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Characterization of a group of experimental Russian hydrothermal synthetic sapphires

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ABSTRACT: Various types of experimental samples of Russian hydrothermally-grown synthetic sapphires are characterized according to causes of colour and microscopic features of diagnostic value. Two types of samples represent the synthetic counterparts of natural basaltic bluish-violet and yellow sapphires. Other synthetic sapphires are coloured by traces of cobalt, manganese and vanadium.

Introduction

Hydrothermal synthetic ruby of Russian production appeared on the market in 1993 (Peretti and Smith, 1993, 1994) and yellow, orange, bluish-green and blue synthetic sapphires have been described more recently (Peretti *et al.*, 1997; Thomas *et al.*, 1997). Most samples examined in these papers were coloured by chromium and/or nickel, but Russian scientists also tried to grow the direct counterparts of natural blue sapphire doped with iron and titanium (Thomas *et al.*, 1997). One sample of this type was briefly described by Peretti *et al.* (1997) and a vanadium-bearing sample was also mentioned.

The present study is based on the examination of what appear to be research samples from Russian production. In the course of examination of 83 samples produced either at the United Institute of Geology, Geophysics and Mineralogy, Novosibirsk, Russia, or at the hydrothermal growth facilities of Tairus Co., Novosibirsk, Russia, 71 belonged to the group of commercially produced colours, which contain chromium and/or nickel as the predominant colour-causing trace elements (Schmetzer and Peretti, 1999).

In the absorption spectra of this group of 71 samples, no bands attributable to Fe^{3+} were observed although traces of iron were found by EDXRF and, consequently, the influence of iron on their colour is not significant. In the hydrothermal synthetic rubies and pink sapphires energy dispersive X-ray fluorescence analyses revealed the presence of various amounts of chromium. In yellow, green, blue-green and blue samples, only traces of nickel were present as colour-causing trace elements, whereas blue-violet to violet and orange to reddish-orange synthetic sapphires contained traces of both chromium and nickel.

Three synthetic sapphires with significant iron contents in addition to chromium and nickel were also described by Schmetzer and Peretti (1999). These samples were either bluish-violet or changed colour from bluish-green in daylight to reddish-violet in incandescent light. Two samples of the group

of 83 mentioned above are colourless synthetic sapphires.

According to visual colour observation, absorption spectroscopy and trace element analysis, the remaining seven hydrothermal synthetic sapphires do not belong to the series coloured by chromium, nickel, chromium and nickel, or by chromium, nickel and iron. Although not widely distributed in the trade, these more or less experimental samples could appear at any time in the future on the free market. Therefore these samples are described briefly in the present paper.

Although a complete and detailed determination of properties of the different types of synthetic sapphires is impossible with the limited number of rough and faceted samples available, some important diagnostic features can be summarized.

Materials and methods

The seven synthetic sapphires to be described in this study are listed in *Table I*.

Two samples were acquired between 1993 and 1996 by one of the authors (AP) during various stays in Bangkok and Novosibirsk (see Peretti *et al.*, 1997). Four samples were found in a collection submitted by C.P. Smith of Lucerne, Switzerland. This collection contained rough and faceted synthetic rubies and sapphires obtained from 1993 to 1998 in Novosibirsk and Bangkok. One faceted sample from the research collection of the GIA at Carlsbad, California, originated directly from Tairus Co., Novosibirsk.

All samples were grown on tabular seeds. One complete crystal and two pieces with external crystal faces that had been sawn from rough crystals were available. Three samples were plates sawn perpendicular to tabular seeds and polished subsequently on both sides. One faceted bluish-violet synthetic sapphire was also examined.

In order to characterize the samples according to causes of colour and trace element contents, all sapphires were spectroscopically examined in the visible and

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Table I: Russian hydrothermal synthetic sapphires, samples and properties

Type of sapphire	Cause of colour	Pleochroism		Samples (number of samples) [orientation of seed]	nat: natural counterpart imit: imitating
		// c	⊥ c		
bluish-violet	Fe^{3+}, Fe^{2+}/Ti^{4+}, Fe^{2+}/Fe^{3+}	light greenish-blue	intense bluish-violet	plate (1) [b], faceted (1)	nat: basaltic type bluish-violet sapphire
yellow	Fe^{3+}, minor Cr^{3+}	light yellow	yellow	crystal (1) [b]	nat: basaltic type yellow sapphire
green	Co^{2+}, Co^{3+}	yellowish-green	bluish-green	plate (1) [-r]	imit: green sapphire
reddish-orange	Mn^{3+}	yellowish-orange	purplish-red	rough piece (1) [40° to c]	imit: padparadscha
colour-change d: greyish-green i: reddish-violet	V^{3+}	d: yellowish-green i: light reddish-violet	d: greyish-violet i: intense reddish-violet	rough piece (1) plate (1) [both 40° to c]	nat: colour-change vanadium-bearing sapphire

d: daylight; i: incandescent light
[b]: seed parallel to a prism {10$\bar{1}$0}
[–r]: seed parallel to a negative rhombohedron {01$\bar{1}$1}
crystal: complete crystal grown on a tabular seed
rough piece: rough piece sawn from a crystal grown on a tabular seed
plate: thin plate sawn perpendicular to a tabular seed and polished on both sides
faceted: faceted gemstone

ultraviolet range by means of a Leitz Unicam SP 800 UV-VIS spectrophotometer. Trace element analysis was performed by X-ray fluorescence (EDXRF) using a Tracor Northern TN 5000 system.

Results

The seven hydrothermal synthetic sapphires were classified into five types according to colour and causes of colour as indicated by absorption spectroscopy and EDXRF trace element analysis (see *Table I*). These are (a) counterparts of basaltic type bluish-violet, (b) counterparts of basaltic type yellow, (c) green cobalt-doped, (d) reddish-orange manganese-doped, and (e) vanadium-doped colour-change sapphires.

In each of the six rough samples at least part of a tabular seed plate was present. Thus, it was possible to determine the orientation of seed used for crystal growth. Two samples were grown on seeds parallel to a hexagonal prism b $\{10\overline{1}0\}$ and one sample was grown on a seed parallel to a negative rhombohedron -r $\{01\overline{1}1\}$. These two orientations are the standard cuts of seed plates used in Russia for commercial production of synthetic rubies and sapphires

Figure 1: Plate of hydrothermal synthetic bluish-violet sapphire cut perpendicular to the c-axis (the thickness of the plate is approximately 1.2 mm); the seed consists of colourless sapphire and synthetic ruby and is oriented parallel to a prism b $\{10\overline{1}0\}$. The synthetic blue sapphire reveals six a $\{11\overline{2}0\}$ prism faces and has an absorption spectrum comparable to the spectrum of basaltic type natural sapphires coloured by iron and titanium. Size of the sample about 14.4 x 11.8 mm.
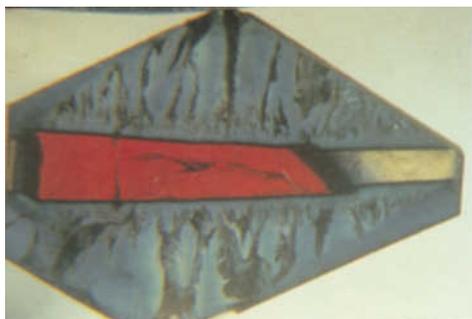
in the chromium- and/or nickel-bearing series (Schmetzer and Peretti, 1999). Three samples were grown with an inclination of the seed plate at 40° to the c-axis.

Microscopic examination revealed the presence in most of the samples of solid, liquid and multiphase inclusions comparable to those described in detail by Peretti *et al.*

Figure 2: Absorption spectra of bluish-violet and yellow synthetic sapphires and their natural counterparts. Bluish-violet sapphires reveal absorption bands of Fe^{3+}, Fe^{2+}/Ti^{4+} and Fe^{2+}/Fe^{3+}; (a) Russian synthetic sapphire, (b, c) natural sapphires from Pailin, Cambodia. Yellow sapphires reveal strong absorption bands of Fe^{3+} and weak bands of Cr^{3+}; (d) Russian synthetic sapphire (e, f) natural sapphires from Thailand.
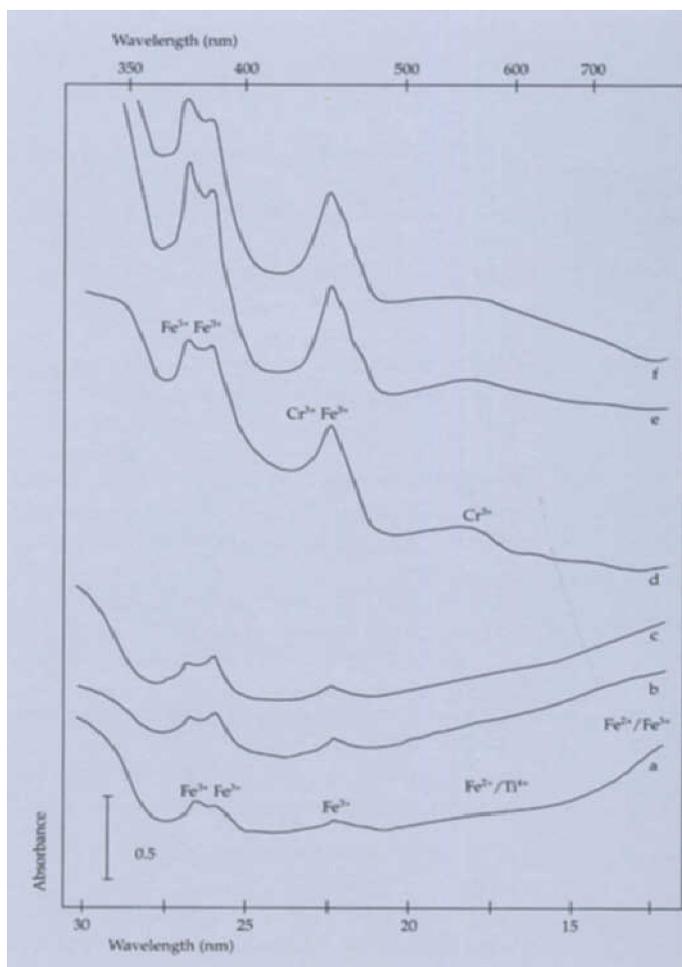
Figure 3: Boundaries of variable orientation between subindividuals and colour zoning in synthetic bluish-violet sapphire; large cavities with multiphase fillings appear opaque in this orientation of the sample. Immersion, magnified 30x.

(1997). Preliminary heating and freezing experiments on multiphase inclusions revealed that they contained aqueous solutions and other phases which did not homogenize at temperatures below 40°C.

A *bluish-violet synthetic sapphire* was grown with a seed parallel to a prism face b (*Figure 1*). From absorption spectroscopy and trace element analysis it is evident that the colour and absorption spectra (*Figure 2*) of this type of synthetic sapphire is consistent with that of natural, basaltic type bluish-violet sapphire (Schmetzer and Bank, 1980, 1981; Schmetzer, 1987; Kiefert and Schmetzer, 1987). Consequently, the pleochroism of this synthetic sapphire is identical to that seen in natural basaltic type sapphires. The closest match of the absorption spectrum to natural sapphires in the authors' collection is with those of some basaltic sapphires from Pailin, Cambodia, which show only weak Fe^{2+}/Ti^{4+} charge transfer absorption bands (*Figure 2*).

Both synthetic samples available contain large multiphase inclusions (*Figure 1*), the exact composition and phase analysis of which is not yet known in detail. The growth patterns are different from those of sapphire samples of the chromium-nickel series (Schmetzer and Peretti, 1999). No parallel or near-parallel striations representing subindividuals of similar diameters were found. In contrast, irregular variable boundaries between different growth zones were observed, which in general represent growth areas of varying colour intensity. In immersion, a somewhat fibrous internal texture is seen, which results from the irregularly varying growth areas (*Figure 3*). This growth pattern resembles the chevron or angular growth features seen in hydrothermal synthetic emeralds (see e.g. Schmetzer, 1988).

A rough crystal plate of yellow synthetic sapphire (*Figure 4*) revealed an absorption spectrum consisting mainly of Fe^{3+} absorption bands with weak Cr^{3+} bands (see references cited above). The spectrum of this sample is similar to that seen in some natural yellow sapphires from basaltic sources, which normally consists of intense Fe^{3+} absorption bands. In some samples from

Figure 4: Crystal of hydrothermal yellow synthetic sapphire grown on a seed parallel to a prism b {10$\overline{1}$0}; the absorption spectrum of the synthetic yellow sapphire is comparable to the spectrum of basaltic type natural sapphires coloured predominantly by iron. Size of sample about 35 x 10 mm; photo by M. Glas.

Thailand, an additional weak Cr^{3+} absorption band can also be present (*Figure 2*). Samples with similar colours and absorption spectra are also known from Umba, Tanzania. The roughness of the crystal plate on both faces parallel to the seed plate prevented a detailed microscopic examination of internal growth features and inclusions.

The absorption spectrum of a plate of *green synthetic sapphire* (*Figure 5*) consists of absorption bands attributed to Co^{2+} and Co^{3+} (*Figure 6*) following McClure, 1962; Müller and Günthard, 1966; Hush and Hobbs, 1968. This interpretation is also consistent with the chemical composition of the sample. The microscopic examination of this green synthetic sapphire grown on a seed with an orientation parallel to -*r* revealed a series of parallel striations inclined to the seed and numerous healing feathers (*Figure 7*). This

Figure 5: Plate of hydrothermal synthetic green sapphire grown on a seed parallel to a negative rhombohedron −r {01$\bar{1}$1}; the absorption spectrum of the synthetic green sapphire reveals absorption bands of bi- and trivalent cobalt. Size of sample about 12 × 8 mm; photo by M. Glas.

Figure 6: Absorption spectra of manganese-, vanadium- and cobalt-bearing synthetic sapphires; (a) reddish-orange sapphire coloured by Mn^{3+}, (b) greyish-green synthetic sapphire coloured by V^{3+}, (c) green synthetic sapphire coloured by Co^{2+} and Co^{3+}.

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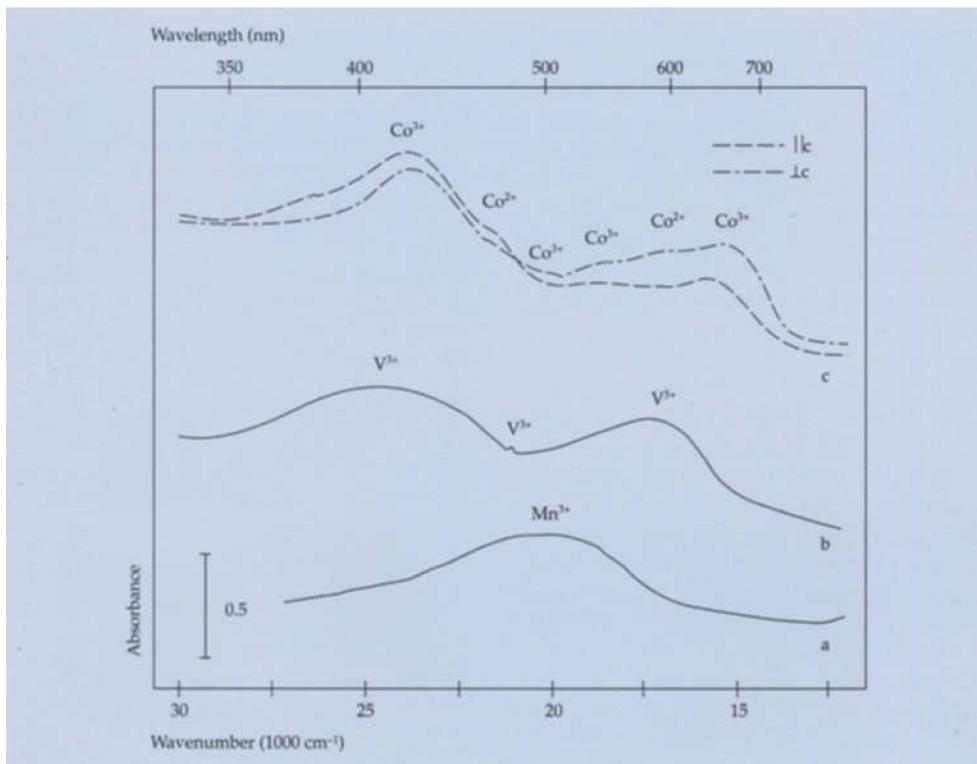
Figure 7: Cobalt-bearing green synthetic sapphire with colourless seed; parallel striations are observed inclined to the seed, numerous small healing feathers are also seen. Immersion, magnified 50x.

kind of colour or absorption spectrum has not been found in natural sapphire.

Three samples, a *reddish-orange synthetic sapphire* (*Figure 8a*) and two *colour change greyish-green synthetic sapphires* (*Figure 8b and c*) were grown on seeds inclined at about 40° to the *c*-axis. All three samples grown with this particular seed orientation revealed intense colour zoning parallel to the seed which decreased in colour intensity outwards away from the seed. The absorption spectrum of the reddish-orange sample (*Figure 6*) consisted of a broad absorption band which was assigned to Mn^{3+} in corundum (McClure, 1962; Hush and Hobbs, 1968). Each absorption spectrum of the two greyish-green samples (*Figure 6*) consists of two dominant absorption bands attributed to V^{3+} (McClure, 1962; Schmetzer and Bank, 1981). Verneuil-grown colour-change synthetic sapphire doped by vanadium is widely known to gemmologists as colour-change synthetic sapphire. In contrast, vanadium-bearing, colour-change natural sapphire is extremely rare. A faceted sample of this type originating from Burma (Myanmar) was first mentioned by Hänni (1983).

A second type of *colour-change bluish-green synthetic sapphire* was found to be a heavily iron-doped member of the chromium-nickel series and was described by Schmetzer and Peretti (1999).

Conclusion

Different types of not yet commercially produced, more or less experimental, hydrothermally grown synthetic sapphires of Russian production were examined. Some of the samples represent synthetic counterparts of natural bluish-violet and natural yellow sapphires from basaltic environments. No natural equivalents of green synthetic sapphire coloured by cobalt and reddish-orange synthetic sapphire coloured by manganese are known. The vanadium-doped, colour-change synthetic sapphire does have a natural equivalent, but it is extremely rare.

The seven synthetic sapphires contain solid, liquid and multiphase inclusions, as well as characteristic growth features and, together with their absorption spectra, these properties are sufficient to identify the materials as synthetic products.

Figure 8: (a) Piece of a crystal of synthetic reddish-orange sapphire coloured by trivalent manganese. Size of sample about 18 x 16 mm. (b) Plate with seed visible and (c) piece of a crystal of colour-change synthetic sapphire; the absorption spectra of the samples, which are greyish-green in daylight and reddish-violet in incandescent light, consist of absorption maxima indicating trivalent vanadium. Incandescent light, the piece of a crystal is about 23 x 16 mm. Photo by M. Glas.
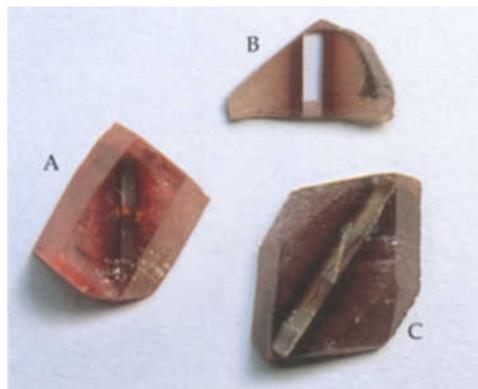
Acknowledgements

Note added in proof

In a poster presented at the International Gemological Symposium, San Diego, California, U.S.A., from 21 to 24 June 1999, a new type of hydrothermally-grown synthetic sapphire was described (see Abstract by Smirnov *et al.*, 1999). It was stated that the dark blue or violetish-blue samples were submitted to heat-treatment subsequent to hydrothermal crystal growth in order to produce a bright blue coloration. An absorption spectrum presented in the poster revealed a dominant Fe^{2+}/Ti^{4+} charge transfer absorption band but no Fe^{2+}/Fe^{3+} absorption. Consequently, this new type of hydrothermal synthetic sapphire reveals spectroscopic properties comparable to those of metamorphic type natural blue sapphires, e.g. from Kashmir, Sri Lanka or Myanmar.

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A very convincing forgery

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ABSTRACT: Cubic zirconia (CZ), is one of the most serious diamond impostors today. It is rare that a well-made ring in silver is encountered set with very well selected cut and polished cubic zirconias, in a deliberate attempt to fool the connoisseurs. One such is described.

Keywords: cubic zirconia, diamond simulant

Introduction

Recently the author received for examination, spectral analysis and origin of colour determination, what seemed to be a cushion-shaped fancy light yellow diamond circled by 16 brilliant-cut diamonds (*Figure 1*). They were mounted in either white gold or platinum, and doubt arose because the hallmark on the ring was unfamiliar to the author (*Figure 2*).

The cushion-shaped light yellow transparent gemstone, which was set with four pairs of claws, was measured with a Leveridge gauge and was 13.38 x 13.15 mm at the girdle with a depth of 7.95 mm. The weight estimate was approximately 12 ct. No characteristic inclusions were observed under the microscope, but it was noticed that the girdle was faceted (*Figure 3*). It was decided to unset the light yellow stone to obtain its exact weight, measurements and complete gemmological properties, which are described below.

Gemmological properties

The loose stone proved to be a cushion-shaped mixed-cut, with a brilliant-cut crown and modified Barion-cut pavilion. The measurements obtained with a Mitutoyo micrometer were 13.21 x 13.14 mm girdle

Figure 1: Enlarged view of the ring received for examination. (The yellow cushion-shaped stone is much more lively than the colour plate shows.)

Figure 2: The unidentified hallmark stamped on the exterior of the ring. Notice also the hammered surface of the ring in order to give it an older appearance.
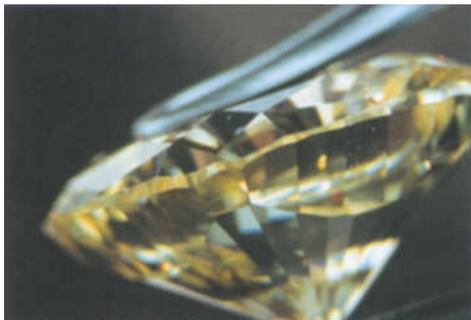
Figure 3: The faceted girdle observed on the 18.11 ct light yellow cushion-shaped cubic zirconia.

diameters and a depth of 7.85 mm. The weight on a Mettler PL 300C carat scale was 18.11 ct. At this stage it was evident from the difference between actual and calculated weights that the stone was not a diamond, but the testing procedure was continued.

Under a Bausch & Lomb Mark V Gemolite binocular microscope using dark field illumination and overhead lighting as appropriate, neither polishing lines nor internal inclusions could be found, but blue and orange flashes as a result of dispersion could be seen on many facets as the stone was rocked (*Figure 4*).

Refractive index (RI) determinations were carried out using a Rayner Dialdex refractometer and monochromatic sodium light. The indices obtained from the table facet proved to be above the limit of the refractive liquid of 1.81.

The thermal conductivity was tested with the Ceres Diamondprobe and proved to be very weak.

Ultraviolet fluorescence was examined with a Multispec combined LW/SW unit and the stone fluoresced a moderate apricot under SW, and a strong yellow under LW.

The specific gravity (SG) was obtained by hydrostatic weighing in distilled water using a Mettler PL 300C carat scale, and was found to have a value of 5.99.

The absorption spectrum was observed through the pavilion, in daylight conditions, with a Beck spectroscope, and revealed

strong absorption between 400 and 410 nm, sharp lines at 412, 415, 418 and 424 nm, a strong line at 490 nm, and diffused lines at 660 and 680 nm.

Conclusion

These properties do not correspond with those of diamond but are consistent with the published values for cubic zirconia (Nassau, 1980; Webster, 1994). It is of interest to note that all 16 colourless brilliant-cut stones set in the ring fluoresced a strong dark yellow under LW when examined in the Multispec LW/SW ultraviolet unit. This again is not characteristic of gem-quality diamonds which, under the same conditions, would be expected to show a range of responses, usually weak to strong blue. Only very rarely (less than 0.2%) is a yellow fluorescence in LW observed in gem-quality fluorescent diamonds. Again the thermal conductivities proved very weak, which confirms that these stones are not diamond. The metal of the ring was also tested and proved to be neither white gold nor platinum, but 970‰ silver.

