Yellow and brown coloration in
beryllium-treated sapphires

Asterism in beryl, aquamarine
and emerald – an update

Nephrite jade
in Finland

The Journal of Gemmology

Asterism in beryl, aquamarine and emerald – an update

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Abstract: *An overview about present knowledge of asterism in beryl, aquamarine and emerald is presented. A bronze-brown beryl from Brazil and several aquamarines from Madagascar revealing six-rayed asterism were examined. An emerald specimen from Madagascar showing four- and six-rayed stars is studied in detail. The asterism of this specimen is due to a combination of a six-rayed star emerald and an emerald cat's-eye. Three causes for six-rayed stars in various members of the beryl family are known: (a) needle-like mineral inclusions, (b) elongated thin fluid films and (c) elongated negative crystals.*

Introduction

Recently, a German dealer purchased a rough emerald specimen in Madagascar, which was – according to the information given by a local gem merchant – most probably originating from the well-known Mananjary emerald mining area. Due to the visual appearance of the rough, it was assumed that the sample could yield another six-rayed star emerald similar to a specimen obtained in 2001[1]. However, after cutting as a cabochon, the emerald showed a weak four-rayed star in the centre of the convex surface. Examining this four-rayed star emerald, we took the opportunity to compare the sample with a six-rayed star beryl from Brazil and several star aquamarines from Madagascar, and to review and summarize the present knowledge about asterism in members of the beryl family.

Beryl with mineral inclusions

Beryl, aquamarine and emerald showing asterism are among the rarer gem materials.

Gemmological literature dealing with asterism in beryl and its varieties is presented in *Table I*. In the 1950s, rough beryl with a specific type of inclusion was discovered in Brazil[2,3,4]. Cabochons with six-rayed asterism were cut and found their way onto the international market and into public or private collections (*Figure 1*). Examination of the cut sample in *Figure 1* and some rough material available to the present authors confirmed the descriptions published in the 1950s. The samples frequently quoted in textbooks and articles dealing with asterism in beryl or other minerals[5,6,7], have been described as almost colourless beryl to very light green aquamarine. The body colour of these specimens, however, is a much more intense bronze or bronze-brown when viewed in a direction parallel to the *c*-axis. This impression is due to a dense pattern of mineral inclusions which are located on planes parallel to the basal pinacoid, i.e. on planes perpendicular to the *c*-axis (*Figure 2*). A mineralogical

Table 1: Asterism in aquamarine, beryl, and emerald.

Locality	Host	Asterism	Inclusions	References
Minas Gerais, Brazil	almost colourless beryl to light green aquamarine, with a dark brown or bronze-brown colour in a view parallel to the *c*-axis	six-rayed	skeletal elongated ilmenite crystals on planes parallel to the basal pinacoid	2, 3, 4, 5, 6, 7, this study
Brazil	greenish-grey, almost opaque beryl	six-rayed	tabular plates or flakes of pyrrhotite parallel to the basal pinacoid, other mineral inclusions without specific orientation	7, 8, 9
Sri Lanka	aquamarine	six-rayed	thin fluid films on planes parallel to the basal pinacoid	7, 10
unknown	emerald	six-rayed	channels parallel to prism faces consisting of two-phase inclusions	7, 11
Nova Era, Minas Gerais, Brazil	emerald	six-rayed	needle-like channels	7, 12
Santa Terezinha, Brazil	emerald	six-rayed	not mentioned	13
Santa Terezinha (?), Brazil	emerald	six-rayed	channels parallel to the *c*-axis, three series of elongated particles perpendicular to the *c*-axis	14
Brazil	aquamarine	six- or four-rayed	thin films on planes parallel to the basal pinacoid, hollow channels parallel to the *c*-axis	15
Mananjary area, Madagascar	emerald	six-rayed	tabular birefringent inclusions parallel to the basal pinacoid	1
Madagascar	aquamarine	six-rayed	three series of elongated channel-like inclusions (thin fluid films) perpendicular to the *c*-axis	this study
Mananjary area, Madagascar	emerald	six- and four-rayed	channels parallel to the *c*-axis, three series of elongated channel-like inclusions (negative crystals) perpendicular to the *c*-axis	this study

N.B.: The items are arranged chronologically in order of their discovery or reporting in the literature.

Figure 1: Bronze-brown six-rayed star beryl from Minas Gerais, Brazil. Diameter of the sample 6.0 mm, weight 1.41 ct.

Figure 2: Bronze-brown six-rayed star beryl from Minas Gerais, Brazil; layers parallel to the basal pinacoid with a dense pattern of skeletal crystals, (a) view perpendicular to the c-axis, immersion, 40×, (b) view oblique to the c-axis, 100×.

examination of these inclusions described them as skeletal ilmenite crystals (*Figure 3*), the elongated directions of which were oriented parallel to prism faces of the beryl host[4], in this way causing the six-rayed star of the beryl cabochons.

A piece of an almost opaque, greenish-grey beryl originating also from Brazil, was described by Eppler (1960)[8]. Asterism in this sample is caused by plates or flakes of pyrrhotite, which are oriented parallel to the basal pinacoid of the host[8,9]. This specimen shows a number of extraordinary inclusions[9] and since no similar material has been described in the gemmological literature, it seems to be unique.
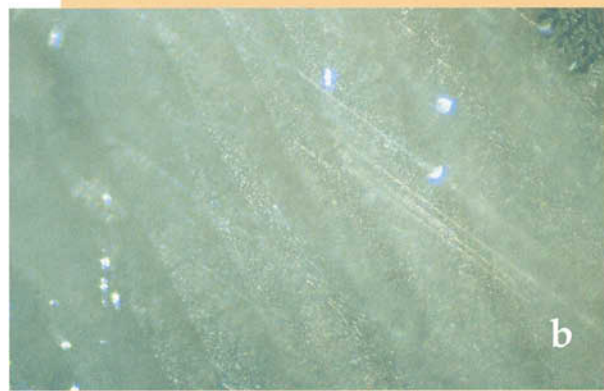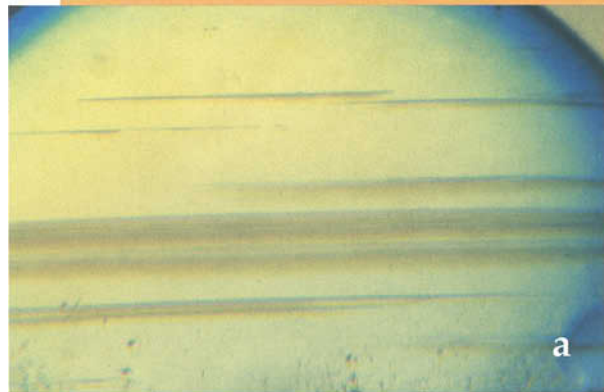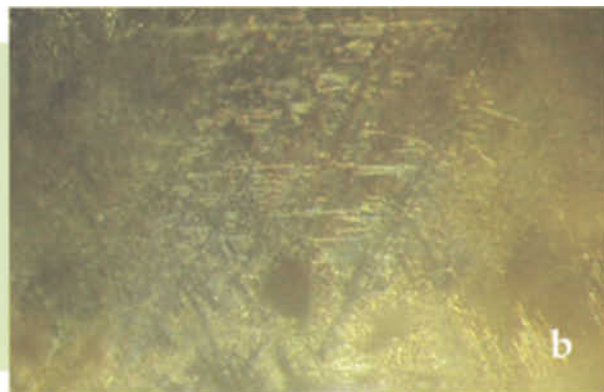

Figure 3: Bronze-brown six-rayed star beryl from Minas Gerais, Brazil; dense pattern of oriented ilmenite skeletal crystals, (a) view oblique to the c-axis, 100×, (b) view parallel to the c-axis, 100×.

Figure 4: Six-rayed star emerald from Brazil. Diameter of the specimen 12.5 mm, weight 10.03 ct. Photo by Tino Hamid, © GIA (reproduced by permission).

Figure 5: Six-rayed star aquamarine from Madagascar; in different orientations (a, b), an intense white sheen in the centre of the aquamarine and the weaker arms of a six-rayed star are visible. Size 18.4 × 12.6 mm, weight 9.53 ct.

Aquamarine with thin fluid films

Several cabochons of asteriated emerald (*Figure 4*) or aquamarine have been reported since the 1980s. These have come from different localities in Brazil as well as from Sri Lanka and Madagascar [1,7,10,11,12,13,14,15]. Microscopic examination commonly reveals that the star emeralds and aquamarines contain three series of small elongated particles[14], needle-like channels[7,12] or channels consisting of two-phase inclusions[7,11]. These inclusions are oriented perpendicular to the *c*-axis and parallel to prism faces of the host. In some samples, thin fluid films on planes parallel to the basal pinacoid[7,10,15] or tabular birefringent

inclusions in the same orientation[1] are also present in asteriated beryl cabochons. Asterism has also been attributed to such fluid films[7].

Fluid films similar to those described by Henn and Bank[7] are also present in four star aquamarines from Madagascar which were available for the present study. In three specimens, the six-rayed star is weak and best seen when moving the cabochons back and forth. The specimen with the most intense star was examined in detail and showed a strong white sheen as well as the somewhat weaker arms of a six-rayed star (*Figure 5*). The asteriated aquamarine contains both disc-like fluid films and oriented channel-like or needle-like inclusions (*Figure 6*). The fluid films are located on planes perpendicular to the *c*-axis (*Figure 7*). Parts of the fluid discs show irregular outlines, but also

Figure 6: Six-rayed star aquamarine from Madagascar; thin disc-like fluid films and channel-like or needle-like inclusions, view parallel to the c-axis, 100×.
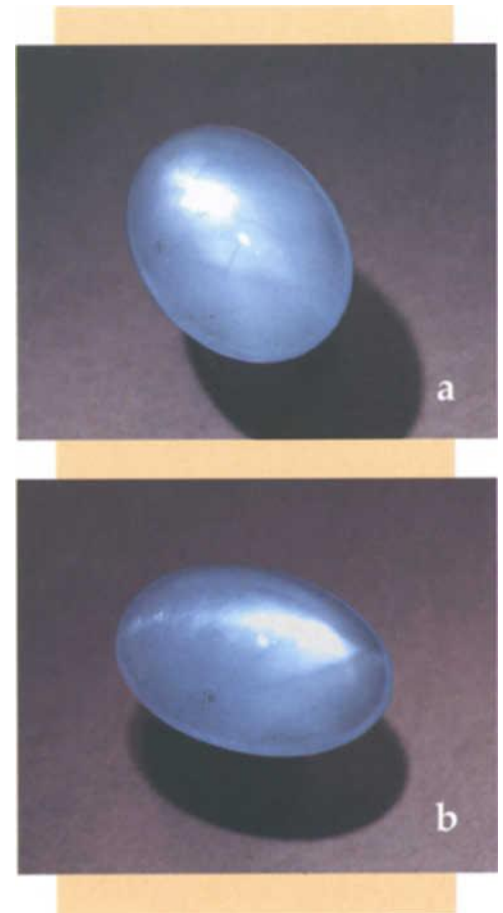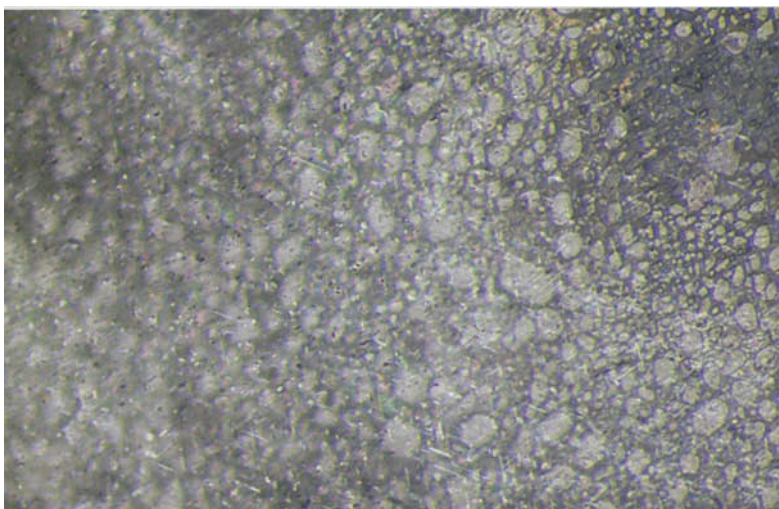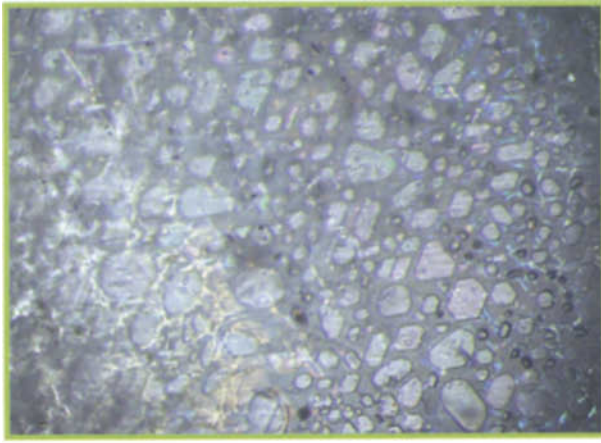
Figure 7: Six-rayed star aquamarine from Madagascar, thin fluid films on planes parallel to the basal pinacoid, the films show irregular and hexagonal or trigonal forms, view parallel to the c-axis, 200×.
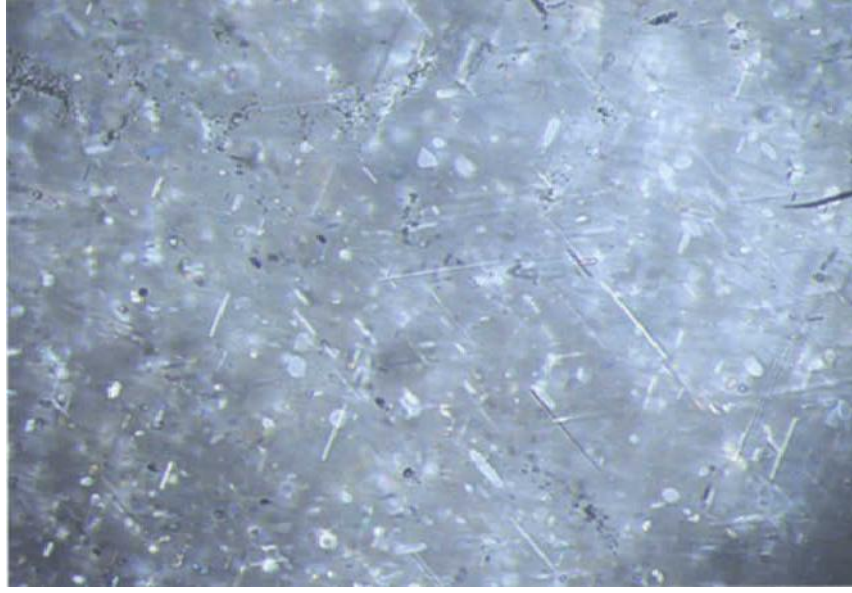

Figure 8: Six-rayed star aquamarine from Madagascar; three series of oriented channel-like or needle-like inclusions are responsible for the asterism; view parallel to the c-axis, 200×.

clear hexagonal or trigonal forms with boundaries parallel to prism faces are seen. In addition, three series of minute, channel-like or needle-like inclusions are present, which are oriented perpendicular to the *c*-axis in directions parallel to prism faces (*Figure 8*). In other words, the orientation of these minute elongated channels or elongated flat fluid films is parallel to the hexagonal boundaries of the flat fluid discs. In this specimen, an examination of the tiny oriented channels with the Raman microprobe did not show any characteristic Raman lines other than those of the beryl host.

Although the fluids on planes parallel to the basal pinacoid reflect at a certain angle to the incident light and cause a white sheen at the centre of the cabochon, they cannot be responsible for the six-rayed asterism of the aquamarine. The star is caused by three sets of elongated channel-like or film-like inclusions oriented in three different directions perpendicular to the *c*-axis. Because both types of inclusion are present, the white sheen of the sample is superimposed on the star and causes a pattern consisting of both optical phenomena. According to the results of the microscopic examination, both types of inclusion are disc-shaped and channel-like thin negative crystals (fluid films) showing boundaries parallel to basal and prism faces.

Multi-star emerald with negative crystals

A four-rayed star aquamarine from Brazil was recently described by Hyrsl (2001)[15]. The specimen was cut from the same type of rough as another cabochon, which yielded a star aquamarine with the ordinary six-rayed asterism but in another orientation. It is assumed that the four-rayed star is caused by a combination of the inclusions that are responsible for the six-rayed asterism and hollow channels which normally cause chatoyancy in beryl[15].

The four-rayed emerald from Madagascar (*Figures 9 and 10*) mentioned above belongs to the same type of beryl, i.e. the sample combines the inclusions causing the ordinary six-rayed asterism with chatoyancy in beryl due to channels parallel to the *c*-axis. The sample shows an absorption spectrum which consists of the absorption bands of Cr^{3+} in emerald superimposed on a strong aquamarine component. This spectrum is consistent with spectra reported for other emeralds from the Mananjary area in Madagascar[1].

The *c*-axis of the emerald is more or less parallel to the elongation of the cabochon which weighs 7.78 ct and measures 12.3 × 10.5 mm. Although the specimen is only semitransparent
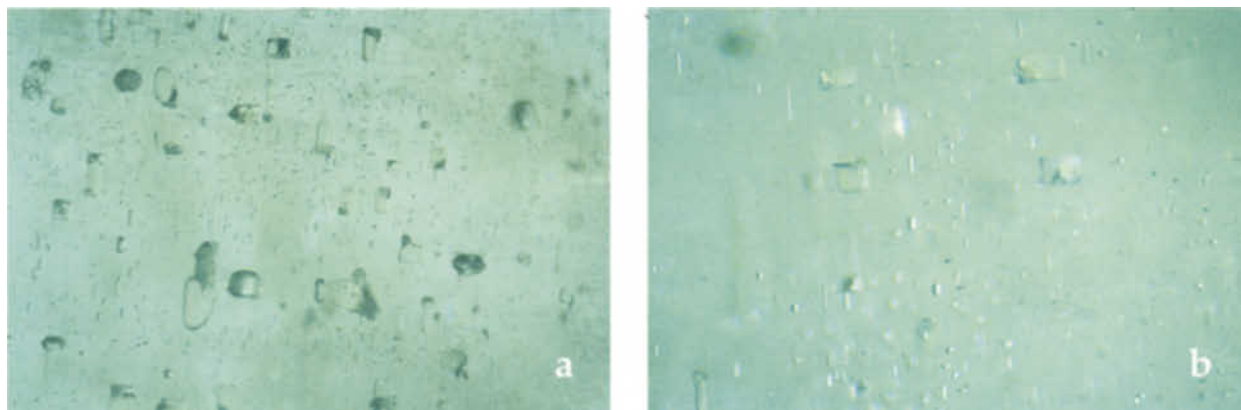
Figure 9: Emerald from Madagascar with six- and four-rayed asterism; short prismatic negative crystals and elongated channels parallel to the c-axis, view perpendicular to the c-axis. (a) 50×, (b) 100×.

(due to numerous inclusions and healing fissures), we observed a series of short prismatic negative crystals or elongated channels in a direction parallel to the c-axis with birefringent solid, liquid and two-phase fillings (*Figure 9*). At high magnification, it was also observed that three series of channel-like or needle-like inclusions are present in directions perpendicular to the c-axis (*Figure 10*). These channels are negative crystals elongated perpendicular to the c-axis and confined by basal and prism faces. An examination with the Raman microprobe showed only the spectrum of the beryl host.

According to the orientation of the different types of channels in this emerald (*Figure 11*), the centre of the four-rayed star in the middle of the dome of the cabochon is observed in a view perpendicular to the c-axis. Turning the cabochon towards a view along the c-axis, i.e. in a view parallel to the curved surface of the sample, one weak six-rayed star is seen at each end of the elongated cabochon. Consequently, the asterism of the emerald is caused by four light bands. The two six-rayed stars, which are observed in views parallel to the c-axis (at both ends of the elongated cabochon), consist of three light bands intersecting at angles of 60° to each other. The four-rayed stars, which are observed in views perpendicular to the c-axis, are formed by intersections of one of the three light bands of the six-rayed star with a fourth light band oriented perpendicular to the c-axis.

This interpretation is confirmed by the results of the microscopic examination described above. The six-rayed stars are formed by three light bands due to three sets of channel- or needle-like inclusions (negative crystals) which are oriented perpendicular to the c-axis intersecting at angles of 60° to each other. These are the light bands of the 'ordinary' six-rayed star in this beryl. Because additional channels or elongated channel- or needle-like inclusions parallel to the c-axis are present, a fourth light band can be observed. This is the light band of an 'ordinary' beryl cat's-eye. The intersection of each of the three 'six-rayed star light bands' and the 'cat's-eye light band' causes the four-rayed stars observed.
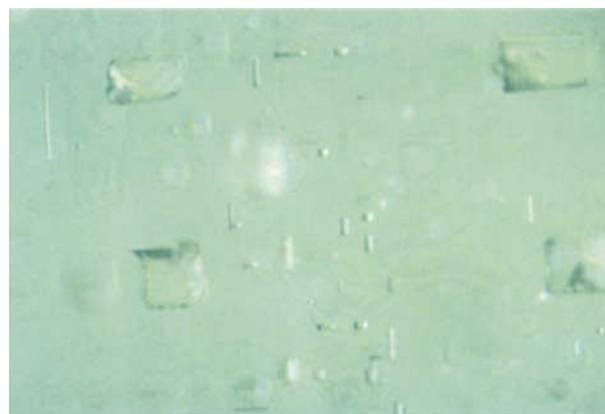

Figure 10: Emerald from Madagascar with six- and four-rayed asterism; short prismatic negative crystals and two series of elongated channels in directions parallel and perpendicular to the c-axis, view perpendicular to the c-axis. 200×.
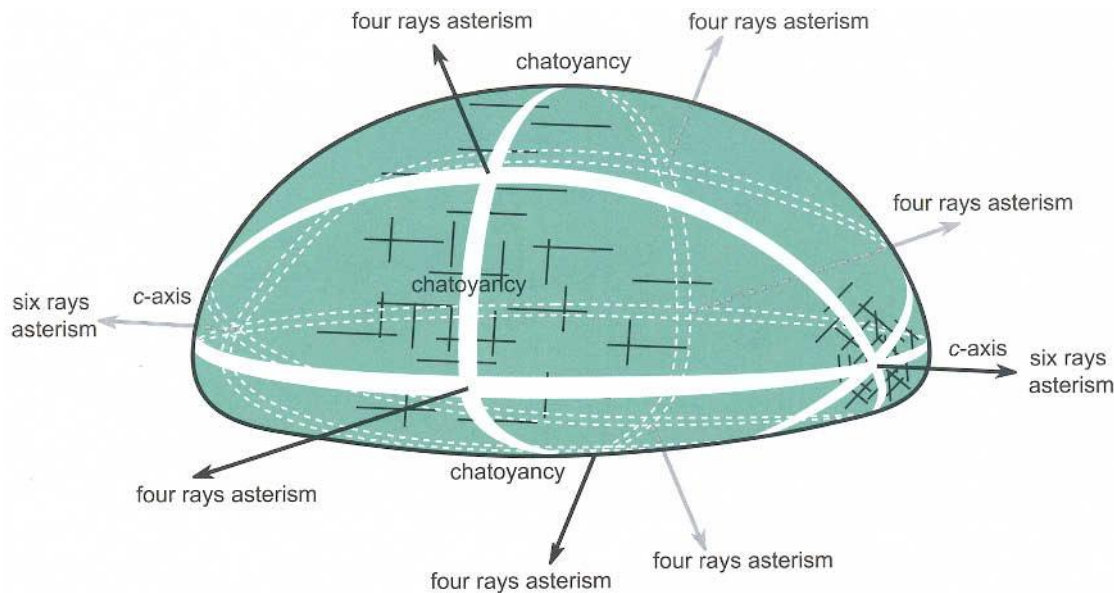
Figure 11: Schematic drawing of the orientation of the four sets of parallel inclusions in the emerald from Madagascar producing four intersecting light bands and a four- and six-rayed multi-star network (artwork by M.S. Krzemnicki).

Conclusion

In summary, asterism in members of the beryl family is caused by oriented solid and fluid inclusions. If three sets of elongated particles (e.g. ilmenite or elongated channel-like fluid films or elongated channel-like negative crystals) oriented perpendicular to the *c*-axis are present, a six-rayed star can be observed. With additional channels parallel to *c*, four- and six-rayed stars are formed. The mineral inclusions causing asterism in beryl which have been determined so far are ilmenite and pyrrhotite. The elongated channel-like inclusions are thin fluid films or negative crystals, both of which are terminated by basal and prism faces. The inclusions are elongated parallel to one of the three equivalent directions parallel to the prism faces of the host.

Acknowledgements

We thank Dr M.S. Krzemnicki for the preparation of the diagram presented in Figure 11 and Tino Hamid and the GIA for permission to reproduce Figure 4.

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Aventurescent oligoclase feldspar from Oregon, USA

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Abstract: *Transparent oligoclase feldspars from Oregon, USA are described. They contain euhedral hematite inclusions, which cause aventurescence.*

Keywords: *aventurescence, chemical composition, gemmological properties, hematite inclusions, oligoclase feldspar, Oregon*

Introduction

Although minerals of the feldspar group are the most abundant minerals in the Earth's crust, gem-quality feldspars are rather rare. However, they can fascinate by their optical phenomena which may be present as adularescence, labradorescence or aventurescence (Henn and Bank, 1992; Henn, 2001).

The feldspars are divided into two main groups on the basis of their composition: the alkali feldspars, aluminosilicates of potassium and sodium, and the plagioclase feldspars, aluminosilicates of sodium and calcium.

The best-known gemstones of the alkali feldspars are moonstone, yellow orthoclase and amazonite, while the most important gem-quality species of the plagioclase group are labradorite and sunstone. The name sunstone or heliolite (from the Greek *helios* = sun and *lithos* = stone) is used for transparent feldspar crystals which were discovered in basaltic rocks in the state of Oregon, USA, in the 1960s by local mineral collectors. The main occurrence is located in the Rabitt Hills, approximately 22 miles north of Plush in Lake County (Pough, 1983). A second locality has been found in Harney County. Small scale mining at several claims has been carried out by local miners since the mid-1970s.

