowledgements for photos: (A) by Robert Weldon, copyright by the Gemological Institute of America; (B) and (C) copyright by Tino Hammid.

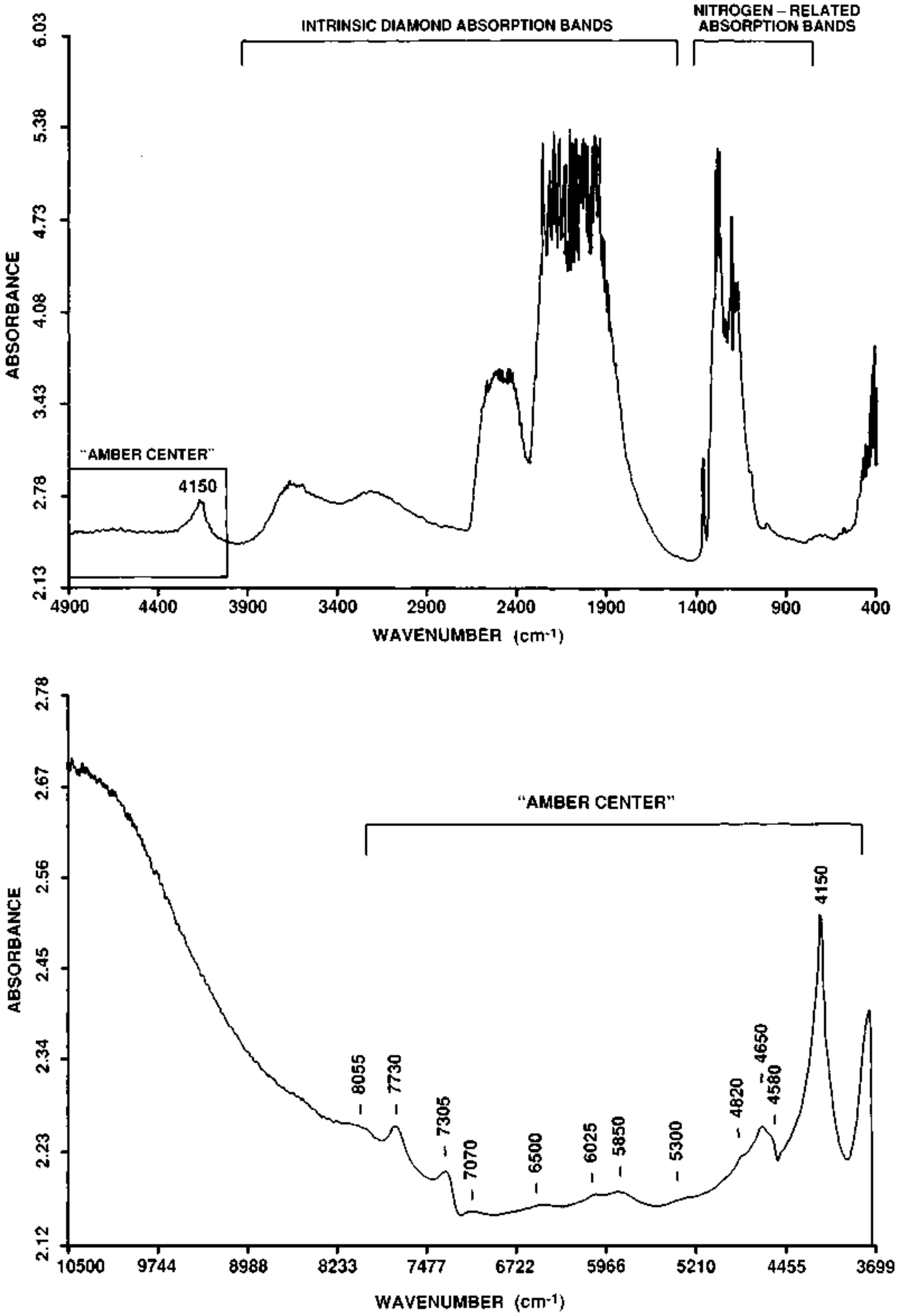

Fig. 5. The near- and mid-infrared absorption spectra of the type Ia 5.03 ct diamond. Note the 'amber centre' starting at 4150cm^{-1} (top spectrum) with further details at higher energies (bottom spectrum).

related cause of these colours. In such cases, deformation of the diamond during its long history in the earth may account for the formation of a colour centre along graining planes that would be responsible for brown, pink, and even 'red' colours.

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Possible prehistoric glasses in the gem trade of Sri Lanka

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Abstract

Variously-coloured glasses are found in Sri Lanka in different geological environments; at or near the surface (hence the Singalese name 'ground glass'), in some gravels of recent rivers and in some gem pits (hence the English name 'pit glass'). If these glasses were really deposited in the Pleistocene times together with the gem gravels, were they tektites? However, the chemical compositions of these glass samples are different from that of real tektites. The very high content of sodium in all samples and the lead content in some samples are strong arguments for an artificial formation of these glasses. These multi-coloured glasses are man-made materials, which were probably produced in prehistoric times. After the mining activity was finished the gem pits were always filled up with overburden and any kind of waste. The waste, which is found during modern gem mining, consists of old bricks, old pottery and other useless things, for instance gem gravel from older mining activities such as geuda, which did not have any value in former times. The gem pit could also be filled up with waste from glass production. Glass was an important article of trade on the old maritime silk route.

Introduction

In the gem trade glass is normally a man-made material. But in some cases glass is of natural origin such as obsidian from volcanic activity or tektite glass which has been formed from sediments on the earth surface which have been fused by heat generated through the impact of enormous meteorites (Preuss, 1935, Heide, 1934 and 1988).

Multi-coloured glasses are well-known in Sri Lanka. Most of them will be sold to tourists after cutting. Some rough uncut glasses will be exported to Thailand as carving material for the production of Buddha images and other articles. Gem dealers think that this glass is of natural origin and locally they call this material in the Singalese language '*Bin vitro*' which may be translated as ground glass. A. Church (1924) mentions that 'moldavite' (glass from Moldavia, Czechoslovakia; today sometimes called tektite (Greek: smelted)) 'occasionally occurs in the gem gravel of Ceylon'. In the English literature this material is called 'pit glass'. Webster (1970), mentions 'there has been no clear confirmation but a number of pieces of so-called 'pit glass' which is mostly brown or green have been credibly reported', but it seems for Webster 'so far be considered unproven?'. The question whether this glass was probably man-made in prehistoric time, has no room in the gem trade of Sri Lanka. Even well reputed gem dealers, who never touch this cheap stuff (which is mostly dealt with in the street) think that it is of natural origin. Some geologists and gemmologists of Sri Lanka with a very good knowledge of Sri Lankan gems consider this material as tektites coming from the gem gravel – the 'Illam'. If this conclusion is correct, it has an important consequence. Since the 'Illam' was probably deposited in the late Pleistocene, this pit glass could not be an artificial product. The multi-coloured appearance of this pit glass is, however, very unusual for a tektite or for similar material of meteoritic origin. This pit glass occurs in red, green, orange, violet and yellow colours, but most pieces which are on the market are colourless or with a very faint shade. Some of the colouring elements, such as cobalt, iron, etc., are enriched in some meteorites. On the other hand these colouring elements were well known in the various prehistoric glass-making factories. Glassy slags from prehistoric metal smelting works may assist in the study of man-made glass. Further information may be obtained by comparing the local pit glass with material from other places with an undisputed origin.

Description of the pit glass material

Glass in Sri Lanka may be found in the gem gravel (illam), in the river load or in some soils. For genetic questions – whether the material is man-made or of natural origin – the size, the shape, the surface, the colour and the chemical composition of the glass are very important.

The size of the Sri Lanka pit glass specimens varies considerably. Small pieces below one gram are to be found among pieces of several kilograms in weight. Even single pieces over 50kg are not uncommon. Real tektites from elsewhere, which were transported through the air, are mostly of

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Fig. 1. Two samples, which are common in Sri Lanka, show a very faint green tint. The surface of the larger glass sample is scarred and pock-marked; the weight of this sample is 940g, size 135 x 75 x 64mm (only part is visible). The smaller sample was collected from a river sediment. The surface of this sample is different from the bigger piece; weight 235g, size 85 x 55 x 45mm. The small blue sample is coloured by cobalt. Weight 50g, size 35 x 35 x 30mm.

Fig. 2. A similar glass sample (to Figure 1) on the illuminated viewing box.

Fig. 3. A prehistoric glass sample with a cut and polished surface. The window allows internal viewing and shows a clear glass body without any bubbles.

hazelnut sizes, but pieces of up to several kilograms have been found. However, tektites of several tens of kilograms are not known, whereas pit glass of this size has been found.

The shape of the pit glass is irregular but more or less isometric. Never have I seen in Sri Lanka pit glass shapes which are found in tektites such as balls (partly hollow), button shapes, drops, peas, ellipsoids, discs, dumb-bells, cones similar to pine cones, etc., which are well-known to collectors of tektites.

The surface of some pit glass is scarred, pock-marked or with cavernous or other weathering marks, but the pit-glass from the river or from the Illam does not show this characteristic surface. The surface markings of tektites may be explained by supersonic and rotational flight through the earth's atmosphere; weathering surfaces are not known from tektites.

As mentioned before, pit glasses from Sri Lanka are of various colours. Most tektites from other localities are black or dark coloured and opaque but colourless and various shades of transparent olive green, bottle green and yellowish-grey are found in some well-known 'tektite' localities such as Moldavia. However, the colours at one locality usually differ only in a relatively small degree. In contrast to these more or less uniform colours of the tektites the pit glasses from Sri Lanka are very different. Red, orange, light blue, deep blue, violet, green, brown and yellow are common in the local trade. But never have I seen a black pit glass, which is normal for most tektites.

Chemical composition

The chemical composition of some glasses may be helpful for the differentiation between man-made material and tektites.

Chemically glass, being a melt, can be produced by the fusion of an acidic oxide with a basic oxide to reduce the melting point of the glass. The acidic

Fig. 6. Cut prehistoric green glass with 0.2% chromium and 0.1% copper. Size: 15 x 15 x 10mm.

Fig. 4. Different coloured glass samples from Sri Lanka, probably of prehistoric origin. The green sample is coloured by chromium, the deep blue by cobalt, the light blue by copper, the deep red is a lead glass.

Fig. 5. Cut prehistoric glasses from Sri Lanka. The red triangular specimen is a lead glass. The small blue (copper) cabochon is not such a clear glass material. Cobalt-blue and chromium-green pieces. The large cut glass piece with a very faint tint is a most important prehistoric glass material in Sri Lanka.

Table 1: Chemical compositions of possible prehistoric glasses ('pit-glass') of different colours from Sri Lanka

	Colourless faint green tint	Cobalt blue	Emerald green	Aquamarine pale blue	Orange	Ruby-red
SiO_2	68.9	69.1	67.6	58.4	70.1	53.4
Al_2O_3	1.7	2.6	2.8	15.0	1.6	2.0
TiO_2	0.03	0.05	0.01	0.2	0.03	0.006
Fe_2O_3	0.2	0.06	0.07	0.2	0.06	0.12
MnO	0.02	0.06	0.02	0.2	0.09	0.18
P_2O_5	0.03	0.05	0.07	0.11	0.08	0.22
CaO	12.5	7.7	11.5	1.3	10.1	0.8
MgO	2.06	0.02	0.02	0.05	0.04	0.02
Na_2O	11.9	14.3	13.6	9.16	10.88	14.8
K_2O	0.86	0.91	2.07	1.28	4.99	0.22
BaO	0.02	0.002	0.005		0.01	
H_2O	0.10	0.15	0.16	0.56	0.34	1.26
ZnO	0.3	3.2	0.03	0.09	0.12	0.06
PbO	0.34		0.04	11.2	0.16	26.2
ZrO_2	0.1	0.03		0.1		
As_2O_3	0.05	0.3	0.4	0.65	0.3	0.5
Cu		0.60	0.14	0.25	0.06	0.07
Co		0.07				
Cr			0.2			
Se					0.15	
Cd					0.02	
	99.11	99.19	98.74	98.95	99.13	99.86
RI	1.510	1.535	1.518	1.524	1.51	1.56

Several single glass samples have been analyzed. The SiO_2 and partly the Al_2O_3 have been analyzed in the classical wet chemical way. Na_2O, K_2O, CaO, MgO, P_2O_5 and PbO by atomic absorption. Fe and Al by spectrophotometric methods. The other trace elements by X-ray fluorescence.

oxide is commonly quartz with a very high melting point. The basic oxides are commonly soda (in prehistoric times from Egypt) or potash (most commonly vegetable ash) together with limestone and possibly with basic lead, barium, zinc, thallium, zirconium or aluminium; glass has an immense range of chemical composition. Artificial glass normally has a much higher content of Na_2O and CaO than is found in tektites (varying between 0.65 and 3.8% Na_2O, 1.85 and 3.16% K_2O, 0.1 and 3.5% CaO). Preuss (1935) showed that the chief constituents and the trace elements of the tektites are similar to those of sandstones, graywackes or loess. Tektites are much higher in aluminium (6-15% Al_2O_3) and to some extent higher in SiO_2 (70-90% SiO_2) than the normal man-made glass. Antique glasses are very rich in sodium and lime, which lowers the melting point. Bezborodov (1975) published an extensive collection of chemical analyses of antique prehistoric glasses. The content of the different elements varied considerably: Na_2O 0.2-30%, CaO 1-25%, K_2O 1-19%, Al_2O_3 0.47-10%, SiO_2 49-72%. These prehistoric glasses were produced during different cultural times; Egyptian, Roman (from different places in Germany), ancient Russian (Ukraine) and Arabic cultures and even from different prehistoric localities in India. Most prehistoric glasses are Na and Ca-rich. The glass samples from India are mostly Na and Ca-rich and Arikamedu (South India) glass is rich in K_2O.

Our analyses of pit glass from Sri Lanka are presented in Table 1. All samples are very rich in sodium (9-15% Na_2O) and CaO (0.8-13% CaO). Pit glass shows a low content of Al_2O_3 (1.8-2.9%, one sample 15% Al_2O_3). The water content (0.09-1.5% H_2O) in these samples is too high for tektites (0.0003-0.01% H_2O). Even the content of all other elements shows very clearly that this so-called pit glass from Sri Lanka is a man-made glass and not a tektite. Another important constituent of some pit glasses is lead (varying in different analysed samples from 0.00-27% PbO). This element gives credence to the opinion that this material is man-made. Even the high content of antimony (up to several %), arsenic (0.0-4.3%), barium (0.2%) and sulphur (in some samples up to 2%) are unexpected elements and have not been found in true tektites in this amount. Even modern glasses normally have different chemical compositions from these prehistoric glasses from Sri Lanka.

Refractive index of glass

The refractive index and the density of pit glass vary over a considerable range and in some cases overlap those of natural stones. Moldavites have a refractive index n near 1.5 – the analysed pit glasses from Sri Lanka varied in this index n = 1.501 – 1.535 and up to 1.56 for lead glass. Some values are given in Table 1 together with the chemical composition.

Table 2: Colouring agents in possible prehistoric glass samples (pit glass) from Sri Lanka by X-ray flourescence analysis

Colour of the glasses	Trade name Imitation	Colouring Trace elements mean value of several samples
Red*	'Ruby'	Copper Cu^{1+} 0.1-0.0X% Gold probably + but very low
Brown red*		Copper with iron Fe^{3+} 0.0X-0.4%
Orange**	'Padparadsha'	Selenium 0.1 Se + 0.0X Cu%
Yellow	'Chrysoberyl'	Cadmium or iron Fe^{3+} 0.0X-0.2%
Blue	'Sapphire'	Cobalt 0.07% Co + 0.2% Cu^{2+}
Pale blue*	'Aquamarine'	Copper 0.0X-0.7% Cu^{2+}
Blue-green	'Aquamarine'	Iron 0.1-0.7% Fe^{2+}
Green**	'Emerald'	Chromium 0.2% Cr + 0.1% Cu
Blue-violet**	'Amethyst'	Cobalt 0.05% Co + 0.4% Cu
Dirty green		Manganese + iron 0.3% Mn + 0.4% Fe

* Partly lead glasses up to 27% PbO
** Partly potash glass
X Varying values in this range

Different types of pit glass

From the historical point of view it is very interesting to note that in the early days very different glass qualities were produced. The varying chemical analyses, densities and the refractive indices of the samples indicate that the pit glasses from Sri Lanka represent different special glass types. In modern glass nomenclature the pit glass is comparable with the following types:
bottle glass or window glass, crown glass (lime – soda – potash) and flint glass (crystal or lead crystal glass – with a high content of lead).

Pit glasses of different colours

Simple glass, made of pure ingredients such as silica and alkali oxides, are colourless, but natural sand is not chemically pure and has a varying content of heavy minerals. These different minerals may give the glass a very faint colour. If a stronger shade of colour is to be present colour-producing agents must be added. Many shades of colour could be attained even in prehistoric glasses. In normal glass, iron is the most important tinctorial agent, some yellow, some green, some brown colours reflect a certain iron content and a different oxidation state. Apart from iron a large number of metallic elements (as oxides) are used for imparting colour into glasses such as Cr, Co, Ni, Cd, Mn, Se and Au. Many of these elements are found in some specially coloured pit glass samples from Sri Lanka, as X-ray fluorescence analyses show (Table 2). The precise colour shades do not depend merely upon the amount of colouring matter, nor upon the overall glass composition, but the conditions of melting, for instance copper under oxidation conditions give a blue colour to the glass and a red colour under reducing conditions.

It is a mixture of different colouring elements, which has been analyzed in the pit glass and not a defined composition, which could be produced by chemically purer elements during modern melting procedures. The fact that the colouring trace elements (compounds) used are not chemically pure is also an argument that this material is made in prehistoric time and probably in most cases not recently man-made material.

The colouring oxides are used in a similar manner today. Blue was the popular colour in Egyptian times. Even in Sri Lanka, copper, cobalt and iron were found in different blue glass samples. Unusual in the analyzed glass samples was the use of selenium. The orange tint of this glass is to be found in some samples together with a high content of aluminium, which is unusual in antique glasses and more common in glasses from the Middle Ages and from modern production.

Glass as imitation of gems

Glass is one of the oldest imitations or substitutes of gems and has been manufactured for thousands of years. Glass-making was considered a great art by the ancient Egyptians and in Greek and Roman times, when glass was so rare that it was considered more precious than natural gem stones. Even today antique glass beads are more expensive in the local trade in Egypt than antique natural gemstones, like agate, onyx, amber and turquoise. In the gem area of Sri Lanka beads of glass are very uncommon.

Interpretation of the results

The Singalese name for this so-called pit glass is 'Bin vitro', which may be translated as 'ground glass'. This name implies that this material is found in the soil. The present investigation indicates that this glass is man-made material and not a tektite or obsidian, neither of which are found in Sri Lanka. A plausible theory was put forward that the pit glasses of Sri Lanka are material that had been left behind on the sites of prehistoric glass factories which had to be abandoned. The prehistoric factory may coincide with the locality in which some pit glass can be found in larger quantities. Prehistoric glass is known not only from India (Bezborodova, 1975) but also from Sri Lanka. Francis (1990), mentions the locality Mantai in the north of Sri Lanka near the 'Adams Bridge' to South India (see Figure 1). From local information, which is difficult to get, glass may come from various localities in Sri Lanka: green and red glass may be found to the east of Matale. Dambulla (60km north of Matale) is famous for red glass. Yellow glass comes from Ginigathene. Various coloured glasses can be found among colourless glasses 35km south east of Anuradhapura. Blue glass comes from Nawalaptya, (100km east of Colombo). Green and pink glasses can be found near Kalawana (near Ratnapura). Very large glass pieces came from Bagawantalawo (near Nuwara Eliya). The route from the exact sources of gems to the market place is mostly secret. Even glass marketed in Ratnapura is mostly found elsewhere.

The gem gravel (illam) bed is mined in Sri Lanka in the dry season. The pit and the underground working may be filled up after the mining activity with overburden and even with any waste. For instance, in some mines in Elahera old pottery, bricks and old Singalese coins were found during modern gem mining activity. Even gems which were not in use in former days, such as star stones and geudas, were discarded and put back in the mined-out pit. Star stones, such as star rubies and star sapphire have come in fashion in the last century. Geuda, the nowadays highly valued poorly coloured corundum, which can be heated and turned into blue sapphire (H. Harder, 1990), was in old days without any value and can be found today in larger quantities in old mining areas. The waste of former days can include glass and this was probably produced in prehistoric times. Later new gem mining started again without knowledge of the previous mining activity and the old areas will be dug over again.

