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Cover Picture

A synthetic diamond during electron bombardment.
Symmetric arrangement of various growth sectors
of greenish-yellow and blue clearly revealed. (*See* Cathodoluminescence
(CL) and CL spectra of De Beers' experimental synthetic
diamonds by Johann Ponahlo, p.3-17.)

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R. Keith Mitchell, FGA

It is fitting that as we introduce this new volume of the *Journal* we honour one of our eminent Fellows who celebrates his eightieth birthday on January 28 1992.

Mr Mitchell joined the silver and leather-goods buying department of Mappin and Webb Ltd in 1928. Geology and minerals had always fascinated him and he eventually obtained a move to their gem department in 1933.

The previous year had been significant since he then joined the gemmology course under J.G. Jardine at Chelsea Polytechnic. In 1934 he won the Tully Memorial Medal despite strong rivalry from Robert Webster and other students in what had been a remarkable year - the first in the charge of B.W. Anderson - when nearly half the students who sat the examination achieved Distinction passes and no one failed.

He wrote occasionally for the *Gemmologist* and other journals until marriage in 1937, and the War two years later, diverted his interests.

1936 had seen him working first for B. Barnett Ltd and then for A.E. Davis Ltd in London's Piccadilly, where he remained through the desperate period of the London Blitz until call-up in 1941 sent him north to Catterick to train as an operator in the Royal Corps of Signals.

Training completed he was shipped to Singapore, arriving ten days before Japan entered the war. Ten weeks later Singapore fell and he was incarcerated with some fifty thousand other prisoners in the Changi area. After 15 months and much ill-health he was shipped to Hokkaido, the northern island of Japan, to slave long and hard under extremely arduous conditions on an insufficient diet of rice, levelling airfields, feeding steel furnaces and mining coal.

At the end of the War he came home to rejoin A.E. Davis in Piccadilly and remained with that firm until 1957. A misguided appointment with a provincial jeweller swiftly foundered and Mr Mitchell started dealing from home on his own account in July of that year.

By this time his interest was largely in antique jewellery and in rare and unusual gems and over the years the writer, who had first met Keith Mitchell in 1950, had, in his capacity as Curator of Gem and Mineral Collections at the Geological Museum, acquired from him many outstanding and mouth-wateringly beautiful gems for those National collections. Some of these had come from contacts with over-seas students in the course of Keith's teaching activities.

He had assisted the late Thorold Jones with practical classes at Chelsea Polytechnic in 1947 and, when Anderson gave up teaching and Webster took over the practical instruction in 1949, moved on to tutor first year students in the Gemmological Association Correspondence Courses. Within a year C.J. Payne opted out of the Diploma course instruction and the late Gordon Andrews, the shrewd secretary of the Gemmological Association, asked Mr Mitchell to take both Courses over. He then ran these single-handed until 1959 when Vera Hinton took on 100 of the first year students and then, a year or so later, the Rev. Nikon-Cooper also took over some of the first year people. Mr Mitchell still coped with a substantial surplus of first year students and with the entire Diploma quota for twenty years (during which eight of his students gained Tully Medals), plus frequent revision of course notes to keep them in line with a rapidly advancing subject, until 1969 when sudden illness forced him to give up this work. One year he had found himself with a work-load of some 240 students, some of whom elected to write in their own languages rather than in English. In 1979 he was once more asked to revise the Course notes which had been allowed to become rather static in the ten years since he had retired as an instructor. By the mid-eighties a veritable team of instructors had taken his place.

In business he continued to work from home until insurance problems forced him to take an office in Holborn in 1967, a happy move which was to prove very rewarding until he retired from active business in 1979. But the habits of a lifetime die hard, and even today he still dabbles a little with gems and jewellery and undertakes some coaching when students ask.

Always interested in writing, he has contributed some fifty papers of greater or lesser scientific importance to this and to other Journals both here and overseas since the mid-thirties and compiled a set of Gem Crystal Transparencies which assist the teaching of crystal recognition. Today he is perhaps best known for the numerous abstracts from foreign magazines which have appeared over the initials R.K.M. for many years in our *Journal*, and for lamentably frequent obituaries of old friends.

In April 1984, 50 years after acquiring his Tully Medal, R. Keith Mitchell was elected Vice-President of our Association - a well-deserved tribute and a fitting reward for the very considerable service he has afforded to the Association for more than half a century. We wish him well for many years to come.

Cathodoluminescence (CL) and CL spectra of De Beers' experimental synthetic diamonds

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1. Introduction

Large man-made experimental diamonds have been described by various authors in the past (Crowningshield (1971), Koivula *et al.* (1984), Shigley *et al.* (1986, 1987)). There is no doubt, anymore, about the technical potentialities to grow single crystals of diamonds up to 20ct. Two years ago, by courtesy of the Diamond Research Laboratory, Johannesburg, and the DTC Laboratories, Great Britain, the author had the opportunity to investigate ten yellow to brown experimental synthetic diamonds made by De Beers (Table I). The gemmological properties of similar stones have already been described (Shigley (1987)). Since little information on cathodoluminescence (CL) of these yellow synthetic diamonds was given their CL properties were studied more thoroughly. Twelve natural diamonds of similar colours were included in the investigation.

Nowadays, not much is known to the average gemmologist on the cathodoluminescence (CL) of diamonds – their interests being focused on transmission spectrography. This paper should give an indication of the wealth of information that can be obtained on natural and synthetic diamonds by means of CL if the CL methods described are properly applied. References are also given to some relevant recent CL literature.

2. Procedures

The CL features and spectra were studied at room temperatures using a modified LUMINOSCOPE® (Ponahlo (1989)). Instead of fibre-optics, direct focusing of the enlarged image of the luminescing sample surface onto the entrance slit of the monochromator proved to be a more efficient arrangement which increased the transmissivity of the whole system.

In the past CL methods have been criticized since they may have induced colour changes during bombardments with electrons. With the present arrangement (Ponahlo (1989)) no such detrimental effects were observed. Due to the high surface energy of a diamond traces of oil from the pumping system may diffuse into the vacuum compartment and become absorbed on the surface of a sample where they are cracked by the electron beam. By placing a molecular sieve between the pumping system and the vacuum compartment contamination can be avoided. If, in rare instances, a slight yellow to brown discoloration of a bombarded diamond facet is observed the thin film may easily be removed using a polishing agent.

Photomicrographs of the CL features and CL spectra were taken with the diamond sample resting on a movable platform inside the vacuum compartment, the table or a (001) face parallel to the stage of the microscope. Visual observations and CL spectra were taken at lower energies of excitation than the photomicrographs, but the data of the latter are given within the captions of the photomicrographs.

3. CL features of synthetic and natural diamonds

The following Figures (1 to 29) represent a selection of photomicrographs and CL spectra of most of the diamonds investigated. In contrast to the very weak luminescence intensities obtained when using UV light, CL is known for bright luminescence effects which are concentrated in a thin surface layer (1 to 2 μm). This offers a striking advantage for both visual observations and microscopic studies as well as for quantitative measurements of the CL spectra. Any sort of morphological luminescing detail (defects, banding, inclusions, etc.) will show brightly, sometimes in different colours or shades.

CL features of synthetic diamonds with cubo-octahedral habit were first studied by Woods and Lang (1975) and by Vishnevsky (1975). Lang also refers extensively to CL studies of natural diamonds in Field (1979). More detailed information on large experimental synthetic diamonds carried out by solid state physicists became available, especially with the papers by Burns *et al.* (1990) and by Frank *et al.* (1990) which contain – besides further references – information on CL spectra taken at low temperatures, on IR-spectra and electron microscopy. From these papers and the information

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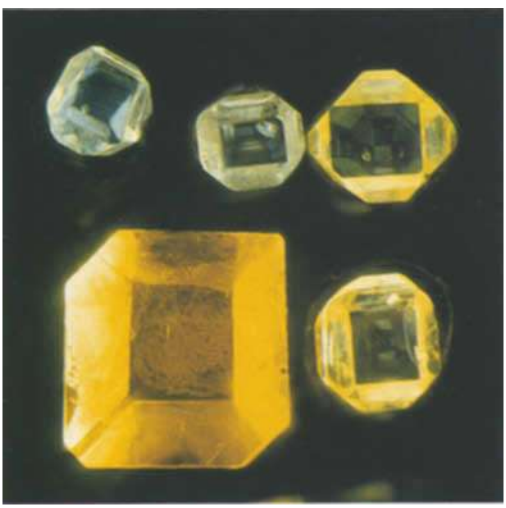
Fig. 1. Set of 7 experimental synthetic diamonds made by De Beers. Top row, left to right: DMY-4 (0.97 ct), DMY-6 (0.40 ct), DMY-10 (0.44 ct) and DMY-5 (1.03 ct). Bottom row, left to right: DMY-1 (5.24 ct), DMY-2 (4.57 ct) and DMY-3 (4.10 ct). Note cubo-octahedral habit and natural colours. 2.6x, incandescent light.

contained in this work it is hoped that it will become evident to the gemmologist that CL constitutes a most useful technique for the identification of synthetic diamonds.

Fig. 2. CL colours of five experimental synthetic diamonds made by De Beers. Top row, left to right: DMY-10, DMY-6 and DMY-5. Bottom row, left to right: DMY-3 and DMY-4. 1.05x, cond. excit.: 7.5 kV, 0.9 mA.



3.1. CL features of the experimental synthetic diamonds

Figure 1 gives an impression of the colour and habit of seven experimental synthetic diamonds in incandescent light. The high CL intensities of some of these synthetic diamonds is evident in Figure 2. During an electron bombardment using a beam-energy of 7,5 kV at 0,9 mA for visual observation, even the inclusions in the synthetic specimens (DMY-10, DMY-6 and DMY-5) become easily visible.

The following two Figures 3 and 4 are close-ups of the synthetic diamond DMY-1. Figure 3 is taken under incandescent light between crossed polars with stress-induced polarization phenomena. Figure 4 shows the same large crystal inclusion at higher magnification during the electron bombardment. The greenish-yellow CL colour as well as a stress-induced cloud around this crystal not visible in Figure 3 should be specially noted. Fine parallel orange-red needles are also noticeable. The blue CL colour may indicate different N-concentrations in otherwise not visible 110 and 113 minor growth sectors.

Figure 5 is a typical example showing the topography of the experimental synthetic diamonds brilliantly made visible by means of CL. The regular pattern of the various growth sectors is

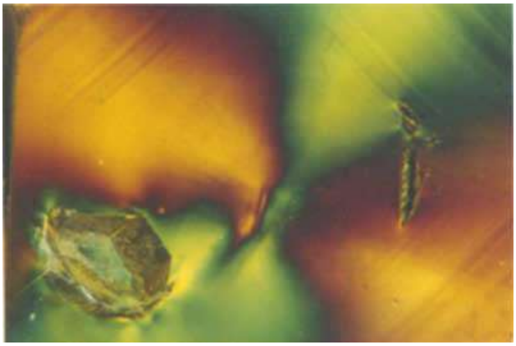


Fig. 3. Inclusions in DMY-1 with stress-induced polarization figures (catalyst and large euhedral crystal of unknown composition). Transmission photograph, crossed polars. 22x.

Fig. 4. The same large crystal inclusion as Fig. 3 during electron bombardment. Note greenish-yellow CL colour, stress-induced cloud around the crystal and fine orange-red needles barely visible in transmitted light. Blue CL colour indicates lower N-concentration, irregularly distributed. 43x (24 x 36mm).

Fig. 5. Typical growth sectors in the experimental synthetic diamonds with characteristic double bell-form of 111 sectors intensely banded, and bright greenish-yellow 001 sector. Intercalated blue and dark green sectors resembling higher indexed faces. Cond. excit.: 12 kV, 0.9 mA. 28x (24 x 36mm).

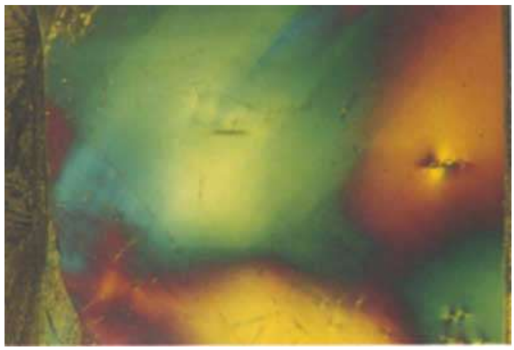


Fig. 6. Transmission photograph of DMY-3 with stress-induced zones of various colours, small transparent inclusions fine needle-like exsolved (?) material. Crossed polars, 22x.

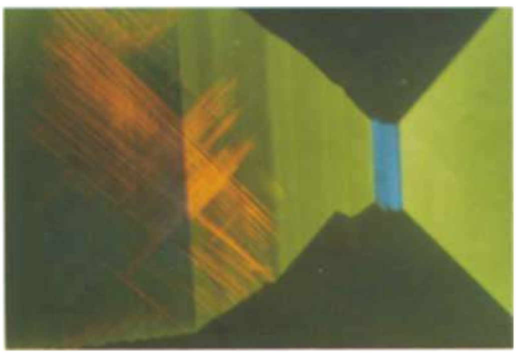


Fig. 7. Part of several growth sectors of DMY-3. Two greenish-yellow growth sectors with strong banding with intercalated blue rectangular area ((110) and (113)) faces. On the left two bundles of orange-red needles intersecting each other at about 90°. Cond. excit.: 15 kV, 0.95 mA. 28x (24 x 36mm).

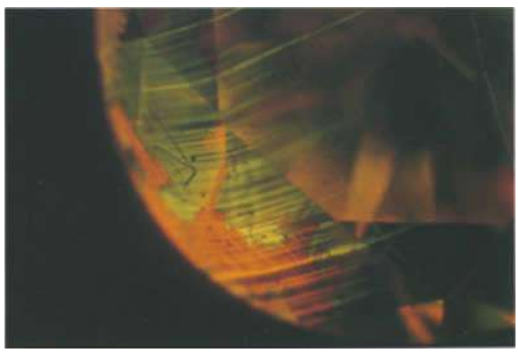


Fig. 8. CL of the natural yellow cut diamond DM-M3. Bundles of parallel (multiple) twinning lines become easily visible by CL, the colour being a golden yellow with a distinct tinge of orange. Such effects in natural diamonds can be clearly differentiated from those visible in Fig. 7. Cond. excit.: 8.5 kV, 0.9 mA. 10x (24 x 36mm).

Table I: CL Spectra of ten experimental synthetic diamonds made by De Beers

Sample	weight (ct)	CL spectra (nm)		CL colour + features	remarks
DMY 1	5.240	526	strong	gr. yell. (100)+(111)	banding
DMY 2	4.570	535 + 570	medium	gr. yell. (100)+(111)	violet incl. in (100)
DMY 3	4.104	526, 544, 575	medium	gr. yell. (100)+(111)	+add. blue in (110) orange-red needles
DMY 4	0.972	548	v. strong	yell. with gr. tint	banding
DMY 5	1.037	484 + 520		blue + gr. + yell.	st. banding
DMY 6	0.40	480, 520, 538	medium	yell. CL colour change	white + blue
DMY 7	0.901	537	v.v. strong	gr. yell.	st. banding orange-red needles
DMY 8	0.386	480, 514, 524	medium	blue + weak yell.	banding
DMY 9	0.270	480, 554, **820!**	weak	blue + golden yell.	st. banding
DMY 10	0.44	532 + 539	med. strong	white + blue + yell.	banding

Abbreviations: gr. yell. = greenish-yellow CL colour; (111) = luminescing growth sectors; incl. = inclusions visible in CL; v. = very; add. = additional CL colours; st. = straight; wavelength in (nm).

striking. Small dark laths and blue geometrical patterns represent higher indexed faces ((110) and (113)). The greenish-yellow 111 sector extending to the upper left in Figure 5 shows regular parallel banding like other octahedral faces of the sample. A 001 growth sector – parallel to the stage of the microscope – does not exhibit such banding although it is brightly luminescing in the same greenish-yellow colour. These features are documents to the differential uptake of impurities (N) by the different types of growth sectors which are unique to these true large cubo-octahedral synthetic diamonds.

Figures 6 to 8 should be studied together so as to compare some rare but characteristic internal structural features of both a synthetic and a natural yellow diamond. DMY-3 was chosen for its orange-red needles running crosswise (Figure 7), and DM-M3 (Figure 8) because of its similar inclusions of a golden-yellow colour. DMY designates a synthetic diamond, DM a natural one.

The orange-red needles – made visible by means of CL only (!) and noticeable in DMY-1 (Figure 4) (and DMY-9 too) exhibit a distinct spectrum (Figure 28 shows the visible and near infrared (VIS-NIR) spectrum of DMY-9). Its origin remained obscure until now, but recently similar orange-red needles with the distinct NIR-spectrum have been discovered in one small yellow synthetic diamond made in the USSR.

Some of the irregularly distributed dark inclusions of Figure 6 – they look like pencil marks – may be inclusions of catalyst or rather large dislocations. In Figure 7 the small blue rectangular growth sector between the greenish-yellow luminescing ones shows a weak banding. Note that the shape and the banding of the 111 growth sectors in DMY-3 are similar to those in DMY-1 and DMY-2 (the latter not shown in a photomicrograph).

These features, made visible by means of CL, should be clearly differentiated from occasionally observed multiple twinning in natural diamonds, an example of which is shown in Figure 8, the weakly luminescing DM-M3. A further differentiation is possible by means of their respective CL spectra (see section 4.2.).

The synthetic diamond DMY-4 shows a more yellow CL colour with a lesser greenish tint but somewhat similar to DMY-3.

The Figures 9 and 10 are other examples of the discriminatory power of the CL microscopy over studies with crossed polars alone. The blue and green CL colours of DMY-5 in Figure 10 disclose a variety of symmetrically arranged growth sectors with strong banding in some of these. Stress phenomena around larger inclusions become easily visible, also a weak orange luminescence of intersecting needles that characterize a (001) face. The blue seams around the green banded sectors are higher indexed (110) and/or (113) faces. Even these small faces show some banding.

Other inherent structural details become strikingly obvious when comparing Figure 11 of DMY-7 with Figure 12 of the natural yellow diamond DM-M2. In the latter the blotchy irregular blue, brownish-yellow and dark brown patterns, with the faint indication of a drawing superimposed, are unmistakable indicators of CL features of a natural diamond. Contrasting evidence of the synthetic origin of DMY-7 is furnished by the symmetrical arrangement of banded growth sectors. They show vivid greenish-yellow CL colours of octahedral faces and an octagonal shaped (001) face with a Maltese cross. A close-up of the latter feature is presented in Figure 14. Such Maltese crosses have frequently been found on cube growth faces when bombarding yellow or greenish-yellow synthetic Sumitomo diamonds (Ponahlo, 1989). Recently, Frank *et al.* (1990) have dealt extensively with that feature caused by inhomogeneities of impurity distributions in cube growth sectors. Figure 13 illustrates other surprisingly beautiful internal features made visible by means of CL: around a large inclusion orange-red needles become visible (compare also Figures 7 and 11).

Figures 15 and 16 refer to the synthetic diamond DMY-8. The photomicrograph of Figure 15 was taken in incandescent light. Only elongated and round inclusions become noticeable. The four isosceles triangles in cross-like arrangement are images of polished facets of this octagonal step-cut experimental synthetic diamond DMY-8. Figure 16 reveals a blue CL colour, its intensity being strong enough to make visible not only the inclusions of Figure 15 but also other features like the symmetrical arrangement of the growth sectors and some banding.

The most colourful synthetic diamond investigated was DMY-9. It displayed a blue CL colour and showed distinct 001 and 111 growth sectors with banding as distinct signs of its man-made origin.

The following Figures 17 and 18 make obvious how much has still to be learned about CL of diamonds. When first looking at the synthetic diamond DMY-10 under crossed polars in incandescent light (Figure 17) a strong greenish-yellow CL was expected with strong banding concentrated within specific growth sectors. Figure 18 shows this man-made product luminescing in a brilliant blue with blue-white banding of growth sectors. CL also reveals more details of and around inclusions. Some parts of this luminescing cubo-octrahedron exhibit a greenish or yellowish CL colour.

3.2. CL features of some natural diamonds

Some advantages of CL as a non-destructive testing method for diamonds are emphasized by the following photomicrographs of yellow and yellowish-brown *natural* diamonds specially selected for similar colour and appearance.

DM-M5, of cognac colour, is emitting blue, green and strong straw-yellow CL with unique geometric patterns that give evidence for its natural origin (Figure 19). The CL colour of the yellow natural diamond DM-K1 is predominantly blue. A small straw-yellow pentagon in its CL topographical pattern makes it easy to distinguish it from any synthetic counterpart (Figure 20). The pentagonal pattern results from octahedral growth horizons intersecting differently inclined polished facets. Welbourn (1989), and Hanley *et al.* (1977) have examined CL effects in natural diamonds and given evidence of type-II natural diamond intermixed within type-I diamonds as a possible cause for the straw-yellow *stratigraphical* patterns that can be seen in the Figures 19 and 20.

The natural colour of diamond DM-M1 is cognac as is DM-M5. However, it luminesces in a saturated greenish-yellow, but the CL topography is completely different from that of other natural diamonds (Figure 21). The rectangular geometrical pattern closely resembles a site of ruins fittingly described as 'Pueblo structure'. It should be stressed that in no case were such yellow and/or blue growth patterns detected in any of the ten experimental synthetic diamonds made by De Beers or in other small synthetic diamonds investigated so far.

4. CL spectra

4.1. Some general remarks

CL spectra of diamonds originates from defect centres which have been the subject of extensive studies in the past. Some have special symbols (Collins, 1982). Marfunin (1979) presents a short survey. In diamond research solid state physicists refer to so-called zero-phonon lines as distinct very small bands visible in absorption and luminescence spectroscopy but below −100°C only. A zero-phonon line is accompanied by a range of additional bands of weaker intensity at the longer wavelength-side of a CL spectrum. As these bands disappear when spectra are taken at room temperature, such CL spectra would show the enveloping curve of such low-temperature signals. Therefore, no final assignments are given here and reference is made to Burns *et al.* (1990).

4.2. CL spectra of the experimental synthetic diamonds

DMY-1 to DMY-3

The peak-maxima of the CL spectra of these diamonds (Figure 22) show a tendency to shift from 526nm (DMY-1) to 535nm (DMY-2) and further to 541nm (DMY-3). The corresponding energies are

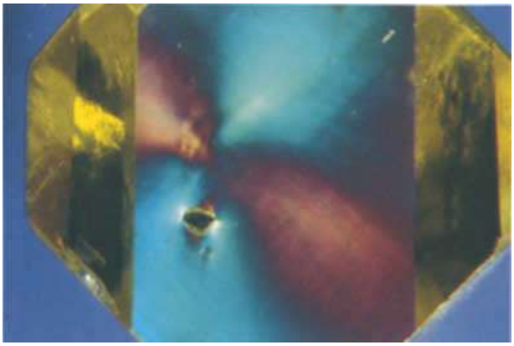


Fig. 9. Undulous extinction figure in DMY-5 and large transparent inclusion of unknown composition. Transmission photomicrograph. Crossed polars. 10x (24 x 36mm).

