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Gemmological Association and Gem Testing Laboratory of Great Britain

27 Greville Street, London EC1N 8TN
Tel: 020 7404 3334 Fax: 020 7404 8843
e-mail: gagtl@btinternet.com Website: www.gem-a.info

Multi-star quartzes from Sri Lanka

Dr Karl Schmetzer[1] and Maximilian Glas[2]

1. Taubenweg 16, D-85238 Petershausen, Germany
2. Theresienstr. 12, D-82319 Starnberg, Germany

ABSTRACT: The patterns of intersecting light bands in multi-star quartzes from Galle, Sri Lanka, are described. Different groups of light bands form various types of networks consisting of numerous four-, six- and even eight-rayed stars. The orientations of needle-like inclusions, the axes of which are perpendicular to these light bands, have been determined. The most common type of a multi-star network is caused by two groups of nine (three plus six) symmetry equivalent sets of inclusions forming nine intersecting light bands. Up to five different groups of inclusions forming 18 intersecting light bands may be present in quartzes with more complex multi-star networks.

Introduction

Asteriated quartz, especially rose quartz, has been known for more than a century. Samples cut as cabochons or as complete spheres, in general, reveal a single six-rayed star which is caused by three sets of needle-like inclusions that are orientated parallel to the basal plane (see e.g. Goldschmidt and Brauns, 1911; Kalkowsky, 1915). The centre of this star is coincident with the *c*-axis of the quartz crystals. Rarely, twelve-rayed stars are also observed in quartz or rose quartz (Cassedanne and Roditi, 1991; *Figure 1*). Occasionally, complete spheres of rose quartz show additional, mostly weak light bands that are not related to the six-rayed or twelve-rayed centre star. These light bands are due to various groups of needle-like inclusions in different orientations in the host crystal (Kalkowsky, 1915; Maier, 1943; von Vultée, 1955). Speaking simply about asterism of cabochon-cut gemstones or of

Figure 1: *Sphere of very lightly coloured Brazilian rose quartz revealing twelve-rayed asterism. The diameter of the sphere is 55 mm, weight 279 g.*

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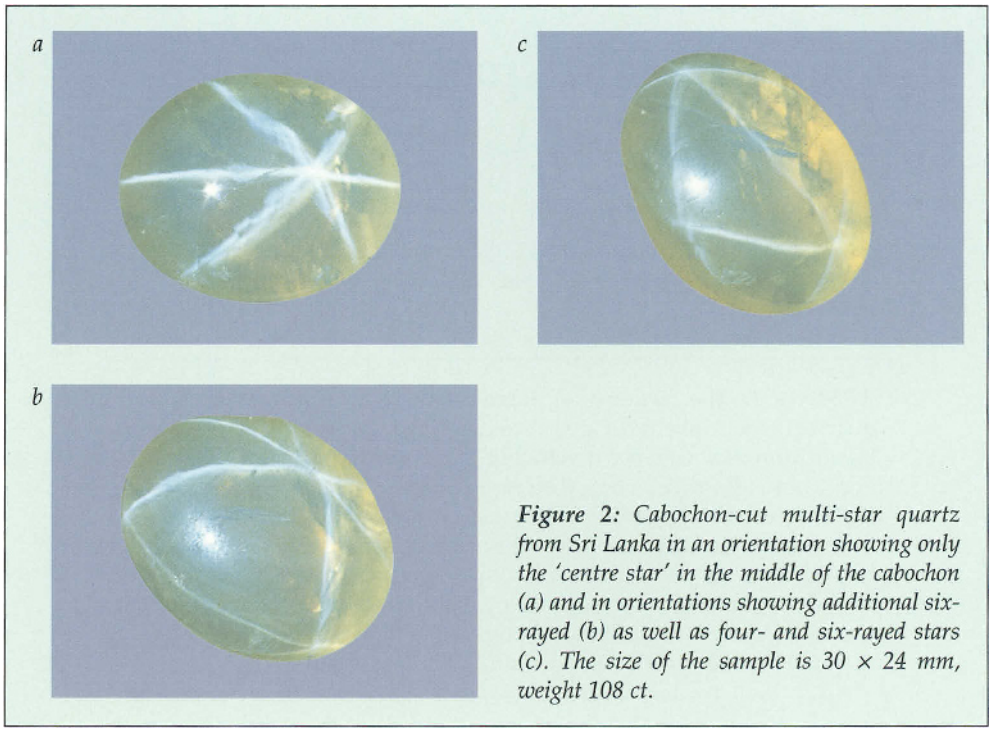


Figure 2: Cabochon-cut multi-star quartz from Sri Lanka in an orientation showing only the 'centre star' in the middle of the cabochon (a) and in orientations showing additional six-rayed (b) as well as four- and six-rayed stars (c). The size of the sample is 30 × 24 mm, weight 108 ct.

samples cut as a complete sphere, we normally describe observations in reflected light. This type of asterism is also called epiasterism. In contrast, asterism observed in transmitted light is called diasterism (see e.g. Kalkowsky, 1915; Maier, 1943; Fryer *et al.*, 1981).

Multi-star quartzes, i.e. quartzes that reveal more than one single star on the surface of a cabochon or a quartz sphere, on the other hand, are quite rare (*Figure 2*). Samples have been briefly described from Sri Lanka (Fryer *et al.*, 1984; Kumaratilake, 1997; Johnson and Koivula, 1999), from Alabama, USA (Fryer *et al.*, 1985) and from California, USA (Koivula and Kammerling, 1990). According to these descriptions, multi-star quartzes show either a six-rayed or a twelve-rayed star with a network of several additional six- and four-rayed stars. A schematic drawing of Kumaratilake (1997) shows a network of six-rayed stars, but the position of the four-rayed stars within this network is not indicated and the position and orientation of the different six-rayed stars relative to the quartz crystal structure is not known. The cause and orientation of multi-stars in other minerals, especially in spinel and garnet, on the other hand, is well understood (Switzer, 1955; Kumaratilake, 1998; Schmetzer *et al.*, 2002).

Specimens

For the present study, the authors obtained 32 cabochon-cut asteriated quartzes from different private collections. Some of these samples were originally bought on various occasions in trade fairs and were said to originate from Sri Lanka, and some were bought directly in Sri Lanka. The samples range from 2 to 108 ct in weight. In addition, one rose quartz cabochon of 12 ct that was studied also comes, most probably, from Sri Lanka. Asteriated quartzes from Sri Lanka originate from alluvial deposits at the village of Panchaliya near the town of

Dikkumbura, about 15 km east of the city of Galle. The local people call the stone 'Kiri palingu' which means milky quartz (D. Kumaratilake, W. Molligoda, P. Entremont and G. Zoysa, pers. comm., 2002).

All cabochons were originally cut with curved upper and lower surfaces and a small flat base. In general, only the upper halves of these cabochons were polished. In order to examine the complete star network of some samples, six cabochons were recut in Germany as complete spheres and polished over the whole surface.

Visual appearance and macroscopic observation

Although diasterism in transmitted light shows a number of interesting and sometimes complex phenomena (*Figure 3*), we shall refer in the following part only to episterism, i.e. to observations in reflected light, simply called asterism.

A minority of six samples revealed only a six-rayed 'centre-star' and some weak to very weak additional light bands, but no complete star network (*see Figure 8a*). The majority of 20 samples as well as the rose quartz cabochon, on the other hand, showed an identical complete three dimensional star network, consisting of:

(a) A six-rayed star, the centre of which was observed in a view parallel to the three-fold axis (*c*-axis) of the quartzes (*Figure 4a*).

(b) Following the arms of these stars from the centre to the rim, on each of the six

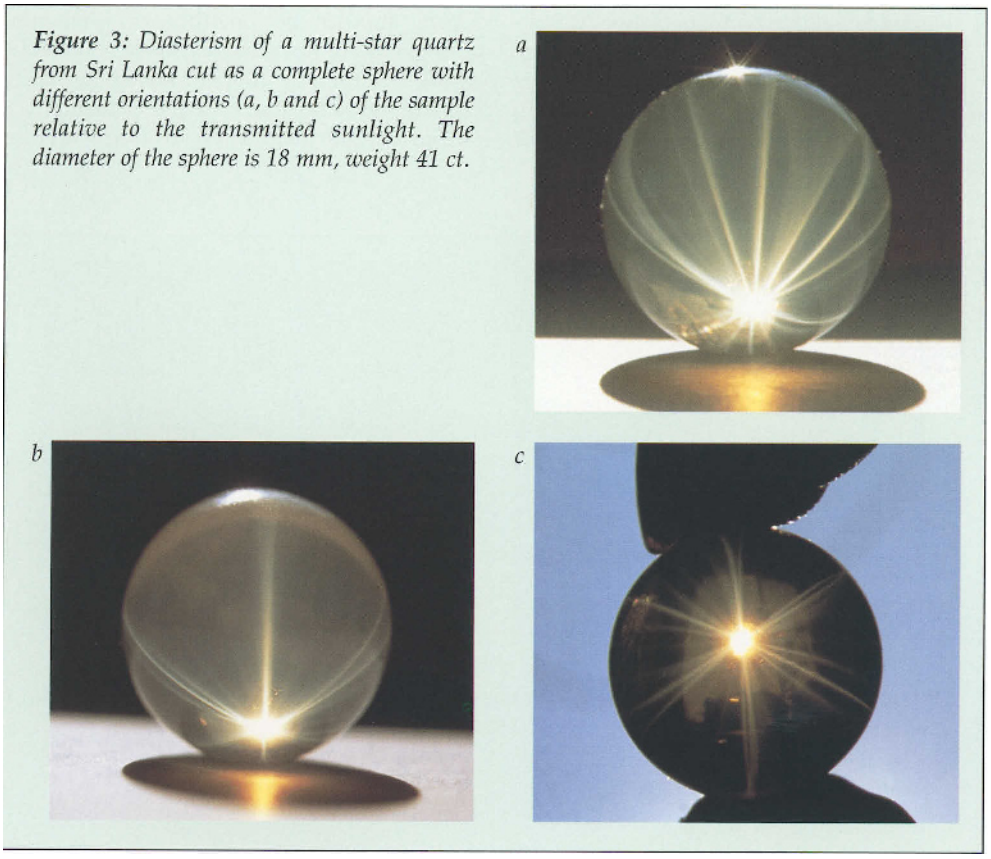


Figure 3: Diasterism of a multi-star quartz from Sri Lanka cut as a complete sphere with different orientations (a, b and c) of the sample relative to the transmitted sunlight. The diameter of the sphere is 18 mm, weight 41 ct.

arms of these 'centre stars' one six-rayed 'middle star' (*Figure 4b*) and one six-rayed 'outer star' (*Figure 4c*) were observed; occasionally the 'middle stars' as well as the 'outer stars' were formed by one more intense light band (the light band of the 'centre star') intersecting with two somewhat weaker light bands, that were not part of the 'centre star'.

(c) The light bands or arms forming the six-rayed 'middle stars' and the six-rayed 'outer stars' intersect and form numerous four-rayed stars (*Figure 4d*).

(d) The arms of the so-called 'centre stars', 'middle stars' and 'outer stars' are connected to each other, in that way forming a three-dimensional network of six-rayed and four-rayed stars (*Figure 4e, f*). The whole network on the surface of a complete sphere consists of two 'centre-stars' (one upper and one lower star), twelve 'middle stars' (six on the upper and six on the lower part of the sphere) as well as six 'outer stars' the centres of which are located at an angle of 90° to the *c*-axis, i.e. perpendicular to the three-fold axis of the quartzes. In addition, six four-rayed stars are located on the upper and six four-rayed stars are located on the lower half of a cabochon or sphere. Thus, the network normally seen on a complete sphere consists of 20 (two 'centre stars' plus twelve 'middle stars' plus six 'outer stars') six-rayed stars and of twelve (six upper and six lower) four-rayed stars (*see Figure 8b*). On the upper (polished) half of a cabochon, as seen normally in the trade, seven (one 'centre star' plus six 'middle stars') six-rayed and six four-rayed stars are observable, and on samples with more or less polished girdles, the six 'outer stars' (or at least part of these stars) are also observable.

It should be mentioned, that the orientation of the cabochons was not always with a 'centre star' more or less in the centre of the curved surface of the cabochon. In some samples, we observed an orientation

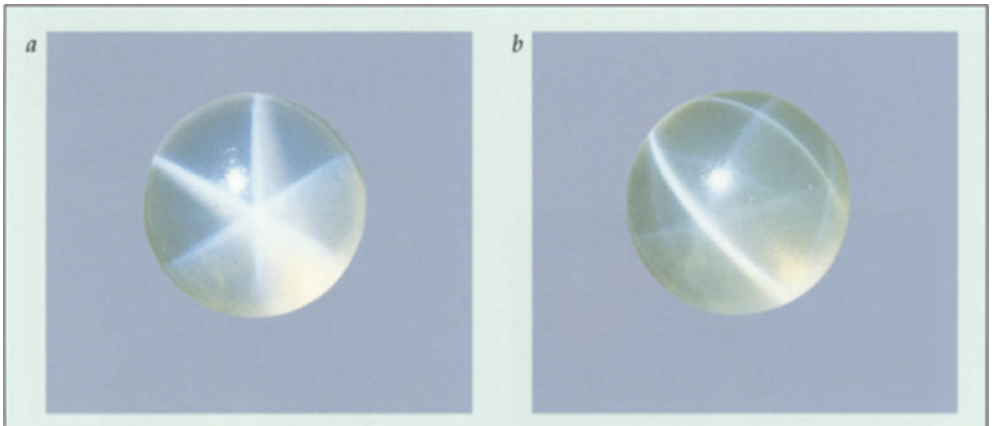
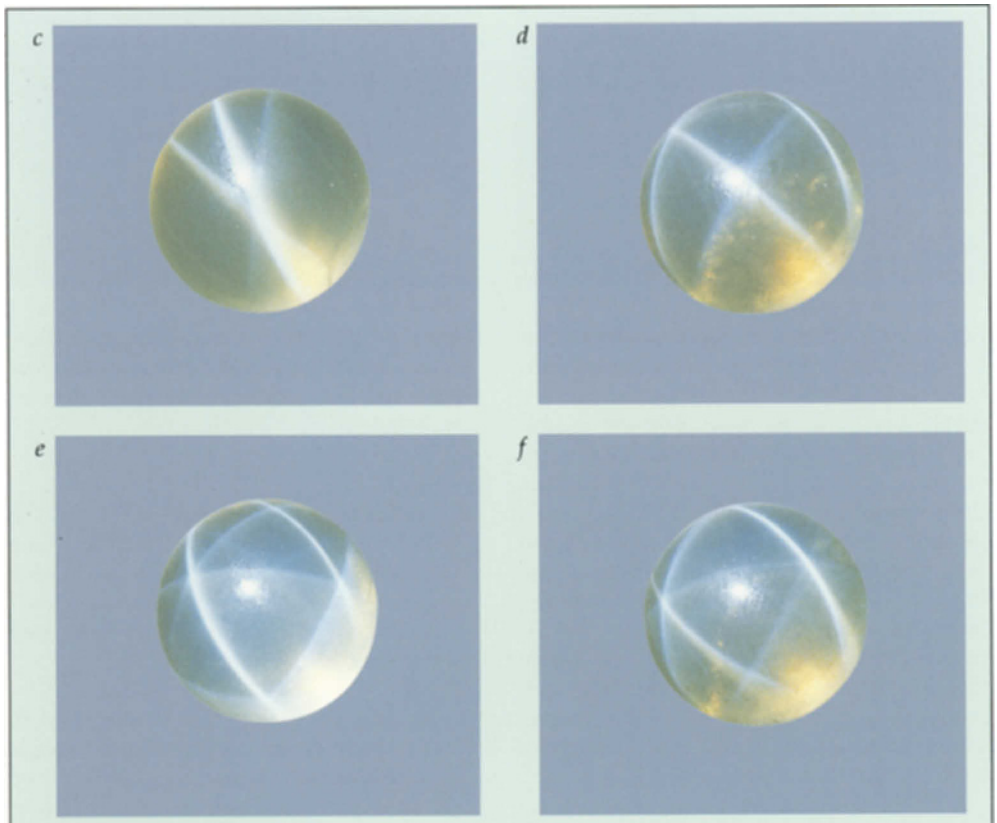


Figure 4: *Asterism of a multi-star quartz from Sri Lanka cut as a complete sphere with different orientations of the sample relative to the illuminant:*
(a) six-rayed 'centre star' consisting of three intersecting light bands of almost identical intensity;
(b) six-rayed 'middle star' consisting of one more intense and two less intense light bands;



(c) six-rayed 'outer star' consisting of one more intense and two less intense light bands;
(d) four-rayed star consisting of two intersecting light bands;
(e) three-dimensional network of six- and four-rayed stars, in this orientation three six-rayed and one four-rayed stars can be seen;
(f) three-dimensional network of six- and four-rayed stars, in this orientation two six-rayed and one four-rayed stars can be seen. The diameter of the sphere is 18 mm, weight 41 ct.

with one of the 'middle stars' in the centre of the cabochon or with other orientations (*Figure 5*).