Discussion

It seems evident that this ring was made to deliberately deceive, for the following reasons:

Figure 4: Blue and orange flashes observed on many facets of the pavilion, as the stone was rocked under the microscope (dark-field illumination).


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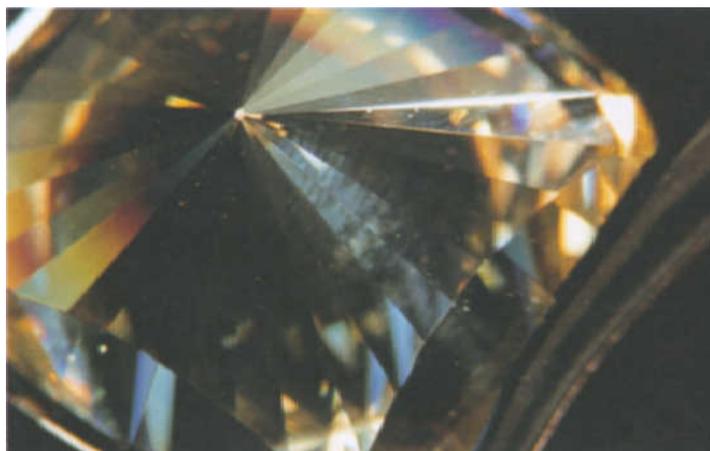
Figure 5: Maker's mark inscribed on the inside of the ring.

- The very convincing mount is of a good workmanship in silver, but with an unidentified hallmark on the outside of the ring (the way some countries have their jewellery stamped), and a mark of the jeweller on the inside of the ring (*Figure 5*).
- The ring, which was voluntarily aged on the outside (hammered), as if it had belonged to a private lady who had worn it over a long period of time (*Figure 2*).
- The classical design of a main stone circled by a row of small brilliant-cut stones.
- The choice of a light colour for the main stone, but strong enough to be attractive and warrant a fancy light grade which, for most professionals dealing with fancy coloured diamonds, evokes a natural colour, and could therefore fool them to take the risk of buying it for such. Had the stone been deep or intense yellow, the same potential buyer would suspect some possible treatment and certainly have the colour origin tested before making an offer for the stone.
- The cutting style, with a cushion-shape brilliant crown and modified Barion-cut pavilion, intensifies the face-up colour appearance.
- The facets are exceptionally well cut and polished; no polishing lines were observed under the microscope.
- A faceted girdle is often observed in diamonds with a slightly thick to thick girdle; here the facets avoid leaving a bruted or plain polished girdle which could betray the cubic zirconia.

It must be said that yellow cubic zirconia, like the stone tested here, has a much more convincing similarity to diamond than the more common colourless variety. This light yellow cushion-shaped stone bears a close visual resemblance to a natural diamond and required appropriate examination and tests to reveal its true identity.

Potential buyers of such goods should be warned that apparent bargains obtainable in the street away from a legitimate supplier, or without a receipt from a reliable source, can often lead to this kind of costly deception.

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Geology of the Yellow Mine (Taita-Taveta District, Kenya) and other yellow tourmaline deposits in East Africa

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ABSTRACT: Tourmaline is a common gemstone in Kenya and Tanzania but little information is available on the geology of its deposits. The geology of a major yellow (savannah) and bicolour tourmaline deposit, the Yellow Mine in the Mangare area (southern Kenya) is described. Mg-tourmaline (dravite-uvite series) of yellow and green colour occurs in a pegmatite which has undergone several stages of deformation, metasomatism and metamorphism. For comparison, several other yellow tourmaline deposits from southern Kenya and Tanzania are also briefly described. Yellow tourmaline deposits may be linked to gneisses and anatectic pegmatites, or to the result of the interaction of such pegmatites with different lithologies such as ultrabasic rocks or marbles. An example of coexistence of dravitic and elbaitic tourmaline in a pegmatite from the John Saul Mine (southern Kenya) is also given. New mineralogical and gemmological data on east African tourmalines are also provided. Tourmaline showing a yellow core and a green rim are common in different kinds of geological environments in east Africa; this indicates the existence of a major, wide scale genetic mechanism for such crystals.

Keywords: East Africa, Kenya, tourmaline

Introduction

Tourmaline is a fairly common gemstone in the Mozambique Metamorphic Belt, particularly in the area stretching from the Taita Hills in southern Kenya to the Umba River Valley in Tanzania (Keller, 1992). In concentrates from eluvial and alluvial deposits, it is common in black, brown, yellow, orange or green hues, coming usually from gneisses where it is an accessory mineral, or from anatectic pegmatites in the gneisses. Often, crystals are green to brown with a sharp green/brown-orange dichroism. These tourmalines are usually solid solutions between dravite and schorl (Na Mg – Na Fe series) or dravite and uvite (Na Mg – Ca Mg series).

Chrome tourmaline (blue-green) is gathered in many deposits as a by-product of ruby mining, both minerals being commonly associated, as for example at the John Saul Ruby Mine, in the Mangare Area of southern Kenya (Key and Ochieng, 1991). A major chrome tourmaline deposit is located next to

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the Landenai Mountain in Tanzania, and other deposits have been mentioned along the Umba River valley (Keller, 1992). Chrome tourmalines are typically solid solutions between dravite and uvite and are Fe-poor, and Cr-rich (Cr_2O_3 = 0.2 to 1 wt %, see *Table IV*). Halvorsen and Jensen (1997) have described green chromiferous and vanadiferous tourmalines from the Umba Area displaying a new colour change effect. These stones show a red hue through sections thicker than 15 mm. Such stones are also present at the John Saul Ruby Mine in metasomatised gneisses next to ultrabasic rocks. Barot *et al.* (1995) also described green cat's-eye tourmalines from southern Kenya. Green colour change tourmaline from the Lelatema area in Tanzania has been described by Bank and Henn (1988). According to Schmetzer and Bank (1979) and Schmetzer *et al.* (1979), vanadium-bearing tourmaline is also common in Tanzania (Landenai, Gerevi near Umba) and southern Kenya (Kwale district). I have observed dark green vanadian tourmaline crystals as poikiloblasts in graphite gneisses of the Lemshuko (Komolo) tsavorite deposit.

Red dravite has been reported next to quartzite outcrops in the Narok District of Kenya (Dunn *et al.*, 1977; Keller, 1992). In southern Kenya, there are no pocket-bearing pegmatites and elbaitic tourmalines are very rare. An example of red elbaitic tourmaline from the Mangare area is described below. In Tanzania, green and red elbaites originate from the pegmatites of the Morogoro area (Keller, 1992).

Yellow, golden and savannah tourmalines from southern Kenya have been mentioned and described several times (e.g. Schmetzer and Bank, 1979; Hänni *et al.*, 1981; Gem News, 1996), but until now no data have been published about the geology of their deposits, which can be complex with many variations. Stones of similar appearance may have a very different geological and geographical origin. The names of golden tourmaline and savannah tourmaline have sometimes been confused (e.g. Gem News, 1996), especially as both colour varieties can occur together in one

deposit. However, these appellations, as they are used in east Africa, have very specific meanings and are respectively used for a bright, slightly orange, yellow tourmaline, and a sharply dichroic yellow-green tourmaline comparable with colours of the African savannah.

The aim of this paper is to describe the geology of a major savannah and green tourmaline deposit in southern Kenya, the 'Yellow Mine'. For comparison, the geology of other yellow tourmaline mineralisations in Kenya and Tanzania are also described. New mineralogical and gemmological data on east African tourmalines are also given. Field trips to the sites that are described here took place during 1996 and 1997, as part of the author's work for Rockland Kenya Ltd.

Instrumentation

Minerals were analysed by means of electron microprobe at the Microprobe Service of the University of Paris-Jussieu (analysis number beginning with 97) and at the Microprobe Service of the IFREMER, Brest, France (analysis number begining with 98). Appropriate standards were used for calibration. Bulk rock analyses were performed at the CRPG of Nancy (France). Major elements were analysed by ICP-AES and trace elements by ICP-MS. F, C1, B, and Li were measured by titration. Absorption spectra were produced with a Unicam UV 4–100 Spectrometer. Standard gemmological instrumentation was used for optical measurements on gemstones.

The Yellow Mine

History and exploitation

The Yellow Mine is located about 4 km south of the John Saul Mine, near the Mangare Swamp, next to the eastern boundary of the Tsavo West National Park, and to the confluence of the Bura and Mwatate rivers (*Figure 1*). It processes material from the deposits mentioned in Gem News (1996) as 'Kasigau Mine' and 'Mangare Area'. Kasigau is an inselberg mountain about 15 km northwest of the Mangare Swamp.
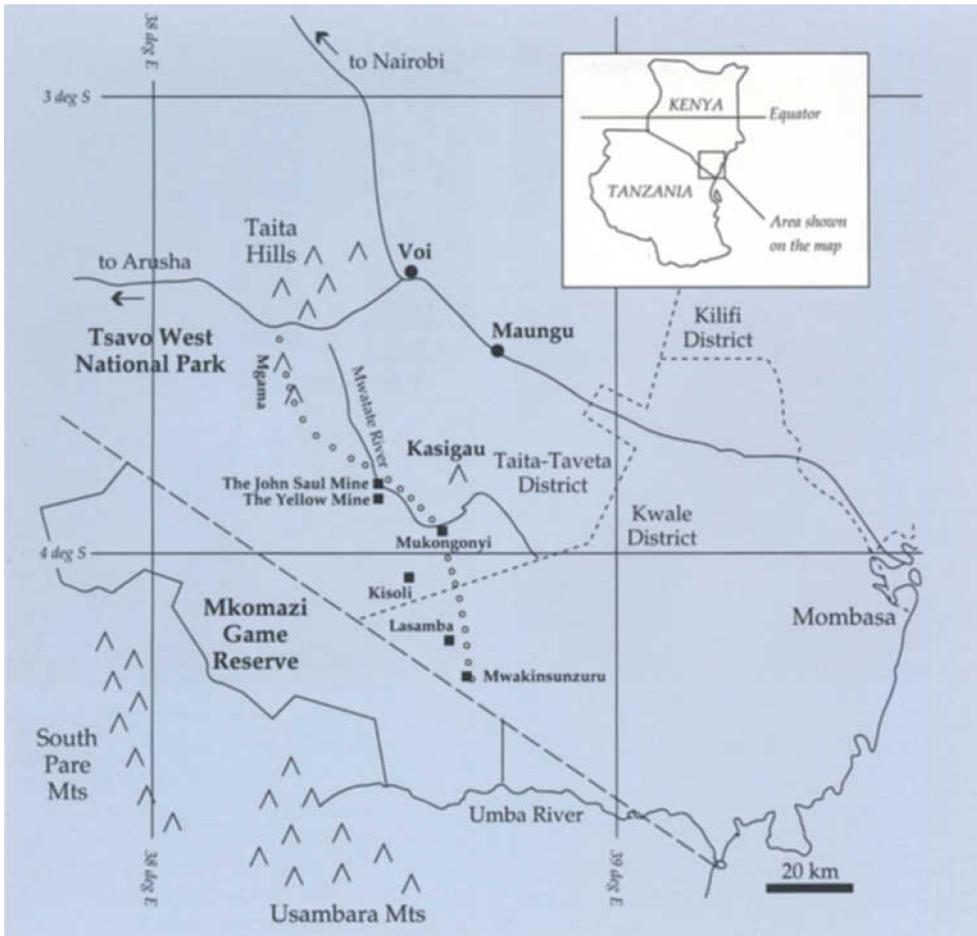
Figure 1: Map of southern Kenya showing most of the places mentioned in the text. The line of small open circles represents the tsavorite belt along which most green garnet deposits of southern Kenya are located.

Discovered in the eighties, the deposit was exploited at the beginning of the nineties by the company Rockland Kenya Ltd., which also runs the John Saul Ruby Mine. During that period, the tourmaline was followed to a depth of about 25 metres. After a few years of inactivity, the mine restarted and now produces 'savannah' (*Figure 2*), golden, and bicolour (green and yellow) tourmaline.

The tourmaline-bearing vein appears as a planar zone following the contact between a kidney shaped ultrabasic body and its

Figure 2: Faceted savannah tourmalines from the Yellow Mine. Weights range from 4.8 to 6.2 ct.

Geology of the Yellow Mine (Taita-Taveta District, Kenya) and other yellow tourmaline deposits in East Africa

Figure 3: Pegmatite vein indicated by crosses in the pit at the Yellow Mine.
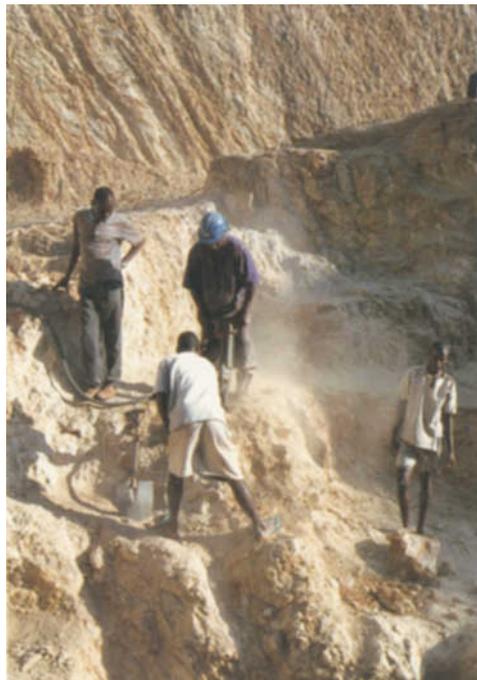
Figure 4: Working on the pegmatite vein at the Yellow Mine using jack hammers; no explosives are used.

graphite gneiss host rock and consists of pegmatite boudins more or less mineralized in tourmaline, kyanite, apatite and graphite.

Extraction is done by open cast pitting, following the vein from the surface (*Figure 3*). The ultrabasic rock is sufficiently homogeneous and coherent to allow high, steep walls in the mine with little risk of collapse. Two-metre-high steps are cut in order to allow access with ladders, and evacuation of the mine waste. Digging is done using jack hammers (*Figure 4*). The barren rock is removed by hand or by mechanized means and dumped outside the mine. A dozen workers are involved in these operations, and work is done under the surveillance of guards and of a security officer to avoid theft of stones.

When tourmaline crystals are encountered, they are carefully extracted using chisels and hammers. The material coming from the disintegration of the rock (sand, gravel) is then sieved in order to recover any smaller crystal fragments from the vein. Rough tourmaline is then cobbed and sorted, with a recovery percentage of marketable material of about 30%.

Regional geology

The Yellow Mine is situated on a major geological structure called the Mozambique Metamorphic Belt, which extends in east Africa along the Tanzanian craton, and which results from Neoproterozoic collision of the Tanzanian craton to the west and an eastern 'Kibaran' plate (Key and Ochieng, 1991). Many east African gemstone deposits are associated with this structure (Malisa and Muhongo 1990; Key and Ochieng, 1991). On a more detailed scale, the deposit is associated with an ultrabasic body contained in the graphite gneisses of the Kurase Group (defined by Saggerson, 1962), a series of mostly metasedimentary rocks metamorphosed to amphibolite or granulite facies (Arneth and Schidlowski, 1985). These

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metasediments include graphite gneisses, biotite garnet gneisses, quartzites and marbles. They are associated with metavolcanic rocks and the whole assemblage is thought to represent metamorphosed shelf sediments and volcanic rocks (Key and Ochieng, 1991). Tsavorite mineralizations of southern Kenya are typically associated with rocks of these series (Pohl and Niedermayr, 1979; Key and Ochieng, 1991).

Another important characteristic of these series is the presence of scattered ultrabasic bodies consisting of talc, enstatite, magnesite, and other magnesian silicates, rich in Mg and poor in Si, Al and Fe (see Table I). They are also rich in Co, Cr and Ni, which shows that they have an igneous origin (Horkel et al., 1979), compared to metasedimentary ultrabasic rocks (rocks derived from sedimentary rocks such as dolomites) which are devoid of these elements (Faust et al., 1956). The origin of these rocks is not clear, but the fact that they underwent, like their host rocks, several phases of metamorphism and deformation shows that their emplacement happened

during an early stage of the evolution of the Mozambique Metamorphic Belt (Prochaska and Pohl, 1984). The ultrabasic bodies of the Mangare area have been described as sheets tectonically interleaved with the metasediments by Key and Ochieng (1991), who consider them as parts of an ophiolitic complex. They range from metres to kilometres in length, and are often associated with gemstone mineralization, the best known being the John Saul Ruby Mine (Pohl and Horkel, 1980; Key and Ochieng, 1991), the Umba sapphire mine in Tanzania (Solesbury, 1996), and the sapphire deposits of southern Madagascar (Kiefert et al., 1996). The crystallization of corundum is due to complex metasomatic desilicification phenomena linked to the silica-deficient character of the ultrabasic rocks. These rocks can also be related to some kinds of rhodolite deposits, such as Kisoli, about 20 km south of the Yellow Mine, or to tsavorite deposits (see below).

Geology of the deposit

The ultrabasic body at the Yellow Mine is about 100 m long and 50 m wide, and is elongated parallel to the regional foliation, which in this area trends 340 degrees (see Figure 5). It mainly consists of enstatite, talc, Mg amphibole and magnesite. Talc is clearly an alteration product which grows along the cleavage directions in enstatite crystals. This assemblage is cut by chlorite veinlets which contain pockets of chlorite with scattered granules of spinel rimmed by phlogopite. The spinel is red-orange, but its small size makes it of no value as a gemstone. These vein minerals have developed by metasomatic reactions between the ultrabasic rock and invading pegmatitic fluids. Opaque pink corundum mineralizations in the form of epidote, plagioclase, phlogopite, and corundum veins are also present. They also have a metasomatic origin, are broadly comparable to plumasites (cf. Lawson, 1904) and reflect the importance of metasomatism in the genesis of many gem deposits in southern Kenya.

The ultrabasic body is associated with a series of graphite, muscovite and sillimanite gneisses which are locally mobilised and

Table I: Composition of three ultrabasic rock samples from the Mangare area, Kenya.

Sample No.	RT001	RT002	RT003
wt. %			
SiO_2	51.30	38.28	15.04
Al_2O_3	0.40	0.34	0.67
Fe_2O_3	5.49	4.21	3.33
MgO	24.27	16.95	19.75
CaO	0.32	12.98	22.00
Na_2O	0.13	0.09	0.09
K_2O	0.06	0.03	0.02
L.O.I.	17.65	26.75	38.72
Total	99.62	99.63	99.62
ppm			
Co	72.9	68	34.4
Cr	2231	1298	1468
Cu	63	31.1	31.1
Ni	1605	947	876
U	4.56	2.77	1.56
V	87.5	44.2	34.4

N.B.: L.O.I. (loss on ignition) represents water and carbon dioxide content of the rock. High L.O.I. can be translated in terms of high carbonate content (dolomite and magnesite). Note high Cr and Ni, and low alkalis and alumina.
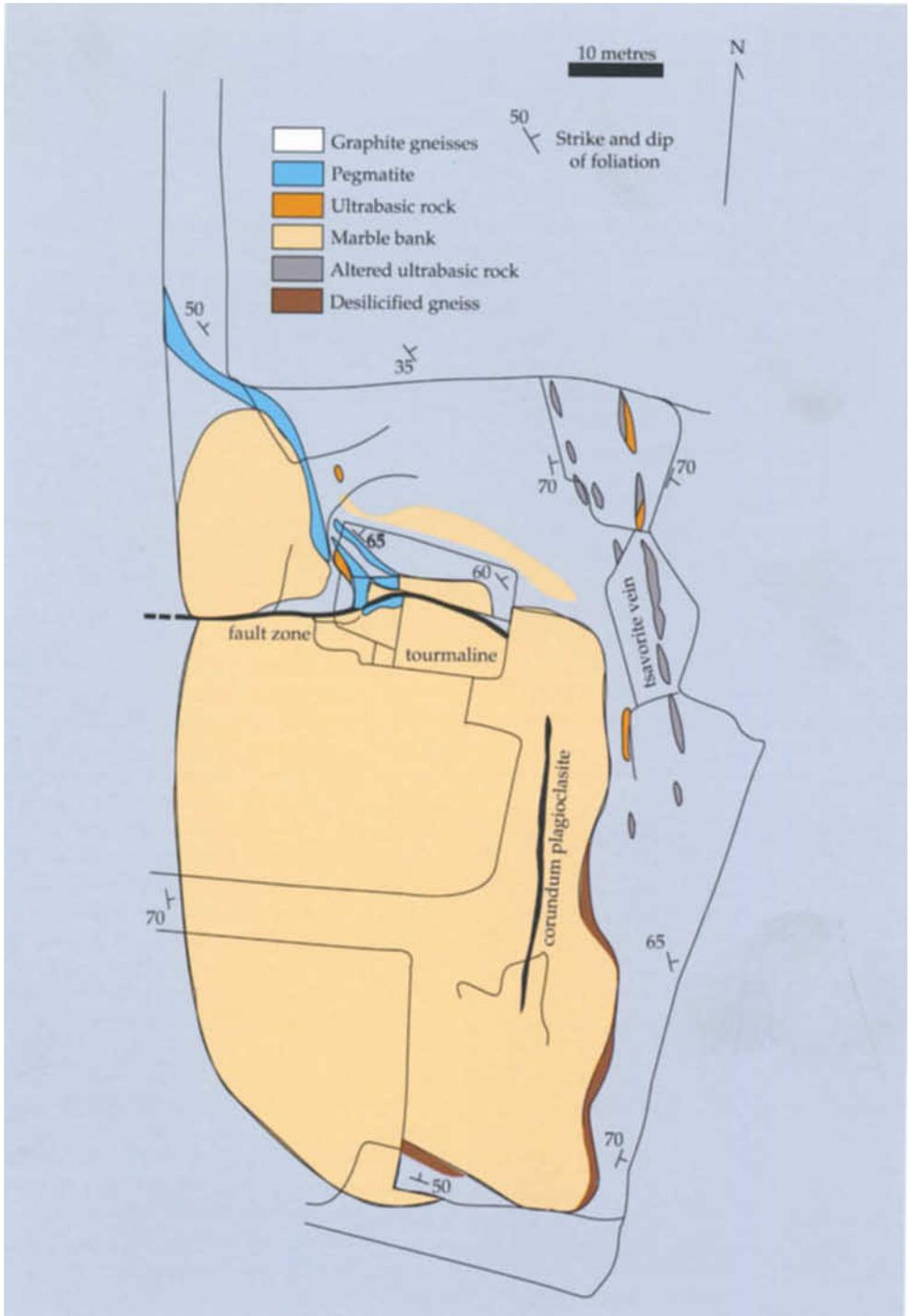
Figure 5: *Geological map of the Yellow Mine. Note the close association of corundum, green garnet and tourmaline mineralizations; and the boudinage of the tourmaline-bearing pegmatite near the fault zone.*
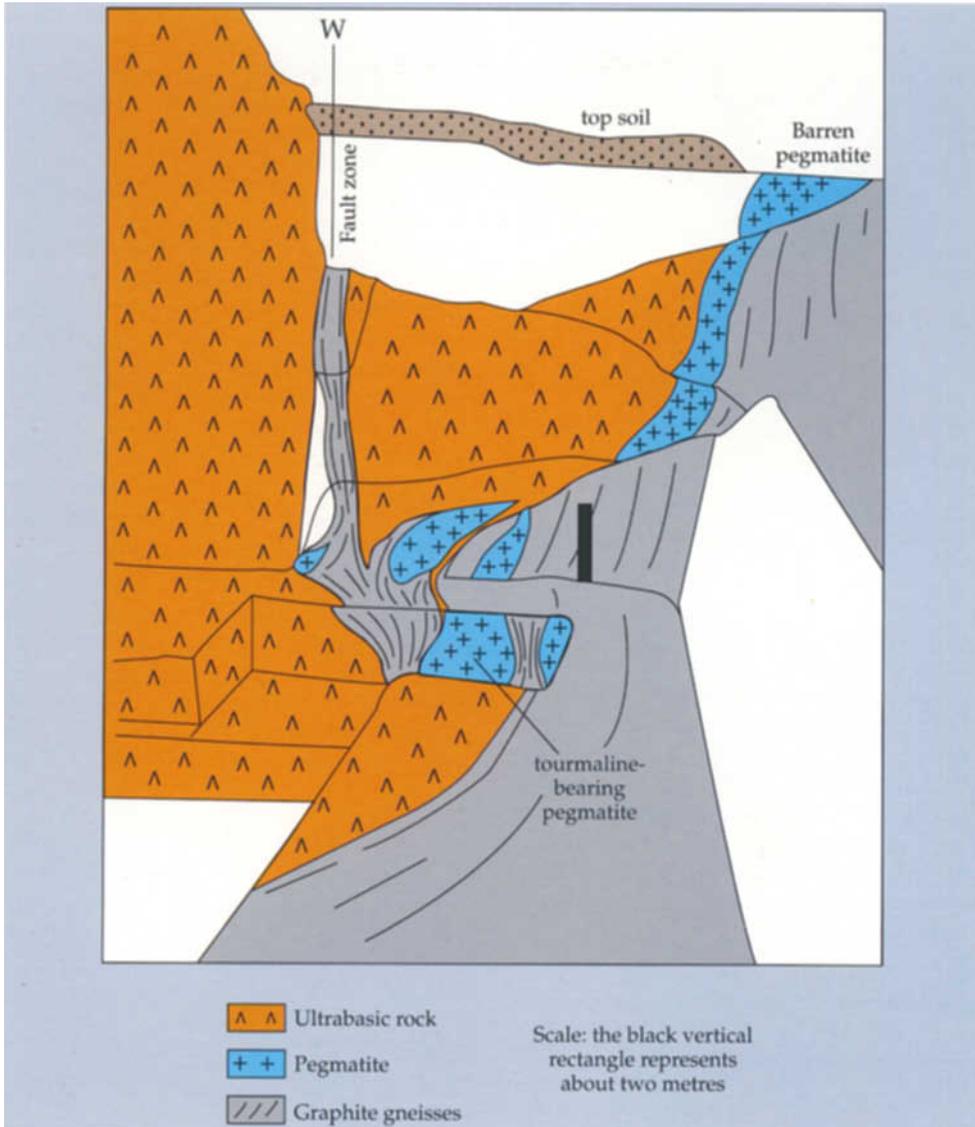
Figure 6: Sketch of the tourmaline mineralization at the Yellow Mine. The pegmatite follows the contact between the ultrabasic body (to the left) and the graphite gneisses (to the right) and enters into the fault zone where the mineralization is more pronounced.

injected with concordant anatectic pegmatite dykes. Except at one point, the contact between the ultrabasic body and its host rock is parallel to the foliation of the gneisses. These gneisses have undergone intense deformation marked by boudinage and the formation of isoclinal folds. Ultrabasic boudins on a scale of metres are also visible in the eastern part of the mine where the rock is more or less altered, and Mg–Al amphibole, Mg mica, corundum and spinel bear witness to the penetration of Si, K and Al fluids into the ultrabasic boudins.