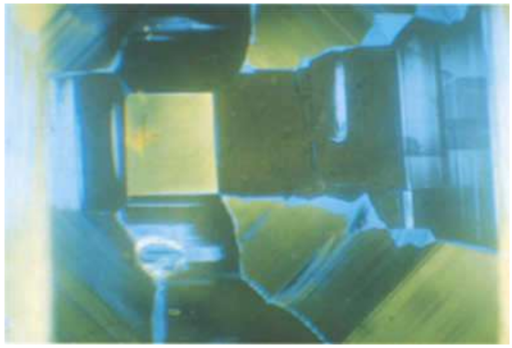


Fig. 10. The same synthetic diamond (DMY-5) as in Fig. 9 during electron bombardment. Symmetric arrangement of various growth sectors of greenish-yellow and blue CL colours clearly revealed. Note strong banding in 111 quasi bell-shaped sectors and different shades of blue in higher indexed ones. Cond. excit.: 11 kV, 0.9 mA. 28 x (24 x 36mm).

2,359 eV (DMY-1), 2,323 eV (DMY-2) and 2,281 eV (DMY-3).

Of these diamonds DMY-3 with its orange-red needles (Figure 7) gave rise to a CL band in the NIR with a peak at 820nm (1,513 eV). Such a signal was also found in the CL spectra of the synthetic diamonds DMY-6 and DMY-9 (compare the spectra in the Figures 24 and 28). The spectra of DMY-3 and DMY-6 are not reproduced because of the similarity of the 820nm band in the NIR.

DMY-4

The CL spectrum of this yellow synthetic diamond resembles that of DMY-3 up to 750nm, but the peak-maximum is shifted to a higher wavelength at 548nm (2,264 eV).

DMY-5

The CL colour of DMY-5 is a mixture of blue and yellow apparently resulting from different growth sectors. The CL spectrum contains, therefore, two distinct peak-maxima; the first at 481nm, the second at 526nm. Other parts luminescing yellowish show weak satellite bands at 612 and 750nm (2,027 eV and 1,654 eV).

DMY-6

DMY-6 is another example of a greenish-yellow luminescing synthetic diamond with distinct banding in the growth sectors. The CL spectrum taken of one of the banded pyramidal growth sectors contains a band with a peak at 481nm similar to DMY-5, DMY-8 and DMY-9. After a few minutes

Fig. 11. CL of DMY-7 with its characteristic growth sectors in perfect symmetric arrangement. Small blue rectangular sectors barely visible between large cubic and octahedral ones. Vivid greenish-yellow CL colour. Maltese cross in cubic sector indicated. Cond. excit.: 11 kV, 0.9 mA. 11.5x (24 x 36mm).

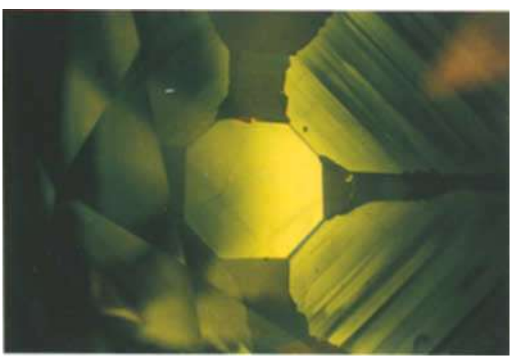


Fig. 12. Natural yellow diamond DM-M2 which luminesces with nearly the same greenish-yellow CL colour as the synthetic diamond DMY-7 but showing totally different growth features. Note the delicate geometric pattern within the yellow central blotch. It should be compared with Fig. 21. Cond. excit.: 9.5 kV, 0.9 mA. 10x (24 x 36mm).

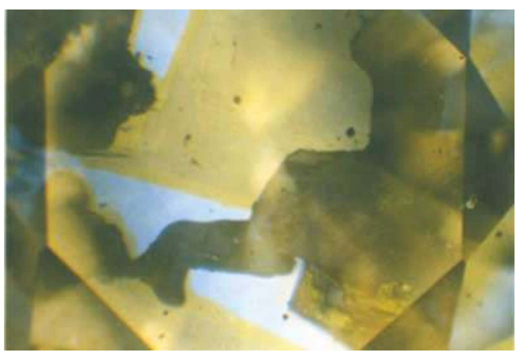


Fig. 13. Same stone (DMY-7) as in Fig. 11 with one 111 growth sector containing large inclusion surrounded by orange-red needles of unknown composition. Higher indexed faces luminescing steel blue. Cond. excit.: 11 kV, 0.9 mA. 10x (24 x 36mm).

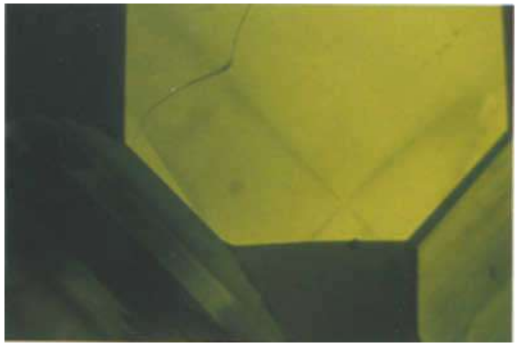


Fig. 14. Same stone (DMY-7) as in Fig. 11 showing dark Maltese cross on greenish-yellow luminescing octagonal growth sector at higher magnification of 28x (24 x 36mm). Same cond. excit.

of bombardment its CL colour starts to change into a steel-blue. Some parts of the growth sectors lose colour turning into a weak whitish-yellow. The new CL spectrum is characterized by two distinct bands with maxima at 481 and 520nm (2,386 eV). The Figure 23 gives an impression of the CL spectra of DMY-4, DMY-5 and DMY-6, the last one with a CL spectrum right before the colour change still showing a band with a maximum at 537nm (2,308 eV) similar to that of DMY-2.

DMY-7

DMY-7 is a brownish-yellow brilliant-cut synthetic diamond. Its CL spectrum is presented in Figure 24. The maximum of the intense band lies at 532nm (2,332 eV). The CL colour resembles that of many Sumitomo-synthetic diamonds, but unlike the Sumitomo-products this large synthetic diamond made by De Beers is characterized by symmetrically arranged growth sectors with pronounced banding.

DMY-8

DMY-8, a greenish-yellow cut synthetic diamond displays a blue CL spectrum which contains a marked shoulder at 480nm followed by a band peaking at 520nm (2,384 eV). A subdued yellow CL is also noticeable. Figure 24 shows a smoothed CL spectrum of this sample.

DMY-9

Of the ten synthetic diamonds tested DMY-9 seems to belong to a rare type. It is the most colourful synthetic diamond tested so far. Its CL colour is a golden-yellow within various growth sectors and some blue. The CL spectrum is of weak intensity and characterized by a shoulder at about 483nm and a peak at 527nm. In the NIR a medium

Fig. 15. Transmission photomicrograph of synthetic octagonal step-cut synthetic diamond DMY-8. Elongated and irregularly shaped opaque metallic inclusions. Four isosceles cross-like triangles are polished facets. 12x (24 x 36mm).

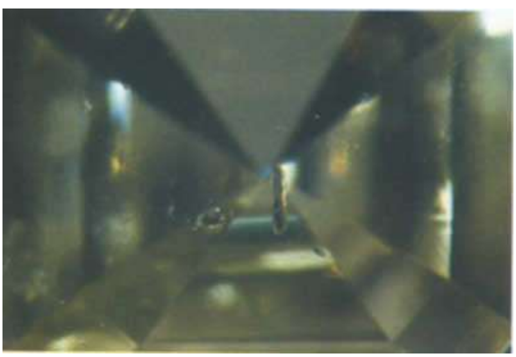


Fig. 16. Same stone (DMY-8) as in Fig. 15 showing blue and subdued yellow CL colours with illuminated but non-luminescing inclusions. Note already familiar geometric arrangement of banded growth sectors. Cond. excit.: 10 kV, 0.95 mA. 10x (24 x 36mm).

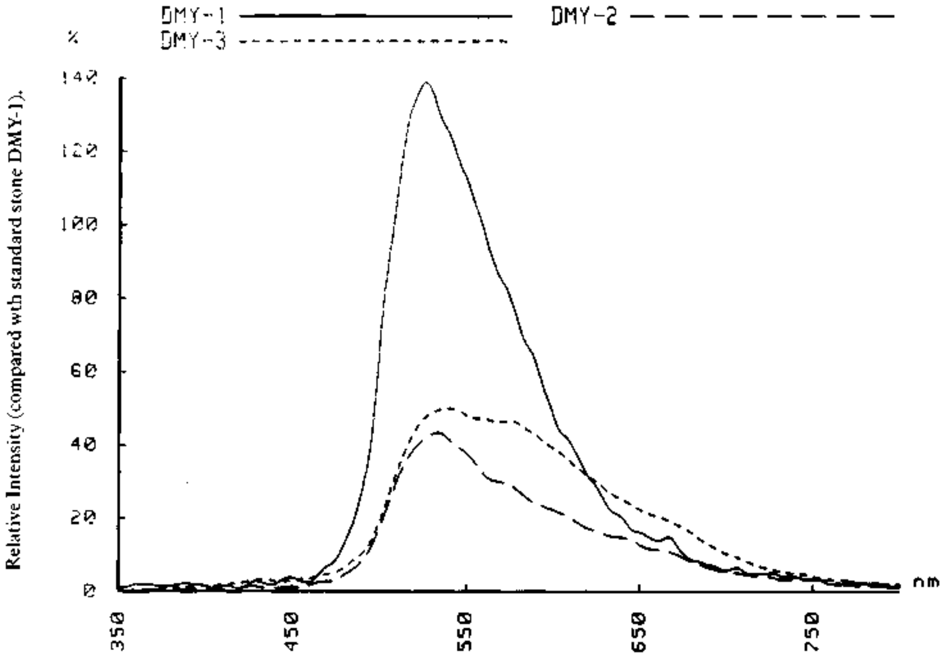


Fig. 22. CL spectra of 3 experimental synthetic diamonds made by De Beers. Polished (001) faces of cubo-octahedral specimens with greenish-yellow CL colour.

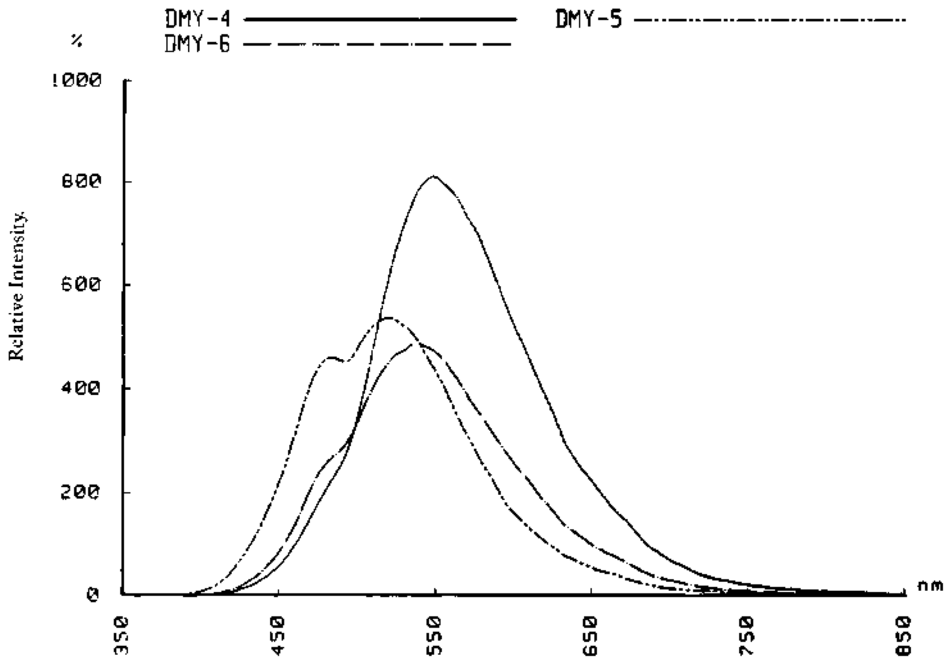


Fig. 23. CL spectra of 3 experimental synthetic diamonds made by De Beers. Polished (001) faces of cubo-octahedral specimens with greenish-yellow CL colour (4 and 6) and blue-yellow section (5).

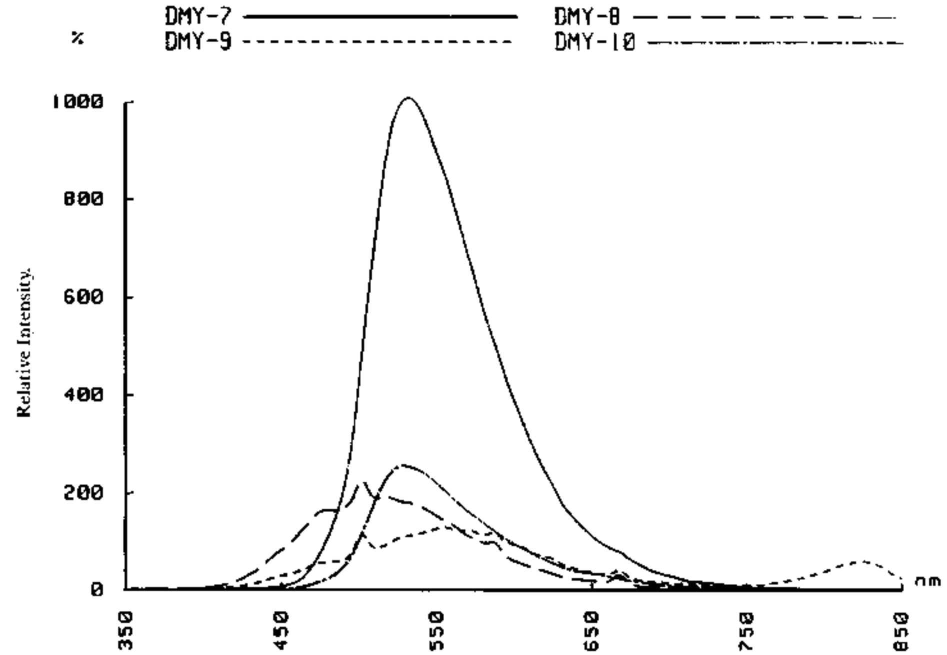


Fig. 24. CL spectra of 4 experimental synthetic diamonds made by De Beers. Polished (001) faces of cubo-octahedral specimens with greenish-yellow to yellowish-green CL colour (7 and 10), blue (8) and blue plus golden-yellow (9).

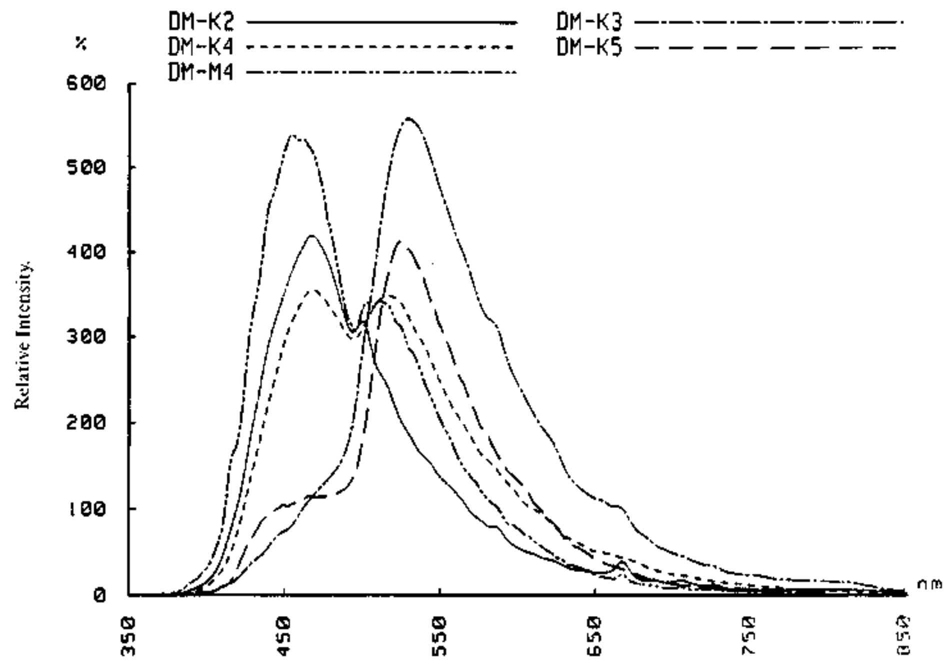


Fig. 25. CL spectra of 5 natural yellow and brownish cut diamonds, table up showing blue CL colour (K2, K4 and K5, M4) and yellowish-green CL colour (K3).

Fig. 17. Transmission photomicrograph of DMY-10 showing vivid interference colours under crossed polars and large inclusions. 6x (24 x 36mm).

Fig. 18. Same stone (DMY-10) as in Fig. 17 showing bright blue and blue-white CL colours with some sections exhibiting greenish yellow CL colours (not shown). Note banded double bell-shaped growth sector. Cond. excit.: 12 kV, 0.9 mA. 28x (24 x 36mm).

to strong band centred at 820nm (1,511 eV) was found. At closer inspection golden-yellow twinning lines and orange-red needles were located. They are thought to be the main cause for the 820nm-band. Figure 24 gives an indication of its intensity.

DMY-10

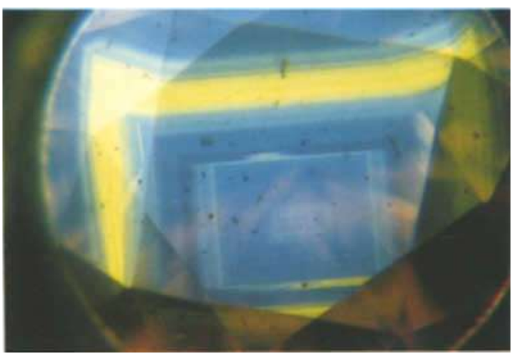
This small yellowish-green synthetic rough DMY-10 luminesces strongly when bombarded by electrons. Its CL colours are blue, greenish-yellow and yellow. The greenish-yellow growth sectors are heavily banded. CL peaks were measured at 532nm and 539nm. Other growth sectors show a shift to lower peak-wavelengths between 527 and 529nm.

4.3. CL spectra of yellow and brown natural diamonds

Table II shows CL and other data on 12 carefully selected yellow and brown natural diamonds (DM-K1 to 6 and DM-M1 to 6) providing a good colour match to the experimental synthetic diamonds described in the previous sections. Much information can already be obtained from visual studies of the CL features of natural diamonds. The Figures 8, 12, 19-21 should serve as relevant examples. According to the data three groups of natural diamonds may be differentiated:

a) medium to weakly blue-luminescing diamonds;
b) diamonds with a very weak blue CL, visible only as a luminescing cap on the table; and
c) diamonds showing mainly a greenish or brownish-yellow or straw-yellow medium to strong CL intensity.

Fig. 19. CL colours and growth stratigraphy of the natural diamond DM-M5. Its daylight colour is cognac. Rectangular dark blue, greenish and straw-yellow zones give evidence of a different growth history of such natural diamonds from their synthetic counterparts (see also text and literature). Cond. excit.: 7 kV, 0.9 mA. 10x (24 x 36mm).



4.3.1. (a and b) Blue CL

At room temperature the blue luminescing yellow or brown natural diamonds have distinct CL peaks at 468nm (2,651 eV) or a little lower. If these diamonds show a straw-yellow geometrical pattern as an indicator of their growth history – such as can be seen from the Figures 19 and 20 – a CL band with a maximum at 636nm (1.949 3V) may be detected. But in most cases the CL spectrum of such natural diamonds will cover the entire visible spectrum range, the tail reaching to 750nm. Some CL spectra show two (or more) bands, one between 440-481 and another between 511-530nm. DM-K4 is a typical example with two CL bands of equally high intensity (Figure 25), one has a maximum at 469nm (2,643 eV), the other at 517nm (2,397 eV).

4.3.2. (c) Yellow CL

DM-M6 luminesces bright yellow (Figures 28 and 29). The CL spectrum shows a distinct band with a peak at 532nm (2.330 eV), the intensity being forty times stronger than any of the other CL

Table II: CL data of natural cut diamonds

Sample	weight (ct)	CL spectra (nm)				CL colour	remarks
DM-K1	0.462	(402)	(481)	–	–	blue	yell. p.p.
DM-K2	0.664		**468** s	–	–	blue	yell. p.
DM-K3	0.559	–	–	**530** s	–	gr. yell	
DM-K4	2.18	–	**469**	**517** s	–	blue	
DM-K5	0.70	(450)*	(470)*	**525** s	–	blue	
DM-K6	1.59	(440)	464 w	–	–	blue cap	
DM-M1 c.	1.661	**452**	–	(519)	–	blue	yell. p.
DM-M2 yell.br.	0.466	–	–	**548**	–	yell. +	w. blue
DM-M3 yell.	0.374	–	–	530	–	br. yell.	
" o.r.p-	"	–	–	–	**612/618**	orange	or. needles
DM-M4 br.yell.	0.21	**456**	**463**	(512)	–	s.blue	milky
DM-M5 br.yell.	0.170	(457)	**464**	(512) w	–	blue	milky
DM-M6 yell.	0.506	–	–	**526** ss	–	yell.	
DM-MX yell.	0.266	–	**476**	**514** s	–	blue	

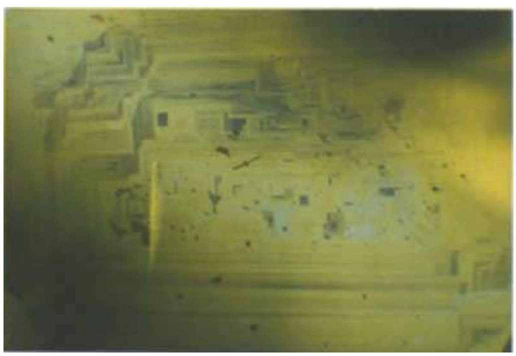
Remarks: s. = strong CL signals; ss = very strong CL signal; w = weak CL signals; yell. = yellow CL colour; yell.p. = straw-yellow rectangular pattern; MX = masterstone; yell.p.p. = straw-yellow pentagonal pattern; o.r.p. = orange-red inclusions; br.yell. = brownish-yellow daylight colour; c = cognac daylight colour; Shoulders = *; weak bands = brackets; main peaks = bold.

spectra of natural yellow and brown diamonds tested so far. Such a CL spectrum comes close to the CL spectra of some of the synthetic diamonds investigated with a peak wavelength of 526nm (2.356 eV). The completely different growth stratigraphies of both types of diamond made visible by means of CL should provide a reliable method to distinguish synthetic from natural diamonds of the types described.

