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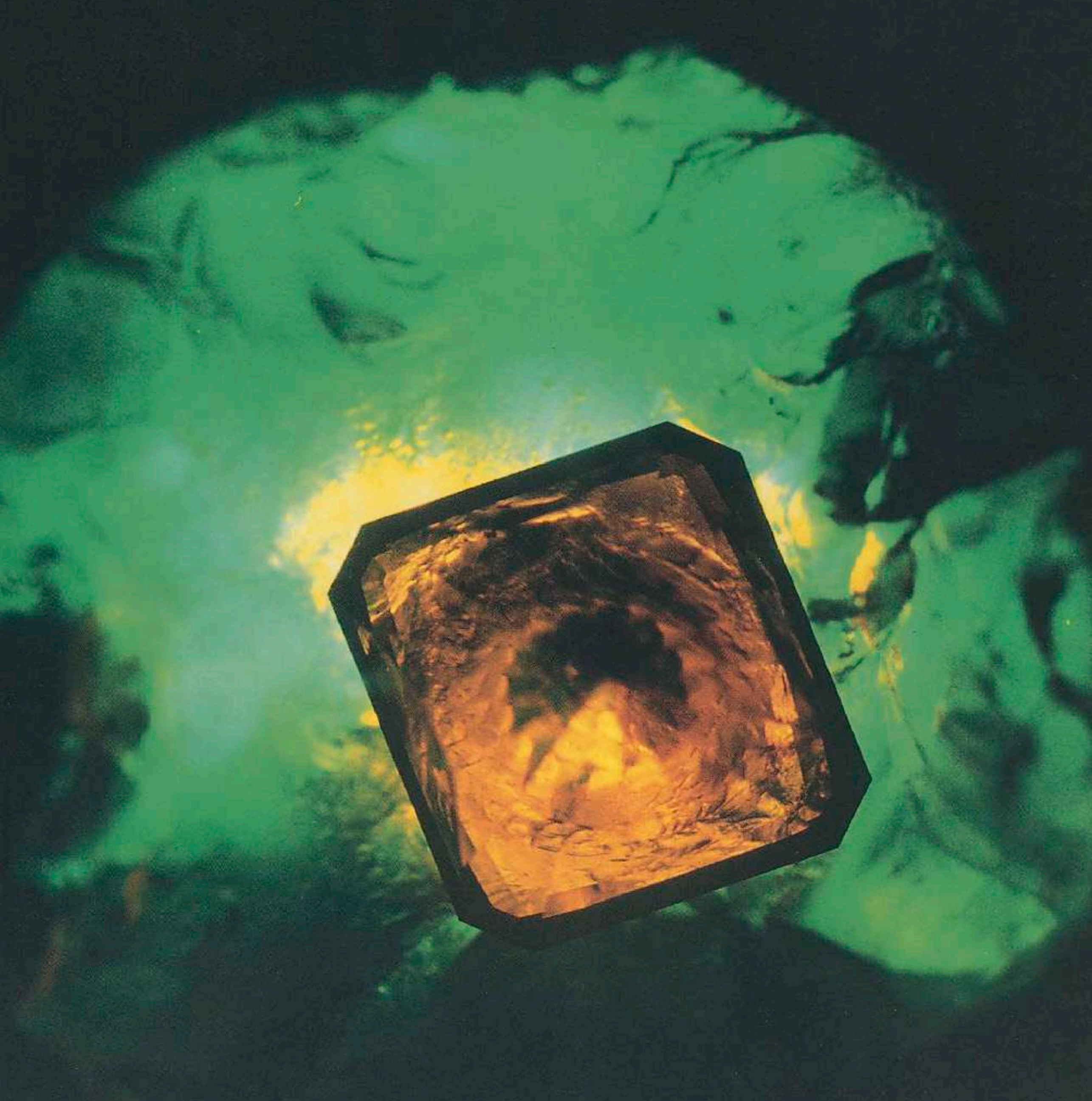

The Gemmological Association and Gem Testing Laboratory of Great Britain

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The Journal of Gemmology

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A new colour-change effect

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ABSTRACT: Crystals of green chrome tourmaline from the Umba Valley (Tanzania) may show a wine-red colour when viewed in certain directions. This is neither pleochroism, nor a colour-change of alexandrite type. The change from green to red depends primarily on the path length of light through the stone and probably also on the content of Cr and V; in the samples tested the stones appear red when more than 15 mm thick. It is suggested that this new type of colour change be called the 'Usambara effect'.

Introduction

We have examined many pieces of green chromiferous tourmaline from the Daluni area in the Umba Valley of north-eastern Tanzania. Several showed a startling green to orange or red colour variation. Bank and Henn (1988) described green tourmaline from Tanzania that exhibited a green/red alexandrite effect and we thought at first that this was the same type of material. However, our studies indicate that since the red colour can be seen in any sufficiently thick portion of a crystal, irrespective of optical direction and only mildly modified by type of illumination, the colour change involves other factors.

The best demonstration of the effect is provided by two pieces which are both strong blue-green when examined separately, but which become red when superimposed, one upon the other, with no change in orientation or in the conditions of illumination.

Locality

The Umba Valley is one of the richest gemstone areas in East Africa producing ruby, sapphire, spinel, garnets, tourmaline, chrome diopside, zircon, scapolite, kornerupine and other gems. Some of these can have rare and unique colours which are not found elsewhere.

The rocks of the area are of medium to high metamorphic grade and belong to the Eastern Granulite Complex of the Precambrian Usagaran system. According to Dirlam *et al.* (1992), the metamorphic processes which have affected the granulites have caused a remobilization of chromophore elements such as chromium and vanadium, which have concentrated in several of the Umba gemstones and resulted in their unusual colours and optical phenomena. Colour-change tourmalines, sapphires and garnets with effects comparable to those seen in alexandrite have been described from this area (Bank and Henn, 1988; Dirlam *et al.*, 1992).

Figure 1 is a general view of the chrome-tourmaline locality from which the material was collected, with the Usambara mountains in the background.

Gemmology

Assuming a common thickness, different shades of green may indicate some chemical variation in the material available, so we examined several pieces in detail, mainly crystals and rough fragments but including some cut stones.

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Figure 1: *General view of the area, with the Usambara mountains in the background. The tourmaline locality is in the foreground of the picture.*

The following gemmological descriptions are based on two crystal fragments (T1 and T2), four pieces of rough (T3–6) and one faceted stone (T7). The weights are respectively T1 (7.735 g), T2 (4.721 g), T3 (1.788 g), T4 (2.161 g), T5 (4.026 g), T6 (5.840 g), T7 (0.719 g).

Specific gravity

The average specific gravity of the seven specimens, determined by hydrostatic weighing, is 3.06.

Crystal habit

Like other chromiferous tourmalines previously reported from this area, the crystals show pyramidal habits (Dirlam *et al.*, 1992). One good crystal (T1) is a fine bluish-green, about 1 cm thick and 2.5 cm in diameter, and carries three large pyramid faces, a small pedion and a fringe of thin prism faces *(Figure 2)*. The back of the crystal is a large irregular fracture surface.

Refractive index

The refractive indices determined on a crystal face of T2 and on a polished surface of T7 were consistent and are ω 1.644 and ε 1.622, with birefringence of 0.022. Uniaxial interference figures were observed in the samples under a polariscope.

Chemistry

Using the general formula for tourmaline of $XY_3Z_6B_3Si_6O_{27}(O,OH)_3(OH,F)$ various end members have previously been defined as follows:

	X	Y	Z	
Dravite	Na	Mg_3	Al_6	B_3......
Liddicoatite	Ca	$(Li,Al)_3$	Al_6	B_3......
Uvite	Ca	Mg_3	Al_5Mg	B_3......

Table I gives the result of microprobe analyses of two samples of our material (T3 and T4) together with analyses from the work of Bank and Henn (1988) on the chromiferous tourmalines from Tanzania which show an alexandrite colour-change effect. Our analytical results are very similar to those of Bank and Henn.

A qualitative X-ray fluorescence spectrum from a sample supplied to S. Bergstøl at Norges Tekniske Høgskole indicates that vanadium content is significant, but only about a quarter of the chromium content, *i.e.*

Figure 2: *A drawing of a tourmaline crystal showing pyramidal habit. In order of degree of development – trigonal pyramid, pedion, hexagonal prism and trigonal prism.*

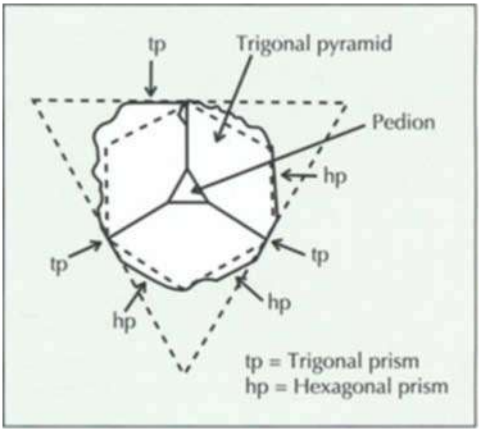

Table I: *Chemical analyses of East African tourmalines*

	1#	*2#*	*3**	*4**
SiO_2	37.84	37.51	35.29	34.87
TiO_2	.43	.36	.18	.48
Al_2O_3	32.49	32.71	33.57	31.73
MgO	11.30	10.58	11.13	11.40
CaO	1.87	1.89	1.95	2.63
Cr_2O_3	.34	.22	.36	.64
V_2O_3	(.05)	(.05)	.04	.06
Na_2O	1.76	1.66	1.53	1.39
FeO	.06	–	–	–
Total	86.14	84.98	84.05	83.20
Number of ions on the basis of 6 Si				
Si	6	6		
Ti	0.051	0.044		
Al	6.065	6.159		
Mg	2.666	2.52		
Ca	.317	.324		
Cr	.042	.029		
Na	.540	.515		
Fe	.008	–		

The analyses were performed by wavelength dispersive spectrometry using a CAMECA electron microprobe at the Mineralogical-Geological Museum in Oslo. Oxides, natural minerals and synthetics were used as standards. Each analysis represents the average of at least six single point analyses. Analytical precision (2sigma) is better than ±1% at concentrations >20wt.% oxide, ±2% in the range 10–20wt.%, ±5% in the range 2–10% and better than 10% in the range 0.5–2wt.%.

* Analysis of colour-change tourmaline from Bank and Henn (1988).

of the order of 0.08–0.05% V_2O_3. In most green tourmalines from Kenya and Tanzania vanadium is in excess of chromium (Schmetzer and Bank, 1979). This spectrum also indicates traces (10–100 ppm) of Zr, Sr and Zn.

Our analyses lack both boron and water, but since there is commonly little or no substitution of Al in the Si site of tourmaline, we are able to calculate a partial formula assuming six silicon atoms to be present. This gives reasonable stoichiometry in the X, Y and Z positions, always remembering that vanadium and possibly a number of other trace elements have not been allowed for in the calculations, and that there may also be vacancies in the X positions (Dietrich, 1985).

According to Bank and Henn (1988) their tourmaline lies about half-way in the isomorphous series dravite-uvite which involves a coupled substitution between the X and Z sites (Na, Al – Ca, Mg). In the present analyses the sodium/calcium ratios support the assumption of a significant uvite component, but the aluminium/magnesium concentrations are not consistent with a compensatory substitution of Mg for Al in the Z position. How then is the charge increase on the X position accommodated? Minor amounts of Li have been found in the Y position of some dravites and might be present here (partial solid solution with liddicoatite). Other types of charge balance, such as adjustment of the O^{2-}/OH^- ratio or the creation of vacancies in the X position are not uncommon in tourmalines (Foit and Rosenberg, 1977) and may be operative here. We would therefore prefer to consider this Umba valley tourmaline as a calcium-bearing dravite until we understand the exact nature of the substitutions.

Fluorescence

Under short-wave (254 nm) ultraviolet illumination all the specimens are mustard yellow. The same reaction was reported by Dunn for 'low-iron chrome-rich tourmaline' from an unknown locality (Dietrich, 1985).

Colour and colour variations

Colour

Viewed in transmitted light (using a Flexilux 30HL 'cold light' with fibre optics) the general colour observed is green in a variety of shades from golden green, via olive green to bluish-green. To some extent, these colour variations may be caused by an orientation effect as all the stones showed some change of colour when rotated over the light source and these were consistent with the well-known dichroism of green tourmaline where the darker colour is seen parallel to the *c*-axis. However, two of the stones (T1 and T5) showed bluish-green in some directions and wine-red in others. A green to orange colour change was seen in several other stones. It was noted that the stones only showed an orange or red colour when viewed through the thickest part of the crystal.

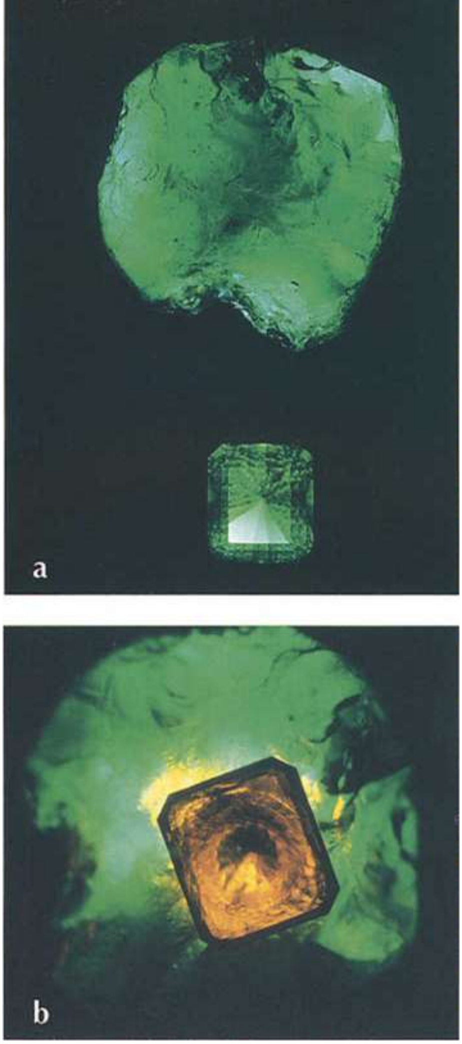

Figure 3: *(a) A crystal fragment (T1) and a cut stone (T7) both viewed looking down the c-axis. (b) The same two stones, superimposed without change in orientation, show a colour change to orange/red.*

Pleochroism

Because of the crystal habit, the red colour was at first seen only at right angles to the *c*-axis. It was therefore a natural next step to test the theory that this was a green/red dichroism. Under the dichroscope, using the same 'cold light' illumination, the large crystal (T1), was found to be pleochroic in two shades of red when viewed at right angles to the *c*-axis, but green when viewed in the direction of the *c*-axis *(Figure 3a)*. This evidence made the mineral trichroic, a feature only found in biaxial crystals. Whilst biaxial tourmalines are known (Dietrich, 1985), T1 gives a quite clear uniaxial interference figure and hence the colour variation is not due to pleochroism.

We then aligned and superimposed T1 and T7 that was also green when viewed along the *c*-axis. Looking along the c direction after superimposition *(Figure 3b)* there was a dramatic colour change which was further evidence against pleochroism and indicates that the decisive factor is path length within the crystal, irrespective of direction.

Influence of source of illumination

When a crystal is thick enough to show red, this colour is seen under both incandescent illumination and sunlight. The red colour is, however, absent under fluorescent lighting. The deepest wine-red is seen under strong illumination rich in the red end of the spectrum. It is best in torch light, being more orange-red than under 'cold light' fibre-optic illumination. One must therefore say that the effect is modified by the type of illumination, but not controlled by it.

Influence of pathlength

In a wedge-shaped sample the colour at the thin end is green; it passes to orange and then to red at the thicker end, but the transition is fairly abrupt. The red colour commonly appears when a bluish-green stone reaches a thickness of about 15–20 mm. However, red flashes are not uncommon in stones which are appreciably thinner than this. Presumably this is due to internal reflection, giving increased effective pathlength of light in the stone. Lighter-coloured stones may show no colour change even in thicknesses of 25 mm.

Cut stones are generally not thick enough to show red in transmitted light. A well proportioned stone of moderate size can, however, under strong illumination (incandescent or sunlight), show very strong red flashes, resulting in marked enhancement of an otherwise rather too dark green stone. The minimum size of cut stone in which red flashes have been observed is 3–4 mm in diameter.

The change from green to red does not occur at exactly the same thickness for all the

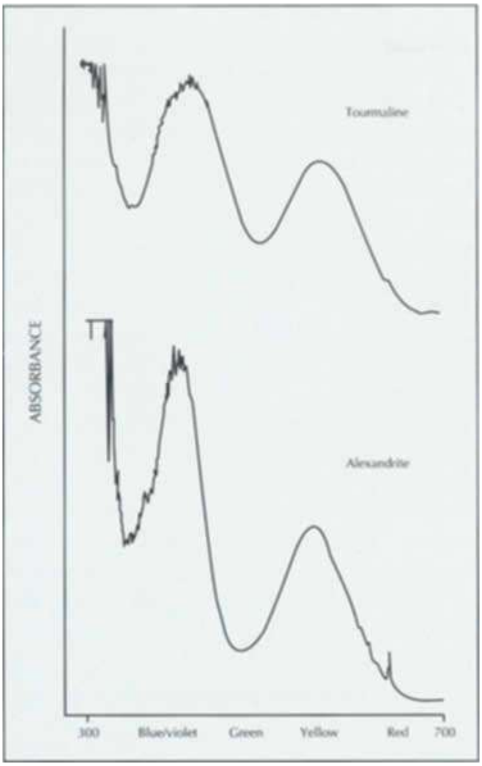

Figure 4: *Spectra over the range 300–700 nm, from Umba Valley tourmaline T3 and from alexandrite. Both have transmission windows in red and green. The spectrophotometer used was a Pye-Unicam PU8800/03 with a UV-visible range.*

examined crystals and, in addition to the pathlength, small chemical variations may have some influence on the absorption and thus on the triggering of this optical effect. The general impression is that the change occurs at shorter pathlengths in dark bluish-green crystals than it does in paler stones.

Spectra

Spectroscope

When the visual impression is green, the stones show a typical chrome spectrum under the optical spectroscope, with heavy absorption in the yellow and blue/violet, transmission 'windows' in red and green and fine absorption lines in the red. When the visual impression is red the spectrum is unaltered except for a marked narrowing and weakening of the transmission in the green 'window'. This spectrum is clearly of the same general pattern as that which gives rise to the alexandrite effect.

In addition, all stones are strongly red under the Chelsea filter, but show no sign of red fluorescence under crossed filters.

Spectrophotometer

Figure 4 shows absorption spectra over the range 300 to 700 nm, made with a UV-VIS spectrophotometer on a small sample of tourmaline T3 and on a piece of alexandrite showing marked colour change. (The spectrometer beam intensity was unfortunately not strong enough to penetrate a thick tourmaline fragment in the direction showing red.)

The two spectra are broadly similar, showing absorption peaks in both traces at blue/violet and yellow, and transmission in green and red. However, there are differences: the transmission valley in the green region is almost as deep as the red valley in the alexandrite, but not in the tourmaline, the blue-violet peak in tourmaline is broader than that in alexandrite, and the absorption peaks in the red are stronger in alexandrite. (Clearly the differences should be confirmed and quantified with specially prepared samples.)

Conclusion

What is the explanation of this effect which, to the best of our knowledge, has not been observed previously in minerals?

Perception of colour in an object depends mainly on the nature of the illumination and the transmission properties of the material, but the response of the eye and brain to light stimulation are an important third factor. Poole (1964) in a study of colour change in chromium compounds spoke of the latter as the *psycho-physical effect.*

The human eye and brain, when presented with two very different transmission bands (colours), may ignore the weaker component. This can result in unexpected colour differences. For example, many chromium-bearing minerals transmit both red and green wavelengths, but to varying degrees. It is then the mineral structure that determines which band is the stronger and thus determines the colour that we register (*e.g.* red in ruby and green in emerald).

In alexandrite the balance is so close that fairly minor differences in the nature of the illumination affect the relative intensity of the two transmitted bands sufficiently to trigger a dramatic change in our colour perception, which alters from green to red when the stone passes from daylight to incandescent light.

In tourmaline T3 the same two wavelength bands are transmitted, but the stone is most transparent to red light. The slight absorption of green is of no significance for thin stones, where the special sensitivity of the human eye to green light ensures that the sensation of green still predominates, but the intensity balance of the two transmitted bands changes significantly with thickness and this tips the colour perception to red once the light has travelled a given distance within the crystal. This change will, of course, only be triggered if the illumination has an adequate red component. A slow change in transmission properties is thus transformed by the eye and brain into a fairly abrupt and startling colour change. It should be possible, with detailed study, to quantify this effect in terms of differences in absorption factors for different wavelengths.

Both rays (ordinary and extraordinary) must be very similarly absorbed, since the colour-change occurs in all directions at about the same thickness and none of our samples showed green/red dichroism under the dichroscope. (However, we have seen one cut stone with an internal reflection from one of the facets where the ω- and ε-rays gave two partly separated images, one of which was red and the other orange.)

If the term 'alexandrite effect' is to be reserved for colour change produced solely by a change of illumination, then we need another name for this additional effect. Webster (1994) in discussing chromium as a source of colour, noted the existence of a colour change in solutions of chrome alum similar to the one we have observed in the chromiferous tourmalines and said, 'Strong solutions of the salt, seen in depth, appear purplish-red while more dilute solutions or thinner samples appear green'. He calls the effect 'dichromatism'. This word, by dictionary or lexicon definition, simply means 'two colours' and has been used in mineralogy in other contexts. For example, Balitsky and Balitskaya (1986) speak of the colour zonation seen in quartz crystals that are part amethyst and part citrine as 'dichromatism in quartz'. For this reason, and because the word dichromatism is uncomfortably close to dichroism, we suggest that another name is necessary. These stones are closely associated with the verdant Usambara region of Tanzania. We make the suggestion, therefore, that it should be given a locality name and called the 'Usambara effect'.

Acknowledgements

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Optical and X-ray topographic study of Verneuil-grown spinels

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ABSTRACT: A boule of synthetic colourless spinel, $1MgO\cdot3.6Al_2O_3$, produced by the Verneuil fusion method has been investigated by optical microscopy and by X-ray transmission topography, Lang method. The X-ray topography shows that the sample is not monocrystalline but that it consists of domains, crystallographically disoriented with respect to each other. At the bottom of the boule there are large homogeneous areas, which pass upwards into large domains, each with the same crystallographic behaviour; towards the top of the boule the domains become very small. The relationships between the quality of the crystal and temperature variations are considered.

Keywords: spinel, crystal defects, X-ray topography, Verneuil method of growth

Introduction

It is known that the Verneuil process is successfully used by the industry to grow oxides with high melting point because it is a very simple, low-cost method which produces pure 'crystals' in open space and does not require crucibles. Nevertheless, the crystal quality of the produced materials is generally poor owing to the thermal stresses undergone by the sample during the growth process, when the first crystallized parts (on top of the rotating rod in the furnace) are moved downward and away from the hotter zone of the flame. Moreover, the sample may suffer further thermal shocks when it is cooled down[1-3]. In order to minimize the crystal damage (defects, polycrystallinity, anomalous birefringence, *etc.*) generated by the thermal gradients, which may even produce cracking of the sample, a variation of the Verneuil technique has been proposed, which allows the growth of larger crystals of better quality[1-2].

Furthermore, the growth of spinel by the Verneuil method produces synthetic spinels with a chemical composition different from the theoretical AB_2O_4, where A is a divalent (Mg^{2+}, Fe^{2+} ...) and B a trivalent (Al^{3+}, Fe^{3+}, Cr^{3+} ...) ion. In fact, synthetic magnesian spinel is normally grown from MgO and Al_2O_3 oxides, whose mutual solubilities depend on the growth temperature. This means that the synthetic crystals are richer in the more soluble oxide Al_2O_3. In consequence Al^{3+} ions also are located in positions normally ascribed to Mg^{2+} ions, and structural gaps (□) are generated following the scheme:

$$3Mg^{2+} \rightarrow 2Al^{3+} + \square$$

An increase of Al^{3+} in the chemical composition of the crystals generally reduces the cell parameters[4].

Thus, the Verneuil-grown spinels may be rich in structural defects, which can be observed under the optical microscope – with crossed nicols – as the so-called *tabby extinction*[5].

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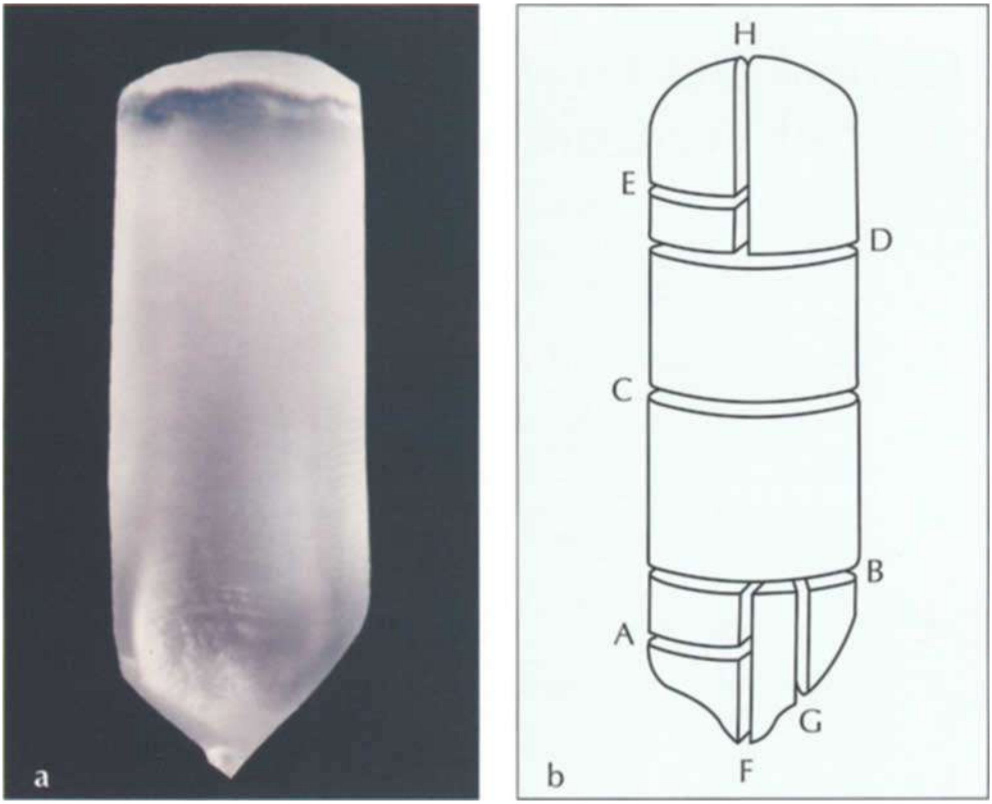


Figure 1: *(a) Boule of synthetic colourless spinel used in the present study. (b) Slices obtained from the boule and their positions. A, B, C, D and E are cut normal, and F, G and H parallel to the elongation axis.*

In order to analyse and correlate the optical and structural aspects of this phenomenon, a boule of colourless spinel *(Figures 1a and 1b)* with the composition of $1MgO\bullet3.6Al_2O_3$, produced by the Verneuil method, has been investigated by optical microscopy and by X-ray transmission topography using the Lang method. This latter technique enables one to detect and locate the crystal defects[6-7].