In six samples, the 'centre star' revealed more than six, i.e. eight, ten or twelve arms. These stars consist of four, five or six light bands intersecting at angles of 30° or 60°, respectively. Three samples show an eight-rayed star (*Figure 6*), in one quartz the 'centre star' had ten arms (*Figure 7*) and in two quartzes, twelve-rayed stars consisting of eight more intense arms and four weak to very weak arms were observed. No star quartzes with twelve arms of identical intensity were found in the 33 samples.

Comparable to the variable intensity of the light bands forming the eight-, ten- or twelve-rayed 'centre stars', additional light bands of variable intensity forming 'middle stars' and 'outer stars' are also present in these six samples (*Figure 7*). Some of these light bands are extremely weak.

Figure 5: *Cabochon of a multi-star quartz from Sri Lanka with an orientation of the c-axis oblique to the centre of the sample; in this orientation two six-rayed and one four-rayed stars can be seen. The size of the sample is 10 × 9 mm, weight 4 ct.*

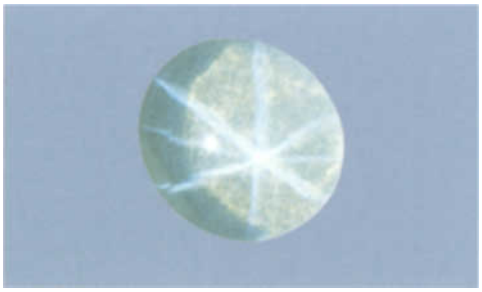


Figure 6: *Asterism of a multi-star quartz from Sri Lanka cut as a cabochon with an eight-rayed 'centre star'. The size of the sample is 15 × 14 mm, weight 20 ct.*

Consequently it was difficult to establish a general scheme for the three dimensional star network in samples with 'centre stars' formed by more than three light bands. Following the arms of these eight-, ten- or twelve-rayed 'centre stars' from the centre towards the rim of the cabochon, four-, six- or eight-rayed 'middle stars' are observable. Three types of multi-star networks were found:

(I) In addition to the network described in (a) to (d) above, one, two or three additional light bands through the 'centre stars' were observed in three samples. On each of these additional arms through the 'centre star', one four-rayed and one six-rayed star is located (*see Figure 8d*).

(II) In addition to the network described in (I) above, three additional light bands which do not intersect the middle of the centre star are present in one sample. As a consequence, on three of the six more intense arms belonging to the 'centre

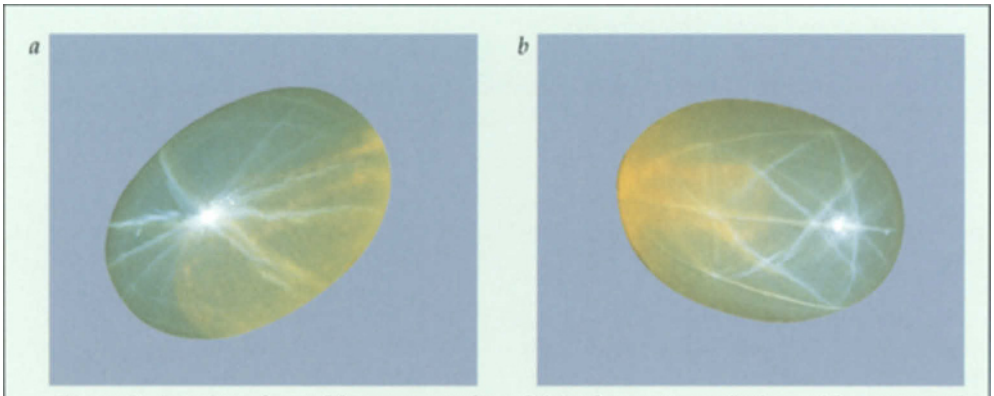


Figure 7: *Asterism of a multi-star quartz from Sri Lanka cut as a cabochon with a ten-rayed 'centre star' in different orientations of the sample relative to the illuminant: (a) ten-rayed 'centre star'; (b) complex network of numerous four-, six- and eight-rayed stars. The size of the sample is 19 × 14 mm, weight 23 ct.*

star', two six-rayed 'middle stars' are observed. On the remaining three of the six more intense arms belonging to the centre star one four-rayed and one six-rayed 'middle stars are observed. On the other six sometimes weaker arms of the 'centre star', two six-rayed stars are observed. At the rim of the cabochon, i.e. at an angle of 90° to the centre, the light bands of the 'centre star' intersect with the light bands of the 'middle stars' and form either one six-rayed or one four-rayed 'outer star'.

Again, the light bands or arms forming the 'middle stars' and the four- and six-rayed 'outer stars' intersect and form numerous four-rayed stars (*see Figure 8e*).

(III) In addition to the network described in (I) above, six light bands which do not intersect the middle of the centre star are present in two samples. As a consequence, on each of the six more intense arms belonging to the 'centre star', one four-rayed and two six-rayed 'middle stars' were observed. On the other sometimes weaker arms of the 'centre star', one eight-rayed and one six-rayed 'middle star' were present. All 'outer stars' on the arms of the 'centre star' consist of six arms in this type of multi-star quartz. Again, the light bands or arms forming the four-, six- and eight-rayed 'middle stars' and the six-rayed 'outer stars' intersect and form numerous four-rayed stars (*see Figure 8f*).

Some samples also contain additional weak to very weak light bands which do not belong to the general networks described so far.

Microscopic observation

With the magnification of the ordinary gemmological microscope (up to 100×), in general, only healing fissures were observed, and no oriented needle-like inclusions were seen.

Formation of the multi-star networks

Asterism, in general, is caused by orientated needle-like inclusions in various mineral species. Four-, six- or eight-rayed asterism is caused by two, three or four sets of intersecting needle-like inclusions. Each set of inclusions causes a light band with an orientation perpendicular to the commonest axial direction of the needles. Without preparation of thin sections and additional examination by microanalytical techniques, e.g. electron diffraction, it is impossible to determine the exact nature of the inclusions in quartzes from Sri Lanka causing the multi-star networks.

The most common needle-like inclusions in quartzes, especially in rose quartz revealing asterism, are rutile needles of microscopic to submicroscopic size, in numerous orientations (Goldschmidt and Brauns, 1911; Kalkowsky, 1915; von Vultée, 1955, 1956). In a six-rayed asteriated quartz from Sri Lanka, the presence of three sets of orientated submicroscopic sillimanite needles was determined by electron diffraction (Weibel *et al.*, 1980; Woensdregt *et al.*, 1980). Randomly distributed dumortierite needles, on the other hand, have been found in rose quartzes from different sources (Applin and Hicks, 1987; Goreva *et al.*, 2001; Ma *et al.*, 2002).

The different types of needles observed in multi-star quartzes from Sri Lanka and their crystallographic orientation in the quartz hosts are summarized in *Table I*. These different orientations are drawn in *Figure 8a* to *f* and examples for multi-star networks consisting of numerous intersecting light bands are also given in *Figure 8b* to *f*.

A normal six-rayed star consisting of three light bands intersecting at angles of 60° to each other is due to one group of three sets of oriented needle-like inclusions. Considering the trigonal symmetry of quartz (crystal class D_3 or 32) with one three-fold

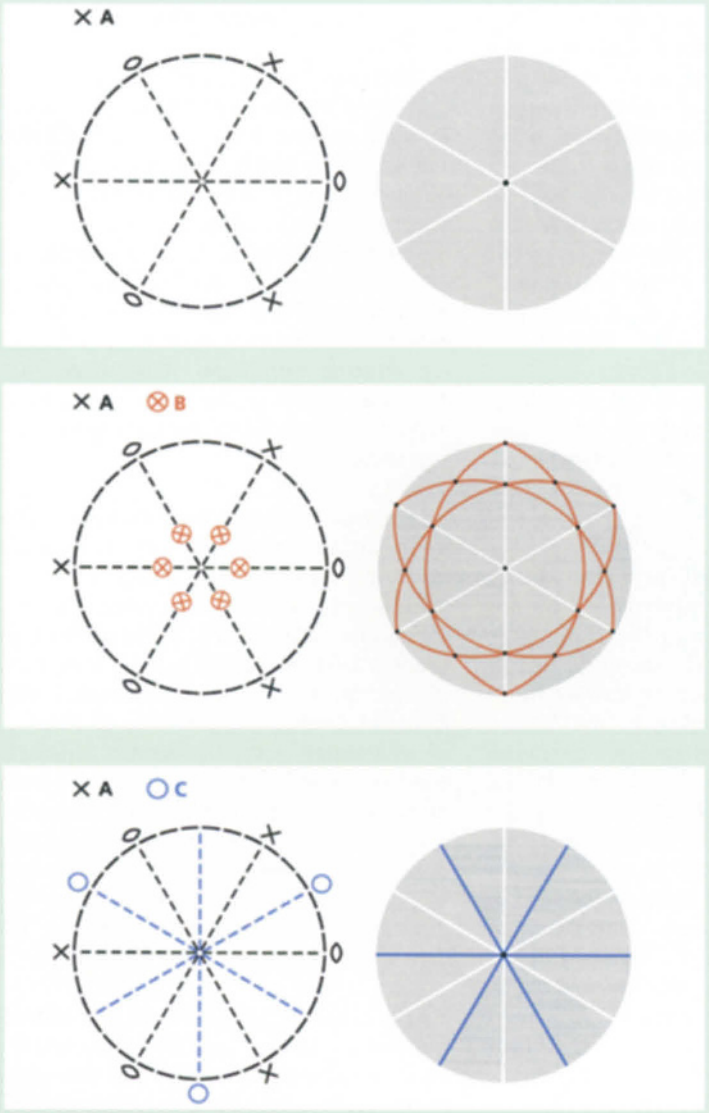
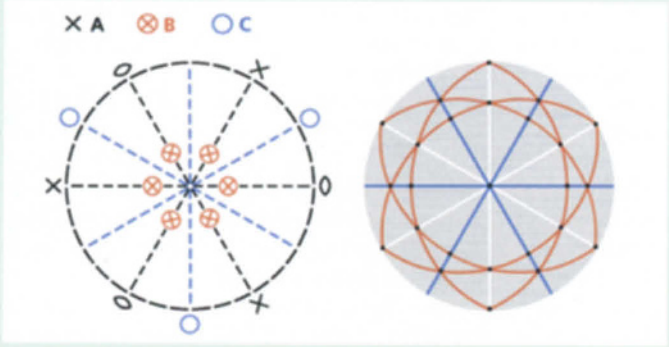


Figure 8: *Stereographic projection of oriented needle-like inclusions (left) and light bands of multi-star networks in quartz from Sri Lanka (right, only the upper hemispheres of the projection spheres are drawn); five different groups of needle-like inclusions were found to occur in asteriated quartzes from Sri Lanka; two groups of needles (designated as groups A and C) are oriented perpendicular to the c-axis; one group of needles (designated group B) is inclined at an angle of 24.4° to the c-axis, two groups of needles (designated as groups D and E) are inclined at an angle of 27.6° to the c-axis; the centres of the stars are indicated by black dots:*

(a) one group of needles (A, three light bands) forms a six-rayed star;

(b) two groups of needles (A, three light bands, and B, six light bands) form the most

d



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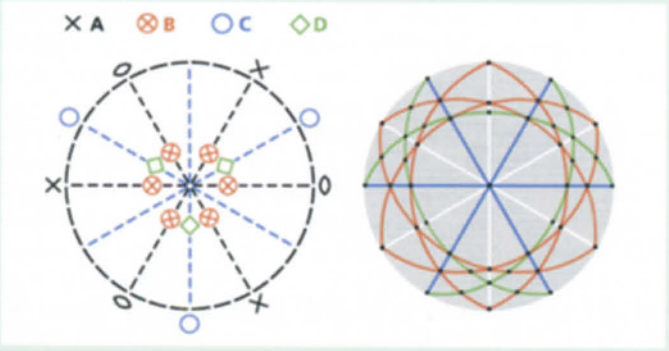

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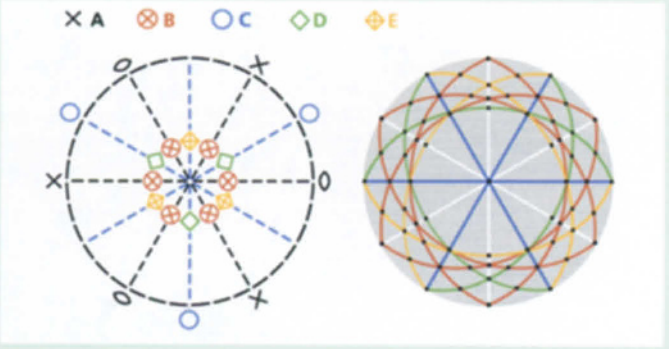

commonly observed multi-star network consisting of 20 six-rayed and 12 four-rayed stars;

(c) two groups of needles (A and C, three light bands each) form a twelve rayed star;

(d) three groups of needles (A, three light bands, B, six light bands, and C, three light bands) form a more complex multi-star network;

(e) four groups of needles (A, three light bands, B, six light bands, C, three light bands and D, three light bands) form a more complex multi-star network;

(f) five groups of needles (A, three light bands, B, six light bands, C, three light bands, D, three light bands and E, three light bands) form a more complex multi-star network.

axis parallel to the *c*-axis and three two-fold axes perpendicular to the *c*-axis, it is evident, that an ordinary six-rayed star is caused by three sets of inclusions (designated as group A) with an orientation perpendicular to the *c*-axis (*Figure 8a*).

According to the orientation of light bands that are not part of the 'centre star' of the multiple star network in quartz from Sri Lanka, it is estimated that the different sets of inclusions causing these light bands are oriented with an inclination of about 20° to 30° to the *c*-axis of the quartz crystals. With this approximation, we first tried to solve the problem graphically. Using the stereographic projection, a quick overview of the number, type and orientation of stars is obtainable. With this means it became evident, that the 'ordinary' network observed most frequently and described above under points (a) to (d) is explained by two groups of oriented needle-like inclusions (*Figure 8b; see Table I*):

(A) A first group consisting of three sets of needles that are oriented perpendicular to the *c*-axis forming an angle of 60° to each other.

(B) A second group consisting of six sets of needles that are inclined at about 20° to 30° to the *c*-axis; in addition, two sets of these needles belonging to group B are always in one plane together with one set of needles from group A.

The nine (three plus six) light bands perpendicular to these nine (three plus six) sets of needles from groups A and B form the complete three-dimensional multi-star network that is frequently observed in our samples from Sri Lanka (*Figure 8b*).

A twelve-rayed star in trigonal minerals is due to two groups of needles, each of which consist of three sets of parallel inclusions that are related to each other by 30° rotation about the *c*-axis (*Figure 8c*). This situation is observed in twelve-rayed star sapphires (see e.g. Weibel, 1985; Schmetzer and Glas, 2001).

Table I: Asterism in quartz from Sri Lanka.

Designation of needles	Crystallographic orientation [uvow]	Inclination of the needle axis to the quartz *c*-axis	Angle of light bands relative to the *c*-axis	Number of symmetry equivalent directions = number of symmetry equivalent sets of needles	Remarks
Group A	[1 $\bar{2}$ 1 0]	90°	0°	3	common
Group B	[1 $\bar{2}$ 1 6]	24.4°	65.6°	6	common
Group C	[1 $\bar{1}$ 0 0]	90°	0°	3	rare
Group D	[1 $\bar{1}$ 0 3]	27.6°	62.4°	3	very rare
Group E	[1 0 $\bar{1}$ 3]	27.6°	62.4°	3	very rare

Combinations observed in samples in this study:

A: common; six samples

A+B: common; twenty samples and one rose quartz

A+B+C: rare; three samples

A+B+C+D: very rare; one sample

A+B+C+D+E: very rare; two samples

Note added in proof: In addition, a quartz specimen from Sri Lanka with a combination of A+B+D+E has been recorded.