DM-M3 seems to be a rarer exception of a yellow natural diamond with a golden to brownish-yellow CL colour plus distinct orange-red patches (Figure 8). The CL intensity is rather low with a band centred at 530nm resembling that of DM-M6 (526nm). The dashed double-dotted line of Figure 28 is the CL spectrum of the golden-yellow luminescing area of DM-M3. The orange-red patches of DM-M3 furnish a clearly different broad band CL spectrum peaking at 614nm (see the long dashed line in Figure 28). The small dashed line in

Fig. 20. Predominantly blue CL colour of another natural diamond. A small straw-yellow pentagonal growth pattern acts as a distinguishing feature from any synthetic diamond tested so far. Cond. excit.: 7.7 kV, 0.9 mA. 10x (24 x 36mm).

Fig. 21. Growth stratigraphy of the natural diamond DM-M1 revealed by means of CL. Daylight colour is cognac. CL colour greenish-yellow. Geometric growth pattern resembles a site of ruins fittingly defined as 'Pueblo structure' indicating a rarer example of growth history of a natural diamond. Cond. excit.: 8.5 kV, 0.9 mA. 28x (24 x 36mm).



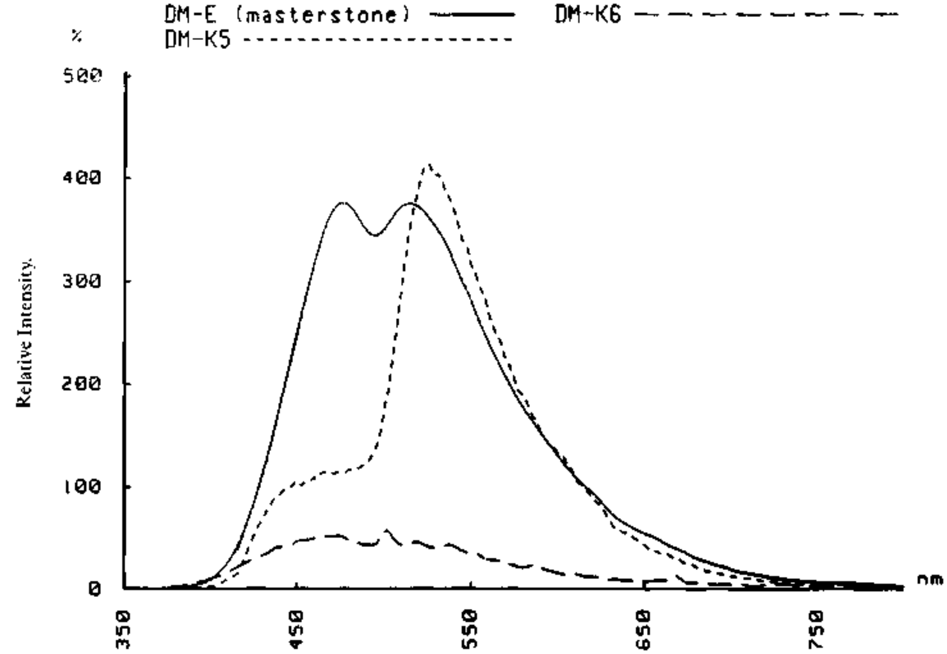


Fig. 26. CL spectra of 3 natural yellow cut diamonds with blue and straw-yellow CL (K5), much more blue (E) and one with a blue cap (K6).

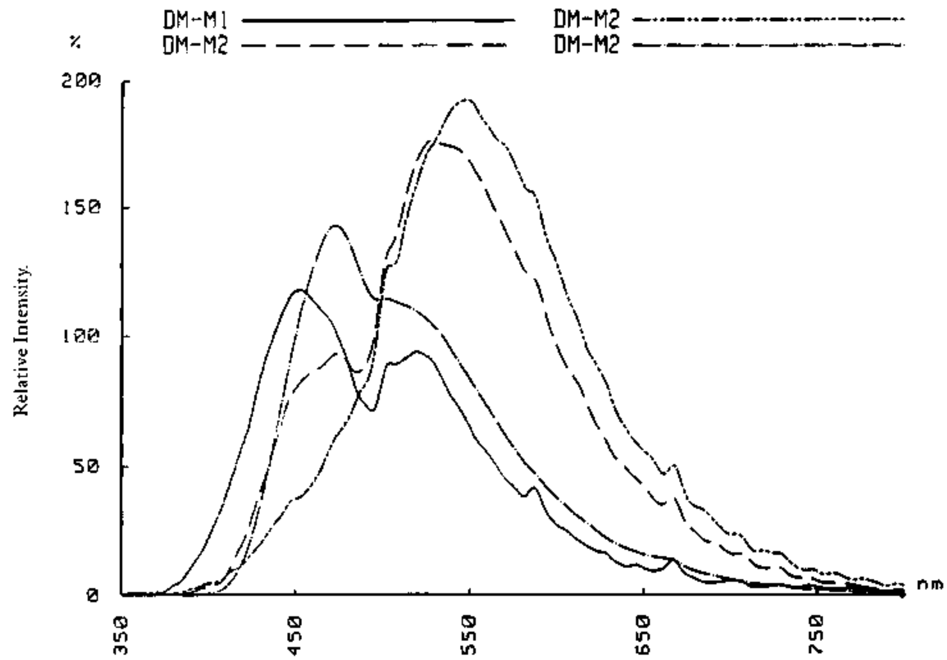


Fig. 27. CL spectra of 2 natural cut diamonds; M1=yellow, M2=brown colour. CL colour of M1=blue, dash twice-dotted line M2 with yellow CL and a little blue. Dashed line M2 with less yellow and more blue. Dash dotted line M2 with much blue and little yellow CL.

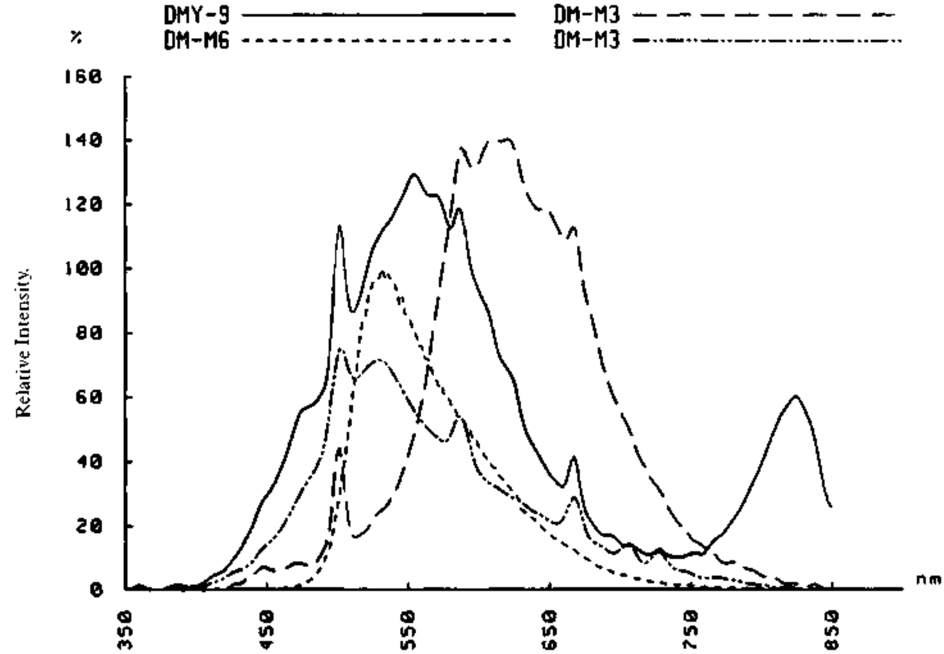


Fig. 28. CL spectra of one experimental synthetic diamond (9) made by De Beers and two natural ones (3 and 6). M6 CL spectrum normalized. Note CL band of DMY-9 at 820nm (red to orange-red needles).

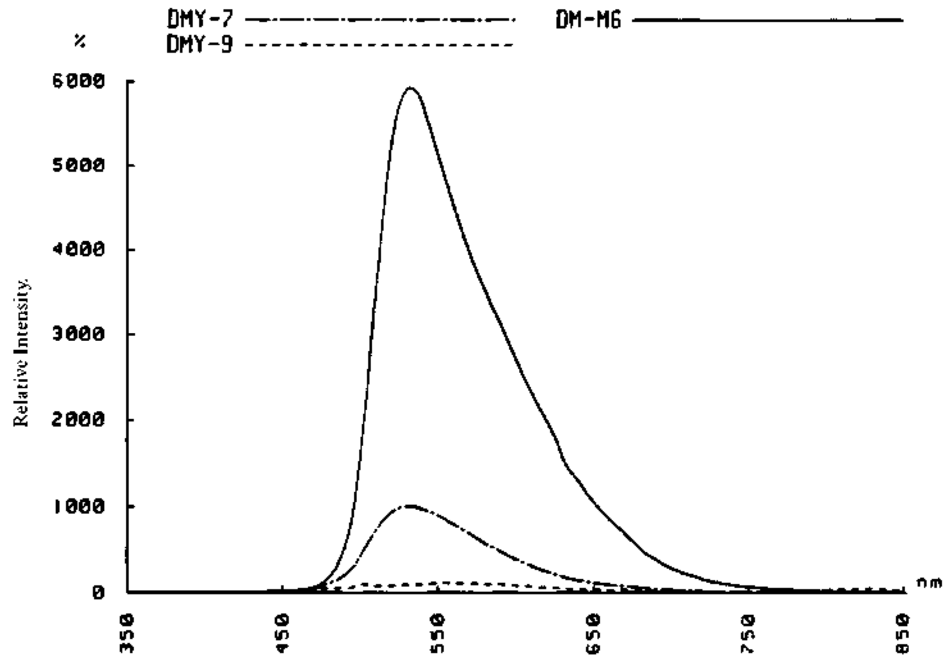


Fig. 29. CL spectra of one natural yellow diamond with high CL intensity (M6) and two experimental synthetic diamonds made by De Beers (7 and 9).

the same figure is the normalized CL spectrum of DM-M6. To compare these spectra with that of the synthetic diamond DMY-3 or DMY-9 the CL spectrum of the latter is included in Figure 28. Remembering the orange-red needles discovered in these man-made diamonds the CL spectrum (full line) is characterized by two distinct bands with maxima at 554 and 820nm (2.237 and 1.512 eV). To the knowledge of the author there exists no similar CL band shown by any yellow or yellowish-brown or brown natural diamond tested so far.

Taken at the same conditions of excitation, Figure 29 shows the CL spectra of three cut stones: the yellow natural DM-M6 and the two yellow synthetic diamonds DMY-7 and DMY-9. These spectra should be compared not only with each other because of the marked difference in CL intensities, but also with reference to their respective growth stratigraphy as disclosed during an electron bombardment.

5. Conclusions

Considering the consistency of results obtained from a rather small number of natural and synthetic diamonds tested so far, the following conclusions can be drawn.

5.1 Microscopic studies of CL phenomena and investigations of CL spectra have proved to be a powerful means of revealing internal features of natural diamonds which differ from those in large experimental synthetic diamonds.

5.2 The luminescing synthetic diamonds show growth-sectors of a distinct geometrical pattern. This results from the cubo-octahedral habit which is unique to such synthetic diamonds grown with low homogeneous supersaturation.

5.3 A greenish-yellow CL colour of high intensity is emitted from cubic and octahedral growth sectors. The CL spectra have peak-wavelengths between 526 and 534nm.

5.4 Pronounced sector banding was primarily found to occur in octahedral faces. On higher indexed faces ((110) and (113)) a moderate to weak blue CL colour was observed. The faces were small, of irregular shape with occasional banding. The CL spectra of the blue sectors showed a band centred at about 480nm. Mixed CL with blue and yellow sector growth was also observed.

5.5 The growth stratigraphy of all natural diamonds tested exhibited distinct differences from the sector growth observed in synthetic diamonds.

5.6 Predominantly, the CL colour of these natural yellow diamonds was blue. But diamonds with yellow and brown CL colours were also found. Two of them revealed so-called 'Pueblo-structures'.

5.7 The CL spectra of the blue luminescing natural diamonds differ from those of the blue luminescing synthetic diamonds.

5.8 Three of the ten experimental synthetic diamonds contained orange-red inclusions not visible under normal conditions of lighting but visible during electron bombardment. These inclusions showed a distinct band in the near infrared (NIR) (820nm).

6. Acknowledgements

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7. References

Burns, R.C., Cvetkovic, V., Dodge, C.N., Evans, D.J.F., Rooney, M.-L.T., Spear, P.M., Welbourn, C.M., 1990. Growth-sector dependence of optical features in large synthetic diamonds. *Journal of Crystal Growth*, **104**, 257-79.

Collins, A.T., 1982. Colour centres in diamond. *Journal of Gemmology*, **XVIII**, 1, 37-75.

Crowningshield, R., 1971. General Electric's cuttable synthetic diamonds. *Gems & Gemology*, **13**, 302-14.

Field, J.E., 1979. *The Properties of Diamond*. Academic Press, London.

Frank, F.C., Lang, A.R., Evans, D.J.F., Rooney, M.-L.T., Spear, P.M., Welbourn, C.M., 1990. Orientation-dependent nitrogen incorporation on vicinals on synthetic diamond cube growth surfaces. *Journal of Crystal Growth*, **100**, 354-76.

Hanley, P.L., Kiflawi, I., Lang, A.R., 1977. On topographical identifiable sources of cathodoluminescence in natural diamonds. *Phil. Trans. Roy. Soc. London*, **284**, 1324, 329-68.

Koivula, J.I., Fryer, C.W., 1984. Identifying gem-quality synthetic diamonds, an update. *Gems & Gemology*, **20**, 3, 146-58.

Lang, A.R., 1979. Internal structure. In: Field, J.E. (loc. cit), 425-69.

Marfunin, A.S., 1979. *Spectroscopy, Luminescence and Radiation Centers in Minerals.* Springer-Verlag, Berlin.

Ponahlo, J., 1988. Quantitative cathodoluminescence – a modern approach to gemstone recognition. *Journal of Gemmology*, **21**, 3, 182-93.

Ponahlo, J., 1989. Mikrospektralphotometrie der Edelstein-Kathodolumineszenz. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **18**, 2/3, 63-84.

Shigley, J.E., Fritsch, E., Stockton, C.M., Koivula, J.I., Fryer, C.W., Kane, R.E., 1986. The gemological properties of the Sumitomo gem-quality synthetic yellow diamonds. *Gems & Gemology*, 22, 4, 192-208.

Shigley, J.E., Fritsch, E., Stockton, C.M., Koivula, J.I., Fryer, C.W., Kane, R.E., Hargett, D.R., Welch, C.W., 1987. The gemological properties of the De Beers gem-quality synthetic diamonds. *Gems & Gemology*, **23**, 4, 187-206.

Suzuki, S., Lang, A.R., 1976. Internal structures of natural diamonds revealing mixed-habit growth. *Diamond Research*, 39-47.

Vishnevsky, A.S., 1975. Sectorial structure and laminar growth of synthetic diamond crystals. *Journal of Crystal Growth*, **29**, 296-300.

Welbourn, C.M., 1989. *Personal communication.*

Woods, G.S, Lang, A.R., 1975. Cathodoluminescence, optical absorption and X-ray topographic studies of synthetic diamonds. *Journal of Crystal Growth*, **28**, 215-26.

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Cut gemstones showing a 'Maltese Cross' and the 'Star of David'

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These ingenious cuts were developed by Paul H. Paulsen, one of Canada's foremost gem cutters, whose family originated from Denmark. The surfaces of these cut gems exhibit a series of polished and cross-grained (frosted) faces.

The 'Maltese Cross cut' is octagonal in outline, with eight simple triangular faces on the pavilion; polished and frosted faces alternate. The crown exhibits an octagonal table with an inner and outer row of triangular facets adjoining the table and girdle respectively; all eight girdle facets are frosted, as is the girdle itself. On looking through the table a 'Maltese Cross' is very clearly displayed (Figure 1).

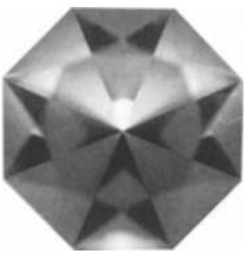
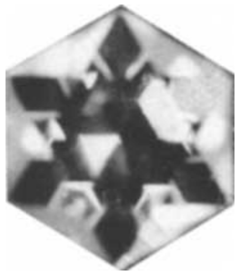


Fig. 1. A 'Maltese Cross' showing in a 'Frosette cut' gemstone by Paul H. Paulsen.

Fig. 2. A 'Star of David' showing in a 'Frosette cut' gemstone by Paul H. Paulsen.



An analogous style of cutting and polishing on a hexagonal stone produces the 'Star of David' (Figure 2) and the 'Lone Star' is developed from a five sided stone.

The Maltese Cross, of course, has associations with the Knights of St John and the island of Malta, and the Star of David with Judaism and the state of Israel. These 'Frosette cuts' are produced by Paul Paulsen in Canada. Frosette Gems Ltd have generously presented two examples of these Maltese Cross cuts (in amethyst and citrine) to The Gemmological Association and Gem Testing Laboratory of Great Britain.

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The Sri Lankan ruby: fact or fable?

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Sri Lanka, or Ceylon as it was called until 1972, was quite conscious of its gem wealth. The early chronicle, *The Mahavamsa*, is replete with references to gems [1]. For instance, this one thousand five hundred years old historical work, in recounting the coronation of an early king, *Devanampiya Tissa*, a contemporary of Emperor Asoka of India, said:

'Pearls of the eight kinds, namely horse-pearl, elephant pearl, waggon-pearl, myrobalan-pearl, bracelet-pearl, ring-pearl, kakuda-fruit pearl, and common [pearls] came out of the ocean and lay upon the shore in heaps. All this was the effect of Devanmpiya Tissa's merit. Sapphire, beryl, ruby, these gems and many jewels and those pearls and those bamboo stems they brought all in the same week to the king.' [2]

It should be noted that the chronicle does not refer to the non-native gems, emerald and diamond.

The indigenous appreciation of gems was reciprocated by foreign elites. Nonetheless, there was a hiatus in the Sri Lankan gem story. As I have written elsewhere:

'While Sri Lanka has had a good press for its gems throughout the centuries, concern for the human element and the mechanics of the gem trade has not been so pervasive [3]. Pliny, the Roman naval officer turned historian, the fifth century Buddhist Chinese pilgrim Fa Hian, Cosmas Indicopleustis, Marco Polo, Odoric, Jordanus, Ibn Batuta, Ribeiro, and in more recent times, Max Bauer, Count de Bournon, C.G. Gmelin, M.H.K. Klaproth, were among those who had written, often admiringly, of Sri Lankan gems. Modern text writers like Herbert Smith (and his subsequent editors), and Anderson deal with Sri Lankan gems more as a class and less as a country. Webster gives more space, but not so much as he devotes to Burma.' [4] [5].

Another hiatus is the nature and scope of the use of the term 'ruby'.

The Sri Lanka Ruby; its natural history

The Concise Oxford Dictionary definition of ruby is a catch-all. It says that 'ruby' is a 'rare precious stone consisting of corundum with colour varying from deep crimson or purple to pale rose' [6]. However, the ideal use of the term is to confine it to the blood-red (or at least crimson) species of corundum. A recent authority on Sri Lanka gems wrote: 'A fine Ceylon pigeon blood ruby takes the first place but is rarely found in nature' [7]. Yet, when one looks through the literature on the gemstones of Sri Lanka of the past and the present (not to speak of the lay press where there is a fair chance of every off-pink stone being conferred the name of 'ruby'), 'ruby' is given the pride of place even over the blue sapphire which is, of course, the staple stone of the gem industry of Sri Lanka. The purpose of this article is to note anomalies in historical gem literature as well as in more recent works and to suggest some possible reasons for the literary proliferation of this rarely-occurring gem.

The reference from the ancient chronicle, the *Mahavamsa* has already been cited. One more reference would be in place. The Mahavamsa, in discussing the auspicious signs occurring in the course of the building of a religious construction, records the following:

'In a south-easterly direction from the city of Anuradhapura, near the village of Sumanava, many precious stones appeared. The dwellers in the village put them, mingled with sapphires and rubies, into a vessel and went and showed them to the king.' [8]

Other classical Sinhala (and Tamil) literary works are full of references to the ruby. The *Amara Kosa*, a medieval Sanskrit thesaurus which was translated into the Sinhala language and was essential reading to the would-be educated Sinhala gentleman, gives considerable space to the ruby [9]. It gives four synonyms for the ruby: (a) rathu keta, (b) gona ratne, (c) lohitaka and (d) padmaraga [10].

A well-informed English traveller and writer of recent times, could state:

'It was always rubies, "The finest yet discovered" says Ribeiro in the 1660s; The finest rubies", echoes du Jarrie, "Rubies esteemed the best in

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the Indies" writes the 'Beschrijving', "Generally more beautiful than those of Pegu" particularizes Tavernier – and he was a jewel-expert.'[11]

The most famous travellers to Ceylon in the Middle Ages were not without their foibles – and one such foible was their exultation over Ceylon rubies, if indeed it was a foible. The Venetian traveller and Kublai Khan's commissary was a case of this sort.

Marco Polo (1254-1324) was in Ceylon – he called it accurately 'Zeilan' in the course of his lengthy travels. Being a trader of luxuries, he should have been knowledgeable of gems, for when he eventually returned to Venice, he had to demonstrate his identity to the cynical Venetians, by ripping off his shabby clothes to reveal cascades of gemstones. Yet, apparently, he was naïve about rubies in Ceylon.

Marco Polo, after enumerating the kinds of gemstones found in Ceylon, wrote, 'The island produces more beautiful and valuable rubies than are found in any other part of the world'[12]. Marco Polo went on to the special ruby possessed by the King of Zeilan, which was a span in length and the thickness of a man's arm, brilliant in its glory and totally flawless [13]. It was obviously beyond any price. Marco Polo also recounted that his patron, Kublai Khan who ruled most of China at that time, had sent emissaries to the King of Zeilan to ask for it, promising to recompense the King of Zeilan with a value of a city. The King, however, declined the offer stating that the ruby was not available at any price and such heirlooms would not leave the country. Kublai Khan had to be content with this refusal [14].