Preparation of samples

The colourless spinel sample (*Figure 1a)* has been cut normal (*Figure 1b:* slices A, B, C, D, E) or parallel (*Figure 1b:* slices F, G, H) to the elongation axis of the boule. The thickness of the slices was ~1 mm.

The crystallographic plane parallel to each slice has been determined by using the X-ray powder method applied to a slice. Obviously, only if the slice is parallel or nearly parallel to a crystallographic plane will the Bragg condition giving a diffraction peak be satisfied. In our case, the slices A, B, C, D and E *(Figure 1b)* normal to the elongation axis are oriented almost parallel to (001), and the slices F, G and H nearly parallel to (110).

Subsequently, all the slices have been studied using a polarizing optical microscope and X-ray transmission topography using $MoK\alpha_1$ radiation.

Observations under the optical microscope

Spinel, $MgO\bullet Al_2O_3$, crystallizes in the cubic system (space group Fd3m) and optically it is expected to be isotropic. Nevertheless, the

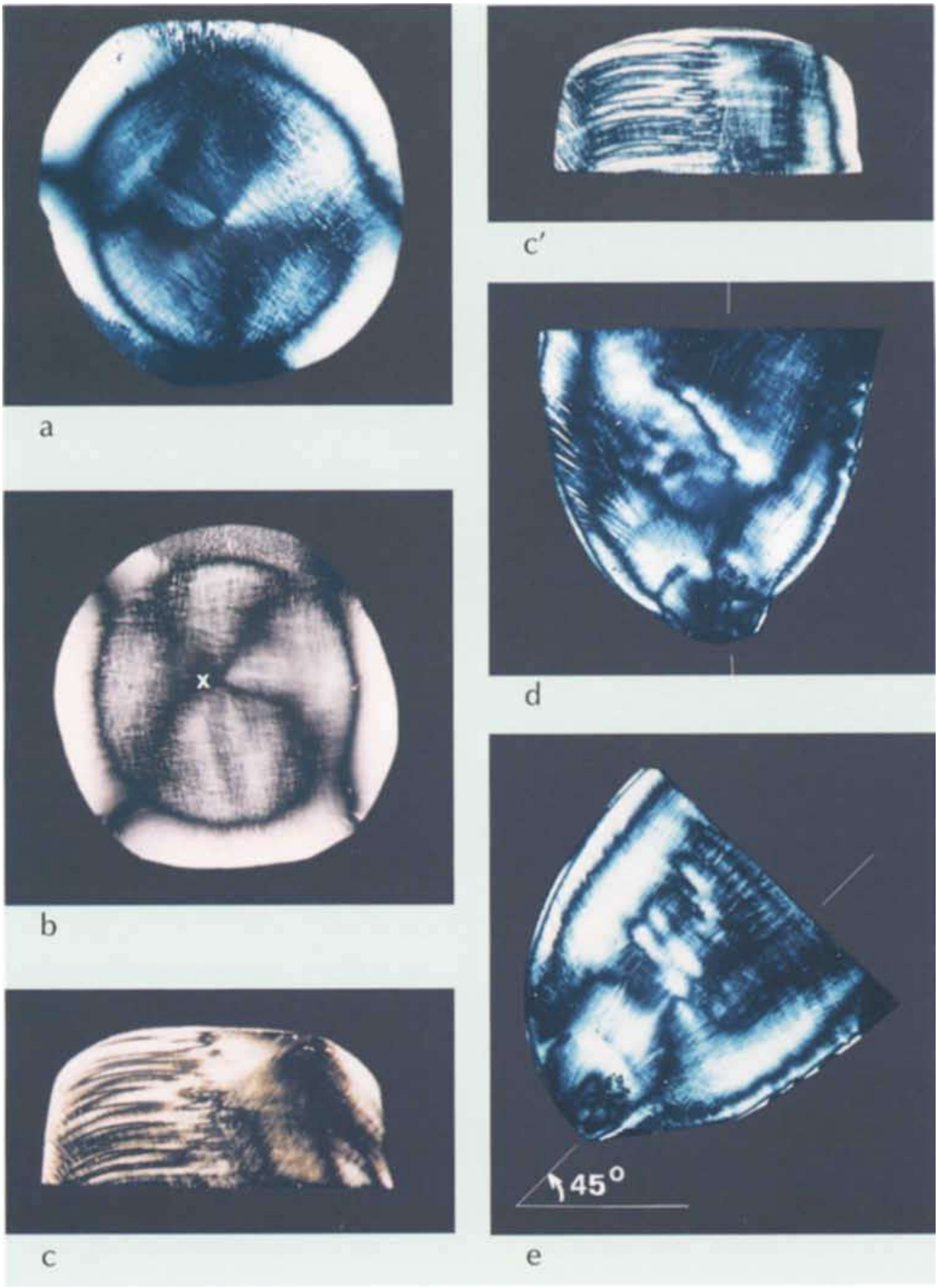


__Figure 2:__ (a) Slice B of Figure 1b, crossed nicols (2x). (b) Same as (a), but rotated through 45°. (c) Slice H of Figure 1b, crossed nicols (2x). (c′) Slice H (crossed nicols) after additional thinning (from 1.4 to 0.7 mm). The anomalous birefringence is still present. (d and e) Slice F of Figure 1b: crossed nicols, (e) has been rotated through 45° Magnification 2x.

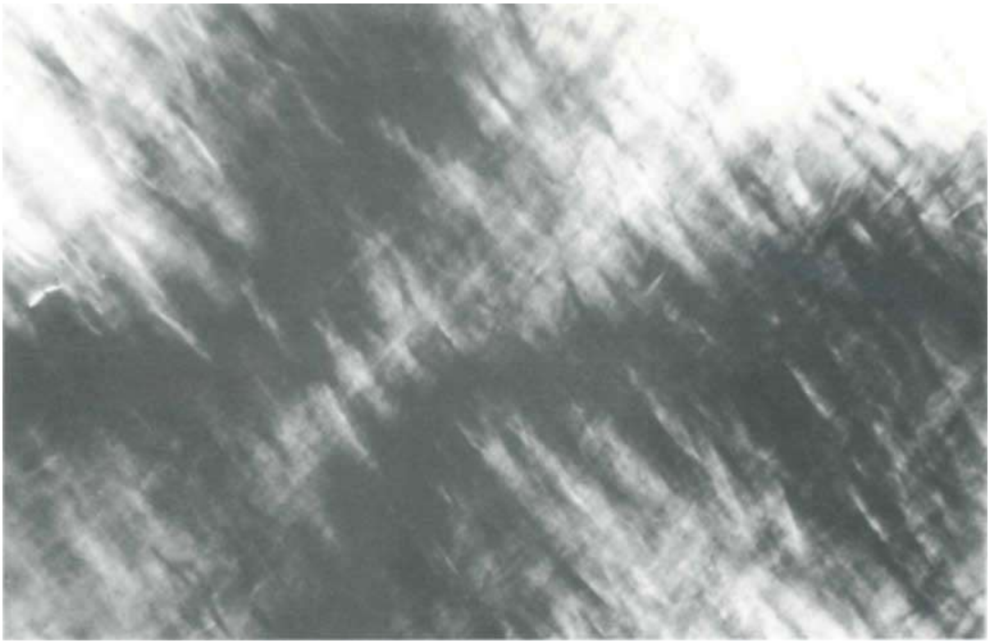


Figure 3: *Region marked by x on Figure 2b seen with the polarizing microscope, at a higher magnification (40x).*

Verneuil-grown spinels display structural defects, *i.e.* lattice distortions, responsible for an optical symmetry lower than the theoretical crystallographic one, resulting in an anomalous birefringence.

Figures 2a, b, c, d and e show the slices B, F and H of *Figure 1b* seen under crossed nicols. Note that *Figures 2a and b* refer to the same slice, B, observed in two positions making an angle of 45°, and showing a different distribution of brighter and darker zones. The same holds for *Figures 2d and e*, which refer to slice F. The sample is, as a whole, birefringent, but displays a configuration of zones with a more homogeneous behaviour, as can be seen in *Figures 2a and b*. The external part of the slice consists of two circular outer zones, *i.e.* an isotropic circular zone (black) and around it an external circular zone nearly completely light transmitting. The interior part of the slice shows four black distorted arms, intercalated with four brighter areas. Nevertheless, at higher magnification *(Figure 3)* the 'isotropic' zone marked by *x* in *Figure 2b* shows additional bright and dark areas. *Figures 2a, c and d* refer to slices cut from different parts of the boule and to sections cut with different orientation (*Figure 1b:* slices B, H and F respectively), that can be recognized by gemmologists when investigating cut synthetic spinels displaying similar images under crossed nicols.

Slice H has been reduced in thickness from 1.4 mm to 0.7 mm to obtain more insight into whether a thinning may lead to the expulsion of some internal stresses and make the slice optically more homogeneous. *Figure 2c'* shows that the optical behaviour (crossed nicols) is unchanged and we may therefore conclude that the internal stresses stored in the crystal during the growth process are not dispersed during the thinning operations.

X-ray topography

It is well known that a crystal lattice is seldom perfect; in fact any crystal is rich in defects such as dislocations and growth

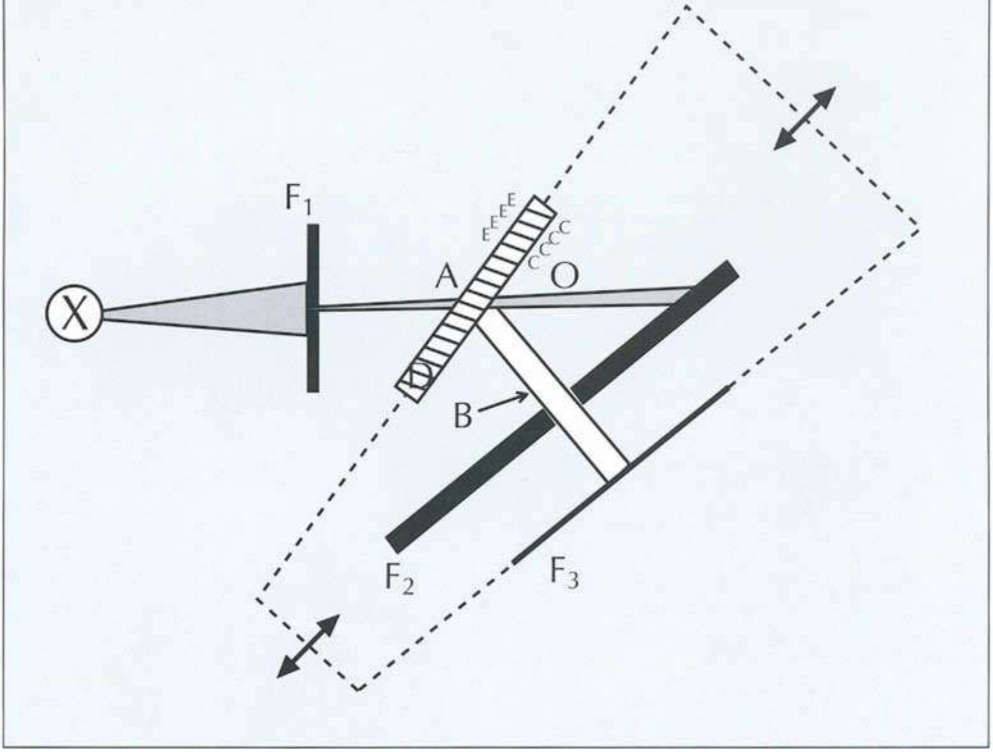


Figure 4: *Diagram of the topographic method after Lang. F_1 and F_2: slits; F_3: photographic plate; D: spinel slice; EC: diffracting planes; X: X-ray source; AB diffracted beam; AO direct beam; the double arrow indicates the movement back and forth of the crystal and the film in the X-ray beam.*

bands. X-ray transmission topography by the Lang method is an experimental technique which establishes the existence and positions of these types of defects[6–7]. The crystal sample (D in *Figure 4*) is oriented by the operator in front of a monochromatic X-ray beam, finely collimated by a slit (F_1) in such a way that a family of reticular crystal planes *hkl* (EC) with high diffraction intensity satisfies Bragg conditions[8]. In the crystal specimen, the beam generates wave fields, the direction of propagation is AB (diffracted beam) and AO (direct beam). The direct beam is absorbed by a lead plate (F_2) and the intensity of the diffracted beam is recorded on a photographic plate (F_3) placed behind the crystal. In a definite position of the sample with respect to the X-ray beam (*i.e.* where a family of reticular crystal planes *hkl* are in the Bragg position) only the perfect parts of the sample will satisfy the Bragg conditions; whereas the zones perturbed by lattice misorientations or by local imperfections, *e.g.* dislocations, change the intensity of the diffracted beam, then generate different contrasts on the photographic plate. The first type of contrast is called *orientation contrast*, the second one *extinction contrast*. Crystal and film, linked together, move slowly back and forth in front of the X-ray beam, maintaining always the Bragg orientation. Thus, the perfect parts and the defects of the sample are projected with different intensities on the photographic plate.

In the topographic study of our boule, the slices A, B, C, D and E are parallel to (001) planes and the relative topographs are made using 400 as diffracting planes; likewise F, G and H slices are studied using ($2\bar{2}0$) topographs. 400 and $2\bar{2}0$ planes are chosen because they are reticular planes with high intensity of diffraction. *Figures 5a, b, c, d and e* show 400 topographs of, respectively, A, B, C, D and E slices normal to the elongation axis of the boule (*Figure 1b*) and *Figures 5f, g and h* show $2\bar{2}0$ topographs of respectively F, G and H slices, parallel to the elongation axis.

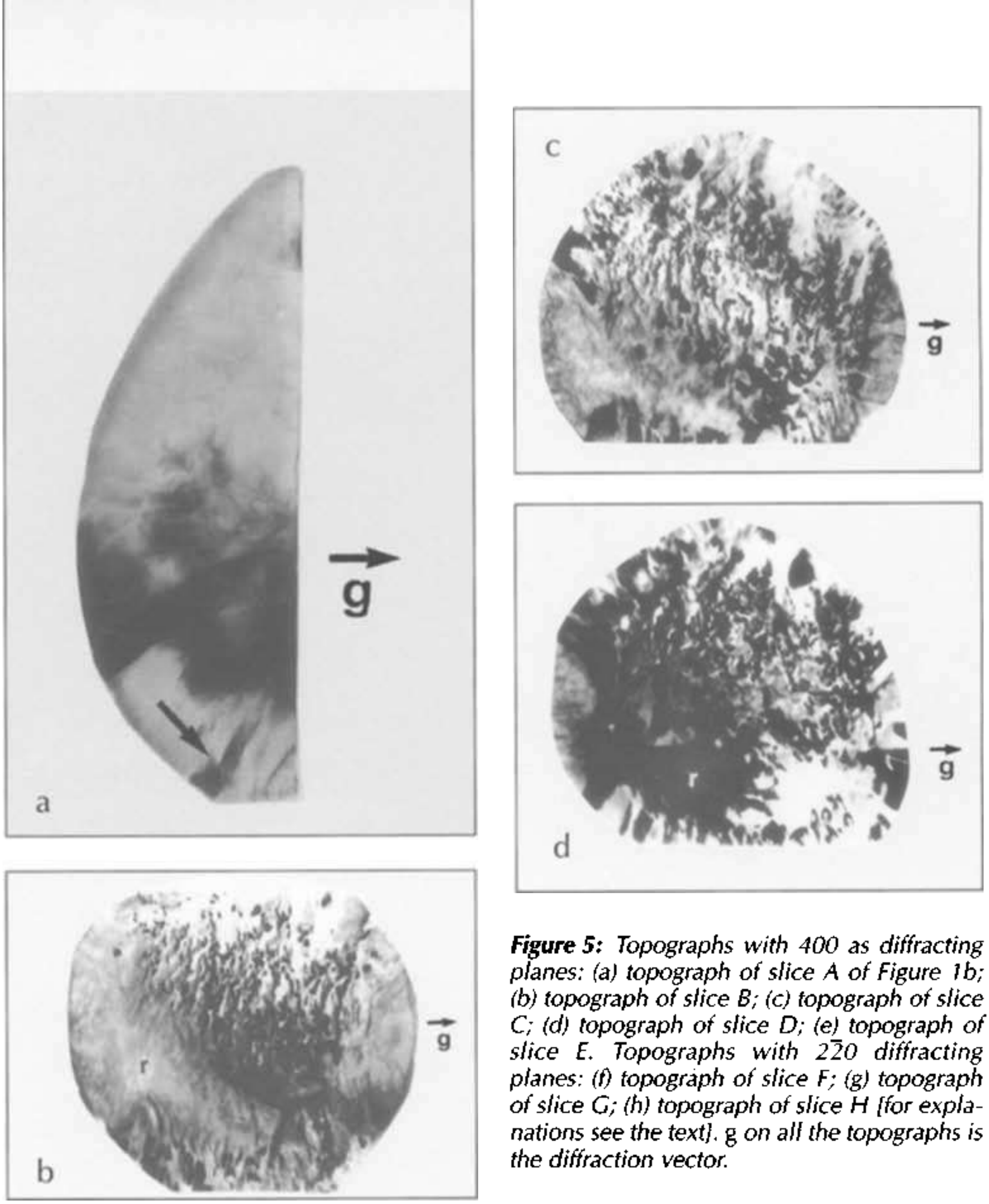
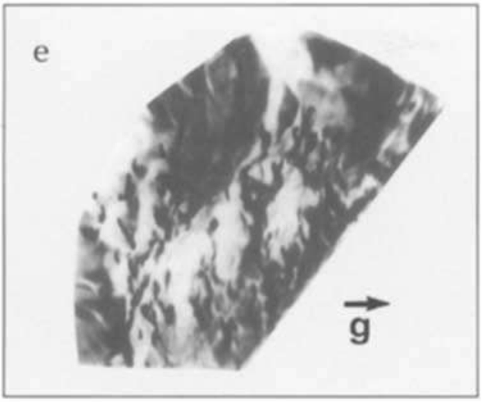
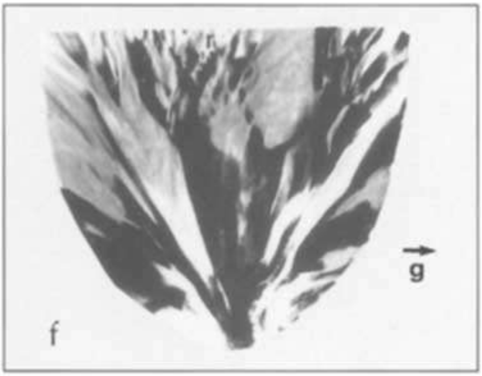


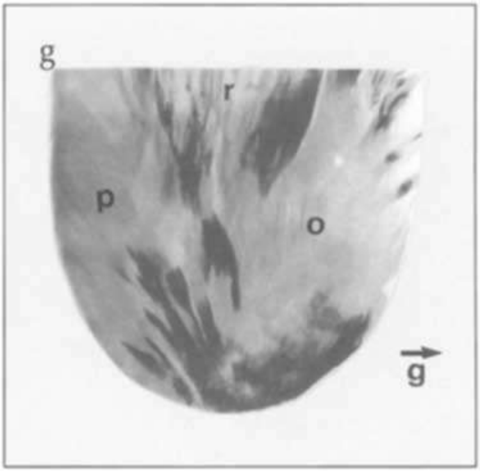
Figure 5: Topographs with 400 as diffracting planes: (a) topograph of slice A of Figure 1b; (b) topograph of slice B; (c) topograph of slice C; (d) topograph of slice D; (e) topograph of slice E. Topographs with 2$\bar{2}$0 diffracting planes: (f) topograph of slice F; (g) topograph of slice G; (h) topograph of slice H [for explanations see the text]. g *on all the topographs is the diffraction vector.*

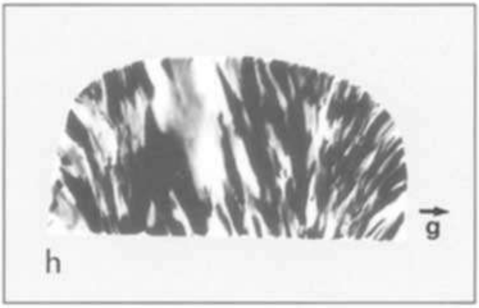
All the topographs of *Figure 5* show black, grey and white areas. This means that in one slice, for a definite position of the slice with respect to the X-ray beam, certain parts of the crystal fulfil the Bragg requirements, while other parts deviate from the diffraction conditions to varying degrees (grey and white areas). When the operator moves the position of the slice with respect to X-ray beam, even a few tenths of a degree, different distributions of black and grey areas are the result *(Figure 6).* In this case, other regions of the crystal display an optimal Bragg reflection. The topographs of *Figure 5* clearly show that the sample is not monocrystalline (if it were, the whole slice would be grey), but is made up of domains, which can be very small, the crystallographic orientation of which may differ by very small angles.

When comparing the topographs of *Figure 5,* the following differences are evident. Slice A *(Figure 5a)* shows two relatively large areas, one black and one grey, and only a limited region (arrow in *Figure 5a)* showing a group of small domains. In this part of the sample, which corresponds to the early growth stages, there are still just a few large









domains homogeneous from a crystallographic point of view. Moving from the bottom part of the boule towards the top (slices B, C, D and E, respectively the topographs of *Figure 5b, c, d and e*), the domains showing the same contrast in the topograph (zone r in *Figures 5b and d*) become progressively narrower, and the zones made up of smaller domains increase. This means that the quality of the sample becomes poorer from the base of the boule to the top *(Figure 5e)*.

The above considerations are confirmed by the topographs of the F, G and H slices, parallel to the elongation direction of the boule *(Figure 5f, g and h)*. In fact, the lower region *(Figure 5, f, g)* displays better quality in the external part *(Figure 5g)* where large areas showing the same contrast on the topograph (*Figure 5g,* zones o and p) can be observed. A trend to form microdomains (*Figure 5g,* zone r) is evident at the top of the slice (which corresponds to slice B, *Figure 5b*) and leads to a poorer crystal quality. The central part of the bottom of the boule *(Figure 5f)* appears more disturbed and, in the upper part (*Figure 5f,* zone r), the presence of small microdomains is apparent. G and F slices *(Figure 5g and f)* show fan-shaped contrasting patterns originating from the bottom of the boule. These images, characteristic for Verneuil-grown materials[2], indicate a migration of the deformations from the core to the periphery of the sample during the crystal growth process.

Finally, the poorest crystal quality at the top of the boule, as observed in topograph E *Figure 5e,* is confirmed by the $2\bar{2}0$ topograph of slice H *(Figure 5h)*. Here the contrasts, which all display a radial pattern of the stresses, are black or white, indicating a higher disorientation of the different domains.

Conclusion

The synthetic spinel studied in the present work shows an anomalous birefringence

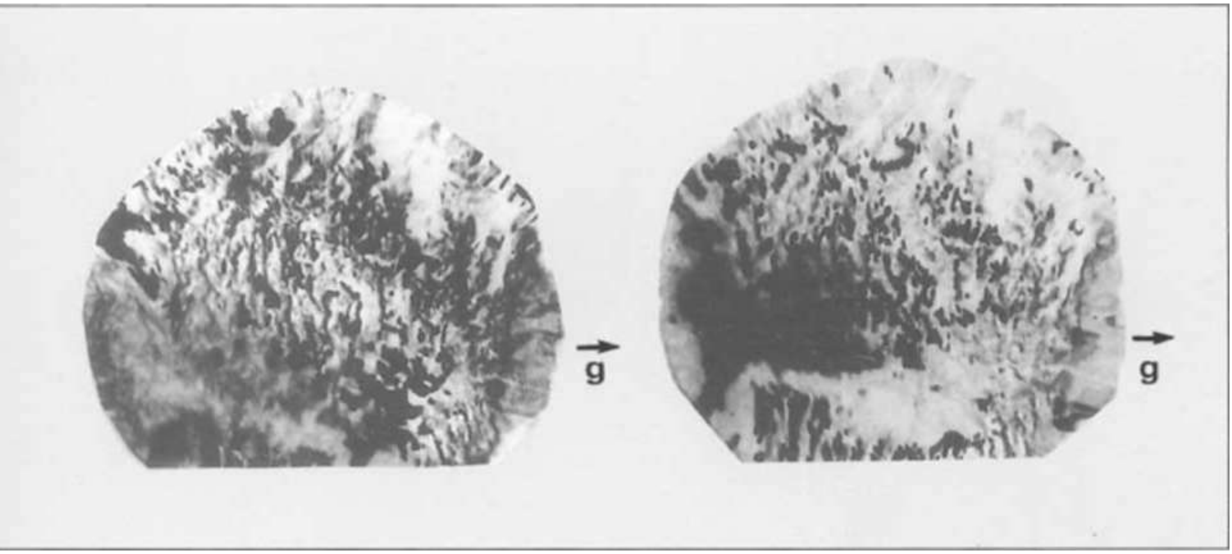


***Figure 6:** Topographs of slice C of Figure 1b using the same diffracting planes 400 after the sample was tilted a few tenths of a degree with respect to the X-ray beam. Note the differences of distribution of the black and grey areas.*

when studied with a polarizing microscope. This birefringence, also known as *tabby extinction*, is the result of stresses built up during the growth process in the Verneuil furnace[1]. X-ray topographs of the sample do not reveal linear defects (edge or screw dislocations). Within the limits of the experimental method used, the sample shows a low density of dislocations. Nevertheless, the same topographs also demonstrate that the boule is not monocrystalline and that the quality of the crystal varies in different parts of the sample. In fact, the basal part of the boule consists of larger homogeneous areas of better crystalline quality. This could be due to the fact that it remains for a longer time in contact with the flame and is removed only slowly from the flame as the growth of the sample increases in height. Therefore, in the bottom part of the boule the temperature decreases slowly, allowing a more correct arrangement of the atoms in the crystal lattice and a relaxation of the stored stresses before the growth ends, when the temperature decreases at a more rapid rate. On the other hand, the median and the upper part of the sample have a shorter time to adapt to the decreasing temperatures before the growth ends, giving the top part of the crystal only a restricted opportunity for a proper arrangement. In fact, the topographs d, e and h *(Figure 5)* show an increase in the poly-crystallinity of the slices approaching the top of the boule. This part of the sample mainly consists of many small domains, which are crystallographically disoriented with respect to each other.