Tsavorite is also present along the lines of ultrabasic boudins. Its Cr_2O_3 content varies from 0.1 to 0.3 wt % and V_2O_3 varies from 0.6

Figure 7: *Closer view of the pegmatite vein with the ultrabasic rock on the left. T: tourmaline; A: apatite.*

to 2.2 wt %, and these elements are responsible for its blue-green colour. Cr probably comes from the ultrabasic rocks and V from the graphitic gneisses. The tsavorite crystals are surrounded by a partially kelyphitic rim of purple tanzanite formed in response to decreasing pressure and temperature conditions. Dark green vanadian tourmaline has also been observed as an accessory mineral in the graphite gneisses.

In its northern part, the ultrabasic body is cut by a fault zone two to four metres wide, consisting of gneiss lumps and anatectic pegmatites (*Figure 6*). The muscovite in these gneisses is a deep green chromiferous variety (fuchsite).

The tourmaline mineralization is partly inside this fault zone (*Figures 3 and 6*) and follows a more or less boudinaged anatectic pegmatite rooted in sillimanite gneisses.

The basic mineral assemblage of the pegmatite is plagioclase, muscovite and quartz. The plagioclase is oligoclase (*Table II*), and is partly altered to fine-grained micaceous material. Graphite and apatite are common accessory minerals, graphite appearing as rounded flakes up to 10 mm across, while apatite forms vivid blue hexagonal prisms up to 10 mm long

(*Figure 7*), regrettably not of gem quality. In some places, the pegmatite is stained with small patches of green copper minerals. At the contact with the ultrabasic rock, the pegmatite has a thin phlogopite blackwall (a reaction wall between a dyke and its host rock) and away from the wall, tourmaline increases, quartz decreases or disappears and centimetre-size blades of light blue (chromiferous) kyanite have been developed (*Table II*). When in contact with plagioclase, kyanite has transformed into a white or pale green mica, but in contact with quartz no reaction is visible. Fibrous sillimanite is also present both in the pegmatite and as inclusions in the zoned tourmalines, which indicates that it appeared earlier than the kyanite. Part of this sillimanite, like the kyanite, has transformed into mica.

The chemical composition of the pegmatite is given in *Table III*. Because of the difficulty of getting a representative sample of the rock owing to the mineralogical variability and grain size, three samples were selected. RT011 and RT012 represent the mica and tourmaline facies with more or less

Table II: *Chemical composition of plagioclase and kyanite from the tourmaline-bearing pegmatite of the Yellow Mine.*

wt. %	Plagioclase Y91/Y94	Kyanite Y92/Y93
SiO_2	62.17	37.20
TiO_2	0.01	0.01
Al_2O_3	23.23	63.00
FeO	0.01	0.02
MnO	0.02	0.01
MgO	0.02	0.02
CaO	4.86	0.01
Na_2O	8.57	0.01
K_2O	0.15	0.01
Cr_2O_3	0.01	0.09
V_2O_3	0.00	0.00
NiO	0.00	0.00
P_2O_5	0.01	0.01
F	0.02	0.01
Total	99.08	100.40
Ab %	75.50	
An %	23.70	
Or %	0.80	

N.B.: Y91/Y94 mean of 2 analyses; Y92/Y93 mean of 2 analyses.

	Yellow Mine tourmaline pegmatite			Mangare area	Madagascar
	RT011	RT012	RT013	RT009/10	
wt. %					
SiO_2	74.52	74.96	80.38	73.84	70.22
TiO_2	0.17	0.06	0.02	0.06	n.d.
Al_2O_3	15.44	13.86	16.93	14.89	17.20
Fe_2O_3	0.11	0.03	0.04	0.04	1.76
MnO	tr	tr	tr	tr	0.28
MgO	1.13	0.56	0.07	0.27	tr
CaO	1.42	0.57	0.21	1.50	1.36
Na_2O	1.92	1.55	0.66	2.90	4.45
K_2O	3.27	7.11	0.67	5.56	2.85
Li_2O	n.d.	0.001	0.002	0.004	1.49
P_2O_5	0.13	0.25	0.06	0.05	2.85
F	n.d.	0.010	0.002	0.026	0.11
L.O.I.	1.67	0.72	0.84	0.72	n.d.
Total	99.78	99.67	99.88	99.83	102.57
ppm					
As	1.43	1.87	0.49	0.16	n.d.
B	n.d.	0.13	0.001	0.004	0.18
Be	2.73	0.62	0.70	7.09	n.d.
Co	39.2	46.4	47.9	45.0	n.d.
Cr	21.6	1.93	8.06	2.27	n.d.
Cu	1.5	1.3	1.3	4.25	n.d.
Ni	10.4	1.76	8.59	23.2	n.d.
Pb	14.2	25.3	4.97	19.2	n.d.
U	14.84	7.93	0.22	5.07	n.d.
V	35.3	7.46	25.4	16.3	n.d.

N.B.: RT009/10 is mean analysis of Main Pit anatectic pegmatite; Madagascar data from Shigley and Kampf, 1984. In the Mangare analyses, Li and F are not included in the totals.
n.d. means not determined; tr means trace; L.O.I. means loss on ignition.

quartz, and RT013 represents the kyanite facies without quartz. For comparison two analyses of anatectic pegmatites with light green tourmaline from the Mangare area (more precisely, the John Saul Mine) are also given. An analysis of a gem-bearing pegmatite from Madagascar is reproduced from Shigley and Kampf (1984).

The very different compositions of the Yellow Mine pegmatite and the Madagascar pegmatite indicate that the Yellow Mine pegmatite is not a typical Na–Li tourmaline-bearing pegmatite. The geochemical similarity between the Mangare area anatectic pegmatites and the Yellow Mine pegmatite could indicate a possible genetic link between them. The high Co, Cr, and Ni contents are unusual for pegmatites and at both localities are due to the proximity of ultrabasic rocks.

Characteristics of the tourmalines

Three types of tourmaline appear in the pegmatite vein:

- *Type 1:* Yellow or green granules (typically about 10 mm across), euthedral or not, associated with feldspar, quartz, fuchsite and kyanite.

- *Type 2:* Euhedral prisms of various size (one to ten centimetres in length and width) showing a yellow core surrounded by a green rim, associated with feldspar, quartz, fuchsite and in some places kyanite. The green rim tourmalines have a blue-green/yellow-green dichroism. This zoning is visible only on macroscopic samples, and cannot be observed in thin sections (*Figure 8*).

- *Type 3:* Euthedral crystals of savannah tourmaline, honey coloured in outcrop;

Figure 8: Sample of tourmaline showing zoning with a yellow core and a thin green rim.

up to several kg in weight; associated with oligoclase but not with quartz (*Figure 9*). Inclusions of apatite, sulphides, graphite, plagioclase, quartz and sillimanite occur in all types, and macroscopic vivid blue apatite inclusions are common in type 3 crystals.

Figure 9: Sample of savannah tourmaline without any colour zoning.

The different kinds of tourmaline crystals are all transparent but may be more or less fractured and included. Gem quality pieces reach 4 to 5 g in weight. Cut stones are very bright and usually display sharp pleochroism.

Yellow tourmaline from the Yellow Mine showed the following optical characteristics:

- RI : ε = 1.622–1.624 and ω = 1.643–1.646 ($\omega - \varepsilon$ = 0.020–0.023) (dichroism yellow/pale green)
- RI : ε = 1.623 and ω = 1.644 $\omega - \varepsilon$ = 0.021) (dichroism yellow/pale yellow)

Analyses of savannah and green tourmalines from the Yellow Mine are given in *Table IV*. These analyses are similar to those reported by Hänni *et al.*, (1981) for tourmalines of the Voi-Taveta area, which strongly suggests that those tourmalines actually came either from the Yellow Mine or from a similar type of deposit.

Mineralogically, these tourmalines are solid solutions between dravite and uvite with a ratio of 78:22 to 90:10. They contain no significant amounts of Fe, V or Mn. The yellow crystals contain small amounts of Ti (see analysis) and no Cr. The green rims contain traces of Cr_2O_3 (0.27 to 0.59 wt %) and lower amounts of Ti. We could not detect any Fe in the green rims (cf. Hänni *et al.*, 1981). The colour zoning is not correlated with any other chemical feature in the tourmalines (*Figure 10*). The dravite:uvite ratio in tourmalines from many sources remains constant from the yellow core to the green rim. Henry and Guidotti (1985) have shown that the chemical composition of tourmaline is strongly linked to the host rock. According to these authors, dravite is characteristic of meta-ultramafic rocks, and dravite-uvite solutions are characteristic of meta-carbonates.

The green rim of the tourmaline probably owes its colour to Cr. Its absorption spectrum shows two wide absorption bands at 437 and 596 nm, and a small peak at 681 nm (*Figure 11*). The yellow core of this tourmaline shows a rather flat spectrum with a wide absorption band centred at 435 nm. (cf. Hänni *et al.*, (1981), who considered that the 440 nm absorption band that they observed in yellow tourmaline is due to Ti).

Table IV: Composition of tourmaline from southern Kenya.

locality	Yellow Mine				John Saul Mine			Mukongonyi	Voi-Taveta
colour	yellow (savannah)	green	light green	blue green	yellow green	yellow pink	red	yellow brown	yellow
source	pegmatite	pegmatite	pegmatite	plagioclasite & eluvial	eluvial	pegmatite	pegmatite	eluvial	
no. of analyses	mean of 3	mean of 2	mean of 2	mean of 3	mean of 2		mean of 2	mean of 2	mean of 2
wt. %									
SiO_2	38.23	37.61	37.44	36.91	37.14	36.83	33.89	38.07	36.54
TiO_2	0.57	0.53	0.06	0.72	n.d.	n.d.	0.20	0.47	0.68
Al_2O_3	35.96	35.50	31.75	34.35	35.41	34.83	48.34	34.11	35.02
FeO	0.02	0.00	0.03	0.02	0.07	0.92	0.01	0.17	0.00
MnO	0.02	0.00	0.00	0.02	0.36	0.02	0.31	0.03	0.00
MgO	9.54	9.64	12.41	9.57	9.25	8.95	0.01	10.57	9.28
CaO	0.65	0.92	3.14	1.24	0.64	0.90	0.62	1.88	1.09
Na_2O	2.15	1.98	1.06	2.01	2.32	1.98	1.58	1.70	2.04
K_2O	0.06	0.04	0.01	0.09	0.05	0.08	0.01	0.08	0.07
Cr_2O_3	0.01	0.43	0.07	0.23	0.06	0.09	0.00	0.06	0.00
V_2O_3	0.02	0.03	0.00	0.02	0.14	0.01	0.00	0.01	0.00
F	0.01	n.d.	0.17	n.d.	n.d.	n.d.	0.00	0.00	n.d.
Total	87.24	86.68	86.14	85.18	85.44	84.61	84.97	87.15	84.72

N.B. Amounts of B and H_2O not determined. n.d. means not determined. F not included in totals. Voi-Taveta analysis taken from Hänni *et al.*, 1981.
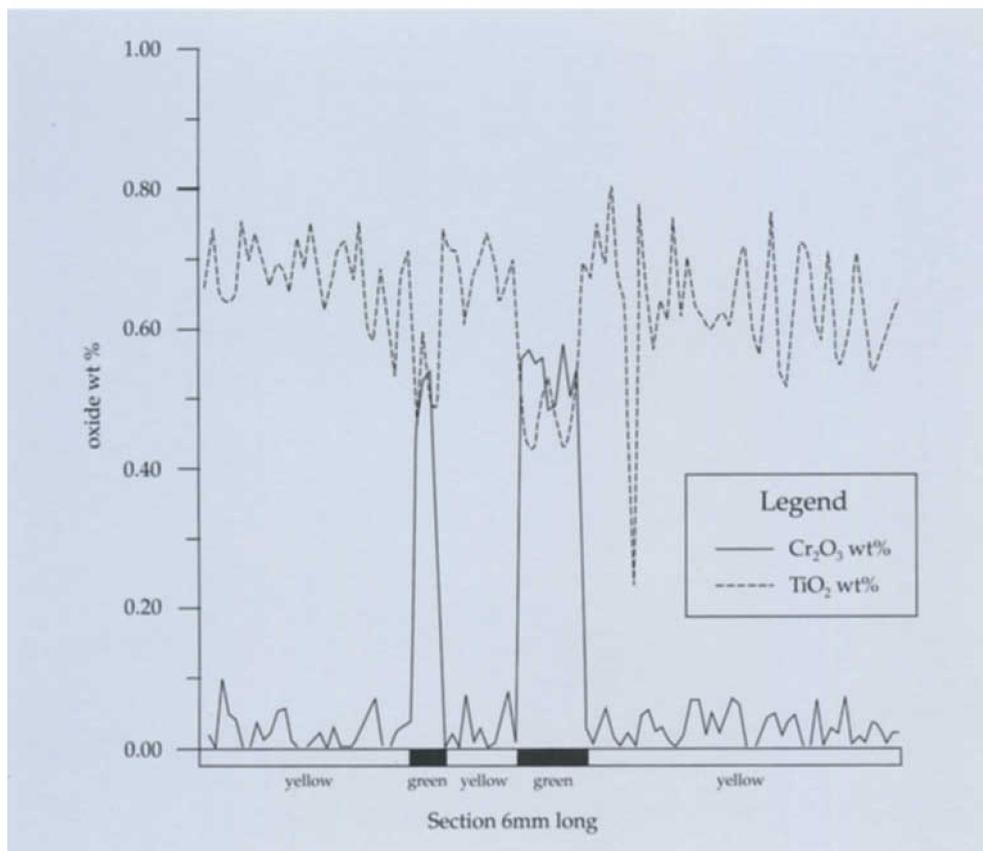
Figure 10: Cr_2O_3 and TiO_2 contents in a section, approximately 6 mm long, containing type 2 tourmaline crystals from the Yellow Mine. The alternate yellow and green bands are due to the juxtaposition of several crystals and not to multiple zoning. Transition from yellow to green is obviously linked to a decrease of TiO_2 and a sharp increase in Cr_2O_3.

Origin of the mineralization

The presence of three different types of tourmaline and the presence of zoned crystals, indicate that the mineralization developed during more than one phase of magmatic and metasomatic crystallization. However, no geode type pockets occur in the pegmatite and, although the tourmalines are mostly euhedral, they are always included in a mass of feldspar and/or quartz. Under the microscope, they appear as poikiloblasts. The pegmatite itself does not show any mineralogical zoning, except the presence of a few sulphide-bearing quartz cores.

No granitic batholith is present within 100 km of the Yellow Mine and this type of pegmatite clearly has an origin totally different from that of the usual gem bearing Na–Li pegmatites, such as those described by Shigley and Kampf (1984), London (1986), and Cassedanne and Roditi (1996).

The following phases, that may not be clearly distinct in time, are proposed for the formation of the vein itself:

1. Formation of a fault zone cutting part of the ultrabasic body.

2. Injection of a local anatectic pegmatite along the contact of the ultrabasic body and its host rock and partly along the fault zone, under *P–T* conditions of the sillimanite stability field.
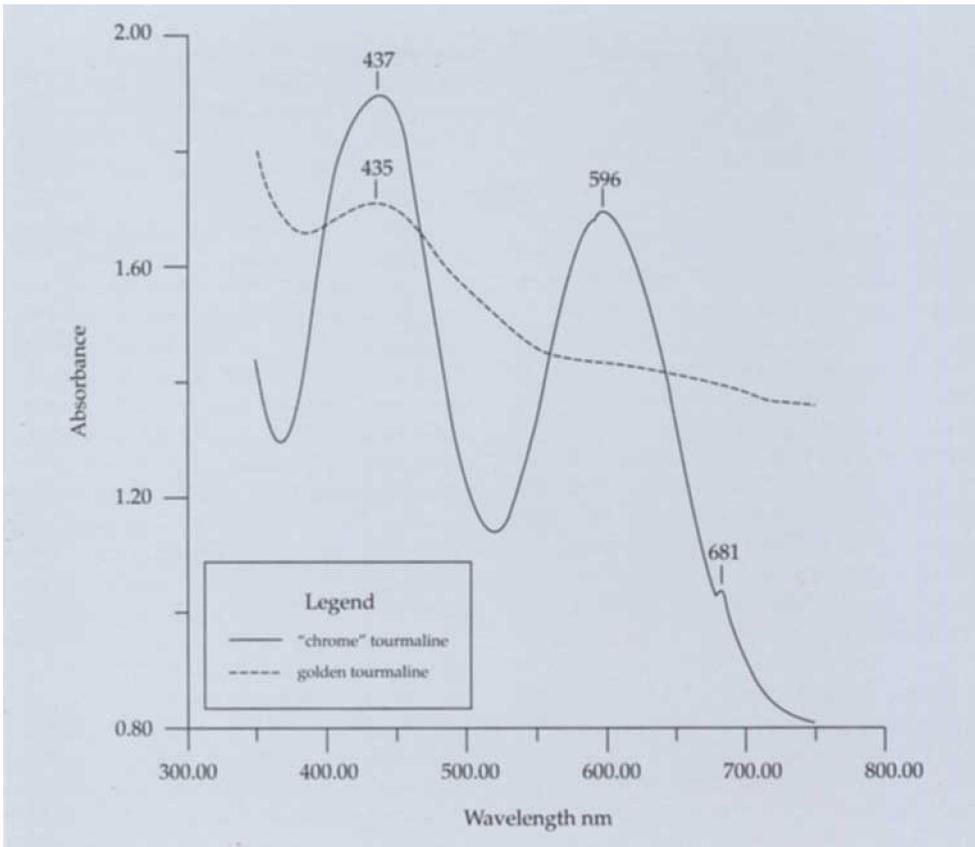
Figure 11: *Absorption spectra of the green and yellow zones of a type 2 tourmaline from the Yellow Mine. The light beam was orientated approximately parallel to the c-axis of the crystals along the respective zones to obtain the spectra.*

3. Deformation inside the fault zone, boudinage of the pegmatite. Kyanite formation may have taken place before or after this phase.

4. Metamorphic transformation of sillimanite and kyanite (+plagioclase) into mica.

Tourmalines of type 1 and 2 are related and probably crystallized together in the following way:

● Crystallization of yellow cores.

● Crystallization of green rims around some of the yellow cores, and of new green cores.

It is likely that type 3 tourmalines crystallized at the same time as the yellow cores of types 1 and 2 tourmalines. Sillimanite inclusions in the yellow cores of type 2 tourmalines show that they crystallised in the stability conditions of sillimanite, whilst the occurrence of the three chromian minerals kyanite, fuchsite and tourmaline, and the common association of kyanite and green tourmalines at outcrop, suggest that kyanite formation is contemporaneous with crystallization of the green tourmalines.

The B-bearing fluids originate in the host gneisses and, as they contain Mg and Cr, are likely to be equilibrated with the ultrabasic rocks. After Rosing and Rose (1993), Cr-bearing minerals such as Cr kyanite and fuchsite indicate that fluids from ultramafic rocks were significant.

Graphitic metasediments of the Mangare area may be an alternative source of Cr for the fluids. The absence of Fe in the tourmalines can be explained by the low iron content of the host rocks (metasediments and ultrabasic rocks), and by the reducing environment (presence of graphite) which causes iron to be fixed in sulphide phases.

The colour zoning of the tourmaline crystals may have appeared during one or several phases of metasomatic crystallization. However, the absence of multiple zonation points rather to one phase. The zoning itself may be due to a change of the chemical composition of the fluid. For example, Ti zoning in Mong Hsu rubies (Myanmar) is controlled by the F content of the fluid which itself depends on the crystallisation of fluorite (Peretti *et al.*, 1996). The zoning of the Yellow Mine tourmalines may well be due to a change of the partition coefficient between Cr and Ti, and the fluid, following perhaps a change in the thermodynamic conditions. This last hypothesis is supported by the fact that for types 1 and 2 tourmalines, yellow cores seem to have crystallized together with sillimanite, while green rims and green crystals probably formed together with kyanite, i.e. in different pressure and temperature conditions.

Other yellow tourmaline deposits

Minor yellow tourmaline deposits are abundant in southern Kenya (Mgama Mindi, Kambanga, Kuranze in Taita-Taveta and Kwale districts) and, for comparison, a few are described below.

The geology of the John Saul Mine tourmaline deposit resembles in appearance that of the Yellow Mine, but striking differences also exist. Other deposits of different origin may be linked to simple magmatic crystallization in anatectic pegmatites, or to interactions between marbles and pegmatites, or fluids of pegmatitic affinities. Such deposits were observed in southern Kenya and Tanzania in the area South of Arusha (Lelatema).

The John Saul Mine tourmaline deposit

This deposit is located a few hundred metres north of the famous ruby deposit. It is a pegmatite vein along an ultrabasic body 200 m long and 10 to 20 m wide. The deposit has not yet been developed, and is visible only in a small exploration trench. The pegmatite vein itself is almost one km long and probably originates in a major E–W shear zone cutting the metasediments at the Bura River. However, the vein seems to be mineralised only in the vicinity of the ultrabasic body. The rock is quartzo-feldspathic and has no mica. It is generally fine grained and is in places more aplitic than pegmatitic, with small patches of yellow tourmaline and blue apatite; at one point it becomes coarser and richer in tourmaline. There, the feldspar crystals reach 20 cm across and the pegmatite yields graphite, blue apatite, green, yellow, and red tourmaline. The rock may locally form quartz-bearing tourmalinites. All three colours can be present in one hand sample. No mineral zoning is visible within the pegmatite, and no other Li-bearing mineral has been observed. Tourmaline crystals do not seem to be zoned and they probably crystallized together with the pegmatite. This, added to the presence of red tourmaline, makes this deposit substantially different from that of the Yellow Mine. However, the small size of the outcrops may hide more complex features of the vein.

