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Cover Picture

An unusual Guyanese agate showing long, interlocking 'quartz' crystals with banded agate filling the interstices. (See 'An unusual agate from Guyana', p.76)

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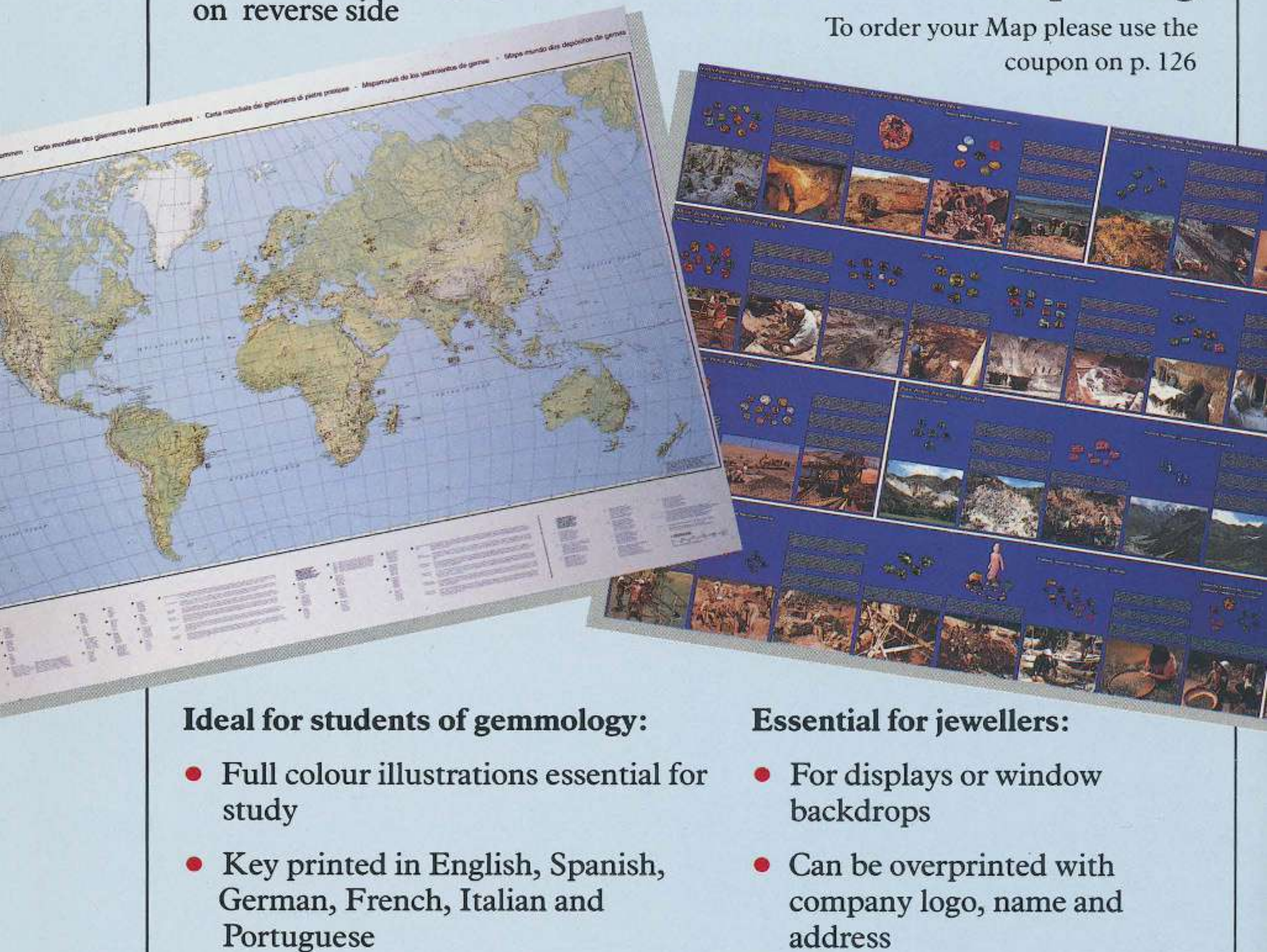

A contribution to the distinguishing characteristics of sapphire from Kashmir

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Abstract

This investigation was undertaken to contribute to the knowledge of sapphire from Kashmir, and over 50 cut stones were studied. Comparison of the observed inclusions with those described in other publications, identified in part using the scanning electron microscope SEM/EDS, confirmed the results of earlier findings (tourmaline, pargasite and zircon inclusions). In addition, some internal characteristics are newly described: plagioclase, uraninite, allanite and rutile (?) occurring in various forms, healed fissures and zoned growth. Spectral properties are presented. The significance of origin reports is discussed.

Introduction

Sapphire, the blue variety of corundum, is produced from numerous deposits distributed worldwide. The term **Kashmir Sapphire** is used to denote the origin of a stone from a specific location, and should not be regarded as a term describing either quality or colour. Some of the earlier worked deposits are no longer in production, their supply being either exhausted or no longer economically viable. This would also seem to be the case of the sapphire deposits of Kashmir.

Sapphire deposits can be classified into a number of types, on the basis of their genesis or geological setting (Deer *et al.*, 1980; Kiefert, 1987). Basaltic occurrences of the mineral (e.g. in Australia, Malawi, Thailand, Cambodia, etc.), often producing too dark, greenish-blue stones, do not host the most coveted blue corundum. Sapphires from pegmatitic dykes and metamorphic deposits are often too light or exhibit mixed colours, and are not generally considered to be of particular value (Montana, Tanzania, Sri Lanka). Nevertheless, the production of rough material with excellent colour from the latter type of deposits is considerable. These sapphires may attain top class quality after cutting (such as some from Burma, Sri Lanka, Kashmir).

Historical review

According to a number of authors (Mallet, 1882; La Touche, 1890), sapphire was discovered in 1881 at Soomjam in the district of Padar (Jammu and Kashmir Province) in India. The deposits, which occur at an altitude of about 4400m, were intermittently mined at several localities (Old Mine, New Mine, Valley). The production included some large crystals and a large quantity of medium-sized and smaller crystals. The colour and transparency of the stones varied considerably (Middlemiss, 1931; Roy, 1949), and mining figures for some years clearly show that the operation was often unprofitable. Due to the low yield and often inferior quality of the sapphire, mining was frequently interrupted and management changed on many occasions. A recent article describing all aspects of the deposit can be found in Atkinson and Kothavala, 1985. In his book on corundum, Hughes (in press) also presents a comprehensive list of literature on sapphire from Kashmir.

Origin of study material

The following study was carried out on cut sapphires submitted to the Swiss Foundation for the Research of Gemstones (SSEF) Laboratory in Zürich (Figure 1). Rough corundum of gem quality from Soomjam was not available to the author, and such material is at present not being mined. Study of inferior grade material (of which much is available), is of limited significance when information on transparent gem quality is required. The author received cloudy material together with host rock from Soomjam from two independent and reliable sources. The samples from both sources appeared identical and corresponded with information given in the original literature (Mallet, 1882; La Touche, 1890; Bauer, 1896). Corundum, which occurs in lenses and pockets, is hosted by a rock often described as kaolin. A sample of this fine-grained 'plumasitic' rock was examined and contains feldspar, sheet silicates and also black tourmaline, as described by La Touche (1890). The sample material studied was supplemented by a transparent sapphire crystal provided by a museum.

Earlier descriptions and photomicrographs of diagnostic inclusions (Phukan, 1966; Schubnel, 1972; Gübelin and Koivula, 1986) are scarce, but

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individual characteristics have been identically described. In the sapphires studied here, new inclusions were identified in addition to the classical diagnostic Kashmir inclusions (pargasite, tourmaline, milky lines with short traverse streaks, see Gübelin and Koivula, 1986). As far as possible, these new inclusions were mineralogically identified by Scanning Electron Microscope with Energy Dispersive System (SEM/EDS).

Absorption spectra exhibit a characteristic course, different from other sapphire curves. Thus, a second diagnostic criterion in addition to the inclusions is available for origin determination. Spectral behaviour, inclusion paragenesis and trace element content has been discussed with colleagues experienced in sapphire identification.

The new internal characteristics revealed in this paper have been used for the determination of origin, as they have consistently been shown to be typical of sapphire from Kashmir. The presence of all mineral inclusions identified so far in Kashmir sapphire can be satisfactorily explained by the geological setting at Soomjam. This paper reveals and discusses the additional characteristics.

The determination of origin by characteristics typical of the locality must be carried out in comparison with the properties of all other occurrences of sapphire. Some properties may be characteristic but not diagnostic for a definite population, since they are also found in stones from other localities. Thus, a fundamentally safe assignment of each stone to a specific locality does not always exist. Further discussion of the certainty of determining origin is presented in Hänni, 1988[a].

Habit and colour of Kashmir sapphire

The crystals normally display a simple pyramidal form with small basal planes (Goldschmidt, 1918). They are either totally or partially transparent, and the frosted to coarse surfaces are covered with a white crust (Bauer, 1896; Middlemiss, 1931), see Figure 2. The small, semi-translucent crystals of a grey colour and with a coarse surface are often still encountered as rough stone material today. They appear to have been found in large amounts and are suitable to a degree for heat treatment ('Kashmir-Geuda', Figure 2). Grey crystals of this kind have been described by Middlemiss (1931).

A particularly marked characteristic of much Kashmir sapphire is the velvety blue colour, due to slightly reduced transparency of the stones. It is the result of a cumulation of effets:

- turbidity due to microscopic and submicroscopic features of an unknown nature (Tyndall Effect on segregations of rutile (?) dust particles). Figure 3.
- scattering of light on microscopically small flat inclusions of an unknown nature (films of rutile or fluid inclusions?), which are distributed both homogeneously and oriented in rows throughout the stone. (Figure 4).
- zonal growth as sequences of transparent (blue or colourless) and turbid white lamellae with sharp borders (Figure 5).
- lamellar or block-like textures of different crystallographic planes with slightly varying refractive indices which tend to disturb the light path.

Absorption spectra

The blue colour of Kashmir sapphire can be explained by iron and titanium contents (Schmetzer and Bank, 1981). The absorption spectra exhibit the characteristic maxima caused by Fe^{2+}/Ti^{4+} pairs, and Fe^{3+}. Occasionally, light red portions occur in larger, bi-coloured crystals or as light pink crystals. Likewise, the occurrence of light rubies has been noted (Middlemiss, 1931). In fact, small quantities of chromium have been occasionally observed in Kashmir sapphire, identifiable by the emission line at 693nm in the absorption spectrum or by energy-dispersive X-ray fluorescence spectroscopy (Stern and Hänni, 1982). The blue colour of sapphire is the result of the relative absorption of all colours but blue (transmission from ca. 420-470nm). The spectral part from red, yellow and green is absorbed by a broad band centred at 580nm for the ordinary ray (*o*) and at 690nm for this extraordinary (*e*) ray. Fe^{2+}/Ti^{4+} pairs are responsible for this absorption behaviour. Absorption in the UV and VIS is also caused by Fe^{3+} eventually present, with absorption maxima at 374, 388 and 450nm. The presence of Fe^{2+}/Fe^{3+} pairs, mainly in green and greenish sapphire, results in an absorption maximum at 700 (*e* vibration) and 600nm (*o* vibration) affecting the colour. Even small amounts of Cr^{3+} in sapphire lead to an absorption at 600nm and the fluorescence line at 693nm. More information can be found in Bosshart (1981) and Schmetzer and Bank (1981).

The intensities of the absorption lines of Kashmir sapphire at 374, 388 and 450nm are similar to those for sapphire from Sri Lanka (weak) and weaker than those for sapphire from Burma (fairly strong). The maximum transmissions for the *e* vibration lie characteristically at 350, 420 and 470nm. The absorption curve edge starts to rise at below 370nm, usually passing into the general absorption at 320-330nm. A low Cr^{3+}-content results in a small band at 410nm (*e* vibration). Thus, the most important portion of the absorption curves of sapphire for determination of origin lies between 500 and 280nm.

Fig. 1. Three cut Kashmir sapphires (6-14ct) showing different degrees of transparency and colour saturation.

Fig. 2. Corundum crystal of low quality from Soomjam, and a slice of parent rock containing black tourmaline. The milky crystals are used for heat-treatment (so-called 'Kashmir Geuda'), blue pieces at right after treatment. Width of photo ca. 10cm.

Inclusions described in literature

Descriptions and illustrations of internal characteristics in sapphire from Kashmir are relatively rare compared to those from other deposits. On the basis of optical study, Phukan (1966) described the following characteristic features:–

P1 – oriented rutile needles, partly decomposed
P2 – fine dust, scattered between rutile needles or concentrated in cloudy patches of extremely fine particles
P3 – zircon, with or without 'winged' fracture haloes
P4 – opaque black prismatic crystals, surrounded by liquid feathers
P5 – liquid feathers, partly with tiny drops arranged in rows
P6 – healing feathers with grid-like patterns
P7 – flat liquid films or fluid-filled cavities

Schubnel (1972) considered the characteristic inclusions (the first two of which were identified using the electron microprobe) to consist of:–

S1 – tourmaline, greenish and possessing irregular forms
S2 – pargasite, fine light green needles up to 6mm in length
S3 – partly corroded colourless crystals (his Figure 26b, p.166)
S4 – flat fluid films.

According to Gübelin and Koivula (1986), the following inclusions are typical of Kashmir sapphire:–

G1 – zoned texture and cloudy haziness
G2 – randomly-scattered brush-stroke-like inclusions and nebulous clouds
G3 – wispy pennant-like inclusions attached to strings
G4 – corroded (profiled) zircon crystals
G5 – pargasitic hornblende
G6 – tourmaline
G7 – 'flags' of sealed fluid remnants.

Confirmation of known and new inclusion types

Modern gem microscopy profits over the old monocular microscopy through the availability of improved illumination and binocular observation. Only the use of powerful oblique illumination (e.g. by fibre optics) against a dark background will reveal certain types of inclusions, for example cloudiness, fine dust tracks and very fine rutile needles. In the past, such features could not be recognized, and thus cannot be expected to be reported in earlier literature.

After observation of an inclusion, the next step is its identification. A definite identification requires knowledge of its chemical composition and its crystal structure. One is usually restricted in the possibilities of analysing inclusions in gemstones (as either they do not reach the surface, or they are fluids, or because the crystals are corroded, not idiomorphic, etc.). In addition, there is also the pressure of time when analysing very precious gems. In this paper, the following abbreviations are used to indicate the method of identification:

LM Optical light microscopy
SEM Scanning electron microscopy with energy-dispersive system
EMP Electron microprobe analysis
XRD X-ray diffraction analysis

Structural features

The methods recommended by Schmetzer (1986) for the optical measurement of crystallographic growth and colour zoning were used by Kiefert (1987) for the study of zoning in sapphire. Due to the lack of suitable material, they could not be applied in the case of the Kashmir sapphire. The evaluation of crystallographic features on a large number of Kashmir sapphires supplied valuable evidence for the determination of origin (Peretti, Schmetzer, 1989). Narrow twin lamellae parallel to the rhombohedron face rarely occur in Kashmir sapphire (Figure 7).

Healed fissures

They presumably originated during various phases of crystallization of the corundum. The patterns of these original fissure planes can be very diverse and in varying stages of healing (see Roedder in Gübelin and Koivula, 1986, p.84). Feathers and veils consisting of minute cavities and negative crystals can exhibit various forms, although they are formed of a mainly simple, lobular fissure plane. Occasionally, this can be bent or folded, but seldom overlapping. Depending on the stage of healing of the original fissure, the veils can exhibit various patterns (Figures 8-12):–

- covered with isometric voids to short tubes, graded in size from outside to inside, occasionally in a sort of fishbone pattern (Figure 8): of type P5.
- covered with connecting canals, but also with extensively dissolved networks (Figure 9).
- containing flat cavities or negative crystals, which often possess trigonal step patterns and sometimes black, opaque platelets (graphite ?) as partial fillings. (Figure 10).
- flat negative crystals with minute satellites, presumably formed by bursting of the main cavity and healing of the fissure plane (Figure 11).
- very incompletely healed fissures with a frost pattern (Figure 12).

The small cavities, flat negative crystals or interlinked canals are suspected of containing fluid inclusions.

Fig. 3. Turbidity induced by dust particles (rutile?) occurring in zonal lamellae and as fine dust tracks or traces. 30X.

Fig. 4. Flaky inclusions of an unknown nature lying in one or several parallel planes. 50X.

Fig. 5. Sequence of transparent and milky bands originating from zoned growth. 10X.

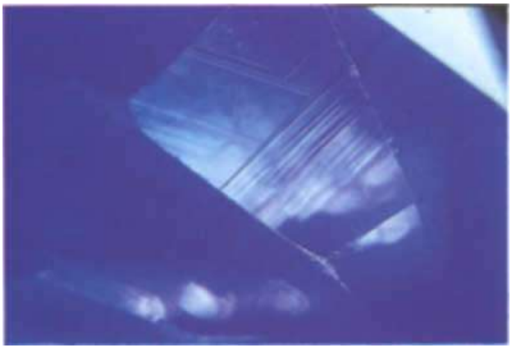

Fig. 6. Reflecting zoned growth in the form of various crystallographic planes and blocks. 20X.

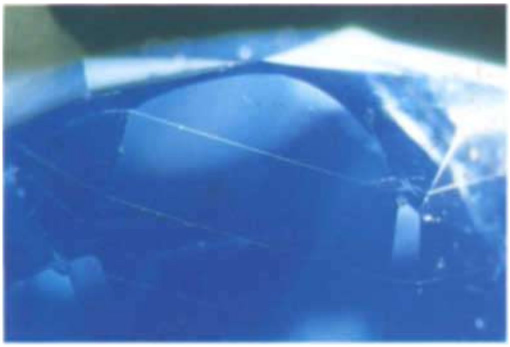

Fig. 7. Very small intercalated twin lamellae. 15X.

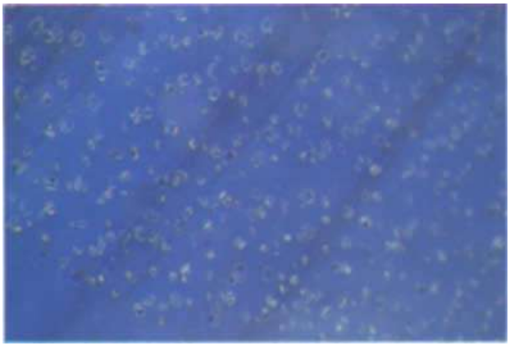

Fig. 10. Healed fissure with flat, strongly recrystallised cavities (negative crystals), a few containing opaque crystallites. 50X.

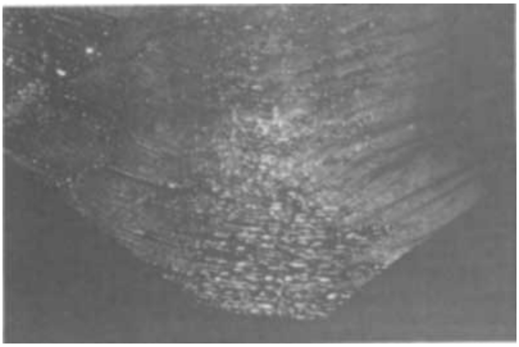

Fig. 8. Graded healed fissure with short tubes and residual droplets. 30X.

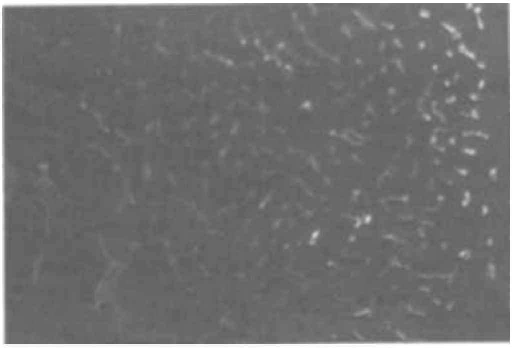

Fig. 9. Healing fissure with a more or less disintegrated network of canal structures. 30X.

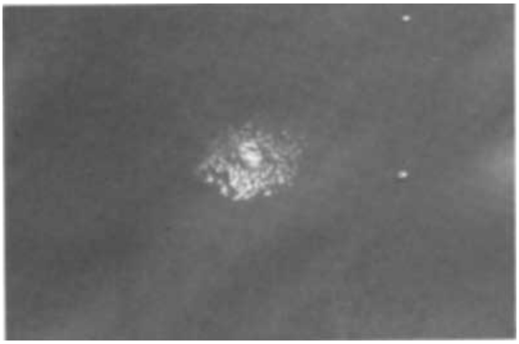

Fig. 11. Apparently burst negative crystal with healed fissure plane containing minute cavities. 50X.

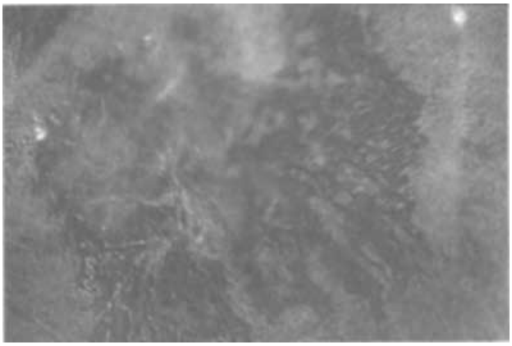

Fig. 12. Incompletely healed fissure with a frost pattern. 30X.

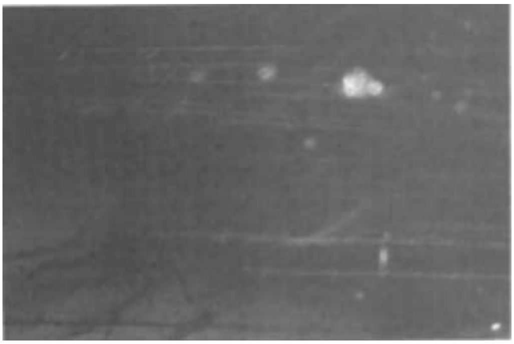

Fig. 13. Lines of dust-like tracks or trails, which cross at acute angles and exhibit fine diagonal striations. 25X.

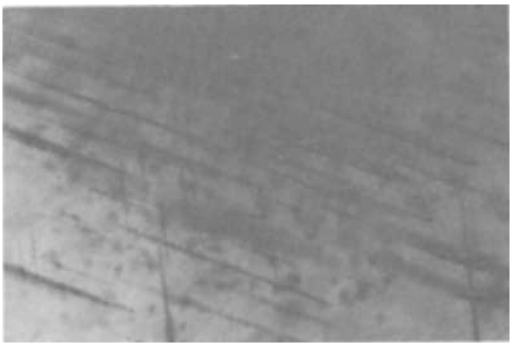

Fig. 14. Intersecting long and shorter dust lines (running in three directions). 25X.

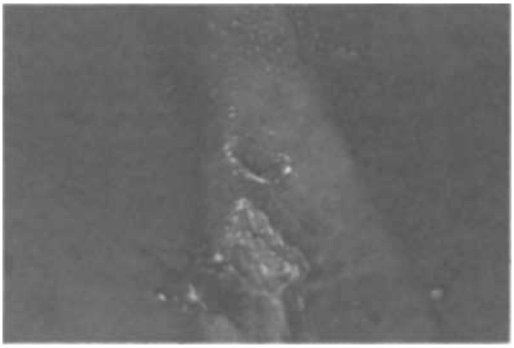

Fig. 15. Green inclusions of tourmaline crystals in Kashmir sapphire, mainly corroded and broken, seldom idiomorphic. 30X.

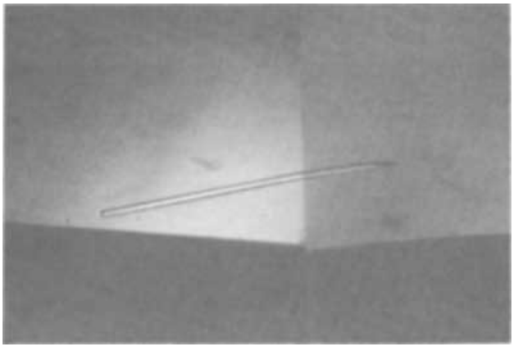

Fig. 16. Long pargasite needle exposed on surface and analysed by SEM/EDS. 45X.