Acknowledgements

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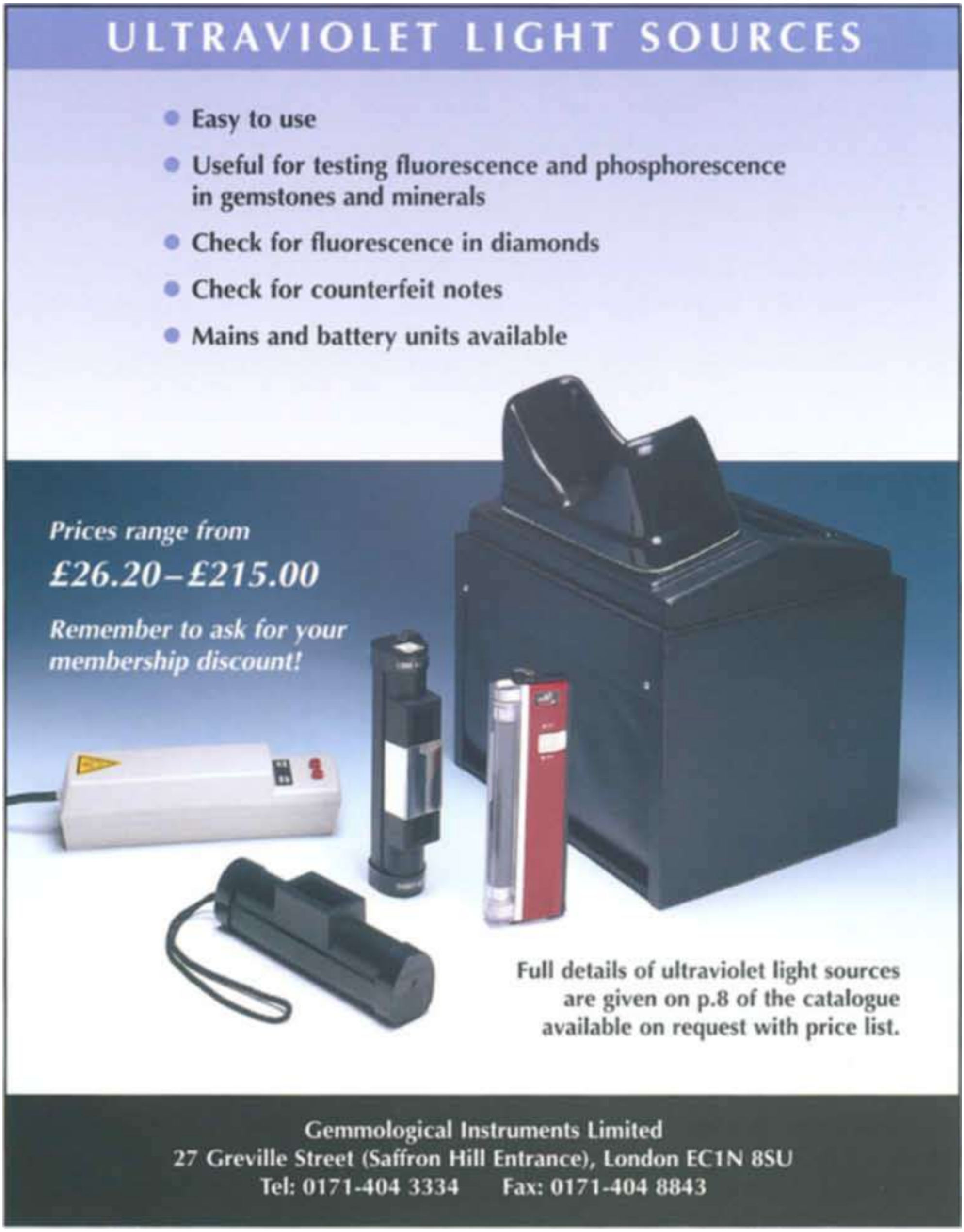

Characterization of alexandrite, emerald and phenakite from Franqueira (NW Spain)

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ABSTRACT: Structural, chemical, physical and microscopic characteristics of emerald, alexandrite and phenakite from Franqueira (Spain) are presented, and their gemmological possibilities are discussed. Comparison of data between Franqueira emeralds and Ural Mountains emeralds is emphasized, because both deposits contain the same associations of beryllium minerals and they are of similar genesis. The Ural Mountains deposit was until now the only one in Europe with these three rare beryllium minerals; it is now joined by the Franqueira deposit which is the only one of this type known in Spain.

Keywords: Emerald, alexandrite, phenakite, Franqueira (Spain), Tokovaja (Ural Mountains)

Introduction

The Franqueira deposit of beryl (emerald), chrysoberyl (alexandrite) and phenakite is the only one of its type known in Spain. A detailed geological description of this deposit was published by Martin-Izard *et al.* (1995).

The mineralization is located between the Braganza-Morais Portuguese complexes and the Ordenes complex in the Galicia-Tras Os Montes zone which is made up of two domains, the schistose and the granitic. The former is composed of metamorphic rocks and mafic-ultramafic overthrusting complexes of an ophiolitic nature. All of the rocks of this domain were affected by the Variscan Orogeny. The granitic domain includes peraluminous inhomogeneous synkinematic two-mica granitoids.

The Franqueira intrusive pegmatitic bodies, rich in fluids and volatile elements (Be, B, P, H_2O), are related to the above-mentioned granitic rocks. At the contact of pegmatite and dunite, a metasomatic zone has been developed. In the zones closest to the pegmatite, the dunitic rock is transformed entirely (chiefly due to the water, Si, Al and K from the pegmatite) into a rock mainly consisting of phlogopite, the Mg of which was provided by the dunite. In the zones furthest from the pegmatite, its influence is less and the dunite is transformed into an amphibolitic (tremolite) rock, in which the Mg is again provided by the dunite.

Beryl (emerald), chrysoberyl (alexandrite) and phenakite appear as accessory minerals beside tourmaline, garnet, apatite and zircon in a phlogopite rock, closest to the pegmatite, this being the only host rock containing beryllium minerals.

As described by Martin-Izard et al. (1995), the volatile element Be was distributed mostly in the zones closest to the pegmatite, favouring the development of beryl porphyroblasts

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Figure 1: *Cut stones from Franqueira; left, top to bottom, phenakite (0.33 ct), alexandrite (preform 3.39 ct and 0.34 ct) and right, emerald (2.53, 1.03 and 2.49 ct). Photo by Angel Ricardo.*

Figure 2: *Emerald (5 cm long) from Franqueira showing the typical prismatic habit. Photo by Angel Ricardo.*

among the phlogopite. The fact that emerald and alexandrite are the varieties of beryl and chrysoberyl present in the assemblage is due to their Cr content, which came from the dunite. Cr entered such crystals in the phlogopite rock but did not penetrate the pegmatite proper.

This deposit is similar to that at Tokovaja (Ural Mountains) studied by Fersman (1929) and summarized in part by Sinkankas (1981) and Sinkankas and Read (1986). Both deposits have produced the same mineral assemblage of beryl, chrysoberyl and phenakite, they occur in the same geological setting – a suture zone, and they are genetically similar. However, the Tokovaja deposit is very large and there are more than 60 species of accessory minerals, whereas the Franqueira deposit is only visible for 15–20 metres although it is probable that it is part of a larger deposit.

A detailed study of the structural, chemical, physical and microscopic properties of the beryllium minerals of the Franqueira deposit was performed in order to place on record its existence as a gemmological locality, before it is completely destroyed by mineral collectors.

On the basis of the resemblance between both deposits in relation to the association of beryllium minerals, the host rock and the genesis of mineralization, we have tried to compare the characteristics of the beryllium minerals from Franqueira with those from the Ural Mountains. However, there are very few data concerning emeralds from the latter locality (Gübelin, 1953; Lokhova *et al.*, 1977, Zhernakov, 1980; Granadchikova *et al.*, 1983, and Gromov *et al.*, 1990) and even less about alexandrite and phenakite; there is mention by Fersman (1929) of their visual appearance, chemical analyses which were published by Vlasov and Kutakova (1960), and more recently other authors have supplied some data *(see Table VI).*

Materials and methods, experimental details

The present study is based on the examination of samples of emerald, alexandrite and

Table I: Chemical composition of Franqueira emerald in a thin section

Wt. %	Range of 17 analyses	Mean
SiO_2	65.61–68.25	67.05
TiO_2	0.00–0.06	0.01
Al_2O_3	14.99–17.58	16.74
Cr_2O_3	0.00–0.16	0.06
MgO	0.62–2.12	1.12
CaO	0.00–0.16	0.06
MnO	0.00–0.06	0.02
FeO	0.16–0.63	0.26
NiO	0.00–0.09	0.02
Na_2O	0.32–1.09	0.68
K_2O	0.00–0.24	0.03
Total		86.05
Atomic contents based on oxygen = 18 and beryllium = 3		
Si	5.940–6.105	5.998
Ti	0.000–0.004	0.001
Al	1.743–1.853	1.765
Cr	0.000–0.011	0.004
Mg	0.084–0.166	0.149
Ca	0.000–0.005	0.006
Mn	0.000–0.004	0.001
Fe	0.013–0.045	0.019
Ni	0.000–0.006	0.002
Na	0.056–0.136	0.118
K	0.000–0.025	0.003

NB. Detailed analyses may be obtained from the authors

phenakite crystals, faceted and cabochon-cut samples, and in thin section.

Fragments of single crystals of emerald (crystal A), alexandrite and phenakite for X-ray diffraction were mounted on the goniometric head of an ENRAF-NONIUS CAD4 automatic four-circle diffractometer equipped with graphite-monochromatized radiation MoKα (λ = 0.71069Å).

Electron microprobe analyses *(Tables I–IV)* were performed with a Cameca SX50 electron microprobe using an acceleration voltage of 15 kV and a beam current of 15 nA on several crystals of emerald, alexandrite and phenakite in a thin section, on a polished plane parallel to a hexagonal prism of an emerald crystal (A), on the bases of two cabochons (B and C) of emerald, on a polished section of a rough crystal (D) of emerald and on three polished fragments of alexandrite. For the calculation of oxide wt. % contents, the correction procedure described by Pouchou and Pichoir (1984) was applied.

The average lithium and beryllium contents of Franqueira emeralds were determined by inductively coupled plasma mass spectrometry (ICP-MS) using the decomposition procedure on a powdered sample (a mixture of several crystals with different shades of colour) in a closed teflon vessel heated by microwaves. The water content of a mixture of samples of beryl was determined by thermogravimetric analysis with a Mettler instrument on approximately 23 mg of powdered sample. Weight loss vs. Time (at a heating rate of 10°C/min) was plotted as a gradual continuous curve from 25 to 140°C, followed by another curve from 140 to 800°C, for a total weight loss of 2%.

Refractive indices were obtained from table facets of cut stones of emerald, alexandrite and phenakite *(Figure 1)*, on the polished surfaces of the crystals A and D and the cabochons (B and C). A gemmological refractometer was used, according to the method described by Hurlbut (1984). Specific gravities were determined hydrostatically from the same samples.

One infrared spectrum was recorded for a mixture of several crystal fragments of emeralds from Franqueira in the range of H_2O stretching modes (from 3200 to 3800 cm^{-1}) using a Perkin-Elmer 1710X spectrophotometer. After microscope examination, samples without major mineral inclusions were selected for spectroscopic examination. A disc was pressed from KBr with about 4 wt. % of sample powder.

Electron microprobe analyses were also made of phlogopite, quartz, pyrite and anthophyllite inclusions exposed at the surfaces of the fashioned emeralds, and of phlogopite inclusions in polished fragments of alexandrite.

Photomicrography was performed with a Zeiss microscope on the samples of *Figure 1* and on a cabochon cut emerald (B).

Properties of emerald

Emerald is the most abundant of the three Be minerals in the Franqueira deposit. The rough samples are light green to medium green and reveal a typical prismatic habit *(Figure 2)*, in sizes of up to 10 cm, with mica

Table II: Chemical analyses and gemmological properties of Franqueira emeralds

Sample *Colour*	*Prismatic crystal* *A* *medium green*	*Cabochon* *B* *medium green*	*Cabochon* *C* *medium green*	*Crystal* *D* *medium green*	
n_ω	1.582 (1)	1.582 (1)	1.582 (1)	–	
n_ε	1.576 (1)	1.576 (2)	1.575 (1)	–	
Δn	0.006 (1)	0.006 (1)	0.007 (1)	–	
SG	2.707	2.706	2.690	–	
Number of analyses	70	49	19	9	Mean 147
Wt. %					
SiO_2	66.247	65.713	65.964	65.610	65.99
TiO_2	0.005	0.006	0.004	0.004	0.01
Al_2O_3	15.157	15.596	15.584	14.999	15.35
V_2O_3	0.045	0.022	0.015	0.043	0.03
Cr_2O_3	0.111	0.042	0.051	0.101	0.08
MgO	2.154	1.613	1.764	2.121	1.92
CaO	0.086	0.079	0.115	0.163	0.09
MnO	0.014	0.022	0.016	0.014	0.02
FeO	0.506	0.589	0.548	0.634	0.55
NiO	0.015	0.015	0.016	0.014	0.02
Na_2O	1.417	0.931	1.036	1.094	1.19
K_2O	0.141	0.109	0.123	0.238	0.13
Total	85.898	84.737	85.236	85.035	85.38
Atomic contents based on O = 18 and Be = 3					
Si	5.934	5.893	5.902	5.882	5.913
Ti	0.000	0.000	0.000	0.000	0.000
Al	1.601	1.645	1.643	1.627	1.623
V	0.003	0.002	0.002	0.002	0.002
Cr	0.008	0.003	0.004	0.005	0.006
Mg	0.287	0.216	0.235	0.240	0.254
Ca	0.008	0.008	0.011	0.012	0.009
Mn	0.001	0.002	0.002	0.001	0.001
Fe	0.038	0.044	0.041	0.044	0.041
Ni	0.001	0.001	0.002	0.001	0.001
Na	0.246	0.162	0.180	0.170	0.205
K	0.016	0.013	0.014	0.018	0.015

crystals either bound to the prism faces or as inclusions. In places, emerald replaces chrysoberyl (alexandrite) and phenakite. Almost all the samples show uneven colour distribution and the majority are translucent.

The microprobe analyses were carried out at 164 analysis points several micrometres apart on several samples: 17 analysis points on 12 crystals of a thin section *(Table I);* 70 analysis points on a prismatic section of the crystal A; 68 analysis points on the cabochons B and C, and 9 analysis points on the crystal D *(Table II).*

Tables I and II report the average chemical compositions thus obtained. Cations were calculated on the basis of 18 oxygens, assuming Fe and Mn as Fe^{2+} and Mn^{2+}, assuming the number of Be atoms to be 3 as in the stoichiometric formula, and neglecting Li and H_2O contents.

The average Li_2O, BeO and H_2O contents determined by ICP–MS were 0.589, 13.71 and 2.00 wt. % respectively for a mixture of emeralds from Franqueira. On the basis of their total alkali content they can be defined as sodium-potassium beryls with low alkali content.

All components varied widely between different crystals. Whereas the variation of the Cr content did cause patchiness of colour, there is no evidence of colour zoning within the samples, even when observed with a microscope.

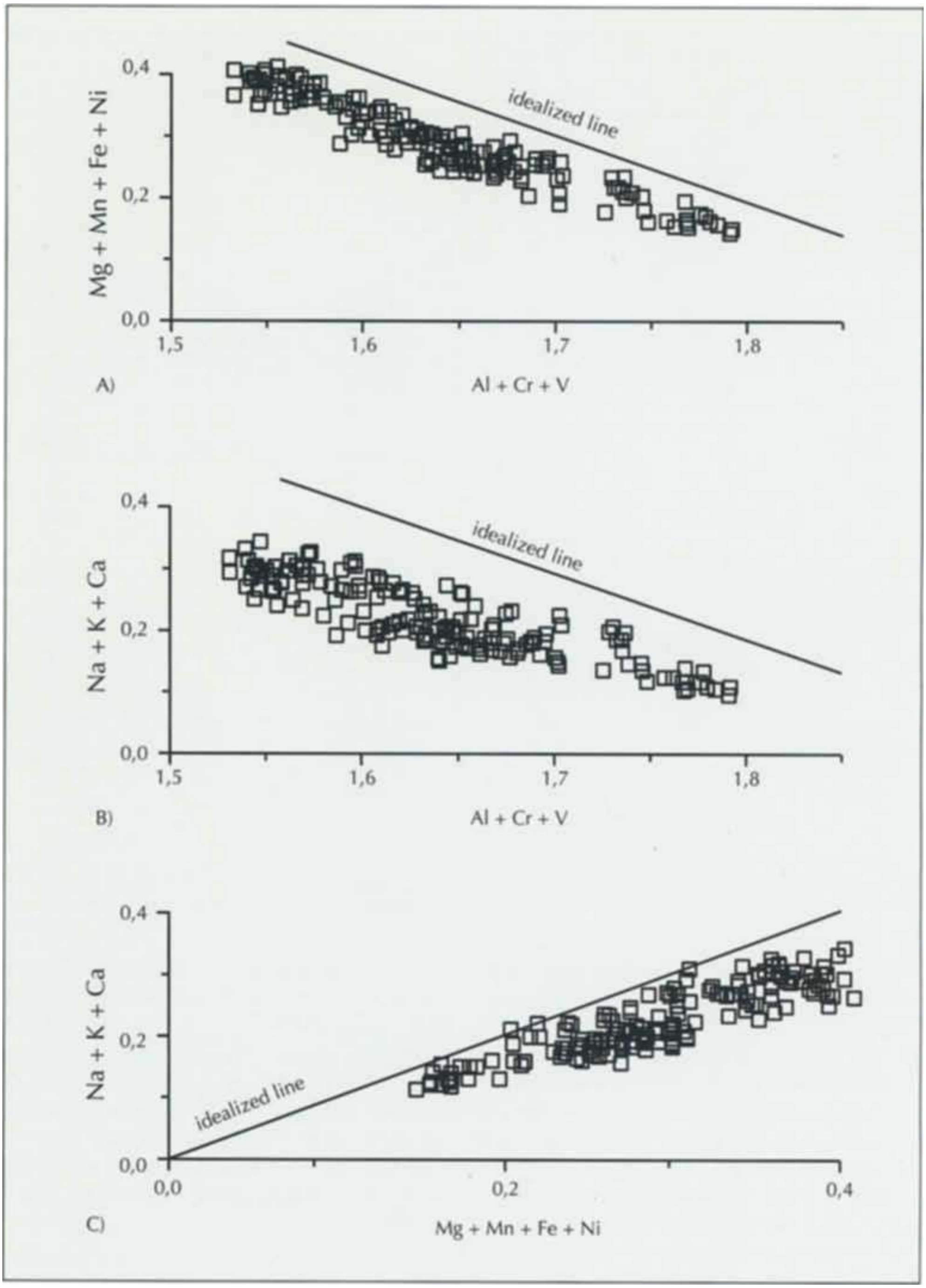


Figure 3: *(A) Plot of* $Al^{3+} + Cr^{3+} + V^{3+}$ *in octahedral sites versus* Mg^{2+} *in octahedral sites showing a negative correlation. (B) Plot of* $Al^{3+} + Cr^{3+} + V^{3+}$ *in octahedral sites versus* $Na^{+} + K^{+}$ *in channel sites showing a similar relationship to that of Figure 3A. (C) Plot of octahedral* Mg^{2+} *versus* $Na^{+} + K^{+}$ *in channel sites showing a positive correlation.*

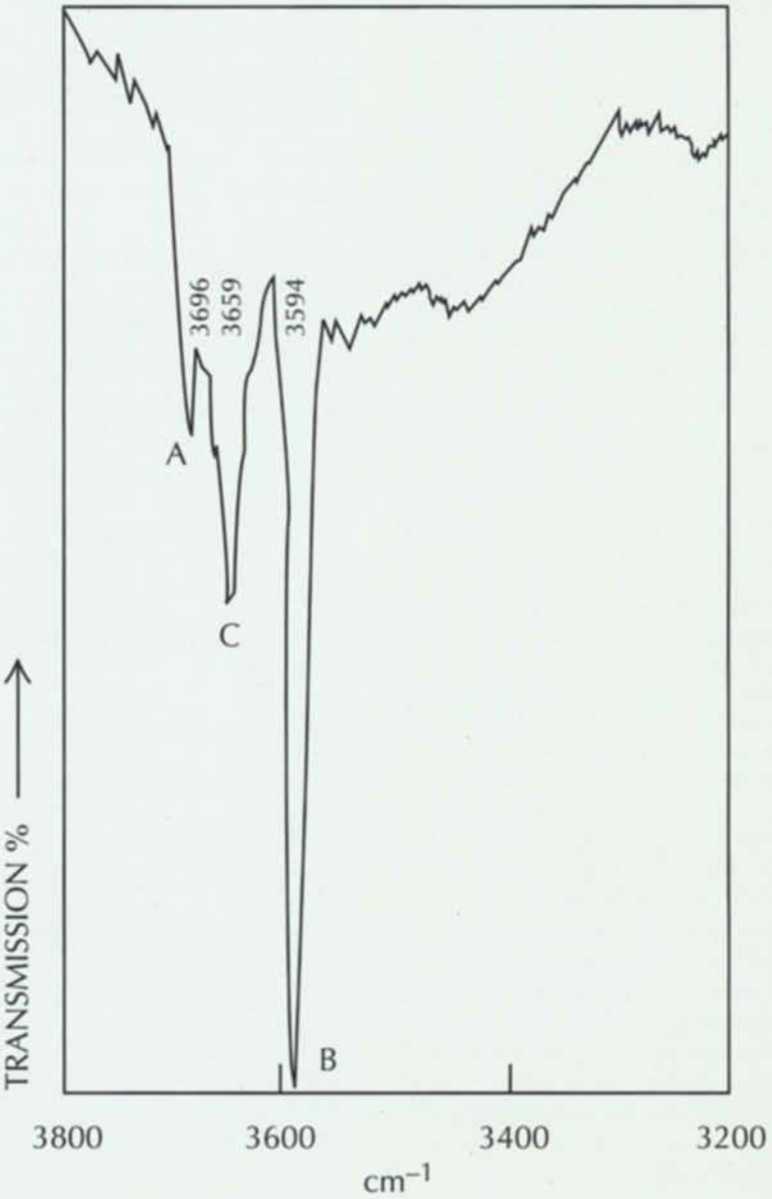


Figure 4: *The infrared spectrum of a mixture of emerald samples from Franqueira shows absorption bands of non-alkali-bonded (A) and alkali-bonded (B) and (C) water molecules. The intensity of absorption bands is B > C > A.*

Crystal chemistry of emerald

The channels of the beryl structure may contain alkalis, H_2O or CO_2 molecules and this relates to a complex substitutional pattern mainly affecting the tetrahedral Be and octahedral Al sites. The substitutional pattern used in this work is the generally accepted one of Aurisicchio *et al.* (1988):

1. *Octahedral substitution*, in which Al^{3+} in octahedral sites is replaced by trivalent transition metal ions or by divalent transition metals or magnesium, with alkali metal ions entering the channels for charge compensation.
2. *Tetrahedral substitution*, in which Be^{2+} in tetrahedral sites is replaced by divalent transition metal ions or possibly by Li^+, with alkali metal ions entering the channels for charge compensation.

The unit cell dimensions of beryls are correlated with their chemical composition and they are classified according to their *c/a* ratios as *octahedral beryls* with predominant octahedral substitution of Al^{3+}, as *tetrahedral beryls* with predominant tetrahedral substitution of Be^{2+} and as *normal beryls* with a limited octahedral and tetrahedral substitution of Al^{3+} and Be^{2+} (De Almeida Sampaio Filho *et al.*, 1973; Hawthorne and Cerný, 1977; Brown and Mills, 1986; Aurisicchio *et al.*, 1988; Sherriff *et al.*, 1991; Artioli *et al.*, 1993).

The microprobe analyses provide proof of the isomorphic replacement of Al in octahedral sites by correlation diagrams of trivalent octahedral cations versus magnesium or versus channel alkalis ($Na^+ + K^+$) and by correlation diagrams of magnesium versus channel alkalis.

These diagrams have been prepared for the above-mentioned 164 point analyses and are based on the following assumptions:

1. Si = 6 with Si in the tetrahedral site
2. Ti abundance is low and
3. V and Cr are trivalent and replace Al through the homovalent exchange:

   $$R^{3+}_{(oct)} = R^{3+}_{(oct)}$$

   So Al^{3+}, V^{3+} and Cr^{3+} only occur in the octahedral site.
4. Mg, Mn, Fe and Ni are all divalent and can only occur in the octahedral site as $R^{2+}_{(total)}$.

   This involves the heterovalent exchange:

   $$R^{3+}_{(replaced)(oct)} = R^{2+}_{(total)(oct)} + \textit{local charge deficit}$$
5. Na and K are monovalent and are large cations which can only enter the channel sites; divalent Ca^{2+} can also enter channel sites and its charge must be taken into account as follows:

   $$R^{+}_{(total)(chan)} = (Na^+ + K^+ + 2Ca^{2+})$$

   So, the overall charge balance is represented by:

   $$R^{+}_{(total)(chan)} = R^{2+}_{(total)(oct)}$$

   The substitution scheme is as follows:

1. in terms of quantities:

   $$Al^{3+}_{(replaced)(oct)} + vacancy_{(replaced)(chan)} = (V^{3+} + Cr^{3+} + Mg^{2+} + Mn^{2+} + Fe^{2+} + Ni^{2+})_{(oct)} + (Na^+ + K^+ + Ca^{2+})_{(chan)}$$
2. in terms of charges:

   $$charge\ deficiency_{(oct)} = (Mg^{2+} + Mn^{2+} + Fe^{2+} + Ni^{2+})_{(oct\ instead\ of\ R^{3+}oct)}$$

   (i.e. one charge loss for each divalent cation)

   $$= charge\ excess_{(chan)} = [Na^+ + K^+ + (2Ca^{2+})]_{(chan)}$$

Figure 3a shows a negative correlation between trivalent cations and divalent magnesium. *Figure 3b* shows a similar negative correlation. *Figure 3c* shows a positive correlation. The points lie below the ideal lines drawn in *Figures 3a, 3b and 3c*, and the reason for this is unknown; there are many unknown factors involved in this kind of crystal-chemistry and these include:

1. the possible replacements of some Si by Al and of some Be by Al have not been included in the above schemes;
2. the occupancy of octahedral sites by Li is unknown;
3. the structural position of Ti has been ignored;
4. $(OH)^-$ groups may be present rather than charge-balanced H_2O.

From these diagrams we can confirm that for Franqueira emeralds the following octahedral substitution scheme is valid:

$$(Al^{3+} + Cr^{3+} + V^{3+})_{(oct)} \rightarrow (Mg^{2+} + Mn^{2+} + Fe^{2+} + Ni^{2+})_{(oct)} + (Na^{+} + K^{+} + Ca^{2+})_{(chan)}$$

X-ray diffraction measurements of sample A indicated that the unit-cell dimensions were a_0 = 9.2483 (6) Å, c_0 = 9.1976 (8) Å, V = 681.28 Å^3; the number of reflections used in the refinement were 25. The *c/a* ratio of 0.9945 is that of emerald with predominant octahedral substitution and is thus compatible with the data presented in *Table II* and *Figure 3*. The structure refinement of this sample showed that Li was present in the channels; Li cannot enter the tetrahedral Si sites and most probably does not enter the tetrahedral Be sites but it might enter octahedral sites and upset the local charge balance.