All samples described under point (I) revealing 'centre stars' with eight, ten or twelve arms consist of the already described first and second groups of needles (groups A and B) and a third group consisting of three sets of needles, designated as group C.

(C) As already described for sapphires (Schmetzer and Glas, 2001), this group consists of three sets of needles that are oriented perpendicular to the *c*-axis forming an angle of 60° to each other; in addition, group C is related to the needles of group A by 30° rotation about the *c*-axis (*Figure 8d*). The light bands belonging to the needles of group C intersect with the light bands related to the needles of group B, thus forming the additional four- and six-rayed 'middle stars'. Twinning according to one or both of the common twin laws found frequently in quartzes, i.e. the Dauphiné and the Brazil laws (see e.g. Frondel, 1962), cannot be responsible for the formation of asterism with eight-, ten- or twelve-rayed 'centre stars' because these twin laws are not related to a 30° rotation about the *c*-axis. According to the different intensities of the three light bands caused by the three sets of needles of group C, it is evident that the number of needles in the three symmetry equivalent directions is not identical. The cause of this phenomenon which is observed in all six samples with eight-, ten- or twelve-rayed 'centre stars' is not known; it may or may not be related to twinning in these samples.

The networks in the three samples described above under points (II) and (III) revealing 'centre stars' with eight, ten or twelve arms and additional light bands not related to the needles of groups A, B and C is more difficult to explain. According to the fact that no exact measurements of the angles of inclusions and the angles of light bands relative to the *c*-axis were performable for our cut samples, we calculated those angles determined for various sets of needles in quartzes in thin sections by von Vultée (1955, 1956) by means of a universal stage. Only three of his twelve groups revealed angles in the range of 20° to 30° as roughly determined for our samples, namely three groups of needles with angles of 24.4°, 27.6°, and 27.6°, respectively. According to the orientation of these needles relative to the quartz lattice, these three groups of needles should consist of six sets at 24.4°, or of three sets at 27.6° or of another three sets of needles at 27.6°, respectively. Plotting the light bands of the six sets of needles of group B according to an inclination angle of the needles of 24.4° together with the light bands for three sets of needles with an inclination of 27.6°, yielded a star network which was consistent with our visual observations in one sample (*Figure 8e*). Consequently, it may be concluded that group:

(D) consists of three sets of needles with an inclination of 27.6° to the *c*-axis and group B consists of six sets of needles with an inclination of 24.4° to the *c*-axis. The light bands belonging to the needles of group D intersect with the light bands related to the needles of groups A, B and C, thus forming additional six-rayed 'middle stars' as well as the additional four-rayed 'outer stars'. Plotting three additional light bands of a fifth group of needles designated.

(E) with an angle of 27.6°, the full network of four-, six- and even eight-rayed stars observed so far in two samples is obtained (*Figure 8f*). This last group of needles of group E is related to the needles of group D by rotation through an angle of 60° about the *c*-axis.

Consequently, all observed networks are consistent using the well established orientations for five groups of needle-like inclusions as determined by von Vultée (1955, 1956) in thin sections of quartzes. A summary of all observed types of multi-star quartz networks as well as all calculated

angles together with the exact crystallographic orientations of the needles is given in *Table I*. Using the angles determined by von Vultée (1955, 1956) as a model for the orientation of three groups of needles of our groups B, D and E, which could not be determined directly in our samples, the number and sequence of four-, six- and/or eight-rayed stars observed in the complex multi-star network of some samples is understandable.

Conclusions

Various types of multi-star networks observed in quartzes from the Ratnapura District, Sri Lanka, are explained by the presence of up to five different groups of needle-like inclusions, each group consisting of three or six sets of symmetry equivalent directions for the needle axes. The frequently observed type of multi-star network consists of nine intersecting light bands caused by two groups of nine (three plus six) sets of needle-like inclusions. In more complex patterns of star-networks with eight-, ten- or twelve-rayed 'centre stars', up to five groups of 18 (three plus six plus three plus three plus three) sets of needles may be present, thus causing 18 intersecting light bands with numerous four-, six- and eight-rayed stars.

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Horse-tail inclusions in demantoid garnet from Val Malenco, Italy

Paul W.O. Hoskin, Rodney H. Grapes, Honza Catchpole and Jurgis Klaudius

Institut für Mineralogie, Petrologie und Geochemie, Albert-Ludwigs-Universität Freiberg, Albertstrasse 23 B, D-79104 Freiburg, Germany

e-mail: paul.hoskin@minpet.uni-freiburg.de

ABSTRACT: Gem-quality bottle-green demantoid garnet from Val Malenco, northern Italy, may contain fibrous hair-like inclusions. Previously described as byssolite (tremolite-actinolite-amphibole), powder X-ray diffraction and electron microprobe analyses show the inclusions to be chrysotile-serpentine and confirm a previous report by Gübelin (1993). Although the presence of chromium in demantoid may be a primary cause of colour, our observations and data indicate that the intensity variations of the green-hue is related to variable density of green-brown chrysotile inclusions.

Introduction

Demantoid is the name given to bottle-green andradite members of the garnet group of minerals. The name, demantoid, is derived from the Dutch word *demant* which means diamond. These garnets are 'diamond-like' because of their impressive yellow-orange dispersion. This variety of garnet is a popular gemstone which was sought after in the past by royalty. For example, detrital demantoid from the Bobrovka River, Russia, adorns jewellery, crowns and sceptres of the Russian czars and czarinas, particularly those crafted by the famous Russian imperial court jeweller, Karl Faberge (Phillips and Talantsev, 1996). Few localities of large demantoid have been located so far, yet famous gem-quality localities include the alluvial deposits of the Sissersk District and the Bobrovka River, both of the central Ural region of Russia (Phillips and Talantsev, 1996); Val Malenco, northern Italy (Bedogné and Sciesa, 1993); and the Erongo Range, Karibib, Namibia. There are less important localities in Korea, Iran, China, Azerbaijan, Mexico, and Eritrea (Milisenda and Hunziker, 1999).

Inclusions in demantoid from Val Malenco

The rocks of northern Val Malenco (*English*: the Malenco Valley) were derived from the upper mantle and were altered to serpentinite after Alpine orogenesis and exhumation (Bedogné and Sciesa, 1993). Demantoids occur in asbestos filled joints that formed during the processes of serpentinization (Amthauer *et al.*, 1974). The crystals range in size from 0.05-10 mm, with rare larger crystals up to 30 mm. The common crystal form is well-formed dodecahedra. Crystals from three locations

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Table I: *Electron microprobe analyses* (wt.% oxide) of horse-tail inclusions of chrysotile asbestos in demantoid garnet from Val Malenco, Italy.*

Oxide	1	2	3	4	5
SiO_2	43.09	43.06	43.15	45.36	44.48
TiO_2	0.04	-	-	-	0.04
Al_2O_3	0.23	1.93	1.84	0.18	0.11
Cr_2O_3	0.03	0.64	0.84	0.03	0.07
Fe_2O_3	2.42	2.71	2.92	1.72	1.45
MnO	0.04	0.03	0.02	0.02	0.01
MgO	38.14	39.00	39.19	40.92	40.91
CaO	0.06	0.02	0.06	0.06	0.07
Na_2O	0.01	0.01	-	-	0.01
K_2O	-	-	-	-	0.01
Total	84.06	87.40	88.02	88.29	87.16
Cations calculated on the basis of 9 (O, OH); OH by difference (100% minus measured total); all iron as Fe_2O_3.					
Si	1.9433	1.9766	1.9949	2.0885	2.0281
Al	0.0122	0.1044	0.1003	0.0098	0.0059
Fe^{3+}	0.0821	0.0936	0.1016	0.0596	0.0498
Cr	0.0011	0.0232	0.0307	0.0011	0.0025
Ti	0.0014				0.0014
Mn	0.0015	0.0012	0.0008	0.0008	0.0004
Mg	2.5638	2.6687	2.7009	2.8086	2.7807
Ca	0.0029	0.0010	0.0030	0.0030	0.0034
Na		0.0009			0.0009
K					0.0006

**Analyses performed by wavelength dispersive spectrometry on a Cameca SX100 electron microprobe; acceleration voltage 15 kV; beam current 20 nA; beam-size 1-5 μm; analysis time 80 s; all standards used were natural minerals; raw intensity data was ZAF corrected.*

- denotes analysed for but below the limit of detection.

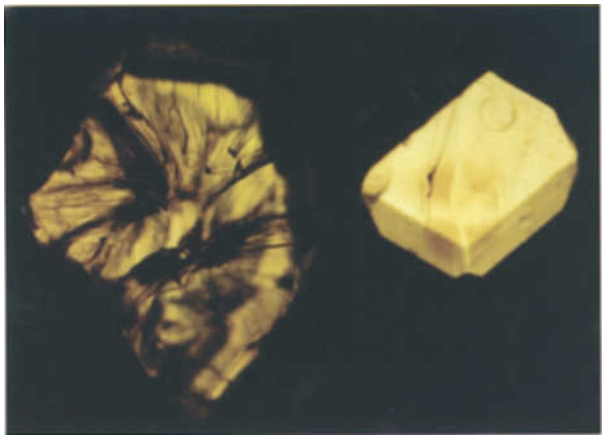

Figure 1: *Horse-tail inclusions in demantoid from Val Malenco. The darker-green crystal (left) has a high density of inclusions and the lighter-green crystal (right) has few inclusions. The width of the crystal on the left is 3.5 mm.*

within Val Malenco indicate that none of the crystals are zoned. The demantoids may also have mineral inclusions. These inclusions are long fibres, or hairs (up to about 2 mm long), up to 100 times longer than they are thick. The fibre width does not significantly vary along the length. Where the fibres are numerous, they form a radiating mat that may look like a horse's tail (*Figure 1*). Less dense occurrences may be spiral-shaped (*Figure 2*) or along one direction. The presence of fibrous minerals in demantoid is thus known as 'horse-tail' inclusions. These are well known for Russian demantoid occurrences, where inclusions of horse-tail byssolite (Phillips and Talantsev, 1996) and diopside (Krzemnicki, 1999) add considerable value to demantoid crystals. This is a rare example of where inclusions add monetary value to a gemstone specimen. The supposed occurrence of byssolite in demantoid from Val Malenco has been reported previously by Feather (1990). The identification of the included mineral as byssolite was on the basis of analogy to Russian demantoid occurrences and the assumption that the matrix-support mineral for samples from Val Malenco was tremolite-amphibole. A report of chrysotile inclusions in demantoid by Phillips and Talantsev (1996) was subsequently correctly attributed (*Gems and Gemology* 1996, p 155) to Dr. E. Gübelin who had presented his results in a lecture to the International Gemmological Conference in 1993. The lecture was entitled 'Mineral inclusions in gemstones recently observed, analysed and identified' and in it, Gübelin indicated that the chrysotile had been identified in Val Malenco demantoid (M. Superchi, pers. comm.). Unfortunately the abstract of the lecture contained no analytical details, so printed supporting data for the identification seem to be lacking.

We performed X-ray powder diffraction analysis of the asbestiform joint fill which forms the matrix-support for the demantoid at Val Malenco, and electron probe microanalysis for fibrous inclusions within the demantoid. Results from both analytical methods indicate that the matrix mineral and the phase included in demantoid is the asbestiform serpentine mineral chrysotile (*Table I*). Other minerals intergrown with the matrix chrysotile and demantoid are chromite, and minor quartz and augite-pyroxene. Our data confirm that the

Figure 2: *A spiral-shaped horse-tail inclusion radiating from a small (50 μm) mineral inclusion within the larger demantoid crystal.*

previous determination of the presence of byssolite is incorrect and that Val Malenco horse-tail inclusions are chrysotile. Transmitted light optical examination of demantoid crystals, cut in half, reveals that the chrysotile fibres have a typical light green to brown colour. This observation is most easily made for the lightest-coloured demantoid crystal (very light-green to colourless). We have found that demantoid with a deeper-green colour has a higher density of chrysotile inclusions, where demantoid with a lighter-green hue has few or no inclusions. The cause of colour variation in demantoid is related by Amthauer *et al.* (1974) to the presence and abundance variation of chromium in the crystal structure. We detected chromium by electron probe microanalysis in our demantoids, but found no systematic relation between green-colour intensity and Cr_2O_3 abundance. Although the occurrence of chromium in demantoid may be a primary cause of colour, our observations and data indicate that the intensity variations of green-colour is related to the variable density of green-brown chrysotile inclusions.

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Recent studies on inky black omphacite jade, a new variety of pyroxene jade

Ou Yang Chiu Mei[1], Li Jian Qi[2], Li Hansheng[3] and Bonita Kwok[1]

1. *Hong Kong Institute of Gemmology, Hong Kong*
2. *China University of Geosciences, Wuhan, China*
3. *Institute of Geology, CAGS, Beijing, China*

ABSTRACT: A dark green jade has recently become more common in the Hong Kong and Chinese gem markets under the name 'inky jadeite jade'. Its gemmological properties are slightly different from pure jadeite with higher RI and SG and it consists of 85% or more of the pyroxene omphacite. Infrared and Raman spectra and microprobe analyses are presented.

Introduction

Among the many colours of jadeite on the market, the most precious is the emerald green variety, called by many imperial jade. Recently however, other colours have started to gain in popularity and have been incorporated in new designs, giving a fresh and attractive feeling to the pieces. One of these colours is an inky green in transmitted light if the piece is thin enough, but appears black in reflected light (*Figures 1 and 2*). This 'hidden nature' of the colour gives the jade a special character which is attractive to many as its name is 'inky jadeite jade'.

The inky green jade differs from the black-skin-chicken jade described recently by Ou Yang and Li (1999) in that it is fine-grained and more transparent. It is usually cut in saddle-shaped cabochons or carved into Guanyin or Buddha figures, but is also found as finger rings, bangles or antique-style pendants in the markets in Taiwan, Hong

Figure 1: *Inky black omphacite jade under reflected light.*

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Figure 2: Inky black omphacite in transmitted light.

Kong and China. Examples of the inky jade which are pure and of good quality are quite difficult to find so prices are not low. There are also many black simulants in the jade markets being sold as inky jade and this stimulated the authors to investigate the inky jade in more detail.

According to jadeite dealers in Myanmar and Hong Kong, this kind of jade has been available for over twenty years, but nothing appears to have been published about it. Traditionally, the Chinese have not been particularly interested in black stones so the inky jade was not noticed, but with changes in fashion more people are now interested in the range of jadeite jade colours.

Rough inky jade can be bought at the jade auctions in Yangon, Myanmar, where it is sold typically as smooth pebbles which have a thin greyish-yellow or brown skin (*Figures 3 and 4*). The shapes of the pebbles suggest a source in secondary alluvial deposits. Traders looking for inky jade have learned from experience to examine a polished surface and to choose those pieces in which a reflection of the viewer can be seen.

Figure 3: Rough inky omphacite jade with a white skin in the jade market.

Figure 4: *Rough inky omphacite jade and polished beads of the same material.*

To investigate the characteristics of inky jade, the authors collected more than 30 samples for SG and RI measurements, thin section analysis, and investigation by electron microprobe, X-ray diffraction and infrared and Raman spectroscopy.

Gemmological characteristics

Colour: Black or blackish-green, if thin enough, in reflected light; blackish-green to intense green in transmitted light. The green itself ranges from bright to dark green.
Lustre: Vitreous strong reflectivity is due to the fine-grained texture and thus very smooth polished surface.
Transparency: Good sub-transparent to translucent.
Texture: Very fine; under transmitted light, it shows microfibrous texture and less commonly, micro-granular.
Hardness: 7 on the Mohs' hardness scale.
SG: 3.34-3.44 (by the hydrostatic method), slightly higher than jadeite jade.
RI: 1.667-1.670 (by the distant vision method).
Chelsea colour filter: Appears black.
Fluorescence under LW and SW ultra-violet: Inert.

X-ray powder diffraction analysis

The X-ray powder diffraction methods are not standard analytical techniques in most gemmological laboratories. However, in order to get more accurate information from inky jade, colleagues in Wuhan have applied this technique to study the mineral composition of inky pyroxene jade. The results were compared with the ICDD data and they indicate that the inky jade is composed of pure omphacite.