A modern editor of Marco Polo had misgivings about this story. He noted, that:

> 'This description [of the ruby] seems to be intended for what is vaguely termed the carbuncle which Woodward defines to be "a stone of the ruby kind of a rich blood-red colour" and is believed to have the quality of shining in the dark... If this extraordinary stone had any real existence it may have been a lump of coloured crystal, but it is not uncommon with eastern princes in the preambles of their letters and warrants, to boast the possession of imaginary and impossible curiosities; and, in this instance, the fallacy of the pretension, will account for the king's rejecting the magnificent terms held out for the purchase of it by the emperor of China.' [15]

A safer guess would be, of course, that the stone in question was a Balas ruby spinel [16].

The next great traveller to Ceylon was the Moroccan of the fourteenth century, Ibn Battuta, who was jurist, scholar but no Tavernier nor even Marco Polo concerning gems. He spoke of the Lake of Rubies in Ceylon, where rubies were found easily [17]; yet, he had some reservations about several of these stones. In discussing the stones put on the forehead of the 'white elephant' owned by the King, he calls these 'marvellous rubies' but also calls them 'bahrimen', which his editor interprets as carbuncles [18].

It is possible to find some reasons for these wholesale confusions of the classical ruby with indifferently pinkish corundums or those of different gem varieties. The reasons might be schematically grouped as follows:

(1) During the classical times and in the early medieval period, ideal (blood-red) rubies actually existed in Ceylon in large quantities, particularly in river beds. These 'veins' were worked out in course of time. Wilhelm Geiger, the Indo-Aryan scholar, who studied the life and culture of Ceylon in medieval times, speculated on the possibility of even gold being found in Ceylon in those early periods [19];

(2) The ideal ruby never existed in Ceylon; the reference to rubies in ancient Sanskrit, Pali and Sinhala works are a purely literary device, which the rules of Sanskrit poetry ('the alankara', the metaphoric use) decreed [19a]. It might be hazardous to accept this thesis, for the total non-existence of a particular jewel or gemstone would opt it out of further literary works;

(3) That the extant techniques of Ceylonese jewellery craft sparingly used the 'reddish' corundum on aesthetic grounds. Since Ceylonese jewellery (gold pieces) are always made of 22 carat gold, any 'insetting' of a red stone (other than a blood red variety) makes the stone look shabby unlike the blues (sapphires) which dazzle pleasingly. This is purely a matter of contiguous-opposed-colour-reflection. Hence, medieval goldsmiths used blues plentifully and when they had to use red stones, avoided 'pink sapphires'. They used lower kinds of stone, perhaps Balas ruby, while keeping up the illusion that they were true rubies. Since jewellery in medieval and modern times is frequently melted and re-made (that is why goldsmithing is a full-time profession), the softness of lesser quality gems does not matter so much. (Even today, a lot of jewellery, particularly of low-income groups carry, 'Rangoon diamonds' or paste) [20];

(4) Then there is the question of the re-constructed stone. It was possible that the technique of reconstructed stones had been mastered by the end of the Middle Ages. That was due partly to the development of ayirveda, the traditional medical science of India and Ceylon in which sublimations of some gems were used [21]. Though perhaps, it could not have reached the sophistication of later years, when an official report could say:

'The beauty and durability of a reconstructed ruby is equal to a good natural ruby. Reconstructed sapphires do not so closely resemble natural sapphires and the colour and lustre are not satisfactory.' [22]

At any rate, since stones were 'sunk' in ancient and medieval jewellery, opportunities for the use of reconstructed stones are substantial;

(5) The trade in gems between Ceylon and the international market of ancient and medieval times was mediated by several ports and landing-stages of south India. Two of them, important even today, are Kayal Pattanam (in the Tinnely district) and Kilakarais (in the Ramnad district). Curiously, they are low-profiled and most topographical and published itineraries [23]. Ibn Batuta confuses them, placing them in the China Seas [24].

However, Marco Polo mentions Kayal Pattanam calling it 'Kael'. He says that it is 'a considerable city' and was ruled by a prince who maintains peace and order. As a result, Kael attracted ships coming from the west such as Ormuz, Shisti, Aden and various parts of Arabia with merchandise and horses, making it well-situated for commerce [25]. The comments of the editor of Marco Polo on this issue are interesting. He writes:

'In the Tamil language, the word 'Kael' or 'Koil' signifies a temple and forms the terminating syllable in the names of several places in the southern part of the peninsula. It was also pre-eminently the name of a considerable town and port in what we now term the Tinneve country, not many miles from Tuticorin. Its situation may be seen on the map prefixed to Valentyn's Beschrvying van Coromadel (vol.v) where its ancient consequence is denoted by the addition of the word 'patnam'; but having disappeared in modern maps, we may conclude that Kael-patnam no longer exists even as a town; yet in Dalrymple's collection of Plans of Ports we find one (from van Keulen) which lays down the situation, not only of Cayl-patnam, but also of Porto Cayl and of a place termed old Cayl.' [26]

It seems reasonable to infer that along with the non-native stones such as emerald and diamond, rubies (perhaps from Burma) were brought into Ceylon for essential purposes such as adorning the regalia;

(6) There is also the question of royal presence. When a courtier or high official or foreign traveller is in the presence, he is not much inclined to critically examine the stones worn on the king's person or in his immediate environment; he is even less inclined to write down his assessment. As the sumptuary laws forbade the use of gems by the normal population, the average layman would not have been able to identify a ruby even if he saw one.

There is the off-chance that 'burnt' pink-sapphires might be converted to good-looking rubies. With the technology of the Middle Ages the possibilities of the stones splintering or 'spotting' were far greater at any event and they would have had a smokey look.

The Ruby: subsequent developments

In the post-Middle Ages ruby continued to play a dominant role in the literature of those times. For instance, Robert Knox, the English mariner of the seventeenth century, who fell into the hands of the King of Kandy, the indigenous prince who ruled the non-maritime parts of Ceylon, and lived many years in those parts almost as a prisoner, recounted in his work, 'Also there are certain rivers out of which it is generally reported they do take rubies and sapphires, for the king's use, and cat's-eyes' [27].

That received doctrine was carried over in British times. Rev. Cordiner, the clergyman who went on to become the first chairman of the School Board (the chief executive as it were of state educational system) in the early part of the last century, and who wrote an authoritative work on Ceylon, enumerated as the precious stones of this country, the ruby, emerald, topaz, amethyst, sapphire, cat's-eye or opal, cinnamon stone or garnet, agate, sardonyx, and some others [28].

The tourists, many of whom were Americans, did not fail to show their appreciation or at least awareness of rubies. For instance, Mary Thorn Carpenter, wrote in 1892, 'You are soon seated at a table before heaps of sparkling rubies, cat's-eyes, pale sapphires and moonstones' [29].

Again in 1903, another American, Clara Kathleen Rogers, who took a critical view of Ceylon stones, said, '... we poked around among the jewellers, examining and buying some of the Ceylon precious stones. Moonstones, rubies, emeralds, pearls and tourmalines of all kinds are found here.' [30]

The official publications were not far behind. For instance, one such work records that, discussing precious stones of Ceylon, 'The important are sapphire and ruby (varieties of corundum), (including cat's-eye and the rare alexandrite), beryl or aquamarine' [31].

The question of ruby was of academic interest to the gem trade of Sri Lanka until recent years. That was because the marketing of gems was in clearly hierarchical lines. There were the handful of top gem dealers, all of them based in Colombo (the metropolis of Sri Lanka for four hundred years or more), who dealt with the top-drawer tourists and exported gems to the world markets; the rural-based 'mine head' gem traders who supplied the top dealers; and the local gem-shops which serviced the normal tourist traffic and the, foreign bargain-hunter seeking gemstones. The pink sapphires (which is the general term for the Sri Lankan ruby) arranged themselves neatly in this scheme. The most pinkish and standard stones were offered to the top dealers, who sold these to their clientele, the more choosy ones would not settle for anything other than those from Burma, which were imported for this purpose. The low-grade pinks were taken up by the local gem shops. Specially backed in jewellery, these were not bad bargains.

World War II changed all that. Burma and other traditional sources for ruby were no longer available. Prices began to rise as the situation of supply did not change for quite some time after the War. The attitude of the international market for ruby is, of course, different say from that of emerald. While the supply of emerald is partly a 're-cycled' one, the market's appreciation for ruby is one of inexhaustible demand. Two factors added to this demand and expectation. One was the easy-money conditions of the Sixties, which created greater demand for luxury articles and antiques. The other factor was the paradoxical one – developments in the technology of synthetics. Anderson noted, in passing, 'As in the case of ruby, the most effective substitute for natural sapphire is its synthetic counterpart' [32]. The better the synthetic, the greater is the demand for the natural stone that is even better (among the elite, that is).

Sri Lanka was immune from all this push-pull till the late-Seventies. Sri Lanka had always been noted for its blue sapphires; it would hardly be an exaggeration to say that it was the leading exporter of standard blue sapphires.

The Thai gem dealers who entered Sri Lanka began to purchase 'geuda', which till that time was a discounted product. A recent report states:

> 'It is well known that Sri Lankan corundum with the milky white opaline character called 'geuda' when subjected to heat treatment can be converted to clear blue sapphires.' [33]

The success (some might even say the enormous success) of the Thai 'geuda-conversion' had several depressing effects on the Sri Lankan gem industry and market. In the first place, it had a disestablishing effect on the Colombo market, while strengthening the Bangkok market, already based on the supply of the Chantaburi fields. Secondly, prices for blues were depressed, knocking the livelihoods out of many middle-middlemen and sub-brokers. The acquisition of the geuda-conversion technique by the Sri Lankan gem industry (at present, perhaps, not fully mastered in its total sophistication) is possibly not a full solution for this is an ideal 'Catch 22' situation. If the Sri Lankan mastery of the technique is less than adequate, the 'burnt' stones will depress the market prices, for the bulk of the natural stones are themselves imperfect. If, on the other hand, the technique is sophisticated enough to create clear blues, every natural good blue will become suspect (since most gem-dealers go by the rule-of-thumb methods) and prices will hug the minima.

The short-fall in the demand for Sri Lanka sapphires has caused a revival of interest in the corundums of the red variety. This re-appraisal was given point at the Third Conference of the International Coloured Gemstone Association (ICA), the sessions of which concluded on 26 May 1989 in Colombo [34]. It was reported that resolutions were passed 'recommending that the pink sapphire be brought into the classification of "ruby"' [35]. It was expected that this recommendation would be submitted to the CIBJO for approval. These moves, of course, will have important consequences, in practical terms as well as academically. It is widely estimated that the price per carat is at least $5000 higher than for pink sapphire. This is obviously a time-bound frame. Academically (or rather, scientifically) speaking, a precise colour-codification will have to be devised and implemented, ranging perhaps from 'very pale pink rubies' to 'blood-red rubies'. In that case, the term 'pink-sapphire' will drop out of the gem-dealer's vocabulary [36].

In summary, the Sri Lankan ruby, though prolific in literature is rare in nature, its literary predominance, perhaps, being attributable to a small cache of naturally-occurring stones, reinforced by some imports and royal 'one-up-manship' [37].

References

1. Among Sri Lanka's repertoire of its own names are, Taprobane (Greek), Palesamundi (Latin), Serendib, Zeilan (both Arabic), Ceilao (Portuguese) and Ceylon (British). In this article, 'Sri Lanka', 'Ceylon', are used depending on the context.
2. Mahanama, *The Mahavamsa or the Great Chronicle of Ceylon* translated by Wilhelm Geiger and Mabel Haynes Bode (London 1912) (reprint, Ceylon Government Information Department, Colombo, 1986) pp. 78 and Cap. XXXI. This is a work of AD 600 (ibid., xii).
3. Mahroof, M.M.M., 1989. 'The Muslim Lapidary: Some Aspects of the Gem Folkways of Sri Lanka', *Journal of Gemmology*, **21**, (7), 405.

4 and 5. Bibliographical details of works cited are in M.M.M. Mahroof, op. cit. 409. The present writer wishes to thank the Editor of *The Journal of Gemmology* and his colleagues in this regard.

6. *The Concise Oxford Dictionary* (OUP, Bombay) 7th Edition, 1987.
7. Louis Siedle, 'Gems' in S.E.N. Nicholas, 'Commercial Ceylon' (*Times of Ceylon, Colombo, 1933*), 130.
8. Geiger & Bode, op. cit, p.188. Anuradhapura was the capital of the ruling prince of Sri Lanka in the ancient and early medieval periods.
9. Ven. Meddepola Wimalajothi Thero (editor), 1934 '*The Amarakosha*' (Bastian & Co, Colombo). The editor writes, 'True enough, there are several other Sanscrit dictionaries compiled by different authors, but none of them has been so

avariciously quoted by Sanscrit scholars as Amarakosha' (ibid. p.i).

10. Ibid., p.149.
11. Raven-Hart, R., 1973. *Ceylon – History in Stone*. Lake House Investments Publishers, Colombo. 106.
12. Masefield, John, (introduction by), *The Travels of Marco Polo* (Everyman's edition). Dent, London. (1967 reprint of 1908 edition), 349. This edition is based on that of W. Marsden (1818), revised by T. Wright (1854).
13. Ibid.
14. Ibid.
15. Ibid., p.350.
16. The Concise Oxford Dictionary defines balas ruby as 'a rose-coloured spinel ruby'. The geologist and mineralogist, P. G. Cooray (*An Introduction to the Geology of Ceylon*, National Museums of Ceylon, Colombo, 1967, p.197) groups balas ruby under spinel, along with ruby spinel, 'rubicelle' and 'amethyst'.
17. Gibb, H.A.R., 1983. (trans.) *Ibn Battuta – Travels in Asia and Africa (1325-1354)*. Darf Publications, London. Reprint of 1929 ed., p.256.
18. Ibid., p.257.
19. Bechert, Heinz, (editor), '*Wilhelm Geiger's Culture of Ceylon in Medieval Times*. Otto Harrosowitz, Wiesbaden, 1960, *passim*. For the role of the Muslims, a principal gem-trading community, see M.M.M. Mahroof, op. cit., and also, M.M.M. Mahroof & M. Azeez (compilers), *An Ethnological Survey of the Muslims of Sri Lanka*, Sir Razik Fareed Foundation, Colombo 1986, *passim*.
19a. Berriedale Keith, A., 1947. *Classical Sanskrit Literature*, YMCA Publishing House, Calcutta, p.126.
20. Mahroof, M.M.M., op. cit. The present writer hopes to treat these issues at length in the comprehensive work on the history of gems and gem craft in Sri Lanka, which he is preparing at present.
21. Geiger & Bode, op. cit. It was believed, for instance, that powdered corundum when taken internally would destroy the intestinal tract.
22. Parsons (Director), *Mineralogical Survey of Ceylon for 1907*. Government Printer, Colombo, p.E13.
23. For instance: *Itineraries in the South Indian Railway Company*, South Indian Railways, Madras, 1900; *Manorama Year Book 1981*, Manorama Newspaper Publishing Company, Kottayam, Kerala, India.
24. Gibb, H.A.R., op. cit. p.263. Gibb, in his editorial notes, writes, 'Ibn Battuta must have called at the small port of Kaylu karia, 19 miles south of Ramnad, which he afterwards transported to somewhere in the China Sea'.
25. Marco Polo, op. cit., p.375-6.
26. Marco Polo, op. cit., p.375. The editor's (Wright's) assertion that the Tamil prefix 'kayal' is derived from a word denoting 'temple' is not correct. Actually, the temple prefix is 'ko' (as in Koil patti'). The Tamil word 'kayal' or 'kael' stands for 'lagoon' and is perfectly descriptive of the town of Kayalpattinan.
27. Knox, Robert, '*Relations of Ceylon*'. ('An Historical Relation of the Island of Ceylon, in the East-Indies, together with the Account of the detaining in activity of the author, and diverse other Englishmen now living there and of the Author's miraculous escape', Chiswell, 1681), p.31, cited in Marco Polo, op. cit., p.349.
28. Cordiner, Rev. James, 1807, '*Description of Ceylon*'. Aberdeen. Vol. I., p.14, cited in Marco Polo. op. cit., p.349. See also Mahroof & Azeez, op. cit., p.169.
29. Carpenter, Mary Thorn, 1892. *A Girl's Winter in India*. New York, cited in H.A.I. Goonetilleke, 1975. '*Images of Sri Lanka Through American Eyes*', Colombo, p.207.
30. Rogers, Clara Kathleen, 1931. '*Journal-Letters from the Orient*' edited by Henry Monroe Rogers, Norwood, Mass., cited, in Goonetilleke, op. cit., p.252. The visit took place in 1908. Other Americans who referred to Sri Lankan rubies included William Maxwell Wood (1856), Victor Heiser (1915), Frances Parkinson Keyes (1926), the last named writer noting that 'rubies – rubies with that slightly violet tinge that characterises those found in Ceylon' (Goonetilleke, op. cit., p.317).
31. Turner, L.J.B., (Superintendent of Census and Director of Statistics, Ceylon), 1922. *Handbook of Commercial and General Information for Ceylon*, Government Printer, Colombo. p.77.
32. Anderson, B.W., *Gem Testing* 6th ed. Butterworths, London. p.177.
33. Ediriweera, R.N., Perera, S.I., 1989. Heat Treatment of Geuda stones – special investigation. *Journal of Gemmology*, **21**, (7), 403.
34. '*Sunday Island*' newspaper (Colombo), 21st May, 1989.
35. '*Island*' newspaper (Colombo), 9th June 1989.
36. Cooray, P. G., op. cit., has refrained from using the term 'pink sapphire' in his list of corundum varieties (p.197).
37. It is hoped to discuss further developments in a future article.

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Jemeter Digital 90 – A test report

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Although experimental reflectance instruments for gemstone identification had been developed in 1959[1] and 1972[2], it was not until 1975[3] that the first commercial model was marketed by Sarasota Instruments of the USA. This instrument, called the 'Gemeter '75' was fitted with an analogue meter calibrated directly in RI values from 1.4 to 2.7 (Figure 1).

Fig. 1. The Sarasota Instruments 'Gemeter '75' – one of the first reflectance meters.

The fact that the Gemeter '75 was calibrated in RI values was probably the main reason why users of the instrument, unfamiliar at first with the operating constraints of a reflectance meter, expected accuracies similar to those achieved with the critical angle refractometer (and were quickly disillusioned!).

Subsequently, reflectance meters produced by other companies were calibrated in gemstone names rather than RI values, and this enabled the expected ranges for these gemstones and the possible overlaps between them to be indicated on the meter scale. Other reflectance meters used a digital display whose readings had to be referred to a table containing the range of readings expected for each gemstone.

In 1990 the development of the reflectance meter came full circle when Sarasota Instruments introduced their Jemeter Digital 90 (Figure 2). Like their first model in 1975, this latest version displays the RI value of the stone being tested. However, this time the display is a 4-digit LCD unit with a high-contrast 12mm-high readout covering the RI range 1.450 to 2.999, and the associated electronics have been much improved.

The direct digital readout of RI is not too remarkable a technical feat. However, it does necessitate matching the reflectance characteristic of a flat polished surface (as indicated both by Fresnel's reflectivity equation and the intervals in the Gemeter '75 scale) to that of the linear digital readout.

The excellence of the electronics design is evidenced by the high stability of the instrument's digital readout (with the light-excluder dust cap placed over the stone, the least significant figure changes only occasionally by one digit). The unique feature of this instrument, however, lies in its use of a polarizing filter between the test aperture and the photodetector. This latter feature allows the double refraction of a gemstone, previously only vaguely detected with a conventional reflectance meter, to be measured in a manner similar to that employed on a critical angle refractometer (i.e. by rotating the stone in small increments to find the minimum/maximum values).

With care, and taking all the precautions necessary with a reflectance meter (i.e. ensuring that the stone is clean and in good condition, keeping it centered over the test aperture, and keeping the test aperture clean and free from dust), repeatable readings to an accuracy of 0.005 can be obtained.

Double refraction up to 0.04 can also be measured to the same accuracy, although with larger DRs this accuracy becomes more difficult to achieve due to the need for precise angular increments. Centering the gemstone over the test aperture is made easier by the provision of a series of concentric rings around the high-impact plastic rim

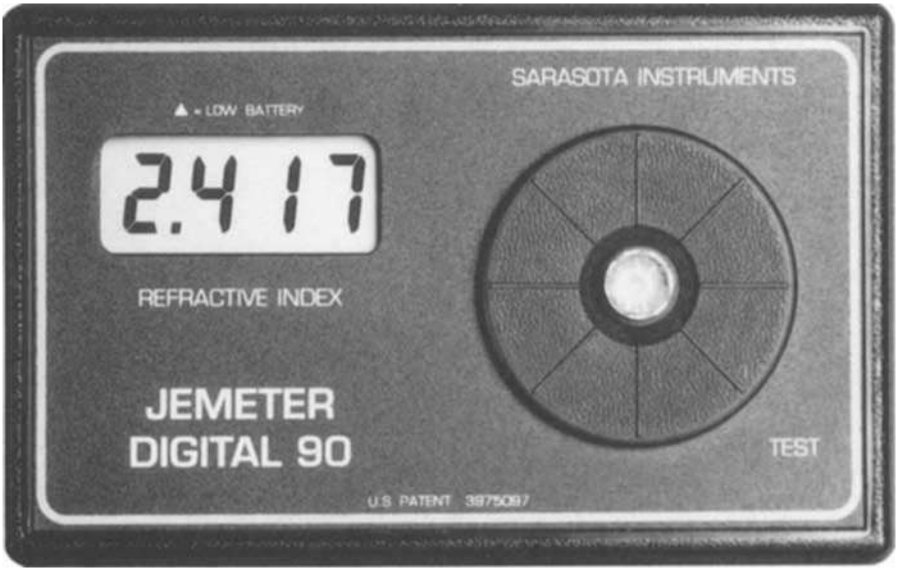

Fig. 2. The Sarasota Instruments 'Jemeter Digital 90' reflectance instrument measures gemstone RIs to three decimal places over the range 1.450 to 2.999. Fitted with a polarizing filter, it can also measure double refraction down to around 0.01.

of the aperture. The area around the test aperture is divided into 45 degree segments and forms a useful guide when rotating a gemstone to check its DR.

The test aperture itself has an internal diameter of 1mm, but this is no problem providing the main facet of the gem under test covers the aperture completely. As continuous rather than pulsed I-R emission is used in the optics, it is necessary to use the supplied light-excluder/dust cap to prevent spurious light rays entering the rear of the stone under test.

The instrument dispenses with the conventional 'on/off' switch, and instead is activated by pressing the section of its front panel labelled 'TEST'. The unit switches itself off automatically after 3 minutes, and also indicates (by means of a triangle symbol on its digital display) when the battery needs replacing and when the unit is about to switch off.