The feldspar crystals of Oregon possess unusual sizes of 8 cm and more and come in a wide range of colours including yellow, yellowish-green, blue-green, violet, orange, red-orange and red. Compositionally, the Oregon sunstones are mixed-crystals in the solid-solution series of the plagioclase feldspars with a range of Na/Ca-ratios.

The most abundant species is labradorite with typical iridescence commonly visible parallel to the cleavage planes, but also bytownite (Bank, 1970), andesine and oligoclase have been found.

Recently, the author had the opportunity to investigate spectacular specimens of transparent oligoclase which were cut by the renowned gemstone cutter Tom Munsteiner.

Figure 1: *Faceted colourless oligoclase feldspar from Oregon, USA, with red inclusions of hematite (45.18 ct, cut by Tom Munsteiner).*

Figure 2: *Faceted oligoclase feldspar from Oregon, USA. The pale red colour is due to concentrations of hematite inclusions (30.90 ct, cut by Tom Munsteiner).*

Description and characteristics

The faceted stones are colourless (*Figure 1*) with red tabular inclusions which are responsible for the pale red colour (*Figure 2*) of some specimens. The pattern of the red inclusions also causes the optical phenomenon of aventurescence which is a spangled sheen caused by the reflection of light from the tiny red platelets. Such aventurescent stones are described as sunstones; they are rather rare and represent only about 1 per cent of the gem-quality Oregon feldspars.

The red inclusions (*Figure 3*) were identified as hematite by microscopical and chemical studies. Aventuescent feldspars from Norway contain a similar inclusion pattern and these also are called sunstone in the gemstone trade.

The refractive indices were measured on a standard refractometer, the SGs were measured by the hydrostatic method and composition was obtained using an energy-dispersive XRF attachment on an electron microscope.

The refractive indices, birefringence, specific gravity and classical composition of the Oregon feldspars are listed in *Table I*. These values classify the feldspars unambiguously as oligoclase. The albite/anorthite-ratio (*Table I, column 3*) characterizes a typical oligoclase composition. Compared with the Norway sunstones and colourless oligoclase from Brazil (Henn and Bank, 1992), the Oregon oligoclases have a lower anorthite content and lower refractive indices.

Acknowledgement

The author thanks Dr Tobias Häger of the University of Mainz, Germany, for the microprobe analyses.

Figure 3: *Microscopic image of euhedral hematite inclusions in oligoclase feldspar from Oregon, USA. Immersed, magnified 30×.*
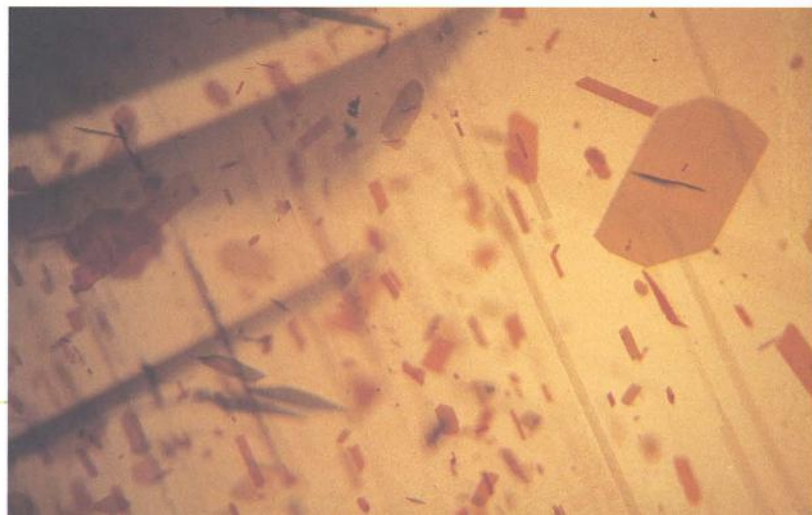
Table I: Physical characteristics and chemical composition of aventurescent oligoclase feldspar from Oregon, U.S.A.

Physical characteristics	Chemical composition of one representative sample. Average of 5 analyses		
$n_x = 1.535\text{-}1.536$	Wt.%		No. of ions on the basis of 32 O
$n_y = 1.538\text{-}1.539$	SiO_2	64.85	Si — 11.35
$n_z = 1.545\text{-}1.547$	Al_2O_3	22.04	Al — 4.62
$\Delta n - 0.010\text{-}0.011$	Fe_2O_3	0.08	Fe — 0.01
	Na_2O	10.31	Na — 3.58
	K_2O	0.24	K — 0.04
	CaO	2.57	Ca — 0.53
	Total	100.09	Feldspar end-member proportions
			Ab — 86.06
			An — 12.74
			Or — 0.96

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Pezzottaite, a new mineral and gem
(supplement to 'Caesium-rich morganite from Afghanistan and Madagascar')

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Abstract: *Nomenclature used to describe new pink mineral specimens from Afghanistan and Madagascar is brought up to date. Structural differences between beryl and pezzotaite are illustrated.*

What appeared to be extraordinary pink beryl with high Cs content in samples from Afghanistan and Madagascar (Hänni and Krzemnicki, 2003) has been found to be a new mineral (Laurs *et al.*, 2003). Our recent publication (op.cit.) was based on results obtained before a decision was available from the 'Commission for new minerals and new mineral names' of the International Mineralogical Association (IMA). The decision of the IMA to accept pezzottaite as a new mineral was issued on 5 September 2003 and a definitive article by Hawthorne *et al.* is expected in the *Mineralogical Record*.

Consequently the terminology used by Hänni and Krzemnicki (2003) relating to pink morganite, pink beryl or Cs-beryl should be replaced by the name pezzottaite when the Li-Cs-rich analogue of beryl is meant (see *Figure 1*). With quantitative Be and Li data from ICP-MS measurements, and lattice dimensions calculated from

Figure 1: A selection of pezzottaite crystals with characteristic tabular habit. The cut stones are from 1.5 to 3.00 ct, (the step-cut sample in the middle is 12 mm long). Pezzottaites with a dense array of fine tubes (parallel to c) are cut as cabochons and produce cat's-eyes.

Beryl
hexagonal

Pezzottaite
trigonal

△ SiO₄ → SiO_4
◎ Al
● Be
· Si
○ Li
● Cs
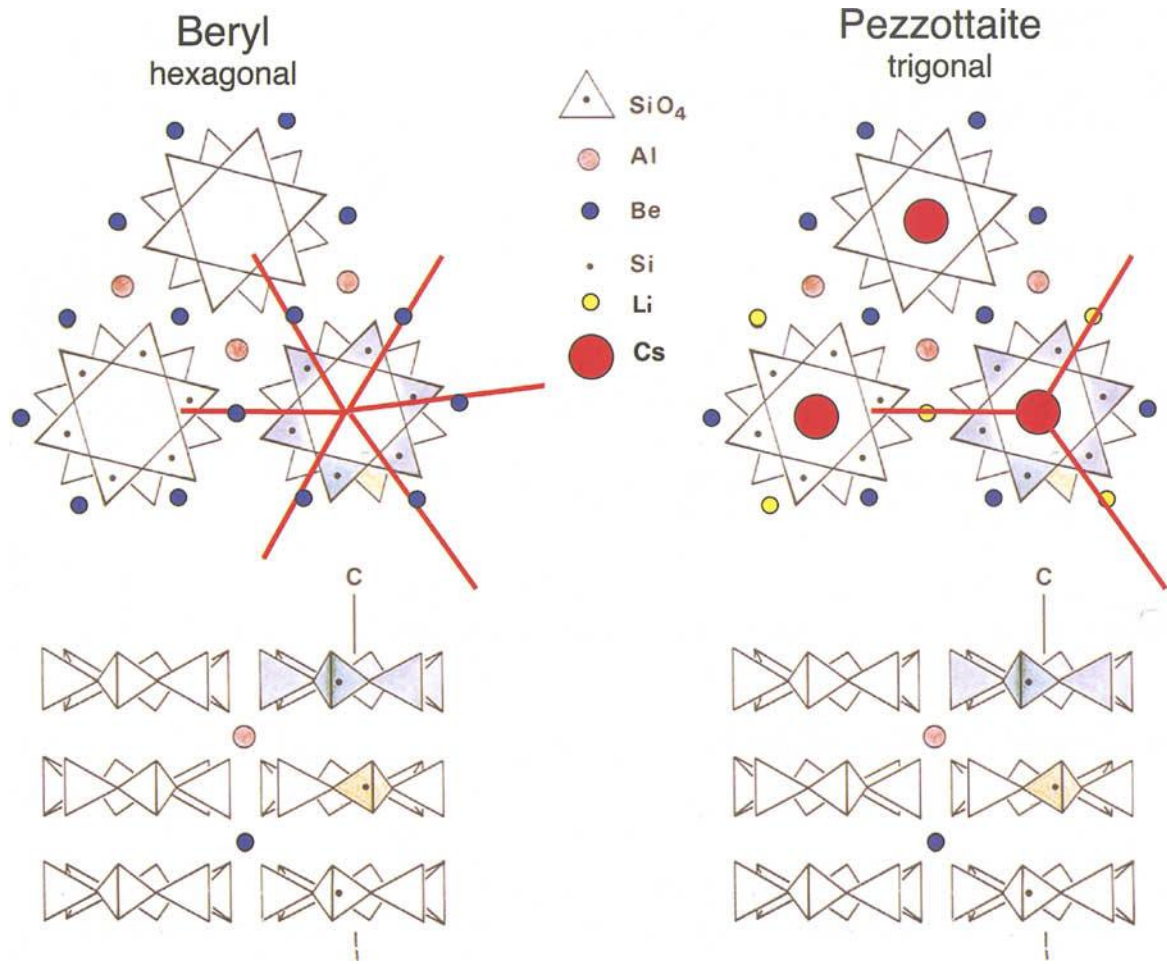
Figure 2: *Schematic diagram of the crystal structures of beryl and pezzottaite. The upper parts show structures projected on a basal plane (perpendicular to c). The lower parts show a side view of the axial direction (parallel to c) with stacked Si_6O_{18} rings and cation positions. The ordered coupled substitution $Be^{2+} = Li^+ + Cs^+$ implies a trigonal symmetry for pezzottaite.*

single crystal X-ray data, the space group of pezzottaite was determined as R3c. Although similar to the beryl structure, the systematic and symmetrical positions of the Li and Cs in the structure of these samples from Afghanistan and Madagascar justify establishment of the new mineral. The similarities and differences in structure between the two minerals are illustrated in *Figure 2*. Ongoing research will show whether or not there is solid solution between pezzottaite and beryl.

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Yellow and brown coloration in beryllium-treated sapphires

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Abstract: The causes of yellow and brown coloration in Be-treated sapphires have been investigated by a series of irradiation and Be-heating experiments on synthetic and natural colourless sapphires. UV-Vis spectra have been recorded and the stones have been analysed for trace elements by LA-ICP-MS. Based on these results it is likely that the Be-heating process could activate stable yellow colour centres in natural sapphires, which are also related to oxygen in the atmosphere and iron; these are stabilized by the diffusion of Be. Brown colour centres could be activated in the synthetic sapphires without iron. Therefore Be is able to act in the same way as has been previously proposed for Mg.

Keywords: beryllium treatment, colour centres, diffusion, heat treatment, irradiation, yellow sapphires

Introduction

Gemstone enhancement is traditional in human history. For several hundred years, rubies have been heated in coal furnaces to reduce the blue hue (Nassau, 1984, 1994; Hughes, 1997). The 'classical' high temperature treatment of corundum has been known for thirty years (Tombs, 1980; Harder, 1980; Crowningshield and Nassau, 1981; Nassau, 1982). Today we understand the mechanisms and the causes of colour much better than in the past. Nevertheless, the gemstone industry of Thailand has surprised us once again with a 'new' corundum enhancement technique that shows new and unexpected colour distribution and reactions. Examples have been presented on a number of websites (e.g. AGTA, GRS) and from Hughes (2002) and McClure et al. (2002).

Typical examples of the product of this 'new' heating process can be seen in *Figure 1*. Many of those samples show surface-related yellow zones or if the stone contains chromium, an orange colour rim was observed (*Figures 2 and 3*). To get a better inside view, the stones were put into an immersion liquid (methylene iodide) and to improve the contrast a blue glass filter was placed between the light source and the stones. The thickness of the surface-related colour zone is about 2.5 mm in *Figure 2* and about 1.2 mm in *Figure 3*. However, colour rims up to 4 mm have been observed in the lab.
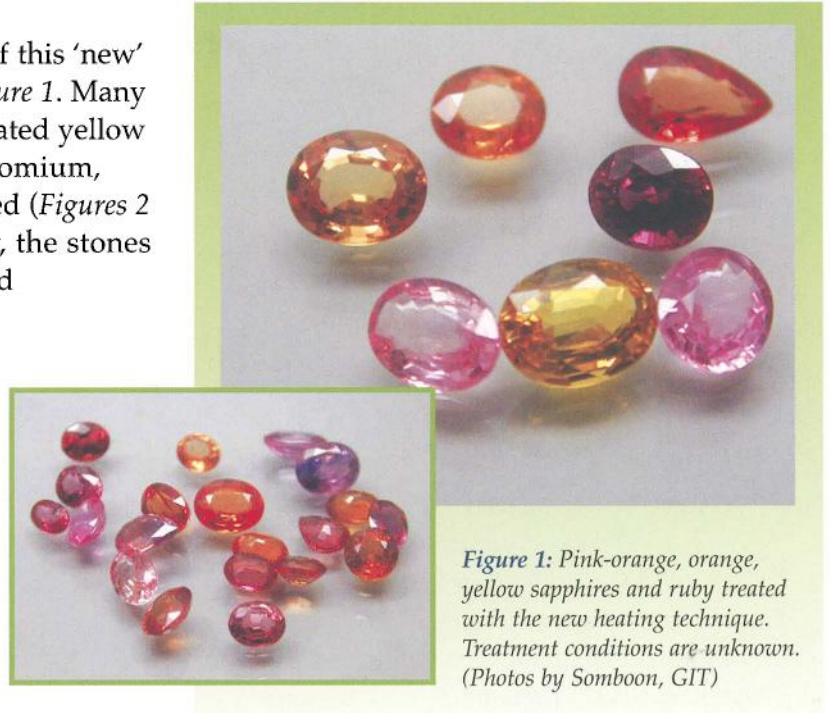
Figure 1: Pink-orange, orange, yellow sapphires and ruby treated with the new heating technique. Treatment conditions are unknown. (Photos by Somboon, GIT)
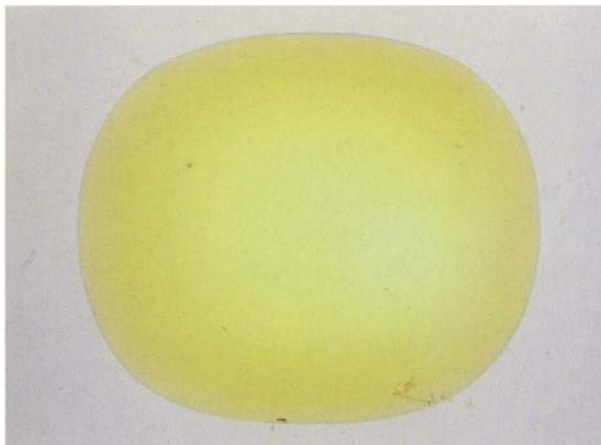
Figure 2: Surface-related colour zones in a yellow sapphire, 10.06 × 11.57 mm. (Immersion, photo by Leelawatanasuk, GIT)

Because the colour zones are parallel to the surface, it suggests that the stones have been subject to diffusion of a foreign element or combination of elements. Hitherto, diffusion of a colour-producing element into a gem mineral lattice on the scale of millimetres has not been observed. The penetration depth of the traditional diffusion treatment shown in *Figure 4*, where Ti and Fe are introduced into the sapphire from outside is about 0.09 mm; this is known as external diffusion. Of course, the penetration depth can vary slightly
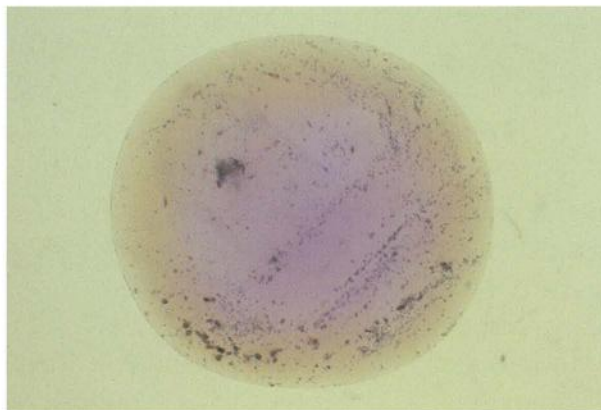
Figure 3: Surface-related colour zones in a pink-orange sapphire, 5.20 × 6.63 mm. (Immersion, photo by Somboon, GIT)

Figure 4: Slice of colourless sapphire with blue rim caused by external diffusion of Ti into the stone; 4 × 7 mm. (Immersion, photo by Häger)

depending on time and temperature of treatment. A similar order of diffusion thickness (0.06 mm in *Figure 5*) can be observed in the case of internal diffusion, where titanium diffuses from natural rutile inclusions into the corundum lattice.

To understand the new enhancement technique applied to create yellow and orange sapphires, it is necessary to understand the causes of colour of natural yellow sapphires in detail. Two groups of natural yellow sapphires exist. The first group owes its colour to a spin forbidden transition of Fe^{3+} (Lehmann and Harder, 1970; Krebs and Maisch, 1971; Ferguson and Fielding, 1971, 1972; Nassau and Valente, 1987). However, the probability of this transition is very low, therefore, approximately 1 weight % Fe^{3+} is needed to create an intense yellow with this mechanism. Sapphires of this group originate for example from the basaltic-type occurrences
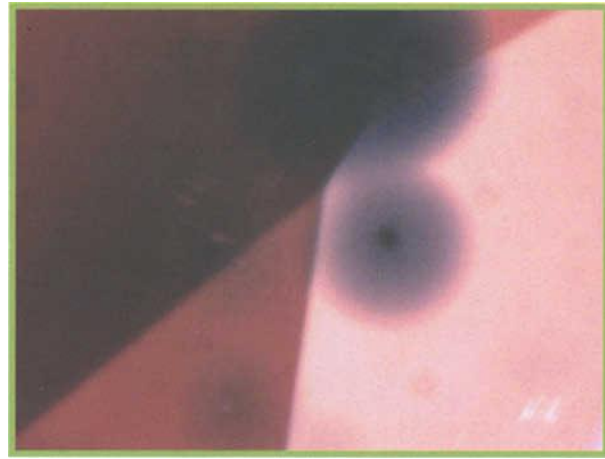
Figure 5: Internal diffusion of Ti from rutile inclusions into the corundum lattice showing the blue haloes. (Photo by Häger)

in Thailand, Australia and North Madagascar, or from the metamorphic occurrence in Umba, Tanzania (D. Schwarz, pers. comm., 2003). Typical spectra resulting from this kind of mechanism are shown in *Figure 6*.
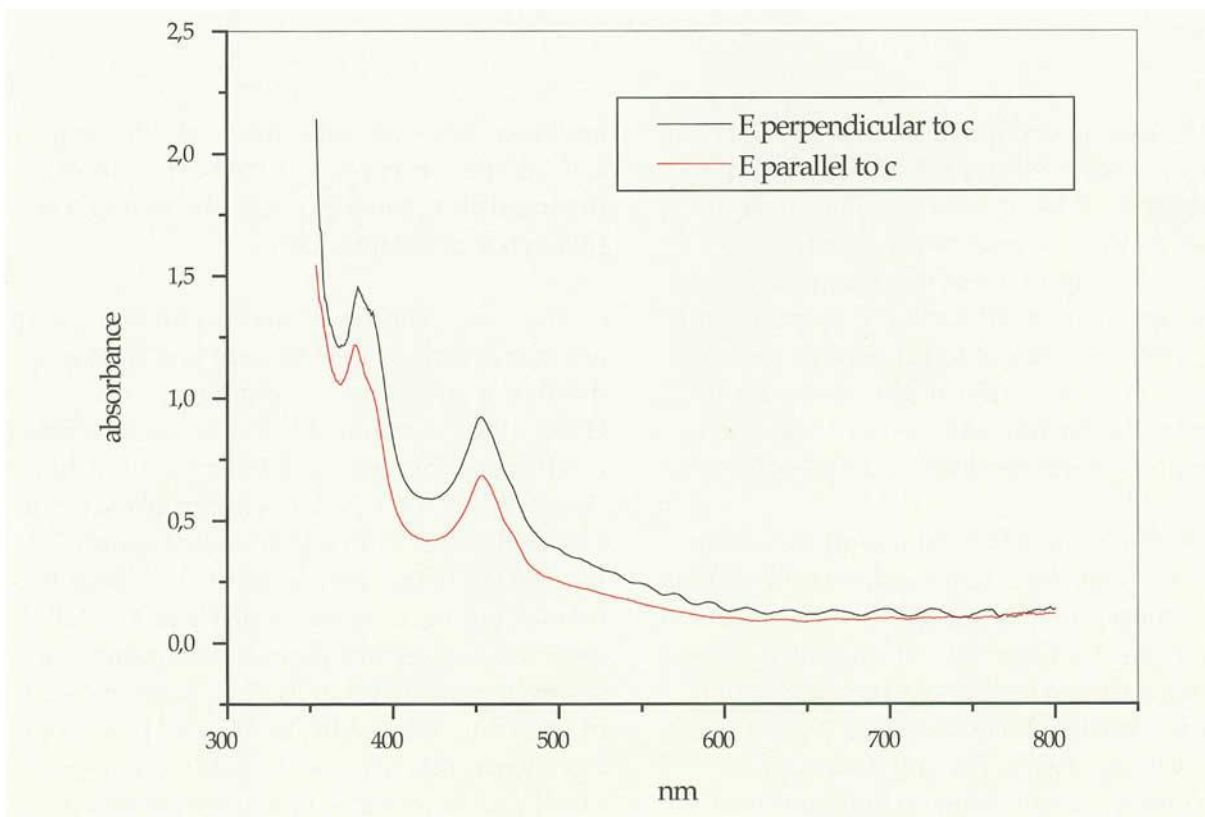
Figure 6: UV-Vis-spectra of an untreated yellow sapphire from Thailand (Khao Phloi Wean Chanthaburi) with E perpendicular to c-axis (o-ray, black) and E parallel to c-axis (e-ray, red). The colour is due mainly to Fe^{3+} forbidden transition.
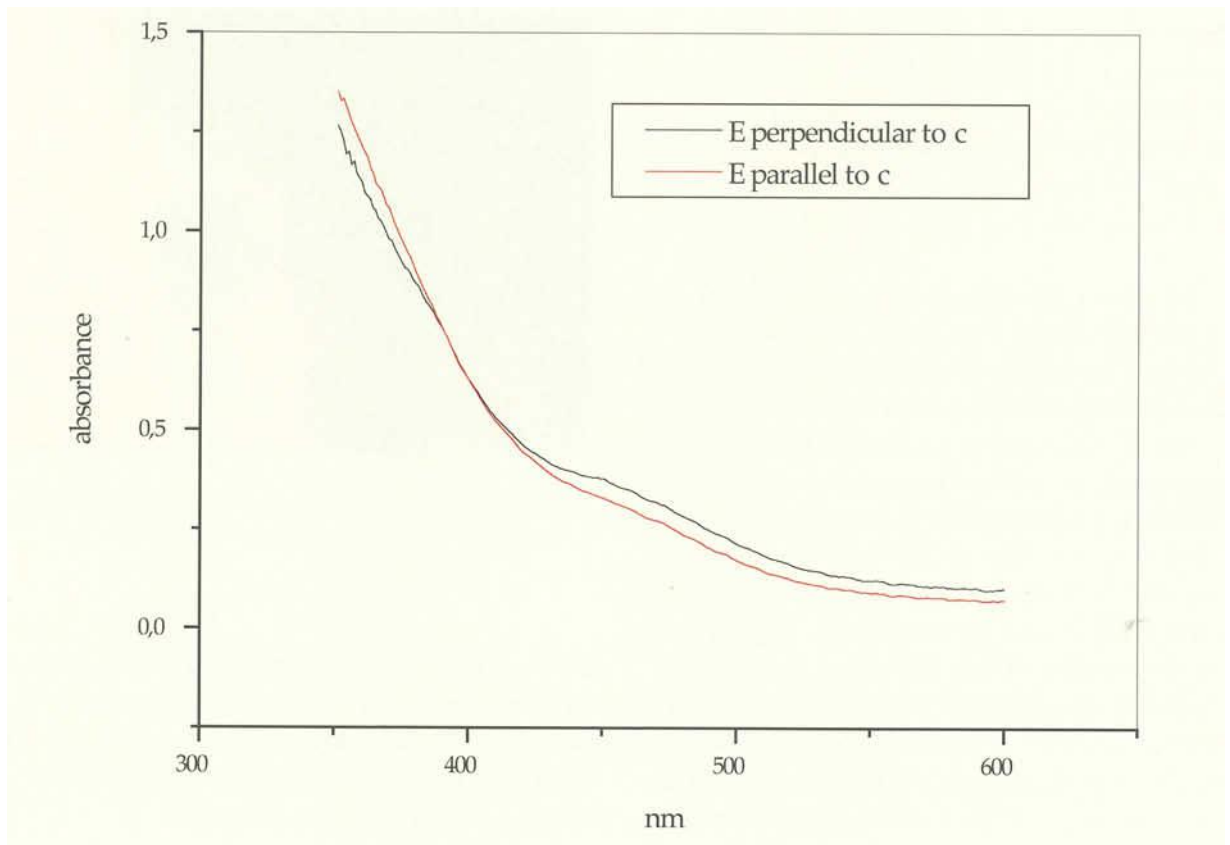
Figure 7: UV-Vis spectra of a heat-treated natural yellow sapphire from Sri Lanka with E perpendicular to c-axis (o-ray, black) and E parallel to c-axis (e-ray, red). The colour is due to stable defect centres.

The second group is coloured by so-called colour centres whose UV-Vis-spectra are characterized by an increase of absorption towards the UV-part of the spectrum (*Figure 7*). Sapphires of this group originate for example from Sri Lanka. The spectrum E (the electric vector of light) parallel to *c*-axis (e-ray) is very similar to the spectrum E perpendicular to *c*-axis (o-ray), and such sapphires therefore show weak pleochroism.

On the basis of the stability of the colour or defect centres, it is possible to differentiate this group into two sub-groups. The first sub-group contains natural sapphires whose colour is due to irradiation (Lehmann and Harder, 1970; Nikolskaya *et al.*, 1978; Nassau and Valente, 1987). The colour centres of this group are not stable to light and heat. The defect centres of the second sub-group are stable to UV light and to heat up to about 500 or 600°C. It is not possible to differentiate

between these two sub-groups on the basis of UV-Vis spectroscopy, and the best method of distinguishing them is to use the fading test (Nassau and Valente, 1987).