Infrared spectrum

Infrared spectra were obtained from the inky jades by reflectance and by KBr powder methods. Typical omphacite spectra were obtained and one is shown next to that of jadeite for comparison in *Figure 5*.

Laser Raman spectrum

Laser Raman spectral measurements were made on 10 samples of omphacite jade and a typical spectrum is shown in *Figure 6*. A Raman spectrum of jadeite is also shown for

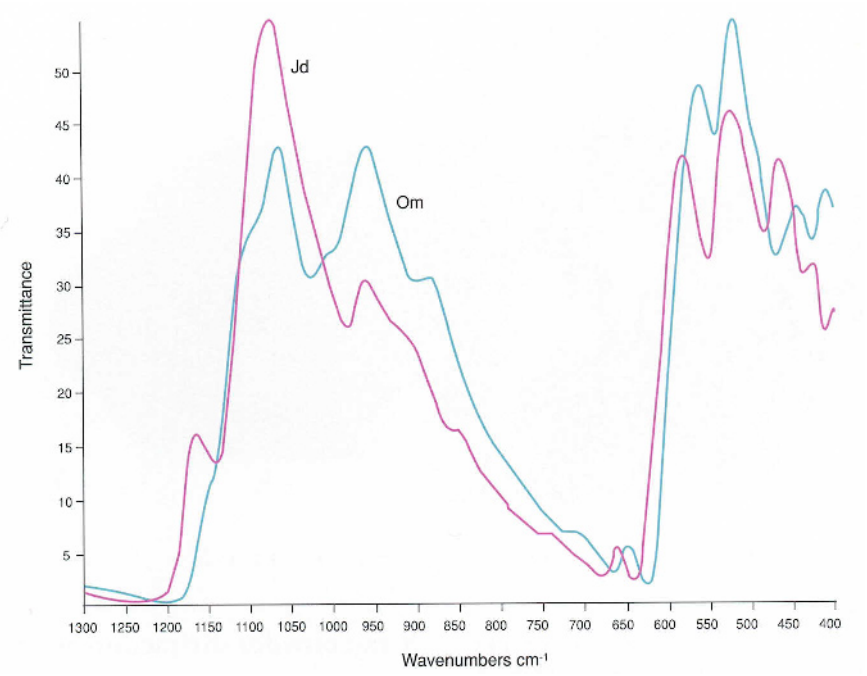

Figure 5: *Infrared spectra of omphacite jade (Om) and jadeite jade (Jd).*

comparison. Since jade is a polycrystalline aggregate with minerals in random orientation, all the main peaks should be displayed and there should be no orientation effect.

Petrology

The authors selected 10 samples for thin section observations. Omphacite comprises 80-90% of the jade and there are minor amounts of jadeite, kosmochlor and small grains of opaque material. These small black opaque materials seem to be metallic, but further work is needed to identify them. In thin section, omphacite is colourless to greyish-green or bluish-green with a distinct pleochroism of yellowish-green to bluish-green. It shows second order interference colours (*Figures 7 and 8*) and is biaxial positive with a 2V angle of 70°. The crystals have a fine-grained fibrous habit, and commonly the fibres are grouped into a granular pattern: technically they are microfibroblastic aggregates, and some specimens show a porphyroblastic texture. These larger grains are generally not well orientated but some may be sub-parallel with sizes ranging from 0.5 × 0.8 mm to 0.4 × 0.9 mm. According to the microprobe analyses, the omphacite is diopsidic, and the textures indicate that it is a product of re-crystallization where calcium was available. Although small amounts of omphacite are commonly found towards the margins of jadeite grains in jadeite jade (Ou Yang and Li, 1999), this is the first description of a virtually monomineralic decorative rock composed of omphacite. Jadeite and omphacite forming a concentric zoned structure are a very common phenomenon. The compositions of zoned crystals are gradational from jadeite at the cores to omphacite and then diopside towards the rims. This compositional zoning is shown by the electron microprobe analyses which

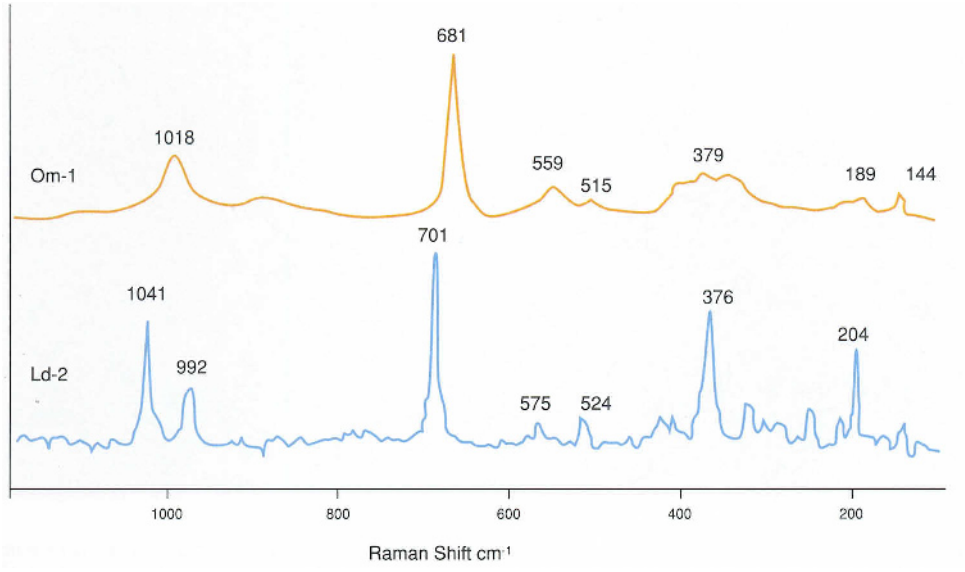

Figure 6: *Raman spectra of omphacite jade (Om-1) and jadeite jade (Ld-2) labelled with the wavenumbers of the main peaks.*

Figure 7: *Thin section of inky black jade in cross polarized light. A few large grains of original omphacite lie in very fine grained omphacite, some diopsidic, which has replaced the original texture. Field of view about 6 mm across.*

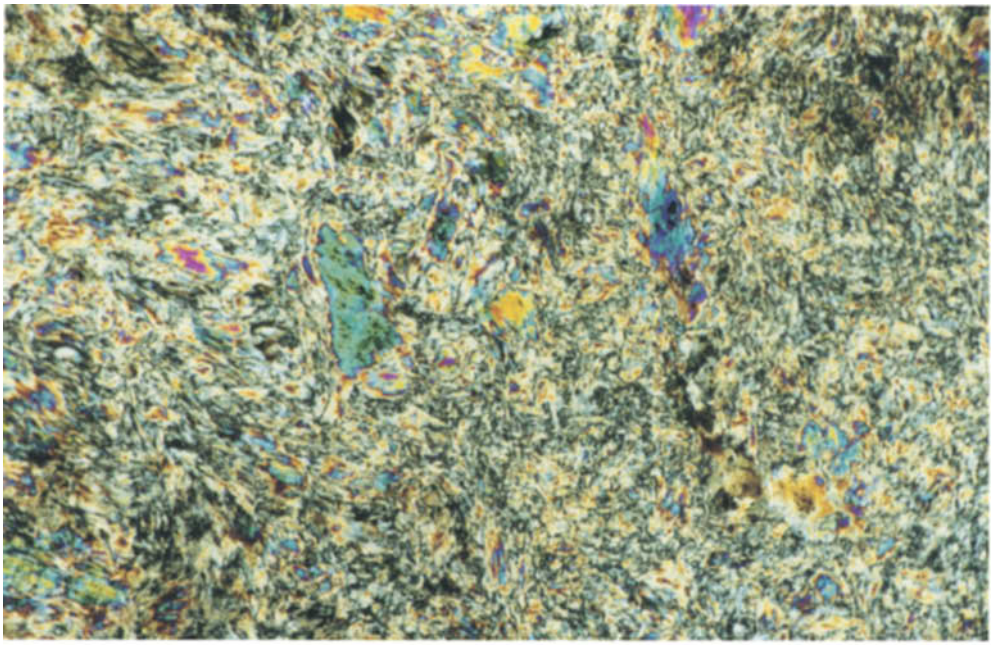

Figure 8: *Thin section of omphacite jade showing intergrown fibrous texture. Field of view about 6 mm across; cross polarized light.*

Table I: *Composition of inky black omphacite jade: summary of electron microprobe analyses of 29 spots in 10 samples.*

Wt.%	Minimum	Maximum	Mean
SiO_2	53.59	58.39	56.45
Al_2O_3	8.83	12.86	11.19
MgO	5.52	10.31	7.84
FeO	1.27	6.59	3.97
CaO	10.42	14.37	11.84
Na_2O	6.38	9.02	7.91
Cr_2O_3	0	3.51	0.16
Total			99.36
Na/Na + Ca	0.313	0.458	0.402
Al/Al + Fe	0.602	0.910	0.742

indicate that Ca content increases from core to margin of the grains at the expense of Na (Ou Yang and Li, 1999). This indicates that the crystallization environment changed from first providing Na to later providing Ca during the crystallization of jadeite and omphacite.

Chemical composition

The major and minor element contents of ten samples of inky black jade were analysed by electron microprobe and are summarized in *Table I*. The results indicate that the samples are omphacite jade.

The chemical formula of omphacite is (Ca, Na)[Mg, Fe^{2+}, Al, Fe^{3+}](Si_2O_6) which lies between jadeite and diopside. The limits of these three pyroxenes, based on their chemistry, are as follows: Na/(Na + Ca) > 0.8 for jadeite; 0.8-0.2 for omphacite and < 0.2 for

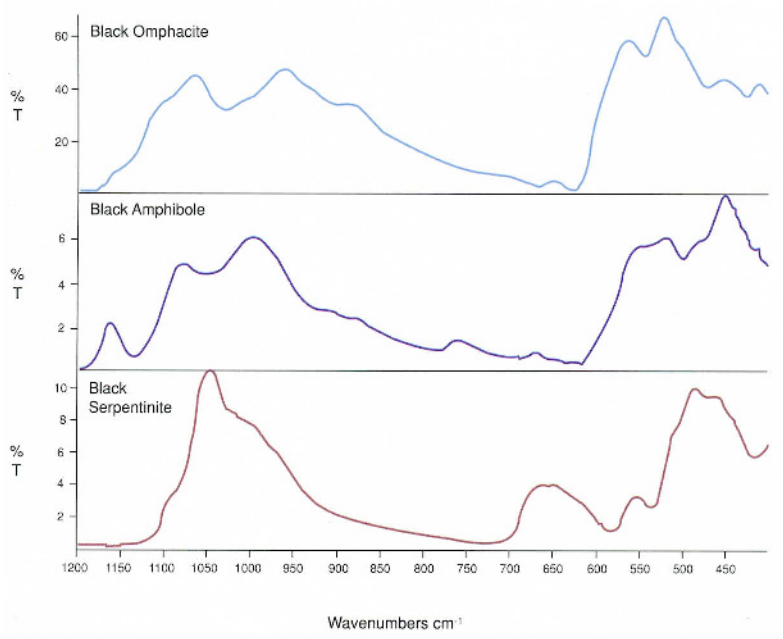

Figure 9: Infrared spectra of omphacite jade and its simulants, black amphibole jade and black serpentinite.

diopside. Also, based on Deer *et al.* (1978) and Wang Pu *et al.* (1984), the Al/(Al + Fe) ratio in omphacite is > 0.5. In terms of these ratios, the results in *Table I* show that the inky black jade falls well in the omphacite field. In addition, concentration of chromium in omphacite jade ranges from 0.00 – 0.16% Cr_2O_3 and in the larger quantities, is the cause of an attractive bright green colour.

Simulants

There are many simulants in the Hong Kong and Chinese jade markets, with appearance, colour, texture and transparency very similar to black omphacite jade. The traditional identification procedure practised by the Chinese has been to examine a 'black jade' under a strong light, and if it appears green then, it is real black jade.

However, the authors believe that there are two main simulants which can also show this effect, so it is not a conclusive test. These simulants are black amphibole jade (mainly composed of minerals of the amphibole group) and black serpentinite, both with mineral compositions and physical properties which differ from pyroxene jade. They may be distinguished from omphacite jade by their SG and RI (*see Table II*), but if such tests are not practical their infrared spectra are also characteristic (*Figure 9*).

Discussion

In the 1990s, with the development of jadeite mining methods, more detailed research on jadeite jade and more advanced techniques for research, omphacite has been found to be consistently present in deep green Burmese jadeite jades, especially the inky green stones. The authors have found

Table II: Comparison of gemmological properties of black omphacite jade and two simulants.

Simulant	*Hardness (Mohs' scale)*	*SG*	*RI*
Black omphacite jade	7	3.34-3.44	1.667-1.670
Black amphibole jade	6	3.00±	1.62±
Black serpentinite	4.5	2.52±	1.52

that Russian and Japanese jadeite jades also contain some omphacite (Ou Yang and Qu. 1999). The presence of omphacite in jadeite jade is not unexpected because it is the central member of the pyroxene series between jadeite and diopside. In thin-sections of dull green jadeite jade, jadeite and omphacite are often in a concentric zoned structure. Ou Yang and Li (1999) suggest that such a structure indicates a variable composition in the host rock and fluctuating conditions of temperature and pressure. The contents of omphacite in dull green jadeite jade are always variable below 25%. However in the inky black jade, the omphacite content is over 80% and this leads to significant differences in colour, structure, SG and RI.

The authors suggest that:

- jade with more than 75% omphacite should be known as omphacite jade;
- jade with between 50% and 75% omphacite should be called jadeite omphacite jade; and
- jade with between 25% and 50% omphacite should be called omphacite jadeite jade.

Conclusion

The inky black jade with fibroblastic texture and good transparency is essentially monomineralic consisting of more than 90% omphacite. The best name for it is omphacite jade. The dark green colour is due to omphacite, small amounts of opaque metallic oxides, and to the presence of tiny specks of graphite or possibly a black organic material. The refractive index and specific gravity are slightly higher than those of jadeite jade. From the infrared spectra, this variety can be easily distinguished from jadeite and from black simulants of jade. It is worth noting that in jadeite jade from Myanmar and from Sayan, Russia, the presence of omphacite commonly adds an element of grey or dark green to the colour of the jadeite.

Acknowledgements

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Ornamental marble from Ledmore, Scottish Highlands

Dr Douglas Nichol

Wrexham, Wales

ABSTRACT: Near Ledmore in Assynt, Cambrian limestones and dolomites lying within the thermal aureole of an alkaline intrusive complex are recrystallized to calcite-marble and associated serpentine-dolomarble (ophicalcite) and brucite-marble. Exploitation of the marble for industrial applications also yields coloured and patterned stone suitable for ornamental and artistic applications. White crystalline marble predominates and grain size ranges from fine- to medium-grained; selected material contains a wide variety of attractive features highlighted by yellow and greenish-yellow hues imparted by serpentine minerals (after forsterite). The variegated marble is fashioned by contemporary sculptors, artisans and jewellers, and examples of their works are exhibited in galleries around the world.

Keywords: Ledmore, marble, Scotland

Introduction

In the Northwest Highlands of Scotland, a marble deposit at Ledmore is extracted mainly for white filler and industrial mineral applications. However, as a by-product of the mining operations, high-quality specimens are selected for the manufacture of carvings, ornamental pieces and costume jewellery, interest being fostered by availability, modern advances in lapidary equipment and the ease of working of the material as well as the growing importance of Scottish tourism.

The marble deposit is located in the geologically classic Assynt district of central Sutherland, about 77 km northwest of Inverness (*Figure 1*). From Ledmore junction,

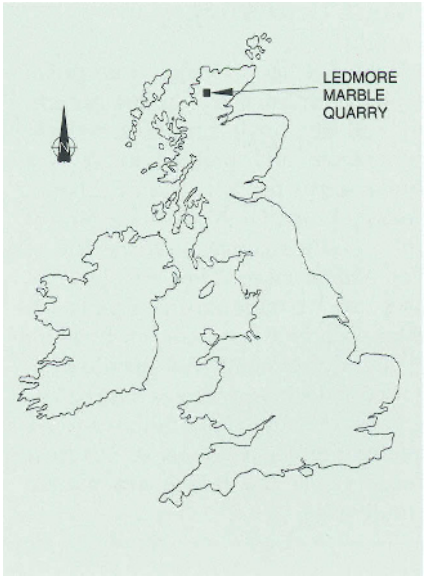

Figure 1 (right): *Location of Ledmore in northern Scotland.*

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access to the deposit is northwards along the A837 Lochinver-Bonar Bridge road for 1.4 km thence 0.6 km eastwards along the quarry access track. National Grid Reference NC 252137 applies. This paper provides a description of the geological setting of the marble deposit and directs attention to the diversity in its ornamental application.