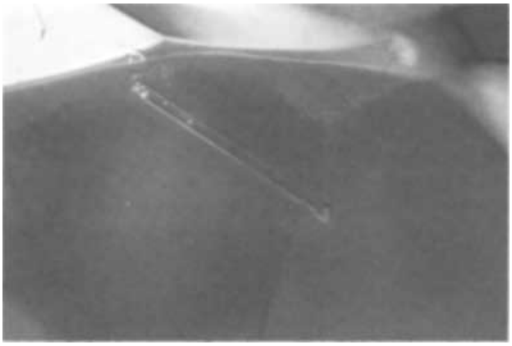

Fig. 17. Long zircon needle exposed on surface and analysed by SEM/EDS. 40X.

Fig. 18. Corroded zircon crystal inclusion. 60X.

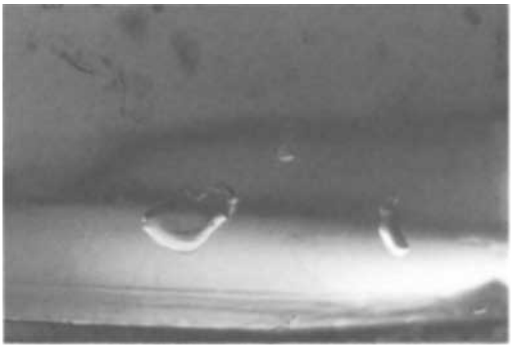

Fig. 19. Strongly corroded plagioclase inclusion exhibiting rounding and indentation. 50X.

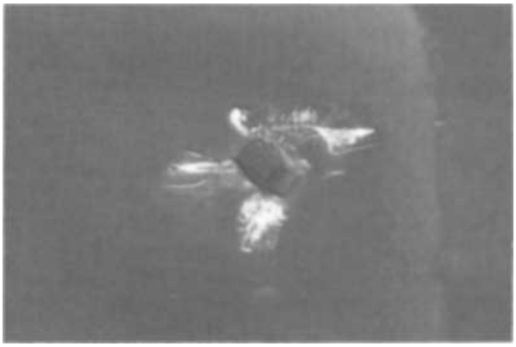

Fig. 20. Opaque cube of uraninite with stress fissures. A number of such crystallites reach the surface and could, therefore, be analysed (SEM/EDS). 40X.

Fig. 21. Allanite (orthite) inclusions occur rarely in Kashmir sapphire. 30X.

Solid inclusions

Rutile (LM) could not be analytically confirmed. Kashmir sapphire can contain few short rutile needles, and it is assumed that the very fine dust particles occurring in zones may be developing rutile crystallites. The formation of rutile needles normally has not taken place. It is assumed that the frequent lamellar turbidity is also due to the presence of extremely fine rutile dust in layers (Figures 3-5). Compare: P1. The segregation of rutile needles from the corundum may have been prevented during fairly rapid cooling, and only dust-like particles were formed and are observed as turbid zones in most of the Kashmir sapphire. The nature of the very fine particles which usually form indistinct, more or less linear white trails is still unclear. Such lines traverse the sapphire roughly perpendicular to possible crystal faces, forming acute angles with each other (Gübelin and Koivula, 1986, p.342). They are constructed of short traverse lines (Figure 13) and could also represent minute rutile features. Compare: P2, G2, G3.

A further form of such minute white structure are the small, cruciform bodies, also shown by Gübelin and Koivula (1986). They seem to be composed of three intersecting planes of dust concentrations, also crystallographically oriented (Figure 14). Compare: G1.

Mineral inclusions in Kashmir sapphire were already observed in the last century (Mallet, 1882). Tourmaline and pargasite are considered to be the classical mineral inclusions specific to the deposit. Zircon has also been mentioned in earlier publications (Phukan, 1966; Schubnel, 1972; Gübelin and Koivula, 1986).

Tourmaline (dravite, SEM) occurs as short greenish crystals occasionally forming groups of inclusions. The stout crystals seldom possess any clear crystallographic forms and could represent partly dissolved crystals (Figure 15). Compare: S1, G6.

Pargasite (EMP, alumino-pargasite to alumino-tschermakitic hornblende) forms fine long needles. These needles are so thin, that they are either colourless or pale green (Figure 16). Pargasite occurring as inclusion in corundum has been described in ruby from Burma (Schubnel, 1972) and in ruby from Tanzania (Schubnel, 1972; Eppler, 1973). Compare: S2, G5.

Zircon (SEM) has been found with varying length:width ratios. A ratio of 3:1 is common. A particularly long zircon needle (SEM) displayed a ratio of 18:1 (Fig 17). Stress fissures are nearly always found around the shorter zircons. They contain traces of uranium which explains the occurrence of the fissures, caused by an increase in volume. Some of the zircons are indented perpendicular to the long axis and occasionally contain small opaque inclusions (Figure 18). Compare: P3, G4.

Plagioclase (SEM, Ca-rich) was often observed, but could seldom be analysed. Plagioclase occurs in small, strongly resorbed crystals, sometimes in groups. Twinning is sometimes present. The colourless plagioclase is most easily identified by its habit – rounded form and often containing indentations (Figure 19). Compare: S3.

Uraninite (SEM) occurs as cubic black crystals, from which stress fissures usually radiate (Figure 20). The crystals often possess the same width as growth lamellae into which they are arranged. Rarely, uraninite can form inclusion groups with zircon.

Allanite (SEM, with traces of U and Th) was identified in one case. Again, stress fissures radiate from the colourless to pale reddish brown crystals into the hosting sapphire, presumably due to its content of radioactive elements (Figure 21).

Significance of determination of origin of Kashmir sapphire

Kashmir sapphire is considered by laymen to be unrivalled, but such a judgement cannot be justified as each deposit can produce high and low grade material. The question arises why sapphire from this region is so highly regarded. The fantasy is, of course, affected by the idea of gemstones originating in the past from legendary regions of the inaccessible East! The mines in question, however, are considered to have been exhausted for the last fifty years, and most of the valuable stones of the productive period may lie in the depths of the treasuries of the Maharajahs. Thus, the few Kashmir sapphires on the free market are avidly sought.

The determination of origin of Kashmir sapphire is of particular importance. Often, large price differences are noted on the market between sapphire from Kashmir, accompanied by a credible original report, and from other sources, despite being otherwise visually similar. The nondesirability of 'documents of origin' for gems is discussed by Hughes (1990). Obviously, a definite geographical origin is not a guarantee of high quality, and value should be determined by the beauty of a stone, governed by its colour, size, transparency and cut.

The origin of many stones cannot be stated with certainty, and even localities well-known for their production of quality material also produce inferior stones (Hänni, 1988[b]). In no respect should a 'superior' origin be used as an excuse to increase the value of a poor stone.

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An unusual agate from Guyana

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Fig. 1. Amerindians collecting agates in a gully leading to the Ireng river.

In a far off part of the world there is a country that has the Kanuku or Blue Mountains, the Kaieteur Falls with a sheer drop of nearly 800 ft, large areas of unexplored jungle, arid savannahs and breathtaking scenery. The Republic of Guyana is located on the northern Atlantic coast of South America and is bordered by Surinam, Brazil and Venezuela. About the size of Great Britain, Guyana has a population of some 850,000, most of whom live on the narrow coastal plain. The mineral-rich interior comprises 70 per cent of the land area and is relatively uninhabited. As a result of geological expeditions in Guyana a new industry was set up in 1973. This was achieved by the setting up of a small industrial lapidary workshop in the capital, Georgetown, and also arranging for the collection of raw materials in the interior. Then after a period of training for a group of young Guyanese the artistic products were arranged for the sale and export.

To the 'Black pearl of Guyana' (Gosling, 1976), an international interest in gold and diamond deposits, and the many varieties of jasper (Gosling, 1986) that occur, may now be added a very unusual form of agate that may prove to be unique to Guyana.

In the early 1970s an investigation of the agate deposits in the north Rupununi savannahs was carried out by a survey team from the Geological Survey and Mines Department in Georgetown.

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The quantity and quality found encouraged the Ministry of Energy and National Resources to set up a new industry based on the utilization of these materials. This project was assisted by British Technical Aid arranged by the Ministry of Overseas Development and the author was privileged to carry out the scheme for the people and Government of Guyana.

Initial prospecting was carried out along the banks of the Ireng, Takutu and Manari rivers. In order to obtain information about conditions under the ground, trial pits and trenches were dug wherever there were good indications of agates. These trial pits and trenches, in addition to providing samples of the deposits excavated allowed inspection of the rocks in the walls of the pit or trench. While working on the commercial collection of the agates some were found to have percussion cracks and it is interesting to speculate on the original geological movements in the area. The best deposits were found near Sunnyside on the Ireng river some 34 miles north of Lethem. The Ireng river is the natural boundary with Brazil. The area is bounded by the Good Hope Mountains in the north and the Kanuku or Blue Mountains in the south. These mountains are largely unexplored and are the site of ancient burial grounds, while further south near Aishalton are some wonderful deep caves undoubtedly used by ancient mankind and containing fine examples of cave paintings deep underground. The savannahs are gently rolling plains covered with sandpaper trees and Itè palms by the water courses. The roads are rough tracks of red ferruginous lateritic soils which are very dusty and full of potholes in the dry season and almost impassable in the wet season.

During the initial surface collection considerable quantities of agates were found in the dry gullies which carry the surplus water off the savannahs in the rainy season into the river. A small number of agate boulders were collected in the low cliffs at the edge of the river. These were mostly cut into magnificent matching book-ends and a set was presented to the Prime Minister at the official opening of the lapidary workshop in Georgetown. These agates were carefully checked and packed into the Landrover and the boxes were transported to Lethem and then to Georgetown on a DC3 plane that was part of a regular transport flight to Georgetown.

Fig. 2. Amerindian digging out agates.

At our various camp sites we found that as southern Guyana is almost on the Equator and there was very little twilight and that the night settles in very quickly – which is instantly the signal for every frog to give voice and for the fireflies or 'candleflies' to light up the darkness with their brilliant displays

Fig. 3. Pit in river terrace deposits showing agates in situ.

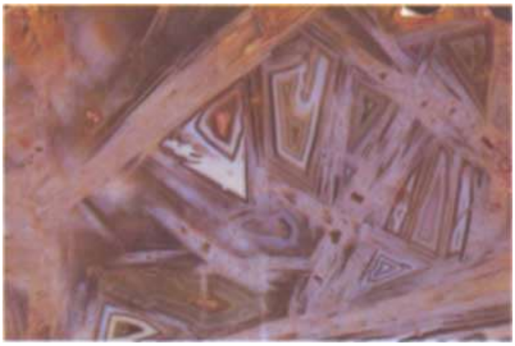

Fig. 4. Guyanese agate showing complex interlocking quartz crystal structure and infilling with banded agate.

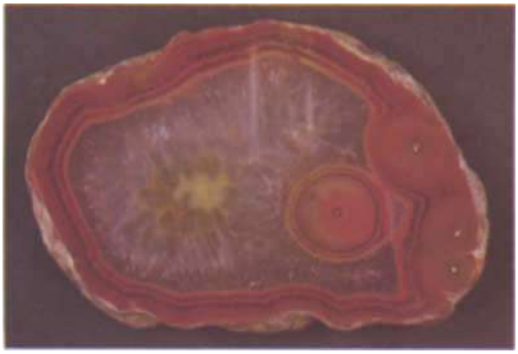

Fig. 5. Example of banded agate found near Sunnyside on the banks of the Ireng river.

Fig. 6. Sliced Guyanese agate used as a clock face.

Fig. 7. Teaching seminar at the lapidary workshop in Georgetown showing the cutting of banded agate with a diamond saw.

of luminescence.

The agates are found on the Rupununi savannah and occur in gravel beds that overlie the Takatu Formation. Most of the agates found in these gravels are very beautiful examples of the banded varieties and are of many different colours and patterns. At the same location are found some agates of a very different type. These were known to the local geologists as 'fire agates' and were formed of a criss-crossing open lattice of quartz crystals (like frost on a window pane) with banded agate filling the interstitial cavities. The outer surfaces of these agates showed a rough fibrous structure quite unlike that found on the more usual type of agate boulder. These were quite unlike any type of agate that the author had experienced and may well be unique to Guyana.

After transporting the materials to the workshop in Georgetown it was found that the cutting and polishing of this 'fire agate' was similar to normal lapidary practice, but that care had to be taken in sawing and grinding to avoid damaging the long crystals of quartz. The lapidary workshop was equipped with two 24" diamond saws and there was always intense interest in cutting agate as each one displayed new shapes, patterns or colours. During the use of 80, 220 and 400 grit sizes of silicon carbide great care had to be taken to wash off all traces of the grit being used before proceeding to the next finer grade as we found it was very easy to miss a few particles trapped in the cavities of the coarse quartz matrix which resulted in disastrous scratches. In the final polishing of the agate using cerium oxide on a felt mop, considerable problems were experienced in removing the polishing compound that had dried in the small holes in the open quartz crystal lattice.

This special Guyanese agate is very unusual and specimen blocks and clock faces aroused intense interest; its formation will surely intrigue geologists. The project continues to flourish and it is hoped in time to expand to other areas of the country.

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Spectroscopic evidence for heat treatment of blue sapphires from Sri Lanka – additional data

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Abstract

Differences in the absorption spectra of particular types of natural blue untreated and heat treated sapphires are due to the presence or absence of Fe^{3+} absorption bands of distinct intensities. These features are useful for the recognition of artificial heat treatment in samples of the trade.

Heat treatment of milky white, bluish or yellowish sapphires from Sri Lanka has been performed for the last ten years (or even longer) in order to develop an intense blue coloration of the samples. Though technical details of the processes used by commercial treaters, e.g. in Bangkok, are kept secret, some information about colour improvement of these so-called 'geuda-sapphires' has been published in recent years (e.g. Harder, 1980, 1982; Crowningshield and Nassau, 1981; Gunaratne, 1981; Nassau, 1981; Keller, 1982; Abraham, 1982).

In general, the development of colour is based on heat treatment of natural samples under reducing conditions at temperatures above 1550°C for several hours. This process causes a dissolution of rutile needles or particles in the corundum host, i.e. the formation of a solid solution between the host crystal and guest minerals (see Nassau, 1982; Harder and Schneider, 1986). The reverse of this process is commercially used for the formation of rutile precipitates in synthetic and natural sapphires. In order to develop or improve asterism, these samples are annealed at temperatures between 1100 and 1500°C for several hours.

In practical gemmology, the detection of heat treatment in natural sapphires as well as the recognition of natural blue samples as untreated sapphires is performed in general by microscopic investigations, which are based on the presence or absence of distinct features, e.g. on the presence of rutile needles or two-phase inclusions in untreated samples as well as on the presence of internal stress fractures around single crystal inclusions in heat treated samples (Nassau, 1981; Crowningshield and Nassau, 1981; Koivula, 1986; Gübelin and Koivula, 1986). However, some hints towards a possible identification of heat treatment of natural sapphires by spectroscopic investigations are found in the papers of Nassau (1981) and Crowningshield and Nassau (1981), who mentioned the absence of the $22{,}200cm^{-1}$ (450nm) absorption band in treated sapphires, which is assigned to Fe^{3+} replacing Al^{3+} in the corundum structure. The aim of the present paper is to elucidate this difference in spectroscopic properties of treated and untreated samples, which is useful for diagnostic purposes.

Natural blue sapphires can be subdivided into two basic types, depending on the presence or absence of the Fe^{2+}/Fe^{3+} charge-transfer absorption band in the near infrared at $11{,}500cm^{-1}$ (870nm) with polarization $\perp c > \parallel c$. Blue sapphires without a prominent Fe^{2+}/Fe^{3+} band (natural sapphires of type I) are known from e.g. Mogok, Burma; different localities in Sri Lanka; Umba Valley, Tanzania; Montana, USA; Kashmir, India; blue sapphires with a dominant Fe^{2+}/Fe^{3+} band (natural sapphires of type II) are known from alkali basalts as mother rocks, e.g. from different localities in Australia and Thailand; Jos, Nigeria; Pailin, Cambodia. Absorption spectra of type I natural blue sapphires are pictured in Figure 1, typical absorption spectra of type II natural blue sapphires were recently published in this journal by Kiefert and Schmetzer (1987).

The colour of both, heat treated and non-heat treated natural blue sapphires of type I is caused exclusively by the Fe^{2+}/Ti^{4+} intervalence transfer absorption, the absorption maxima of which are found at $17{,}880cm^{-1}$ (559nm) [polarization $\perp c > \parallel c$] and at $14{,}300cm^{-1}$ (699nm) [polarization $\parallel c \approx \perp c$] (Schmetzer and Bank, 1980; Burns and Burns, 1984; Schmetzer, 1987). All samples of this particular type reveal an identical pleochroism of light blue $\parallel c$ and intense blue to bluish violet $\perp c$. In this type of blue sapphire, the presence or absence of a weak Fe^{3+} absorption at $22{,}200cm^{-1}$ (450nm) does not influence colour or pleochroism of the samples.

Heat treatment of milky white so-called 'geuda' sapphires from Sri Lanka (and only this type of heat treated sapphires will be discussed in this paper)

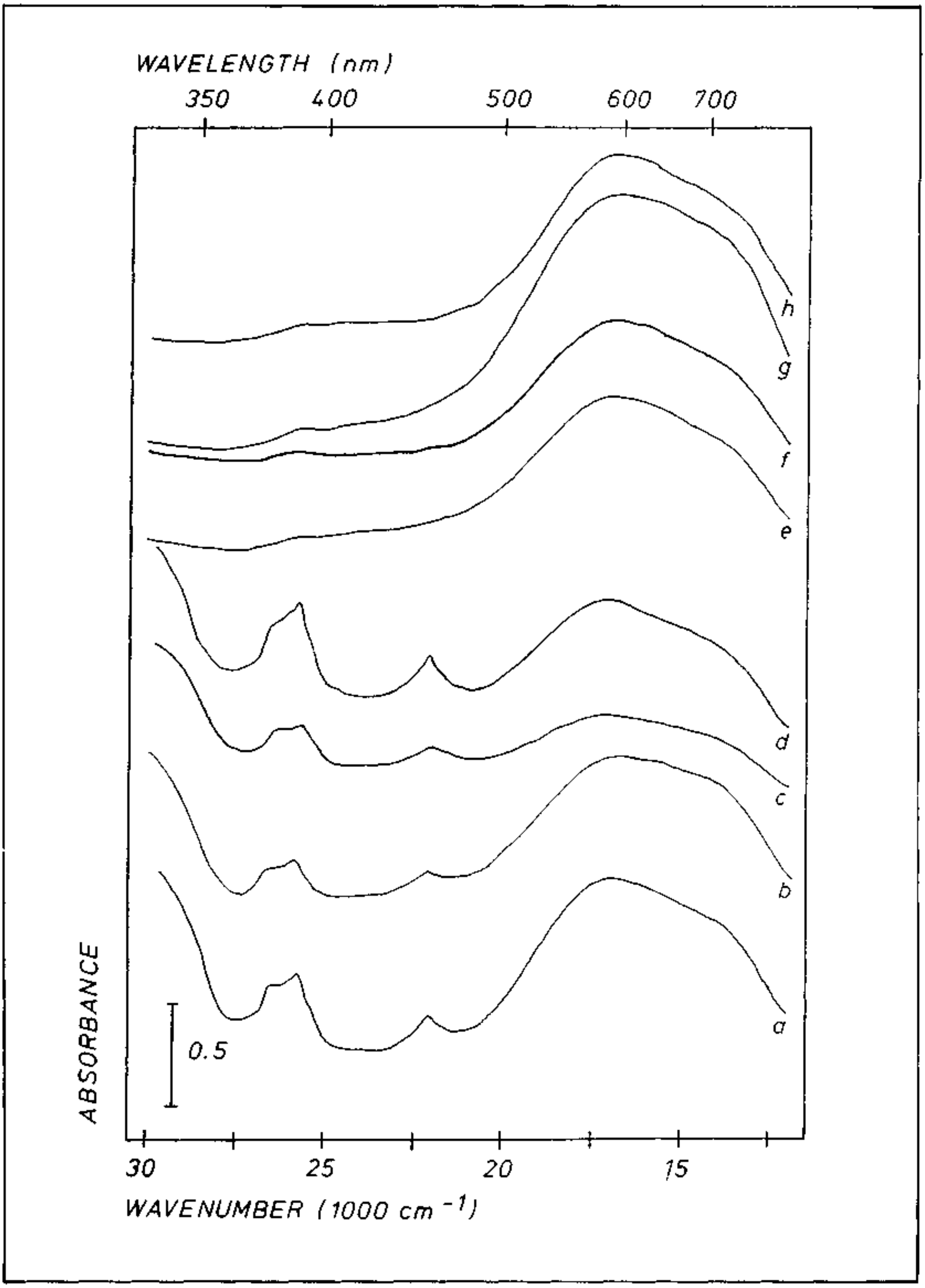

Fig. 1. Absorption spectra of natural untreated and heat treated blue sapphires. Untreated samples: (a) Mogok, Burma, (b) Sri Lanka, (c) Montana, USA, (d) Umba, Tanzania. Heat treated samples: (e) and (f) Sri Lanka, samples of the trade, (g) and (h) Sri Lanka, samples treated by the authors.

produces absorption spectra with dominant Fe^{2+}/Ti^{4+} absorption bands but without any Fe^{2+}/Fe^{3+} intervalence transfer absorption (Figure 1). In addition, samples of the trade and also those samples treated by the authors in general did not reveal any absorption bands of Fe^{3+} in the blue and ultraviolet range at 22,200, 25,800 and 26,600cm^{-1} (at 450, 388 and 376nm). An absorption spectrum of this type was never observed by the authors in untreated natural blue sapphires from different localities.

The absence of Fe^{3+} absorption bands in heat treated samples, which were spectroscopically found to be present in untreated samples before treatment was applied by the authors, is explainable by the conversion of trivalent iron to bivalent iron in connection with the dissolution of rutile particles after the scheme:

$$\underset{\text{rutile}}{TiO_2} + \underset{\text{corundum (colourless)}}{(Al^{3+},Fe^{3+})_2O_3} \rightarrow \underset{\text{corundum (blue)}}{(Al^{3+},Ti^{4+},Fe^{2+})_2O_3}$$

According to this scheme, in samples in which titanium contents exceed iron contents, no residual Fe^{3+} absorption bands are expected to be present after extended heat treatment. Similar facts are responsible for the absence of Fe^{3+} absorption bands in the spectra of synthetic Verneuil-grown blue sapphires with a chemical composition revealing higher amounts of titanium than iron.

However, in some heat treated natural samples, residues of small amounts of Fe^{3+} were observed by spectroscopic investigations. Two possible explanations can be quoted for this observation; on the one hand, the time of heat treatment can be too short to finalize the reaction according to the scheme given above or, on the other hand, the amounts of iron in the samples may exceed the amounts of titanium. In addition, the influences of different reducing or oxidizing atmospheres on the reaction described has not yet been studied in detail by the authors. According to these facts, the presence of Fe^{3+} absorption bands of distinct intensities is not thought to be useful as an unequivocal criterion for untreated blue sapphire, but the absence of Fe^{3+} absorption bands of distinct intensities is useful to classify a sample of undoubtedly natural origin (proved by microscopic examination) as artificially heat treated natural blue sapphire.

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Red and orange corundum (ruby and padparadscha) from Malawi

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Abstract

Physical, chemical, spectroscopical and microscopical features of red and orange corundum from Malawi are described. The stones investigated show good gem quality. The rubies vary in colour from pale red to dark red. The variation of colour intensity is accompanied by a remarkable variation of the physical data (refractive indices, birefringence, specific gravity) as well as chemical characteristics (chromium and iron contents).

Introduction

An occurrence of gem quality corundum in Southern Malawi was reported by Bloomfield (1958). The locality described is situated on the Chimwadzulu Hill, approximately 50 miles south of Lake Nyasa, close to the frontier of Mozambique. (Figure 1). The corundums occur in situ in an epidotized amphibolite. The crystals are embedded in a coarse aggregate of hornblende crystals, enclosed in a matrix of epidote and plagioclase.