Only part of this new working will be in untouched illam. The other part is overburden and waste from the previous mining activity. During the new mining they may encounter the old workings and even the waste and other useful things of previous time, such as old Singalese coins. In the same way it could explain the possibility that man-made glass was mined from the illam. Only a completely untouched illam could show that no glass would be found in the Pleistocene horizon. An investigation in some newly opened gem mining areas might give some information but as nowadays (1989) travelling in some remote areas is difficult, this project could not be carried out.

The question of glass manufacture in Sri Lanka or imported glass

More than 2000 years ago when South India and even Sri Lanka were in close contact with the Mediterranean and even with the Chinese world, Mantei (now known as Mannar) was an ancient port of the maritime silk route. Beads of glass and gems were one of the important trade products. A further question is whether the rough glass was imported from elsewhere or whether the people of the Far East had their own glass production. The very large pieces of prehistoric glass may be a hint that the glass manufacture was in Sri Lanka itself. Another hint may be the unusually high content of zirconium and titanium in the glass. The mineral zircon is an important heavy mineral in the sands of Sri Lanka. Most glass analyses from Sri Lanka (Table 1) show a high content of Na_2O. Imported soda from Egypt or elsewhere or imported glass from the Mediterranean area or even sodium-rich plant ashes could be the source. The analyses also show a very unusually low content of magnesium for prehistoric glasses.

All these questions need further investigation but at the present time (1989) a visit to remote places in the northern part of Sri Lanka is impossible for political reasons. Francis (1990) says 'the South East Asian branch of glass industry died out in 1200'. It may be that in those times in Sri Lanka the glass factory became uninteresting and the people may have forgotten that glass was produced in this area. The deficiency of fuel seems, as in other places, also to be a reason why the glass production came to an end. This may apply also in the north of Sri Lanka since the production of 1kg glass needs two cubic metres of solid timber.

Prehistoric glasses as valuable collector pieces

In the past 'pit glass' stood in the shadow of the local gem business; only some poor tourists were happy to buy the rough or the attractive cut glass pieces. These glass pieces resembled sapphire, ruby, chrysoberyl, aquamarine and other gems. Prehistoric glasses are highly esteemed all over the world nowadays. The poor broker who deals on the gem market in Ratnapura with this glass material will not complain that it is not a tektite. As prehistoric glass this material is more valuable for collectors than the tektites, which are mostly found in larger quantities.

Acknowledgements

I express my thanks to Dr Kaboth from Deutsche Glastechnische Gesellschaft in Frankfurt for in-

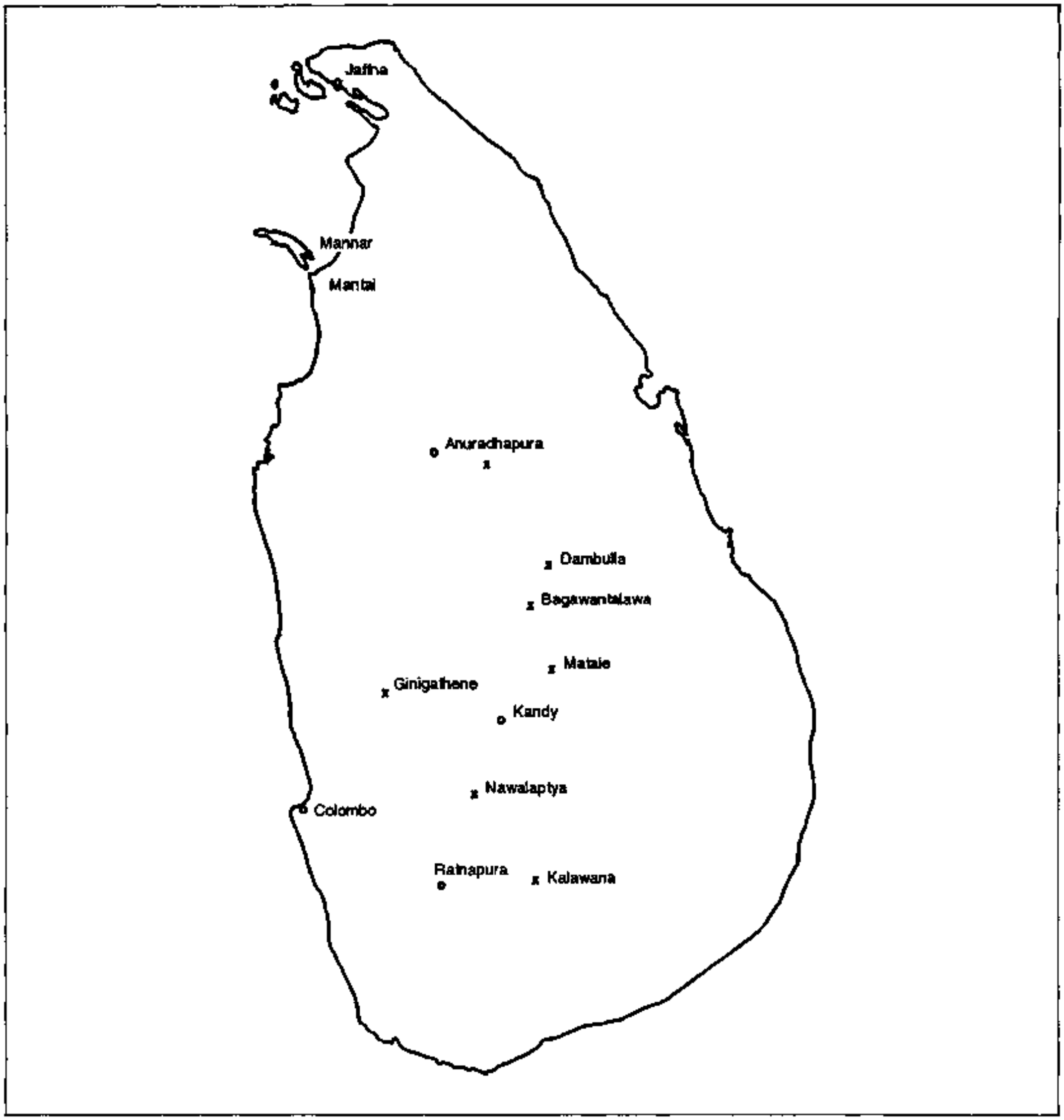

Fig. 7. Outline map of Sri Lanka showing some 'pit glass' localities.

formation on helpful literature. Mrs Cierny made the chemical analyses, which were very important for the scientific interpretation. Some friends in Sri Lanka, especially Mr Leslie J. Punchihewa, gave some information on local glasses.

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J. Gemm., 1993, 23, 5

Notes from the Laboratory – 17

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Three unusual Diamonds

The laboratory is involved with four areas of diamond activity – distinguishing diamond from its simulants; in the grading of the quality of gem diamonds, through the issuing of Diamond Grading Reports; and with respect to fancy coloured diamonds, grading the colour and identifying the origin of colour (whether this is of natural occurrence or whether it has been enhanced by irradiation and in some cases subsequent annealing).

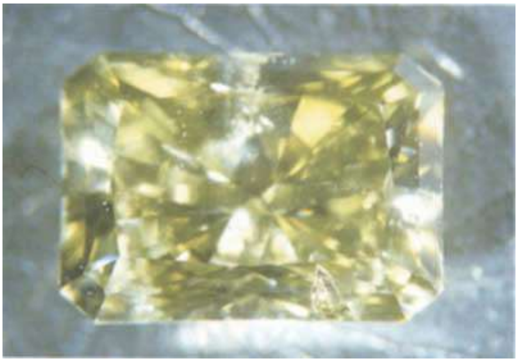

Fig. 1. The 0.49 ct chameleon diamond showing its 'stable' colour.

Coloured diamonds are rare – of the estimated 110 million carats of diamonds mined in 1992, a minute proportion will be graded as 'Fancy' in colour. Consequently few gemmologists and retail jewellers see many such fancies in the course of their working year. Those of us working in the laboratory are fortunate in seeing and identifying a great many such stones. However it is indeed exceptional for us to see three unusual fancy coloured diamonds pass through the laboratory at the same time.

The first stone (Figure 1) was submitted by a diamond cutter who had noticed that while polishing from the rough, the diamond glowed a bright orange-yellow on the polishing wheel and continued to glow for a few minutes after the stone came off the wheel. He found the finished gem diamond had 'stabilized' to a sufficiently interesting colour to warrant a laboratory report.

The rectangular, modified brilliant-cut stone, weighing 0.49 carats and measuring 5.13 x 3.70 x 2.90mm, was seen under our colour grading light to have an underlying yellow coloration somewhat modified by a less saturated secondary green colour. The overall saturation of colour when viewed through the crown of the stone ('face-up' position) was of such intensity that the stone was graded as 'Fancy'. When it was subjected to long-wave ultraviolet light, an intense yellow fluorescence and persistent (over five minutes) yellow phosphorescence was noted. After the diamond had been kept in a dark safe overnight and then exposed to light the following day, an intense yellow coloration was immediately apparent which slowly changed over the next few minutes to the normal 'stable' colour of greenish-yellow.

The characteristic colour and fluorescence indicated that the diamond could be a so-called 'chameleon' diamond – a diamond that changes its colour according to prevailing temperature and light conditions (Nassau, 1983). Our suspicions were confirmed when a gentle, careful heating of the stone in the flame of a spirit lamp once again induced the unstable yellow colour which decayed upon cooling to the stable colour. The ultraviolet/visible (UV-Vis) spectrum was similar to other chameleon spectra we have recorded (Scarratt, 1984), and the infrared (I-R) curve proved the diamond to be of Type IaA (with nitrogen in the A-aggregate form) with moderate to high amounts of hydrogen present (see major peak at 3107cm^{-1} in Figure 2). Hydrogen is seen in the I-R spectrum of other types of diamonds (see below) so its presence cannot be considered to be the cause of the chameleon effect.

We were indeed fortunate to have Dr Kurt Nassau, an acknowledged authority on the causes of colour, visiting the laboratory at the time of our examination (see 'Conference 1992' and 'Presentation of Awards') and it was a pleasure to discuss with him the possible causes of the unstable nature of the colour change in such diamonds.

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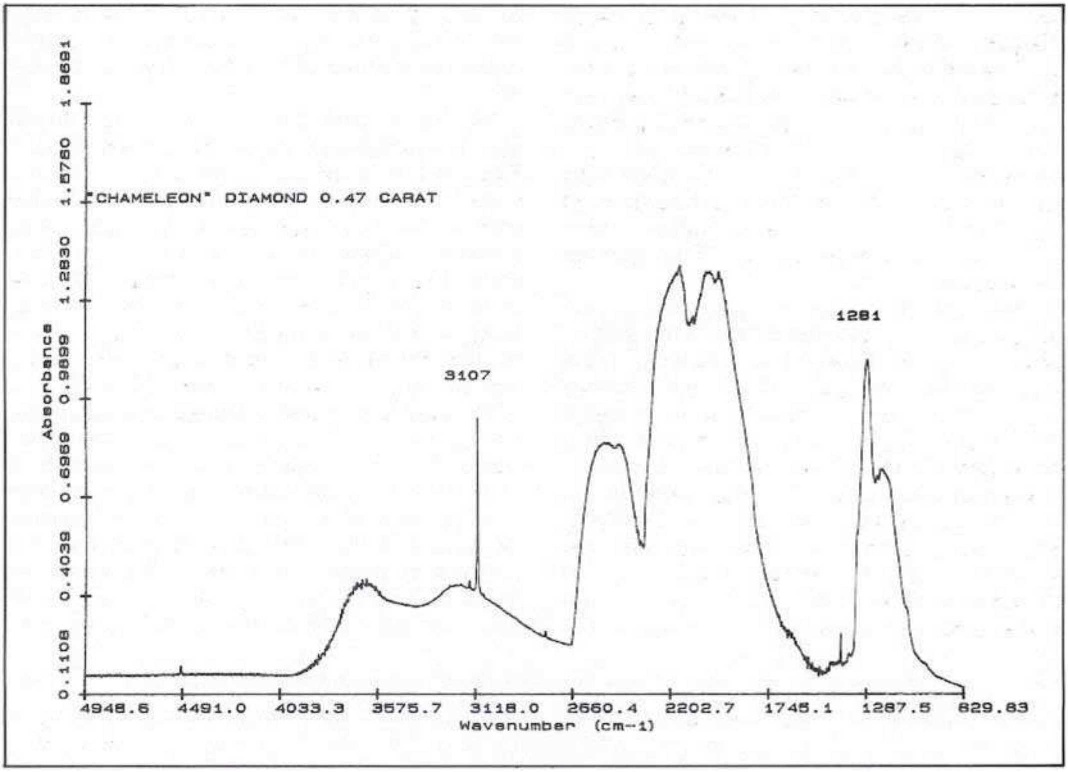


Fig. 2. The I-R spectrum of the chameleon diamond. Note the A-aggregate peak at 1281cm^{-1} and the major hydrogen peak at 3107cm^{-1}.

The second unusual coloured diamond we saw was a parti-coloured tapered baguette weighing 0.04 carats. One part of the diamond was colourless and the other part pink. The pink coloration was confined to parallel zones (Figure 3). We could find no evidence of artificial coloration. Very many pink diamonds we have examined, such as those from Argyle in Australia, exhibit strong internal pink 'grain' lines, visible in many cases to the un-aided eye.

The causes of pink coloration in diamond are not known for certain – it may well be produced by deformation of the diamond structure by stresses during growth in the Earth's upper mantle before the stone's ascent to the surface. Such plastic deformation may cause slippage of the lattice along the octahedral direction producing so-called 'grain lines' visible both within and on the surface of the polished gem.

Perhaps the reader would like to speculate on the

Fig. 3. The 0.04 ct parti-coloured pink diamond. Note the coloration in parallel zones.

Fig. 4. The 0.24 ct non-conductive blue diamond showing a high saturation of grey.

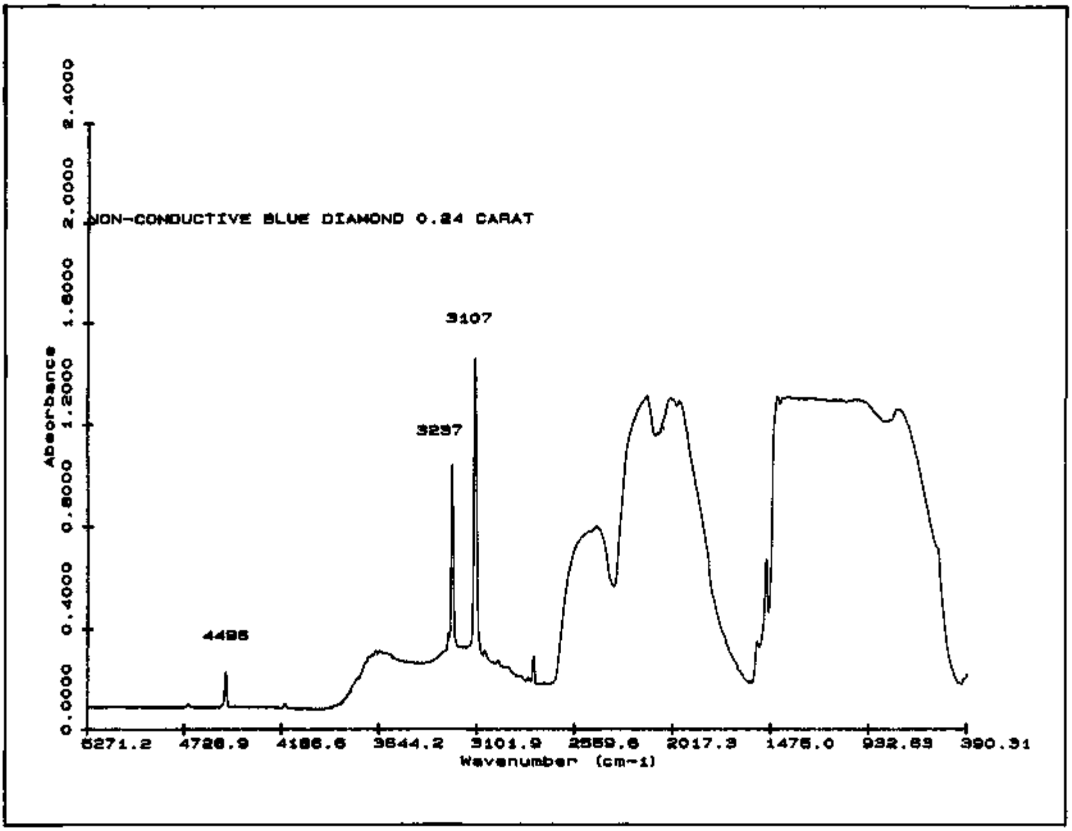
cause of the parti-coloration. If we reason that in this diamond plastic deformation is the cause of pink coloration then presumably only a part of the rough crystal was deformed and so only a part was coloured. Incorporation of that deformed coloured area together with an area of undeformed colourless diamond into the finished stone would produce the parti-coloured effect. Other workers (Chapman and Humble, 1991) have suggested that parti-coloration of pink diamonds may be due to a diffusion process involving an impurity.

The subject of pink coloration and colour instability reminds us of the pink diamonds that fade on exposure to bright light and heat. In the past, the Laboratory has graded several large pink diamonds of over forty carats, of pleasant colour saturation and graded as 'Fancy Light Pink'. When examined for clarity under the bright illumination and inevitable heat of a microscope, the colour soon faded to colourless literally before our very eyes! Happily for the diamond grader, the pink coloration soon returned at normal room temperature. We have also noted that many pink diamonds temporarily turn brown after brief exposure to X-ray irradiation. Again, the pink colour is soon restored. Presumably the cause of colour in these diamonds is an unstable colour centre susceptible to bleaching and irradiation.

Most of the pink diamonds we examine are of Type Ia – nitrogen present in the aggregated form. However it is interesting to note that, in contrast, many larger pink diamonds, including the fading ones we have examined are of Type IIa. These diamonds exhibit fugitive 'whitish' grain lines under 10x magnification. The famous Agra diamond mined in India exhibits whitish graining (Emms, 1990) and it would be fascinating to learn whether the Agra temporarily fades under strong light and whether it is, as I suspect, of Type IIa.

The third unusual rare coloured diamond to pass our way was an example of a non-conductive 'blue' diamond. The vast majority of blue diamonds are of Type IIb – the diamond lattice lacks nitrogen but contains boron as a single substitutional impurity (Wilks and Wilks, 1991). It is believed that the presence of boron causes the coloration and is responsible for the electro-conductive property of blue diamonds. Non-electroconductive blue dia-

Fig. 5. The I-R spectrum of the non-conductive blue diamond. The high hydrogen content is revealed as peaks at 3107, 3237 and 4496cm^{-1}.



