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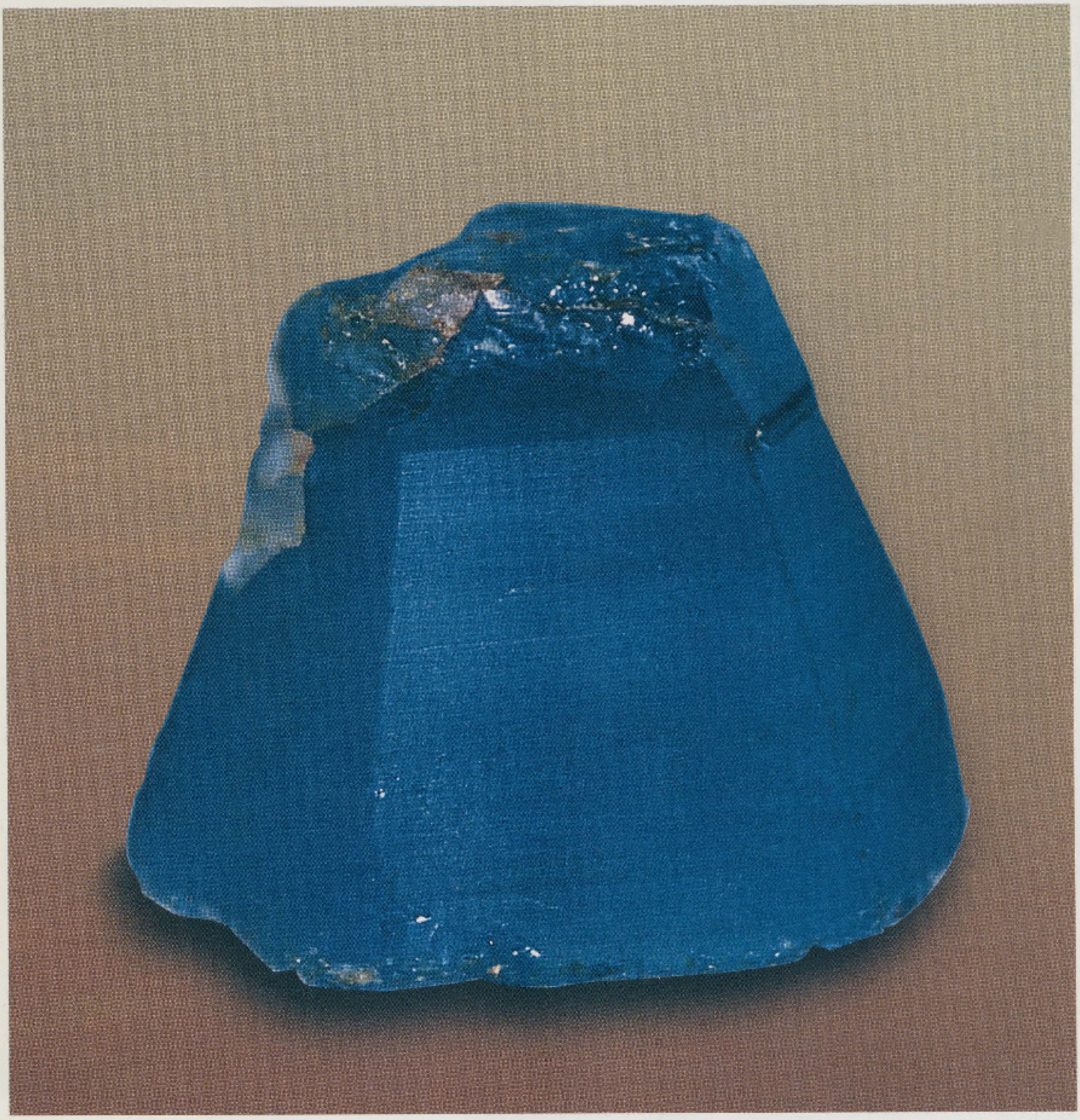

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Cover Picture

Burmese sapphire crystal weighing 502 ct, unearthed in 1994 at Khabine, near Gwebin, in Burma's Mogok Stone Tract. (See Burmese sapphire giants, p. 551)

Photo by U Khin Mg Win

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In this issue...

This issue completes volume 24 of the *Journal* in which 43 original papers from 58 authors in 21 countries have been published. Five hundred abstracts and 99 book reviews have also appeared and together these figures offer a convincing testimony to the expanding activity across the whole spectrum of gemmology. The papers in the *Journal* have ranged from a comprehensive review of gems from Myanmar to origin determination for cut gemstones, and from historical gemmology in Afghanistan, Sri Lanka or the UK to the criteria for distinguishing natural from synthetic diamond.

In this issue Dr Gübelin discusses a synthesis of recent practical study and theoretical ideas of pearl formation, reviewing the current position and indicating a possible sequence of formation not involving a grain of sand! This paper is followed by a comprehensive description of the nephrite jade produced at Chuncheon, Korea, since 1976.

As East Africa continues to yield more gems from different localities, thirteen gem species are recorded here as stars or cat's-eyes. Their properties are listed and the variety of inclusions, including those responsible for optical effects are described. As yet the region has not yielded a corundum crystal large enough to be included in the list of sapphire giants discussed in the Burmese sapphire paper. But with verified occurrences of large corundums in the Transvaal perhaps it is only a matter of time and recognition.

The world of materials science is of growing influence in the gem market and if it is not laser development or space research that is generating new and interesting crystals, it is some other branch of activity such as those concerned with insulators or fibre optics. The latest challenge to the gemmologist's testing skills reportedly comes from the chimney of a kiln used in paint manufacture, and the zincite which condensed on the chimney walls is now on the market in a range of yellow and orange crystals and cut stones. Features are described which should enable its rapid identification.

The final form of each of these papers and indeed of most of the contributions in this volume owes a great deal to the expertise and wisdom of the Associate Editors. With their constructive comments and pertinent advice they have contributed significantly to the value of the papers; it is a privilege to have their support. A brief look at the initials following an abstract or book review will remind readers of the dedicated hard work put in by a wide range of experts, and among those who supply such a readable source of condensed information I would particularly like to record our appreciation of the efforts of Michael O'Donoghue, Evelyne Stern, Peter Read, Professor Bob Howie and Reg Peace.

Papers for the new volume are already in preparation and will include important contributions on rubies, emeralds and collectors' gems. Plans are in hand for further improvements in the design of the *Journal* and we would welcome your comments on these or any other matters gemmological.

R.R.H.

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An attempt to explain the instigation of the formation of the natural pearl

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Abstract

Biological research discloses that the instigation of the formation of a natural pearl is based upon the excrescence of epithelial cells which, while accumulating and slowly forming a pearl bag, secrete substances to create pearl and shell in the same succession. During this process the organic substance *'conchin'* is continuously secreted to wrap the inorganic crystals of calcite and aragonite as a sponge embraces its voids. There is no evidence of a sand grain being the original stimulus of the formation of the natural pearl.

Keywords: Epithelium, nacre, periostracum, protein.

Introduction

The following article is based upon studies carried out in Germany between the two world wars, but not continued later, and first published by F. Haas (1931). The pearl is the most perfect of all jewels nature presents us with. Other than gemstones, which are caused to sparkle and shine only by the artistic styles of cut, the pearl does not require the help of human hands to obtain its fullest beauty. Already in its original form, the pearl is of accomplished splendour. In the same form as it is extracted from the mollusc – noble, promising and enigmatic – it is mounted onto a ring or strung onto a necklace, together with its sisters.

Where the play of water, the rise and fall of the waves, the teasing to and fro of the sunbeams, the roaring of the riverbed and the quiet trickle of sand on the bottom of the sea stir up everlasting motion – there lies the cradle of the pearl – the Aphrodite gift of the water.

Many legends have been spun about the origin of the pearl. The least romantic but most persistent yarn about its formation is that a sand grain is the instigator of the pearl's formation. This is as erroneous as another story nurtured by Christopher Columbus that during his third voyage, when he circumnavigated the island of Trinidad, one morning during low tide, he observed open shells lying among the roots of the mangrove trees. He thought that pearls were dew drops which had fallen off the mangrove leaves into the open shells where they 'crystallized', but of course we know that this idea is fantasy.

The anatomy of the mollusc and the formation of the shell

If one considers how the mollusc develops its shell, it is possible to understand how difficult it would be for a grain of sand to enter between the shell and the mantle. Figure 1 depicts a longitudinal cross section of an adult mollusc. The centre consists of the animal's body and three muscular wings on each side, of which the outer one is the *'mantle'*. The mantle is coated on the inner and outer side by a thin skin of epithelium, which has its origin in the mantle's fold, situated immediately below and inside the lip of the

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shell, whether the latter is tiny or large. From this fold two different types of epithelia wrap as a mono-cell layer all over the inside and outside of the mantle. On the mantle's inner surface is the endoderm, a passive mono-layered skin whose purpose it is to protect the inner side of the mantle. The outer monolayer is the active 'ectoderm', whose task it is to build up the shell. It covers the mantle from the fold to the hinge of the shell and from its cells the shell-forming substances are secreted in three subsequent phases (Figure 2).

The shell is composed of three layers of different substances: the first layer, the periostracum, consists of a dark leathery, protective matter composed of the organic substance conchiolin ($C_{32}H_{48}O_{11}$) whose correct biological term is now 'conchin'. It is a scleroprotein of the keratin type. The second layer of the shell is inorganic and is made up of oriented prismatic columns of crystalline calcium carbonate ($CaCO_3$), usually in the form of calcite. The prisms of this layer are perpendicular to the inner side of the periostracum. The correct name for this layer is the prismatic layer or 'calcite primer'. The third and innermost layer forms the internal surface of the shell. It is normally secreted by the entire length and width of the ectoderm epithelium and it increases during the entire span of the animal's life. This layer also consists of calcium carbonate ($CaCO_3$), but is the orthorhombic form 'aragonite'. The aragonite layer accumulates by crystallization of a large number of flakes and forms the smooth iridescent inside of the shell called 'nacre' or 'mother of pearl'. The principal axis of these flakes or platy crystals is orientated parallel to the *c*-axis of the calcite prisms, or in other words at right angles to the inner shell surface. Being the third and innermost part of the shell the nacre lies in direct contact with the secreting monocell ectoderm (Hänni, 1982).

During growth of the mollusc and its shell from its tiniest shape as a spat and from its hinge towards its rim, the youngest epithelial cells at the tip of the mantle secrete the periostracum (forming the outside of the shell), while the oldest are responsible for forming the aragonite (nacre) which lines the inside of the shell. In other words, the product of the epithelium changes with the latter's age from conchin via calcite to aragonite. This has been vaguely known for a long time, but only recently has it been precisely defined and explained by Gutmannsbauer (1992).

The switch from the prismatic calcite layer to the tabular aragonite nacre was investigated and explained by Fritz *et al.* (1994), in their description of biofabrication of highly organic composite flat pearls on synthetic materials, which they had inserted into abalone molluscs. Nevertheless, they did not gain knowledge of the nature of this process. They postulate a dynamic relationship at the cell-mineral interface in which cell recognition of the inorganic surface governs the genetic reversal controlling the structure of the new mineral (aragonite). This results first in the precipitation of a prismatic calcite layer succeeded by the tabular aragonite crystals.

Along its rim the shell is directly connected to the ectoderm – not only during the continued growth of the shell, but as long as the mollusc is alive. Consequently, the boundary between the ectoderm and the nacre has no gaps, and no passive substance, such as a sand grain, withered plant matter or dead animals can penetrate this region (Gübelin, 1987) unless forced by some external agency. It is possible that certain adhesive barnacles might drill a hole through the shell and thus irritate the ectoderm, which would react by secreting the three shell substances in the aforementioned sequence. In most cases the mollusc would be killed by the barnacle. However, an irritation caused by a barnacle is relatively rare and does not normally result in the formation of a baroque or spherical pearl, but rather in the attached so-called 'blister pearl'. The possible devastating

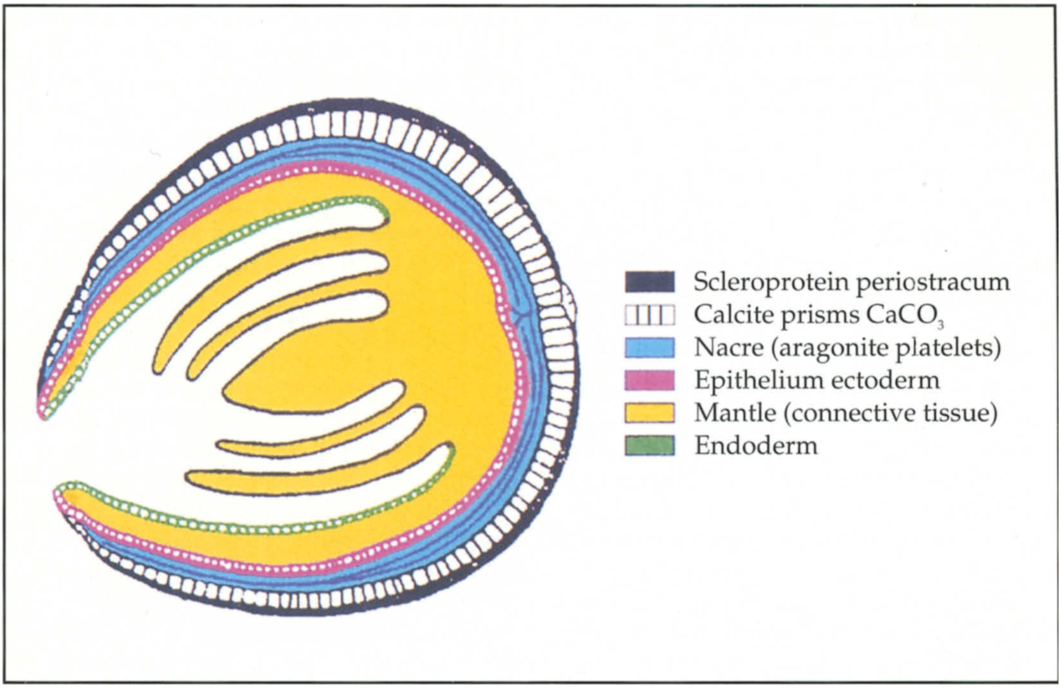

Fig. 1. A longitudinal cross section of an adult mollusc.

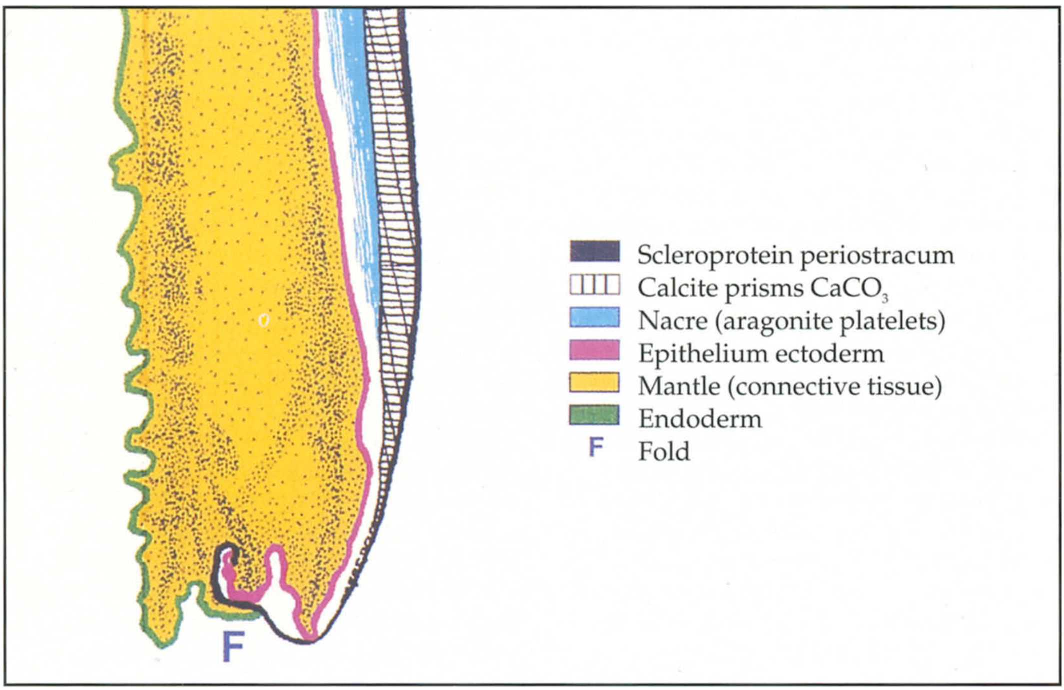

Fig. 2. Detail of the growth pattern of cells from the mantle fold.

action of barnacles however is well known to the cultivators of cultured pearls and is the reason why the molluscs used for cultivating pearls must be cleaned regularly while suspended in wire baskets from the rafts. The risk of obtaining a baroque, blister or freak pearl is the reason why the nucleus is implanted into a gonad of the Akoya bivalve by the cultivators instead of inserting it between the ectoderm and the shell.

In the pearl as well as in the shell, the inorganic elements (i.e. the calcite prisms as well as the aragonite platelets) are 'cemented' together by very thin films of conchin which forms a kind of mortar (Gutmannsbauer *et al.*, 1994). They call the conchin 'periostracum' (while the author of the present article limits this term to the conchin covering the outermost surface of the shell), whereas to the conchin 'scaffoldings', mortaring the inorganic carbonate crystals together, they give the name 'matrix'. The author of the present article likes to compare the conchin wrapping the carbonate crystals to a sponge, in the voids of which the calcite prisms and the aragonite platelets are embedded.

The effect of this sponge-like scleroprotein is to prevent the aragonite from lining the inner side of the shell as one large sheet-like crystal of aragonite, but rather to limit its size to innumerable tiny platelets.

The instigation of the formation of the natural pearl

All previous opinions published seem to agree about the stimulation of the natural pearl as a consequence of an intruded sand grain which somehow had penetrated the region between the shell and the shell-building ectoderm. The possibility of passive transfer of pieces of epithelium, or of the so-called 'yellow particles' (hardened grains of conchin) into the connective tissue of the mantle as growth nuclei for pearls has also been discussed.

Biological studies have revealed another possible cause of exciting epithelial cells; this is in the form of an excrescence, a kind of epithelial tumour resulting either from some injury or arising from a natural stimulus (benign tumour). The repeated permanent development of such benign tumours within the epithelium seems to be a genetic heritage of some species of marine molluscs and freshwater mussels.

Biologists still do not seem to know the precise cause whereby the ectoderm cells form monolayered tumours at certain places, although the molecular mechanisms of the process are known in principle. Very recent research has revealed that certain proteins bonding guanylnucleotides – called G-proteins – play a central role as converters, multipliers and messengers of signals. Disturbances of the normal functions of G-proteins are directly connected with diseases such as cholera and some forms of cancer (Brunner, 1994). The excrescences of the ectoderm cells can therefore be interpreted as a kind of benign cancer, and it may be feasible that ectoderm cells receive signals from G-proteins to excresce. Also nobody seems to have asked the question why these benign tumours expand as monolayers instead of accumulating clusters of cells. Modern laboratory experiments with tissue cultivation may yield the answer.

According to observations on the mechanisms of formation of the monolayered tumour, the substratum – i.e. the connective mantle tissue, upon which the ectoderm as well as the tumour cells spread – is essential in that it exerts an attractive, positively chemotactic stimulus upon the epithelial cells. This was perceived in the course of cultivation experiments.The two different tissues (mantle and epithelium) seem to act as competitors and force their own cells as well as the cells of the other tissue to differentiate in a manner characteristic of each tissue. Mono-cultivation causes proliferation, while mixed cultivation leads to a differentiation of the cells. Differentiation is exactly what happens between the epithelium and the mantle tissue. The epithelial cells do not, therefore, form clumps, but on account of the competition from the mantle tissue, the epithelial cells can only multiply as a one-layered skin. The presence of the underlying tissue, mostly of mesodermal origin – as in our case the mantle tissue – exerts such an attractive positively chemotactic and stimulating influence upon the epithelial cells that these cannot help arranging themselves and settle with their bases upon the mantle tissue as a monolayered skin. Consequently, in view of the regularly flat, tabular shape of the individual ectoderm cells, the evenly arranged one-layered epithelium must spread on and over the outer surface of the mantle tissue.

The encystation of the natural pearl

Hence, while proliferating rampantly, the epithelial cells cannot form random accumulations of irregularly stacked cells, but are forced by nature to align themselves side by side to expand as a monocell layer over its substratum. The epithelial cells, however, cannot spread towards the hard shell, but must do so in the direction of the soft mantle tissue (see Figure 3a). As a result of continuous multiplication of the excrescent cells the original depression deepens into the connective tissue of the soft mantle, slowly forming a kind of bag – the so-called 'pearl bag', (see Figure 3b). Following nature's tendency to favour shapes with the largest volume but smallest surface – and simultaneously assisted by the accrescent pearl, the pearl bag, under ideal conditions, assumes the shape of a sphere which in biological terms is called a 'blastula' (see Figure 3c). The pearl itself consists of exactly the same substances as the shell and forms also in precisely the same sequence: first, conchin is secreted in a smaller or larger quantity by the excrescent ectoderm cells. This 'embryo' of a natural pearl is usually

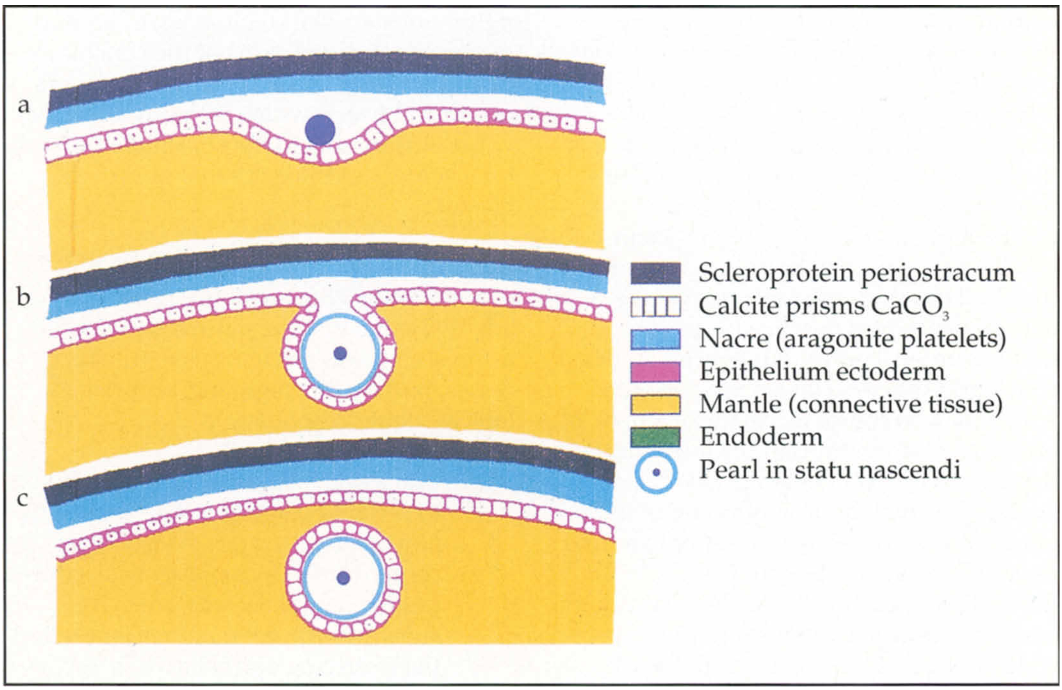

Fig. 3. The encystation of the natural pearl.

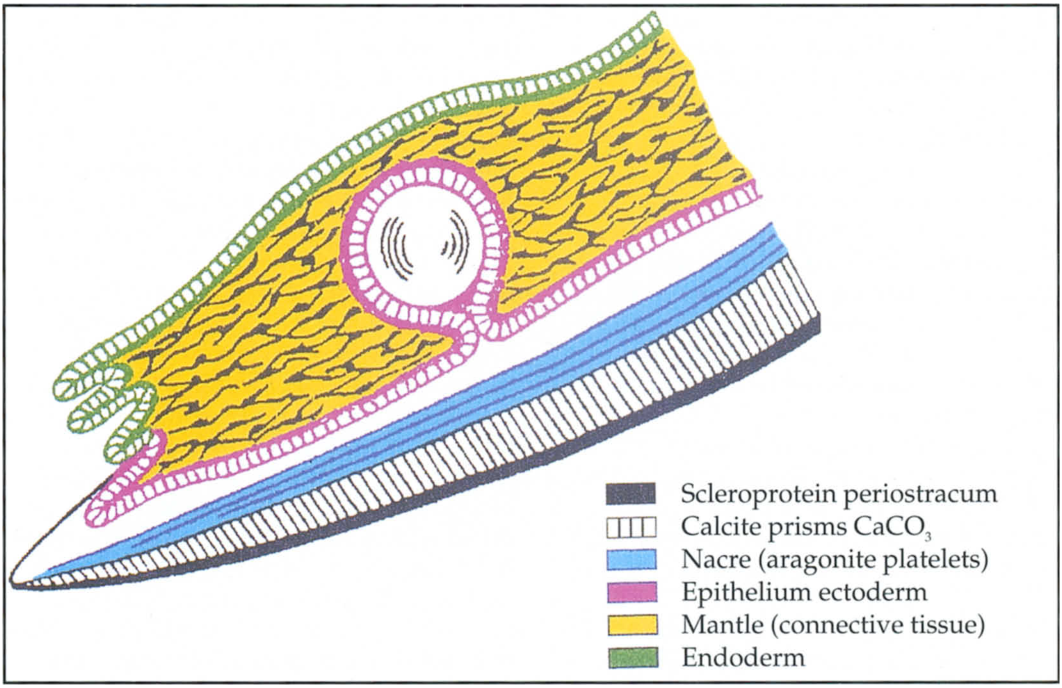

Fig. 4. The ideal result of the instigation of the natural pearl is a spherical product consisting of the three shell substances conchin, calcite primer and aragonite nacre.

extremely tiny and commonly not even visible by X-rays. Pearls containing a relatively large centre of conchin are called 'blue pearls' in the trade, and in X-ray shadowgraphs their centre appears darker than the surrounding body of the natural pearl. This 'core' is then overgrown by layers of prismatic calcite, which themselves are covered by layers of aragonite (nacre). However, the formation of the natural pearl does not take place as an uninterrupted, continuous process in that concentric spherical layers are deposited which may be compared to the layers of an onion, but rather through the intermittent deposits in the form of small calottes or skull caps which quite commonly overlap one another. This seems to testify to a regional activity of the ectoderm cells depending upon their age. The results may easily be observed when examining the walls of the drillhole of a natural pearl. These walls reveal an irregular, successive pattern of step-like semicircles, enhanced by the interlayered skins of the conchin. Yet, sometimes there are aragonite layers on natural pearls which may envelope the entire surface due to the simultaneous and total activity of the epithelial cells of the blastula.

Summary

In summarizing, we may now acknowledge that the natural pearl is the astonishing result of various natural processes, partly still enigmatic, occurring in logical sequences:

(a) first a secret signal seems to be given to certain ectoderm cells – maybe by G-proteins – to start excrescence;
(b) on account of a chemotactical, competitive correlation between the substratum – the mantle tissue – and the overlying epithelial cells, the latter do not form clumps but

expand as a monolayer, first forming an indentation in the mantle and later deepening and widening into a pearl bag;

(c) while multiplying, the epithelial cells secrete shell substances in exactly the same sequence in the pearl as in the shell, and in both, the inorganic components (calcite prisms and aragonite platelets) are wrapped by ultra-thin films of the scleroprotein conchin.

The author has based this article partly on actual experimentations and partly on theoretical reflections. Yet, until it is possible to film the actual process of pearl formation, we must depend upon this combination of practical experience and hypothesis to advance our understanding of one of the mysteries of nature.

References

Brunner, J., 1994. G-Proteine: Zelluläre Umwandler, Verstärker und Übermittler von Signalen. *NZZ*, Nr. 286, p. 45

Fritz, M., 1994. Flat pearls from biofabrication of organized composites on inorganic substrates. *Nature*, 371(6492), 49-51

Gübelin, E., 1987. Origin of natural pearls. *Lapidary Journal*, 1987, 4

Gutmannsbauer, W., 1992. *Morphologische, strukturelle und chemische Untersuchungen an Perlmutter und Perlen einiger perlenbildender Muscheln*. Diplomarbeit, Mineralogisch-Petrographisches Institut der Universität Basel

Gutmannsbauer, W., and Hänni, H.A., 1994. Structural and chemical investigation on shells and pearls of nacre forming salt-and fresh-water bivalve molluscs. *Journal of Gemmology*, 1994, **24**, 4

Haas, F., 1931. *Bau und Bildung der Perlen, Akadem.* Verlagsgesellschaft mbH, Leipzig

Hänni, H.A., 1982. Perlendiagnose mit Laue-Aufnahmen. *Zeitschrift der Deutschen Gemmologischen Gesellschaft.*, **3**, 131-42

Rutland, E.H., 1971. The constituents of the pearl. *Journal of Gemmology*, **12**, 6

Nephrite from Chuncheon, Korea

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Abstract

Nephrite from Chuncheon, Korea, and traded under the name 'Chuncheon Ok' (meaning Chuncheon jade) or 'Baek Ok' (meaning white jade) has been produced since 1976. The high-quality nephrite is monomineralic consisting almost entirely of tremolite, whereas the poor-quality nephrite is polymineralic, containing small amounts of diopside, calcite and chlorite. Gemmological properties and electron microprobe analyses of the nephrite are given.

Keywords: Nephrite, Chuncheon jade, Korea jade, nephrite jade, Baek Ok

Introduction

Nephrite jade has been produced since 1976 from the Chuncheon area, north east of Seoul, in the Province of Kangwondo, which is in the central part of the Korean peninsula (in some atlases the name is spelt Ch'unch'on). Annual production of the nephrite mine (the Daeil Mine) is reported to be approximately 80 000–90 000kg. The nephrite has been fashioned mainly as rings, beads, bracelets, tabs, cabochons, brooches, drop earrings and carvings (Figure 1).

Fig. 1. Fashioned nephrite jade from Chuncheon, Korea. Bracelets, a string of prayer beads (top), curved ornaments for crowns, rings, and buttons (bottom).

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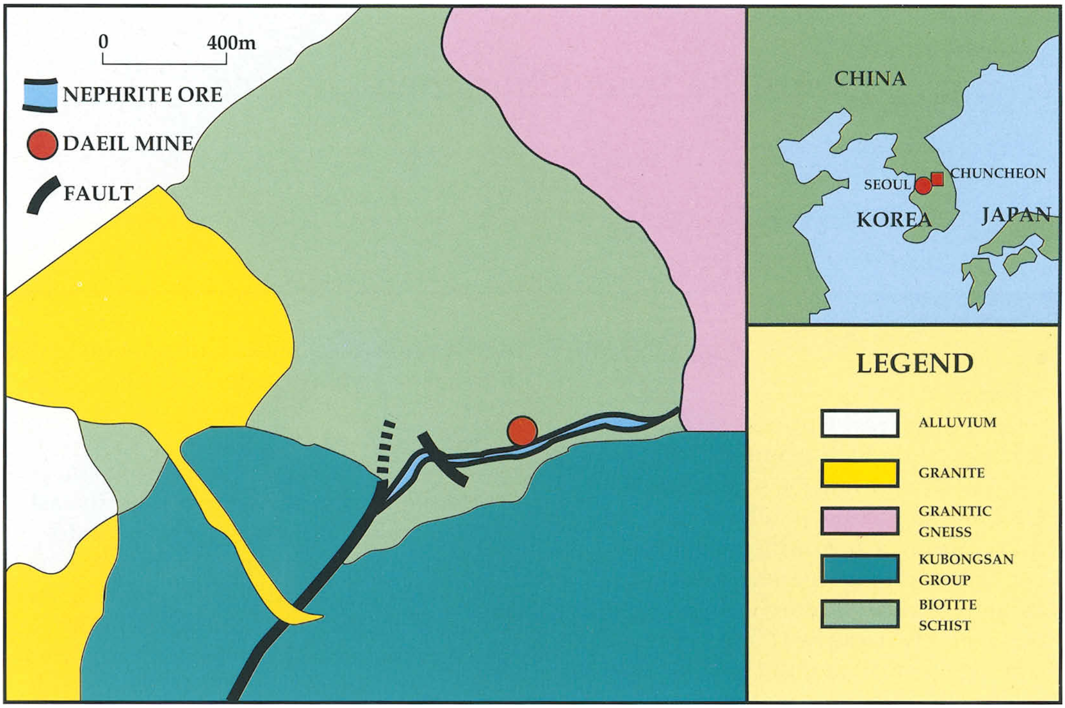

Fig. 2. Geological map of nephrite mine area, Chuncheon, Korea.