Because the beryllium contents of emeralds could not be determined by electron microprobe analyses we cannot comment about possible tetrahedral isomorphic replacements (Shatskiy *et al.*, 1981; Schmetzer and Bernhardt, 1994).

The measurements of refractive index and specific gravity *(Table II)* are typical for medium alkali-bearing beryl (Cerný and Hawthorne, 1976).

The IR spectrum recorded *(Figure 4)* corresponds to the H_2O stretching modes (from 3200 to 3800 cm^{-1}) assigned to three different types of water molecules and/or hydroxyl groups (Wood and Nassau, 1967, 1968). Band A at 3696 cm^{-1} is assigned to *Type I* water molecules which are not bound to adjacent alkali ions. Bands B and C at 3594 and 3659 cm^{-1} are caused by *Type II* water molecules and hydroxyl groups, which are bound to alkali ions. Two other bands appear at 1580 and 1634 cm^{-1} due to deformation and are assigned to *Type I* and *Type II* water molecules, respectively. *Type I* water molecules have their 2-fold axis perpendicular to the 6-fold axis and the H–H direction parallel to the 6-fold axis, and the *Type II* water molecules are aligned with the molecular symmetry axis parallel to the 6-fold axis (Wood and Nassau, 1967).

The intensity of the absorption bands A, B and C is as follows: B > C > A. According to Schmetzer and Kiefert (1990), a correlation was found between increasing sodium contents from about 0.03 to 2.5 wt % Na_2O and increasing intensities of the B and C absorption bands and decreasing intensities of the A band. According to the classification of emeralds proposed by Schmetzer and Kiefert (1990) based on spectral features in the range of H_2O and OH stretching modes, the spectrum in the range from 3500 to 3800 cm^{-1} of the Franqueira emeralds indicates that they belong to *Group III;* these are medium to high alkali-bearing emeralds with distinct amounts of alkali-bonded *Type II* water molecules and lower amounts of non-alkali-bonded *Type I* water molecules. Consequently, the relations of the band intensities of bands A, B and C in the sample from Franqueira indicate that most of the H_2O is of *Type II*.

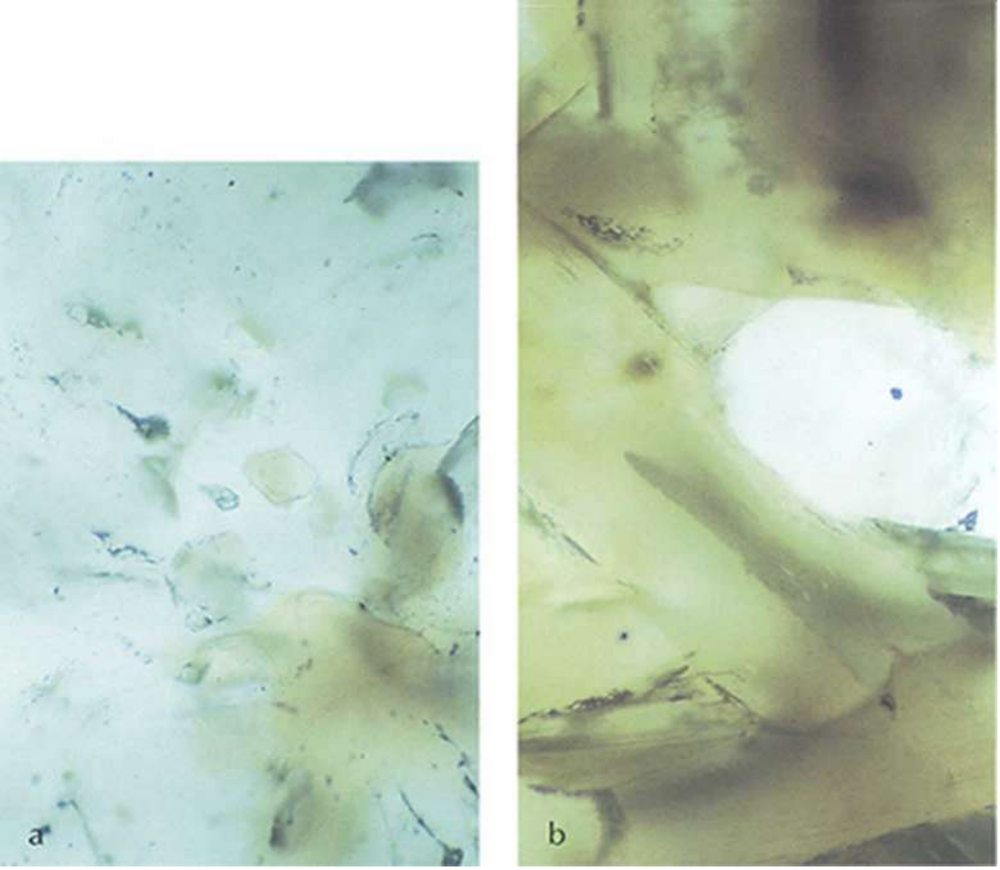


Figure 5: *(a) Isolated tabular crystal of phlogopite visible in an emerald from Franqueira (field dimensions 0.65 x 0.46 mm). (b) Cluster of brown phlogopite crystals in an emerald from Franqueira (field dimensions 0.65 x 0.34 mm).*

Inclusions in emerald

Under a transmission polarizing microscope abundant primary mineral and multiphase inclusions were seen in several cut stones, cabochons and some small emerald crystals in a thin section. Other inclusions related to fractures are pseudosecondary or secondary.

Mineral inclusions: Different forms of birefringent mineral inclusions are commonly present. Some are clustered or irregularly distributed elongated, tabular or rounded brown crystals *(Figure 5).* Microprobe analyses indicate these to be iron-rich phlogopite with an average iron content of 8.32 wt. % FeO, which is similar to the FeO content (8.33 wt. %) of the phlogopite in the host rock. A curious effect, which consists of haloes free of multi-phase inclusions *(Figure 6)* around elongated brown crystals of phlogopite, was observed in distinct zones in a cabochon, viewed perpendicular to the *c*-axis. Phlogopite crystals are parallel to *c*-axis of the beryl host.

Other inclusions consist of quartz, pyrite, phenakite, beryl, ilmenite, alexandrite and another mineral which corresponds to anthophyllite according to electron microprobe analysis (SiO_2 62.90 wt. %, MgO 27.78 wt. %, FeO 5.76 wt. %, Al_2O_3 0.40 wt %), but they are not very common.

Multi-phase inclusions: Most multi-phase inclusions prove to be fillings in negative crystals *(Figure 7a),* which are parallel to the *c*-axis, or filling fractures described as 'feathers'. Occasionally a section parallel to the *c*-axis shows typical prismatic faces, with dihexagonal dipyramids terminating in pinacoids *(Figure 7b),* and some of them show a saw-like internal structure *(Figure 7c).*

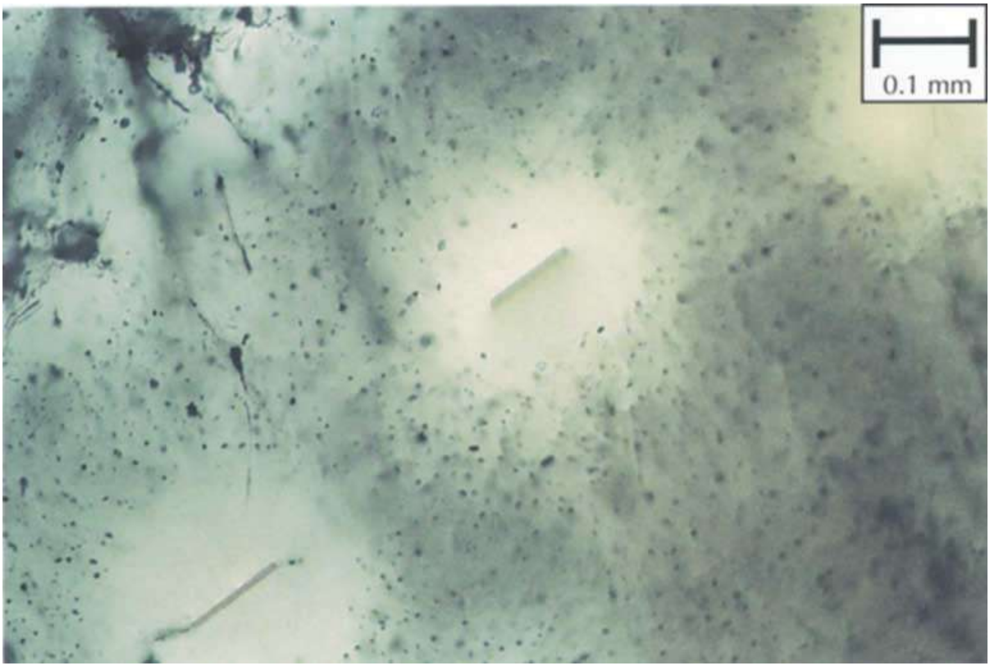
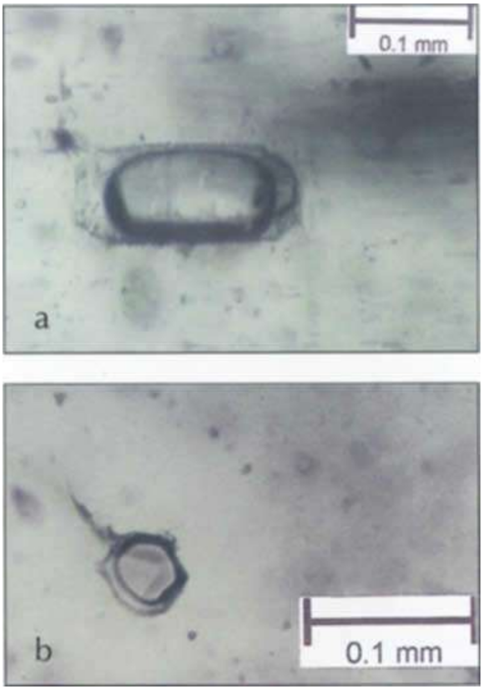


Figure 6: *Haloes free of multi-phase inclusions around elongated brown crystals of phlogopite in an emerald from Franqueira. The phlogopite crystals are oriented parallel to the c-axis of the emerald host.*



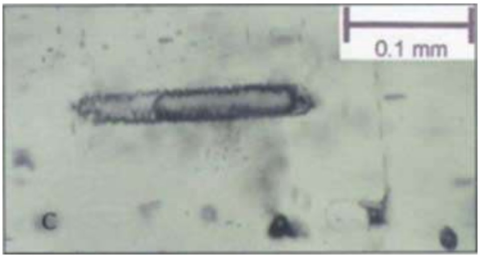
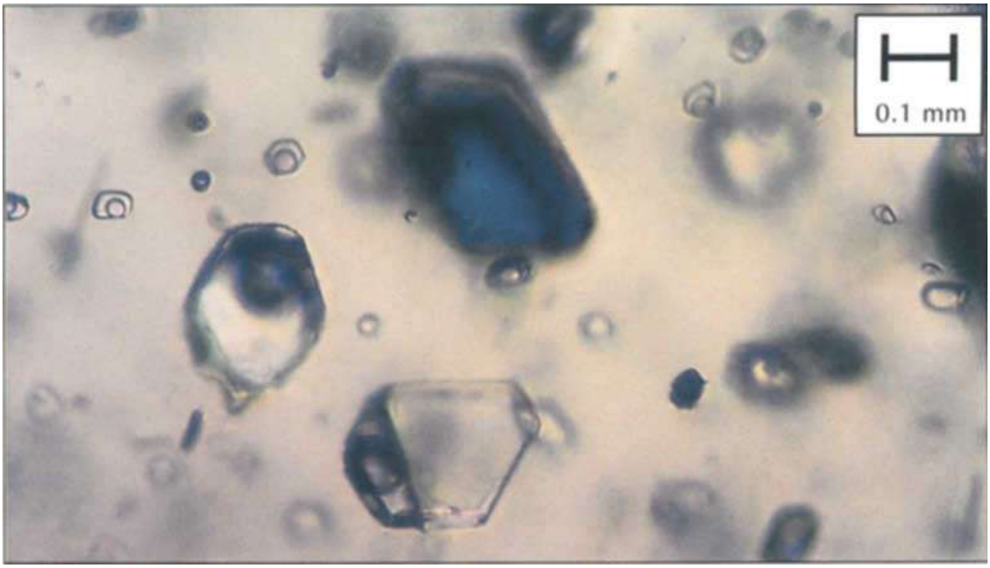


Figure 7: *(a) The commonest inclusions in emeralds from Franqueira are negative crystals containing liquid and gas, as shown in this view perpendicular to the c-axis in a cut stone. (b) Negative crystals in emeralds of Franqueira show the typical prismatic faces with dihexagonal dipyramids terminating in pinacoids, as shown in this view parallel to the c-axis in a cut stone. (c) Some negative crystals in emeralds from Franqueira show a saw-like internal structure. View perpendicular to the c-axis in a cut stone.*



Microthermometry studies (Martín-Izard *et al.*, 1995) show three types of fluid fillings in these inclusions:

Type 1: Complex two-phase CH4 and aqueous inclusions (H_2O–NaCl–CH_4 and other volatiles). They are found in groups, isolated or in microfractures and mostly contain liquid H_2O and vapour CH_4. They are primary or pseudosecondary and are more common in the emeralds than in alexandrite or phenakite.

Type 2: Complex two-phase CO_2 and aqueous inclusions (H_2O–NaCl–CO_2 and other volatiles). These inclusions have the same distribution as type 1 but are less abundant, consisting mostly of liquid H_2O and vapour CO_2.

Type 3: Mixed salt two-phase aqueous inclusions (H_2O–NaCl and other salts). These contain liquid and vapour H_2O and are always secondary in character.

The inclusions of *type 1* frequently contain crystalline solids with hexagonal, prismatic or irregular habit; they are transparent and colourless and some are birefringent. They may be phlogopite, phenakite, emerald or possibly other minerals *(Figure 8)*.

Figure 8: *The two-phase liquid-gas inclusions in emeralds from Franqueira commonly contain birefringent crystals, which may be phlogopite, phenakite or emerald, as shown in this view of a thin section.*

Figure 9: *Twinned crystal (7 x 5.5 x 3 mm) of Franqueira alexandrite showing two of the three pleochroic colours, as viewed with polarized transmitted and oblique illumination.*

***Table III:** Chemical composition of Franqueira alexandrite*

Sample	*Thin section*	*Polished surfaces of rough crystals*	*Inclusion in beryl*	
Wt. %	*Range*	*Range*		*Mean of 30 analyses*
SiO_2	0.000–0.029	0.033–0.780	0.06	0.13
TiO_2	0.008–0.128	0.107–0.638	0.06	0.24
Al_2O_3	79.626–80.997	70.298–77.341	74.44	76.00
V_2O_3	n.a.	0.017–0.100	0.03	0.05
Cr_2O_3	0.194–0.351	0.152–4.408	0.26	1.49
MgO	0.006–0.070	0.023–0.319	0.02	0.07
CaO	0.000–0.021	0.010–0.050	0.01	0.01
MnO	0.000–0.031	0.000–0.010	0.02	0.02
FeO	0.597–1.053	0.863–1.098	0.65	0.88
NiO	0.000–0.023	0.000–0.047	0.02	0.02
Na_2O	0.000–0.025	0.025–0.037	0.02	0.02
K_2O	0.000–0.020	0.004–0.091	0.00	0.01
Total	–	–	75.59	78.94

N.B. n.a. = not analysed

Properties of alexandrite

Alexandrite is less abundant than beryl and appears as three-member twins, in sizes up to 1 cm, in the phlogopite rock or as skeletal intergrowths within emerald. The crystals are cracked, the cracks being filled by phlogopite, and covered with flakes of phlogopite. The crystals show a pronounced colour change from purple-red under incandescent light to olive-green (or bluish-green, depending on observer) in daylight, and exhibit strong trichroism of blue-green, orange-yellow and red in daylight. In incandescent light the reds are stronger and greens weaker. In *Figure 9* two of the three colours of a twinned crystal are shown.

***Figure 10:** Healing feathers consisting of two-phase inclusions in a cut alexandrite from Franqueira.*

Franqueira alexandrite contains numerous phlogopite inclusions and it is difficult to obtain cut stones of good quality *(Figure 1)*.

The unit-cell dimensions are a_0 = 9.404 (4) Å, b_0 = 5.483 (2) Å, c_0 = 4.401 (8) Å, V = 226.9 (4) Å^3; the number of reflections used in the refinement was 25.

The chemical analyses were performed on several crystals in a thin section (*Table III* samples 1 to 5), on polished sections of three fragments (6, 7 and 8) and on one inclusion in emerald. The iron content ranges from 0.597 to 1.098 wt. % FeO and the Cr_2O_3 content was generally found to be between 0.152 and 0.351 wt. %, although one sample (crystal 8) contains over 4.4 wt. % Cr_2O_3.

The refractive indices obtained from the table facet of the cut stone are: n_α = 1.742, n_β = 1.746 and n_γ = 1.751, with a birefringence of 0.009. The measured specific gravity is 3.64.

The inclusions in alexandrite consist of phlogopite crystals with a composition similar to that of phlogopite in the host rock, and healed 'feathers' containing two-phase inclusions *(Figure 10)*.

Table IV: *Chemical composition of Franqueira phenakite in a thin section*

Wt. %	Range	Mean of 14 analyses
SiO_2	56.712–57.749	57.11
TiO_2	0.000–0.016	0.01
Al_2O_3	0.000–0.022	0.01
V_2O_3	0.000–0.013	0.01
Cr_2O_3	0.001–0.028	0.02
MgO	0.000–0.020	0.01
CaO	0.000–0.020	0.01
MnO	0.000–0.044	0.02
FeO	0.000–0.076	0.04
NiO	0.000–0.079	0.02
Na_2O	0.000–0.022	0.01
K_2O	0.000–0.015	0.01
Total	–	57.28

Figure 11: *Brown crystals of phlogopite and healed fractures in a cut phenakite from Franqueira.*

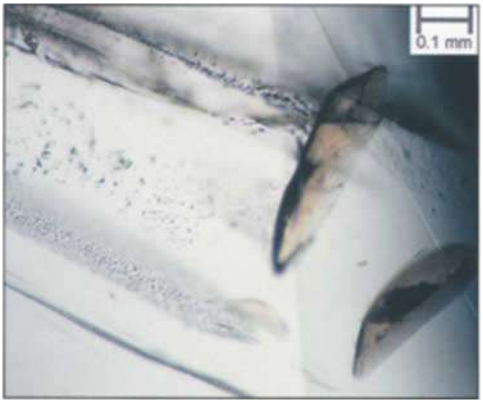
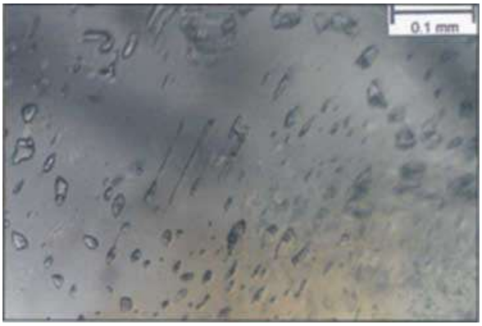


Figure 12: *The healed feathers in phenakite from Franqueira commonly contain two- or three-phase inclusions, liquid and vapour H_2O with NaCl dissolved in the aqueous medium.*



Properties of phenakite

At Franqueira phenakite is less abundant than emerald or alexandrite. It appears as angular or rounded grains, or sometimes as short subhedral and colourless prismatic crystals up to 3 cm long. Phenakite-apatite is a common association in the phlogopitic rock. In thin sections where chrysoberyl and phenakite are found together they may suffer partial replacement by emerald (Martín-Izard *et al.*, 1995). The phenakite is transparent and of cuttable quality *(Figure 1)*.

The unit-cell dimensions are a_0 = 12.472 (2) Å, c = 8.252 (2) Å, V = 1111.7 (3) $Å^3$; the number of reflections used in the refinement were 25. Chemical analyses carried out on several crystals in the same thin section are shown in *Table IV*.

The refractive indices measured on the table facet of the cut stone are: $n_\omega = 1.648$ and $n_\varepsilon = 1.664$, with a birefringence of 0.016. The measured specific gravity is 2.959.

The crystals examined contain tabular or elongated brown crystals of phlogopite, partly healed fractures *(Figure 11)*, and some isolated two- or three-phase inclusions *(Figure 12)*.

The healed 'feathers' contain two-phase inclusions. These are generally pseudo-secondary or secondary and most consist of liquid and vapour H_2O with dissolved NaCl (from microthermometric data of Martín-Izard *et al.*, 1995).

Properties of Uralian samples compared with samples from Spain

As was mentioned in the introduction, the resemblance between the Franqueira and Tokovaja (Ural Mountains) deposits in terms of their assemblages of beryllium minerals, the host rock and the mineralization genesis, led us to compare the characteristics of emerald, alexandrite and phenakite from both deposits *(Tables V, VI and VII)*.

The properties of alexandrite and phenakite from each locality are practically identical but those of emerald show some differences which are now summarized:

1. The Franqueira emeralds are generally paler in colour than the Tokovaja emeralds because of their lower Cr content;

***Table V:** Comparison between the properties of emerald from Franqueira (Spain) and Tokovaja (Ural Mountains)*

	Franqueira (Spain)	*Tokovaja (Ural Mountains)*
Occurrence	Metasomatic zone	Metasomatic zone
Emerald-bearing host rock	Phlogopite rock	Biotite[1] or phlogopite[2] rocks
Mineral assemblage	Phlogopite, phenakite, alexandrite, tourmaline, garnet, apatite, zircon	Phlogopite, fluorite, apatite, phenakite[1]
Visual appearance	Prismatic crystals, translucent and light green in colour with several tones of colour distributed unevenly	Prismatic crystals, transparent, most of them are dark green and show colour zoning
Chemical analyses	Cr_2O_3 wt. % = 0.04–0.11 V_2O_3 wt. % = 0.02–0.05 FeO wt. % = 0.51–0.63 $Na_2O + K_2O$ wt. % = 1.04–1.66	Cr_2O_3 wt. % = 0.02–0.50 V_2O_3 wt. % = 0.01–0.04 FeO wt. % = 0.16–0.57 $Na_2O + K_2O$ wt. % = 0.64–1.80[3]
Refractive indices	$n_\omega = 1.581–1.582$ $n_\varepsilon = 1.575–1.576$ $\Delta n = 0.006–0.007$	$n_\omega = 1.581–1.590$ $n_\varepsilon = 1.575–1.582$ $\Delta n = 0.006–0.008$[3,4]
Specific gravity	2.69–2.71	2.71–2.75[3]
Spectroscopic characteristics in the infrared ($3500–3800\ \text{cm}^{-1}$)	Intensity ratios of bands: B > C > A Typical of medium alkali-bearing emeralds	Intensity ratios of bands: B > A > C Typical of medium alkali-bearing emeralds
Mineral inclusions	Phlogopite (FeO wt. % ≅ 8) beryl, alexandrite, phenakite, pyrite, ilmenite, quartz, anthophyllite	Phlogopite (FeO wt. % ≅ 4) and biotite-phlogopite (FeO wt. % ≅ 7),[3] actinolite, tourmaline, biotite[5], rutile[2]
Fluid inclusions	Fluid fillings[6]: *Type 1:* Primary or pseudosecondary complex two-phase CH_4aqueous inclusions. These mainly show H_2O liquid and CH_4 vapour. They frequently also contain crystalline solids. *Type 2:* Complex two-phase CO_2 aqueous inclusions. These mainly consist of H_2O liquid and CO_2 vapour. *Type 3:* Secondary mixed salt two-phase aqueous inclusions. These show H_2O liquid and vapour.	Fluid fillings[7]: *Type 1:* Primary two-phase, aqueous solution and gas. *Type 2:* Primary and pseudosecondary three-phase aqueous solution, gas and liquid CO_2. *Type 3:* Primary and pseudosecondary three-phase aqueous solution, gas and a small halite crystal. *Type 4:* Pseudosecondary and secondary aqueous solution with a small gas component. *Type 5:* Extremely rare pseudosecondary inclusions consisting of small aqueous solution and/or gas phases with larger crystal inclusions.
Morphology of inclusions	Negative crystals // to the *c*-axis Healed 'feathers'	Thin channel-like structures // to the *c*-axis Thin and flat cavities Channel-like growth tubes // to the *c*-axis Healed 'feathers'(3)

[1] Fersmann (1929)
[2] Zhernakov (1980); Laskovenkov (1991)
[3] Schmetzer *et al.* (1991)
[4] Vlasov and Kutakova (1960)
[5] Gübelin and Koivula (1986)
[6] Martìn-Izard *et al.* (1995)
[7] Gromov *et al.* (1990)

***Table VI:** Comparison between the properties of alexandrite from Franqueira (Spain) and Tokovaja (Ural Mountains)*

	Franqueira (Spain)	*Tokovaja (Ural Mountains)*
Occurrence	Metasomatic zone	Metasomatic zone[1,2]
Alexandrite-bearing host rock	Phlogopite rock	Phlogopite rock[1,2]
Mineral assemblage	Phlogopite, beryl, phenakite, tourmaline, garnet, apatite, zircon	Phlogopite, phenakite, apatite, tourmaline, beryllium-margarite, fluorite and occasionally associated with beryl[1,2]
Visual appearance	Euhedral or subhedral crystals composed of three twin units. Crystals are covered with flakes of phlogopite. Purplish-red (incandescent light) and green (in daylight). Green, orange and red trichroic colours.	Euhedral or subhedral crystals composed of three twin units. Crystals are covered with flakes of phlogopite and chlorite. Purplish-red (incandescent light) and bluish-green (in daylight). Green, orange and red trichroic colours[1,2]
Chemical analyses	FeO wt. % = 0.60–1.10 Cr_2O_3 wt. % = 0.15–4.41 V_2O_3 wt. % = 0.02–0.10	FeO wt. % = 0.69–0.99 1.75 Cr_2O_3 wt. % = 0.18–1.45[3] 0.06[4] V_2O_3 wt. % = 0.02–0.05 0.03
Refractive indices	$n_\alpha = 1.742$ $n_\beta = 1.746$ $n_\gamma = 1.751$ $\Delta n = 0.009$	$n_\alpha = 1.749$ $n_\beta = 1.753$ $n_\gamma = 1.759$ $\Delta n = 0.010$[5]
Specific gravity	3.64	3.644–3.663[6]
Inclusions	Phlogopite crystals Healed 'feathers'	Healed 'feathers'

[1] Vlasov and Kutakova (1960)
[2] Fersman (1929)
[3] Ottemann *et al.* (1978)
[4] Henn (1985)
[5] Webster (1983)
[6] Vlasov (1964)

2. Most of the Franqueira samples show uneven colour distribution and the microprobe analyses revealed a large range of Cr content, but colour zoning, which is always present in the Tokovaja samples, has not been observed.
3. In all the Uralian emeralds examined by Schmetzer *et al.* (1991) a dominant octahedral substitution and a subordinate tetrahedral substitution were established, whereas in the Franqueira emeralds only an octahedral substitution has been established. Because the beryllium and lithium content of emeralds from both localities have not been determined in detail it is not possible to comment on possible tetrahedral isomorphic replacements.
4. The Uralian emeralds studied by Schmetzer *et al.* (1991) show a large range in their refractive indices, birefringence and specific gravity values which is probably due to the fact that the samples came from different mines in the Tokovaja area. The refractive indices, birefringence and specific gravity of the Franqueira samples agree perfectly with the values given by Vlasov and Kutakova (1960) for emeralds from the phlogopite zone in the Central Zone of the Tokovaja area.
5. In the Uralian emeralds Schmetzer *et al.* (1991) established the presence of both colourless Fe-poor phlogopites and more iron-rich brown crystals of the biotite-phlogopite series; the Franqueira emeralds contain only brown phlogopite with an Fe content comparable to that of the brown biotite-phlogopite of the Uralian emeralds.