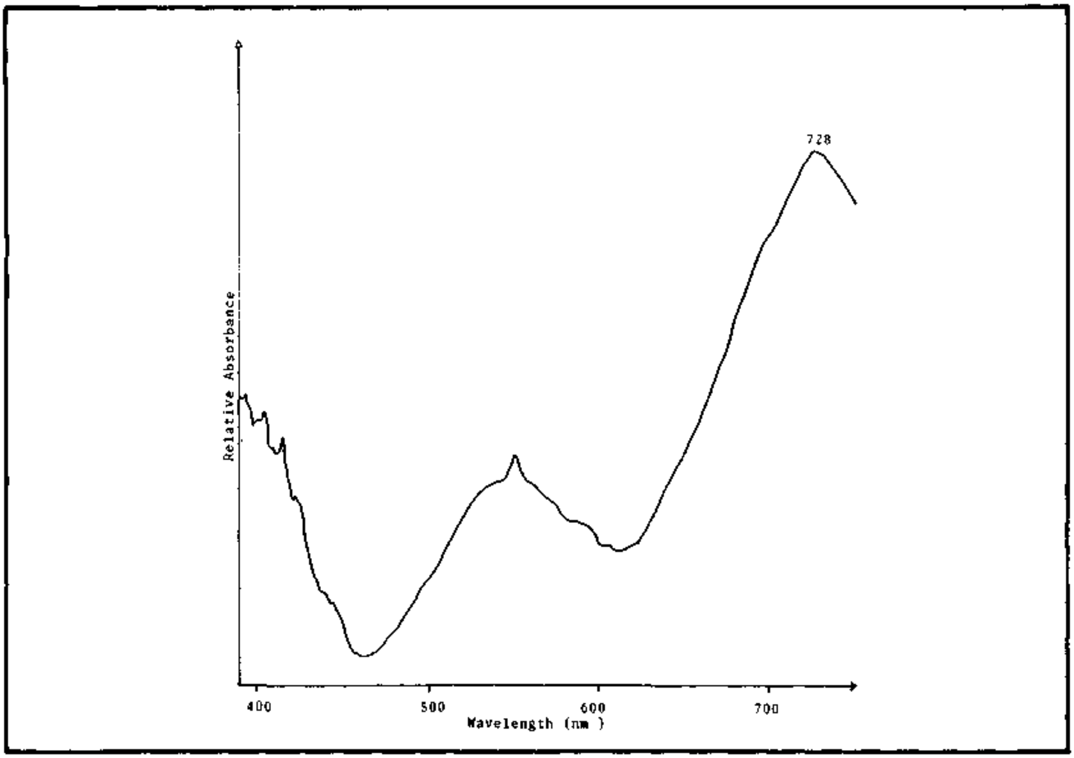


Fig. 6. The UV-Vis spectrum of the non-conductive blue diamond. Note the broad absorption in the red end (728nm) of the spectrum.

monds do not contain boron and may have nitrogen in both the A-aggregate and B-aggregate form (Type IaAB). Those diamonds we have examined have a violet, in addition to the blue component, together with a varying saturation of a grey tone.

This third unusual diamond was a round brilliant-cut (Figure 4) weighing 0.24 carats. Under LWUV light the stone fluoresced a strong yellowish-green colour; a somewhat weaker intensity of similar colour was seen under SWUV light. A prolonged greenish-yellow phosphorescence of up to ten seconds was observed after exposure to LWUV and SWUV light. The I-R curve confirmed the diamond to be Type IaAB with high hydrogen content (Figure 5) and the broad absorption in the red end of the UV-Vis spectrum (Figure 6) may account for the violet-blue colour component. Again the cause of the coloration of this type of stone is unknown, although hydrogen has been proposed tentatively as the impurity responsible (Fritsch and Scarratt, 1992).

These three fancy diamonds we have examined were all of natural colour yet they illustrate the uncertainty of the cause of the coloration in each type of diamond. We shall endeavour to collect more data in each case as part of our continuing programme of diamond colour research.

Acknowledgements

The author has pleasure in thanking Dr Kurt Nassau for a stimulating discussion on chameleon diamonds and thanks his colleagues at the Gem Testing Laboratory, namely Ana Castro, Steve Kennedy, Alan Clark, Louise Prior and Riitta Spencer, for their help. The author would also like to thank Dr Roger Harding for his helpful advice and is grateful to Ian Day and Richard Vainer for bringing these diamonds to our notice.

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Microscopic studies of Burmese jadeite jade – 1*

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Introduction

The 102 specimens used in this study were selected on the basis of their colour variation, differing grain size and appearance, and also taking into account the classification used by the Hong Kong jade dealers from whom a large proportion of the specimens was obtained. In this paper some of the results of the microscopic examination are described.

The rock types of Burmese jadeite jade

Based on the constituent minerals and textural features as seen under the microscope, Burmese jadeite jade can be divided into the following rock types:

(A) Pure jadeite rock (Jadeite)

This is an essentially monomineralic jadeite rock which may contain a little diopside and albite also. Examined samples are granoblastic in texture with measured grain sizes in the range 0.8 x 0.2mm – 1.76 x 0.3mm. Jadeite is colourless with long to short prismatic form, it has typical 2-direction pyroxene cleavages (at angles of about 87° and 93°). Under crossed polars the interference colour is 1st order grey to 1st order yellow. The extinction angles range from 32° to 44°. The optical sign is positive with 2V=70°-75° and the elongation is positive. Diopside is also colourless, but usually of short prismatic form, with two-direction cleavages. But the interference colour is higher than jadeite, usually of second order and the maximum extinction angle of longitudinal sections (010) is larger than jadeite, usually jadeite is 33° and diopside is 41°.

Apparently, this type of jadeite jade has not been subjected to alteration. The colour is usually white, but in some cases lavender and (Figures 1, 2) pale green.

(B) Crushed jadeite jade

Although this type of jadeite jade is also composed of jadeite mineral, its texture is quite complex. The grain size is quite uneven, larger grains are crushed into smaller grains. The larger grains may be up to 2mm and surrounded by a border of fine granular grains (0.001 to 0.05mm) produced by the grinding down of the crystal itself and its neighbour. This is called mortar structure (Harker, 1964).

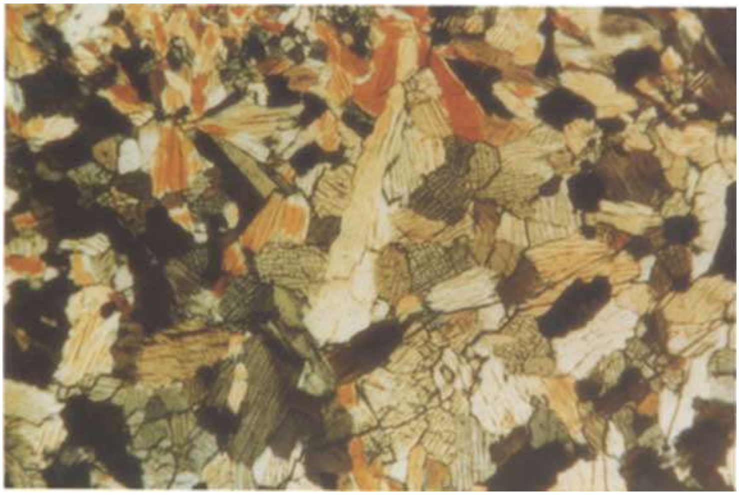

Fig. 1. Pure jadeite jade. Crossed polars. x35.

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* Part of a thesis submitted to the University of Hong Kong for the degree of M.Phil. Burma is now known as Myanmar.

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Fig. 2. Pure jadeite jade. Plane polarized light. x30.

Fig. 3. Crushed jadeite jade. Crossed polars. x35.

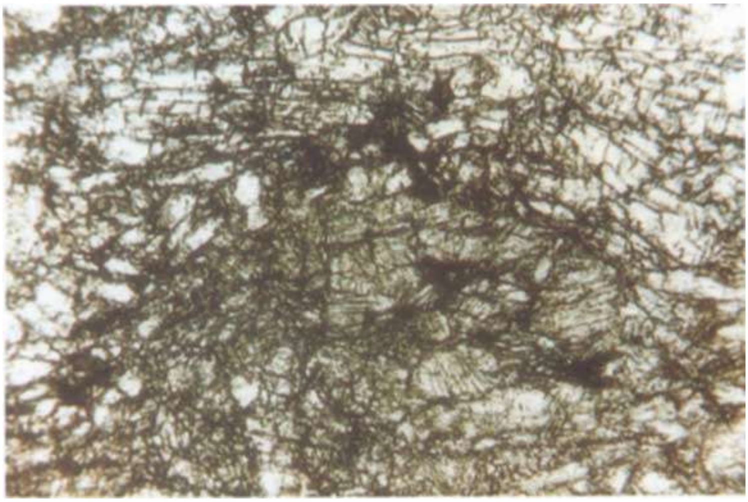

Fig. 4. Crushed jadeite jade. Plane polarized light. x35.

Under ordinary or plane polarized light, the smaller grain boundaries are not easily observed, they seem to be within the larger grain. Under crossed polars, however, they differ in extinction position so the boundaries between smaller and larger grains can easily be observed. This is evidence that the smaller grains are the result of crushing of larger grains (Figures 3, 4).

According to the degree of crushing, crushed jadeite jade can be divided into the following groups:

i. Composed mainly of coarse grains, which are surrounded by a few crushed fine grains as a result of the grinding along the grain boundaries.

ii. Large grains and crushed fine grains in equal proportion, e.g. the larger grains of jadeite are surrounded by about an equal amount of fine grains resulting from more grinding down of the larger grains.

iii. Essentially composed of fine granular grains resulting from the grinding and rolling processes. A small amount of uncrushed larger grains are isolated and separated by the finer groundmass, just like 'eyes' in mylonite rock.

Sometimes, under ordinary or plane polarized light, the uneven distribution of colour can be observed. Most of the larger grains are colourless, while the finer grains are slightly green. The result of electron-microprobe analysis of different grains shows that the average chemical composition of larger grains is:
$(Na_{0.87}Ca_{0.02}Mg_{0.02})_{0.91}(Al_{0.99}Fe_{0.01})_{1.0}Si_2O_6$ and that of the finer grains is $(Na_{0.99}Ca_{0.07})_{1.06}$-$(Al_{0.89}Mg_{0.06}Cr_{0.05})_{1.00}Si_{1.98}O_6$.
It is clear that they are both jadeite but the white large grains do not contain Cr (chromium) while the smaller grains contain chromium and have a green colour.

This explains why some of the samples of Burmese jade show different patterns of green colour on a white background.

(C) Actinolitized/tremolitized jadeite jade

This type of jadeite jade was originally composed of jadeite mineral but has been subjected to slight or strong alteration, so that part of the jadeite has been converted to tremolite/actinolite.

The actinolite and tremolite are of fibrous, acicular form, with lower relief than jadeite. Their interference colour ranges from 2nd order yellow to 2nd order blue and extinction angle from 10° to 20°. Their optical sign is negative with $2V=79°$ to 85°. Tremolite is white in colour while actinolite is green in colour. They can easily be distinguished from jadeite mineral under the microscope.

The different stages of replacement of jadeite by actinolite/tremolite can also easily be observed under the microscope, based on the degree of alteration (proportion of actinolite/tremolite present). The types of rock can be grouped into slightly altered, moderately altered and strongly altered jadeite jade.

i. Slightly altered jadeite jade

In the primary stage of alteration, the jadeite crystals are replaced only along the cleavage planes and grain boundaries (Figure 5). The proportion of actinolite/tremolite is small, about 15-20%. The granoblastic texture of the rock and the optical properties of jadeite remain unchanged.

ii. Moderately altered jadeite jade

The rock shows relict porphyroblastic texture. The short prismatic form of the jadeite crystal is largely replaced by the fibrous form of tremolite/actinolite. Isolated spots of jadeite embedded in fibrous amphibole give rise to the porphyroblastic texture. The tremolite/actinolite constitutes up to about 50-60% of the material; it is of acicular or fibrous form with grain size 0.2 x 0.002mm to 0.4 x 0.1mm. Sometimes, muscovite and/or chlorite may be observed as associated minerals. Microveins of quartz with comb structure can also be observed.

iii. Strongly altered jadeite jade

The rock has fibroblastic texture, and may be 80-98% composed of tremolite/actinolite, which has replaced the original jadeite. Relict texture of jadeite can be observed (Figure 6). The tremolite/actinolite occurs as fibres from 0.05 to 0.2mm in length. Samples which consist mainly of tremolite are white to grey colour, while those consisting mainly of actinolite are dark green, characterized by the oily lustre of their polished surface and greater transparency than jadeite jade.

(D) Ureyite jade*

The samples which were identified as ureyite are opaque, and dark green to bright green in colour. They are compact polycrystalline aggregates with grain sizes between 0.03 and 2mm.

Under the microscope, the ureyite jade shows a granular and/or fibrous texture. The samples examined contain 90-95% ureyite, the remainder being mostly chromite. The ureyite occurs both as tiny fibrous (Figures 7, 8) and short prismatic crystals with lengths up to 2mm. It has perfect cleavage in two directions parallel to {110}, intersecting in 85° or 95°, and a pronounced parting parallel to (001).

The refractive indices for monochromatic light (Na) are $\alpha=1.722\pm0.003$, $\beta=1.734\pm0.002$, $\gamma=1.745\pm0.003$. The mineral is strongly pleochroic

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*Under the rules of priority, ureyite is now properly known as kosmochlor.

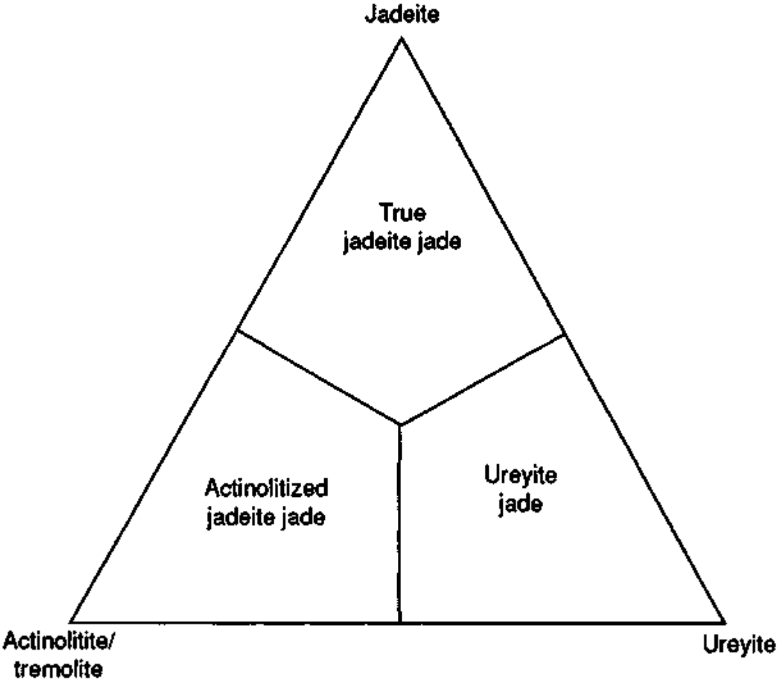

Fig. 11. The major mineral composition of Burmese jade.

with α yellow, β blue-green, γ bright emerald green. It is optically negative with $2V=70°$ (measured on the universal stage); the extinction angle, C equals 28°-30°. Some prismatic ureyite shows an exsolution texture with jadeite (Figure 9). This suggests that at very high temperature/pressure ureyite and jadeite mix more completely together; while at low temperature/pressure, they tend to separate. This finding is quite similar to that of Abs-Wurmbach and Neuhaus in 1976. The aggregate of tiny fibres, which can be seen from the extinction pattern; have replaced original grains. Wavy extinction is quite common. This indicates that the ureyite was subjected to stress during its formation.

The remaining minerals (associated minerals) are chromite and/or amphibole group minerals, feldspar and chlorite.

The process responsible for the paragenetic relation between the ureyite and the chromite is still under investigation. A mesh texture between chromite and ureyite can be observed (Figure 10), but in some cases chromite can also be observed surrounding the margins of the ureyite grains. In general, the texture of the chromite gives some hints that it may be the result of alteration of a Cr-rich mineral which has been largely replaced by ureyite.

At least two generations of an amphibole group mineral can be observed, as shown in Figure 8. One is of coarsely fibrous form, yellowish-green in colour and strongly pleochroic, which is found surrounding the ureyite. This amphibole is formed by direct alteration of the ureyite; this replacement phenomenon can be observed very easily. The other is of fine fibrous form, white to pale green in colour and weakly pleochroic, it comprises tiny veins intruding or enclosing the former (Ou Yang, 1984).

Conclusion

(1) The microscopic study of Burmese jade reveals that although it is composed mainly of jadeite, it is not pure. It has been subjected to alteration under stress. This gives rise to complicated compositions. The alteration product of jadeite is tremolite/actinolite (Kerr, 1977) and the rock contains some other pyroxene minerals. One characteristic of Burmese jade is that it is composed of mainly sodium rather than calcium pyroxene minerals. It is also very significant that ureyite, hitherto not known to occur in nature except in meteorites, is also present in Burmese jade.

(2) The microscope study shows that none of the determined optical properties fall in the aegirine field. It is suggested that there is not enough iron to form aegirine ($NaFeSi_2O_6$). This agrees with the results of chemical analyses.

(3) The major mineral components of Burmese jade are jadeite, ureyite and tremolite/actinolite (Figure 11).

(4) The relationship between jadeite and ureyite is an isomorphic one. The relationship between

Fig. 5. Replacement of jadeite by actinolite along cleavage planes and boundaries. Crossed polars. x35.

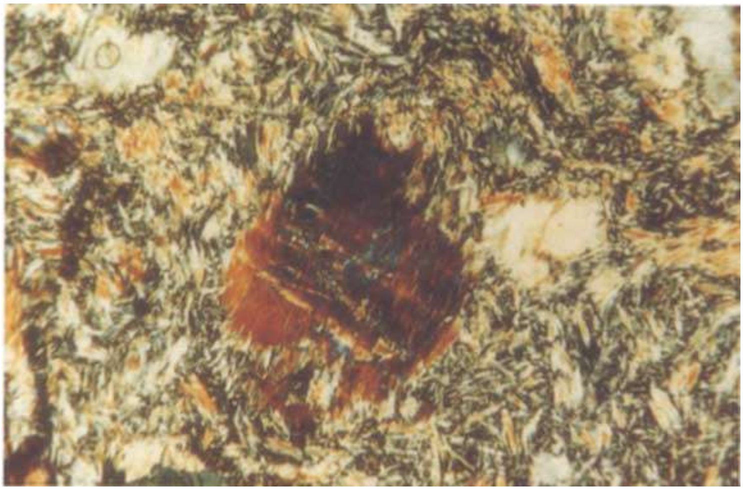

Fig. 6. Strong replacement of short prismatic form of jadeite by fibrous form of actinolite resulting in porphyroblastic texture. Crossed polars. x35.

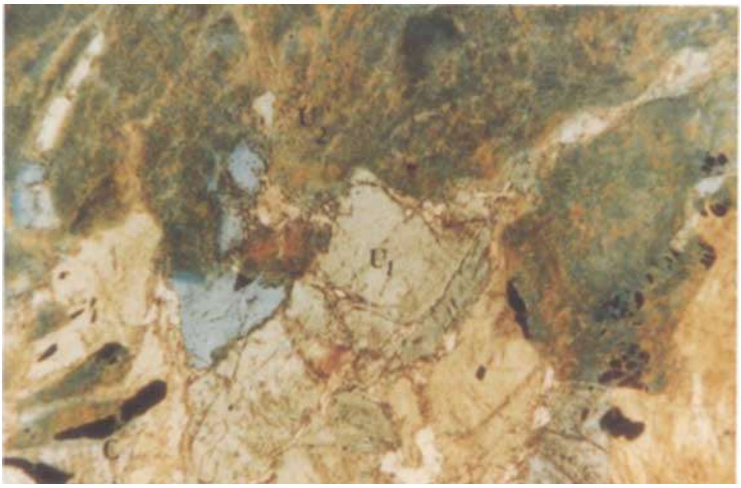

Fig. 7. Ureyite jade. Plane polarized light. x35.
U_1 – granular ureyite;
U_2 – fibrous ureyite;
C – chromite.

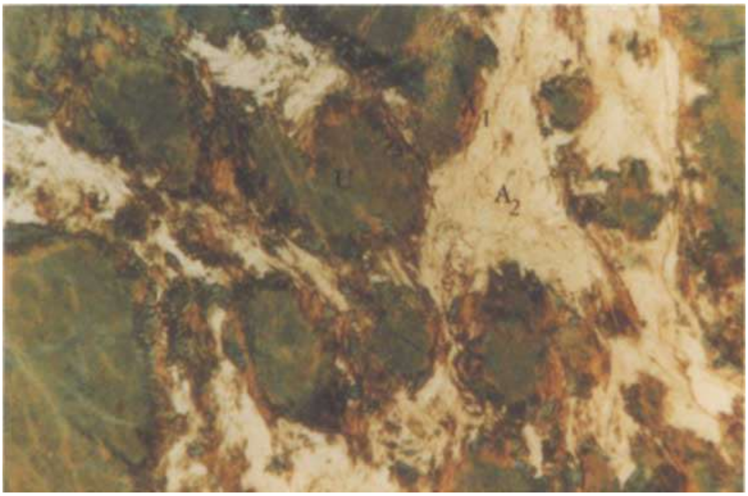

Fig. 8. Ureyite jade. Plane polarized light. x35. U – ureyite; A_1 - amphibole; A_2 - amphibole (see text).