Occurrences

The geology of the nephrite mine area consists largely of Precambrian biotite schist (Youngduri Complex), amphibolite, limestone and quartzite (Kubongsan Group), granitic gneiss of unknown age and Jurassic granite (Figure 2). Nephrite has developed along the contact between the dolomitic marble lens and the enclosing biotite schist (Figure 3), and attains a maximum thickness of 3m with a confirmed extension of 1km at the surface. Investigations using polarizing microscopy, X-ray diffraction and electron microprobe analysis are reported also by Kim *et al.*, 1986; Noh *et al.*, 1993; see also Park *et al.*, 1974.

Gemmological properties

Colour, diaphaneity and lustre

The Chuncheon nephrite varies in colour from greenish-white and pale yellowish-green to pale green. It is rarely deep green. Colour distribution is quite uniform and the material is translucent. It shows a resinous or waxy lustre. Very recently, nephrite dyed green has appeared on the market.

Mineral composition of nephrite

Under a polarizing microscope, the pure (high-quality) nephrite is found to consist essentially of tremolite in the form of aggregates of minute fibres (Figure 4).

Tremolite aggregates are sometimes bounded by rounded or rhombic outlines, most clearly seen in plane polarized light, indicating that tremolite was formed by alteration of pre-existing diopside and calcite (Figure 5). However, impure (low-quality) nephrite is polymineralic, containing small amounts of calcite, diopside and chlorite in the nephrite matrix. All the mineral constituents described above were identified by X-ray diffraction analysis as well as from thin section observations. Depending upon the

Fig. 3.
Mine workers remove nephrite ore at the Daeil Mine, Chuncheon, Korea. The nephrite ore develops along the contact between the dolomite marble bed and the enclosing biotite schist.

amounts of accessory minerals present in the nephrite matrix, refractive indices, specific gravity and hardness may vary slightly.

It should be emphasized that the so-called 'Korean jade', referring to serpentine material, should not be confused with the Chuncheon jade.

Refractive indices

Owing to the aggregated nature of the microscopically small tremolite crystals, only a single reading of about 1.62 can be obtained on a standard gemmological refractometer.

Hardness and toughness

The hardness is measured at 6-6½ on Mohs' scale. Due to the felted nature of the crystal aggregates, it is extremely tough.

Specific gravity

The specific gravity determined by the hydrostatic weighing technique ranges from 2.96 to 3.01.

Absorption spectrum

No distinctive absorption spectrum is displayed by the natural nephrite. However, some nephrite dyed green shows a marked absorption band at 630 - 650nm.

Ultraviolet luminescence

The nephrite shows no luminescence under ultraviolet light.

Chemical composition

The general chemical formula $Ca_2(Mg,Fe)_5(Si_4O_{11})_2(OH)_2$ is assigned to the tremolite- actinolite solid solution series. Electron microprobe analyses of four nephrite specimens (Table I) each with slightly different colours show that all lie in the tremolite composition range. It is generally believed that a deepening of the green colour in nephrite is attributable to an increase in the amount of ferrous iron present. Although the Fe/Mg ratio for each analysis, 0.0178(1), 0.0167(2), 0.0196(3) and 0.0221(4), appears to be consistent with this assumption, it should be remembered that the iron contents shown in Table I are values calculated on the

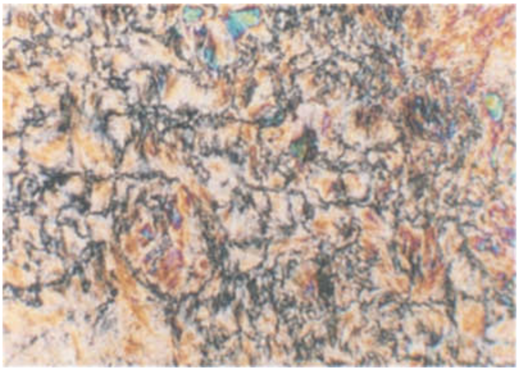

Fig. 4. Thin section photomicrograph of Chuncheon nephrite, Korea. It is made up of fibrous aggregates of tremolite. Crossed polars. x20.

Fig. 5. The same Chuncheon nephrite as Fig. 4, but taken under plane polarized light. Crystal shapes of pre-existing diopside, now replaced by tremolite, are visible. x20.

Table I. Electron microprobe analyses of nephrite from Chuncheon, Korea.

Wt % oxide	*1*	*2*	*3*	*4*
SiO_2	57.62	57.54	57.76	56.98
MgO	24.11	23.26	24.38	23.06
CaO	13.10	13.42	13.34	13.29
Al_2O_3	0.54	0.61	0.68	0.59
FeO	0.43	0.39	0.48	0.51
MnO	0.08	0.12	0.08	0.10
Na_2O	0.03	0.07	0.09	0.06
K_2O	0.03	0.05	0.01	0.03
TiO_2	0.01	0.02	0.03	0.01
Total	95.95	95.48	96.85	94.63

1. greenish-white
2. pale yellowish-green
3. pale green
4. pale green

assumption that all the iron present in the mineral exists in the ferrous state. This may not be so and the iron values reported in the Table may also represent some iron in the ferric state.

Acknowledgements

I thank the Daeil Mine for allowing access to the mine. Thanks are also due to S.E. Lee, Y.W. Lee, J.Y. Lee and K.H. Kim, who assisted the author during field work. I am indebted to an anonymous referee for providing useful comments that improved the manuscript. Financial support was given by the Center for Mineral Resources Research and the Basic Science Research Institute Program (BSRI 95-5418), Ministry of Education of Korea.

References

Kim, S.J., Lee, D.J. and Chang, S.W., 1986. A mineralogical and gemmological characterization of the Korea jade from Chuncheon, Korea. *Journal of Geological Society of Korea*, **22**, 3, 278-88

Noh, J.W., Yu, J.Y. and Choi, J.B., 1993. Genesis of nephrite and associated calc-silicate minerals in the Chuncheon area. *Journal of Geological Society of Korea*, **29**, 3, 199-224

Park, H.I., Chang, K.H., Ji, J.M. and Ko, I.S., 1974. *The geological map of Naepyeong sheet*. Geological Survey of Korea

Burmese sapphire giants

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Abstract

The Mogok area of Myanmar (Burma) has long been noted for producing some of the world's finest blue sapphires. Burmese sapphire mining is reviewed, along with some of the most important blue sapphires from Burma, particularly those of large size. Mention is also made of some giant corundum crystals from other localities. The article contains sections based upon eyewitness accounts and discussions with some of Mogok's long-time gem dealers.

Keywords: Burma, Myanmar, Mogok, sapphire, large gems, corundum, precious stones

Introduction to Burmese sapphires

Although it is rubies for which Burma is famous, some of the world's finest blue sapphires are also mined in the Mogok area. Today the world gem trade recognizes the quality of Burmese sapphires, but this was not always the case. Edwin Streeter (1892) described Burmese sapphires as being overly dark. Unfortunately this error was later repeated by Max Bauer and others. G. Herbert Smith wrote:

> While the Burma ruby is famed throughout the world as the finest of its kind the Burma sapphire has been ignominiously, but unjustly, dismissed as of poor quality. In actual fact nowhere in the world are such superb sapphires produced as in Burma.
>
> G.F. Herbert Smith, *Gemstones*, 1972

While this statement must be qualified by adding that the finest Kashmir sapphires are in a class by themselves, those from Burma are also magnificent. J. Coggin Brown (1955) said:

> It has been stated that Burmese sapphires as a whole are usually too dark for general approval, but this is quite incorrect; next to the Kashmir sapphires they are unsurpassed. Speaking generally, Ceylon sapphires are too light and Siamese sapphires too dark, and it is more than probable that many of the best 'Ceylon' stones first saw the light of day from the mountainsides of the Mogok Stone Tract.
>
> J. Coggin Brown and A.K. Dey, *India's mineral wealth*, 1955

Not all Burma sapphires are deep in colour. The best display a rich, intense, slightly violetish blue, but some are quite light, similar to those from Sri Lanka. The key difference between Burma and Sri Lankan sapphires is saturation, with those from Burma possessing much more colour in the stone. Colour banding, so prominent in Ceylon stones, may be entirely absent in Burma sapphires.

Burmese sapphires

Although rubies are found with much greater frequency at Mogok (rubies form about 80-90 per cent of the total output), sapphires may reach larger sizes. Cut gems of over 100 carats are not unknown. Large fine star sapphires are also found at Mogok, in addition to star rubies. Near

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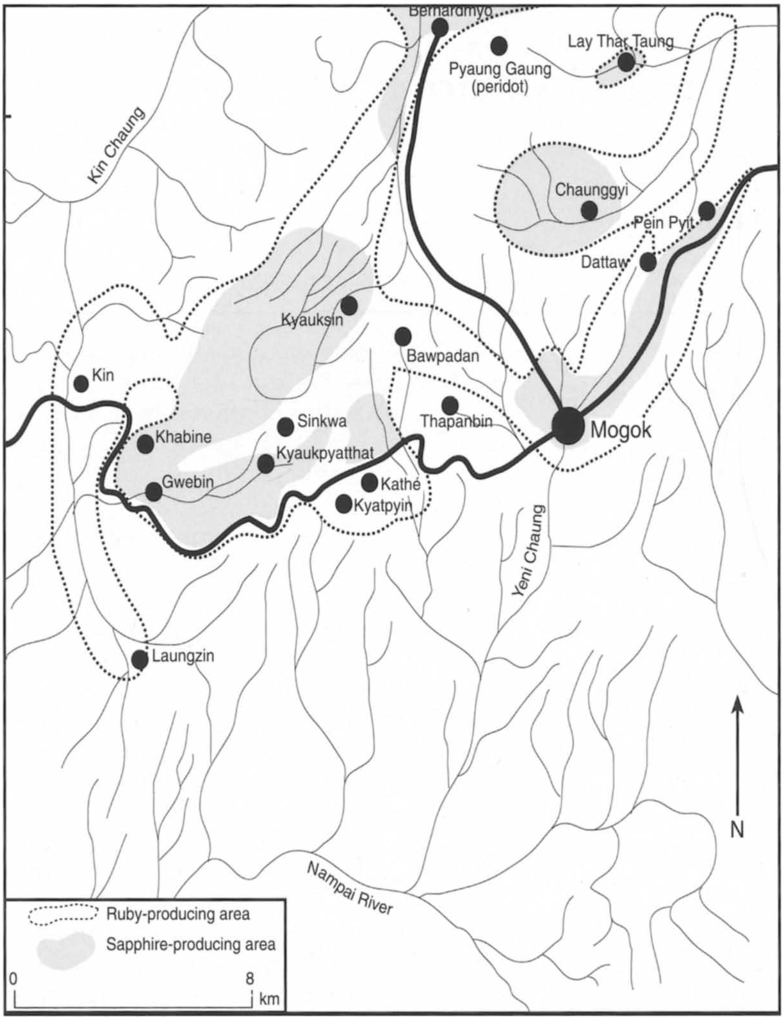

Fig. 1.
Map of the sapphire-producing regions of Burma's Mogok Stone Tract. (Modified from Halford-Watkins, 1935b).

Kabaing (Khabine), at Kin, is located a mine famous for star sapphires (see Figure 1).

The sapphires of Burma occur in intimate association with rubies in virtually all alluvial deposits throughout the Mogok area, but are found in quantity at only a few localities, particularly 8 miles (13 km) west of Mogok, near Kathé (Kathe). At Kyaungdwin, near Kathé, in 1926 a small pocket was discovered that yielded 'many thousand of pounds' [sterling] worth of magnificent sapphires within a few weeks' (Halford-Watkins, 1935b).

According to Halford-Watkins (1935b), the majority of fine sapphires were derived from the area between Ingaung and Gwebin. Sapphires have also been found near Bernardmyo.[1] According to Halford-Watkins (1935b):

> Bernardmyo itself at one time produced large quantities of sapphires, many of which

1. The plateau of Bernardmyo was chosen by the first British expedition to Mogok as a suitable place for a sanatorium for British troops. It was thought that the climate was more suitable for Europeans and that eventually the place would develop into the Simla of Burma. Bernardmyo was Christened after the first British Chief Commissioner of Upper Burma, Sir Charles Bernard (G.S. Streeter, 1887, 1889).

An interview with U Thu Daw

Longtime Mogok gem dealer, U Thu Daw, a contemporary of A.C.D. Pain (of *painite* fame), was interviewed by one of the authors (U Hla Win). The following are some of his edited comments on Burmese sapphires:

H Hla Win: 'Were there any big sapphires found in the pre- World War II days?'

U Thu Daw: 'Yes, including some famous stones. U Kyauk Lon from Gwebin village found one and sold it to Albert Ramsay for one lakh of kyats (US$13,000). [Ramsay later named the 958ct giant the *Gem of the Jungle*.]'

UHW: 'Isn't he the one who was famous for star sapphires?'

UTD: 'Yes. U Shwe Hlaing of Zegyi found one which weighed over 100ct after cutting. I saw it with my own eyes and it was quite beautiful.'

UHW: 'How much did it sell for?'

UTD: 'U Shwe Hlaing did not sell it in Mogok. After attempting to sell the gem in England, it was eventually sold to U Shwe Kin, owner of Rangoon's Kwan Louk Hotel, for under one lakh kyats. U Shwe Kin reportedly later sold it in Hong Kong.'

UHW: 'Any other sapphires?'

UTD: 'Of course. U Kan from Ze Haung (Old Market) had one which weighed 1450ct. U Shwe Kin also bought this one, for 70,000 kyats. But this time he wasn't so lucky. I think he cut it on a Saturday, U Shwe Kin's brother took it to Hong Kong. He was killed in a train wreck there and the stone lost. It was a fine sapphire and might have fetched 10,000 kyats.'

UHW: 'Were there any famous sapphires in the post-war period?'

UTD: I did not notice much. The famous sapphire mines are Loke Khat (Kaday-kadar), Chaunggyi (north of Mogok) and Lay Thar Taung. At Lay Thar Taung, the brothers, U Thein and U Ba Thaw, made a successful sapphire mine. There were so many sapphires mined that they had to be moved by horses. Those brothers were so kind-hearted that those who came to buy sapphires were sold bucketfuls. Many got rich because of those brothers.'

UHW: 'Were the sapphires of good quality?'

UTD: 'They were Lay Thar Taung sapphires are famous in Mogok.'

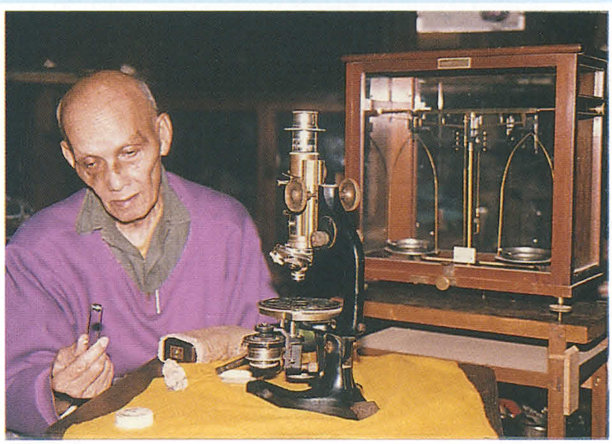

Fig. 2. U Thu Daw of Mogok with his microscope formerly owned by A.C.D. Pain
Photo by U Khin Mg Win

were of magnificent colour and quality, though a number were of a peculiar indigo shade, which appeared either very dark or an objectionable greenish tint by artificial light. During an extensive native mining rush to Bernardmyo in 1913 a number of these stones were placed on the London market.

Many of the stones found in this area were coated with a thin skin of almost opaque indigo colour which, on being ground off, revealed a centre sometimes of a fine gem quality, but in many cases of greenish shade. The method of occurrence was different from that anywhere else as the majority of stones were taken from a hard black iron-cemented conglomerate, which was found in layers a few inches thick, often only a few feet below the surface. This area now appears to be exhausted, and little mining is carried on there today except for peridots, which are abundant.

Another isolated local deposit which has produced some fine sapphires occurs at Chaunggyi, four miles north of Mogok, and about a thousand feet higher.

As well as blue, sapphires also occur in violet, purple, colourless and yellow colours at Mogok. The violet and purple stones may be fine; yellows tend to be on the light side and are not common. Green sapphires are known, but rare.

Orientation of sapphire rough

While stones from localities such as Kyauk Pyat That retain their rich blue hue in various orientations, those from Chaunggyi and Painpyit take on a greenish tint when the *c*-axis is not exactly perpendicular to the table so correct orientation for cutting is important. Many Mogok dealers attribute this phenomenon to ' invisible black silk' and currently (1994) pay strict attention to locality when buying sapphire rough.

Fig. 3. Sapphire mine of U Mya Mg at Khabine, near Gwebin, Mogok, Burma. In February of 1994 this mine yielded the 502ct sapphire crystal in Figure 6. *Photo by U Khin Mg Win.*

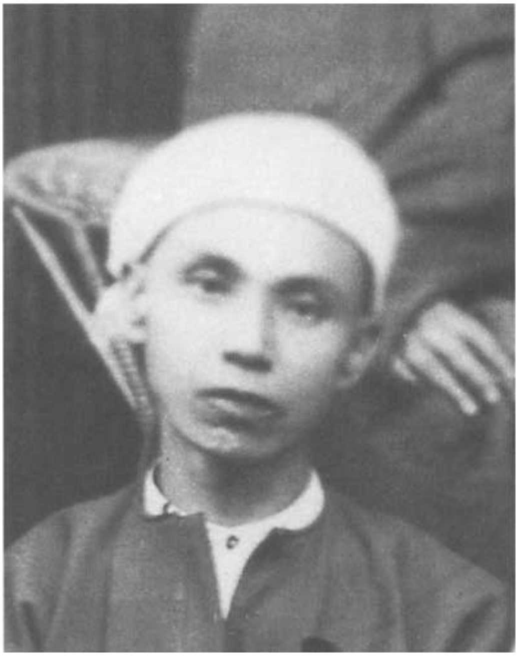

Fig.4. Left: U Tun, one of the most prominent sapphire dealers in Mogok in colonial times. Right: U Thein, one of the brothers who mined sapphires at Lay Thar Taung.
Photos by U Khin Mg Win, Mogok.

Famous Burmese sapphires

S.M. Tagore in his classic work, *Mani-Málá* (1879), described several celebrated sapphires. One of these was a fabulous stone of 951ct, and was seen by an English ambassador to the Court of Ava (Burma). Tagore also mentions a curious custom among the Hindus of India. They were said to have a prejudice against sapphires, believing the blue gem to be the bringer of misfortune.

> In consequence of this notion, some of them would invariably keep a stone on trial for several days before they would make final settlement with the sellers. Hence, perhaps, the paucity in the numbers of sapphires in their possession.
>
> S.M. Tagore, Mani-Málá, 1879

One magnificent Gwebin gem was scratched up from just below the grass in 1929 by miners preparing a site for digging. Found by U Kyauk Lon, it was a water-worn, doubly-truncated pyramid weighing an incredible 958ct. Purchased for $13,000 by Albert Ramsay, who dubbed it the *Gem of the Jungle*, the rough produced nine fine cut stones, weighing 66.53, 20.25, 20.00, 13.11, 12.25, 11.33, 11.11, 5.50 and 4.33ct. All stones were personally cut by Ramsay and were said to be of exceptional colour. A marvellous account of the purchase and cutting of the Gem of the Jungle was published in the *Saturday Evening Post* in 1934 (Ramsay and Sparkes, 1934).

About 1967, a 12.6kg (63,000 ct) crystal surfaced at Mogok. Today this sapphire colossus is on display at the Myanma Gems Enterprise (MGE) office. Like virtu-

Fig. 5. The 12.6kg sapphire giant owned by Myanma Gems Enterprise. Note the large central piece which was removed in an attempt to see if gem material might lie within. *Photos by U Khin Mg Win.*

ally all giant specimens, it is far from gem quality. In order to see if something of gem quality might be lurking within, MGE staff disembowelled it with drill and saw. Alas, the interior was just as opaque as the skin (see Figure 5). While this piece is billed by MGE as the 'world's largest sapphire crystal', in fact a number of much larger specimens are known, including a 40.3kg crystal from Sri Lanka which contains gemmy portions (see Table II).

On 22 February 1994, a large sapphire of 502ct was unearthed at Khabine, about 2.4kms from Gwebin. The crystal is a single pyramid of rich blue colour, and slightly silky (see Figure 6).

Table I is a first attempt to catalogue some of the more famous Burmese sapphires. Criteria for listing include titled specimens, specimens large or fine enough to merit mention in newspaper/magazine articles and those which have set auction records. Unfortunately, due to the secretive nature of the gem business, many fine specimens have never been publicly described. The authors would love to hear from readers with additional information.

Acknowledgements

U Hla Win would like to give thanks to U Thu Daw for educating him about Burmese sapphires and to U Khin Mg Win for the photographs.

Richard Hughes would like to thank Bob Frey, expert in various things Chinese and founding member of HAW HAW, who has gone above and beyond the call of duty in both editing and locating obscure references.

Fig. 6. Below: 502ct Burmese sapphire crystal. This was unearthed on 22 February 1994, at Khabine, near Gwebin, in Burma's Mogok Stone Tract. Right: the Base of the crystal, showing concentrations of silk. *Photos by U Khin Mg Win.*

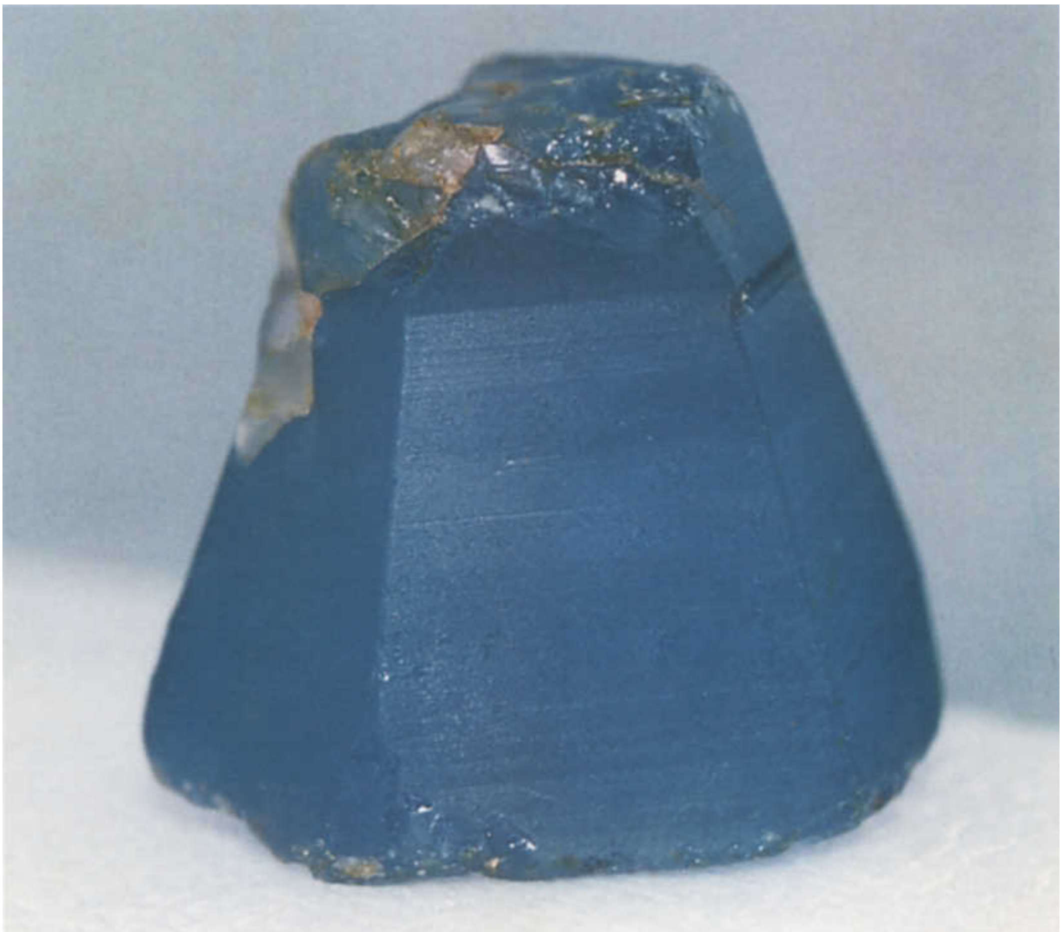

Table I: Summary of famous Burmese blue sapphires

Name, weight, description and sale price[a]	*Source & date found*	*Current location*	*Reference*
Ruspoli's Sapphire (*' Wooden spoon Seller's Sapphire' or ' Great Sapphire of Louis XIV'*) 135.8ct; faceted; rhomb shaped (only six facets); said to have been found by a wooden spoon seller in Bengal; sold by the House of Ruspoli (Rospoli?) of Rome to a German prince (salesman?), who in turn sold it to the French jeweller Perret for 170,000 francs. Later purchased by Louis XIV.	Said to be Bengal; probably Burma or Sri Lanka Date unknown	Muséum National D'Histoire Naturelle, Paris. Valued at 100,000 pounds in 1791	Tagore, 1879, 1881; Streeter, 1892; Bank, 1973; H.-J. Schubnel (pers. comm., 16 December 1994; 5 January 1995)
Unnamed 951 ct; rough or cut unknown; seen in 1827 in the treasury of the King of Ava	Unknown (Burma?) Date unknown	Unknown	Smith, 1913
Unnamed Rough, weight unknown; sold for Rs28,000 (£1,870)	Redhill Mine Mogok, Burma, 1917	Unknown	*Times of London*, 11 July 1917
Unnamed 113ct; rough; sold for Rs45,000	Bernardmyo, Mogok, Burma, 10 May 1919	Unknown	*Times of London*, 15 July 1919
Unnamed Weight unknown; rough; sold for Rs40,000	Mogok, Burma 1919	Unknown	*Times of London*, 15 July 1919
Unnamed 437ct; not stated whether rough or cut; valued at over £11,000	Mogok, Burma 1928	Unknown	*Mineral Industry*, 1929
Gem of the Jungle 958ct rough; cut stones of 66.50 (66.53?), 20.25, 20.00, 13.11, 12.25, 11.33, 11.11, 5.50 and 4.33ct; purchased by Albert Ramsay for over £13,000	Gwebin, Mogok, Burma August 1929 (or July 1930)	Unknown	*Mineral Industry*, 1930, 1931; Ramsay and Sparkes, 1934; Halford- Watkins, 1935a
Star of Asia 330ct; cabochon cut; blue-violet star sapphire; acquired in 1961 from Martin Ehrmann; once said to belong to the Maharajah of Jodhpur	Burma Date unknown	Smithsonian	Desautels, 1972; White, 1991
Unnamed 630ct rough (upon breaking up for cutting, it proved less valuable than expected)	Kathé, Mogok, Burma May 1930	Unknown	*Times of London*, 31 May 1930 *Mineral Industry*, 1930, 1932
Unnamed 293ct rough	Kathé, Mogok, Burma 1930	Unknown	Brown, 1933

Table I: Summary of famous Burmese blue sapphires (continued)

Name, weight, description and sale price[a]	*Source & date found*	*Current location*	*Reference*
Unnamed nearly 1000ct rough	Gwebin, Mogok, Burma 12 August 1932	Unknown	Brown 1933
Unnamed 514ct rough	Mogok, Burma December 1932	Unknown	Brown 1933
Unnamed star sapphire 435ct; not known whether rough or cut	Kathé, Mogok, Burma December 1932	Unknown	*Mineral Industry*, 1934
Unnamed 390ct; rough; sold for over £3,000	Mogok, Burma 1930s	Unknown	Halford-Watkins, 1935b
Unnamed about 99ct; faceted; round; offered for sale in Bangkok in early 1980s for $10,000/ct	Burma Date unknown	Unknown	Author, R.W.H.
Unnamed 41.04ct; faceted; emerald-cut; sold at Sotheby's New York, October 1986 for $924,000 ($22,515/ct)	Burma Date unknown	Purchased by American retailer	Anonymous, 1986
Rockefeller Sapphire 62.02ct; faceted, rectangular step-cut; mounted in diamond ring; sold at Sotheby's St. Moritz, 20 February 1988, for $2,828,546 ($45,607/ct). **Per carat and total price world record for a single blue sapphire**	Burma Date unknown	Unknown	Hughes and Sersen, 1988; Matthews, 1993
Unnamed 4145ct; rough; offered for sale at 1993 Myanma Gems Enterprise Emporium (Lot 95; reserve price $300,000)	Burma Date unknown	Unknown	Author, U H.W.
Unnamed 14,387ct; rough; offered for sale at 1993 Myanma Gems Enterprise Emporium (Lot 96; reserve price $50,000)	Burma Date unknown	Unknown	Author, U H.W.
Unnamed 251.60ct; star cabochon; offered for sale at 1993 Myanma Gems Enterprise Emporium (Lot 165; reserve price $300,000)	Burma Date unknown	Unknown	Author, U H.W.
Unnamed 502ct; rough, pyramid- shaped crystal, silky, of good colour	Kabaing, Mogok, Burma 22 February 1994	Unknown	Author, U H.W.

Table II: Summary of rough corundum giants (not gem quality)

Name, weight, description and sale price[a]	*Source & date found*	*Current location*	*Reference*
Unnamed 312lb (141.5kg; 707,500ct); opaque, red and blue crystal (not gem quality)	Franklin, NC Before 1882	Shepard Collection Amherst College, USA	Kunz, 1892
Unnamed Over 10lb (4.5kg); sapphire crystal	Mogok, Burma 1928	Unknown	*Mineral Industry,* 1929
Unnamed 335lb (152kg); hexagonal bipyramid crystal (not gem quality); 2ft 3in (68.58cm) in width. **This is the largest corundum crystal on record.**	Leydsdorp, Northern Transvaal, South Africa Date unknown	Geological Survey Museum, Pretoria, South Africa	Spencer, 1933 Anonymous, 1951
Unnamed 42lb (19kg); crystal said to be in the shape of the island of Sri Lanka	Sri Lanka Date unknown	American Museum of Natural History?	Anonymous, 1936 Wijesekera, 1980
Unnamed 136.5lb (61.92kg); crystal	18km from Santa Barbara, Minas Gerais, Brazil	Natural History Museum London	Personal communication
Unnamed 63,000 ct (12.6kg; 27.783lb); rough crystal, bluish-grey pyramid (not gem quality); 27 x 14.25 x 6.75 in (68.58 x 36.195 x 17.145 cm)	Mogok, Burma *ca.* 1967	Myanma Gems Enterprise, Burma	Anonymous, 1967
Unnamed 40.3kg; rough, doubly- terminated bipyramid crystal	Rakwana, Sri Lanka Date unknown	Unknown	Koivula and Kammerling, 1989
Unnamed 4.230ct; rough; bluish bipyramidal crystals, not gemmy	Lokekhet ('Kadegadar') Mogok, Burma September 1990	Myanma Gems Enterprise, Burma	*Working People's Daily,* 5 February 1991 Clark, 1991, p. 68

[a] On 1 April 1914, the carat was standardized as 200 milligrams. Weights before that date are approximate only. All dollar prices in US dollars unless stated otherwise.