Table VII: *Comparison between the properties of phenakite from Franqueira (Spain) and Tokovaja (Ural Mountains)*

	Franqueira (Spain)	*Tokovaja (Ural Mountains)*
Occurrence	Metasomatic zone	Metasomatic zone[1]
Phenakite-bearing host rock	Phlogopite rock	Phlogopite rock[1]
Mineral assemblage	Phlogopite, beryl, alexandrite, tourmaline, garnet, apatite, zircon	Phlogopite, phenakite, apatite, tourmaline, beryllium-margarite, fluorite and rarely associated with beryl[1]
Visual appearance	Annular or rounded and sometimes short subhedral prismatic crystals Transparent Colourless	Annular or rounded and sometimes sharp and short prismatic crystals with rhombohedral terminations. Crystals are transparent to translucent. White, colourless and pale yellow in colour.[2]
Chemical analyses	SiO_2 wt. % = 56.71–57.75 BeO wt. % = not analyzed In addition to the principal components, also contains small quantities of Al, Fe^{3+}, Fe^{2+}, Ca Mg, Na, K	SiO_2 wt. % =52.92 BeO wt. % = 45.82[2] In addition to the principal components, also contains small quantities of Al, Fe^{3+}, Fe^{2+}, Ca, Mg, Na, K
Refractive indices	$n_\omega = 1.648$ $n_\varepsilon = 1.664$ $\Delta n = 0.016$	$n_\omega = 1.654$ $n_\varepsilon = 1.670$ $\Delta n = 0.016$[1]
Specific gravity	2.959	2.93–3.00[1]
Inclusions	Phlogopite crystals Healed 'feathers'	

[1] Vlasov (1964)

[2] Vlasov and Kutakova (1960)

6. The intensity of the absorption bands in the IR spectrum (3200 to 3800 cm^{-1}) of the Franqueira emeralds is B > C > A, whereas in the Uralian ones it is B > A > C (Schmetzer *et al.*, 1991). In both cases the IR spectra are typical of medium alkali-bearing emeralds.

7. The morphologies of fluid inclusions in emeralds from each deposit differ in the following respects; the Uralian emeralds contain thin channel-like structures, thin and flat cavities, channel-like growth tubes and healed 'feathers', whereas the Franqueira emeralds contain only negative crystals and healed 'feathers'.

8. The following comparisons of inclusions described by Schmetzer *et al.* (1991) and those in Franqueira emeralds are proposed:

   type 1 of Uralian emeralds could correspond to *type 1* in Franqueira emeralds;

   types 1 and 2 of Uralian emeralds correspond to *type 2* in Franqueira emeralds;

   type 3 of Uralian emeralds have not been observed in the Franqueira emeralds;

   type 4 of Uralian emeralds correspond to some inclusions of *types 1 and 2* in Franqueira emeralds.

Finally, *type 5* of Uralian emeralds may correspond to some inclusions of *types 1, 2 and 3* of Franqueira emeralds.

Conclusions

The beryllium minerals from Franqueira and Tokovaja occur in Palaeozoic rocks trapped between acidic rocks (granites, pegmatites) and ultrabasic rocks (dunites) and gabbros.

The metasomatic rocks of the beryllium-bearing central metasomatic zone generally include phlogopite, which is commonly altered to chlorite, especially in Tokovaja.

The mechanism for the formation of the two deposits involves the emplacement of pegmatite and associated mobile elements (Be, B, P) into the basic rocks, with subsequent metasomatism and transformation of these rocks into phlogopitite, generally near to the pegmatite body. Gem mineral formation resulted when elements such as beryllium from the pegmatite and chromium from the basic rocks were brought together during the process of metasomatism.

In the Tokovaja area the metasomatic zone is more complex than at Franqueira, and it consists of serpentine, talc-serpentine, talc, talc-chlorite, talc-phlogopite, tremolitic rocks, amphibolites, amphibole-gneisses, quartzites and others. According to Fersman (1929) emeralds are found almost exclusively in biotite schists where the darkest and best-grade crystals were found; less commonly, emeralds appear in actinolite-talc or talc-schists, but biotite is present in quantity. Vlasov and Kutakova (1960) stated that the emeralds tend to occur in the phlogopite zone and at its contact with plagioclase bodies. It is rarer for the emeralds to be observed in the phlogopite-talc zones, although the emeralds found in this zone display an intense green colour. In a few places fine emerald crystals occur in actinolite lenses and phlogopite-tremolite zones.

Because both deposits are genetically similar the characteristics of their beryllium minerals are similar. Whereas in Tokovaja the metasomatic zone extends over a distance of more than 20 km, at Franqueira the zone is 3 m thick and crops out for only 15 m, although it may extend underground.

The limited extent of the Franqueira deposit probably explains the scarcity of different mineral species compared to their abundance (up to 80) in the Tokovaja area and this is probably the major difference between the two deposits. However, the chemical and physical properties and even the solid inclusions of the Tokovaja emeralds studied by Schmetzer *et al.* (1991) show differences from those of the emeralds at Franqueira; these differences can be attributed to the different geological sources tapped by the mines in the Tokovaja area.

With regard to the fluid inclusions the main differences are found in their morphology: the Tokovaja emeralds show thin channel-like structures, thin and flat cavities and channel-like growth tubes which are absent in the Franqueira samples; this may reflect different growth mechanisms of the emeralds or simply that the Franqueira deposit is smaller, with a smaller range of features displayed in its emeralds.

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Abstracts

Diamonds

Instruments and Techniques

Gems

Jewellery

Synthetics and Simulants

Diamonds

Trace elements in sulfide inclusions from Yakutian diamonds.

G.P. Bulanova, W.L. Griffin, C.G. Ryan, O.Ye. Shestakova and S.J. Barnes. *Contributions to Mineralogy and Petrology*, **124**, 1996, pp 111–25.

Sulphide inclusions in diamonds are possibly the best samples of mantle sulphides, giving clues to the distribution and abundance of chalcophile elements in the deep lithosphere. Trace element abundances from >50 sulphide inclusions in diamonds from Yakutia, Russia, were measured by proton microprobe. Peridotitic diamonds contain sulphide inclusions with Ni content 22–36%; in eclogitic diamonds the Ni content ranges 0–12% in the sulphide inclusions. Some specimens with no silicate or oxide inclusions had 11–18% Ni. Investigations of traces of other elements in sulphide inclusions are also given. M.O'D.

Microdiamond in high-grade metamorphic rocks of the Western Gneiss Region, Norway.

L.F. Dobrzhinetskaya, E.A. Eide, R.B. Larsen, B.A. Sturt, R.G. Trønnes, D.C. Smith, W.R. Taylor and T.V. Posukhova. *Geology*, **23**(7), 1995, pp 597–600.

Microdiamond grains were recovered from high-grade gneiss exposed in the Western Gneiss region, Norway. Raman and IR spectra indicate the presence of substitutional impurities of H and N in the diamonds. Primary fluid inclusions in garnet and quartz in the diamond-bearing rock demonstrate the evolution of metamorphic volatile fluids from reduced N_2–CO_2 composition during the peak phase of metamorphism to N_2–CH_4 ± H_2O bearing composition during the retrograde phase. Compatible geological, petrological and fluid composition data imply a metamorphic origin for the microdiamond. L.C.H.

Linear decorations defining edges of an internal octahedron within a natural diamond: observations and an explanation.

F.C. Frank, J.W. Harris, K. Kaneko and A.R. Lang. *Journal of Crystal Growth*, **143**, 1994, pp 46–57, 7 figs.

A 2.13 ct natural diamond, a slightly flattened octahedron with roughly-pitted surfaces, exhibits an internal framework of dense black 'lines' located a short distance below the present surface. Most of the lines lie closely parallel to <110> and connect up to delineate edges of an octahedron concentric with and slightly smaller than the present body. The lines are agglomerations of thin black discs (thickness too small to be measured in situ by optical microscopy), diameters ranging from 1 to 40 µm (but mainly in the 5 to 20 µm range), equally distributed on diamond {111}, and consistent with graphite. Special optical techniques were developed for examining this specimen and they provided control of relative visibility of internal versus superficial features. Optical micrographs taken in all eight <111> directions are discussed. Synchrotron X-ray topography detected the internal linear framework with good contrast, and helpfully displayed spatial relations between its segments. Findings from cathodoluminescence topography are described. An explanation proposes a sequence of pressure and temperature conditions and of resulting stresses between diamond and encasing solid matrix whereby graphitization was caused to occur locally along edges of an octahedron, which was subsequently enclosed by further diamond growth. Implications for the origin of the edge grooves frequently exhibited by diamond octahedra are suggested. (Author's abstract) F.C.F.

[Morphology of diamond crystals from kimberlites of Belomorye in relation to the history of their formation.] (Russian with English abstract).

V.K. Garanin and T.V. Posukhova. *Proceedings of the Russian Mineralogical Society*, **124**(2), 1995, pp 55–61.

Abstractors

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F.C. Frank	F.C.F.	M. O'Donoghue	M.O'D.	E. Stern	E.S.
R.K. Harrison	R.K.H.	R.J. Peace	R.J.P.	I. Sunagawa	I.S.
R.A. Howie	R.A.H.	S.A.T. Redfern	S.A.T.R.	I. Vesselinov	I.V.

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

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Two kinds of diamond microcrystals have been found in the Pioneer pipe, the normal octahedra and rhombododecahedra developed with intergrown faces, and skeletal box-zoned sectorial diamonds which grew by a normal (fibrous) mechanism. The conditions of the formation of these diamonds are discussed on the basis of crystallomorphological analysis and compared with experimental results. Numerous photomicrographs are presented. R.A.H.

Diamond and silicon carbide in impact melt rock from the Ries impact crater.

R.M. Hough, I. Gilmour, C.T. Pillinger, J.W. Arden, K.W.R. Gilkes, J. Yuan and H.J. Milledge. *Nature*, **378**(6552), 1995, pp 41–4.

Diamond/lonsdaleite plates and cubic diamond in association with SiC are reported from impact melts in this crater in S. Germany. These phases can be formed by chemical vapour deposition from the ejecta plume of an impact. Cubic diamond and SiC may be formed at any impact site from vaporized C-bearing rocks. Diamond and SiC occurrences may be criteria for identifying impact structures, as are also coesite, stishovite, planar deformation features in quartz and shatter cones. R.K.H.

Diamanten des Espinhaço Gebirges (Minas Gerais, Brasilien): Gemmologische und ökonomische Folgen geologischer Geschichte.

J. Karfunkel, M.L.S.C. Chaves, A. Hoppe and A. Banko. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(3), 1996, pp 113–28, 10 photographs in colour, 4 in black-and-white, 1 map, 2 tables, 2 diagrams, bibl.

Once Minas Gerais was the world's main producer of diamonds, today it only produces 220 000 ct annually, half from the Espinhaço range of mountains. Within the Precambrian São Francisco Craton diamonds reached the upper crust through (kimberlite/lamproite?) pipes. After erosion the diamonds were probably transported to the mid-proterozoic Espinhaço rift lying to the east. The diamond-bearing conglomerates originated in fluvial and alluvial fan systems; today these rocks produce only 2 per cent of diamonds from the Espinhaço range. Uplift during Pliocene times was responsible for the physiographic features of the Serre do Espinhaço; and fanglomeratic deposits were formed. Erosion during the late Pleistocene formed a colluvium layer which for hundreds of years was explored as the main source of diamonds. Today the most important mining areas are the recent river systems. Although low-grade, the deposits are economically important because they comprise over 400 million cubic meters. The percentage of cuttable stones as opposed to industrial stones is in places 98 per cent as compared to 70–90 per cent in Precambrian conglomerates. E.S.

La grande table de diamant de Tavernier.

B. Morel. *Revue de Gemmologie*, **128**, 1996, pp 13–16, illus. in colour.

A diamond known as the Grande Table was described by Tavernier in *Six voyages*, published in 1676. Divided into two portions, one of which at least is now believed to form the Dariya-i-Nur diamond and the other the Nur ul-Ain diamond. M.O'D.

Are euhedral microdiamonds formed during ascent and decompression of kimberlite magma? Implications for use of microdiamonds in diamond grade estimation.

D.R.M. Pattison and A.A. Levinson. *Applied Geochemistry*, **10**(6), 1995, pp 725–38.

The relationship between euhedral microdiamonds and macrodiamonds is problematic. It is paradoxical that the former, by virtue of their smallness, should be more susceptible to resorption than the latter, whereas the opposite is commonly observed. Difficulties with published mechanisms for euhedral microdiamond formation and eruption are discussed. An alternative hypothesis is proposed, showing there is a significant decrease in the C-bearing volatile content of kimberlite magma as *P* decreases. During magma ascent this may result in a *P*-related transition from fluid-undersaturated conditions at which diamond is unstable to conditions at which diamond becomes stable/metastable as the magma reaches fluid saturation. In this scenario macrodiamond xenocrysts (of an early generation), entrained at asthenospheric or deep lithospheric depths, may partially or totally dissolve in the undersaturated magma upon disaggregation of their host rocks; upon ascent to shallow depths, and in appropriate oxidation conditions, the lowered capacity of the magma to dissolve C-bearing volatiles may result in euhedral microdiamond precipitation, probably just before final eruption. It is therefore suggested that the use of microdiamond abundances from small samples as a guide to economic microdiamond grade is problematic as an exploration strategy. R.E.S.

Petrology and diamonds.

B.H. Scott Smith. *Exploration & Mining Geology*, 4(2), 1995, pp 127–40.

Petrology and the necessary genetic terminology are essential if the origin and relationships of different rocks are to be understood, and have an important role in modern diamond exploration programmes. Groups 1 and 2 kimberlites and lamproites, the only known economic primary sources of diamond, have been shown to be petrogenetically distinct rock types. Although their magmas act only as transporting agents for diamond, there are important implications for the differences between these and other rock types. The uses of petrology in exploration are illustrated using examples from known kimberlites in Canada; lamproites and group 2 kimberlites are rare and have yet to be found in Canada. R.E.S.

Geology of the Sturgeon Lake 02 kimberlite block, Saskatchewan.

B.H. Scott Smith. *Exploration & Mining Geology*, 4(2), 1995, pp 141–51.

This diamondiferous body is the first documented glacially transported block of kimberlite. It is 50–240 m in size and up to 21 m thick. During glacial transport, it was juxtaposed between shale blocks, probably of Cretaceous age. It consists of a thinly laminated to thinly bedded sequence of primary pyroclastic airfall coarse ash and lapilli tuffs which have probably undergone little or no reworking. More than one eruptive phase was involved in its formation. The kimberlite contains vesicular lapilli and may have formed by a style of subaerial eruption different from many other kimberlites. R.E.S

Gems

The genesis of emeralds and their host rocks from Swat, northwestern Pakistan: a stable-isotope investigation.

M. Arif, A.E. Fallick and C.J. Moon. *Mineralium Deposita*, *31*, 1996, pp 255–68.

Emerald deposits in Swat, NE Pakistan, occur in talc-magnesite and quartz-magnetite assemblages which are investigated using stable isotope studies. Notes on the general geology of the area are given and extensive notes on the occurrence and distribution of emerald are provided. It is concluded that emerald formation in magnesites occurred at high temperatures and that emerald, quartz, fuchsite and tourmaline, compared to pegmatitic and other magmatic minerals from other places, show a strong enrichment in ^{18}O and are genetically related. M.O'D.

Gemmologie aktuell.

H. Bank, U. Henn and C.C. Milisenda. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(3), 1996, pp 97–101, 6 photos in colour.

Beautiful pegmatitic gem crystals from Gilgit in Pakistan are being offered on the market as well as gem quality chrome diopside from Pakistan, exact occurrence unknown; these stones have a distinctive pleochroism, green, brownish-green and yellowish-green. Some red-purple almandine garnets have been found near Clarkston in Idaho, USA, RI 1.787–1.803, SG 4.10–4.15. Some bi-coloured quartzes from Bolivia have come on the market; these resemble the amethyst/rock crystal and smoky quartz/citrines varieties from Brazil. From Brazil also some multicolour fluorites with distinctly yellow, brown and green colour zones. From Mali came some yellowish-green to green grossular-andradite garnets. The occurrences near the villages of Kandia, Sangafe and Sibinndi produce non-transparent and therefore non-gem epidote, but some grossular garnets were found with long prismatic epidote crystals. Mali also produced some brownish almandine garnets and near Kayes some euhedral rock crystals with crystal faces on both sides with a lustre not dissimilar to that of 'Herkimer diamonds'. E.S.

Der Korallenachat von Halsbach bei Freiberg/Sachsen.

W. Beck. *Lapis*, **21**(6), 1996, pp 44–6, 1 map, illus. in colour.

Pink to brown banded agate is reported from the area of Halsbach, Freiberg, Saxony, Germany. The coral-like banded material has been fashioned. M.O'D.

Mineralien aus dem Bergell, den Màsino-, Codera- und Splügentälern.

F. Bedogné and E. Sciesa. *Lapis*, **21**(10), 1996, pp 15–26, 3 maps, illus. in colour.

Fine crystals of garnet and aquamarine are included in an extensive suite of minerals found in areas on the Swiss-Italian border. Eight distinctive mineralized regions are identified and their mineral species described. M.O'D.

Gems around Australia – Part 12.

H. Bracewell. *Australian Gemmologist*, **19**(6), 1996, pp 252–54, 7 illus. in colour.

In this continuing personal account, Yinnietharra and Mt. Phillip Stations in a remote part of Western Australia were visited. Yinnietharra provided some dravite tourmaline. Mining of the original deposit has stopped owing to the difficulty of extracting the tourmaline when the deposit ran in a gully between quartz and granite outcrops. Further north, the Mt. Phillip Station produced beautiful dark purple gem quality amethyst. R.J.P.

Charakterisierung von Saphiren mit Hilfe von Fluessigkeitseinschluessen.

B. Bruder. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(2), 1996, pp 47–54, 6 photos, 1 graph, 2 diagrams, 1 table, bibl.

Fluid inclusions in sapphires from Burma, Kashmir, Sri Lanka, Madagascar and Rwanda have been studied with the help of microthermometry and the Raman-laser spectroscope. The fluid consists of pure CO_2; daughter crystals of diaspore suggest the former presence of water in the fluid phase. Four different types of inclusions were found on the basis of their morphology and density. Type one consisted of primary, euhedral, isometric negative crystals with high-density fluid; type two were secondary, short prismatic negative crystals in well preserved healed fissures, some also with high-density fluid. Types three and four are secondary inclusions in poorly healed cracks. Unequal densities of the primary fluid inclusions allow sapphires from Sri Lanka and Kashmir to be separated from those from the other studied locations. E.S.

Mon aventure vietnamienne.

M. Bruley. *Revue de Gemmologie*, **127**, 1996, pp 21–2.

The writer's journey to Vietnam in search of gemstones is further described and includes reports of dealers' methods. More is to come. M.O'D.

What's new in minerals?

M.P. Cooper *et al. Mineralogical Record*, **27**, 1996, pp 207–23, illus. in colour.

Among minerals and gemstones seen at a number of shows worldwide are transparent bright-yellow anglesite from Touissit, Morocco; blue-green elbaite crystals with rose-pink tips from Pederneira, Cruzeiro, Minas Gerais, Brazil; yellow transparent brazilianite from Linopolis, Minas Gerais; orange-yellow topaz from Zacatecas, Mexico; colourless to pale blue topaz from the Hawthorne area, Mineral County, Nevada; green diopside from the Merelani Hills near Arusha, Tanzania; blue sapphire bipyramids from Galbkka, Vallivaya, Uva Province, Sri Lanka; ruby crystals of fine quality from the area of Jegdalek, Kabul Province, Afghanistan. M.O'D.

Estudio de los materials gemológicos del Tesoro de Guarrazar.

J.S. Cozar and C. Sapalski. *Boletin del Instituto Gemológico Espanol*, **37**, 1996, pp 5–18, illus. in colour.

The Guarrazar Treasure dates from the time of the Visigoths and is now housed in the Museo Arqueológico Nacional and in the Real Armería del Palacio Real. Gemstones in the artefacts are described and photographed. M.O'D.

Zoning of the Kremikovtsi marble onyx.

Z. Damyanov. *Comptes Rendus de l'Academie Bulgare des Sciences*, **48**(3), 1995, pp 33–6.

Calcite marble onyx occurs in the weathering crust of the Kremikovtski iron deposit near Sofia, Bulgaria. Four main factors have been responsible for its colour banding: (1) pigmentation by iron and manganese oxide-hydroxide particles, (2) refractivity variation due to rhythmic increase of Mg in calcite from nil up to 5 wt.% $MgCO_3$ in the individual bands, (3) porosity differences causing different refraction of the optical spectrum resulting in a variety of colour shades, and (4) textural alternation of spherulitic, grained and parallel rod-like aggregates which also affects the colour shades. Banded formation is explained by rhythmic auto-oscillations during calcite crystallization coupled with the tectonic-hydrogeological evolution of the area. I.V.

The Picos de Europa lead-zinc deposits, Spain.

B. Sainz de Baranda and G. Garcia Garcia. *Mineralogical Record*, **27**, 1996, pp 177–88.

The Picos de Europa range of mountains in northern Spain contain a number of lead-zinc deposits. Fine gem-quality specimens of sphalerite have been produced over the years, especially from the Aliva mines. The deposits are no longer worked, making the future supply of specimens uncertain. M.O'D.

Les camées double face sous la renaissance.

M. Duchamp. *Revue de Gemmologie*, **127** 1996, pp 13–16.

Short note on double-sided cameos with particular reference to six notable examples. M.O'D.

The structure of metamict zircon: a temperature-dependent EXAFS study.

F. Farges. *Physics & Chemistry of Minerals*, **20**(7), 1994, pp 504–14.

Two stages of thermal annealing within aperiodic zircon are identified between 293 and 1700 K. The first stage (≤600°C) shows a decrease of the *c*-cell parameter from 6.674 (at 300°C) to 6.610 (at 600°C) ± 0.005 Å. The average local environment around Zr (presence of ^{vii}Zr and *d*(Zr–Zr) ~ 3.3–3.6 Å) shows a weak, but significant increase of the Zr–Zr correlations located at 3.3–3.4 Å, undetectable by XRD. At $T \leq 700$°C (stage 2), the XRD-Bragg component arising from crystalline zircon increases in magnitude, whereas Zr–*K* EXAFS analysis indicates a progressive ^{vii}Zr → ^{viii}Zr transition, associated with a recovery of the crystalline zircon medium-range environment. For both techniques, the zircon structure is fully recovered at annealing $T \leq 900$°C. S.A.T.R.

Gem Trade Lab notes.

C.W. Fryer. *Gems & Gemology*. **32**(1), 1996, pp 44–51, 20 illus. in colour.

A grossular-garnet-bearing rock resembled impregnated jadeite. Magnification showed the grossular standing out against the softer undercut white areas. The latter did not react to a hot point but X-ray diffraction analysis showed it to be a chlorite mineral. Bright brownish-orange metallic flakes present in mottled green and white beads of jadeite were shown to be elemental copper. Several abalone pearls have been encountered shaped like sharks' teeth. An X-radiograph revealed a large hollow centre; several new abalone pearl culturing farms are reported. A string of pearls had been partially coated to fill drill holes which did not pass near the centre (presumably for attachment to fabric). The pearls had then been re-drilled through the centre.

A transparent near-colourless emerald-cut stone had properties not significantly different from grossular garnet. EDXRF spectrometry and X-ray diffraction showed it to be periclase MgO. R.J.P.

Pietre dure.

N.N. Germanova. *World of Stones*. **9**, 1996, pp 37–40.

The use of pietre dure in ornament is described with particular reference to Russian craftsmen and artefacts.

M.O'D.

Coal as a gemmological object.

S.V. Glushnev. *World of Stones*. **9**, 1996, pp 50–3.

Short account of the ornamental use of coal varieties with different names explained and a list of eleven references in Russian. M.O'D.

Corundum from basaltic terrains: a mineral inclusion approach to the enigma.

J. Guo, S.Y. O'Reilly and W.L. Griffin. *Contributions to Mineralogy & Petrology*, **122**(4), 1996, pp 368–86.

This paper investigates the origin of corundum (Al_2O_3) megacrysts that occur in many basaltic terrains, and which are considered to be eroded from basaltic rocks. Geochemical data for >80 primary mineral inclusions within corundum megacrysts are used to gain a new insight into the petrogenetic history of the corundum megacrysts from a wide spectrum of minerals present as inclusions; the most common are Nb-Ta oxides, alkali feldspar, low-Ca plagioclase, and zircon. Rare inclusions include Fe,Cu-sulphide (low in Ni), Co-rich spinel, Th,Ce-rich phosphate and uraninite. The similar chemistry of some inclusion minerals from corundum occurring in widely separated areas suggests that the corundum megacrysts in basalts have a similar petrogenesis. Geochemical characteristics of the inclusions indicate a bimodal grouping, which is best explained by a mixing-hybridization process. The corundum megacrysts are not cogenetic with their basaltic hosts but are crustal fragments accidentally incorporated into the erupting magma. Interactions between a silicic component and an intruding carbonatitic or similar Si-poor magma were responsible for Al-oversaturation, resulting in locally distributed lenses of corundum-bearing rock of mixed paragenesis. Feldspar exsolution textures provide strong evidence that this hybridization occurred at mid-crustal levels. Subsequent volcanic eruptions brought the corundum-bearing rocks (later disintegrated in the magma) up to the Earth's surface. P.Br.

Über die Behandlung von Opalen.