The defect centres of the second sub-group are stable with respect to light and heat in an oxidizing atmosphere. Schmetzer *et al.* (1982, 1983) mentioned that the colour centres might be stabilized by divalent cations like Fe^{2+} or Mg^{2+}, by trivalent cations like Cr^{3+} or Fe^{3+} or by several di- and tri-valent cations. Häger (1993) and Emmett and Douthit (1993) pointed out the importance of Mg as a stabilizer of the colour centres in natural sapphires and strongly indicated that Mg has to be in excess of intrinsic Ti. In addition, Häger (1996, 2001) has shown that Mg+Fe, an oxidizing atmosphere and high temperature are necessary to develop stable yellow colour centres. Interactions of trace elements in corundum are briefly summarized in Box I.

Box I: Interaction of trace elements in corundum at high temperatures

Based on several quantitative experiments it has been shown that in addition to the classical trace elements like Fe and Ti which influence the colour of blue sapphire, Mg is also important. This element is able to form colourless $MgTiO_3$-clusters. If Ti exceeds the Mg-content, the excess of Ti leads in combination with Fe to colour-active $FeTiO_3$-clusters (Häger, 1992). In the case of a yellow sapphire which is coloured by stable defect centres, Mg is in excess after the calculation of the colourless $MgTiO_3$-clusters (Häger, 1993; Emmett and Douthit, 1993). But in contrast to Emmett and Douthit, it was shown that the excess of Mg in combination with low Fe causes stable colour centres identical to those of natural yellow sapphires from Sri Lanka, while Mg by itself stabilizes another kind of colour centre (Häger, 1996). If Ti-content exceeds the sum of Mg + Fe, the excess of Ti will precipitate during heat treatment at 1850°C in an oxidizing atmosphere. To summarize the above, the following diagrams were developed (Häger, 1996, 2001).

*	colour centre due to Mg
***	yellow due to Fe^{3+}
*****	Fe^{2+}/Ti^{4+}-charge transfer

**	colour centre due to Mg and Fe
****	Fe^{2+}/Fe^{3+}-charge transfer green due to Fe^{3+}
******	precipitation of TiO_2
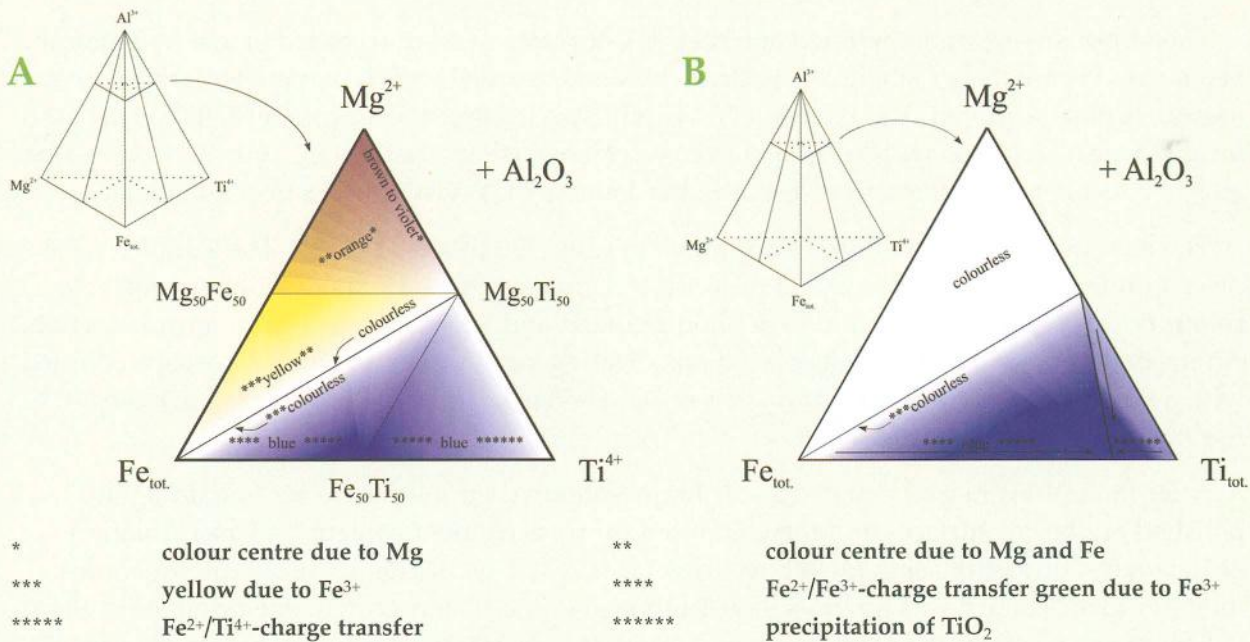
Figure I: *Model representing the interaction of trace elements in the system Mg, Fe, Al and Ti for samples which were heat treated in oxidising (A) and reducing atmospheres (B) at high temperatures.*

The diagram in *Figure IA* represents the system Al-Mg-Fe-Ti (tetrahedron). Out of this tetrahedron a slice is cut. This slice represents sapphires with total trace element content in the ppm region. The resulting diagram is a triangle. Sapphires of this composition were heat treated at 1850°C in an oxidizing atmosphere (*Figure IA*) and at 1750°C in a reducing atmosphere (*Figure IB*). The most important line in the large triangle in *Figure IA* is the connecting line between the Fe corner and the $Mg_{50}Ti_{50}$ point where the Mg to Ti ratio is always 1:1; there, the samples neither show any kind of colour centres nor an Fe^{2+}/Ti^{4+} charge transfer band. Above this line are stable yellow colour centres such as found in natural sapphires from Sri Lanka. In the Mg corner are stable defect centres, but not with the same UV-Vis spectral pattern as the samples containing both Fe and Mg. Below the line, where Ti:Mg ratio is more than 1:1, are the Fe^{2+}/Ti^{4+} charge transfer bands. If the titanium content exceeds the sum of Mg + Fe a titanium-containing phase can precipitate. If the sapphires are treated in reducing conditions, the colour centres are destroyed completely and additional titanium precipitates are dissolved (*Figure IB*). The amount of additionally dissolved precipitates now depends on the kinds of the reducing gases used.

Box II: Materials and methods

In this study two flame-fusion-grown colourless sapphires, a disc of synthetic colourless corundum or 'watch glass', and three natural colourless sapphires were heat-treated under unknown conditions by a Thai heater. Five yellow, orangey-yellow and blue sapphires, reportedly the results of heat-treatment by the Be-technique in Thailand were also studied. A similar set of samples (two flame-fusion-grown colourless and nine natural colourless sapphires) was also irradiated by soft X-rays (4 mA, 80 kV) for four hours.

The heat-treatment experiments were also carried out by one author (TH) to confirm results. A synthetic colourless ('watch glass') and two natural colourless, one natural blue and many natural pink sapphires mixed with ground chrysoberyl in the crucibles were heated in a resistance furnace with Super Kanthal 1900 heating elements at 1750°C in air (i.e. under oxidizing conditions) for 30 hours.

The samples were photographed and their UV-Vis spectra were recorded before and after the heating and irradiation. Only if the spectrum was not recorded with E perpendicular to the c-axis (o-ray), is this fact noted. The Hitachi UV-Vis-NIR spectrophotometer (model U4001) was used for most measurements with additional measurements using a Leica/Leitz UV-Vis microscope attached to a spectrometer and a Perkin-Elmer Lamda 9 UV-Vis-NIR spectrophotometer.

The heat-treated and irradiated samples were subjected to a fading test. The samples were placed under a 100 W light bulb at a distance of 4 cm for several hours to fade any unstable colour centres. The samples were then photographed and UV-Vis spectra were recorded again. An irradiated natural sample was placed on a heating stage under a Leica microscope coupled with a spectrometer with a resolution of 1 nm. A UV-Vis-spectrum was recorded at every 10°C rise in temperature up to 300°C.

After the UV-Vis measurements, a set of representative samples were cut in half, lightly polished on the cut surfaces and then analysed for trace element content by Laser Ablation Inductively-Coupled-Plasma Mass Spectrometry (LA-ICP-MS). This set of samples includes three synthetic colourless sapphires (one Be-treated flame-fusion-grown, one original flame-fusion-grown cut from the same boule and one disc of synthetic corundum or 'watch glass'), two natural colourless sapphires (one Be-treated, one original sample obtained from the same gemstone dealer), three yellow and orangey-yellow Be-treated natural sapphires and two Be-treated natural blue sapphires obtained from different heaters. The 5-points profile analysis (Rim1, Mid-Point1, Core, Mid-Point2, Rim2) and 3-points profile analysis (Rim1, Core, Rim2) were performed across the cut surface by this technique.

Detailed descriptions of LA-ICP-MS instrumentation, analytical and calibration procedures are similar to those given by Norman *et al.* (1996). The UV laser ablation microprobe (a New Wave Research 266 nm Nd: YAG) is coupled to an Agilent 7500 ICP-MS. All analyses were done with a pulse rate of 5 Hz and beam energy of approximately 0.5 mJ per pulse, producing a spatial resolution of 30-50 µm in diameter on the samples. Quantitative results of isotopes for nine trace elements (Be9, Na23, Mg24, Ti47, V51, Cr53, Mn55, Fe57 and Ga71) were obtained through calibration of relative element sensitivities using the NIST-610 multi-element glass standard and pure Al_2O_3 as internal standards. The BCR2G basaltic glass standard was also used as an external standard. The contents are reported as µg/g or ppm by weight. The detection limits vary from analysis to analysis and are typically less than 1 ppm for Be, V and Ga; less than 4 ppm for Mg, Ti and Mn; less than 13 ppm for Cr; less than 40 ppm for Na and less than 80 ppm for Fe.

With the 'new' heating technique, pink-orange or orange sapphires can be produced from original pink or reddish-brown corundum, and colourless or white sapphires can be enhanced by addition of a yellow hue to the stones. Some yellow sapphires can even be obtained by heat-treatment of original green or blue sapphires by the 'new' technique (Coldham, 2002). In the press release from the Chantaburi Gem and Jewelry Association (CGA) on 20 February 2003, the 'new' heating technique was disclosed as 'Be-treatment or Be-heating' technique. Hence, understanding how this yellow hue is caused by this technique is very important.

Results

Irradiation

In the first series of tests, the irradiation experiment was carried out on a flame-fusion-grown colourless sapphire and a natural colourless sapphire (*Figures 8-12*). The synthetic sample is relatively pure Al_2O_3 in which most of the trace elements including Be are below the detection limits; a typical analysis, taken from the core of a stone, is shown in *Table I*. The natural sample contains relatively higher trace element content, in particular Mg, Ti and Fe, while the Be content is below the detection limit (*Table I*). After the irradiation the synthetic stone turned slightly
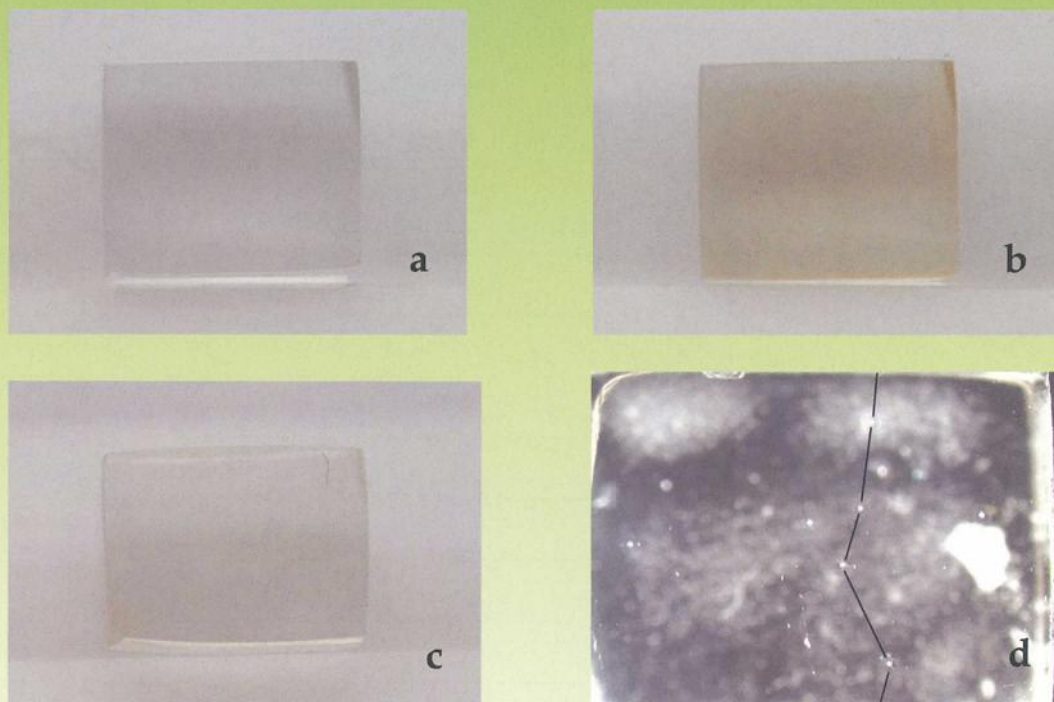
Figure 8: Photos of the 2.44 ct flame-fusion-grown colourless sapphire (PKSCS02) before treatment (a), pale brown after X-ray irradiation treatment (b), and almost colourless after a fading test (c). Afterwards the sample was cut in half and six-points on a traverse (d) were analysed across the cut surface using LA-ICP-MS (see also Table I and Figure 9). (Photos by Somboon, GIT and Lomthong, KU)

Figure 9: *UV-Vis spectra of the 2.44 ct cube of flame-fusion-grown colourless sapphire (PKSCS02) before treatment (c), pale brown after X-ray irradiation treatment (a), and after a fading test (b).*

Table I: *Some typical trace element contents of a flame-fusion-grown colourless sapphire (PKSCS02), and a natural colourless sapphire (POMCS04), both untreated with Be, obtained by LA-ICP-MS.*

μ/g	Core of synthetic sapphire PKSCS02	Core of natural sapphire POMCS04
Be	<0.95	<0.75
Na	<40.97	57.55
Mg	5.50	81.01
Al	529250.40	529250.40
Ti	<3.74	129.98
V	<0.59	17.44
Cr	<12.58	15.40
Mn	<2.85	<2.26
Fe	<77.93	719.27
Ga	<0.55	89.82
Total %	52.93	53.04
< = below detection limit		

brown (*Figure 8b*) whereas the natural one became intense yellow (*Figure 10b*). The UV-Vis spectra of the synthetic sample (*Figure 9*) changed from a flat line before irradiation to a broad absorption band at approximately 400 nm with only a weak absorption in the UV-part of the spectrum after irradiation (see also Kvapil *et al.*, 1972, 1973). The UV-Vis spectra of the natural sapphire (*Figure 11*) changed from a flat line before irradiation to a pronounced increase in absorption in the UV-part of the spectrum with a distinct shoulder at approximately 460 nm after irradiation (similar results have previously been reported by Schmetzer *et al.*, 1982, 1983; Nassau and Valente, 1987). The colour of all the irradiated samples was not stable during the fading test and they returned to their original 'colourless' state (*see Figures 8 and 10*). The same results were obtained from several runs on synthetic and natural colourless samples.

Figure 10: Photos of a 0.73 ct natural colourless sapphire (POMCS04) before treatment (a), yellow after X-ray irradiation treatment (b), and almost colourless after a fading test (c). A five-point-profile (d) was analysed across the cut surface afterwards using LA-ICP-MS (see also Table I and Figure 11). (Photos by Somboon, GIT and Lomthong, KU)

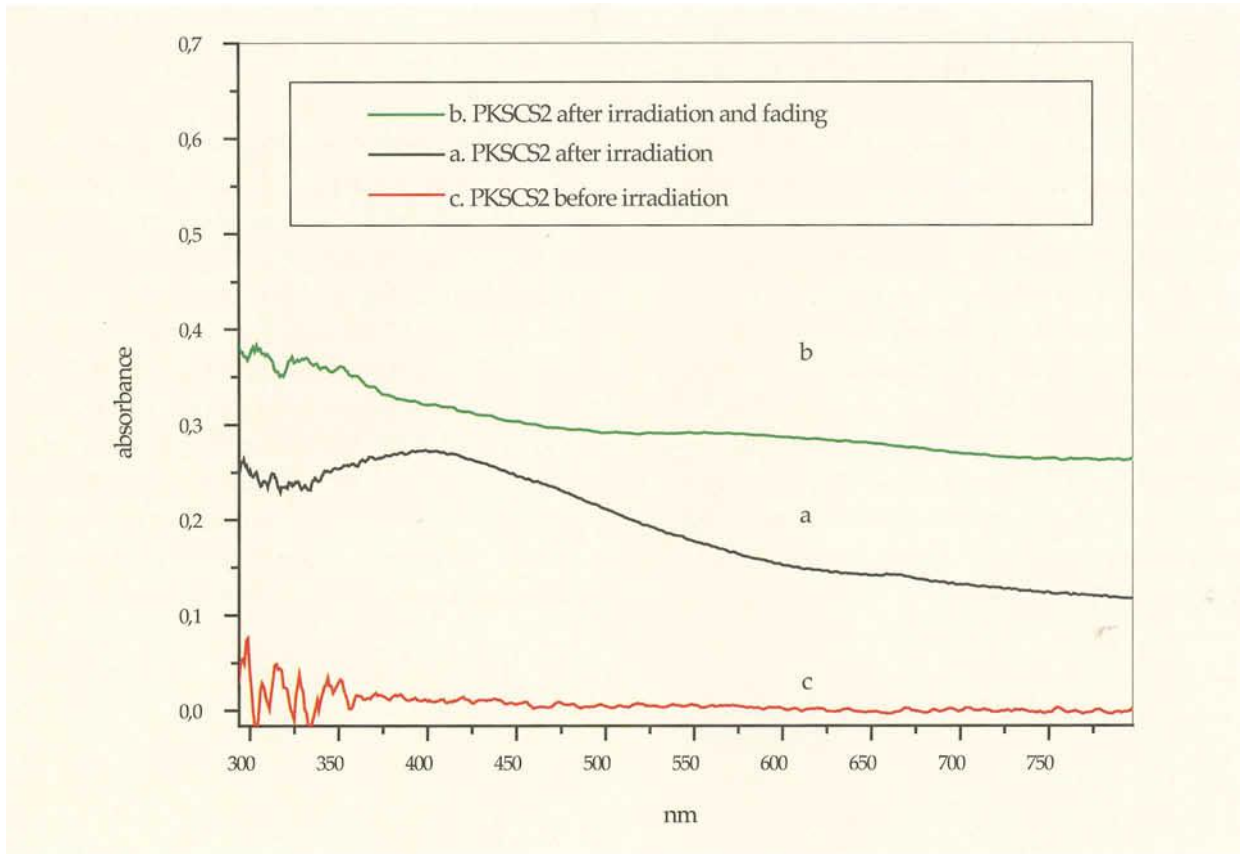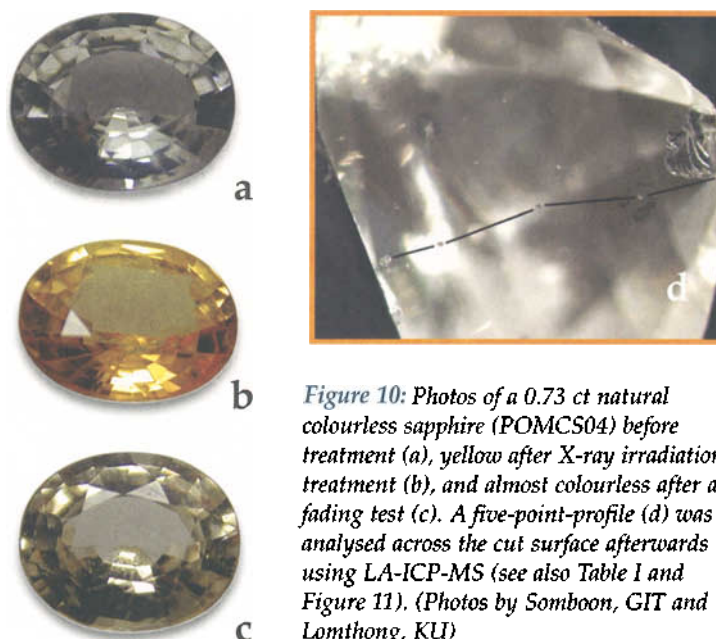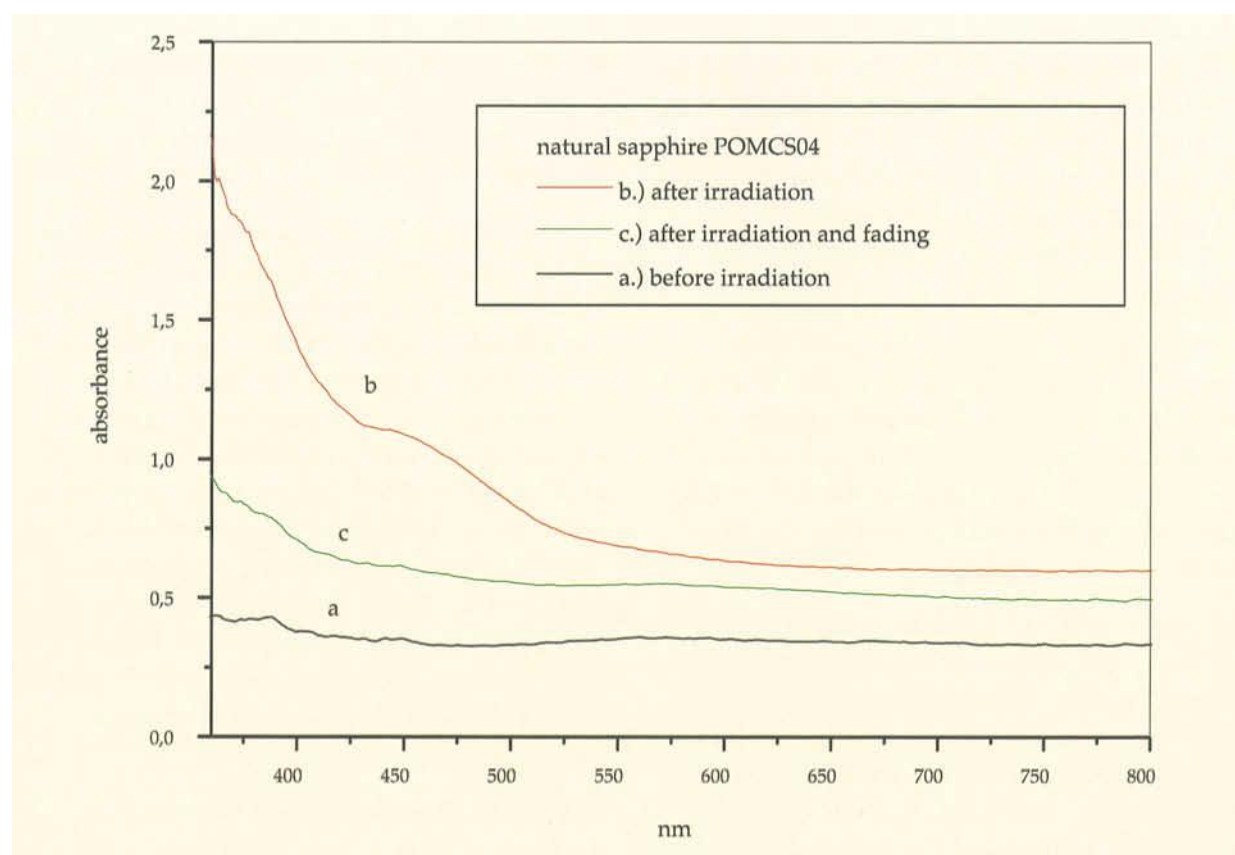*Figure 11: UV-Vis spectra of the 0.73 ct natural colourless sapphire (POMCS04) before treatment (a), after X-ray irradiation treatment (b) and after a fading test (c).*
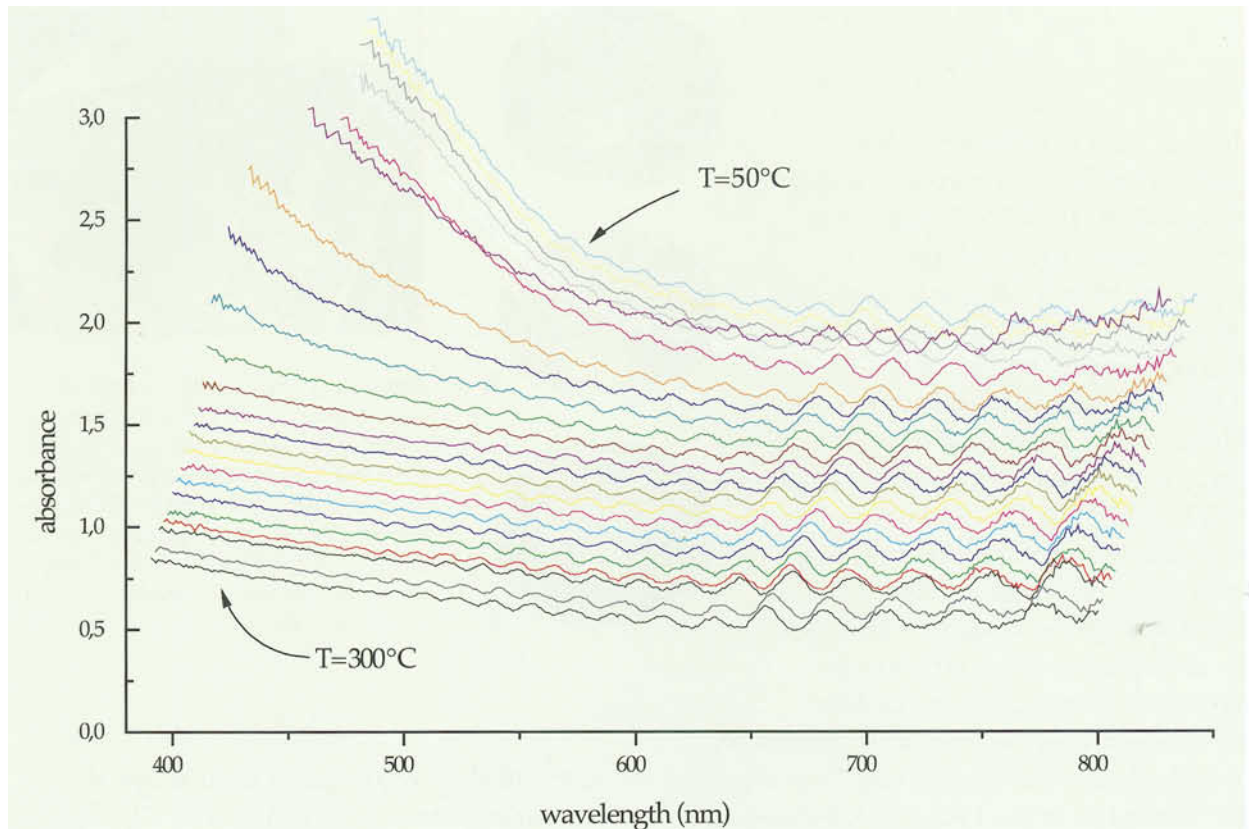
Figure 12: UV-Vis spectra of an irradiated natural sapphire heated up at a rate of 2°C/min; spectra were recorded every 10°C and a selection is shown. The main point to note is that the intensity of colour fades to near-colourless at 300°C.