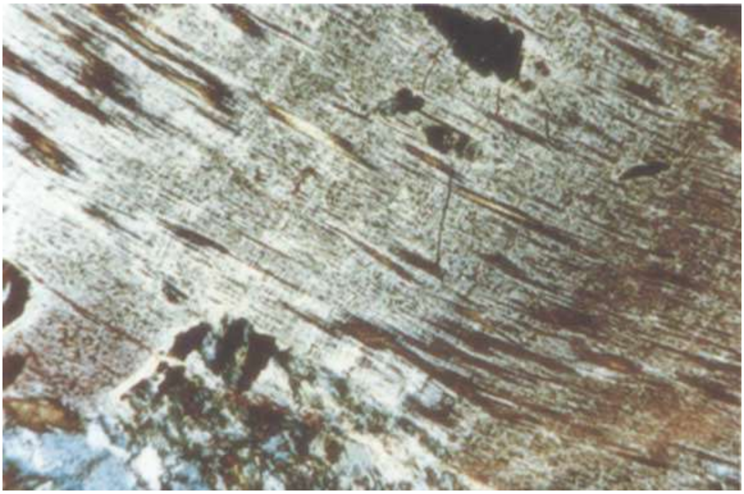

Fig. 9. Exsolution lamellae of jadeite in ureyite. Crossed polars. x70.

Fig. 10. Chromite and ureyite. Plane polarized light. x70. Chromite (black), ureyite (green).

jadeite and tremolite/actinolite is replacement. That between ureyite and tremolite/actinolite is also replacement.

(5) According to the constituent minerals Burmese jade can be classified into the following groups:

A. Jadeite jade (major);
B. Tremolitized jade/actinolitized jade (common);
C. Ureyite jade (comparatively rare);

(6) The different mineral compositions of jade affect properties such as colour, lustre, transparency and specific gravity, and thus gem quality. By means of their appearance and some physical properties, the three types of Burmese jade can be recognized.

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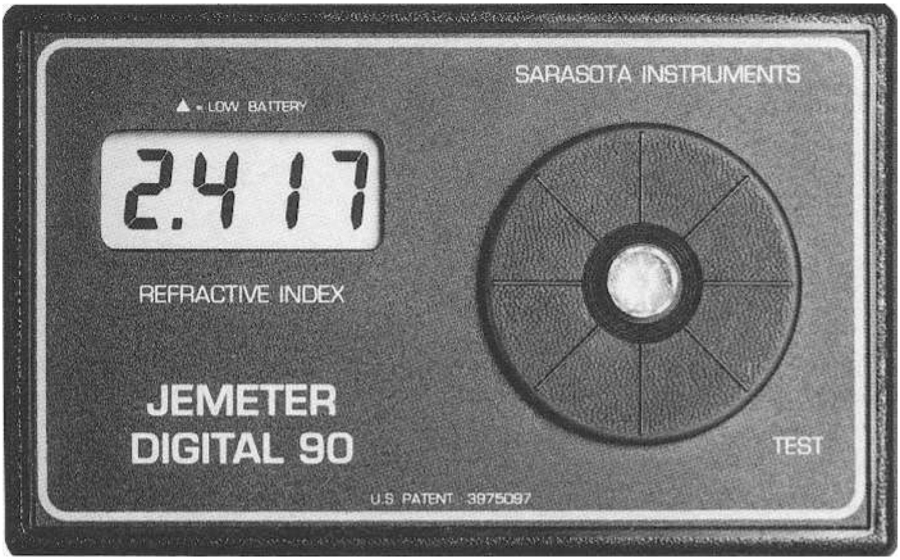

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Unusual inclusion in an aquamarine

Anthony de Goutiere, GG, CG

2542 Estevan Avenue, Victoria, BC, Canada

As a gemmologist with a passion for photomicrographing gemstone inclusions, (we are sometimes referred to as 'inclusionists'), it is always exciting to find something new in a specimen that perhaps has not been previously photographed.

Because this thin film inclusion was obviously three phase I decided to test it for reaction to a heat probe and was rewarded with the results shown in the accompanying photomicrographs:

Figure 1 is the inclusion at room temperature and the following three sequential photos illustrate the changes that take place as the specimen is warmed to a maximum of approximately 31.5°C. It is rather like watching a solar eclipse in miniature and the whole effect is enhanced by the beautiful interference colours.

It is also unusual in that the reaction to the thermal probe is quite slow. The oval liquid and gaseous phase appear almost viscous as it moves about. Occasionally, when the heat is first applied three or four small pink bubbles slowly rise from the black appearing spires and coalesce with the central pink oval.

Figs 1 to 4. A series of Photomicrographs showing the effects of warming an inclusion in aquamarine to a temperature of 31.5°C. Oblique illumination (without polars) using a fibre-optic pin-point illuminator. x22.

Fig 1

Fig 2

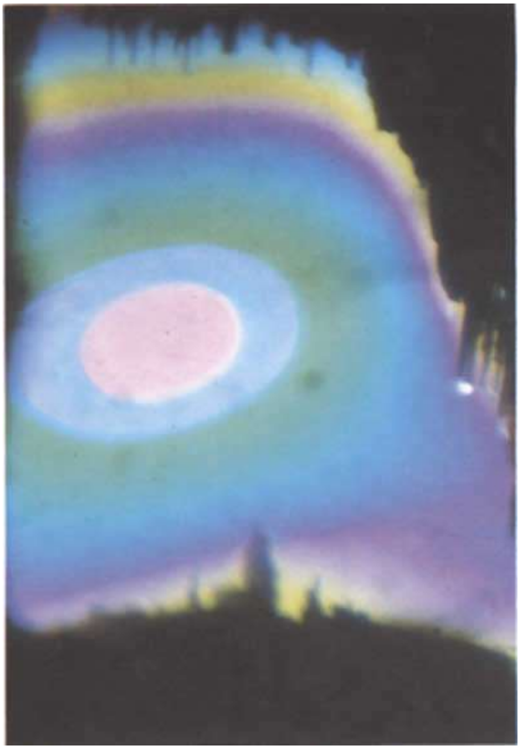

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Fig 3

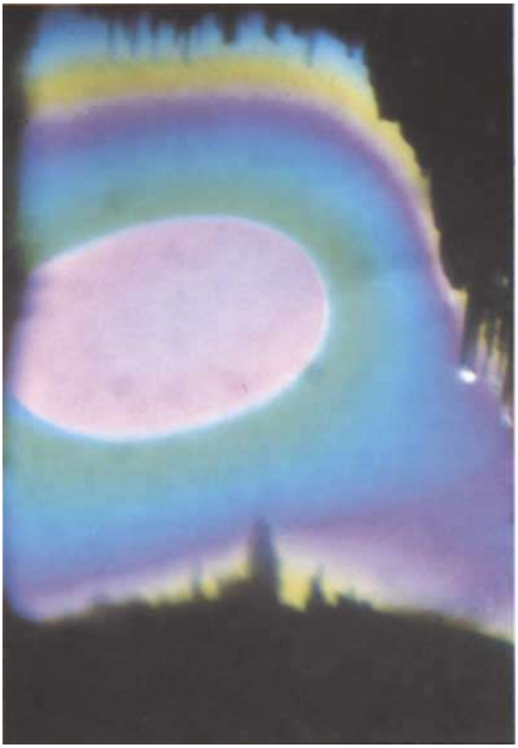

Fig 4

This is the second of two specimens of this material I have had the opportunity to examine. The first crystal also had several of the same type of slow moving heat-sensitive thin-film inclusions (1). It would be interesting to ascertain if this is a characteristic of aquamarines from Pakistan.

I sent the first specimen to Dr Edwin Roedder at Harvard University and he describes the reaction of this type of fluid inclusion as a combination of several effects happening simultaneously. For example: Changes in surface tension from temperature differences may make bubbles move and in this case surface tension may also change due to compositional changes from CO_2 moving from a gaseous to a liquid phase and vice versa (2).

The photomicrographs (Figures 1 to 4) were taken using an Olympus OM2 SLR camera coupled to a Wetzlar trinocular microscope mounted on an Eickhorst Gemmaster base. Oblique lighting using a fibre-optic pin-point illuminator.

References:

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(2) Roedder, E. 1984, Fluid inclusions, *Reviews in Mineralogy*, 92.

Radiation-induced colour change in natural and synthetic emerald

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Abstract

Radiation-induced colour changes in natural emeralds from different sources, in hydrothermally-grown synthetic emeralds, and in flux-grown synthetic emeralds are described. Irradiation experiments were performed by an X-ray fluorescence facility, in a cobalt 60 gamma cell, by a linear accelerator, and in a nuclear reactor. Two types of yellow colour centres are induced which turn natural emeralds yellowish-green or greenish-yellow and synthetic emeralds greenish-black or black. A first type of yellow colour centre with low thermal stability is produced by all types of treatment, mainly in hydrothermally grown and flux-grown synthetic emeralds. A second type of yellow colour centre with higher thermal stability, which is most probably confined to iron, is mainly observed in natural emeralds. The applicability of irradiation experiments in combination with absorption spectroscopy as a method for the distinction of natural and synthetic emeralds is discussed.

Introduction

A remarkable colour change of synthetic emeralds from green to smoky black or violet after irradiation treatment with X-rays, gamma-rays and neutrons is mentioned by various authors (Bank, 1982; Lind *et al.*, 1985; Schrader, 1987, 1988). According to the absorption spectra of irradiated and non-irradiated samples, which are published in some of the papers cited above, these colour changes are caused by a strong absorption band centred in the ultraviolet, the low energy tail of which is extending to the whole visible area, and/or by an additional absorption band in the green range between 520 and 530 nm. These absorption bands are due to different colour centres which are designated yellow and violet colour centres respectively.

The assignment of irradiation induced colour centres in natural and synthetic beryl is discussed by Schmetzer (1989). Most probably, the absorption band of the violet colour centre with an absorption maximum in the green and low thermal stability is assigned to an oxygen electron hole centre confined to Al^{3+} substituting for Si^{4+} in tetrahedral sites, and at least part of the yellow colour centres with an absorption maximum in the ultraviolet are related to traces of iron. This was later confirmed by Rink *et al.* (1990), who assigned the yellow colour centres of electron irradiated beryl to an iron related colour centre, which is produced by oxidation of Fe^{2+} to Fe^{3+} by irradiation.

Although the possibility of inducing different colour centres in natural and synthetic beryl and emerald by X-rays, gamma rays, electrons and neutrons has been known to the present author for more than ten years, only a limited application of radiation induced colour centres to problems of the distinction of natural and synthetic emeralds was performed. Occasionally, colour causing trace element contents of emeralds of known or unknown origin were examined by X-ray fluorescence analysis. According to the fact, that the colour of synthetic emeralds of known origin was, in general, altered to black or greenish-black after exposure to X-rays, a similar colour change in samples of unknown origin was used as an indication of synthetic emerald. In addition, irradiation experiments of a limited number of natural emeralds of known sources were performed by the author at the request of the trade in order to evaluate a possible stable colour enhancement of these stones. However, a systematic examination of possible irradiation induced colour changes of known natural and synthetic emeralds was neither performed until now, nor is described in gemmological literature. In other words, it was unknown if the colour of all synthetic emeralds is altered by different irradiation treatments in the same way and if, in addition, the colour of stones from different natural sources remains more or less unchanged upon irradiation treatment.

To overcome these disadvantages, the present paper describes some systematic irradiation experiments on natural and synthetic emeralds in order to evaluate the significance of the presence or absence of colour changes in emeralds after irradiation treatment for the distinction of natural

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and synthetic emeralds. Although the spectroscopic examination of the samples -performed for this study can also indicate some new aspects towards an assignment of the irradiation induced absorption bands to distinct colour centres, these special topics are not discussed in great detail in this publication.

Experimental details

Two series of irradiation experiments will be described in the present paper.

In the first series of experiments, six natural emeralds from different sources with low, medium and high iron contents, three hydrothermally-grown synthetic emeralds, and three flux-grown synthetic emeralds were sawn into four slices each. Three of the four slices of each sample were irradiated in a gamma cell, by a linear accelerator or in a nuclear reactor using the following experimental conditions:

a) cobalt 60 gamma cell, gamma dose 100 megarads, temperature in the gamma cell approx. 110°C;
b) linear accelerator, energy of the electrons 4.5 MeV, electron dose approx. 4 gigarads, cooling of the samples with running water;
c) nuclear reactor, thermal fluence rate 8.10^{13} n cm^{-2} sec^{-1}, irradiation time 1 h, gamma dose approx. 1.2 gigarads.

After exposure to gamma rays, electrons and/or neutrons, the colours of the three irradiated samples were visually compared with the colour of the remaining untreated slices of the twelve samples. Absorption spectra in the visible and ultraviolet area were measured of all untreated and all gamma and electron irradiated samples, but not of those emeralds treated in the nuclear reactor because of the high induced radioactivity of those slices.

In the second series of experiments, absorption spectra in the visible and UV were first recorded for 228 natural emeralds from different sources, 31 hydrothermally-grown synthetic emeralds and 41 flux-grown synthetic emeralds. Subsequently. each stone of these 300 samples was exposed to X-rays for 20 minutes using a commercially available Siemens SRS 300 X-ray fluorescence analysis facility with a Ru/Rh X-ray tube (operating conditions 40 mA at 50 kV). Subsequently, the colour of the samples was visually examined and absorption spectra were recorded of all irradiated natural and synthetic emeralds. The data collection within this second series of experiments was performed during a period of about four years.

Results

The results of the irradiation experiments are presented in Tables 1 and 2. Surprisingly, visual inspection and absorption spectroscopy did not indicate any production of violet colour centres, either in the experiments of the first series or in those of the second series. For the first series, this result is explained by the low thermal stability of violet colour centres in beryl, which are easily bleached in sunlight (Schrader 1987, 1988). As indicated by Solntsev (1981), the stability of these violet colour centres in beryl is in the range of 80°C.

Thus, according to the temperature in the gamma cell used for the cobalt 60 experiments, violet colour centres are immediately bleached.

Using the experimental conditions in a nuclear reactor as described above for the irradiation of topaz, exclusively blue topaz is produced. This indicates, that the brown colour centres of topaz, the stability limit of which is in the range of 200°C (cf. Schmetzer, 1987), are also faded by the radiation induced heat due to the extremely high gamma dose rate. Consequently, it is not expected that violet colour centres can be formed in beryl under these experimental conditions.

If topaz is treated in a linear accelerator under the circumstances described for the present experiments, most topaz crystals turn brown. This indicates that, due to water cooling, the radiation induced heat is lower than approx. 200°C. According to the fact, however, that no violet colour centres in beryl were formed under the experimental conditions applied, the violet colour centres must have been bleached by radiation induced heat, too.

Using X-rays for the irradiation of natural and synthetic emeralds, no violet colour centres were observed. This effect is not explained by radiation induced heat, but, obviously, the energy of X-rays was not sufficient for the production of violet colour centres in beryl.

At least two different types of yellow colour centres were formed in natural and synthetic emeralds upon exposure to X-rays, gamma rays, electrons and neutrons. Both types of yellow colour centres, designated type A and type B yellow colour centres, reveal a strong absorption band in the ultraviolet, the low energy tail of which extends to at least parts of the visible area. In natural and synthetic emerald, this absorption is superimposed upon the chromium-vanadium-iron spectrum of natural emerald and, depending on the type of synthesis, to the chromium-vanadium-iron-copper-nickel spectrum of synthetic emerald (cf. Schmetzer, 1988). Due to the intensity of the ultraviolet absorption band caused by irradiation

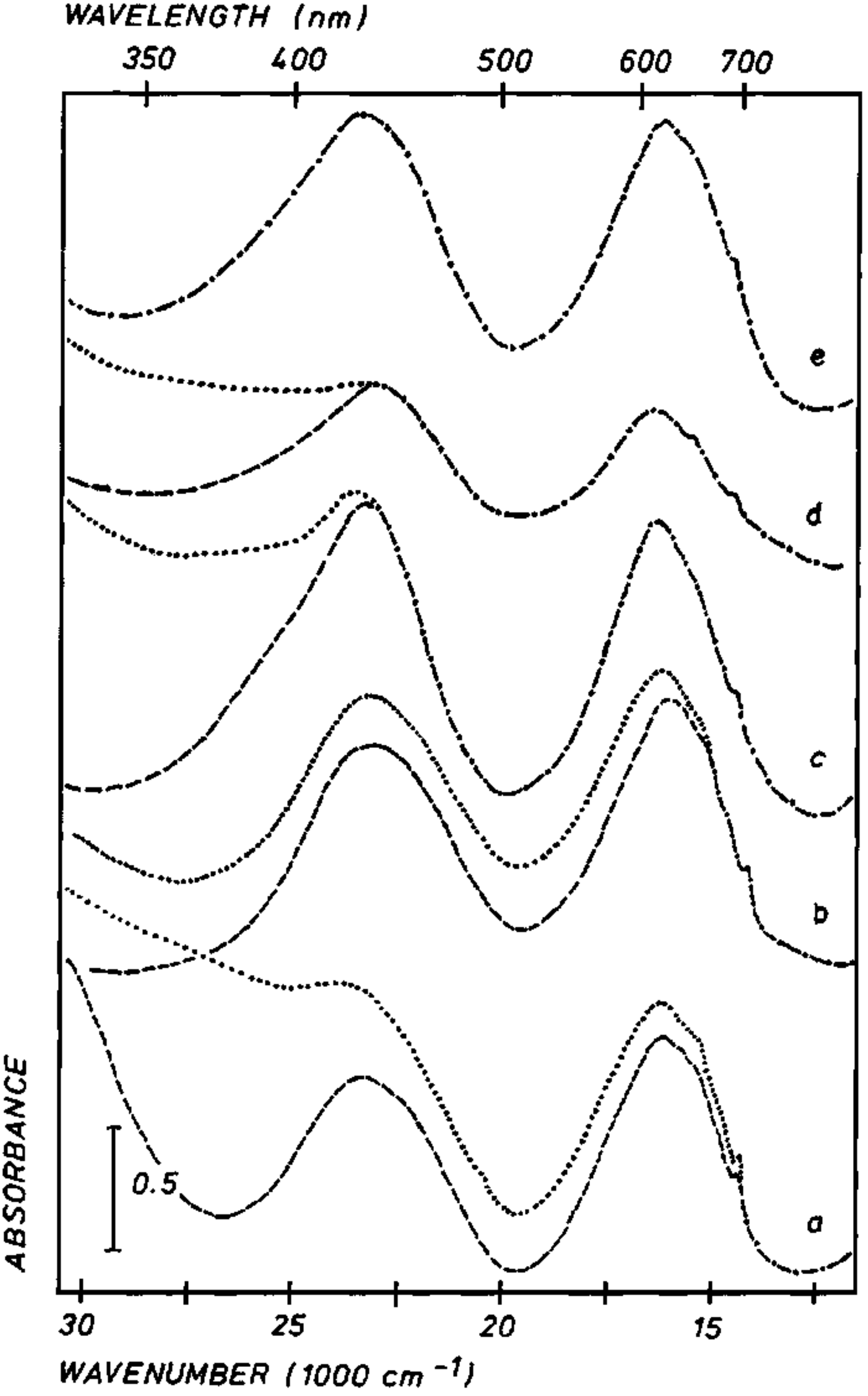

Fig. 1: Absorption spectra of untreated and X-ray irradiated natural and synthetic emeralds; -·-· absorption spectrum or part of an absorption spectrum, which is identical for untreated and treated samples, --- spectrum before treatment, ··· spectrum after treatment;
a Inamori flux-grown synthetic emerald, b Regency hydrothermally-grown synthetic emerald, c Biron hydrothermally-grown synthetic emerald, d Colombian emerald, e Colombian emerald.

Table 1: Radiation induced colour changes of natural and synthetic emeralds

		Irradiation treatment		
	Iron content	Gamma cell	Linear accelerator	Nuclear reactor
Natural samples, localities				
Colombia	low		yellowish-green	yellowish-green
Colombia	low	a slight yellowish-green colour tone is superimposed on the natural colour of the samples	yellowish-green	yellowish-green
Habachtal, Austria	medium		yellow-green	yellow-green
Gravelotte, South Africa	medium		yellow-green	yellow-green
Maria Mine, Mozambique	high		greenish-yellow	greenish-yellow
Zambia	high		greenish-yellow	greenish-yellow
Hydrothermally-grown synthetic emeralds				
Lechleitner, type D	low	greenish-black	greyish-green	greyish-green
Linde	not obs.	greenish-black	greyish-green	greyish-green
Russian sample	high	greenish-black	blackish-green	blackish-green
Flux-grown synthetic emeralds				
Gilson, Cr-bearing	not obs.	black	black	black
Chatham	not obs.	black	greenish-black	greenish-black
Lennix	not obs.	black	greenish-black	greenish-black

induced yellow colour centres in emerald, this additional absorption can more or less strongly alter the transparency of the absorption minimum of emerald in the green range and, thus, produces a yellowish-green, greenish-yellow, greenish-black or 'smoky' black coloration of the irradiated samples (Figures 1 a, b). If the intensity of the radiation induced ultraviolet absorption is somewhat weaker, the absorption minimum in the green is not affected and, consequently, no visual colour change is observed after irradiation treatment (Figures 1 c, d).