The Jemeter Digital 90 represents an important advance in the design of reflectance meters, and used with the degree of care necessary with this class of instrument fully deserves the description of 'reflectance refractometer'. The reduction in sensitivity as compared to the standard critical angle refractometer is more than compensated for by the fact that the instrument does not require the use of a contact fluid.

The unit is calibrated by means of its two preset adjustments (as instructed in the accompanying manual) using beryl at 1.575 and diamond at 2.417. Because the instrument is measuring RI at a wavelength of around 930nm rather than at the sodium wavelength of 589.3nm, highly dispersive gems such as zircon, strontium titanate and rutile will produce lower readings in rough proportion to the size of their dispersions (e.g. strontium titanate reads typically 2.220 instead of 2.420). For this reason, the operating manual includes a list of gems, grouped under colour varieties, which indicates the low, mean and high values to be expected. Stones having a dispersion from 0.04 downwards are only minimally affected because the scale is calibrated against diamond towards the top end of the range.

The instrument's manual is well written and contains gemmologically correct definitions of refractive index and double refraction, and of the terms mineral, synthetic and imitation (a welcome change!).

The Jemeter Digital 90 measures 5.7 × 3.6 × 1.2 in. (14.5 × 9 × 3.25cm), and uses a long-life alkaline 9-volt PP3 type battery. The manufacturers are Sarasota Instruments, 1960 Main Street, Sarasota, Florida 34236, USA and the instrument is also available from GAGTL.

References

1. Trumper, L.C., – see footnote on page 283 of Robert Webster's 1975 Report on a new Electronic Refractometer. *Journal of Gemmology*, **XIV**, 6, 281-8.
2. Wilkins, R., 1972. An amateur gemcutter looks at refractometers. *Lapidary Journal*, **26**, 432-4.
3. Webster, R., 1975. A Report on the Gemeter '75. *Journal of Gemmology*, **XIV**, 8, 378-81.

Moonstone mining in Sri Lanka: new aspects

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Abstract

Moonstones with a deep blue mobile shine are sodium-rich potassium feldspars. Exsolution of sodium and the concentration of the very fine sub-microscopic albite lamellae more or less orientated in the schiller-plane are the reason for the beauty of this gem.

The most important moonstone deposit during this century for top qualities is economically Metiyagoda, which is situated in the south of Sri Lanka. Here moonstones are mined from a strongly kaolinised feldspar pegmatite. The weathering has enlarged the schiller-plane, which might suggest that albite weathered more easily than orthoclase.

The hard unweathered pegmatite, locally called 'moonstone-rock', has been reached at some places by the intense mining activity. The hard feldspars show a close-meshed net of cleavages and cracks. The plate tectonic position of this pegmatite is the reason for these numerous cracks. This geological reason explains the fact that the cut moonstones from Metiyagoda are mostly very small and too flat. The costs of mining and cutting are much higher in the unweathered moonstone than the production from the weathered material, where the moonstone is recovered ready for cutting.

Moonstones from newly opened mines near Balangoda in the central mountains area have not the same top qualities as those from Metiyagoda.

The blue, semi-blue and the white moonstones have different alkali-contents. The white quality is richer in potassium, the highly appreciated blue moonstones are richer in sodium. In top blue moonstone qualities more than half of the alkali position in the lattice of the feldspar is occupied by sodium, so top blue moonstones are more an albite than an orthoclase.

Introduction

Moonstones with a characteristic deep blue sheen, which suddenly appears to float within the stone, are feldspars, whose beauty can easily compare with many other gems. The formation place of these gems are the pegmatites. Chemically moonstones are mainly potassium feldspars with a content of sodium (Bauer, 1932). This sodium content, which is installed in the lattice as solid solution by higher formation temperatures, exsolved through the formation of sodium feldspar lamellae during the time of cooling down. According to W.C. Bröger (1890) the perthitic exsolution of lamellar albite-feldspars are responsible for the beauty of the moonstones. They occur in extremely fine microscopic size. The study of microstructures has been expanded to transmission electron microscope observation (a summary has been given by R.A. Yund, 1983). The perthitic exsolution lamellae are mostly regularly ordered in a feldspar lattice and thus are visible in the so-called 'schiller'-plane when observed from a special direction. This effect is also called adularescence, a term which stems from the feldspar locality of Switzerland in Graubünden 'Mons Adular', which is the Rätoromanian name for the Rheinwaldhorn. This 'schiller'-plane is more or less nearly vertically orientated to two cleavages of the feldspars. In cut stones this 'schiller'-plane should lie parallel to the top of the cabochon. Only in this way may the effect of beauty of the moonstone be realised in its best quality. The high domed top of the cabochon makes the light reflection even more brilliant. The more convex the cabochon the more intense is the optical effect. The top of the rounded cabochon acts as a magnifying glass.

Besides the moonstones with a clearly blue sheen, qualities occur in semi-blue and mainly white schiller, showing a silvery to pearl-white lustre (Table 1). The blue, the semi-blue and the white moonstone qualities of Metiyagoda can be seen in Figure 12. Besides the schiller effect a specific body colour may be seen in some moonstones. This body colour can be seen from all directions and not only from a special direction as the schiller colour.

The moonstones of Sri Lanka partly show their body colour in a very faint grey, greenish or brown colour shades, which in local trade are called 'muddy' moonstones. The clarity or transparency is decisive and another factor for the quality of moonstones. Some of the moonstones of Sri Lanka are not transparent but are translucent. The various qualities are linked throughout the whole colour scale. The most attractive qualities are the transparent moonstones (crystal quality), particularly with

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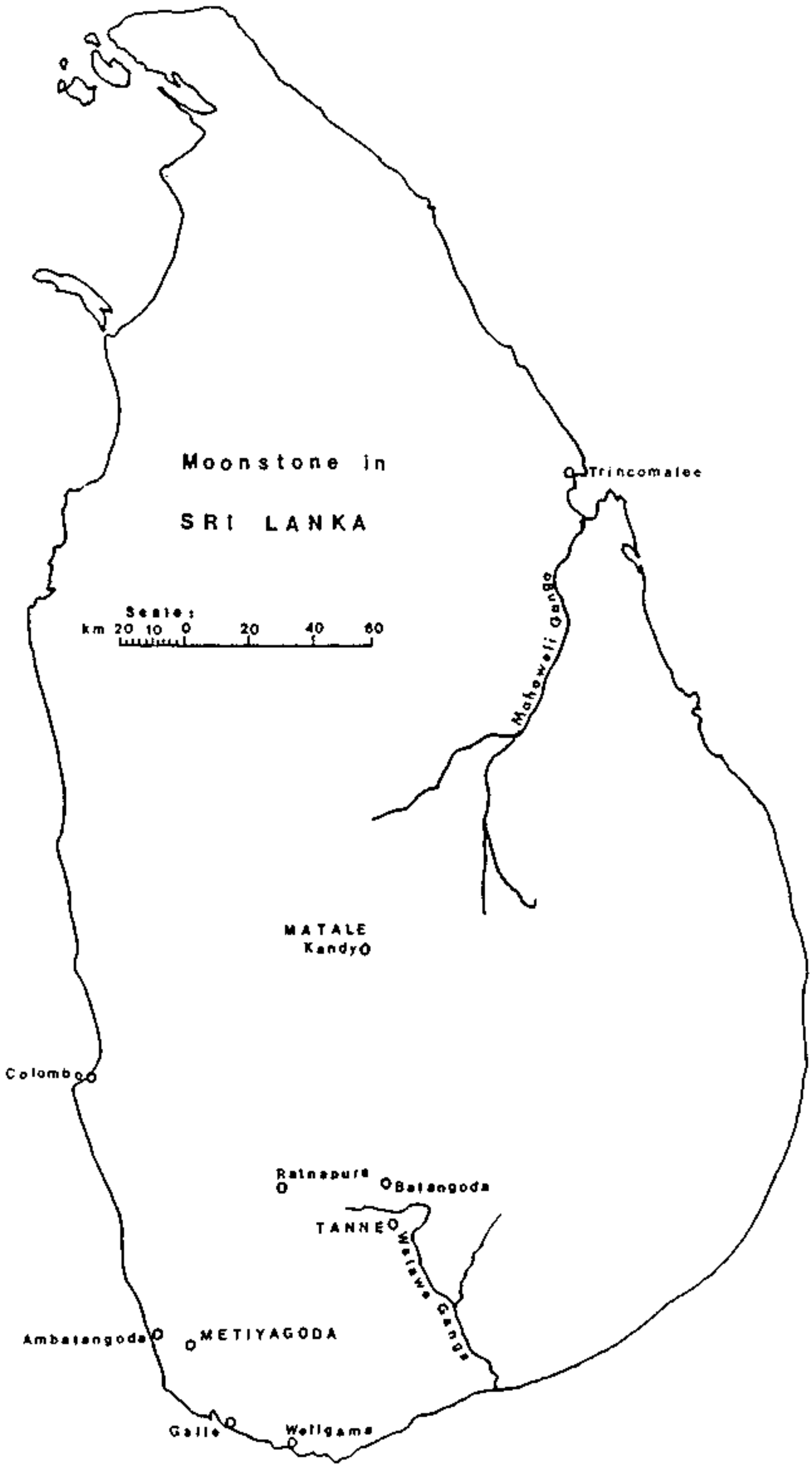

Fig. 1. Map of Sri Lanka showing principal localities.

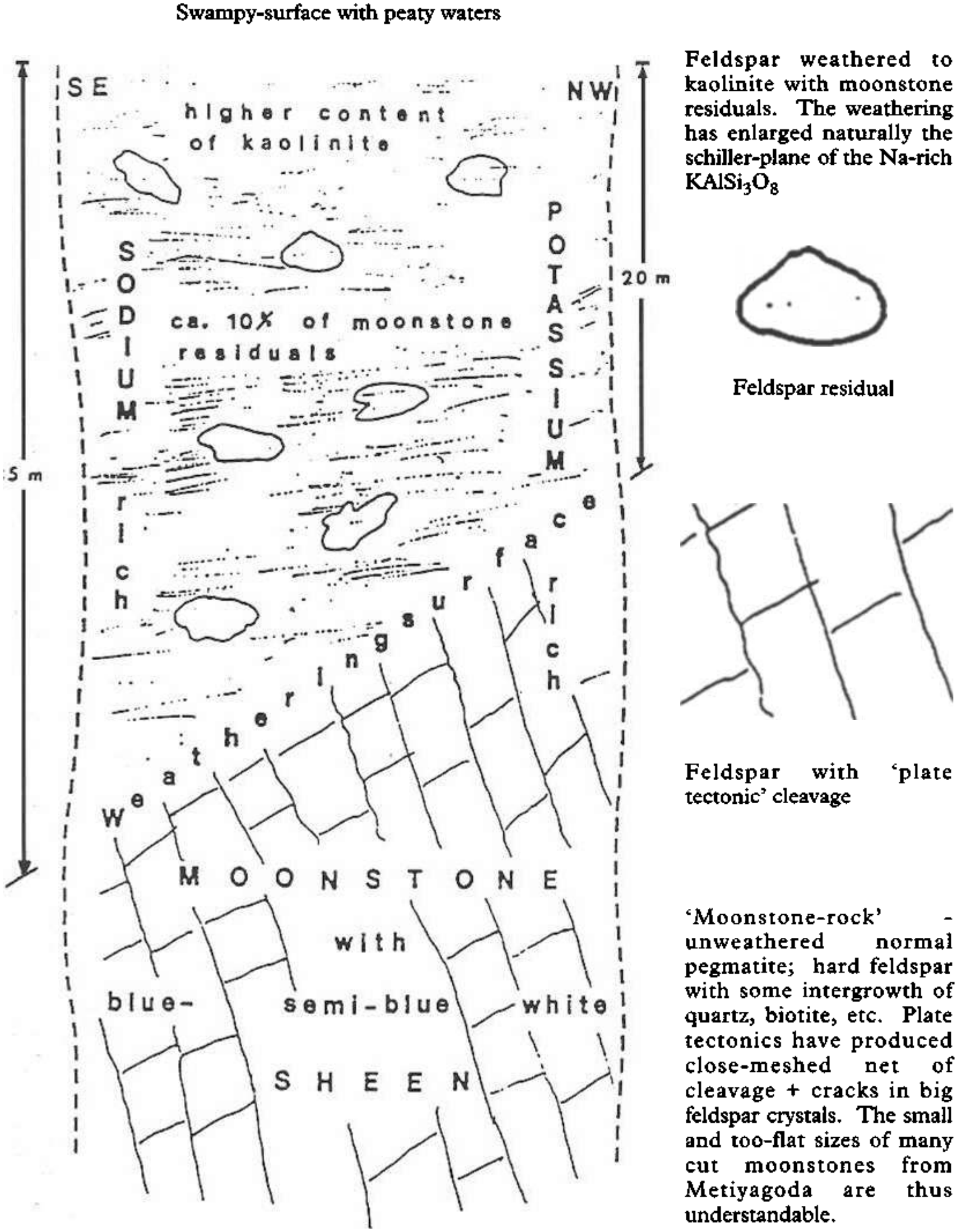

Fig 2. Schematic profile of moonstone mines of METIYAGODA with a soft rotted china clay surface and in depth primary unweathered feldspar pegmatite. The blue moonstones are in the SE, the semi-blue in the middle part, and the white in the NW of this pegmatite.

Table 1. Moonstone qualities of Sri Lanka

Blue Moonstone	
Crystal blue*	
normal blue	
muddy blue**	
Semi-blue Moonstone	
Top semi-blue*	
normal semi-blue	
muddy semi-blue	
White Moonstone	
Crystal white*	
silvery	} white*
pearly	} white*
normal white	
muddy white	

*only in Metiyagoda
**only in Balangoda

the strong sky-blue to dark blue schiller colours, which unfortunately occur very rarely.

Moonstones with a blue schiller do not only appear on the market from Sri Lanka but also originate from Burma (Mogok) and south India (where they are called Ceylon-qualities). The better qualities – particularly from the mining of Metiyagoda, near Ambalangoda in the south of Sri Lanka (Figure 1) – dominate the market. In the last decade the growing demand from Switzerland, Germany and recently Japan, for blue moonstones has reduced the quantities of blue moonstone in bigger sizes. In this paper some new information about the mine of Metiyagoda and some other mines of Sri Lanka is given. Furthermore, it is intended to analyse the chemical or mineralogical difference between the blue and the white moonstone qualities, which is not well known in modern scientific literature.

Moonstone from the rotted pegmatite of Metiyagoda

This famous moonstone deposit was discovered during agricultural work in the year 1906 and is described in detail in the work of Spencer, 1930. The situation mentioned in the paper above is still in existence. The moonstone deposit underlies a swampy area. The ore material which is mined is a strongly kaolinised feldspar pegmatite, the feldspars occurring as weathering residuals in minor quantities (Figures 2 and 4).

Kaolinite is often formed by decomposition of feldspar. The lattice of kaolinite can either be formed from weathering solution or from hydrothermal waters. Postmagmatic, hydrothermal solutions may have circulated after the formation of pegmatite and may have decomposed the feldspar. In contrast to weathering processes, hydrothermal processes may occur even in the lower part of the pegmatite. Tropical weathering conditions, mainly under the influence of peat solutions are favourable for kaolinisation. These conditions are nowadays found in Sri Lanka. Spencer discussed both kaolinite formation possibilities of the moonstone deposit of Metiyagoda. Recent exploration shows that strong weathering took place even in the surrounding rocks which leads to some china clay mining.

The mined kaolinite-rich material is washed out in order to enrich the residual feldspar. The remaining material consists of feldspar with a pitted or frosted external brittle surface and a compact unweathered moonstone core. The inner feldspar material is exposed by breaking it out from the

Fig. 3. Schematic diagram showing the different moonstone qualities in the mines of Metiyagoda.

NW	4a White (some muddy colour) 20 m MS-Rock	1 White (some muddy colour).
	4b White and top semi-blue 30 m MS-Rock	2 White and top semi-blue
SE	4c Top-blue and semi-blue 35 m MS-Rock	3 Top-blue and semi-blue

Mines numbered 4a-c belong to 'The World Crafts', Galle. In these mines the unweathered pegmatite is reached at depths of 20-35m. Locally this hard material is called 'moonstone rock' (MS-Rock). Beyond these depths all other mines work in the soft kaolinite-rich material. Mine No. 1 has stopped mining in recent years due to water problems.

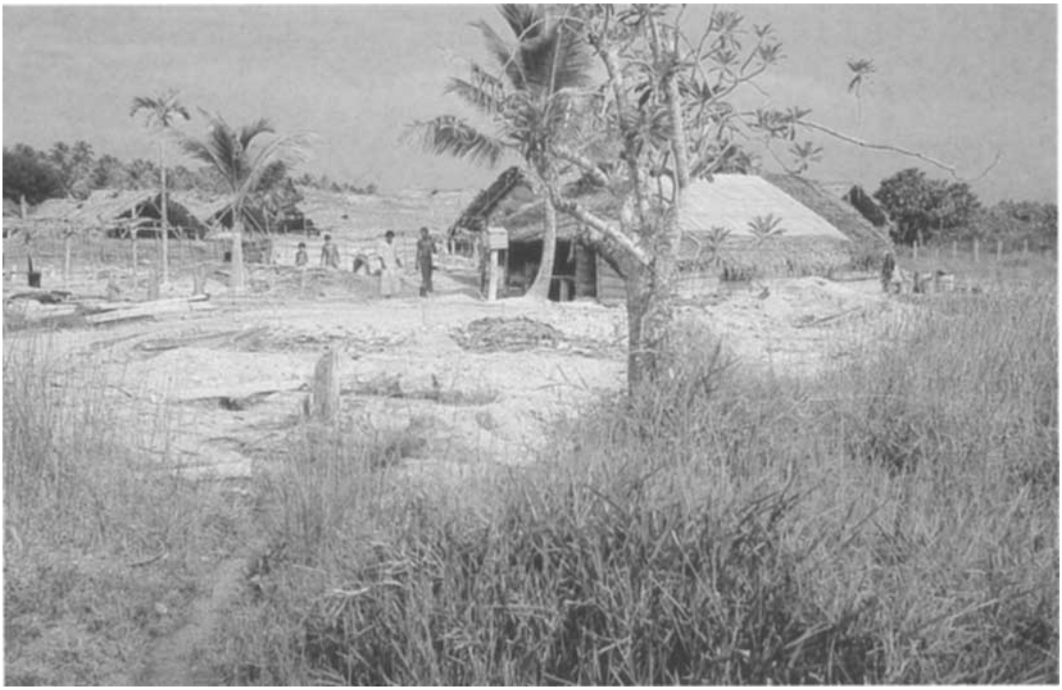

Fig. 4. Moonstone pegmatite mine Metiyagoda. The material, which is mined here is a strongly kaolinised feldspar pegmatite containing moonstone as weathering residuals.

weathered rim. The weathering has enlarged the tablets of the schillerized feldspar plane. This observation is mineralogically reasonable because sodium feldspar weathers more easily than potassium feldspar (Correns, 1961). The remains of weathering often show naturally formed planes which are parallel with the schiller-plane and which are thus suitable for the cabochon cut. The first rough and form-giving cutting work, the so-called 'ebauchieren' is not necessary for moonstones from the weathering zone, as the schiller-plane has been exposed through weathering.

Occurrence of moonstones with different colour sheens in the pegmatite of Metiyagoda

Moonstones with a blue, semi-blue or white schiller are not regularly distributed over the whole pegmatite. The area where the moonstone is mined is about one acre (4068 m^2, ie a square of 64m) according to the information of S.H.M. Mohideen. Today the mining is done by digging pits to a depth of 35m, which corresponds to the statement of Spencer, who mentions 100 feet. The mining is controlled today by 4 companies, see Figure 3. Blue moonstones are to be found in areas 3 and 4c, semi-blue in the areas 2 and 4b, whereas only white moonstones in the areas 1 and 4a.

Unweathered core of the moonstone-pegmatite of Metiyagoda

The kaolinised surface of the pegmatite has been mined for nearly one century and the unweathered pegmatite has been reached at some places. This pegmatite material is locally called moonstone rock (in Figures 2 and 3 it is called 'MS-Rock'). It is interesting to mention that the weathering surface reaches much deeper in this pegmatite area, which contains blue moonstones. It may be caused by unknown geological factors but the higher sodium content of this part of the pegmatite seems to be the reason for it, since albite weathers more easily than the orthoclase. In the unweathered feldspars of this area no kaolinite is detected, neither optically nor by X-ray investigation, nor by differential thermal analysis. All moonstone qualities which are known from the kaolinised part of the deposits, also occur in the unweathered part of the pegmatites. In some of the hard unweathered pegmatite an intergrowth of feldspar and quartz may be found, less frequently with biotite and phlogopite. The various stones which the author examined, showed a relatively tight net of cleavage and cracks. The reason why these moonstones from Metiyagoda occur in relatively small and mostly flat pieces is found in the tectonic-geological position of this deposit. This pegmatite occurs near the shore and even more important near a tectonic border of the island. Moonstones which occur farther from the tectonic border show far less cleavage and these mines produce much bigger stones. The carat-price of these moonstones does not much depend on the size of the stone, whereas the moonstone prices of Metiyagoda stones strongly increase with the size.

Economic differences in the mining of moonstones of kaolinised or unweathered pegmatites

The mining of moonstone from the unweathered feldspar material is far more expensive. The breaking of hard feldspar rocks is much more difficult than mining of the soft kaolinite material. The remains of the residual feldspar material appear in a form, which is very favourable for moonstone cutting, whereas the big unweathered feldspar crystals must be split first and knocked to pieces in order to get clear moonstones. During this process the feldspars crack in the direction of both cleavages but seldom in the schiller-plane. This schiller-plane must be cut artificially in order to produce the beauty of the moonstone. The ebauching, the first rough cutting, of the moonstones from the unweathered core of the pegmatite is necessary and causes additional cost. Only 1-5% of the feldspar material could be cut as gems from the unweathered pegmatite, whereas 25% of the residual moonstone from the rotted pegmatite could be commercially used according to the information given by S.H.M. Mohideen (Jeiser), the owner of the biggest part of the mine (in Figure 3, the areas 4a, 4b and 4c).

Fig. 5. The mined kaolinite-rich material is washed out in order to enrich the moonstone.

Fig. 6. Collected washed out rough moonstone. Below the brittle surface of the rough moonstone is a hard, cuttable core of feldspar, with an enlarged 'schiller'-plane weathering.

The weathering of moonstone has not only enriched the crack- and inclusion-free material, as it is the case with some other gems, but in addition to that it has exposed the schiller-plane, which shows the real beauty of the moonstone.