The yellow tourmaline from this deposit cannot be termed savannah because of the lack of the green hue. It has a yellow/pale yellow or yellow/pinkish yellow dichroism that makes it different from the stones of Yellow Mine. The resultant colour is more orange and may be termed 'golden'. Mineralogically these stones are also dravite-uvite solid solutions with a ratio of 80:20 (*Table IV*, yellow pink analysis), and they are richer in Fe (FeO = 0.92 wt %) than the Yellow Mine stones.

Gem-quality samples of red tourmaline have not yet been found, but may be present at depth. The red tourmaline crystals that were sampled are rendered opaque by

alteration minerals in the fractures. Chemical analysis (*Table IV*) showed that they are elbaite (82%)-liddicoatite (18%) solid solutions. The presence of Mn (MnO = 0.29 to 0.32 wt %) shows that small amounts of the Li–Mn end member tsilaisite are present. Gem tsilaisite was described by Schmetzer and Bank (1984), who commented that only small amounts of Mn in elbaitic tourmalines leads to pink or red colours.

Optically, these red tourmalines have refractive indices higher than those of the dravitic yellow tourmalines ($\epsilon = 1.637$ and $\omega = 1.656$, $\omega - \epsilon = 0.019$). They show a red/orange pink dichroism.

Deer *et al.* (1962) and Henry and Guidotti (1985) state that there is an immiscibility gap in the elbaite-dravite series, an idea which is clearly supported here by the presence of two completely different tourmalines in the same pegmatite vein. Dunn *et al.* (1977) also showed that there is no solid solution between uvite and liddicoatite, the respective Ca bearing equivalents of dravite and elbaite. In their study of the crystal chemistry of tourmaline, Foit and Rosenberg (1979) showed that there is no chemical or crystallographic reason for the lack of solid solution between dravite and elbaite observed in natural samples. They proposed that extreme fractionation between Mg and Li during petrogenesis, as well as fractionation due to the different field strengths of these cations, is responsible for this apparent lack of intermediate members. For these authors, this is an example of modification which does not involve a change of the chemical environment .

At the John Saul Mine, field observations indicate that both types of tourmaline (dravitic and elbaitic) crystallized together (i.e. more or less simultaneously) during the cooling of the pegmatite. This would imply that the *P–T*, and chemical crystallization conditions of the two tourmalines are very close.

Anatectic pegmatites of southern Kenya

Blue-green, green, yellow and orange tourmalines have been observed as accessory minerals in anatectic pegmatoids in gneisses of the Kurase series. This kind of mineralization, not economically important because of the scarcity of crystals in the rock, is nevertheless an important source of tourmaline for eluvial and alluvial deposits. Such deposits are present, for example, at Mukongonyi, Kisoli, Lasamba and Mwakisunzuru. In some deposits chrome dravite is associated with kornerupine. The composition of tourmaline samples from Mukongonyi are given in *Table IV*. These tourmalines are of a brownish yellow colour and are richer in uvite than those from Yellow Mine, with a dravite:uvite ratio of 62:38. They are also richer in Cr ($Cr_2O_3 = 0.05$ to 0.07 wt %). Refractive indices of $\omega = 1.648$ and $\epsilon = 1.628$ ($\omega - \epsilon = 0.020$) have been measured. The dichroism is brownish-yellow/pale green. In the concentrates, they are found together with ruby, kyanite, tsavorite, and blue green, bottle green and brown tourmaline.

Metasomatised marbles at Kisoli

Tourmalines with a yellow core and a green rim have been recovered during the eighties from the sides of Kisoli Hill, in the southern part of the Taita-Taveta District of Kenya. The tourmalines occur in micaceous veinlets cutting across graphite-bearing marbles and as crystals scattered in the marble next to the veinlets. Locally, the veinlets have been reworked in faults and

*Figure 12: Tourmaline mines in the marbles of Lengasti, Tanzania.*
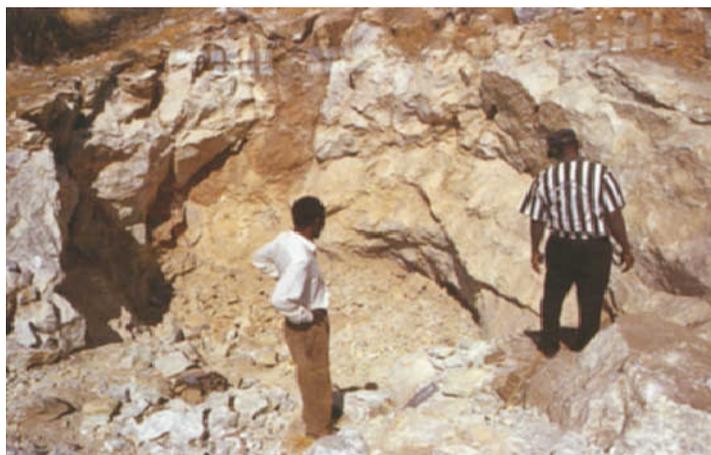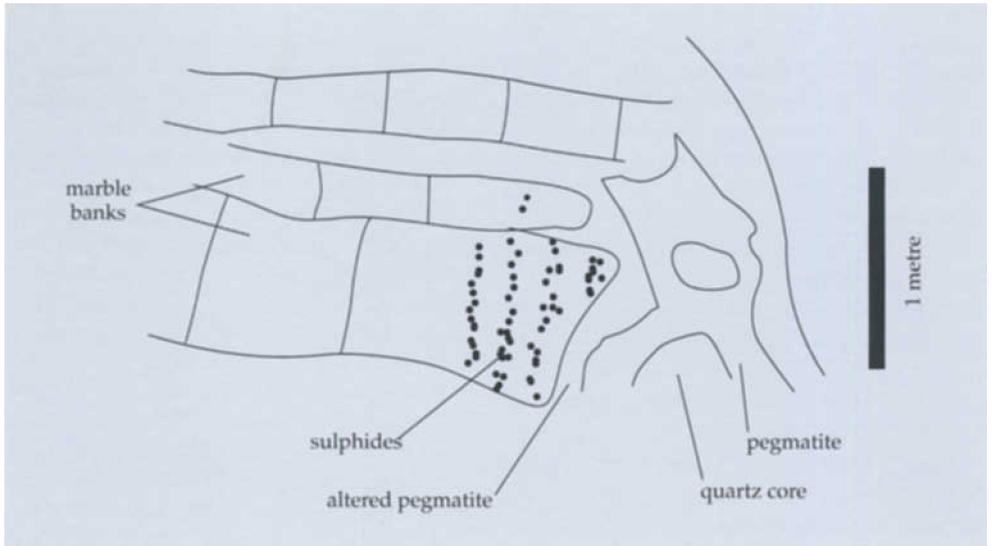
Figure 13: Geological sketch of a tourmaline-bearing pegmatite in a marble environment at Lengasti, Tanzania.

joints filled with a carbonate cement. The mineralization then appears as a tourmaline breccia, from a centimetre to a decimetre thick.

This kind of mineralization is similar to the chrome tourmaline mineralization described by Jan *et al.* (1972) from Swat in western Pakistan, except that at Swat, the chromium is provided by a nearby serpentinite, while at Kisoli no ultrabasic rock is directly associated with the deposit. The traces of chromium in the green rims of the Kisoli tourmalines are thought to have come from the graphitic metasediments.

Marble-pegmatite interactions at Lengasti

The Lengasti tourmaline deposit in Tanzania is located in the northern part of the Lelatema Hills, on a group of marble ridges hosted in graphite, sillimanite and muscovite gneisses. These gneisses contain concentrations of tsavorite and rhodolite.

The tourmaline mineralizations are associated with a set of pegmatitic veins and veinlets which cut at right angles across sub-horizontal marble banks. Both lithologies (the marble and the pegmatite)

have the same structural direction and it is likely that the marbles are at this place folded into an anticlinal structure and that the pegmatites were emplaced in its axial plane thus cutting the top of the structure. The mineralized area extends over several hundreds of metres, and has been followed by Tanzanian prospectors and miners who use explosives to enable the digging of small pits a few metres deep in the marbles (*Figure 12*).

On the outcrop, one can observe altered feldspathic masses (the pegmatite veins) cutting through the marbles (*Figure 13*). Tourmaline occurs in nests in the central part of the pegmatite, together with masses of transparent granular quartz. Here again, no geodes have been observed. Tourmaline crystals are zoned with a yellow core and a green rim (*Figure 14*). At the contact of the pegmatite, the marble displays a coarser structure than in the main mass: the carbonate crystals are more transparent and there are patches of lime yellow sulphur. Sulphide enriched zones in the marble form bands parallel to and a few decimetres away from the contact with the pegmatite (*Figure 13*).

The occurrence of sulphides and graphite associated with the mineralization indicates that the pegmatites could have originated by anatexis of graphite gneisses underlying the marbles.

Conclusions

Studies of the Yellow Mine tourmaline deposit, and of some other east African yellow tourmaline deposits, show that yellow (savannah and golden) and bicolour tourmalines of east Africa can have very different geological origins. However, all the mineralizations are more or less directly associated with anatectic mobilization of the metasediments of the Kurase Series in Kenya and their equivalent in Tanzania.

Most of these tourmalines are dravite-uvite compounds in which dravite is dominant. Their particular chemistry is due to the association of the mineralizations with Mg-rich ultrabasic rocks and with metasediments where Fe is low or fixed in sulphides due to the reducing environment established by the presence of graphite.

The low Fe content of the tourmalines described above and of other green tourmalines whose analyses are also given in *Table IV* (analyses of John Saul Mine stones), is important for gemmology in that gem quality stones tend to have little Fe and higher contents of Fe (and Ti) tend to opacify tourmalines (Michailidis *et al.*, 1996).

The survey of many Kenyan and Tanzanian deposits has shown that the yellow core/green rim zoning in tourmaline has a regional value, whatever the geology. Similar zoning has also been observed in other minerals; for example, some (but not all) rubies of the Mangare area display zoning with a pink silky core (more Ti, less Cr) and a bright red rim devoid of rutile silk (more Cr, less Ti). This suggests that some of the gemstones in the Kurase Series were formed in one major phase of crystallization. For the tourmalines, it is proposed that the zoning may be linked to a change in metamorphic conditions in the whole Kurase Series, leading to dramatic modifications in the partition coefficients of Cr and Ti between metasomatic fluids and the host rocks.
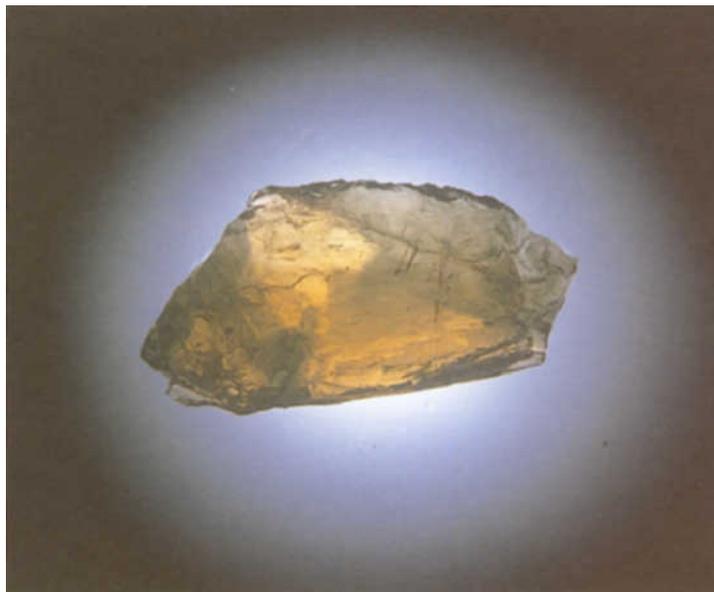
Figure 14: Yellow and green zoning in a tourmaline from Lengasti, Tanzania.

On the Al–Fe–Mg diagrams of Henry and Guidotti (1985), tourmalines of southern Kenya lie in the field of ultramafic rocks and of Al-saturated metapelites and metapsammites, which is consistent with field observations (see *Figure 15*). Most of the samples fall in field 7, except elbaites from the John Saul Mine which fall in field 1. It is interesting that two very different tourmalines from the same rock the Mg-tourmaline and the Al-tourmaline from the pegmatite vein of the John Saul Mine, fall in two different fields (respectively 7 and 1), but nevertheless this pegmatite remains consistent with the definition of these two fields: it is a Li bearing pegmatite hosted in an ultrabasic rock.

Another example of the close proximity of dravite and elbaitic tourmalines has been described recently by Novak *et al.* (1999) in an elbaite subtype pegmatite in the Czech Republic.

Through these examples, the geology of tourmaline deposits (and more generally gemstone deposits) in east Africa has been shown to be complex and many studies are still to be done, both in detail and regionally.

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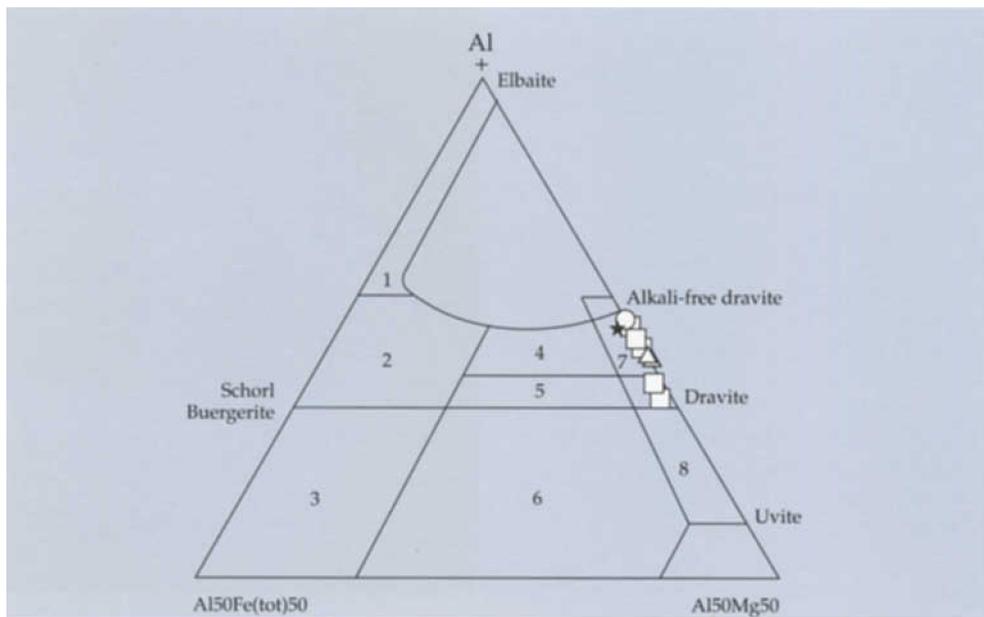
Figure 15: *Ternary diagram taken from Henry and Guidotti (1985), where Al, Fe, and Mg are molecular proportions, and the symbols represent tourmalines from southern Kenya as follows: cross: Al-tourmaline from the John Saul Mine; star: yellow Mg-tourmaline from the John Saul Mine; circle: Mg-tourmaline from the Yellow Mine; square: green tourmaline from the ruby deposit of the John Saul Mine; triangle: brownish-yellow tourmaline from Mukongonyi.*
The fields are:
1 *Li-rich granitoid pegmatites and aplites;*
2 *Li-poor granitoid and their associated pegmatites and aplites;*
3 *Fe^{3+}-quartz tourmaline rocks (hydrothermally altered granites);*
4 *Metapelites and metapsammites coexisting with an Al-saturated phase;*
5 *Metapelites and metapsammites not coexisting with an Al-saturated phase;*
6 *Fe^{3+}-rich quartz-tourmaline rocks, calc-silicate rocks, and metapelites;*
7 *Low-Ca ultramafics and Cr, V-rich metasediments;*
8 *Metacarbonates and meta-pyroxenites.*
Fields 4 and 5 overlap with field 7.

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Identification of synthetic spinels by means of photoluminescence spectroscopy

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ABSTRACT: Blue synthetic spinels resembling sapphires in an old brooch were identified using photoluminescence spectroscopy.

Keywords: photoluminescence, spinel, synthetic

Introduction

The main advantage of photoluminescence (PL) spectroscopy in identifying materials of gemmological interest is that it is totally non-destructive and the only requirement for the sample is that it is clean. Most chemical methods require more elaborate preparation.

In this spectroscopy the most relevant feature of rubies and of most sapphires (Carbonin *et al.*, 1998) is the luminescence band centred at $\lambda_{Cr} = 694$ nm which is related to the position of Cr^{3+} in the crystal structure. However, there are many imitations of ruby and sapphire, and this paper describes a brooch with blue stones which were identified as spinels (*Figure 1*).

Experimental

The apparatus developed at Istituto di Chimica e Tecnologie Inorganiche e dei Materiali Avanzati (ICTIMA) includes a versatile sample-holder designed for the investigation of samples of any shape (even irregular) and a large range of sizes (from a few hundredths of a millimetre to several centimetres). Rough materials such as sapphire in its host rock (Carbonin *et al.*, 1998) and finished objects can be studied.

The PL spectra presented here were obtained from equipment containing a frequency doubled Nd continuous wave laser ($\lambda = 532$ nm) (CASIX), a grating spectrometer (640-HR, Jobin Yvon) with a reciprocal dispersion of 2.4 nm/mm, and a

Figure 1: Brooch containing a central blue gem (A) and several smaller ones (A').

germanium detector (EO817L, North Coast) cooled by liquid nitrogen. Spectra are compared with those on a database of standard spectra obtained from known stones.

Results and discussion

The central blue gem (A) (oval cut, 14 x 11 mm) of an old brooch (*Figure 1*) exhibited a PL λ_{Cr} value of 691.5 nm, significantly lower than that of sapphires (*Figure 2*). This observation, together with the value (1.73) of the single refractive index, led us to identify this gem as a synthetic spinel (Webster, 1994).

The PL spectrum of Cr^{3+} in natural spinel is complex but the relevant component for comparison with the above spectra is a peak at 686 nm, distinctly different from those of synthetic spinel and sapphire.

The position in the brooch of the twelve smaller gems (A') that encircle A prevented the application of some gemmological techniques (including measurement of the refractive index), but the PL spectra are comparable with that of the central stone and indicate that these gems also are synthetic spinel.

Conclusions

The use of PL spectroscopy, in the present case by means of the 'tracing' Cr^{+3} ion, whose behaviour is sensitive to its crystal environment, is particularly appropriate for the investigation of mounted gems or jewels of unusual shape or size.

Acknowledgements

We are much indebted to Mrs Brunella Fabro for the loan of the brooch, and thank Dr Claudio Brogiato [Dept. Mineralogia e Petrologia, University of Padova] for the picture.
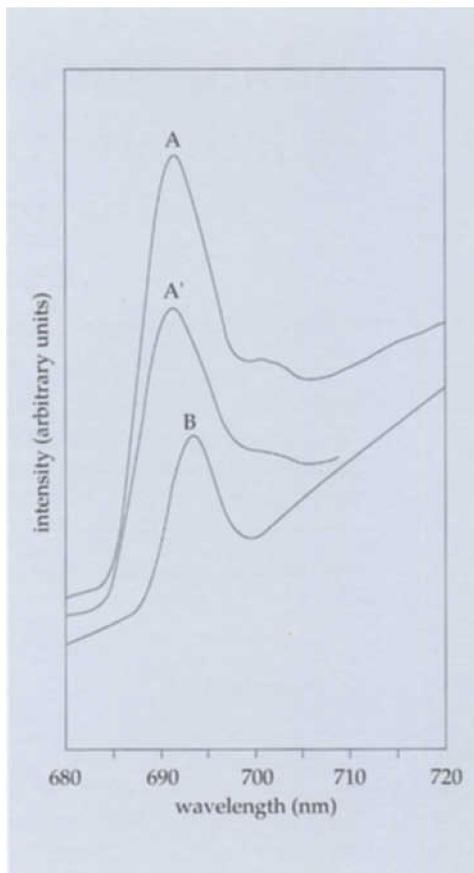
Figure 2: PL spectra of central synthetic spinel A, surrounding synthetic spinels (typical example A'), and blue sapphire B.

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An independent gemmological examination of six De Beers synthetic diamonds

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ABSTRACT: A study has been made of six De Beers synthetic diamonds – one yellow, two brown, one blue and two 'colourless' stones.
Published information about synthetic diamonds already exists, but independent investigations can justifiably add to existing knowledge.

Introduction

Substantial and meaningful data on synthetic diamonds have already been published and a selection of papers is given in references (1–11). The object of this particular study is to either independently confirm that which has, in part, already been reported, or to describe possible significant variations of phenomena already observed, which may be of additional benefit to other gemmologists. As much supportive information as possible is always beneficial for identification work of any kind. Although one can criticize duplication of data, this author believes it can strengthen a case already put, perhaps from a different viewpoint.

At the present time there appears to be relatively few synthetic diamonds on the market, but there are strong indications that other interests, such as Chatham Created Gems and Sumitomo, may wish to market stones. The author has recently identified two Sumitomo synthetic diamonds that were set in gold earrings and belong to a member of the general public. Chatham has, for some time now, made it clear that marketing will go ahead as soon as production yields suitable synthetic diamonds. In any case, the stones are still expensive to produce, particularly the 'white' range. It is in fact the latter group that is important in this context.

Major advances have been made in the knowledge of, and the means of differentiating between, natural and synthetic stones, particularly in the past few years. The Gemological Institute of America has published much useful and practical knowledge in *Gems & Gemology*[2–9], and De Beers, through their Research Centre, has developed the DiamondSure[1] and DiamondView[1]. Enough data now exist to identify the stones with confidence and it could be said that the principal laboratories are in a position to successfully handle a substantially increased volume of synthetics should this occur. As so often happens with many synthetics, while producers show good intentions with accompanying documentation of the true identity of their stones, further along the trading chain – even among the public – such documents are often discarded and the products unscrupulously sold as natural.

Associated education is priceless in terms of establishing a solid foundation. Student gemmologists should be taught the
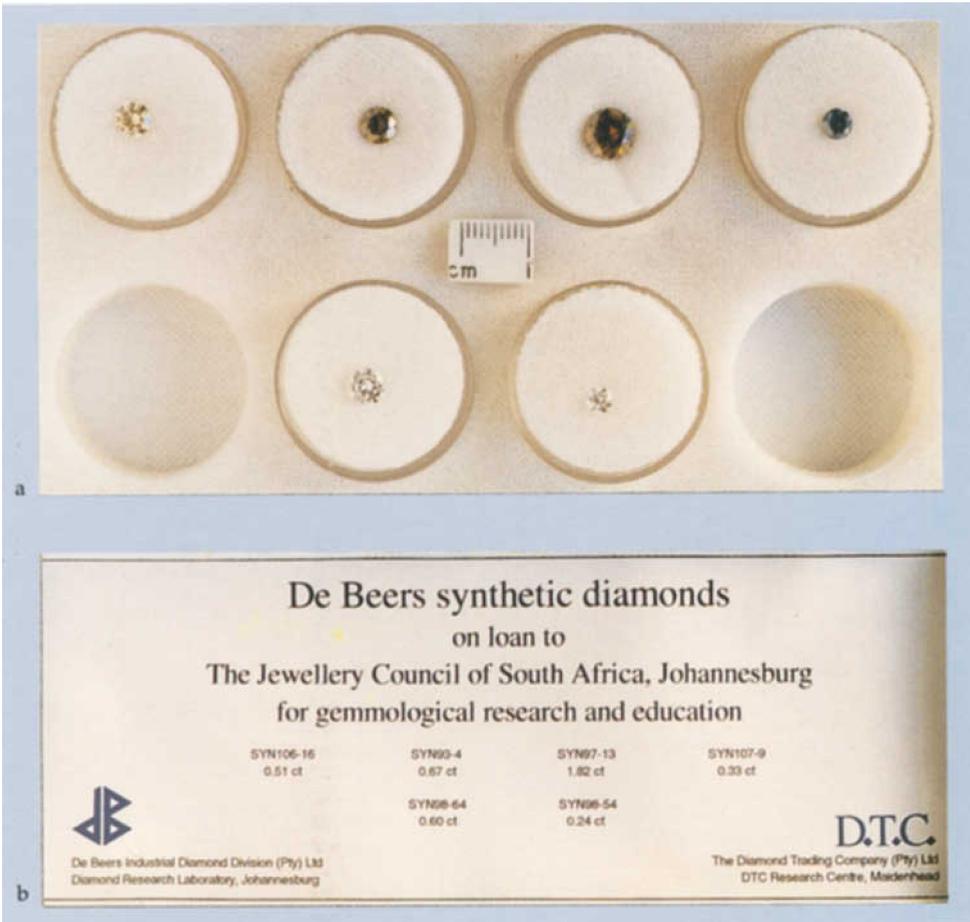
Figure 1a and b: *(a) The six synthetic diamonds examined (actual size) and (b) details in the same order.*

fundamentals of synthesis in more detail – particularly in the context of gem-quality diamonds which until recently were deemed as being 'safe' because of high costs and limited production.