Historical background

According to the historical record, mining operations for marble at Ledmore can be traced as far back as 1796. However, early operations were very small in scale and almost invariably short-lived.

More recently, the marble deposit was opened up initially for the production of white calcium carbonate as a filler and coating agent in paper manufacturing. However, variable marble quality prompted interest in other end-uses and subsequent operations have concentrated on a wider range of markets including architectural rock, harling chips (see below), decorative aggregates and ornamental stone.

Harling

Harling is an exterior wall finish composed of mortar against which, while still wet, small chips of stone have been thrown and pressed in. It is a popular finish for houses in Scotland, especially in the Highlands (e.g. almost all of the white cottages on the Isle of Skye). Other names for this type of finish are pebble-dash, roughcast, spatter-dash and dry-dash but they are also slightly different (e.g. pebble-dash has rounded stones whereas harling has angular fragments). In addition, harling provides a protective layer against frost damage while the others are mainly decorative.

The marble deposit is operated by Ledmore Marble Limited and production commenced in January 1991. Programmes of exploration drilling around the quarry area have indicated more than two million tonnes (Mt) of all grades of marble available for extraction from the site. Additional deposits of similar marble also exist in other nearby areas (Smith *et al.*, 1992).

Interestingly in 1996, 190 t of marble blocks were exported from Ledmore to Carrara in Tuscany, Italy (Anonymous, 1996).

Geological setting

The Ledmore marble deposit is situated in the lower southwestern foothills of the Ben More range and between Loch Borralan and Loch Awe.

Geologically, the oldest bedrocks in the district comprise Precambrian Lewisian gneiss to the west and Torridonian sandstone to the north. A sequence of limestones and dolomites of the Durness Limestone Group of Cambrian age overlie these basement rocks. At Ledmore, the Cambrian strata are intruded by the Loch Borralan Igneous Complex, an unusual suite of alkaline plutonic rocks of Lower Silurian age (430 ± 40 Ma, U-Pb zircon; van Breemen *et al.*, 1979). The geological setting is then further complicated by extensive structural deformation and faulting associated with the development of the Moine Thrust Belt of northwest Scotland (*Figure 2*).

The Loch Borralan Igneous Complex underlies an area of about 26 km^2. It is described in detail by Johnson and Parsons (1979) and Parsons (1979). The rocks of the Complex have been shown by Woolley (1970) to be divisible into an earlier suite composed of feldspathic syenites injected as a sheet-like body and a later suite composed of feldspathic syenites emplaced as a plug. The latter form the prominent ridge of Cnoc na Sròine (390 m).

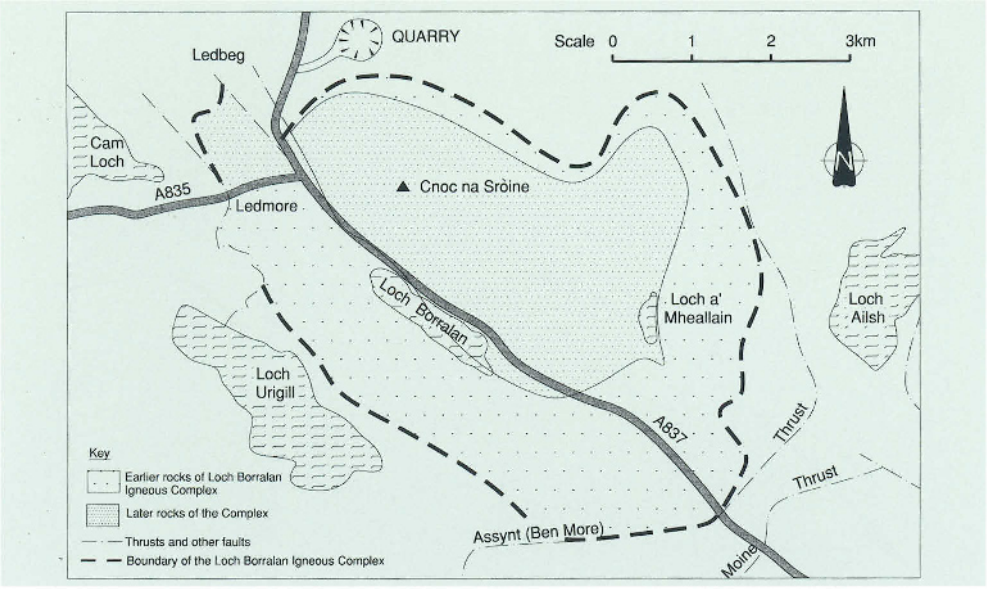

Figure 2: *General Geology of the Ledmore area and the Loch Borralan Igneous Complex. The country rock (unshaded) consists predominantly of Cambrian limestone and dolomite strata of the Durness Limestone Group.*

The deposit

At Ledmore quarry, the marble deposit crops out on a topographic platform surrounded by higher ground that shields the workings from general view and prevents obtrusion on the local landscape. Minor pockets of overburden consist of glacial moraine with thin blankets of peat.

The deposit comprises a wedge-shaped mass of marble up to 120 m in width that dips to the southeast and is traceable continuously for 450 m along strike (*Figure 3*). Resistant quartzite (basal Cambrian) forms a low ridge along the western flank of the operational area. It appears in thrust relationship to the marble with a thin sheared basic intrusion intervening along the thrust plane. The eastern boundary of the marble is traceable discontinuously across the surface and abuts the Cnoc na Sròine syenite. Boreholes through the mass of marble encountered syenite and associated igneous rocks at depth that are interpreted as irregular sheets with many complex interdigitations within the marble. The marble deposit lies within the thermal aureole surrounding the Loch Borralan Igneous Complex and contact metamorphism of the carbonate beds was probably effected by the Cnoc na Sròine syenite. However, the patterns of alteration exposed in the quarry suggest that reactions with underlying igneous intrusions have exerted greater influence than previously thought. Indeed, Allen *et al.* (1994) postulated three separate and distinct phases of contact metamorphism in the quarry area. In any case, where the original carbonates were particularly pure, extremely white marble has resulted from the contact metamorphism. More specifically, limestones have transformed to calcite-marbles whilst dolomites have produced brucite-marbles and carbonate beds containing impurities have produced attractively coloured marbles.

Mineralogically, calcite and dolomite predominate in the marble. Both minerals are usually present but proportions are variable with interlayers parallel to stratigraphy on a

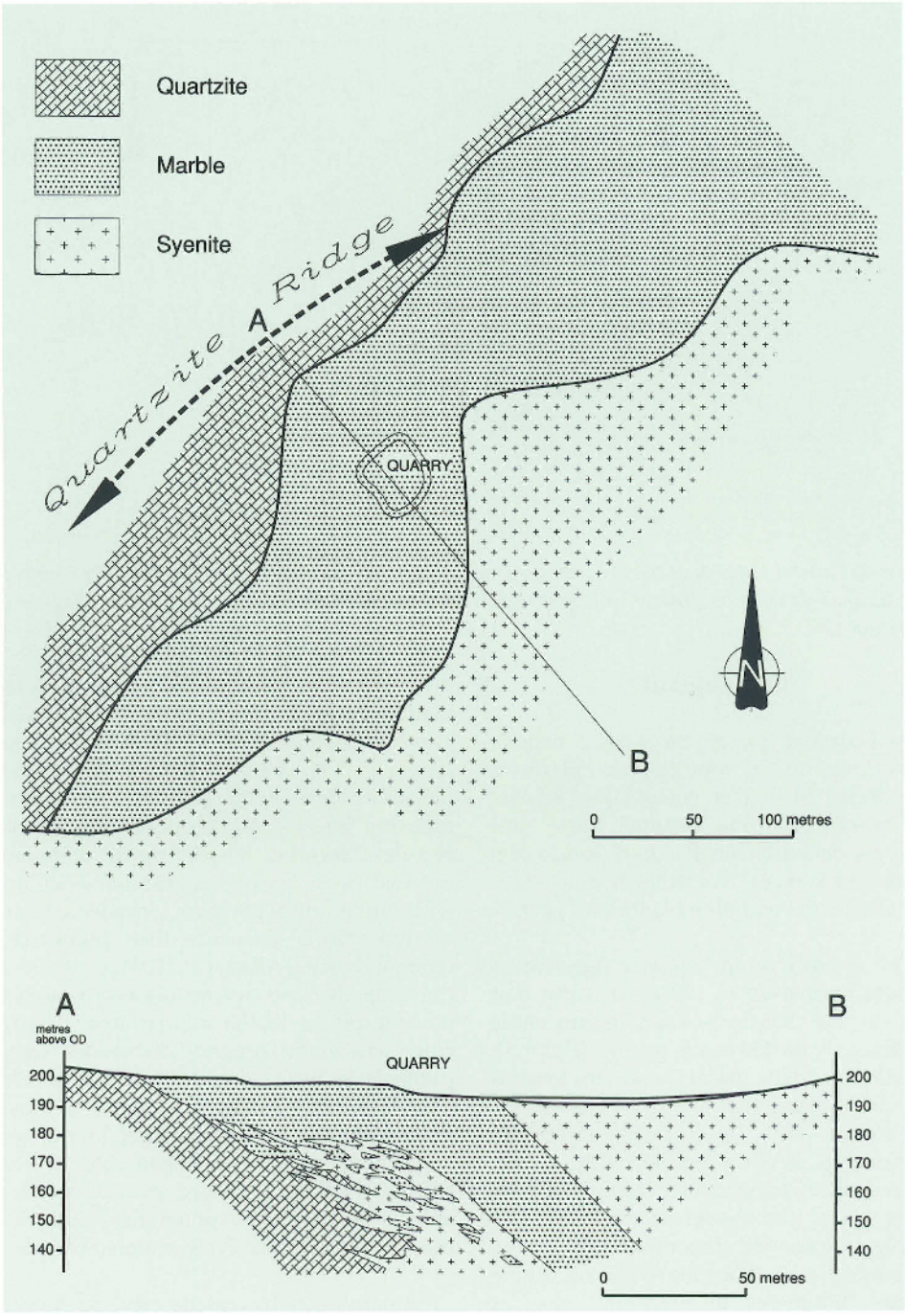

Figure 3: *Geological sketch map and cross section of the Ledmore marble deposit (after Smith et al., 1992).*

Figure 4: *Ledmore marble quarry. View looking westwards at wire-saw cut faces. Hills in the background consist of Cnoc na Sròine syenite. Photo by Douglas Nichol.*

Figure 5: *Ledmore marble quarry. Slabs of grey architectural marble showing typical deformation textures. Photo by Douglas Nichol.*

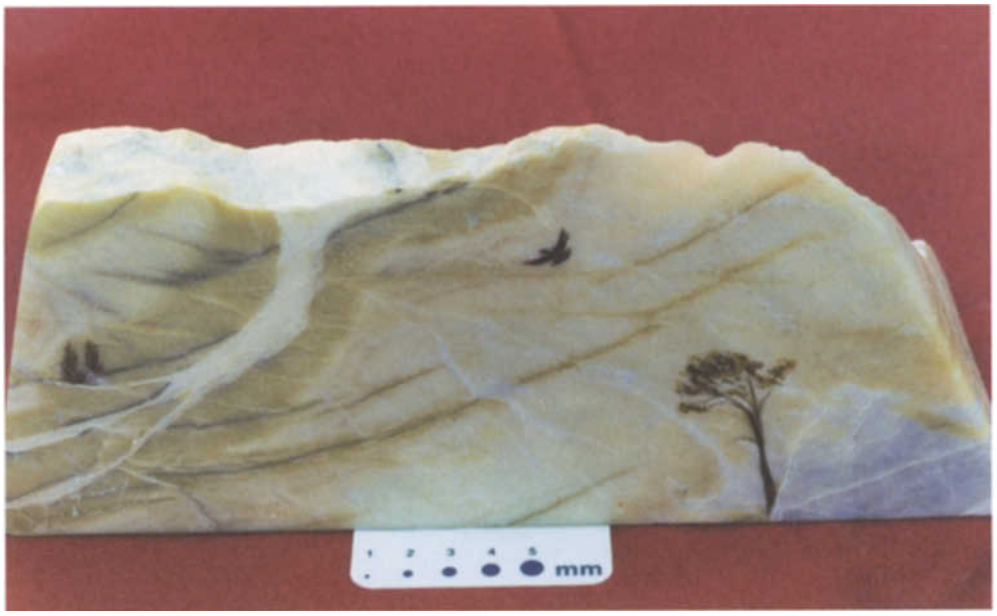

Figure 6: *Landscape in stone. Black ink on Ledmore marble; length about 200 mm. Artist, Murray Henderson. Photo by Douglas Nichol.*

metre scale that probably reflect different compositions of the original sediments. Textures range from fine-grained crystalline to medium-grained and granular. During the process of alteration to marble, chert nodules present in the original carbonate beds reacted with magnesia in the dolomites to form forsterite (Mg_2SiO_4) which in turn was partially or fully hydrated to form serpentine minerals. The serpentinous marble is also called ophicalcite. Another characteristic mineral found in the marble is brucite ($Mg(OH)_2$). It constitutes as much as 28% of certain bands and resulted from the hydration of periclase (MgO). Other accessory minerals that have been identified in trace amounts include tremolite, diopside, larnite, chlorite and rare magnesium titanium oxides.

Within the marbles there are concordant bands on a millimetre to centimetre scale. Lenses, specks, streaks, flecks and lenticles contain non-carbonate components and impart a range of attractive yellow, green, grey and cream-brown patterns. In addition, deformation features and brecciated zones that formed during tectonic disruption are also present and create different styles of textural patterns.

Mining and processing

The quarry measures approximately 100 m long and 100 m wide by up to 10 m deep and the processing and stockpiling areas occupy the adjoining ground (*Figure 4*). Extraction of marble involves conventional quarrying methods for bulk stone but monofilament wire-saw techniques are employed to extract blocks of architectural stone (*Figure 5*). Minor northwest trending dykes cut through the marble deposit and, as far as possible, these are avoided during mining operations.

Figure 7: *Turtle LVIII. Ledmore marble. Length 540 mm. Sculptor Laurence Broderick. Photo by Michelle Sadgrove.*

Figure 8: *Jewellery and giftware items of, or containing, Ledmore marble. Fashioned by Orcadian Stone Company Ltd. Photo by Douglas Nichol.*

The marble from Ledmore varies from pure white (N9) material suitable for industrial markets to coloured and textured stone suitable for ornamental applications and sculptural stone carving. Based on the Munsell system of colour identification (Rock-Colour Chart Committee, 1963) the predominant colours of ornamental grades of ophicalcite range from moderate yellow-green (5GY 7/4) through moderate greenish-yellow (10Y 7/4) to dark greenish-yellow (10Y 6/6).

Roughly hewn blocks of ornamental stone (gallets) are selected in the quarry and stockpiled for direct supply to the local trade. The proportion of ornamental grades is generally much less than 10 per cent. The small-scale soundness or quality of the marble in the gallet is important but not crucial because the processed item tends to be smaller then the fracture spacings. More important are colours and textures, and for this reason gallets are selectively extracted from certain parts of the deposit whenever suitable pockets of material are encountered during quarrying operations.

Individual artists and sculptors fashion a wide variety of ornamental pieces and figurines from Ledmore marble that are displayed in galleries and studios throughout the world (*Figures 6 and 7*). Distinctively patterned greenish-yellow marbles and ophicalcite are also used for jewellery, as well as small giftware and souvenir items with a high craft content (*Figure 8*).

Conclusions

At Ledmore in Scotland, white marble and variegated ophicalcite have formed within a multiply deformed and metamorphosed terrain adjacent to the Loch Borralan Igneous Complex. Ornamental grades of marble and ophicalcite are available as a by-product of quarrying operations for industrial stone.

Ornamental grades feature irregular patches, bands and streaks through the rock mass that typically range in colour from yellow to greenish yellow. Texture ranges from fine- to medium-grained.

The quantity of marble available for extraction appears substantial and ornamental material is anticipated to increase in variety as the quarry reaches deeper levels. An extensive range of ornaments, giftware and jewellery items is produced from Ledmore marble using conventional lapidary equipment.