Figure 12 shows clearly the changes in spectra relating to instability of the colour of an irradiated natural sample. After irradiation, the sample faded during heating especially in the temperature range between 50°C and 150°C and returned to its original colour.

Beryllium heat-treatment

In the second series of tests, Be-heat-treatment was carried out by a Thai heater on both synthetic and natural colourless sapphires. A similar set of samples was used for our own heating experiment. The precise conditions and procedure used by the Thai heater were not divulged.

Be-treated synthetic colourless sapphires

The 3.85 ct cube of colourless flame-fusion grown sapphire (*Figure 13a*) treated by the Thai heater, turned pale brown at the rim with a gradual decrease in intensity towards the colourless core (*Figure 13b*). The pale brown rim and colourless core are better seen in the immersion liquid (*Figure 13c*). This

sample turned colourless after heating in reducing conditions and returned to pale brown again after re-heating in oxidizing conditions (*Figure 13e* and *f*).

Another 11.03 ct square-cabochon sample cut from the same boule and heat-treated under the same conditions gave exactly the same result (not shown here). A similar pale brown colour was observed in our own experiment on a colourless 'watch glass' sample mixed with ground chrysoberyl and heated at 1750°C in oxidizing conditions for 30 hours. Moreover, the same brown coloration was also reported by Emmett and Douthit (2002), Emmett *et al.* (2003) and Themelis (2003) on colourless flame-fusion-grown, Czochralski-grown (high purity) and heat-exchanger-grown (ultra-high purity) sapphires.

The UV-Vis spectrum of the synthetic sapphire changed from a flat line before heating to a broad absorption band at

Figure 13: *Photos of a 3.85 ct flame-fusion-grown colourless sapphire (PKSCS01) before treatment (a) and pale brown after Be-treatment under unknown conditions (b). The pale brown rim and colourless core are better seen under immersion (c). After the treatment the sample was cut in half and a five-point profile (d) was analysed across the cut surface using LA-ICP-MS (see also Table II, Figures 14 and 15). The other half was then cut into three pieces; one piece was kept as the reference and the other two were heated in a pure nitrogen atmosphere at 1650°C for three hours, which turned the stones colourless (e). One of the colourless pieces was then re-heated in air (i.e. oxidation conditions) at 1650°C for 1 hour, which turned the sample back to pale brown (f). (Photos by Somboon, GIT and Lomthong, KU)*
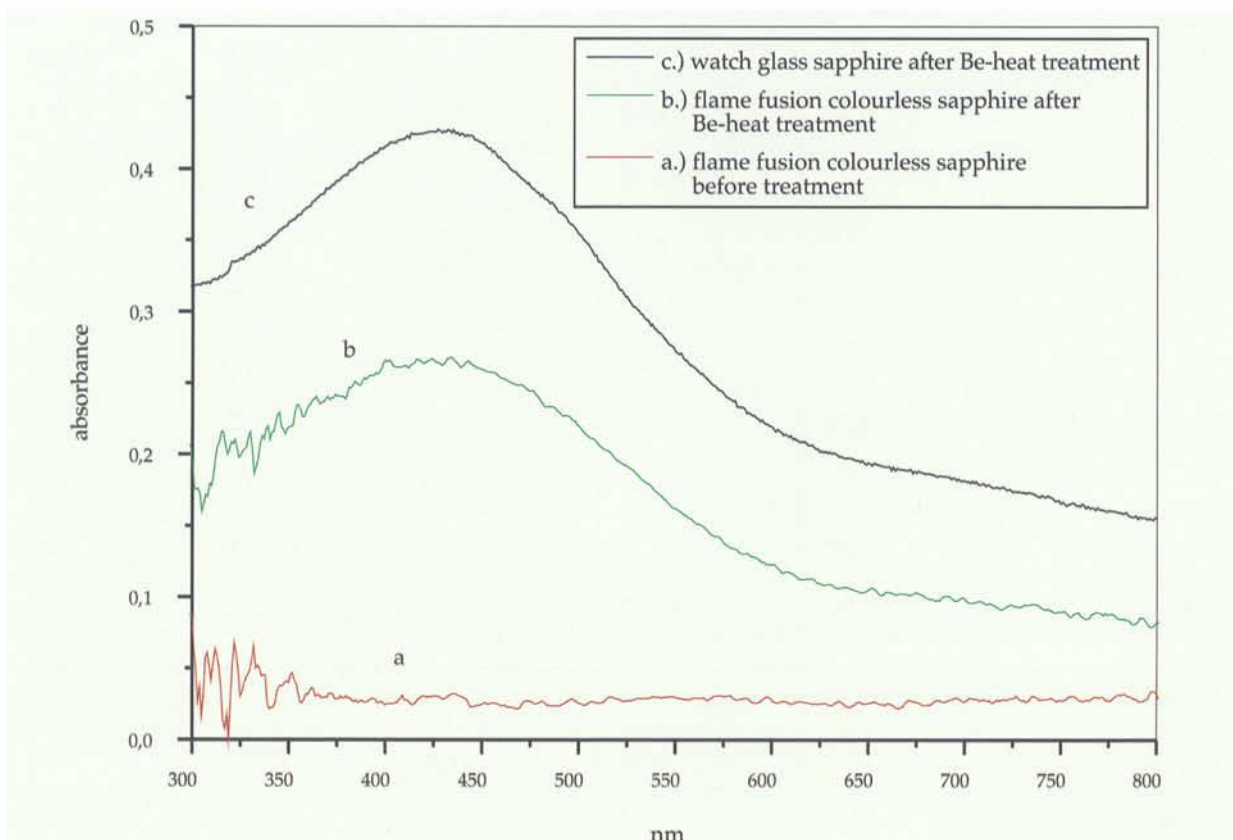

Figure 14: *UV-Vis spectra of the flame-fusion-grown sapphire (PKSCS01) before treatment (a) and after Be-heat treatment (b) under unknown conditions. Spectrum c was recorded from a 'watch glass' sapphire (WG02) which had been turned pale brown from originally colourless material by heating at 1750°C in an oxidizing atmosphere with chrysoberyl in the crucible.*
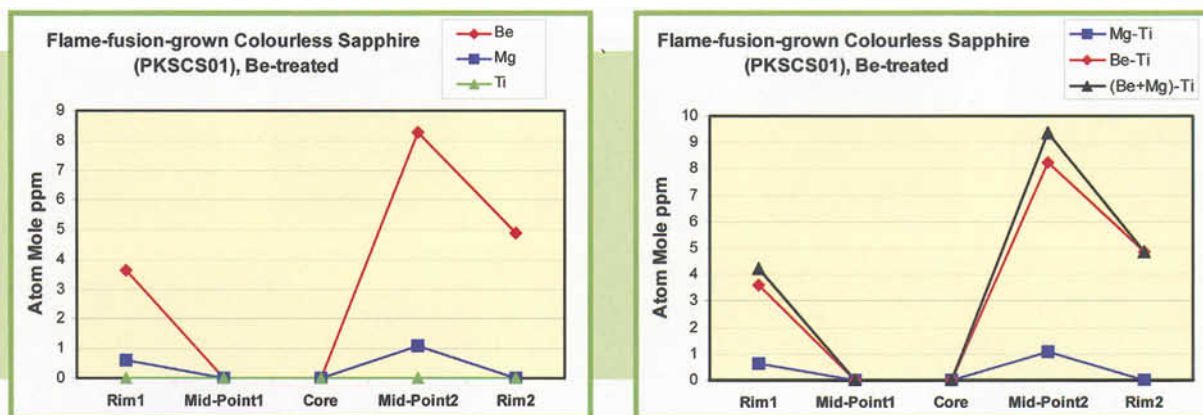
Figure 15: *Plots of trace element content variation across the cut surface of the pale brown Be-treated flame-fusion-grown sapphire (PKSCS01), see Figure 13d and text for discussion.*

Table II: *Trace element contents of the pale brown Be-treated flame-fusion-grown sapphire (PKSCS01) obtained by LA-ICP-MS.*

μ/g	Rim 1	Mid-Point 1	Core	Mid-Point 2	Rim 2
Be	1.60	<1.02	<0.99	3.65	2.15
Na	<17.83	<39.36	<38.43	<38.41	<16.54
Mg	0.73	<1.23	<1.26	1.31	<0.51
Al	529250.40	529250.40	529250.40	529250.40	529250.40
Ti	<2.04	<4.42	<4.14	<3.99	<1.5
V	<0.26	<0.56	<0.57	<0.53	<0.25
Cr	<5.79	<12.7	<12.01	<12.11	<5.25
Mn	<1.26	<2.78	<2.7	3.20	<1.17
Fe	<35.74	<78.59	<77.61	<76.8	<33.21
Ga	0.38	<0.53	<0.51	<0.47	0.29
Total %	52.93	52.93	52.93	52.93	52.93
Element factors based on atom mole ppm					
Mg-Ti	0.61	0.00	0.00	1.10	0.00
Be-Ti	3.62	0.00	0.00	8.26	4.86
(Be+Mg)-Ti	4.23	0.00	0.00	9.36	4.86
< = below detection limit					

approximately 420 nm with only weak absorption in the UV-part of the spectrum after heating (*Figure 14*). The same UV-Vis spectrum was also obtained from our own run on the 'watch glass' sample (*Figure 14*). A similar result was also found by Emmett *et al.* (2003). The brown colour of all the samples produced by the Thai heater and our Be-treated sample was stable during the fading test. Furthermore both colour and UV-Vis spectra produced by the Be-heating process are very similar to those produced by irradiation. The only difference is a small shift of the absorption peak from approximately 400 nm (irradiated sample) to 420 nm (Be-treated sample).

The LA-ICP-MS results of the five-point-profile analysis on the cut surface of the 3.85 ct cubic sample (*Figure 13d*) are listed in *Table II*. In order to compare the trace element contents and understand their interaction, all cations are calculated as atom mole ppm (or abbreviated as amp) and normalized to 40 atoms of cation, which corresponds to 60 atoms of oxygen in the Al_2O_3 structure. As shown in *Table II* and plotted in *Figure 15*, slightly elevated Be contents appear at the

rims as compared to those at the core and correspond well with the brown rim. The extremely low Be content at the colourless core is also similar to those analysed in the unheated sample cut from the same boule (*Table I*). Other important trace element contents such as Mg, Ti, V, Cr, Fe and Ga are extremely low without noticeable variation from the core to the rim. These contents are comparable to those in the unheated sample (mostly below the detection limits) suggesting rather pure Al_2O_3 originally. A similar result was also obtained from the three-point-profile analysis across the cut surface (not shown here).

As shown in *Figure 15* and *Table II*, the brown rims are strongly correlated with Be. These data therefore suggest that the divalent Be (without Mg) could play an important role in the creation of the brown coloration. This is because it is very unlikely that colour can be created in a pure Al_2O_3 system by simple heating without the introduction of an element or elements from an external source.

The synthetic sapphire treated by the Thai heater was heated without addition of any

Figure 16: Photos of the 13.51 ct disc of colourless 'watch glass' sapphire (WG01) before treatment (a), and pale brown throughout the entire disc after Be-treatment under unknown conditions (b). After the treatment, a five-point-profile (c) was analysed across the 1.25 mm thick cut surface using LA-ICP-MS (see also Figure 17). The other half of the sample was then cut into three pieces; one piece was kept as the reference and the other two pieces were heated in a pure nitrogen atmosphere at 1650°C for three hours which turned the stone colourless (d). One of the resulting colourless pieces was re-heated in air (in oxidation conditions) at 1650°C for one hour, which turned the sample back to pale brown (e). (Photos by Somboon, GIT and Lomthong, KU)
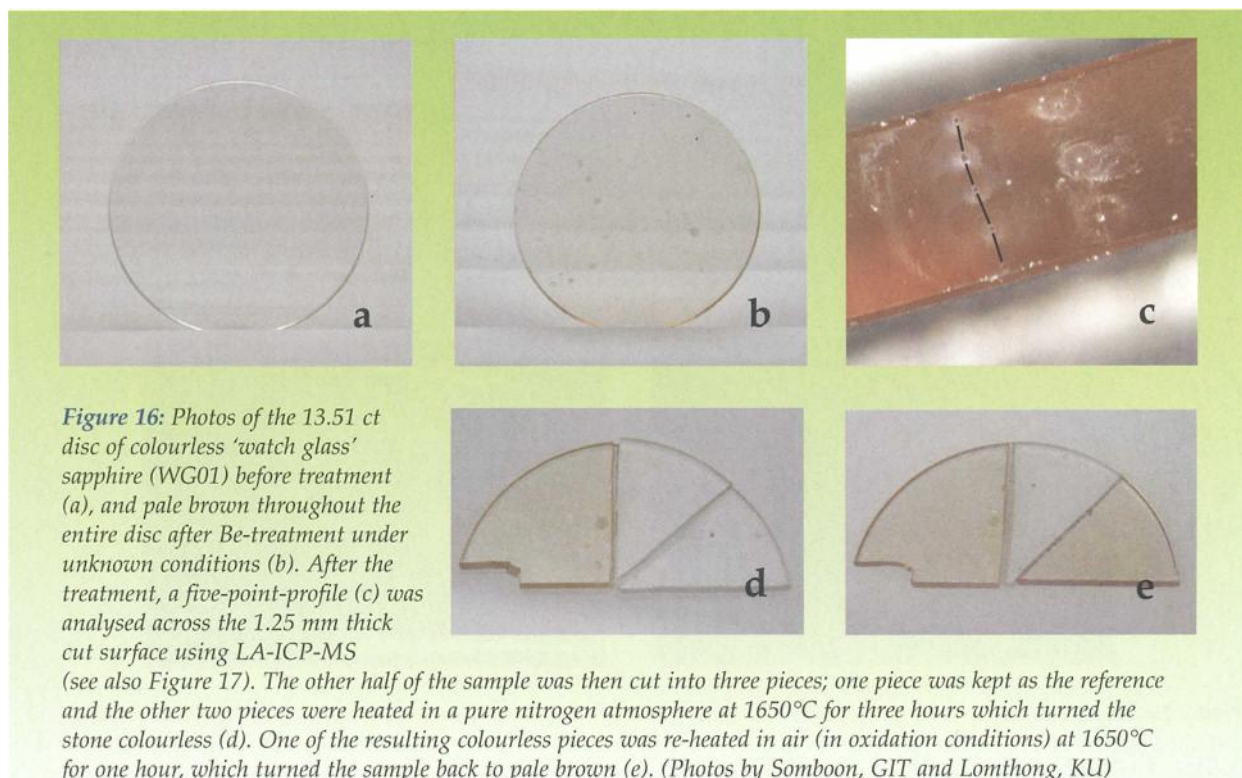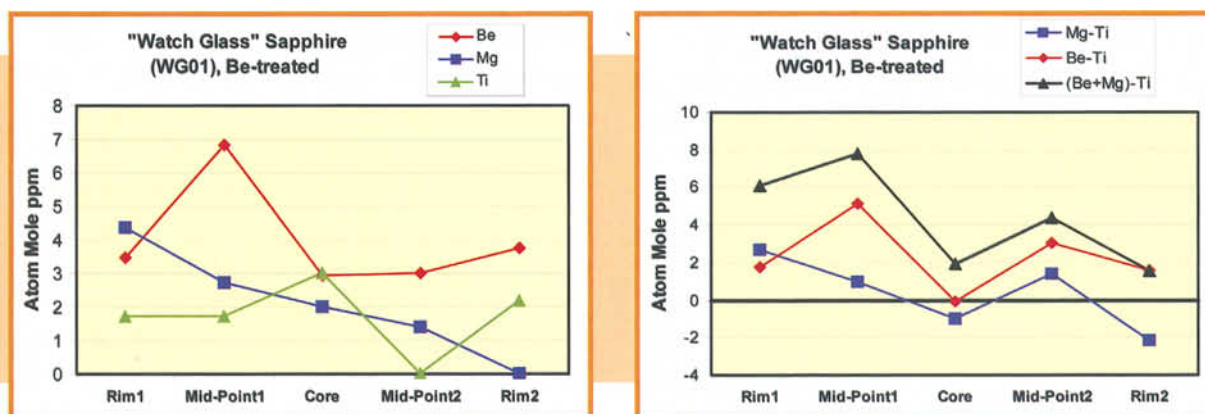
Figure 17: *Plots of trace element content variation across the 1.25 mm thick cut surface of the pale brown Be-treated 'watch glass' sapphire disc (WG01). The contents of Be are dominant over those of Mg and Ti in almost all the points analysed, and (Be+Mg) > Ti in all analysed points (cf. Figure 16c).*

Be-containing substance, e.g. chrysoberyl. Nonetheless, the LA-ICP-MS results have proved without doubt that a few ppm of Be must have entered the sample from an external source. The Be might have come from the crucible and/or furnace that previously had been heat-treated with Be-containing substances. This could explain why there are such low Be contents in this batch of samples (see also the next two samples) as compared with ten of ppm in the other samples obtained from other heaters (see later section). It is also surprising to realize that only a few ppm of Be are enough to create a pale brown colour in this relatively pure Al_2O_3 sample. A 'watch glass' of colourless synthetic sapphire (WG01) was heat-treated under the same conditions as those used for the flame-fusion stones and gave similar results, shown in *Figures 16* and *17*.
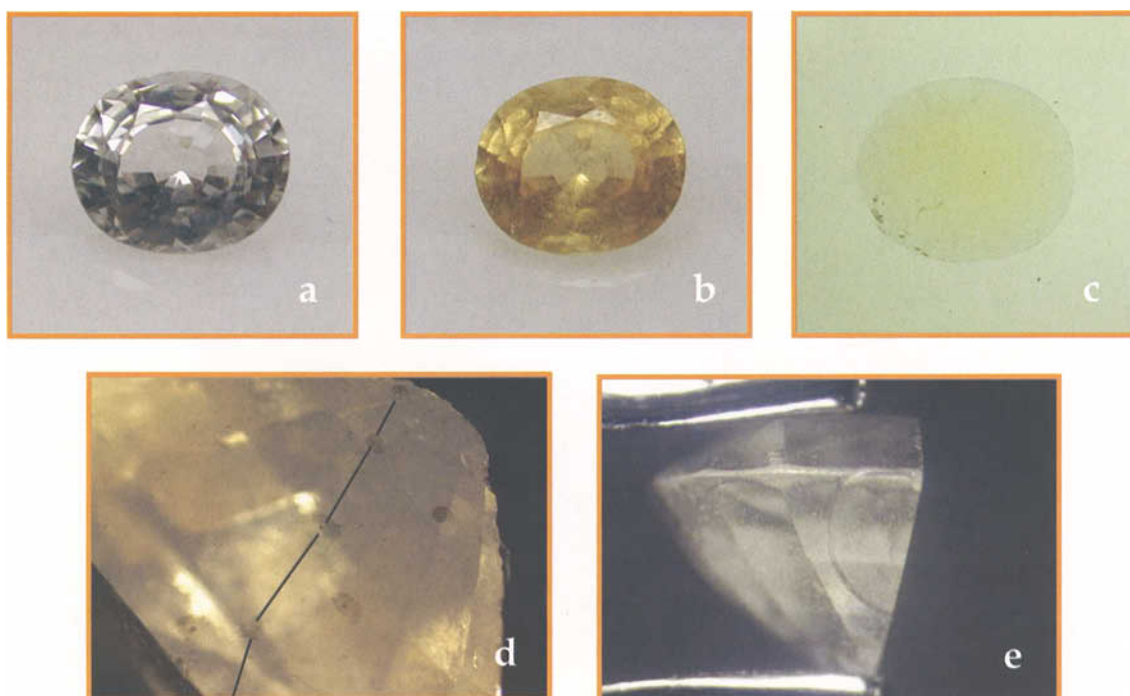
Figure 18: *Photos of a 0.80 ct natural colourless sapphire (POMCS03) before treatment (a), yellow after Be-heat treatment (b) and in the immersion liquid (c). A five-point profile (d) was analysed across the cut surface after the treatment using LA-ICP-MS (see also Table III and Figure 20). The other half was heated in a reducing atmosphere at 1650°C for three hours, which turned the stone colourless (e). (Photos by Somboon, GIT and Lomthong, KU)*

Be-treated natural colourless sapphires

The 0.80 ct oval natural colourless sapphire was heat-treated by the Thai heater under the same conditions as the flame-fusion grown specimen. The sample has turned intense yellow throughout without any particular surface-related colour after the treatment (*Figure 18*). Of two other natural samples (obtained from the same gemstone dealer) in the same run, however, one turned slightly yellow and in the other there was almost no colour change. Similar yellow colours were also observed in our own heating experiment on two natural colourless sapphires mixed with ground chrysoberyl and heated at 1750°C in an oxidizing atmosphere (in air) for 30 hours. The UV-Vis spectra of the intense yellow one changed from a flat line before heating to a pronounced increase of absorption in the UV-part of the spectrum with a shoulder at 460 nm after heating (*Figure 19*). The yellow colour was stable under a fading test.

The LA-ICP-MS results of the 5-point profiles across the cut surface (*Table III* and *Figure 20*) reveal a few ppm of Be (all values are above the detection limits) without noticeable concentration in the rims. These Be values are distinctly higher than those of the unheated sapphire where all Be values are below the detection limits (*Table I*). These data therefore suggest that a small amount of Be has been diffused into the stone from an external source – similar to the conclusion reached for the flame-fusion grown and the 'watch glass' samples, again probably from a contaminated crucible and/or furnace.

All the points analysed show rather high Mg content (*Table III* and *Figure 20*) compared with Ti and Be contents but there is no particular concentration in core or rim of any of the trace elements measured. The Cr contents are extremely low (below detection limit). When Mg and Ti are
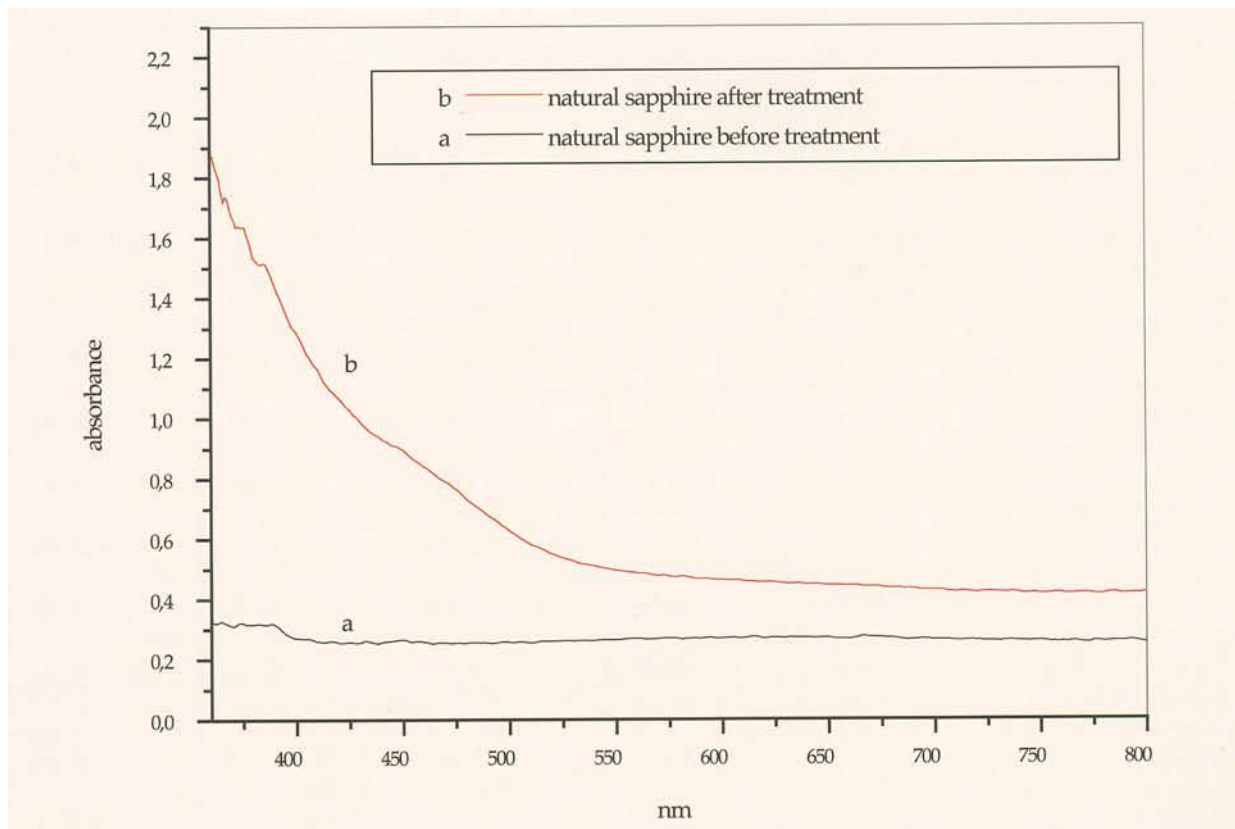

Figure 19: Spectra of the natural colourless sample (POMCS03) before treatment (a) and after the Be-heat treatment (b) (see also Figure 18a, b).

Table III: Trace element contents of the 0.80 ct Be-treated natural colourless sapphire (POMSC03) which became yellow after the treatment, obtained by LA-ICP-MS.