References[2]

Anonymous, 1936. Largest sapphire to be cut. *The Gemmologist,* **5**, 58, 247, RWHL

Anonymous, 1951. Famous sapphires. *The Gemmologist,* **20**, 240, 165, RWHL

Anonymous, 1967. Gemological digests: world's largest star sapphire. *Gems & Gemology,* **12**, 5, 158, RWHL

Anonymous, 1986. Sotheby's sets records with ruby and diamond. *Jewelers' Circular-Keystone,* December, 75, RWHL*

Bank, H., 1973. *From the world of gemstones.* Trans. by E.H. Rutland, Pinguin-Verlag, Innsbruck, 178 pp, RWHL

Brown, J.C., 1933. Ruby mining in Upper Burma. *Mining Magazine,* June, pp. 329-40, RWHL*

Brown, J.C. and Dey A.K., 1955. *India's mineral wealth.* 2nd ed. Oxford University Press, Bombay, 761 pp, RWHL*

Clark, C., 1991. Burma Emporium: the ultimate treasure hunt. *JewelSiam,* 2, April/May, pp 58-71, RWHL

Desautels, P.E., 1972. *Gems in the Smithsonian.* Smithsonian Institution Press, Washington, D.C., 63 pp, RWHL

Halford-Watkins, J.F., 1935a. Burma sapphires - in defence of a much-abused name. *The Gemmologist,* **5**, 50, September, pp 39-43, RWHL*

Halford-Watkins, J.F., 1935b. Burma sapphires - locations and characteristics. *The Gemmologist,* **5**, 52, November, pp 89-98, RWHL*

Hughes, R.W. and Sersen, W.J. 1988. Bangkok gem market review. *Gemological Digest,* **2**, 1 & 2, 20-2, RWHL

Koivula, J.I. and Kammerling, R.C., 1989. Gem news: Huge, doubly-terminated sapphire crystal. *Gems and Gemology,* **25**, 4, 247, RWHL

Kunz, G.F. 1892. *Gems and precious stones of North America.* Reprinted by Dover, 1968 (367 pp), The Scientific Publishing Co., New York, 336 pp., RWHL

Matthews, P., (ed.), 1993. *The Guinness Book of Records 1993,* Bantam Books, New York, 847pp., RWHL

Mineral Industry, 1893-1942. Precious and semi-precious stones [famous gems]. In *The mineral industry, its statistics, technology and trade during ...,* Ed. by G.F. Kunz and G.A. Roush, McGraw-Hill, New York, 1924: pp. 579-82; 1929: pp. 532-4; 1930: pp. 549-50; 1931: pp. 524-5; 1932: pp. 478-9; 1934; pp. 508-9; 1935: p. 508; 1942: p. 483, RWHL

Ramsay, A., and Sparkes, B., 1934. Bright jewels of the mine. *The Saturday Evening Post,* Parts 1-3, 15 Sept.: pp. 10-11, 65-66, 69; 29 Sept.: pp. 26, 28, 34, 36, 39; 20 Oct.: pp 26-27, 76, 78, 80; RWHL*

Smith, G.F.H., 1913. *Gem-stones and their distinctive characters.* Methuen & Co., London, 2nd edn (1st edn. 1912), 312 pp., RWHL*

Smith G.F.H., 1972. *Gemstones.* 14th edn, revised by F.C. Phillips, Chapman and Hall, London, 580pp., RWHL

Spencer, L.J., 1933. Nation acquires large ruby. *The Gemmologist,* **2**, 18, 176-8, RWHL

Streeter, G.S., 1887. The ruby mines of Burma. *Journal of the Manchester Geographic Society,* No. 3, pp. 216-20, map, RWHL*

Streeter, G.S., 1889. The ruby mines of Burma. *Journal of the Society of Arts,* No. 37, 22 February, pp. 266-75; RWHL*

Streeter, E.W., 1892. *Precious stones and gems.* 5th edn, Bell, London, 355pp., RWHL*

Tagore, S.M., 1879, 1881. *Mani-Mâlá, or a Treatise on Gems.* I.C. Bose & Co., Calcutta, 2 vols, 1046pp, RWHL*

Times of London 1878-1933 [Important rubies and sapphires]. *The Times,* London, 1878, Dec. 20, p. 6d; 1880, 5 March, p. 7d; 6 March, p. 5e; 22 June, p. 10f; 11 Oct, p. 5b; 1885, Dec, 5, p. 5; 1886, March 17, p. 5; 1889, 1917, 11 July, p. 13c; 1918, July 10, 12e; 1919, July 15, p. 20a; Aug. 25, p. 9f; 1920, July 12, p. 22f; July 20, p. 20e; 1921, 23 June, p. 12c; 1924, 12 Nov, p. 11b, 11g, 3*, 4*; 1930, 31 May, p. 12e; 1931, 4 June, p. 13g; 1932, 27 April, p. 13g; 1933, 3 Feb., RWHL

White, J.S., 1991. *The Smithsonian treasury: minerals and gems.* Smithsonian Institution Press, Washington, D.C., 96pp, RWHL

Wijesekera, N., 1980. Gemstones of Sri Lanka. *Lapidary Journal,* pp. 1616-18, RWHL

Working People's Daily, 1991. SLORC Chairman Senior General Saw Maung inspects world's largest sapphire. *Working People's Daily,* Rangoon, 5 February.

[2] RWHL = References contained in the personal library of Richard W. Hughes
* = References of particular merit

An examination of 'serendipitous' synthetic zincite

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Abstract

This article describes the gemmological investigation of synthetic zincite from Poland. The material is reported to have formed as an accidental by-product of an industrial process.

Keywords: gem mineral, gemstone, mineral, synthetic, zincite.

Introduction

A *mineral* may be defined as a naturally occurring, crystallized chemical element or compound having either a definite chemical composition or range in composition and usually formed as a product of inorganic processes (Hurlbut and Kammerling, 1991). When a mineral is deemed to be sufficiently attractive and durable to be used for personal adornment, it may be referred to as a *gem material*, with the fashioned product generally called a *gemstone.* (Sometimes minerals with the requisite beauty but lacking in durability are also fashioned and are sometimes referred to as *collectors' gemstones.*)

A *synthetic mineral* or *gemstone*, on the other hand, is an artificial or manufactured (that is, non-natural) product. Unlike imitations which merely resemble a natural gem, synthetic gemstones duplicate their natural counterpart's chemical composition and crystal structure (resulting in the same optical and physical properties) (Nassau, 1980; Hurlbut and Kammerling, 1991).

Some natural minerals are formed under somewhat exotic conditions, including fumaroles and volcanic vents (e.g. cotunnite and scacchite: Palache *et al.*, 1951); in guano deposits (struvite, which was first found in bat deposits in a church basement, and newberryite: Palache *et al*, 1951; urea: Bridge, 1973); and in lichen colonies (moolooite: Chisholm *et al.*, 1987).

Isolated synthetic crystals or crystal aggregates may also form in artificial environments. However, in the absence of other considerations, these are not considered minerals (and, by extension, would not qualify in fashioned form as natural gemstones). For example, both mullite and brownmillerite crystals form in ceramics, but until they were found in natural environments, were not considered minerals (Bowen, 1924; Johnson *et al.*, 1994; Hentschel, 1964). Similarly, phases found only in weathered slags (e.g. barium sulphite, $BaSO_3$: Braithwaite *et al.*, 1993) are not currently accepted as minerals (Jambor, 1994).

Current study

In February 1995, while attending the many concurrent gem and mineral shows in Tucson, Arizona, USA, the authors encountered a considerable amount of synthetic zincite. (Small quantities had been noticed at the Tucson shows in previous years and have occasionally been submitted to the GIA Gem Trade Laboratory for examination, including material reported to be from Poland [Crowningshield, 1985].) Although the majority of this material was

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Fig. 1. These crystals (95.85 and 179.65ct) are accidental by-products of an industrial kiln in Silesia, Poland. *Photo by Maha DeMaggio © GIA*

Fig. 2. These three gems (1.35 to 3.26ct), fashioned from single crystals of synthetic zincite, were the subjects of the current investigation. *Photo by Maha DeMaggio © GIA*

in the form of single crystals up to 15cm in length and as complex crystal aggregates (Figure 1), faceted stones were also being sold. The colour of the material ranged from a medium-toned yellow through orange and dark orangey red, with a very few yellowish-green crystals seen as well.

Discussions with representatives of the Krakow Poland-based firm Minerals and Gemstones shed some light on this material (D. and J. Wachowiak, pers. comm., 1995). They reported that it was an accidental by-product of an industrial kiln in Silesia, Poland, used to produce zinc-based paint. The synthetic zincite would form spontaneously and randomly by vapour deposition in the kiln's chimney/air vents due to some undetermined error in the commercial production process.

Both rough and faceted samples were purchased for examination. Gemmological properties were determined for three modified round brilliant-cuts weighing 1.35, 3.18, and 3.26ct (Figure 2).

Gemmological Properties

Appearance

All three specimens have a sub-adamantine lustre and are transparent, as were others seen by the authors but not examined in detail. The colours of the three are medium-light yellow, medium orange and medium-dark reddish-orange, all of high saturation and even distribution. These samples were felt to be representative of the range of hues and depths of colour exhibited by the material being offered at the Tucson shows. These properties are generally consistent with those reported in the literature for the rare natural zincite

Table I. Ultraviolet fluorescence of samples

	Long wave	*Short wave*
Medium-light yellow specimen	Moderate yellow	Weak to moderate yellow
Medium orange specimen	Very weak yellowish-orange	Very weak orange
Medium-dark reddish-orange specimen	Very weak yellowish-orange	Inert

(Webster, 1983; Arem, 1987), although cuttable natural material is described as being slightly cloudy to translucent, and frequently darker or more brownish in colour.

Refractive indices

All three stones are over the limits of a standard Duplex II refractometer, i.e. with a refractive index of more than 1.80. Such a determination is consistent with the values $\omega = 2.013$, $\varepsilon = 2.029$ reported for natural zincite (Webster, 1983; Arem, 1987).

Optic character

The material was determined to be doubly refractive, by observing weak doubling of back facet edges under magnification and by the presence of weak pleochroism (see below). In addition, two of the three stones were confirmed to be uniaxial by resolving an optical interference figure between crossed polarizers. These data are consistent with those for natural zincite which crystallizes in the hexagonal crystal system and has a birefringence of 0.016 (Webster, 1983; Arem, 1987).

Pleochroism

Dichroism is very weak, in two tones of the body colour. It should be noted that both Webster (1983) and Arem (1987) report natural zincite as having no pleochroism. This apparent inconsistency may be explained by the very weak reaction of the synthetic material noted by the authors and by the fact that natural zincite is rarely transparent, for even minor scattering of light in the natural material could obscure a weak pleochroic reaction. Webster (1983) also reports that small crystals of synthetic zincite showed no apparent dichroism; here, the combination of a weak reaction in possibly pale-coloured specimens might account for the differences noted.

Ultraviolet fluorescence

In all three stones, the reaction to long wave was stronger than the reaction to short wave (see Table I).

Furthermore, the strengths of the reactions were inversely proportional to the depth of body colour. Both Webster (1983) and Arem (1987) report that natural zincite does not fluoresce. This lack of reaction in natural zincite is most likely caused by one or more fluorescence-quenching impurities. Webster (1983) reports a dull to bright yellow fluorescent reaction for small synthetic specimens, although the excitation wavelength(s) is not specified.

Chelsea filter reaction

The appearance through the Chelsea filter varied with the body colour of the test sample. The medium-light yellow stone gave no reaction (that is, it appeared yellowish- green, the colour of the filter).

Table II. Summary of gemmological properties of synthetic zincite	
Colour	Medium-light yellow, medium orange, medium-dark reddish-orange
Diaphaneity	Transparent
Lustre	Sub-adamantine
RI	Over the limits of standard refractometer (1.80+)
Optic character	Doubly refractive, uniaxial
Pleochroism	Very weak, in two tones of body colour
UV Fluorescence:	
Long wave	Very weak to moderate, yellow to yellow-orange
Short wave	Inert to very weak to moderate, yellow to orange
	LWUV > SWUV; both inversely proportional to depth of body colour
Chelsea filter reaction	Yellow stone: no reaction (appears yellowish-green)
	Orange stone: weak pink
	Reddish-orange stone: moderate red
Absorption spectra	Weak general absorption to about 430nm and a weak band centred at 500nm (lightest-coloured stone); Weak general absorption to about 510 or 530nm (other two stones)
SG	5.70 ± 0.02
Electrical conduction	Non-conducting (two lighter-coloured stones)
	Conducting (darkest-coloured stone)
Magnification	Dislocations; cloud of small particles; small crystals, some acicular

The medium orange stone appeared weak pink while the medium-dark reddish-orange specimen appeared moderate red.

Absorption spectra

These were observed using a Beck prism-type spectroscope mounted on a GIA GEM transmitted/fibre-optic light base. The lightest-toned specimen showed weak general absorption from 400 to about 430nm plus a diffused band centred at approximately 500nm. The other two showed weak general absorption from 400 to 510 and 530nm respectively. Webster (1983) reports no distinctive absorption features for small specimens of synthetic material, although this may be due to their relatively light body colour (they are described as being yellow).

Specific gravity

This was determined through hydrostatic weighing on a Mettler AM100 electronic balance, with three separate sets of calculations performed for each stone. Values obtained were 5.70±0.02 and are consistent with the 5.68 value reported by Arem (1987) and close to the 5.66 value Webster (1983) reports for gem-quality natural material.

Electrical conduction

Electrical conduction was measured qualitatively using a GIA Gem Instruments electrical conductivity meter. The medium-light yellow and medium orange stones gave a negative reaction (i.e. did not conduct electricity), but the medium-dark reddish-orange stone gave a positive reaction (i.e. did conduct electricity).

Magnification

The lightest-toned stone contained only a cloud of small particles (Figure 3). The two darker stones showed dislocations and small included crystals that could only be seen under fairly high magnification (Figure 4). The darkest stone also contained acicular inclusions (Figure 5). As none of the inclusions broke the surface, they were not further characterized.

The gemmological properties are summarized in Table II.

Chemistry

Qualitative chemical analyses were performed using a Tracor X-ray Spectrace 5000 EDXRF spectrometer. The only element revealed was zinc (Zn), which is consistent with the chemistry of zincite (ZnO), as oxygen and other light elements are not detectable with this method of analysis.

For comparison purposes, a dark brownish red faceted natural zincite from Franklin, New Jersey, USA, was also tested using the EDXRF system; this stone contained manganese (Mn) as well as Zn. Microprobe analysis of a natural 'light green' zincite from Sterling Hill, New Jersey, USA, showed contents of 98.88% ZnO, 0.23% iron (Fe) as FeO, and 0.29% Mn as MnO (Dunn, 1979).

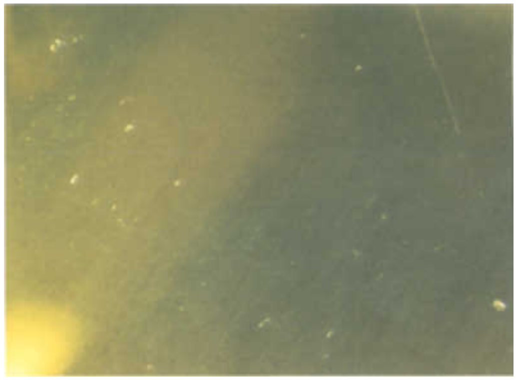

Fig. 3. A cloud of minute particles was noted in the 3.18ct light yellow specimen. 60x. *Photomicrograph by John I. Koivula © GIA*

Fig. 4. Veil-like dislocations and small included crystals of undetermined nature were detected in two of the test samples. 50x. *Photomicrograph by John I. Koivula © GIA*

Fig. 5. One of the three samples contained acicular inclusions. 60x. *Photomicrograph by John I. Koivula © GIA*

Discussion

The gemmological properties of the synthetic zincites described in this investigation were in their essentials consistent with those reported in the literature for the rare, gem-quality facetable natural zincite from Franklin, New Jersey, USA. The data obtained are also in agreement with what is documented in the literature for synthetic material.

Although the red colour in many natural zincites is thought to be due to Mn (Webster, 1983), none of the three faceted synthetic stones examined by the authors contained any detectable Mn. We suspect that the yellow, orange and reddish-orange colours, and corresponding absorption spectra, may be due to increasing amounts of band-gap absorption from defect states within zincite (see, for instance, Fritsch and Rossman, 1988); in agreement with this model, the darkest stone conducts electricity.

The synthetic zincite examined by the authors is unusual in that it is reported to have formed as an accidental by-product of a commercial manufacturing process, rather than having been grown for a specific gem or industrial application. However, *intent* is not a consideration in the definition of a synthetic gem material. For instance, additional synthetic crystals form under conditions meant to grow other materials including, for example, the synthetic phenakite crystals found in synthetic emeralds, and the synthetic acmite and eucryptite 'breadcrumb' inclusions sometimes found in synthetic quartz.

It is worth noting that this is not the first such occurrence of synthetic zincite crystallizing by accident. In an article titled 'A modern miracle' (Kennedy, 1983), the author describes yellow and red-orange amber-coloured crystals of synthetic zincite that were found at the Blackwell Zinc Smelter in Blackwell, Oklahoma, USA, when an old furnace used to produce zinc ore concentrates was torn down.

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References

Arem, J., 1987. *Color encyclopedia of gemstones.* Van Nostrand Reinhold Company, New York, 2nd. ed., 207-8

Bowen, N.L., 1924. Mullite, a silicate of alumina. *Journal of the Washington Academy of Sciences*, **14**, 9, 183-91

Braithwaite, R.S.W., Kampf, A.R., Prichard, R.G., and Lamb, R.P.H., 1993. The occurrence of thiosulphates and other unstable sulphur species as natural weathering products of old smelting slags. *Mineralogy and Petrology*, **47**, 255-61

Bridge, P.J., 1973. Urea, a new mineral, and neotype phosphammite from Western Australia. *Mineralogical Magazine*, **39**, 346-8

Chisholm, J.E., Jones, G.C., and Purvis, O.W., 1987. Hydrated copper oxalate, moolooite, in lichens. *Mineralogical Magazine*, **51**, 5, 715-18

Crowningshield, R., 1985. Gem Trade Lab notes: synthetic zincite. *Gems & Gemology*, **21**, 4, 237-8

Dunn, P.J., 1979. Light green zincite from Sterling Hill, Ogdensburg, New Jersey. *Mineralogical Record*, **10**, 1, 45-7

Fritsch, E., and Rossman, G.R., 1988. An update on color in gems. Part 3: Colors caused by band gaps and physical phenomena. *Gems & Gemology*, **24**, 2, 81-102

Hentschel, G., 1964. Mayenit, $12CaO\,7Al_2O_3$, und Browmillerit, $2CaO\,(Al,Fe)_2O_3$, zwei neue Minerale in den Kalksteineinschlüssen der Lava des Ettringer Belleberges. *Neues Jahrbuch für Mineralogie Monatschefte*, 22-9

Hurlbut, C.S., and Kammerling, R.C., 1991. *Gemology*. John Wiley & Sons, New York, 2nd ed., 2,6

Jambor, J.L., 1994. $BaS_2O_3\,H_2O$, $Ba_2S_2O_3F_2$, $Ba_2Al_2S_3(OH)_8\,8H_2O$: discussion; in Jambor, J.L. and Vanko, D.A., New mineral names. *American Mineralogist*, **79**, 11-12, 1318

Johnson, M.L., DeGhionno, D., and Maddison, P., 1994. Gem Trade Lab notes: Ceramic statue. *Gems & Gemology*, **30**, 3, 184

Kennedy, M., 1983. A modern miracle. *Lapidary Journal*, **36**, 12, 1974-9

Lausen, C., 1928. Hydrous sulfates formed under fumerolic conditions at the United Verde Mine. *American Mineralogist*, **13**, 6, 203-29

Nassau, K., 1980. *Gems made by man.* Chilton Book Company, Radnor, Pennsylvania, USA, 4

Palache, C., Berman, H., and Frondel, C., 1951. *The system of mineralogy of James Dwight Dana and Edward Salisbury Dana, Yale University 1837-1892*, Vol. II: halides, nitrates, borates, carbonates, sulfates, phosphates, arsenates, tungstates, molybdates, etc., John Wiley & Sons, New York, 7th ed.

Webster, R., 1983. *Gems, their sources, descriptions and identification*, 4th ed. revised by B.W. Anderson, Butterworth, London, pp. 369, 434-5

Cat's-eye and asteriated gemstones from East Africa

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Abstract

The study was carried out on nineteen cat's-eye or asteriated cabochon-cut examples of the following gems from Tanzania and Kenya: almandine, apatite, aquamarine, beryl, grossular, kyanite, kornerupine, rhodolite, ruby, sapphire, scapolite, tourmaline and zoisite.

Optical observations, electron microprobe and X-ray analyses were carried out to investigate chemical compositions of the bulk crystals and the role of the inclusions.

Inclusions, responsible for the optical effects, i.e. tubes, acicular inclusions, lamellae, laminae and platelets, are described and some deductions about conditions of growth of the gems are made.

Keywords: Gemstones, cat's-eye, chatoyancy, asterism, cabochon, inclusions.

Introduction

Tanzania and Kenya now contribute significantly to the world market in supplying unusual gemstones which display chatoyancy and asterism.

For several years, cabochon-cut gemstones of different mineral species producing these optical phenomena have appeared on the Kenyan market.

A group of 19 cabochon-cut gemstones of different mineral species, selected according to their origin, weight, size and with evident cat's-eye or asterian effect, were examined.

This article describes the physical and chemical properties of the gems with particular emphasis on the inclusions responsible for the optical effects.

Sample location and geology

The samples were obtained by N.R. Barot from North Tanzania and South Kenya and are of known origin (Figure 1). The regional geology is complicated and has not been mapped in detail.

Sample 1 is from the Ngorongoro volcanic complex at Lake Manyara, in north central Tanzania. The erosion of the metamorphic rocks, which lie on the northern border of the Masai Steppe, produced the neogenic deposits in which the sample was found.

Samples 7, 12, 13, 14 and 15 are from the Dodoma area, 17, 18 and 19 from the Lelatema District and 2, 9 and 11 from the Pare and Usambara Mountains, all in Tanzania.

Samples 3, 6, 8, 10 and 16 are from the Taita Mountains and 4 and 5 from the Embu and Meru areas respectively, in Kenya.

These areas are part of the central system of the Rift Valley (Pangani Rift). The rocks are affected by extensive tensional tectonic events and consist of high grade gneisses (granulite facies) of Tertiary age, and lower grade metamorphic rocks (amphibolite

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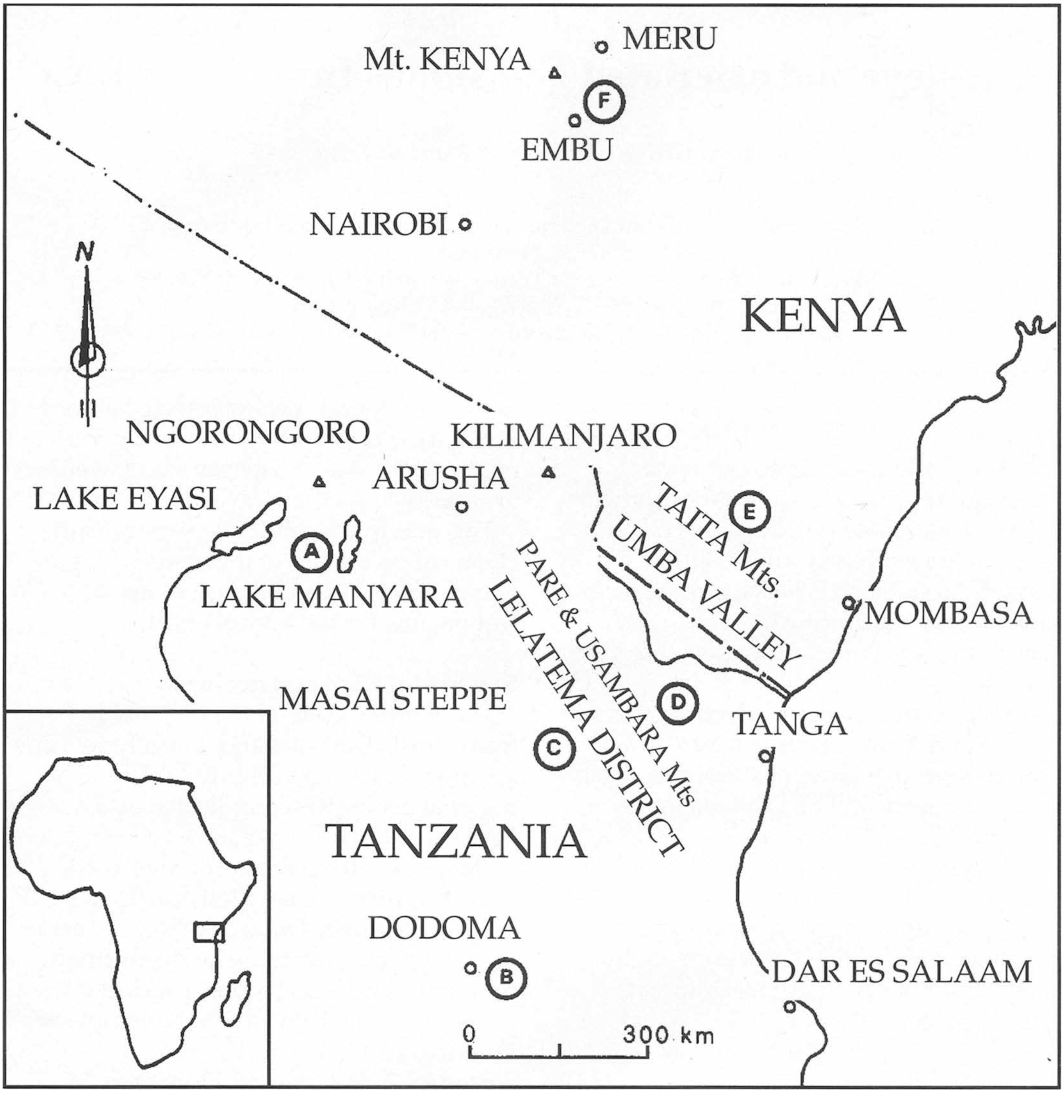

Fig. 1. The map shows the origin of the gemstones studied from East Africa. A: Sample 1; B: Samples 7, 12, 13, 14 and 15; C: Samples 17, 18 and 19; D: Samples 2, 9 and 11; E: Samples 3, 6, 8, 10 and 16; F: Samples 4 and 5

facies) of Precambrian age. In particular they comprise pyroxene granulites, gneisses with kyanite, amphibolites, crystalline limestones with graphite, serpentine and sporadic pegmatite complexes of syn-orogenic metasomatic or post-orogenic magmatic origin.

All the gems are oval cabochon-cuts, ranging in size from 5.40x5.20x4.90mm (sample 6) to 12.80x10.27x6.67mm (sample 15). Their weights vary between 0.58ct (sample 17) and 6.37ct (sample 15).

Elongate, thin inclusions parallel to the base of the cabochons cause the cat's-eye effect in samples 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18 and 19 and traverse the whole body of the host crystal (Figures 2, 3, 5 and 10). Also, a hazy six-pointed star, not

Fig. 2. Sample 2. This almandine from Mt. Pare (Tanzania) is decorated by syngenetic intergrowth of rutile needles with a crystallographically dictated arrangement along the edges of the rhombdodecahedral faces. 60x.

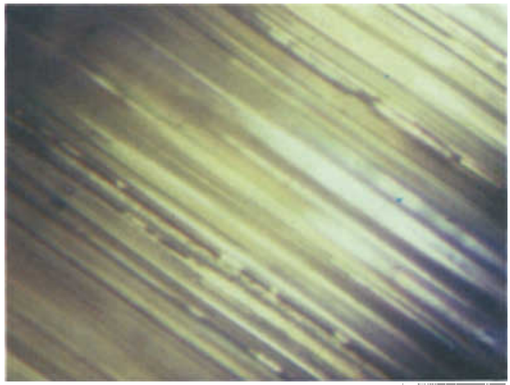

Fig. 3. Sample 3. In this yellow fluorapatite from Mt. Taita (Kenya), the tubes are parallel to the *c*-axis, partly filled with epigenetic laminae of iron compounds, and are considered to be mainly responsible for the cat's-eye. 50x.

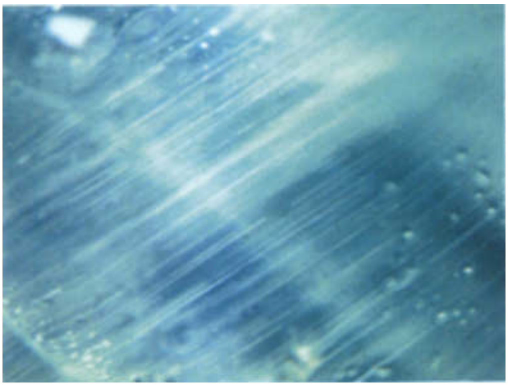

Fig. 4. Sample 4. In this aquamarine from Embu and Meru area (Kenya), the cat's-eye effect is caused by massed parallel, hair-like tubes. 20x.

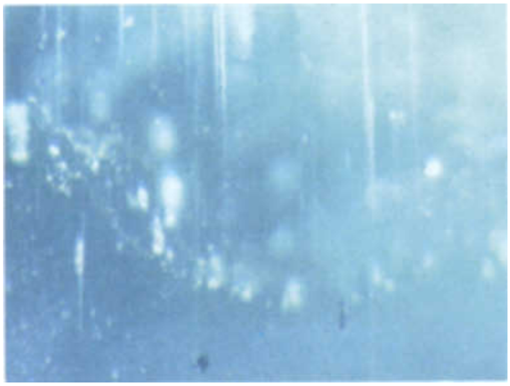

Fig. 5. Sample 8. Healing fissures of different patterns, narrow tubes and some crystals, with a vaporous appearance, decorate this green kornerupine from Mt. Taita (Kenya). 30x.

Fig. 6. Sample 10. The straight edged growth zoning, present in this ruby from Mt. Taita (Kenya), indicates many changes in the physico-chemical environment of the host gem. Inclusions of fine rutile needles were confined to growth zoning. 20x.

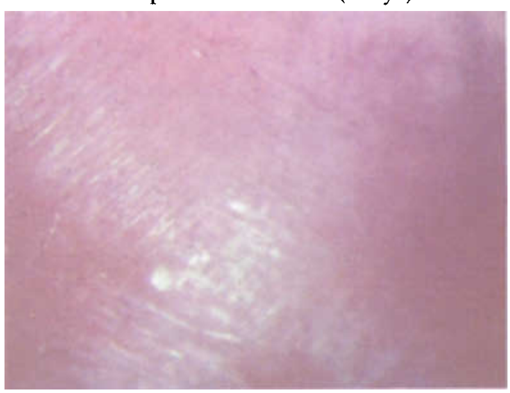

Fig. 7. Sample 10. In this ruby from Mt. Taita (Kenya), the crystallographically dictated arrangement of syngenetic rutile needles and lamellar structures cause the hazy asterism displayed by this cabochon. 10x.

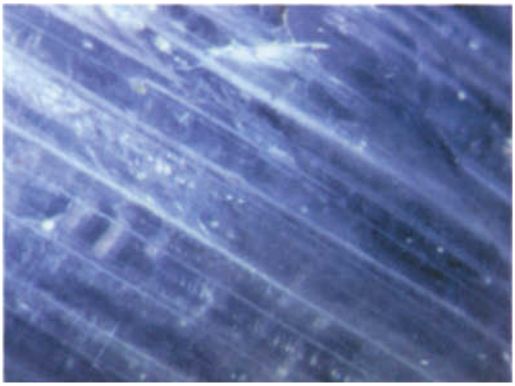

Fig. 8. Sample 11. Broad hollow tubes and boehmite laminae traverse this lilac sapphire from Mt. Pare (Tanzania), and produce the cat's-eye effect. 30x.

Fig. 9. Sample 13. In a yellowish scapolite, 45% Me content, from Dodoma (Tanzania), the filled cleavage laths are yellow, reddish-brown and black due to iron oxides and hydroxides. The opaque laminae consist of pyrrhotite and have the appearance of stripes. The laths and the laminae are parallel and crystallographically oriented. 20x.

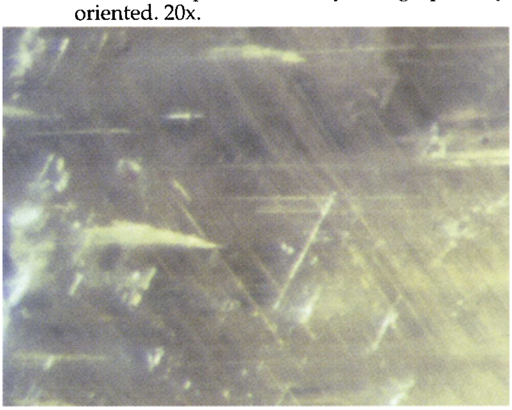

Fig. 10. Sample 17. Systems of parallel tubes and healing fissures cross this brownish-yellow zoisite from Lelatema District (Tanzania). 30x.

extending fully, is displayed by samples 9 and 10. The width and the shortness of these rays may be related to three factors.

First, many stones are quite transparent with patchy development of inclusions; secondly, some stones are poorly cut; and thirdly, variation of alignment of the elongate inclusions tends to make the chatoyancy or asterism less well-defined (Figure 6).

Gemmological and analytical tests

The cabochon-cut gemstones were submitted to standard gemmological and appropriate analytical tests (see Table I).

Visual appearance and absorption spectra

The samples present different grades of clarity and are classified as cabochon-cut gemstones either transparent (samples 3, 4, 5, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18 and 19), semi-transparent (samples 1, 2, 6 and 7), or translucent (sample 16). To the unaided eye, the samples appear of medium hue, only one being dark (sample 16).