Type A yellow colour centres are produced by all types of irradiation, even by X-rays, and in all types of synthesis as well as in part of the Colombian emeralds examined (Tables 1, 2). After exposure to X-rays, all types of synthetic emeralds with the exception of Biron synthetic emeralds turn black or greenish-black (Table 2). Upon irradiation with gamma rays, electrons or neutrons, the six synthetic emeralds also turned greenish-black or black (type A, table 1). The stability of these type A yellow colour centres is relatively low. Part of them are already bleached in daylight or on exposure to ultraviolet radiation using a commercially available UV lamp. After heat treatment at 300°C for 1 hour no remaining colour change was visible. This low thermal stability of type A yellow colour centres explains the somewhat weaker coloration of electron and neutron exposed samples compared with the slices of the same crystals treated in the gamma cell (Table l) by fading of type A yellow colour centres due to the high radiation doses applied to these samples.

Type B yellow colour centres, which are most probably confined to iron, are not produced by X-rays (Table 2). Subsequent to an exposure to a dose of 100 megarads of cobalt 60 in the gamma cell, all natural emeralds revealed a weak yellow colour tone, which was superimposed on the natural colour of the samples (Table 1). This shade of yellow was intensified by higher radiation doses, e.g. after exposure to 500 megarads of cobalt 60. The irradiation experiments performed with a linear accelerator or in the nuclear reactor with extremely high doses also produced type B yellow colour centres in the samples and indicated, that the absorption band in the ultraviolet due to irradiation induced yellow colour centres is correlated with the iron content of the samples (Table 1). The thermal stability of type B radiation induced yellow colour centres in emerald is relatively high, i.e. this type of colour centre is not bleached by daylight, on exposure to UV radiation or upon heat treatment at 300°C for 1 hour.

Applicability of irradiation experiments for the distinction of natural and synthetic emeralds?

Although distinct differences in colour change between natural and synthetic emeralds were observed on exposure to gamma rays, electrons and neutrons (Table 1), this procedure has strong disadvantages and therefore is not practicable in a gemmological laboratory. Neutron exposed samples reveal irradiation induced radioactivity and cannot be returned to the customer within a short period of time. Electron treated emeralds may reveal radiation induced defects, e.g. cracks, which is also not acceptable. In addition, natural emeralds exposed to cobalt 60, electrons and/or neutrons turn yellowish-green or greenish-yellow. A complete bleaching of these iron related yellow colour centres is possible by heat treatment at temperatures higher than 300°C, which can also produce cracks in heat-treated samples.

Compared with the disadvantages described above, an application of a combination of X-ray irradiation experiments with absorption spectroscopy has certain advantages. Although such a procedure is not expected to become a routine procedure for emerald testing, every gemmologist working in a laboratory should be aware of the possibilities of this method and of the overlaps of properties between natural and synthetic emeralds:

Colour and absorption spectrum of most natural emeralds were not affected upon exposure to X-rays (Table 2, group I; Figure 1e).

In a small group of samples, the colour was unchanged upon X-ray irradiation, though yellow colour centres of low concentration were formed (Table 2, group II; Figure 1 c, d). This is the only overlap in this testing procedure between natural and synthetic emeralds observed so far. This second group consists of some of natural Colombian emeralds and of all Biron synthetic emeralds tested. Although a great number of 82 different Colombian emeralds were examined for this study, which were made available by different trade persons and from various collections, the author is unable to indicate the particular sources or mines of Colombian emeralds, the samples of which belong to groups I or II, respectively. If at least some of the samples examined were labelled correctly, both types of emeralds, samples belonging to group I and group II, emanate from both important Colombian mining areas, Muzo and Chivor.

Table 2: Reaction of natural and synthetic emeralds to X-ray irradiation *

Group I: colour visually not affected, absorption spectrum unchanged:

Gravelotte, Transvaal, South Africa (9);
Sandawana, Zimbabwe (8);
Filabusi, Zimbabwe (3);
Machingwe, Zimbabwe (6);
Maria Mine, Morrua, Mozambique (7);
Tauá, Ceará, Brazil (3);
Santa Terezinha, Goiás, Brazil (12);
Socotó, Bahia, Brazil (7);
Carnaiba, Bahia, Brazil (9);
Bom Jesus das Meiras, Bahia, Brazil (1);
Itabira, Minas Gerais, Brazil (7);
Ferros, Minas Gerais, Brazil (2);
Salininha, Bahia, Brazil (6);
Takovaya, Ural mountains, Russia (7);
Habachtal, Austria (8);
Ankadilalana, Madagascar (4);
Lake Manyara, Tanzania (6);
Swat, Pakistan (8);
Charbagh, Pakistan (2);
Makad, Pakistan (3);
Afghanistan (2);
Zambia, different localities (19);
Jos, Nigeria (7);
Colombia, different localities (38);

Group II: colour visually not affected, absorption spectrum changed in the blue and ultraviolet area:
Colombia, different localities (44);
Biron hydrothermally-grown synthetic emeralds (8);

Group III: colour visually affected, absorption spectrum changed in the visible and ultraviolet area, green samples turn greenish-black or black ('smoky'):

hydrothermally-grown synthetic emeralds:
Linde (3);
Regency (2);
Swarovski (2);
Russian samples (7);
Lechleitner, synthetic overgrowth, type B (5);
Lechleitner, fully synthetic, type D (4);

flux-grown synthetic emeralds:
Inamori (4);
Russian samples (6);
Lennix (4);
Seiko (2);
Chatham (8);
Gilson, Cr-Ni-bearing (2);
Gilson, Cr-Fe-bearing (2);
Gilson, Cr-bearing (10);
Lechleitner, fully synthetic, type F (3)

* numbers of samples examined are given in parentheses.

Colours and absorption spectra of most synthetic emeralds were strongly affected upon exposure to X-rays (Table 2, group III; Figure 1 a, b). The colour of these samples turns 'smoky' black or greenish-black. The yellow colour centres induced by X-rays are extremely unstable. Most of them fade in daylight or on exposure to UV radiation and only part of these samples need heat treatment to remove the influence of X-ray induced colour centres on the visual coloration of the synthetic emeralds.

Since spectrophotometers and X-ray fluorescence facilities are available in some of the greater gemmological laboratories in Europe, USA, and Japan, or are at least available to gemmologists, a combination of absorption spectroscopy and X-ray irradiation is generally performable. Consequently, every gemmologist should be familiar with the possibilities of the method and, in addition, every gemmologist should be aware of the fact, that a colour change is possible in synthetic emeralds after X-ray fluorescence analysis, e.g. for the determination of colour causing trace elements or for the detection of residual flux components. Consequently, these procedures should be applied to samples of unknown origin only by permission of the customer as a last possible diagnostic step, if all other diagnostic possibilities, e.g. microscopy or absorption spectroscopy in the visible or infrared, did not lead to an unambiguous identification of the emerald.

However, a possible application of X-ray irradiation in emerald identification procedures is the quick testing of larger parcels of rough or faceted stones for admixtures of synthetics.

Acknowledgement

The author is grateful to numerous colleagues and trade persons who kindly supplied samples of natural and synthetic emerald for the present study.

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[Manuscript received 22 July 1992]

1992 Annual Conference

Mary Burland

The second GAGTL Annual Conference held on 8 and 9 November at the Great Western Hotel, Paddington, London, was a truly international event with delegates attending from Canada, Hong Kong, Sri Lanka, Thailand and the USA, as well as from many European countries. There was a relaxed atmosphere as delegates had the opportunity to meet informally between lectures, and to examine various treated gemstones.

The theme was gemstone enhancement and the keynote speaker, Dr Kurt Nassau, launched the conference with a lecture on the history of gem treatments. Ancient literature dating back to Pliny contains many interesting recipes for the enhancement of gemstones and pearls, and Dr Nassau gave a fascinating account of some that he had tested in his laboratory. He then went on to review the history of various treatments, including the dyeing of agate, foil-backed stones, sugared opal, oiling of emeralds, heating of rubies and sapphires, irradiation of such stones as aquamarine, sapphire, topaz and tourmaline, and plastic impregnated opal. He also reported that it had been found that freshwater pearls became black when irradiated.

Dr Nassau described many of the current techniques used, the methods of identification of treated stones, the stability of the resulting colour and long-lasting radioactivity in irradiated specimens.

DEMONSTRATIONS

Between sessions delegates had the opportunity to microscopically examine, under the expert guidance of laboratory staff, some of the treated gemstones that had been discussed during lectures. Samples included laser drilled diamonds, diffusion treated corundum, fissure filled emeralds, cavity filled rubies and Yehuda and Koss glass filled fractures in diamond.

Also on display was a scintillation device made by Dr J. Nelson for demonstrating the separate contributions of lustre, fire, brilliance and sparkliness towards a stone's liveliness. A multi-faceted YAG doped with neodymium, which had been cut by Dr George Harrison Jones, was used for the demonstration.

Delegates examining treated and fracture filled specimens.

Dr Jamie Nelson explains his scintillation device.

Valuation and appraisal

Methods of valuation and appraisal, both British and American, were discussed by Terry Davidson of Cartier and Ann Dale from the USA.

Terry Davidson of Cartier speaking on appraisals.

Terry Davidson stressed that an item '... is worth what an individual is willing to pay for it'. He cited a number of examples of factors affecting the value, such as its antiquity, fashion trends, or the history of the piece.

Also consideration should be given to the difficulty in replacing items, particularly matching sets of rare stones such as Burma sapphires. Appraisers should be aware of fakes, and be able to identify reproduction pieces, and always consult experts if in any doubt. As much information as possible should be given in the descriptions of pieces.

Ann Dale speaking on valuations in the USA.

Ann Dale then gave an account of methods used in America. As well as the fascination of the items she appraised, Ann often found the stories behind pieces and the personalities involved to be very interesting.

Fees charged in the USA are based on an hourly rate, rather than a percentage of the value which is the custom in Britain. Approximately 80 per cent of appraisals are for insurance purposes, but estate parcels and the valuation of goods belonging to separated or divorced people were also discussed.

The Windsor Jewels

After lunch David Callaghan gave a talk on the Windsor Jewels. As well as giving fascinating details of lives of the Duke and Duchess of Windsor, he also recounted the background stories and disclosed hidden meanings associated with the pieces of jewellery. In a number of cases the code 'WE [Wallis and Edward] are two' was used. David went on to describe a number of the pieces in the collection in detail.

Gem certification

Ana Castro of the GAGTL gave a talk emphasizing the necessity for gem certification. It is essential that anyone connected with the jewellery trade should have knowledge of the exact nature of the gemstones being traded. It is possible to keep up- to-date with modern synthetics and treatments by reading gemmological journals and other literature, and by attending lectures and workshops on the subject. However, with the increasingly deceptive synthetic materials and ingenious treatments being developed it is essential that the expertise of the GAGTL Laboratory is available to be called upon. If you are in doubt about a material it should be submitted to the Gem Testing Department for a report.

Ana gave examples of various stones submitted to the laboratory, and described methods used in testing before a report is issued. In the case of a blue faceted stone, for example, the laboratory is asked to make the following determinations:

1. Is it sapphire or not?
2. Is it natural, treated or synthetic?
3. Is the sapphire's colour natural or a result of diffusion treatment?
4. Have any of the sapphire's surface-reaching features been infilled with artificial material?
5. Has the sapphire been artificially heat treated to enhance its appearance?
6. What is the sapphire's country of origin?

The main body of the report consists of a brief yet exact description of the material submitted for testing, including the predominant colour of the gemstone together with any notable optical effects, its shape and cut, and the millimetre size and the weight.

Ana concluded by emphasizing the importance of knowing the exact nature of the gemstones that you are dealing with.

Disclosure of fracture filling

Continuing the theme of gemstone enhancement, the final session of the day was a panel discussion on the need for disclosure of fracture filling. The panel, chaired by Ken Scarratt, comprised Steven Kennedy, John Kessler, Jeff Monnickendam, Dr Kurt Nassau and Eric Poyser, representing all aspects of the gemstone trade.

Steve Kennedy of the GAGTL opened the discussion with a brief explanation of the fracture filling process. Panellists then expressed their differing views before the subject was thrown open to the meeting when a lively debate ensued.

Thin diamond films

The proceedings began on the second day with a talk by Dr Kurt Nassau on thin diamond films. After giving a brief history of diamond synthesis, Dr Nassau described the process for producing thin diamond films. When tested many of the stones were found to have diamond-like films, such as amorphous carbon, hydrocarbon, super hard carbon and glassy carbon, which are easier to produce than the single crystal diamond film which will grow until it is 5-10 microns and then, for reasons not yet known, stop growing.


Keynote lecturer Dr Kurt Nassau (right) with David Callaghan.

The thin diamond film can be grown on silicon and silicon carbide but it does not adhere to other surfaces. An illustration was shown of a cubic zirconia from which part of the thin film had peeled off. Dr Nassau listed the various types of synthetic diamond, their commercial viability, and means by which they could be identified.

Gemstone treatments

The final talk on the theme of gemstone enhancement was given by Ken Scarratt, who gave an up-date on fracture filling.

Fractures in emeralds have for some time been filled with oil, and Ken pointed out that under CIBJO rules colourless oil is not declarable but coloured oil is. He went on to explain the process used in Opticon filled fractures, which can be identified by the yellow flash which changes to blue when the stone is turned. Large cavities common in rubies from Thailand and Burma are filled with plastic and then glass, which may give a considerable difference in weight before and after treatment. These fillings can be seen in reflected light.

Fracture Filled diamonds

Diamonds treated by Yehuda are filled with a yellowish glass, which reduces the colour grade of the stone. The London laboratory does not grade such treated stones.

The first stones treated could be identified by the bright blue flash from the substance in the fracture, changing colour as the stone was turned, but now flashes can be seen in various colours, for example blue changing to orange, blue to green or purple to red. It is also possible that bubbles can be seen in the fracture.

Very low quality material is now being treated, whereas previously the stones contained only one or two fractures.

Diamonds are now being treated in Israel. It is being claimed that a new colourless glass with an RI close to that of diamond, which gives no colour flash has been introduced. Stones tested did show a colour flash, but as could be seen from slides shown before and after treatment, visibility of the fractures was vastly reduced. On X- ray the glass appears opaque.

Ken concluded by describing an 'oscillation' treatment by which process fractures changed from black to white. After acid oscillation the surface is sealed with an organic hardener.

Diamond certification

An increasingly important aspect of the work of the GAGTL laboratory is that of diamond grading and the production of diamond grading reports.

Eric Emms of GAGTL told delegates of the work involved in producing a report. He stressed that a thorough knowledge of gemmology is essential for a competent diamond grader, as it is necessary to know whether a stone is a diamond - not synthetic or a simulant - and whether it has been treated to alter the colour or had its clarity 'enhanced'. 'Whereas gemmology and gem testing is *identification*, diamond grading is, in addition, an analysis of *quality*, and a diamond grading report is the written description of a stone's quality'.

Eric went on to explain the methods used in grading the 'Four C's' - carat weight, colour, clarity and cut.

A particularly important area of diamond grading is that of control. At least three graders examine each stone - the first person will grade the stone and the second and third check their work. Because the GAGTL issues CIBJO and GIA reports that are produced by other laboratories around the world, it is essential that our grades should accord with those of other laboratories. To this end stones are exchanged on a regular basis and the resultant grades monitored. In addition grading philosophy and procedure is shared by an exchange of grading staff with other laboratories.

With the increasing awareness of the public of the quality of diamonds, many retailers now appreciate the advantage of highlighting diamond quality and necessity for grading reports to instill confidence at the point of sale.

'Quality is the essence of a diamond', concluded Eric. 'The word I have used most frequently today is 'diamond' followed by 'quality'. That has been my intention'.

Burma and Vietnam

The afternoon session was devoted to Alan Jobbins and Ken Scarratt of GAGTL who spoke about their recent trip to South East Asia, a report of which was published in *Gem & Jewellery News*, Vol. 2, No.1, December 1992. Together with Edward Gübelin and Adolf Peretti of the Gübelin Laboratory, they spent five weeks visiting new gemstone deposits, at the invitation of Henry Ho of the Jewelry Trade Center in Bangkok.

As well as describing the various deposits, geology of the areas, methods of mining and recovery of the gemstones, they treated delegates to a marvellous 'travelogue' of the countries visited.

Sean O'Connell from Ireland with Vice President David Kent.

Diploma winner Rui Galopim de Carvalho from Lisbon, Portugal.

Ken dealt with the journey into Vietnam, describing the country as a 'gemstone paradise'. The ruby deposits at Luc Yen in north Vietnam were the first to be visited. Here the deposits are essentially alluvial, the BH Mining Co. exploiting concessions along a river valley. The rubies are associated with limestones and pegmatites, but the associated alluvial deposits are the main source of gemstones. The overburden is removed before the gem-bearing gravels can be recovered. The gravels are then washed and the gems extracted. The rubies are sorted at open windows on a mirrored surface allowing the light to pass through them.

Unfortunately, because of torrential rains and flooding in the area, it had been impossible to inspect the ruby deposit at Quy Chau, north west of Vinh, where rubies are recovered from beneath a thick whitish clay.

The party then stayed in the hill town of Dalat and visited a small sapphire working in Lam Dong province. In this region dark blue sapphires characteristic of lava deposits are found.

The visit to Burma was then discussed by Alan Jobbins. He described in detail the geology of the areas visited, as well as the mining methods used to extract the many minerals, including sapphire, ruby, peridot and spinel.

NEW SYNTHETICS

Dr Nassau reported briefly on synthetic forsterite and synthetic peridot which are now commercially available for laser work.

Gemmological Abstracts

ALEKSANDROV, V.I., VISHNJAKOVA, M.A., KALABUKHOVA, V.F., LOMONOVA, E.E., PANOV, V.A., 1991. Growth of zirconia single crystals by direct crystallization in a cold container. *Advances in Crystallography and Crystal Growth, 1991*, 17-28, 5 figs.

Problems of zirconia growth by RF heating in a cold container are reviewed. Solid solution composition, dopants and impurities, thermal conditions and growth regime all affect size and perfection of the crystals. M.O'D.

BANK, H., HENN, U., 1991. Smaragde und ihre Vorkommen in Nigeria. *Mineralientage München 1991, Messekatalog*, 29-31, 6 photos (3 in colour), 1 fig.

Gem quality emerald is reported from the pegmatites of the Jos plateau, Nigeria. Crystals up to 10cm long are recorded. Two- and three-phase inclusions have been noted together with zoning normal to the *c*-axis. M.O'D.

BAROT, N.R., BOEHM, E.W., 1992. Gem-quality green zoisite. *Gems & Gemology*, **28**, 1, 4-15, 17 figs.

Green zoisite has hitherto been known as a sugary-textured opaque aggregate associated with large low-grade ruby crystals at Longido, Tanzania. In the 1960s an important facetable violet-blue version, which was named tanzanite, was found in the Merelani Hills some 150km south of Longido. Since then brown and yellow versions have been found. Now a transparent faceted green version is reported, again from the Merelani Hills. Gemmological properties are identical with those of the blue gems and the new materials is here referred to as 'green tanzanite'. Chromium absorption seen in well-coloured stones, pleochroism naturally differs from that of the blue variety while inclusions consist of finger-print healed cracks, two- and three-phase cavities, and zircons with expansion haloes; some acicular inclusions provide cat's-eyes when cabochon cut. Heating finer green material produces no colour change, but some green-browns do change to blue when heated. Authors suggest that this new version of tanzanite should be specifically named. R.K.M.

BRACEWELL, H., 1992. Gems around Australia 7. *Australian Gemmologist*, **18**, 2, 38- 9, 4 figs.