µg/g	Rim 1	Mid-Point 1	Core	Mid-Point 2	Rim 2
Be	1.23	4.68	2.52	2.79	2.90
Na	<18.10	<33.67	<29.32	<29.56	<18.11
Mg	95.38	144.81	71.52	67.48	80.15
Al	529250.40	529250.40	529250.40	529250.40	529250.40
Ti	74.48	78.19	65.95	58.30	51.33
V	2.44	2.82	2.47	2.33	1.98
Cr	<5.28	<9.51	<8.30	<8.73	<5.37
Mn	<1.25	<2.32	<2.01	<2.05	<1.27
Fe	347.76	402.65	348.55	325.47	342.53
Ga	68.88	61.42	58.20	61.22	64.24
Total %	52.98	52.99	52.98	52.98	52.98

Cations (Atom Mole ppm)					
Be	2.78	10.58	5.7	6.31	6.56
Na	0.00	0.00	0.00	0.00	0.00
Mg	79.97	121.39	59.97	56.58	67.20
Al	399737.57	399668.81	399761.10	399774.71	399759.85
Ti	31.69	33.26	28.06	24.80	21.84
V	0.98	1.13	0.99	0.93	0.79
Cr	0.00	0.00	0.00	0.00	0.00
Mn	0.00	0.00	0.00	0.00	0.00
Fe	126.89	146.89	127.18	118.76	124.98
Ga	20.13	17.95	17.01	17.90	18.78
Total (Atom Mole%)	40.00	40.00	40.00	40.00	40.00
Mg-Ti	48.28	88.13	31.91	31.78	45.36
Be-Ti	-28.90	-22.68	-22.36	-18.49	-15.28
(Be+Mg)-Ti	51.06	98.71	37.61	38.09	51.92

< = below detection limit of which 0.00 value is used for calculation of atom mole ppm
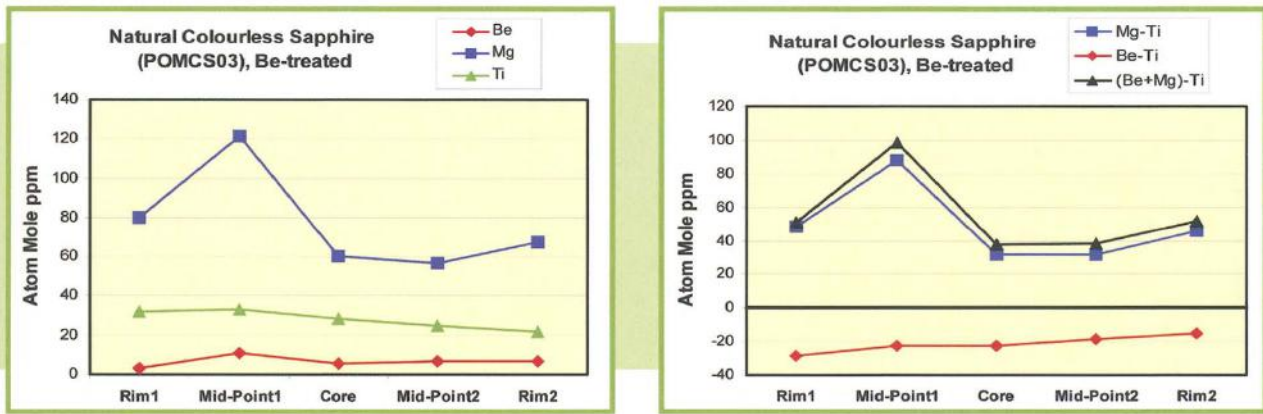
Figure 20: Plots of trace element content variation across the cut surface of the Be-treated natural colourless sapphire (POMCS03), which became yellow after the treatment, cf. Figure 18d and see text.

present in corundum they commonly form $MgTiO_3$ clusters, and it is the amount of excess Mg over Ti that is significant in forming yellow colour centres (see Box I; Häger, 1996, 2001; and Emmett et al., 2003). This sample has strong excess of Mg and Mg-Ti contents range from 32 to 88 amp. Hence, the excess Mg or Mg+Be could lead to the formation of a stable yellow colour in this sample.
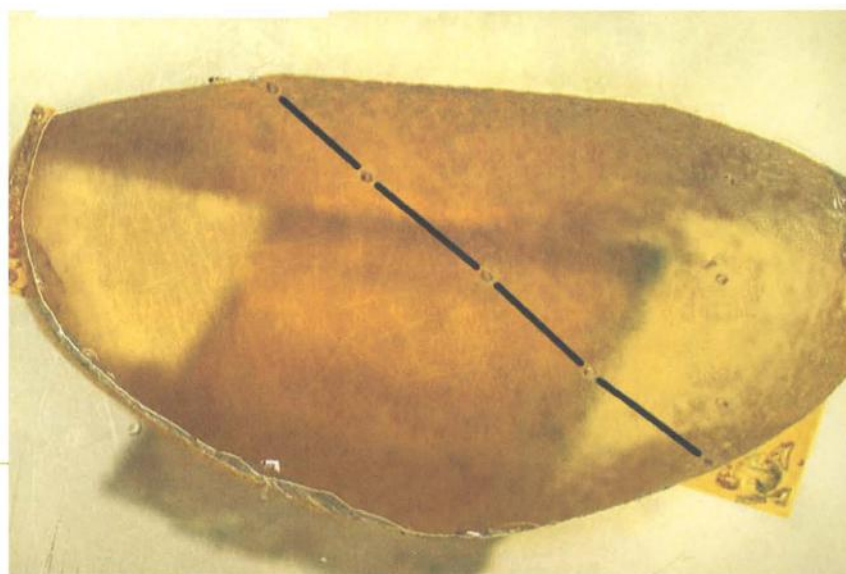
Yellow and orangey-yellow Be-treated sapphires

All three yellow and orangey-yellow sapphires stated to have been heat-treated in Thailand also gave similar results. The LA-ICP-MS results reveal rather high Be contents in the samples and an excess of Be+Mg over Ti content in all the points analysed (two samples are shown in Figures 21-24 and Tables IV and V). Although Cr is present, it appears to be too low to create a pink hue in sample PPYS1, but in MadaRough01 (Table V) it is sufficient to make the stone appear orange.

Be-treated blue sapphires

Two blue sapphires from an unknown source reportedly heat-treated with Be by a Thai heater show a thin surface-related yellow zone surrounding a blue core (one is shown in Figure 25). High magnification

shows that the blue core contains oriented blue dots probably resulting from partial dissolution of rutile needles. The LA-ICP-MS data (Table VI and Figure 26) reveal the elevated Be contents of the yellow rims and its absence at the blue core, again indicating Be diffusion from an external source. All the analysed points in the cores show an excess of Ti after calculation of colourless $MgTiO_3$ or $BeTiO_3$ clusters (i.e. Mg–Ti and Be–Ti content show negative values). In the yellow rim there is an excess of Be+Mg over Ti, while in the blue core Be+Mg is lower than Ti.

Figure 21: Photo of a yellow sapphire (PPYS1) reportedly heat-treated with Be under unknown conditions by a Thai heater. The sample appears yellow throughout the entire stone and lacks a surface-related colour zone. A five-point profile was analysed across its cut surface (see Table IV and Figure 22). (Photo by Somboon, GIT, and Lom-thong, KU)

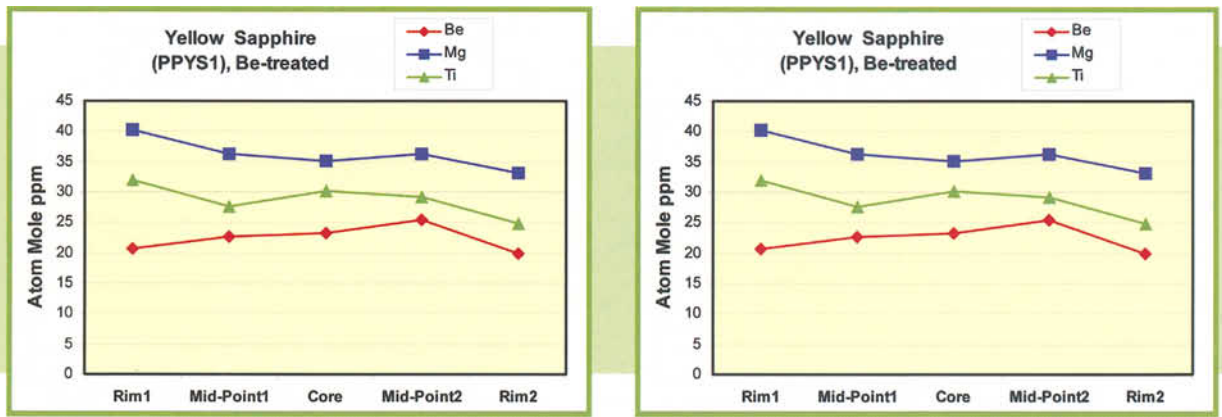Yellow and brown coloration in beryllium-treated sapphires

Figure 22: Plots of trace element content variation across the cut surface of the yellow Be-treated sapphire (PPYS1). No significant variation of Be, Mg and Ti content is apparent (see Table IV) across the profile. All the points analysed (Figure 21) however, show (Be+Mg)>Ti contents.
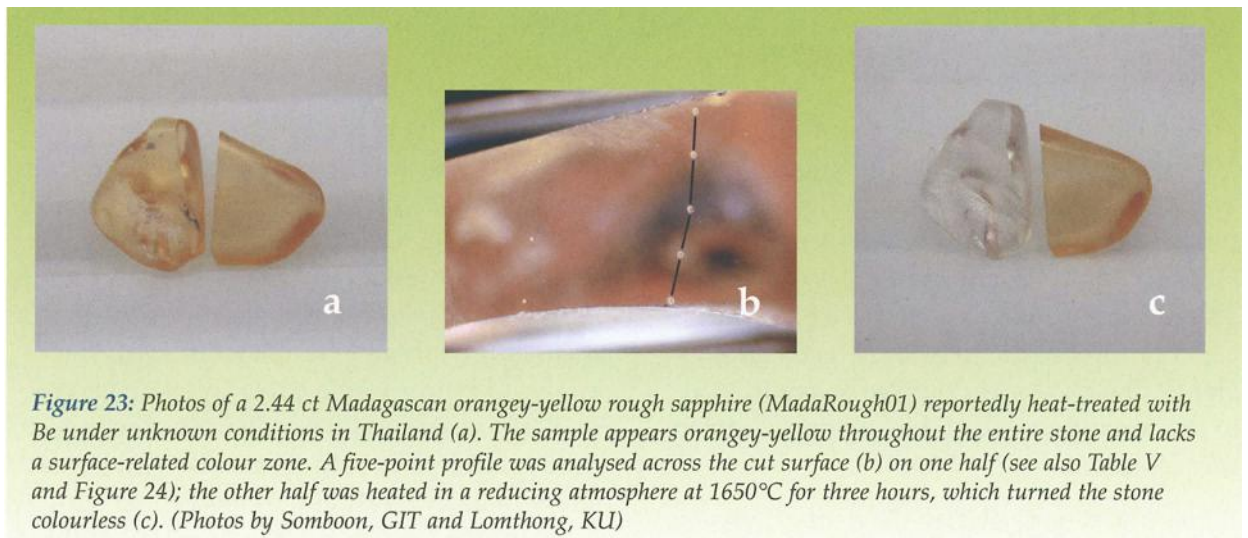

Figure 23: Photos of a 2.44 ct Madagascan orangey-yellow rough sapphire (MadaRough01) reportedly heat-treated with Be under unknown conditions in Thailand (a). The sample appears orangey-yellow throughout the entire stone and lacks a surface-related colour zone. A five-point profile was analysed across the cut surface (b) on one half (see also Table V and Figure 24); the other half was heated in a reducing atmosphere at 1650°C for three hours, which turned the stone colourless (c). (Photos by Somboon, GIT and Lomthong, KU)

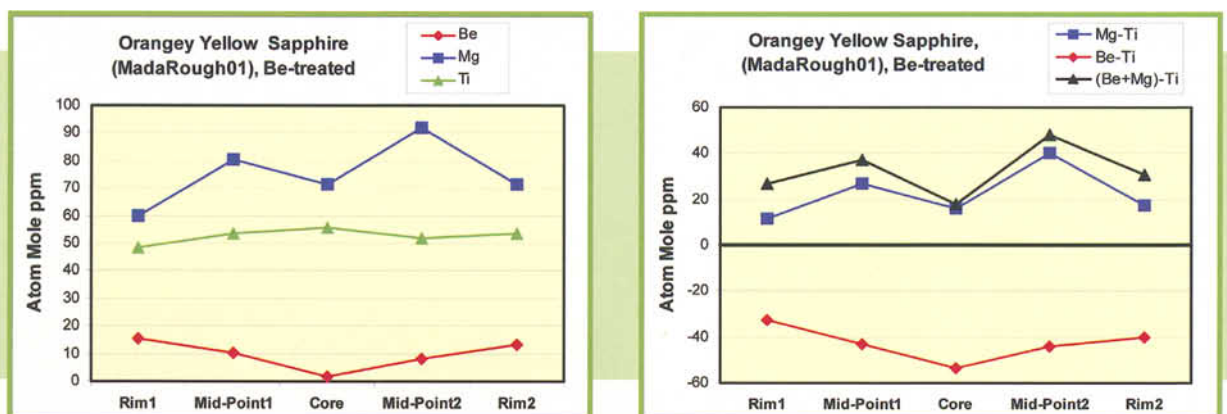*Figure 24: Plots of trace element content variation across the cut surface of the orangey-yellow Be-treated rough sapphire (MadaRough01, Figure 23b) The analyses show higher Be contents at the rims, gradually decreasing toward the core. The contents of Mg, Ti and other trace elements (see Table V) however, show no consistent variation across the profile. At all the points analysed (Be+Mg) > Ti.*

Table IV: *Trace element contents of a yellow Be-treated sapphire (PPYS1) showing rather high content of Be, Mg, Ti and Fe but low Cr content across the profile. Results obtained from LA-ICP-MS.*

µ/g	Rim 1	Mid-Point 1	Core	Mid-Point 2	Rim 2
Be	9.14	10.02	10.29	11.27	8.86
Na	<13.54	<11.63	<13.89	<11.89	<11.30
Mg	48.01	43.39	42.03	43.44	39.61
Al	529250.40	529250.40	529250.40	529250.40	529250.40
Ti	75.47	65.06	71.09	68.82	58.36
V	20.11	19.62	18.88	19.76	21.50
Cr	32.58	35.65	35.68	32.94	34.43
Mn	<0.67	<0.58	<0.72	<0.58	<0.55
Fe	2237.19	2210.06	2119.11	2375.70	2424.42
Ga	73.94	74.56	73.07	76.35	81.14
Total %	53.17	53.17	53.16	53.19	53.19

Cations (Atom Mole ppm)

	Rim 1	Mid-Point 1	Core	Mid-Point 2	Rim 2
Be	20.63	22.62	23.23	25.44	20.00
Na	0.00	0.00	0.00	0.00	0.00
Mg	40.18	36.32	35.18	36.35	33.15
Al	399049.91	399064.88	399096.62	399000.72	398993.41
Ti	32.05	27.63	30.19	29.22	24.78
V	8.03	7.84	7.54	7.89	8.58
Cr	12.75	13.95	13.96	12.89	13.47
Mn	0.00	0.00	0.00	0.00	0.00
Fe	814.87	805.02	771.95	865.21	882.94
Ga	21.57	21.76	21.32	22.27	23.67
Total (Atom Mole%)	40.00	40.00	40.00	40.00	40.00
Mg-Ti	8.13	8.69	4.99	7.13	8.37
Be-Ti	-11.42	-5.01	-6.96	-3.79	-4.78
(Be+Mg)-Ti	28.76	31.31	28.22	32.57	28.36

< = below detection limit of which 0.00 value is used for calculation of atom mole ppm

Table V: Trace element contents of the orangey yellow Be-treated rough sapphire (MadaRough01), obtained from LA-ICP-MS.

µg/g	Rim 1	Mid-Point 1	Core	Mid-Point 2	Rim 2
Be	6.87	4.52	0.82	3.54	5.88
Na	45.25	96.93	<11.99	15.76	17.37
Mg	71.34	95.96	85.65	110.10	85.21
Al	529250.50	529250.50	529250.50	529250.50	529250.50
Ti	113.57	125.74	131.06	122.41	126.47
V	7.42	8.94	9.43	10.72	9.07
Cr	74.00	90.48	90.78	100.04	92.79
Mn	<0.39	<0.67	<0.60	<0.69	<0.23
Fe	3575.26	4099.17	4355.35	4697.28	3939.04
Ga	100.22	116.12	122.64	142.13	124.44
Total %	53.32	53.39	53.40	53.45	53.37
Cations (Atom Mole ppm)					
Be	15.49	10.18	1.85	7.97	13.25
Na	39.98	85.59	0.00	13.91	15.34
Mg	59.62	80.15	71.54	91.92	71.19
Al	398475.31	398208.18	398213.11	398043.06	398338.32
Ti	48.16	53.29	55.54	51.86	53.61
V	2.96	3.56	3.76	4.27	3.62
Cr	28.91	35.32	35.44	39.04	36.24
Mn	0.00	0.00	0.00	0.00	0.00
Fe	1300.37	1489.92	1583.06	1706.61	1432.19
Ga	29.20	33.81	35.71	41.37	36.24
Total (Atom Mole%)	40.00	40.00	40.00	40.00	40.00
Mg-Ti	11.46	26.86	15.99	40.06	17.58
Be-Ti	-32.68	-43.11	-53.70	-43.88	-40.37
(Be+Mg)-Ti	26.95	37.04	17.84	48.03	30.83

< = below detection limit of which 0.00 value is used for calculation of atom mole ppm

Figure 25: Photo of a blue sapphire (PPBS1) reportedly heat treated with Be under unknown conditions by a Thai heater. The sample shows a thin surface-related yellow rim surrounding the blue core. High magnification reveals that the blue core contains oriented blue dots probably resulting from partial dissolution of rutile needles. A five-point profile was analysed across the cut surface with two points in the surface-related yellow zone (rims) and three points in the blue core. (Photo by Somboon, GIT and Lomthong, KU)
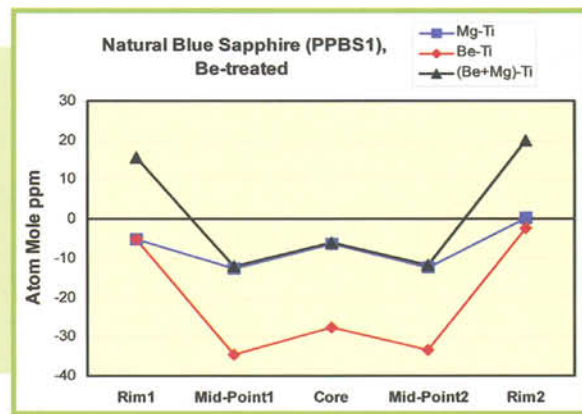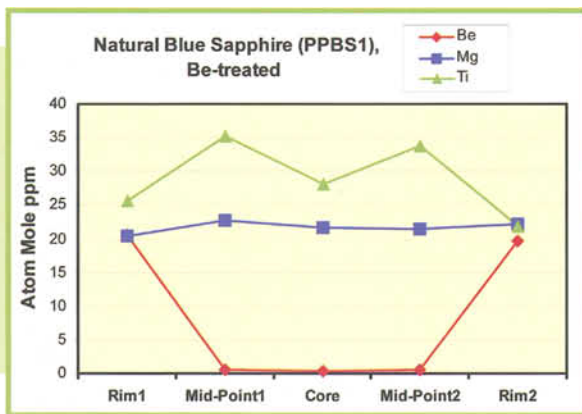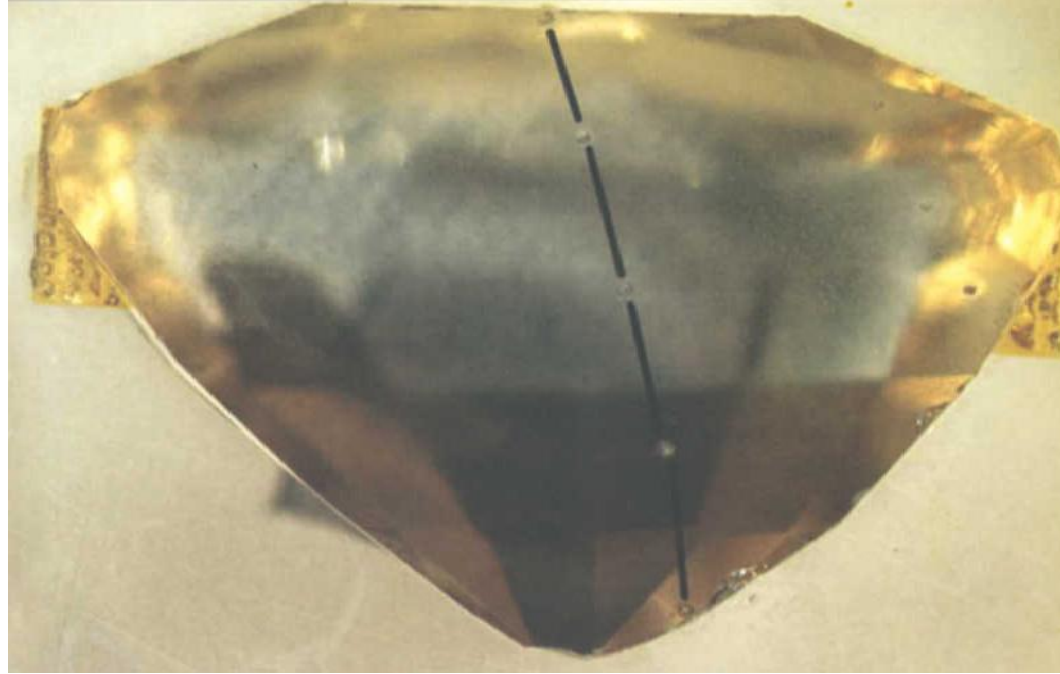

Figure 26: Plots of the trace element content variation across the cut surface of the Be-treated blue sapphire (PPBS1, Figure 25). The Be contents are obviously high at the yellow rims and are negligible in the blue core. The contents of Mg and Ti (also other trace elements, see Table VI) however show no consistent variation across the profile. The analyses also show (Be+Mg)>Ti at the yellow rims in contrast to Ti > (Be+Mg) in the blue core.
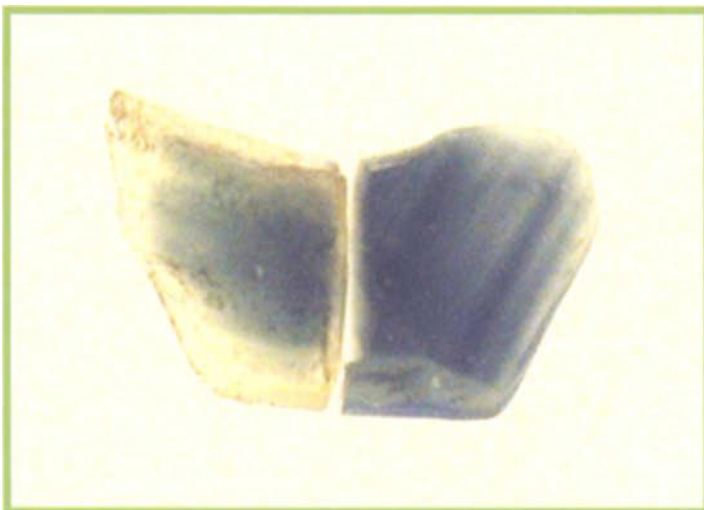

Figure 27: A natural blue sapphire was cut in half; the left half was heat treated with ground chrysoberyl in a crucible while the right half was heated in another crucible without chrysoberyl. The heating procedure for both crucibles was 1750°C for 30 hours in air. After heat treatment the left half shows a surface-related yellow rim whereas the right half is blue through-out the stone. (Photo by Häger)

Table VI: Trace element content of a Be-treated blue sapphire (PPBS1), obtained from LA-ICP-MS.

μ/g	Rim 1	Mid-Point 1	Core	Mid-Point 2	Rim 2
Be	9.15	0.26	<0.17	<0.22	8.71
Na	<10.82	<9.77	<10.63	<14.53	<12.40
Mg	24.54	27.14	25.86	25.66	26.55
Al	529250.40	529250.40	529250.40	529250.40	529250.40
Ti	60.45	83.16	65.99	79.49	51.58
V	12.83	12.87	12.47	12.53	12.23
Cr	36.34	37.86	32.32	31.33	38.61
Mn	<0.53	<0.48	<0.53	<0.73	<0.62
Fe	3013.78	4303.34	3015.91	3139.35	3182.56
Ga	51.66	56.00	53.22	53.84	54.13
Total %	53.25	53.38	53.25	53.26	53.26

Cations (Atom Mole ppm)					
Be	20.64	0.58	0.00	0.00	19.65
Na	0.00	0.00	0.00	0.00	0.00
Mg	20.53	22.68	21.63	21.46	22.20
Al	398801.73	398340.61	398819.35	398769.19	398742.19
Ti	25.66	35.25	28.01	33.73	21.89
V	5.12	5.13	4.98	5.00	4.88
Cr	14.21	14.79	12.64	12.25	15.09
Mn	0.00	0.00	0.00	0.00	0.00
Fe	1097.05	1564.65	1097.87	1142.66	1158.31
Ga	15.06	16.31	15.52	15.70	15.78
Total (Atom Mole%)	40.00	40.00	40.00	40.00	40.00
Mg-Ti	-5.13	-12.58	-6.38	-12.27	0.32
Be-Ti	-5.02	-34.67	-28.01	-33.73	-2.24
(Be+Mg)-Ti	15.51	-12.00	-6.38	-12.27	19.96

< = below detection limit of which 0.00 value is used for calculation of atom mole ppm
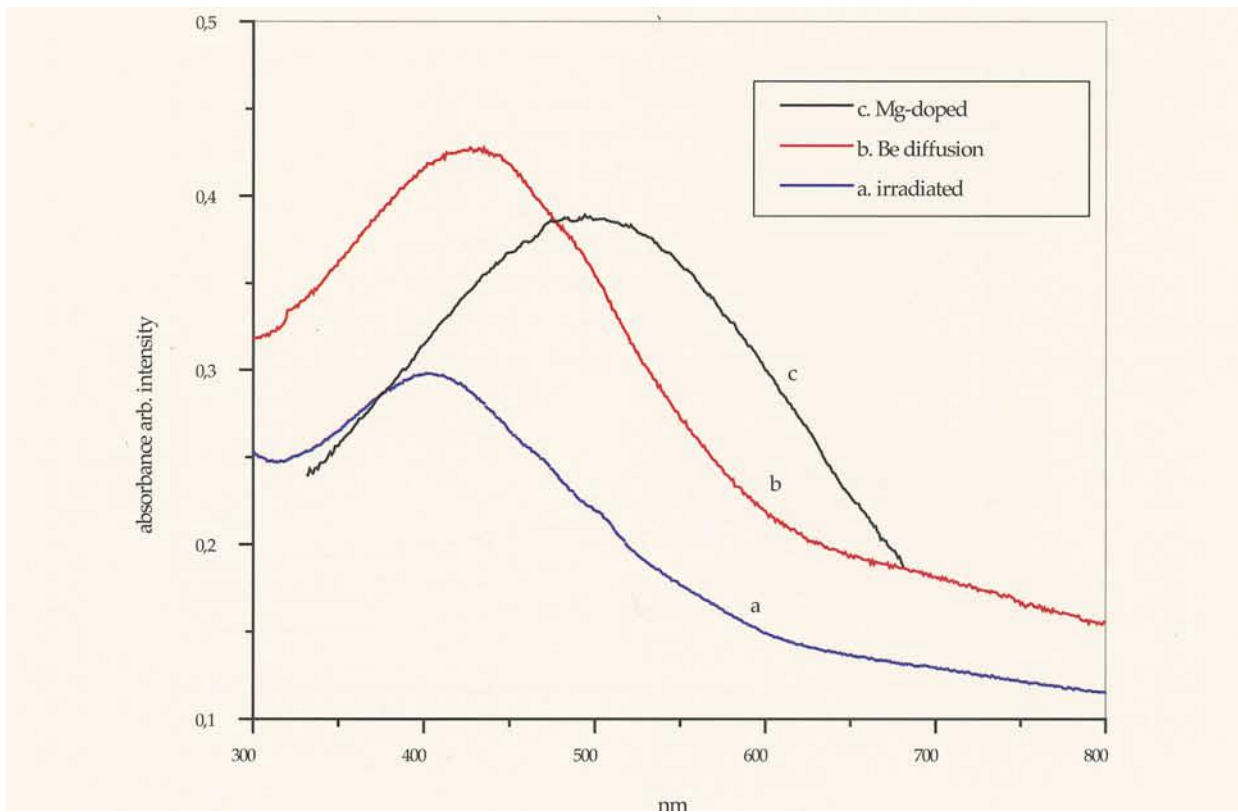
Figure 28: Three UV-Vis spectra of synthetic corundums: pale brown after irradiation with X-rays (a), pale brown after diffusion treatment with Be (b), and brown to violet after doping with Mg (c).