The visible-light absorption spectrum of all the cabochons was observed through the hand-held spectroscope and measured with the Cary 219 dual-beam spectrophotometer over the spectral range 400 to 800 nm.

Refractive index, pleochroism and luminescence

The refractive indices of the cabochons were assessed by means of a gemmological refractometer using the distant vision method. It was possible to determine only average values.

Pleochroism and luminescence under long and short wave were observed and evaluated.

Specific gravity

The specific gravity of all the samples was measured with a Berman balance. Due to the variable inclusion content of the cabochons, the results should be interpreted with caution.

Table I. Gemmological properties and mineralogical classification of the cat's-eye and asteriated gemstones from East Africa.

Sample number	*Refractive index (average value)*	*Pleochroism*	*Absorption (nm)*	*Luminescence (UV)*	*Specific gravity*	*Gem*
1	1.75	Reddish Greenish	Broad band: 430 Broad band: 450 Narrow lines: 488, 503	Long wave: faint Short wave: greenish	3.71	Alexandrite
2	1.76	—	Indistinct band: 420 Narrow line: 460 Bands: 500, 520, 576 Faint lines: 470, 605	—	3.96	Almandine
3	1.64	Blue Yellowish	Indistinct band: 450 Narrow line: 478 Faint bands: 520 Strong band: 580	Long wave: greenish Short wave: greenish	3.21	Apatite
4	1.57	Bluish Colourless	Broad band: 427 Diffuse band: 456 Narrow line: 537	—	2.68	Aqua-marine
5	1.58	Sea-green Yellowish	No characteristic	—	2.72	Beryl
6	1.74	—	Main bands: 410, 421, 435 Weak bands: 460, 480, 504 Weak line: 520 Broad band: 573	—	3.93	Grossular
7	1.72	Colourless Blue	Vague lines: 450-500 Vague line at 700	Long wave: dim red Short wave: inert	3.68	Kyanite
8	1.67	Greenish Reddish	Indistinct band: 430 Faint line: 445 Band: 503	Long wave: yellow glow Short wave: yellow glow	3.30	Korner-upine
9	1.75	—	Indistinct band: 460 Main band: 500 Broad bands: 520, 576	—	3.84	Rhodolite
10	1.77	Yellowish Purple	Indistinct band: 463 Narrow lines: 475, 469 Absorption area: 485-600 Weak line: 663 Strong line: 694	Long wave: crimson Short wave: weaker red	3.99	Ruby

Table I. continued

11	1.77	Yellowish Blue	Indistinct band: 435 Complex band: 450	—	4.00	Sapphire
12	1.56	Yellowish Colourless	Broad band: 530-590 Weak line: 650	Long wave: inert Short wave: vague pink	2.68	Scapolite
13	1.56	Yellow Colourless	Broad band: 530-590 Weak line: 650	Long wave: inert Short wave: vague pink	2.72	Scapolite
14	1.55	Yellow Yellowish	Broad band: 530-590 Weak line: 650	Long wave: inert Short wave: vague pink	2.63	Scapolite
15	1.56	Yellow Colourless	Broad band: 530-590 Weak line: 650	Long wave: inert Short wave: vague pink	2.68	Scapolite
16	1.63	Dark green Yellowish	Strong line: 498	Long wave: faint Short wave: yellow	3.04	Tourmaline
17	1.70	Blue Sage-green	Broad band: 590 Faint bands: 530, 455	—	3.36	Zoisite
18	1.70	Blue Sage-green	Broad band: 590 Faint bands: 530, 455	—	3.35	Zoisite
19	1.69	Blue Sage-green	Broad band: 590 Faint bands: 530, 455	— —	3.35	Zoisite

Note: – means no pleochroism or fluorescence was observed

Electron microprobe, X-ray diffraction and thermal analyses

Electron microprobe analyses and X-ray powder diffraction measurements were carried out on all samples to investigate any chemical variation and possible structural change of the host gems and of the inclusions, whenever they were exposed at the surface of the cabochons.

Electron microprobe analyses were carried out on a Jeol JMS-50A. Matrix corrections were made according to the EMPADR VII programme described by Rucklidge and Gasparrini (1969). Total iron was calculated as FeO; beryllium and boron were not detectable by the microprobe.

The unit cell parameters were calculated by means of X-ray powder diffractometry, using nickel-filtered copper K_α radiation with five oscillatory scans at 1/4° 2θ per minute from 10° to 80° 2θ. Pure semiconductor grade crystalline silicon metal (Jarrel Ash JM, spectroscopy impurity less than 300 ppm) was used as an internal standard. The lattice constants were estimated using a least-squares refinement (Appleman and Evans, 1973) of the X-ray data, indexed by comparison with the data listed by the JCPDS files.

Thermogravimetric analyses were performed with a TGS-2 Perkin Elmer system using about 0.10mg of material for each analysis. The H_2O content was estimated by assessing the difference between the thermogravimetric results and the chemical data for the other volatile components, i.e. CO_2, F, Cl and S.

The CO_2 content of the total gaseous phase emitted by the substance after heating at 1000°C was determined by means of the high sensitivity analyzer of Scarano and Calcagno (1975), using an air current with constant CO_2 content as carrier.

Identification of the gems

The specimens were submitted to the standard gemmological tests, thus identifying the mineral species (Table I). Detailed analytical features are given in Table II and Appendix.

Sample 1 is a chrysoberyl. The iron content (1.36%) and the small amount of chromium are responsible for the dark greenish colour of the gem (Schmetzer, 1985). The reddish colour of the sample in transmitted light (Dana, 1944) and the X-ray powder diffraction data (Vlasov, 1966) suggest that it may be the alexandrite variety.

Samples 2, 6 and 9 are red, greenish-red and brownish-red garnets respectively. On the basis of the lattice constants, refractive index and specific gravity values, they are classified as almandine, grossular (Bank, 1979; Deer *et al.*, 1982) and rhodolite, a mixed crystal within the pyrope-almandine isomorphous series (Anderson, 1959; Bank and Henn, 1989) with a notable pyrope molecular percent end member (62.7%). The calculation was performed according to the dominant molecular content of the end- member components present in each garnet (Table II). The percentage of the andradite end-member was calculated on the basis of Fe^{3+} estimated according to Droop, 1987. The calculated Fe_2O_3 contents were: 0.34, 2.26 and 0.69 wt.% for samples 2, 6 and 9 respectively.

Sample 3 is a yellow apatite. The microchemical analyses, the amount of fluorine (3.15%) and the lattice constants values (c/a = 0.736) identify it as a fluorapatite (Deer et al., 1967; Altschuler *et al.*, 1953).

Samples 4 and 5 are beryls with very similar optical properties, specific gravity, microchemical and lattice constants (Deer *et al.*, 1986; Radcliffe, 1969; Winchell and Winchell, 1953). The relatively high content of MgO and the pale bluish appearance of sample number 4 allows its classification as an aquamarine (Schaller *et al.*, 1962).

Sample 7 is a moderately blue kyanite. The low iron and titanium content may be responsible for the faint colour of the host cabochon and consists of an aggregate of colour patches spread in a colourless matrix (Ghera *et al.*, 1986).

Sample 8 is a dark green kornerupine on the basis of the optical properties, microchemical analyses and lattice constants (Hey *et al.*, 1941; Girault, 1952).

Samples 10 and 11 are ruby and lilac sapphire, based on their appearance and the presence of chromium, iron and traces of titanium, respectively.

Samples 12, 13, 14 and 15, are colourless or yellowish scapolites. The microchemical analyses and lattice constants allow esti-

Table II. Molecular percentage end member and X-ray data of cat's-eye and asteriated garnets from East Africa

Sample number	*Lattice constant a (Å)*			*molecular percent end member*			
		Alm.	*Andr.*	*Gross*	*Pyr.*	*Spess.*	*Uv.*
2	11.566 ± 0.004	45.7	1.0	21.4	30.3	1.6	–
6	11.495 ± 0.005	32.6	4.3	55.6	5.7	1.8	–
9	11.495 ± 0.004	19.3	1.1	16.4	61.9	1.1	–

mates following the relationship proposed by Shaw (1960) and Burley *et al.* (1961), of the percentage of meionite, namely, 39, 48, 28 and 41%, respectively.

Sample 16 is a dark green tourmaline. The chemical data and the lattice constants (c/a = 0.451) indicate that it is a member of the schorl–dravite series (Dunn *et al.*, 1975; Epprecht, 1953; Sahama *et al.*, 1979).

Samples 17, 18 and 19 are brownish-yellow zoisites on the basis of their compositions and lattice constants (Deer *et al.*, 1986).

Examination of the inclusions

The cabochons were examined by means of a stereoscopic microscope and the inclusions were analyzed by the electron microprobe, wherever they intersected the surface.

The specimens were observed in immersion and often showed the presence of a colour pattern unevenly distributed in bands. Broader zones and colour areas are exhibited by the clustering of tiny needles.

A multitude of inclusions were observed and segregated into six main categories. The different types of inclusions are listed in Table III. Only the inclusions in groups 1, 2, 3 and 4 are involved in producing cat's-eyes or asterism.

1. Tube like inclusions

These inclusions are present in numerous cabochons of different mineral species and are the main cause of the chatoyancy (samples 3, 4, 8, 9, 11, 12, 13, 14, 15, 16, 17, 18 and 19).

They are primary cavities which are normally caused by irregularities in the growth process of the host crystal. Such tubes may be filled by scaly aggregates with a colour varying from brownish-red to yellow and variously mixed (Figures 3, 4, 5, 8, 9 and 10), by two-phase inclusions (Schmetzer *et al.*, 1977; Graziani and Gübelin, 1981; Schmetzer and Bank, 1983) or by powdery birefringent material (Graziani *et al.*, 1982).

Around these cavities, 'fingerprint' veils are often present, and also healing fractures, surrounded by brown or reddish-brown vague haloes which alter the appearance both of the cat's-eye or star effect.

Electron microprobe analyses indicate the presence of iron, therefore the haloes were attributed to iron oxides or hydroxides. This has been documented by Schmetzer and Bank, 1983; Ghera *et al.*, 1988, and is common to numerous minerals.

2. Acicular inclusions

Analysis of the fine (<30μm diameter) acicular inclusions is experimentally difficult and results are commonly similar to composition of the host crystal (samples 1, 2, 3, 6, 9, 10, 11 and 16).

Analyzing the acicular inclusions of maximum diameter, the semi-quantitative microprobe analyses showed small amounts of titanium. Considering the visually estimated high birefringence, the growth conditions and the high formation temperature, the inclusions are probably rutile.

The colour hue of the cabochons appears to be linked to these acicular inclusions which are responsible for the clear or for the opalescent appearance of the samples (Figures 2, 6 and 7).

Optical and electron microprobe observations showed the presence (samples 1 and 16) of bunches of yellowish brucite fibres (Koivula and Fryer, 1985) and (sample 3) of acicular goethite (Gübelin and Schmetzer, 1982).

3. Lamellae

Some specimens (samples 1, 2, 3, 6, 10, 11, 17, 18 and 19) showed planar textures. These are polysynthetic lamellar structures with the same microchemical composition of the host crystals and are either twinning or cleavage surfaces.

The individual lamellae are often limited both by an incipient decomposition along

Table III. Recognized inclusions in the cat's-eye and asteriated gemstones from East Africa

Sample number	*Host gem*	*Inclusions*					
		Tubes	*Lamellae*	*Laminae*	*Feathers*	*Minerals*	
						acicular	*other habits*
1	Alexandrite	---	Present	---	Present	Brucite Rutile	Diopside Unidentified
2	Almandine	---	Present	---	Present	Rutile	Unidentified
3	Apatite	Present	Present	---	---	Goethite Rutile	Unidentified
4	Aquamarine	Present	---	Biotite	---	---	---
5	Beryl	---	---	Hematite	---	---	Apatite
6	Grossular	---	Present	---	Present	Rutile	Diopside, Unidentified
7	Kyanite	---	---	Hematite	---	---	Unidentified
8	Kornerupine	Present	---	Graphite	Present	---	Apatite
9	Rhodolite	Present	---	---	Present	Rutile	Apatite, Unidentified
10	Ruby	---	Present	---	Present	Rutile	Apatite
11	Sapphire	Present	Boehmite	---	Present	Rutile	Apatite
12	Scapolite	Present	---	Muscovite	Present	---	---
13	Scapolite	Present	---	Pyrrhotite	Present	---	---
14	Scapolite	Present	---	Biotite	---	---	Unidentified-
15	Scapolite	Present	---	---	Present	---	---
16	Tourmaline	Present	---	Graphite	---	Brucite	---
17	Zoisite	Present	Present	Graphite	Present	---	---
18	Zoisite	Present	Present	Graphite Hematite	Present	---	---
19	Zoisite	Present	Present	Graphite	Present	---	---

these planes (samples 10 and 11), by parallel arrangements of laminae (samples 2, 3, 6, 17, 18 and 19), or may be covered with disseminated, lenticular, colourless lamellae, (sample 11), probably boehmite (Eppler, 1974; Hänni and Schmetzer, 1991) (Figure 8).

4. Laminae and platelets

Brown laminae of biotite and transparent, colourless platelets of biotite and muscovite occur in samples 4, 12 and 14.

Dark grey, pseudo-hexagonal laminae of hematite and pyrrhotite, often partially decomposed and surrounded by rings of yellow-orange iron hydroxides, represent common epigenetic inclusions (samples 5, 7, 13 and 18) and when present, darken the colour of the cabochon.

Rounded black platelets of graphite often forming groups, are present in some cabochons from East Africa (samples 8, 16, 17, 18 and 19) as a product of intense metamorphism.

5. Feathers and healed fractures

Healed fractures are indicated by cleavages or veil-like feathers of fluid remnants and by haloes of a yellow or brownish-red matter (samples 1, 2, 6, 8, 9, 10, 11, 12, 13, 15, 17, 18 and 19) and are generally unrelated to the cat's-eye or asterism effect.

Electron microprobe analyses of the fractures showed the almost exclusive presence of iron, and consequently the haloes were ascribed to iron oxides or hydroxides.

6. Mineral inclusions

Sporadic transparent and opaque inclusions are present in almost all the cabochon-cut gemstones (Figures 9 and 10). The crystals (approx. 0.03 x 0.06mm), are often elusive or difficult to study, they seem to disappear like vapour and occur singly (Figure 10). Careful optical observations may enable one to identify these peculiar inclusions (samples 1, 2, 3, 6, 7, 9 and 14), and so far, diopside (samples 1 and 6) and apatite (samples 5, 8, 9, 10 and 11) prismatic crystals have been recognized (diameter: min.: 0.01mm; max.: 0.2mm).

Discussion and conclusions

The cabochon-cut gemstones are remarkable for the presence in all samples of a multitude of inclusions, many of which are responsible for the chatoyancy or star effects (Table III).

The straight-edged colour bands and growth zoning (Figures 7 and 8) are due to the sporadic variations in the physico-chemical growth conditions and document intermittent episodes of the host crystal's growth (samples 10 and 19).

Tubes, acicular inclusions and lamellae, sometimes with a crystallographically dictated parallel arrangement of minute lines, decorate the host minerals and represent the main cause of these optical effects.

Laminae and platelets are related to the cat's-eye effect only if they are oriented perpendicularly to the base of an elliptical cabochon.

Feathers, healed fractures and mineral inclusions are not confined to stones with the cat's-eye or star effect and are present incidentally.

Nevertheless, tubes, acicular inclusions, healed fractures and feathers are responsible for the yellowish appearance of the cabochons. This colour is due to iron oxides or hydroxides and indicates that the latter iron minerals crystallized after a late-stage filling of these cavities. Sporadic alterations of the physico-chemical conditions probably produced fractures into which the mother fluid penetrated and where iron compounds segregated. The colour variability of the haloes, from yellowish to reddish, also probably indicate a possible sequence of transformation of iron hydroxides into iron oxides due to an increase of the environmental temperature.

The presence of hematite in samples 5, 7 and 18 shows that the temperature of crystallization was more than 500°C (Kulp *et al.*, 1951).

The frequent occurrence of graphite platelets (samples 8, 16, 17, 18 and 19) is witness to intense metamorphic events which characterized the East African geological situation.

The data obtained from the cabochon-cut gemstones and their identified inclusions are consistent with their derivation from medium- to high-grade metamorphic rocks which are common throughout the whole East African region.

References

Altschuler, Z.S., Cisney, E.A., and Barlow, I.H., 1953. X-ray evidence of the nature of carbonate apatite. *American Mineralogist*, **38**, 328

Anderson, B.W., 1959. Properties and classification of individual garnets. *Journal of Gemmology*, **7**, 1-7

Appleman, D.E., and Evans, H.T., 1973. Job. 9214: Indexing and least-squares refinement of powder diffraction data. *U.S. Department of Commerce, National Technological Information Service, Document No PB- 216 188*

Bank, H., 1979. Orange-('Padparascha'-) und andersfarbige Granate aus Ostafrika. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **28**, 146-7

Bank, H., and Henn, U., 1989. Gemmologische Kurzinformationen. Ein ungewohulicher Granat aus Ostafrica. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **38**, 161-8

Burley, B.J., Freeman, E.B., and Shaw, D.M., 1961. Studies on scapolite. *Canadian Mineralogist*, **6**, 670-9

Dana, J.D., 1944. *The system of mineralogy, Vol. 1.* Wiley & Sons, New York

Deer, W.A., Howie, R.A., and Zussman, J., 1967. *Rock forming minerals, Vol. 5, Non silicates.* Longman, London

Deer, W.A., Howie, R.A., and Zussman, J., 1982. *Rock forming minerals, Vol. 1A, Orthosilicates.* Longman, London

Deer, W.A., Howie, R.A., and Zussman, J., 1986. *Rock forming minerals, Vol. 1B, Disilicates and ring silicates.* Longman, London

Droop, G.T.R., 1987. A general equation for estimating Fe^{3+} concentration in ferromagnesian silicates and oxides from microprobe analyses using stoichiometric criteria. *Mineralogical Magazine*, **51**, 431-5

Dunn, P.J., Arem, J.E., and Saul, J., 1975. Red dravite from Kenya. *Journal of Gemmology*, **14**, 386-7

Eppler, W.F., 1974. Uber einige Einschlusse in Birma-Rubin. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **23**, 102-8

Epprecht, W., 1953. Die Gitterkonstanten der Turmalin. *Schweizerische Mineralogische und Petrographische Mitteinlungen*, **33**, 481-505

Ghera, A., Graziani, G., and Gübelin, E., 1988. Notes on the inclusions in a greyish kyanite. *Journal of Gemmology*, **21**, 83-7

Ghera, A., Graziani, G., and Lucchesi, S., 1986. Uneven distribution of blue colour in kyanite. *Neues Jahrbuch fur Mineralogie Abhandlungen*, **155**, 109-27

Girault, J.P., 1952. Kornerupine from Lac Ste. Marie, Quebec, Canada. *American Mineralogist*, **37**, 531-41

Graziani, G., Gübelin, E., 1981. Observations on some scapolites of Central Tanzania. *Journal of Gemmology*, **17**, 395-405

Graziani, G., and Gübelin, E., and Lucchesi, S., 1982. Tourmaline chatoyancy. *Journal of Gemmology*, **18**, 181-93

Graziani, G., Gübelin, E., and Lucchesi, S., 1983. Observations on some scapolites of Central Tanzania: further investigations. *Journal of Gemmology*, **18**, 379-81

Gübelin, E., and Schmetzer K., 1982. Eine neue Edelstein-Varietat aus Tansania: Gelbe, grune und rotlich-braune Apatit-Katzenaugen. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **31**, 261-3

Hänni, H.A., and Schmetzer, K., 1991. New rubies from the Morogoro Area, Tanzania. *Gems & Gemology*, **27**, 156-67

Hey, M.H., Anderson, B.W., and Payne, C.J., 1941. Some new data concerning kornerupine and its chemistry. *Mineralogical Magazine*, **26**, 119-30

Koivula, I., and Fryer, C.W., 1985. Interesting red tourmaline from Zambia. *Gems & Gemology*, **21**, 40-2

Kulp, J.L., and Trites, A.F., 1951. Differential thermal analysis of natural hydrous ferric oxides. *American Mineralogist*, **36**, 23-44

Radcliffe, D., 1969. Cell constants of Birch Portage beryl, Saskatchewan. *Canadian Mineralogist*, **8**, 493-505

Rucklidge, J., and Gasparrini, E.L., 1969. *Electron microprobe analytical data reduction. EMPADR VII. Manual reissue.* Dep. of Geology, University of Toronto, Toronto, Canada

Sahama, Th. G., Von Knorring, O., and Tornroos, R., 1979. On tourmaline. *Lithos*, **12**, 109-14

Scarano, E., and Calcagno, C., 1975. High sensitivity carbon dioxide analyzer. *Analytical Chemistry*, **47**, 1055-65

Schaller, W.T., Stevens, R.E., and Jahns, R.H., 1962. An unusual beryl from Arizona. *American Mineralogist*, **47**, 672-99

Schmetzer, K., 1985. Colourless chrysoberyl natural or synthetic. *Journal of Gemmology*, **19**, 682-91

Schmetzer, K., and Bank, H., 1983. Investigation of a cat's-eye scapolite from Sri Lanka. *Gems & Gemology*, **19**, 108-10

Schmetzer, K., Gübelin, E., Medenbach, O., and Krupp, H, 1977. Skapolith Katzenauge und Sternskapolith aus Zentral Tansania. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **26**, 3-5

Shaw, D.M., 1960. The geochemistry of scapolite. Previous work and general mineralogy. *Journal of Petrology*, **1**, 218-60

Vlasov, K.A., 1966. *Mineralogy of rare elements. Vol. II.* Israel Program for Scientific Translations, Jerusalem

Winchell, A.N., and Winchell, H., 1951. *Elements of optical mineralogy: an introduction to microscopic petrography. Part. II. Descriptions of minerals, with special reference to their optical and microscopical characters. IV Edition.* John Wiley & Sons, New York

Further reading

Barot, N.R., Flamini, A., Graziani, G., and Gübelin, E.J., 1989. Star sapphire from Kenya. *Journal of Gemmology*, **21**, 467-73

Cassedanne, J., and Roditi, M., 1993. The location, geology, mineralogy and gem deposits of alexandrite, cat's-eye and chrysoberyl in Brazil. *Journal of Gemmology*, **23**, 333-54

De Kun, N., 1965. *The mineral resources of Africa.* Elsevier Publishing Company, Amsterdam

Kammerling, R.C., and Koivula, J.I., 1990. Star rhodolite garnet from Tanzania. *Journal of Gemmology*, **22**, 16-18

Kammerling, R.C., and Koivula, J.I., 1991. Two strongly pleochroic chatoyant gems. *Journal of Gemmology*, **22**, 395-8

Koivula, J.I., Kammerling, R.C., and Fritsch, E., 1993. Two interesting 'double star' sapphires. *Australian Gemmologist*, **18**, 7, 235-6

Appendix
Electron microprobe analyses of cat's-eye and asteriated gemstones from East Africa

	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*
SiO_2	0.50	39.48	-	65.40	65.92	38.00	37.70	32.10	41.31	0.22	0.20	52.85	52.58	57.12	52.67	37.38	40.10	41.10	41.76
TiO_2	0.00	tr.	-	0.00	0.00	0.00	0.05	0.16	0.00	0.06	0.03	0.04	0.04	0.04	0.05	0.23	0.05	0.09	0.14
Al_2O_3	78.76	21.48	-	18.25	18.90	21.80	61.79	44.43	24.17	98.65	98.46	24.81	24.07	22.05	23.46	31.39	33.40	32.47	32.95
FeO[1]	1.36	21.92	0.14	0.70	0.64	17.50	0.40	0.17	10.29	0.06	1.02	0.27	0.09	0.11	0.06	3.50	1.11	0.05	0.07
MnO	0.00	0.75	0.00	0.00	0.06	0.85	0.00	0.00	0.54	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.04	0.04	0.05
MgO	0.00	8.04	0.25	0.45	0.06	1.52	-	19.90	17.36	0.00	0.01	0.11	0.10	0.00	0.14	10.87	0.14	0.15	0.17
CaO	0.30	8.18	52.54	0.50	0.00	20.60	-	0.05	6.41	0.00	0.00	12.92	11.62	6.80	10.22	1.03	23.50	23.91	24.01
Na_2O	0.00	-	0.27	0.70	0.55	-	0.00	0.02	-	-	-	3.94	6.23	9.22	7.19	2.01	0.10	0.74	0.53
K_2O	0.00	-	0.00	0.30	0.09	-	0.10	0.03	0.00	-	-	1.08	1.25	0.86	1.25	0.08	tr.	0.21	0.20
P_2O_5	-	0.00	41.90	-	-	0.00	0.00	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.00
SO_3	-	-	-	-	-	-	tr.	tr.	-	-	-	0.57	0.76	0.05	0.72	-	-	-	-
Cr_2O_3	0.18	0.00	-	0.03	0.04	0.00	0.00	0.05	-	0.45	0.09	-	-	-	-	0.19	tr.	tr.	tr.
V_2O_5	tr.	0.00	-	0.00	0.00	0.00	0.00	0.00	-	0.05	0.02	-	-	-	-	tr.	tr.	tr.	tr.
Cl	tr.	-	1.15	-	-	-	tr.	0.18	-	-	-	1.56	1.70	3.03	1.85	-	-	-	-
F	0.00	-	3.15	0.00	-	-	0.00	0.00	-	-	-	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
BeO[(1)]	18.85	-	-	12.25	12.63	-	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-
B_2O_3[(2)]	0.00	-	-	0.00	-	-	0.00	3.17	-	-	-	-	-	-	-	10.76	-	-	-
CO_2[(3)]	0.00	-	1.00	-	-	-	0.00	0.00	-	-	-	2.00	1.50	0.85	2.15	0.00	-	-	-
H_2O^+ / H_2O^- [(4)]	0.00	0.00	0.00	1.47	1.47	0.00	0.00	0.00	0.00	-	-	0.10	0.19	0.15	0.15	3.30	1.10	1.13	0.14
	99.95	99.85	100.40	100.05	100.36	100.27	100.04	100.26	100.08	99.49	99.89	100.25	100.13	100.28	99.91	100.74	99.54	99.89	100.02
O≡Cl,F			0.13									0.35	0.38	0.68	0.42				
TOTAL	99.95	99.85	100.27	100.02	100.36	100.27	100.04	100.26	100.08	99.49	99.89	99.90	99.75	99.60	99.49	100.74	99.54	99.89	100.02

See Table I for sample identities 1-19

(1) Total iron recorded as FeO

(2) Calculated

(3) Measured with CO_2 analyser

(4) Determined with a thermogravimetric analyser

A note on red beryl

R.R. Harding

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Abstract

The gemmological characteristics of a 4.66ct cut red beryl are described. Electron microprobe analyses of the beryl indicate contents of 2.8 per cent FeO (total iron) and 0.8 per cent MnO, and a complex inclusion cluster of opaque minerals comprising bixbyite columbite and two unidentified species, one largely composed of manganese and cerium oxides, the other containing these two elements together with significant uranium and thorium.

Introduction

The recent publication of Hosaka, Tubokawa, Hatushika and Yamashita on red beryl crystals from Utah (*Journal of Gemmology*, July 1993) complements the earlier work of Shigley and Foord in 1984 (*Gems & Gemology*, Winter 1984). Recently Alan Hodgkinson provided the opportunity to examine one of the larger faceted red beryls in existence and it is appropriate to comment briefly on both the spectrum displayed by this stone and the complexity of its inclusions.

Gemmology and composition

The stone is a deep mixed-cut of fine colour (Figure 1) weighing 4.66ct, with RI of 1.568 – 1.572 and DR of 0.004. Through a hand–held spectroscope the absorption pattern appears as shown in Figure 2 with a wide absorption band from 590–500nm, a weak band at 455nm, a stronger band at 430nm, and general absorption from 420-400nm.

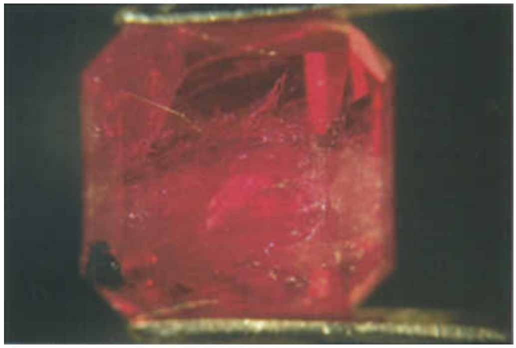

Fig. I. Red beryl of 4.66ct, viewed from pavilion side, with cluster of opaque inclusions located just below the girdle. *Photo: R.R. Harding*

These data are consistent with the spectrophotometer traces published by Shigley and Foord (1984) and by Hosaka *et al.* (1993), although the absorption peaks of the polarized spectra given by Shigley and Foord are slightly different in detail. This variability may be related to the differences in iron content between the stones measured (see below).

Analyses of the red beryl were carried out on a Hitachi scanning electron microscope (SEM) with Link Systems energy dispersive system (EDS) and the mean of 3 spot analyses is given in Table I, column 1. As indicated above, the main difference between the composition of this red beryl and of those reported in the papers cited is the iron content – 2.8 per cent compared with 1.3 per cent (Hosaka *et al.*) and 1.5 – 1.8 per cent (Shigley and Foord).

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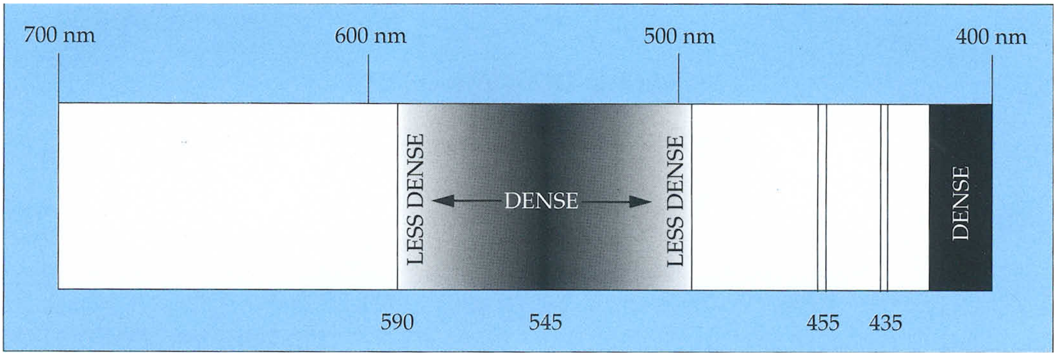

Fig. 2. Visible absorption spectrum of red beryl through diffraction grating spectroscope. The 455nm line is weak.

Manganese (0.8 per cent) is also higher in Alan Hodgkinson's stone and these higher minor element contents may be responsible for the appearance of a spectral absorption band at 455nm.

The red beryl contains a number of black inclusions and conveniently for SEM-EDS analysis, some intersect the surface close to the girdle (Figures 3 and 4). They are rounded or equant polygonal in polished section, and most consist of the iron manganese oxide bixbyite (Table I, column 2). However, not all the grains are bixbyite, and both within and at the rims of the bixbyite are opaque grains of other species, some not yet identified.

At the core of one bixbyite grain is ferrocolumbite whose composition is given in Table I, column 3; the high total may be a combination of some experimental error and perhaps different oxidation states of the niobium and tantalum. Within and at the edges of the bixbyite are unidentified minerals variably rich in cerium, uranium

Table I: Electron microprobe analyses of 4.66ct red beryl and inclusions

Red Beryl (mean of 3)		*Bixbyite (mean of 3)*		*Columbite*		*Unidentified mineral UA*		*Unidentified Mineral UB (mean of 5)*	
SiO_2	67.17	SiO_2	2.41	SiO_2	1.69	SiO_2	1.06	SiO_2	6.35
TiO_2	0.29	TiO_2	1.48	TiO_2	7.47	TiO_2	0.25	TiO_2	0.59
Al_2O_3	16.75	Al_2O_3	1.71	FeO	19.92	Al_2O_3	0.58	Al_2O_3	2.31
FeO	2.81	Fe_2O_3	44.37	MnO	8.21	FeO	3.50	FeO	5.50
MnO	0.82	Mn_2O_3	49.02	CaO	0.27	MnO	9.42	MnO	37.01
CaO	0.13	CaO	0.31	SrO	2.40	CaO	0.56	CaO	1.07
K_2O	0.10	Na_2O	0.40	ZrO_2	2.69	K_2O	0.40	K_2O	2.29
		ZrO_2	0.48	SnO_2	1.43	ZrO_2	3.55	SrO	0.90
		MgO	0.07	UO_2	0.89	UO_2	15.60	PbO	3.62
				Nb_2O_5	54.09	ThO_2	14.26	Ce_2O_3	22.05
				Ta_2O_5	4.08	Ce_2O_3	47.77	SO_3	0.85
						SO_3	0.23		
Total	88.07		100.25		103.14		97.18		82.54

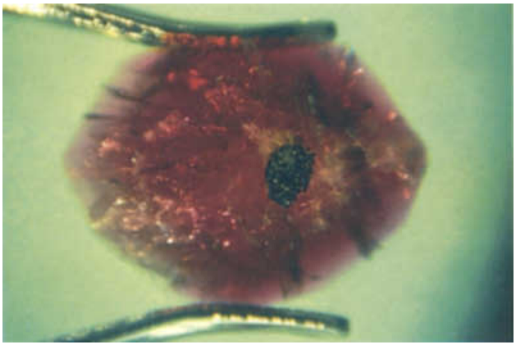

Fig. 3. Red beryl immersed in fluid with opaque inclusions visible just beneath the girdle. *Photo: A. Hodgkinson*

Fig. 4. Cluster of opaque inclusions intersecting the facets of the red beryl show a range of reflectivities. *Photo: R.R. Harding*

or thorium and two compositions are given in columns 4 and 5 of Table I. The composition given in column 5 is the mean of the analyses of 5 spots which gave consistently low totals; these may be due to the presence of low atomic number elements such as lithium or beryllium or hydrogen (water), none of which are detectable by this method of analysis.