Tour continues from Broome WA via Eighty Mile Beach to Port Hedland area for tiger-iron jaspilite; Marble Bar for ancient minerals, with gold and metallic ores. Lionel yields a chlorite marketed as 'Pilbara Jade'. R.K.M.

BROWN, G., 1992. Vietnamese ruby: a discriminatory problem for gemmologists. *Australian Gemmologist*, **18**, 2, 43-6, 13 figs.

Rubies discovered in 1987 near Luc Yen and Quy Chau in Vietnam are similar in colour and character to Burmese ruby. Some parcels have been salted with look-alike Verneuil synthetic rough or cut stones and identification of these and provenance of the natural stones is difficult, needing careful study of immersed stones under magnification if mistakes are not to occur. Burmese and Vietnamese rubies are closely similar in their inclusions, although blue zoning, pyrrhotite rods, orange rutile, bluish clouds of fine rutile and orange flux-like masses of the rare aluminium hydroxide, nordstrandite, are unique to those from Vietnam. The synthetics have been heat-treated to eliminate curved striae, and may have developed natural looking fissures due to prolonged treatment. R.K.M.

BROWN, G., 1992. Mintabie opal. *South African Gemmologist*, **6**, 1, 10-15, 4 photos in colour, 2 maps and 1 fig. in colour.

In 1990 28% of the production of the world's gem quality opal came from the Mintabie field, approximately 1,000km north-west of Adelaide. The history and geology of the field are described. M.O'D.

BROWN, G., KELLY, S.M.B., 1992. Fiber-eye: a gemmological study club report. *Australian Gemmologist*, **18**, 2, 52-3, 7 figs.

A new cat's-eye imitation made from fused cubic packed glass fibres. H about 6, brittle, RI estimated at 1.86 [high for a comparatively hard glass. More research needed?]. R.K.M.

BROWN, G., KELLY, S.M.B., 1992. Gemmology study club lab reports. *Australian*

Gemmologist, **18**, 2, 56-60, 21 figs.

New pyrope/almandine from Northern territory described; four- and six-rayed blue star spinel illustrated; golden zircons submitted to determine whether they were heat- treated or not, evoked information on the heating methods but could not test whether they had been so treated [the heat-treated colour is usually far better than that of natural golden zircons]; a laser carved turquoise-blue cameo on a black base is thought to be imitation, granular appearance under magnification should identify; a 'pippin' shaped cultured pearl is described as a 'twin'; three stones with dendritic inclusions are identified by RIs as quartz, chalcedony and opal; two blue-green Egyptian faience scarabs were alleged to be of New Kingdom period, about 1400BC [Their apparent excellent condition suggests to abstracter that these may have been reglazed in modern times, a not unusual practice in Egypt]. R.K.M.

CAMPBELL, I.C.C., 1992. Another two examples of uncut simulated emeralds. *South African Gemmologist*, **6**, 1, 23-6, 6 photos in colour.

A simulant of rough emerald proved to be a piece of flux-grown Chatham emerald within a matrix of Zambian host. The matrix was natural and not glued in place. Two further hoaxes involved dyed quartz crystals and glass emerald simulants offered in a sealed capsule. M.O'D.

CLACKSON, S., MORETON MOORE, 1992. An X-ray study of some Argyle diamonds. *Industrial Diamond Review*, **52**, 551, 192-4. 1 table, 1 graph, 4 electron micrographs, 9 Laue photographs, bibl.

The Argyle diamond mine produces one third of the world output. The diamonds occur in lamproite, the sample examined by the authors showed a wide range of qualities, mostly irregularly shaped, the next common morphology was octahedral. Most diamonds were grey or brown, a small number were pink. 70% had black inclusions. Examination by Laue X-rays showed that most Argyle diamonds have a mosaic structure, i.e. the crystal is composed of many misorientated constituent crystals. This might account for their high wear resistance as experienced by diamond polishers and in industry. E.S.

CODY, A., BROWN, G., 1992. Robotic opal cutting: an Australian solution to an old problem. *Australian Gemmologist*, **18**, 2, 40-1, 4 figs.

Automatic cutting of small calibrated opals requiring preform and colour selection before robot takes over. Polished by tumbling. R.K.M.

FRITSCH, E., SCARRATT, K., 1992. Natural colour non-conductive grey-to-blue diamonds. *Gems & Gemology*, **28**, 1, 35-42, 5 figs.

To date all natural blue diamonds tested have been Type IIb and have conducted electricity. Now grey to greyish-blue diamonds of unknown origin tested by the London Laboratory were found to have a coating of Type IIa diamond and to be non-conducting, but became conducting once they were cut. Four greyish-blue faceted stones from the Argyle mine in Australia were tested at Santa Monica Lab and found to be non- conducting. An N3 absorption was seen which identified these as Type Ia rather than IIb. The infrared spectrum was also unusual in type and intensity. Lack of electrical conductivity cannot now be regarded as proof that a diamond has been artificially blued, although luminescence of yellow to yellowish-green, stronger in LUV than in SUV, will indicate that the blue colour is probably natural. R.K.M.

FRYER, C.W., CROWNINGSHIELD, R., HARGETT, D., MOSES, T., HURWIT., KANE, R.E., 1992. Gem Trade lab notes. *Gems & Gemology*, **28**, 1, 52-57, 19 figs.

A large brownish-yellow non-nacreous concretion exhibiting 'flame' structure similar to that in conch and clam pearls was thought to be from a Bailer mollusc from Indo-Pacific waters.

A conjoined pair of dodecahedral diamonds is described and illustrated, as are two dice cut from black diamond with inserted gem diamond spots, and two square-cut brilliant grey diamonds exhibiting central dark grey clouds of particles in the form of matched crosses; a severely burnt diamond is depicted 'before and after' recutting to a fine stone half the original weight; a green-coated diamond was cleverly faceted to give two stones retaining the green colour and 91% of the uncut weight by using octahedral faces as main pavilion facets.

Two emeralds had very similar capped spicule inclusions, one with phenakite caps which identified a hydrothermal synthetic, the other with opaque yellow caps (calcite?) which confirmed it as natural, infrared spectrum also confirmed; a cylindrical imitation of lapis was recognized as ceramic but the colouring agent is not known. Black opal is illustrated which has brilliant play-of-colour in saw-edged patches separated by fine lines of black potch; a large bead Polynesian naturally black cultured pearl necklace had two pearls which were non-nucleated; a green bead, sold as jade, was identified by X-ray diffraction as the muscovite mica mineral pinite (RI 1.57, SG 2.80, H 3 1/2, chrome absorption). R.K.M.

FUHRBACH, J.R., 1992. Kilbourne Hole peridot. *Gems & Gemology*, **28**, 1, 16-27, 20 figs.

This volcanic crater located in SW New Mexico near Las Cruces, was described in 1975, and Mr Fuhrbach has recently carried out an investigation which revealed a number of cuttable nodules capable of yielding reasonably sized faceted gems, although most of the gem quality pieces were under two carats but still capable of giving small stones of good colour and clarity. Constants and inclusions as for terrestrial peridot but lily-pad formations centred by black hercynite are new; chrome diopside, biotite and glass bleb inclusions were also found. The deposit is not actively worked. R.K.M.

GRAMACCIOLI, C.M., 1991. Application of mineralogical techniques to gemmology. *European Journal of Mineralogy*, **3**, 703-6.

The paper gives an undetailed overview of some of the techniques used by mineralogists which may also be useful in gem testing. M.O'D.

GRUNDMANN, G. Smaragd. Grünes Feuer unterm Eis. *Extra Lapis* no 1, pp. 96, illus. in black and white and in colour.

Habachtal emerald and other minerals associated with them are described in this first special issue of the journal *Lapis*. Mineralogy, geology and characterization are all discussed in an attractively produced large format book. M.O'D.

GRUNDMANN, G., 1991. Der grüne Schatz der Hohen Tauern. Mineralientage München 1991, *Messekatalog*, 33-47, 22 photos (16 in colour), 7 figs.

Emerald from the Austrian Habachtal is described with notes on the general geology and mineralogy of the area. The use of Habachtal emerald in jewellery is reviewed. Characteristic inclusions are illustrated and listed. M.O'D.

HAPUARACHCHI, D.J.A.C., 1989. Some observations on the origin of gem corundum in Sri Lanka. *Journal of the Geological Society of Sri Lanka*, **2**, 5-9, 4 figs, 2 maps.

Silica-deficient rocks of pelitic composition with corundum, biotite, sillimanite, perthitic K-feldspar, plagioclase, spinel, cordierite and garnet are described from the Sri Lanka Highland Series at Talatu Oya, Haldamulla and Gangoda. It is postulated that the textures of the corundum-bearing gneisses suggest a reaction between biotite and sillimanite to give corundum and K-feldspar, with cordierite, spinel and rutile. M.O'D.

KERREMAN, Y., WANTEN, E., 1992. Material loss when sawing gem diamond. *Australian Gemmologist*, **18**, 2, 49-51, 5 figs.

Compares weight loss between stones sawn mechanically by disc saw and those sawn by laser beam. In general the former is cleaner and a little less wasteful, but restricted in direction, while the laser gives less smooth surfaces with slightly more wastage but cuts equally well in any direction. Laser is twenty times faster. Differences in weight loss are not large and laser can be made less wasteful. R.K.M.

KOIVULA, J.I., KAMMERLING, R.C., 1991. Gemmological properties of emeralds from the Panjshir Valley, Afghanistan. *South African Gemmologist*, **5**, 3, 9-14, 1991, 7 photos in colour.

Small rough emerald crystals from the Panjshir Valley in Afghanistan with the longest measuring 14.62 x 4.01 x 3.03mm and weighing 1.48ct were examined for optical and physical properties. RI is recorded at 1.571 and 1.578 for the extraordinary and ordinary rays respectively with a birefringence of 0.007. Specific gravity falls in the range 2.69-2.72. Though two apparently treated crystals gave a whitish-yellow response to LWUV the remainder were inert to ultra-violet radiations. Two- and three-phase inclusions were noticed: also included were random crystals of beryl and possibly albite. Possible pyrite crystals are also noted. M.O'D.

KOIVULA, J.I., KAMMERLING, R.C., FRITSCH, E., 1992. Gem news. *Gems & Gemology*, **28**, 1, 58-67, 19 figs.

The Tucson Show came round again in February and this excellent report reflects highlights of this great annual event.

Diamonds

Coloured diamonds abundant in small sizes, mainly yellows and browns, plus one show of pinks, and another of white 'opalescent' diamonds from Panna in India.

Coloured Stones

A fire agate with built-in 'frame' of clear chalcedony; fine blue-green amazonite from Minas Gerais, Brazil; Baltic amber; Madagascan green-blue apatites; deep blue aquamarines from Mozambique; specimen beryl crystals from Nigeria; greyish-blue aquamarines from Zambia; chalcedonies coloured by chrysocolla from Mexico were porous and improved with immersion in water. Cat's-eye emerald, normally rare, were on show in quantity by two exhibitors; moldavite from Czechoslovakia; fire-opal from Querétaro, Mexico; large peridots from newly exploited San Carlos deposits and from China and Ethiopia; pietersite hawk's-eye from Namibia; rubies and sapphires from Vietnam; a newly found ruby deposit in Namibia similar in type to Longido rubies; rubies from Central Australia; rubies and pink sapphires from Azad Kashmir, Pakistan; ruby in green zoisite from Longido; blue Chinese spinel; green and green-blue tourmaline from Paraiba scarcer this year; fine pink and red tourmalines from Namibia and from Madagascar; the new faceted green tanzanite and a number of rare gems from Mont St-Hilaire, Quebec are all described and most are illustrated.

Enhancements

Quantities of blue diffusion-treated sapphires in calibrated sizes available, no other colours seen; white hydrophane opal dyed dark blue with potassium-ferrocyanide and sealed with plasticizing liquid, detectable by light weight, plastic feel and blue translucency to strong light; irradiated green topaz from Sri Lanka also seen.

Synthetics and Simulants

Synthetic alexandrites by J.O. Crystals now being promoted as 'Nicholas Created Alexandrite', these Czochralski-pulled rods have negative crystal inclusions at their cores which are used for cabochons, faceted stones of good quality are from the outer parts of the rods; a range of colours in hydrothermal synthetic beryls from Russia and Australia were seen; cubic zirconia plentiful in many colours some of which were opaque; rare laboratory grown crystals were again available; earstuds held in place magnetically were an innovation; chatoyant fibre-optic glass gems; glass embedded natural opal; several colours of Russian synthetic sapphire grown primarily for laser use; opaque materials imitating sugilite, coral, turquoise, malachite azur-malachite and black onyx were evidently plastic based; faceted YAG in various colours and desk ornaments made from pulled rods of neodymium-doped YAG were all seen and illustrated.

Instrumentation

An illuminated immersion cell has been made to facilitate testing for diffusion treatment in sapphires. R.K.M.

KRIJGER, B., 1978. Fluoriet als edelsteen. *GEA*, **11**, 1, 17-18, 4 figs.

The possibilities of fluorite as an ornamental material are discussed with particular reference to the Blue John variety. M.O'D.

LINTON, T., BROWN, G., 1992. Gemmology study club lab reports. *Australian Gemmologist*, **18**, 2, 56-60, 21 figs.

An assessment of four filters marketed by Hanneman Gemological Instruments, Calif., arrives at conclusions rather similar to my own when I reviewed these in 1990. Use with caution. [*Journal of Gemmology*, 22, 4, 212-14]. R.K.M.

MOXON, T.J., 1991. On the origin of agate with particular reference to fortification agate found in the Midland Valley, Scotland. *Chemie der Erde*, **51**, 4, pp 251-60, maps.

SEM and TEM photographs show that the translucent white and blue-white bands in fortification agate (a variety of banded chalcedony whose pattern is reminiscent of the plan view of a castle) from Scottish andesites and basalts of Devonian age have a plate-like structure. The edges of plates scatter transmitted white light, causing the bands to appear red-brown; the blue-white bands also contain dusty inclusions which scatter white reflected light. The banding in agate can only form after the residue is full of silica. Recent theories of spherulitic growth combined with EM photographs support ideas first proposed by Jessop [*Proc. Geol. Assoc.*, 42, 1930, 29-43] which allow a rhythmic deposition of different impurities. R.A.H.

MULLIS, J., 1991. Bergkristall. *Schweizer Strahler*, **9**, 3, 127-61, 27 photos in colour, 22 figs.

The occurrence and crystallization of rock crystal is examined with particular reference to Alpine localities, and especially those in

Switzerland. The nature of twinning in quartz is discussed and variation in crystal habit from one locality to another is also described. The paper ends with a bibliography of 65 references. M.O'D.

Niedermayr, G., 1992. Die Bestimmung von geschliffenen Edel-und Schmuck-steinen mit einfachen Hilfsmitteln. *Mineralien Welt*, 3, 1, 47-50, 1 photo in colour.

A brief overview of some of the simpler methods of gem testing. M.O'D.

O'Donoghue, M., 1992. Industrial review-Gemstones. *Britannica book of the Year*, p.188.

The expected swift upturn in the developed world's economies did not materialize and the gemstone and jewellery trade continues depressed with fewer major auction sales and small firms ceasing to trade. Few new gem varieties are reported but the question of alteration/enhancement of colour continues to occupy regulatory bodies. [Author's abstract M.O'D.].

Pearson, G., 1992. Torrington emerald. *Australian Gemmologist*, 18, 2, 47-9, 7 figs.

Discusses prolific three-phase inclusions in stones from near Glen Innes, NSW. Absorption suggest that vanadium is the dominant chromophore but evidence of chromium justifies calling this material emerald although it is green through the emerald filter. Narrow colour zoning parallel to the basal pinacoid is common. R.K.M.

Petrusenko, S., 1991. Kamienie szlachetne i ozdobne Bulgarii. *Mineralogia Polonica*, 22, 1, 81-7, 1 map, 4 photos.

Gem minerals found in Bulgaria include aquamarine, emerald, quartz (amethyst, agate, jasper), garnet (almandine-spessartine), epidote, rhodonite, corundum (ruby), turquoise, malachite and fluorite. A bibliography is appended. M.O'D.

Read, P.G., 1992. Recent innovations refine effectiveness of reflectance meter. *Canadian Jeweller*, June 1992. 26-7, 2 figs.

Describes the Sarasota Jemeter Digital 90 reflectance meter and its innovative features, which include the ability to provide a direct digital readout of a gem's RI and to measure double refraction down to 0.01. Included in the article are details of the pocket-size Rosgem refractometer which uses a pen torch source of illumination. (Author's abstract) P.G.R.

Rossman, G.R., Fritsch, E., Shigley, J.E., 1991. Origin of color in cuprian elbaite from Sao Jose de Batalha, Paraiba, Brazil. *American Mineralogist*, 76, 1479-84, 3 figs.

Gem quality elbaite containing up to 1.4wt% Cu is reported from Mina da Batalha, close to Sao Jose de Batalha, north-eastern Brazil. Optical absorption bands for divalent Cu have maxima in the 940-695nm region and are more intense in the $E\perp c$ direction. Colour can be modified to violet-blue and violet by increasing absorptions from trivalent Mn. M.O'D.

Sangeeta, Sabharwal, S.C., Gupta, M.K., 1991. On the growth of single crystal $Y_3Al_5O_{12}$. *Advances in Crystallography and Crystal Growth*, 1991, 37-41, 2 figs.

Crystals of YAG grown by the Czochralski method have their morphology affected by flow of ambient gas in the vicinity of solid/melt interface. The oxygen fraction in the ambient is found to affect crystal transparency. M.O'D.

Sinkankas, J., Koivula, J.I., Becker, G., 1992. Peridot as an interplanetary gemstone. *Gems & Gemology*, 28, 1, 43-51, 10 figs.

Peridot is a common constituent of the stony meteorites called pallasites. They were first faceted early this century but it has only now become possible to examine specimens in detail. In 1990 Gerhard Becker identified several promising olivines in slices of the Esquel meteorite, which fell in Argentina, and took them back to Idar where Andreas Becker very carefully extracted and cut them to give small faceted stones. Eight of these and one from the Eagle Station pallasite were examined by the authors, confirming that their physical constants were in complete accord with those of terrestrial peridots, but that small included fragments, believed to be nickel-iron, are specific to stones from such sources. Faceted meteoric peridots are rare. R.K.M.

Sobol, A.A., 1991. New easy melted laser garnet crystals: structural defects, spectroscopic and laser action study. *Advances in Crystallography and Crystal Growth*, 1991, 9-16, 6 figs.

Garnets doped with trivalent Nd are grown by Czochralski pulling from Pt crucibles. Raman spectroscopy is used to study structural defects. M.O'D.

SPENCER, R.J., LEVINSON, A.A., KOIVULA, J.I., 1992. Opal from Querétaro, Mexico: fluid inclusion study. *Gems & Gemology*, **28**, 1, 28-34, 6 figs.

Three-phase, two-phase and single-phase inclusions are known in these opals and this paper describes the chemical nature of the gases and liquids by freezing or heating them to establish the temperatures achieving solid or gaseous stages. Results suggest that liquids are hydrated silica gel rather than water. Solids are trapped inclusions rather than crystals grown from inherent impurities. Parent opals probably formed at about 160°C. Salt crystals were tentatively identified. Included air was not found. R.K.M.

STALDER, H.A., 1992. Edel-und Schmucksteine aus der Schweiz. Teil 2: Die Mineralien der Quarzgruppe. *Schweizer Strahler*, **9**, 6, 305-26, 22 photos (8 in colour).

Quartz group minerals are dealt with in this second part of a review of Swiss gemstones. Occurrence and use are described with some comments on inclusions and other gemmological features. M.O'D.

STALDER, H.A., VOLLENWEIDER, P., HÜGI, M., OFFERMANN, E., 1991. Edel-und schmucksteine aus der Schweiz. *Schweizer Strahler*, **9**, 4, 173-268.

The entire issue is devoted to a review of the gem minerals found in Switzerland. Among the species described are kyanite, corundum, axinite, cordierite, tourmaline, aquamarine, anhydrite, dolomite, epidote, grossular and demantoid. A list of references is appended. M.O'D.

STATHER, M., 1992. The care and cleaning of gem materials. *Australian Gemmologist*, **18**, 2, 34-8.

Cautious advice. R.K.M.

SURY, E., 1992. Synthetische Kristalle, synthetische Steine, weshalf, wie, wozu? *Lapis*, **17**, 13-23, 16 photos, 13 in colour, 9 figs.