Other moonstone occurrences in the mountains of Sri Lanka

In former times moonstones of various qualities have been found in the central mountains at different localities. These moonstones could be cut to bigger stones than those from Metiyagoda. The pegmatite hosts of these feldspars were found in various places, for example in Matele north of Kandy (Figure 1). The geological surroundings of these pegmatites are the gneisses, which are the most important rock formation of the island. In the

Metiyagoda moonstone area these gneisses are to some extent different from those in the central mountains. In the past numerous moonstones were found in the gravels of recent rivers and also from worked gem gravel, for instance the illam from Elipitiya, Pitigala, Horton Plains and Weligama in the south of Sri Lanka; also from the recent rivers, the Mahawelli Ganga in the north-east and the Walawá Ganga in the south, where probably material from the pegmatite of Balangoda has been deposited.

A newly opened moonstone mine at Tanne near Balangoda is situated in the central mountains, 45 km east of Ratnapura and has similar geological surrounding as in the Kandy moonstone area. The exact location lies south-east of Balangoda at the side road to Uggalkaltota, near the village Tanne at milestone 12 (about 19 km). At about 5 km from this village traces of mining activities are to be seen. From the dump material it can be deduced that normal unweathered pegmatite material is mined. Many feldspars, quartz and large biotites are found. Nowadays topaz is mined to the west of this road. There must be a large number of pegmatites.

At the end of 1990 two new moonstone pegmatite localities were found in the mountains of Sri Lanka. One is near Yatiyantota, about 40km east of Colombo; the other is near Haputala, about 35km east of Balangoda in Uva province. The latter locality produces moonstone with an unusually strong blue sheen and is known as 'Royal blue'.

The moonstone schiller of the material of Balangoda does not have the intensity of the moonstones from Metiyagoda. The clear top blue qualities and the top semi- and top white qualities were not found in this deposit. The moonstones show a lower semi-blue and mostly a pearly white quality. The body of the moonstones are not so clear and the medium light muddy colour could easily be detected. These qualities, which in trade are called Balangoda, are similar to some moonstones of south India, which are called 'Ceylon'-quality. In 1987 a large quantity of Balangoda material was mined and cut in the environs of Galle, the former capital in Dutch times and in those days and even today an important gem trade centre. Meanwhile the trade has learned that there are different qualities of Sri Lanka moonstones. As the sale of cheap moonstone qualities was reduced due to declining tourism, the mining of the moonstone deposit of Balangoda stopped working at the end of 1988.

Chemical investigation of Sri Lanka moonstones

Two full analyses of material from these two most important moonstone localities were carried out (Table 2). The SiO_2 and Al_2O_3 contents were determined by means of gravimetric analyses. The K_2O, Na_2O, CaO, and MgO contents were analysed by atomic absorption, Fe by spectrophotometric investigation and the trace elements Mn, Ba, Sr, Rb and Cs by X-ray fluorescence. Apart from the significant difference in the alkali-content of the two different moonstone localities, the values of the other main and trace element contents are very similar, as shown in Table 2. The Fe content of the sample from Ambolangoda is a little higher, which may be explained by the stronger greenish body colour of the stone. The brighter blue moonstones of Metiyagoda have essentially higher sodium contents, whereas the sample of Balangoda shows higher potassium content. In general Ba (up to 0.05%) and Rb (up to 0.07%) tend to favour the white potassium-rich rather than the blue sodium-rich feldspar (Ba only 0.004% and lower, Rb only 0.00X – 0.024%). Calcium replaces more easily in the sodium position and is found in slightly increased amounts in the blue moonstone of Metiyagoda. The result of the different sodium content in the blue and white moonstone quality could be verified by numerous X-ray fluorescence determinations of potassium in the various qualities, but X-ray fluorescence analysis of potassium with an inner standard of Si is not as precise as the wet chemical analysis. Since the X-ray fluorescence

Table 2. Chemical composition of two moonstones from Sri Lanka

		Ambalangoda Metiyagoda	Balangoda Tanne
SiO_2		66.2	65.1
TiO_2		0.004	0.02
Al_2O_3		18.8	18.6
Ga_2O_3		≈ 0.002	≈ 0.002
FeO		0.02	0.03
Cr_2O_3		0.003	0.02
MnO		0.01	0.03
MgO		< 0.00	< 0.00
PbO		≈ 0.02	≈ 0.00X
BaO		0.004	0.03
CaO		0.3	0.2
SrO		0.02	0.08
Na_2O		3.7	1.8
Rb_2O		≈ 0.3	≈ 0.04
K_2O		10.1	13.8
Ign. loss 950°C		0.16	0.07
		99.64%	99.82%
Potash	-feldspar	59.7%	81.5%
Soda	-feldspar	31.3%	15.2%
Lime	-feldspar	3.1%	1.8%

Fig. 7. Unweathered moonstone pegmatite material of Metiyagoda locally called 'moonstone rock'. Crystal-clear feldspar with a strong deep blue sheen (size of the sample 100 × 60mm). The picture shows a single feldspar crystal. The two cleavages and the 'schiller'-plane are clearly visible. These three directions cross each other more or less at right angles. In the middle part of the sample an intergrowth of quartz and small micas with the moonstone is visible.

Fig. 8. Blue moonstone in a crystal blue quality (size of the sample: 58 × 45mm). The clear transparent and colourless area of the moonstone is limited by a tight net of cleavage and cracks. The size of cut moonstone from this sample could only be up to 7mm. This pegmatite occurs near the plate tectonic border of the island. This geological fact is the reason why cut moonstones from Metiyagoda mostly occur in small flat pieces.

does not destroy the gems, more expensive moonstones could be analysed. The irregular shape of the moonstone samples could be one reason for the analytical error of the X-ray fluorescence methods. The rounded cabochons of the moonstones are not very suitable for these X-ray methods. A further reason for differences between the wet and the X-ray fluorescence analyses is the possible loss of sodium from the moonstone surface which was in contact with water. The natural weathering or the activity of water during the cutting, takes more sodium away from the surface layer and slightly enriches the potassium on the surface. The X-ray fluorescence only analysed the surface layer and not the whole moonstone body, which is analysed during the wet analysis. One other chemical difference could be produced by the exsolution of the sodium during the forming of the schiller-plane in the moonstone. The side of the moonstone, which shows a strong sheen, is richer in sodium than the other side, which shows higher potassium values in X-ray fluorescence analyses.

Chemical difference between Sri Lanka moonstones with a blue or with a white sheen

The bluish schiller is attributed to the layered micro-structure in the cryptoperthite of orthoclase-albite. The interference phenomenon, which is possible in this structure and/or the scattering from very fine particles cause the bluish moonstone effect. But apart from all these differences in microstructure it could be shown by numerous analyses that the colour of the schiller of the different moonstones reflects the different alkali content of the moonstone. Blue colour moonstones show a very high content of sodium, up to 6.3%

Fig. 9. Intergrowth of feldspar with quartz from the 'moon stone rock' of Metiyagoda. The moonstones show a non-transparent quality with a normal white sheen.

Fig. 10. Baveno twin feldspar in a crystal blue moonstone quality. One side of the twin shown in this position exhibits the strong blue moonstone sheen. The other side (the small part) shows the blue sheen when turned.

Fig. 11. Semi-blue moonstones.

Fig. 12. Different qualities of moonstones from Meetiyagoda. The deep blue quality (the small stone on the left) normal blue, semi-blue and the silvery white qualities with a strong white sheen on the right side, are seen in this picture.

Na_2O in some analysed samples. The sodium content in the semi-blue samples is to some extent lower than in the blue samples. Samples of white moonstones are much richer in potassium than in sodium, some of these samples contain only 2% Na_2O (Table 3).

Table 3. Table showing how the different sodium/potassium content controls the blue, semi-blue or white sheen of the moonstone from Sri Lanka

Blue moonstones
- 7.9-9.5% K_2O (16 analysed samples)
- soda – feldspar content up to 51%

Semi-blue moonstone
- 9.5-10.9% K_2O (12 analysed samples)
- soda – feldspar content between 45-37%

White moonstones
- 10.1-14% K_2O (12 analysed samples)
- soda – feldspar content lower than 38%

Top blue moonstone qualities of Sri Lanka are more an albite than an orthoclase; an albite, which contains up to 46% potassium feldspar.

Acknowledgement

It is a pleasure for me to express my thanks to several friends in Sri Lanka. Talks with well-informed moonstone merchants were very helpful for this paper. The information from S.H.M. Mohideen (Jeiser) was especially valuable.

References

Bauer, M., 1932. *Edelsteinkunde*. 3rd edition.

Brögger, W.C., 1890. Die Mineralien der Syenitpegmatitgänge der südnorwegischen Augit- und Nephelinsyenite. *Zeitschr. Kryst. Min.*, **16**, 524-51.

Correns, C.W., 1961. The experimental chemical weathering of silicates. *Clays and Clay Minerals*, **4**, 249-65.

Harder, H., 1977. Clay mineral formation under lateritic weathering conditions. *Clay Minerals*, **12**, 281-288.

Spencer, E., 1930. A contribution to the study of moonstone from Ceylon and other areas and of the stability-relations of the alkali-feldspars. *Mineralogical Magazine*, **XXII**, 291-367.

Yund, R.A., 1983. Microstructure, kinetics and mechanisms of alkali feldspar exsolution. *Reviews in Mineralogy, Vol. 2, Feldspar Mineralogy*, edited by P.H. Ribbe.

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XXIII International Gemmological Conference, South Africa 1991

Alan Jobbins

At this conference, which was superbly organized by Herbert Pienaar and his helpers, the excursions (5-12 October) preceded the scientific sessions. Delegates visited The Diamond Research Laboratory (DRL) near Johannesburg; the Daggafontein operations of the East Rand Gold and Uranium Division (ERGO); the Vaal Reefs Gold Mine near Klerksdorp; the Premier Diamond Mine at Cullinan near Pretoria; Western Deep Levels Gold Mine near Carletonville; the alluvial diggings on the Vaal River; De Beers Consolidated Mines, the Big Hole and Kimberley Mine Museum and various safari game parks. The scientific sessions (14-18 October) were held in Stellenbosch at the Public Library Hall, by courtesy of the Town Council; and at the University of Stellenbosch. The papers presented are listed below in alphabetical author order.

Arps, C.E.S. (The Netherlands). Agates: composition, petrogenesis and structures.

Bank, H. (Germany). Gemstone news from Idar-Oberstein.

Barot, N.R. (Kenya), and Gübelin, E.J. (Switzerland). Chatoyant East African gemstones.

Becker, G.F.A. (Germany). Emeralds from Nigeria and olivines from outer space.

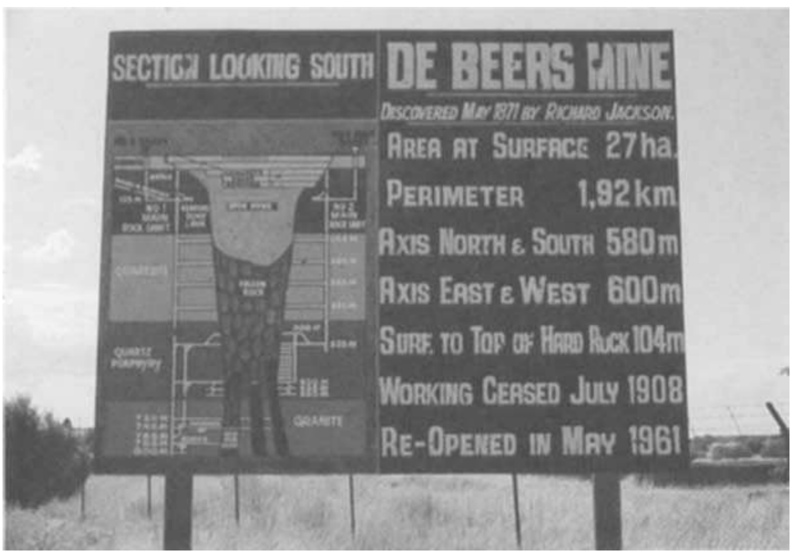
Chikayama, A. (Japan). Modern large-scale mining of ruby and sapphire in Thailand.

Gurney, J. (South Africa). Different crystallographic forms of diamond; origin and post-crystallization history.

Gurney, J., *et al.* (South Africa). Television film on recovery of diamonds from coastal deposits of Namaqualand, South Africa.

Harding, R.R. (UK). Notes on two unusual archaeological materials.

Jobbins, E.A. (UK). The gemmology of the Cheapside Hoard of jewellery.



The vital statistics of the De Beers Mine, Kimberley. To complete the story, the mine was closed in October 1990.

Kane, R.E. (USA). The current status of ruby and sapphire mining in the Mogok Stone Tract, Burma (Myanmar).

Kanis, J. (Germany). Gemstone chips from Orissa, India.

Kirkley, M., and Gurney, J. (South Africa). Diamonds from algae: organic sources for carbon in diamond.

Koivula, J.I. (USA). Recent observations of inclusions.

Levinson, A.A. (Canada). (1) Diamond exploration in Western Canada. (2) The mineralogy and geochemistry of human urinary stones.

Meyer, H.O.A. (USA). Marine diamonds from Namibia.

Meyer, H.O.A., and Winston, R. (USA). Famous diamonds at the House of Winston.

Miyata, T. (Japan). A new ceramic cameo made by Kyocera, Japan.

Pie Roger, R.M., Balagua, E., and Madred, I. (Spain). Coral from the Catalan Costa Brava, Spain.

Pienaar, H.S., Glenister, D. (South Africa). On a gift of diamonds from Cecil John Rhodes - for services rendered.

Poirot, J.-P. (France). Spectrometry and X-ray fluorescence on some sapphires.

Ramos, Z., Skinner, E.M.W., Bristow, J.W., and Robinson, D.N. (South Africa).

Read by C. Hatton. Kimberlites and the mantle in Southern Africa.

Saul, J.M. (France), Sturman, N.P.G., Castro, A.I., and Harding, R.R. (UK). Characteristics of some gem materials from East Africa, Madagascar and Afghanistan.

Scarratt, K. (UK). Read by R.R. Harding. A cultured pearl grading system.

Schwarz, D. (Germany). The chemical properties of Colombian emeralds.

Segnit, R.E., and Jones, J.B. (Australia). On the cracking of opal.

Shida, J. (Japan). Treated jadeite.

Sunagawa, I. (Japan). (1) Basic concepts in the identification of natural and synthetic diamonds. (2) Crystal growth and gemstones.

Superchi, M., and Cusi, R. (Italy). The pink topazes of an historical jewellery set.

Tombs, G. (Australia). Inclusions and internal features of Kenyan golden sapphires.

Zoysa, G.E. (Sri Lanka). Some recent discoveries from Sri Lankan gem-rich soil.

Zwaan, P.C. (The Netherlands). More data on the kornerupines from Embilipitiya, Sri Lanka.

1991 Conference and Presentation of Awards

Mary A. Burland

The first Conference of the recently amalgamated Gemmological Association and Gem Testing Laboratory of Great Britain was held in London on Sunday 3 and Monday 4 November 1991, sponsored by T.H. March & Co. Ltd, Insurance Brokers. The venue for the events on the first day was the Tower Thistle Hotel, with a magnificent view of Tower Bridge and the River Thames, and also overlooking St Katharine's Dock. Proceedings continued on the Monday afternoon at Goldsmiths' Hall, where delegates had the opportunity of viewing the exhibition of the work of the designer De Vroomen. The Conference was well attended with delegates from Australia, Canada, Japan and the USA, as well as many European countries. A range of instruments and books were on display, and the Directors and staff were present to discuss the services offered by the GAGTL. David Larcher of the Midlands Branch and Irene Knight of the North West Branch were available to explain the advantages of taking part in Branch activities. As well as a programme of excellent lectures, full reports of which are given below, Gem Identification and Diamond Grading workshops were held throughout the first day. Two video shows were also arranged, 'Gemstones of America' and 'Mogok Valley of Rubies', a film made by Dr E. Gubelin providing an insight into the mining and trading of rubies in the country famed for the finest stones. Social events included a Dinner Dance on the Sunday evening at the Tower Thistle Hotel and a dinner following the Presentation of Awards ceremony.

Workshops

The workshops, which offered 90 minutes of intensive instruction and hands-on experience, proved very popular, the only problem being which of the excellent lectures or video shows should one miss in order to take part in one of the sessions.

Diamond Grading

After a short introductory talk on the various aspects of diamond grading, each student had a work station with a grading lamp, 10 x lens, dia-

Fig. 1. Students participating in the Diamond Grading workshop.

mond cloth and course notes. An integral part of the workshop was the demonstration of the use of diamond colour comparison stones to colour grade polished diamonds. Under the instruction of Eric Emms and Alan Clarke students examined many diamonds through the microscope. Stones studied included stones with glass-infilled fractures, and also laser-drilled diamonds (a method whereby dark inclusions can be modified by laser drilling) in which the fine drill holes targeted on inclusions could be seen. The way in which variations of symmetry and proportions are graded in brilliant cut diamonds was demonstrated with the use of the proportionscope.

Gem Identification

Each session commenced with an illustrated talk on the problems of identification posed by various synthetic and treated gemstones on the market today. At four work stations, equipped with microscopes and a light box to view the radiographs of pearls, students were able to examine the stones that had been discussed during the talk. These included corundum with cavity filling, deceptive synthetic stones with straight growth lines, and deep-diffusion-treated sapphires;

Fig. 2. Ian Mercer assisting students at the diamond work station.

Fig. 3. Colette Bensimon giving instruction on the identification of pearls.

Yehuda-treated diamonds, laser drilled diamonds, a Sumitomo synthetic diamond and a diamond-topped doublet; natural emeralds from Colombia and Sandawana, Opticon filled fractures in emerald and Lennix synthetic emerald; natural, cultured, non-nucleated and dyed pearls.

Practical Gemmology

An illustrated lecture entitled 'Practical Gemmology' in two parts and covering a range of subjects was given by Alan Hodgkinson.

Refractometer

Mr Hodgkinson commenced by stressing the importance of accuracy when using the refractometer. It is essential that the stone being tested is placed centrally on the prism, and that as well as your eye being very close to the eye-piece it should be in the same position for every reading,and this calls for a comfortable posture. It is also vital to check the accuracy of your refractometer, and a stone with a known RI, e.g. rock crystal, should be kept for this purpose. If readings are slightly incorrect they can be adjusted with the use of colour filters; 'Quality Street' chocolate wrappers was one inexpensive suggestion.

It is becoming increasingly necessary to confirm that your refractometer readings indicate whether uniaxial gems are positive or negative. Also to pinpoint *beta* so that biaxial gems can be designated as positive or negative. Mr Hodgkinson demonstrated a simple inexpensive method of optical sign interpretation for all birefringent gems.

For those who had difficulty in obtaining a reading by the *distant vision* method it was suggested that, as well as using the normal light source, a fibre optic should be additionally directed through the top of the specimen. The *distant vision* method was demonstrated using such items as carvings, bangles, etc., as well as cabochon-cut stones.

Visual Optics

Mr Hodgkinson then went on to discuss the use of visual optics, a method whereby various optical phenomena can be detected at the retina.

It is possible, using only a light source, to calculate the RI and DR of a stone, measured against a 48 inch adding machine paper roll, which made for a delightful refractometer substitute. The prototype of a Hanneman/Hodgkinson student refractometer encapsulated the technique into a pocket instrument.

Opals

Natural, synthetic, plastic and stained opals were illustrated. Transmitted and crossed polarized light was shown to be a useful means of identification and a fibre optic light was used on a difficult mounted doublet.

'Always expect the unexpected'

The second part of the lecture warned of the dangers of making assumptions about gemstones. Even when the identity of a stone appears obvious, confirmation should be obtained by testing the specimen thoroughly. Examples illustrated included cobalt-coloured synthetic spinel, a green sapphire boule coated with synthetic blue spinel, a doublet composed of a diamond crown on the cubic zirconia pavilion, flux-grown rubies, and some surprising alexandrites which had crystallized out in a 'Chatham synthetic ruby' accident some years ago.

Polarization

Mr Hodgkinson explained how cross polarization could be used by various techniques to determine whether a cut stone was uniaxial or biaxial. Many excellent illustrations of the phenomena were shown.

Earlier this year gemmologist Pat Daly introduced Mr Hodgkinson to the theory that there was a polarized band in the sky. The following morning their student group discovered this for themselves by experimenting with gemstones, and found that part of the sky could be used as a dichroscope. The highlight was a slide transparency showing the interference figure of quartz using the sky crossed with a single polaroid as a polariscope.

Corundum

The second part of the lecture concluded by looking at corundum. Those illustrated included Scottish sapphires of 58 and 100 carats; a cabochon displaying an adjacent double star; natural and synthetic star stones; 'gas bubbles' impersonated in corundum caused by heat treatment and identified as a balled-up form of alumina; synthetic sapphires ingeniously damaged to imitate natural inclusions; and finally, the increasing quantity of sapphirine which resembles sapphire in more than name.

The History of Gemmology and its Literature

A review of gemmological literature from the Bible to the present day was given by Nigel Israel. Slides shown included a number of beautifully illustrated books that had been published on the subject. The lecture proved that much of the knowledge that is generally thought of as 20th century can be traced back hundreds of years.

In the final part, Nigel Israel dealt with the development of gemmology from the first synthetics in 1885, through the first gemmology classes in 1893 and early refractometers, up to UV and IF meters.

A full report of 'The history of gemmology and its literature' will be published in a future issue of The Journal.

The Crown Jewels

Dr Roger Harding continued the historical theme with an illustrated lecture on the British Crown Jewels, from their origins in the unification of the Crowns of England and Scotland under the reign of James I to the present day. In 1605 a decree was issued which declared that certain jewels be 'indivisible and inseparate, forever and hereafter annexed to the Kingdom of this realm'.

During the time of Charles I and Cromwell, however, many items disappeared from the collection, notably 'The Sancy' and 'The Mirror of Portugal', two famous diamonds which were pledged, together with many other pieces, to the Duc d'Epernon by Henrietta Maria, the wife of

King Charles I, to raise money for the Royalist cause. Unfortunately she could not afford to redeem the diamonds and in 1657 the Duc released her from the debt and sold them to Cardinal Mazarin. Subsequently the Sancy was also known as Mazarin I and the Mirror of Portugal as Mazarin III. On his death, Mazarin left both diamonds to the French crown.

Many of the remaining Crown Jewels were sold during the Commonwealth Period, but those that survived form the nucleus of the collection which is in existence today.