Conclusion

Other methods of analysis would be needed to fully identify these minerals but the SEM-EDS has revealed some of the complexity that may be present among opaque inclusions in gemstones. The presence of cerium-bearing inclusions brings to mind the brown cerium carbonate parisite which is found in association with the Muzo emeralds in Colombia.

Acknowledgements

I would like to thank Alan Hodgkinson for the opportunity to examine this rare cut stone, and Ana Castro and Stephen Kennedy for discussion in the laboratory, and Frances Wall and Terry Williams, Natural History Museum, for assistance with micrprobe analyses.

Refcrences

Hosaka, M., Tubokawa, K., Hatushika, T., Yamashita, T., 1993. Observations of red beryl crystals from the Wah Wah mountains, Utah. *Journal of Gemmology*, **23**, 7, 409-11

Shigley J.E., Foord, E.E., 1984. Gem quality red beryl from the Wah Wah mountains, Utah. *Gems & Gemology*, **XX**, 4, 208-21

Abstracts

Diamonds | Gems and Minerals
Instruments and Techniques | Synthetics and Simulants

Diamonds

Crystal morphology identification of diamond and ABN.

M.W. Bailey and L.K. Hedges. *Industrial Diamond Review*, **55**(1), 1995, 11-14.

The structures of diamond and cubic boron nitride are similar in that they are both strongly bonded covalently with tetrahedral bonding, but are dissimilar in that diamond has a centre of symmetry whereas cBN does not. Crystals of each can be described and distinguished by a simple crystallographic system referred to as the 'morphology index'. This index has been used by De Beers for many years to characterize the extensive range of diamond and ABN (abrasive boron nitride) offered on the market. The morphology index describes the basic characteristics of a crystal in terms of the growth of different crystal faces, which have different mechanical properties (indentation hardness, abrasion resistance and polishing rates, cleavage or fracture energy), and different chemical properties (absorption of chemical species and chemical reactions with oxygen or, for diamond, with carbon solvent metals or carbide formers).
R.A.H.

Carbon dioxide in strongly silica undersaturated melts and origin of kimberlite magmas.

G.P. Brey and I.D. Ryabchikov. *Neues Jahrbuch für Mineralogie, Monatshefte*, (10), 1994, pp 449-63.

The solubility of CO_2 in melts on the olivine-melilitite-($CaCO_3$-$MgCO_3$) join has been determined at 5-30 kbar. The CO_2 content of gas-saturated melts increases almost linearly with (Ca + Mg) from 9 to 37 wt.% at 30 kbar; at 10 kbar it increases non- linearly with (Ca + Mg), and more rapidly on the carbonate-rich side of the join. A simple thermodynamic model is proposed for CO_2 solubility, which takes into account the higher stability of $CaCO_3$ compared with $(Mg,Fe)CO_3$ complexes in the melt. The CO_2 solubility for compositions similar to type 1A kimberlites (characterized by high MgO and relatively low CaO levels) changes sharply in the *P*-range corresponding with the stability field of diamond. The vigorous degassing resulting in hydraulic fracturing of wall rocks may explain the diamondiferous character of these MgO-rich melts.
R.A.H.

Dating lower crust and upper mantle events: an ion microprobe study of xenoliths from kimberlitic pipes, South Australia.

Y.D. Chen, S.Y. O'Reilly, P.D. Kinny and W.L. Griffin. *Lithos*, **32**(1-2), 1994, pp 77-94.

Zircons separated from five xenoliths from the Calcutteroo kimberlitic pipes (167-174 m.y.) (three quartzofeldspathic granulites, one mafic granulite and one eclogite) were dated using the SHRIMP ion microprobe. The zircon data indicate that different types of xenoliths had different origins and formed at different times. The combined data-set of all zircon U-Pb ages from all the xenoliths records four major tectonic events associated with zircon formation, recrystallization or

ABSTRACTORS

R.K. Harrison	R.K.H.	R.J. Peace	R.J.P.	K.A. Riggs	K.A.R.
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For further information on many of the topics referred to consult *Mineralogical Abstracts* or *Industrial Diamond Review.*

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Pb loss. These events at about 1600-1500, 780, 620 or earlier and 330 m.y., correlate with large-scale tectonic events recorded in adjacent crustal and mantle rocks. The identification of multiple zircon-forming events and the inferred different times of formation of different xenolith assemblages show that Sm-Nd isochron ages based on an assumption of a cogenetic relationship are invalid. G.R.

Majhgawan diamondiferous pipe, Madhya Pradesh, India - a review.

A.K. CHATTERJEE AND K.S. RAO. *Journal of Geological Society of India*, **45**(2), 1995, 175-89, 2 maps.

The alkaline ultrabasic Majhgawan diatreme was intruded into the Kaimur sandstones of the Lower Vindhyan supergroup (1400–1100 m.y.) overlying the cratonic Bundelkhand granite basement (2550 m.y.), which is a typical archon; recent Rb/Sr age data indicate 1042–1067 m.y. for the Majhgawan pipe. This pipe has a surface dimension of 500 x 320m, and is a carrot-shaped body reminiscent of a typical kimberlite. The rock has been classified as an olivine lamproite lapilli tuff of crater facies. High TiO_2 (4-6%), less abundant heavy indicator minerals such as pyrope and ilmenite, and overall petrological character of the pipe reflect its lamproite nature, as do high amounts of Ba (3000 ppm), Sr (1000 ppm) and *REE*. On the other hand, the almost concentric distribution of diamonds, mode of occurrence of mantle-derived xenocrysts and overall geochemistry, with high MgO (25%), low K_2O (1%) and fair amounts of Cr and Ni, are characteristics of a kimberlite. The garnet population and composition are intermediate in character between kimberlite and lamproite. The Majhgawan diamonds (42% of gem grade) have predominantly curved faces and modified forms indicative of resorption. R.A.H.

Origin of vein graphite in high-grade metamorphic terrains. Role of organic matter and sediment subduction.

C.G. DISSANAYAKE. *Mineralium Deposita*, **29**(1), 1994, 57-67, 2 maps.

A voluminous source of mantle-derived CO_2 has been suggested for the phenomenon of granulite formation. Recent studies on the granulite terrain of Sri Lanka have clearly shown that it is only an upper crustal section and that it was subjected to a much smaller influx of CO_2 than previously envisaged. The close association of graphite with the granulites, and the recent discovery of grain-boundary graphite in the lower crust, implies graphite as a major source of CO_2. Recent reports on the discovery of alluvial diamonds within the granulite belt of the Highland complex of Sri Lanka, where graphite is abundant, may indicate penetration of the graphite-diamond inversion line. R.E.S.

Nitrogen aggregation in metamorphic diamonds from Kazakhstan.

K.S. FINNIE, D. FISHER, W.L. GRIFFIN, J.W. HARRIS AND N.V. SOBOLEV. *Geochimica Cosmochimica Acta*, **58**(23), 1994, 5173-77.

Proton-probe analyses are presented of diamonds separated from Tertiary sands 20km from the type locality of the diamondiferous rocks of the Kokchetav massif; for K, Ca, Ti, Cr, Cu, Zn, Zr and Fe the results are compared to those of diamonds from Zaire, South Africa and the Argyle field. IR and visible absorption spectra show ~48-63% aggregation of single N substitution to A centres. Calculated residence times assuming peak metamorphic T of 800-900°C are <0.5 m.y. to 40 m.y. These times, together with petrographical evidence, indicate that the diamonds formed during high-P metamorphism rather than being derived from pre-metamorphic sediments. R.K.H.

An atomistic model for stepped diamond growth.

M. FRANKLACH, S. SKOKOV AND B. WEINER. *Nature*, **372**(6506), 1994, 535-7.

Theoretically, bridging methylene (CH_2) groups on the {100} plane of diamond growing in the presence of hydrogen can migrate in a manner analogous to surface diffusion. It is shown that this theory can be developed into an atomistic model accounting for stepped growth in diamond through the formation of surface-bound species from gaseous precursors, followed by their migration through surface chemical reactions involving covalent bond breaking and formation. R.K.H.

Trace elements in garnets and chromites: diamond formation in the Siberian lithosphere.

W.L. GRIFFIN, N.V. SOBOLEV, C.G. RYAN, N.P. POKHILENKO, T.T. WIN AND E.S. YEFIMOVA. *Lithos*, 29(3-4), 1993, 235-56.

Proton EPMA of trace elements in garnet and chromite inclusions in diamonds from the Mir, Udachnaya, Aikhal and Sytykanskaya kimberlites in Yakutia provide new insights into the processes that form diamond. Equivalent data on garnet and chromite concentrates from these pipes yield information on the thermal state and chemical stratification of the Siberian lithosphere. Peridotite-suite diamonds from Yakutia have formed over a T interval of ~600°C, as measured by Ni and Zn thermometry on garnet and chromite inclusions. Individual diamonds contain inclusions recording T intervals of >400°C; ranges of >100°C are common. Diamond formation followed a severe depletion event, and a separate enrichment in Sr. Comparison of T on garnet and spinel inclusions with T derived from diamondiferous harzburgites, exposed inclusions in boart and concentrate minerals suggest that the diamond-containing part of the lithosphere has cooled significantly since the Siberian diamonds crystallized. The peridotite-suite diamonds probably formed mainly in response to one or more relatively short-lived events, related to magmatic intrusion. The *N* part of the Daldyn-Alakit district may have had a typical cratonic geotherm at the time of diamond formation, and during kimberlite intrusion. The *S* part of the district, and the Malo-Botuobiya kimberlite field, probably had a relatively low geotherm (~35 mW/m²). The vertical distribution of garnet and chromite types indicates that the mantle above 120km depth is dominated by lherzolites, whereas the deeper parts of the lithosphere are a mixture of lherzolite and more depleted harzburgites and dunites. G.R.

Trace elements in diamond inclusions from eclogites reveal link to Archean granites.

T.R. Ireland, R.L. Rudnick and Z. Spetsius. *Earth & Planetary Science Letters*, **128**(3-4), 1994, 199-213.

Trace element data are reported for rare inclusions of garnet and clinopyroxene in diamonds in eclogite xenoliths from the Udachnaya pipe in the Daldyn-Alakit kimberlite field of Siberia. These inclusions are more depleted in incompatible trace elements and have lower *mg* numbers than the eclogite host minerals, reflecting metasomatic enrichment of the eclogites after diamond formation.

Experimental studies are interpreted as showing that eclogites of this type are in equilibrium with silicic melts such as tonalites or trondhjemites. Thus, both the trace element data and petrological considerations are consistent with the eclogites forming in equilibrium with Archaean tonalitic or trondhjemitic magmas.

R.A.H.

Gem Trade Lab notes.

R.C. Kammerling and C.W. Fryer. *Gems & Gemology*, **31**(1), 1995, pp 52-8, 15 illus. in colour.

A marquise-cut diamond showed an unusual fracture with thin film iridescence and natural colour staining which might be confused with the flash effect of a filled diamond. However, the 'feathery' appearance was typical of an unfilled break.

A new type triangular inclusion in a diamond is described. A triangular plane containing separate trigons was seen to be one of the octahedral faces of a phantom crystal within the host. The high relief of the trigons was attributed to gas trapped in the triangular voids formed at the interface of the phantom crystal and the host.

A dark red brilliant-cut diamond could be picked up with a hand magnet and contained inclusions with metallic lustre. Long wave UV revealed a cross-shaped area with green fluorescence whilst the rest of the stone remained inert; the stone fluoresced a faint orange under short wave UV. Visible spectroscopy revealed several absorption lines between 500 and 660nm including lines at 595 and 635nm with an emission line at 580nm. This pattern is typical of a treated stone. R.J.P.

Gem news.

J.I. Koivula, R.C. Kammerling and E. Fritsch. *Gems & Gemology*, **30**(4), 1994, pp 271-80, 16 illus. in colour.

The occasional diamond found in the Appalachian Mountains has been suggested to have local sources. Previous explanations include glacial transport and deposition by migratory birds.

Initial surveying on the Kahama/Shinyanga diamond leases in Tanzania by Serengeti Diamonds shows that diamond concentration in these secondary deposits is higher than that in the initial pipe due to wind action with an estimated deposit of 258 000ct. A US$8 million upgrade of the Mwadui mine discovered by Dr J. Williamson in 1940 is to be carried out since superficial reserves were exhausted in the 1980s.

United Reef Ltd of South Africa have reported results of valuations on diamonds from its Bamingui Project showing US$150 per carat making this one of the world's highest in terms of dollars per carat.

Canadian diamond prospects received a major setback in August 1994 when sampling at the Tli Kwi Cho kimberlite pipe in the Lac de Gras area of the Northwest Territories showed unexpectedly low results. A further poor report from the Torrie pipe in the Yamba Lake area produced a crash in diamond stocks which hurt investor confidence. However encouraging results have been obtained from a cluster of pipes in the Corridor of Hope which cuts through the Lac De Gras area. BHP/Dia Met are starting a feasibility study and hope to start mining before the year 2000.

Prospecting in Finland has received increased interest after Ashton Mining (Australia) discovered 21 kimberlite pipes and recovered several diamonds over 2 carats. R.J.P.

Geoscience 1994 and beyond: thoughts on geology and exploration for world-class ore deposits.

P.J. Legge. *Australian Journal of Earth Sciences*, **42**(1), 1995, 1-10.

In this Presidential Address, the use of new technologies is highlighted in a summary of developing concepts for exploration criteria. By determining the Ni content of a suite of kimberlite pyropes, it is possible to estimate the *P-T* conditions of garnet formation and hence judge the probability of formation in the diamond window of 850-1200°C at 150-200km depth depending on the geotherm. This work has been extended to estimate maximum grade (carats/tonne) in a kimberlite, based on the mix of mantle rocks entrained and the degree of metasomatism as measured by the Zr content of a suite Cr- pyropes from a pipe. R.A.H.

Diamonds and their sources in the Venezuelan portion of the Guyana Shield.

H.O.A. Meyer and M.E. McCallum. *Economic Geology*, **88** (5), 1993, pp 989-98, 5 maps.

Two sources are suggested for the diamonds. The secondary source is the 2000m thick Roraima group of Proterozoic age. The main sources probably are unknown Proterozoic kimberlites or lamproites in the Guyana Shield of the Amazonian craton. No evidence exists to support an African source. K.A.R.

Paleomagnetism of some Indian kimberlites and lamproites.

K.C. Miller and R.B. Hargraves. *Precambrian Research*, **69**(1-4), 1994, pp 259-67, 1 map.

Consistent vectors have been isolated by AF demagnetization of 22 cores from two sites in Proterozoic kimberlites in the Wajrakarur district of the Dharwar craton (pole at 45.4°S, 121.5°W), and 12 cores from two sites from the mine at Majhgawan in the Panna district of the Aravalli craton (pole at 38.9°N, 216.5°E). Surprisingly, these 1200-1000 m.y. poles fall close to roughly coeval points on the APW curve for the Kalahari craton in a Gondwana reconstruction. If the poles and their ages are correct, these data constrain Mesoproterozoic supercontinental reconstructions. R.E.S.

Compositions of garnet and spinel from the Aries diamondiferous kimberlite pipe, central Kimberley block, Western Australia - implications for exploration.

R.R. Ramsay, D. Edwards, W.R. Taylor, N.M.S. Rock and B.J. Griffin. *Journal of Geochemical Exploration*, **51**(1), 1994, 59-78, 2 maps.

This weathered, micaceous kimberlite pipe is the largest and most diamondiferous of the few kimberlites currently known in Australia. It contains abundant country rock xenoliths, but the only mantle-type inclusions so far recovered are individual grains of Cr-spinel, rare chromian pyrope and diamond. Aries differs from other kimberlites of similar age in the block in the absence of megacrystic minerals. Chromian pyrope has compositions which indicate garnet lherzolite and garnet wehrlite in the upper mantle, but harzburgitic 'G10' garnets, considered the paramount indicator of diamondiferous kimberlite in S. Africa, have not been recovered at Aries where spinel has been the most important indicator mineral in the discovery. This can be distinguished, morphologically and compositionally, from spinel in local basaltic country rocks. The spinels in the pipe have a range of internal features which can be allocated to six types which in turn can be combined into two broader classes. Both Class 1 and 2 spinels may be associated with Ti-rich Cr-spinel which is compositionally similar to titaniferous Cr-spinel from the groundmass. R.E.S.

[Mineralogical and petrological features of alkali-ultramafic lamprophyres and kimberlites of Kola Peninsula.] (Russian with English Abstract.)

S.K. Simakov, E.A. Bagdasarov and L.I.

LUKJANOVA. *Proceedings of the Russian Mineralogical Society*, **123**(1), 1994, 26-40.

Dykes and explosion pipes of alkali-ultramafic lamprophyres and kimberlites occur mainly in the S part of the Kola Peninsula, controlled by deep fault structures. Their formation corresponds with the final stage of alkali magmatism in the Palaeozoic Kandalaksha graben. Geochemically, these lamprophyres are rich in Fe and Ti, with high Na content. In kimberlites the Al_2O_3, ΣFe and SiO_2 decrease with increasing MgO content and K_2O/Na_2O ratio. Numerous EPMA results are reported for olivines, clinopyroxenes, garnets, chrome spinels, ilmenites and micas, together with clinopyroxenes, garnets and amphiboles from xenoliths in the explosion pipes, and native gold from a melteigite dyke, and native copper, solver, argentite, chalcocite and gersdorffite from a fine-grained kimberlite. The *P-T* conditions for lamprophyre magma formation are estimated to be in the range 10-40 kbar, 1425-1320°C, corresponding with a depth for the magma chamber of 40-130km. For kimberlitic magma, the formation *T* is estimated at 1360-1450°C, the *P* 30-51 kbar and the depth of magma chamber 110-160km. In general, there is a tendency for increase in chamber depth from W to E, towards the Archangelsky kimberlite province; this is reflected in the chemistry of the rocks and minerals, with increasing Mg, reduction in Ti and Na and a decrease of Ca in the olivines. R.A.H.

Story on the 'Cross of Asia' fancy yellow radiant cut diamond.

A. SZYMANSKI. *Archiwum Mineralogiczne*, **50**(1), 1994, 137-8.

An examination by the author of this diamond (fifteenth on the GIA list of clearly yellow coloured diamonds) is reported. Found in Jagersfontein mine, South Africa, in 1902, this stone originally weighed 280ct; it was cut first to 142ct and later recut three times to 112, 109.28 and finally to 79.12ct. It now has a rectangular shape (28.67 x 22.21 x 15.77mm) and the play of colours on the table facet create the outline of a Maltese cross. R.A.H.

The generation of kimberlites, lamproites and their source rocks.

K.M. TAINTON AND D. MCKENZIE. *Journal of Petrology*, **35**(3), 1994, 787-817, 1 map.

Measurements of the *REE* concentrations in South African kimberlites and in the Argyle lamproite from Western Australia constrain the composition of the source rocks from which these melts originate. To account for the amounts of Tm, Yb and Lu in these magmas, their sources must first have been strongly depleted by ~20% melting in the garnet stability field, and then enriched by a metasomatic melt rich in *LREE* and other incompatible elements. The calculated source compositions strongly resemble those of coarse, low-*T*, depleted peridotite nodules that are the commonest nodules in kimberlites. The *REE* composition of the metasomatic melt calculated from the diopsides and garnets in the sheared nodules, from the diopside megacrysts and from majorite garnet inclusions in diamonds is in excellent agreement with that expected for a melt produced by melting ~0.5% of the source region of ocean ridge basalts. The initial depletion event requires the extraction of ~20% melt from a region in which garnet and chrome-spinel were stable. The melt distribution obtained from the inversion of komatiite composition satisfies both these conditions. Kimberlite source rocks are shallower than the layer from which fertile nodules originate. Such nodules must therefore be transported by entrainment of the lower boundary of the layer that became unstable.

R.A.H.

The Luanda diamond fields [Part 1].

A. THOMAS. *South African Gemmologist*, **9**(2), 1995, pp 10-23, 3 maps (2 in colour).

First part of an account of the author's study of the history of exploration for diamonds in north-east Angola giving notes on the history of diamond recovery, export and marketing from this area. The bibliography is less helpful than at first appears, with some citations mistranscribed.

M.O'D.

UV-induced colour change in pink diamonds.

J. VAN ROYEN. *Antwerp facets*, March 1995, 21-4, 4 photos in colour, 3 figs. in colour.

This issue contains the 1994 annual report of the Diamond High Council.

Some pink diamonds have been found to change to a brown colour when exposed to intense UV radiation, the pink colour returning after a period of time. The absorption band near 550nm is reduced in strength by the irradiation. Heating to approximately 250°C will restore the original colour more quickly. M.O'D.

Analysis of diamonds and indicator minerals for diamond exploration by laser ablation inductively coupled plasma mass spectrometry.

R.J. WATLING, H.K. HERBERT, I.S. BARROW AND A.G. THOMAS. *Analyst*, **120**(5), 1995, pp 1357-64.

A method has been developed, using laser ablation – inductively coupled plasma – mass spectrometry (LA-ICP-MS), for the semiquantitative determination of 43 elements in diamonds, chromites and garnets. Samples of diamonds from five different countries and the interrelationship between their trace elements gives distinctive patterns for each source. This should allow the tracing of stolen diamonds and can also be used to establish the trace element distribution in indicator minerals for diamond exploration, such as garnets and chromites. The relative distributions of the REE, Ta and Hf indicate a consistent inter- element relationship for garnets associated with diamondiferous kimberlites; the trace element partitioning pattern of chromites can be used to establish a kimberlite or non-kimberlite provenance of this mineral. R.A.H.

Gems and Minerals

Die Cabochonsammlung, eine interessante Variante des Sammlung von Mineralien.

W. BECK. *Aufschluss*, **46**, 1995, pp 181-3, 6 photos (3 in colour).

A review of the fashioning and collecting of cabochon-cut gem and ornamental minerals, with particular reference to agate. M.O'D.

Gems around Australia - part 10.

H. BRACEWELL. *Australian Gemmologist*, **19**(1), 1995, pp 23-4, 6 illus. in colour.

This section describes a visit to the Marra Mamba tiger's-eye deposit 6km south of the majestic Hamersley Range main escarpment in the Pilbara area of Western Australia. Specimens range from a rich coppery coloured tiger's-eye to tiger's-eye with an attractive picture jasper. Although extensive deposits of blue asbestos or crocidolite are present, it takes a silica enrichment to leach into the seams to produce golden tiger's-eye. R.J.P.

A new variety of grossular garnet with extended gemmological constants.

R. BRIGHTMAN. *Australian Gemmologist*, **19**(1), 1995, pp 19-22, 1 table, 3 illus. in colour.

A new source of grossular garnet from Mali, West Africa, has produced specimens in a wide range of colour. X-ray diffraction and X-ray fluorescence analysis confirmed it as grossular but the refractive indices of a number of specimens ranged from 1.764 to 1.782 which are in excess of the range up to 1.760 quoted by Stockton and Manson (1985). Specific gravity determinations were within the quoted range of 3.65 to 3.67. All the specimens showed an absorption band at 440 - 445 nm (attributed to iron), which is not normally expected in grossular garnet. R.J.P.

A further update on value-enhanced jadeite.

G. BROWN. *South African Gemmologist*, **9**(1), 1995, pp 8, 17-18, 26-27, 30-31.

Notes on CIBJO rulings on value-enhanced jadeite, the enhancement commonly arising through waxing, resin coatings or epoxy-type fracture fillings. The writer feels that disclosure of enhancement should always be made. Details of some treatments and methods of identification are given. M.O'D.

An unusual sapphire-zircon-magnetite xenolith from the Chanthaburi gem province, Thailand.

R.R. COENRAADS, P. VICHIT AND F.L. SUTHERLAND. *Mineralogical Magazine*, **59**(3), 1995, pp 467-81.

A sapphire-, zircon- and magnetite-bearing xenolith is reported from alkali basalt at Khao Wua, near Chanthaburi, and is taken to demonstrate a common origin for sapphire, zircon and magnetite found in alluvial deposits in the Chanthaburi gem fields. The original Al- and Ti-rich octahedral magnetite crystal in the xenolith exsolved into hercynite, magnetite and hematite during cooling; it includes minor anhedral jarosite-alunite, possibly from an iron-sulphide-rich immiscible liquid. U-Pb dating of zircon in the xenolith gives an age of 1-2 ($\pm < 1$) m.y., falling within the fission-track ages for alluvial zircons (2.57 ± 0.20 m.y.) from the Chanthaburi-Trat gem fields and within the K-Ar ages of 0.44-3.0 m.y. for the alkali basalt volcanism in the Chanthaburi province. These data suggest a common origin for sapphire, zircon and magnetite, and link them with the processes involved in alkali basaltic magma generation. The high Fe and Zr, low Mg, and the inferred sulphides suggest pegmatite-like crystallization in an incompatible-element-enriched, silica-poor magma (partial melt or fractionation product) in the deep crust or upper mantle. Etch features on exposed surfaces of the xenolith indicate that it was transported out of its equilibrium environment by the rise of later magma. R.A.H.

Alteración de las inclusiones de zircón, apatito y vidrio en el tratamiento térmico de rubies y zafiros.

J.S. CÓZAR AND I. DE VICENTE-MINGARRO. *Boletin del Instituto Gemologico Espanol*, **36**, 1995, pp 47-54, illus. in colour.

Alteration of mineral inclusions is one of the indications of the heat treatment of corundum. Features of the alteration of zircon, apatite and glass are discussed. M.O'D.

A la recherche de la glyptique moderne.

M. DUCHAMP. *Revue de Gemmologie*, **123**, 1995, pp 4-8, 8 photos (2 in colour).

Description of the work of some contemporary glyptic artists with notes on the ornamental materials used. M.O'D.

Pink topaz from the Thomas Range, Juab County, Utah.

E.E. FOORD, W. CHIRNSIDE, F.E. LICHTE AND P.H. BRIGGS. *Mineralogical Record*, **26**(1), 1995, 57-60, illus. in colour.

Topaz is found in lithophysal cavities in rhyolite in the Thomas Range, Juab County, Utah, USA. The geology and mineralogy of the area are described and there is a list of minerals identified from the Topaz Mountain rhyolite. Topaz crystals showing a sherry-brown colour typically fade to colourless within weeks: some other crystals show a more or less uniform pink colour and are of gem quality. Some crystals show a pink-red colour masked to some degree by a sherry-brown colour which fades on exposure to sunlight: the underlying pink-red colour in such cases does not fade. The topaz is extremely fluorine-rich and contains almost no water. The pink colour is not ascribed, as formerly, to Cr as a trace element but to the substitution of Al^{3+} by $Mn^{3+}\pm Fe^{3+}$. M.O'D.

Occurrences of boron-free and boron-poor kornerupine.

C.R.L. FRIEND. *Mineralogical Magazine*, **59**(1), 1995, pp 163-6.

The problem of kornerupine virtually free of B is discussed and a new analysis is reported of a cream-coloured kornerupine from an area of amphibolite-facies rocks 50km E of Fiskenæsset, SW Greenland; this mineral has B_2O_3 0.38 wt.%, equivalent to B 0.081 pfu. It is suggested that a new term 'boron-free' kornerupine be introduced to cover those samples with 0.2 B pfu. R.A.H.

An evaporitic origin of the parent brines of Colombian emeralds: fluid inclusion and sulphur isotope evidence.

G. GIULIANI, A. CHEILLETZ, C. ARBOLEDA, V. CARRILLO, F. RUEDA AND J.H. BAKER. *European Journal of Mineralogy*, **7**(1), 1995, 151-165.

The fluids trapped by emerald, dolomite and pyrite in the Colombian emerald deposits consist predominantly of Na-Ca brines with some KCl; the similarity of the fluid composition in the E and W emerald zones demonstrates the homogeneity of the parent fluids. The Na-Ca-K chemistry of the brines gives strong support for an evaporitic origin of the parent hydrothermal fluids. The $\delta^{34}S$ values of H_2S in solution in equilibrium with pyrite from six emerald deposits range from 14.8 to 19.4‰ whereas sedimentary pyrite from the enclosing black shales yield a $\delta^{34}S$ of -2.4‰. The narrow range in $\delta^{34}S_{H2S}$ between the different deposits suggests a uniform and probably unique source for the sulphide-sulphur. The high $\delta^{34}S_{H2S}$ values suggest the non-participation of magmatic or early Cretaceous black-shale sulphur sources. Saline diapirs occur in the emeraldiferous areas and the most likely explanation for high $\delta^{34}S$ involves the reduction of sedimentary marine evaporitic sulphates. This type of unique emerald deposit corresponds with mesothermal deposits (300°C), formed in a sedimentary environment and produced through thermochemical reaction of sulphate-rich brines to H_2S by interaction with organic-rich strata.

R.A.H.

The symmetry of vesuvianite.

L.A. GROAT, F.C. HAWTHORNE, T.S. ERCIT AND A. PUTNIS. *Canadian Mineralogist*, **31**(3), 1993, pp 617-35.

Examination of the physical and chemical properties of 76 samples of vesuvianite from 50 localities is reported. On the basis of optical properties, three groups are recognized: 1) normal crystals which show uniform extinction and small (0-5o) 2V, 2) blocky crystals showing irregularly-shaped areas of variable birefringence in a (001) section, with 2V 5-35°, and 3) sector-zoned crystals showing {001}, {101} and {100} sectors with low (~5°), intermediate (20-35°) and high (40-60°) 2V, respectively. A combination of optical and XRD evidence indicates that the symmetry of vesuvianite is *P2/n* (or *Pn*). It is suggested that there is a virtually continuous ferroelastic phase transition between a high-*T* *P4/nnc* structure and a low-*T* *P2/n* or *Pn* structure. The variety of optical types of vesuvianite results from different relationships between the *T* interval of crystallization and the T of the phase transition. R.A.H.

Precious layer opal with a complex sedimentary formation process as colloid chemical precipitation, sedimentation and evaporation.

H. HARDER. Neues Jahrbuch für Mineralogie, Monatshefte, (3), 1995, pp 121-6.

Experimental work leads to the conclusion that the formation of layer opal in desert conditions is controlled not only by evaporation but also by the enrichment and separation of SiO_2 from the primary alkaline weathering solutions. Neutralization by CO_2 vapour may result in an oversaturation and a slow precipitation of $Al(OH)_3$ together with a strong colloid chemical enrichment of SiO_2. After deposition as porous jelly opal, the primary water-rich layer opal can slowly dry out to a solid opal, which may rarely form a layer of precious opal. R.A.H.

Influence of chemistry on the pyroelectric effect in tourmaline.

K.D. HAWKINS, I.D.R. MACKINNON AND H. SCHNEEBERGER. *American Mineralogist*, **80**, 1995, pp 491-501, 5 figs.

In tourmaline the pyroelectric coefficient is variously affected by elements occupying the X, Y and Z cation sites in the structure. The effect is strong when Fe occupies the octahedral Y site since Fe prefers this position and the effect increases when Fe and Mg cations are added to the smaller Z octahedral site. Whether or not this indicates a determinable trend is hard to distinguish since in tourmaline in almost all samples Al occupies the Z site to the exclusion of other cations. Occupancy of the X site does not affect pyroelectricity. M.O'D.

Eindrücke und mineralogisch-geologische Notizien von der Tansanit-Grube in Mirerani bei Arusha/Tansania.