First gemmological investigations were carried out by Rutland (1969). He examined rough crystals of blue, pink, yellow, pale green and dark greyish-green colours, showing well developed basal pinacoids and less rhombohedral faces. The crystals were 5 to 40mm in length and had a distinct basal parting. Later he investigated, together with E.A. Jobbins, some lots of several hundred cut stones, weighing up to 12ct each. The colours of these corundums varied from yellow to blue, pale blue, greyish-blue and greenish-blue. The red stones were smaller in size and pale in colour. Only some stones showed fine colours, comparable with good rubies from Thailand. The quantity of the mined mineral is unknown and for a long time nothing was heard about that occurrence.

In April 1988 the authors obtained some specimens of corundum, showing partly fine ruby quality with varying colour intensity from pale red to intense and dark red (Bank and Henn, 1988; Bank *et al.*, 1988). The crystals showed well developed basal pinacoids and were up to 15mm in length. Distinct basal parting was also visible. Later, in March 1989, one of the authors has visited the mine at the Chimwadzulu Hill (Figure 2) and brought with some more material and larger crystals for examination, also orange coloured corundums.

Physical features

The determination of the physical characteristics, refractive indices, birefringence and specific gravity demonstrated a remarkable rise in constants of the rubies investigated (Table 1). The refractive indices increase from 1.760 to 1.770 for n_e and 1.768 to 1.780 for n_o with Δn = 0.008 to 0.010. Also the specific gravity increases from 3.96 to 4.04g/cm^3. Rutland (1969) described refractive indices of n_e = 1.762-1.763 and n_o = 1.771-1.772 for red corundums from Malawi. The intense red and dark red specimens investigated by the authors have refractive indices, which were never described and/or

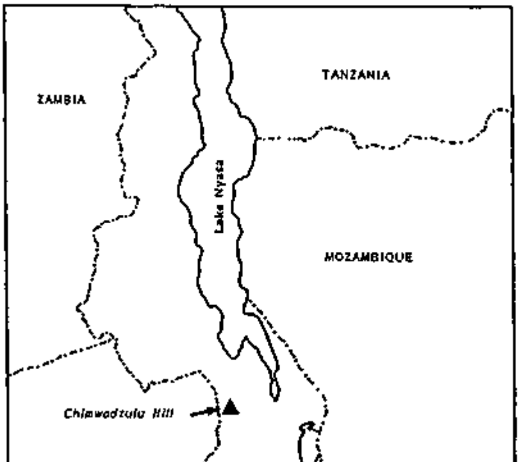

Fig. 1. The Chimwadzulu Hill corundum occurrence in Malawi.

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Fig. 2. One of the authors near the Chimwadzulu Hill (visible in the background) corundum occurrence in Malawi.

published before for rubies. Hitherto, such high values of refractive indices were measured and published only for orange corundums from the Umba Valley in Tanzania (Bank, 1970) and green stones (Webster, 1983). The refractive indices, birefringence and specific gravity of the orange coloured corundums from Malawi are in the known ranges hitherto measured for stones from Sri Lanka and Tanzania.

Chemical features

Chemical analyses of the trace elements chromium and iron were carried out with the microprobe. The results are shown in Table 1 together

Table 1. Physical and chemical features (in wt.%) of rubies and orange coloured corundums from Malawi.

colour	n_e	n_o	$\triangle n$	SG (g/cm^3)	Cr	Fe
reddish	1.760	1.768	0.008	3.96	0.08	0.38
pale red	1.761	1.769	0.008	3.97	0.20	0.32
red	1.765	1.773	0.008	3.99	0.29	0.53
red	1.766	1.775	0.009	4.02	0.48	0.51
intense red	1.768	1.778	0.010	4.04	0.79	0.50
dark red	1.770	1.780	0.010	4.05	1.55	0.64
orange	1.763	1.771	0.008	3.97	0.04	0.38
orange	1.765	1.773	0.008	3.98	0.11	0.74

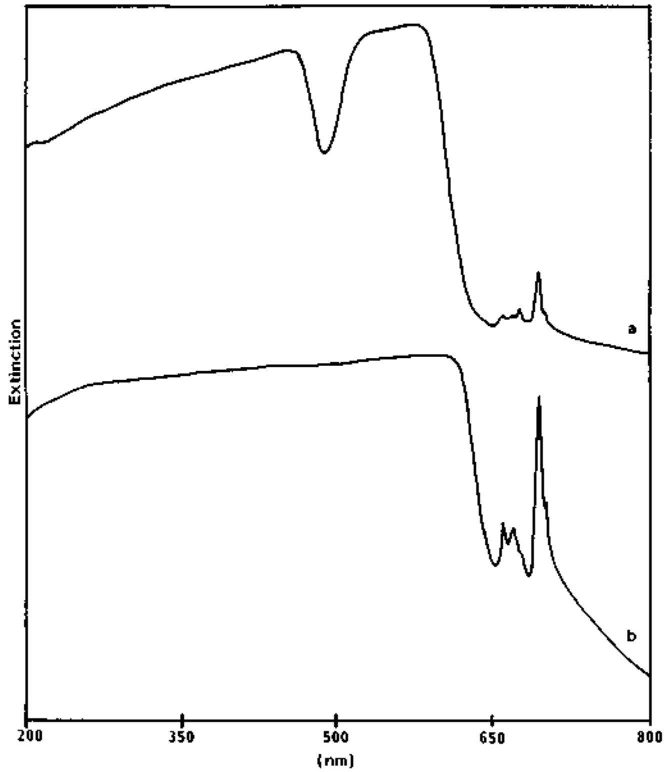

Fig. 3. Absorption spectra of a red (a) and a dark red (b) corundum from Malawi.

with the values of refractive indices, birefringence and specific gravity. From the reddish to the dark red ruby a distinct increase of the chromium contents from 0.08 to 1.55wt.%Cr is visible. Such high values of 1.55wt%Cr were hitherto only measured in rubies from Mogok/Burma, Longido/Tanzania and Manyari/Kenya (Kuhlmann, 1982). The iron contents of the rubies from Malawi vary between 0.32 and 0.64wt%Fe and are relatively high compared with iron concentrations of rubies from other occurrences. Only for some stones from Sri Lanka, Umba/Tanzania and Greenland were comparable values determined hitherto (Zwaan, 1974; Kuhlmann, 1982). The orange coloured corundums from Malawi show chromium and iron contents, which are comparable with yellow-orange to orange-brown specimens from the Umba Valley in Tanzania (Schmetzer *et al.*, 1982).

Spectroscopical features

Spectroscopical investigations were carried out with a Perkin Elmer Lambda 9 Spectrophotometer in the 800-200nm range. Only the ruby with the lowest physical and chemical values (n_e = 1.760, n_o = 1.768, Cr = 0.08wt%, Fe = 0.38wt%) shows a typical chromium spectrum with two broad absorption bands in the green and violet range and a minimum in the blue region of the spectrum. A second absorption minimum is situated in the UV range at 363nm. The rubies with medium physical and chemical data (n_e = 1.761-1.768, n_o = 1.769-1.778, Cr = 0.20-0.79wt%, Fe = 0.32-0.50wt%) show an increase of the Cr^{3+}-lines in the red range at 695, 669 and 659nm and only one Cr^{3+}-absorption-band in the green region at 555nm (Figure 3a). Additionally a decrease of the absorption minimum in the blue range is visible. This decrease and the increase of the Cr-lines in the red region are due to the rise in the chromium content. The ruby from Malawi with the highest physical and chemical values (n_e = 1.770, n_o = 1.780, Cr = 1.55wt%, Fe = 0.64wt%) shows only the sharp Cr^{3+}-lines in the red range of the spectrum with maxima at 700, 694, 675, 669 and 659nm (Figure 3b). From orange to violet a complete absorption can be recognized in this sample.

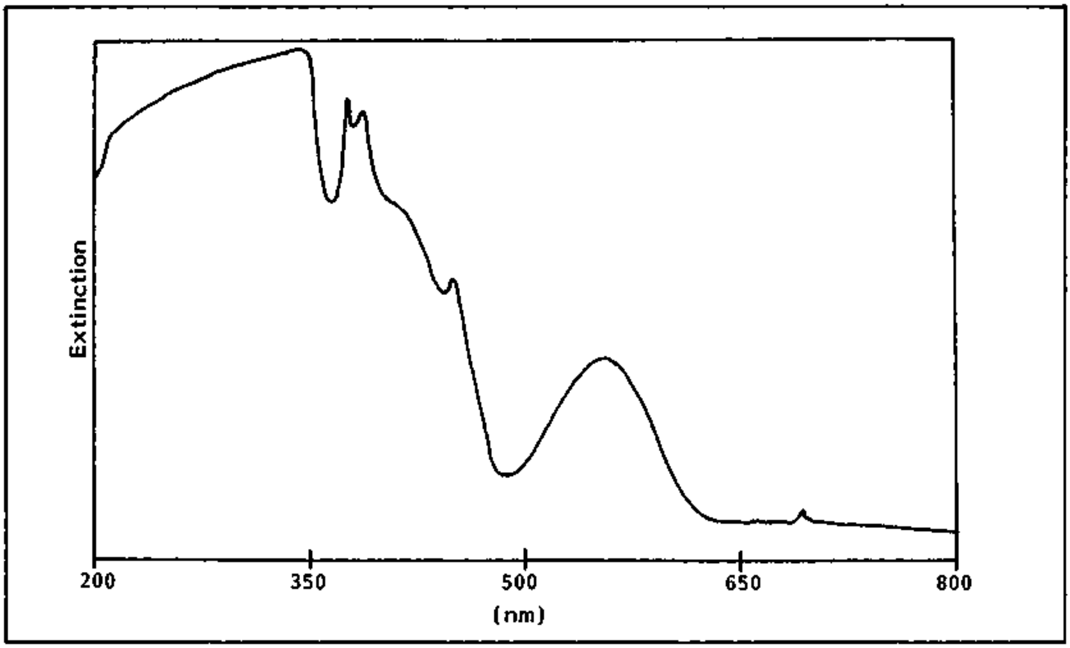

Fig. 4. Absorption spectrum of an orange corundum from Malawi.

The orange coloured corundums from Malawi show absorption spectra with bands of Cr^{3+} and Fe^{3+} (Figure 4). Such a type of absorption spectra was described by Schmetzer *et al.* (1982) with yellow-orange to orange-brown corundums from the Umba Valley in Tanzania. Cr^{3+} causes a broad absorption band in the green range with a maximum at 555nm. Bands caused by Fe^{3+} are situated at 450, 388 and 377nm in the blue and violet part of the absorption spectrum.

Microscopical features

Fine channels, small black crystals, short rods (presumably of hornblende), twinning planes, healing fissures (containing both liquid and gas) and colour zoning were described as inclusions in corundums from Malawi by Rutland (1969). A remarkable three-phase-inclusion in a yellow corundum from this locality was mentioned by Grubessi and Marcon (1986), a cavity, surrounded by fingerprint-like healing fissures, is filled with a liquid, gas and rutile-needles.

Microscopical studies of the rubies and orange coloured corundums from Malawi yielded three general groups of inclusions.

1. *Mineral inclusions*

Nearly all corundums from Malawi investigated show enclosed crystal inclusions. The most frequent type of enclosed minerals are rounded, prismatic, double refractive crystals (Figure 5), which sometimes form clusters (Figure 6). These inclusions were identified by microprobe analyses as zircons. Other doubly refractive mineral inclusions were determined by chemical analyses with the microprobe as anorthite and hornblende. Orientated interbedded rutile-needles were observed in some stones (Figure 7). More frequent is fine distributed rutile dust, interbedded along growth planes of the corundum host (Figure 8). Black, opaque inclusions were also observed (Figure 9), but not identified in detail, also some flat, rounded, double refractive crystals (Figure 10).

2. *Liquid inclusions*

Healing fissures and liquid feathers are the most frequent inclusions in the corundums investigated. Two different types of feathers were observed. One consists of elongated, more or less parallel orientated cavities (Figure 11), containing two inmiscible liquids or both liquid and gas. The second type is built up by irregularly shaped cavities (Figure 12), generally filled with liquid and gas.

3. *Twinning lamellae and growth structures*

Lamellar twinning (Figure 13) was observed in nearly all rubies and orange corundums from Malawi. The twinning lamellae are often orientated parallel to the three rhombohedron planes (Figure 14) and are invested with thin hollow tubes, filled with doubly refractive mineral substance, presum-

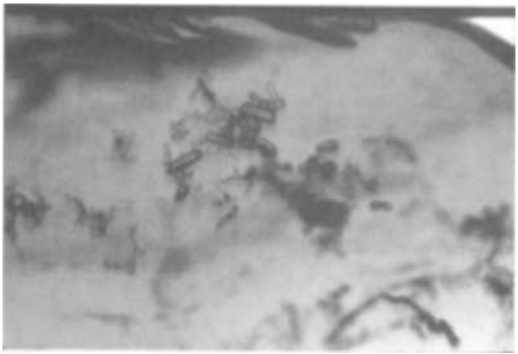

Fig. 5. Ruby from Malawi enclosing rounded zircons. 40X.

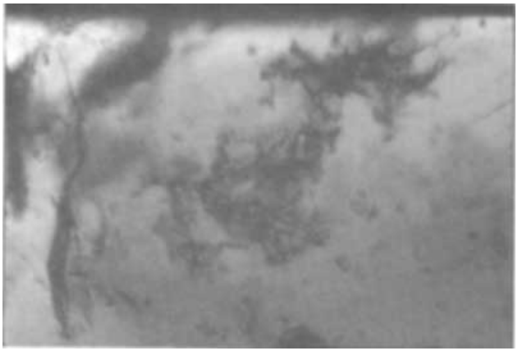

Fig. 6. Ruby from Malawi with clusters of rounded zircon inclusions. 50X.

Fig. 7. Orange corundum from Malawi showing a net of orientated rutile-needles. 15X.

Fig. 8. Ruby from Malawi showing rutile dust, interbedded along growth planes of the corundum host. Darkfield. 10X.

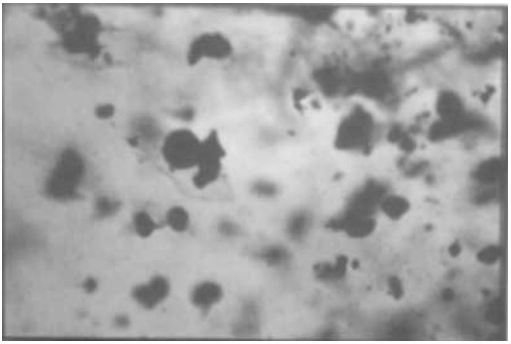

Fig. 9. Orange corundum from Malawi with black, opaque mineral inclusions. 40X.

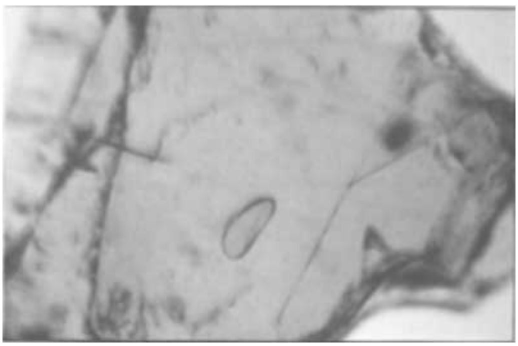

Fig. 10. Pale red corundum from Malawi with flat, rounded, transparent, doubly refractive crystal inclusion. 35X.

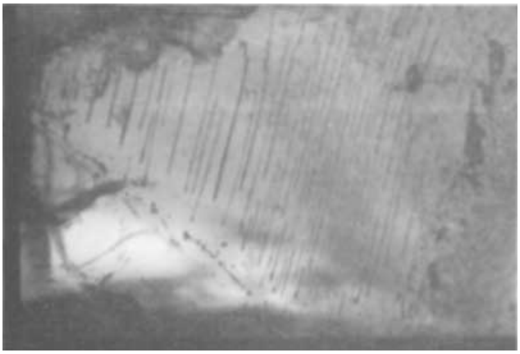

Fig. 11. Ruby from Malawi showing liquid feather, consisting of elongated, more or less parallel orientated cavities, containing two inmiscible liquids or both liquid and gas. 30X.

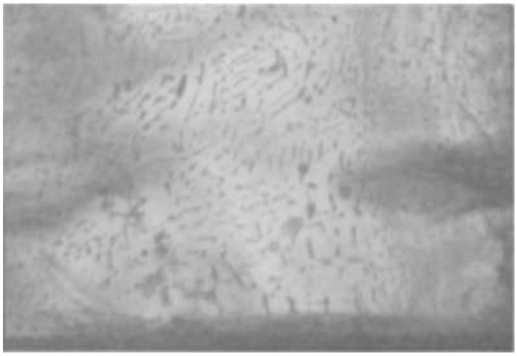

Fig. 12. Ruby from Malawi with liquid feather, consisting of irregularly shaped cavities, generally filled with liquid and gas. 35X.

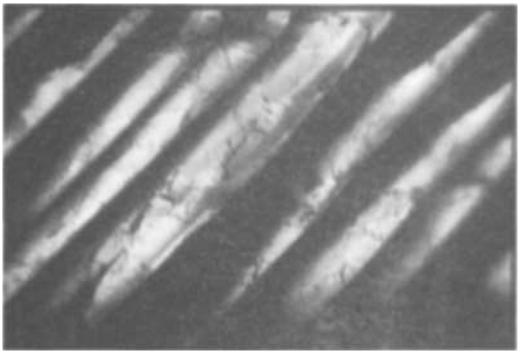

Fig. 13. Ruby from Malawi showing lamellar twinning. Crossed polars. 10X.

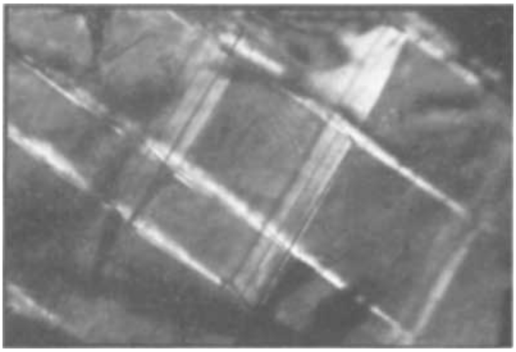

Fig. 14. Ruby from Malawi with twinning lamellae orientated parallel to the rhombohedral planes of the corundum host. Crossed polars. 15X.

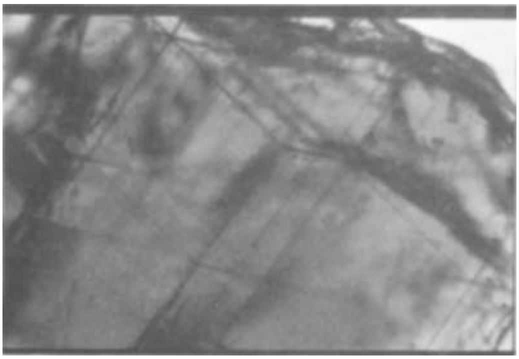

Fig. 15. Ruby from Malawi with thin hollow tubes, filled with doubly refractive mineral substance (boehmite?). 15X.

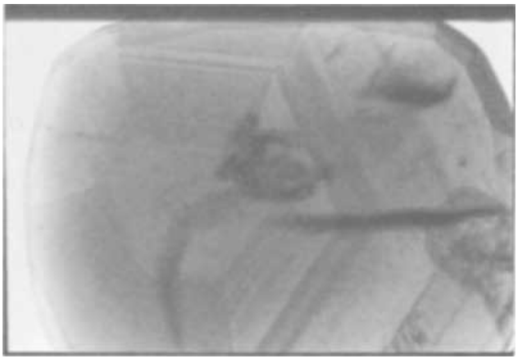

Fig. 16. Ruby from Malawi showing distinct colour zoning. 10X.

ably boehmite (Figure 15). Typical growth structures showing hexagonal symmetry perpendicular to the *c*-axis of the corundum host crystal have been observed (Figure 16). In some stones the colour is distributed along these growth planes. Such colour zoning is sometimes visible by the naked eye.

Conclusions

Production of corundum in the East African state Malawi started at the end of the fifties of this century, but for a long time nothing was reported about the occurrence and the mining. In 1988 red and orange corundums were obtained from that locality, sometimes showing fine gem quality. The rubies enclose a remarkable variation of colour intensity from pale red to dark red. In relation to that variation of colour intensity an alteration of the physical characteristics such as refractive indices, birefringence and specific gravity was demonstrated. The variation of the physical values is due to the concentrations of the trace elements chromium and iron.

Acknowledgements

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The diamond drill used in the Cambay bead industry

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Abstract

A simple but very effective diamond-tipped bow drill constructed by indigenous technology is being used by the Cambay lapidary to perforate tough and hard silica beads. To start with a single diamond drill is used for marking and then further full length drilling is carried out by a double diamond bit driller. Each bead is perforated from both the ends so as to meet at the centre. Construction of the primitive, yet efficient, bow drill unit; intricacies of the mechanism of single as well as double diamond bit drill and the resultant features will be discussed in the paper.

Introduction

Perforation of hard and tough stones like chalcedony is a highly difficult job. However, it is being executed at ease by the lapidary of Cambay with the help of primitive diamond-tipped bow drill at an astonishing speed. It takes less than a minute for drilling a bead of one centimetre diameter.

Cambay (Khambhat:22°19′N and 72°38′E) is a large town in western India, situated at the estuary of Mahi River which flows into the Gulf of Cambay. The town is known for gem cutting for more than two thousand years. Archaeological excavations have unearthed a large number of ornamental beads processed in the Early Historic times (Mehta, 1968). Even today a majority of its population is involved in gem cutting.

According to Janaki (1972), Cambay was an important international trade centre since the 10th Century AD from where gemstones were among the important items exported. Arkell (1937), Possehl (1981), Francis (1982) and Karanth (1988) have given the details of bead making in Cambay. Recently Gorelick and Gwinnett (1988) have attempted to interpret the mechanism of drilling of beads with the help of the scanning electron microscope (SEM) pictures of drill hole impressions. Their explanations are, however, inadequate. The present author, having studied the Cambay bead industry for nearly a decade, is attempting to give a detailed account of diamond-tipped drilling carried out by the artisans of Cambay.

Construction of bow drill

To construct a bow drill, it requires neither great expertise nor expensive gadgets. But for the diamond bits, the drill unit can be constructed from the materials thrown out at a junk yard. Even the diamond bits used are not specially splintered or cut, but they are the discarded rough pieces that are unfit for jewellery purposes. A look at the materials used for its construction can explain to a greater extent how a bead can be sold at a fraction of a penny.

The bow drill consists of two main units (Figure 1), viz. (1) the *bow* made from a long bamboo stick measuring about three-fourths of a metre and a loosely-tied thick strong string and (2) the *arrow* consisting of a wooden rod about 12-14cm long, 1cm thick fixed with metal sticks at either end. Generally the metal stick used is the steel rib meant for holding umbrella cloth. The upper metal stick is about 1cm long and the length of the lower one depends on the length of the bead to be drilled (usually 2-3cm long). The top of the drilling end is provided with a diamond bit.

For perforating, the string of the bow is tied around the drill-shaft with one loop and driven to and fro by one hand while the other hand is busy in pressing the drill-shaft against the bead. In order to protect the palm from the upper steel rib, a piece of coconut shell is kept in between. To have a better grip over the bow, the artisan prefers to tie the bow-string around his forefinger with one loop. Tying the string around his skilful index finger also helps in producing subtle changes in the movements of the drill-shaft.

The bead to be perforated is placed on a wooden platform (Figure 1). A slit is provided in the platform for holding longer beads in proper position at the time of boring. The slit is held tight with the help of a metal ring. At the time of drilling water is made to fall drop by drop on the bead which acts as a coolant as well as lubricant. It is quite appropriate to mention the way water is transported.