Although records of the Crown Jewels were kept by the Crown Jewellers and various books have been published on the subject, in 1986 it was decided to compile a detailed account of the collection, including a gemmological description of the more important stones. This was done by Alan Jobbins, assisted by Roger Harding and Ken Scarratt, which involved transporting all the necessary equipment into the Jewel House at the Tower of London during a period when it was closed to the public. Roger Harding then described some of the pieces examined, as well as giving details of their history.

Two of the items mentioned were the Sovereign's Orb and the Sceptre with Dove made for the Coronation of Charles II. The Orb contains a total of 772 gemstones including diamonds, emeralds, sapphires, rubies, amethyst and pearls. The emeralds are believed to be of Colombian origin, and the rubies contain silk and crystal inclusions typical of Burmese stones. Although the Sceptre with Dove has fewer stones (285) than the Orb, it contains one more gem species - three spinels (polished rough) very similar in colour to the rubies.

George IV introduced the concept of the rose, thistle and shamrock to the Crown Jewels in two items on display in the Jewel House, the Jewelled Sword of State and the Diamond Diadem. The latter was a favourite of Queen Victoria, and our present Queen is depicted wearing the Diadem on stamps and banknotes. The Diadem is set with 1333 diamonds weighing 320 ct, the largest being a pale yellow round brilliant-cut of 4 ct, as well as 169 pearls (those examined were found to be natural).

The most famous of Queen Victoria's acquisitions was the Koh-i-Noor diamond. It weighed 186.10 ct, and a model is on display in the Tower of London. In 1852 it was recut to a cushion-shaped brilliant weighing 105.60 ct. In 1905 the Cullinan Diamond was found and was offered to Edward VII. Cutting began in 1908 and Cullinan I, a pear-shape stone weighing 530.20 ct and of exceptional colour and clarity, was set in the Sceptre with Cross in 1910.

Cullinan II was set in the front of the Imperial State Crown, directly below the Black Prince's Ruby. This is a polished red spinel crystal of good colour, although it is in a foil-backed setting. At the rear of the crown is the Stuart Sapphire, supposedly part of the Crown Jewels when the Stuarts reigned, but with a documented history only from the time of George IV. At the summit of the crown is a cross containing the St Edward's Sapphire, reputed to have been set in a ring which belonged to Edward the Confessor. With this range of stones in the Imperial State Crown about nine hundred years of history are symbolically represented, from the sapphire of Edward the Confessor, to the rough polished spinel of the 14th century, the early cuts of diamonds, the high quality of the emeralds, sapphires and rubies, the pearls and cultured pearls, and finally the Cullinan II diamond.

Items of regalia in the Tower of London are regularly used and are not merely museum pieces, and it is to be hoped that in the future they will be joined by new pieces symbolic of important events in the country's history.

The Conference continued on the afternoon of Monday 4 November at Goldsmiths' Hall, Foster Lane, London EC2, with the Annual General Meeting, a full report of which appears on p.50.

Review of treated gemstones

Following the AGM, Mr Ken Scarratt gave an illustrated lecture on treated gemstones. A tremendous number of gemstones are now treated, and Mr Scarratt began by giving the official definition of a treated stone as being one in which the 'appearance or durability has been artificially enhanced'. He then gave details of those currently on the market, and methods by which the various treatments could be identified.

Amber:

The appearance of amber can be improved by gradual heat treatment If it is heated too quickly a spangling effect occurs. The colour does not penetrate but is concentrated on the surface of the stone, so amber treated in this way should not be repolished as the colourless material below could be revealed. Specimens of amber with a surface lacquer coating and reconstituted amber were also illustrated.

Coral:

Much of the coral on the market today has been

Fig. 4. Rough amber and three cabochons cut from the same material. Bottom, from left to right: before heat treatment, after heat treatment, and after heat treatment and repolishing.

stained to a red colour. This may be detected by the concentration of colour around the drill hole. Coral can also be coated with plastic to improve the finish.

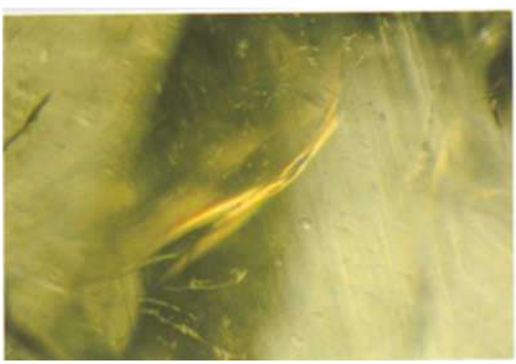
Diamond:

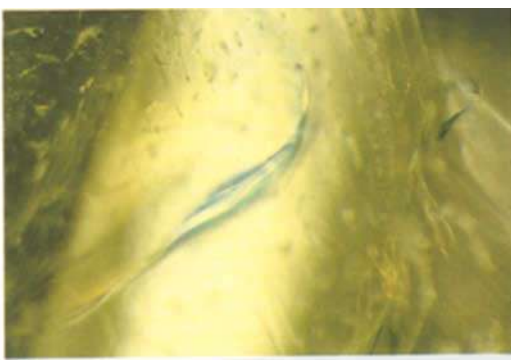
There are many types of diamond treatment used today and the identification of artificial colouring is a complex subject. Recent advances in identification techniques include the observation of slight colour concentrations in the area of the culet and the discovery of two extra peaks in the infrared spectrum when stones have been heated above the 1000°C point.

Natural blue diamonds, one reputedly from India and others from Australia, have been found to be non-conducting. Australian stones have been identified as Type Ia, hydrogen rich.

Diamonds have been laser drilled to reduce the visibility of black inclusions. Open fractures had been infilled for some time; under the microscope fractures show a blue flash which changes to orange when the stone is turned. Some of the more modern infills show a blue flash changing to pink. Faceted cubic zirconia coated with a diamond film were first seen in South Africa three years ago. The coating can sometimes be seen to be uneven, and these stones do not react in the same way as diamond on the reflectance meter.

Fig. 5(a) and (b). Colour flashes in feathers seen in a resin treated emerald *(Photographs R. Kammerling).*





Emerald:

The speaker first discussed the oiling of emeralds, which is not a declarable treatment. A tremendous number of emeralds nowadays are being filled with one of the resins, one of which has the trade name Opticon, which greatly reduces the visibility of fractures. This treatment is declarable, according to CIBJO rules. Opticon-treated stones can be difficult to identify, but under the microscope the fracture has a yellowish colour which changes to a blue flash when the stone is turned. A similar infill treatment may be applied to other stones with a similar refractive index, such as amethyst and tourmaline.

Jade:

Although jade has been stained since time immemorial, specimens are now coated with a type of epoxy resin. Approximately 80% of jade in Hong Kong is now treated in this way. The coating is raised from the surface in some cases, which aids identification.

Opal:

Plastic impregnated opal can be detected by the specific gravity of the stone, or by the infrared spectrum.

Pearl:

Stained pearls can be identified by the deepening of the colour around the drill hole, and this may be seen with a 10X lens. Some treated black pearls owe their colour to irradiation treatment; the mother-of pearl bead discolours when irradiated which shows through the outer layers. Large hollow pearls have been drilled and filled with various substances, including wire, to strengthen them and increase their weight.

Corundum:

Examples of glass infilling in both ruby and sapphire were shown. The majority of sapphires coming on to the market today have been heat treated. Although this improves the colour of the stone, the wonderful silk seen in reflected light is lost after heat treatment, and the whole of the internal world of the sapphire is changing. Diffusion treated sapphires, i.e. the introduction of colour into the surface area of the stone, can be identified by the concentration of colour on facet edges. Colourless sapphire can be changed to yellow by exposure to X-rays, but the colour lasts only a few days.

Quartz:

Quartz can be coated with a thin layer of gold to produce Aqua Aura. Again, a concentration of

Fig. 6. Heat altered inclusion in sapphire.

colour can be seen on the facet edges.

Turquoise:

To identify turquoise stabilised with plastic, cavities on the back of the stone, which often contain pyrite, should be examined for residue of impregnation. Turquoise can also be reconstructed.

Zircon:

Blue zircon will change to brown under ultraviolet light (if worn whilst on a sun bed for example), and will change back to blue if heated in an

Irradiated stones:

There have been scares in America about the dangers of radioactivity in treated stones. US Customs officials are particularly concerned about large parcels of such stones that they are handling.

In conclusion, Ken Scarratt suggested that, when handling treated gemstones, three aspects should be taken into account:

'Is anything artificial added'

'Is it permanent'

'Is it safe'

Fig. 7. A specimen of Aqua Aura.

Presentation of Awards

The Conference culminated in the 1991 Presentation of Awards ceremony, also held at Goldsmiths' Hall. Mr David J. Callaghan presided and welcomed those present, particularly Jeanne Miller from the USA who qualified in the Association's examinations 25 years ago and had made the trip to celebrate the anniversary of her achievement. This year award winners from Finland, Germany, Greece, Japan, The Netherlands and Spain were present to receive their Diplomas.

Mr Callaghan went on to say that for the 1991 Examinations it had been necessary to arrange 62 centres in 26 countries which takes a lot of organisation, particularly getting the specimens for the practical section through Customs to arrive at the centres on time. He thanked the examination team, headed by Ian Mercer, for their hard work, and also paid tribute to the Examiners.

He then called upon Mr George F.H. Burne, Director of the Central Selling Organisation, to present the awards.

In his address, Mr Burne reminded those present that 1991 was the 60th anniversary of the Association - the Diamond Jubilee, a celebration honoured by the King of Gems. He went on: 'I have worked for 34 fascinating years in the diamond business and can therefore only commend you on your choice of subject.

Fig. 8. Mr George F.H. Burne, Director of the CSO.

Address by Mr George Burne

'One thing I can assure you is that each day brings something new, some extra experience and knowledge. I am of course biased towards diamonds and you must forgive me for that. However, whatever gem we specialise in we know that all are beautiful, all have their own special magic, all can create masterpieces of jewellery to delight the eye and raise the spirit. The modern world is often beset by problems of tedious practicality; an obsession with the ordinary, and the mundane. In jewellery we can seek a more spontaneous celebration of life, a return to a time when adornment was seen as a basic need. Our forefathers had no doubts. They attributed strange and wonderful properties to gems, particularly diamonds. Resistance to disease, fortitude in battle, good fortune. Your task, our task, is to defend the integrity of our business. To ensure that what is false, what is synthetic, what is treated is exposed and shown to the world for what it is. Your knowledge and your skills should protect and advise our industry, encouraging excellence, meticulous appreciation and the setting of the highest standards. You are now qualified, or are in the course of qualifying, to join a large and growing industry. Worldwide sales of jewellery last year are estimated to have totalled $70bn and with growing prosperity in the Far East who can doubt the future?

'My congratulations go to all 580 candidates who were successful in the examinations set in various locations in 26 different countries. The percentage of the pass rate, 61% for the preliminary and 48% for the diploma, indicates the high standard set.

'We, at De Beers Centenary and the CSO, are fully aware that to be elected to the Fellowship of your Association represents a considerable personal achievement. To have the initials FGA appearing after one's name commands respect and credibility throughout the entire jewellery

Fig. 9. David Callaghan with the Anderson/Bank Prize winner, Peter J. Wates of Coulsdon, and Preliminary Trade Prize winner Anne Margaret Bailey of Rugby.

world. That the Diploma Trade Prize should have been awarded to a Sri Lankan, the Anderson medal to a Korean, and that thirteen of the 17 distinctions were earned by candidates from Canada to China and from Norway to Nairobi, certainly makes this point. This large overseas interest in attaining the FGA qualification continues to demonstrate the international appreciation of your Association in this, your 'Diamond Anniversary' year.

'The first Chairman of the Gemmological Committee was Samuel Barnett who held the office in 1908 and the first Diploma Holders are recorded in 1913. Of Samuel Barnett it was said, "he had sown the seed which marked the beginning of organised gemmology not only in this country, but in the whole world". 'A sentiment which reflects the fact that the first American correspondence course candidate, Robert M. Shipley, who gained his diploma in 1929, went on to found the Gemmological Institute of America two years later.

'As so often with inventions and ideas started in this country we may reflect, somewhat wryly, on the extent of the knowledge, we have so generously helped to export abroad!

'In the souvenir catalogue prepared for your Golden Anniversary and '50 Years of Gemmology' exhibition held there at the Goldsmiths' Hall ten years ago, I note that it was my former colleague, Lionel Burke, who presented these awards in 1963. We are fortunate to join an illustrious line of distinguished presenters who have distributed awards almost without interruption since 1931.

'You now have a new diamond course starting this year and we are impressed with its professional presentation and scope. We have given and will continue to give it our support. A number of CSO executives have enrolled and I am sure they will be followed by many more in the years to come. Howard Vaughan tells me that you are already being bombarded with questions on crystallography from Charterhouse Street. This course is a descendent of those held by Norman Harper in Birmingham and Eric Bruton at the Sir John Cass College in London. As Mr. Bruton would be the first to admit, a lot of water has passed under the bridge since then, and certainly the world, its peoples, and the jewellery business have changed out of all recognition. With diamonds, for example, who could have expected that the production of natural diamonds would double to over 100 million carats over the last 10 years. Or, that competitive labour rates and a vastly expanded market (may I say as a result of De Beers advertising) would have resulted in the emergence of a diamond cutting centre employing 700,000 workers in India. It is surprising that automation has progressed so little in our industry, perhaps because it continues to pride itself in craftsmanship and personal skills. However De Beers has just held the first international technical symposium for the diamond industry in Israel, an event which may herald change in the future. For 1990 our researchers estimate that some 14 million carats of polished diamonds were set into some 52 million pieces of jewellery, which would have sold for a mere 39 billion dollars.

'The diamond industry has indeed been democratised giving wealth to the miners, often in developing countries, employment for many hundreds of thousands in cutting and polishing, jewellery manufacturing and in retail shops and joy to millions of customers. Long may this happy industry prosper, ensuring that every woman, and man if he wishes, may wear the radiance of the stars trapped for ever in ice'.

Mr Burne concluded his address by again congratulating the award winners. He also complimented those concerned in the production of the new Gem Diamond Course stating 'How just and appropriate that it should have started in this year Diamond Anniversary year'. Mr Ken Scarratt thanked Mr Burne for presenting the awards. He also thanked the CSO for their help and support with the new Gem Diamond Course, which now provides the diamond trade with its own professional qualification.

In conclusion Mr Callaghan thanked the Worshipful Company of Goldsmiths for allowing the Association to hold the ceremony in the Hall.

He also thanked T.H. March and Co. Ltd. for sponsoring the Conference which had proved very successful.

F.G.A.

your key to the fascinating world of Gemmology

The Gemmological Association and Gem Testing Laboratory of Great Britain has been actively involved in the very beginning of Gemmology as an independent science.

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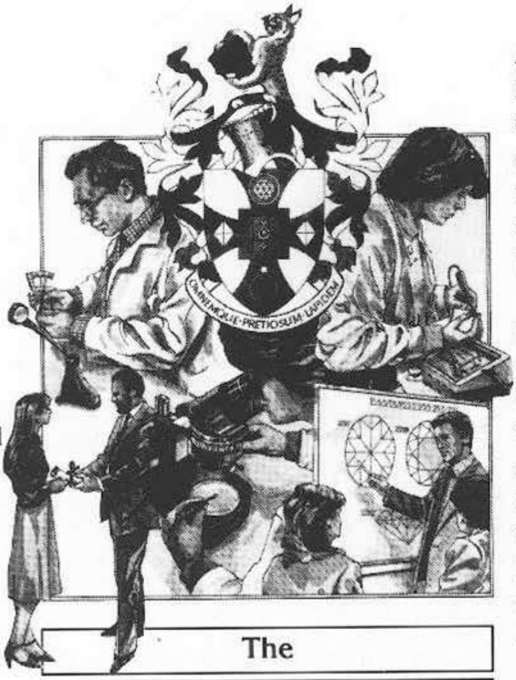

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and Gem Testing Laboratory

Of Great Britain

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Book Reviews

HUGHES, F.E., 1990. *Geology of the mineral deposits of Australia and Papua New Guinea.* Australasian Institute of Mining and Metallurgy, Parkville, Victoria. 2 vols., pp. xxiii, 1828, 45, 3. Illus. in black-and-white and in colour. Both volumes include maps in pockets. Price approximately £150.00.

This very large work contains papers on the geological details of important minerals deposits (exclusive of coal and oil). Many papers describe gold deposits but a number deal with gem materials. Atkinson, Smith, Danchin and Janse provide an overview of Australian diamond deposits (pp. 69-76): opal deposits are described by Barnes and Townsend (77-84): Boxer and Jaques outline the Argyle (AKl) diamond deposit (697-706): the Arunta block, in which some gem quality pink corundum is located, is described by Shaw (869-874). In the second volume Flint and Dubowski deal with the Cowell nephrite jade deposits (1059-1062): the Ellendale diamond deposits feature in a paper by Hughes and Smith (1115-22) and the Argyle alluvial diamond deposits are in a paper by Boxer and Deakin (1655-8). Fazakerley (1659-64) describes the Bow River alluvial diamond deposit. A detailed reading of the whole book would no doubt throw up more hidden information. Each paper has its own list of references and there are very extensive author and subject indexes, repeated in each volume. Finally large geological maps are provided, one to each volume, covering Australia and Papua New Guinea respectively. M.O'D.

MITRA, S., 1989. *Fundamentals of optical, spectroscopic and X-ray mineralogy.* Wiley, New York. pp. xv, 236. Illus. in black-and-white and in colour. £16.30.

The book gives a useful overview on a variety of topics of interest to the gemmologist although the information is no longer new. Readers may find the sections on spectroscopic studies and on reflection optics the most interesting. A number of inaccuracies can be found. M.O'D.

MURANO, A.P., SAGGESSE, A.P., 1989. *L'Arte del corallo.* Gaetano Macchiaroli, Naples. pp.145. Illus. in colour. £54.00.

This well-illustrated book tells the story of coral manufacture at Naples and Torre del Greco during the eighteenth and nineteenth centuries. Each chapter [there is neither a list of contents nor index] has its own extensive list of references and there is a section of colour plates at the end of the book. In addition there is a general bibliography arranged chronologically. The book gives accounts of the major manufacturers and methods of coral working; particular attention is paid to the major manufacturer, Ascione of Torre del Greco.

M.O'D.

NEWMAN, R., 1991. *The ruby and sapphire buying guide.* International Jewelry Publications, Los Angeles. pp. 204. Illus. in black-and-white and in colour. US$19.95.

The book is subtitled How to spot value and avoid ripoffs, but this to a European reader suggests a more commercial type of book than in fact is the case. The text covers colour, fashioning, synthetics and imitations, colour alteration, sources, appraisals, certification, care of corundum-set jewellery, travel abroad and buying stones and jewellery there and how to find a bargain in so far as that is possible. The text is clear and includes a great deal of gemmological as well as commercial information; text photographs are clear and cover many situations for appraisal which have rarely been put forward in gemmology texts before. Some of these points include colour assessment in different types of light and the provision of a section of questions at the ends of the chapters will be useful to the gemmology student as well as to the dealer or purchaser of jewellery. At the price this book can be highly recommended. M.O'D.

QUELLMALZ, W., 1990. *Die Edlen Steine Sachsens.* Deutscher Verlag fUr Grundstoffindustrie, Leipzig. pp.200. Illus. in black-and-white and in colour. DM 49.80.

Among the gem minerals found in Saxony are varieties of quartz, tourmaline, topaz, beryl and turquoise. Details of mining in the past three centuries are outlined; there is an excellent bibliography and good quality coloured pictures.

M.O'D.

READ, P.G., 1991. *Gemmology*. Butterworth-Heinemann, London. pp.358. Illus. in black-and-white and in colour. £30.00

Peter Read is the author of several gemmological books, and series editor for a number of others by various writers. His particular interest has been in gemmological instruments, a fact which adds strength to his latest volume.

Clearly and explicitly written and profusely illustrated, it perhaps runs to rather more detail than is needed for a teaching text, but is none the worse for that. Most students are sufficiently selective to avoid swotting up on many microscopes and several refractometers when one of each is enough. The fourteen colour plates are realistic and convincing, while most black-and-white illustrations have printed well.

The sequence of chapters is perhaps unconventional and among other changes 'The fashioning of gemstones' and 'Diamond grading' are left until the end of the main book. I found this re-arrangement of subject matter refreshing and in no way detrimental to understanding. The main text is followed by eleven appendices covering: A Bibliography; B Organic gems; C Inorganic gems; D Synthetic gems not occurring in nature; E A summary of colour theory; F Examination notes, including sample theory papers for Preliminary and Diploma years; G Two lists of constants, one alphabetic and a more useful second one in order of RI values; H Units of measurement; I Table of the elements; J Principal Fraunhofer lines; and K Gemstone weighing.

Appendix C deals with gem species in a note form suitable for memorizing for examination purposes; stones needed for the Preliminary syllabus are marked with an asterisk.

It should be noted that since the book was written the Gemmological Association has issued a new Prospectus of Examinations which will apply from 1992 onwards. According to this the appearance and names of stones may be required in the Diploma Theory paper, for any of about forty of the more rarely cut collectors' gems, most of which do not feature in this book. Mr Read has added a short paragraph on this requirement, but has listed only twelve of the extra stones, saying that occurrence and distinguishing features may be required.

A very few minor misprints were noted but on p.161 the words 'achromatic and aplanatic' have been transposed in the description of pocket lenses; p.189 '59 band' should be '594 band'; p.273 Webster's inexact 'ten teaspoons of salt' recipe for brine to float amber is repeated. Teaspoons vary considerably in size and it is safer to say 50 grams of table salt. Mr Read has also used the term 'metamerism', I think incorrectly, to describe the colour change in alexandrite. Far better to call it 'the alexandrite effect' since there seems to be no specific term for it.

This attractive and well-produced book is a valuable and up-to-date addition to any gemmological library, written in explicit terms which are easy to understand, and priced reasonably when the very considerable content is taken into consideration.

R.K.M.

SOFIANIDES, A.S., HARLOW, G.E., 1990. *Gems and crystals from the American Museum of Natural History*. Simon and Schuster, New York. pp.208. Illus. in colour. US$40.00. ISBN O 671 68704 2.

With photographs by Harold and Erica Van Pelt, this is a large-format guide to the collections of the American Museum of Natural History in New York City. The book is arranged in order of the most important gemstones followed by pearls, rare and unusual species, glossary, short reading list and index. An introduction describes the formation and development of the Museum's gemstone collection, with notes on prominent personalities such as G.F. Kunz and J.P. Morgan. This section is followed by general remarks on gemstones and how they were successively valued as talismans, palliatives and ornament.