B. HERGARTEN AND M. HERGARTEN. *Aufschluss*, **46**, 1995, 43-6, 5 photos, 1 map.

Account of the tanzanite deposits of Mirerani in the area of Arusha, Tanzania, and their working. M.O'D.

Alexandrite chrysoberyl surprises.

A. HODGKINSON. *Australian Gemmologist*, **19**(1), 1995, pp 25-8, 1 illus. in black-and-white, 5 in colour.

Attention was drawn to the striking trichroism shown by natural alexandrite but refractive indices of alpha = 1.761, beta = 1.770 and gamma = 1.773 not only showed anomalously high values but also that it was biaxial negative rather than positive. These properties were attributed to a higher than normal iron content. Alexandrite and ruby absorption spectra are normally quite similar but in this stone there is a strong band at 444nm typical of chrysoberyl. Examination of a synthetic alexandrite showed that it possessed properties identical to those of natural alexandrite. Another stone, a Uralian alexandrite, appeared red in incandescent light but blue rather than green in daylight conditions. It has normal constants for chrysoberyl and its chromium content was confirmed by chemical analysis. In this case the iron content was greater than that of chromium. A synthetic green chrysoberyl with chromium provided additional interest and prompted the suggestion that despite a Cr spectrum its lack of colour change could be attributed to nickel and iron being leached from the walls of the growth cylinders. R.J.P.

Gem Trade Lab notes.

R.C. KAMMERLING AND C.W. FRYER. *Gems & Gemology*, **30**(4), 1994, 264-70, 17 illus. in colour.

A light yellow diamond was shown to have been treated by examination of the mid- infrared spectrum which revealed H1b and H1c lines. A carved emerald fetish from a pre-Columbian necklace was confirmed as natural with no clarity enhancement. A feldspar represented as sanidine was shown to be labradorite with refractive index values of 1.559-1.568. A simple test to distinguish some plagioclase feldspars from alkali feldspars is the appearance of brilliant multicoloured stripes showing polysynthetic twinning which only occurs in feldspars of the triclinic system, thus microcline and the plagioclases show twinning but not sanidine or orthoclase. A grossular-andradite garnet from Mali West Africa as yellow-green rough had a single RI value of 1.77 an SG of 3.65 and strong ADR. Microscopy showed an unusual pattern resembling dodecahedral growth and a wispy horse-tail inclusion. Its nature was confirmed by X-ray powder diffraction and EDXRF analysis. A jadeite bracelet was shown to be bleached and impregnated. Removal of impurities with acid had left a honeycomb surface. A drop of hydrochloric acid remained intact and infra-red spectroscopy showed evidence of polymer treatment. A synthetic malachite necklace had a spot RI of 1.55 and only slight effervescence with hydrochloric acid. It showed a conchoidal fracture and fluoresced green to both long and short-wave UV. Destructive tests with a hot needle turned the material a chalky white with melting. A genuine malachite necklace showed a strong birefringent blink on the refractometer and effervesced strongly with hydrochloric acid. It was inert to both forms of UV and with a hot needle produced a brown spot with no melting.

Abalone 'Mabe' pearls made with blister pearls cultivated in the abalone shell showed a fine cellular structure in the blister portion while strong yellow fluorescence to long wave UV showed its derivation from abalone. A non-nacreous cultured pearl described as resembling a shiny black marble from the black-lipped oyster harvested in French Polynesia was thought to be the result of an unusual culture in which critical epithelial cells were missing.

A sapphire with an unusual reddish-brown colour, similar to that of alexandrite in incandescent light but with no colour change was due to pink and green-blue bands with some influence from the stone's dichroism. The high RI values of 1.775-1.784 still fell within the quoted limits for natural brown sapphire. A synthetic pink sapphire showed a strong red fluorescence but the typical bluish-white reaction to short-wave UV was uneven and confined to clearly defined curved colour bands. R.J.P.

Gem Trade Lab notes.

R.C. KAMMERLING AND C.W. FRYER. *Gems & Gemology*, **31**(1), 1995, pp 52-8, 15 illus. in colour.

An alexandrite with a green to purple colour change had optical properties typical of alexandrite but twinning was shown by brightly coloured irregularly-shaped worm-like areas under magnification and using a polar.

A filled emerald with unusual flash-effect colours showed orange to pinkish-purple in one direction and a blue and orange effect in another. The reason may be that emerald, being uniaxial with two distinct refractive indices, produced two crossing dispersion curves in conjunction with a non-crystalline filler. The flashes occur at the wavelength at which the refractive indices match. Bright field illumination produces blue whilst dark field illumination gives the complementary colour orange, these forming a colour pair. In the other orientation orange to pink forms the dark field colour. The expected bright field colour green to blue green was probably masked by the body colour.

A mottled green cabochon with typical jadeite properties was shown to be bleached and polymer impregnated. Microscopically, certain grains were shown to be eroded, whilst infrared spectroscopy confirmed the presence of a polymer. A jadeite necklace was shown to contain both natural and treated beads. Of the two jades, jadeite is much more commonly colour-enhanced, so it was unusual to come across nephrite cabochons dyed green. The visible spectrum showed a dye band in the red centred at 660nm. A purple sapphire cabochon with diffusion induced colour and star on immersion in methylene iodide showed a red colour confined to the surface and a number of red spots near the centre of the star which suggested that the original intention was to produce ruby.

A green star sapphire was described with an absorption line at 670nm attributed to cobalt and showing uneven asterism. Energy dispersive X-ray fluorescence spectroscopy (EDXRF) indicated cobalt as the colouring agent. A natural spinel with a dendritic iron stain which could be confused with yellowish-white or yellowish-brown flux was confirmed by EDXRF spectroscopy. In addition the stone had inclusions in the form of octahedral crystals as well as large feathers. In some flux-grown synthetic spinels pyramid-shaped phantoms in near perfect alignment with external faces and edges of the octahedra are present and could be confused with octahedral inclusions present in the natural stone. R.J.P.

Ruby and sapphire from the southern Ural Mountains, Russia.

A.J. KISSIN. *Gems & Gemology*, **30**(4), 243-52, 2 tables, 10 illus. in colour.

Ruby and sapphire have been known in the South Urals for over a century and were presumed to be in pegmatites. In 1978 the author postulated that these may have originated in the marbles which were widespread in the Kootchinskoye area. Ruby and sapphire mineralization is now known to occur in marbles within four metamorphic complexes in the Urals. These gemstones were found *in situ* as well as in alluvial deposits. From the known geology other corundum bearing areas are believed to exist in the 600km linear belt including Ekaterinburg, Chelyabinsk and Plast. At present gem quality stones are being evaluated prior to commercial extraction.

A detailed examination of the Kootchinskoye marbles revealed that of three types only dolomitic calcite marble contained corundum. Rubies and sapphires could be grouped in three main classes but only two had good enough colour and clarity for faceting. One class consisted of ruby in thick platy well formed crystals with inclusions of pyrites and gas. The other consisted of rounded and acicular pink sapphires with pyrites, black rutile and gas inclusions.

Some corundum deposits in Myanmar, Pakistan, Afghanistan and Tanzania are similar. In the system corundum + dolomite = spinel + calcite + carbon changes in pressure and temperature are important and the magnesium content of the marble will have a major influence on whether spinel is the preferred (stable) mineral phase. R.J.P.

Inclusions in quartz.

J.I. KOIVULA AND R.C. KAMMERLING. *South African Gemmologist*, **9**(1), 1995, pp 7-16, 12 photos in colour.

An illustrated summary of mineral and other inclusions in quartz with a table of minerals so far identified. M.O'D.

Inclusions in garnets.

J.I. KOIVULA AND R.C. KAMMERLING. *South African Gemmologist*, **9**(2), 1995, pp 24-32, 12 photos in colour.

Illustrated general survey of the main inclusions in gemstones of the garnet group. The horsetail effect in the demantoid variety of andradite is now ascribed to tremolite-actinolite or to chrysotile. In orange spessartine recently found in Namibia black grains are identified as manganese oxide, and transparent virtually colourless needles as tremolite. M.O'D.

Gem news.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, **30**(4), 1994, pp 271-80, 16 illus. in colour.

A new source of amethyst from North Namibia yields several tons annually but mining can only take place in the six-month dry season. An unusual chatoyant demantoid garnet had the horsetail inclusions orientated in a parallel fashion with some inclusions 'bending back' on themselves. A colour-change diaspore from Turkey showed a distinct colour change from brownish-pink in incandescent light to brownish-green in daylight. The brown colour was attributed to Fe^{3+} whilst Cr^{3+} caused the colour change. White translucent cabochons with red crystal inclusions from Myanmar were shown by X-ray diffraction analysis to be plagioclase feldspar with ruby. Gems from North Carolina included cabochons of emerald matrix and of kyanite of greenish- blue to blue with colourless areas. Peridot from Pakistan in the far western Himalayas has standard gemmological properties. On the basis of RI and SG values the material is 90 per cent forsterite and 10 per cent fayalite. Black rod-like inclusions present in the rough proved to be the magnesium iron borate mineral ludwigite. Large blue sapphire crystals were reported from the Isle of Lewis, Scotland, including one of 242 carats. A blue cobalt-coloured spinel from Burma showed abundant iron, a trace of manganese and unusually high nickel content; cobalt was not detected.

A general shortage of gems from Sri Lanka has been blamed on unusual weather conditions. Large reserves of 'zebra stone' are reported from Arizona consisting of actinolite or tremolite amphibole and plagioclase feldspar. R.J.P.

Gem corundum in alkali basalt: origin and occurrence.

A.A. LEVINSON AND F.A. COOK. *Gems & Gemology*, **30**(4), 1994, 253-63, 1 table, 7 illus. in colour.

The majority of gem corundums in the jewellery industry are derived from secondary deposits in SE Asia and Australia, and are associated with alkali basalts which are uncommon geologically. The mineralogy and chemistry of the basalts are well reviewed; the basalts are silica-deficient and do not contain visible quartz. From the theory of plate tectonics the subduction of oceanic basalts beneath a continental plate may eventually give rise to tholeiite basalts and alkali basalts with the latter forming at depths greater than 50-60km. Although associated with alkali basalt, sapphires may not have crystallized from it, being xenocrysts derived from broken or molten xenoliths. Other xenocrysts in alkali basalts include zircon, some garnets and spinel. Two mechanisms of corundum formation each involving a different starting material are discussed. One mechanism involves subduction of aluminium-rich shales with muscovite which breaks down to give orthoclase feldspar and corundum, providing that quartz is absent. A second mechanism involves hydrated aluminium oxides such as gibbsite and diaspore. Conditions for this may exist at depths as shallow as 24km. The mechanism for the transport of corundum to the surface is described in detail.

Alternative theories based on studies on Australian deposits attach great importance to associated inclusions such as zircon. A model involving two magmas was evolved by Coenraads. The first, a carbonate-enriched mafic magma containing metals not associated with common rock forming minerals, allows corundum to crystallize within it. The second magma of alkali basalt entrains the corundum on eruption. Guo developed a more complex multi-stage model involving four magmas and possibly too many special conditions to occur on a large scale. It is hoped that the use of such models will enable future sites of corundum deposits to be predicted. R.J.P.

Farbenstehung und -verteilung in fluorit.

W. Lieber. *Aufschluss*, **46**, 1995, 1-11, 18 photos (15 in colour).

The cause of colour in fluorite is discussed with examples taken from a variety of locations.

M.O'D.

Hanneman-Hodgkinson synthetic emerald filter.

T. Linton and A. Shields. *Australian Gemmologist*, **19**(2), 1995, pp 65-8, 1 table, 5 illus. in black-and-white.

The Hanneman-Hodgkinson synthetic emerald filter (referred to as the H-H filter) holds two gelatin filters, one an orange-yellow and the other blue. These combined filters allow transmission of 3 per cent of the 480-560nm wavelengths and 66 per cent of all red wavelengths above 670nm. Essentially it transmits more red, yellow and green wavelengths than the Chelsea Filter. Whilst the Chelsea Filter spots most emeralds by a pink/red response, the H-H Filter distinguishes all synthetics from natural by the pinkish/reddish response of the synthetics (with stated exceptions of the Biron/Pool hydrothermal synthetic emeralds, unspecified Russian hydrothermal synthetics and Lechleitner coated beryl). The manufacturers suggest that the stone should have its optical properties checked to confirm its identity as an emerald and that a microscopic examination be made before a positive judgement is made. The Evaluation Committee coopted several competent students whose pooled results showed that the Chelsea Filter detected most emeralds and the H-H Filter reacted to most synthetics as the inventors suggested. It appears that 60 years after the introduction of the Chelsea Filter, emeralds still defy a definitive means of identification using filters of this type. R.J.P.

Mineralization and potential of the gemstone industry of Zambia.

S.H. Mambwe and C. Sikatali. *In Industrial minerals in developing countries*, S.J. Mathers and A.J.G. Notholt, eds. British Geological Survey/Association of Geoscientists for International Development: AGID Report Series No. 18, 1994, 265-72, 1 map.

Gemstones are found in all nine provinces of Zambia, hosted in pegmatites and veins in Pre-Karoo rocks. They include emerald, aquamarine, amethyst, beryl, tourmaline and garnet. There is some potential for ruby and sapphire, as well as for the recovery of rose quartz and other silica varieties. R.A.H.

The mineralogy, geology and occurrence of topaz.

M.A. Menzies. *Mineralogical record*, **26**(1), 1995, 5-53, illus. in colour.

A major study of topaz, the paper discusses geology, mineralogy and occurrence of topaz with a good deal of comment on gem-quality crystals, a number of which are illustrated in colour. The major topaz-producing areas are described with historical notes on locations such as Schneckenstein. A table lists gem topaz deposits worldwide with references to the literature and there is also an 11-column bibliography. Among the coloured illustrations are reproductions from older mineralogical books, including Richard Braun's *The mineral kingdom* (1908). Figures in the text draw comprehensively from Goldschmidt's *Atlas der Krystallformen*. Maps and figures illustrate major deposits generally and particularly. M.O'D.

What's new in minerals?

T. Moore. *Mineralogical Record*, **26**(2), 1995, 147-53, 14 photos in colour.

Among specimens on display at the 1995 Tucson Gem and Mineral Show were fine elbaites, with one crystal 8cm long, from the

Himalaya Mine, California; red beryl from the Wah Wah Mountains, Beaver County, Utah, with some crystals up to 6cm long; emerald crystals on a calcite matrix from the Coscuez Mine, Boyact, Colombia. The matrix in which the crystals are found, in underground working at the Coscuez-Los Gavilanes mine, 12 miles from the Muzo mine, may be calcite or black shale or both. Orange scapolite from the Mpwampwe mine, Morogoro, Tanzania, and loose dodecahedrons of what is probably andradite from Mali, diaspore from what is said to be the Aydin-Mugla region of Turkey, golden beryl and blue beryl from Volodarsk, Ukraine, with reddish-brown vesuvianite from an as yet unspecified locality in Pakistan, complete the gem mineral portion of the report - apart from further praise for the Pakistan peridot. M.O'D.

What's new in minerals?

T. MOORE. *Mineralogical Record*, **26**(3), 1995, pp 215-30, 45 photos (42 in colour).

Minerals exhibited at the 1995 Tucson Gem & Mineral Show included peridot crystals from Pakistan: the locality is now placed as Suppatt, between Kamila and Naran, North West Frontier Province. The site is reported to be a string of prospect pits with Dasu the closest town. It is believed that some peridot hitherto attributed to China and to Afghanistan may come from this site in Pakistan. Colourless prisms of hambergite are reported from Drot, Gilgit-Skardu Road, Northern Areas of Pakistan. Fine rhodochrosite crystals were exhibited from the Sweet Home mine, Colorado, and yellow apatite crystals from the Sceptre Claims, Emerald Lake, Yukon, Canada. Reddish-pink grossular crystals from Sierra de las Cruces, Coahuila, Mexico, appear to be of gem quality and there was some attractive green smithsonite from the 79 mine in Arizona. Red beryl from the Maynard claim in the Thomas Range in Utah was prominent along with topaz crystals from the same area of the state. Diamond crystals in matrix were shown from both China and Russia: fine clear yellow beryl crystals were shown from mine no 2, Volodarsk-Volynsk, Zhitomir region, Ukraine. M.O'D.

The Yogo sapphire deposit.

K.A. MYCHALUK. *Gems & Gemology*, **31**(1), 1995, pp 28-41, 14 illus. in colour.

Sapphires were discovered at Yogo Gulch over a century ago and the deposit is one of four major sapphire producing areas in Montana, USA. The Yogo sapphires are noted for their uniform well-saturated blue colour ('corn flower' blue) and a relative absence of inclusions and zonation. They do not require heat treatment and their flat rough crystals generally weigh less than one carat. Unlike other Montana deposits the Yogo deposits are primary with the sapphires being mined directly from at least six parallel dykes of lamprophyre rock. In one hundred years the Yogo deposit has produced 18.2 million carats of rough which has yielded more than 0.5 million carats of cut stones.

The history of the deposit is described. Now the Vortex Mine is the only active underground mine and Yogo sapphires are marketed as the world's only sapphires guaranteed not to have been heat treated. An early theory of the origin of the sapphires was their direct formation from the Yogo magma as phenocrysts in which silica-deficient Yogo magma incorporated large amounts of Al-rich shales as it rose towards the surface. Later it was suggested that the Yogo magma incorporated fragments of kyanite bearing gneiss instead of shales. The kyanite, a source of aluminium, was then consumed by the magma and later crystallized as corundum. Observed inclusions such as carbon dioxide gas and analcime are consistent with the direct formation of sapphires from the magma. However it is also possible that the sapphires were incorporated as xenocrysts by a Yogo magma which captured fragments of the corundum-bearing gneiss and transported it upwards as xenoliths. Support for this theory has come from computer simulations of multi-component crystallization but additional research will be required to finally resolve the question. R.J.P.

Einschlusse-Phänomene im Quarz.

G. NIEDERMAYR. *Mineralien Welt*, **6**(4), 1995, pp 15-16, 3 photos (2 in colour).

The presence and types of mineral inclusion in quartz are discussed. Lepidocrocite, antimonite, rutile and ilmenite are illustrated. M.O'D.

Mineralogische Reise nach Pakistan.

P. PAULITSCH. *Aufschluss*, **46**, 1995, 37-41, 2 photos (1 in colour).

Short account of an excursion to Pakistan with particular reference to emerald deposits, emerald synthesis and tourmaline. M.O'D.

Rubies from Mong Hsu.

A. PERETTI, K. SCHMETZER, B. HEINZ-JÜRGEN AND

F. MOUAWAD. *Gems & Gemology*, **31**(1), 1995, pp 2-26, 4 tables, 4 illus. in black- and-white, 30 in colour.

Since 1992 a primary source of ruby has been Mong Hsu in north eastern Myanmar. Untreated samples showed a distinctive dark violet to almost black cores with ruby rims.

Geological studies in the Mong Hsu area showed that the ruby deposits occurred in upper Palaeozoic marbles. Other minerals found with the ruby rough include green and brown tourmaline, andalusite, almandine, quartz and tremolite and they indicate that the deposits are metamorphic. Associated secondary deposits occurred as gravels which are removed and processed for gems by using elaborate sluicing systems.

Cut stones are usually heat treated and many have glass fillings. The stones are heated to remove the violet colour and then in borax to fill any fissures. Typical crystals were well-terminated barrel shaped and the distinctive colour distribution was reflected in some of their gemmological properties. The commonest inclusions are whitish particles; rutile, fluorite and spinel were rarely found. Whitish streamers orientated perpendicularly to growth planes extend from the outermost edge of the violet core. Heat treatment not only removes the violet colour but may cause additional fractures due to decrepitation of entrapped solid matter which decreases the transparency of the stone. Second stage heating in the presence of borax can result in solution of alumina and healing of open fracture planes.

X-ray fluorescence analysis and electron probe analysis showed significant trace concentrations of chromium, iron, titanium, vanadium and gallium; refractive indices correlated with the total concentration of these.

Spectra of the violet cores showed a Cr^{3+} absorption spectrum with a superimposed broad Fe^{2+}/Ti^{4+} charge transfer absorption and an additional line at 675nm whose cause is unknown.

R.J.P.

Eudialyte crystals from the Kola Peninsula.

N.A. PEKOVA. *World of Stones*, **5/6**, 1995, pp 8-11, 5 photos in colour, 8 figs.

Near-gem quality eudialyte crystals have been recovered from underground mines in the Yukspor and Rasvumchorr mountains, Kola Peninsula, Russia. Crystals reach no more than 7mm in size but are a transparent red. Fine quality crystals are described from other locations in the same region and the properties and crystallography of eudialyte are discussed.

M.O'D.

En direct de Madagascar.

D. PIAT AND M.-P. BOUQUEAU. *Revue de Gemmologie*, **123**, 1995, pp 12-13, 3 photos (1 in colour), 1 map (in colour).

Brief account of a visit to a sapphire-bearing mine at Andranondambo, Malagasy Republic. Gem-bearing sites in the vicinity are reported to be controlled by Swiss, Thai and Israeli enterprises. M.O'D.

Euhedral sinhalite crystals from Sri Lanka.

L.C. PITMAN, C.S. HURLBUT AND C.A. FRANCIS. *Mineralogical Record*, **26**(2), 1995, 91-4, 3 photos (2 in colour) 1 fig.

Morphological details of two euhedral sinhalite crystals from Sri Lanka (the first recorded from this location) accord with data given for a crystal from Burma. There are 32 faces, giving 13 forms for one crystal and 31 faces and 9 forms for another. The pale brown colour is attributed to ferric iron. One specimen was a pale transparent pebble of 36ct and measuring 2.6 x 1.6 x 1.2cm, the other was one of a pair of transparent pale brown crystals. The location is reported to be Balangoda, about 25km east of Ratnapura.

M.O'D.

Porcelanite - ein neuer Landschaftsmarmor aus Tschechien.

L. REJL AND A. TUMA. *Lapis*, **20**(3), 1995, 42-4, 4 photos in colour, 1 map.

A marble with landscape patterning has been given the name porcelanite, the location being in the Bućník area of the Czech Republic. M.O'D.

Zur Entstehung der sternförmigen Achate in sauren Vulkaniten.

R. RYKART. *Aufschluss*, **46**, 1995, 33-6, 7 photos (6 in colour), 1 fig.

Formation of agate with a star-shaped interior is discussed with examples taken from acidic volcanic rocks. M.O'D.

Meerschaum from Eskisehir Province, Turkey.

K. SARIIZ AND I. ISIK. *Gems & Gemology*, **31**(1), 1995, pp 42-51, 11 illus. in colour.

Sepiolite, a hydrated magnesium silicate, is commonly known as meerschaum in its massive compact form. It has a very low specific gravity and hardness, and is easily carved and polished.

The Eskisehir deposits have been used since the eighteenth century and the meerschaum is mined using rudimentary mining methods. Examination of sepiolite nodules shows that many have a magnesite core indicating that magnesite formed first and was later replaced by sepiolite. The physico-chemical behaviour of Mg^{2+}, $SiO_{2(aq)}$ and H_2O has been thoroughly investigated and it is concluded that meerschaum nodules probably formed at shallow depths under alkaline conditions in the vicinity of paleo-shorelines of a large inland lake.

During carving the meerschaum has to be kept wet to maintain its softness. After carving it is slowly dried in the sun and finally for two hours in an oven at 110°C. After polishing with a fine abrasive it is immersed in liquid beeswax for a few minutes. The creamy-white colour of pipe bowls progressively turn yellow due to absorption of nicotine. Although the recent decline in smoking has affected the demand for pipe bowls, sepiolite has many other industrial uses including that of an ivory simulant. However, ivory is much harder than meerschaum and can bend without breaking. R.J.P.

Tucson 1995: Neues, Neues Altes, Altes.

J. Scovil and C. Weise. *Lapis*, **20**(4), 1995, 25-8, 8 photos in colour.

Among the minerals reported from the 1995 Tucson Gem & Mineral show were reddish grossular from Mexico, hambergite from Pakistan in crystals up to 1.8cm across and gem-quality olivine from Sopat, Pakistan, with a crystal 7.9cm in length pictured with a faceted stone: this material occurs in a white talc matrix. M.O'D.

[The pulse cathodoluminescence of corundums.] (Russian with English abstract)

V.I. Solomonov, S.G. Mikhailov, V.V. Osipov, V.N. Avdonin, M.F. Vasilevskaya and V.I. Yakshin. *Proceedings of the Russian Mineralogical Society*, **123**(6), 1994, pp 39-51.

This proposed pulse cathodoluminescence (PCL) method uses nanosecond high-current, pulse-repeated e-beams, as an alternative to the usual continuous low-current electron streams. Measurements are taken in the 340-800nm range and do not involve destruction of the sample, or its previous heating. Spectra of natural and synthetic corundums (except for Vietnamese sapphires) have a strong red band with dominant chromium lines at 694.3 and 692.9nm; its maximum intensity was shown by synthetic rubies and the minimum intensity in grey-blue natural corundum. A long wave wing of this red band is formed by N-Cr lines; S-lines are fixed in the short wave wing of the spectrum. There are two new wide bands seen in the PCL spectrum of corundums: blue (482nm) and green (555nm); they dominate the PCL spectra of Vietnam sapphires. Some PCL spectra of spinels are also presented. R.A.H.

Granatfund aus dem Täschtal bei Zermatt (VS).

H.A. Stalder and M. Aufdenblatten. *Auschluss*, **10**(7), 1995, pp 267-79, 10 photos in colour, 4 figs.

Dark red crystals of garnet from which faceted stones have been cut are found in the Täschtal, close to Zermatt in canton Valais, Switzerland. Diopside and vesuvianite are found with the garnets which occur as combinations of rhombic dodecahedra and icositetrahedra and which are classified as the hessonite variety of grossular. M.O'D.

Texture formation of agate in geode.

L. Taijing and I. Sunagawa. *Mineralogical Journal*, **17**(2), 1994, 53-76.

Optically observable individual fibres in agate bands are shown by electron microscopy to be composed of much finer fibres in which quartz crystallites, 8-100nm in length, are aligned parallel to $\langle 11\bar{2}0\rangle$ or $\langle 10\bar{1}0\rangle$, with the *c* axes perpendicular to the fibre elongation. Both uniformly spaced systematic striations and 'Runzelbänderung' in agate bands, and coarse quartz or amethyst crystals radiating inwards to the open space in a geode have essentially the same texture as that of ordinary agate bands, and were formed when growth conditions were stabilized. The coarse quartz represents the final stage in the formation of agate bands, whereas the strata-forming horizontal banding consists of only euhedral quartz grains 0.5-4 µm across, or spherulites with a diameter ≤ 100 µm, or both; they were precipitated due to gravity after the formation of agate bands and coarse quartz crystals. Based on these observations, it is suggested that the quartz crystallites in agate were precipitated from a hydrothermal solution invading a geode in which polymerized embryonic particles with a quartz structure with a size of ~10nm were already present. R.A.H.

Achatähnlicher Kalkstein aus Niederösterreich.

L. THALHAMMER. *Lapis*, **20**(3), 1995, 45-6, 3 photos (2 in colour).

A limestone with patterning and colour resembling agate is reported from the Piestingtal area of Lower Austria, close to the B21 road. M.O'D.

Heat treating sapphires from the Anakie District, Australia.

T. THEMELIS. *Australian Gemmologist*, **19**(2), 1995, pp 55-60, 5 illus. in black-and-white, 5 in colour.

The effects of heat on colour and clarity were systematically studied to determine the optimum conditions for maximizing the enhancement potential of sapphires. Regardless of the type of atmosphere used it was found that 'silk' was partially dissolved at 1400°C and was completely dissolved at 1650°C and upwards. This increased the clarity of the stones and increased their value. Green to yellow sapphires on heat treatment did not produce stones of significant value. Blue to green stones produced better results whereas near-colourless, silky and brown spotted sapphires produced the best results. Using carefully controlled rates of heating and cooling prevented cracking.

The sapphires were initially cleaned in dilute hydrofluoric acid after which orange to reddish-brown zircons were identified and removed. The sapphires were then classified into nine types according to colour and milkiness and subjected to a total of eight separate heating runs under specific conditions. From this it was deducted that four sets of conditions could satisfactorily deal with all the types.

A batch heating system was discussed and involved reheating in many cases. The author did not reveal details of the gas mixtures used but stressed their poisonous nature and highly explosive characteristics which required expert handling.

The author concluded that high quality sapphires should be treated by type whilst commercial and lower quality stones should be batch treated. The author followed a systematic approach but retained the mystique expected of such treatments. R.J.P.

Vanadian-chromian garnet in mafic pyroclastic rocks of the Malé Karpaty Mountains, western Carpathians, Slovakia.

P. UHER, M. CHOVAN AND J. MAJZIAN. *Canadian Mineralogist*, **32**(2), 1994, 319- 26, 2 maps.

Unusual examples of V-Cr garnets are described from Lower Palaeozoic metamorphosed mafic pyroclastic rocks enriched in V, Cr and C_{org}, in the Pezinok-Pernek complex of the Malé Karpaty Mts, NE of Bratislava. The garnet is emerald-green, 0.5mm in size with *a* 11.98 Å, *n* 1.810, *D* 3.75 g/cm³ and contains V_2O_5 9.5-22.1, Cr_2O_3 5.5-10.9, Al_2O_3 0.4-7.6 wt.%, corresponding with goldmanite 27-65, uvarovite 19-34, grossular 1.5-33, yamatoite 2-5 mol.%. The associated hydromica contains $V_2O_3 \leq 9.2$, Cr_2O_3 0.5-7.2 wt.%; coexisting chlorite and tremolite also exhibit elevated levels of V and Cr. This assemblage of V, Cr-rich minerals formed at ~500°C as a result of thermal metamorphism induced by Hercynian granitic intrusions. R.A.H.

Die grosse Kluft am Planggenstock, UR.

F. VON ARX. *Schweizer Strahler*, **10**(6), 1995, pp 201-11, 15 photos (7 in colour).

Fine rose-coloured fluorite of gem quality is among the minerals found in the great cleft of the Planggenstock, Uri, Switzerland. Crystals range up to 3-4cm in size and occur as octahedra or twins. The most recent discovery was in 1994. M.O'D.

Das Kalahari-Manganerzfeld und seine Mineralien. 1.

L. VON BEZING, J. GUTZNER. *Mineralien Welt*, **5** (4), 1994, pp 24-43, 5 illus. in black-and-white, 28 in colour, 2 maps in black-and-white, 1 map in colour, 2 figs.

Though for the gemmologist rhodochrosite takes pride of place among the minerals of the Kalahari area of South Africa, green opal and fine well-crystallized hematite are also found, with many other non-ornamental species. This first part of a general geological and mineralogical survey of the Kalahari lists minerals in chemical order with notes on the geology and the present state of mining. M.O'D.

Ontario - Amethyst County.

J. ZENZ. *Lapis*, **20**(2), 1995, 35-40, 13 photos (9 in colour), 1 map.

Gem-quality amethyst is found at several sites in the Thunder Bay region of Ontario, Canada, The Panorama, Pearl Lake, Ontario gem amethyst mine, Diamond Willow mine and Blue Points mine have been involved in amethyst production which has been known from the region since the seventeenth century. M.O'D.

$^{23}Na^{27}Al^{9}Be^{29}Si$ solid state NMR study of tugtupite.

ZHI XU AND B.L. SHERRIFF. *Canadian Mineralogist*, **32**(4), 1994, 935-43, 9 figs.

Tugtupite was found to have a well-ordered structure with only one Si, Al, Na and Be environment when studied with the NMR techniques of MAS (magic angle spinning), DAS (dynamic angle spinning) and DOR (double rotation). Quadrupolar parameters C_Q (quadrupolar coupling constant) and τ (asymmetry parameter) of ^{23}Na and ^{27}Al were found by a comparison of a computer simulation of the MAS central transition lineshape at two different fields with experimental results. M.O'D.

FM-TGMS-MSA Symposium on topaz.

Mineralogical Record, **26**(1), 1995, pp 63-71, illus. in black-and- white.

Synopses or complete papers on topaz and other topics presented to the 16th Annual Symposium of the Friends of Mineralogy, the Tucson Gem & Mineral Society and the Mineralogical Society of America, held at Tucson 11 February 1995. Topics of papers are: the occurrence of topaz in northern New England pegmatites: the occurrence of topaz in the southeastern United States: Colorado topaz: notes on the occurrence of topaz in Idaho: geology and occurrence of well-crystallized topaz: where's the proton? – symmetry and structure variations in topaz: topaz – environments of crystallization, crystal chemistry and infrared spectra: items of North American mineralogical and gemmological note during 1994, covering a salmon-pink colour obtained by heating cornflower blue coloured benitoite, the development of diamond pipe mining in the Northwest Territories of Canada, an option taken by Kennecott Corporation [RTZ subsidiary] on the Utah red beryl deposits, and on further recovery of tourmaline from Mt Mica, Paris, Maine. Some of the crystal drawings accompanying the reports are taken from Goldschmidt, *Atlas der Krystallformen*. M.O'D.