U. Henn. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft.* **45**(3), 1996, pp 129–33, 6 photos in colour, bibl.

Opals can be enhanced by using three basic treatment processes: (1) restoration, (2) artificial coloration and (3) impregnation. Lost water can be restored by water supply in vacuum. The porosity of some opals allows dyeing with colouring substances, especially matrix opals (in particular from Andamooka), hydrophane opals from Mexico and Brazil as well as oolitic opals, opalite sandstones and conglomerates. The most frequently used process is the sugar and acid method. Cracked opals can be treated with oils and resins to improve translucency and play of colour. According to CIBJO any dyed stones or stones treated with resin must be specifically declared. E.S.

Über 'Ammolith' einen irisierenden fossilen Schmuckstein aus Kanada.

U. Henn. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft.* **43**(3), 1996, pp 138–40, 2 photos in colour, 1 table, bibl.

Ammolite is a fossilized ornamental material from Alberta, Canada, and is composed of thin iridescent shell fragments in a shale matrix. The material is also called 'korite' and shows iridescence of red, orange, golden yellow, green and deep blue colours. The cut ammolite is often sealed with resin; also doublets and triplets are known: in doublets the material is mounted on dark slate, in triplets this is covered with rock crystal or colourless synthetic spinel. E.S.

Transluzente Nepheline und Nephelin-Katzenaugen aus Norwegen.

U. Henn and H. Bank. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft,* **43**(3), 1996, pp 134-5, bibl.

Nepheline is a sodium-potassium-aluminium silicate crystallizing in the hexagonal system, hardness $5\frac{1}{2}$ to 6, colour varies from green and bluish-green to brown and dark red. It is found in Norway, Russia, Canada and the USA. In its massive form it is used as ornament and known commercially as elaelite. Gem quality translucent nepheline and nepheline cat's-eyes from south Norway have an RI of 1.531–1.539, DR 0.003–0.004; SG 2.58–2.60. The reddish-brown to bluish-green colour is caused by ferric iron. The cat's-eye effect is due to tiny needle-like inclusions parallel to the c-axis. E.S.

Edelsteine der Amphibol-Gruppe.

U. Henn and H. Bank. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft.* **43**(3), 1996, pp 135–8, 1 table, bibl.

The authors survey gem materials found in the amphibole group, the most important being nephrite, but also the iridescent nuumite, tremolite and members of the tremolite-actinolite-ferroactinolite series, such as smaragdite and hornblende. E.S.

Agate Creek agate.

P. Howard. *Australian Gemmologist.* **19**(5), 1996, pp 215–20, 2 illus. in black-and-white, 16 in colour.

Agate Creek in North Queensland is noted for its attractively patterned agates which occur in and are weathered from amygdaloidal basalt of Carboniferous age. The occurrence of the agate deposit was first reported in 1900 and was realised to be large. Attempts to use heavy machinery for extraction after World War II caused animosity between the miners and rockhounds which resulted in legislation prohibiting the use of machinery. Excellent coloured photographs indicate the wide range and types of agate found. Red agates appear to predominate; the colour is due to iron but when other transition elements are also present a rainbow of colours can be exhibited. A somewhat chatoyant gold-flecked variety is the prized variety found in this location. Detailed maps are given. R.J.P.

Les sapphires de Montana [part 1].

R.W. Hughes and O. Galibert. *Revue de Gemmologie,* **128**, 1996, pp 4–6, illus. in colour.

Gives dates of significant events in the life of the Montana sapphire mines at Dry Cottonwood Creek, Yogo Gulch and Rock Creek. M.O'D.

Gem aragonite from the Czech Republic.

J. Hyrsl. *Canadian Gemmologist,* **17**, 1996, pp 76–7.

Description of gem-quality colourless, yellow, multicoloured and green aragonite from Horenec near Bilina, northern Bohemia, Czech Republic. Aragonite occurs in monomineralic veins cutting hydrothermally altered Tertiary basalts and production dates back to the early nineteenth century. M.O'D.

Kazakhstan landscape chalcedony.

F.M. Ibragimov. *World of Stones,* **9**, 1996, p 24.

Examples of landscape agate found in Kazakhstan are briefly described. M.O'D.

Gem news.

M.L. Johnson and J.I. Koivula. *Gems & Gemology*, **32**(1), 1996, pp 52–62, 17 illus. in colour.

Colour-change garnet, virtually indistinguishable in colour from fine alexandrite, emphasized the need for thorough testing. Fine crystals and cut stones of heliodor from Tajikistan are described. A new material 'leopard opal' from Mexico is a black and white opal-bearing rock with good colour distribution. Namibian spessartine garnets are found in matrix with high manganese concentration. A large (36.05 ct) taaffeite crystal from Sri Lanka was shown at Tucson. A new source at Tunduru, Tanzania, appears to have large reserves of gem materials. An additional report from the 25th International Gemmological Conference included summaries of cathodoluminescence in diamonds and the extraction of Montana sapphires involving methylene iodide. R.J.P.

An examination of colour-change sapphires from Tanzania.

R.C. Kammerling, M.L. Johnson and Y. Liu. *Australian Gemmologist*, **19**(6), 1996, pp 255–8, 6 illus. in colour.

A new source of sapphires in the far south-west of Tanzania occurs in a wide range of colours including light pink, purple, dark red, blue and dark green. A small percentage show an alexandrite effect from a greyish-bluish-green in daylight conditions to a reddish-brown under incandescent light, reminiscent of the effect shown by vanadium-doped synthetic sapphires. Pleochroism was complicated by strong colour zoning. Refractive indices, double refraction and optic character were normal. All the stones were inert to the long- and short-wave ultraviolet radiation and showed red through the Chelsea filter. Absorption spectra combined features typical of ruby and pink sapphire along with iron-related lines at about 450, 460 and 470 nm. Chemical analysis using EDXRF detected traces of iron, chromium, titanium and vanadium although the colour-change could not be attributed to any one single element.

Colorimetric analysis of the colour-change showed that nine of the 11 stones had a type 1 colour change. In this class the hues in CIELAB colour space showed a hue angle change ΔH1 from 26.9 to 115.8° between CIE illuminants D65 and A and therefore qualify as a true alexandrite effect. R.J.P.

Gem news.

R.C. Kammerling, J.I. Koivula and M.L. Johnson. *Gems & Gemology*, **31**(4), 1995, pp 274–88, 20 illus. in colour.

Papers given at the 25th International Gemmological Conference held in Thailand included the following topics.

Some Botswana diamonds contained hydrous fluid probably derived from a potassium-rich parent melt.

Unusual inclusions included a small insect trapped in the flower stamen of an extinct tree *Hymenaea protera* in amber from the Dominican Republic; blue-green inclusions of sapphirine in pebbles of iolite; tiny blue spinel octahedra in a swirled yellow background in a pale yellow hessonite from a new locality in Sri Lanka.

Green beryl and emerald from Central Nigeria were described.

A review of gem localities in China included diamonds, rubies, sapphires, emeralds and a long list of other gem species.

New gem deposits reported include a corundum deposit in Shan State, Myanmar, with mainly pink sapphires and a new find of emeralds in Tamil Nadu State, India.

A review of tektites with an origin from ejected residue of terrestrial rocks blasted by meteoric impact was given. Australian tektites are the youngest at 0.7 million years with North American tektites the oldest at 34.2 million years.

The polishing of the jadeite using bamboo on a lathe shaft and a jade market in Mandalay were described.

A report on pearls from freshwater oysters from Lac St. Jean, Quebec, showed that aragonite occurred as long slender crystals radiating from a point, although in the thin outer layer it was in the form of tabular crystals.

Rubies from the Barrington volcanic field, East Australia, are unusual as the parent rock contains ruby, sapphire, sapphirine and spinel.

In Laos gem-bearing lateritic soil was removed from vertical shafts and washed to reveal sapphires which ranged from a light to a dark blue and seemed of good quality.

Sapphires from a new source in southern Madagascar showed colour zoning and/or turbid areas and probably require heat treatment to become marketable.

Tanzanites and other zoisites from Merelani, Tanzania, were extensively examined. Brown and blue samples contained a V_2O_3/Cr_2O_3 ratio greater than two; this ratio was less than two in green zoisites. Light-blue crystals with elevated Ti content showed only a weak response to heat treatment despite their vanadium content. Violet zoisites owe their colour to V^{3+} and the presence of a little Cr_2O_3 results in a purer blue. The transition brown to blue is caused by the destruction of the 450 nm absorption band on heat treatment. R.J.P.

Dyed opalised sandstone and conglomerate – a new product from Andamooka.

J.L. Keeling and L.J. Townsend. *Australian Gemmologist*, **19**(5), 1996, pp 226–31, 4 illus. in black-and-white, 8 in colour.

This newly marketed product is a naturally occurring slightly porous silicified sandstone or sandy conglomerate in which the clay matrix and some quartz grains have been partially replaced by precious opal cement, and the whole is treated to darken the body colour and enhance the play of colours.

A characteristic of opal-cemented sandstone is that when viewed at right angles to bedding, opal colours often show as columns similar to those seen in some Gilson synthetic opal with stacks up to 10 mm high.

In the original treatment involving sugar solution followed by concentrated sulphuric acid, removal from the sandstone of the last traces of acid was very difficult. Although the precise details are secret, the new treatment involves organic impregnation followed by conversion to carbon by heating under non-oxidising conditions to temperatures above 500°C; acid treatment hazards are avoided.

Opal-cemented sandstone and conglomerate are readily identified from other forms of opal by the presence of abundant sand-sized quartz grains (clasts). As the product does not readily take a polish it will usually be encountered in composite form as a quartz or glass-topped doublet or coated with clear polymer. R.J.P.

Southern African gem minerals: sugilite.

A. Kleyenstüber. *South African Gemmologist*, **10**(1), 1996, pp 23–30, illus. in colour.

Geological and mineralogical description of purple manganoan sugilite occurring in the Kalahari manganese field of South Africa. M.O'D.

Copper inclusions in gemstones.

J.I. Koivula. *South African Gemmologist*, **10**(1), 1996, pp 11–17, illus. in colour.

Summary of examples of native copper inclusions in gemstones. Copper is recorded as an inclusion in 13 different mineral species, some of gem significance. M.O'D.

Exkursion zu Mineralvorkommen des Urals.

B. Kühn. *Aufschluss*, **45**, 1996, pp 129–44, illus. in colour.

Details of an expedition through the Ural Mountains of Russia, including details of geology and mineralization. Several of the sites described contain gem-quality minerals: these include the Mursinka pegmatite producing a number of major species, the Sedelnikowo area, producing rhodonite, the Lipowskoje area with ruby deposits, the Tokowaja district with major emerald occurrences and including the Malyschewo and Krasnoarmeiski beryl finds. M.O'D.

Karneol und Chalcedon aus Thüringen.

C. Linde. *Lapis*, **21**(10), 1996, pp 38–41, 1 map, illus. in colour.

Fine ornamental chalcedony varieties, including carnelian and agate are described from the vicinity of Schöngleina, Thuringia, Germany. M.O'D.

Die Entdeckung der 'goldenen Calcite' in der Malmberget-Grube, Lappland, Schweden.

P. Lyckberg. *Mineralien Welt*, **7**(3), 1996, pp 12–15.

Golden calcite with clear crystals attaining 6 cm in length is reported from the Malmberget mine, Lapland, Sweden. A report on the geology of the occurrence is given. M.O'D.

Luminescence of minerals and its application in geology.

V.V. Moroshkin. *World of Stones*, **9**, 1996, pp 4–7.

Examples of luminescence as a geological test are given: specimens illustrated include diamond crystals from China and Russia. M.O'D.

Blauquarze vom Calanda, Graubünden, Schweiz.

D. Mühlschlegel. *Lapis*, **21**(6), 1996, pp 42–3.

The blue colour in some quartz crystals reported from Calanda, Canton Grisons, Switzerland, arises from scattering by minute inclusions: facetable crystals have been found.

M.O'D.

Warrierite: a new black tourmaline from Western Australia.

J.G. Olliver and M. Thompson. *Australian Gemmologist*, **19**(5), 1996, pp 210–14, 4 illus. in black-and-white, 6 in colour.

A fine-grained massive black tourmaline marketed as warrierite formed within a major fault zone by metasomatic replacement of Archean volcanic rocks and was subsequently brecciated and intruded by white quartz veins. Warrierite contains both ferrous iron and magnesium and lies between dravite and schorl in the isomorphous tourmaline series. Due to its interlocking microscopic structure it has a toughness only slightly inferior to that of nephrite. Having a hardness of 7 to 7.5 on the Mohs' scale both the pure tourmaline, warrierite, and the mottled tourmaline-quartz rock are capable of displaying a superb polish. R.J.P.

Nouveaux gisements d'émeraude de l'inde méridionale.

J. Panjikar, K.T. Ramchandran and K. Balu. *Revue de Gemmologie*, **128**, 1996, pp 7–10.

Deposits of emerald are reported from sites near the villages of Idappadi and Konganapuram in the Sankari Taluka, Salem district, State of Tamil Nadu, India: geographical co-ordinates are given and specimens described. Mica is the most prominent mineral inclusion. M.O'D.

Neue Mineralienfunde aus den Pegmatiten der Insel Elba.

F. Pezzotta and P. Orlandi. *Lapis*, **21**(10), 1996, pp 27–35, 1 map.

A survey of the pegmatites of Elba has produced gem-quality and near-gem-quality crystals of tourmaline, morganite and spessartine. They are described with other minerals found on the island in recent years. M.O'D.

Mangatobangy. Amethyst-Zepter aus Madagaskar.

F. Pezzotta. *Lapis*, **21**(9), 1996, pp 32–5.

Fine large crystals of amethyst with sceptre shape are mined in the neighbourhood of Mangatobangy in the central mountainous region of Madagascar. Crystals up to 40 cm in length and weighing at least 20 kg are reported. M.O'D.

Russian demantoid, Czar of the garnet family.

W.R. Phillips and A. Talantsev. *Gems & Gemology*, **32**(2), 1996, pp 100–11, 2 tables, 15 illus. in colour, 15 in black-and-white.

Although demantoid was discovered in Russia in the mid-nineteenth century, mining was halted at the beginning of the Revolution. Today independent miners are recovering notable quantities of stream-worn pebbles near Ekaterinburg in the Urals. Recovery of demantoid garnet has been erratic and it can be a by-product of platinum mining. Demantoid garnet is $Ca_3Fe_2[SiO_4]_3$ with minor chromium contributing the valued green colour. The colour varies from yellowish- or brownish-green to golden green and the rarest 'emerald' green with most stones being less than 1 ct. The unique 'horse-tail' inclusion generally referred to as hair-like byssolite has recently been identified as serpentine (chrysolite) usually diverging from a tiny source such as a small opaque crystal of a spinel-group mineral, probably chromite or magnesiochromite. R.J.P.

Notes sur le gisement d'émeraude de Mananjary (Madagascar).

N. Ranorosoa. *Revue de Gemmologie*, **127**, 1996, pp 4–5, 1 map.

Emerald with properties in the normal range and containing inclusions of plagioclase, quartz, pyrite, goethite/hematite, phlogopite in hexagonal or pseudohexagonal plates, allanite [undifferentiated] and baryte, is reported from the area of Mananjary in east Madagascar. Crystals also contain a variety of fluid and two- and three-phase inclusions: they are found in schists encased within gneiss cut by quartzites or pegmatites. M.O'D.

Sapphires from the Andranondambo region, Madagascar.

D. Schwarz, E.J. Petsch and E. Kanis. *Gems & Gemology*, **32**(2), 1996, pp 80–99, 26 illus. in colour, 2 tables.

Over the last three years, large amounts of gem-quality sapphires have come from this region of southern Madagascar. Found in metamorphic skarn-type deposits they show a broad range of gemmological and chemical properties similar to those of sapphires from Sri Lanka, Burma and even Kashmir. Most of the Andranondambo sapphires are heat-treated in Bangkok. Separation of the heat-treated and non-heat-treated sapphires is easy when so-called HT-bands (Heat Treatment) are present. These are greyish-white (rarely greyish-brown) fine- medium- or coarse-grained bands. Also after heat-treatment mineral inclusions become turbid, translucent or even opaque and stress fissures are formed round crystal inclusions and negative crystals often showing a mirror or frosted effect. In most non-heat-treated stones the most pronounced spectral absorption minimum is at around 490 nm (e-spectrum) but spectra may be complex and detailed work is necessary.

Separation of Andranondambo sapphires from synthetics from various manufacturers depends upon the chemistry (synthetics have little or no gallium) and on the internal features. R.J.P.

Agates of Armenia: the past and the present.

V.B. Seiranyan. *World of Stones*, **9**, 1996, pp 19–23.

A map gives the main locations for agates in Armenia and the geology of different deposits is discussed. A list of six references appears in the separate Russian version of the journal. M.O'D.

Farbiger Bernstein-die Minen der Dominikanischen Republik.

G. Steiner. *Lapis*, **21**(10), 1996, pp 43–6, 1 map.

General account of amber deposits and working in the Dominican Republic. M.O'D.

'Oregon sunstone' aus der Ponderosa mine-ein Labradorit mit vielen Gesichtern.

A. Stucki. *Mineralien Welt*, 7(5), 1996, pp 16–20.

Description of the local geology of the Ponderosa mine, Oregon, USA, and of the occurrence of deep red to orange transparent labradorite which has been faceted into gemstones. M.O'D.

Crystal growth in the mineral kingdom.

I. Sunagawa. *Journal of Crystal Growth*, **128**, 1993, pp 397–402, 2 figs.

The methodologies used to investigate the kinetic problems of mineral formation in Earth and Planetary solid materials are briefly summarized. These include deductive analysis of growth and post-growth histories of mineral crystals based on their characterization, dynamic crystallization experiments and in-situ observation methods at high temperatures. (Author's Abstract) I.S.

Comment s'est développé la taille brillant actuelle?

H. Tillander. *Revue de Gemmologie*, **127**, 1996, pp 17–20.

Notes with diagrams of the development of the brilliant cut. M.O'D.

The problem of jadeite jade in China.

C. Wang. *Friends of Jade Newsletter*, April/May 1996.

A brief summary of the occurrence of jade minerals in China with particular reference to the term *fei-ts'ui*, used with various meanings as far back as the Zhou dynasty. M.O'D.

Johann Georg Lenz and his Mustertafeln.

W.E. Wilson. *Mineralogical Record*, **27**, 1996, pp 191–5, illus. in colour.

The *Mustertafeln* was published in 1794 for only 26 patrons so copies are extremely scarce. The book contains 344 hand-painted examples of crystal specimens including many of quartz and is the first general illustrated field guide to minerals. M.O'D.

The status of pearl culture in Indonesia.

T. Winanto and K. Mintardjo. *Australian Gemmologist*, **19**(6), 1996, pp 245–9, 2 tables.

Indonesia is an emerging producer of bead nucleated saltwater cultured pearls commonly referred to as South Sea pearls. Marine pearl oysters are widely distributed in Indonesian waters but more abundant in the eastern areas. The potential area for development is approximately 5600 hectares. *Pinctada maxima* which produces the larger pearls is the most common oyster used.

The pearl culture techniques are described in detail producing both round pearls and blister pearls, the latter in oysters which are not suitable for bead insertion. Constraints in future expansion include limited seed supply and the necessity to improve the training of the people in the industry. R.J.P.

The behavior of chromium ions in forsterite.

Y. Yamaguchi, K. Yamagishi and Y. Nobe. *Journal of Crystal Growth*, **128**, 1993, pp 996–1000, 4 figs, 3 tables.

Single crystals of Cr-doped forsterite were grown by the Czochralski and floating zone methods under varying growth atmospheres and Cr concentrations in the melt. Samples were also annealed under different oxygen partial pressures. The Cr absorption intensity was gradually saturated by increasing Cr concentrations or by changing oxygen partial pressure during growth. The results indicated that the tetravalent Cr ion is able to migrate between the Si and Mg sites in the forsterite structure. I.S.

[Composition, crystallostructural peculiarities and genesis of gem cordierite from the Eastern Pamirs.] (Russian with English abstract).

A.A. Zolotarev and M.S. Dufour. *Proceedings of the Russian Mineralogical Society*, **124**(2), 1995, pp 76–87.

Gem-grade cordierite occurs in the Sasyksky area of the Muzkolsky metamorphic complex. It is distinguished by a high degree of ordering (Δ0.233–0.247°) and low ferruginosity (8.5–16.0%), and was formed at the retrograde stage of amphibolite-facies metamorphism at 700–600°C and 340–470 MPa fluid *P*, with an intermediate fluid composition (X_{H_2O} 0.45–0.67). Chemical analyses and refractive indices are tabulated for eight cordierites, together with EPMA results and cell parameters for six cordierites. Calculated H_2O contents, X-ray diffraction patterns and IR spectra are also presented. R.A.H.

Antwerp gemmological update.

Antwerp Facets, **August 1996**, 1996, pp 43–63.

Brief coverage of risks and legal aspects of radioactive diamonds, of the first HRD-GGL Pearl Grading and Identification Seminar held in November 1995, of the present position of gemstones from Vietnam, and of diamond synthesis and identification. M.O'D.

Instruments and Techniques

A microscopic model for surface-induced diamond-to-graphite transitions.

A. de Vita, G. Galli, A. Canning and R. Car. *Nature*, **379**(6565), 1996, pp 523–6.

Results are presented of first-principles molecular dynamics simulations of a surface-induced diamond-to-graphite transition as a function of *T*, providing a microscopic model for graphitization processes. A well-defined diamond/graphite interface forms during the transition; the electronic properties of the atoms at this interface indicate that they are highly chemically active sites. A prediction of preferential hydrogenation sites at the coherent insertion of the (stable) graphitic phase into the (unstable) diamond phase substantiates the role of hydrogen in inhibiting graphite growth. R.K.H.

Kathodolumineszenz von Quarz-Grundlagen und Anwendung in den Geowissenschaften.

J. Götze. *Aufschluss*, **47**, 1996, pp 215–23.

Description of the effects shown under cathode rays by silica glass, quartz and chalcedony, with extensive bibliography. M.O'D.

Ein Renishaw Raman Mikroskop im gemmologischen Labor: Erste Erfahrungen bei der Anwendung.

H.A. Hänni, L. Kiefert, J.P. Chalain and I.C. Wilcock. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(2), 1996, pp 55–70, 8 illus., 1 table, 8 graphs, bibl.

Various applications of the Raman spectroscope in a gemmological laboratory are shown and examples given. The major use of this system is the destruction-free identification of inclusions in gemstones and determination of organic fracture fillings in emeralds. Also quick and precise identification of a series of gemstones or of gems in jewellery as well as destruction-free analysis of archaeological samples are possible. Due to the high resolution of the instrument, several phases within a gemstone can be identified. E.S.

The Bailey light source.

T. Linton, R. Beattie and G. Brown. *Australian Gemmologist*, **19**(6), 1996, pp 250–1, 1 illus. in black-and-white, 1 table.

This light emitting diode (LED) light source uses Stanley high brightness 5000 series LEDs and produces a cool yellow light of constant colour and intensity. Power is provided by step-down transformer or a 9v dry cell battery which has a working life of about four hours.

The refractive indices determined using these LEDs and a sodium vapour lamp showed no significant differences. However, the luminance of the six LEDs was only 18 per cent of that of the sodium lamp at an equivalent distance. The six LEDs are mounted vertically in pairs in a plastic case giving a rectangular beam of light.

Brighter scale images are produced by light which is angled upwards into the refractometer portal. The Bailey light source which has essentially horizontal directed light should be angled for this better illumination. R.J.P.

Scotch tape and a magic box.

J. Nelson. *Diamond International*, November/December 1995, 1995, pp 47–54.

So far the easiest way to detect fracture-filled diamonds has been observation of the colour flashes produced by the filler. The flashes could be eliminated, however, by ensuring that the RI dispersion curve of the stone does not intersect the dispersion curve of the glass infill in the visible region. Producers could achieve the absence of flashes while allowing for a slightly enhanced stone/filler interface, which would appear when they raised the intersection point from approximately 560 nm to 800 nm. While fairly elaborate LWUV methods might serve (and have been used) to observe different fluorescence strengths in Cape diamonds and, if present, in their fillers, a better means of detecting fillings is suggested.

A laboratory X-radiography unit has been devised for the purpose of filler detection. The unit, described in detail, is reported to be able to detect fillings even if no colour flash is seen and operates quickly and effectively over large quantities of specimens tested together, irrespective of individual stone size. The incorporation of a traversing stereoscopic microscope allows observation of fillings which are otherwise very hard to detect, particularly those whose planes lie at right angles to the incident beam direction. A depth enhancement of 6x has been obtained with the unit operating with 30KV X-rays: the contrast between a thin film of lead glass and the virtually X-ray transparent diamond host allows the smallest particle of glass to stand out. M.O'D.

Moderne Technologien im Farbedelstein-Bergbau. Teil 1.

K.C. Taupitz. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(2), 1996, pp 71–82, 10 diagrams, 2 tables, bibl.

The author describes the most important types of gemstone occurrences such as veins, pegmatites, emerald deposits, amygdales-druses-geodes, stratabound as well as eluvial and alluvial secondary deposits. Open pit mining is economic to a depth of 30 to 40 metres, but where vertical veins are thin, only to about 10–15 metres.

Hydraulic excavators with tractor or trailer or articulated dump truck haulage were found to be more efficient than exclusive use of bulldozers, especially in deeper mines. The recovered ground should be treated in a washing or reduction plant in order to minimize losses. Diagrams illustrate safety angles in open pit mining. Profitability of the various methods are discussed. E.S.

Moderne Technologien im Farbedelstein-Bergbau: Teil 2.

K.C. Taupitz. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(3), 1996, pp 103–12, 7 diagrams, bibl.

In mining coloured gemstones modern technology is taking over from the classical primitive artisan methods. This article discusses underground mining at more than 30 m depth, similar to those used in small gold mines; trackless diesel-driven equipment is also considered. Most gemstone ores should be treated in a washing or reduction plant in order to minimize losses. The article also discusses water, air, dust and lighting in the mine as well as the general infrastructure. E.S.

Jewellery

History of development of jewellery in the western world. Part 1.

J. Dykstra. *Canadian Gemmologist*, 17, 1996, pp 82–7.

First article in a series introducing jewellery designs, materials and techniques used in non-Oriental countries with descriptions based on items in the collections of the Royal Ontario Museum. The first part covers items to the end of the Classical era. M.O'D.

Synthetics and Simulants

Gemmologie Aktuell.

H. Bank, U. Henn and C.C. Milisenda. *Gemmologie. Zeitschrift der Deutschen Gemmologischen Gesellschaft*. **45**(3), 1996, pp 97–101, 6 photos. in colour.

Some alexandrites were offered on the market said to be from a new find in Brazil, but these were found to be Czochralski synthetic (Russian) with veil-like features induced by heat cracks to simulate a more natural appearance. Also from Russia synthetic phenakites produced by the flux method. At the German Gemmological Association conference 1996, two cut colourless synthetic diamonds from De Beers were shown, 0.48 ct and 0.60 ct. Results of laboratory examination of these stones will be published later. E.S.

Gem Trade Lab notes.