Acknowledgements

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A critical review of the 'Hanneman refractometer'

D.B. Hoover

1274 E. Crystal Wood Ln., Springfield, MO. 65803, U.S.A.

ABSTRACT: A recent paper in this journal by W.W. Hanneman describes the Hanneman refractometer, an inexpensive device, which measures the deviation angle of a light beam as it passes through a faceted gemstone. In the paper Hanneman states that he believes that the treatment of the concepts of the refractometer should be incorporated in gemmological studies programmes. Because of errors relating to basic optical principles, and omissions of necessary constraints on the device, this author disagrees. Problems with the device are detailed, and simple experiments are described for the reader to better understand deviation angle refractometers.

Keywords: deviation angle refractometers, Hanneman refractometer

Introduction

Refractometers which determine a transparent solid's refractive index (RI) by measuring the deviation angle of a beam of light passing through a prism of the solid have been around for over 100 years, yet are seldom used by gemmologists. This lack of use by gemmologists is due in part to their expense and in part to the attention to detail required for accurate measurement. However, because they are capable of providing extremely accurate RIs as well as dispersion values, they are often described in gemmological texts where they are usually called goniometers (e.g. Walton, 1952) or prism spectrometers (e.g. Webster, 1994). Webster even gives details on the use of the instrument for RI determination, but notes that considerable skill and calculation is required to obtain results. Although Walton (1952) gives details of a simplified version of the goniometer or table spectrometer which he developed, his instrument has not found much use.

More recently work by Alan Hodgkinson (1979, 1989, 1994, 1995), who extended a visual method due to Crowningshield and Ellison (1951) for estimating optical properties to include estimation of RI, has resulted in renewed interest in deviation angle methods. Hanneman (2000) in a recent paper in this Journal has described the 'Hanneman refractometer' in which the deviation angle of light passing through a faceted gem is presumed to be determined in order to find its RI or RIs. In this paper Hanneman (2000, p.155) states that his 'Hanneman refractometer' "... has culminated in a new unlimited range refractometer. Surprisingly, it can be constructed by any student at a cost of only a few pennies. Because of the educational features offered

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by this instrument, the author believes a treatment of the concepts should be incorporated into the basic programme of every gemmological student."

There are only three essential elements in Hanneman's device: a light source, the gem to be measured, and a scale to measure deviation angles. This great simplification makes his device inexpensive to construct, but results in so many measurement problems that it is of questionable utility. *Caveat emptor!* However, of much greater concern to this author are the claimed educational features for students of gemmology and comments are made about the optical principles of the 'Hanneman refractometer' and omissions of necessary constraints in its operation.

Let us look at the problems with the 'Hanneman refractometer', and some simple demonstrations any student can make by which he or she will be able to appreciate these problems and obtain a better understanding of prism optics.

Background

Before we examine the 'Hanneman refractometer', we need to know a little about the conventional table spectrometer. Details of this instrument can be found in various editions of the classic text *Gems* by R. Webster (1994). Readers not familiar with the instrument should review this material. Major components of this instrument include a light source, typically a gas discharge tube to give accurately known wavelengths of light, although for crude work an incandescent source may be used. Light from the source passes through a slit and achromatic lens combination called a collimator, which gives a light beam containing parallel rays. A pin-hole could be used in place of the slit. The collimator is positioned to point at the centre of a rotatable table, at the centre of which the prism or gemstone to be measured is placed. The collimator may or may not be constructed to rotate around the centre of the table. Means are provided so that the gemstone can be orientated so as to place both facets to be used perpendicular to the axis of the collimator. The measurement is then made with a telescope which can be rotated about the centre of the table, and an angle scale is provided to measure the angle of rotation of the telescope. The telescope needs to be focused at infinity and must have provision to be brought exactly in line with the axis of the collimator.

Linton and others (2000) have evaluated the Hanneman refractometer and have concluded that it could give readings 'almost equivalent' to the conventional critical angle instrument gemmologists use. However they did not recognize the various technical deficiencies, nor give an evaluation of the accuracy or precision of the device. This paper addresses those problems, and suggests that the 'Hanneman refractometer' will not give 'almost equivalent' readings.

The problems

Problem 1 – the pinhole

First, the 'Hanneman refractometer' is described as a 'pinhole refractometer', presumably because an opaque 'pinhole' shield as shown in his *Figure 2* is used. While Hanneman is free to describe his device in terms of his choosing, his 'pinhole' doesn't function as an optical pinhole in the device. He states that the 'pinhole' is to be made a little larger than the diameter of the faceted gem. Thus for measuring gems up to several carats a 'pinhole' of something like 15 mm is needed. Linton and others (2000) note that Hanneman recommends a 5mm hole. If one looks at texts on optical physics where pinholes and pinhole cameras are described (e.g. Wood, 1961) one finds that a pinhole can act as a simple lens. A 15 mm pinhole lens can form a good image of the sun, but unfortunately it is at a distance of some 65 m from the pinhole. It should be clear that the 'pinhole' in Dr Hanneman's refractometer is functioning only as a shield against stray

light from the light source, and not as an optical pinhole or simple lens.

Problem 2 – "any light source will do"

In his construction notes Hanneman (2000) states: "Any light source will do." The reader can easily test this. Take a faceted quartz gem in the range of 5 to 10 ct, a brilliant cut is best because of the pattern produced. Cut a hole just larger than the table in a piece of stiff cardboard or similar material, and affix the gem with its table centred in the hole with an adhesive wax. Hold the card with its gem about 150 mm from a light-coloured wall with the pavilion away from the wall. If a scale were placed properly on the wall, this configuration would constitute the essential components of Hanneman's device. The distance between the wall, or scale, and the gem in Hanneman's device will play a part later, so we need to consider that now. Hanneman does not state what that distance is, but Linton and others (2000) indicate that it is adjustable from 50 to 100 mm (about 2 to 4 inches).

Next, shine the light from a small penlight or torch on the pavilion and observe the pattern of light on the wall, as the penlight is positioned first at the pavilion and then drawn farther away. With the light close to the pavilion you will see no clear pattern. But, as the light source is withdrawn farther and farther away the pattern will sharpen. Further, the pattern mimics the shapes of the pavilion facets. For a brilliant-cut gem eight diamond-shaped and 16 triangular light spots should be seen on the wall arranged in a circular pattern as shown in *Figure 1*. Note also that as the light source recedes from the gemstone the size of each individual facet pattern becomes smaller (*Figures 1a and 1b*), but that each is larger than the facet on the gem. What is happening is that as the source moves away, the light entering the gem becomes more nearly parallel or collimated. These patterns are, in effect, shadow patterns from light refracted through the stone.

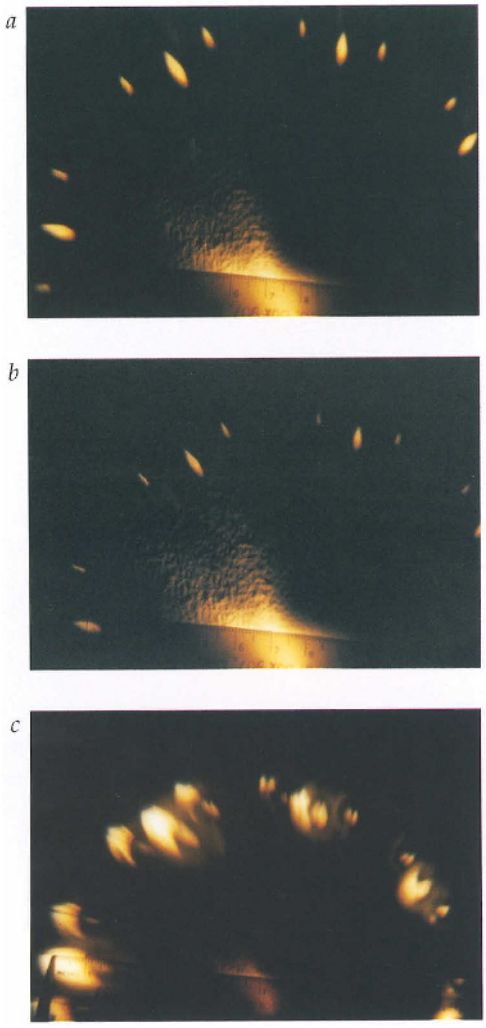

Figure 1: *Photographs showing the effects of different light sources at different distances from a gem. The 4.43 ct quartz was fixed at 150 mm from the viewing wall, and camera fixed for all illustrations. Note the centimetre scale. 1a shows a diamond pattern from a small lens-in-bulb torch held at 300 mm from the gem. 1b shows the same torch held at 600 mm from the gem. Note the smaller diamond pattern. 1c shows a distorted pattern from a small torch with an aluminium reflector behind a bulb held at 150 mm from gem. Distortion arises from multiple light paths at differing angles.*

Figure 2: *Photograph of the spectral images of a distant light source as seen by photographing the light passing through a faceted gem held at the lens, when illuminated from the pavilion side. Colour reproduction is poor, but the overlapping spectra of the ordinary and extraordinary rays of quartz are clear. This is the image that would be seen if the faceted gem were held close to the human eye. The camera has simply substituted for the eye.*

Now measure, approximately, the length of the diamond-shaped facet pattern from the inner to outer edge. This will provide an idea of the error involved as will be developed later.

Also, a decrease in the intensity of the light patterns occurs either as the torch is withdrawn, or as the cardboard and gem are moved farther away from the wall. Thus, if an expanded scale (for greater precision) is desired, an intense light source would be required.

If available, other small torches should be tested and those with a more uniform beam intensity will perform better than others. Two examples are shown in *Figures 1a and 1c*. If this test is tried with a frosted incandescent source, the light source must be much farther away before any clear pattern is seen. These tests indicate rather clearly that not all light sources are suitable but that one really needs a collimated source just as is needed in a conventional table spectrometer.

Problem 3 – "spectral images should appear"

Under operation notes, Hanneman (op. cit. p.159) tells the reader that for a brilliant-cut stone a symmetrical circle of spectral images will appear. We have already determined that the pattern of lighted areas mimics the facet shapes, and that they are not spectra. This is interesting, since in the table spectrometer the spectral images seen are of the slit of the collimator. Because Hanneman uses no slit or true pin-hole in such position, nor a telescope, what spectral image is he referring to? It appears that Hanneman, who has championed Hodgkinson's 'Visual Optics', may believe that what one sees when looking into a gem with the 'visual optics' method is identical to what is seen if one simply projects the light onto a flat surface. This is not so, and *Figure 1* shows the shadow patterns seen on a wall using a 4.43 ct faceted quartz. This is what is seen with the experiment described under Problem 2. In *Figure 2*, a faceted quartz was simply placed at the front of the 35 mm camera focused at infinity and titled slightly; the image is of sharp small spectra associated with a few of the pavilion facets. The camera does not have a lens of wide enough angle to view the refraction patterns from all facets. This is what the eye would see if substituted for the camera. Note that one does not see triangular and diamond-shaped patterns that mimic the facets, but a series of bright overlapping spectra corresponding to each of the bright shadow patterns seen in *Figure 1*. What is happening?

Go back to the cardboard-held gem and look at the patterns you see on the wall; look very closely and darken the room. If your penlight is bright enough you should see a faint red coloration at the inner part of each facet pattern and a blue fringe on the outer part. Look closely as the coloured part will be less than 1.5 mm broad.

A clean pure spectrum is not produced because each facet image on the wall consists of infinite series of overlapping spectra produced by light refracting along the entire

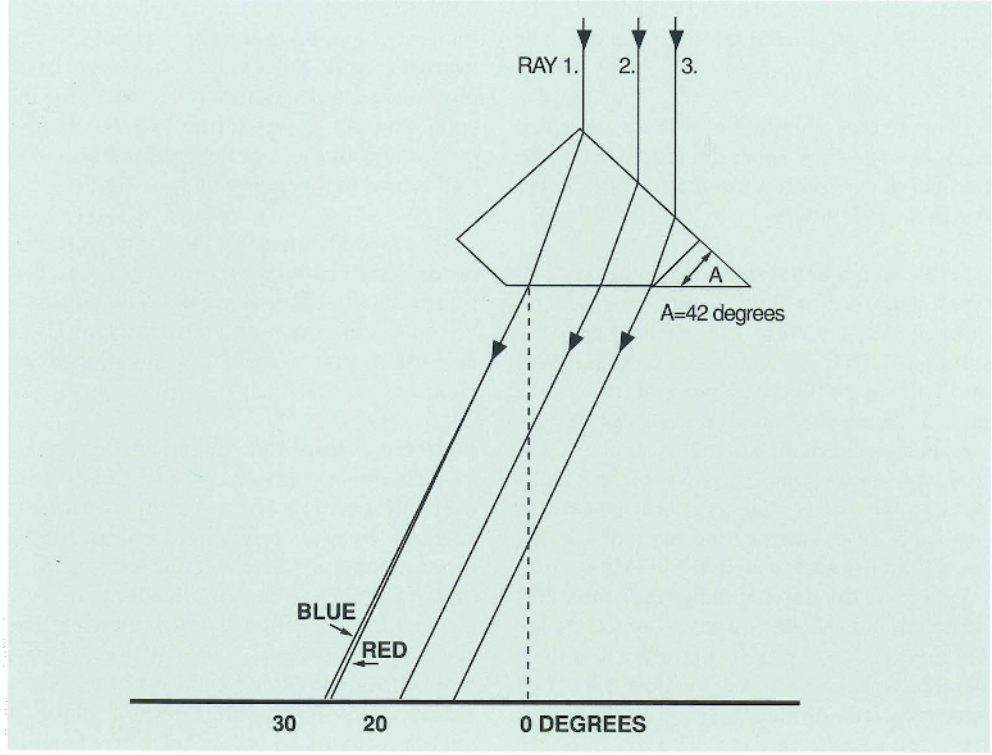

Figure 3: *Diagram illustrating the ray paths through a quartz gemstone and falling on a distant surface. Incident rays are normal to the table surface. Ray 1 shows, to scale, the difference in deviation angle for red and blue light.*

length of the pavilion facet and incident at various angles. The bulk of the image shows the colour of the light source where images overlap; only the outer part shows blue and the inner part red where there is incomplete overlap. These are *not* spectra. This very serious problem results from the absence of collimated light and a lens following the gemstone.

Figure 3 may help to explain the true situation. This shows ray paths for collimated light which is normal to the table facet, passing through a stone with indices of refraction and dispersion similar to quartz. Look at ray 1 that enters the pavilion just to the right of the culet. This is bent to the left with an angle of refraction of 25.677 degrees for the O ray within the stone, and exits the table at 25.729 degrees. The angles are for sodium light. If another parallel ray impinges further down the main facet, the angles and directions will be the same, but each offset, such as rays 2 and 3. If a flat surface is placed in the ray path beyond the gem, the heavy line in *Figure 3*, one obtains a projection of the facet shape on that surface such as was seen with the cardboard experiment. If, instead of monochromatic light, white light is used, then because of the small differences in RIs with wavelength, the deviation angles will be slightly different for each colour. For quartz that difference is 0.6 degrees, shown for ray 1 with the blue and red ends indicated. Thus, except for a small region on the inner and outer edges of the

facet pattern, the spectral colours of each ray will overlap producing the colour of the light source.

The reader should be able to visualize from *Figure 3* how small deviations from the parallel of rays within the beam would affect the projected pattern.

However, if one restricts the light rays to a small bundle or limits the size of the gemstone, a crude spectrum can be produced. That size limit can be calculated, and will vary with the distance of the surface or scale to the gem, its RI and its dispersion. Let us assume that the scale distance is 150 mm, 1.5 times that used in Hanneman's device, so there is greater measuring precision. And, assume that we will tolerate quite a bit of overlap so that the yellow from one ray will overlap the red of the other. This means that in *Figure 3*, if rays 1 and 2 define the limits of the light beam, how close does ray 2 have to be so that the yellow part of its spectrum falls on the red of ray 1? For this, the light beam, or facet length, must be smaller than 0.37 mm for quartz. Hanneman's device obviously does not meet the requirement with its large light beam. Since the dispersion of quartz (0.0131 B–G for the O ray) and its birefringence (0.0091) are similar in magnitude, it should be clear that one would not be able to measure either with the device.