The earthenware pot used for holding water is bored with a hole and a tubular earthenware piece is cemented to it. A metal stick is inserted deep into

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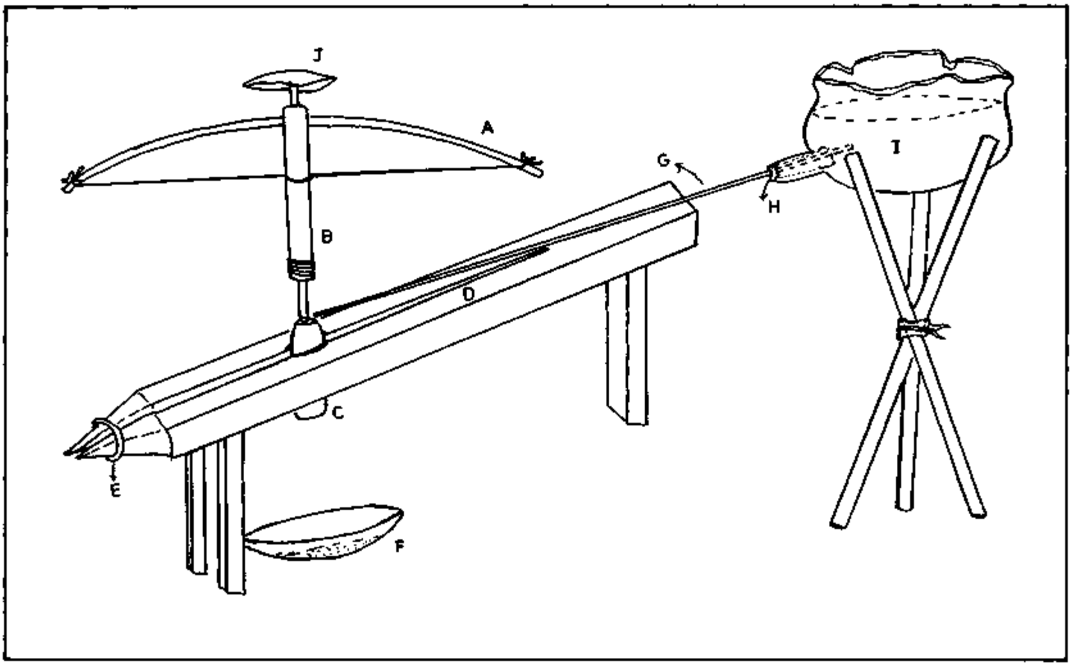

Fig. 1. Complete drilling unit: A – bow with string; B – drill shaft; C – bead; D – wooden platform; E – metal ring for tightening; F – earthen bowl for collecting mixture of silica powder and water; G – water transporting stick; H – cotton cloth; I – water pot; J – coconut shell.

the tube with a piece of cotton cloth around it. Water creeps through the damp cloth and is eventually transported along the stick and finally falls on the bead. The cloth piece is also used in regulating the flow of water by loosening or tightening it. Once again the metal stick used here is the umbrella rib.

It is interesting to note that almost invariably the pots used here are broken at the rim. Either the driller has picked up a broken pot discarded at the junk yard or he has not bothered to replace it when the rim is broken. The explanation given by a lapidary is 'whether broken or whole, it serves the purpose'.

Drilling is executed in two steps, viz., (1) marking and (2) full length drilling. Different drill points are used for these two purposes, namely single diamond bit driller and double diamond bit driller respectively (Figure 2). The bead whether small or long, is bored from both ends so as to meet at the centre thus producing a continuous hole.

To start with, the place for drilling is marked with a shallow depression (Gwinnett and Gorelick, (1988) prefer to call it a guide hole or starter hole) by using a single diamond bit drill. Generally the bead is taken for drilling before the final step of polishing, so that marking the place for boring becomes easier on a rough ground surface. If the bead is already polished, it is again ground at opposite ends for marking. The single bit drill is placed on the bead and rotated with the help of the bow string. Initial play of the rotating drill shaft on the bead results in a rather broader rim (Figure 3: compare A-B with C-D and E-F). The depth of the depression seldom exceeds a millimetre or two. The main boring is performed by using the double bit drill. Whilst drilling the scooped out powder from the bead falls out along with the thin flow of water that drops on the bead and this powder is then collected carefully in a bowl placed below the platform. Not that the artisan is interested to maintain cleanliness of his surroundings from the messy fluid that stains, but it has a special significance which will be described briefly in a later section.

The most important part of the drilling operation is, however, the position of the diamond bit placed at the drilling end.

Diamond bits

Diamond bits used for drilling are of very small dimensions, weighing about 5 cents/point/grains (1 carat = 100 cents), i.e. 10mg. Bits with rugged surface are prepared for boring. If the bit has a smooth surface, such as crystal face, it is made uneven with the help of another diamond fragment.

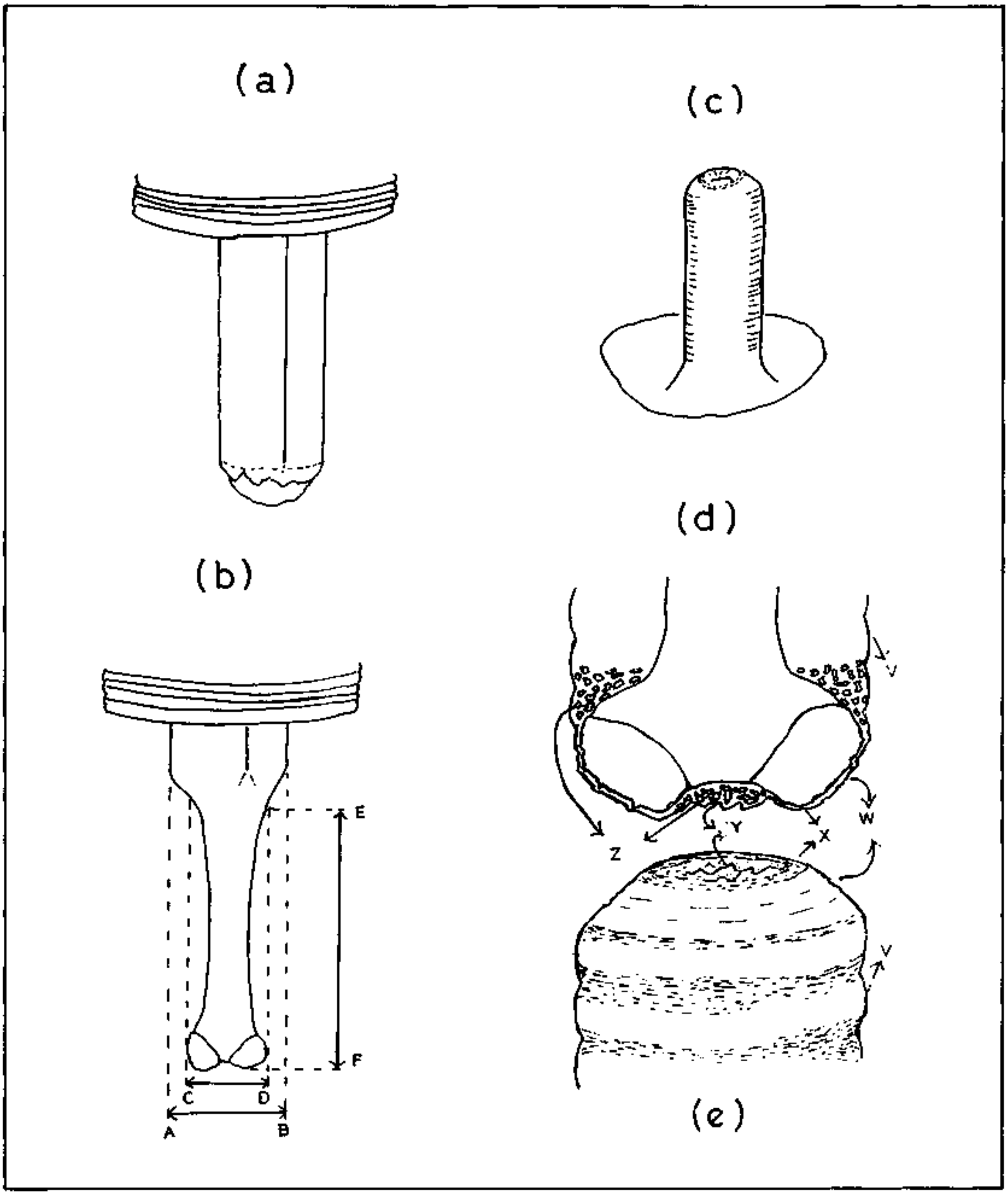

Fig. 2a. Single diamond bit drill with diamond bit fixed in the tip of the metal stick.

Fig. 2b. Double diamond bit drill: A-B – original width of metal stick; C-D – width of leading end; E-F – effective length that can get into drilled hole.

Fig. 2c. Sketch drawn from silicone impression of drill hole: Figure 1a of Gorelick and Gwinnett, 1988.

Figs. 2d. and 2e Cross-section of hole under drilling and sketch of drill hole impression respectively: V – grooved side wall; W – slope of the leading edge; X – deepest part drilled; Y – central elevation at the leading edge showing conchoidal fracture pattern; Z – scraped out and chipped off fragments from side wall and the gap between drill bits.

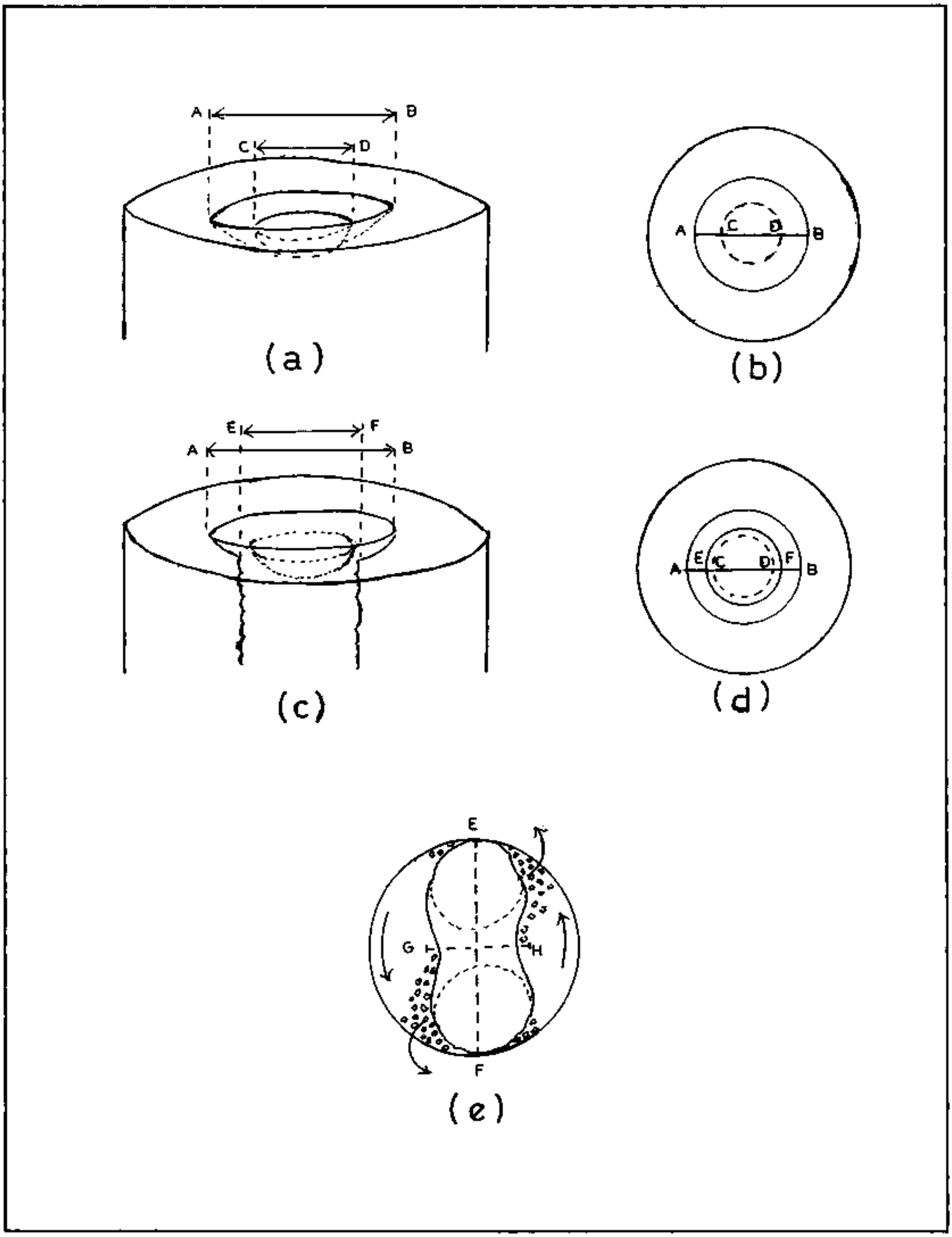

Fig. 3. Patterns produced by single bit (a,b) and double bit (c,d) drills respectively: A-B – width of broader depression created by initial play of marker drill; C-D – diameter of marker diamond bit; E-F – diameter of hole created by double bit driller. Sketch (e) illustrating the width of the broader axis of the double bit drill (E-F) and width of the trimmed metal holder (G-H). Note the space in which cut bead fragments collect.

Interestingly no adhesive or soldering material is used to fasten the diamond bit to the metal stick, but the artisan follows certain indigenously developed methods. For the single bit marker, a depression is carved at the tip of the holder by using a pointed steel rod driven by the bow-string and the diamond bit is then place in it. Further, rim of the carved depression is pressed against diamond bit so that it gets fixed properly in the tip and will not fall off in action (Figure 2a). In the case of the double bit point used for full length performation, initially the metal stick is trimmed with a steel file up to a length that may enter the bead and the tip of it is flattened. Two diamond fragments are placed in the depressions carved on either side of the flattened metal tip (Figure 2b). After placing, the drill bit is hit gently but firmly by a thick metal or wooden piece so that it gets fixed in the metal holder. This action can better be called pressing than hitting. During the act of pressing, the thick metal piece glides over diamond bit and rim of the metal depression clasps diamond tightly.

The single bit marker tip is more or less a permanent arrangement, but in the case of the double bit perforator, the diamond fragment gets loosened and falls off after boring a few beads. The artisan can feel its detachment during rotation. However, the detached diamond bit seldom escapes the alert eyes of the artisan who puts it back in the same way as explained earlier. The broader axis of the drilling tip is always maintained wider than the metal stick that enters the bead, lest the metal stick gets worn out or would not enter the drill hole, (compare E-F with G-H in Figure 3e). Furthermore, the gap produced at right angles to the longer axis of the leading end (Figure 3e) offers space for collecting scooped out bead fragments which pass through the space between the drilled wall and trimmed metal holder. Thus, trimming of the metal stick, flattening of the tip and arrangement of diamond bits are of the utmost importance. Single bit drill is incapable of doing this job as no space is offered by it to displace the scooped material and proceed farther.

Slope of the leading edge (Figures 2d and 2e) depends on the shape and position of the diamond bits used. The conchoidal pattern in the central elevation of leading edge (Figure 2e, sketch drawn after Gorelick and Gwinnett's silicone impressions) can be explained by the following mechanism: while diamond bits scrape out the sides, the central portion situated in the gap between two drill bits remains unscratched. At the same time, the impact of drill bits rotating around the gap forces the bead portion to be chipped off (Figure 2d). Obviously, when silica mineral is chipped off, conchoidal pattern is obtained. Curiously enough, this kind of fractured central elevated portion is not seen in the beads drilled by copper rod and loose grit of emery (Figures 4a and 4b of Gwinnett and Gorelick, 1986). On the contrary, such leading edge is characterized by relatively smooth central elevation. Here the smoothness is entirely due to abrasive action of the loose grit of emery, but not due to the forced chipping that the rotating diamond bits induce.

Each groove in the side wall (Figures 2d and 2e) represents one way movement of the bow, i.e. when the bow is moved to one side, say left, the drill bits carve up to a particular depth, resulting in the development of a groove and again when it is further pressed and moved to the right, the bead is further cut for some more depth resulting in another groove. The shaft rotates for at least 10-12 revolutions in one run of the bow for drilling one groove length. If the movement is continuous in only one direction, the grooves would be having helical pattern (either dextro or laevo) but not in a concentric pattern.

Diamond bits get eroded during the action of cutting and usually last for drilling about 100 bead holes of 5cm length each. Enormous heat is produced during this process, both in the upper metal portion and the drilling end. When both the ends are touched, immediately after drilling, the heat can be felt at the upper metal stick that touches the coconut shell, whereas heat felt in the drilling end is considerably less because of the continuous supply of coolant. A charring effect can be seen at the place where the metal rod pierces the shell.

In this connection it is also worthwhile discussing the fading of grooves in the leading edge that Gwinnett and Gorelick (1988) have observed. Unlike the prominent and deeper grooves of the side wall, the faint grooves are formed by the uneven surface of the cutting slopes of diamond bits. Since two such sloping rugged diamond bits are in action, the grooves carved out by one may be eroded or modified by the other simultaneously rotating bit and thus the leading edge becomes more or less smooth. Even if the grooves are present, they are very faint and shallow.

Scooped out silica powder

The drilled out silica powder is carefully collected in a bowl kept below the platform. The slit provided in the platform ensures that powder suspended in water would not flow elsewhere and be lost, but it would fall directly into a bowl. The powder thus collected is processed further for use as an efficient agent for polishing highly precious stones like ruby, sapphire and emerald. The details of processing, grain size analysis and polishing laps used have been discussed elsewhere (Karanth, 1989). However, the major objection against the Cambay bead is that in some examples the holes drilled from either side are offset and barely touch each other's side walls resulting in a crooked passage. Driving a string through such perforation becomes exceedingly difficult. The reward of the precious silica powder by-product is the main reason for the Cambay lapidary not going for modern ultrasonic perforator, though the latter does the job of drilling more efficiently producing a continuous and elegant hole. A couple of ultrasonic perforators installed a few years back have been more or less ignored by the lapidaries of Cambay.

Time taken for marking and perforating

Marking with a single drill bit takes only about a couple of seconds, whereas the time taken for full length drilling varies with the length of the bead. As Possehl (1981) has stated, drilling a 5mm bead takes 20 seconds and a 4.5cm bead takes about 7 minutes. On an average about 50 beads of 5cm length can be bored in one day by a single artisan. Longer beads take more time per millimetre as care has to be taken to keep the drill rod in proper alignment with the axis of the bead or else the metal rod bends and consequently might even break or the hole gets misaligned.

Conclusion

Perforating tough, hard silica beads is a specialised art and involves many intricate mechanisms which the Cambay lapidary has mastered. Indeed, often threading the bead with a crooked hole is difficult, nevertheless one would not mind when one sees the effort involved in producing it. Probably crookedness of the perforation adds value to such bead as it is something odd and hence special. After all, not all beads are blessed with crooked holes!

Acknowledgements

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Reflections on reflectivity

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Acting as tutor in the Association's correspondence courses, and helping to run various preparation courses for the Association's Preliminary and Diploma examinations has made me realize that the connecting links between some of the interesting phenomena in gemmology are often overlooked.

While most of us are well aware of the use of immersion techniques in microscopy, have occasionally been inconvenienced by the disappearance of a gemstone in a heavy liquid, and are quite familiar with the reflectivity meter, the connection, particularly at the student level, may not have been made between these practicalities and the vital relationship which links them together.

This relationship is the one which exists between reflectivity and refractive index which (for an isotropic mineral with the incident light at normal to its reflecting surface*) is quantified in the simplified version of Fresnel's equation[1]:–

Reflectivity (ratio of reflected to incident light intensity) $= (n-A)^2/(n+A)^2$

Where n = refractive index of gemstone.
A = refractive index of surrounding medium (for air = 1)

For example, expressed as a percentage:–
reflectivity of diamond = 17%
reflectivity of quartz = 4.5%

When a gem is immersed in a liquid whose RI is close to that of the gem, the value of A in the numerator section of the Fresnel equation approaches that of n, and the resultant reflectivity from the surface of the gem falls towards zero. In the case of the immersion microscope this reduces the amount of unwanted surface reflections from the facets of a polished gem and allows more light to enter the stone. The same circumstance explains why a gemstone sometimes 'disappears' in a heavy liquid whose RI is close to that of the gem, and this can also be used as a means of estimating the RI of a gem by the immersion and the Becke Line methods.

The third link is with the reflectivity meter which depends on the Fresnel relationship between reflectivity (lustre) and refractive index for its operation. Although not capable of giving readings with the same degree of precision as a refractometer and being much more dependent on the cleanliness and condition of a gem's surface, the reflectivity meter has the big advantage of being able to identify diamond and its high RI simulants.

As a gem instrument it has a long history. The first device of this kind for gemstone identification was developed in 1959 by L.C. Trumper[2], who was awarded a Research Diploma by the Gemmological Association for his thesis on the measurement of RI by reflection. His instrument took the form of an optical comparator in which the intensity of reflection from a gem's surface was visually matched against a calibrated and manually adjustable source of illumination. However, because it was too complex for economic manufacture it was not exploited commercially.

The advent of the low-cost reflectivity meter had to await the introduction of the miniature light-emitting diode and its associated photo-detector. As the most efficient LED available emitted its peak energy in the near infra-red at around 830nm, this also favoured the instrument's ability to separate diamond from strontium titanate. Despite the fact that at the sodium wavelength of 589.3nm the refractive indices of these two materials are very close, at 830nm the large difference in their dispersions makes their effective RIs easily separated by the reflectivity meter.

Since the introduction in 1975 of the first commercial reflectivity meter[3,4] (the 'Gemeter' – Figure 1), there have been many versions of varying sophistication. Perhaps the simplest of these was the Hanneman 'Jeweler's Eye'[5]. Of the more complex models, there have been three which illustrate the extent to which a simple concept can be developed.

* For absolute measurement. (When making comparative measurements using a gemmological reflectivity meter, the relationship is sufficiently close to identify anisotropic and isotropic gems. For practical reasons of construction, the incident angle to the normal in most gem reflectivity meters is around 20 degrees.)

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Fig. 1. Gemeter, the first commercial reflectivity meter. The top section of its meter scale is calibrated in RI values 1.4 to 2.7. Printed letters on the lower portion of the scale indicate the meter readings for some of the principal gems (Q for quartz, Z for zircon, D for diamond, etc.).

Fig. 2. The Martin Gem Analyser was the first reflectivity meter to use pulsed infra-red illumination which minimized the effect of ambient light entering through the rear of the stone under test.

The first of these was the 'Martin Gem Analyser'[6] (Figure 2) which introduced pulsed infra-red illumination/detection (Figure 3) as a means of combating the effect of spurious light entering the back of the stone under test.

The next major innovation was the 'Gemexpert'[7] (Figure 4) which used a microcomputer to store the reflectivities of gems and identify them by name on an alpha-numeric LCD display panel.

My own contribution to the development of the reflectivity meter was the Rayner 'DiamondScan'[8] (Figure 4). This is a reflectivity probe using an LED display for the identification of diamond and its simulants, and, as far as I am aware, the only version to use fibre optics to achieve incident illumination at normal to the gem's surface.

The refractometer, which exploits the critical angle resulting from the optical contact between the surface of its prism and that of the gem under test, also relies partly on reflection for its operation, as it is the light striking this surface at angles greater than the critical angle that is reflected back into the prism to illuminate the bright section of the scale. However, there are two other practical aspects of the

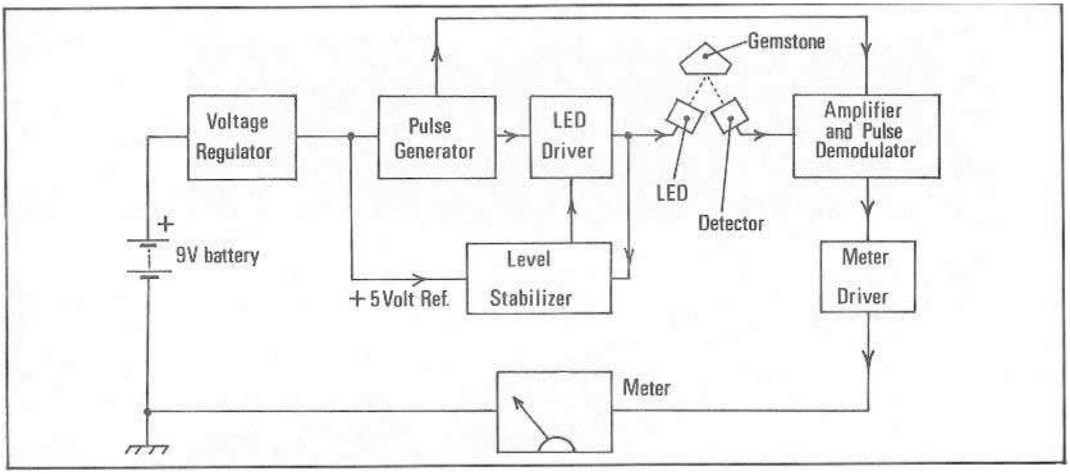

Fig. 3. Block diagram of Martin Gem Analyser circuit, showing a method of pulsing the infra-red LED and decoding the resultant reflectivity signal from the photo-detector.

critical angle of a gemstone, both of which are connected with reflection.