The De Beers synthetic diamonds

The details of six synthetic diamonds examined in this study are illustrated in *Figures 1a* and *1b*.

In *Figure 1a*, the upper row consists of (left to right): yellow, two brown, blue; and the lower row contains two white (colourless) stones. *Figure 1b* shows details in the same order – the De Beers reference

numbers can be seen to be 106–16 (0.51 ct), 93–4 (0.67 ct), 97–13 (1.82 ct), 107–9 (0.33 ct), 98–64 (0.60 ct) and 98–54 (0.24 ct) in the above order. All are prefixed by 'SYN' and are modern round brilliant cuts.

Description of colour

Colour descriptions used here are based on rules laid down by the International Diamond Council (IDC) representing the World Federation of Diamond Bourses and the International Diamond Manufacturers Association. The two 'colourless' stones are shown with the GIA equivalent grades (H to I, probably a low H), the HRD colour grade being 'white'. The other four

Table I: *Weight, colour and luminescence of six De Beers synthetic diamonds.*

Reference Number		SYN 106-16	SYN 93-4	SYN 97-13	SYN 107-9	SYN 98-64	SYN 98-54
Weight (ct)	actual:	0.510	0.677	1.822	0.338	0.604	0.240
	estimated:	0.52	0.66	1.78	0.33	0.60	0.23
Colour Appearance		*yellow fancy*	*brown fancy*	*brown fancy*	*intense blue fancy*	*HRD: White GIA: H-I* [i]	*HRD:White GIA: H-I* [i]
UV Luminescence (fluorescence)							
Raytech L5-7	LW	none	none	none	none	none	none
	SW	none	mod-weak yellowish-green X-type pattern	weak yellowish-green X-type pattern	strong yellowish-green obvious X-type pattern	strong yellowish-green X-type pattern	strong yellowish-green X-type pattern but not as obvious as SYN 98-64
Chromato-Vue	LW	Extremely weak yellowish-green	Extremely weak yellowish-green	Extremely weak yellowish-green	None	Weak yellowish-green	Weak yellowish-green
	SW	None	None	None	Moderately strong yellowish-green	Not tested	Not tested
SB.2000SW [ii]		Slight, non-descriptive. X-pattern	Strong yellowish-green. X-pattern	Fairly strong yellowish-green. X-pattern but not well defined	Strong yellowish-greenish. Dark X-pattern	Strong yellowish-green with a dark X-pattern	Fairly strong yellow-green. Ill-defined X-pattern
De Beers DiamondView [iii]		Growth sectors: blue and slightly greenish-blue	Growth sectors: brownish yellow and green	Growth sectors: brownish yellow, brown and green	Growth sectors: blue and slightly greenish blue	Growth sectors: blue and very slightly greenish-blue	Growth sectors: Blue and very slightly greenish-blue
Phosphorescence		None	None	None	Strong and persistent (extinction of SWUV). None after LWUV	Strong and persistent (extinction of SWUV). None after LWUV	Strong and persistent (extinction of SWUV). None after LWUV

i. It is not normal to give split grades. A 'very low' H is probably closer.
ii. This SW source is considerably more sensitive than other standard SW sources.
iii. This SW source provides wavelengths shorter than standard sources, i.e. <230 nm as opposed to 253.7 nm.

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Equipment used

1. To examine inclusions: Wild Heerbrugg M4 binocular stereoscopic microscope with magnification 6–160x. Also a Leica MZ12 binocular stereoscopic microscope with zoom magnification 8–320x (the upper magnification when using 32x oculars). Photomicrographs were taken under the M4 using an adapted Nikon FE.2 35 mm camera and periscope type optical photo-tube designed for the microscope under reference. Introlux 5000, 150 watt, variable brightness, constant colour temperature (5000 K) fibre optics illumination was used in all cases.

2. De Beers DiamondSure[1] (which referred all stones for further tests).

3. De Beers DiamondView[1] which yielded the images showing internal structures of the stones and other comparisons against natural diamonds.

4. The Adamas Advantage SAS2000 Spectrophotometer Analysis System: a dual channel system, dedicated to gemstone analysis and, in particular, diamonds. Specifications: PC based, with fibre optic coupling, 380–850 nm wavelength range (normalized to 400–850 nm), ~ 0.3 nm or better wavelength quantization; ~ 1.5 nm or better optical resolution. It is comparatively fast, very compact, and the software is upgraded regularly.

5. To assess magnetism: 50 x 10 x 5 mm bar magnet, a relatively powerful little magnet capable of attracting and holding a 750 g (maximum) steel weight positioned 90° to its base, and 1250 g (maximum) at 90° to its 10 mm wide face at one end.

6. Electrical conductivity: Gem Instruments 0–150 AC volts conductivity tester.

7. Specific gravity: determined hydrostatically in softened H_2O, drops of domestic liquid detergent were added to remove surface tension. Mettler H.800 C balance. Weights estimated from the GIA formula based on dimensions for round brilliants are also given for comparison – see the summary *Table I*.

8. Fluorescence: dark conditions. Four instruments used:

   (a) Raytech LS-7 LW and SWUV (diamonds placed 20 cm from source).

   (b) Ultra-Violet Products Inc., CHROMATO-VUE. Cabinet Model CC-20. LW and SWUV (stones approximtely 20 cm from source).

   (c) SuperBright 2000SW. SWUV (large u-shaped quartz tube). Very sensitive, giving a much better response than other standard SWUV. The stones were placed approximately 20 cm from the source.

   (d) De Beers DiamondView[1] (DV), the fluorescent results of which were photographed from the instrument's monitor using the camera mentioned above.

All stones were tested by the De Beers DiamondSure[1], not passed as natural and referred for further tests.

stones have had their face-up (table-up) colour appearances described according to procedures used for natural fancy-coloured stones. (Strictly speaking, in the trade the terminology 'fancy' does not apply to either synthesized or treated natural stones.)

The spectra and fluorescence patterns of the synthetic diamonds and some natural diamonds

The following description consists of annotated illustrations and a summary in tabular form. The spectra obtained from the

six stones using an Adamas Advantage SAS2000 PC based spectrophotometer, are as shown in *Figures 2* and *3*. Although most gemmologists are used to viewing absorption spectra, transmittance spectra also contain the same essential information necessary to differentiate between natural and synthetic diamonds, the results of which, in certain cases, can be diagnostic.

The DiamondView shows with spectacular clarity the visual differences between natural and synthetic diamonds and examples are shown in *Figures 4* and *5*.

The advantages and limitations of spectra

Spectral features when examined in isolation, are not always diagnostic of natural or synthetic diamonds, but are extremely useful when aided by back-up tests. There are diagnostic differences between the De Beers colourless stones and Type Ia Cape Series with the exception of a natural diamond of colour D on the GIA scale. The latter transmittance spectrum can be ambiguous and is open to misinterpretation without supporting data such as ultraviolet fluorescence and phosphorescence tests. A microscopic examination alone can be used to identify the stone as being diamond, even if internally clean. A diamond has characteristically sharply defined facet edges and can even be distinguished from the latest simulant, moissanite (SiC), in this way.

Similarly, back-up tests can also be done to determine the differences between a colourless synthetic (Type IIa) and a colourless natural stone. The former has been found to be, within itself, selectively electrically conductive. This is due to the nickel catalyst, essentially used to date, to
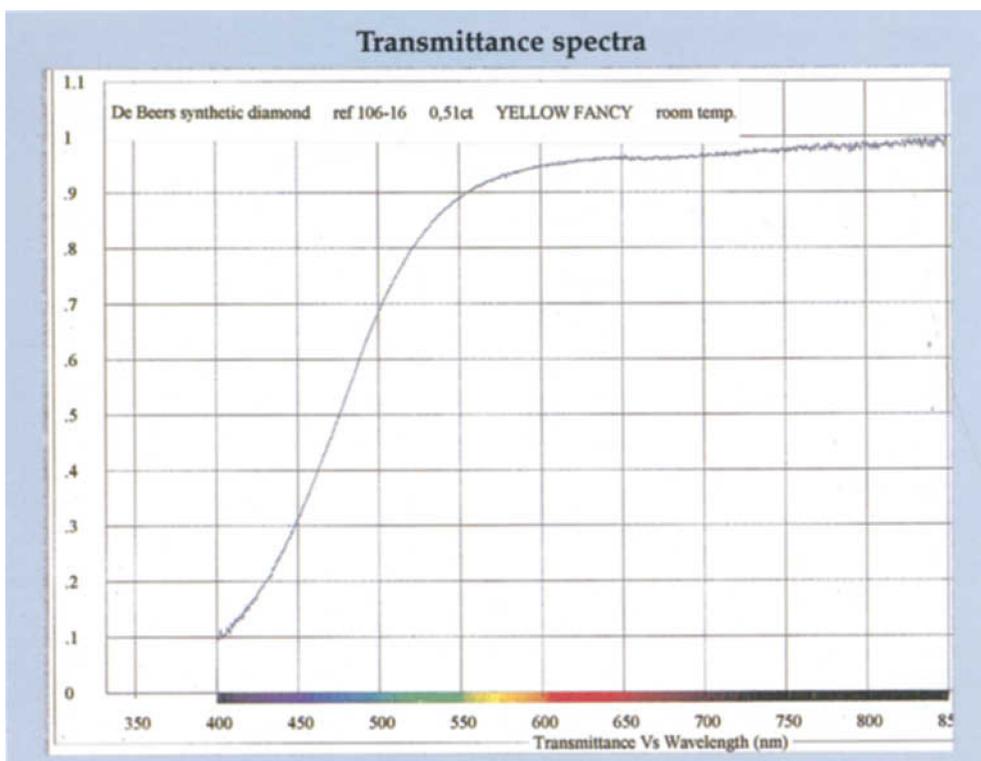
Figure 2a: Fancy yellow synthetic diamond. Spectrum differs from a Cape series spectrum (see Figure 3c), although some natural yellow diamonds do exhibit this type of absorption.

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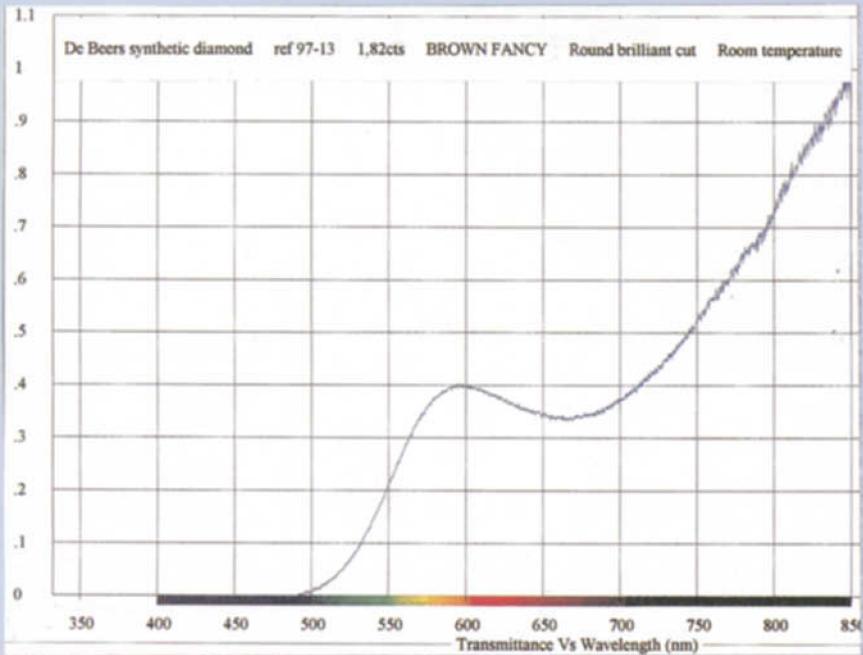
Figures 2b and c: *Fancy brown synthetic diamonds. Spectra show absorption below 490 nm and 475 nm respectively; similar to some natural brown diamonds.*
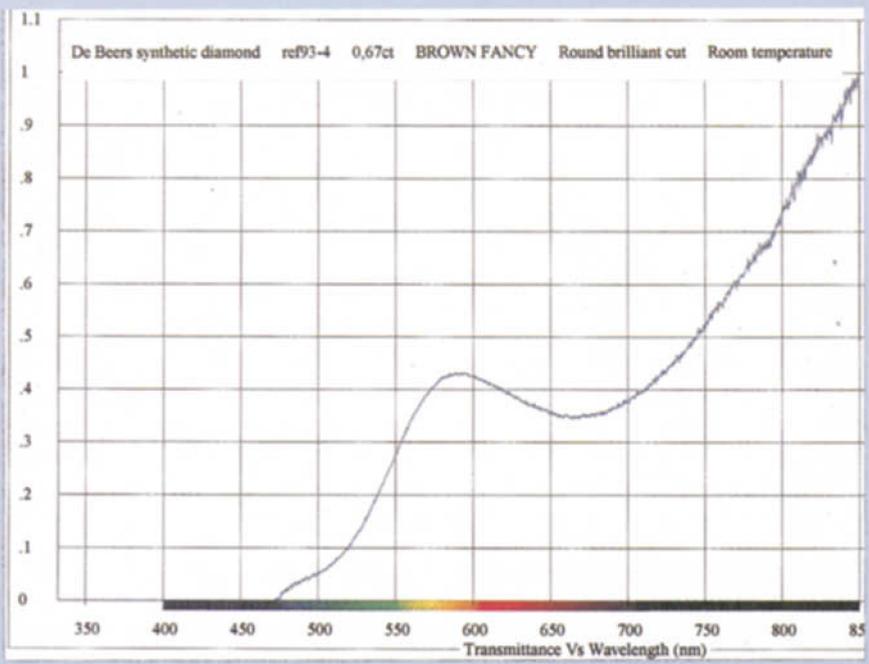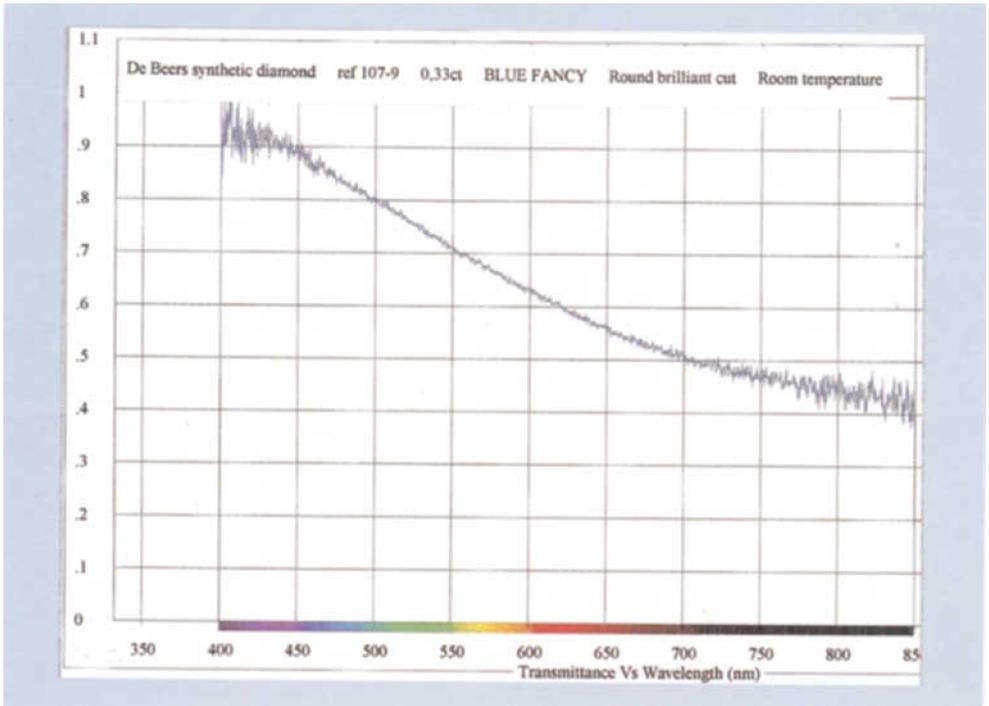
Figure 2d: *Fancy blue synthetic diamond. Spectrum is similar to that of natural blue diamond. This stone is highly phosphorescent (after exposure to SWUV).*

produce the colourless synthetic stones. Its natural counterpart is not electrically conductive. A new portable hand-held instrument that shows this electrical property in Type IIa colourless synthetic diamonds very successfully is the Moissketeer SD-2000 manufactured in the USA. It was primarily designed to detect synthetic moissanite – a spin-off being the results obtained from colourless synthetic diamonds (both from De Beers and from other sources).

Standard fluorescence tests are usefully employed to differentiate between brown synthetic and natural stones. The x-configuration seen is easily differentiated from natural stones which do not show it.

The spectra of blue natural and synthetic diamonds are similar and again there are clear differences between the phosphorescence of each. The De Beers synthetic has very strong and persistent phosphorescence with the characteristic x-configuration fluorescence pattern. The natural has not.

Every instrument has its strong points and limitations. The SAS2000 spectrophotometer is no exception to this rule, but its strength lies in its ability to accurately differentiate between treated (irradiated/annealed) fancy colours and natural ones, with very few exceptions.

General discussion on techniques and related educational topics

There are a number of ways to differentiate between natural and synthetic diamonds, namely: by using a dedicated spectrophotometer such as the SAS2000; by microscopic examination and additional supportive gemmological tests; or by using the De Beers DiamondView. The last of these is the surest, quickest method if the equipment were available. Alternatively, a combination of the first method, specifically using the SAS2000 and conventional gemmological means is viable. This depends
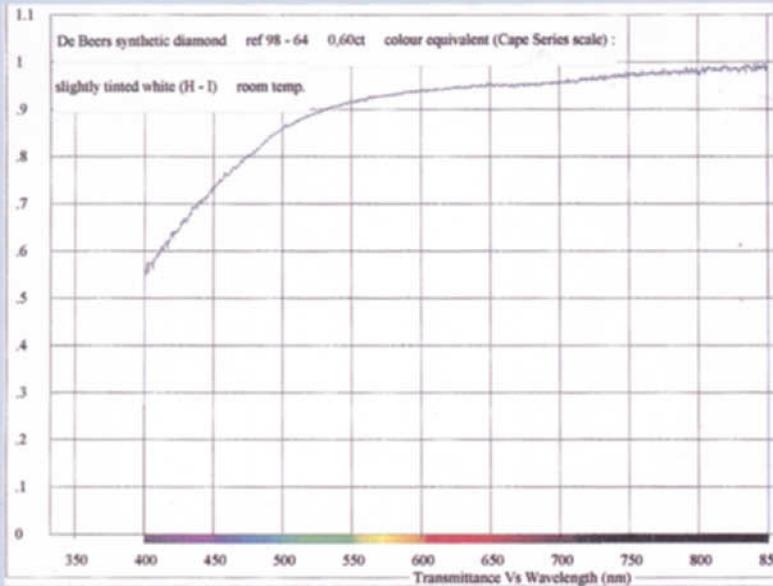
Figures 3a and b: Colourless synthetic diamonds

These spectra lack absorption features typical of Cape Series diamonds, specifically, due to the absence of the N3 centre (responsible for absorption at 415 nm). The synthetic diamonds are strongly and persistently phosphorescent after irradiation by short-wave UV, the effect lasting 10 seconds or more. White natural stones only very rarely have this property, and then only relatively slightly. There appears to be pronounced absorption below approximately 575 nm showing a smooth increase without any peaks.

An independent gemmological examination of six De Beers synthetic diamonds
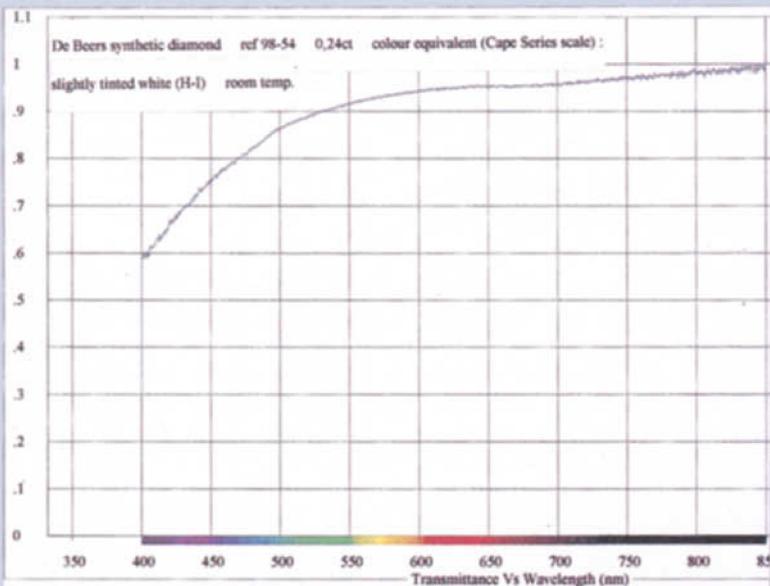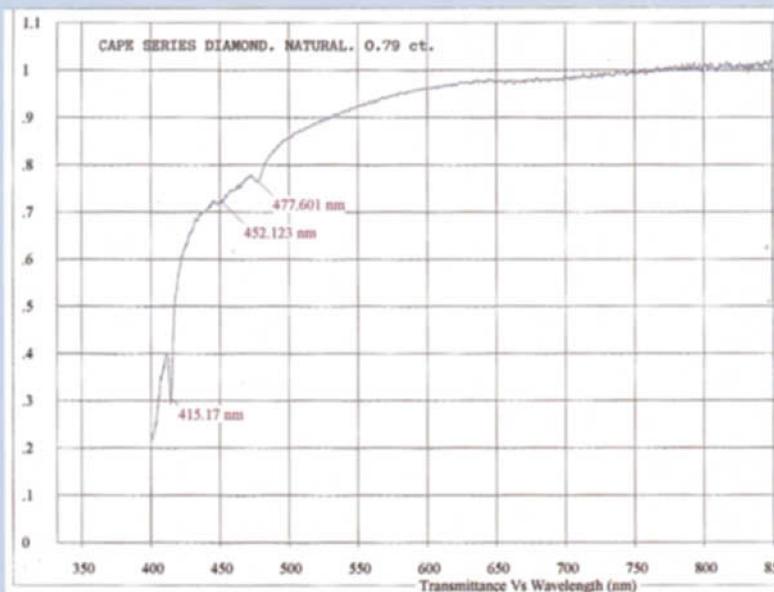
Figure 3c: Transmittance spectrum of a Cape Series natural diamond showing the peaks that distinguish it from the synthetic diamond spectra.

on circumstances (i.e. the extent of inclusions, etc.), although the latter can be slow because of the often painstaking supportive back-up tests required. One can also use cathodoluminescence techniques, but specialized equipment is required. Standard long- and short-wave ultraviolet radiation sources can also provide useful supporting information. However, the emphasis here is on what is now becoming more accepted – the increasing use of dedicated scientific equipment to do the job.

There will *always* be the standard gemmological approach which will continue to be used by the majority of gemmologists to provide a basic framework of information. In any case, training and acquisition of experience is necessary along these lines in the first instance -- basics, like any scientific subject, must be known and understood first before other building blocks of knowledge can be added. Only then can the advanced and dedicated high-tech equipment be used with advantage.