One can more readily appreciate this by placing a piece of aluminium foil over the pavilion of the gem mounted on the cardboard and carefully punching a very small hole at the culet. Illuminate this configuration on the wall with your torch, and note that this provides a much smaller spot that does not reflect the shape of the facet and shows a better spectrum. The room should be darkened to be able to see this.

To understand what is happening, remember that the red component of the light as it passes through the gem is bent at a slightly smaller angle than the green which is bent just a bit less than the blue, etc. Also remember that the gem is only about 150 mm from the wall. Thus we need a very small pinhole in the aluminium foil in order for the spot due to the red light to be visibly separate from those of the green or blue. We will return to this point later.

Thus for Hanneman's device to work one needs a collimated light beam, and one that is very small in diameter, especially if there is no lens in the ray path after the gem. These important points were not mentioned by Hanneman (2000).

Problem 4 – reading the refractive indices

Hanneman states that the RI can be read from the position of the yellow part of the spectral image on his scale, and that a monochromatic filter could be used if desired, with the implication that a monochromatic filter would increase the accuracy. However, in his device a monochromatic filter would do little, as the reader can easily determine. Place a monochromatic filter or just a piece of strongly coloured glass in front of your light source and project the facet images on the wall. The same large images of the pavilion should be there, but without the coloured edges. It should be apparent that if we had an angle scale on the wall, a facet image would still cover a wide range of angles, and that that range would increase in direct proportion to the size of the gem. Hanneman does not discuss what part of this large image to use, nor how much error is represented by the angular span of the image. Note, also, that there is no evidence for birefringence in the wall images.

One can calculate by how much this shadow image of the facet is too large for precise determination of RI. The 4.43 ct quartz has an 8 mm long main pavilion facet, and when projected on the horizontal surface as shown in *Figure 3* its image length is about 6 mm. How does this compare with the length you measured under problem 2? At a 150 mm radius 6 mm represents an angular

range of 2.25 degrees. The B–G dispersion in quartz would give only an angular range of 0.591 degrees. Thus, the image is four times the width of the entire spectrum and many more times that of the width of the sodium doublet.

Another simple experiment may help, but knowledge of Hodgkinson's visual optics is needed. If the reader does not know how to observe images with this technique, consult the references and you will be more than adequately rewarded for your time.

Take the cardboard in which the quartz gem is mounted, and the same torch used previously to observe the refracted images. Hold the gem's table close to your eye as is normal in visual optics. If the torch is say 3m away, the spectral images will be sharp and birefringence clearly seen. Now, move closer to the light and observe the deterioration of the spectral images. However, even when fairly close, one still sees bright spectra, not simple images of the facets as seen when projected on the wall. You will also see that even when the torch is at some distance, the spectra are still very bright. Here, the eye is functioning as the telescope used in the table spectrometer. Thus Hodgkinson's technique for estimating RI has all the elements of the table spectrometer except for a scale to measure angles.

There is yet another unstated problem concerning how to read the proper position on Hanneman's scale. This can best be appreciated by going back again to the simple wall experiment. When a pattern of facet images on the wall has been obtained, change the angle of the light beam as it shines on the gemstone. You will see a corresponding change in position of each facet image, corresponding to a change in deviation angle, measurable if a scale were present. Hanneman's scale is calculated on the assumption that the light is collimated and that the beam is perpendicular to the table facet, but this very important point is not mentioned in the paper. How much difference does this make? If your gem has a pavilion angle of 42 degrees and an RI of 1.55, the deviation angle would be 26 degrees. If your measurement is off by 2.4 degrees you would erroneously believe that its RI would be 1.60 (see Hoover, 1998 for detailed tables), an error that is too large for accurate identification.

To test this idea, have an associate hold the cardboard with the gem 150 mm from a wall. Then shine the beam of a laser pen on the pavilion while trying to hold the beam perpendicular to the gem's table. Make sure you are not able to see where the laser spot is located on the wall. Have your associate mark where the beam is, and repeat the procedure to obtain a scatter pattern showing how much perpendicularity error you would have in making such a measurement.

Problem 5 – measuring dispersion

Hanneman explains (2000, p.158) that dispersion can be measured with his device by measuring the angles, and thus RIs, at which the blue and red ends of the image spectrum are seen. It has been shown above that his device does not produce true spectra, so dispersion cannot be measured. However, even if the spectra were adequate, comments about the measurement of dispersion in this and in a previous paper (Hanneman, 1992) on dispersion are in error (see also Hoover and Linton, 2000). A minor error was corrected in the following issue (erratum 2000), but many remain. What are these errors?

First, that the maximum and minimum wavelengths observed using the Hanneman refractometer are 760 nm in the red, and 397 nm in the violet. These wavelengths correspond approximately to the maximum range of human vision. However, the range of human vision is dependent partly on the visual input. To see this, look at an incandescent source through a spectroscope. You should be able to distinguish colours from about 700 to 420 or 430 nm. Now,

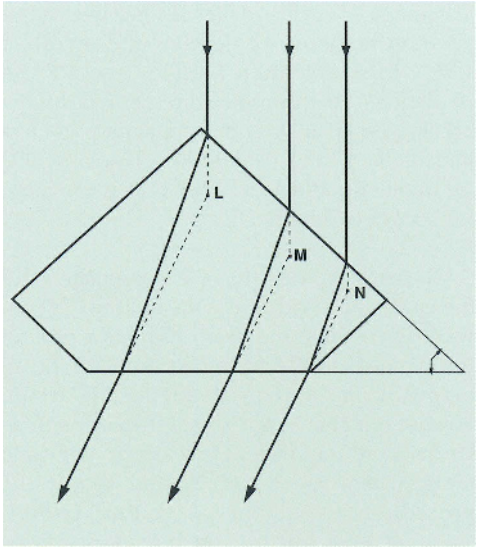

Figure 4: *Diagram illustrating the ray paths through a quartz gemstone. Incident rays are normal to the table surface. Points L, M and N show the intersections of each pair of incident and exiting rays within the gemstone.*

without changing anything else just place your Chelsea colour filter in the light path. The bright full spectrum will be gone and all you will see are the Chelsea colour filter bands. These are in the yellow-green and red with the red extending from about 700 to 750 nm where no colour was discernible without the filter.

Additionally, Hanneman's assignment of 760 to 397 nm to the observed red and violet ends of the spectrum does not take into consideration absorption in many coloured gemstones of either the red or blue/violet ends of the spectrum. One only has to look at absorption spectra of gems given in many gemmological texts to appreciate how this may affect assigning fixed wavelength values to the end colours seen. Thus, a user of Hanneman's device could not be certain of the end wavelengths for any particular gem.

Hanneman (2000, p.158) states that in order to correct the 760 to 397 dispersion value to the more generally used B–G interval one only has to multiply by the ratio of the wavelength intervals. This introduces further possible errors, since a plot of RI versus wavelength (a dispersion curve) is not linear but curved. Means to correct dispersion values between differing wavelength intervals have been known for many years, but are rather more complicated that a simple linear conversion (see Hoover and Linton, 2001).

Problem 6 – where is the zero position?

To position the scale in Hanneman's device he states that the gemstone should be placed so that it is centred above the O, or origin, of the scale. In another section he states that the height of the bottom (table) of the gem should be exactly equal to the distance of the 45 degree line on the scale. If one could do this precisely, and if the table were also perpendicular to the light beam, a necessary requirement, then the device would still not necessarily read properly. The requirements set forth by Hanneman are valid only if the gem is infinitely small. This can be illustrated with reference to *Figure 4*, with quartz as an example. If a narrow ray enters at the culet, then the position for measuring the deviation angle (if the plane of the table is reference) is near the left edge of the table and not the centre as suggested by Hanneman. It should be clear that the exit position will vary with the RI, which is also unknown. *Figure 4* shows several ray paths within a faceted stone, and the intersection points, L, M and N, for the entering and exiting rays. If the scale is to be centred below the culet, then the height of the gem to the scale zero point must be adjusted to reflect the depth of the point L within the gem. But clearly this height varies with RI as well, meeting the table for an RI near that of diamond. Thus positions L, M and N, and points of exit, cover a major fraction of the depth and width of a stone. For larger gems this can amount to large errors in RI. If one considers that for quartz with a birefringence of 0.0091 the two rays show an angular range of only 0.43 degrees. At Hanneman's 100 mm

working distance, 0.43 degrees spans a length of only 0.75 mm. Thus a 3 mm error would be equivalent to an error in RI of 0.036.

Error analysis

A true error analysis of Hanneman's device would be difficult because they come from three principal sources. The first is the measurement of the deviation angle itself, where the error is a function of stone size, RIs and dispersion, and not having true spectra displayed by the device. This is the most difficult to quantify, but may be quite large as discussed. The second is knowing the error in the angle between the light beam and the table of the gem, assuming the beam is collimated. The author estimates that this could be of the order of a few degrees. The third is the error in measurement of the pavilion angle, which has not been discussed. Unless the goniometer or optical comparator is used, the author estimates this at a few degrees also.

The final measurement error is a compound of these three errors. In some cases one may cancel another, but in other cases all three may add together producing great uncertainty in the result.

With the device, one can distinguish between RIs of gems as different as quartz and cubic zirconia. But, until there is a way to rigorously calibrate the device and to quantify the errors, the actual errors of measurement will remain unknown.

Summary

In attempting to simplify a deviation angle refractometer Hanneman has produced a device which is not sufficiently accurate for much gemmological work.

Further, instructions for its use are inadequate, or erroneous. The device can be used to demonstrate the refraction of light, but this is something better done by other, simpler means.

In this author's opinion, Hanneman's explanation of the device contains erroneous explanation and application of optical principles and it would be wrong to use these as educational material for gemmological students. It is hoped that the above discussion helps to make clearer to students the basis of deviation angle refractometers. The author also recommends that all readers should make appropriate amendments to their copies of Hanneman's paper.

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Abstracts

Diamonds

Gems and Minerals

Instruments and Techniques

Synthetics and Simulants

Diamonds

Impact origin of ancient diamonds with eclogitic and meteoritic parageneses of mineral inclusions.

V.N. ANFILOGOV. *Doklady, Russian Academy of Sciences, Earth Sciences Section*, **377**(2), 2001, 219-20. (English translation.)

Diamonds can be divided into three paragenetic assemblages: eclogitic (E-type), peridotitic (P-type) and meteoritic (M-type). Geochronological and carbon isotope data on diamonds revealed that the E-type diamonds are dated at 500-300 ± 300 m.y. whereas the P-type diamonds and rims of E-type diamonds widely range in age up to the timing of kimberlite emplacement in the upper horizons of the Earth's crust. Also, the carbon isotopic composition of P-type diamonds approximates that of the mantle-derived variety, whereas E-type diamonds are enriched in light carbon. A.M.C.

High-pressure coesite inclusions in diamond: Raman spectroscopy.

B.A. FURSENKO, S.V. GORYAINOV AND N.V. SOBOLEV. *Doklady, Russian Academy of Sciences, Earth Sciences Section*, **379A**(6), 2001, 749-52. (English translation.)

Coesite inclusions 60 and 200 μm in size were localized at a depth of 170-250 μm beneath the (111) face of a flattened octahedral diamond crystal, 1.5 mm in diameter. The smaller inclusion had a typical triangular shape of a negative diamond crystal. Measurements were made with a multichannel Raman microspectrometer and the spectra from each of the inclusions were virtually identical, yielding the same shift of the 521 cm^{-1} line; 8 ± 0.5 cm^{-1} for the large inclusion and 10.5 ± 0.5 cm^{-1} for the smaller inclusion. A.M.C.

Diamonds in Canada.

B.A. KJARSGAARD AND A.A. LEVINSON. *Gems & Gemology*, **38**(3), 2002, 208-38.

A newcomer (since 1998) as a supplier of rough diamonds to the world market, Canada is currently the seventh most important diamond producer by weight and fifth by value. In this paper, the history of the explanation for, and the discovery of, primary diamond deposits throughout Canada (538 kimberlites reported) is chronicled, with particular emphasis on the important kimberlite pipes in the Northwest Territories. These pipes typically are small but have high diamond grades. Sales of the rough diamonds, and the developing cutting and polishing industry in Canada, are described. The Lac de Gras area in the Slave craton contains the most important Canadian deposits so far recognized, with economic pipes at Ekati and Diavik. R.A.H

Legal protection for proprietary diamond cuts.

T.W. OVERTON. *Gems & Gemology*, **38**(4), 2002, 310-25.

Proprietary brand names can be protected by trademark registration (typically noted by a registration symbol [®] next to the brand name), while proprietary designs or products can be protected by patents. Both methods have limitations, but it is important to protect a valuable diamond cut. A list of recent U.S. proprietary designs is given in an appendix. [The author is a licensed attorney and a gemmologist.] R.A.H.

Report on the diamondiferous kimberlite fields in the State of Chattisgarh and neighbouring states based on various papers presented at the International Conference on Diamonds and Gemstones held at Raipur from 9th-15th February 2002.

J. PANJIKAR, M. DHANDIA AND K.T. RAMCHANDRAN. *Indian Gemmologist*, **10**(4), 2002, 11-21.

General survey of the diamondiferous areas of the State of Chattisgarh, western India and neighbouring states with respect to recently discovered occurrences. M.O'D.

[On the discovery of diamonds in the Msta River middle stream (Novgorodsky region).]

E.G. PANOVA AND A.P. KAZAK. *Proceedings of the Russian*

Abstractors

R. Arnaudova	R.A.	R.A. Howie	R.A.H.	P.G. Read	P.G.R.
A.M.Clark	A.M.C.	M. O'Donoghue	M.O'D.	E. Stern	E.S.
J. Flinders	J.F.				

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

ISSN: 1355–4565

Mineralogical Society, **131**(1), 2002, 45-7. (Russian with English abstract.)

In the East European platform, kimberlites are related to the Middle Devonian stage of platform development. In this epoch, the kimberlites of the Belomorsko-Kuloiskoye plateau and the Middle Timan ridge pipe-shaped alkaline-ultramafic bodies of the Arkhangelskaya region and the complex of kimberlites and alkaline-ultramafic rocks of the Tersky coast of the White Sea were intruded. A new aureole of diamonds and associated minerals is reported from the central Devonian field; they were found in a 20 litre sample and include one 2 mm octahedron and four fragments. R.A.H.

Crystalline inclusions in diamonds from kimberlites of the Snap Lake area (Slave Craton, Canada): new evidences for the anomalous lithospheric structure.

N.P. POKHILENKO, N.V. SOBOLEV, J.A. MCDONALD, A.E. HALL, E.S. YEFIMOVA, D.A. ZEDGENIZOV, A.M. LOGVINOVA AND L.F. REIMERS. *Doklady, Russian Academy of Sciences, Earth Sciences Section*, **380**(7), 2001, 806-11. (English translation.)

This kimberlite dyke complex is the largest American native diamond deposit. The compositions of crystalline inclusions in 109 diamond crystals are reported, the distribution demonstrating that most of the diamonds examined contain inclusions of minerals of ultramafic paragenesis. Olivine inclusions occurred in 84 crystals. Analyses are tabulated of garnet and clinopyroxene inclusions in ten diamonds. The data obtained confirm the assumption of the anomalous composition of kimberlites and the unusual structure of the lithosphere beneath them. A.M.C.

Coesite inclusions in rounded diamonds from placers of the northeastern Siberian Platform.

A.L. RAGOZIN, V.S. SHATSKY, G.M. RYLOV AND S.V. GORYAINOV. *Doklady, Russian Academy of Sciences, Earth Sciences Section*, **384**(4), 2002, 385-9. (English translation.)

The diamond crystals studied (3–4 mm in size) have a dark grey to almost black colour caused by abundant fluid inclusions with graphite-type carbon on the walls. In addition, colourless faceted mineral inclusions were also present. The chemical composition and intense band at 521 cm^{-1} in the Raman spectra indicate the presence of coesite in the inclusions. A table is presented of impurity centres and nitrogen content in eight diamonds from these placers. The discovery of coesite inclusions significantly constrains the genesis of the diamonds, suggesting that they belong to an eclogite paragenesis. A.M.C.

A note on diamond incidence in Wairagarh area, Garhchiroli District, Maharashtra.

K. SASHIDHARAN, A.K. MOHANTY AND A. GUPTA. *Journal of the Geological Society of India*, **59**(3), 2002, 265-8.

During an ongoing search for kimberlite-lamproite rocks in the W Bastar craton, a single octahedral crystal (0.15 ct) of gem-quality diamond with a light greenish tint was found in a highly deformed polymictic conglomerate of probable early Proterozoic age in the Wairagarh area of central India. R.A.H.