The most important of these concerns the lapidary and diamond polisher, who determines the angles and proportions of a gemstone to achieve an optimum total internal reflection of light rays entering its crown facets. The critical angle of a gem is related to its refractive index as follows:–

$$\text{Critical angle} = \text{the angle whose sine} = \frac{\text{RI of rarer medium}}{\text{RI of denser medium}}$$

With air as the rare medium, critical angle = arc.sine

$$\frac{1}{\text{RI of gemstone}}$$

For diamond the critical angle is 24.43 degrees (compared with 40.33 degrees for quartz). Rays of light entering the crown facets to meet the pavilion facets at angles greater than this will be totally internally reflected (rays 1 in Figure 6), but those rays meeting the pavilion facets at less than this angle will be refracted out of the pavilion (ray 2 in Figure 6).

However, if the pavilion facets of a gemstone become coated with grease (or, as frequently happens, with soap!) the RI of the medium surrounding the pavilion increases, typically to 1.6. Diamond, with its affinity for grease, is particularly vulnerable in this respect and such a coating would result in an increase in the critical angle to around 41 degrees, with the consequent loss of rays through the pavilion facets and a reduction in the stone's overall brilliance.

To complete this brief survey of inter-related reflectivity phenomena, I will mention one that is of

Fig. 4. The GfD Gemexpert contained a microprocessor which enabled it to display the name of the gem under test on its LCD panel.

Fig. 5. The Rayner DiamondScan used fibre optics to produce an 0.75mm diameter infra-red beam at normal to the test surface. For large stones it could be fitted with an end cap which provided a flat reference face.

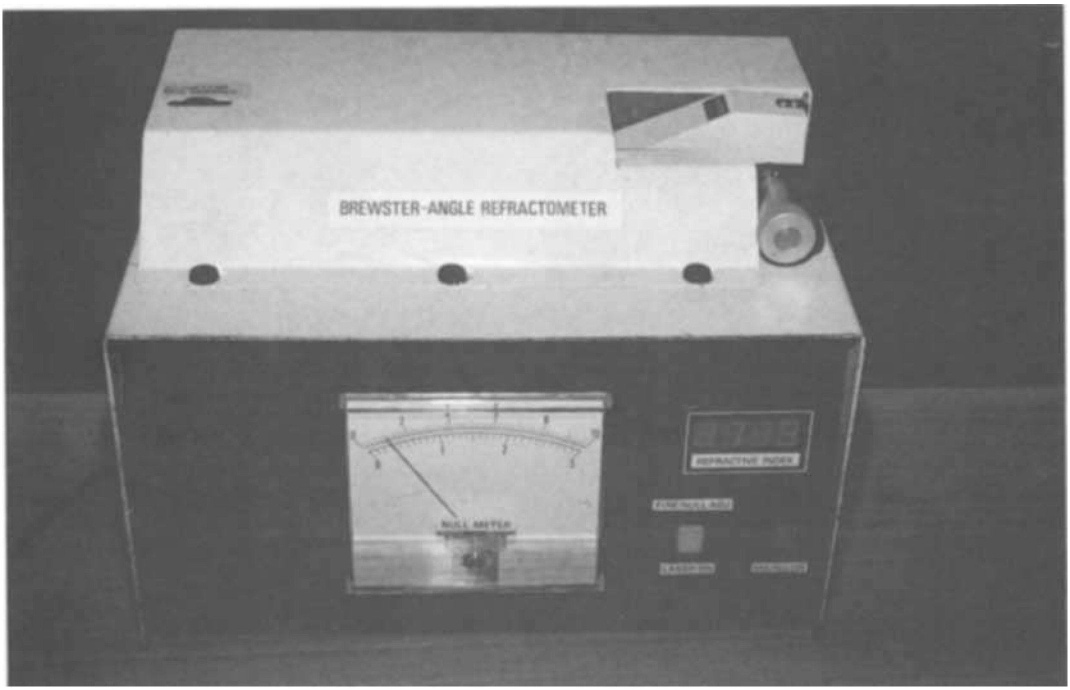

Fig. 7. The latest version of a Brewster-angle refractometer developed by the author. The instrument uses a small polarized laser. The reflected ray from the gem under test is displayed on the null meter in the centre; the laser beam angle is adjusted (by means of the knurled edge control at the top left) for a minimum reading, and the resultant RI reading is displayed on the LED panel meter on the right.

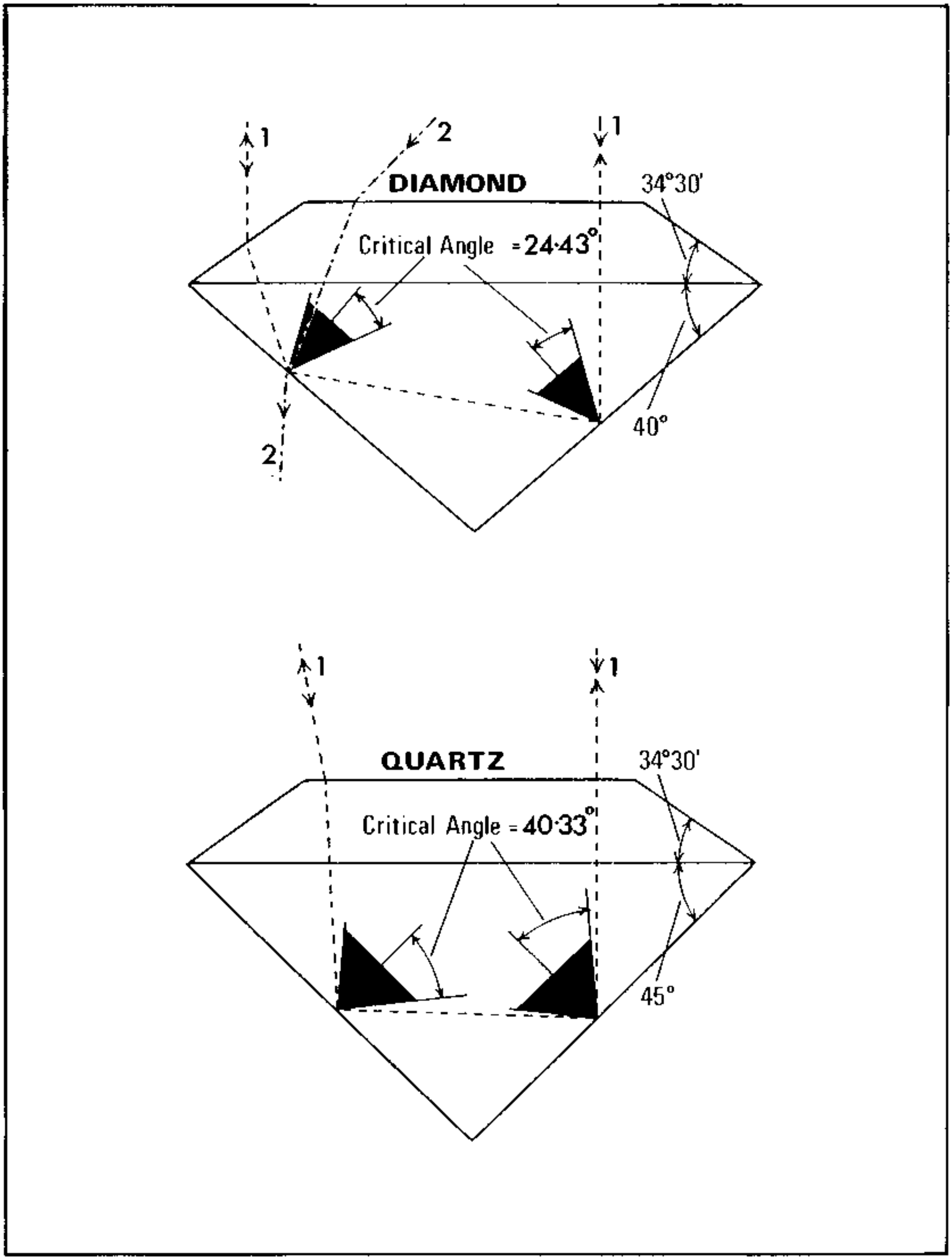

Fig. 6. Showing how the brilliance of a polished gem (in terms of total internal reflection) depends on its cut which in turn is dictated by the critical angle of the gem. Ray 2 in the top illustration indicates how light rays entering the cone of the critical angle are refracted out of the pavilion. The lower illustration shows how the pavilion of a quartz gem has to be cut deeper to achieve a similar total internal reflection (for ray 1) as shown in the diamond above it.

particular interest to me – the Brewster-angle of polarisation. This is the angle at which only those rays whose plane of polarization coincides with the plane of the reflecting surface obey the laws of reflection.

An historic application of this phenomenon occurred in an early polariscope, which used a plate of glass tilted at the Brewster-angle to produce polarized light.

Naturally-occurring polarized light is also produced as the result of the Brewster-angle of polarization. It is generated from horizontal surfaces such as water, and its glare can be reduced by means of vertically-polarized sun glasses.

Of more relevance to gemmology is the law relating the Brewster-angle of polarization of a material to its refractive index. Brewster's law states that complete polarization of light reflected from the surface of a denser medium occurs when it is normal (i.e., at right angles) to its associated refracted ray in that medium. From this, the relationship between a material's Brewster-angle and its RI can be formulated:–

RI of reflecting material = tan of its Brewster-angle

The first person to make use of this relationship to measure the refractive index of a gemstone was B.W. Anderson[9], who in 1941 used the newly introduced Polaroid filter sheet to confirm the practicality of this method. Thirty-eight years later I too built an experimental refractometer[10] using the Brewster-angle phenomenon (an even simpler instrument was proposed in the same year by R.M. Yu of Hong Kong University[11]). When a relatively low-cost polarized laser became available I was finally able to translate my simple optical model into an elecronic version[12].

With the assistance f the Rayner Optical Company, this latest example of the exploitation of reflection in the aid of gemmology has been developed into an instrument with an RI measuring range of 1.4 to 3.3 and with the ability to measure double refraction from 0.01 upwards (Figure 7).

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Gemmological Abstracts

AKIZUKI, A., 1989. Growth structure and crystal symmetry of grossular garnets from the Jeffrey mine, Asbestos, Quebec, Canada. *American Mineralogist*, 74, 859-64, 4 figs.

Orange garnets from the Jeffrey mine, Asbestos, Quebec, Canada, may show non-cubic symmetry and birefringence. Study of the ordered atomic arrangements show that the symmetry is monoclinic. Some colourless and green grossular crystals show orthorhombic symmetry though some parts are strained. These findings do not apply to all grossular garnets from this locality. M.O'D.

ARANYAKANENI, P., 1989. Amphoe Bo Phloi. A New Thai sapphire deposit. *Wahroongai News*, 23, 7, 7-12.

Reprinted from *The Great Mine of Thailand*, published by SAP Mining Co. Ltd, this is a long account of a new deposit on a hillside about 40km from Kanchanaburi which is itself about 130km west of Bangkok. Sapphires are found in basalt, some of which is columnar. Alluvial deposits concentrate the sapphire but are often found as hard conglomerates. The paper is concerned almost entirely with geological provenance and the occurrence of the sapphire-bearing load and gives little indication of quality, sizes and quantities found. But deposits are apparently mined with some enthusiasm so the find is probably an important one in an area already known for its sapphires. [On a personal note, abstractor is fairly certain that Kanchanaburi relates closely to 'Kanburi', one of the many terrible prisoner-of-war camps on the route of the Burma/Siam railway along the River Kwai. He missed those camps by the skin of his teeth in 1943 and was shipped up to northern Japan instead. But a great many good friends died on that appalling railway.] R.K.M.

BALFOUR, I., 1989. Famous diamonds of the world, XLII. The Agra. *Indiaqua*, 54, (1989/3), 171-5.

The Agra diamond, a light pink cushion-cut stone weighing 41.25ct, was said to have been worn in the turban of the first Mogul ruler, Babur. The city of Agra, from which the gem takes its name, was founded by the Mogul emperors as their capital and is the site of the Taj Mahal.

In 1844 a diamond thought to be the Agra was acquired by the Duke of Brunswick. Later, this stone was recut to 31.4 ct (32.24 metric carats) to eliminate some internal black spots. After a complicated history, described in detail by the author (and updated in this article subsequent to the publication of his book *Famous diamonds* in 1987), a 31.5 ct pink diamond believed to be the Agra was purchased for 82,000 francs at a Paris auction in 1909. It is now in private ownership. P.G.R.

BANK, H., HENN, U., 1989. Changierender Taaffeit aus Sri Lanka. (Colour-changing taaffeite from Sri Lanka.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 38, 2/3, 89-94, 5 figs (1 in colour), graph, bibl.

The taaffeite from Sri Lanka weighed 12.23 ct and showed a colour change from reddish to blue. RI 1.724-1.720, DR 0.004, SG 3.61. The absorption spectrum showed typical bands caused by Fe^{2+} and is characterized by absorption minima in the red and blue range and an intense maximum in the green. E.S.

BANK, H., HENN, U., 1989. Farbloser, klar durchsichtiger, geschliffener Sellait aus Brasilien. (Colourless, clear transparent, cut sellaite from Brazil.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 38, 4, 143-5, 2 figs, bibl.

The faceted, cut, colourless, transparent specimens were said to come from the Brumado mine in Bahia, Brazil. RI 1.378-1.390, DR 0.12, SG 3.15. Microscopic examination showed multiple growth tubes, flat, irregularly shaped cavities with liquid gaseous filling, as well as three-phase inclusions. Sellaite is a magnesium fluoride. E.S.

BANK, H., HENN, U., 1989. Gemmologische Kurzinformationen. Schleifwürdiger, transparenter blauer Saphir aus Kenia. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 38, 2/3, 105-6, bibl.

Describes a cuttable, transparent, blue sapphire from Lodwar on Lake Turkana in Kenya. There was lamellar twinning and distinct growth structures. E.S.

BANK, H., HENN U., 1989. Gemmologische Kurzinformationen. Ein ungewöhnlicher Granat aus Ostafrika. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 38, 4, 161-4, 2 figs, bibl.

Describes an unusual orange-brown garnet from

East Africa weighing 64.47 ct. RI 1.739, SG 3.74, found to be a pyrope-spessartine mixed crystal containing grossular as well as almandine. E.S.

Bank, H., Henn, U., Petsch, E., 1989. Gemmologische Kurzinformationen. Spinelle aus dem Umba-Tal, Tansania. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 4, 166-8, 1 fig., bibl.

Deals with spinels from the Umba Valley in Tanzania. The spinels were of pink, red, orangish-red and bluish-violet colour, RI 1.713-1.718, SG between 3.54-3.69. Colouring matter determined by spectroscopy. E.S.

Bank, H., Henn, U., Schmidt, S.Th., 1989. Gemmologische Kurzinformationen. Hochlichtbrechender Rubin aus Malawi. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 2/3, 106-8, 1 table, bibl.

Describes a ruby from Malawi, RI 1.770-1.780, DR 0.01, SG 4.05. The stone was found about 50 miles south of Lake Nyasa. E.S.

Bank, H., Platen, H.v., Amarasinghe, A.G.B., 1989. Gemmologische Kurzinformationen. Saphirblauer, durchsichtiger Sapphirin aus Sri Lanka. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 2/3, 103-5, 4 tables, bibl.

Describes a sapphire-blue, transparent stone from Sri Lanka which was identified as sapphirine. RI 1.704-1.711. E.S.

Beattie, R., 1989. Personalities behind the gem world: Kokichi Mikimoto 1858-1956 [1954?]. *Wahroongai News*, **23**, 6, 27-30.

A concise biography based on Eunson's book *The Pearl King*, about the first successful producer of spherical cultured pearls. Born in humble circumstances only five years after Commodore Peary landed in Japan, forcing that country out of the feudal system and into the modern world, Mikimoto by sheer hard work and dedicated purpose throughout his long life eventually achieved what has to be seen as a major advance in the world of gems. R.K.M.

Berk, M., 1989. New from New England. *Lapidary Journal*, **43**, 8, 44-8, 2 figs in colour.

Amethyst has recently been found at locations in Maine and New Hampshire, USA. M.O'D.

Bille, C., Chapoule, R., Dorbes, J., Schvoerer, M., 1989. Reconnaissance d'un diamant de synthèse De Beers parmi d'autres gemmes grâce a la cathodoluminescence. (Recognition of a De Beers synthetic diamond from others thanks to cathodoluminescence.) *Revue de Gemmologie*, **100**, 19-21, 4 figs (2 in colour).

Cathodoluminescence was able to distinguish a De Beers synthetic diamond from natural diamond, YAG and zircon, giving a strong characteristic emission line at 520nm. M.O'D.

Birmingham, J.C., 1989. Mourning jewellery. *Australian Gemmologist*, **17**, 3, 82-4, 4 figs.

A brief history of memorial jewellery through the ages. R.K.M.

Borelli, A., 1988. A brief note on problematical yellow-brown diamond. *La Gemmologia*, **13**, 3/4, 27-32, 6 figs in colour.

A brilliant-cut stone of yellow to yellowish-brown colour with zoning along possible crystal faces was identified as natural diamond. No trace was seen of absorption in the 594nm region though lines were observed at 478 and 415.5nm, though the latter was difficult to detect. Under LWUV the stone showed a strong bluish-white to nearly white fluorescence and a persistent yellow phosphorescence. Under SWUV the stone gave a medium intensity bluish-white to pale yellow. M.O'D.

Bracewell, H., 1989. Wave Hill prehnite. *Australian Gemmologist*, **17**, 4, 127-8, 7 figs in colour.

Gives details of prehnite bearing areas near Kalkaring, south of Darwin. Colours white, through green, yellowish-green and yellow; SG about 2.87; RI 1.614-1.637, quite variable; H 6-7; fluorescence under LUV dull brown; absorption band vague at 440nm; some material is facetable. R.K.M.

Brown, G., 1989. Dayboro variscite. *Australian Gemmologist*, **17**, 3, 98-100, 4 figs in colour.

Once thought to be bluish-green turquoise, this hydrated aluminium phosphate is now identified as variscite, found at nicely named Mt Scrubbytop, Queensland, it occurs in thin veins and, more rarely, in nodules in a blackish chert. H 4, SG 2.4, RI 1.56, all appreciably lower than turquoise constants. Chalky green fluorescence in LUV. No absorption bands. R.K.M.

Brown, G., 1989. Kauri gum revisited. *Wahroongai News*, **23**, 10, 21-8, 4 figs and sketches.

An excellent account of a comparatively unconsidered New Zealand gem material, based at least in part on the work of the GANZ study group. Found only in the north of North Island, the gum can be either fossil, possibly of great age, or recent. Kauri trees are still thriving so can be bled for the gum even today. This paper covers history, mode of occurrence, prospecting and 'mining', plus gemmological and other testing. SG 1.03 to 1.09, increasing with age; RI 1.54; young gum is more soluble in ether than amber, but this decreases with age of the gem; alcohol is perhaps a better solvent but again it will not distinguish ancient fossil kauri gum (perhaps 30m years old) from amber (similar age?); UV fluorescence is variable and very similar to that of amber. Crazed surface is much more common in young kauri gum, but can occur in amber. General conclusion is that it would be hard to distinguish between the better fossil qualities of kauri gum and amber. R.K.M.

Brown, G., Bracewell, H., 1989. Yundamindera 'fire' opal. *Australian Gemmologist*, **17**, 3, 101-3, 8 figs in colour.

Yellowish-brown to amber common opal is found at this attractively named semi-desert locality in Western Australia. SG about 2, RI 1.42, inclusions: flow structures and dendrites, no play of colour, but an attractive gem which 'deserves greater promotion'. R.K.M.

Brown, G., Kelly, S.M.B., Snow, J., 1989. Russian hydrothermally-grown emerald. *Australian Gemmologist*, **17**, 3, 103-5, 6 figs in colour.

These synthetic emeralds are generally eye-clean but microscope reveals characteristic phenakite based 'dagger' inclusions, partly healed cracks, wavey growth patterning, occasional brassy metallic needles. Colour dark bluish-green; Chelsea filter gives green; inert to UV; dichroism blue and green. RI 1.571-1.579, DR 0.009, SG 2.76. Investigators report that 680nm fluorescent doublet was no seen [but it is listed in their table of properties]. Physical properties overlap those of natural emerald, so inclusions are vital for identification. R.K.M.

Brown, G., Snow, J., 1989. Some observations on helenite. *Australian Gemmologist*, **17**, 3, 88-90, 5 figs in colour.

An American olive-green glass said to be made from 'pure' volcanic ash from the Mt St Helen's eruption in Washington State in 1980, some specimens from pure ash and some from ash 'diluted' with glass. Discs of the latter are cut from rods spun from highly viscous glass and retain marked concentric lamellae. SG 2.448, RI 1.508, grains of possible ash, bubbles and swirls were seen. R.K.M.

Burt, D.M., 1989. Vector representation of tourmaline compositions. *American Mineralogist*, **74**, 826-39, 21 figs.

Instead of the traditional triangular method of representing tourmaline group composition, a vector method is proposed. This method has been used successfully for the mica and amphibole mineral groups. M.O'D.

Buzas, Z., 1989. Interessante Einschlüsse in mexicanischem Opal. (Interesting inclusions in Mexican opal.) *Lapis*, **14**, 10, 27-8, 2 figs in colour.

Quartz crystals are reported as inclusions in opal from Queretaro, Mexico. M.O'D.

Campbell, I.C.C., 1989. Visual structural differences between elephant ivory, bone and vegetable ivory. *South African Gemmologist*, **3**, 3, 20-7, 17 figs (11 in colour).

Scrapings of elephant ivory, bovine bone, vegetable ivory and walrus tusk are examined and photomicrographs illustrated. M.O'D.

Campbell, I.C.C., Kleyenstüber, A.S.E., 1989. An alexandrite of apparent Hematita origin. *South African Gemmologist*, **3**, 4, 8-11, 7 figs in colour.

An alexandrite reported to have come from the Hematita deposits in Brazil showed quartz and kaolin traces on electron microprobe analysis, suggested a pegmatitic origin. The traces appear to have come from inclusions breaking the surface. M.O'D.

Cassedanne, J.P., 1989. Diamonds in Brazil. *Mineralogical Record*, **20**, 5, 325-36, 16 figs.

The paper gives a history of the working and discovery of diamond in Brazil. By the end of the 1700s Brazil was the world's leading diamond producer, only yielding this place to South Africa in the nineteenth century. Typical crystal forms are illustrated and there is a map of the diamond-bearing areas. A table lists some of the major diamonds found in Brazil. M.O'D.

Cassedanne, J.-P., 1989. Découverte d'un nouveau gîte d'émeraude. *Revue de Gemmologie*, 98, 3-4, 7 figs (1 in colour).

Emerald is reported from a ravine called Riacho do Mamao, Fazenda Paioli (Capoeirana), in the municipality of Nova Era. The area is about 90km ENE from Belo Horizonte, Minas Gerais, Brazil. The established Belmont emerald mine is only about 10km distant from the new site. Stones examined have SG 2.660, RI 1.577-1.584, with DR 0.007. There is no luminescence nor radioactivity. Pleochroism is greenish-blue/pale yellowish-green and crystals consisting of broken prisms with signs of corrosion and frequently colour-zoned are found in schists close to pegmatite bodies. Two-phase inclusions are reported but no mineral inclusions. M.O'D.

Cassedanne, J., 1989. Maricota, un nouveau gisement d'andalousite (Minas Gerais, Brésil). (Maricota, a new location for andalusite, Minas Gerais, Brazil.) *Revue de Gemmologie*, 100, 7-9, 6 figs in colour.