Inclusions

Details of inclusions in the synthetic diamonds are summarized in *Table II*. There appear to be subtle variations in the inclusions depending on the source of manufacture. It would be potentially useful if a greater in-depth comparative study of inclusions could be made and published in a concise way. For example, Sumitomo synthetic diamonds have some individual characteristics which have already been published[4].

The DiamondView images

The images presented here as groups clearly highlight the visual differences between the De Beers synthetic diamonds and some natural diamonds. Comments are given in the captions.

White (colourless) stones

It is evident that good quality white synthetic diamonds *can* be grown and the larger of the two examined here would create

Table II Inclusions and some physical properties of six De Beers synthetic diamonds.

Reference Number	SYN 106–16	SYN 93–4	SYN 97–13	SYN 107–9	SYN 98–64	SYN 98–54
Figure	4(a)	4(b)		4(c)	4(d)	
Inclusions	Round and rod-shaped inclusions	Cloud of pin-prick sized particles, and some larger irregular ones. Zone type graining.	Fine particles in clouds – small rounded shapes. 'Mosquito larva' shaped inclusion under table. Graining visible through pavillion.	Flux in irregular shapes. Fracture iridescence recorded in photomicrograph.	Small flux globule only. In VS range of clarity grade.	Flux inclusion and associated cleavage. Irregular flux rods and rounded shapes. In VS range of clarity grade.
Electrical conductivity	None	None	None	Present	None*	None*
Magnetic attraction (stones resting on glass)	Magnet approx. 1.00 mm from stone when moved. Stone was not lifted	No reaction	No reaction	Magnet approx. 10 mm from stone when moved. At a distance of 5 mm, stone lifted to magnet.	No reaction	No reaction
SG (Hydrostatic)	3.517	3.526	3.517	3.521	3.516	3.529

NB: (i) The mean SG of the six stones is 3.518.
* (ii) The Moissketeer SD-2000, not available at the time of these tests, has since detected electrical conductivity selectively in both of the two 'colourless' stones. This is due to the nickel catalyst essentially used in the production of colourless synthetic diamonds.

Figure 4: *DiamondView images of synthetic diamonds.*
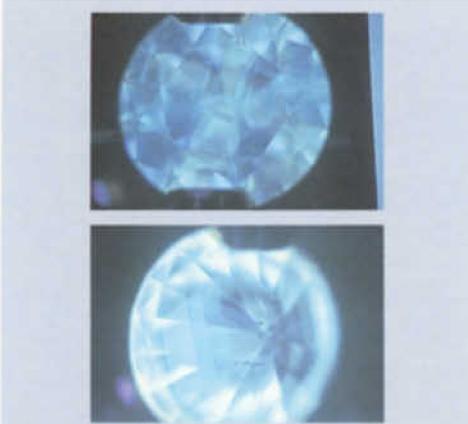
Figure 4a: *De Beers yellow synthetic diamond 0.51 ct (106–16).*
In this case the seed is evident at the centre of the image through the table facet. Compare the very different internal structure to that of the 5 ct natural yellow-brown diamond also shown for comparative purposes (see Figure 5a).
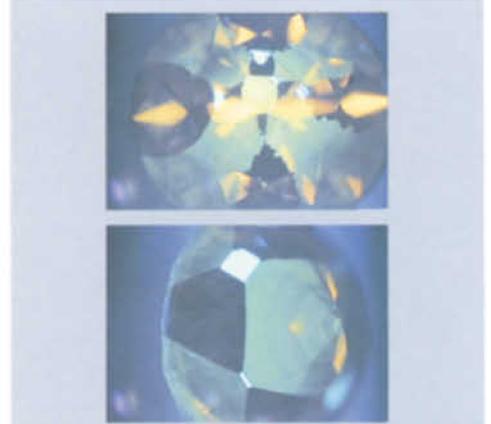
Figure 4b: *De Beers brown synthetic diamond 0.67 ct (93–4).*
The seed is clearly evident at the centre of the image through the table facet. The other view is at an oblique angle to the pavilion. The structure of this stone is quite different from that of the 5 ct natural one. The characteristic growth sectors of the two brown stones and the yellow synthetic listed above all show a common pattern. 97–13 shows similar images.
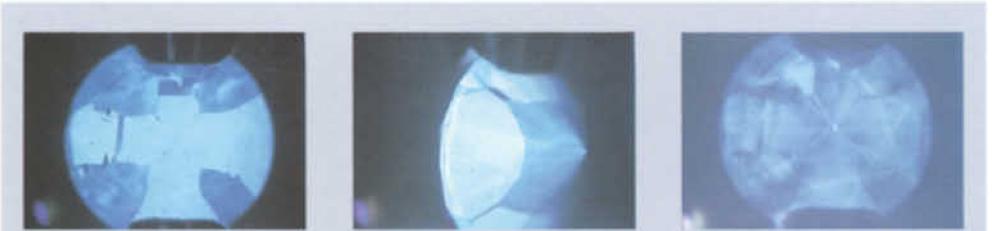
Figure 4c: *De Beers blue synthetic diamond 0.33 ct (107–9).*
The fluorescence is basically blue, some of the growth sectors showing as a paler blue in a characteristic pattern. The last image shows the very strong and persistent phosphorescence.

Figure 4d: *De Beers white synthetic diamond, 0.60 ct (98–64).*
The characteristic internal structure of the synthetic origin of this stone is clearly evident. The last image records the strong and persistent phosphorescence. Stone 98–54 (0.24 ct) is similar.

Figure 5: *Typical growth phenomena in a selection of five natural diamonds*

Figure 5a: Yellowish-brown, 5 ct.

Figure 5b: Greenish-brown, 1.15 ct.

Figure 5c: Brown tinted 13.78 ct.

Figure 5d: White 5.27 ct.

Figure 5e: White 3.36 ct.

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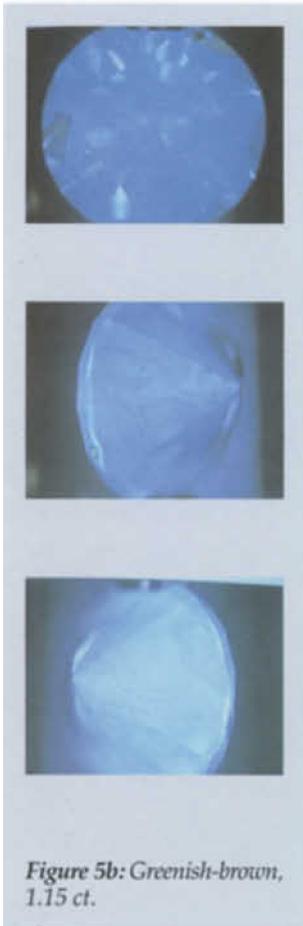
much consternation in the retail jewellery trade if it entered the supply pipeline. The small inclusion under the table has a very natural appearance and could quite easily be missed for what it really is – metal flux. If stones with similar characteristics come into the trade in any numbers it would certainly underline the need for routine testing using high-tech means.

Technology does not stand still – neither must defensive education. Much more is now being done in this context than ever before, but we cannot afford to be complacent.

Acknowledgement

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Abstracts

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| Gems and Minerals | Synthetics and Simulants |

Diamonds

New CVD Diamond products.

J.L. COLLINS. IDR, **59**, 212–13, 3 photographs, 1 table.

Collins describes a number of new chemical vapour deposition (CVD) diamond products in a range by De Beers Industrial Division during the last six months; these include not only cutting, dressing and truing materials, but also diafilms which can be used in the optical and precision industries, and radiofrequency and high power semi-conducting devices. Seven different types of CVD diamond products are listed.   E.S.

Ekati – Canada's first commercial diamond mine (an editorial review).

Australian Gemmologist, **20**(7), 1999, 293–7, 4 coloured illus., 2 maps.

The Ekati mine in Canada's Northwest Territories was officially opened on 14 October 1998. It comprises five kimberlite pipes that are located in the Lac de Gras area 300 km northeast of Yellowknife. Initial production started from the Panda pit, 277,770 ct being produced in the first three months of its operation. It is anticipated that beyond the year 2000 the Ekati mine will be producing 4% by weight and 6% by value of the world's diamonds.   P.G.R.

Gem news.

M.L. JOHNSON AND J.I. KOIVULA. *Gems & Gemology*, **34**(3), 1998, 218–30, 23 coloured illus.

At the International Mineralogical Meeting held in Canada the main feature was on diamonds. Under discussion were the advances in UV-visible-infrared spectroscopy, X-ray topography and the genesis of diamond, especially gem material. Diamonds have been found in two additional small pipes in the Ekati Project area at Lac de Gras in Canada.   J.J.

Gem news.

M.L. JOHNSON AND J.I. KOIVULA. *Gems & Gemology*, **34**(4), 1998, 290-302, 23 coloured illus.

A detailed report is given on the diamond production that has commenced at Canada's Ekati Mine in the North West Territories. At the *Financial Times* Diamond Conference held in Antwerp, De Beers said that they continue to restrict sights for stability in rough diamond prices although there are economic problems bedevilling manufacturers due to over capacity and financial liquidity.   J.J.

Characterizing natural-color Type IIB blue diamonds.

J.M. KING, T.M. MOSES, J.E. SHIGLEY, C.M. WELBOURN, S.C. LAWSON AND M. COOPER. *Gems & Gemology*, **34**(4), 1998, 246–68, 20 coloured illus. and 3 tables.

Of all diamonds, blue diamonds are some of the rarest and some of the most expensive. The colour differences of blue diamonds are subtle and difficult to appreciate. The GIA have studied over 400 predominantly blue IIb diamonds. It was found that the degree of difference in the appearance within each fancy grade is much narrower for fancy blue diamonds than for yellow diamonds. There is a limited saturation zone, which leads to subtle differences between the fancy terms. They have a higher degree of clarity than other fancy diamonds, but tend to exhibit graining and colour zoning. Phosphorescence is never seen under long-wave UV but they react to short-wave UV and the deeper coloured stones give rise to the more persistent phosphorescence. Also it was found that the stronger and/or darker blue stones tended to have a higher electrical conductivity. The colouring agent is boron. This paper hopes to provide a better understanding of the narrow colour range in which type IIb diamonds occur and the colour appearances associated with their various 'fancy' grades.   J.J.

L'exploitation diamantifère en République Centre-Africaine.

B. LANCET. *Revue de gemmologie*, **137**, 1999, 24–8, 1999.

Survey of the history and present state of diamond mining in the Central African Republic.   M.O'D.

Abstractors

For further information on many of the topics referred to, consult *Mineralogical Abstracts*

Gem Trade Lab notes.

T. Moses, I. Reinitz and S.F. McClure. *Gems & Gemology*, **34**(3), 1998, 212–17, 13 coloured illus.

With the use of a laser Raman microscope inclusions in two diamonds were identified; the green elongate crystals were olivine and the purplish-red crystals were pyrope.   J.J.

Gem Trade Lab notes.

T. Moses, I. Reinitz and S.F. McClure. *Gems & Gemology*, **34**(4), 1998, 284–9, 11 coloured illus.

By use of laser Raman microspectrometry, a black inclusion in a marquise diamond was identified as a mixture of graphite and chromite. Internal trigons all orientated in the same direction and apparently aligned along an octahedral plane were seen in an oval brilliant-cut diamond.   J.J.

Modeling the appearance of the round brilliant-cut diamond: an analysis of brilliance.

T. Scott Hemphill, I.M. Reinitz, M.L. Johnson and J.E. Shigley. *Gems & Gemology*, **34**(3), 1998, 158–83, 16 illus. in colour and 4 tables.

This paper presents a three dimensional mathematical model of round brilliant-cut symmetrical, colourless diamonds that interprets and describes the interaction of light with diamonds. The aim of the model was to explore how brilliance, fire and scintillation depend on the varying proportions of a faceted diamond. The report is based on the effect of brilliance, which is considered to be the main factor in the appearance of a diamond and is quantified on weighted light return (WLR). WLR is the weighted sum of the amount of light returned through the crown of the diamond to all positions of observation above the girdle. Computer graphics simulation techniques have been used to develop the model together with years of research on how to express mathematically the interaction of light with diamonds. As brilliance is just one aspect of a faceted diamond more research is being done on models for scintillation and fire.   J.J.

Fingerprinting of two diamonds cut from the same rough.

I. Sunagawa, T. Yasuda and H. Fukushima. *Gems & Gemology*, **34**(4), 1998, 270–80, 13 illus.

Three diamonds were examined as two of the stones were reportedly from the same rough. X-ray topography and cathodoluminescence (CL) tomography were used and showed conclusively that two of the diamonds came from the same rough. They exhibited the same dislocation densities and a good correlation in the morphology and position of the dislocation bundles. Also discernible were two distinctly different growth histories, which were revealed from the original crystals. One diamond originated from a crystal which had grown by spiral growth mechanisms on octahedral faces in near equilibrium conditions, and the other two diamonds originated from a crystal that showed growth of octahedral or dodecahedral forms on a cuboid seed in two

different environments. Fingerprinting of any diamond is possible as each natural single crystal experiences its own unique growth and post-growth history, which is recorded in its internal imperfections and inhomogeneities. Although the future demand for fingerprinting diamonds is unknown, these techniques could also be used for distinguishing natural from synthetic gem diamonds.   J.J

Gems and Minerals

Occurrences of minerals in Himachal Pradesh.

D. Bagai. *Indian Gemmologist*, **8**(1/2), 1999, 30–1.

A short general survey of Himachal Pradesh State in India has not yet uncovered gemstone deposits of importance although reports of blue sapphires of gem quality in the rocks of Kullu district have not been followed up.   M.O'D.

Amethyst aus Brasilien.

R. Balzer. *Lapis*, **24**(10), 1999, 13–18, 1 map.

Describes some of the amethyst deposits in the Brazilian state of Rio Grande do Sul. Basaltic deposits of amethyst frequently occur in unusually-shaped geodes.   M.O'D.

Gemmological news.

H. Bank, U. Henn and C.C. Milisenda. *Gemmologie. Z. Dt. Gemmol. Ges.*, **48**(2), 1999, 61–4, 4 photographs.

Madagascar continues to provide new gem materials, including fancy coloured sapphires, variously coloured spinels and many others. Especially mentioned are colour-changing garnets (bluish-green in daylight to reddish-violet in artificial light) RI 1.760–1.763, SG 3.76–3.87. Some spessartine garnets from Nigeria range from yellowish-orange to dark orange, RI 1.801–1.803, SG 4.18–4.22. Also from Nigeria some red tourmalines found near Ibadan. Some dark blue labradorite feldspar beads from India offered in Tucson were found to be dyed and other shiny black beads offered turned out to be onyx coated with plastic.   E.S.

Geozoological prospecting for gold and gems.

D.M. Colchester. *Australian Gemmologist*, **20**(6), 1999, 218–21.

Plants and many animals disturb the soil fabric by detaching, transporting and redepositing soil material. This bioturbation activity of animals in mineral prospecting may be termed geozoological in contrast to geobotanical which employs the growth and trace element chemistry of plants as an aid to prospecting. The bioturbation activities of rabbits and ants have been used successfully in kimberlite prospecting in Botswana and South Australia. In alluvial gravel deposits in northern New South Wales, meat ants occasionally expose grains of sapphire, zircon, topaz and even diamond on the bare surface of their nests. In ancient times the processing of material thrown up by 'ants' was used by miners to

extract gold. However, in the accounts of classical writers, these ants were described as smaller than dogs but bigger than foxes! Allowing for changes in the word usage over the millennia, these 'ants' were most likely medium-sized burrowing vertebrates. P.G.R.

Identification of some colourless gemstones from Sri Lanka.

P.G.R. DHARMARATNE. Gemmologie. Z. Dt. Gemmol. Ges. 48(2), 1999, 105–9, 1 photograph, 2 tables, bibl.

In a parcel of colourless rough gemstones weighing over 1000 ct, 17 different mineral varieties could be identified. The bulk of the stones were shown to be sapphire, quartz and topaz, but there were also orthoclase, cordierite, scapolite, beryl, tourmaline, danburite, euclase, fibrolite (sillimanite) and zircon. Of special interest was the identification of gemstones such as chrysoberyl, sinhalite, forsterite and spinel which rarely occur colourless. E.S.

L'origine de la couleur dans les gemmes. 1er partie.

E. FRITSCH AND G.R. ROSSMAN. Revue de gemmologie, 137, 1999, 17–23, illus. in colour.

First part of a descriptive paper on the origin of colour in gemstones. Notes on the role played by chromophores are given together with examples of absorption spectra and the influence of structure on colour. M.O'D.

The fluid inclusions in the gem-quality lazulite from the Banderinha formation (Diamantina, Minas Gerais, Brazil).

I. GATTER AND G. MORTEANI. Gemmologie. Z. Dt. Gemmol. Ges., 48(2), 1999, 65–76, 3 photographs, 2 tables, 4 diagrams, bibl..

At the Fazienda Rapadura near Diamantina a second and hitherto unknown site of gem-quality lazulite crystals was found in quartz-kyanite-hematite veins in the metaquartzites of the Middle Proterozoic Banderinha formation. The oldest generation of fluid inclusions were found to be rich in CO_2, the youngest rich in H_2O. The different quartz generations only showed hydrous fluid inclusions. It is difficult to determine the time of vein formation; they may have formed during the Espinhaço tectonothermal event. E.S.

Neu: grüner Pargasit aus Pakistan.

V.M.F HAMMER, F. BRANDSTÄTTER AND C.L. LENGAUER. Lapis, 24(10), 1999, 41.

Green transparent pargasite of probable gem quality is briefly reported from the Nagar area of the Hunza valley, Gilgit Province, in the Northern Area of Pakistan. The colour is said to be between the green of peridot and that of diopside: the chemical composition was given as $Na_{0.9}Ca_{2.7}Mg_{3.7}Al_{1.0}[(OH)_2](Si_{6.3}Al_{1.7})O_{22}$. M.O'D.

Sur la formation de nacre et de perles.

H.A. HÄNNI. Revue de Gemmologie, 137, 1999, 30–5, Illus. in colour.

Paper bringing together from current literature the state of present-day knowledge on nacre and pearl formation since both nacre and pearl show a similar structure. General cultured and keshi pearl structure are considered as well as natural examples. M.O'D.

Gemmological short notes.

U. HENN. Gemmologie. Z. Dt. Gemmol. Ges., 48(2), 1999, 111–16, bibl.

Emerald-green grossular garnets near Bekily in Southern Madagascar were found in 1998. RI 1.741–1.746, SG 3.58–3.62. The absorption spectrum shows two broad bands in the red and violet. Under the microscope apatite crystals and some other tiny inclusions were observed. Gem-quality peridot has been found near the village of Damaping in the Huebei province, China, since 1979. The mining is concentrated on tertiary basalt flows which contain peridot crystals in nodule-like cavities. The quality is similar to that found in San Carlos, Arizona. RI 1.652–1.688 to 1.654–1.690. DR 0.034–0.036. SG 3.34–3.36. There are fingerprint-like healing cracks, lily-pad inclusions and fine growth inhomogeneities. E.S.

Burmite – Burmese amber.

U.T. HLAING. Australian Gemmologist, 20(6), 1999, 250–3, 5 illus. in colour, 1 map, 1 table.

A review of the history, geology and gemmological properties (including patterns of inclusions) of Burmese (Myanmar) amber mined from a deposit near Maingkwan in the Hukawang Valley of Myanmar's Kachin state. P.G.R.

Mong Hsu ruby revisited – some further data.

U.T. HLAING. Australian Gemmologist, 20(7), 1999, 289–92, illus. in black-and-white and colour, 3 tables.

Since the publication of two previous reports by U.T. Hlaing in the Australian Gemmologist (Mong Hsu ruby update, 18(5), 157–60, and New extension of Mong Hsu ruby deposits, 19(2), 51) further spectrographic and HIAF proton microprobe analysis of selected rubies from the deposits has revealed the presence of sapphire. With the recovery of two blue corundum crystals it is hoped that a commercial deposit of sapphire will soon be discovered. P.G.R.

Sodalite from Bolivia.

J. HYRSL AND A. PETROV. Canadian Gemmologist, 20(2), 1999, 54–6.

Specimens of blue sodalite are reported from Cerro Sapo (Toad Mountain) in the Ayopaya region, near the town of Independencia (formerly Palca), Bolivia. Though the deposit has been known for at least 80 years, renewed prospecting work in the early 1990s has produced more sodalite, most of which has been used for indoor decorative work. Sodalite also occurs in a vein at Cerro San Cristobal and good quality material at another site approximately 20 km south of Cerro Sapo. M.O'D.

Gem news.

M.L. JOHNSON AND J.I. KOIVULA. Gems & Gemology, 34(3), 1998, 218–30, 23 coloured illus.

Amethyst is being mined again from the Four Pearls mine in Maricopa County near Phoenix, much of the material is 0.5–2 ct with very limited quantities of 2–6 ct stones being mined. Recently seen were four yellowish-green to brownish faceted andradite garnets from the Yemen, all showing typical andradite properties. Danburite has recently been found at the Little Three mine near Ramona, California. Three orange to brown stones from Mali were found to be gem-quality grossular and not grossular-andradite, illustrating the complex classification problems of garnets. Three faceted colour-change pyrope-spessartine garnets were recently examined and described as light greenish-yellow in daylight and intense pink to red in incandescent light, but their exact locality in Madagascar is unknown. Hackmanite, the UV-sensitive luminescent colour-change variety of sulphur-rich sodalite, has recently been discovered at the Dattawa Mine in Mogok, Myanmar. Striped bicolour labradorite from Ylamaa, Finland, was found to have two sets of stripes in different orientations caused by twinning and exsolution. Lapis lazuli is being marketed from the Blue Winkle mine, southwest of Denver, with the best material occurring in veinlets within the host rock. Trapiche rubies have reportedly come from secondary deposits, some eluvial in the Yen Bai Province, Vietnam: some stones showed slightly lower SGs than normal due to mica and other secondary minerals. A new deposit of blue sapphire is being mined in the Chelyabinsk region of the Urals and crystals are found embedded in a tough metamorphic matrix. A worn green pebble purchased in Myanmar from a jade dealer was a mixture of two sodic amphiboles, magnesioarfvedsonite and glaucophane with minor quantities of chamosite and jadeite; this rock has possibly formed as a result of high pressure and low temperature metamorphism of gabbro or basalt. A new variety of tourmaline has been named rossmanite $(LiAl_2)Al_6(Si_6O_{18})(BO_3)_3(OH)_4$, an alkali deficient pale pink tourmaline, found in granitic pegmatite in the Czech Republic, Canada and Sweden; it can only be distinguished from elbaite by quantitative chemistry.   J.J.

Gem news.

M.L. JOHNSON AND J.I. KOIVULA. *Gems & Gemology,* **34**(4), 1998, 290–302, 23 coloured illus.

At the Coloured Stone Presentation at the International Mineralogical Association meeting, presentations included talks on the coloration of tourmaline, garnet and coloured quartz being due to transition metal ions, colour can also be induced by natural irradiation especially yellow to brown colours in silicate minerals; models for the origin of corundum; the use of Raman spectra of emeralds to differentiate emerald localities, plus many more papers. Chalcedony containing abundant tiny dark spherical aggregates of goethite have come from Madagascar. A colourless transparent oval faceted stone (1.48 ct) posed a challenge for identification; properties were typical for plagioclase feldspar, but when analyzed by a laser Raman microspectrometer it indicated it was cordierite (iolite). On further examination of low quality sapphires from Day Cotton Gulch, Montana, unusually pyrrhotite and clinozoisite were found as

inclusions together with microscopic grains of gold found in the cavities and cracks in some of the sapphires. Unusually, translucent yellowish-green beads reportedly from Afghanistan were antigorite, a serpentine mineral. Colourless topaz contained channels that had been subsequently filled with yellowish-brown limonite that had been deposited later by ground waters. Tourmalines are now being produced in Nigeria from a locality near Ogbomosho near the Benin border, most are purplish-red to pink or nearly colourless.   J.J.

Barite Inclusions in Fluorite

J.I. KOIVULA AND S. ELEN. *Gems & Gemology,* **34**(4), 1998, 281–3, 3 coloured illus.

Fibrous white hemisperical aggregates of baryte were identified as inclusions in fluorite from Illinois. One baryte inclusion appeared purple in incandescent light and blue in fluorescent light. This pseudo colour change was imparted to the white inclusion by reflection from the fluorite host, which showed the actual colour change.   J.J.