Simple but well-illustrated account of the manufacture of artificial gem crystals by the main methods. M.O'D.

THOMAS, A., 1991. 'Blue-green emerald'. *South African Gemmologist*, **5**, 3, 26-32, 3 photos in colour.

A rambling account of emerald from the Miku deposit in Zambia and of green beryl from the Jos area of Nigeria. M.O'D.

TIN, HLAING, 1992. A deposit of greenstone, Shan State, Myanmar. *Australian Gemmologist*, **18**, 2, 42, map.

Nephritic material identified as a mixture of quartz, calcite, tremolite and diopside. R.K.M.

WANG, A., WANG, W., ZHANG, A., 1991. Microstructural variations of a pyrope inclusion in diamond as revealed by a micro-Raman spectroscopic study. *Canadian Mineralogist*, **29**, 517-24, 6 figs.

Two microstructural variations of a syngenetic pyrope inclusion in a diamond from Liaoning, China, are described. A micro-Raman technique was used for the investigation. M.O'D.

WILSON, W.E., BARTSCH, J.A., 1992. Minerals of the Houston Museum of Natural Science. *Mineralogical Record*, **23**, 1, [33 pages in separately paged bound-in supplement], 64 photos in colour.

The mineral collection of the Houston Museum of Natural Science, Texas, USA, contains a number of gem-quality specimens, some of which are illustrated. M.O'D.

Book Reviews

DOWNING, P.B., 1992. *Opal identification and value.* Majestic Press, Tallahassee. pp. x, 210. Illus. in colour. Price US$ 38.95.

Although there have been several books on opal valuation in recent years this is larger and includes information on opal from a number of countries other than Australia (where most previous accounts have been published). The first chapter introduces the factors influencing value and the second outlines the techniques used and gives a guide to simple equipment needed by the valuer. The reader is then introduced to opal types, which are well illustrated and then to the dangers offered by synthetic and imitation stones.

The book then turns to the classification of colour base and play of colour. In a sense, this is entirely subjective but the book makes a gallant attempt to simplify types and nomenclature; it certainly illustrates many of the main colour patterns very well. There are remarks on deficiencies and then the topic of valuation is introduced. The remarks are clear and sensible but some of the pictures in this section are not well reproduced - a pity, since the quality of the stones is apparent. Opal from the USA, Brazil, Java [i.e. Indonesia], Honduras, Mexico and Hungary [i.e. Czechoslovakia] is also valued. The author suggests that some Brazilian opal is sent to Australia and sold there as native material. Much Brazilian opal I have seen is not very like Australian material, having a characteristic pinfire effect.

The next section deals with synthetic opal valuation and with the valuation of rough opal. There is a useful bibliography and a glossary. The effort to keep the text simple and the exclusion of unnecessary terms has produced a good book which I can recommend. M.O'D.

FIELD, L., 1992. *The Jewels of Queen Elizabeth II - her personal collection.* Thames & Hudson. Paperback edition. Price £12.95.

This is an extremely well produced catalogue of some of the Queen's jewellery, giving a potted history of each piece with photographs of the Queen or another Royal wearing it. It includes such valued pieces as the Cullinan, a brooch belonging to the Empress Marie Feodorovna of Russia, Queen Mary's Stomacher and the Delhi Durbar Parure. The jewellery is sub-divided into tiara, necklaces, ear-rings, bracelets, brooches, watches and rings. A number of anecdotes make for amusing reading. E.S.

KAZMI, A.H., AND SNEE, L.W., Eds. *Emeralds of Pakistan: Geology, Gemology and Genesis.* Pakistan (Geological Survey of Pakistan) & New York (Van Nostrand Reinhold Co.), 1990. xii + 269pp., 90 colour photos., 49 maps. Price £29.00.

This attractively presented book, with a foreword by Edward Gübelin, contains nine chapters by a variety of international experts. Each chapter has its own references but there is also a selected bibliography on worldwide emerald occurrences, with some 530 references.

In northern Pakistan the spectacularly rugged Himalayan ranges dissected by the awe-inspiring canyon of the Indus River, which reaches over 6100m of relief in places, provide a fascinating background to the discovery and working of the emerald deposits in the Surat-Malakand-Mohmand area.

The gemmological characteristics of the Pakistan emeralds are fully documented by a chapter by E. Gübelin, who notes that they have refractive indices rather high for gem-quality emeralds, but which are in agreement with emeralds containing appreciable iron. This chapter also deals with both primary and secondary fluid inclusions from the petrographic viewpoint. In a later chapter, the chemistry of these inclusions is considered by R.R. Seal, who concludes that they were probably entrapped at 250-449°C at a confining pressure of 900 bars. A joint contribution from staff of the U.S. Geological survey and of the Geology Department of Oregon State University deals in detail with the major, minor and trace element composition of the emeralds from several Pakistan localities and also their host rocks; most of the emeralds owe their colour to the substitution of chromium for aluminium in the beryl structure (though a green beryl from Gandao has 13300 ppm V but only 340 ppm Cr). A further chapter by Jane Hammarstrom of the U.S.G.S. reports on the colour zoning shown by some of the emeralds and also demonstrates that the substitution of magnesium for aluminium in the octahedral site is charge-balanced by the entry of sodium into the channel site (these emeralds are notably poor in Rb and Cs).

The remaining five chapters are concerned with the geology and genesis of these emerald deposits, and in these the work of A.H. Kazmi, Director General of the Geological Survey of Pakistan, and of L.W. Snee of the USGS, point the way to a more fundamental understanding of the genesis of emeralds. In Pakistan all the emerald deposits are located in the Indus suture zone; most are associated with the Mingora ophiolitic mélange which has provided the chromium, whereas the beryllium came from later mineralizing fluids from the younger granitic rocks. In a wider consideration of all known emerald occurrences worldwide, a possible classification takes into account the geochemical incompatibility of Cr and Be and lists emerald deposits according to the source of the chromium (suture zones, granite-greenstone terrain or shale (metashale) and of the beryllium (generally pegmatitic or hydrothermal fluids but more rarely metamorphic fluids). With the exception of the Colombian occurrences, most emeralds exist as a result of crustal plate movements that juxtaposed chromium-bearing ultramafic oceanic plate movements with beryllium-bearing felsic continental rocks. Thus as the Editors suggest, we may marvel at each emerald crystal not only for its intrinsic beauty, but also for its untold tale of continental collisions. R.A.H.

MITCHELL, R.H., BERGMAN, S.C., 1991. *Petrology of lamproites.* Plenum Press, New York and London. pp. xvi, 447, illus. in black-and-white and in colour. US$ 75.00.

Only in recent years have lamproites been distinguished from kimberlites as a source of diamond, though this is not their only petrological and mineralogical significance. Recent surveys have found that several diamond deposits, once thought to be kimberlitic, are in fact lamproitic; they include the very important fields in Western Australia as well as some in Africa and on all the other continents.

Lamproites are igneous rocks characterized by high levels of K_2O and MgO and the history of the definition forms the first part of the book. The next section discusses potassic rocks and the lamproite clan and this is followed by a survey of lamproite occurrences and of the tectonic framework of lamproite genesis. A chapter on petrological facies and igneous forms of the lamproite clan prefaces a major section on lamproite mineralogy and geochemistry. Gemmologists will find the later part of the book particularly interesting as there is an examination of diamonds, xenoliths and exploration techniques. Diamonds in lamproites are considered to be xenocrysts and derived from parts of the lithospheric mantle lying above the regions of lamproite genesis. This section contains a very useful resumé of diamond types and inclusions. Lamproitic diamonds show similarities with and differences from kimberlitic stones, though Argyle stones (Western Australia) are richer in K, Al and Fe. In general lamproite diamonds are of poorer quality, the majority being grey, yellow, brown or of industrial quality. They show no morphological characteristics or colours which would unambiguously distinguish them from kimberlite diamonds.

This is a most useful book and the data presented is backed up by an excellent bibliography. M.O'D.

NICKEL, E.H., NICHOLS, M.C., 1991. *Mineral reference manual.* Van Nostrand, New York. pp. iv, 250. £10.95.

This is an alphabetical list of all mineral names available from extant literature to May 1990. No attempt is made to give mineral groupings; though the names of groups appear in sequence, group membership is not amplified. Entries give composition, status according to the Commission on New Minerals and Mineral Names, crystal system, lustre, main colour, type locality, hardness, measured and calculated densities. Major references are given, including re-descriptions; papers descriptive of crystal structure are cited where the senior paper needs amplification. Those familiar with Fleischer's Glossary of mineral species (various editions) will find the present work equally useful and complementary; it is well presented and lies open fairly well. The text is broken in one or two places by crystal diagrams and an appendix gives a synonymy of non-species names. Over 3800 entries are given in the book as a whole. M.O'D.

PECKETT, A., 1992. *The colours of opaque minerals.* Wiley, Chichester. pp. xxxviii, 471, illus. in black-and-white and in colour. Price £95.00.

Though the main purpose of this book is to aid the microscopist in the identification of ore minerals on the basis of their colour, there is a great deal of interest to anyone dealing with natural specimens with only colour upon which to base an identification. The early chapters give a rigorous treatment on the nature of light and of colour with notes on the operation of the eye. Several of the various colour evaluation systems are fully described and the inevitable mathematical treatment is at least explained in an appendix which pays particular attention to complex numbers and matrix algebra.

The book is divided almost into two halves; the first part deals with the theoretical aspect of opaque mineral colour description, the second with the minerals themselves. In this section each mineral is described as seen in polished mounts with the reflected light microscope in plane polarized light and between crossed polars. The colours seen depend upon the crystal structure and the electronic structure of the minerals. Each mineral description includes name and composition, crystal structure and optical properties, quantitative colour description, IMA approved name, X-ray diffraction data and atomic co-ordinates, with much other useful material and latest abstract in mineralogical abstracts where available. M.O'D.

RAILTON, G.T., WATTERS, W.A., 1990. *Minerals of New Zealand.* New Zealand Geological Survey, Lower Hutt. pp. 89, Illus. in black-and-white and in colour. Price on application. (New Zealand Geological Survey Bulletin 104).

New Zealand is not especially noted for its gem minerals but green nephrite is highly prized on the islands. The entry for nephrite correctly states that nephrite is now discouraged as a mineral name, most nephrite being a variety of actinolite or tremolite (IMA advice) but localities and references are given for this and for other minerals in alphabetical order. Each entry gives name, chemical composition, localities and references, with notes on synonyms. There is a really excellent bibliography and some attractive mineral photographs showing both hand specimens and thin sections in polarized light. M.O'D.

SCHUMANN, W., 1992. *Edle Steine.* BLV Verlagsgesellschaft, München. pp. 159, Illus. in colour. Price on application.

Many years ago this author produced a book Gemstones of the world in which several serious errors escaped the editor (and the translator) thus rendering the text unreliable for any professional purpose. The pictures were good, however, and they are good this time too, accompanying a general survey of gem and ornamental materials with a good deal of historical data. I can recommend the book for its excellent standard of production. M.O'D.

WARD, F., 1992. *Rubies and sapphires.* Gem Book Publishers, Bethesda MD. pp. 64, Illus. in colour. Price to be announced.

First in a promised series that is to include diamond, jade, pearl and emerald, this very attractive book should be a part of every gemmological library. The simple and lucid text deals with the main occurrences of corundum, methods of mining and cutting, synthesis and colour alteration, enlivened by high-quality colour pictures, some of which have previously been published in the author's National Geographic article on corundum in October 1991. Final text covers buying corundum, looking after it and a brief note on gem and jewellery journals. This book should be a pleasing gift to turn almost anyone into a gemmologist. M.O'D.

Gold, Mineral, Macht und Illusion: 500 Jahre Goldrausch. Extra Lapis no 2. 1992. Christian Weise Verlag, München. pp. 96. Illus. in black-and-white and in colour. Price DM 29.80 exclusive of postage.

Gemmologists will find an interesting mixture of topics covered by this colourful book. The contents range from the geology and mineralogy of gold to gold assaying, gold rushes and amateur prospecting. It is worth noting that many journals have supplements like this and the subscription does not always cover them (it hardly ever does, in fact). M.O'D.

Association Française de Gemmologie, 1992. *Gemmes.* Paris. Unpaged. Price on application.

A useful and pleasantly printed alphabetical list of the major gem materials, one to a double page, giving (in rough order) colour and occurrence, a typical crystal where appropriate, chemical composition, physical and optical constants, general remarks, likely simulants and a space for the reader's own notes. A short bibliography ends the book which many will find handy. It is perhaps too tightly bound and may not stand up to heavy wear; space could have been found for 'best reference' (in whatever language!) and there are some trifling inconsistencies but nonetheless a pleasing and acceptable topical guide. M.O'D.

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

NEWS OF FELLOWS

After some 19 years with the Gem Testing Laboratory, **Ken Scarratt** has left GAGTL to take up a position as a Director of GIA Gem Trade Laboratory Inc. in New York. Ken joined the London laboratory in 1974 shortly after the retirement of B.W. Anderson, C.J. Payne and R. Webster. He worked under the direction of Alec Farn until 1981, and was then appointed Director on Farn's retirement.

In his years with the laboratory Ken has supervised the move to the present premises in Greville Street and, more importantly, has masterminded the introduction of new techniques and equipment. His initial work with low temperature spectroscopy to detect artificially coloured diamonds gained the London laboratory great international respect and this was complemented by the subsequent introduction of the UV/visible spectrophotometer, which was provided by the Anderson appeal to Fellows and members. The infrared spectrometer (FTIR). the latest of the sophisticated tools acquired by the laboratory through Ken's influence, has proved of immense assistance in diamond identification, distinguishing between natural and synthetic gems and detection of plastic treatments. His world-wide reputation resulted in constant requests for lectures - in some twenty different countries. He has written papers for *The Journal of Gemmology* and other publications.

His enterprise also resulted in service contracts between the laboratory and organizations in Qatar and India and in the establishment of an excellent gem testing laboratory in Bahrain, where new designs of X-ray equipment for pearl testing were developed.

Following the decision in 1989 to amalgamate the London Gem Testing Laboratory with the Gemmological Association of Great Britain, it was Ken Scarratt who instituted the modernizing and computerizing of the administration. The successful progress of the Diamond Nomenclature Harmonization talks are largely due to Ken's chairmanship. His enthusiasm and expertise will undoubtedly greatly benefit his future work with GIA and the Asian Institute of Gemological Sciences in Bangkok where he has been appointed to the Board of Governors.

During the period 21 September to 6 October 1992 **Alan Hodgkinson, FGA**, gave a series of lectures, workshops and update courses in Kowloon, which were co-sponsored by the Gemmological Association of Hong Kong and the GIA Alumni Association (Hong Kong Chapter). He also presented a paper entitled 'Scottish view of gemmology' at the Hong Kong Gemmological Symposium 1992 on 22 September at the Hong Kong Convention and Exhibition Centre.

At the Canadian Gemmological Association's Gem Conference '92 held at the Park Plaza Hotel, Avenue Road at Bloor Street, Toronto, on 24 and 25 October 1992, Alan Hodgkinson gave two lectures entitled 'Gemmology! What good will that do you?' and 'A small taste of Scottish gemmology', as well as running a workshop on gem identification techniques. Following the lectures, he was made an Honorary Member of the Canadian Gemmological Association.

OBITUARIES

Mr John Edwards (D.1952 with Dist.), died suddenly at the beginning of December 1992. He was for many years a tutor for our correspondence course students worldwide. He has helped very many students obtain their Diploma in Gemmology through both the home study and Central Manchester College courses. Following his retirement from work as a jewellery retail Senior Manager, during which he ran company training, John was employed at the College to teach gemmology, gem diamond and retail jewellery courses and was in charge of the gemmology section until his retirement from the College two years ago.

We greatly regret the loss to this organization of

John Edwards as an able and willing correspondence course tutor.

As John is well remembered as a practical gemmologist, the College (now South Manchester College) is arranging in his memory a specially inscribed gem testing instrument for use in gemmology practical courses. Donations for this commemoration should be addressed c/o Mrs Sharon Longden and sent to her direct at South Manchester College, Arden Centre, Sale Road, Northenden, Manchester M23 ODD.

Mr Paul Ruppenthal of A. Ruppenthal GmbH & Co KG, passed away peacefully on 11 November 1992. He will be dearly missed by all.

GIFTS TO THE GAGTL

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

David J. Callaghan, FGA, for the following items for the Gem Tutorial Centre workshops: colourless topaz (44 x 39mm), a set of four 'Famous diamond' models, and a set of Gilson synthetic and simulant materials.

Christopher Cavey, FGA, for a modern carving in precious serpentine for the Gem Tutorial Centre.

Mr A. Ebelthite of A. & J. Ebelthite for a green paste.

M. Jhaveri of Precitone for a silver nitrate stained natural American freshwater pearl.

N.K. Lambrinides, FGA, President of the Gemmological Association of Greece, for dyed and varnished coral, black coral and horn specimens.

Marcus McCallum, FGA, for plastic imitation shell cameos.

Beverley Mitchell, FGA, of A. & G. Landesberg Ltd. for synthetic emeralds.

MEMBERS' MEETINGS

London

On 24 November 1992 at the City Conference Centre, Mark Lane, London EC3R 7JN, Dr Roger Harding and Howard Vaughan gave lectures on the gemstones of Africa.

Midlands Branch

On 30 October 1992 at Dr Johnson House, Bull Street, Birmingham, a Bring and Buy sale was held.

On 1 November 1992 at the Cobden Hotel, Birmingham, the Annual Practical Gemmology Seminar was held.

On 27 November 1992 at Dr Johnson House, Mark Jackson gave a talk on his experiences of working in jewellery factories abroad as a production consultant and discussed the social and working attitudes predominating in the countries concerned.

On 5 December 1992 the Fortieth Anniversary Dinner was held.

North West Branch

On 21 October 1992 at Church House, Hanover Street, Liverpool 1, Dr Jamie Nelson gave a lecture entitled 'The four optical attributes of a diamond'. One demonstration unit was used to help visualize the ray paths traced out in each of four simulated diamond profiles. Another device showed how each of the four attributes could be separately distinguished by means of three rotating parallel light beams falling on a brilliant-faceted stone.

On 18 November 1992 at Church House the Annual General Meeting was held at which Irene Knight, FGA, DGA, and Joe Azzopardi, FGA, were elected Chairman and Secretary/Treasurer respectively.

ANNUAL GENERAL MEETING

The Annual General Meeting of the Gemmological Association and Gem Testing Laboratory of Great Britain was held on 30 September 1992 at 27 Greville Street, London EC1N 8SU.

David Callaghan chaired the meeting and began by welcoming those present. He announced that this was the first meeting to be held in the newly acquired second floor accommodation at Greville Street, which was to be used for teaching purposes and lectures, as well as housing the library.

Nigel Israel was thanked for his work in packing the books that were transported from the library at Saint Dunstan's House. David Callaghan then thanked all those who worked in a voluntary capacity for the GAGTL and also the staff for their work, particularly during the difficult period when alterations were being made to the building.

Thanks were expressed to the Council of Management who spent considerable hours working on behalf of the Company, and to Noel Deeks who had been appointed overall administrator and has proved a tremendous asset.

The Annual Report and Accounts were approved and signed.

Alec Farn and David Kent were elected and R. Keith Mitchell re-elected as Vice Presidents.

D. Callaghan, R.R. Harding and E.A. Jobbins were re-elected to the Council of Management.

All members of the Members' Council were re-elected.

Messrs Hazlems Fenton were re-appointed Auditors.

This concluded the business of the meeting.

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PRESENTATION OF AWARDS

The Presentation of Awards gained in the 1992 examinations was held on 9 November at Goldsmiths' Hall, Foster Lane, London EC2. Mr David J. Callaghan presided and welcomed those present. 1142 candidates had taken the Association's examinations in 1992 and among those present were award winners from Canada, Finland, Greece, Hong Kong, Kenya, Malaysia, The Netherlands, Portugal, the People's Republic of China, Singapore, Spain and Thailand, as well as from the UK. Mr Callaghan paid tribute to the education team and the Examiners for the tremendous amount of work they do in organizing the annual worldwide examinations.

Dr Kurt Nassau - awarded Honorary FGA.