Instruments and Techniques

Optical anisotropy of cuprite caused by polishing.

E. LIBOWITZKY. *Canadian Mineralogist*, **32**(2), 1994, 353-8.

Optical investigations on bulk samples of cuprite (Cu_2O, space group P_n3_m), as well as on oriented single crystals, confirm that all diamond-polished sections except (111) and (100) are anisotropic. Electron channelling patterns obtained by SEM reveal that these mechanically polished surfaces of cuprite are always extremely deformed. An alternative chemomechanical polishing procedure with alkaline silica solutions, however, results in isotropic sections without exceptions. R.A.H.

ROS/GEM Optics Model RFA 322 Refractometer; an instrument evaluation.

A. SHIELDS AND B. NEVILLE. *Australian Gemmologist*, **18**(11), 354-5, 3 illus. in black-and-white.

This new critical angle refractometer manufactured in the USA was considered to be a robust easily portable instrument due to its smaller than average dimensions. Graduations of 0.005 should increase the accuracy of the readings and appeal to many potential users. R.J.P.

GIA evaluates progress in color detection technology.

J.E. SHIGLEY, R.C. KAMMERLING AND T.M. MOSES. *Diamond World Review*, **85**, pp 96-8, 3 photos in colour.

The authors first list the variables involved in colour description, and then describe the technical problems which occur when using instrumentation to quantify the colour of gemstones. The principles used in the two main types of colour measuring instruments (colorimeters and spectrophotometers) are then discussed. Two of the newer colour-measurement instruments, the Hitachi U4001 spectrophotometer and the Gran colorimeter, have recently been evaluated. When used to check isotropic coloured gem material, the Hitachi produced colour hue measurements consistent with visual observations. The Gran colorimeter gave quite consistent results for non-fluorescent round brilliant-cut diamonds in the Cape series. However, observations on these and other commercial gemstone colour measuring instruments indicate that instrumentation of this type cannot yet be used in place of visual colour grading. P.G.R.

The fingerprinting of gold samples.

ANON. *Assay, magazine of the Johnson Matthey Group*, Autumn 1994, pp 21, 2 photos in colour.

A new technique, LA-ICP-MS (laser ablation -

inductively coupled plasma - mass spectrometry), is forecast to revolutionize tracing methods for the identification of stolen gold. The technique enables scientists to compare the elemental associations in any given sample of gold. The detailed analysis can be specific to precise locations and the gold sample can be related to a specific mineralising event, mine or bullion sample. Initial investigations also suggest that the technique could be equally successful in the fingerprinting of antique silver, and gold and platinum artefacts, facilitating positive identification of important stolen objects. LA-ICP-MS was pioneered by the Chemistry Centre, Western Australia in conjunction with Fisons Instruments Elemental Analysis. P.G.R.

Synthetics and Simulants

An interesting imitation opal.

G. Brown. *South African Gemmologist*, **9**(2), 1995, pp 7-9, 4 photos in colour.

An opal imitation in which the play-of-colour emanated from a holographic projection from an aluminised grating sandwiched between plastic covers gave an SG of 1.2, a single RI of 1.48 and felt very light. These values are taken from the plastic cover. The gemmological microscope enables the very thin grating to be observed.

M.O'D.

Another flux-grown synthetic ruby.

I.C. Campbell. *South African Gemmologist*, **9**(1), 1995, pp 22-5, 5 photos in colour.

A ruby crystal offered as natural at a gem show in the United States was cut into three stones in which lead was discovered on analysis, thus proving artificial origin. M.O'D.

An examination of Swarogreen : a new imitation emerald from Austria.

E. Fritsch, R.C. Kammerling and J.I. Koivula. *Australian Gemmologist*, **19**(11), 1995, pp 15-18, 2 illus. in black-and-white, 3 in colour.

This was shown to be a silicate glass with a relatively high refractive index of 1.608-1.612 attributed to calcium and aluminium. The green colour is due to a transmission window formed by Pr^{3+} and Cu^{2+}. Although it is an attractive simulant almost all its gemmological properties are quite different from those of emerald. All the samples were of a medium dark bluish- green colour and were free from inclusions. R.J.P.

Gem news.

J.I. Koivula, R.C. Kammerling and E. Fritsch. *Gems & Gemology*, **30**(4), 1994, pp 271-80, 16 illus. in colour.

Described as a new man-made material from Russia 'Minkovite' is monoclinic synthetic yttrium silicate with neodymium providing the blue colouring agent. A visit to the Russian synthetic research facility at Alexandrov revealed an active concern with 2000 workers. The main products are synthetic quartz and synthetic calcite. Recent laboratory grown material include a medium-dark blue GGG and 'YAP' (yttrium aluminium perovskite). An interesting variety of hydrothermal synthetic quartz was predominantly brown with a shallow green layer offered as a simulant for andalusite. R.J.P.

The cathodoluminescence of synthetic periclase.

J. Ponahlo. *Australian Gemmologist*, **19**(1), 1995, pp 31-7, 1 table, 2 illus. in black-and-white, 4 in colour.

The author has presented a very detailed study of synthetic periclase (magnesium oxide) comparing its cathodoluminescence (CL) and analysis of CL spectra with trace element content. The causes of CL colour are discussed with reference to Ni, Cr, Fe and Mn contents. R.J.P.

BOOK REVIEWS

Handbook of mineralogy. Volume 2. Silica, silicates.

J.W. ANTHONY, R.A. BIDEAUX, K.W. BLADH AND M.C. NICHOLS, 1995. Mineral Data Publishing, Tucson, AZ. 2 vol. Hardcover. US$142.50 (including shipping). ISBN 0 9622097 0 8 [from vol. 1].

The first volume of this most welcome series covered the elements, sulphides and sulphosalts. With the silicates, on which so much reclassification has been postulated over recent years and to which so many new species have been added, two volumes have been found necessary to contain all the (highly edited) data available. As in the first volume the minerals are presented in alphabetical order; also following precedent there are no crystal drawings; locality information is strictly edited and based on specimens in major collections. The aim of the book is to present data rather than to give background information on how to use it.

Members of the silicate class have increased by about three times from the 1950s and growth in the sophistication of investigative techniques has been responsible for this as well as extensions in field work with consequent finds of new species. Many of the silicate species fall into groups and while these are not set out as in Fleischer and Mandarino's *Glossary of mineral species*, group membership is indicated by a note at the top of the page devoted to each species. For cross-referencing between names and compositions the program SEARCH is available from the publishers at PO Box 37072, Tucson AZ 85740. While many of the silicate groups are quite complicated the amphiboles have always given particular problems and for this reason a classification in diagram form is provided.

Some 'rogue' silicates such as thaumasite (cut stones exist) in which silicon occurs without oxygen to bond with are included as true members of the class, this membership depending, as conventionally agreed, on the presence in a mineral of mutually bonded silicon and oxygen atoms. Diadochic substitution of SiO_4 for PO_4 places a species in the phosphates when the atomic ratio of the silica is subordinate to that of the phosphate and in the silicates if the reverse is the case.

The convenience of having one species per page by far outweighs the slight inconvenience of having to look elsewhere for some classes of information; the readership for this excellent book will know how to do this already. M.O'D.

The properties of optical glass.

H. BACH AND N. NEUROTH (Eds), 1995. Springer, Berlin. pp xvii, 410, hardcover. DM268. ISBN 3 540 58357 2.

Forming part of the Schott series on glass and glass ceramics (the Schott Glasswerke in Mainz carries a large research group whose work is publicized in a series of *Forschungsberichte*), the book updates and consolidates material contained in the seminal *Beiträge zur angewandten Glasforschung* which began in 1959. Since that date there has been a great increase in the use of glass and glass ceramic substances.

The first part of the book describes the manufacture and use of optical glass with some historical material on its development. The bulk of the text, however, describes the optical properties, chemical composition, optical quality, mechanical and thermal properties, chemical durability, processing and applications of glass and gemmologists would expect to find a good deal of useful information in many of the sections. Probably most interest will come from the chapters on refraction and chemical composition though a later chapter on coloured glasses presents material which usefully adjoins what we know about the colouring of natural and synthetic inorganic substances. While the treatment (of dispersion, for example) is of necessity mathematical the text is quite easy to read and since each major section includes an extensive list of references the book forms a major reference tool for anyone using glass. Two further volumes, covering low thermal expansion glass ceramics and thin films on glass, will complete this part of the Schott series. M.O'D.

A century-plus of opal publications.

H.E.R. DE BOER, 1994. [Published by the author] c/o Middleton Post Office, Tasmania. pp 87 [81 of text, space for notes], AU$ 26, including air mail to Great Britain, AU$ 23 surface mail.

Published in an edition of 500 copies, this most

 ISSN: 1355-4565

useful bibliography of opal includes both monographs and papers in journals. A careful comparison with other opal books has shown that there seem to be few omissions, at least with the monographs, and citations of papers are adequately done. This is a well-produced and essential guide to an important part of gemmological literature. Later editions might well include the pagination of monographs from which the reader will get some idea of the text size. M.O'D.

Gemstones of Afghanistan.

G.W. Bowersox and B. Chamberlin, 1995. Geoscience Press, Tucson, AZ. pp xx, 172, illus. in black-and-white and in colour, hardcover. Price on application. ISBN 0 945005 19 9.

Having co-authored the standard book on the gemstones of neighbouring and geologically-similar Pakistan, the present reviewer has been waiting a long time for this book since looking over the MS and photographs with the authors back in 1993. There have long been problems with placing the location of gem species from these countries and descriptions of the mines and their minerals have been long overdue. As always seems to happen, the finest specimens of emerald and ruby are found in places particularly difficult of access so that many attributions are merely to the name of the nearest settlement. Equally mystifying are the many travellers' tales, some dating back many centuries and prone to colourful exaggerations of the size and nature of gemstones seen in places which few readers would and few authors actually did visit.

The book opens with an account of how this area, a fruitful area for plate tectonic studies, came to produce such a wealth of major gem species. This is followed by a history of geological explorations in Afghanistan. These chapters, like those following, have their own lists of references. Major gem species of Afghanistan are then treated in fine detail, beginning with the lapis lazuli occurrences of Badakhshan and proceeding to the spinel deposits of the same area, to the ruby and sapphire deposits of Jegdalek and Gandamak, the emerald mines of the Panjshir Valley and the deposits of tourmaline, kunzite and aquamarine in Nuristan. The main text closes with an assessment of the mineral potential of Afghanistan: appendices give the properties of the gemstones described, the coordinates of the major occurrences (what a valuable feature and one increasingly necessary for a serious study), a glossary and a general bibliography. An introductory statement outlines the pitfalls of transliteration and gives examples of some important variations. Interestingly the words panjsher and panjshir have different meanings so it is easy to see how ambiguities occur!

Such a care over detail and indication of where accounts can appear to treat quite different places while in fact pertaining to the same site parallels the care taken with the whole text. Even more remarkable, it is easy to read for relaxation and of course vital for gemmological, mineralogical and geological reference. Each occurrence is set in its geological context and the authors have actually visited them, not always the case in the gem books of not so long ago. Even better, once there, they understood the nature of the deposits. I could not wait to get into the book and wish that I had written it. M.O'D.

The honours of Scotland: the story of the Scottish crown jewels.

C.J. Burnett and C.J. Tabraham, 1993. Historic Scotland, Edinburgh. pp 56, illus. in colour, softcover. ISBN 0 7480 0626 5.

The crown jewels of Scotland were re-discovered in a dramatic scene played in 1818. An oak chest, long believed to be empty and housed in a sealed room in Edinburgh Castle, was opened to reveal the Scottish regalia which had been left there in 1707, the year of the Act of Union.

On New Year's day 1651 Charles II was crowned King of Scots near Scone Palace. At this last Scottish coronation the king was presented with the Honours of Scotland, crown, sceptre and sword, with a pair of spurs. They date back at least to the reign of James IV (1488-1513) but it is believed that Scottish kings may have been crowned since the sixth century though no regalia are known to have survived for so long. When Robert the Bruce, who seized the Scottish throne in 1306 was crowned, an improvised gold circlet was used but this disappeared to the English conquerors very soon afterwards. Although legend suggests that the circlet forms part of the present Scottish crown, there is no backing for the story.

Returning to Scotland and victorious over the English at Bannockburn in 1314, Robert would have ordered new Honours to be made and the coronation of his only son David in 1331 would have included those items of regalia which later appeared at the coronation of James IV. The story after this is unclear since the present displayed regalia took their place at some time during the reign of James IV or James V.

The present Italian-made sceptre was perhaps given to James IV by Pope Alexander VI. There had been a tradition of papal gifts to Kings of Scotland and the sceptre is said to have been presented to James in 1494. The sword of state was made in Edinburgh rather than in Italy and is known to have been ordered in 1502. In 1536 the sceptre was re-modelled by the Edinburgh goldsmith Adam Leys and includes a polished globe of rock crystal.

While the exact form of the crown inherited by James V is not known, his marriage in 1540 to Mary of Guise-Lorraine gave an impetus towards the remodelling of the crown and this was undertaken by John Mosman of Edinburgh.

These major items of regalia are fully described, together with other pieces which have joined them. The remainder of the book describes the later history of the Honours, the period during which their whereabouts was uncertain and their present state and display. There is, in addition, a great deal of ancillary material on Scottish history: there is also a short but useful bibliography. The book is a really first-class account, worthy of its unique subjects. M.O'D.

Ore microscopy and ore petrography.

J.R. Craig and D.J. Vaughan. 1994. Wiley, New York. pp xiv, 434, illus. in black-and-white, softcover. £18.95. ISBN 0 471 11599 1.

Many gemmologists are mineral collectors too and by some chance many minerals most accessible to the collector are ore species. While this book would have been greatly enhanced by colour photographs the text is lucid and provides a wealth of detail on the operations of many types of microscope, with particular reference to specimen preparation, qualitative methods of mineral identification and reflected light optics. These sections occupy approximately half the text. The remainder is devoted to ore mineral paragenesis, formation and fluid inclusion geothermometry of ores, the nature of ore mineral assemblages in igneous rocks and vein deposits and in a variety of other environments. There are excellent lists of references and useful tables, making this a cheap and accessible text for the student. M.O'D.

Meisterwerke Sächsischer Minerale.

E. Equit, 1994. Eberhard Equit & Co., Berlin. pp 151, illus. in colour, hardcover. US$120.00. ISBN 3 930874 00 8.

Full-colour paintings of 98 mineral specimens and 11 mining landscapes from Saxony, together with a short bibliography and list of Saxon minerals in public and private German collections make up a superb album for the mineral collector. Since the edition is limited to 1500 copies the book will soon have scarcity value; more costly is a leather-bound edition with included maps but the gemmologist will be quite happy with the illustrations of fluorite, smoky quartz and yellow topaz from Schneckenstein, as well as with the many specimens of native silver that Saxony had always produced. Mineral paintings are becoming more popular and it is good that photographs do not always have it their own way; the artist may very well have a particular feature in view when the camera sees everything dispassionately. M.O'D.

Fabergé [Catalogue of an exhibition held at The Queen's Gallery, Buckingham Palace, 1995-96].

1995, Merrell Holberton, London. pp 80, illus. in colour, softcover, price on application.

The Carl Fabergé shop in London's Dover St was established in 1903 and Queen Alexandra was one of the first royal customers, receiving Fabergé artefacts as birthday presents at least by 1909. Since then various members of the royal family have been assiduous collectors and the present royal collection is one of the largest and finest in existence.

The present exhibition contains 543 items and covers many ornamental materials. Nephrite, as might be expected, takes pride of place but there are some magnificent examples of rhodonite, rock crystal, various colours of chalcedony and the small diamonds, often set in dark backgrounds, with which Fabergé so often decorated his pieces.

Items selected for the catalogue are given descriptive entries containing notes of materials used, date of manufacture and craftsman's name where known, dimensions, details and translations of inscriptions and notes on provenance. A number of items are known to have been purchased from particular shops and such transactions are given. The standard of illustration is well up to that now taken as customary and the catalogue should be added to the collections of all with an interest in these distinctive productions.

Handlist to the exhibition. While the illustrated catalogue has selected items for inclusion the visitor needing a quick overview of all the pieces on show has a first-class, well-printed list available without charge. Apart from the illustrations, it contains virtually all the information printed in the illustrated catalogue. M.O'D.

Classical gems. Ancient and modern intaglios and cameos in the Fitzwilliam Museum, Cambridge.

M. HENIG, 1994. Cambridge University Press, Cambridge. pp xxx, 538, illus. in black-and-white and in colour. £125.00. ISBN 0 521 23901 X.

This catalogue raisonné of one of the world's major collections of classical and modern intaglios and cameos was compiled by Martin Henig with major contributions by Diana Scarisbrick and Mary Whiting. The Fitzwilliam Museum is the university museum of Cambridge and the systematic acquisition of gems began in 1864 with the purchase of the Leake collection of Greek and Roman coins and antiquities, including a major collection of ancient gems. Since that time the museum has acquired many important items and even while the catalogue was in press another very large set of engraved gems was presented by the Trustees of the Wellcome Trust - this last being the largest single accession of engraved gems ever received by the museum. The present catalogue stops short of this gift but otherwise includes all artefacts acquired up to the early 1980s.

Problems of preparation are bound to be large in this kind of work and the original preface is dated 1990. An additional problem has been cost and the museum was enabled to proceed with the publication of the catalogue only after a major donation had been received from the J. Paul Getty Trust.

The history of the collections is given in the first prefatory chapter : the second gives an account of how engraved gemstones were appreciated in antiquity. Notes on English collectors of engraved gems occupy the nine pages of the third chapter while ring and ringstone typology is set out in chapter four. Extensive lists of references accompany all the introductory chapters.

The catalogue is arranged in Greek and Roman and Medieval and Modern sections. The classical collections are subdivided into intaglios, cameos and miniature sculpture in precious stones and into metal rings and stamps. The medieval and modern collections are arranged by gemstones in intaglios, cameos, gem carvings in the round, non-mineral recipients and forgeries of ancient intaglios. Appendices describe items from the Davis collection of Iranian seals and similar items from the [first] Wellcome Trust donation. The Burges Ewer and the Burn bequest (one item) conclude the catalogue, while the book closes with lists of inventory numbers, of donors and provenances, details of proper names in Greek, Latin, Etruscan, in transcribed oriental and ancient languages and in modern European languages. Previous publications (i.e. of individual items) are listed and there are subject and general indices.

Catalogue entries give number, brief description, materials used, dimensions, provenance, date and style, followed by a full description including references. The majority of the gem materials used are varieties of the silica gems (cornelian, jasper, sard, agate and amethyst) while garnet, sapphire and glass also appear.

It is rare today for this kind of catalogue to be published at all, let alone at what is really a reasonable price. While the illustrations are almost all in black-and-white the central colour section includes high-quality photographs of 19 of the finest items. The authors and their assistants are to be congratulated for their production of a catalogue of international and lasting worth. M.O'D.

Chinese snuff bottles in the collection of Mary and George Bloch.

R. KLEINER, 1995. British Museum Press, London. pp xxxix, 665, illus. in colour, hardcover. £65.00. ISBN 0 7141 14650.

The days of the sumptuous, fully-illustrated catalogue of artefacts are not over! For a very reasonable price the reader is admitted to one of the finest private collections of Chinese snuff-bottles presently extant and on view at the time of writing in The British Museum. The standard of photography and of reproduction is as high as could be expected today and all we need to establish is the importance of the snuff bottle to the gemmologist.

The Chinese snuff-bottle is often made of a material with which all gemmologists will be familiar: perhaps rock crystal, perhaps one of the opaque varieties of quartz, perhaps jade, glass, ivory, coral, enamel, shale, soapstone, turquoise, amber, horn or other things: where the bottle is not itself made from a notable ornamental substance the stopper may be good quality jade or, a popular choice, pink tourmaline: snuff-bottle stoppers helped the Californian tourmaline mines to establish themselves.

Bottles in the collection are presented in colour together with notes on materials, size, period, details of publication where applicable, description of item and any notable points of design, fashioning, inscriptions, decoration or reign/date markings. Similar pieces are compared. There is a first-rate bibliography and introductory material gives a short biography of the owners of the collection, George and Mary Bloch. A chapter on Qing imperial glass by another author occupies 17 pages and includes its own coloured photographs, taken from another collection, not displayed at the Museum.

The charm of the small and easily-handled snuff-bottle will be appreciated by those who also admire the generally small size and beauty of jewellery and gemstones and I strongly recommend readers to take the opportunity to find out more about how these materials are worked and why they are so valued. M.O'D.

Standard catalog of gem values. Second edition.

A.M. Miller and J. Sinkankas, 1994. Geoscience Press, Tucson, AZ. pp ix, 271. £15.99. ISBN 0 945005 16 4.

A clue to the sudden appearance of the *Catalog* came in an advertisement in the German journal *Lapis* and very soon afterwards it was upon us. I was particularly pleased to see a revised text of an old friend which was first published in 1968 and reissued with inserted price update pages in 1988. The format remains the same with tables of prices for rough, faceted, engraved and carved gem materials and a chapter devoted to pearls. Details of fashioning are among the best and clearest of any book and how prices are arrived at forms a section rarely attempted by any author.

The deadline for updated prices was 1993 so alexandrite from the Hematita mine, Brazil, the production of the Argyle diamond mine in Western Australia and the intense blue copper-bearing tourmalines from the state of Paraiba, Brazil, are not included. There will always be a new find just after a book is published so these and other examples will have to wait for a third edition. Nonetheless the information given is profuse and welcome and especially useful are the short introductions to each species, telling the reader what features establish the best quality material.

The book is well produced on the whole though there are many misprints - the first author appears to have been born in the year that the copy deadline expired, according to the cataloguing in progress entry on the verso of the title-page! I am delighted that a new edition has been attempted and very pleased with the result. M.O'D.

Emerald and tanzanite buying guide.

R. Newman, 1995. International Jewelry Publications, Los Angeles. pp 155, illus. in colour, softcover. US$19.95. ISBN 0 929975 23 5.

This book forms part of an informal series which includes buyers' guides for ruby and sapphire, for pearl, diamond rings and gold jewellery. The present book reaches the high standard set by its companions and can be highly recommended both for buying stones and for many gemmological purposes.

While emerald and tanzanite may seem unlikely bedfellows they are both sought supremely for their colour rather than for any particular effect. Some of their properties are also similar: they are both brittle and so need extra care in setting and cleaning and they both have imitators which can cause the gemmologist difficulties. Emerald, of course has its synthetic counterpart too and to make identification even more difficult there are filled and treated stones.

For the student, each chapter ends with a short set of questions which form good examination revision materials, and there is also an extensive bibliography. The book deals with many topics from the standpoint of the beginner with a view to helping the jeweller to sell his stones and the notes on judging the colour of emerald and later of tanzanite. The reader is also shown how to evaluate the cut of a stone and is then told in some detail about the treatments now commonly used. Very sensibly the author gives advice on how disclosure of treatment should be presented. The customer is also helped in the questions that should be asked when buying emerald or tanzanite.

The chapter on synthetic emeralds neatly summarizes the present position and with the help of some excellent colour photographs gives an overview for the student and even for the practised gemmologist.

Where else can you find coloured photographs of tanzanite in different lighting conditions and of inclusions, composites and set pieces as good as any so far published in specialist books? All gemmologists should get a copy at the very reasonable price. M.O'D.

Gemstones in Australia: a review of the industry and the first Australian assessment of gemstone resources.

J.G. Olliver and I.J. Townsend, 1993. Australian Gemstone Industry Council, Sydney. pp x, 72, illus. in colour. A$50.00. ISBN 0 644 29617 8.

This most useful book reviews resources and production of Australia's major gemstones, opal, sapphire and ruby and diamond state by state, with shorter notes on the production of jade, chrysoprase, emerald and other gem beryl, agate, garnet, rhodonite, turquoise, topaz, tourmaline, zircon and chiastolite. In addition there is an historical review of the Australian gemstone industry and details of regulations on mining imposed by South Australia, as well as maps of the locations of major species. Tables give the values of Australian gemstone production, of actual and inferred opal resources in New South Wales and in western Queensland and similar details of sapphire and diamond production and resources. Chrysoprase production is also described and South Australian opal production 1978-1990 is summarized. Each section has its own list of references and the book is a most welcome addition to the rarely-covered topic of gemstone production. M.O'D.

Chinese jade from the Neolithic to the Qing.

J. Rawson, 1995. British Museum Press for the British Museum, London. pp 463, illus. in black-and-white and in colour, hardcover. £66.00. ISBN 0 7141 1469 3.

Despite the near-reverence held by so many for artefacts cut and polished in the jade minerals there has been no serious study in Western languages for many years. Since the Oriental Ceramic Society published the catalogue to the exhibition *Chinese jade throughout the ages* in 1975 (in the compilation of which the present author collaborated with John Ayers) the reader has to assume (correctly, in the main) that most of the major jade works must have been published in Chinese if not in China itself. Fortunately this book has an excellent bibliography in which Chinese studies feature largely. Before 1975 the Oriental Ceramic Society had held an exhibition in 1948, *Chinese jades*, which, like its successor exhibition, was catalogued in the Transactions of the Society. *Chinese jade throughout the ages* is by chance the title of one of Stanley C. Nott's books, first published in 1936, reprinted in 1962, and as this is the only large text in English (there are some good but small ones) likely to have been available for years the present book can be seen to be very long overdue.

The book accompanies an exhibition of Sir Joseph Hotung's jade collection and opens with explanation not only of the nature of the jade minerals but of the high value invariably placed on them by the Chinese. It is customary to say that this is because jadeite in particular is pleasing to the touch but far greater importance attaches to the capability of jade, like bronze, for supporting and perpetually preserving inscriptions, a property which has always been of particular significance to the Chinese. The toughness and hardness of the jades suggests power, whether political or religious: it is no accident that the linguistic character for jade is the same as that indicating 'precious stone'. The introduction goes on to discuss those shapes of jade which have been fashioned since the earliest times, to describe known fashioning sites and something of the methods used in working the materials. The book then begins the period-by-period study which occupies the bulk of the text.

Over 300 artefacts from the Hotung collection are described and illustrated and where appropriate reference is made to similar objects in the major collections of The British Museum. Each chronological section has its own list of references: full descriptions, including details of publication, accompany the excellent colour and black-and-white photographs (which also give the size of the object). The descriptions also speculate on the possible uses of the objects, their shapes and the nature of the fabulous animals, as well as their provenance.

A chapter on jade mineralogy follows the catalogue and includes a map showing possible nephrite sources in China. The book ends with the bibliography and index.

In so many ways this is the book that the jade connoisseur has always wanted and perhaps it is not too serious that there has been so long a gap between the publication dates of the major English texts. Along with modern identification techniques has come a much greater familiarity with Chinese classical and later texts, so that a book published near the end of the century has been able to draw on far more material than its predecessors. We hope that more Chinese sources, geological, mineralogical and textual, will be available for a second edition. M.O'D.

The Peking diamonds. [A tale.]

P. READ, 1995. Gembooks, Bournemouth. pp 208, softcover. £7.95 including post & packing: £8.50 surface mail overseas. ISBN 0 9525315 O X.

Forming part of a planned trilogy (the first part was *Diamond mine**) this story is about the planned substitution of flux-grown spinel crystals for diamond in the pre-sight routines of the De Beers organization. Two large countries (read the book to find out which they are) are behind the operation and the whole thing is not entirely unrealistic. I found this a jolly good read, moving more quickly than *Diamond mine* and with the sort of detail which gemmologists at least will find familiar. With Dick Francis' *Straight* (1989), *The Peking diamonds* should be required reading for students who need some lighter books from time to time. Two small points of interest: flux-grown colourless corundum may also take octahedral form and show trigons; as with spinel grown in this way, the trigons echo the edges of the octahedron and diamond sorters would spot this, since in diamond crystals the trigons are reversed. While a single flux of lead fluoride might be used for spinel growth, the combination lead oxide-lead fluoride-boron oxide is perhaps preferred today. M.O'D.

Images of the Anakie sapphire fields, Queensland.

W.L. SCHOLLER, 1993. E & W Scholler, Anakie 4702, Queensland. pp viii 136, illus. in black-and-white and in colour, softcover. ISBN 0 9589968 2 2.

For a fairly short historical account of a major gemstone locality you could not do much better than this. The Anakie fields in Queensland have produced good quality sapphire with fine blue and yellow stones predominating. The author laments the diminution of activity in the fields today (most blue sapphires on the market come from Thailand and lately from China) and suggests a number of reasons why activity has slackened. The main portion of the book, though, describes the fields, the sapphires and the miners, drawing heavily upon local newspaper accounts which would not be available anywhere else and there is a great amount of detail on personalities of the fields and a very useful bibliography, again giving information quite impossible to obtain any other way. There are many black-and-white photographs and some major finds are shown in colour. This reviewer appeals to anyone with such a personal knowledge of a gemstone location to get the facts written down at once. If their accounts are as good as this one, gemmological history (where is it?) will start life as a subject of its own. M.O'D.

*Diamond mine was reviewed in *J. Gemm.*, **23** 3

Diamond cuts in historic jewellery 1381-1910.

H. TILLANDER, 1995. Art Books International, London. Illus. in black-and-white, hardcover. £52.00. ISBN 1 874044 07 4.

This study covers ground which has never been treated monographically before. Long-awaited and written by the acknowledged authority on the history of diamond cutting and its relation to jewellery styles, it will be welcomed by a wide readership, the gemmologist and the historian of jewellery design together with those interested in the applied arts in general who may find the study of diamond cutting of much greater interest than they could have imagined. The combination of art and technology which has led so many to undertake gemmology as a study has never been better shown than here. While the author admits that some of his conclusions are intuitive in the absence of much written material, he nevertheless manages to compile a most useful bibliography and to include many valuable citations in the text. While the illustrations are in black-and-white they none the less serve to illustrate points of argument and description at least adequately and often better than adequately.

The text is arranged by style of cutting, beginning with the use of the natural diamond point and progressing through ever more complicated cuts to the various ideal brilliants and to those cuts recently developed with a view to enhancing diamond's properties still further. Appendices describe proportioning, the rock crystal bowl of Queen Elizabeth I, the wedding ring of Albrecht V, early price lists and the relationship between artists and diamonds. Photographs are supplemented by diagrams and sketches: these are especially useful in displaying how a particular cut is obtained from the rough crystal, information which will be most useful for the student of diamonds. Particular attention is paid to some of the named diamonds such as the Sancy, Tiffany and Koh-i-Nor and the section dealing with what may be thought of as the modern brilliant discusses the various 'ideal' cuts at length, bringing in data which have either been unpublished before or which are making a welcome reappearance. It is good to see Frank B. Wade's 'finely cut diamond' with some of whose features

Tolkowsky later disagreed, rejecting Wade's table but retaining a very visible culet spurned by Wade. This kind of history is what makes the book unique and highly desirable at a very reasonable price. M.O'D.

Faszination Edelstein aus den Schatzkammern der Welt. Mythos, Kunst, Wissenschaft.

1992. Hessisches Landesmuseum, Darmstadt. pp 275, illus. in black-and-white and in colour, softcover. £36.00. ISBN 3 7165 0871 3.

Catalogue of an exhibition shown at the Hessisches Landesmuseum at Darmstadt in 1992, the book takes gemstones as its theme and describes exhibits in order of species, after some general introductory material on gemstones as ornament. Diverse topics are covered, including trade in gemstones in the Middle Ages, gemstones in the classical period and the synthesis and imitation of gemstones. The major gemstone families are described next and in all sections artefacts are shown and described. Each section too has its own list of references. Without saying that the catalogue contains enough substance to present a definite theme as thoroughly as might have been possible, a read-through shows a large number of interesting objects and commentary, with many of the exhibits getting a rare airing. M.O'D.

A private collection of early Chinese jade carvings 28 November to 9 December 1994. [Catalogue].

Weisbrod Chinese Art Ltd, Weisbrod, New York, 1994. pp 85, illus. in colour, softcover, £8.00.

Very well-illustrated catalogue of an exhibition of early Chinese jades with an introductory essay, chronology and bibliography. Entries include a full description with provenance where applicable as well as notes on publication. M.O'D.

Jade in Chinese culture.

Palm Springs Desert Museum, 8 February-29 April 1990 [The Museum] Palm Springs, 1990. pp 155, illus. in colour, softcover, £22.00.