Pearls and pearl oysters in the Gulf of California, Mexico – an update.

D. MCLAURIN, E. ARIZMENDI, S. FARELL AND M. NAVA. *Australian Gemmologist,* **20**(6), 1999, 239–45, 10 illus. in colour, 1 map, 1 table.

The Mexican pearl farm, which in 1996 was the first to be established on the American continent, is based near the coastal town of Guaymas in the northern State of Sonora. This update on a 1997 paper (*Australian Gemmologist,* **19**(12), 497–502) by the same authors includes news that production of whole pearls (round, baroque, keshi) has increased, and that the Gulf of California mabe pearls have successfully made their debut in international markets. The production target for 1999 is a harvest of 1300 whole cultured pearls, rising to 3000 for the year 2000.   P.G.R.

Die Edelsteine Sri Lankas: Vorkommen und Genese.

C.C. MILISENDA AND U. HENN. *Gemmologie. Z. Dt. Gemmol. Ges.,* **48**(2), 1999, 85–96. 7 photographs, 2 geological maps, 2 tables, bibl.

This study of the gemstone occurrences and their formation is mainly based on the results of a study carried out by a German-Sri Lankan Consortium within a programme for the study of the lower continental crust established by the Deutsche Forschungsgemeinschaft (German research co-operative). The genesis of the stones is strongly associated with metasedimentary rocks of the Highland Complex. This goes back to the main thermo-tectonic evolution during the Pan-African event, known to have affected large parts of Africa. Recent investigations suggest that the high grade rocks of Sri Lanka once formed part of the East African Mozambique belt, which is regarded as having resulted from the collision of East Gondwana (India-Antarctica-Australia) and West Gondwana (Africa-South America) some 600 Ma ago. A table gives a comprehensive survey of the Sri Lankan gemstones and where they are found.   E.S.

Gem Trade Lab notes.

T. Moses, I. Reinitz, and S.F. McClure. *Gems & Gemology,* 34(3), 1998, 212–17, 13 coloured illus.

A dark green chrysoberyl coloured by vanadium rather than chromium came from the Tunduru region of Tanzania. A ruby cabochon showed an unusual phenomenon of a double star, two six-ray stars slightly offset, which was caused by a difference in the orientation of the rutile silk across the pervasive twin planes. Synthetic and natural rock crystal can be difficult to distinguish, which was the case with a large colourless rock crystal sphere (9.6 cm in diameter), only by using darkfield illumination were tiny rods of tourmaline visible (63x).   J.J.

Gem Trade Lab notes.

T. Moses, I. Reinitz and S.F. McClure, *Gems & Gemology,* 34(4), 1998, 284–89, 11 coloured illus.

A light greenish-blue beryl and three blue beryls were found to be maxixe beryls; the latter three beryls were placed in a solar simulator and after four hours the colour had started to fade. Symmetrical oval drop shaped light pink concretions were shown to be natural carbonate by X-ray and reportedly originate from an oyster found along the Pacific Coast of North America. An unusual red spinel from Mogok not only exhibited colour zoning but two different RIs of 1.732 and 1.718; on immersion it was revealed that the spinel had a dark core and a paler surround and it was the darker core that gave the higher reading, together with a higher content of chromium and vanadium.   J.J.

Comparative study of corundum from various Indian occurrences: corundum from Karnataka.

J. Panjikar. *Indian Gemmologist,* 8(1/2), 1999, 3–7, illus. in colour.

Ruby from Karnataka occurs as well-formed crystals with orthoclase and shows pinkish-red to red colour with diaphaneity ranging from semi-transparent to translucent. Rutile is the most prominent solid inclusion and is found in a range of sizes from very small needles up to 1 mm: the crystals show perfect tetragonal cross-section. Feathers and veils of liquid are also found and both growth and twin planes are reported, the latter containing boehmite needles. Some biotite and possibly chromite have been found. Absorption spectroscopy shows the presence of both iron and chromium.   M.O'D.

The effect of the gamma-irradiation dose combined with heat on the colour enhancement of colourless quartz.

M.V.B. Pinheiro, K. Krambrock, J. Karfunkel and J.B. da Silva. *Australian Gemmologist,* 20(7), 1999, 285–8, 4 coloured illus., 1 table.

Using a combination of gamma irradiation and thermal treatment, colours ranging from pale yellow, yellow, greenish-yellow, olive-green, greenish-orange, orange and reddish-brown were produced from colourless quartz. The irradiation treatments used a conventional cobalt-60 gamma cell at room temperature.

The final colour was obtained by heating batches of irradiated quartz at atmospheric pressure in an alumina crucible, the temperature being raised in steps by 5 degree C per minute intervals to 250 degrees C. All nineteen colourless quartz specimens used in the experiment originated from Minas Gerais, Brazil.   P.G.R.

Characterisation of recent and fossil ivory.

V. Rolandi. *Australian Gemmologist,* 20(7), 1999, 266–76, 3 coloured illus., 14 illus. in black-and-white.

Although some physical properties are common to all types of ivory, sometimes the appearance of its surface under magnification is diagnostic. However, elephant and 'fossil' mammoth ivory are similar texturally and require more sophisticated test techniques for their identification. Although Fourier Transform Infrared and Raman spectroscopy may be useful for discriminating recent from fossil ivory, biochemical tests indicate that differences in the amino acid content of their collagen can positively separate these look-alike ivories.   P.G.R

White Cliffs: Australia's first commercial opal field – a century of history.

G. Rowe. *Australian Gemmologist,* 20(6), 1999, 230–1, 1 black-and-white illus.

In 1899 White Cliffs opal field became the world's largest producer of precious opal. During the last hundred years White Cliffs has been a magnet for geologists, palaeontologists, government officials and hopeful fortune-hunters. The intense summer heat drove the first miners underground. By 1900 most other residents followed suit. Today, around 220 residents occupy 40 above-ground dwellings and 130 dugouts on Smith's Hill, Turkey's Hill and the southern outskirts of the main field. White Cliffs History Group, and White Cliffs Opal Fields Tourist Association have applied for Federation funding for 1999-2000, and plan to convert two town blocks into a tree-lined picnic area for the use of visitors.   P.G.R.

Vogelschnäbel und Sterne.

K. Schäfer. *Lapis,* 24(10), 1999, 19–26.

Describes quartz twins found in the area of Idar-Oberstein, Germany. Many show a star-like form while others are said to resemble the beak of a bird.   M.O'D.

Ruby and variously coloured sapphires from Ilakaka, Madagascar.

K. Schmetzer. *Australian Gemmologist,* 20(7), 1999, 282–4, 5 coloured illus.

The appearance, absorption spectra and microscopic features of faceted non-heat-treated rubies and pink, blue-violet, violet, purple and orange sapphires from a recently discovered secondary deposit at Ilakaka, Madagascar, closely resemble those corundums from Umba, northern Tanzania, which have been known in the trade for more than 30 years.   P.G.R.

Amethystfund in den Hohen Tauern.

R. Scholze. *Lapis,* **24**(9), 1999, 43–5, illus. in colour.

Large amethyst crystals of good colour are reported from Rauris in the Hohe Tauern area of Austria. Some show sceptre habits. M.O'D.

The nomenclature of gemstones. With special reference to the garnet and tourmaline mineral groups.

E.L. Stevens. *Australian Gemmologist,* **20**(7), 1999, 277–9, 4 tables.

Gemmological nomenclature sometimes confuses the mineral species name with either its group or variety name. There is also frequently a contradiction by gemmologists about the naming of certain species and varieties of gem minerals, although the rules of nomenclature for minerals should apply equally to the gemstone subset. Tables list the mineral species names for the garnet, tourmaline and olivine groups of minerals, and illustrate the fact that there is no such mineral as 'garnet', 'tourmaline' or 'olivine'. Although an overnight change of gemstone nomenclature (e.g. from tourmaline to elbaite) would be too much of a shock at the retail end of the jewellery world, an effort to increase the gemmological student's awareness of mineralogy and its nomenclature rules would be a good starting point. P.G.R

Explosion of interest in Canadian gemstones.

W. Wight. *Canadian Gemmologist,* **20**(2), 1999, 45–53.

Precious opal, diamond, emerald, blue sapphire and ruby have been found at various sites in Canada. While work on evaluating the products, some of which have so far been recovered in very small sizes only, is still going on, it is likely that Canada will play a larger part in gemstone production than it has done so far. Details of the specimens and locations are given. M.O'D.

Instruments and Techniques

Estimating weights of mounted coloured stones.

C.I. Carmona. *Gems & Gemology,* **34**(3), 1998, 202–11, 13 coloured illus.

The author has updated formulas for estimating the weights of mounted coloured stones. These formulas have been derived from the measurements of weights of thousands of German cut calibrated amethysts and citrines. As the face-up outlines of faceted stones vary from one classic shape to another, the shape factors in their weight estimation formulas change accordingly. Both precise face-up measurements and profile observations are critical to the accurate estimation of the weight of a mounted coloured stone. The results have been published in *The Complete Handbook for Gemstone Estimation.* It includes the estimation of weights of twenty-four common shapes of coloured stones and 48 formulas for stones with unusual shapes. Also, it has a section dealing with diamonds and pearls. The updated formulas

presented by the author are meant to set a new standard for weight estimation. It is claimed this method reduces the margin of error from 15 – 10% to 5% and less. J.J.

Synthetischer Moissanit und Diamant: Sichere Unterscheidung mit Hilfe des reflektometers.

J.P. Chalain and M.S. Krzemnicki. *Gemmologie. Z. Dt. Gemmol. Ges.,* **48**(2), 1999, 77–84, 4 photographs, 1 table, bibl.

The thermal conductivity of synthetic moissanite is similar to that of diamond and the two cannot be told apart by using a thermotester. However, the reflectance power for synthetic moissanite is higher (0.19–0.20, 116–119) than that of diamond (0.17, 100). The authors suggest a two-step routine for jewellers; first the use of a thermotester to separate moissanite and diamond from other imitations, then a reflectometer to distinguish moissanite from diamond. The authors do add that moissanite has a slightly greyish colour and strong double refraction. (Abstractor's note: the double refraction alone is a complete give-away.) E.S.

Tester Model 590 for colourless moissanite/diamond – an instrument evaluation.

V.M.F. Hammer and J. Stephan. *Australian Gemmologist,* **20**(7), 1999, 298–302, 2 black-and-white illus.

The tester, manufactured by C3 Inc. of North Carolina U.S.A., uses a halogen lamp to check the absorption characteristic of diamond and synthetic moissanite in the blue and near visible UV end of their spectra. Synthetic moissanite exhibits an intense absorption from around 425 nm down to the UV region, while colourless diamonds transmit well down into the UV range. Light from the instrument's halogen light source is reflected from the table facet of the stone under test. If this reflected light contains wavelengths from the blue end of the visible spectrum to the near UV region, a buzzer and a green warning light are activated to indicate that the stone is a diamond. Absorption of this range of wavelengths by the test stone will not activate the buzzer/lamp and will indicate that the stone is a moissanite. The evaluation report includes some result errors due to the colour grade of the diamonds tested. Further test reservations are made by the Instrument Evaluation Committee of the Gemmological Association of Australia whose comments form an addendum to the main paper. P.G.R.

L_H – an 'old' gemmological property.

W.W. Hanneman. *Australian Gemmologist,* **20**(6), 1999, 236–8.

The author refers back to his 1978 paper 'The role of reflectivity in gemmology' which appeared in the *Journal of Gemmology* (**16**(2), 109–20) and which introduced his concept of a scale of lustre using L_H (Lustre-Hanneman) values. Although the L_H concept has never been universally adopted by gemmologists, the author criticizes other writers for quoting reflectance meter readings in terms of RI values rather than L_H values (in which YAG, GGG, strontium titanate and diamond are

used as reference standards, and are given the L_H values 1, 2, 3, 4). Reference is made to two topaz treatments which produce misleading high readings on a reflectance meter, and negative readings on a refractometer. The reason for this is that both instruments are making surface rather than bulk measurements. However, the use of Hodgkinson's visual optics method, or the Hanneman-Hodgkinson refractometer, both of which examine the bulk properties of a gem, reveal readings characteristic of topaz when applied to this treated material.   P.G.R.

Gemstones in a new light.

A. HODGKINSON. *Australian Gemmologist*, **20**(6), 1999, 246–9, 12 illus. in colour.

Methods suitable for the rapid screening of large numbers of diamonds to detect the presence of synthetic moissanites are described. This method uses the Nelson Pavilion Facet Fingerprinter technique, but by using inexpensive items such as a plastic immersion cell and a pen torch this technique can become available to a wide range of users. Another identifying technique for synthetic moissanite involves heating suspect stones on the hot plate of an electric cooker. With the cooker set to medium heat, synthetic moissanites (unlike diamonds) turn bright yellow when they reach this temperature. Alternatively, this reversible colour change can be produced by the heat from a 250 watt electric lamp bulb or by placing the flame of a match 15 mm beneath a suspect stone.   P.G.R.

Gem news.

M. L. JOHNSON AND J. I. KOIVULA, *Gems & Gemology*, **34**(3), 1998, 218–30, 23 coloured illus.

New methods will be used in the future for the exploitation of Colombian emerald deposits, with side-scan radar promising to be the most versatile for mapping the emerald district.   J.J.

Refractometers and the pin-hole disc.

T. LINTON. *Australian Gemmologist*, **20**(6), 1999, 227–9, 4 black-and white illus.

Although a paper by G.S. Walker titled 'A new spot reading technique for the refractometer' appeared in the *Australian Gemmologist* (1987, **16**, 253–6), this was concerned with improving the accuracy and ease of using the 'spot' or 'distant vision' method of measuring the refractive index of cabochons. In the current paper, the author has extended the use of the pin-hole disc to improving the weak shadow edge image produced by small and poorly polished gem facets. With the low light level produced by such an image, the eye's iris dilates, but if the shadow edge is viewed through a pin-hole disc, this increases the depth of focus and reduces the exposed area of the eye's lens, thus reducing any optical errors likely to occur at the perimeter of the lens.   P.G.R.

Evaluation of a teaching aid for 'Visual Optics'.

T. LINTON. *Australian Gemmologist*, **20**(6), 1999, 232–5, 6 colour, 1 black-and-white illus.

D. Hoover's lecture aid for demonstrating the major features of Hodgkinson's Visual Optics consists of half a ping-pong ball, a glass microscope slide, and an inexpensive hand-held laser pointer. The gem used in the demonstration is mounted table facet upwards under the glass slide, and the half ping-pong ball cemented centrally over the table side of the stone on the slide. The laser pointer is then used to illuminate the stone's pavilion. The primary refracted rays, used to identify gems by the 'visual optics' method, appear as red spots on the surface of the ping-pong ball. A warning is given of the dangers of directing the laser beam directly into the eyes (*a laser pointer must not be used for examining the gemstones using the conventional Hodgkinson technique of visual optics*).   P.G.R.

Cathodoluminescence du jade.

J. PONAHLO. *Revue de gemmologie*, **137**, 1999, 10–6, illus. in colour.

Cathodoluminescence (CL) provides a non-destructive method of distinguishing natural jadeite from maw-sit-sit and chloromelantite, treated and non-treated materials. Descriptive examples of CL spectra for the various substances are given.   M.O'D.

Synthetics and Simulants

Gemmological miscellany.

G. BROWN. *Australian Gemmologist*, **20**(6), 1999, 223–6, 11 illus. in colour.

Short laboratory reports with illustrations describe the identifying features of Chinese synthetic amethyst, two unusual composite stones, a colourless faceted glass, synthetic moissanite, imitation sapphire rough, and blue-dyed lapis.   P.G.R.

Synthetische rote Berylle aus Russland.

U. HENN AND C.C. MILISENDA. *Gemmologie. Z. Dt. Gemmol. Ges.*, **48**(2), 1999, 97–104. 5 photographs, 3 tables, 1 graph, bibl.

Constants of the recently obtained synthetic red beryls correspond to those of the known range for hydrothermally grown beryls from Russia, i.e. RI 1.570–1.580, DR 0.008, SG 2.63–2.65. The spectrum is characterized by maxima in the green and blue, and yellow-green and blue respectively. There is a strong pleochroism (cinnamon brown and violet) and there is no fluorescence under UV. The colour of the stones is similar to that of the natural red beryls from Utah. The examined samples were 6.5 x 5.00 mm in size and weighed between 0.98 and 1.08 ct.   E.S.

Gem news.

M.L. JOHNSON AND J.I. KOIVULA, *Gems & Gemology*, **34**(3), 1998, 218–30, 23 coloured illus.

Two brownish-red radioactive rubies with bubble-filled inclusions from Indonesia were received by the AGTA for examination and it was thought that these

stones had been treated by irradiation. An unusual material, gallium phosphide has been faceted; it resembled a dark orange diamond but has a hardness of 5–6 and gave off a very pungent (phosphorous) odour when cut.   J.J.

Gem news.

M.L. Johnson and J.I. Koivula, *Gems & Gemology*, **34**(4), 1998, 290–302, 23 coloured illus.

Problems arise in testing polymer impregnated materials, e.g. turquoise, jade and especially opal; some treated opals were ignited and burnt very readily and lost up to 16–27% of their weight. When exposed to gamma irradiation, inclusions in topaz of colourless halite (NaCl), sylvite (KCl) and villiaumite (NaF) became yellow, lilac and brown respectively. Great quantities of diffusion-treated synthetic sapphires are appearing on the market in Bangkok, but when immersed all showed uneven coloration from one facet to another.   J.J.

Lab notes.

T. Moses, I. Reinitz and S. McClure. *Gems & Gemology*, **34**(3), 1998, 212–17, 13 coloured illus.

When viewed from the back, the sections of a green and black oval cabochon imitation trapiche emerald were misaligned and under magnification a plastic coating was seen. An orangey-yellow diamond known to have some type Ib component was irradiated with low energy electrons and the colour changed to a reddish-purple, with a strong concentration of colour in the culet. Diamonds sent to be graded have been found to be synthetic moissanite; they were readily distinguished by their specific gravity and polish lines that smoothly crossed the facet junctions but doubling of the pavilion facets was not visible. China is now the dominant producer of tissue nucleated cultured pearls and recently a necklace examined was composed of pearls up to 15 mm in both white and pink shades.   J.J.

Gem Trade Lab notes.

T. Moses, I. Reinitz and S.F. McClure, *Gems & Gemology*, **34**(4), 1998, 284–9, 11 coloured illus.

Two diamonds with a brown body colour with concentrated colour zones of green and blue were examined, one was found to be irradiated and the colour origin of the other was undeterminable. An interesting synthetic diamond exhibited a colour change from greenish-yellow in daylight to an orange hue in incandescent light. A strand of light grey faceted pearls that had been faceted were cultured pearls.   J.J.

Cultured abalone blister pearls from New Zealand.

C.Y. Wentzell. *Gems & Gemology*, **34**(3), 1998, 184–200, 18 coloured illus.

Since 1995 the Empress Abalone Company in South Island, New Zealand, has successfully produced cultured blister pearls with vibrant bright colours and a rainbow like iridescence that are unique to New Zealand's *Haliotis iris* abalone. Details of the biology and gathering techniques of the abalone are given. The author explains how the cultured blister pearls are cut from the shell, filled with a blue polymer, backed with mother-of-pearl and finally buffed into a high lustre. The thickness of the conchiolin is important to the face up appearance of the 'mabes'. If the conchiolin layer is thin or absent, then the blue polymer layer affects the colour of the nacre, whereas the presence of a thick layer of conchiolin optimizes the naturally vivid colours and iridescence. None of the stones examined revealed any evidence of surface treatment. Size, colour, lustre and surface blemishes control the price of these abalone 'mabes'. Research is in progress to decrease the mortality rate and increase production rates, together with commercial production of whole free-formed beads and tissue-nucleated cultured abalone pearls.   J.J.

BOOK REVIEWS

Jewellery: Two in one manual.

M. Coles, 1999. Apple Press, London. pp. 128, illus. in colour, hardcover, ring-bound. ISBN 1 84092 197 8. £12.99.

Ingenious guide to simple jewellery making, most of the text being divided horizontally to form what are in effect two books whose pages can be turned independently, the upper section illustrating step-by-step projects and the lower one the basic techniques needed. This approach is very handy, provided always that the upper and lower pages line up. There are useful tables and a glossary at the back of the book: the standard of illustration is high and beginners could work from the text and pictures combined.   M.O'D.

The Ekati diamond mine.

BHP Diamonds Inc., Yellowknife, NWT, Canada, 1998. pp. 58, illus. in colour, softcover, landscape format. Unpriced.

As recently as 1985 minerals associated with possible diamond occurrence were detected in the Lac de Gras area of Canada's Northwest territories. The Ekati mine is the first diamond mine to be established in Canada and is expected to produce 3.5 to 4.5 million carats of rough industrial and gem-quality diamonds a year. This would represent about 4% of current global production by weight and about 6% by value. This beautifully-produced and illustrated account of the Ekati mine shows all areas of diamond production from (possible) formation and transport through recovery, sorting and sale. Copies of this kind of book go out of print quickly and anyone with an interest in diamond mining (or in the minerals of Canada) should try to get one.   M.O'D

Hallmark. A history of the London Assay Office.

J.S. Forbes, 1999. Unicorn Press in conjunction with the Goldsmiths' Company, London. pp. 367, illus. in black-and-white and in colour. Hardcover ISBN 0 906290 26 0. £35 + £3 post and packing.

At the time of publication, it was still uncertain what effect possible new European legislation would have on the continued use and legal force of hallmarking in constituent countries and especially in the UK where hallmarking has been in use since the king's mark of the fourteenth century. John Forbes, Assay Master from 1953 to 1983, is uniquely fitted to write the history of hallmarking and his concentration in particular upon the work of the London Assay Office in the capital of a major trading country serves to make this book a notable monograph on a special area of economic history as well as a study of the practice of hallmarking itself.

The Goldsmiths' Company is fortunate to have been able to preserve its records, especially minute books and archives: the author has been able to draw freely on them and to illustrate not only the excellent supervision which was exercised over the gold and silver trades but also the ingenious efforts made by some to profit by evading the rules. The links between the company and the Royal Mint are emphasized and a description given of the Trial of the Pyx, still conducted annually.

The book is arranged chronologically with special notes on a number of important topics: they include Britannia Silver, Plate Duty, the Hallmarking Act of 1973 (taking effect in 1975) and London hallmarks for silver. The historical commentary is continuously accompanied by notes on the different techniques used by assayers over the years and there is a useful glossary and a bibliography. Colour plates illustrate some significant artefacts and documents.

This is a book for anyone concerned with the jewellery or precious metal trades: it is very easy to read, very economically priced and a worthy climax to the distinguished career of its author.   M.O'D.

Les pierres de lune bleues de Meethiyagoda, Sri Lanka. [A thesis.]

L. Genot, 1998. Université de Nantes UFR des sciences et des techniques, Nantes. pp. 105. Illus. in colour, softcover, unpriced.

This study of blue moonstones from Meethiyagoda, Sri Lanka, forms a thesis submitted to the Université de Gemmologie of the University of Nantes. Theses on topics of gemmological interest appear from time to time but are not often published in printed form and this example is welcome as something of a rarity of information production. It is much more welcome of course, for the light which it throws upon a beautiful gemstone. The author begins with geological and mineralogical studies of the Meethiyagoda area in the south-west of Sri Lanka and bravely discusses the place of the blue moonstone in the feldspar group of minerals. Details of the moonstone's recovery from alluvial deposits are given and, with other sections of the study, are illustrated by colour photographs taken during the author's time in Sri Lanka. Tests used to examine the moonstones are described: they include Raman spectroscopy as well as the usual gemmological tests.

Colours, fashioning and values are briefly described, and the author concludes with a useful bibliography, a vocabulary, notes on the use of moonstone in jewellery and in literature, a description of the electron microscope and its workings, and of the alteration of feldspar minerals. This is a useful study and one which would stand a wider exposure by a commercial publisher.   M.O'D.

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Edelsteine: Symbole der Schönheit und der Macht.

E. Gübelin and F-X. Erni, 1999. Verlag Hans Schoner GmbH., Königsbach-Stein, Germany. pp. 240, illus. in colour. Hardcover ISBN 3 923765 30 4. DM 73.84.