Discussion

The samples can be divided into two groups on the basis of their trace element contents. The first group consists of synthetic colourless sapphires with extremely low trace element contents, and the second group is dominated by trace contents of iron.

First group: 'pure' colourless sapphires

In the first group, the irradiation experiments with colourless flame-fusion grown sapphires produced a pale brown colour and a broad absorption band near 400 nm. This absorption band is unstable to normal heat and light and can be attributed to irradiation-related colour centres (see *Figure 28*). The detailed assignment of this absorption band is outside the scope of the present paper and will be discussed in another paper.

After Be-treatment, the synthetic colourless sapphires also turned pale brown and although the absorption pattern is similar to that of the irradiated sapphire, the broad absorption band is centred at about 420 nm. LA-ICP-MS analyses of sapphires supplied by the trade and our own Be-heating experiments indicate that Be has diffused into the stones from an external source. Be is directly related to the brown coloration. The other trace element contents remained unchanged. This absorption band is stable to normal daylight and to heating in an oxidizing atmosphere and has been clearly influenced by the diffusion of Be. In the corundum structure there are probably Be-related colour centres (or Be-trapped hole centres) which are created and stable only in an oxidizing environment and which can easily be eliminated by heating in a reducing environment (see also Emmett *et al.*, 2003).

Synthetic Mg-doped sapphires show a broad absorption band with a maximum at about 500 nm (*see Figure 28*) and are brownish-violet. Similar spectra of Mg-doped
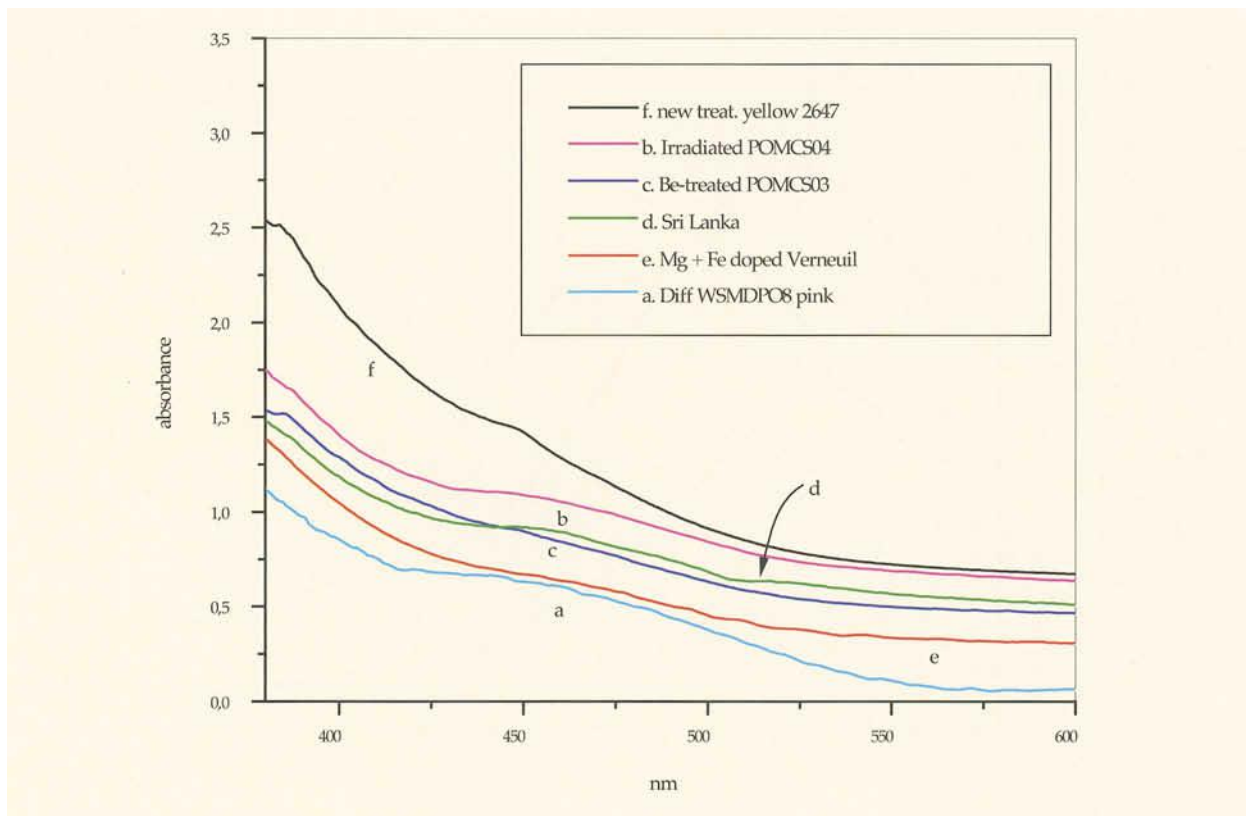
Figure 29: *UV-Vis spectra of yellow sapphires: a natural sample irradiated with X-rays (b), natural samples after Be-treatment (c and f), a natural sample from Sri Lanka (d), the residual spectrum obtained by the subtraction of the spectrum of a pale pink natural sapphire before treatment from that of an orange Be-treated natural sapphire (a), a synthetic sample double-doped with Mg and Fe (e).*

sapphires have been described by Andreev *et al.* (1976), Wang *et al.* (1983) and Häger (1996, 2001). The Mg-related colour centres (or Mg-trapped hole centres) are created only by heating in an oxidizing atmosphere and can easily be eliminated by reduction heating (e.g. Kvapil *et al.*, 1972, 1973; Andreev *et al.*, 1976; Wang *et al.*, 1983; Emmett and Douthit, 1993; Häger, 1996; 2001; Emmett *et al.*, 2003).

Hence, based on their similar behaviour, we believe that Be^{2+} and Mg^{2+} act in a very similar way as stabilizers of colour centres in these synthetic sapphires. It has been shown in this study that yellow coloration cannot be produced by irradiation or by Be-heat treatment in the pure Al_2O_3 system. The absorption spectra of brown and yellow sapphires are shown in *Figures 28* and *29* and do not have absorption bands in common. It seems that combination with other trace element(s) is required to produce yellow colour centres.

Second group: sapphires with significant Fe content

Natural colourless sapphires and a synthetic sapphire double-doped with Fe and Mg belong to the second group. Irradiated samples with a significant Fe content show an intense yellow colour after treatment. The UV-Vis spectra of the irradiated samples show a pronounced increase of absorption in the UV-part of the spectrum and a shoulder at about 460 nm (*Figure 29*). Similar colours and spectra can be observed in natural unheated Sri Lankan yellow sapphires and in the synthetic sapphire double-doped with Fe+Mg (*Figure 29*).

Elevated Be contents have been found in the treated stones obtained from a number of heaters in Thailand, but no consistent variation in Mg or any other trace element was detected in the core to the rim. This is in contrast to the observation of Peretti and

Günther (2002) who found a decrease in Fe, Cr, Ti, V, Ga and Mg towards the rim. This discrepancy might be due to different kinds of flux material being used in those runs. The Be-treated samples are generally intense yellow and show an excess of Be+Mg content after calculation of $MgTiO_3$ and /or $BeTiO_3$ clusters. Some samples however show only a very pale yellow or almost no colour change; such stones probably have more or less the same amount of Ti and Mg+Be. The absorption spectra are essentially identical to those of the natural untreated yellow sapphire from Sri Lanka, the Mg+Fe doped synthetic crystals and the irradiated samples (see *Figure 29*). As pointed out above, the irradiated samples are unstable to daylight and heat, while all the others are stable in daylight and oxidizing heat.

The blue sapphire (PPBS1) shown in *Figures 25* and *26* is a stone in which Ti exceeds the Mg content in all analysed points. However, in the yellow rim the sum of Be+Mg exceeds the Ti content. These data strongly suggest that the yellow hue can only be formed if there is an excess of Be+Mg over Ti content in the lattice. With the 'classical' heat treatment, it was not possible to turn such a sample yellow, but with diffusion of Be into the corundum lattice it is now possible to change the balance of the Ti/(Be+Mg) ratio. This is confirmed by our own heating experiment (see *Figure 27*). Although at first sight this result seems to be in contrast to that reported by Peretti and Günther (2002), their analytical data are presented in ppm by weight (D. Günther, pers. comm., 2002) and not in atom mole ppm. If the data are recalculated into atom mole ppm in all yellow stones and yellow zones, the sum of Mg+Be exceeds the Ti contents and the results are in fact consistent with ours.

In summary, the results lead us to believe that the unstable yellow colour produced by irradiation is caused by a combination of iron and a defect centre, and the stable yellow colour centre produced by heat and Be diffusion in an oxidizing atmosphere is caused by a combination of excess Be+Mg over Ti, the presence of Fe and a defect centre.

Because of the important role of iron in this scenario, the absorption spectra presented in *Figure 29* might be called Fe-related stable (if it is stabilized by a divalent element) or unstable (if it is due to irradiation) colour centres. In orange Be-treated sapphires, besides chromium and iron related absorption bands, an absorption band near 470 nm was reported by Hänni and Pettke (2002), and UV absorption at 380 nm was reported by Fritsch *et al.* (2003) and Emmett *et al.* (2003). Those absorption spectra are somewhat different from our Fe-related colour centres spectra and might be due to a high amount of Cr in those samples.

Conclusion

It was found that elevated Be contents have been detected in the treated synthetic and natural sapphires obtained from a number of heaters in Thailand and that Be has diffused into the stones from an external source. Yellow or brown coloration could develop in the Be-treated stones depending upon the (Be + Mg) /Ti ratio, the presence or absence of iron and the heating atmosphere. It is obvious that the excess of the divalent elements, Be+Mg, after calculation of colourless $MgTiO_3$ and/or $BeTiO_3$ clusters, in combination with iron and heat treatment in an oxidizing atmosphere can produce stable yellow colour centres. These yellow colour centres show similar UV-Vis patterns to those of the natural yellow sapphires from Sri Lanka and the synthetic sample double-doped with Mg and Fe. In synthetic samples without iron, however, the situation is somewhat different. The divalent Be could act in the same way as was found earlier for Mg, as a stabilizer of brown colour centres, but with a shift in the absorption maxima. If the Be-treated sapphires are heated in a reducing atmosphere, the yellow or brown colour centres are destroyed completely. Therefore it is possible to change the presented two diagrams in Box I in such a way that we add Be into the Mg corner.
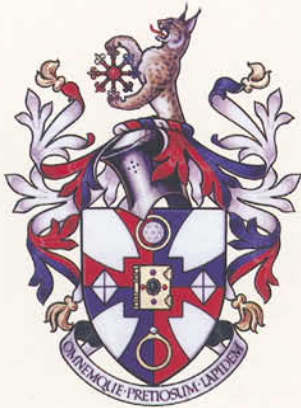
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Nephrite jade in Finland

Dr Douglas Nichol

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Abstract: *Three occurrences of nephrite jade have been found in Finland; ortho-nephrite at Paakkila, para-nephrite at Stansvik and glacially transported material at Hakkila. No commercial production is recorded. However, mineral specimens have been won for museums and private collections.*

Introduction

In the extensive literature on jade, Finland receives frequent mention as one of the nations in Europe where nephrite jade is found (e.g. Kolesnik, 1970; Leaming, 1978). Although no commercial production of nephrite has actually taken place in Finland, the known localities are of considerable geological interest and provide an indication of exploration potential. This note provides a brief review and description of the Finnish occurrences as part of a wider study of nephrite jade in Europe. Colours are quoted using the Munsell notation (Rock-Colour Chart Committee, 1980).

Background

During the 19th and 20th centuries, numerous boulders of nephrite jade were discovered throughout northern Europe, the finds in Germany at Potsdam, 30 km SW of Berlin, and at Schwemsal, 35 km NNE of Leipzig, being the most frequently cited (e.g. Ruff, 1963; Kolesnik, 1970). Since the boulders were believed to be glacial erratics transported by glaciers from a sourceland to the north, the whole of Scandinavia was generally considered to be prospective for primary deposits of nephrite jade.

Subsequently, an outcrop of nephrite-like rock was found in Sweden (Törnebohm, 1886; Meyer, 1886) but more significantly, three occurrences of nephrite jade were reported in Finland at Paakkila, Hakkila and Stansvik (*Figure 1*).

Figure 1: Location of nephrite jade occurrences in Finland.

Geological setting

The bedrock of Finland comprises a wide variety of metasedimentary and meta-igneous rocks of Precambrian age that form part of the Baltic Shield. However, thick glacial deposits, peatlands and countless lakes cover the Precambrian crystalline basement. Indeed, it has been estimated that only about 3 per cent of the bedrock crops out at the surface.

Paakkila occurrence

The old, abandoned Paakkila quarry is located in the municipality of Tuusniemi, 70 km southeast of Kuopio and 18 km west of Outokumpu in central Finland. It is a former mining area for anthophyllite asbestos that closed in 1975 when demand for asbestos slumped (*Figure 2*). The asbestos is associated with a series of elongate bodies of serpentinized ultramafic rock enclosed by Precambrian gneiss and the Maarianvaara granite. According to Isokangas (1978), the lenses of serpentinite exhibit a zonal structure arranged as follows: (1) mica zone, (2) tremolite-actinolite zone, (3) talc zone, and (4) core zone of anthophyllite asbestos.

The discovery of nephrite jade at the Paakkila asbestos quarry is attributed to the geologist Eberhard Rimann of Dresden who visited the site in 1930 during a field excursion organized by the German Mineralogical Society.

Figure 2: The Paakkila asbestos quarry. Circa 1967. (after Palomäki and Halonen, 1968).

Based on detailed studies of samples of rock from a 60-70 mm wide vein within the working quarry, he concluded that the vein was nephrite jade (Rimann, 1936). The rock consisted predominantly of nephrite ranging from greyish green (10G 4/2) to dusky green (5G 3/2) in colour with occasional patches of talc. Also contained within the nephrite jade were minute inclusions of anthophyllite of similar chemical composition and optical properties to the anthophyllite in the host serpentinite. Based on the intimate field relationship with serpentinite, the occurrence is classed as ortho-nephrite in type (Nichol, 2000).

Although the discovery of nephrite jade at Paakkila aroused widespread interest at the time, further information is singularly lacking. The site where Rimann collected his specimen was apparently destroyed during the course of mining operations and, according to the Geological Survey of Finland, reconnaissance exploration for nephrite jade in other serpentinite bodies around Paakkila has so far proved negative.

Interestingly, Rimann's original specimens from Paakkila are held in the collection of the Museum für Mineralogie und Geologie, Dresden, under catalogue number 9863 Sy (MMG Dresden). However, samples of the nephrite appear to be missing and only pieces of anthophyllitic serpentinite remain.

Hakkila occurrence

A few pebbles and boulders of nephrite jade have been found in glacial deposits in the Vantaa district on the northern outskirts of Helsinki. Specimens collected from gravel pits in an esker at Hakkila were described by Lindqvist and Kinnunen (1985). The pebbles and boulders are rounded to subrounded with smooth surfaces. Typically, the nephrite jade ranges from dusky yellow-green (5GY 5/2) through light olive grey (5Y 5/2) to yellowish-grey (5Y 7/2) in colour and varies from fine- to medium-grained in texture (*Figure 3*).

Figure 3: Polished nephrite pebble from Hakkila esker (diameter 24 mm). Finder, V. Kotilainen. Photo by K.A. Kinnunen.

According to the Geological Survey of Finland this locality is no longer available for collection purposes due to urban development.

Stansvik occurrence

Numerous small iron-ore mines were worked in pre-industrial times throughout coastal areas of southern Finland. They served local demands for iron in populated areas where both charcoal and labour were readily available (Puustinen, 1997; Saltikoff *et al.*, 1994). The discovery of nephrite jade at one of these historical sites, the Stansvik iron mine, was first reported by Lindqvist and Kinnunen (1985). The site is located on the western part of the island of Laajasalo in the southern suburbs of Helsinki.

At the old Stansvik iron mine, discontinuous, narrow (<1 mm) veins composed of very fine-grained tremolite fill fractures in the ancient mine walls. The veins vary in composition between nephrite and mixtures of tremolite and nephrite with the latter predominant. Typically, the colour ranges from moderate yellowish-green (10 GY 6/4) to pale greenish-yellow (10Y8/2) (*Figure 4*).

The veins appear restricted to lensoid bodies of massive tremolite that have developed within a skarn assemblage of rocks.

Figure 4: Slab of nephrite jade from the old Stansvik iron mine, Helsinki (size 27 × 19 mm). Photo by K.A. Kinnunen.

The skarns are a suite of banded calc-silicate rocks of complex mineralogical composition formed by contact metamorphism and metasomatism of limestone and dolomite. Based on the close association of the nephrite with metasedimentary strata, the occurrence is classed as para-nephrite in type.

According to the Geological Survey of Finland, the quantity of nephrite jade at the Stansvik locality appears very small. In addition, prospecting work carried out in similar geological formations elsewhere in the region has failed to identify further occurrences of nephrite.

Conclusion

In Finland, primary occurrences of jade of ortho-nephrite and para-nephrite types are recorded at Paakkila and Stansvik respectively and a secondary occurrence is recorded in glacially transported gravel at Hakkila.

Although no commercial production has eventuated, these minor occurrences indicate that some scope exists for further exploration work, especially in central Finland where numerous serpentinite bodies are scattered throughout the Precambrian crystalline basement.

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Letters to the Editor

Optimizing faceting for beauty*

We read with interest the above article and whilst we agree with the majority of it, we felt we would like to clarify one main point in the section Shape vs. weight (p.28), where Anton Vasiliev criticizes rubies and sapphires cut in Indo-China, India and Southeast Asia as not being cut like diamonds. We would like to know if Mr Vasiliev is a diamond cutter or a lapidary.

Whilst we agree that most rubies and sapphires in these countries are cut for weight, we would like to stress most strongly that they should not be cut like diamonds. The modern diamond cuts have been scientifically designed to give a diamond maximum brilliance as this is the only quality that a diamond has to give it beauty, whilst the main quality that a ruby or sapphire has is its colour.

Most sapphires and rubies do not have an even saturation of colour like synthetic stones which are often cut like diamonds. In reality most natural sapphires and rubies have a secondary colour, i.e. blue sapphires have either grey, purple or green as a secondary colour and rubies, purple or brown. If these stones are diamond-cut the secondary colour comes into play, thus reducing its beauty, and colour will be lost.

We have nearly 80 years' gem-cutting experience between us at Chas. Mathews, and Peter Rome had a couple of years before that cutting diamonds.

We have noticed a worrying trend over the last few years of notable institutions associated with our trade that are teaching people to cut coloured gems like diamonds, who have no experience at all!

Cutting diamonds is a science; cutting rubies, sapphires and emeralds is an art.

Peter R. Rome and John M. Taylor
Chas. Mathews (Lapidaries) Ltd.,
5 Hatton Garden, London EC1N 8AR

Anton Vasiliev replies:

Be assured, the author is a technologist of a cutting factory (coloured gems only) and a practising facetor. There is no contradiction between diamonds and other gems in this article; it must help facetors to make any gem more beautiful. The author agrees with opinion about narrowness of modern diamond design and noted the role of traditions in this article. There are many beautiful designs for coloured gems and one object of this article is to help facetors choose the best. The author's main opinion is that beauty is primary!

Responding to the second paragraph of the letter, investigation of the nature of colour of gems is one of the directions of scientific investigation at the LAL company. A special article devoted to optimizing colour is in the author's plans. The faceting factory LAL (well-known in Russia) has extensive experience of recutting Indo-Chinese cutting. The gems lose weight (up to 30%) but become much more beautiful and usually don't lose colour. Indeed, in some cases the colour improves!

I agree with the comments made in the penultimate paragraph of the letter. Diamond is just one kind of gem. Other gems must not be cut like a diamond; all gems must be cut for maximum beauty. Sometimes the brilliant arrangement of facets is preferable, but slopes of main facets at least must be different.

Cutting any gem must be an art! It's the subject of this article. But the cutting of rubies and sapphires in Indo-China, India and Southeast Asia is usually a native art, which can be improved with input of new technical knowledge.

Anton Vasiliev
LAL Scientific & Industrial Firm,
Moscow, Russia

Having just finished reading 'Optimizing faceting for beauty' by Vasiliev in the January issue of the Journal, I would say that in terms of numbers, the majority of faceted gems, and particularly diamond, have found their way to the 'round' shape through the ages. Oftentimes when lecturing on gems over the past 50 or more years, the question coming from the audience has been 'Just how much is *lost* in cutting a gem, from the rough material to the finished gem?'

In response, I pointed out that for practical work, we could assume a round brilliant being cut from a cube. Within the cube, the pavilion can be thought of as a cone (without the facets) and the crown as a truncated cone (a frustum), and calculation of their volumes indicates that such a 'preform' of the round

brilliant would constitute between 30 and 31% of the volume of the original cube. Most rough, of course, does not conform to ideal shapes for optimum recovery, but much of it dictates that a 'cube of sorts' be preformed before faceting begins. So yields will generally be much smaller than the figure given above.

In the past 55 years, I have kept meticulous records of yield from rough in a wide variety of coloured gems and find that, if you cut to the ideal angles for the different species, you are fortunate to recover an average of 25% from all the rough.

John R. Führbach
Jonz Fine Jewels, Amarillo, Texas, U.S.A.

Anton Vasiliev replies:

Gems cut in Indo-China are often recut at LAL company. Generally they lose from 10 to 30% weight but gain very much beauty! But if we cut gem from rough directly with correct proportions, the loss is much smaller. This value depends more upon the expertise of the facetor (positioning and orienting the gem into the rough piece) than on choosing the best facet slopes. With best cutting we recover an average of more of 25% from rough using correct slopes.

Translator's note: I too have recut foreign-cut stones (mostly Brazilian) to improve their beauty. They make great 'preforms'! Yes, there is loss (less than on Indo-Chinese stones) and it is worth it to a gem connoisseur (sadly, it makes no difference to the average buyer). Bruce Harding

Abstracts

Diamonds

Diamonds from Myanmar and Thailand: characteristics and possible origins.

W.L. Griffin, T.T. Win, R. Davies, P. Wathanakul, A. Andrew, I. Metcalfe and P. Cartigny. *Economic Geology*, **96**(1), 2001,159-70.

Diamonds occur in modern alluvial deposits at several localities in Myanmar, Thailand and Sumatra. These deposits do not contain typical diamond indicator minerals, and no obvious primary sources have been found in the surrounding terrain, which is characterized by Phanerozoic tectonic and magmatic activity. Detailed studies of diamonds from Theindaw and Momeik in Myanmar and Phuket in Thailand have been undertaken to clarify their origin. Syngenetic mineral inclusions in the diamonds are largely of the peridotitic paragenesis, with a smaller eclogitic component. Carbon and nitrogen isotope compositions are typical of kimberlitic and lamproitic diamond suites worldwide. Nitrogen aggregation states indicate a long residence and/or significant deformation at mantle T; many stones show plastic deformation features. The rounded and polished surfaces of most of the diamonds reflect resorption in a corrosive magma. The isotopic data and the dominantly peridotitic nature of syngenetic inclusions rule out the Argyle lamproite as a possible source and also distinguish the Myanmar-Thailand diamonds from morphologically similar stones from E Australia.   G.L.B.

Obtaining U.S. copyright registration for the Elara square cut-cornered brilliant diamond.

H.B. Rockman. *Gems & Gemology*, **39**(3), 2003, 210-13.

The U.S. Copyright Office has granted what is believed to be the first copyright registration covering a gemstone design, when the application to register the Elara cut was accepted. Previously, it had been argued that cut design lacked artistic or sculptural authority.   R.A.H.

[A study of X-ray diffraction of diamond inclusions from Luobusha, Tibet.]

N. Shi, W.S. Bai, Z. Ma, Q. Fang, M. Xiong, B. Yan, M. Dai and J. Yang. *Acta Geologica Sinica*, **76**(4), 2002, 496-500. (Chinese with English abstract.)

Diamonds have been found in podiform chromitites and olivine-bearing rocks from ophiolite in the Yarlung Zangbo River, Tibet; some of the diamonds have silicate inclusions. Using the charge-coupled detector system for XRD, the authors have obtained powder XRD patterns for inclusion minerals only 20 μm in size; these were found to be talc and chrysolite, confirming the natural origin of these diamonds.   R.A.H.