Green and rose-coloured andalusite is reported from a new location named Maricota in the Fazenda Lageadão, 40km north-east of Araçuai and 10km west of Itinga, in the north-east of the Brazilian state of Minas Gerais. The colour of faceted stones is olive-green to yellowish-green and rose colour. Pleochroism gives a pale olive green to a violet-red. The material is found in quartz. M.O'D.

Cozar, J.S., 1989. Determinación de rasgos de tratamiento, en topacios azules irradiados, por espectroscopia gamma de alta resolución. (Determination of signs of treatment in irradiated blue topaz, using high-resolution gamma-ray spectroscopy.) *Boletin del Instituto Gemmologógico Español*, **31**, 8-18, 7 figs in colour.

Gamma-ray spectroscopy is at present the only way to detect treatment of gemstones by ionizing radiations, if these have stimulated activation. Details of the methodology are given. M.O'D.

Crowningshield, R., 1989. Grading the Hope diamond. *Gems & Gemology*, 25, 2, 91-4, 5 figs in colour.

A modern assessment of the world's most famous blue diamond by a team from the New York Lab found it to be a 'fancy dark greyish-blue', weighing 45.52 ct, of VVS clarity. No fluorescence in LUV and possibly faint fluorescence in SUV, followed by strong red phosphorescence after SUV. R.K.M.

Dawidowicz, T., 1989. L'influence des inclusions sur la structure cristalline. (The influence of inclusions on crystal structure.) *Revue de Gemmologie*, **100**, 23-4.

The paper gives a brief account of crystalline defects and their influence on spectrographic testing methods. M.O'D.

Dubois-Fournier, J., Lenain, B., Le Maguer, D., 1989. La microspectrofluorescence et ses applications en gemmologie. (Microspectrofluorescence and its gemmological applications.) *Revue de Gemmologie*, **100**, 15-18, **10** figs (1 in colour).

Microspectrofluorescence is used to detect elements in gemstones – in this case, in corundum. Fluorescence spectra are measured and illustrated and compared with those given by the Verneuil product. M.O'D.

Epstein, D.S., 1989. The Capoeirana emerald deposit near Nova Era, Minas Gerais, Brazil. *Gems & Gemology*, **25**, 3, 150-8, 12 figs in colour.

Discovered in 1988 this mine is yielding quantities of gem emerald very similar in quality and properties to stones from the Belmont mine 10 kilometres away. Most are light bluish-green in colour and some best described as green beryl. RI of ten stones tested varied slightly around 1.577-1.583. SG about 2.71. Some had been oiled. No red or pink through emerald filter; two-and three-phase inclusions seen, but unlike the jagged-edged cavities in Colombian stones; biotite and calcite or dolomite were identified; inclusions plentiful but fewer than in the Belmont stones and identical in type. Chemical composition was also consistent with those stones. R.K.M.

Epstein, D.S., 1989. Brazilian trio. *Lapidary Journal*, **43**, 8, 22-8, 4 figs in colour.

Three amethyst-producing areas in Brazil are described, Maraba, Pau D'Arco and Rio Grande do Sul. Differences in the product are discussed. M.O'D.

Frazier, S., Frazier, A., 1989. Phantoms. *Lapidary Journal*, **43**, 9, 66-80, 3 figs in colour.

The development of phantom crystals, mostly in quartz, is discussed. M.O'D.

Frazier, S., Frazier, A., 1989. Inter-Agate. *Lapidary Journal*, **43**, 5, 28-42, 5 figs (3 in colour).

The agate deposits in the Idar-Oberstein area of West Germany are described with a note on their

Fritsch, E., Conner, L., Koivula, J.I., 1989. A preliminary gemological study of synthetic diamond thin films. *Gems & Gemology*, **25**, 2, 84-90, 7 figs in colour.

The past two decades have seen diamond or diamond-like carbon (DLC) films grown onto surfaces by a chemical vapour deposition technique from carbo-hydrate gases. DCLs seem easier and it is thought such films might be used on gems to increase resistance to wear. They are mostly polycrystalline but Sumitomo have experimented with producing single crystal diamond on synthetic diamond [to increase size?.

Other possible gemmological uses to improve diamond simulants, or add a diamond surface to softer gems are discussed. The films seem to be detectable with little trouble, and so far there do not appear to be any commercially diamond-coated gems on the market. R.K.M.

Fryer, C.W., (Ed.), Crowningshield, R., Hurwit, K.N., Kane, R.E., Hargett, D., 1989. Gem Trade Lab notes. *Gems & Gemology*, **25**, 3, 171-6, 15 figs in colour.

'Black onyx' seal stones from Hong Kong were identified as glass; SG 2.51 and RI 1.53 suggest an effort to get near to chalcedony constants; H 5.5 to 6 was low.

A 2.68 ct 'Old Mine' diamond with a concave table facet probably dated from 1910 when J.L.Gonard patented the cut, to 'increase brilliancy'; it does reduce table reflection. A flat six-sided lozenge of diamond had a central Latin cross machine-engraved and painted black; today the engraving would be simpler by laser. Facet edges of diamonds in a bracelet were abraded, evidentally what used to be known as 'paper-worn'. [This happened when a stone-paper of diamonds was carried around in the pocket of a dealer for a long time; the diamonds did did the damage, not the paper.] A diamond brooch had five dead iridescent green beetles set in it for added colour [a minor Victorian fashion].

Necklace pearls chipped at one end of the drill-hole had been drilled through from the opposite end, instead of half way from each side. A yellowish 'demi-pearl' is illustrated, one end nacreous, the other dull and pitted; why is not known. Pinkish cultured pearls often show traces of dye around the string hole; one is illustrated with a red clot alongside the hole.

A star ruby illustrated is thought to be an early synthetic one and resembles a purplish-red natural star stone; strings of minute gas bubbles looking like silk, and curved striae were seen. A tanzanite had an unexplained iridescent coating which did not affect tanzanite RIs. It was easily removed by an ink eraser. [Hair lacquer deposited accidentally while holding hair in place with the ring hand? Such coatings usually come off with paint stripper!]

R.K.M.

GENDRON, F., 1989. Le jade en Meso-Amérique, symbole de pureté et de vie. (Jade in Central America, symbol of purity and of life.) *Revue de Gemmologie*, 98, 5-10, 6 figs (3 in colour).

The article gives an historical review of the uses of jade in the civilizations of Central America. Useful names and categories are distinguished.

M.O'D.

GODOVIKOV, A.A., BULGAK, L.V., 1989. (Fersman.) *Lapis*, **14**, 10, 11-17, 11 figs (8 in colour). [In Russian.]

The collections of the A.E. Fersman Mineralogical Museum in Moscow are described. Among the specimens illustrated are outstanding examples of emerald and alexandrite. M.O'D.

GOEBEL, M., DIRLAM, D.M., 1989. Polynesian black pearls. *Gems & Gemology*, **25**, 3, 130-48, 23 figs in colour.

Superbly illustrated account of naturally coloured black and grey cultured pearls grown in the large black-lipped oyster *P. Margaritifera*, in the lagoons of the Tuomotu Archipelago and the Gambier Islands in French Polynesia. These large pearls have better lustre and iridescence than most natural black pearls, and supercede black-stained cultured pearls which dominated this market until the 1960s. *P. Margaritifera* was overfished for shell last century and natural black pearls became rare. Today the oyster is farmed and cosseted, and the shell a bi-product of a multi-million dollar production of fine pearls. Largest recorded specimen, 20.8mm diameter, is illustrated.

Bead nucleus and mantle tissue are inserted in the gonad (reproductive gland) of the oyster rather than in the mantle. Bead sometimes ejected and a 'keshi' (tissue-nucleated) black pearl may result. R.K.M.

GOUPIL, V., 1989. Les évangéliaires précieux. (The precious gospels.) *Revue de Gemmologie*, 98, 11-19, 8 figs (6 in colour).

Discusses the jewelled bindings of 9th-10th century versions of the Gospels. M.O'D.

GRIFFIN, W.L., COUSENS, D.R., RYAN, C.G., SIE, S.H. SUTER, G.F., 1989. Ni in chrome pyrope garnets: a new geothermometer. *Contributions to Mineralogy and Petrology*, 103, 199-202, 2 figs.

The positioning of nickel between chrome pyrope and olivine found in garnet-peridotite xenoliths from kimberlites is found to be strongly temperature-dependent and allows an estimation of the temperature of formation for single pyrope grains such as those found as diamond inclusions.

M.O'D.

HÄNNI, H.A., 1989. Les feldspaths. (The feldspars.) *Revue de Gemmologie*, 101, 19-20, 3 figs in colour.

A brief introduction to the ornamental varieties of the feldspar mineral group. M.O'D.

HÄNNI, H.A., 1989. Irisierendes natürliches Glas aus Mexiko. (Iridescent natural glass from Mexico.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 2/3, 51-62, 9 figs (2 in colour), 2 tables, bibl.

An English version of this paper appeared in *Journal of Gemmology*, **21**, 8, 488-95. E.S.

HÄNNI, H.A., WEIBEL, M., 1989. Ursache des Katzenaugen-Effekts bei erhitzten Zirkonen aus Sri Lanka. (Cause of cat's-eye effect in heated zircons from Sri Lanka.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 2/3, 95-101, 5 figs (2 in colour), bibl.

After heat treatment, certain zircons from Sri

Lanka showed a cat's-eye effect. The oriented inclusions which caused the chatoyancy are very fine fissures crystallographically orientated parallel to the *c*-axis, apparently in the (100) and (010) planes. Prismatic crystals were found in the centre of the disc-shaped fissures (diameter approximately 5 microns), probably thermally decomposed apatite. E.S.

HARDER, H., 1990. Spinell-attraktive, aber wenig bekannte Edelstine. (Spinel, attractive but little-known gemstone.) *Aufschluss*, **41**, 13-25, 7 figs in colour.

The gem variety of spinel is less well-known than its beauty warrants. The paper gives physical, chemical and geological details of the spinel minerals, grouping the red stones according to their resemblance to ruby, pyrope and almandine. Blue spinel is compared to sapphire and some stones are compared to padparadscha. M.O'D.

HENN, U., BANK, H., BANK, F.H., 1989. Gemmologische Kurzinformationen. Orangefarbene Korunde aus Malawi. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 4, 164-6, 1 fig., bibl.

A note on orange coloured corundums from Malawi. RI 1.763-1.773, DR 0.008, SG 3.97-3.98. Lamellar twinning, healing cracks, and double refractive, rounded inclusions were observed. E.S.

HICKS, W.H., 1989. Editorial appreciation. *Australian Gemmologist*, **17**, 4, 139, 1 fig.

Bill Hicks illustrates a photo-copying attachment supplied by Jack Snow in answer to a dire editorial need. R.K.M.

HISS, D.A., 1989. Geuda transforms Sri Lanka's 'City of gems'. *Jewelers' Circular Keystone*, October 1989, 244-7, 5 figs in colour.

The geuda sapphire industry in which colourless corundum is heated to give a fine blue has revived some of the fortunes of Sri Lanka's gem merchants. M.O'D.

HLAING, T., 1989. The characteristics of Burmese spinel. *Australian Gemmologist*, **17**, 3, 84-7, 3 figs.

Part of a thesis which made a detailed study of spinel from the Mogok area. Notes that Burma is now called Myanmar [which will take some getting used to!]. R.K.M.

HOCHLEITNER, R., 1989. Blauer Euklas aus Zimbabwe. (Blue euclase from Zimbabwe.) *Lapis*, **14**, 10, 24-7, 7 figs (5 in colour).

A sapphire-blue variety of euclase is reported from south west of Miami in Zimbabwe, Central Africa. The mineral occurs in a pegmatite. M.O'D.

HOCHLEITNER, R., 1989. Die Sonderausstellung des Fersman-Museums in München. (Special exhibition of the Fersman Museum in Munich.) *Lapis*, **14**, 12, 25-7, 6 figs (4 in colour).

Fine specimens from the Fersman Mineralogical Museum in Moscow on exhibition in Munich included a red crystal of topaz from the Sanarka River, Ural Mountains and two specimens from Mursinka, a blue topaz and a greenish-yellow beryl. M.O'D.

HODGKINSON, A., 1989. Visual optics. *Australian Gemmologist*, **17**, 4, 137-8, 4 figs in colour.

A brief résumé of Hodgkinson's direct vision testing as applied to diamond and some of its imitations, a skill calling for careful assessment of tiny spectra which needs to be used with caution. R.K.M.

HOLZHEY, G., 1989. Untersuchung einer Opal-Imitation. (Investigation of an opal imitation.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 4, 139-42, 4 figs (3 in colour), 1 table, bibl.

The stone investigated was of unknown origin, a cabochon weighing 0.48 ct, 10 x 7 mm. It did not look polished, but probably pressed or cast. The colourful stone was found to be glass, but could not be identified with any previously known imitation. E.S.

HUGHES, R.W., 1989. Talkin' 'bout gem-testing instruments. *Australian Gemmologist*, **17**, 4, 159-64.

A long and rather flippant diatribe which attacks in humorous terms several instrument manufacturers, either disguised by a pseudonym or named, for bad design, unreliable construction and other offences. I find myself puzzled that having found one table spectrometer quite unsatisfactory Mr Hughes apparently went on and requested three more of them.

In the matter of spares, he says 'The frequency of bulb failure will be in direct proportion to the importance of that bulb, and in inverse proportion to the ease of getting spares. Those bulbs which fail most often will be located in totally inaccessible locations within the instrument, and will be exotic items containing radon gas encased in a hollowed out taaffeite chamber, utilizing the pubic hair of a now-extinct homosexual Amazonian flea as the filament. The bulb is available only from an obscure black magic shop in Burundi, and no, they don't accept American Express.' – and more in that vein. This is patently fiction and serves no real purpose if this gentleman has genuine complaints about instrument design or supply.

[I am left wondering whether this long and amusing paper is intended to be taken seriously, or whether it has been written simply as a humorous exercise. If the former, then it does itself a disservice in including the fictitious invention extracted.] More is promised. R.K.M.

HUNSTIGER, C., 1989. Darstellung und Vergleich primärer Rubinvorkommen in metamorphen Muttergesteinen. Petrographie und Phasenpetrologie. Teil I. (Description and comparison of primary ruby occurrences in metamorphic rock. Petrography and phase petrology. Part I.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 4, 113-38, 8 figs (3 in colour) 8 tables, bibl.

The formation of ruby requires relative accumulation of Al_2O_2 compared to SiO_2 plus some chromium to produce the red colour. During metamorphism corundum is formed from diaspore, or can be changed from muscovite or margarite into feldspar + vapour + corundum. This article deals with rubies in amphibolites: Fiskenaesset in Greenland, Kittilae in Finnish Lapland, Valle d'Arbedo in Switzerland and also north of Locarno in Switzerland, Chantel in France, Longido in Tanzania and the Harts Range in Australia. The mineral analysis of corundum carrying amphibolites are compared. E.S.

KAMMERLING, R.C., KOIVULA, J.I., 1989. Thermal alteration of inclusions in 'rutilated' topaz. *Gems & Gemology*, **25**, 3, 165-7, 3 figs in colour.

Colourless faceted topaz with acicular inclusions has been offered as 'rutilated'. Needles identified as dislocation channels stained with limonite. Heat altered the yellowish-brown limonite to dark red hematite and inclusions became more prominent. The dark red colour is regarded as proof of heat treatment. R.K.M.

KARWOWSKI, L., DORDA, J., 1986. The mineral-forming environment of 'Marmaros diamonds'. *Mineralogia Polonica*, **17**, 1, 3-16, 21 figs.

'Marmaros diamonds' are euhedral, transparent and generally colourless quartz crystals found at a number of locations in the Flysch Carpathians, Poland. Thermo-and barometric study of the fluid inclusions contained in the crystals revealed a chloroform content which appears to indicate that the principal components of the mineral-forming fluids were aliphatic hydrocarbons. Other hydrocarbons are found in minor amounts. M.O'D.

KELLY, S.M.B., 1989. Using the spectroscope. A personal assessment of the contribution to gemmology of J.J. Snow, FGAA, FGA. *Australian Gemmologist*, **17**, 4, 118-19.

This edition of the magazine is a memorial to Jack Snow, one of the most active exponents of gemmology in Australia for many years, who died last June. Ms Kelly describes Jack's dedicated tuition when she had problems with this rather difficult instrument. R.K.M.

KOIVULA, J.I., 1989. Geofingerprints. *Lapidary Journal*, **43**, 6, 20-35, 6 figs in colour.

An introduction to the study and classification of inclusions in gemstones, with a list of references. M.O'D.

KELLY, S.M.B., BROWN, G., 1989. Synthetic periclase. *Australian Gemmologist*, **17**, 3, 90-2, 5 figs, some in colour.

Offered as 'natural sapphire', this material had H 5.5 and cubic cleavage, SG 3.57, RI 1.73, single and an included bubble. Identified as the magnesium oxide, periclase, and had been manufactured in Austria. After some months polished surfaces became dulled by hydration which gave a whitish efflorescence, probably brucite. R.K.M.

KOIVULA, J.I., 1989. The hidden beauties of gemstones:-Artistry through the microscope. *Australian Gemmologist*, **17**, 4, 139-42, 10 figs in colour.

Some quite remarkable pictures of gem surfaces and inclusions contributed by one of the greatest specialist photographers of such things as a photo-essay in memory of Jack Snow. R.K.M.

KOIVULA, J.I., FRITSCH, E., 1989. The growth of Brazil-twinned synthetic quartz and the potential for synthetic amethyst twinned on the Brazil law. *Gems & Gemology*, **25**, 3, 159-64, 8 figs in colour.

Natural amethyst is interpenetrantly twinned on what is known as the Brazil law, which is evinced by interrupted spectral rings seen between crossed polarizers, a feature which has been regarded as proof of natural origin. But quartz is being synthesized with this twinned habit and test can no longer be considered reliable. There is no proof that commercial amethyst growers are yet exploiting this, but the quartz is easy to grow and Brazil twinned synthetic amethysts may be expected. R.K.M.

KOIVULA, J.I., KAMMERLING, R.C., 1989. Gemmological properties of emerald from Nova Era, Minas Gerais, Brazil. *South African Gemmologist*, **3**, 4, 20-5, 4 figs in colour.

Emeralds are found in a biotite-phlogopite-mica schist at the Nova Era mine, Minas Gerais, Brazil. Ten faceted stones were tested and showed properties in the established range for emerald. Two-and three-phase inclusions and fine acicular growth tubes parallel to the *c*-axis were observed. M.O'D.

Koivula, J.I., Kammerling, R.C., 1989. A gemmological study of 'Opalite' and 'Opal Essence'. *Australian Gemmologist*, 17, 3, 93-8, 5 figs, some in colour.

Two names for the same 'new' plastic opal which seemed to be identical to earlier plastic imitation opals. A needle pressed lightly onto these 'stones' dented them readily; very warm to touch; hot needle gave acrid smell; the plastic was hydrophobic and a drop of water placed on it formed a hemispheric bead; natural or synthetic opal are hydrophilic and water spreads rapidly across the surface. Low SG 1.15 to 1.25, RI 1.51, H 2.5 and the usual microscopic features should identify. But in a setting these can deceive. R.K.M.

Koivula, J.I., Kammerling, R.C., 1989. An investigation of three imitation opalized shells. *Australian Gemmologist*, 17, 4, 148-52, 10 figs in colour.

It is fitting that these shells should be discussed in the *Australian Gemmologist* for they originated in that country and were undoubtedly made to deceive.

The shells looked entirely wrong with large angular chunks of boulder opal conforming in some strange way to the required outlines of the fossil shapes, not at all like the normal homogeneous opalized shell. Examination showed a mixture of opal, opal breccia, and iron-stone held in a plastic matrix and either moulded or ground to shape. They were too well polished, and had spherical bubbles trapped in the binding material. Hardness, hot needle and water spot tests all confirmed plastic. Spot RIs of about 1.55 were obtained from each of them. Opal portions fluoresced bluish-white under LUV, other parts were inert, some gas bubbles also fluoresced. It seems another chapter has been added to the opal story. [A deception to look out for!] R.K.M.

Koivula, J.I., Kammerling, R.C., 1989. Gem news. *Gems & Gemology*, 25, 3, 177-84, 12 figs in colour.

Diamond

CSO report diamond sales of $2 317 billion, highest ever for a six month period. Diamond cutting seen at Foshan, Guangzhau Province, China, used jam peg dops more normal for coloured stones; no mechanical dops seen and each stone was worked short time only, to avoid cement softening. Argyle officials, Australia, deny recruiting Indian diamond cutters to train cutters in China. Economic viability of a kimberlite intersection is being tested near Prince Albert, Saskatchewan. Australians are exploring possibilities of kimberlite pipes in Wisconsin and Michigan. A De Beers subsidiary is joining Max Resources of New Zealand to explore for diamonds near Darwin, Australia.

Coloured stones

Plumbago Mining have opened an amethyst mine at Sweden, Maine, New England. Same company are reopening the Mt Mica tourmaline mine, also in Maine. Sceptre amethyst is reported from Malawi. The Bolivian amethyst-citrine mine is reported closed but 'poached?' material is still readily available. Fine quality large aquamarines are coming from Madras State, India; blasting and heat damage spoils much of the material; 41 ct specimen examined had graining due to strain but colour was exceptional and not due to heating. A cave in the Namib desert is yielding 'chandeliers' of quartz crystals, one formation was estimated to weigh 13 tons. Rough Santa Terezinha de Goias emeralds, Brazil, are being heated moderately with Opticon, a synthetic sealant; a further report is in preparation.

A large bi-colour yellow and green water-worn sapphire from Anakie, Queensland, is illustrated.

Kanchanaburi, Thailand, sapphires are often heat treated, resultant colour sleepy or a greyish blue rather like similarly treated stones from Sri Lanka; pin points of dark blue 'ink-drops' occur as inclusions; untreated stones have fine dust-like silk (as in Burmese sapphires) or long needles (as in Sri Lankan); boehmite and apatite crystals also included. Undersea searches inspired by Thai Government and UN Development Department are seeking corundum, titanium, zirconium and gold in the Gulf of Thailand; they have already found tin under the Andaman Sea. Paraiba, Brazil, is producing some exceptional colour blue and green tourmalines, mostly under one carat but largest seen was 15.18 ct.

Pearls

A large cultured blister pearl was seen in a fresh-water mussel shell represented the goddess Kwan Yin; insert was probably carved shell or plastic and X-ray did not detect it.

Synthetics and Simulants

'Jadeite' concentric mobile sphere balls seen in a Guangzhou (Canton) factory were mostly bowenite, with a few of low-grade jadeite; workers insisted that all were 'jade', confirming that this word has broader application in Chinese. 'Opalized fossil' shells from Australia were found to be composite made from opal, boulder opal and iron-stone matrix cemented with a plastic, moulded or ground to shape. R.K.M.

Koivula, J.I., Kammerling, R.C., 1989. Examination of a gem spinel crystal from the Pamir

Mountains. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 2/3, 85-8, 3 figs in colour, bibl.

The gem quality pink spinel crystal examined came from the Pamir mountain range in the south of the USSR, almost parallel to the northern border of Pakistan and the Wakhan Corridor belonging to Afghanistan. RI 1.711, SG 3.55. Inclusions are described. E.S.

KORITNING, S., 1989. Achate aus dem Harz. (Agate from the Harz.) *Aufschluss*, **40**, 349-59, 12 figs (10 in colour).

Fine agates are described from the Harz region of West and East Germany. M.O'D.

LARSSON, T., 1989. Adelstenar bland Fältspaterna. (Feldspar gemstones.) *Gem Bulletinen*, 2, [unpaged] 1 fig.

Varieties of the feldspar mineral group with gem or ornamental application are described. M.O'D.

LIEBER, W., 1989. Smithsonit von der Kelly Mine, New Mexico, USA. (Smithsonite from the Kelly Mine, New Mexico, USA.) *Lapis*, **14**, 10, 29-31, 6 figs (4 in colour).

Fine bluish-green smithsonite from the classic source of the Kelly Mine, Socorro County, New Mexico, USA, is described. The mineral is found in the Magdalena Range. M.O'D.

LIEBER, W., 1989. Broken Hill. *Lapis*, **14**, 5, 11-29, 38 figs (26 in colour).