Despite the title, this beautifully-illustrated history of the use of gemstones would also serve as a vehicle for gemmological study since considerable detail is given on many of the species described and because it is so well illustrated. So we find notes not only on cutting and polishing but also in some cases on those properties able to be tested gemmologically: major groups have appended notes sufficient for tests to be made on unknown specimens and if the eye of the reader jumps over the notes to the next photograph this is only to be expected! However, the stimulus given to the imagination by such a book will impel many readers who may come across the book accidentally to study further in the world of gemstones.

The table of contents shows that the text follows a well-tried and virtually inevitable path via formation, occurrence, the major species, symbolism and medical properties to the internal world of stones, stones for the collector and man-made products. There is a useful bibliography and an English edition is promised.

Readers familiar with gemstone literature over the past 30 years will expect new photographs: here they are, many by the renowned team of Harold and Erica Van Pelt whose work is, as always, first-class. But many pictures are by the first author and by others: all reach the same high standard. Take no notice of imagined language difficulties and buy this beautiful book.   M.O'D.

The diamond makers.

R.M. Hazen, 1999. Cambridge Univ. Press, Cambridge. xiv, 244 pp. Paperback ISBN 0 521 65474 2. £9.95.

This book spans centuries of ground-breaking science, bitter rivalry, outright fraud and self-delusion, and is centred around the brilliant but often controversial pioneers of high-pressure research. It represents a new and heavily revised edition of *The New Alchemists* (1994), and is presented as a blend of dramatic personal stories and scientific advances (and failures) in the quest to create synthetic diamonds. After a brief account of the natural occurrences of diamond, details are presented of the early work by Hannay, Moissan, Crookes, Hershey and Sir Charles Parsons, and the founding of modern high-pressure research by P.W. Bridgman, before turning to the first true synthesis of diamond by ASEA in Sweden 1953 followed by the General Electric Company in the U.S.A. in 1955.

One of the delights of this book is its inclusion of many photographs of the experimenters and their apparatus. We are given insights into the belt apparatus, the tetrahedral-anvil press and the cubic-anvil press with its six carbide anvils arranged in three opposed pairs to give a cube-shaped sample chamber.

A whole chapter is devoted to the crystal syntheses carried out by Loring Coes, a chemist working for the Norton Company. Rather than tackle diamond synthesis directly, Coes crept up on the conditions necessary for its formation by first producing more than forty silicates

never before synthesized, such as pyrope, staurolite, kyanite, topaz, zircon, etc. These were produced not from the pure oxides of the conventional logic but from mixing such ingredients as, for pyrope, $Mg(NO_3)_2$, $Al(OH)_3$ and SiC and reacting them in a slightly open capsule allowing the volatile components to escape leaving tiny but perfect crystals of garnet. The results were not initially published, but after the synthesis of a new dense form of crystalline silica, now coesite, a short note appeared on this together with a remark that 'the synthesis of several naturally occurring minerals' was to be reported in a subsequent paper. This led to a meeting in December 1953, at the Norton Co., at which Coes demonstrated his methods and results to Messrs. Birch, Boyd, Hurlbut, MacDonald, Robertson, Roy, Thompson, Van Valkenburg and Yoder. Coes never did succeed in making diamonds, but these nine scientists left in amazement and on return to their respective laboratories developed research techniques which continue to be of lasting importance to the earth sciences.

In further chapters are the six-year legal battle between De Beers and General Electric in which the former challenged the originality and accuracy of description of the latter's discovery, the production of diamonds via explosive processes, and their successful synthesis from chemical vapour deposition. A final chapter details the invention and development of the diamond-anvil cell, with an interesting history of Van Valkenburg and Weir having an abundant supply of natural gem diamonds confiscated by the U.S. Customs and offered to scientists at the National Bureau of Standards.

This is an eminently readable book, full of fascinating, often first-hand, accounts of the trials and tribulations of high-pressure research workers in academic, commercial and government laboratories. The price should encourage a wide readership.   R.A.H.

Visual optics II: diamond and gem identification without instruments: the Hodgkinson method.

A. Hodgkinson, 1999. Gemworld International Inc. Northbrook, Illinois, U.S.A. pp. 77. illus. in colour, softcover, ring-bound. ISBN 0 964 17334 4. US$29.95

The advent of synthetic moissanite stimulated author and publishers (by their own account) to revise *Visual optics* and useful information on this latest diamond imitation is provided. Like the previous edition, this one is attractively produced and readers will want to try the tests out for themselves. Apart from hints on catching moissanite out, of equal interest are the descriptions of several uses of Nelson's Fingerprinter, devised in 1984, which records, among other things, the optical behaviour of every pavilion facet of a specimen. 'Try this one at home' can safely be said of all the tests described (but at least read up on general gem testing first, so that the full benefit of visual optics can be obtained).

While the book is easy to read, the lack of an index does hinder the reader and a glossary too is a desideratum. I wonder whether an A4 format would frame each section better? Some personal names are mis-spelt and this reviewer at least tires of obtrusive and rather fulsome praise directed at gemmological worthies who don't need

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it: the author could now completely abandon his stance of the one against the many since his methods have long been recognized and he can be well satisfied with what he has accomplished to the benefit of all.   M.O'D.

Romance of the Golconda diamonds.

O. KHALIDI, 1999. Mapin Publishing Pvt. Ltd., Ahmedabad, India. pp. 127, illus. in colour, hardcover ISBN 1 890206 10 5 and 81 85822 57 3. £28.00.

Accounts of the Golconda mines are hard to come by and this one is well-produced and illustrated. After a short account of diamond in general and of the legends associated with the stone the author describes the Golconda mines and some of the famous diamonds which they have produced, presenting them in a useful and convenient table. The account is written in a pleasing, informal style and various larger-than-life personalities are introduced. According to the author no mining is carried out in the Golconda area today (though the situation may have changed by now). Most of the remainder of the book is anecdotal: many of the stories, some involving important jewellery sales and pieces, are new (to the reviewer, at least). There is a useful annotated bibliography. Few books would make more acceptable presents than this one, which would interest a very wide potential readership.   M.O'D.

Cameos old and new. 2nd edn.

A.M. MILLER. 1998. GemStone Press, Woodstock VT. pp. x, 270, illus. in colour, softcover. ISBN 0 943763 17 7. £18.00.

Though described as a second edition there is no reference to a first, and the entries in the bibliography are no more up-to-date than 1989. The second imprint is that of the UK distributors Robert Hale and it may be that the putative first edition may have been the American one. None the less this is a very important book on a major subject and is well worth buying. Beginning with a history of the glyptic arts the author goes on to describe some at least of the most popular subjects portrayed by the cameo, giving short accounts of some of the most persisting legends. The technique of cameo manufacture is then addressed and succeeding chapters deal with distinguishing old and new cameos, modifications and imitations, and all the details needed for building up a collection: major world collections are described and market prices are discussed. The cameo has never lost its popularity and some fine examples are still available from time to time on the market. This lucid and concise study will be widely read and deserves to be. There is a satisfactory bibliography, illustrations are good and the price very reasonable.   M.O'D.

Ruby, sapphire and emerald buying guide.

R. NEWMAN, 2000. International Jewelry Publications, Los Angeles. pp. 164, illustrated in colour, softcover. ISBN 0 929975 28 6. £11.95.

The best-produced book on gemstones I have yet seen in this price range (how is it done?). This is the book for anyone who buys, sells or studies gemstones and also for the casual reader who notices the cover which reproduces three gem-set rings: such a reader may begin a life-long friendship with gemstones and for an author to have achieved this is a rare prize. This style of book (and similar ones by the same author) is the only one I know which introduces actual trade conditions and successfully combines a good deal of gemmology with them. Especially good are remarks on the influence of local lighting conditions – hardly ever mentioned elsewhere but profoundly affecting display and sales: colour taste and preference are considered too and the purpose and effect of different cutting styles. As well as all this are the details any gemmologist would want. Last of all, the pictures are very good, and no internet reproductions have achieved this quality so far. Buy it, read it and keep it.   M.O'D

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

PHOTO COMPETITION 2000
The Light Fantastic:
optical effects in gems

Capture the most beautiful or extraordinary effects of light on gems. Submit your favourite picture taken by yourself of iridescence, fire, star or cat's-eye, or any other optical feature that you find attractive. Entries will be judged for originality, beauty and gemmological interest. The following prizes will be awarded:

First Prize: £100

Second Prize: £75

Third Prize: £50

The closing date for the Competition is *30 April.*

OBITUARY

Michael B. Aburrow FGA (D.1983), Poole, Dorset, died in September 1999.

Mark S. Milton (D.1967), Liverpool, died suddenly on 19 August 1999.

MEMBERS' MEETINGS
1999 Annual Conference

The 1999 GAGTL Conference on the theme *New Developments in the Gem World* was held on Sunday 31 October at the Barbican Conference Centre. A full report was published in the December 1999 issue of *Gem & Jewellery News.*

London

On 12 October 1999 at Imperial College, South Kensington, Michael Marks, Production Manager for Elizabeth Gage, gave a talk entitled *Jewellery production problems and what to look out for.* A report of the talk was published in the December issue of *Gem & Jewellery News.*

On 8 December at Imperial College, Chris Walton of the Goldsmiths' Company gave a talk on *Jewellery and silverware today.*

Midlands Branch

On 29 October 1999 at the Earth Sciences Building, University of Birmingham, Edgbaston, Professor Dr H.A. Hänni of the SSEF Swiss Gemmological Institute, Basel, gave a presentation of his considerable expertise in the recognition and identification of treatments, particularly of diamonds, corundum and emerald.

On 26 November at the Earth Sciences Building, Alan Jobbins gave an illustrated talk on the Crown Jewels.

On 4 December the 47th Annual Branch Dinner was held at Barnt Green.

North West Branch

On 20 October 1999 at Church House, Hanover Street, Liverpool 1, Piero Di Bela gave a talk entitled *Window to Beauty.*

On 17 November at Church House the Branch AGM was held at which Irene Knight, Deanna Brady and Dr John Franks were re-elected Chairman, Secretary and Treasurer respectively.

This was followed by an informal session on diamonds and simulants.

Scottish Branch

On 4 October 1999 at the British Geological Survey, Murchison House, Edinburgh, John Wheeler gave a presentation on Australian opal, including a video on black opal from Lightning Ridge. Samples of top-quality black opal, boulder opal and white opal were displayed.

On 13 October at the British Geological Survey Michael Gray gave a talk entitled *Extraordinary gemstones. Benitoite: diamond and sapphire in one stone.*

On 3 November at the National Museums of Scotland, Chambers Street, Edinburgh, Campbell Bridges gave a talk on the new gemstones from East Africa.

PRESENTATION OF AWARDS

The Presentation of Awards gained in the 1999 Examinations was held at Goldsmiths' Hall, Foster Lane, London EC2, on Monday 1 November. The President, Professor R.A. Howie, presided and welcomed those present, particularly students who had travelled from as far away as China, Hong Kong, Japan, Kenya, Sri Lanka, Thailand and the U.S.A. He announced that in January and June 1999 a total of 1001 students entered the Gemmology Preliminary and Diploma, and the

Gem Diamond Examinations. A total of 183 students qualified in the Diploma examination and they came from 21 countries in all five continents. 105 students passed the Gem Diamond Examination and there were successful candidates from seven countries.

'Getting your Diploma in Gemmology', continued Professor Howie, 'is rather similar to taking your driving test: it allows you to go forward in the knowledge that you have been taught special skills. But I always remember the words of my driving test examiner: "Right, you've passed the test safely, but now the real learning begins and will continue all your life!" And so it is with gemmology – you have learnt all the procedures employed in examining and assessing a gemstone, but now you will have to continue to integrate and expand that knowledge and to develop that sixth sense that enables a gemmologist to feel that everything is not quite as it should be, and to continue testing and examining the stone until the uncertainty is quelled.

'Reverting again to the comparison with driving, my own view is that the most important factor in driving safely on the roads is to drive with "intelligent anticipation"; to expect the unexpected. I well remember that while my wife was learning to drive, I was driving in the narrow winding lanes in Cornwall with high banks and hedges on each side, and had just enunciated the principle that one should always drive expecting a steam-roller around the next corner: this time there

Miss Liu Jiewen, Guilin, China, receiving the Anderson medal.

was! We squeezed by, but on arrival at my destination, the Camborne School of Mines, the car park attendant seemed to be looking hard at the offside front of my old Morris and eventually enquired why I had got half a hedge wrapped round the end of the bumper!

'And so it is with gemmology. Expect your steam-roller, whether it be a moissanite or blue cobalt-doped synthetic forsterite showing strong pleochroism and convincingly masquerading as tanzanite, or indeed some new trickery of which there assuredly will be plenty. Be prepared to examine all its properties in detail as well as its overall appearance. But be ready to be surprised and delighted by yet further new gem mineral varieties in nature: some years ago no one would have dreamt of a blue zoisite – or indeed a gem johachidolite.

'To quote from Michael O'Donoghue's book *Synthetic, imitation and treated gemstones,* gemmologists, jewellers and gemstone collectors now have to accept that nothing is what it seems – or as Shakespeare has it in Macbeth "...and nothing is but what is not!" Take care and good luck in your future careers.'

Professor Howie introduced Mr E. Alan Jobbins, past Editor of the *Journal of Gemmology* and Chairman of the Board of Examiners, who presented the awards. Alan Jobbins delivered his address (see below) and a vote of thanks was given by Michael O'Donoghue.

Professor Howie concluded the proceedings by thanking the Goldsmiths' Company for kindly permitting the GAGTL to hold the ceremony at the Hall.

Address by E. Alan Jobbins

'You have passed your FGA Diploma, you have a great deal of theoretical knowledge and some practical experience – you have (as does a newly qualified doctor) a licence to practise. How are you to approach or continue in your future career? May I give you some useful tips. Which facts of the syllabus do you particularly need to remember; let us go back to Basil Anderson who often spoke of the three legs of the tripod of gem testing – the microscope, the spectroscope and the refractometer – they all depend on making use of light as does revealing the beauty of the gemstones themselves. By now all of you should be carrying your 10x lens (your low power microscope) in your pocket and this alone could usually help to distinguish diamond from the new simulant synthetic moissanite. Your pocket spectroscope will help with many coloured stones and your pen torch will provide the light. The refractometer will require operation on a bench or table and it is not that portable. Let us return to *light*, not only will it help to identify stones, but it will also help you to display and sell them. Good lighting in a shop or exhibition is is essential, and if your employer is not providing it you should use persuasion to get it improved.

'Another important topic I want to discuss is the making and taking of opportunities. Hopefully, by now you will have some idea of the career you hope you will be able to carve out for yourself. You will need to keep up with the latest developments and opportunities; you will need to read trade magazines (such as the *Retail Jeweller*) for adverts for new jobs (opportunities) and be prepared to apply for them; and gemmological journals such as *The Journal of Gemmology* to keep up-to-date with the latest gemmological developments.

'Shortly I will mention some of the opportunities that I have been able to take, but first I would like to tell you of the *great* opportunity taken by our President, Professor Howie, (way back in the '60s). He took over the editorship and developed *Mineralogical Abstracts*, which is now consulted in every country of the world by gemmologists, mineralogists, geologists and others for short abstracts of scientific papers published worldwide – it was a great opportunity taken and subsequently recognized as a colossal international achievement.

'I come now to an opportunity which has ultimately resulted in Chinese students gaining three of the four prizes awarded this year. The story started in 1981 when I visited Hong Kong en route to the International Gemmological

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Conference in Tokyo. In Hong Kong I met Mrs Ou Yang who ran the Hong Kong Gem Laboratory and is a leading expert in jadeite jade. She had been teaching at Beijing University and many members of the staff there had moved to Wuhan during the revolution in China where they joined the China University of Geosciences – the powerful geological training university. In 1988 Dr Jamie Nelson and I, through the good offices of Mrs Ou Yang, were invited to go to Wuhan to give a series of gemmological lectures. We went via Hong Kong and spent 24 hours on a train to get to Wuhan – quite an interesting experience! We lectured and ran laboratory tutorials from 8 am to after midnight each day for a week – they were the keenest students we had ever met. I returned in 1989 with Ken Scarratt, who was then Director of the Gem Testing Laboratory in London and is now Director of the American Gem Trade Association laboratory in New York. The opportunities we took up then have resulted in the Association having many allied teaching centres in China, and the FGA being a coveted qualification in China as well as other Chinese-speaking countries.

'I could go on with opportunities taken – they took me to Burma, Sri Lanka, India, Brazil and many other places during my 35 years at the Geological Survey and Museum. I didn't *have* to go on these overseas assignments – I took the opportunity.

'In 1982 the stocks of the small volume describing the English Regalia were running out and I was asked if I would be prepared to carry out a gemmological study of all the stones in the Regalia. I readily agreed. In late 1985 I was told that the examination would take place in February 1986 during the annual cleaning of the Regalia in the Tower of London. I was able to co-opt Dr Roger Harding and Ken Scarratt to assist me since I thought I had some idea of the magnitude of the task – little did I realize that we would examine 22,599 gemstones before we finished our work in February 1989. The major two-volume treatise *The Crown Jewels* was eventually published in 1998 – there were seven authors encompassing a wide range of subjects. An opportunity which none of us would have missed and is unlikely to be repeated.

'Nowadays permanent jobs are almost the exception and most of you will need to move – maybe to similar jobs in the jewellery industry. However, even if you leave gemmology for another profession, it will never leave you. Your power of observation and appreciation of beauty will stay with you. Seek out your opportunities, consider them carefully, and take the promising ones.

(From the left) Dr Roger Harding, Alan Jobbins, Professor Bob Howie and Michael O'Donoghue at the Presentation of Awards ceremony.

'Let me finish with the words of Francis Bacon, the statesman and philosopher. "A wise man will make more opportunities than he finds."

'Good luck to you all in your future careers.'

MEMBERSHIP

The following have been elected to membership during October and November 1999:

Fellowship (FGA)

Carvey, Robyn, Charleston, SC, U.S.A. 1983
Clouder, Carol J., Southampton, Hampshire. 1999
Hill, Stephen E., Rickmansworth, Hertfordshire. 1999
Isacsson, Johanna, Stockholm, Sweden. 1999
Lam Ho Keung, Hong Kong. 1999
Lam King Nam, Hong Kong. 1999
Li Yat Choi Johnson, Hong Kong. 1999
Li Yuling, Zibo, Shandong, P.R. China. 1999
McKeown, Nicola, Landrake, Cornwall. 1999
Morton, Heather D., Vancouver, BC, Canada. 1999
Osborne-Shaw, Lisa M., London. 1999
Parikh, Purnima, Vancouver, BC, Canada. 1999
Petropoulos, Andreas, Athens, Greece. 1999
Raniga, Dhanesh G., Burnaby, B.C., Canada. 1999
Schepers, Reinhold M., Limbricht, The Netherlands. 1999
Scholtes, Wanda, Schaijk, The Netherlands. 1999
Sietsma, Talke, Breda, The Netherlands. 1999

FORTHCOMING EVENTS

28 January	**Midlands Branch.** Bring and Buy followed by a quiz
30 January	**Midlands Branch.** Gem Play Group
15 February	**London.** *Some sites of precious minerals in England.* **Dr R.F. Symes**
16 February	**North West Branch.** *Ages and variety of amber.* **Wendy Simkiss**
21 February	**Scottish Branch.** *The lore of gemstones.* **Brian Jackson**
25 February	**Midlands Branch.** *Gem trails from the Orient to Germany.* **Ian Mercer**
27 February	**Midlands Branch.** Gem Play Group
15 March	**London.** *Chalcedony – 21st century girl's best friend.* **Stephen Webster**
15 March	**North West Branch.** *Moissanite.* **Alan Hodgkinson**
31 March	**Midlands Branch.** *All that glisters is not gold.* **Dr Rob Ixer**
7 April	**London.** *Visit to Kingston University*
19 April	**London.** *The colour of diamond and how it can be changed.* **Prof. Alan Collins**
27 April	**London.** *Visit to De Beers*
28 April	**Midlands Branch.** *Martyn Pugh – Silversmith: designer and manufacturer*
30 April	**Midlands Branch.** Gem Play Group
28 April to 1 May	**Scottish Branch Conference, Perth.** *Keynote speaker:* **Ken Scarratt**
10-12 May	**London – Kingston.** User school in Raman analysis for gemmologists
18 May*	**London.** *The Rose – nature's jewel as a decorative emblem.* **Corinna Pike**
21 May	**Midlands Branch.** *Memory Stather: Sources of inspiration and samples of her work. Doug Morgan: Gem cutting explained and demonstrated.*
14 June	**London.** *Visit to Treasures of the 20th Century exhibition at Goldsmiths' Hall*
24 June	**Midlands Branch.** Summer supper
26 June	**London.** AGM, Reunion of Members, and Bring and Buy Sale
12 July	**London.** *Faceting revolution.* **Roger Young**
30 July	**Midlands Branch.** Gem Play Group
27 August	**Midlands Branch.** Gem Play Group

* Note change of date for this event.

For further information on the above events contact:

London:	Mary Burland on 020 7404 3334
Midlands Branch:	Gwyn Green on 0121 445 5359
North West Branch:	Deanna Brady on 0151 648 4266
Scottish Branch:	Catriona McInnes on 0131 667 2199

GAGTL WEB SITE
For up-to-the-minute information on GAGTL events visit our web site on www.gagtl.ac.uk/gagtl

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Sopers, Margarita B.M., Den Haag, The Netherlands. 1999
Susitha, Pothmulla K., Colombo, Sri Lanka. 1999
Tang Tak Chuen, Hong Kong. 1999
van der Have, Ciska A., Amsterdam, The Netherlands. 1999
Vidoni, Tanya M., Toronto, Ontario, Canada. 1999
Wunna, Kyaw, Yangon, Myanmar. 1995
Xu Lizhen, San Francisco, Calif., U.S.A. 1998
Yang Hui Ning, Taichung, Taiwan, R.O.C. 1999

Diamond Membership (DGA)

Ao Yan, Beijing, P.R. China. 1998
Barbarovich, Peter M., North Crawley, Buckinghamshire. 1999
Chan Lai Lai Lily, Hong Kong. 1999
Chen Hui Lan, Shenzhen, P.R. China. 1995
Deng Xiuquan, Beijing, P.R. China. 1999
Griffin, Anthony Edgar, Haslemere, Surrey. 1994
Huang Yichun, Guangdong, P.R. China. 1998
Iconomou, Politimi, Athens, Greece. 1999
Kong Jie, Beijing, P.R. China. 1998
Li Li, Beijing, P.R. China. 1998
Li Wei, Beijing, P.R. China. 1999
Liu Feng, Beijing, P.R. China. 1998
Ma Si Ji, Beijing, P.R. China. 1998
Ngala, Dadou K., London. 1999
Parnell, Alexander J., Hove, E. Sussex. 1999
Shi Yan, Beijing, P.R. China. 1998

Ordinary Membership

Abeid, Ahmed, Southall, Middlesex
Brunt, Emily F., Fivemiletown, Co. Tyrone
Chan Hin Tung, Tony, Hong Kong
Checkley, Emma L., Warley, Birmingham
Christianos, Melina Z., Notting Hill, London
Cosmelli, Diana F., London
Damalis, George H., Winchmore Hill, London
Donovan, Matthew J.R., Berkhamstead, Hertfordshire
Fung Wai Chu, Edwina, Hong Kong
García Oliver, Eugenia M., London
Hunter, Thomas S., Southport, Lancashire
Killingback, Harold, Brooke, Oakham, Leicestershire
Reid, Rosa Maria, London
Sansford, Martin, Ayr
Stone, Roger W., Parwich, Derbyshire
van Doren, Jean-Paul, London
Walton, Ralph N., Hermanus, Cape, South Africa

Laboratory Membership

Chris Chaplin, St. Martin, Guernsey, CI.

CORRIGENDUM

In *J. Gemm.*, 1999, **26**(8), p. 550, second column, Diploma Examination results 'Kamil, Ruzwain' should read 'Kamil, Ruzwan'. We apologize for the error.

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Contents

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Cover Picture

From the depths of the Earth or the depths of the laboratory. Images of synthetic sapphire, tourmaline mining and synthetic diamond – see inside