An investigation into the cause of colour in natural black diamonds from Siberia.

S.V. Titkov, N.G. Zudin, A.I. Gorshkov, A.V. Sivtsov and L.O. Magazina. *Gems & Gemology*, **39**(3), 2003, 200-9.

Black and dark grey diamonds from Siberia were studied by analytical scanning and TEM. Their colour was found to be due to the presence of dark inclusions, not of graphite but predominantly magnetite in the black diamonds, and hematite and native iron in the grey diamonds. The black diamonds exhibited anomalously high magnetic susceptibility, which may serve as one criterion for determining the natural origin of the black colour.   R.A.H.

An infrared investigation of inclusion-bearing diamonds from the Venetia kimberlite, Northern Province, South Africa: implications for diamonds from craton-margin settings.

K.S. Viljoen. *Contributions to Mineralogy & Petrology*, **144**(1), 2002, 98-108.

The Venetia kimberlites sampled diamonds from the lithosphere underlying the central zone of the Limpopo Belt, an anomalous tectonic setting. A suite of diamonds from the Venetia mine spans a large range of N contents (from less than the detection limit to 1355 ppm). Diamond N contents are higher in the eclogitic diamond population relative to websteritic and peridotitic diamonds. Nitrogen aggregation states vary from pure type 1aA (poorly aggregated N) to pure type 1aB diamond (highly aggregated N). Two groups of diamonds can be distinguished: a minor population with N>500 ppm and N aggregation states of <40% 1aB and a dominant population with higher and more variable N aggregation. The unusually aggregated diamonds are unique to Venetia relative to other intrusives on the Kaapvaal–Kalahari craton, but similar to other craton margin or adjacent mobile belt settings such as the Argyle lamproite, though the Argyle setting involved a higher level of deformation (with a higher abundance of brown diamonds).   R.A.H.

Gems and Minerals

The history and importance of heat treatment of Australian sapphire.

T. COLDHAM. *Australian Gemmologist*, 21(11), 2003, 450-62, 14 illus.

This paper appears in the special Geoff Tombs Memorial issue (Part 1) together with a reproduced article by Geoff Tombs ('Synthetic-like fluorescence in a natural sapphire') which first appeared in the *Australian Gemmologist*, 12(3) in 1974.

Geoff Tombs's interest and articles on heat treatments are mentioned in the preamble to the Coldham paper. The author believes that Tombs's references to SW U-V fluorescence in a natural sapphire may mean that he was examining a heat-treated Ceylon blue sapphire a few years before such a treatment became generally known to the gemmological community. The author then reviews the heat treatment processes used to enhance Australian sapphires from 1969 to the present time. While the advent of the Thai heat treatment processes dramatically increased the demand for Australian rough, the profits made by the Thais enabled them to invest in buying, mining, processing and treating rough sapphire from around the world. The resulting competition now threatens to destroy the Australian mining industry. He concludes with the question: "Will the discovery of the beryllium treatment process be the straw that broke the camel's back?" P.G.R.

Some preliminary observations of primary corundum occurrences from Balangoda region, Sri Lanka.

M.D.P.L. FRANCIS, P.G.R. DHARMARATNE AND R. GIERE. *Gemmologie. Z. Dt. Gemmol. Ges.*, 52(2/3), 2003, 81-90. 2 maps, 12 photographs, 2 diagrams, bibl.

The region of Balangoda lies midway along the Colombo-Badulla road and is famous for top quality stones, including rubies and sapphires. Most finds are alluvial, but some corundum deposits are found, producing good quality stones.

The corundum bearing granulitic gneisses were found as a narrow band near to Balandoga and consist of corundum, biotite, sillimanite, perthitic K-feldspar and plagioclase together with graphite, zircon, apatite, sapphirine and spinel. Most of the region's corundums contain zircon inclusions. E.S.

Cäsiumreiche Morganite aus Afghanistan und Madagaskar.

H.A. HÄNNI AND M.S. KRZEMNICKI. *Gemmologie. Z. Dt. Gemmol. Ges.*, 52(2/3), 2003, 67-80. 7 photographs, 3 diagrams, 3 tables, bibl.

The beryls have a very saturated pink colour and their physical and optical data exceed previously reported details. SG = 2.91-3.10, RI = 1.608-1.615, caesium concentration was up to 15.18%. Samples from Afghanistan are semi-transparent, but transparent stones are found among the Madagascar stones. Inclusions are mainly fine tubes parallel to the *c*-axis, flat fluid inclusions parallel to the basal pinacoid, and tension fractures. Based on chemical composition, spectral analyses and colour saturation, the authors suggest that these stones are morganites. Because of the extremely high content of caesium a new mineral name within the beryl group will be discussed in the IMA. [This material has been approved by the IMA as a new mineral – pezzottaite – E.S.] E.S.

Lapis lazuli from Sar-e-Sang, Badakshan, Afghanistan.

W. HEFLIK AND L. NATKANIEC-MOWAK. *Gemmologie*, 52, 2003, 11-24.

Fresh mineralogical and petrological details are provided for the classic lapis lazuli locality of Sar-e-Sang, Badakshan, Afghanistan. Tests involved SEM electron microscopy with energy-dispersive X-ray analysis and chemical determinations using NAA, ICP-AES. The lapis-lazuli arises from contact metamorphism. M.O'D.

Aventurisierender Oligoklas aus USA.

U. HENN. *Gemmologie. Z. Dt. Gemmol. Ges.*, 52(2/3), 2003, 117-8. 2 photographs, bibl.

The author describes transparent oligoclase feldspars from Oregon with euhedral haematite inclusions, which cause aventurescence. E.S.

Bestrahlter farbwechselnder Fluorit aus Brasilien.

J. HYRSL AND C.C. MILISENDA. *Gemmologie. Z. Dt. Gemmol. Ges.*, 52(2/3), 2003, 115-6. 1 photograph, bibl.

Some faceted dark sapphire-blue fluorites came on the market in Brazil in 2002. The stones showed the rare blue colour both in day and under fluorescent light. Under incandescent light the colour changed from blue to an amethyst-like violet. The original stones were colourless to yellow and came from the Espirito Santo state and were irradiated with a Co-source in Sao Paulo. RI = 1.432. There are numerous two-phase inclusions. The colour seems to be evenly distributed, but under a microscope one can see dark coloured patches. Apparently thousands of carats of faceted stones have been sold, mainly to Japan. E.S.

Mineral inclusions in zircon from diamond-bearing marble in the Kokchetav massif, northern Kazakhstan.

I. KATAYAMA, M. OHTA AND Y. OGASAWARA. *European Journal of Mineralogy*, 14(6), 2002, 1103-8.

Zircon is known to protect inclusions of UHP phases from late-stage overprinting. Matrix diopsides contain abundant exsolved phengite lamellae, whereas the exsolution is absent in the inclusions in zircon. The diopside inclusions contain more K_2O (< 0.56 wt.%) and Ca-Eskola component (< 3.5 mol.%) than those of the matrix (0.14 wt.% and 2.1 mol.%, respectively). Thus phengite exsolution occurs in matrix pyroxene with low K_2O and Ca-Eskola components compared to the inclusions in zircon, indicating that decreasing K_2O and Ca-Eskola components during decompression resulted in the phengite exsolution in diopside. The peak metamorphic *P-T* conditions of the impure marble are estimated to be 60-80 kbar and 960-1050°C. R.A.H.

Amethyst mit Eisenrosen aus dem Zillertal.

A. KUGLER. *Lapis*, 28(10), 2002, 55-9.

Fine crystals of amethyst have been found in association with 'iron roses' of hematite in the Zillertal, Austria. M.O'D.

Gem news international.

B.M. Laurs (ed.). *Gems & Gemology*, **39**(3), 2003, 222-49.

Items mentioned include Australia's largest gem-quality rough diamond (104.73 ct) found in the Gareth pipe at the Merlin project in the Northern Territory, the Koala kimberlite at Ekati in the Canadian Northwest Territories, an alexandrite-emerald intergrowth from Russia, an unusually large crystal (3.7 cm long) of hiddenite from North Carolina, bright pink Cs-'beryl' (pezzottaite) from a pegmatite near Ambatovita, Madagascar, and three synthetic diamonds (0.14-0.31 ct) grown by chemical vapour deposition.
R.A.H.

Gemmologie Aktuell.

C.C. Milisenda. *Gemmologie. Z. Dt. Gemmol. Ges.*, **52**(2/3), 2003, 63-6. 6 photographs.

Strawberry quartzes are colourless quartzes with haematite inclusions; they came from Mexico in the 1960s, then from Kazakhstan in the 1990s and are now on the market from Madagascar. Faceted specimens were about 2 cm in length.

A dark brown scapolite cat's-eye from Tanzania, weighing 14.45 ct, 18.5 × 10.85 × 9.61mm, had an RI = 1.56, SG = 2.76. The chatoyancy was caused by parallel orientated acicular mineral inclusions. These are two-phase inclusions and under the microscope one can see brownish-red platelets, resembling those found in the strawberry quartzes described above.

Iridescent ammonites from Russia, resembling the specimens from Alberta, Canada known as 'ammolite' in the trade, were examined. The specimens weigh about 12.5 g each and measure roughly 5.5 × 2.5 × 0.5 cm. They show only a vague shadow on the refractometer at about 1.52 and 1.67, with a birefringence of 0.15. Thin aragonite layers are responsible for the iridescent effect.
E.S.

Lab Notes.

T.M. Moses, I. Reinitz, S.F. McClure and M.L. Johnson (eds). *Gems & Gemology*, **39**(3), 2003, 214-21.

Notes include details of a faceted 6.34 ct colourless leadhillite (reportedly from Tsumeb), a 4.75 ct yellow beryllium-diffused sapphire and a 6.97 cabochon of stichite with pinkish-purple

floral masses apparently nucleated around minute crystals of chromite.
R.A.H.

Eine fossile Perle aus den Niederlanden.

J. Schlüter and M. Danner. *Gemmologie. Z. Dt. Gemmol. Ges.*, **52**(2/3), 2003, 91-6. 4 photographs, bibl.

The fossil pearl was found in the Langenboom pit, district of Mill in the Netherlands in Neogene marine sediments in 2002. It is estimated to be 3.3 million years old. It is round, white to beige, 4.4 mm in diameter, weighing 0.096 g. It is built up of concentric aragonite layers and is non-nacreous. The pearl has alternating layers of aragonitic cross lamellae and prismatic aragonite, common to mollusc shells. The pearl was found close to shell fragments from the gastropod genus Xenophora. The colour, internal structure and reaction to ultra-violet light suggest that pearl and shell fragments have a common origin.
E.S.

Geochemie und Petrologie von Smaragdvorkommen – Erfahrungen aus dem Smaragdbergbau in Sambia und Simbabwe. Teil I: Kafubu, Sambia.

K.C. Taupitz. *Gemmologie. Z. Dt. Gemmol. Ges.*, **52**(2/3), 2003 97-114. 5 maps, 3 tables, 1 diagram, bibl.

The Zambian emeralds occur in the early Proterozoic Kafubu formation and crystallized during the Pan African orogenesis and metamorphism, whereas the Sandawana emeralds occur in the mid-Archaean Sandawana formation below the lower Bulawayo greenstones of the Zimbabwe craton. Borates and potassium predominate in Kafubu, while in Sandawana it is mainly sodium with a little potassium and lithium. The Kafubu emeralds mainly crystallized as porphyroblasts in the host rocks. In the regional metamorphism nothing was added and nothing removed except volatile fluids. Only where enough beryllium and sufficient chromium (and of course Si, Al, Na and Fe) was present, could emerald porphyroblasts grow under the conditions of strong metamorphism.

It was concluded that the emerald pockets and ore shoots (only about

10-20% of the ore zone) are due to beryllium enrichment during or shortly after the sedimentary deposition. Influences by tectonic structures or hydrothermal activity could not be found.
E.S.

Lambina opalfield: An update.

J. Townsend. *Australian Gemmologist*, **21**(12), Geoff Tombs Memorial Issue (Part 2), 2003, 490-4, 8 illus. in colour, 3 maps.

The Lambina opalfield diggings are situated some 200 km north west of Coober Pedy. Although they have been worked intermittently for at least 30 years, it has only been in the last decade that production of precious opal from this field has become significant. This update includes details of the geology of opal occurrence, annual estimates of Lambina opal production from 1995 to 2002 and characteristics of the opal recovered from this site.
P.G.R.

Instruments and Techniques

Annealing radiation damage and the recovery of cathodoluminescence.

L. Nasdala, C.L. Lengauer, J.M. Hanchar, A. Kronz, R. Wirth, P. Blanc, A.K. Kennedy and A.-M. Sydoux-Guillaume. *Chemical Geology*, **191**(1-3), 2002, 121-40.

The structural recovery upon heat treatment of a highly metamict actinide-rich zircon (U ~ 6000 ppm) was studied in detail using a range of techniques including XRD, Raman spectroscopy, SHRIMP ion probe, EPMA, TEM and CL analysis. The structural regeneration of the amorphous starting material depends on random nucleation. It starts between 800 and 900°C when amorphous $ZrSiO_4$ decomposes to form crystalline ZrO_2 and amorphous SiO_2. At ~ 1100°C, well-crystallized $ZrSiO_4$ grows at the expense of the oxides. U has been retained in the newly grown zircon whereas Pb was evaporated during the heat treatment. This process is in marked opposition to the reconstitution of moderately metamict minerals, which experience a gradual recovery controlled by the epitaxial growth at the

crystalline-amorphous boundaries. Both recovery processes are not the direct inverse of metamictization. The structural regeneration is connected with a significant increase in the emission of CL. In all cases (annealing heavily damaged zircon and moderately damaged zircon and monazite), it was observed that the final, well crystallized annealing products emit more intense CL than their radiation-damaged starting minerals, although having almost identical elemental composition. The observations are taken as evidence that the CL is not only determined by the chemical composition of the sample but also strongly controlled by structural parameters such as crystallinity or the presence of defect centres. G.L.B.

Spectra of gem materials.

G. PEARSON. *Australian Gemmologist*, **21**(12), Geoff Tombs Memorial Issue (Part 2), 2003, 478-85. 7 illus.

This paper discusses the usefulness of the hand spectroscope in the identification of gemstones. The author compares transmission spectra derived from a UV-Visible scanning spectrophotometer with the spectra observed using a prism spectroscope. His research raises questions about the visibility of spectral absorption features which have been long published as characteristic of many gemstones. The Relative Luminous Efficiency curve indicates the sensitivity of human vision across the visible wavelength range and is used to develop a parameter termed the *RLE Corrected Transmission*. This parameter is based on the relative intensities of the various wavelengths that can be seen by observers having average visual sensitivity and indicates that some of the absorption spectra presented in many gemmology texts cannot be seen with the hand-held spectroscope. P.G.R.

Synthetics and Simulants

[Growth of diamond from solution in the CaCO$_3$ melt.]

A.F. KHOKHRYAKOV, YU. M. BORZDOV. YU. N. PAL'YANOV AND A.G. SOKOL. *Proceedings of the Russian Mineralogical Society*, **132**(2), 2003, 87-95. (Russian with English abstract.)

Diamond nucleation and growth kinetics on the [100] and [111] faces of seed diamond crystals in the CaCO$_3$-C system were studied in a non-pressing device of 'cross-cut sphere' type at 7 Gpa and 1700-1750°C in experiments of 10 min to 18 h duration. The growth on [100] develops in the diffusion-limiting regime, and growth on [111] is determined mainly by the kinetics of superficial processes. Evolution of the surface accessories on the [111] faces was traced from triangular frame defects up to large trigonal pyramids. Comparison with similar Si and Ge patterns shows that the trigonal pyramids are complex twins. The only stable cubic forms of diamond growth in the CaCO$_3$-C system are tetragontrioctahedron faces; among them only {322} faces achieve the habit scale of development. R.A.H.

Alkaline-chloride components in processes of diamond growth in the mantle and high-pressure experimental conditions.

YU. A. LITVIN. *Doklady, Russian Academy of Sciences, Earth Sciences Section*, **389A**(3), 2003, 388-91. (English translation.)

An experimental study was carried out into the spontaneous nucleation and crystallization of diamond and its growth on monocrystal seeds in melts of the key system (potassium chloride-carbon) at high P. The investigations have shown that spontaneous nucleation is effectively realized in melts of the KC1-C system, which is an essential aspect of the problem of alkaline-chloride brines in natural diamond-hosted cloud-like microinclusions. The author concludes that the growth of natural diamonds in the parent carbonate-silicate will not cease during local high concentrations of alkaline-chloride aqueous solutions. A.M.C.

35 years on: a new look at synthetic opal.

A. SMALLWOOD. *Australian Gemmologist*, **21**(11), *Geoff Tombs Memorial Issue (Part 1)*, 2003, 438-47. 22 illus., 2 tables.

This paper appears in the special Geoff Tombs Memorial issue (Part 1) and follows a reproduced article by Geoff Tombs ('Notes on identification of Gilson opal') which first appeared in the *Australian Gemmologist*, **12**(6) in 1975.

The Smallwood paper reviews the history of opal synthesis from the early days of Pierre Gilson's original production to the more recent manufacture of synthetic and imitation opals from Japan, Russia and China. Tables of gemmological constants are provided and compared with those of the natural material. P.G.R.

Abstractors					
G.L. Barron	G.L.B.	R.A. Howie	R.A.H.	P.G. Read	P.G.R.
A.M. Clark	A.M.C.	M. O'Donoghue	M.O'D.	E. Stern	E. Stern

Book Reviews

Handbook of mineralogy. Borates, carbonates, sulphates

J.W. ANTHONY, R.A. BIDEAUX, K.W. BLADH, M.C. NICHOLS, 2003. Mineral Data Processing, Tucson, AZ, pp ix, 813. Hardcover ISBN 0 9622097 4 0. US $ 150.00.

This is the final volume to be published of this excellent series in which the aim of one species, one page has been triumphantly achieved without the loss of any major data. Previous volumes covered elements, sulphides and sulphosalts (volume 1), silica and the silicates (volume 2, in two parts), halides, hydroxides and oxides (3), arsenates, phosphates and vanadates (4). Species are presented in alphabetical order of name throughout.

Gemmologists may find the price of the complete set or even a single volume sends them to the nearest major library but the convenience of the single page of data is considerable. Since the publication was commenced in 1970 the compilers have made use of the GEOREF database of the American Geological Institute and the GEOBASE database of Elsevier Science Ltd.

In the present volumes the gem minerals rhodochrosite, sinhalite, jeremejevite and johachidolite are among species with ornamental application, as well as calcite which succeeds in not over-running its page despite the more than 1000 forms attributed to it.   M.O.D.

Calcite: the mineral with the most forms

Lapis International LLC, East Hampton, Conn., U.S.A. pp 114, illus. in colour. Softcover. ISBN 0 971 5371 3 5. *extralapis English no 4*. Price on application.

English version of the monograph first published in German.   M.O'D.

Fluorspar in the North Pennines

R.A. FAIRBAIRN (ED.), 2003. North of England Lead Mining Museum, Killhope. pp iv, 132, illus. in black-and-white. Softcover ISBN 0 9518939 3 9. £8.50.

This is a most useful multi-author survey of the occurrence and working of fluorite in the Northern Pennine orefield of England. The first chapter deals with the properties, origin and distribution of fluorite both in the area described and on the Earth in general. Following chapters cover the activities of dealers and collectors, the demand for fluorite in the steel industry and the rise and fall of fluorite mining in the area.

The remainder of the book describes ore mining and dressing including a description of the Frazer's Grove mine, the last of the major fluorite mines to work (the Frazer's Hush portion of the mine ceased production by the end of July 1999). The site is said to be mothballed. This reviewer went underground during the 1980s when production was still in progress.

Each chapter has its own excellent list of references and the whole book reflects the greatest credit on the publishers and contributors as well as on the Friends of Killhope who have done and are doing so much to preserve the history of mining in one of England's major mining areas.   M.O'D.

Pearling in the Arabian Gulf: A Kuwaiti Memoir

SAIF MARSOOQ AL-SHAMLAN translated from Arabic by P. CLARK, 2000. London Centre for Arab Studies. pp 190, 19 black-and-white photographs, 1 map, glossary and index. ISBN 1900 404 192. Price on application.

This is an edited version in translation of a two volume work first published in Arabic in 1970. Based on documentary and oral evidence, private archives and the author's memory, it describes the pearl industry between 1900 and 1930 when the arrival of the Japanese cultured pearl brought disaster to the industry. It records the conditions of the divers, their food, tools of their trade, their illnesses and generally their difficult life at sea. There are many anecdotal stories of divers, captains and pearl merchants, which make reading of this little book very enjoyable.   E.S.

Pearl Buying Guide. 4th edn

RENEE NEWMAN, 2004. International Jewelry Publications, Los Angeles, CA,U.S.A. pp 156, illus. in colour. Softcover. ISBN 0 929975 35 9. £14.50.

This is the book to get whether or not you intend to buy pearls. It is also ideal for examination preparation! Matters which can seem rather confusing when studied in the abstract are clarified by the many photographs and the questions set for each chapter are excellent ways in which to test your knowledge. In more than one place the author states that to all intents and purposes any pearl likely to be encountered in general commerce is going to be cultured. This is an interesting point and almost certainly true.   M.O'D.

Burma ruby: a history of Mogok's rubies from antiquity to the present

S.K. SAMUELS, 2003. SKS Enterprises Inc., Tucson, AZ, U.S.A. pp xvii, 254. Illus. in black-and-white and in colour, Hardcover ISBN 0 9725323 0 7. Price on application.

Studies of Myanmar and its rubies are leaving the presses with increasing frequency. Two recent ones are Themelis, *Mogok, valley of rubies and sapphires* (2000) and Schlüssel, *Mogok, Myanmar* (2002), both of which are

general surveys of the Mogok area with plenty of space given to the ruby mines and their products. The author of the present book has long experience of the country, having worked in the medical profession in different capacities from the 1950s and returning there in 1971. After studying gemmology in the 1980s, he returned to the country to assess the state of the ruby and gem markets after years of political and commercial uncertainty.

The book begins with a short history of the place held by ruby in the lore of Myanmar and then proceeds to a description of the area and the place held by ruby in early Burmese kingdoms, from the 16th century, during which travellers from the west began to publish accounts of their travels, supplementing with fertile imaginations those places, objects and customs actually seen. Exceptional ruby specimens were known to the Burmese population and by the end of the 17th century the published writings of Tavernier had brought them to the notice of Europeans.

The next chapter describes Mogok during the second Burmese dynasty roughly corresponding to the 16th century. During this time the ruby mines in the area had begun to provide major (and some legendary) specimens: by the time of the last Burmese dynasty (1752-1885), the history of which is comprehensively described, royal treasures were well known, many featuring fine rubies. The whereabouts of some of them have been investigated and are discussed.

Details of the history of Burma on annexation by the British in 1852 and of the subsequent events of the Second World War are given in some detail. The Oriental and India Office collections of The British Library contain great amounts of information but it is uncertain whether or not the author has been given access to them. However, he has drawn comprehensively from the publications of the Burma Research Society. The occasional remarks and speculations on the motives behind British policies in south Asia are less well-informed.

So far we have an interesting overview of historical events against which the activities of the ruby mines have been taking place. By page 101 we turn, profitably, to accounts of the development or re-development of the gem trade in Burma.

First we see how relations between government and miners became the subject of regulations and how the establishment of a gem emporium affected ruby production and sales. By 1988/89 and under a new government the 29th Emporium included some exceptional rubies though by 1995 there was a decline in ruby production and quality. Some of the provisions of a new law aimed at improving relations between government and ethnic groups are set out. The author has been able to reproduce entries from some of the sale catalogues of the mid-1990s.

The next chapter describes the stone tract with brief notes on the geology and a list of the mines operating in 2002. Some mines produce only ruby, others sapphire and some other species. The properties of ruby and sapphire are then introduced and I have the impression that the author now finds himself on less familiar ground. Names of authorities are frequently and persistently misspelt; rutile needles are said to be negative crystals; 'crystallites of olive' have not turned up in any corundum I have encountered.

There is no doubt that the sudden diminution of accuracy from this point makes this reviewer less confident about the previous chapters. It is all too easy to pick up scraps of history, very little of which can be verified, but much harder to deal with specimens whose essential nature and properties science has already established. The carelessness shown here makes me wonder why the MS was not scrutinized by a competent authority. Gemmologists could staple together pages 143-50 without losing any vital information.

The bibliography is uneven and there is no index, the most serious fault of the book. The colour photographs have not reproduced well: the inclusions mentioned in the captions are not always visible and the blues of the sapphires are too dark.

I should add here that despite some strictures I found this a very readable book with valuable notes on and

photographs of the more recent emporia. There is also advice on buying gemstones in Myanmar (internet sales are promised).
M.O'D.

Flux-enhanced rubies and sapphires

T. THEMELIS, 2004. The author, Bangkok, Thailand [www.themelis.com]. pp 48, illus. in colour. Softcover ISBN 0 940965 42 9. Price on application.

The book describes the processes involved in the heat treatment of rubies and sapphires. This is very nearly a step-by-step recipe for the treatment as all stages are illustrated on each side of the text which occupies the centre of each page. The all-colour illustrations and the strong red page headers make the book seem quite aggressive and the effect is memorable.

The text is, too, or should be as this is probably the best account so far of this type of treatment. Several authorities are cited and the dangers of doing it yourself are emphasized in a general disclaimer. There is a glossary and a short bibliography. The final part of the text deals with identifying treatment of this kind: disclosure and market value are also briefly discussed. Questions and answers cover several of the areas which gemmologists could well study.
M.O'D.

Secrets of the gem trade

R.W. WISE, 2003. Brunswick House Press, Lenox, MA, U.S.A. pp 274, illus. in colour. Hardcover. ISBN 0 9728223 9 9. US $79.95.

This book, which is partly an autobiography, gives a readable account of many of the major gem materials as seen through the eyes of an experienced dealer and editor. The book's appearance is particularly attractive with an airy typeface and good spacing. The photographs are of a good standard and there is a fairly complete bibliography. The text gives an imaginative introduction to gemstones, just the thing to start off a career in gemmology.
M.O'D.