The survey of the mineralization of Broken Hill, New South Wales, Australia, contains details of the occurrence and photographs of transparent crystals of rhodonite which is usually found on galena. M.O'D.

LINTON, T., BROWN, G., 1989. Economic microscopes for gemmologists. *Australian Gemmologist*, **17**, 4, 120-1 and 156-8, 5 figs.

Describes the SZM-1 Stereozoom microscope, A$665; the SZM-2 Stereozoom microscope with phototube; the SM-4G Stereoscopic microscope (Chinese) at A$355; the SMS-10 Stereoscopic microscope at A$150 and the EK-1 Fibre optic cold light illuminator, A$563. Other microscopes are briefly mentioned. Prices are tax-exclusive and in any case would not apply in Britain. R.K.M.

MCCAUGHTRY, G., 1989. An evaluation of the 'Gemdata' gem identification program. READ, P. Comments on the evaluation of 'Gemdata'. Editorial comment. *Australian Gemmologist*, **17**, 3, 107-9.

Assessment based on test reports by one student were used,and 'Gemdata' gave approximately two-thirds correct results, including a number in which a multiple choice of answers was offered. The narrow tolerances of the program plus the use of broad SG ranges provided by flotation methods of testing probably increased the failure rate. Microscopic and spectroscopic tests were not included. Spot RIs were too approximate. Criticism suggests that the program could not be used for examination purposes. [Examinations are to test gemmological interpretation by the student. A computer could hardly do that.]

Peter Read, the originator of 'Gemdata', replies and intends further modifications which may increase its efficiency. Editorial comment makes further suggestions. [One can see weaknesses in the method of assessment as well as in the program itself, and is left wondering whether the computor offers any real improvement over old fashioned brain-power and gemmological 'nous'?] R.K.M.

MCKAY, D.J., O'DONOGHUE, M., 1989. Computerized information services. In: WOOD, D.N., HARDY, J.E., HARVEY, A.P., (EDS), *Information Sources in the Earth Sciences*, 78-133.

Available earth science databases are listed and critically discussed. (Author's abstract) M.O'D.

MITCHELL, R.K., 1989. Some thoughts on snuff-bottles. *Australian Gemmologist*, **17**, 4, 129-31, 1 fig. in colour.

An attempt to list the many materials used to make these collectable Chinese items, and to describe the methods of fashioning. Inspired by a stray question in a 1982 examination paper. (Author's abstract) R.K.M.

MIYAMOTO, M., AKAISHI, M., OHSAWA, T., YAMAOKA, S., FUKUNAGA, O., 1989. Morphology and formation process of diamond from glassy carbon. *Journal of Crystal Growth*, 97, 731-8, 9 figs.

Glassy carbon was used as a starting material for diamond formation with a catalyst metal. The hydrogen present in the starting carbon greatly affects the diamond formation and for this to take place the hydrogen content has to be between 1200 and 2200ppm. Using an iron-rich catalyst a characteristic needle-like diamond was formed. M.O'D.

MÖLLER, R., 1989. Filatelia y gemas. (Philately and gems.) *Gemologia*, **30**, 81/82, 17-20, 10 figs.

Some examples of the use of gemstones on stamps are given. M.O'D.

NASSAU, K., 1989. Amethyst and citrine. *Lapidary Journal*, **43**, 8, 30-4, 5 figs (4 in colour).

The transformation of amethyst into citrine by heat treatment and the conversion of citrine into amethyst by irradiation are discussed. M.O'D.

O'Donoghue, M., 1989. Secondary literature: bibliographies, abstracts and indexes. In: Wood, D.N., Hardy, J.E., Harvey, A.P., (Eds), *Information Sources in the Earth Sciences*, 64-77.

Bibliographies, indexes and abstracts in the earth science field are listed and critically discussed.

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

Pilati, T., Gramaccioli, C.M., Sosso, F., 1988. Identification of gemstones by single-crystal X-ray diffractometer. *La Gemmologia*, **13**, 3/4, 19-25.

Distinction between quartz and scapolite, topaz and danburite and sinhalite and olivine are made by the single-crystal X-ray diffractometer. The technique is applicable both to crystals and to faceted stones. M.O'D.

Platonov, A.N., Taran, M.N., Klyakhin, K., Klyakhin, V.A., 1989. On two colour types of Mn^{3+}-bearing beryls. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 4, 147-54, 5 figs, 1 table, bibl.

Two types of Mn^{3+} coloured natural beryls are investigated. Differences in absorption spectra, thermal stability of colour and behaviour under irradiation are caused by differing crystal field symmetry of the Mn^{3+} ions in the beryl structure. The difference between morganite and pink beryl as caused by Mn^{3+} distortion is discussed. E.S.

Ponahlo, J., 1989. Mikrospektralphotometrie der Edelstein-Kathodolumineszenz. (Microspectrophotometry of gemstone cathodoluminescence.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 2/3, 63-84, 27 figs (17 in colour), 2 tables, bibl.

The author explains the use of microspectrophotometry of cathodoluminescence of gemstones as a method of distinguishing between natural and synthetic stones. The method can be used on luminescing gemstones and ornamental stones. The necessary apparatus is described in detail, as are the CL-spectra of rubies, emeralds, padparadschahs, alexandrites, diamonds and lapis lazuli. The method has a number of advantages: results are easily compared, parcels can be examined as well as single stones, it can be applied to all stones with usable CL bands, although also weakly luminescent material can be tested and differences between natural and synthetic stones can be explored. E.S.

Pough, F.H., 1989. Chrysoprase. *Lapidary Journal*, **43**, 9, 20-4, 1 fig. in colour.

A short account of the mineralogy and properties of the chrysoprase variety of quartz. M.O'D.

Read, P., 1989. A synthetic by any other name. *Australian Gemmologist*, **17**, 4, 153-6, 4 figs, some in colour.

'Synthetic' is a word which carries a stigma when connected with gems and Mr Read discusses the urge among some manufacturers to find ways around its use when describing their products.

In Britain a synthetic is a synthetic and must be so described, but in some other countries the rules are less exacting and there appear to be ways round the problem. Thus Chatham in the US is, after considerable litigation, legally allowed to call his stones 'created emeralds', while the Australian 'Pool emerald', although very similar to the Biron synthetic emerald, is to be described as 'refined natural emerald recrystallized under hydrothermal conditions'.

The Knischka synthetic rubies are advertised as 'Knischka-created-rubies' and are produced by what is called a 'luxury synthetic process', because it takes about a year to produce the stones.

In many cases such semantics are backed by claims that the product in question is practically indistinguishable from the natural stone except by sophisticated methods of analysis; indeed the best examples are often so good that their very purity and superb colour can themselves arouse suspicions of synthesis. In most cases they can in fact be identified as synthetic fairly simply and must, in the UK at least, be sold as such. The other common factor seems to be that once the repugnant term 'synthetic' has been eliminated, the prices tend to rise dramatically.

The writer finally makes the point that these evasions may not be so serious at the point of first sale but that they could become much more problematical when a stone is inherited or sold on through several owners long after the initial transaction was completed. R.K.M.

Robert, D., 1989. Synthèses de l'émeraude. (Syntheses of emerald.) *Revue de Gemmologie*, 100, 4-6, 4 figs in colour.

The paper forms the first part of a series in which emerald syntheses are described. This part deals with some hydrothermal and the Chatam product. Characteristic inclusions are illustrated. M.O'D.

Robert, D., 1989. Synthèses de l'émeraude. 2nd part. *Revue de Gemmologie*, 101, 5-7, 2 figs in colour.

The productions of Lens, Gilson and Lechleitner are reviewed with notes on Soviet and Japanese material. M.O'D.

ROMBOUTS, L., 1987. Geology and evaluation of the Guinean diamond deposits. *Annales de la Société Géologique de Belgique*, **110**, 1, 214-59, 5 maps.

Nineteen Cretaceous kimberlite pipes, classified into three types, with area surfaces from 1100 up to 95 000 m^2, and alluvial diamond deposits are located in Upper Guinea, in the area bounded by Kissidougou, Kerouane and Macenata. The kimberlites, which seem all diamond-bearing, are intruded into the Archaean craton of the Guinea Rise and are closely related to the break-up of Gondwana. About 1700 diamonds, $\leqslant$ 10 ct, were examined for their crystallography and colour. Octahedra, dodecahedra and their twins are best represented, while cubes are very rare. White and yellow colours predominate over brown, grey and green. In the alluvial deposits of the Gbenko-Banankoro area, 93 per cent of the stones are of gem quality. R.V.T.

RUSTIONI, M., BERTONI, S., 1988. BGO, a new material of gemmological interest? *La Gemmologia*, **13**, 3/4, 7-17, 4 figs (2 in colour).

Bismuth germanium oxide is described and its ornamental potential discussed. Grown by heat exchange, Bridgman or pulling techniques it has a hardness of 5, SG 7.12 and RI 2.10. It crystallizes in the cubic system. With a dispersion of 0.050 it might be considered as a possible diamond substitute, were it not for the low hardness. [The abstractor commented on BGO several years ago in *Synthetic Crystals Newsletter* and also observed its high degree of brittleness. M.O'D.

SCHMETZER, K., 1989. Im hydrothermalverfahren hergestellter synthetischer Aquamarin aus der UdSSR. (Hydrothermally-grown synthetic aquamarine from the USSR.) *Goldschmiede und Uhrmacher Zeitung*, 9-89, 139-41, 12 figs in colour.

Aquamarine is now manufactured by the hydrothermal growth process in the USSR. Constants given are SG 2.69, RI 1.583 and 1.575 with DR 0.008. A variety of different types of inclusion is found and some are illustrated. M.O'D.

SCHÜPBACH, T., 1989. Ein interessanter Quarz-Epidotfund aus dem Val Punteglias. (An interesting quartz-epidote find from the Val Punteglias.) *Schweizer Strahler*, **8**, 8, 353-65, 9 figs (7 in colour).

Gem quality crystals of quartz and green epidote have been found in the Val Punteglias, Switzerland. M.O'D.

SCHWARZ, D., 1989. Smaragdabbau in Kolumbien: Neue Aspekte. (Emerald mining in Colombia: new aspects.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 4, 155-60, 1 map, 3 tables, bibl.

Survey of emerald production in Colombia in early 1989. Coscuez could not be visited for security reasons. Yacopi was producing, but mainly light green crystals, well formed and transparent. Penas Blancas is situated in a district controlled by guerillas. Gachala is being cleaned and prepared for working. Production from Chivor varies a lot, both in quality and quantity. Buenavista is at the moment not being worked. Difficulties in export of emeralds and other gem materials is also discussed. E.S.

SERGUNENKOV, B.B., 1989. (Gem scapolite from the Tarakuloma Ridge (the Pamirs).) *Zapiski Vses, Min, Obshch.*, **118**, 4, 84-90. (Russian with English abstract.)

Gem scapolites of lilac and other colours occur in secondary cavities in granite pegmatites cutting marbles in this area. They are dipyres of composition $Me_{18}{=}Me_{37}$. Their lilac colour is related to $Mn^{3+}{}_6$ and electron centres $SO^-{}_3$. IR spectra are presented. The blocky crystals have faces {010}, {110}, {120}, {111}. {011} and {001}, with surface sculpture including hillocks and pits at the outlets of acicular channels oriented along *c*. These channels are hollow or contain dispersed material. Refractive indices and cell dimensions are reported; a scapolite with composition Me_{18} has ε 1.536, ω 1.541, *a* 12.070, *c* 7.583 Å. R.A.H.

SNOW, J.J., 1989. The use of the Figure-O-Scope in gemmology. *Australian Gemmologist*, **17**, 4, 122-6, 9 figs, some in colour.

A reprint from a 1979 issue in which Jack Snow described the simplified conoscope that he designed to facilitate observation of interference figures in birefringent stones. R.K.M.

SNOW, J., BROWN, G., 1989. Inamori stones' rough (some observations and speculations). *Australian Gemmologist*, **17**, 4, 132-5, 9 figs in colour.

A résumé of observations on the synthetic gem products of the Kyocera Corporation, discussing aspects of bubble inclusions and other identifying features. Synthetic corundum, alexandrite and opal are dealt with. Some illustrations seem not to convey what the captions suggest they should. Have a couple of them got mixed? A useful paper! R.K.M.

THEMELIS, T., 1989. Clues to identity. *Lapidary Journal*, **43**, 6, 36-40, 2 figs in colour.

A short note on the use of inclusions as gem testing tools. M.O'D.

THEMELIS, T., 1989. Some inclusions in Umba corundums. *Lapidary Journal*, **43**, 8, 19, 2 figs in colour.

Among inclusions noted in corundum from the Umba region of East Africa are apatite, rutile, boehmite and graphite. M.O'D.

THEMELIS, T., 1989. Longido. *Lapidary Journal*, **43**, 9, 49-50, 3 figs (2 in colour).

The Longido mine is located near the settlement of Mdara in northern Tanzania and is celebrated for ruby crystals in green zoisite. After a lengthy cessation of mining limited operations have recommenced. M.O'D.

WANG, F., GUO, J., 1989. Chicken-blood stone from China. *Gems & Gemology*, **25**, 3, 168-70, 3 figs in colour.

This Chinese Cretaceous or Jurassic rock of volcanic origin is found at Changhua, Zhejiang Province, and at Balinyouqi in Inner Mongolia. The fine-grained dickite-kaolinite and quartz mixture is known as chicken-blood stone, a material prized for carving for many centuries. Once incorrectly called pyrophyllite, it may be white, yellow, green or grey, with patches, clouds or spots of bright to dark red of cinnabar, the redder the higher the value. SG varies 2.6 to 3.0; H 3; RI for background material ('dong') about 1.55-1.56; microgranular; very easy to carve.

R.K.M.

WIERSEMA, B., 1989. Spotlight on Scripps. *Lapidary Journal*, **43**, 5, 20-6, 4 figs (3 in colour).

The newly-opened Scripps Hall of Mineralogy at the San Diego Museum of Natural History is described. M.O'D.

WILSON, A.F., 1989. The use of isotopes in exploration for gemstones. *Australian Gemmologist*, **17**, 4, 142-6.

A detailed account of the use of isotopes of radio-active elements such as uranium, thorium, rubidium and potassium to determine 'age signatures' of host rocks in order to assess gem bearing potentials and save expensive exploration of barren pegmatites.

A totally different approach uses stable, non-radio-active isotopes of oxygen, carbon, hydrogen or sulphur to assess physical conditions of mineral formations, while potassium/argon ageing can also be assessed.

Methods and applications are explained together with some examples. An important and highly technical paper which puts modern prospecting and mining into a new and very intriguing light. R.K.M.

XU, M.Y., JAIN, H., NOTIS, M.R., 1989. Electrical properties of opal. *American Mineralogist*, 74, 821-5, 4 figs.

One natural and two synthetic opals were tested for electrical conductivity with a complex impedance analysis. The conductivity of the synthetic material is lower and its activation enthalpy higher. This may be due to the lower concentration of Na^+ charge carriers. The dielectric constant of the synthetic opal is anisotropic and is dominated by the presence of water. M.O'D.

ZEITNER, J.C., 1989. Thunder Bay. *Lapidary Journal*, **43**, 8, 36-42, 3 figs (2 in colour).

A large deposit of amethyst is found at Thunder Bay, Ontario, Canada, on the northern shore of Lake Superior. The deposit has been worked for amethyst since the early seventeenth century.

M.O'D.

ANON. 1989. Diamond sorting made easy. *Industrial Diamond Review*, **49**, 6, 265-6, 5 figs.

Examination of large quantities of diamonds or jewellery under a loupe or miscroscope is extremely time consuming. A new microscope system (the Sortoscope) is described which is suitable for the examination of polished gem diamonds, precious stones, pearls and finished jewellery, but can also be used for examining uncut gem and industrial diamonds. The acrylic glass slides suitable for examining diamonds have an 84.5° notch on the top side and are slightly recessed on the underside; the diamaonds are scattered on the notch and examined with the aid of stereozoom optics using dark-field optic fibre lighting. To inspect an individual diamond more closely, it can be rolled about its own axis while simultaneously pulling the slide. The position of the diamond is not changed with tweezers but with a fine retouching brush, which is also used to remove dust particles. R.A.H.

ANON. 1989. Debex's diamond recovery plants double for andalusite. *Indiaqua*, **54**, 3, 59-60, 5 figs in colour.

This article, in the form of a press release, describes the use of a dense medium separation plant (DBS) designed by Van Eck and Lurie and manufactured in South Africa by Debex (Pty) for the recovery of industrial andalusite in the Northern Transvaal area of South Africa. Unlike the rare gem quality andalusite, this aluminium silicate is used in high-grade refractories and ceramics. When heated to a sufficiently high temperature it changes to mullite which is in demand for its high melting point, good electrical and thermal insulating properties, low coefficient of expansion and high resistance to mechanical and thermal shock. The mineral is used in refractories for furnaces, oil and gas fire boxes, combustion funnels, spark plugs, enamel and chinaware. P.G.R.

Book reviews

CHAUVET, M., 1989. *Frédéric Cailliaud.* Editions ACL-Crocus. pp.371. Illus. in black-and-white and in colour. F.295.

This book was written by a Nantais, to commemorate the bicentenary of one of Nantes' famous sons: the naturalist and egyptologist Frédéric Cailliaud (1787-1869). The author painstakingly retraces the expeditions of his compatriot in Egypt and the Sudan, covering the period 1815-1822.

Although primarily of interest to the student of egyptology, it will be remembered that M. Cailliaud also held the position of mineralogist to the Khedive, Mehemet Ali, and in this connection chapters 3 and 5 – dealing with Cailliaud's rediscovery of the ancient 'lost' emerald mines of Zabara and Gebel Sikait – are of particular, and historic, interest to the gemmologist. Illustrations are from original prints of the period complemented by present-day photographs and there is a fold-out map of the country.

N.C.

LEVINE, G., VOOKLES, L.L., 1986. *The jeweler's eye.* Hudson River Museum, Yonkers, New York. pp.111. Illus. in black-and-white and in colour. Price on application.

The catalogue illustrates and describes a collection of nineteenth century jewellery in the collection of Nancy and Gilbert Levine. A preliminary essay discusses the social setting of nineteenth century jewellery and is followed by the catalogue itself in which the majority of the pieces are illustrated in colour. The catalogue is followed by an essay on the culture of beauty. This is a well-produced catalogue with good quality photographs and interesting essays. M.O'D.

MACPHERSON, H.G., 1989. *Agates.* Natural History Museum, London, and National Museums of Scotland, Edinburgh. pp.72. Illus. in colour. £5.95.

This is a most welcome short guide to agates with particular reference to specimens found in the British Isles. As might be expected, most of the sites are in Scotland. There is a discussion of the types of rock in which agates are found and of why they are there; this is followed by a description of agate structure and coloration. Most of the book is devoted to descriptions of fine British specimens and there are also notes on cutting and on the use of agate in ornament. It is good to have established sites mentioned – many of the locations quoted by Matthew Heddle in the *Mineralogy of Scotland* have never been identified. M.O'D.

MOREL, B., 1988. *The French crown jewels.* Fonds Mercator, Antwerp. pp.417. Illus. in colour. £60.00.

This sumptuous book gives the history of the French crown jewels from the earliest times to their final incorporation into the collections of the Louvre. It should be noted that the articles used as coronation regalia did not form part of the crown jewels in the same way as in England, and for this reason this particular group of artefacts is treated separately in the first section of the book. The crown jewels proper were the result of the establishment by Francois I of a national collection of jewels and although they have been dispersed more than once many have been recovered. The book in fact covers ten centuries of French history as well as describing the manufacture and history of the pieces themselves. After the opening section describing the artefacts of the coronation ceremonies the book goes on to discuss the collection founded by Francois I on 15 June 1530 and its development. This takes up sixteen chapters and is a chronological account ending with the acquisition by the Louvre of some pieces long dispersed from the collection. Despite the price of the book (by no means excessive for what you get) it is very well worth buying if you have the smallest interest in fine historical jewellery. The illustrations are of high quality and there are useful bibliographies of a topic which has not been covered in detail since the nineteenth century and a lot has happened since then. M.O'D.

STRASSER, A., 1989. *Die Minerale Salzburgs.* (The minerals of Salzburg.) Published by the author: Salzburg. pp.348. Illus. in black-and-white and in colour. Price on application.

Notes on beryl and phenakite deposits can be found in this excellent guide to the minerals of the Salzburg area of Austria which includes a first-class bibliography. M.O'D.

Proceedings of the Gemmological Association of Great Britain and Association Notices

OBITUARIES

John Joseph (Jack) Snow 1923-1989.

We are deeply sorry to report the death of one of Queensland's leading gemmologists on 2 July 1989, after a long and courageous battle with emphysema.

John Joseph (Jack) Snow, FGAA, FGA, was born in Brisbane in 1923, the youngest son of James and Maud Snow. He had little formal education but was apprenticed as an optical mechanic after leaving primary school. For the remainder of his working life he was closely associated with various aspects of the optical industry. He even came into gemmology as a result of his then employment as Queensland Manager for British Optical, who were the distributors for Rayner gemmological instruments.

Jack joined the Queensland Branch of the Australian Gemmological Association in May 1959, according to his application, solely in order to learn something of the gemmological instruments he was selling. By the end of 1960 he had obtained his Fellowship Diploma for the GAA and was starting almost thirty years of devotion to gemmology. Characteristically, he confirmed his knowledge and ability by sitting and passing the Gemmological Association of Great Britain's examination in 1976. His significant and valuable contribution to Australian gemmology was formally acknowledged when he was awarded Honorary Life Membership of the GAA in 1980.

Jack Snow's contribution to gemmology was considerable. At various times over the three decades he occupied most of the elected positions on the Queensland Branch Council; lectured and demonstrated optics, gemmological instruments and practical gem testing to several generations of students and to members of the general public; was on the GAA's Instrument Evaluation Committee; a member of several Federal Executives and was a gemmological researcher of international standing. As a consequence of these many interests he contributed some 45 papers to gemmological publications world-wide as well as writing regularly for the Queensland Branch publication – *Wahroongai News* and for the *Australian Gemmologist.*

The November 1989 issue of the latter journal was published most fittingly as a memorial issue to Jack Snow, and in it Geoff Tombs, GAA Patron, described him as 'One of the quiet achievers' who was known to so many as 'Practical Jack'. There is little doubt that this kindly and clever man will be greatly missed, but the hope is expressed that his example will be echoed in the achievements of future Australian gemmologists.

Grahame Brown, Federal President, GAA
R. Keith Mitchell, Vice President, GAGB

* * *

Mrs Anne Eaton, FGA (D.1984), Lymm, Cheshire, died in June 1989.

Mrs Linda Hennessy, FGA (D.1984), Wahroonga, NSW, Australia, during 1989.

Mr John G. Luder, FGA (D.1969) of Den Haag, The Netherlands, died in November 1989, aged 77. After a long and brave fight with kidney failure, the end came peacefully, and at his request he was buried by the sea near his home. A good man and an excellent gemmologist. He leaves a widow, Elizabeth, and one son.

NEWS OF FELLOWS

On 26 January 1990 Mr Michael O'Donoghue gave a lecture entitled 'Gemstones of Pakistan' to the Russell Society at the University of Loughborough.

MEMBERS' MEETINGS

London

On 19 March 1990 at the Flett Theatre, Geological Museum, Exhibition Road, South Kensington, London SW7, Mr George Bosshart, M.Sc., GG, gave an illustrated lecture entitled 'The coloration of green diamonds'.

Midlands Branch

On 19 January 1990 at the Society of Friends, Dr Johnson House, Colmore Circus, Birmingham, Mr David Callaghan, FGA, gave an illustrated lecture entitled 'The Duchess of Windsor's jewellery'.

On 16 February at the Society of Friends Gwen Kingsley gave a lecture entitled 'History of the Stonbridge Glass Industry'.

North West Branch

On 20 September 1989 at Church House, Hanover Street, Liverpool 1, Val Duke gave a lecture on the gemstone trade in Brazil.

On 18 October 1989 at Church House, David Callaghan, FGA, gave an illustrated lecture entitled 'The Duchess of Windsor's jewels'.