C.W. Fryer. *Gems & Gemology*, **32**(1), 1996, pp 44–51, 20 illus. in colour.

An imitation ruby necklace was shown to be dyed, quench-crackled quartz whilst a ruby doublet was shown to have two natural parts. A green synthetic sapphire revealed curved colour zones and EDXRF analysis showed Co^{3+} as the cause of the colour. R.J.P.

Face statistics on the dissolution forms of garnet crystals.

E. Hartmann and E. Beregi. *Journal of Crystal Growth*, **128**, 1993, pp 74–81, 9 figs., 2 tables.

Statistics based on 390 crystal faces appearing as dissolution forms of garnet crystals showed that octahedron and tetrahexahedron faces occurred most frequently as dissolution forms on single crystal garnet spheres. The dissolution forms were compared with growth forms of natural and synthetic garnets. I.S.

Growth and perfection of chromium-doped forsterite.

B. Hu, H. Zhu, P. Deng and P. Pan. *Journal of Crystal Growth*, **128**, 1993, pp 991–5, 4 figs., 1 table.

Large single crystal boules of Cr-doped forsterite were synthesized by the Czochralski method, and their defects were investigated. Three typical defects were observed. By adjusting growth parameters and choosing optimum composition of the charge, two of these defects could be reduced, and large crystal boules with good quality were obtained. I.S.

Gemological investigation of a new type of Russian hydrothermal synthetic emerald.

J.I. Koivula, R.C. Kammerling, D. DeGhionno, I. Reinitz, E. Fritsch and M.L. Johnson. *Gems & Gemology*, **32**(1), 1996, pp 32–9, 10 illus. in colour, 1 table.

A new type of Russian hydrothermal synthetic emerald produced by Tairus in Novosibirsk is being marketed in Bangkok. Examination of several faceted samples revealed that with the exception of certain characteristic inclusions, the basic gemmological properties are the same as those encountered in other hydrothermally-grown synthetic emeralds and some natural emeralds. When characteristic inclusions are absent distinctive spectral characteristics in both the mid- and near-infrared regions of the spectrum will serve to distinguish these synthetics from their natural counterparts.

In the near-infrared spectra two broad absorptions produced by the extraordinary ray centred at 1500 nm and 900 nm and one in the ordinary ray spectrum at about 1180 nm have not been reported in natural emeralds. Although the roiled, chevron-shaped growth zoning that is generally considered characteristic of Russian synthetic beryls was absent in the new product, tiny red-brown particles of an unidentified nature were found in all the faceted samples and have not been noted in other Russian hydrothermal products or natural emeralds. R.J.P.

Dendritic diamonds synthesized by simple hot-filament-assisted chemical vapor deposition.

M. Sakai, Y. Aoki, Y. Nakamuta and M. Ishii. *Journal of Crystal Growth*, **133**, 1993, pp 329–31, 2 figs.

By a simple method of hot-filament-assisted vapor deposition, dendritic single crystals of diamond, consisting of three square prisms elongated in the [100], [010] and [001] directions and one to four triangular pyramids elongated in <111>, were obtained. Twins and aggregates attached to dendritic individuals were also formed. Dendritic diamonds were formed under conditions of higher filament temperature and substrate temperature than those used for polyhedral diamond growth. I.S.

Growth method and growth-related properties of a new type of Russian hydrothermal synthetic emerald.

K. Schmetzer. *Gems & Gemology*, **32**(1), 1996, pp 40–3, 4 illus. in colour, 1 table.

A new type of Russian hydrothermal synthetic emerald is produced by seeded growth in steel autoclaves without noble-metal inserts; the seed slices have been cut parallel to a face of the second-order hexagonal dipyramid $s\{11\bar{2}1\}$. This orientation avoids the easily recognizable growth pattern seen in earlier Russian production. Characteristic growth planes of a different nature are present being parallel to *s* and forming a 45° angle with the optic axis.

With this seed orientation extremely fast growth can be obtained. The recognition of one dominant growth pattern parallel to *s* in an emerald of doubtful origin may indicate that it is synthetic but absorption spectroscopy and/or EDXRF should be used to confirm or disprove such a preliminary result. R.J.P.

Flux growth of pure and doped zircons.

A.K. Sinha, D.M. Wayne and R. Essex. *Journal of Crystal Growth*, **125**, 1992, pp 431–9, 8 figs, 2 tables.

Crystals up to 2 mm (relatively large for zircon) of pure and doped zircon were synthesized by a flux method. Morphological variation of zircon crystals was correlated with different growth conditions and dopant contents, and interpreted in terms of growth mechanisms associated with element substitutions in the zircon structure. I.S.

Combustion growth of large diamond crystals.

X.H. Wang, W. Zhu, J. von Windheim and J.T. Glass. *Journal of Crystal Growth*, **129**, 1993, pp 45–55, 8 figs.

Optically transparent, individual diamond crystals attaining mm size in diameter were successfully synthesized on Si substrate by oxygen-acetylene combustion flames at atmospheric pressure. The growth process involves three steps: (1) achievement of a suitable nucleation density by pretreating the Si substrate in an acetylene-rich flame (oxygen-to-acetylene ratio R_f = 0.95) for about 30 min at a downstream position (7–10 mm away from the tip of the flame inner cone); (2) growing crystals up to 200 µm in diameter in an annular area on the substrate at R_f = 0.98 and a substrate-to-tip of the flame inner core distance of 2 mm; (3) moving the preferred crystals from the annular region into either the central core region of the flame feather or near the edge of the flame feather for further growth up to mm diameters under carefully controlled conditions. The final step was necessary to avoid extensive secondary nucleation and structural defects. The key factor was to maintain the growth conditions at the growing surface constant throughout the process. The crystal surface could be effectively maintained at constant temperature by decreasing the total gas flow rate as growth continued. Both the crystal growth orientations and the amount of nitrogen impurity incorporated in the diamond were closely related to the crystal surface temperature. It is believed that the gas flow dynamics or the boundary layer thickness played an important role in the growth and morphological development of large diamond crystals. I.S.

BOOK REVIEWS

Caratteristiche interne delle gemme.

W. ANDERGASSEN, 1996. C. Bossi and C. Bossi, S.r.l., Via dei Pioppi n.6, 38033 Cavalese (Tn), Italy. Unpaged. Issued in parts with binder, illus. in colour. Price on application.

The first part of this work in progress contains coloured photographs of eighteen natural and synthetic gemstones, the majority being ruby and emerald, with topaz and biotite. Single pictures cover calcite, apatite, selenite [gypsum], kyanite, andalusite, peridot, natrolite and spodumene. Each page of eight photographs is accompanied by a facing page of description, with magnification and lighting conditions included. The quality is well up to the most exacting contemporary standard and the book should certainly be in the libraries of all working gemmologists. English and Spanish versions are promised.

M.O'D.

Mineralogy of Arizona. (Third edition)

J.W. ANTHONY, S.A. WILLIAMS, R.A. BIDEAUX AND R.W. GRANT, 1995. University of Arizona Press, Tucson. pp xvi, 508, illus. in colour, softcover. US$35.00. ISBN 0 8165 1555 7.

The first edition of this major mineralogy was published in 1977 and was followed by a second edition (in fact a revised reprinting) in 1982. Since that time the total of recorded Arizona mineral species has risen to 809, of which 76 were first discovered in the state. For each species the chemical composition, mode of occurrence and locations by county and mine are given.

For the gemmologist turquoise deposits must be of particular interest but Arizona also provides smithsonite, azurite, malachite, sphalerite, cuprite, chrysocolla and quartz varieties. Many of these provide such fine specimens that fashioning is out of the question. A 45-page bibliography and a comprehensive map section are given and in all respects the book is worthy of its subject.

M.O'D.

Opal, South Australia's gemstone. (Second edition)

L.C. BARNES, I.J. TOWNSEND, R.S. ROBERTSON AND D.C. SCOTT, 1992. South Australia Department of Mines and Energy, Adelaide. pp 176, illus. in colour, softcover [Geological survey of South Australia. *Handbook* no 5]. £13.95. ISBN 0 7308 1709 1.

The second edition of this guide appears ten years after the first and during this period more work has taken place at the two main opal fields, Coober Pedy and Mintabie. All South Australian opal fields are described from the geologist's point of view and for this reason the book includes many geological maps and details of opal recovery. Interesting notes on claim establishment are included and the very useful bibliography has been updated. This is a book for the geologist rather than for the gemmologist but readers with a geological background will find a great deal of unique information.

M.O'D.

Minerals of South Africa.

B. CAIRNCROSS AND R. DIXON, 1995. Geological Society of South Africa, PO Box 44283, Linden 2104, Johannesburg. pp xix, 290, illus. in colour, hardcover. Price on application. ISBN 0 620 19324 7.

Published to celebrate the centennial year of the Geological Society of South Africa, this book includes so much information on gem minerals that simply to turn to page 69, rhodochrosite crystals, or 53-quartz, or 162-map of the diamond field of Griqualand West, will compel gemmologists to consider buying the book. While there is the expected descriptive section covering South African minerals, this comes towards the end of the text and is preceded by chapters arranged under Archaean, Proterozoic and Phanerozoic periods: each of these sections is subdivided to give the geology and mineralization of major areas in South Africa. Maps and diagrams accompany a set of colour photographs of very high quality: the species descriptions give chemical composition, colours and localities, and there is an extensive bibliography, arranged alphabetically within geological periods. Gemmologists who are not geologists should not for that reason ignore this book which is likely to remain the standard work on South African minerals for some years.

M.O'D.

The gem merchant: how to be one, how to deal with one.

D.S. EPSTEIN, 1996. Gem Business Publications, Murfreesboro, TN [PO Box 3145 Murfreesboro TN 37130]. pp 149, illus. in colour, softcover. US$18.00.

Despite the *doppelgänger*-ish suggestion of the title, the author has found it fun to be a gem dealer and others must have enjoyed dealing with this amiable and loquacious resident of Teofilo Otoni, Brazil. A welcome change from the serious tone of many gem books, this is a delightful account of the difficulties to be born in mind when setting up (or out) as a peripatetic gem dealer. There is a good deal of common sense (and, it must be said, a number of unimportant misprints) in the book and the stones shown in the final colour plate are badly out of focus: but, as the author might have said – for this price, what do you expect? I recommend all gemmologists to buy it – there have been few accounts of a gem dealer's life since the 1960s and the book is fun.

M.O'D.

ISSN: 1355–4565

The Weardale mines.

R.A. Fairbairn, 1996. Northern Mine Research Society, Keighley. pp 151, illus. in black-and-white, softcover. [*British mining*. No. 56]. Covered by annual subscription to the Society. ISBN 0 901450 46 4.

Gemmologists with an interest in minerals will greatly welcome this monograph which describes the mining of lead and iron ores in the Weardale parishes of Stanhope and Wolsington in north-east England. With the ores came magnificently-coloured specimens of fluorite. Following the concise but lucid presentation of mining history the book describes mines and veins in detail, following a geographical arrangement, backed up by a reliable index. As anyone who has investigated old mines will know, names change bewilderingly! The information given is very detailed and in many cases veins and levels are shown in maps.

M.O'D.

Minerals of the Burra mine, South Australia.

B. Grguric, A. Pring and G. Drew, [1995]. Mines and Energy South Australia, Eastwood SA. (*Special publication* no. 11, Mines and Energy South Australia.) pp 32, illus. in colour, softcover. Price on application. ISBN 0 7308 0108 X.

The Burra mine is a source of high-grade ornamental-quality malachite which occurs with azurite. Specimens were known as long ago as 1877: some botryoidal pieces have a high natural polish and crystals up to 10 mm in length are also known. A list of mineral species found at the mine is given: a number of species are shown in colour and there is a short bibliography. This is a useful booklet for those interested in ornamental copper minerals.

M.O'D.

Minerale: Bestimmen nach äusseren Kennzeichen. 3 Auflage.

R. von Hochleitner, H. Philipsborn and K.L. Weiner, 1996. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. pp v, 390, illus. in colour, hardcover. DM 98.00. ISBN 3 510 65164 2.

This text is the third edition of *Tafeln zum Bestimmung der Minerale nach äusseren Kennzeichen*, a title which first appeared in 1866 under the authorship of Albin Weisbach of the Bergakademie Freiberg. The most recent edition was published in 1983. The text is simply and clearly laid out and represents a quick-reference guide to 487 mineral species, for which name, composition, crystal system, form and habit, physical and optical properties, mode of occurrence and location are given, the data occupying a whole opening section and concluding with notes on associated species. Brief introductory material includes notes on crystal morphology and notation and there is a short bibliography and a polyglot glossary. A section of high-standard colour photographs occupies the end of the book which is an excellent addition to the German tradition of well-produced mineral guides.

M.O'D.

Bulgari.

D. Mascetti and A. Triossi, 1996. Abbeville Press, New York. [488 Madison Avenue, New York, NY 10022]. pp 255, illus. in colour, hardcover. £57.00. ISBN 0 7892 0202 6.

The Italian jewellery firm of Bulgari has been prominent in Rome for virtually the whole of this century and is remarkable for its recognizable style of artefacts which are beautifully illustrated in this excellent book. This history of the firm is recounted with interesting notes on various personalities, including some celebrated customers, and the book will be essential reading for jewellery historians. Both jewellery and watches are included and the various threads in the development of the distinctive Bulgari style are examined. There is a short bibliography and the book displays the continuing excellence of modern jewellery history books.

M.O'D.

The pearl book: the definitive buying guide.

A.L. Matlins, 1996. GemStone Press, Woodstock VT. pp ix, 198, illus. in colour, softcover. US$19.00. ISBN 0 943763 15 0.

Though the author claims that there are many books on pearl, I have not seen an excess of good ones! This, though, could well be the one worth waiting for! As usual this author is eminently practical in her approach to a tricky subject and directs her advice to the potential pearl buyer. The text includes descriptions of some of the important pearls in history, biographies of some of the major figures in the pearl world and also a section in which leading jewellers and designers describe their feelings for and their use of pearls. Pearl price tables are also provided.

These novel sections are accompanied by plenty of bread-and-butter information which will help both buyer and student. Details of imitations and enhancements are given and identification tests described. I recommend the book, at so reasonable a price, to all gemmologists and students.

M.O'D.

Jewelry & gems: the buying guide.

(Third edition, revised)

A.L. Matlins and A.C. Bonanno, 1995. GemStone Press, Woodstock VT. pp xx, 262, illus. in colour, softcover. US$16.95. ISBN 0 943763 11 8.

This book can be recommended particularly for students for whom the standard gemmology textbooks lack trade coverage. The approach is well away from the airy advice given by other books attempting similar coverage: anecdotes are pointed and data accurate. Though it cannot be said too often, the book yet again encourages the trade to look more kindly on education and emphasizes the point by selected stories recounting loss of money and reputation when neither need to have been put at risk. The chapter on appraisals is timely and sensible and so are the remarks on investing in gemstones. At the price, all gemmologists should have the book.

M.O'D.

Agate, microstructure and possible origin.

T. Moxon, 1996. Terra Publications, Auckley, Doncaster. [Copies available from the author at 55 Common Lane, Auckley, Doncaster, DN9 3HX.] pp 106, illus. in black-and-white, softcover. £7.50 including post and packing. ISBN 0 9528512 0 2.

A description of the formation and structure of agate with a discussion on how its varied colours arise. Particular attention is paid to specimens from the United Kingdom and an overview is given of the various theories on agate formation proposed since the eighteenth century. An interesting book which will act as a springboard for further speculation.

M.O'D.

Minerals of New Mexico.

(Third edition, revised by Florence A. LaBruzza)

S.A. Northrop, 1996. University of New Mexico Press, Albuquerque. pp xiii, 346, hardcover. US$75.00. ISBN 0 8263 1662 X.

Revised from the previous edition published in 1959, the book lists and describes New Mexico mineral species in alphabetical order, this main section following introductory matter covering highlights of New Mexico mineralogy and mining with dates of notable finds. Following the descriptive section is a list of 172 districts, subdistricts and camps, some of which are referred to the following map section. Mineral species are then presented under alphabetical order of county and the book concludes with a bibliography and eight maps.

In the descriptive section chemical composition is given in words rather than symbols and this could easily lead to inadequate presentation of a mineral's true nature and to confusion. Crystal system and predominating colour are also given but nothing else, apart from accounts of discovery, where significant records exist and location details which are rather sketchy. The ornamental minerals of the state are well known and some details can be found, but there is disappointingly little information on many species and too many out-dated and discredited names are included, jamming up the text and making the jumbled information hard to sort through.

The book bears too many signs of the breathless style long associated with the enthusiastic amateur collector to be worthy of consideration as a serious state mineralogy: there are no colour photographs and the maps are unworthy of a tourist leaflet. We must hope that a fourth edition redresses the situation: the state's mineralogy is of considerable importance and deserves better than this.

M.O'D.

The regalia of the Russian empire.

I. Polynina and Rakhmanov, 1994. Red Square, Moscow. [23 Vorontsovskaya, Moscow, 109147.] pp 239, illus. in colour, hardcover. Approx. £90.00. ISBN 5 900743 04 2.

The senior author is head of the Diamond Fund Exhibition at the Moscow Kremlin and has previously co-authored *Russia's Diamond Treasury*. The present work is therefore of an expected high standard both of text and especially of illustration and can rank with the very best Russian productions of recent years.

The subject is the crown jewels and robes of the Russian state and is treated chronologically, with a number of reproductions from major MS and printed texts: a good deal of history is lucidly presented and there is an extensive bibliography consisting entirely of works in Russian: many can be consulted in major university libraries and it is a relief to find an information source which does not circulate the same few books which are well-known to all.

It is the colour plates, however, that catch the eye and which will sell the book. Most of them are full-page and the stones in some of the regalia show up clearly: I was pleased to renew acquaintances with several items from the Diamond Treasury which I remembered from a visit in less easy times. Since copies of Russian books often sell out quickly in western Europe readers are advised to buy one as soon as they can.

M.O'D.

Mysteries of ancient China: new discoveries from the early dynasties.

J. Rawson, 1996. British Museum Press, London. pp 303, illus. in colour, softcover. £25.00. ISBN 0 7141 1472 3.

Forming the catalogue of an exhibition held at the British Museum in 1996, the book covers a range of Chinese artefacts from discoveries made in recent years. The rate of discovery has greatly increased and it is not surprising that some jade artefacts have turned up along with bronzes, stoneware and textiles.

The exhibition and thus the catalogue is arranged chronologically so that the different materials have to be sought in more than one section. This is no disadvantage since turning through the pages reveals much interesting matter. Though there are not many specimens of jade (nephrite), the examples shown and described are especially fine. There are useful maps and an excellent bibliography.

M.O'D.

Photographing minerals, fossils and lapidary materials.

J.A. Scovil, 1996. Geoscience Press, Tucson, AZ. pp xv, 224, illus. in colour, hardcover. About £35.00. ISBN 0 945005 21 0.

This book fills an inexplicable gap in earth science literature and should be considered for purchase by any gemmologist with a camera. Scovil is a well-published photographer and the colour photographs are of exceptional quality even for today.

The text ranges from specimen choice, preparation and support (important for crystals and groups) through the advantages and disadvantages of different formats, choice of film, camera and lenses, lighting, meters, filters and paper. Microphotography and stereophotography sections precede notes on fluorescence photography. Final chapters deal with packing and transportation, slide presentations, gadgets and sources of supply. There is a glossary and an excellent bibliography, including the valuable technical leaflets published by Kodak and others. Gemmologists will find so much information touching on gem testing that they should get the book, whether or not they are photographers.

M.O'D.

The dealer's book of gems and diamonds.

M. Sevdermish and A. Mashiah, 1996. Kal Printing House, Israel. pp xxiv, 1004, 2 vol., illus. in colour, hardcover, in slip case. £70.00. ISBN 965 90072 1 3.

It is some years since a comprehensive survey of gemstones was published in English and it hardly seemed possible that there would ever be a completely new book of this kind. Nonetheless, the authors have provided the gemstone and gemmology community with a major work, conveniently divided into two volumes, the second of which is devoted almost entirely to diamonds, which are thus separated from the discussions of other major gemstones in the first volume. This arrangement works quite well and apart from a small section in the second volume which deals with gemstone formation, properties, inclusions and testing – perhaps these would have made the first volume too long – the order seems perfectly logical. To test the arrangement I looked first at the diamond section to see if it did indeed stand alone without constant references to the first volume.

The second volume begins with diamond sources and mining and is sufficiently up-to-date for Chinese and Canadian deposits to be included. Next comes a description of diamond trade development, followed by a discussion of diamond crystallography and properties. This section contains all that the student should know and will also be useful to the diamond polisher and dealer. The rest of the volume covers synthetic diamond and diamond simulants, exhaustive sections on polishing and grading, with tables, notes on the history of diamond polishing and on diamond re-cutting appearing as appendices. Between the diamond section and the appendices comes the gemstone formation section already mentioned.

It is possible that readers of the second volume will need to turn to the first to find out the meaning of some of the instrument names and the significance of some of the tests used for diamond and its simulants but this is not a great disadvantage: the alternative would have been to explain everything as the text went along and would have made an unwieldy book.

The authors' enthusiasm clearly shows in the first volume where many old friends step on to the stage once more and very welcome they are: faceted painite still eludes us (there must be some) and if painite is in, what about taaffeite, smithsonite, tugtupite, willemite, zincite? They lurk in the index, tables and in the coloured pictures, however, and no book can or even should be fully comprehensive. But it does look as though rare stones beginning with T onwards have been banished! This is not a serious criticism. A silver star, however, for the authors' explanation of varying refractive index and other numerical values in the literature: such an explanation ought to be in all texts and notes but isn't. A gold star for the typography which is one of the best I have seen in any book on gemstones, making it exceptionally pleasing and comfortable to read. Some of the photographs, too, are quite first-class and many of them are the responsibility of the senior author. The book is successful and deserves wide circulation.

M.O'D.

A collector's guide to rock, mineral and fossil localities of Utah.

J.R. Wilson, 1995. Utah Geological Survey, Salt Lake City. [Utah Geological Survey. *Miscellaneous publication* 95–4.] pp vi, 148, illus. in colour, softcover. Price on application. ISBN 1 55791 336 8.

The name Utah will send gemmologists searching for remarks on red beryl and brown topaz locations and here they are in this lucid and interesting survey arranged in order of counties. While the coloured pictures lose by being set against a pinkish rocky background the text is simple, well-referenced and indexed. Directions to the locations are given, with the exception of the red beryl deposit in the Wah Wah Mountains, commercially important and in the news at the time of writing. The reviewer worked on this mine a few years ago and can testify that it would be hard to find – 80 miles from the mine office! The author does not fail to mention that many of the sherry-brown topaz crystals fade on exposure to bright sunlight.

M.O'D.

The Scottish pearl in its world context.

F. Woodward, 1994, Diehard, Edinburgh. pp iii, 165, softcover. £6.50. ISBN 0 946230 27 7.

This excellent book successfully combines up-to-date zoology, conchology, history, commerce and conservation with gemmology waiting in the wings. It is thus not a gemmological treatment of Scottish freshwater pearls, but rather an attempt to place them in their zoological context with accounts of their recovery over the years and of attempts to preserve their habitat. But there is plenty of useful information on a topic scarcely covered monographically during this century. Celebrated Scottish pearls are described and some of the best-known locations are mentioned. A welcome freshwater mussel recording scheme deserves public support and details are given, while the Universal Naiad Information Organization [UNIO] is now working on the establishment of an international network co-ordinating workers and projects on freshwater bivalves. With details of some monographs and papers scattered through the text a separate bibliography would have been welcome, but this is a very small blemish on an otherwise praiseworthy effort. Anyone with an interest in organic ornamental materials should buy the book which is very reasonably priced.

M.O'D.

Opal: the gem of the Never Never.

T.C. Wollaston, 1924. Thomas Murby & Co., London. pp 168, illus. in colour, softcover. Privately published in Australia and unpriced.

'By degrees [the black opal's] rare beauty has triumphed and it is the author's personal belief that fifty years hence the finest specimens of it may prove to be the costliest gems on earth – he writes enthusiastically and also with abundant knowledge. His book is neither a scientific treatise nor a history of the opal industry: it is a mixture of both, combined with sketches of the human daring and endeavour that such a speculative job as opal-mining must have inevitably produced. Its unconventionality is one of its charms.'

This is part of a review published in *The Birmingham Post* in December 1924 and the original colour photographs have reproduced well in this smaller format reprint. Readers should watch for a wider distribution of this fascinating book.

M.O'D.

Cartier, splendeurs de la joallerie.

ANON, 1996. La Bibliothèque des Arts, Lausanne. pp 157, illus. in colour, softcover. £36.00. ISBN 2 88453 013 4.

An exhibition catalogue forming a review of work by the Paris firm of Cartier with major ornamental artefacts illustrated in colour and smaller items in black-and-white. A brief history of the firm is given: colour photographs are well up to the best quality obtaining today.

M.O'D.

Boucheron.

ANON, 1996. London. pp 44, illus. in colour, hardcover. £14.00.

An illustrated catalogue of items currently available from the London branch of Boucheron and featuring a collection of enamels as well as jewellery and watches. Colour reproduction is excellent.

M.O'D.

Catalogue of the Exhibition of Ch'ing Dynasty costume accessories.

National Palace Museum, Taipei, Taiwan, 1986. pp 352, illus. in colour, softcover. Price on application. ISBN 957 562 021 6.

Though ten years old, this beautifully-illustrated catalogue has just come to my attention and is worth noting for its notes on the exhibits (which include artefacts containing jade, organic substances and gemstones) which are described in English and in Chinese. In addition the catalogue describes the materials used in a very useful introduction presented both in English and Chinese. The colour reproduction of jade and gold, in particular, is exceptionally good.

M.O'D.

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

OBITUARY

Reginald Jewitt Peace, B.Sc., AIBMS, C.Chem., FGA, FRSC, died suddenly at home on 28 September 1996. Reg was born in Hull on 10 December 1927. He attended Hymers College and was a promising Rugby Union player for Withernsea 1st XV. After serving in the RAMC mainly on the Hospital Ship 'Somersetshire' in the Middle and Far East, he qualified as a chemist and later as a biochemist at the old Hull Royal Infirmary. He then spent ten years as a chemistry lecturer at the College of Technology, gaining the Fellowship of the Royal Institute of Chemistry before joining the staff of Beverley High School as Head of Chemistry, a post he held for 21 years.

Reg married Heather in 1955 and recently celebrated their 41st anniversary. He had two daughters, Elizabeth and Bridget, and five grandchildren, Siobhan, Nathan, Joel, James and Joseph. They gave him a great deal of happiness and a few more grey hairs!

An interest in gemstones saw him qualify as a gemmologist, becoming a Fellow of the Gemmological Association of Great Britain. Very soon after he put his teaching experience to good use and as a tutor in gemmology. Reg taught students from the four corners of the world, many of whom became personal friends. Reg also contributed materially to the educational development of the Association and latterly contributed a regular stream of abstracts for the *Journal*.