Tribute

Alexander E. Farn
(1916-2004)

A tribute by Kenneth Scarratt

I first had the pleasure of meeting Alexander E. Farn (Alec as he was widely known) towards the end of 1973. As the then Director of the Laboratory of the Diamond, Pearl, and Precious Stone Trade Section of the London Chamber of Commerce (usually known as 'the Laboratory') he greeted me with a warm yet formal smile as I walked into an interview that was to place a stamp upon my future as a professional gemmologist. The office was that of Denis Bradshaw, a noted Hatton Garden coloured stone merchant, who was then the Chairman of the DPPS Trade Section of the London Chamber of Commerce (and the Laboratory Committee) and who in the same vein as Alec was one of the industry's true gentlemen. I remember sitting before these two and several other members of this initially forbidding and exceptionally formal 'selection panel'– a young gemmologist with no history, just a desire for knowledge and a hope that this could be the start of my gemmological career. Within moments of sitting I can remember feeling the warmth in the questions coming towards me from Alec and my fears of rejection melting away, allowing me to be myself and ultimately being given the honour of working for and alongside Alec until his retirement on St. Patrick's Day 1981.

Working with Alec from early 1974 to 1981, I was privileged to hear some of the anecdotal history of the Laboratory through his first hand knowledge of his colleagues' sometimes incredible experiments. At the same time I learned something of the man himself. As a child he lived over a jeweller/pawnbroker's shop and he began his gemmologically-oriented career as a pawnbroker's assistant (again living over the shop) in an area known as 'World's End' Chelsea, an area of London that he described as being 'not the best' at the time he was working there. He eventually graduated to work in George Attenborough & Son, pawnbrokers, jewellers and silversmiths, in Oxford Street, where one of the tasks he related was 'smashing' sterling silver teapots, candelabra, etc, with a sledge hammer and throwing the remains into a large walk-in vault. It was while working at Attenborough's and pondering over some wonderful coloured gemstones that a good friend and colleague, George Ratcliffe, said to him, "God, you are ignorant, you need to get yourself gemmologically educated."

Motivated by his colleague's comments, Alec joined Basil Anderson's gemmology class at Chelsea Polytechnic just before World War II. He revelled in this new and fascinating direction and, like so many of us, "caught the gemmological bug". Also present in this class was a future Secretary of the Gemmological Association, Harry Wheeler. Both he and Harry passed their first year examinations but unfortunately for them both their careers were interrupted by

World War II. Alec served his country admirably during the war in the Royal Pioneer Corps while Harry was in the Royal Army Service Corps.

Following the end of the war, in 1946 both Alec and Harry Wheeler enrolled for their second year gemmology course and passed the Diploma Examination with distinction. A short time later Basil Anderson asked Alec to join the Laboratory to work alongside himself, Robert Webster and Cecil (C.J.) Payne. An offer he was delighted to accept.

During his time at the Laboratory Alec provided the solid base that the UK trade came to rely upon. It was to him that fell the task of ensuring the trade's needs were met, and that the reports were both accurate and on time. The other members of the phalanx of four provided the vital research needed to ensure accuracy and keep the world informed, Alec put the research into practice, "testing scores of thousands of pearls and rubies annually". After the war, the greatest need along with pearl testing was testing coloured stones, mostly calibrated rubies. At its peak in the post war years, the Laboratory tested more than 100,000 coloured stones annually. Alec was indeed the 'trade's gemmologist', never leaving his roots but embracing the scientific and technical in so far as it served a clear purpose. His numerous publications were always lucidly presented, stemming from his many years of practical gem testing, and this continued into the writing of his book Pearls, Natural, Cultured and Imitation. This much needed text was published in 1986 and is still one of the few volumes that are available on the subject. He describes the use of such instruments as the pearl endoscope and radiography units and the practical testing of pearls from personal experience rather than from the repetition of others.

His work with the industry was not restricted to laboratory reports or papers in journals. He worked diligently with the then President of the CIBJO Coloured Stone Commission, E.A. Thomson, to correct the CIBJO Blue Book and attended CIBJO meetings as an advisor to the UK delegation.

Upon the retirement of Basil Anderson, Alec took over the helm of the worlds' first and most noted Gemmological Laboratory. During his tenure he led the first tentative steps taken towards the use of modern analytical techniques in gemmological laboratories. One of his first improvements was the installation of an X-ray powder diffraction camera and this was closely followed by the introduction of low temperature (liquid nitrogen cooled) spectroscopy, which was a first for any gemmological laboratory. Apart from these and other technical improvements he was responsible for the introduction of a CIBJO diamond grading service at the Laboratory.

The 'phalanx of four' in the laboratory; (from the left) Robert Webster, Alec Farn, C.J. Payne and, standing, Basil Anderson.

(From the left) C.J. Payne, Alec Farn, Denis Bradshaw, Basil Anderson and Robert Webster, at Goldsmiths' Hall in 1975 on the 50th anniversary of the Laboratory.

Alexander Farn was an exceedingly private person who loved the challenges of his hillside garden at Riddlesdown in Surrey, a small village- like community nestled in a valley but only 25 minutes from Central London. He developed his love for 'caravanning' and levelled off the land in front of his house to accommodate his caravan. Each year he and his wife Ethel would travel through France discovering the wonders of that incredibly beautiful country and fast becoming devoted Francophiles. They both regularly attended French language classes and it pleased him greatly to converse in French when meeting with gemmological colleagues from the Paris laboratory. It was during a vacation in France that he noticed an irritation in one eye that was subsequently diagnosed as shingles. For many years thereafter he struggled with the ongoing pain caused by this problem. However, his professionalism was such that few knew of this. He and his wife moved from Riddlesdown to a flatter garden in Selsdon and after retirement they moved to Frinton-on-Sea and then later to Seaford.

Alec Farn, the last of the phalanx of four passed away on 6 January 2004. On the 50th anniversary of the Gemmological Association he wrote:

"Far from being a scientist I am a member of the trade, fortunate enough to have secured a job in the Laboratory, a job I was not seeking but when offered I accepted. I hoped some mistake in identity had not occurred but if so I hoped I could be kept on."

There is no question that Basil Anderson was not mistaken in choosing Alec Farn as his eventual successor.

He will be greatly missed by his wonderful wife Ethel and his son Edward, and all those who were fortunate enough to come into contact with him. I was one of those fortunate enough to have gained in so many ways from having been acquainted with him and like others mourn his death, and with this the passing of the most significant era in the UK's gemmological history.

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

Members' Meetings

Midlands Branch

On 30 January at the Earth Sciences Building, University of Birmingham, Edgbaston, the Branch's annual Bring and Buy Sale and Team Quiz were held.

The Midlands Branch Conference was held on 22 February at Barnt Green, Worcestershire. The keynote speaker, Stephen Dale, a specialist in the works and techniques of Carl Fabergé, gave a talk entitled 'Carl Fabergé – a Russian Revolution'. Michael O'Donoghue gave a presentation on imitation gemstones entitled 'Where are they now?' and Roy Starkey spoke on various aspects of Scottish geology and mineralogy.

On 27 February at the Earth Sciences Building Professor Henry Hänni gave a presentation entitled 'The latest from the SSEF and the University of Basel'.

On 26 March at the Earth Sciences Building Chris Tarratt gave a talk on the history and development of hallmarking.

North West Branch

On 18 February at Church House, Hanover Street, Liverpool 1, Alan Bowden gave a talk entitled 'Gems in space: an introduction to the world of meteorites'.

On 17 March at Church House Terry Davidson gave a talk on 'Cartier: the 20th century'.

Scottish Branch

On 20 January at the British Geological Survey, Murchison House, West Mains Road, Edinburgh, Michael O'Donoghue gave a talk on 'Some unusual and historical synthetics'.

On 23 February at the Bruntsfield Hotel, Bruntsfield Place, Edinburgh, a social evening was held which included a Quiz, a Bring and Buy Sale and a buffet.

On 23 March at Jury's Hotel, Great Western Road, Glasgow, Brian Jackson gave an in-depth review of the feldspar family entitled 'Feldspar; the forgotten gem'.

South East Branch

On 25 February at the Society of Antiquaries of London, Burlington House, Piccadilly, London, Nigel Israel gave a talk entitled 'Tavernier, his travels and gemstones'.

Gem-A USA

Gabi Tolkowsky was guest-speaker at the Gem-A USA Dinner held during the AGTA show at the Tucson Gem and Mineral Fair in February. The dinner was well attended and attracted Gem-A members from Australia, Austria, Canada, China, Madagascar and the UK as well as from America.

Annual General Meeting

The 2003 Annual General Meeting of Gem-A was held on 9 September 2003 at 27 Greville Street, London EC1 8TN. Michael O'Donoghue chaired the meeting and welcomed those present. The Annual Report and Accounts were approved.

Donations

The Council of Management are most grateful to the following for responding to the appeal for donations to enable the Association to extend its membership and education services. Donation levels were Diamond (£1000 and above), Ruby (£500 to £999), Emerald (£250 to £499), Sapphire (£100 to £249) and Pearl (£25 to £99).

The following join those donors listed in previous issues of *The Journal*:

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    New York, U.S.A.

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Gifts to the Association

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of Borneo amber

Charles & Colvard (HK) Ltd, Hong Kong,
for 40 round and fancy-shape moissanites,
and a J-Fire Unit for testing moissanite

John R. Führbach, FGA, Amarillo, Texas,
U.S.A., for samples of feldspar, emerald,
amethyst and calcite

Gem-A Awards

Gem-A Examinations were held worldwide in January 2004. In the Examinations in Gemmology 130 candidates sat the Diploma Examination of whom 39 qualified, including one with Distinction and three with Merit. In the Foundation Examination, 129 candidates sat of whom 85 qualified. In the Gem Diamond Examination 73 candidates sat of whom 51 qualified, including six with Distinction and ten with Merit. The names of the successful candidates are listed below:

EXAMINATIONS IN GEMMOLOGY

Gemmology Diploma
Qualified with Distinction
Miao Fu-chiang, Taipei, Taiwan, R.O. China

Qualified with Merit
Kelly, Jennifer Liu, London
Sillem, Hayaatun, London
Wood, Naoko W., Kensington, London

Qualified
Andronikou, Stamatina, Didsbury,
  Greater Manchester
Aye, Nwe Nwe, Yangon, Myanmar
Behennah, Andrew C., Didcot, Oxfordshire
Borahan, F. Oya, Istanbul, Turkey
Cheng Yili, Wuhan, Hubei, P.R. China
Cui Xiwen, Wuhan, Hubei, P.R. China
Deligiannis, Marios, Athens, Greece
Fan Yu-Hsiang, Taipei, Taiwan, R.O. China
Filadelfeos, Eleni-Anna, Athens, Greece
Glasgow, Sarah A., Fulham, London
Holman, Meryan, London
Huang Jin, Wuhan, Hubei, P.R. China
Ingridsson, Anna-Lis, Lannavaara, Sweden
Kwok Nai Chiu, Hong Kong
Lal, Sumit Kumar, Surat, India
Lalitha, R., Rajasthan, India
Latumena, Warli, Jakarta, Indonesia
Law Cheuk Yee, Annie, New Territories, Hong Kong
Lee Fung Mei, Kowloon, Hong Kong
Leung Kit Ling, Neon, Kowloon, Hong Kong
Ma Danni, Wuhan, Hubei, P.R. China
Mohamed, Ahmed, Lannavaara, Sweden
Naing, Saw, Yangon, Myanmar
Ngan Hin Wah, Michael, Hong Kong
O'Donnell, Craig, Smethwick, West Midlands
Okada, Hiroko, Kamakura, Kanagawa, Japan
Park, Sang-Suk, Seoul, Korea
Peeters, Irene F., Warmond, The Netherlands
Petrozello, Ryan J., Randolph, New Jersey, U.S.A.
Plain, Lyndsey, Barnsley, South Yorkshire
Singh, Gurmit, New Delhi, India
Tseng Chien Min, Taichung, Taiwan, R.O. China
Underwood, Thom, San Diego, California, U.S.A.
Wang Chun, Wuhan, Hubei, P.R. China
Zhang Guochen, Wuhan, Hubei, P.R. China

Gemmology Foundation Certificate
Qualified
Ahmed, Abdirashid F., Lannavaara, Sweden
Alliston, Erica, Hammersmith, London
Anderson, Tricia K.W., Montreal, Quebec, Canada
Appleyard, Catherine J., Lewes, East Sussex
Aung Htet Su, Yangon, Myanmar
Barqadle, Mahamed M., South Harrow, Middlesex
Blanksma, Eelco, Arnhem, The Netherlands
Callaway, Heather, Stone, Staffordshire
Cao Lu, Guilin, Guangxi, P.R. China
Chan Ye-Lay, Daniel, Kowloon, Hong Kong
Chen Manli, Zhongshan, Guangzhou, P.R. China
Chen Li Zhen, Zhongshan, Guangzhou, P.R. China
Cheung Yiu Hung, Kowloon, Hong Kong
Chien Kuo Shan, Taichung, Taiwan, R.O. China
Chiu Wai Yu, Yuki, Hong Kong
Chow Lai-Kwan, Kwinnie, Hong Kong
Clement, Jenny, London
Delpachitra, Malintha, Kandy, Sri Lanka
Fong Tik Kwan, Kowloon, Hong Kong
Fu Ming, Guilin, Guangxi, P.R. China
Gerber, Doris C., Zurich, Switzerland
Gu Jun, Singapore
Henning, Sarah A., Edgbaston, West Midlands
Ho Hay Mo, John, Yangon, Myanmar
Holdsworth, Isabel, Surbiton, Surrey
Hong Da Wun, Buk-Gu, Daegu, Korea
Hornsby, Rebecca A., Spalding, Lincolnshire
Hu Ruoxin, Guilin, Guangxi, P.R. China
Isse, Abdirisak H. Abdi, Lannavaara, Sweden
Jiang Huijing, Guilin, Guangxi, P.R. China
Johns, Catherine M., London
Ka Tsz Man, Kowloon, Hong Kong
Kahari, Risto, Helsinki, Finland
Kim You Mi, London
Kiviniemi, Sanna M., Ojakkala, Finland
Kueon, Seon-Il, Bupyong-ku, Inchon, South Korea
Kwok Chi Fu, Hong Kong
Lee, Sharon, Norwich, Norfolk
Lee, Phyllis E., Sacramento, California, U.S.A.
Lee Jeong Im, Seoul, South Korea
Lee Siu Ling, Kowloon, Hong Kong
Lek Chin Kwang Leon, Singapore
Leung Shuk Fun, Kowloon, Hong Kong
Li Mengjie, Guilin, Guangxi, P.R. China

Gem-A Awards

Li Yue, Shanghai, P.R. China
Liang Liming, Guilin, Guangxi, P.R. China
Liao Baoli, Guilin, Guangxi, P.R. China
Lin Shu-Zhen, Taipei, Taiwan, R.O. China
Lin Qingchun, Guilin, Guangxi, P.R. China
Liu Jing, Guilin, Guangxi, P.R. China
Luk Sau Wai, Kowloon, Hong Kong
Lwin Min, Yangon, Myanmar
Ma Mei Chuan, Kowloon, Hong Kong
Mak Tze Him, Gary, New Territories, Hong Kong
Pang Taotao, Guilin, Guangxi, P.R. China
Rosas, Jose L.M., Porto, Portugal
Rowley, Elaine, London
Ruan Yaohua, Guilin, Guangxi, P.R. China
Saw Kalaya Kyi, Yangon, Myanmar
Sien Pe (a) Yang Cheng Pei, Yangon, Myanmar
Singh, Amrinder P., Delhi, India
Song Dong, Shanghai, P.R. China
Southam, Karen L., Oldbury, West Midlands
Surawy, Laura K., Haywards Heath, West Sussex
Tang Wai-Leung, Kowloon, Hong Kong

Taylor, Richard E., Carlsbad, California, U.S.A.
Thet Phu Ngon, Yangon, Myanmar
Tsui, Cary, Melbourne, Victoria, Australia
Tun Tun U., Yangon, Myanmar
Van Spaendonk, Ann, Kalmthout, Belgium
Wong Ka Wai, Hong Kong
Wong Ching Man, Discovery Bay, Hong Kong
Wong Ka Yee, Clarie, Kowloon, Hong Kong
Wong Yuen Ching, Kowloon, Hong Kong
Wreford, David, London
Xie Shanshan, Guilin, Guangxi, P.R. China
Xu Xue Ying, Shanghai, P.R. China
Yang Xiao, Guilin, Guangxi, P.R. China
Yang Zhi, Guilin, Guangxi, P.R. China
Yee Yee Mon, Yangon, Myanmar
Zee Gar Bo, Kowloon, Hong Kong
Zhang Li, Shanghai, P.R. China
Zhao Zhan, Zhongshan, Guangzhou, P.R. China
Zhou Xihua, Shanghai, P.R. China
Zhu Jingjing, Shanghai, P.R. China

GEM DIAMOND EXAMINATION

Qualified with Distinction
Johnson, Adam J., Edgbaston, West Midlands
Johnson, Sally G., Welwyn Garden City, Hertfordshire
McMillan, Emma L., Solihull, West Midlands
Ng Wai Ling, Kowloon, Hong Kong
Ren Ming, Wuhan, Hubei, P.R. China
Watling, David, Sidcup, Kent

Qualified with Merit
Barnett, Catherine E., Balham, London
Cheng Suk Man, Hong Kong
Jackson, Antoinette, London
Lu Xi, Beijing, P.R. China
Ma Yuli, Wuhan, Hubei, P.R. China
Wong Ching Ping, Kowloon, Hong Kong
Xiong Jin, Wuhan, Hubei, P.R. China
Yeung Ka Yee, Anthea, Kowloon, Hong Kong
Yiu Ka Wah, Kowloon, Hong Kong
You Hongwen, Wuhan, Hubei, P.R. China

Qualified
Bennett, Martin C., Sherfield English, Hampshire
Berthault, Alexandra, London
Chan Kin Yuen, Wan Chai, Hong Kong
Chow Lai-Kwan, Kwinnie, Hong Kong
Filadelfeos, Eleni-Anna, Athens, Greece
Guzadhur, Carlos M.V., Dunstable, Bedfordshire
Ha Lai, Kowloon, Hong Kong

Heywood, Natalie L., Enfield, Middlesex
Hislop, Donna, London
Ho Lai Ho, Kowloon, Hong Kong
Ho Siu Ming, Hong Kong
Johnson, Lisa A., Kinver, Staffordshire
Kaffo, Moulero B., Hounslow, Middlesex
Kau Yuk Ming, Eddie, Hong Kong
Konstantopoulos, Konstantinos, Athens, Greece
Kwan Ka Lun, Karen, Hong Kong
Lam Wai Han, Kowloon, Hong Kong
Lee Sui Kam, Monita, New Territories, Hong Kong
Lee Wai-Kwok, Kowloon, Hong Kong
Lee Young Ji, Goyangshi, Kyunggido, South Korea
Lesetedi, Madichaba N., Billesley, West Midlands
Leung Sui Bong, Central, Hong Kong
Leung Yee Wai, Rosa, Kowloon, Hong Kong
Li Chi Wai, Kowloon, Hong Kong
Ng Yick Ling, Kowloon, Hong Kong
Paterson, Deborah L., Northampton
Prince, Ronald F., Richmond, London
Ren Lei, Beijing, P.R. China
Riley, Deborah M., Kowloon, Hong Kong
Shing Tsz Ki, Kowloon, Hong Kong
Szemencsuk, Galina, Goodmayes, Essex
Tuen Sai Hing, Hong Kong
Udeshi, Sheela, Stourbridge, West Midlands
Wat Wing Suet, Hong Kong
Yeung Ho Man, New Territories, Hong Kong

Dr Roger Harding and Vivian Watson were re-elected and Lawrence Hudson elected to the Council of Management.

Sally Everitt, Dr Jamie Nelson and Colin Winter were re-elected to the Members' Council. Hazlems Fenton were re-appointed auditors.

The AGM was followed by an illustrated talk by David Callaghan entitled 'Jewellery of the Art Nouveau period'.

Membership

Between 1 December 2003 and 31 March 2004 the Council of Management approved the election to membership of the following:

Fellowship (FGA)

Choudhary, Gagan, Jaipur, India, 2002
Gaynor, David, Tyne and Wear, 1987
Holt, Jason Bruno Acker, London, 2002
Lam Koon-Wah, Francis, Kowloon, Hong Kong. 2003
Phyu, Thin Khine, Yangon, Myanmar, 2003
Vyas, Meenu, Jaipur, India, 2003

Diamond Membership (DGA)

Chaudhary, Mazafar, Ali, Upton Park, London, 2002
Sheikh, Mohammed, 2003
Spear, Paul M., Maidenhead, Berkshire, 2003

Associate Membership

Ahmed, Mohammed Salikh, Bradford, West Yorkshire
Ayabe, Hiroko, Nishinomiya City, Hyogo Pref., Japan
Brard, Jagvindersingh, Hatch End, Middlesex
Broglie, Nicole, London
Campbell, William, Monmouth
Chung, Geum-Lyul, South Korea
Clark, Katherine, Piccadilly, London
Curtis-Taylor, Tracey, London
Dillingham, Annabella Louise, Watford, Hertfordshire
Fullagar, Suzannah, London
Furuya, Satoshi, Bunkyo-ku, Tokyo, Japan
Gettleson, Anita R., Scottsdale, Arizona, U.S.A.
Hayashi, Kinya, Tokushima City, Tokushima Pref., Japan

Hill, David John, Morriston, Swansea, West Glamorgan
Jaipuria, Anuja, Stevenage, Hertfordshire
Johnson, David, Mitcham, Surrey
Kamo, Kenichi, Hirohata-ku, Himeji City, Japan
Kishimoto, Yoshiko, Nishinomiya City, Hyogo Pref., Japan
Lambert, Joyce, Wisbech, Cambridgeshire
Larsson, Jacqueline, London
Lu, Shan, Kofu City, Yamanashi Pref., Japan
Mera, Kanako, Toyonaka City, Osaka, Japan
Moreaux, Claudette, Court St Etienne, Belgium
Mori, Miyako, Yokohama City, Kanagawa Pref., Japan
Muratsu, Takamichi, Neyagawa City, Osaka, Japan
Natsuka, Masaki, Toyonaka City, Osaka, Japan
Newman, Ralph M., Tregaron, Dyfed
Ogata, Etsuko, Suita City, Osaka, Japan
Rae, Gillian, E., Reigate, Surrey
Ramerison, Tokinomena A., London
Rivers, Michael, London
Rolls, Shirley Ann, London
Rouse Huth, Dee, Carmichael, California, U.S.A.
Sakata, Yuko, Kanazawa City, Ishikawa Pref., Japan
Sàlerno, Pierre Stephane Landry, Luynes, France
Schwarzenberg, Al, River Ridge, Louisiana, U.S.A.
Segi, Naoko, Nagoya City, Aichi Pref., Japan
Shiralkar, Vinod, Wallasey, Merseyside
Singh, Gurmit, New Delhi, India
Skaraas, Sonia C., London
Tabar, Mahyar A., London
Takahata, Yoshichika, Takamatsu City, Japan
Tsutsui, Kazumi, London
Wessels, Jurie H.W., Roosendaal, The Netherlands
Whistance, Mary Margaret Nancy Tolladay, Exeter, Devon
Wiltshire, William E., London

Obituary

Kenneth W. Findlay FGA (D.1974), Randburg, South Africa, died on 19 January 2004.

Gem-A Website

For up-to-the-minute information on Gem-A events visit our website on www.gem-a.info

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Manchester 1st Floor, Paragon House, Seymour Grove, M16 0LN
Tel 0161 877 5271 Fax 0161 877 5288
Plymouth Hare Park House, Yelverton Business Park, Yelverton PL20 7LS
Tel 01822 855555 Fax 01822 855566
Sevenoaks Sackville House, 55 Buckhurst Avenue, Kent TN13 1LZ
Tel 01732 462886 Fax 01732 462911

MEMBER

General Insurance
STANDARDS COUNCIL

Forthcoming Events

30 April   **Midlands Branch:** Branch AGM followed by Bond Street jewellers of the 19th and 20th centuries. *Terry Davidson*

Scottish Branch Conference
30 April to 3 May – Lovat Hotel, Perth
Speakers:
John I.Koivula – Keynote speaker
Peter Buckie, Alan Hodgkinson, Elisabeth Strack,
Colin Towler and Chris Walton

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19 May   **North West Branch:** Diamonds. *Mark C. Barrows*

19 May   **North East Branch:** Organics, gems from life. *Maggie Campbell Pederson*

South East Branch Conference
28 to 31 May – Idar-Oberstein, Germany
Speakers:
David Lancaster, Bernd Munsteiner, Gerhard Becker
and Julius Petsch

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16 June   **North West Branch:** Some gemmological and lapidary diversions. *Doug Morgan*

26 June   **Midlands Branch:** Summer Supper Party.

26 July   **North East Branch:** Putting the 'Gee' back into gemmology. *Alan Hodgkinson*

14 September   **London:** Annual General Meeting.

15 September   **North West Branch:** Emeralds. *Alan Hodgkinson*

20 October   **North West Branch:** The trade industry today. *Marcus McCallum*

31 October   **Gem-A Annual Conference:** Kempton Park Racecourse

16 - 30 Nov   **Thailand Gem Jamboree:** Visit to Thailand. Further details from Doug Garrod on 020 7404 3334

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contact details

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North West Branch: Deanna Brady 0151 648 4266

Scottish Branch: Catriona McInnes on 0131 667 2199; e-mail scotgem@blueyonder.co.uk

South East Branch: Colin Winter on 01372 360290; e-mail info@ga-seb.org

South West Branch: Richard Slater on 01635 553572; e-mail rslater@dreweatt-neate.co.uk

Gem-A Website
For up-to-the-minute information on Gem-A events visit our website on **www.gem-a.info**

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 25 mm. 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.

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

B ### *This is a second level heading*

First and second level headings are in bold and are ranged left on a separate line.

Third level headings are in italics and are indented within the first line of text.

Illustrations High resolution digital files, for both colour and black-and-white images, at 300 dpi TIFF or JPEG, and at an optimum size, can be submitted on CD or by email. Vector files (EPS) should, if possible, include fonts. Match proofs are essential when submitting digital files as they represent the colour balance approved by the author(s).

Transparencies, photographs and high quality printouts can also be submitted. 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. Collins, 2001, 341). 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 Collins 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 Collins, A.T., 2001. The colour of diamond and how it may be changed. *J.Gemm.*, **27**(6), 341-59

Books Balfour, I., 2000. *Famous diamonds*. 4th edn. Christie's, London. p. 200

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.

Contents

Cover Picture: Faceted colourless oligoclase feldspar with red inclusions of hematite. (See Aventurescent oligoclase feldspar from Oregon, USA, pp 72-74.)