Following the presentation of the awards by Dr Kurt Nassau, the two newly elected Vice Presidents, Alec Farn and David Kent, were presented with framed certificates. 'They are both remarkable men', said David Callaghan, 'and have served the Association for many years, one as a Director of the Gem Testing Laboratory and the other as a stalwart of the jewellery industry.

'David worked for Bravingtons and has for many years given considerable help to the GA. He is widely travelled and he has our grateful thanks for all he has done. Alec has written many articles as well as his book on pearls. He was a member of the team that worked together for many years at the gem testing laboratory, becoming Director in 1972, and is the last of what B.W. Anderson referred to as the 'phalanx of four' [B.W. Anderson, A.E. Farn, C.W. Payne and R. Webster].'

Anderson Medal winner Sarah Hue-Williams, London.

The Chairman then came to what he explained as a rare event. 'From time to time an Honorary Fellowship is awarded to someone who has made a great contribution to the world of gemmology - Dr Kurt Nassau is such a man'. A chemist who specialized in colour and the reasons for colour, Dr Nassau was awarded an Honorary Fellowship

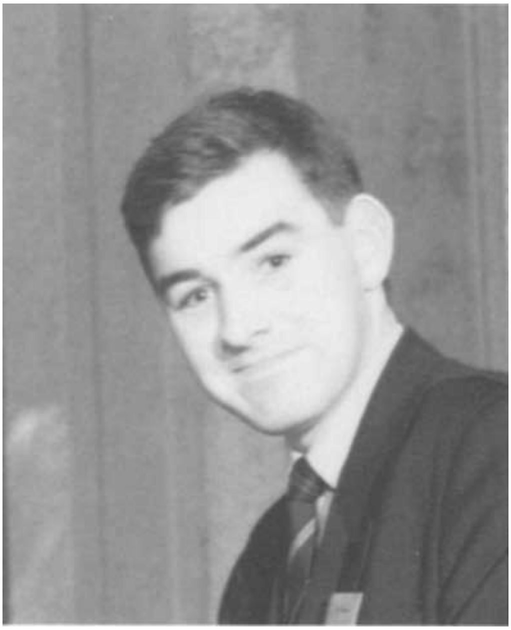
Diploma Trade Prize winner Anne Bailey, Rugby.

in recognition of his extensive contributions to understanding in the field of gemmology.

David Callaghan then introduced Dr Kurt Nassau who gave the address. His interest in gemmology began when, as a research scientist at the Bell Telephone Laboratories in New Jersey, he was asked to work on laser materials and began to grow crystals. Over the years he investigated many aspects of gemmology, including synthetic and enhanced gemstones, and the causes of colour in gemstones, and has published a number of books on the subject. He told those present about many of the specimens he had seen over the years, and methods he had employed to test them.

'Do not believe everything you have read', Dr Nassau advised. 'Much of it is wrong, incomplete or misleading. Do question things - if something does not make sense to you, think about it, read up on it in many sources, and try some experiments. Do not limit yourself to the field in which you are working. Combine gemmology with physics, chemistry and mineralogy. Interest and enthusiasm are the best things to have and will further your understanding and professionalism'.

A vote of thanks was given by Alan Jobbins.



Preliminary Trade Prize winner Alexander Hammond, Sandy.

David Callaghan with the newly elected Vice Presidents, David Kent (left) and Alec Farn.

MEETINGS OF THE COUNCIL OF MANAGEMENT

At the meeting of the Council of Management held on 21 October 1992 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership

Baker, Paul, Ringmer. 1992

Fellowship and Diamond Membership

Amor Cubeiro, Carmen, Barcelona, Spain. 1974/5
Blasi Casal, Juan, Barcelona, Spain. 1974/5.
Sancho de Gelaberto, Ma Pilar, Barcelona, Spain.

Fellowship

Anantwatanapong, Angkana, Bangkok, Thailand. 1992
Ball, Pamela, Hong Kong. 1992
Bierlein, Chari, Paris, Tex., USA. 1992
Chan, Lily Siu Chan, Hong Kong. 1992
Cheang, Chong Nun, Macua, Via Hong Kong. 1992
Cheng, Chi Chung, Hong Kong. 1992
Cheung, Chi Ho, Hong Kong. 1992
Chow, Shui Wah, Hong Kong. 1992
Chow Tze Joak, Kenickie, Hong Kong. 1992
De Gruyter, Barbara, Tielt-Winge, Belgium. 1992
De La Torre Lopez, Luisa, Tarragona, Spain. 1992
De Wit, Lambertus, Den Haag, The Netherlands. 1992
Dharmaratne, D. Rosemary O., Rajagiriya, Sri Lanka. 1992
Downing, Lucy Nicola, London. 1992
Emslie, Gail, Harrogate. 1992
Falco, Joaquim, Llanca, Spain. 1992
Groeneveld, Pauline, Giessenburg, The Netherlands. 1992
Harjula, Katri, Helsinki, Finland. 1992
Hawrelko, Donna P., West Vancouver, Canada. 1992
Ho, Po Mi, Avis, Hong Kong. 1992
Hui, Chak Lun, Hong Kong. 1992
Itoh, Yasuhiro, Osaka, Japan. 1984
Jewitt, Laura Kathleen, West Vancouver, Canada. 1992
Karkkainen, Niilo Kalevi, Espoo, Finland. 1992
Khudhairy-Gaylani, Bann, Toronto, Canada. 1992
Klumpes, Eric, Ag Veere, The Netherlands. 1992
Lau, Sau-Kuen, Heddy, Hong Kong. 1992
Lau, Ying Chi, Hong Kong. 1992
Lau, Yuen Mee, Hong Kong. 1992
Leung, Chee Wing, Hong Kong. 1992
Li, Chi Man, Hong Kong. 1992
Lum, Yin Kew, Samantha, Hong Kong. 1992
McCrary Weinberg, Dianna, Madrid, Spain. 1992
Nadal Cerezo, Antonio, Barcelona, Spain. 1970
Ng, Kwok Yin, Hong Kong. 1992
Ohira, Shino, Calif., USA. 1992
Quek, Cho Siang, Jessie, Hong Kong. 1992
See, Yat Sun, Hong Kong. 1992
Siu, Wai Chung, Norman, Hong Kong. 1992
Slui, Cornelis, Krimpen A/D Yssel, The Netherlands. 1992
Strachan, Elizabeth, Finchley. 1992
Takarada, Michiko, Hong Kong. 1992
Tse, Kwok Wing, Hong Kong. 1992
Tse, On Na, Anna, Hong Kong. 1992
Tsui, Kam Luen, Vincent, Hong Kong. 1992
Tun, Maung Win Myint, Bangkok, Thailand. 1992
Van Hillo, Geertruida J., Almere-Buiten, The Netherlands. 1992
Van Lamoen, Hans Thom, Rosmalen, The Netherlands. 1992
Williams, Georgette, Bangkok, Thailand. 1992
Wong, Queenie, Hong Kong. 1992
Yu, Sum Pui, Frankie, Hong Kong. 1992

Transfer to Fellowship

Friedland, Melissa, Omaha, Nebr., USA. 1992

Ordinary Membership

Adamson, Mary Joan Ariane Sheila, London.
Bark, David, London.
Bevers-Reinders, L.M., Rotterdam, The Netherlands.
Eggington, Roy, Bournemouth.
Joseph, Denise Taouk, Kensington, London.
Ma, Siu Lam, Hong Kong.
McCarthy, Emily, Hornsey, London.
Mohamed Hamza, Mohamed Hassan, Kandy, Sri Lanka.
Paul, Neelam, Northwood.
Pegg, Delia, Petts Wood.
Ruts, Willem G., Den Helder, The Netherlands.
Sana, Atisa Julie, London.
Tonn, Heleen, Rotterdam, The Netherlands.
Whistance, Mary Margaret Nancy Tolladay, Exmouth, Devon.
Yip, Man Loong, Hong Kong.

Gold Laboratory Membership

Bae's Gem Testing Laboratory, 30-7 Namdaemunro-3 ka, Chung-ku, Seoul, Korea.

At a meeting of the Council of Management held on 16 November 1992 at GAGTL, 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Fellowship

Asanis, Nikolaos, Athens, Greece. 1992
Barker, Maxwell, Johannesburg, South Africa. 1979
Barrie, Lindsay M.O., London. 1992
Cheung, Mei Ping Liann, Hong Kong. 1992
Cooper, Carolyn, Hong Kong. 1992
Dharmaratne, Pannipitiye Gamathi Ralalage, Rajagiriya, Sri Lanka. 1992
Karlsson, Andreas, Malmo, Sweden. 1992
Kim, Gum Jo, Pusan, Korea. 1992
Kuwabara, Rie, Hong Kong. 1992
Marsh, Leona Claire, Harare, Zimbabwe, South Africa. 1992
Patel, Rekha Mahesh, Nairobi, Kenya. 1992
Yung, Tak Yi, Hong Kong. 1992

Transfer to Fellowship

Bevoort-Alwicher, Terrence, Numegen, The Netherlands. 1992
De Jongh, Laurentia Melissa, The Hague, The Netherlands. 1992
Lang, Bernard, Basel, Switzerland. 1992
Liu, Zhao, Harbin, China. 1992
Zhang, Yabin, Harbin, China. 1992

Ordinary

Chedta-Thaiyawong, Kanitha, Bangkok, Thailand
Cho, Yong-Sang, Seoul, Korea
Daniels, Razia, Chester
Furze, Cindy Jane, Cheshunt
Lee, Tonny Song, Taiwan, China
Levy-Thomas, Katherine, Woking
Lu, Jei-Chih, Chelsea, London
Maclean, Hamish Donald, Seamill, Ayrshire
Micheli, Annika, London
Pelham Burn, Kate Ruth, London
Perera, Christel S.A., Colombo, Sri Lanka
Robinson, Zoe Lavinia, London
Takahashi, Masumi, Kanagawa, Japan
Williams, John Harold, Manchester
Zhang, Beili, Beijing, China

At a meeting of the Council of Management held on 16 December 1992 at GAGTL, 27 Greville Street, London EC1N 8SU, the business transacted included:

(a) election of T.J. Davidson, FGA, to the Council of Management;
(b) election to membership of the following:

Fellowship

Cheng, Sau Chun Hemans, Hong Kong. 1992
Chow, Chun Hung William, Hong Kong. 1992
Haberli, Sabine, Bottmingen, Switzerland. 1992
Lee, Siu Yin Ann, Hong Kong. 1992
Safar, Ali, Manama, Bahrain. 1992
Yuen, Chai Hung Teresa, Hong Kong. 1992

Ordinary Membership

Archutowski, Victor, London
Debrah, Kwame, London
Erilena, Cian Seren, Vicenza, Italy
Gregory, Fiona, Chalfont St. Peter
Hamissi, Ismail Djuma Shabah, London
Jo, Yoon-Hee, Wimbledon, London
Kabanda, Lolo-Manunga, Romford
Kang, Joo-Youn, Seoul, Korea
Rabstein, Wolf Isidore, London
Rodriguez, Lourdes, West Hampstead, London
Rose, Neil Robert, Stockport
Takamura, Hiyori, London
Violati Tescari, Ottaviano, Vicenza, Italy
Watanabe, Tatsuo, Kanagawahen, Japan

GEM DIAMOND EXAMINATIONS 1992 OVERSEAS

In the 1992 Gem Diamond Examination held overseas, the names of the successful candidates are as follows:

Qualified

Koundourou, Radka Lalovska, Athens, Greece.
Sergoulopoulos, Alexandros, Athens, Greece.
Stather, Memory, Hong Kong.

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For further details contact Louise Macdougall at GAGTL, 27 Greville Street, London EC1N 8SU.

CORRIGENDA

On p.197 above, under 'Congratulations to the Deutsche Gemmologische Gesellschaft E.V. on the occasion of their 60th Anniversary', second column, first line, for 'DDG' read 'DGG'

On p.202 above, first column, line 9, for 'diamond and corundum are' read 'corundum is'; on line 12 after 'Kane, 1984' add 'Scarratt *et al* 1984'

On p.204 above, first column, Line 21, for 'Organic fillers,' read 'Most organic fillers'

On p.205 above, second column, under References add: 'Kane, R., 1984. Natural rubies with glass-filled cavities. *Gems & Gemology*, Winter, 187-99'

On p.250 above, first column, line 12, for 'Ordinary Membership' read 'Fellowship'

On p.251 above, first column, the following were elected to Ordinary Membership on 24 June 1992 and not Fellowship as stated:

Jehu, A.G., Virginia Water.
Jones, Lloyd E., Gold Coast, Australia.
Kiernan, Janeien E., Cheddar Gorge.
Porter, Mark A., Hartley Wintney.
Sandy, Paul R., Bournemouth.
Smith, Richard S.N., Exmouth.
Van't Hooft, Jacobus A., Uught, The Netherlands.

We apologize for the above errors.

FORTHCOMING MEETINGS

London

Throughout 1993 there will be a programme of meetings on the second floor at 27 Greville Street. Refreshments will be available from 6.00 p.m. and we plan to start the lectures at 6.30p.m.; these will be followed by discussion at 7.15 p.m., and closing about 7.45 p.m. The charge for a member will be £3.50 and, since places are limited to 55, entry will be by ticket only, obtainable from GAGTL.

The programme until May is as follows:

8 February	'Emeralds in the Laboratory'.	Ana I. Castro & Stephen Kennedy
24 February	'New Gem Testing Instruments'.	Peter Read
8 March	'Colour in Diamonds'.	Dr Alan Collins
31 March	'From the Gem to the Jewel'.	David Callaghan
14 April	'Fluorescence Effects in Gemstones'.	Dr Jamie Nelson
27 April	'Rubies in the Laboratory'.	Ana I. Castro & Stephen Kennedy
11 May	'Engraved Gems'.	Christopher Cavey

Midlands Branch

26 February	'The Art of Engraver'.	Robert Campbell-Legg
26 March	'Crystal Healing'.	Peggy Stock
30 April	Annual General Meeting followed by a gem collection talk	

Meetings will be held at Dr Johnson House, Bull Street, Birmingham. Further details from Gwyn Green on 021-445 5359.

North West Branch

17 February	Video viewing 'Gemstones of America'.	
17 March	'Cameos and intaglios in antique jewellery'.	Richard Digby
19 May	'Lalique jewels from the 1992 Paris Exhibition'.	Dr J. Franks
16 June	Members and friends evening. Bring and Buy: crystals, books and instruments, and exchange of views.	

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

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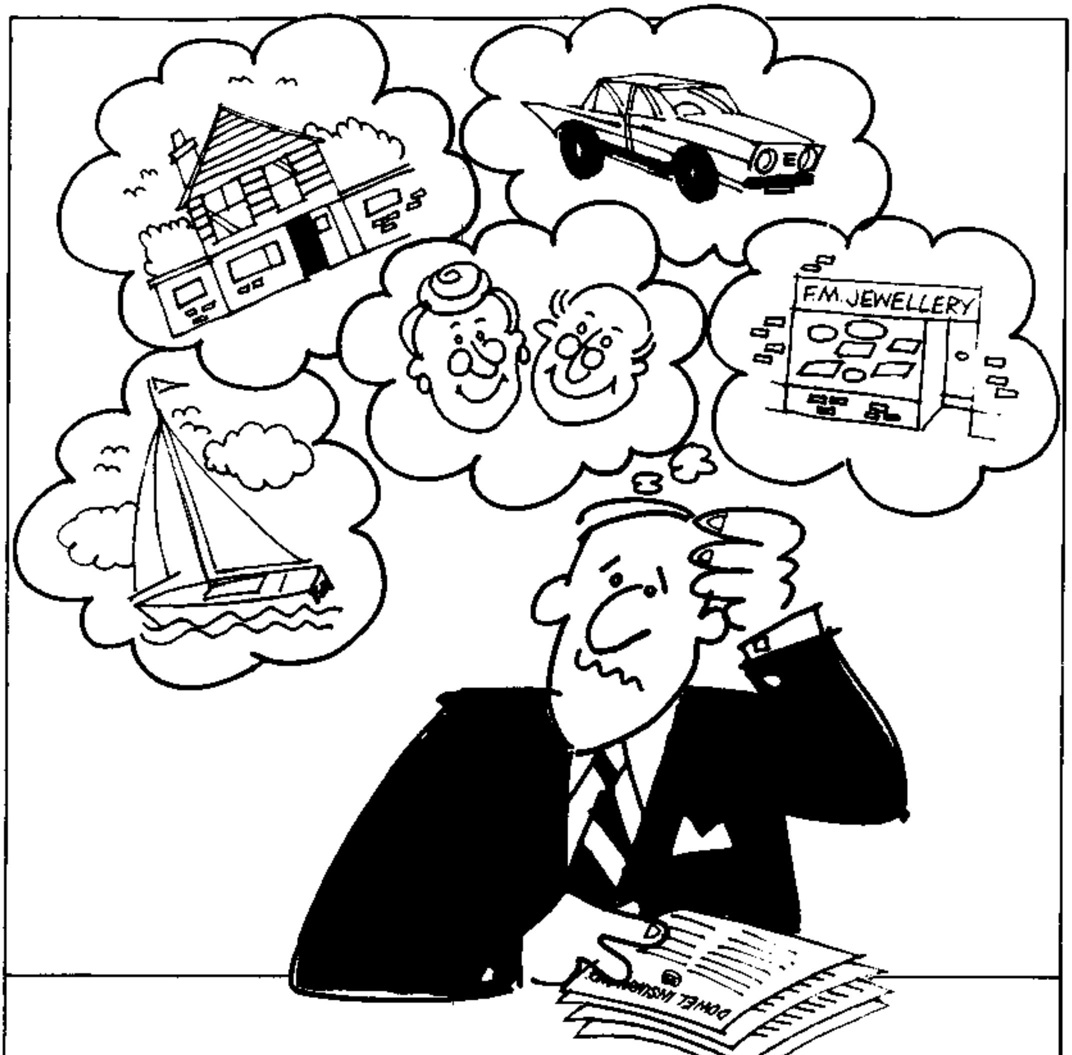
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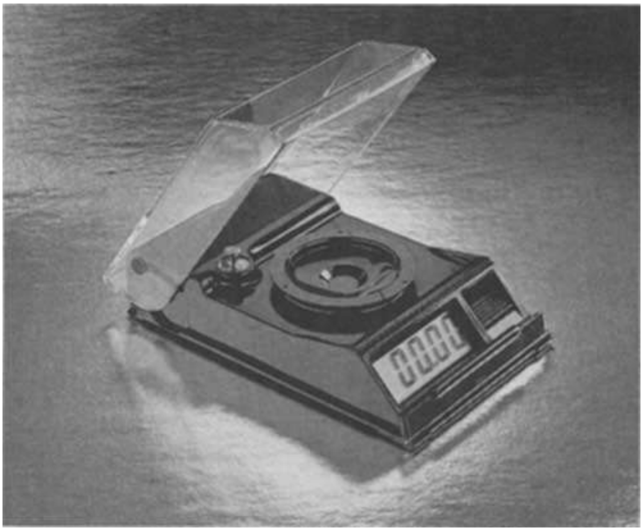

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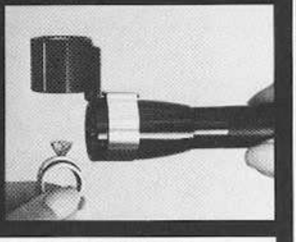

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Papers should be submitted in duplicate on A4 paper. They should be typed with double line spacing with ample margins of at least 25mm all round. The title should be as brief as is consistent with clear indication of the content of the paper. It should be followed by the names (with initials) of the authors and by their addresses. A short abstract of 50–100 words should be provided. Papers may be of any length, but long papers of more than 10 000 words (unless capable of division into parts or of exceptional importance) are unlikely to be acceptable, whereas a short paper of 400–500 words may achieve early publication.

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January 1993

The Journal of Gemmology

Contents

A notable red-brown diamond *J. E. Shigley and E. Fritsch* 259

Possible prehistoric glasses in the gem trade in Sri Lanka *H. Harder* 267

Notes from the Laboratory –17 *E. C. Emms* 274

Microscopic studies of Burmese jadeite jade – 1 *C. M. Ou Yang* 278

Unusual inclusion in an aquamarine *A. de Goutiere* 286

Radiation-induced colour change in natural and synthetic emerald *K. Schmetzer* 288

1992 Annual Conference 294

Gemmological Abstracts 298

Book Reviews 304

Proceedings of The Gemmological Association and Gem Testing Laboratory of Great Britain and Notices 307

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