With the sub-[or series] heading Magic, Art and Order this catalogue of Chinese jade artefacts illustrates an exhibition describing the development of jade working in Chinese culture from the neolithic period to 1911. Additional material covers ritual objects, animals, copies of objects in other media, objects of aesthetic delight and objects of ornament. The standard of the photographs is high and there is a useful bibliography. M.O'D.

Bärnsten. Guldet fran Östersjön. Bursztyn. Zloto Baltyku.

1992. Oficyna Wydawnicza Excalibur, Bydgoszcz. pp 77 [colour section unpaged], illus. in black-and-white, hardback. Price £40.00. ISBN 83-900152 6 9.

Magnificently illustrated by a series of colour photographs, the book forms the catalogue of an exhibition of Baltic amber artefacts assembled by two Swedish and two Polish museums and sent on tour during 1992/93. The short text (by Elzbieta Mierzwínska) is in Polish and Swedish and includes a short bibliography and a list of the objects, the best of which have been selected for reproduction in this catalogue (probably best ordered as *SHM utställningskatalog* no. 120 from the Statens Historiska Museum, Stockholm). Details of the history of amber recovery in the Baltic countries and a short account of the nature of amber form part of the text. Most readers will, however, turn straight to the illustrations; there are 122 and all forms of representation are included. M.O'D.

Gemme e Diamanti dal Kremlino. Gems and diamonds from the Kremlin.

1994, Musei Statali del Kremlino, Moscow, pp 208, illus. in black-and-white, hardback. Price £45.00.

The Kremlin Museum in cooperation with an Italian printer/publisher [Ferrero Editore] has produced a magnificently-illustrated selection of some of the artefacts in its care. Readers familiar with Moscow should note that the museum concerned is the Palace of the Armoury, not the Diamond Treasury (both are in the Kremlin). Both contain jewellery and both need to be visited (visits to the Diamond Treasury need to be arranged in advance). The Museum and its history are fully described in the introduction and it is good to learn that new objects are being made by Russian jewellers and goldsmiths and added to the collections. In the illustrated section 90 items are illustrated in colour, each photograph occupying a full page with facing text; as in the rest of the book Italian and English are used. M.O'D.

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

The 1996 GAGTL Photo Competition

Images in Gems

In the competition this year members are asked to submit pictures of gems with colour shapes, structures or inclusions that suggest a particular item to the viewer - the more spectacular the better.

Develop the range of evocative names established by 'feather', 'fingerprint', 'Chinese aeroplane', 'jardin', etc. What images are suggested to you by an unusual cut or by an unconventional arrangement of gems in jewellery?

All entries will be judged for originality, beauty and gemmological interest.

The following prizes will be awarded:

First Prize: £100.00
Second Prize: £75.00
Third Prize: £50.00

Entry forms and details of the rules of entry will be circulated to all members.

OBITUARY

Mr William J. Boxall, FGA (D.1952), Midcalder, West Lothian, died recently.

GIFTS TO THE ASSOCIATION

The Association is most grateful to the following for their gifts of gems and gem materials for research and teaching purposes:

Mr D.H. Ariyaratna, FGA, DGA, London, for a stained ruby crystal approximately 8mm in length.

Gina Latendresse, GG, President of the American Pearl Company, Nashville, Tennessee, for 'designer-shaped' cultured pearls.

Louise Sinclair, FGA, London, for a cubic zirconia weighing 3.22 ct.

Mr Wu Chao-Ming, Taiwan, for a piece of rough nephrite from Taiwan.

 ISSN: 1355-4565

FORTHCOMING MEETINGS

London

Dr Grahame Brown, Editor of *The Australian Gemmologist*, will be giving the following lecture during his visit to Britain in January 1996:

1996

4 January — **Gemstones - Australia's national treasure.** Dr Grahame Brown.
Evening lecture, charge £3.50 for members and £5.00 for non-members.

To be held in the GAGTL Gem Tutorial Centre, 2nd Floor, 27 Greville Street (entrance in Saffron Hill), London EC1N 8SU. Entry will be by ticket only, obtainable from the GAGTL.

Midlands Branch

27 October — **Pearls – production and identification** Stephen Kennedy

29 October — **Practical Autumn Seminar**
Beginners/refresher day. To be held at the New Cobden Hotel.

24 November — **Jewels in the hand** James Gosling

2 December — **Annual Dinner**
To be held at Denehurst Close, Barnt Green

1996

21 January — **Gem Club – Is it the real McCoy?**
Details of venue from Gwyn Green on 0121 445 5359

26 January — **Bring and Buy, and Quiz Night**

Unless otherwise indicated meetings will be held at the new venue of the Discovery Centre, 77 Vyse Street, Birmingham 18. Further details from Mandy MacKinnon on 0121 624 3225 or Neil Rose on 0161 483 8919.

North West Branch

15 November — **Annual General Meeting**
The meeting will be held at Church House, Hanover Street, Liverpool 1.

Further details from Joe Azzopardi on 01270 628251.

NEWS OF FELLOWS

Michael O'Donoghue has been appointed to the Editorial Board of the German mineral journal *Lapis* and also to the Editorial Board of the Russian journal *World of stones.*

GEM DIAMOND EXAMINATIONS

In June 1995 83 candidates sat the Gem Diamond Examination worldwide, of whom 64 qualified including seven with Distinction. The names of the successful candidates are as follows:

Qualified with Distinction

Auzmendi, Amaia Garin, Madrid, Spain.
Kassam, Sultan Mohamed S., London.
Nicholson, Charles J., London.
Pattni, Jilesh Hirji, Wembley Park.
Sheng, Beili, Wuhan, China.
Smyth, Lesley, London.
Wu, Zhanxia, Wuhan, China.

Qualified

Allberg, Mauritz, Stockholm, Sweden.
Arulnathan, Jayabalan, London.
Badibanga, Carine, Brussels, Belgium.
Bagchi, Debal N., Brentford.
Capisano, Eric, London.
Carroll Marshall, Anne E., Hong Kong.
Cassarino, Paul R., Rochester, NY, USA.
Chan, Yuk Fan, Kowloon, Hong Kong.
Chong, Gar Leok Grace, London.
Eggleston, Avrina, London.
Fan, Siu Kam, Hong Kong.
Fantis, Charoulla, London.
Farion, Jean-Christophe, South Kensington.
Fong, Tsz Pan, Kowloon, Hong Kong.
Fukushima, Katsue, London.
Fung, Wai Yin, Hong Kong.
Gantzidis, Adam, Athens, Greece.
Garland, Annette J., London.
Hamp-Gopsill, David, Burton-on-Trent.
Hofer, Peter M., Northwood.
Hui, Sze Wai, Kowloon, Hong Kong.
Hung, Vivian Chi Ling, Hong Kong.
Ji, Xiaoyan, Wuhan, China. Joey,
Leung Wing Yee, Kowloon, Hong Kong.
Kam, Chih, Hong Kong.
Kam, Ka Dung, Hong Kong.
Keating, Elaine, London.
Kwan, Wai Shun, Kowloon, Hong Kong.
Lai, Mui Guk Margaret, Hong Kong.
Lakhtaria, Yashwin, London.
Lam Chiu Hung, David, Kowloon, Hong Kong.
Mo Jing Lee, Grace, Wanchai, Hong Kong.
Lu, Yefei, Wuhan, China.
Mamo, Charles, London.
Papadopoulos, Iraklis, London.
Pattani, Shobna, London.
Pawlyna, Andrea G., Hong Kong.
Pegg, Delia, Petts Wood.
Poon, Loi Chuen, Hong Kong.
Ren, Jiakai, Wuhan, China.
Roca Massotti, Joaquin J., London.
Ruhmer, Fiona J., London.
Spooner, Carole, Wokingham.
Summerfield, Susan, London.
Tsoi, Chung Ho, Kowloon, Hong Kong.
Victor, Chau Tak Ming, Kong Kong.
Wakefield, Melanie, Horsham.
Wan, Stephen, Kowloon, Hong Kong.
Wang, Hui, Wuhan, China.
Wang, Xin, Wuhan, China.
Warrington, Jennifer L., Palmerston North, New Zealand.
Weng, Ping, Wuhan, China.
Williams, Jason, Cobham.
Wong, Mei Wai May, Kowloon, Hong Kong.
Xi, Bo, Wuhan, China.
Xu, Rupeng, Wuhan, China.
Zhang, Weichao, Wuhan, China.

EXAMINATIONS IN GEMMOLOGY

In the June 1995 Examinations in Gemmology 354 candidates sat the Prelminary Examination, 247 of whom qualified; 336 sat the Diploma Examination and 105 qualified.

The Anderson/Bank Prize for the best non-trade candidate of the year in the Diploma examination was awarded to Miss Zhou Shuzhen of Wuhan, China.

The Diploma Trade Prize for the best candidate of the year who derives her main income from activities essentially connected with the jewellery trade was awarded to Miss Johanna Carlsson of London.

The Anderson Medal for the best candidate of the year in the Preliminary examination was awarded to Miss Sau Ping Pamela Cheung of Kowloon, Hong Kong.

The Preliminary Trade Prize for the best candidate under the age of 21 years on 1 June 1995 who derives her main income from activities essentially connected with the jewellery trade was awarded to Miss Seema Dayaldasani of Bombay, India.

This year no candidate was considered to be of sufficient merit for award of the Tully Medal.

The names of the successful candidates are as follows:

DIPLOMA

Qualified

Au, Yeung Kwok Ho, Hong Kong.
Baxter, Richard, Birmingham.
Bray, Betty A., Abilene, Tx, USA.
Cadby, John H.V., Trowbridge.
Cadby, Sarah, London.
Can, Cao, Wuhan, China.
Carlsson, Johanna A., London.
Carr, John R., Cheltenham.
Chen, Jyh-Shyang, Taipei, Taiwan, ROC.
Cheng, Ming Chi, Hong Kong.
Clay, Gretchen F., Boston.
Dang, Xiaoying, Wuhan, China.
Day, Stephen J., Peterborough, Ont., Canada.
Dayaldasani, Seema Kamlesh, Bombay, India.
Ding, Weijun, Wuhan, China.
Dokken, Aarrynne D.C., Sutton.
Everitt, Sally A., London.
Guo, Hui, Wuhan, China.
Guo, Xiaodan, Wuhan, China.
Haittoniemi, Mia, Helsinki, Finland.
Hawken, Diana B., Hong Kong.
Higo, Kenji, Osaka, Japan.
Ho, Hsiung-Chien, Taipei, Taiwan, ROC.
Ho, Shuk Ching Rebecca, Hong Kong.
Ho, Tung Tak, Hong Kong.
Iwata, Kaoru, London.
Javeri, Mitesh J., Bombay, India.
Jiang, Xinshun, Wuhan, China.
Kuixi, Jin, Wuhan, China.
Kathoon, Junaida, London.
Kawamura, Toshiko, Sakurai City, Japan.
Kennedy, Karen F., Egham.
Kenny, Sark, Kowloon, Hong Kong.
Kissoon, Sasha N., London.
Kleiser, Alwen M., Holyhead.
Lee, Angela Sau Mui, Kowloon, Hong Kong.
Leung, Stephen Ping-Kwong, Thornhill, Ont., Canada.
Li, Yuan, Wuhan, China.
Lin, Fiona, Taipei, Taiwan, ROC.
Lin, Bing, Wuhan, China.
Lo, Shuk Lan, Hong Kong.
Loungani, Jagdish, Jaipur, India.
Lu, Fude, Wuhan, China.
Luo, Yiguang, Wuhan, China.
Ma, Yugao, Wuhan, China.
Maheshwari, Ashoo, Jaipur, India.
Mallo Sanz, Maria Cristina, Madrid, Spain.
Marathe, Tanjua, Pune, India.
Moore, Julie L., Measham.
Nam, Chang Soo, Daejon, Korea.
Ng, Yee Mei Kathy, Hong Kong.
Owens, Suzanne, Dublin, Republic of Ireland.
Pachchigar, Dharmesh N., Bombay, India.
Papadopoulos, Dimitrios, Athens, Greece.
Pattni, Jilesh Hirji, Wembley Park.
Purkiss, Karen A., Colchester.
Qin, Shule, Wuhan, China.
Rabstein, Wolf I., London.
Rickard, Sarah V., Market Harborough.
Roca Massotti, Joaquin J., London.
Rose, Christina, Liverpool.
Rosier, Wendy, Hong Kong.
Rossiter, John T., Weston-Super-Mare.
Salm-Reifferscheidt, Sophie, London.
Sharma, Animesh, Jaipur, India.
Sharma, Rajeev, Jaipur, India.
Sim, Hoo Joung, Daejon, Korea.
Siu, Ming Wa, Hong Kong.
Smallenburg, M.A., Amsterdam, The Netherlands.
So, Che Shing, Hong Kong.

Solves Camara, Jose Daniel, Valencia, Spain.
Soo, Hoi Leung, Hong Kong.
Sotolongo,Sachiko Kashiba, London.
Stead, Graham Scott, Tillsonburg, Ont., Canada.
Sun, Yanling, Wuhan, China.
Sung, Soo Kyung, Taegu, Korea.
Tada, Reiko, Osaka, Japan.
Tan, Hongwei, Wuhan, China.
Tanaka, Daisuke, Kobe City, Japan.
Tang, Zhen Yi, Hong Kong.
Thornton, Timothy J., Kettering.
Tompkins, Alison L., Brierly Hill.
Turner, Caroline, London.
Wang, Xuqiang, Wuhan, China.
Wen, Li, Wuhan, China.
Whipp, David, London.
White, Michele, Birmingham.
Win, Mai Mu Mu, Yangon, Myanmar.
Winiski, Ken R., Vancouver, BC, Canada.
Wu, Chun-Li, Taipei, Taiwan, ROC.
Wu, Zhaoyang, Wuhan, China.
Wunna, Kyaw, Yangon, Myanmar.
Yates, David Hayman, Derby.
Yoshida, Miyuki, Hong Kong.
Yan, Yuan, Wuhan, China.
Zaw, Oo, Yangon, Myanmar.
Zhang, Juan, Wuhan, China.
Zhang, Yongwen, Wuhan, China.
Zheng, Bei, Wuhan, China.
Zhong, Liyi, Wuhan, China.
Zhou, Jun, Wuhan, China.
Zhou, Min, Wuhan, China.
Zhou, Shuzhen, Wuhan, China.
Zhu, Dawei, Wuhan, China.
Zou, Juan, Wuhan, China.

PRELIMINARY

Qualified

Achten, Louisa W., Horst, The Netherlands.
Alzamil, Farida A., London.
Anderson, Lesley, Wivanhoe.
Archibald, Mhari-Louise, Sutton.
Arulnathan, Jayabalan A., London.
Atkins, Elizabeth M., Chipperfield, Kings Langley.
Au-Yeung, Chi Fung, Kowloon, Hong Kong.
Backstrom, Ingrid A., Froson, Sweden.
Bahrani, David J., Crewe.
Baker, Kate E., Hornton, Nr Banbury.
Barnes, Patricia E., Dunkirt, Md., U.S.A.
Bhansali, Raju, Bombay, India.
Bi, Zhengyun, Wuhan, China.
Bienemann, A.M., Polsbroek, The Netherlands.
Boyle, Catherine S., Mickleham.
Brangulis, Peters, Riga, Latvia.
Brooks, Gillian E., Edinburgh.
Bulmer, George P., Colchester.
Cameron, Iain A., London.
Chan, Lai Min, Hong Kong.
Chan, Sau King, Hong Kong.
Chan, Yiu Pui, Hong Kong.
Chandaria, Anuradha Paras, Nairobi, Kenya.
Chang, Chiao Yi, Taipei, Taiwan, ROC.
Chang, Mei-Chu Joyce, Tapei, Taiwan, ROC.
Chang, Shiao-Fen, Tapei, Taiwan, ROC.
Chatta, Harvinder, Bombay, India.
Chen, Binghui,Guangzhou, China.
Chen, Yumei, Guangzhou, China.
Cheung, Sau Ping Pamela, Hong Kong.
Ching, Mei Ying, Hong Kong.
Choi, Hyo-Jin, Taegu, Korea.
Chopada, A. Dilip Anraj, Hyderabad, India.
Chow, Michelle Yan Wai, London.
Chu, Yin Yee Terry, Hong Kong.
Ciaralli, Tiziana, London.
Clark, Antony, Bolton.
Clarkson, James D., Reno, Nev., U.S.A.
Clevers, Irene L., Utrecht, The Netherlands.
Cragg, Steve, Shaw.
Damianidou, Teresa, Piraeus, Greece.
Dapper, Sylvia, London.
Das, Rajesh Shakti, Bombay, India.
Davis, Roberta K., Birmingham.
Day, Stephen J., Peterborough, Ont., Canada.
Dayaldasani, Seema K., Bombay, India.
De Klerk, Ton, Roosendaal, The Netherlands.
Dean, John E., Bath.
Dewan, Prasoon, Bombay, India.

Dey, Tapas K., Chandannagore, India.
Ding, Qian, Jiangsu, China.
Dokken, Aarrynne, D.C., Sutton.
Dooley, Kaeren, Manchester.
Duggan, Rory P., Phetchabun, Thailand.
Duguid, Angus K., Kadoma, Zimbabwe.
Duncan, Kenneth G., Reston, Va., U.S.A.
Dupuy, David J., Dublin, Republic of Ireland.
Dyjkstra, Menno, Sluis, The Netherlands.
Effendi, Megawaty, Hong Kong.
Everitt, Sally A., London.
Han, Fan Suk, Hong Kong.
Fang, Huei Yu, Karen, Taipei, Taiwan, ROC.
Field, Beverly, Gravesend.
Fok, Raymond Siu Ki, Hong Kong.
Fong, Ka Chun, Hong Kong.
Friedberg, Guy, Gants Hill, Ilford.
Fukuda, Kenji, Ikoma City, Japan.
Ghika, Jean V., London.
Glaser, N.V.K., Sonja I., Zurich, Switzerland.
Goodwin, Gregory M., Wilmslow.
Graham-Blomgren, Berdie, Stockholm, Sweden.
Grannudd, Stig, Lannavaara, Sweden.
Gray, Vivienne M., London.
Grimley, Andrew F., London.
Grondin, Daniel B., Geneva, Switzerland.
Grondin, Magali, Geneva, Switzerland.
Guan, Zichuan, Wuhan, China.
Hansen, Edith E., Stavanger, Norway.
Hui, Hao, Wuhan, China.
Harris, Annette Mia, Worcester.
He, Lin, Wuhan, China.
Hino, Toshiaki, Owase City, Japan.
Ho, Chi Tai, Hong Kong.
Ho, Mary Malai, London.
Ho, Shuk Ching, Rebecca, Hong Kong.
Ho, Yan Yee, Winnie, Hong Kong.
Honda, Takashi, Tokyo, Japan.
Hopkinson, Barrie, Nottingham.
Hopley, Katharine B., Coventry.
Hsieh, Chung-Wei, Taipei, Taiwan, ROC.
Htoo, Thidar, Yangon, Myanmar.
Htun, Han, Yangon, Myanmar.
Hung, Yu Ling, Taipei, Taiwan, ROC.
Hussain, Jemanzeb Khan, Diemen Zuid, The Netherlands.
Javeri, Mitesh J., Bombay, India.
Johnson, Brian J., Birkenhead.
Joseph, Elizabeth, Hale Barns.
Joseph, Tomy, Cherthala, India.
Kafetsis, Georgios, Athens, Greece.
Kamani, Priscilla, Nairobi, Kenya.
Kaprili, Maria, Athens, Greece.
Kasseyet, Charles K., London.
Kathriarachchie, Siripalan, Idar Oberstein, Germany.
Kato, Junko, Osaka, Japan.
Kawahara, Tamami, Osaka, Japan.
Khanbhai, Shabbir, London.
Khine, Kay, Yangon, Myanmar.
Kilian A., Den Haag, The Netherlands.
Kissoon, Sasha N., London.
Kalmer, F.H.G., Oss, The Netherlands.
Knapkik, Paulina, Ronneby, Sweden.
Knight, Eloise, Kenilworth.
Kobayashi, Yukiko, Osaka, Japan.
Kodera, Yukiko, Willowdale, Ont., Canada.
Koh, Yeon Kyeong, Daejon, Korea
Kuulman, Heli, Tallinn, Estonia.
Kwong, Yan Lam, Kowloon, Hong Kong.
Lamb, Maria Tegwen Hotung, Hong Kong.
Landgren, Angelica, Vichtis, Finland.
Lau, Wai Keung Leslie, Hong Kong.
Law, Chun Yip, Hong Kong.
Lee, Jin-Hwan, Taegu, Korea.
Lee, Kin Ming Jackie, Kowloon, Hong Kong.
Lee, Shuet Fong, Hong Kong.
Lee, Ping (Jeff), Kowloon, Hong Kong.
Lee, Young Woo, Seoul, Korea.
Lemessiou, Maria, Nicosia, Cyprus.
Lennie, James, Glasgow.
Leung, Stephen Ping-Kwong,Thornhill, Ont., Canada.
Leung, Vanda Mo-Lan, Kowloon, Hong Kong.
Leung Yuen Fan, Yuen Tan, Hong Kong.
Li, Li-Ping, Taipei, Taiwan, ROC.
Li, Liung Hsing, Taipei, Taiwan, ROC.
Li, Ruling, Guangzhou, China.
Li, Kong Loon Paul, Kowloon, Hong Kong.
Li, Qingnian, Wuhan China.
Liao, Zhongting, Shanghai, China.
Lin, Yuk Ying, Hong Kong.

Lindblom, Joachim, Turku, Finland.
Lindroos, Anna, Pori, Finland.
Liu, Kyin Han, Yangon, Myanmar.
Liu, Xu, Wuhan, China.
Lo, Sui Ying Eugenie, Hong Kong.
Lock, Natasha C., George, Somerset.
Lullin, Cedric, Geneva, Switzerland.
Lynch, Melissa, Glasgow.
Mackay, Colin A., Edinburgh.
Made, Lollo, Hong Kong.
Maheshwari Ashoo, Jaipur, India.
Mao, Yanying, Wuhan, China.
Marathe, Tanuja, Pune, India.
Marolla, Marianna, Athens, Greece.
Marshall, Andrew P., Gravesend.
Miller, Kenneth R., North York, Ont., Canada.
Moe, Kyaw, Yangon, Myanmar.
Mohan, T.V. Jagan, Salem, India.
Mucciolella, Raul, London.
Murphy, Ditas, Colchester.
Nagaoka, Mikage, Nishinomiya City, Japan.
Ng, Yee Mei, Kathy, Hong Kong.
Ng, Wai Man, Kowloon, Hong Kong.
Niemi, Markku, Lappeenranta, Finland.
Orjales, Carlos Nunez, Geneva, Switzerland.
Otsuka, Mayumi, Osaka, Japan.
Pachchigar, Dharmesh N., Bombay, India.
Pan, Jianqiang, Wuhan, China.
Panagopoulou, Anastasia, Athens, Greece.
Pang, Helen Yee Man, Colchester.
Pani, Tonu, Tartu, Estonia.
Pawlowska, Magda L., Christchurch, New Zealand.
Pepprell, Eija-Liisa, London.
Pereira, Sharon A., Basildon.
Permal, Charles M.A., Birmingham.
Phillips, Sarah L., Kinross.
Poon, Ka Yee, Carrie, Kowloon, Hong Kong.
Popov, Vladimir, Tallinn, Estonia.
Proske, Oktavio R., Amsterdam, The Netherlands.
Qin, Zhili, Guangzhou, China.
Raghavendra, N.S., Bangalore, India.
Rai, Ashish, Jaipur, India.
Rimmer, Ray I., Bootle.
Ross, Peter M., London.
Rutter, Fay, Walsall.
Rynbergen, J.G., Utrecht, The Netherlands.
Salm-Reifferscheidt, Sophie, London.
Schjolberg, Liv, Stavanger, Norway.
Seki, Shoko, Osaka, Japan.
Seligmann, Marianne E. Heilner, Huizen, The Netherlands.
Seng, Zau, Yangon, Myanmar.
Shah, Monica, Cheadle.
Shahani, Neeta K., Pune, India.
Shi, Dongsheng, Wuhan, China.
Silvero, Ma Rita Talao, Mandaluyong City, The Philippines.
Siu, Ming Wa, Hong Kong.
Smith, Marina V., London.
Snyman, Johanna E.W., Pretoria, S. Africa.
So, Woo Sze Sze, Hong Kong.
Soderstrom, Jenny, Lannavaara, Sweden.
Song, Gyu Bong, Kyungnam, Korea.
Song, Sang-Hun, Taegu, Korea.
Soong, Jackie, Ipoh, West Malaysia.
Spiteri, Ruth, Sta Venera, Malta.
Starreveld, Francis M.M., Hilversum, The Netherlands.
Stern, Sara, Arlington, Va., U.S.A.
Stopelli, Christopher J.D., Oakville, Ont., Canada.
Sufian, Shaffy Musnad, Galle, Sri Lanka.
Sundell, Johanna, Helsingfors, Finland.
Tam, Kam Biu, Wanchai, Hong Kong.
Tang, Deping, Wuhan, China.
Thornton, Timothy J., Kettering.
Tian, Liangguang, Wuhan, China.
Torrent, Denise, Geneva, Switzerland.
Triantafillos, Spiros, Athens, Greece.
Trivedi, Ishwar, Bombay, India.
Tsai, Yao Chu, Taipei, Taiwan, ROC.
Tsang, Wai Yi, Rita, Hong Kong.
Tsay, Jyh-Tsong, Taipei, Taiwan, ROC.
Tsoi, Yu Lum, Henry, Kowloon, Hong Kong.
Than, Tun, Yangon, Myanmar.
Urm, Tanel, Voru, Estonia.
Van Gelder, Marie C., London.
Veryis, Anastassios, Athens, Greece.
Vincent, Arthur J., Norwich.
Vummidi, Sreeramakishna, Madras, India.
Vummidi, Nagaraj, Madras, India.

MEMBERSHIP '96

Members, Fellows and Diamond Members receive *The Journal of Gemmology* and the *Gem and Jewellery News* quarterly. Fellows (members who hold our Diploma in Gemmology) may use FGA after their name and Diamond Members (members who hold the Gem Diamond Diploma) the title DGA, and both may also apply for the use of the Coat of Arms on their stationery.

Laboratory Members receive an annual membership certificate for display, *The Journal of Gemmology* and *Gem and Jewellery News* quarterly, discounted testing and grading fees, and may apply for use of the Laboratory logo on their business stationery. Overseas members are assisted with the temporary importation of gemstones for grading or testing.

All members are eligible for a 10 per cent discount on the retail price of most instruments and specimens, and a 5 per cent discount on books purchased from Gemmological Instruments Limited. Overseas Members benefit from arrangements to pay membership fees by credit card and their journals will be sent by airmail.

Subscription Rates 1996

	UK	Overseas
Ordinary Member / Fellow / Diamond Member	£49.50	£70.00
Laboratory Member	£225.00 + VAT	£225.00

Wang, Dequan, Wuhan, China.
Wang, San Zen, Taipei, Taiwan, ROC.
Wanjohi, Jacqueline W., Nairobi, Kenya.
Wewa, Peter, Nairobi, Kenya.
Whitewood, Steven G., Rochester.
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Wong, Heather Ti Yin, Hong Kong.
Wong, Siu Lai, Hong Kong.
Wooter, Ronny, Amsterdam, The Netherlands.
Wu, Yaoxing, Jiangsu, China.
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Yao, Teng Long, Taipei, Taiwan, ROC.
Yim, Yat-Hung, Cannia, Hong Kong.
Yogalingam, Nirupa, Kandy, Sri Lanka.
Yoshikoshi, Naoko, London.
Yulo, Kathleen Linda Velayo, Metro Manila, Philippines.
Zhang, Xueli, Wuhan, China.
Zhang, Yixiang, Wuhan, China.

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 19 July at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership
Zhenghua, Zhuang, Wuhan, China, 1995.

Transfer - Ordinary Membership to FGA
Ayles, Catherine, Edinburgh, 1995.
Wren, Amanda, Edinburgh, 1995.

Fellowship
Baozhen, Tian, Wuhan, China, 1995.
Bing, Zhang, Wuhan, China, 1995.
Cuihua, Cai, Wuhan, China, 1995.
Haiqing, Zhou, Wuhan, China, 1995.
Jiansen, Feng, Wuhan, China, 1995.
Meidi, Zhu, Wuhan, China, 1995.
Wei, Zhou, Wuhan, China, 1995.

Ordinary Membership
Brimble, Stephen, Heanor.
Britton, Andrea L., Knaphill, Woking.
Chandaria, Anuradha, London.
Crawford, Henry David, London.
Griffiths, Robert William, Northwich.
Kalinin, Julia, Bayswater.
Mitchell, Brenda Hilary, Cosham.
Weyli, Ali A., London.
Wismayer, Lawrence Paul, St Julians, Malta.

Laboratory Membership
Elisabeth's Antiques, London, W1Y 9AE
Kamsco Ltd, London, E7 OEX

Corrigenda

On p.500 above, for '£115.00 plus VAT' read '£275.00 plus VAT'

On p.508 above, Abstract, first paragraph, last line, for '0.1 to 0.2' read '0.1 to 0.5'

On p.509 above, second column, under Trace elements in jadeite, first paragraph, line 8, add 'chromium,' before 'iron'

On p.510 above, Table I:Fe2+/Fe3+ content of leaf-green jadeite, for '0.1-0.2' read '0.1- 0.5'; Cr%, emerald green (chrome-rich), for '0.3-0.4' read '0.3-0.04'

On p.510 above, first column, line 6 of text, for '0.1-0.2' read '0.1-0.5'

On p.524 above, first column, last line in Gifts to the Association section, for 'serpentine' read 'nephrite from Taiwan'

Guide to the preparation of typescripts for publication in *The Journal of Gemmology*

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

Typescripts Two copies of all papers should be submitted on A4 paper (or USA equivalent) to the Editor. Typescripts should be double spaced with margins of at least 25mm. They should be set out in the manner of recent issues of *The Journal* and in conformity with the information set out below. 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.

The abstract, references, notes, captions and tables should be typed double spaced on separate sheets.

On matters of style and rendering, please consult *The Oxford dictionary for writers and editors* (Oxford University Press, 1981).

Title page 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.

Abstract A short abstract of 50-100 words is required.

Key Words Up to six key words indicating the subject matter of the article should be supplied.

Headings In all headings only the first letter and proper names are capitalized.

A **This is a first level heading**

First level headings are in bold and are flush left on a separate line. The first text line following is flush left.

B *This is a second level heading*

Second level headings are in italics and are flush left on a separate line. The first text line following is flush left.

Illustrations Either transparencies or photographs of good quality can be submitted for both coloured and black-and-white illustrations. It is recommended that authors retain copies of all illustrations because of the risk of loss or damage either during the printing process or in transit.

Diagrams must be of a professional quality and prepared in *dense* black ink on a good quality surface. Original illustrations will not be returned unless specifically requested.

All illustrations (maps, diagrams and pictures) are numbered consecutively with Arabic numerals and labelled Figure 1, Figure 2, etc. All illustrations are referred to as 'Figures'.

Tables Must be typed double spaced, using few horizontal rules and no vertical rules. They are numbered consecutively with Roman numerals (Table IV, etc.). Titles should be concise, but as independently informative as possible. The approximate position of the Table in the text should be marked in the margin of the typescript.

Notes and References Authors may choose one of two systems:

(1) The Harvard system in which authors' names (no initials) and dates (and specific pages, only in the case of quotations) are given in the main body of the text, e.g. (Gübelin and Koivula, 1986, 29). References are listed alphabetically at the end of the paper under the heading References.

(2) The system in which superscript numbers are inserted in the text (e.g. ... to which Gübelin refers.[3]) and referred to in numerical order at the end of the paper under the heading Notes. Informational notes must be restricted to the minimum; usually the material can be incorporated in the text. If absolutely necessary both systems may be used.

References in both systems should be set out as follows, with *double spacing* for all lines.

Papers Hurwit, K., 1991. Gem Trade Lab notes. *Gems & Gemology*, **27**, 2, 110-11

Books Hughes, R.W., 1990. *Corundum*. Butterworth-Heinemann, London. p. 162

Abbreviations for titles of periodicals are those sanctioned by the *World List of scientific periodicals* 4th edn. The place of publication should always be given when books are referred to.

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Compiled by Robin W. Sanderson

Alphabetical arrangement is letter-by-letter.
Names of authors are printed in capitals, pages of abstracts and book reviews in italics.
Special usages:
above and *below* in cross-references indicate that the reference is to another subheading under the same heading, not a separate heading.
A number in brackets following a page number indicates that there is more than one reference to the subject on the page.

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