During his ten years of retirement he continued to develop a wide range of interests and became Captain of the Elderly Gentlemen's Golfing Society; his final match in Pocklington brought him back, appropriately enough, to the place of his childhood evacuation during the Second World War. His thirst for knowledge was unquenchable and his interest in computers became a consuming passion. He recently gained qualifications in computing and spent many happy hours surfing the internet!

Reg was a man of immense loyalty and integrity being thought of by many as one of life's true gentlemen. He tackled any task with enthusiasm and fervour and would not let anything beat him. His memory will live as an inspiration to us all, to learn from every experience, to use every second to advantage and to strive for perfection.

Compiled from contributions by Reg's family and friends.

Mr Graham D. Llewellyn, FGA (D.1948), Chislehurst, died on 28 September 1996.

GIFTS TO THE ASSOCIATION

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

Mr Arlid Anderson, FGA, Oslo, Norway, for a cabochon-cut peridot 4.77 ct and an oval faceted peridot 2.15 ct from Sunmøre, Norway, and three emerald crystals from Byrud Farm, Lake Mjøsa, Norway.

Mr Michael Gray, Missoula, Montana, USA, for a sample of mica from pegmatite.

Judith Osmer, Los Angeles, California, USA, for a YGG crystal.

ISSN: 1355–4565

Dr Xia Songyao, BG Gemmological Institute, Beijing, P.R. China, for seven crystals of beryl, variety emerald, from Yunnan, China.

Matthew Woods of Siegen, Germany, for a crystal and a cut stone of spessartine garnet from Kashmir.

NEWS OF FELLOWS

On 27 October 1996 **Michael O'Donoghue** gave a hands-on demonstration of Montana sapphires and their colour to the Gemmologisch Gilde Nederland; on 3 November he presented a paper on synthetic gemstones to the South-East branch of the Russell Society at Beckenham. Alan Hodgkinson gave a series of lectures in a number of locations throughout the USA during October and November 1996.

MEMBERS' MEETINGS

London

The Annual Conference on the theme 'Exceptional Gems' was held at the Scientific Society's Lecture Theatre, London W1, on 13 October 1996. A report was published in *Gem and Jewellery News*, December 1996.

On 20 November at the Gem Tutorial Centre, 27 Greville Street, London EC1N 8SU, David Callaghan gave an illustrated lecture entitled 'The mystery of opal'. His presentation included a live video camera recording of a revolving opal, emphasizing the ever-changing display of colours produced by these gems.

On 4 December at the Gem Tutorial Centre, Cally Hall gave a lecture entitled 'Burmese gems at the Natural History Museum'.

Midlands Branch

On 27 September 1996 at the Discovery Centre, 77 Vyse Street, Birmingham 18, John Henn spoke on 'Technological developments in the jewellery trade'.

On 25 October at the Discovery Centre, Richard Taylor gave a talk entitled 'Jewellery, gems and litigation'.

A practical training day was held at the New Cobden Hotel on 27 October.

On 29 November at the Discovery Centre, Shena Mason gave a talk entitled 'Jewellery for the world and his wife'.

North-West Branch

On 16 October at Church House, Hanover Street, Liverpool 1, Richard Digby gave an illustrated talk entitled 'Cameos, second-hand and antique jewellery'. A report was published in the December 1996 issue of *Gem and Jewellery News*.

Scottish Branch

On 17 October 1996 a Quiz Night and Bring and Buy was held at the Royal British Hotel, Princes Street, Edinburgh.

On 13 November a Lab Night was held at Telford College, Edinburgh.

PRESENTATION OF AWARDS

The Presentation of Awards gained in the 1996 examinations was held at Goldsmiths' Hall, Foster Lane, London EC2, on Monday, 11 November 1996. The President, Professor R.A. Howie, presided and congratulated the successful candidates. Among those present were award winners from as far away as Canada, China, Japan, Kenya and Taiwan, as well as Belgium, Finland, Greece and The Netherlands.

Professor Howie then related some of his early experiences in the world of gemmology: 'As one gets older and rises up the hierarchy of various organizations', he said, 'I have found that one gets increasing pleasure from being in a position to organize and facilitate rewards to one's colleagues for work often far beyond the normal call of duty: a pleasure quite distinct from any recognition of one's own work. When I first came to King's College, London, in 1962 as a Reader in Geology, having long been interested in gemstones as presenting a particularly attractive example of the problems arising in the identification of minerals, I was delighted to be invited along to the old work rooms in Hatton Garden where Basil Anderson and Robert Webster demonstrated for me the techniques of distinguishing between natural and synthetic ruby by their growth rings and inclusions. Indeed, Robert Webster came along to one of my peripatetic gemstone lectures at Chelsea College and afterwards said he could fault me only in having the specific gravity of alexandrite slightly wrong – but as I was only using this as an example of yet another property which could distinguish between synthetic ruby with a touch of vanadium, masquerading as alexandrite, and the true alexandrite, the principle was still valid.

'However, Basil Anderson was a King's man, having graduated with a joint degree in Chemistry and Geology, and I was able therefore to propose him for a Fellowship of the College. This took the best part of a year to get through the appropriate committees, but one day I was tackled in the corridor by the College Secretary – Lord High everything at that time – who asked me if I knew that the Americans spelt gemmology with only one m. I assured him that I did indeed know that, but it was only later on that I realized that this was his coded way of telling me that due checks had been made with the GIA in California. The response must have been reassuring, and in due course Basil Anderson became a Fellow of King's, an honour of which I know he was particularly proud.'

Professor Howie introduced David Callaghan who presented the awards and his address is set out below. Following the presentation of awards gained in the Gemmology and Gem Diamond examinations, David Callaghan presented Professor Howie with an Honorary Fellowship in recognition of his work in the field of gemmology.

The new Bruton Medal was displayed at the reception preceding the presentation. The award is named in honour of the immediate

David Callaghan, Professor Howie, Evelyne Stern, Noel Deeks and Roger Harding at the Presentation of Awards.

Bruton Medal design winner Garry Barrett receiving his prize from Evelyne Stern.

past President, Eric Bruton, who is well known internationally for his work on diamonds, and is to be awarded to the candidate who submits the best set of answers of sufficiently high standard in the Gem Diamond Examination. A design competition was held in 1996 for the medal. The prize-winning entry was submitted by Garry Barrett of Chatham, and he was presented with the prize of £250 by Gem Diamond Examiner Evelyne Stern.

A vote of thanks was given to David Callaghan by Noel Deeks, who referred to the major contribution David had made to both the Gemmological Association and the Gem Testing Laboratory. Noel encouraged those present to continue their involvement with gemmology. 'It may well be', he said, 'that, like David, you may consider becoming seriously involved with the Association as tutors or later as examiners to help us spread the knowledge of gemmology and follow in the footsteps of the people who have helped you reach your goal today.

'Our courses are now taught in over forty countries and in the UK we are seeking people to start new branches of the Association, especially in East Anglia and the West Country. To make these things possible we require the help of enthusiastic, qualified people. So if you feel you can assist, please get in touch.'

In conclusion Professor Howie thanked the Goldsmiths' Company for allowing the GAGTL to hold the ceremony at the Hall.

ADDRESS BY DAVID CALLAGHAN

'I began my career in the jewellery trade as apprentice to Hancocks & Company in September 1955. At that time apprenticeships were still available to retail jewellers but these were phased out by the end of the 1950s and have not been replaced. So I first sat in this room in the summer of 1956 when I sat the Preliminary exam having completed my first year at Chelsea Polytechnic. Those of you who have some interest in the history – or perhaps the folk-lore – of the Gemmological Association will know that the Chelsea filter was named after this school, it having been 'invented' by B.W. Anderson in the 1930s. Incidentally, I am so old-fashioned as to still use it frequently as a preliminary diagnostic instrument.

'I digress – I first sat in this awe-inspiring room in 1956 and soon found myself staring at the ceiling because I soon realized how little I knew once I started on the question paper. By the way – I failed the exam. I was convinced that it was the examiners' age, lack of comprehension of my work and general debility that caused me to fail – and my conceit enabled me to try again and give the examiners another chance! I did pass the next time. The first lesson learned therefore was:

> Be as sure as you can to understand how little you know, and you will still have a mind open to learning. However, the trick is to make sure others do not find out how little you know!!

'I have been very fortunate over the many years in this trade, and my good fortune began early when I first went down the stairs to the old Gem Testing Laboratory in Hatton Garden, known then as the Diamond, Pearl and Precious Stone Laboratory of the London

Chamber of Commerce – the Lab, for short. The Director then was the great gemmologist B.W. Anderson, leading the team of C.J. Payne, Robert Webster and Alec Farn – now 80 years old and the last of what B.W. Anderson referred to as the phalanx of four.

'What were the problems facing the gem trade at that time? 1955 saw the first synthetic diamonds produced, and in the same year the revolutionary strontium titanate arrived. That year the Gem Lab tested 138,484 pearls! To give you some idea of how synthetics occupied our minds I have referred to the *Journal of Gemmology* for the decades from 1955–56 to date:

Volume 5 1955–56	6 entries
Volume 10 1966	4 entries
Volume 15 1976–77	23 entries
Volume 20 1986–87	A whole page from alexandrite to zircon.

'We now talk blithely of metallic and gallium inclusions in synthetics, diamond-topped doublets, and quantitative cathodoluminescence of ..... This is just of synthetics but that is not the only problem for the gemmologist today. In my opinion the problem of the synthetic pales into simplicity when compared with the 'treatment' of gemstones. This is said as if a doctor is curing a patient, or in similar terms that politicians refer to the continual problems in Ireland by the euphemism 'the troubles'. In my opinion the synthetic gemstone is an honest product of man's ingenuity, but what of the 'treated' gemstone? Consider just a few of these treatments:

- the oiling of emerald;
- the impregnation of emerald with plastic;
- the similar treatment to precious opal;
- pearls are bleached, dyed, stained and irradiated;
- diamonds are laser drilled and glass infilled; and
- sapphires and rubies are heated and glass infilled.

Does the trade in general mind? Let me warn you that much of the trade does not. It is 'accepted trade practice' and therefore an acceptable part of the business. I reject that utterly.

'Those of you now qualified are going to be subjected to enormous pressures in your career, pressures by those who have only a vested interest in the sale of their product. These sinister practices hide behind words such as 'enhancement' and 'induced colour'. The very use of the word synthetic is avoided wherever possible by the promoters of their product. I have looked at definitions of the words:

Synthetic – not natural – man made – not sincere – sham –

Enhance – to intensify – to rise in value.

'Now we are getting near the reason, are we not? The trade is fast becoming, or indeed may have already become, the victim of marketing. Let me define that 'technique' to you:

Marketing – the business techniques or process by which anything may be sold – note anything!!

'I have thought long and hard about these words and the glossing over of what is happening to the gemstone today. I wish to suggest to you a new definition of stones which have been tampered with – they are an *enticement.*

Entice – to tempt or persuade by arousing hopes or desires or by promising a reward – to lead astray.

'There you have it, Mr President, ladies and gentlemen – those last three words – to lead astray!!

'On top of all this the marketing agents all want to have Reports of Origin particularly when it adds to the price of a stone.

'Please note I say the price – I do not say the value. Other reports which give such information as 'No evidence of heat treatment was observed' or 'No evidence of staining was observed', become translated as *unheated* or *not stained.* In other words no treatment. That is not honest.

'And you, the new entrants to the trade, are going to be pushed further and further to provide pieces of paper which allow the Auction Rooms and uncaring trades the comfort of selling someone else's property with clean hands.

'When Basil Anderson first wrote his book *Gem Testing* in 1942 he spoke clearly about the gemstones. He always spoke clearly and he wrote as he spoke. Please read his works – they may be 'old hat' now but they came from the heart, and from one who loved the trade and its history. He had no commercial slant to his words and neither should you. In his book *Gemstones for Everyman* his first chapter is entitled "What exactly is a gemstone?" and I will read the first paragraph.

> "The World is full of a vast variety of beautiful things, but most of them are ephemeral. The dewdrop and the daffodil, the rainbow and butterfly, last for a few moments or a few days and are gone; preserved only in memory or in lines written by a great poet. Precious stones, more than any other things which are lovely to the eye, endure, in terms of human measurement, eternally."

'I accept that man is ingenious, inventive and curious. That is fine and of course there is a place for the synthetic and the heated gemstone. But say so, unequivocally. Don't hide behind such words as Gilson, Chatham, Biwa, South Sea, etc. Say it for what it is – synthetic, freshwater cultured pearl, South Sea cultured pearl. In other words, it is not enough to mean what you say, you must say what you mean.

'In his last public lecture Basil Anderson closed with these words, the words of an unassuming man but a giant in his field:

> "Through all my life I reckon myself very, very lucky to have just by chance become a gemmologist. I've no particular skills or talents but great enthusiasm, and I've been able to use it to my limit, and I've made wonderful friends throughout the world in consequence."

'I say Amen to that and I truly wish that you will be able to say the same at the end of your career. Thank you for listening to me for so long.'

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held at 27 Greville Street, London EC1N 8SU, on 18 September 1996, the business transacted included the election of the following:

Diamond Membership (DGA)

Daniel, Eliena May Josephine, Brighton, 1996.
Ezzeddine, Marwan, Winchmore Hill, London, 1996.
Jurvakainen, Risto Kalervo, Helsinki, Finland, 1996.
Sveen, Per Olav, Heimdal, Norway, 1996.

Diamond Membership and Fellowship (FGA/DGA)

Kesheng, Chen, Guangxi, China, 1991/1995.

Fellowship (FGA)

Barnes, Patricia Ellen, Dunkirk, Md, USA, 1996.
Brangulis, Peters, Riga, Latvia, 1996.
Cameron, Iain Alexander, Wimbledon, London, 1996.
Chan, Wai Keung Addy, Hong Kong, 1996.
Cheung, Sau Ping Pamela, Kowloon, Hong Kong, 1996.
Clark, Antony, Bolton, 1996.
Curtis, Simon James, Paignton, 1996.
Getgood, Fiona Josephine, Hastings, 1996.
Harris, Annette Mia, Hanbury, 1996.
Janssen, Maurice Jan-Willem, Aruba, Dutch Caribbean, 1996.
Kenny, Sark, Kowloon, Hong Kong, 1995.
Kwok, Esther, W.S., Vancouver, B.C., Canada, 1996.
Lloyd-George, Kim, Los Angeles, Calif., USA, 1985.
McKenzie, Wilma Anne, S. Surrey, BC, Canada, 1996.
Naing, Aye Myo, Yangon, Myanmar, 1996.
North, Sara Elizabeth, York, 1991.
Parsons, Michael John, Bath, 1996.
Popov, Vladimir, Tallinn, Estonia, 1996.
Rege, Sonal, Pune, India, 1996.
Sallinen, Virpi Hannele, Helsinki, Finland, 1996.
Tsang, Wai Yi Rita, Hong Kong, 1996.
Whiting, Sarah Katherine, Crouch End, London, 1996.
Willis, Kathryn, Muswell Hill, London, 1996.
Yoshikawa, Yoichi, Osaka, Japan, 1996.

FORTHCOMING MEETINGS

LONDON BRANCH

Meetings will be held at the GAGTL Gem Tutorial Centre, 2nd floor, 27 Greville Street (Saffron Hill entrance), London EC1N 8SU. Entry will be by ticket only at £3.50 for a member (£5.00 for a non-member) available from the GAGTL.

12 February
Sleepers – rediscovery and reattribution in the antique jewellery trade Geoffrey C. Munn

12 March
How will our Garden grow? Adrian Klein

16 April
Make paste! Imitating precious and semi-precious stones over 5000 years Ian Freestone

7 May
150 years of Cartier Terry Davidson

MIDLANDS BRANCH

Monthly meetings will be held at the Discovery Centre, 77 Vyse Street, Birmingham 18. Further details from Gwyn Green on 0121 445 5359.

23 February
Gem Club – **Treated stones** Eric Emms

28 February
A gemmological journey from the Alps to Vesuvius E. Alan Jobbins

21 March
A talk on pearls

23 March
Gem Club – **Synthetic gemstones and their identification** Alan Hodgkinson

20 April
Gem Club – **Demonstration of diamond cutting techniques** David Proudlove

25 April
AGM followed by **Gems from the Law** John Bugg

18 May
Gem Club – **Diamond grading day** Gwyn Green

NORTH-WEST BRANCH

For details of meetings contact Joe Azzopardi on 01270 628251.

19 February
Power and Gold. A talk and conducted tour at the Liverpool Museum

19 March
A talk by Brian Dunn of Garrard's

SCOTTISH BRANCH

For details of Scottish Branch meetings contact Joanna Thomson on 01721 722936.

12 February
Lab Night Barmulloch College, Barmulloch Road, Glasgow

14 March
Valuations Euan Taylor

18–20 April
AGM. **Weekend Tutorial** in Peebles with Alan Hodgkinson and **Field Trip**

Ordinary Membership

Aladin, Naila, London.
Adeleye, Ernest, London.
Bang, Michael, East Grinstead.
Biberstein, Adrienne Francine, Kilchberg, Switzerland.
Christou, Angelos, Limassol, Cyprus.
Chung Luk-Mui, Ivy, Kowloon, Hong Kong.
Davies, Paul Brian, Great Missenden.
Deligianni, Christina, Athens, Greece.
Deutscher, Gilad, Kiryat-Ono, Israel.
Dewey, Paul, Netherfield.
Forward, Stephen, London.
Halday, Farzana, London.
Hashimoto, Hiroko, London.
Hill, Emma, Maida Vale, London.
Iqbal, Sameer, Gold Souq, Dubai.
John, Victoria Alexei, London.
Kaneko, Miki, St John's Wood, London.
Kerr-Patton, Cecilia, Hampstead, London.
Kim, Jung Shin, Hammersmith, London.
Lai, Ya Yu, Richmond.
Lam, Jill, Rochester.
Leal, Barbara, L., Cambridge.
Malik, Javaid, I., Lusaka, Zambia.
Muller, Hellen, A.D., Wierden, The Netherlands.
Munro, Camilla Morna, Holland Park, London.
Ng, Melloney, Bexleyheath.
Nunes, Clive Neville, London.
Pancratz, Mark, Weybridge.
Renard, Joelle, M., Ruislip.
Roobol, Michael John, Canterbury.
Seth, Rashni, Cobham.
Shah, Varsheet, Kingston.
Sham, Raymond, Vancouver, BC, Canada.
Speake, Malcolm Frank, Ladywood, Birmingham.
Thomas, Jessica Catrin, Glasgow.
Vassiliou, Marianna, Nicosia, Cyprus.
Verny-White, Catherine, Richmond.
Weldon, James, Dublin, Ireland.
Williams, Lisa Jocelynne, Worcester.
Wong Poon, Wai Chun Olivia, Hong Kong.
Yoshitake, Yumi, Cardiff.

Transfers – Fellowship to Fellowship and Diamond Membership (FGA/DGA)

Abramian, Levon, London, 1996.
Baker, Kimberly Helen, Mountsorrel, Loughborough, 1996.
Bowis, Mark Lister, Colliers Wood, London, 1996.
Buxani, Naina Mahesh, Kowloon, Hong Kong, 1996.
Cadby, Sarah, Highgate, London, 1996.
Clarke, Norman V., Dunfermline, 1996.
Daniels, Razia, Chester, 1996.
Dinnis, Simon John, Swadlincote, 1996.
Dokken, Aarrynne, D.C., Carshalton, 1996.
Kathoon, Junaida, Singapore, 1996.
Lake, Richard John, Gorey Village, Grouville, Jersey, 1996.
Lin, Sung-Shan, Taipei Hsien, Taiwan, 1996.
Lodge, Sara Anne-Marie, Lowdham, 1996.
Lord, Karen, Lutterworth, 1996.
McIntosh, Robert P., Penicuik, 1996.
Mitchell, Beverly J., Hendon Central, London, 1996.
Sotolongo, Sachiko Kashiba, London, 1996.
Turner, Caroline, Walberswick, 1996.
White, Michele, Moseley, Birmingham, 1996.
Withington, Terry, Aylesbury, 1996.

Transfers – Ordinary Membership to Fellowship and Diamond Membership (FGA/DGA)

Mitteregger, Unni, London, 1996.
Pepprell, Eija-Liisa, London, 1996.

Transfers – Ordinary Membership to Diamond Membership (DGA)

Burch, Clive, Cleadon near Sunderland, 1996.
Coker, Olive Admira, London, 1996.
Jones, Maureen, Allesley, Coventry, 1996.
Lam, Siu-Wing, Hong Kong, 1996.

Transfers – Ordinary Members to Fellowship (FGA)

Aarden-Kilger, Flavia, L.M., Haalderen, The Netherlands, 1996.
Achten, Louisa W.W., Horst, The Netherlands, 1996.
Adams, Victoria, London, 1996.
Forbes, Victoria E., Portadown, Co. Armagh, N. Ireland, 1996.
Fujii, Noboru, Nara City, Nara Pref, Japan, 1996.
Haria, Aarti Vipul, Nairobi, Kenya, 1996.

GAGTL Gem Tutorial Centre

5 February	**Emeralds Today** A valuable and concentrated look at all aspects of emerald: natural, rough and cut stones, treated, synthetic and imitation stones. *Price £123.00 (including sandwich lunch)*
11–12 February	**Synthetics and Enhancements Today** Are *you* aware of the various treated and synthetic materials that are likely to be masquerading amongst the stones you are buying and selling? Whether you are valuing, repairing or dealing, these two days of insights, tips and practical investigation will increase your knowledge of current gems on the market. *Price £245.00 (including sandwich lunches)*
19 February	**Diamonds Today** A valuable and concentrated look at all aspects of diamonds: rough and cut stones, treated, synthetic and imitation materials. *Price £123.00 (including sandwich lunch)*
5 March	**Ruby and Sapphire – The Inside Story** A day looking at all aspects of these gems – natural, treated, synthetic and imitation. *Price £123.00 (including sandwich lunch)*
19 March	**Preliminary Workshop** A day of practical tuition for Preliminary students and those who need an introduction to instruments, stones and crystals. You can learn to use the 10x lens to maximum efficiency, to observe the effects and results from the main gem testing instruments and to understand important aspects of crystals in gemmology. *Price £51.70; GAGTL students £37.00 (including sandwich lunch)*
26–27 April	**Two-Day Preliminary Practical Workshop** This new course is designed to help students prepare for the Preliminary examination by providing the opportunity to see first hand the material discussed in the notes. *Price £131.60 (£94.00 for GAGTL registered students) – includes sandwich lunches*

NOTE: All prices include VAT at 17.5%

Please ring the Education Office (0171 404 3334) for further information

Hegi, Matthieu Manuel Marie, Geneva, Switzerland, 1996.
Ho Yan Yee, Winnie, Hong Kong, 1996.
Hopley, Katharine Bridget, Coventry, 1996.
Khairallah, Theresa, London, 1996.
Kitamon, Hideaki, Yamatokouriyam City, Nara Pref, Japan, 1996.
Kritikou, Eleni, London, 1996.
Lam Chiu Hung, Kowloon, Hong Kong, 1996.

Transfer – Ordinary Members to Fellowship (FGA)

Li, Lung Hsing, Taichung, Taiwan, 1996.
Lindwall, Torbjorn, Lannavaara, Sweden, 1996.
Mackay, Colin Alexander, Edinburgh, 1996.
Mourtzanos, Stefanos M., Rethymno, Crete, 1996.
Raphael, Menachem, Alwoodley, Leeds, 1996.
Ren Jiakai, Wuhan, P.R. China, 1996.
Ronkko, Veera Viktoria, London, 1996.
Schutt, Alan W., Coombe Dingle, Bristol, 1996.
Sharpe, Erica Jane, Wells, 1996.
Susan-Roet, V.E., Naarden, The Netherlands, 1996.
Yoshimura, Shinya, Osaka-City, Osaka, Japan, 1996.

At a meeting of the Council of Management held at 27 Greville Street, London EC1N 8SU, on 23 October 1996 the business transacted included the election of the following:

Diamond Membership (DGA)

Lao, Weng Hong, Macau, Hong Kong, 1996.
Mistry, Janak, Nanpura, Surat, India, 1996.
Wu, Liang-Chin, Tianan, Taiwan, 1996.

Diamond Membership and Fellowship (FGA/DGA)

Birrell, Andrew Tierney, N'Maidens, 1992/1996.

Fellowship (FGA)

Bäckström, Ingrid, Frösön, Sweden, 1996.
Clevers, Irene Laurina Rita, Utrecht, The Netherlands, 1996.
Darmudas, Nathan, London, 1983.
Dinh Ly, Huong, Weston, Ont., Canada, 1996.
Lindblom, Joachim Peter Leander, Turku, Finland, 1996.
Pham, Christina Tuyet Lieu Thi, Markham, Ont., Canada, 1996.
Seligman, Dominic, London, 1996.
Verma, Hitesh, Jaipur, India, 1996.
Wu, Ming-Hsun, Taipei, Taiwan, ROC, 1996.

Ordinary Membership

Abaee, Soleman, London.
Boccard, Jean-Marie, Geneva, Switzerland.
Borg Olivier, Kathleen, London.
Chan, Chi-Kian, Hong Kong.
Curran, Rose, Bath.
Day, Rebecca, Whiston.
Kiaer, Elisabeth, London.
Leadbitter, Elizabeth Victoria, South Ruislip.
Mao, Lingyun, Beijing, PR China.
Panagiotou, Panagiotis, Corfu, Greece.
Rosenberg, David, London.
Samaraweera, Basil Jayanatha, Basingstoke.
Shah, Rohit, Nairobi, Kenya.
Shih, Shu-Chuan, Hampstead, London.
Van Zanten, Sander, Arnhem, The Netherlands.
Williams, Cynthia Clare, Uxbridge.
Yang, Yuk Ngor, Sally, Hong Kong.

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Editorial: Box 162 Moscow 103050 Russia. Telephone/Fax: (7-095) 203 3574


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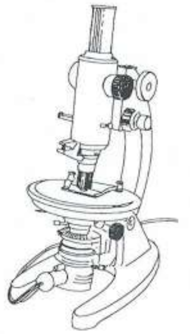

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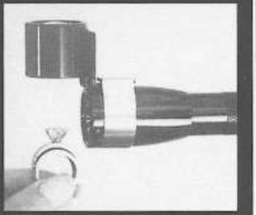

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Guide to the preparation of typescripts for publication in *The Journal of Gemmology*

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.

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

Title page The title should be as brief as is consistent with clear indication of the content of the paper. It should be followed by the names (with initials) of the authors and by their addresses.

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

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

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

A **This is a first level heading**

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

B *This is a second level heading*

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

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

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

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

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

Notes and References Authors may choose one of two systems:

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

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

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

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

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

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

Volume 25 No. 5

January 1997

The Journal of Gemmology

Contents

Cover Picture

A crystal fragment of tourmaline (green) partly superimposed with a cut green tourmaline which results in a remarkable change of colour. (See 'A new colour-change effect' p.325)

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