On 15 November at Church House, the Annual General Meeting was held, at which Mr William Franks, FGA, was elected Chairman and Mrs Irene Knight, FGA, re-elected Secretary.

On 17 January 1990 at Church House, a social evening was held, when members brought along interesting gemmological specimens. On 21 February 1990 at Church House, Dr Jeff Harris gave a lecture on colour in diamonds.

On 21 March 1990 at Church House, Mr David Callaghan, FGA, gave an illustrated lecture entitled 'From gem to jewel'.

COUNCIL MEETING

At a meeting of the Council of the Association held on 22 February 1990 at the Royal Automobile Club, Pall Mall, London SW1, the business transacted included the election to membership of the following:

Fellowship

Chiu, Sau K.D., New Territory, Hong Kong. 1989
Civitello, Odile, Outremont, Canada. 1989
Cope, Andrew R.W., Nottingham. 1989
Ellis, Phillipa, Sydney, Australia. 1989
Hawkins, Richard A., Sutton. 1989.
Hitchin, Peter F., Bangkok, Thailand. 1989
Ho Kiam Fong, Steve, Singapore. 1989
Lambley, Jenifer G., Brightwell cum Sotwell. 1981
Lau, Ellen Y.Y., Hong Kong. 1989
MacGregor, Rory, Teresopolis, Brazil. 1989
Nevalainen, Tuula M.L., Helsinki, Finland. 1989
Pette, Jan W., Arnhem, The Netherlands. 1989
Pun, Yuk L.M., New Territory, Hong Kong. 1989
Rieger, Catherine J., Maidstone. 1989

Ordinary Membership

Adams, Suzanne, Sutton.
Ashitaka, Nobuyoshi, Osaka, Japan.
Azizollahoff, Geoffrey, London.
Bauer, La Shawn, Kingman, Kan., USA.
Birrell, Andrew T., London.
Clark, Susan W., London.
Davis, David R., London.
De Silva, Nihal G.J., Mitcham.
Echeverry, Jose F.O., Bedford.
Forge, Claude, Paris, France.
Fujimori, Syohei, Fukuoka-Pref, Japan.
Fujisawa, Takako, Chiba-Pref, Japan.
Galligan, Fiona L., Greenford.
Gilson, Pascale N., Brussels, Belgium.
Hausler, Rebecca, Bangkok, Thailand.
Hills, Margaret A., Tonbridge.
Horiguchi, Yasuhiko, Tokyo, Japan.
Irikura, Hisanobu, Tokyo, Japan.
Ishikawa, Noriko, Tokyo, Japan.
Jain, Neerja, Birmingham.
Jinbo, Kazuko, Tokyo, Japan.
Jupp, Thomas H., London.
Kewell, Geoffrey, Cranbrook.
Kimura, Hiroyuki, Tokyo, Japan.
Lake, Richard J., Grouville, Jersey, CI.
Lim, Heng M., Burong, Singapore.
Madhvani, Marie-Laure, Nairobi, Kenya.
Mason, Alec J., Retford.
Matsumoto, Masako, Osaka, Japan.
Matsumoto, Tamio, Takyo, Japan.
Millot, Valerie, Paris, France.
Moreiras-Blanco, Damaso, Oviedo, Spain.
Munakata, Yoshio, Wakayama-Pref, Japan.
McCarthy, Edward J., Cambridge.
Nilsson, Assar, Varmdo, Sweden.
Oda, Mineko, Tokyo, Japan.
Pattni, Mamta C.P., Nairobi, Kenya.
Peh, Angeline, Glasgow.
Rigby, L. Clare, Doncaster.
Sasako, Miyuki, Kanagawa-Pref, Japan.
Schmidt, Simon P., London.
Shibata, Hirofumi, Osaka, Japan.
Smith, Alan J., Alton.
Soma, Hiroshi, Kanagawa-Pref, Japan.
Suzuki, Hiroshi, Tokyo, Japan.
Takeda, Mari, Tokyo, Japan.
Takeuchi, Kumi, Chiba-Pref, Japan.
Tanigawa, Sonoh, Tokyo, Japan.
Tazima, Kazumi, Tokyo, Japan.
Tsuda, Miwako, Hyogo-Pref, Japan.
Van Opstal, W.B.M., Tilburg, The Netherlands.
Von Redlich, Anna B.A., Monza, Italy.
Watanabe, Naoki, Tokyo, Japan.
Wells, Andrew, Caterham.
Wilson, Nean E., Longniddry.
Wooldridge, James M., Worcester.
Yasuda, Atsuko, Tokyo, Japan.

INTERGEMLAB GROUP

The INTERGEMLAB Group comprises a number of gemmologists representing internationally recognized laboratories. The Group meets twice a year to discuss gemmological problems which directly effect their laboratories. The members of the group as at January 1990 are listed below:

France
J.-P. Poirot, Public Service for the Control of Diamonds, Natural Pearls and Precious Stones, Chamber of Commerce of Paris, Paris.

Great Britain
K. Scarratt, The Gem Testing Laboratory of Great Britain, London.

Italy
M. Superchi, CISGEM, Chamber of Commerce of Milan, Milan.

The Netherlands
P.C. Zwaan, Netherlands Gem Laboratory, Leiden.

Switzerland
C.A. Schiffmann, Gemmological Laboratory Gübelin, Lucerne.

Following the Intergemlab Group meetings in 1986, the Group announces that an Agreement has been reached between its members with regard to the issuing of reports on pearls.

The Agreement is specific both with regard to the wording used in reports and the methods of examination. In all cases, regardless of the type or number of pearls involved, the reports issued by the member laboratories will describe the pearls both in terms of weight and size, and sometimes state the method(s) used for examination, e.g. X-ray, radiography, Laue diffraction and/or optical methods. The units to be used in specific instances both for weight and size descriptions and the form of wording to be used in cases relating to various possible results have been agreed.

The Agreement has been in operation for two years and has been found to work well for each member. The results given in one laboratory are similar in wording to those given in another.

One of the reasons why members felt it was necessary to draw up an agreement of this kind was the increase in inexperienced persons setting up 'X-ray' equipment and declaring themselves 'pearl experts'. A number of inaccurate and/or misleading reports have been issued by such inexperienced persons over the last few years. The Group also felt that the trade and the public should have consistent reporting from each member and most importantly they should be informed of the limitations of each method used for examination.

An area for concern is the reporting on natural pearl necklaces by X-radiography. On rare occasions, using X-radiography alone, it is possible to give a result for every pearl in a natural pearl necklace but in the majority of cases this is not possible. The Group strongly recommend that in the case of natural pearl necklaces, the pearls should be cut from the silk to allow for each pearl to be examined and reported upon. In the vast majority of cases, reports on natural pearl necklaces based upon X-radiography alone may only be considered as 'sample reports'. Amongst those pearls which remain unidentified by this method could be a number of cultured pearls, particularly of the non-nucleated variety (i.e. with organic implant). When the client insists upon a 'sample report' he will find the following statement on reports issued by the Group:

'NB This single examination by X-radiography did not prove the identity of every pearl in the necklace; therefore the 'pearls' must be removed from the silk for every pearl to be determined.'

In the issuing of 'sample reports' each member is operating to specific but unpublished guidelines.

The Group also warns those inexperienced in the examination of pearls that the identification of a large number of natural and non-nucleated cultured pearls cannot be relied upon from radiographs taken only in one direction. The Group also works to specific guidelines for reports on both cultured pearl necklaces and those with a mixture of natural and cultured pearls.

TRADE FAIRS

The **Gem and Mineral Fairs 1990**, organized by the British Lapidary and Mineral Dealers Association, are listed below. Full details may be obtained fromJohn F. Turner, Glenjoy, 19/21 Sun Lane, Wakefield, Yorkshire, telephone 0924 373786.

Bristol and West
Watershed Media Centre, Canons Road, Bristol. 26 and 27 May

Harrogate International
Crown Hotel, Harrogate. 25, 26 and 27 August

London International
Holiday Inn, Swiss Cottage, London. 20 and 21 October

The **3rd World Gems Expo** is to be held from 2 to 5 June 1990 at the Hong Kong Convention and Exhibition Centre, 1 Harbour Road, Wanchai, Hong Kong. Details from co-organizers: Hong Kong Diamond Bourse and Headway Trade Fairs Ltd, 9/F Sing-Ho Finance Building, 168 Gloucester Road, Hong Kong.

The **Bangkok Gems and Jewellery Fair 1990** is to be held from 12 to 16 September in the Exhibitions Halls, Department of Export Promotion, Bangkok. For further information contact the Secretariat Office of the Fair, Exporter Service Division, Department of Export Promotion, 22/77 Rachadapisek Road, Bangkok 10900, Thailand. Telephone 5131909 Ext. 272, 273.

NEW AND UPDATED PRODUCTS FROM THE ASSOCIATION

The Association is proud to announce that it has been appointed sole UK distributor for the **World Map of Gem Deposits** published by the Swiss Gemmological Society and based upon the work of Dr Edward Gübelin and his colleagues.

The Map is said by many to be a gemmological masterpiece and is the culmination of much investigative research. It measures 92 x 128cm and has an information key printed in English, Spanish, German, French, Italian and Portuguese. All maps are discretely overprinted with the Association's Coat of Arms (unless otherwise requested).

Such a publishing achievement is remarkable and will be a constant visual source of vital information, not only for students and persons interested in gemmology and jewellery, but as a 'backdrop' for window displays wherever quality gems and jewellery are exhibited.

The face side identifies deposits world-wide and a colour code is used to highlight the sites of eleven major gems and various ornamental gem materials. The reverse side features 65 full colour illustrations of gems as well as photographs of gem deposits and mining operations.

The whole concept of such a work has been enthusiastically received by the world's leading jewellers and gemmologists, and the following are just two reviews:

'A most useful display document for both customers and staff. The Map can be used as a sales aid for normal business and special promotions, and I have no hesitation in recommending this wonderful pictorial chart to both retail jewellers and gemmologists.' – *Richard Peplow of W.H. Peplow, Worcester, and Chairman of the National Association of Goldsmiths*

'This modern production updates and extends the pioneer work produced by H.J.Schubnel some decades ago. The map is much larger enabling more deposits to be shown in greater detail. The series of fine photographs of gem deposits on the reverse of the Map provides a convenient cross section of the methods of mining, both primative and sophisticated, used around the world. A most useful publication for teaching and for display in jewellers' shops and elsewhere.' – *Alan Jobbins, Editor, the Journal of Gemmology.*

The map can be supplied either folded or flat. Your company's logo, name and address can be overprinted on the Map (minimum order 100 copies) making it an ideal gift for valued clients. The price for the folded map is £13.50 (£14.50 flat) plus postage and packing.

The second annual update of the computer program **GEMDATA**, developed to assist in gemstone appraisal identifications and gemmological studies, has just been released. The new version has been designed mainly in response to user requests and as a result of independent evaluation tests. In addition to small modifications to gem constants, a new section enables crystal specimens to be identified from inputs for crystal system/optical character, colour, transparency and SG, and is supported by a graphics page of typical crystal habits.

In the polished stone section there are now optional inputs for uniaxial/biaxial stones, for 'negative' readings above the range of the standard refractometer, and for extended SG tolerance limits for the hydrostatic weighing of small stones. Crystal system/optical character is now included with the information displayed for each gemstone. When a list of gemstones is requested there is also a scroll stop-continue feature which provides a page-by-page view of the data, and it is now possible to re-run a gem identification using alternative search limits without having to input the test data again.

GEMDATA is compiled in QuickBASIC and can be loaded direct from DOS on any IBM PC-compatible computer having a minimum memory of 128K. GEMDATA is supplied on either a single 5.25 inch double-sided double-density disk or a 3.5 inch disk, and comes complete with operating instructions and gem index. Separate versions of the program are available for use with colour or monochrome monitors. GEMDATA (Update 2) is available from the Gemmological Association, price £90.00 (plus VAT, postage and packing).

To order either of these products please use the coupons on p.126. Payment can be made by the major credit/charge cards. To obtain a catalogue and price list of instruments contact the Gemmological Association of Great Britain, Saint Dunstan's House, Carey Lane, London EC2V 8AB.

THE JOURNAL OF GEMMOLOGY BACK NUMBERS

A member of the Association has for sale a complete set of *The Journal* from 1972 to 1989, as well as back issues of overseas journals. Enquiries to the Association, Box No. 1713.

CORRIGENDA

On the front inside cover, Vol. 22, No. 1, under 'Members elected to Council', C.R. Burch, B.Sc., FGS, R.J.Peace, B.Sc., C.Chem, FRSC, FGA, and E.Stern, FGA, should have been included, and E.M.Bruton, FGA, omitted. The South Yorkshire and District Branch Chairman, G.A.Massie, FGA, should have been omitted also

On p.52 above, second column, Stig E. Sundin, Hylkje, Norway, was omitted from the list of those that qualified in the 1989 Preliminary Examination.

Letters to the Editor

From K. Scarratt
The Gem Testing Laboratory of Great Britain

Dear Sir,

A short paper written by S. Scandella was published in the July 1989 issue of *The Journal* (21, 7, p.411) regarding observations made during the examination of a number of black diamonds. The paper, in its title and content, assumed that the stones in question were of the Type IIb. This assumption had been made, in the main, from two clear facts, (a) that the stones were diamond, and (b) that they conducted electricity.

Whilst realizing the difficulties involved in arriving at a 'Type' for what must have been almost, if not entirely, opaque diamonds, one has to question the wisdom of publishing statements that are based upon insufficient evidence. The paper made no mention of the UV/visible or IR absorption characteristics of the stones, even though it is these very factors which assign a 'Type' to a given diamond.

Shortly before the publication of this paper the Gem Testing Laboratory in London had been examining a similar group of black diamonds which also conducted electricity. However, it was concluded that as graphite (the black appearance of the stones resulted from the inclusion in the diamond of a black material that was possibly graphite) conducted electricity no safe conclusion with regard to the diamonds' Type could be made without more detailed work. Indeed, tests indicated that the stones did not conduct in those areas where the included material did not reach the surface.

In order that we might clearly 'Type' these stones, the Laboratory purchased one example in which there appeared to be a narrow tunnel of inclusion-free diamond running through the stone. So that visible and infrared spectra could be obtained, the stone was laser-cut and polished to take best advantage of the inclusion-free area. The resulting visible and infrared spectra (Figures 1 and 2) determined the stone to be Type IaA.

In concluding we would like to thank Mr C. Welbourne of the Diamond Trading Company

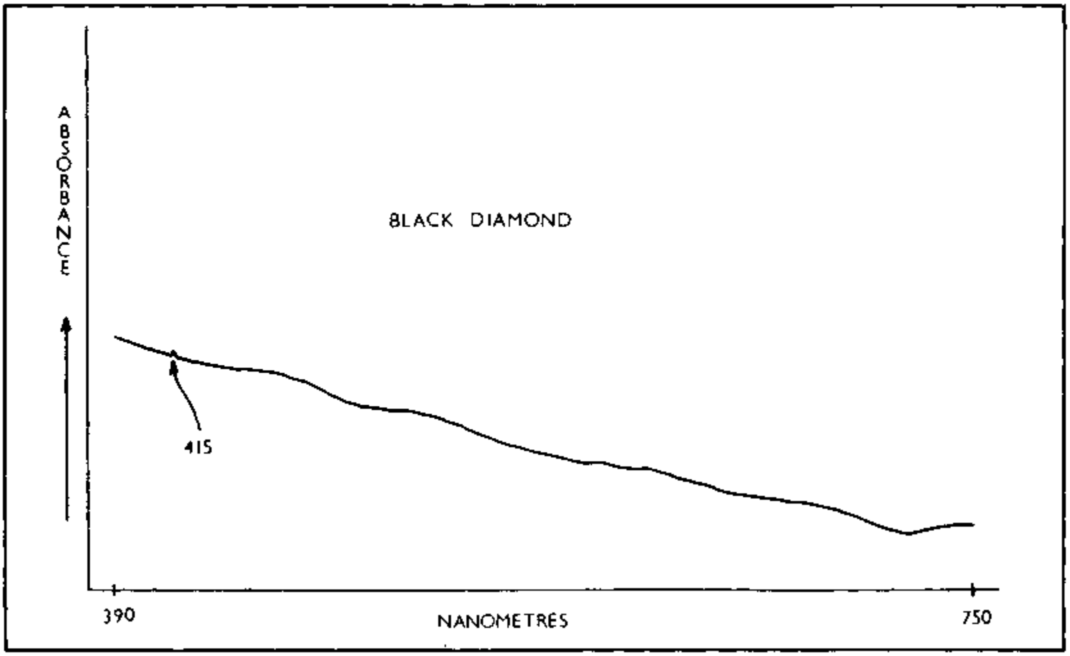

Fig. 1

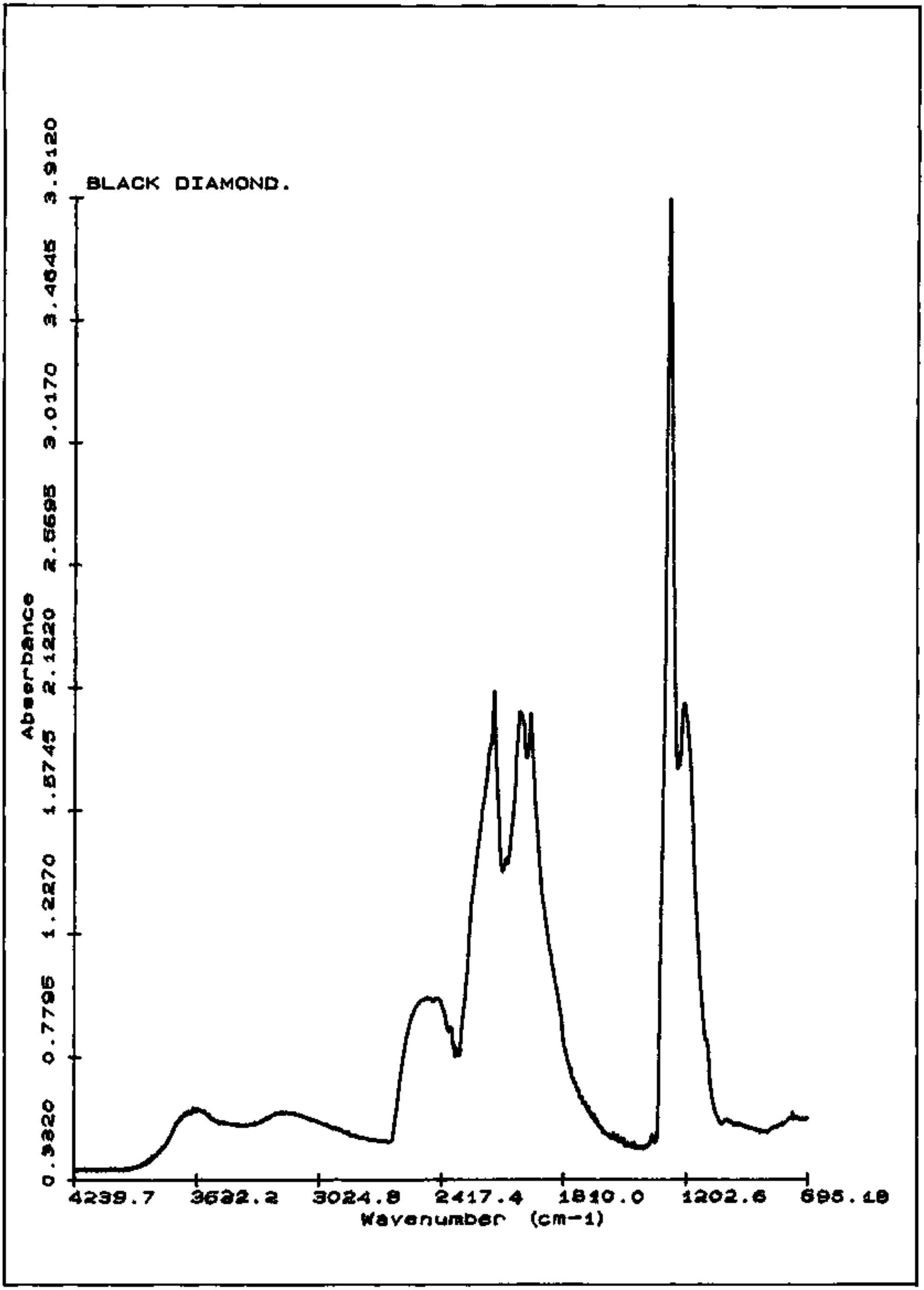
BLACK DIAMOND.
Absorbance
0.3320
0.7795
1.2270
1.8745
2.1220
2.5695
3.0170
3.4645
3.9120
4239.7
3632.2
3024.8
2417.4
1810.0
1202.6
595.18
Wavenumber (cm-1)

Fig. 2

Research Department both for his assistance in arranging for the stone to be laser-cut and polished and for his comments upon the spectra.

Yours etc.,
K. Scarratt

26 February 1990
The Gem Testing Laboratory of Great Britain, 27 Greville Street, London EC1N 8SU.

From S.Scandella and C.A.Schiffmann
Gübelin Gemmological Laboratory

Dear Sir,

Thank you for informing us of the letter of Mr Ken Scarratt referring to the testing of two black diamonds. The remarks of Mr Scarratt are correct in showing the steps to be taken in such an analysis.

On the other hand, we know that gemmology must often be practised under quite limiting circumstances. In this case the diamonds were opaque, there was no permission to slice them and they had to be given back within a short time.

Going back to the semi-conducting behaviour of these diamonds, we don't quite see how a Type I diamond full of graphite (?) would still retain the usual tenacity and hardness of diamond.

We would welcome any further suggestion!

Yours etc.,
S.Scandella and C.A.Schiffmann

6 March 1990
Gübelin Gemmological Laboratory, Denmalstrasse 2, CH-6000 Lucerne 6, Switzerland.

From R. Keith Mitchell FGA

Dear Sir,

In an abstract of mine on p.42 of the January 1990 issue of the *Journal*, the comment '[part of the text is missing so this entry is difficult to understand]' has been printed. That comment was incorrect and my misreading was due to slightly awkward phrasing at the beginning of the next column. I tried to cancel this at the time, but my 'phone call was evidently too late. My apologies to the author for carelessness on my part.

Yours etc.,
R. Keith Mitchell

5 March 1990
Orpington, Kent.

GEMDATA – UPDATE 2

A computer program for gem identification

* Now available in 3.5-inch disk version *

Now available in its second updated version, GEMDATA is compiled in QuickBASIC and will run directly from MS-DOS on any IBM PC-compatible computer. It is designed to help with both appraisal identifications and gemmological studies.

Optional yearly update of GEMDATA will be available.

GEMDATA is supplied on either a 5¼-inch double-sided, double-density disk, or a 3½-inch disk, and contains the following two sections:–

Gem 1. Gem and Crystal Identification from a databank of over 220 gems

Gem 2. Gem Comparisons (side-by-side display of the constants and crystal systems of selected gems), Tables of RI and SG values, Gem Calculations (SG, reflectivity, critical angle, Brewster angle and gem weight/diameter estimation)

The GEMDATA package, complete with disk, operating notes and gem index, costs £90.00 (plus postage and VAT).

To order your package please use the coupon given on p. 126.

Gemmological Association of Great Britain
Saint Dunstan's House, Carey Lane, London EC2V 8AB

GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

The Arms and Crest of the Association, conferred by a grant of Arms made by the Kings of Arms under royal authority. The cross is a variation of that in the Arms of the National Association of Goldsmiths of Great Britain and Ireland. In the middle is a gold jewelled book representing the study of gemmology and the examination work of the Association. Above it is a top plan of a rose-cut diamond inside a ring, suggesting the scrutiny of gems by magnification under a lens. The lozenges represent uncut **octahedra and the gem-set ring indicates the use of gems in ornamentation. The lynx of the crest at the top was credited, in ancient times, with being able to see through opaque substances. He represents the lapidary and the student scrutinizing every aspect of gemmology. In the paws is one of the oldest heraldic emblems, an escarbuncle, to represent a very brilliant jewel, usually a ruby. The radiating arms suggest light diffused by the escarbuncle and their tips are shown as jewels representing the colours of the spectrum.**

Historical Note

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

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

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

Notes for Contributors

The 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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