Each major gem species is introduced by general remarks with constants shown separately and usefully in a box. In general the notes are clear and accurate and major stones have historical notes appended. As expected the Van Pelts have excelled themselves once more and the pictures are beautiful. Apart from slight inaccuracies and the misspelling of gahnite throughout the text appears to be reliable and in any case the book succeeds admirably in displaying the beauty of gemstones to museum visitors.

M.O'D.

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

GEM AND JEWELLERY NEWS

In December 1991 the first issue of *Gem and Jewellery News* was published. This newsletter is a joint venture between the Gemmological Association and Gem Testing Laboratory of Great Britain and the Society of Jewellery Historians, and will be published alternately with the *Journal of Gemmology*.

Comments and contributions should be sent to the Editor, *Gem and Jewellery News*, GAGTL, 1st Floor, 27 Greville Street, London ECIN 8SU.

OBITUARY

Mr Darel W.J. Dambrink, FGA (D.1963 with Dist.), Beekbergen, The Netherlands, died in 1991.

Mr Douglas N. King, FGA (D.1949), Birmingham, Chairman of the Association from 1978 to 1980, died on 26 December 1991. A full obituary will be published in the April issue of *The Journal.*

Mr Eric Robert Levett, FGA (D.1946 with Distinction and the Tully Medal) died 22 September 1991, aged 84.

Eric Levett had been one of the last two surviving subscribers to the Memorandum and Articles of Association which in 1947 gave the Gemmological Association its status as a Company Limited by Guarantee.

He was the proprietor of 'Frances Harling', a delightful period shop in Heath Street, Hampstead, retaining the name of its previous owner, for a number of years. Here he dealt largely in antique jewellery and developed a collector's interest in Japanese *netsuke* and other specialized items.

He moved to Rhodesia for several years before coming back to take over the Harling shop again until retirement, when he went to live in North Devon and ultimately in the Lot et Garonne area of SW France for some twenty years.

After his second wife, Christine, died in 1987 he came home to live at Martlesham in Suffolk, near his only remaining relative, Mrs D.E.C. (Mac) Levett, widow of his elder brother Frank, who took such great care of him in his last illness.

A highly intelligent man, remembered as 'a bright, penetratingly eager and lively mind', interested in natural history and science, a life-long vegetarian, devoted to fine classical music and to art, closely associated with Ernest Rutland, Basil Anderson, Robert Webster and others well-known in our specialized world, an excellent gemmologist and a wonderful friend of more than forty years, he will be greatly missed.

R.K.M.

MEMBERS' MEETINGS

London

On 3 and 4 November 1991 at the Tower Thistle Hotel and Goldsmiths' Hall the Annual Conference and Presentation of Awards were held. A full report is given on p.38.

Midlands Branch

On 17 October 1991 at Dr Johnson House, Bull Street, Birmingham, an informal evening was held.

On 15 November 1991 at Dr Johnson House, Mr J. Gosling gave a talk entitled 'The Guyana Lapidary Project'.

North West Branch

On 20 November 1991 at Church House, Hanover Street, Liverpool 1, the Annual General Meeting was held at which Mrs Irene Knight and Mr Joe Azzopardi were elected Chairman and Secretary respectively.

ANNUAL GENERAL MEETING

On 4 November 1991 at Goldsmiths' Hall, Foster Lane, London EC2, the Annual General

Meeting of the Gemmological Association and Gem Testing Laboratory of Great Britain was held.

Mr David Callaghan, FGA, chaired the meeting, and began by paying tribute to Noel Deeks and Nigel Israel for the tremendous amount of work they had undertaken during the year for the Association. He then thanked the Council of Management for their help and support, and the staff of GAGTL for their hard work.

The Annual Report and Accounts were approved and signed.

Mr Callaghan reported with regret that Sir Frank Claringbull, President of the GAGTL, had died during the year. Mr R. Keith Mitchell was re-elected Vice-President.

Mr V.P. Watson was re-elected and Mr C.R. Cavey elected to the Council of Management. Mr N. Deeks and Mr N.B. Israel retired from the Council of Management and did not seek re-election.

All members of the Members' Council were re-elected, with the exception of Mr C.R. Cavey and Mr A. Hodgkinson who did not seek re-election.

Messrs Hazlems Fenton were re-appointed Auditors.

Mr Callaghan thanked the retiring members of the Council of Management, Noel Deeks and Nigel Israel, for all they had done for the Association. He then made a presentation to them, saying: 'It is customary when someone leaves you to give them a small token to commemorate the event. On this occasion it is very difficult because of extent of the work they have undertaken, but we wish to offer them a small token of our thanks'.

This concluded the business of the meeting.

MEMBERSHIP AND QUALIFICATIONS

With the introduction of the Gem Diamond Correspondence Course and the Gem Diamond Diploma, we should like to remind members of the qualifications governed by the GAGTL and outline the circumstances of their use.

Anyone may apply to join the GAGTL and, upon approval by the Council of Management will be accepted for membership.

A member who passes the Diploma Examination in Gemmology may apply for Fellowship of the GAGTL and, upon approval by the Council of Management, may use the initials FGA after his or her name. Likewise, members who pass the examination for the Gem Diamond Diploma may use the initials DGA after their name.

Non-members may NOT use any of the above initials after their name, even if they hold our qualifications (Diploma in Gemmology, Gem Diamond Diploma, or the Diamond Certificate). Those wishing to use the initials must have current membership of the GAGTL.

Holders of the Diamond Certificate, awarded up to 1991, may use the initials DGA after their name if they are current members of the GAGTL.

Members holding both the FGA and DGA are required to pay only one membership fee.

MEETING OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 16 October 1991 at Chapel House, Hatton Place, London ECIN 8RX, the business transacted included the election to membership of the following:

Fellowship

Abel, Arlan R., Minneapolis, Minn., USA. D.1991

Achakane, Abdelaaziz, Marrakech, Morocco. D.1989

Amo, Christopher P., Amherst, Buffalo, NY, USA. D.1991

Atkinson, Henry N., Cape Town, S. Africa. D.1991

Bailey, Lisa J., Birmingham. D.1991

Ball-Edwards, Chantal, Cheltenham. D.1991

Barratt, Claire A., Gillingham. D.1991

Benham, Spencer H., Braddan, Isle of Man. D.1991

Bouvier, Benoit, Cornwall, Ont., Canada. D.1991

Boyd, Heather K., Chorlton-cum-Hardy. D.1991

Cage, Corrall E., Ipswich. D.1991

Campbell, Daniel W., Bedminster, NJ, USA. D.1991

Chan, Chi K.R., Kowloon, Hong Kong. D.1991

Chan, Suk K.B., Pokfulam, Hong Kong. D.1991

Cheng, Kit L.C., Kowloon, Hong Kong. D.1991

Cheng, Siu H.M., Kowloon, Hong Kong. D.1991

Chow, Kam K., Central, Hong Kong. D.1991

Christaki, Ourania, London. D.199Cipriani, Tony, St Laurent, Quebec, Canada. D.1991

Clifton, Sarah E., Edgbaston. D.1991

Collingwood, Mark A., Bradford. D.1991

Combe, Ian, Haddington. D.1991

Dayasagara, Kalupahana L.D., Nugegoda, Sri Lanka. D.1981
Dennis, Stuart G., London. D.1991
Dhir, Pablo, Nairobi, Kenya. D.1991
Evangelou, George G., Enfield Wash. D.1991
Falk, Carita L., Helsinki, Finland. D.1991
Fixter, Robert H., Lincoln, Nebr., USA. D.1991
Fromming, David E., Aylesbury. D.1991
Fung, Chung M.N., Tuen Mun, Hong Kong. D.1991
Georgiadou, Elizabeth, London. D.1991
Green, Alan A., Kidlington. D.1991
Green, Christopher M., Slough. D.1991
Hendry, Adrian L., Stansted. D.1991
Hobbs, Peter G.A., Lavenham. D.1991
Hogguer, Virginia N., AD Rijn, The Netherlands. D.1991
Hoogendoorn, Elizabeth G., Houten, The Netherlands. D.1991
Ichniowski, Jacqueline A., Ellicott City, Md, USA. D.1991
Jain, Neerja, Birmingham. 1991
Jakobsson, Thomas A., Huddinge, Sweden. D.1991
Jameson, Cynthia C.V., Bethesda, Md, USA. D.1991
King, Margaret A., Glasgow. D.1991
Kwan, Pik S., Kowloon, Hong Kong. D.1991
Lam, Kwong K., Pokfulam, Hong Kong. D.1991
Lam-Paktsun, Christiana K., Brisbane, Queensland, Australia. D.1991
Lau, Yan W.G., NT, Hong Kong. D.1991
Laurie-Lynch, Carl, Birmingham. D.1991
Lavin, Padraic, Co. Roscommon, Eire. D.1991
Lee, Mary F.A., Addlestone. D.1991
Lentz, Janine, CD Haarlem, The Netherlands. D.1991
Leung, Wing S., Kowloon, Hong Kong. D.1991
Li, Kam Y.D., Shatin, NT, Hong Kong. D.1991
Liu, Shang I., NT, Hong Kong. D.1991
Long, Ann D., Colchester. D.1991
Loong, Kok 0., Butterworth, Malaysia. D.1991
McConnachie, David C., Bearsden. D.1991
Mak, Wing H.W., North Point, Hong Kong. D.1991
Mathieson, Jacqueline N., Edinburgh. D.1991
Matthews, Lisa K., London. D.1991
Mehta, Reshma, Hong Kong. D.1991
Mueller, Hilda M.M., Karlsruhe, Germany. D.1991
Nikookar, Tahmineh, Vancouver, BC, Canada. D.1991
Pasini, Roy J., N. Olmsted, Ohio, USA. D.1991
Pattni, Rajendra A., Nairobi, Kenya. D.1991
Peers, Sharon M., Bromley. D.1991
Pehkonen, Kaarina A., Helsinki, Finland. D.1990
Penton, Keith, London. D.1991
Pool, Richard J., York. D.1991
Redgrove, Claire A., Selsey. D.1991
Rogers, John W.S., Stroud. D.1991
Rohmer, Neva D., Hong Kong. D.1991
Sabbagh, Samuel J., Minas Gerais, Brazil. D.1991
Sabbagh, Steven E., London. D.1991
Salmi, Tarja A., Helsinki, Finland. D.1991
Stewart, Carolyn L., Hong Kong. D.1991
Tamblin, Carol S., Liskeard. D.1991
Tees Audrey, Glasgow. D.1991
Tsang, Sui C., Central, Hong Kong. D.1991
Vaughan, Michael J., Budleigh Salterton. D.1991
Veenemans, Vivianne M.M., Antwerp, Belgium. D.1991
Waller, Mark S., Bradford. D.1991
Washbrook, Simon J., Stockport. D.1991
Webster, Kathleen A., London. D.1991
Welch, Lizanne, Taunton. D.1991
Wenting, Eduard J., EH Wehl, The Netherlands. D.1991
Wilson, Jane, Marford, Nr Wrexham. D.1981
Zebrowski, Rafal, Mississauga, Ont., Canada. D.1991

Ordinary Membership

Baker, Maj-Britt A.K., London.
Barnes, Stephen P., London.
Baruah, Tipsuda, London.
Batis, David, Athens, Greece.
Brahmbhatt, Baldevbhai B., Nairobi, Kenya.
Coughlin, Donald G., Colombo, Sri Lanka.
Eames, Lucy, Belgrade, Yugoslavia.
Edgerton, Edward G., Taunton. Goddard, Valerie J., Cranleigh.
Goldingay, Raymond F., St John, Jersey, CI.
Hofer, Peter, Northwood.
Hue Williams, Sarah G., London.
Jeha, Zead, Beirut, Lebanon.
Kim, Hei J., Seoul, Korea.
Kim, Sang-ki, Seoul, Korea.
Kyoung, Byun J., Seoul, Korea.
Lee, Tonny S., Taiwan, China.
Luke, Ting C.L.A., Kowloon, Hong Kong.
Lysons, Jon D.E., Macclesfield.
Magnusson, Peter A., Goteborg, Sweden.
May, Frank, Edinburgh.
Moth, Anthony D., High Wycombe.
Ozaki, Ken, Sapporo, Japan.
Piper, Rachel, London.
Prior, Louise, London.
Rajani, Kishorkumar M., Daressalaam, Tanzania.
Rawat, M.S., London.

Requena, Juan A.S., Barcelona, Spain.
Robins, Eric M., Hauraki Plains, New Zealand.
Rossell, Ramon, Andorra la Vella, Andorra.
Sakon, Yuichi, Bougival, France.
Saunders, Frank, Spennymoor, Co. Durham.
Sharma, Kul B., Lusaka, Zambia.
Shindler, Bernard D., Stanmore.
Tasaki, Kazuyo, Kobe, Japan
Tasaki, Toshiaki, Kobe, Japan.
Topham, Darren M., Brighton.
Travis, Peter J.B.C., London.
Tsipoura-Vlachou, Maria, Athens, Greece.
Turner, Ian B., Bury St Edmunds.
Van der Wal, Peter, Antwerp, Belgium.
Walker, Errol J., Oldham.
Ward-Jones, Ann, London. Williams, Alison D., Cobham.

Transfers - Ordinary Membership to Fellowship

Adams, Suzanne, Sutton. D.1991
Arbisman, Alexander, Selsdon. D.1991
Bascombe, Frieda M., Hong Kong. D.1991
Bassioudis, Vassilis, Thessaloniki, Greece. D.1991
Bensimon, Colette Z., London. D.1991
Brooks, Anna, Watford. D.1991
Chiu, Roy S.H., Hong Kong. D.1991
Collins, Stephanie, New Malden. D.1991
D'Alessandro, Martha, Rio de Janeiro, Brazil. D.1991
De Silva, Gamini, London. D.1991
De Winter, Rene G., Amsterdam, The Netherlands. D.1991
Egner, Valerie S., London. D.1991
English, Dora P., Hong Kong. D.1991
Foster, Brenda C., St Albans. D.1991 Franklin, Neil, Newcastle upon Tyne. D.1991
Fukushima, Hideali, Tokyo, Japan. D.1991
Galloway, Linda L., Hong Kong. D.1991
Gau, Robert B.R., Taipei, Taiwan, China. D.1991
Gofa, Sophia, Athens, Greece. D.1991
Grant, Miranda J., Edinburgh. D.1991
Hare, Rebecca M.A., Fleet. D.1991
Hunter, Charlotte T., Northampton. D.1991
Ito, Yuko, Kanangawa-ken, Japan. D.1991
Kejriwal, Bindu, London. D.1991
Killias, Andree, Hong Kong. D.1991
Kimura, Hiroyuki, Tokyo, Japan. D.1991
Lalovska-Koundourou, Radka, Athens, Greece. D.1991
Leblans, Isabelle, Ottignies, Belgium. D.1991
Maeda, Katsuya, Kakogawa-Shi, Japan. D.1991
Mansfield, James G., London. D.1991
Mason, Alec J., Retford. D.1991
Matoba, Hiroshi, Nara-City, Japan. D.1991
Michallat, Mark, Shipley . D . 1991
Mitchell, Beverly, London. D. 1991
Mori, Junko, Hyogo Pref, Japan. D. 1991
Oura, Mamiko, Tokyo, Japan. D. 1991
Patel, Pankaj, London. D. 1991
Pople, Cecilia, Guildford. D.1991
Rigby, (Lesley) Claire, Bolton Abbey . D. 1991
Rowlands , Alan F ., Calgary , Alta , Canada . D. 1991
Schmidt, Simon, London. D.1991
Shalvi, Judy, Hong Kong. D. 1991
Shinjo, Yasushi, Osaka, Japan. D.1991
Spencer , Riita M., Helsinki , Finland . D . 1991
Sundin, Stig E., Bergen, Norway. D.1991
Takano, Hirofumi, Tokyo, Japan. D. 1991
Takeda, Mari, Tokyo, Japan. D.1991
Tanigaki, Takako, Osaka City, Japan. D . 1991
Thomas-Everard, Lucilla, London. D.1991
Tsuda, Miwako, Takarazuka City, Japan. D. 1991
Tsurita, Kazuo, Osaka, Japan. D. 1991
Walter, Keith, Peebles. D. 1991
Wasserman, Caron J., London. D. 1991
Wates , Peter J ., Coulsdon . D . 1991
Wells, Andrew, Banstead. D. 1991
Yonehara, Machiko, Hyogo Pref, Japan. D . 1991
Zander, Marie-Claire M., Sao Paulo, Brazil. D.1991
Zwaan , Johannes C ., London . D . 1991

EXAMINATIONS IN GEMMOLOGY 1991

The following qualified in the 1991 Diploma Examinations in Gemmology, but were omitted from the list published in *The Journal of Gemmology*, 22, 8, 506-9.

Gemma Auberni i Serra, Barcelona, Spain.
Ravinda Samaranayake, Colombo, Sri Lanka.

GEM & MINERAL FAIRS 1992

Gem and Mineral Fairs will be organized by the British Lapidary & Mineral Dealers' Association during 1992 as follows:

London 11-12 April 1992. Holiday Inn, Swiss Cottage.
Leicester 16-17 May 1992. Holiday Inn.
Harrogate 29-31 August 1992. Crown Hotel.
London 17-18 October 1992. Holiday Inn, Swiss Cottage.

Further details from Fair Organizer: John F. Turner, Glenjoy, 19/21 Sun Lane, Wakefield, W. Yorkshire. Telephone 0924 373786.

FORTHCOMING EVENTS

London

Meetings will be held at the City Conference Centre, 76 Mark Lane, London EC3R 7JN, at a cost per lecture of £5.00 for GAGTL members, £10.00 a member and a guest, and £8.00 for non-members. Further details and tickets from the GAGTL.

Gemstone deposits and the trade associated with them

Tuesday 10 March 1992	Sri Lanka
Wednesday 13 May 1992	Australia
Tuesday 9 June 1992	South East Asia
Tuesday 24 November 1992	Africa

Midlands Branch

Meetings will be held at Dr Johnson House, Bull Street, Birmingham.
Further details from David Larcher on 021 554 3871.

21 February 1992	Mr Clive Burch (subject to be announced)
20 March 1992	Mr David Callaghan (subject to be announced)
10 April 1992	Annual General Meeting followed by lecture

North West Branch

Meetings to be held at Church House, Hanover Street, Liverpool 1.
Further details from Irene Knight on 051-924 3103.

19 February 1992	Helen Fraquet. 'Amber'
18 March 1992	Dr Jeff Harris. 'An aspect on diamonds'
20 May 1992	Nigel Israel. 'Historical aspects and valuations'
17 June 1992	'Exchange and Mart'. Buying and selling of books, crystals and instruments, plus social evening.
16 September 1992	Adrian Klein. 'Emerald'
21 October 1992	Dr Jamie Nelson. 'Optical attributes of a diamond'
18 November 1992	Annual General Meeting

EXAMINATIONS 1992

The examination dates for 1992 are as follows:

Gem Diamond Examination:
Theory - Wednesday 17 June
Practical - College students Wednesday 17 June
Correspondence Course students to be advised

Examinations in Gemmology:
Preliminary - Monday 29 June
Diploma Theory - Tuesday 30 June
Diploma Practical - Wednesday 1 July, or as advised
The final date for receiving examination entry forms is 31 **March.**

GAGTL GEM WORKSHOPS 1992

Diamond Grading Workshop

Three-day Diamond Grading Workshops are being arranged in March and May 1992, at a cost of £300.00 plus VAT.

Diploma Course Students

Intensive two-day practical tutorials are to be held for the Diploma Course students and all those wishing to gain a deeper insight into gems and practical gem testing. Based on the syllabus of the Diploma examination, the sessions will provide instruction on all instruments and equipment required for the practical examination, using a wide range of gemstones. Four workshops are to be held as follows:

Wednesday 1 and Thursday 2 April
Tuesday 7 and Wednesday 8 April
Saturday 11 and Sunday 12 April
Saturday 25 and Sunday 26 April

The price of the Diploma Workshop is £120.00 plus VAT.

For further information and a booking form please contact Ian Mercer or Louise Macdougall at the GAGTL Education Office on 071-404 3334.

Letter to the Editor

From R. Keith Mitchell, FGA

Dear Sir,

I am a little surprised that Mr Farn's letter in your July issue should have been published without some attempt to check its facts.

I refer primarily to 'a forthcoming treatise by Eric Bruton and Keith Mitchell on Anderson's research and work with the spectroscope'. I have corrected Alec Farn on this more than once yet he persists in the error.

Eric Bruton is concerned only in so far as he has agreed to publish the book, which is not in any sense a treatise either by him or by me, jointly or otherwise. Ninety per cent of the written text is pure Anderson and if it is to be regarded as a treatise at all then it is by his hand and not mine or Eric Bruton's. My task, self-appointed, has been to edit and up-date Anderson's vastly important series of 40 articles published in the 1950s in the now defunct Gemmologist. Added to which I found it necessary to re-draw almost all of the spectra, since about half of the original T.H. Smith drawings were missing and the rest were too spoiled and dilapidated for satisfactory plates to be made. Some additional chapters were needed and many minor alterations of text were found necessary. The whole task has taken me several years, roughly three times as long as I anticipated when I originally volunteered to do the work with Barbara Anderson's approval.

It may seem strange to 'book' these articles now after more than thirty years. But the facts written so explicitly by Anderson, who, with C.J. Payne, pioneered the methods of spectroscopic gem testing, are still completely valid and applicable to normal gemmology today. This book has been needed for far too long and should now be regarded as a vital text for students and for practising gemmologists; and as a memorial to this country's greatest, and the World's first, full-time Gemmologist.

Regarding α-monobromonaphthalene, I well remember having a bottle of that liquid which was so labelled. This to my mind meant that somewhere there had to be a β-version of the stuff. But now the only text I can find which uses this antideluvian prefix to the name is Sir Henry Miers' *Mineralogy* published in 1902. Bauer, Dana Ford, Herbert Smith, Anderson, Webster and many other books I have referred to, have either dropped the practice or fail to mention the liquid at all. In a book review and letter dealing with its recent renaming there was no point at all in resuscitating ancient terminology.

My old English master more than 60 years ago made the comment that 'verbal' meant 'in words' and that those words could equally well be by 'word of mouth' or in print. However the stones sent by post for 'verbal testing' would surely be identified in a telephoned reply, so Mr Farn's interpretation of 'verbal' would apply. Strictly the word 'oral' should be used rather than 'verbal' (see *The Complete Plain Words* by Sir Ernest Gowers). For me 'verbal testing' conjures up a vision of someone talking to gems rather as Prince Charles is said to talk to flowers.

Yours sincerely,
R. Keith Mitchell
12 August 1991
Orpington, Kent.

Notes for Contributors

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

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

Twenty five copies of individual papers are provided on request free of charge; additional copies may be supplied, but they must be ordered at first proof stage or earlier.

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