Kankan diamonds (Guinea) III: $\delta^{13}C$ and nitrogen characteristics of deep diamonds.

T. STACHEL, J.W. HARRIS, S. AULBACH AND P. DEINES. *Contributions to Mineralogy & Petrology*, **142**(4), 2002, 465-75.

Kankan diamonds formed over a large depth profile from the cratonic mantle lithosphere through the asthenosphere and transition zone, and into the lower mantle. Diamonds from this whole depth range have had their C isotope composition, N impurity content and N aggregation level determined. Lithospheric peridotitic and eclogitic diamonds have $\delta^{13}C$ of –5.4 to –2.2‰ (peridotitic) and –19.7 to –0.7‰ (eclogitic), and N contents of 17–648 atomic ppm (peridotitic) and 0–1313 atomic ppm (eclogitic) typical for these diamonds worldwide. Geothermobarometry on these two suites implies they formed under similar conditions, inconsistent with derivation of diamonds with light C isotope composition from subducted organic matter within subducting oceanic slabs. Diamonds with majorite garnet inclusions are isotopically heavy ($\delta^{13}C$ of –3.1 to –0.09‰) and have N contents of 0–126 atomic ppm, precluding prolonged exposure within the transition zone. This implies rapid upwards transport and coincident Kankan diamond formation and Cretaceous kimberlite activity. Similar to the asthenosphere and transition zone diamonds, those from the lower mantle are also isotopically heavy ($\delta^{13}C$ of –6.6 to –0.5‰). This shift towards heavier isotope compositions of sub-lithospheric diamonds suggests a common C source that may have inherited this heavy composition from a subducted carbonate component. J.F.

Evidence to show the presence of seed in natural diamond crystals and its implication to the genesis of diamond.

I. SUNAGAWA, T. YASUDA AND H. FUKUSHIMA. *Indian Gemmologist*, **10**(4), 2002, 8-10.

In two brilliant-cut diamonds proved to have come from the same rough crystal it was shown that growth took place on a cuboid diamond seed which after formation in one environment was transported to another in which the major growth took place. The cuboid may have formed in ultra-high pressure metamorphic rocks in a subduction zone. M.O'D.

[Change of colour produced in natural brown diamonds by HPHT-processing.]

V.G. VINS. *Proceedings of the Russian Mineralogical Society*, **131**(4), 2002, 111-17. (Russian with English abstract.)

The change in colour produced by high-*P*–high-*T* processing of natural brown diamonds at 5.0–6.0 GPa and 2100–2300 K has been investigated by absorption spectroscopy in UV, visible and IR ranges. Such treatment of the IIa type makes them colourless, but occasionally

they acquire a light pink colour. Diamonds of the Ia type change from brown to bright yellow-green of various tints. The depth of colour, as well as the ratio between yellow and green tints, depends on the absorption intensity of N3, H4, H3 and H2 nitrogen-vacancy centres formed during the HPHT treatment. It is concluded that annealing of plastic deformation takes place during the HPHT treatment and thus the density of dislocations decreases. The energy activating the dislocation movement due to the plastic deformation annealing amounts to 6.4 eV. Models of the colour centre transformations are discussed and colour photographs of diamonds faceted after HPHT processing are presented. R.A.H.

[Lattice distortion in diamonds.]

Z.-Z. YUAN, Z.-J. YANG AND M.S. PENG. *Bulletin of Mineralogy, Petrology and Geochemistry*, **21**(2), 2002, 114-16. (Chinese with English abstract.)

Although diamond is isotropic, it shows anisotropism in polarized light. The optical properties of 24 diamonds have been examined and their oriented IR spectra measured ⊥ (100), ⊥ (110) and ⊥ (111). The occurrence of anisotropism is due not only to the uneven distribution of impurities such as N, B and H, but also to the presence of inclusions which induce lattice distortion. R.A.

Ferropericlase inclusions in a diamond microcrystal from the Udachnaya kimberlite pipe, Yakutia.

D.A. ZEDGENIZOV, E.S. YEFIMOVA, A. M. LOGVONOVA, V. S. SHATSKY AND N. V. SOBOLEV. *Doklady, Russian Academy of Sciences, Earth Sciences Section*, **377A**(3), 2001, 319-21. (English translation.)

In a small diamond several prismatic inclusions of yellow-brown ferropericlase were found. EPMA of two inclusions are presented and these contain respectively 23.6 and 21.0 wt.% and 21.0 wt.% FeO and 1.44 and 1.39 wt.% NiO. Two possible explanations for their presence in diamond are proposed. The mineral may be formed at the expense of olivine decomposition in the lower mantle or it may represent a product of peridotite and eclogite formed under extreme reducing conditions. A.M.C.

Gems and Minerals

Gemmological observations as clues to problems of ore and rock genesis and vice-versa.

G.C. AMSTUTZ. *Gemmologie. Z. Dt. Gemmol. Ges.*, **51**(2/ 3), 2002, 61-6, 1 table, bibl.

Successful exploration of ore and gemstones depends on sound ideas about where to find them and sound ideas as to why they were formed in particular places. Gemstones are amongst the most investigated of all minerals and it is logical that we should use the results of gemstone research as guidance in our attempt to understand their mode of formation. A few examples are mentioned and it is recommended that we stick to sound facts instead of jumping on new bandwagons of dogmatic interpretation. E.S.

Mineralien finden! Abenteuer alpine Strahlerei.

C. BODENMANN. *Lapis*, **27**(5), 2002, 13-29.

An Alpine crystal collector reviews some of his expeditions and describes some of the more spectacular crystals he has found. They include amethyst and rock crystal, kyanite and sphene. M.O'D.

Some lesser known Australian opals.

G. BROWN. *Gemmologie. Z. Dt. Gemmol. Ges.*, **51**(2/3), 2002, 97-106. 1 map, 13 photographs, 5 diagrams, bibl.

Australia produces 95% of the world's precious opal. This is exported mainly as rough consisting of a mix of black, dark and light type 1 natural opal, boulder opal (type 2 natural opal) and type 3 natural opal or opal matrix. Australia also produces a range of lesser known opals that display properties and features of interest to gemmologists, although most have little commercial value. The article describes some lesser known opals, such as the White Cliffs opal 'pineapples', Tintenbar volcanic opal which are of historic interest, Andamooka matrix opal, opal associated with 'thunder eggs' and some facetable common opals, such as siliciophyte cat's-eye. E.S.

New imitation gemstones from Australia.

G. BROWN AND T. LINTON. *Australian Gemmologist*, **21**(7), 2002, 283-6, 11 illus. in colour, 2 tables.

Controlled devitrification of melts based on finely ground chrysoprase is being used in Brisbane, Queensland, by Australian Crystallization Technology Pty Ltd, to produce a range of semitranslucent to opaque imitations of chrysoprase, jadeite, turquoise, and other ornamental materials including a number of attractive transparent glasses of various colours. Details are given of the method of manufacture of these products and of their gemmological properties and features. P.G.R.

Faszination blauer Bernstein.

R. BURGLER. *Schweizer Strahler*, 2/2002. 12-14.

A description of amber in general and in particular of a specimen in the Natural History Museum, Stuttgart, which was found to show a blue colour in sunlight, under a halogen lamp and under fluorescent light. In the light from a traditional incandescent source the blue colour was less pronounced. Under UV radiation the specimen gave an intense blue. M.O'D.

Orange sapphires or just lemons?

T. COLDHAM. *Australian Gemmologist*, **21**(7), 2002, 288-93, 15 illus. in colour.

Parcels of orange sapphire from Songea in Tanzania, which had been subjected to a 'new' form of heat treatment, initiated the start of investigations by the author and other gemmologists into this new colour enhancement process. Songea ruby, when subjected to the new Thai process, lost its brownish shade and became the colour of burmese red spinel. More importantly poor colour Songea material in the brownish-yellows, reddish-orange and palish yellows also changed colour to various shades of

bright orange through to reddish-orange. By January of 2001 the new process was being applied to Malagasy pink sapphires making these stones look like naturally coloured 'padparadscha' sapphires and in some instances being certified as such. By the time of the Tucson Gem Show, the GIA reported the presence of small quantities of beryllium in the orange rim of these sapphires which increased in concentration towards the surface of the stone, indicating that the new treatment was a bulk diffusion process. The biggest problem identifying corundum treated by the new process occurs when no outer rim is visible, either because the rough was treated before cutting or the induced colour continues through to the core of the stone or the colour and size of the stone make visual detection of a differently coloured rim difficult. P.G.R.

Some aspects of precious opal synthesis.

S.V. Filin, A.I. Puzynin and V.N. Samoilov. *Australian Gemmologist*, **21**(7), 2002, 278-82, 10 illus., 1 table.

The total production time of the multi-step synthesis process as researched and developed by the authors is around 10 months. All the properties of the opals synthesized by this method (their 'closed' porosity, chemical composition of silica and up to 8% water, and hardness) are identical to those of natural precious opal. In addition, the rough synthetic opal can be easily cut and polished. P.G.R.

Gem and rare-element pegmatites of southern California.

J. Fisher. *Mineralogical record*, **33**, 2002, 363-407.

The pegmatites of the Himalaya, Tourmaline Queen, Stewart, Pala Chief and Little Three mines are among the world's leading producers of high-quality tourmaline, morganite and spodumene, together with aquamarine, topaz and spessartine. The history of gem mining in the region is described with reference to well-documented previous sources of which Jahns and Wright's study of this area (1951) is probably the most important. Individual mines are described in detail with diagrams and some of the claims and workings. Notable gem mineral specimens are illustrated and there is a bibliography of more than 50 entries. M.O'D.

Vom Smaragd zum Tanteuxenit.

F. Girlanda. *Schweizer Strahler*, 1/2002, 10-14.

Emerald is among the minerals found in the Val Vigezzo, Piedmont, Italy where it occurs in a pegmatite together with yellow-green beryl and other minerals. Two faceted stones are illustrated but their size is not given. M.O'D.

Amethyste vom Schöderhorn.

D. Grolig. *Mineralien Welt*, **14**, 2003, 41-8.

Well-formed crystals of amethyst are described from the Schöderhorn region of the Hohe Tauern national park, Austria. Sceptre crystals of deep colour have been found. Citrine was discovered during prospecting in 2000. M.O'D.

Die weltbesten Kosnarite aus Brasilien und das Amblygonit-Montebrasit-Problem.

J.C. Hyrsl and J. Sejkora. *Mineralien Welt*, **14**, 2003, 60-2.

Very fine crystals of kosnarite are described from a pegmatite at Limoeiro, Minas Gerais, Brazil, and crystals of montebrasite of exceptional quality from pegmatites between Linopolis and Galilea and between Virgem da Lapa and Taquaral, NW of Teofilo Otoni, in the same State. The relationship between the two minerals and with amblygonite is discussed. M.O'D.

Piteiras, Brasilien: erfolgreiche Smaragdsuche mit modernen Methoden.

J. Kanis. *Lapis*, **27**(3), 2002, 13-18.

Modern methods of recovery are in use at the Piteiras emerald deposit in Minas Gerais, Brazil where emerald is found with phlogopite and biotite. A crystal 18 cm in length is illustrated. M.O'D.

Zuchtperlen vom Golf of Kalifornien, Mexiko.

L.Kiefert. *Gemmologie. Z. Dt. Gemmol. Ges.*, **51**(2/3), 2002, 121-32.

In the Mexican part of the Gulf of California, natural black pearls have been found for a long time. Because of their high commercial value efforts to produce cultured pearls have been tried for some time with varying success. Now cultured mabe pearls have been produced in the indigenous pearl oyster *Pinctada mazatlantica* and round loose beaded cultured pearls have been produced in the indigenous *Pteria sterna*. The medium sized pearls are marked by a grey to dark grey body colour which is overlaid by interference colours caused by the stacking of aragonite tiles of 0.2–0.3 microns. Their colour is considered natural if their fluorescence in long wave UV light is red. E.S.

Bernstein an den Küsten und im Binnenland von Dänemark.

K. Krause. *Aufschluss*, **54**, 2003, 2-10.

Brief illustrated account of amber deposits around the coasts and on land sites in Denmark. M.O'D.

Gem news international.

B.M. Laurs (ed). *Gems & Gemology*, **38**(3), 2002, 258-75.

Items mentioned include aquamarine and spessartine from Tanzania, a dark brown beryl from Mozambique, gem tourmalines with a range of colours even from a single mine, three faceted morganites (3.34 – 4.19 ct) from a new pegmatite mine near Ambositra, Madagascar, and emeralds from Somaliland. R.A.H.

Gem news international.

B.M. Laurs (ed). *Gems & Gemology*, **38**(4), 2002, 348-69.

Items reported include alexandrite from Mananjary, Madagascar; a gem-quality colour-change apatite from

Kazakhstan; the reactivated San Pedro emerald mine in the Chivor region of Colombia; boulders of bluish-green and greenish-blue jadeite from Guatemala; faceted rossmanite and other tourmalines from Nigeria; brownish-orange uvite from Kunar Province, Afghanistan; new SIMS analyses of 20 examples of yellow, orange, pink or red Be-diffused corundum from Thailand; and a 2.95 ct topaz coloured orange by a thin coating of synthetic hematite applied to the pavilion. R.A.H.

Rhodizite-londonite from the Antsongombato pegmatite, central Madagascar.

B.M. Laurs, F. Pezzotta, W.B. Simmons, A.U. Falster and S. Muhlmeister. *Gems & Gemology*, **38**(4), 2002, 326-39.

The rare Al-Be borate londonite is the caesium-rich analogue of rhodizite (which has K>Cs), these two end-members being distinguishable only by quantitative chemical analysis. Gem-quality londonite is recorded from the Antsongombato pegmatite in the Betafo region of central Madagascar, where colourless to greenish-yellow rhodizite-londonite has *n* 1.689–1.691, H. 8, SG 3.34–3.42. EPMA results are given for eight faceted specimens, showing that two are londonite, four are rhodizite and two contain both londonite and rhodizite. Raman, visible and FTIR spectra are discussed. R.A.H.

Die schönen Kiesel des Osterzgebirges.

M. Lüttich. *Lapis*, **27**(3), 2002, 19-24.

Fine ornamental agate is described from the eastern Erzgebirge of Germany: individual locations include Altenberg near Bärenstein, Cunnersdorf, Dönschten, Hartmannsdorf, Hirschsprung, Johnsbach, Bobritzsch, Carsdorf and Reichstädt. M.O'D.

Eine neue Opalsynthese aus Russland.

C.C. Milisenda. *Gemmologie. Z. Dt. Gemmol. Ges.*, **51**(2/3), 2002, 115-20. 8 photographs, 1 table, 2 graphs, bibl.

Four types of synthetic opal have recently been produced by the Scientific Centre for Allied Research in Dubna, Russia. Type 1 and 2 resemble plastic impregnated material such as Gilson and earlier Russian productions. Type 3 resembles a natural white opal with distinct play-of-colour. It has no organic compounds and is virtually free of water. In a strict sense these samples have to be designated as opal imitations. However, Type 4 resembles natural opal not only in appearance but also in water content and can therefore be called 'synthetic'. It can be detected by the well known mosaic 'lizard-skin' pattern. E.S.

Gem Trade Lab notes.

T.M. Moses, I. Reinitz, S.F. McClure and M.L. Johnson (eds). *Gems & Gemology*, **38**(3), 2002, 250-7.

Notes are given on three faceted colourless crystals of synthetic bromellite (BeO), inclusions of charoite in a quartz-feldspar rock and a 9.80 ct oval greenish-blue cabochon of hemimorphite. R.A.H.

Gem Trade Lab notes.

T.M. Moses, I. Reinitz, S.F. McClure and M.L. Johnson (eds). *Gems & Gemology*, **38**(4), 2002, 340-7.

Notes are given on high-temperature Be lattice diffusion in corundum to yield pinkish-orange, orange, orangey-red and yellow sapphires as well as ruby. A bleached, polymer-impregnated and dyed bangle of jadeite jade is also reported. R.A.H.

Agate: a study of ageing.

T. Moxton. *European Journal of Mineralogy*, **14**(6), 2002, 1109-18.

The degree of crystallinity in wall-lining agates from host rocks of varying ages has been measured using XRD. A plot of agate crystalline size *vs* log age of host rock shows a general increase in crystalline size with increasing age of the host rock: a regression line: size =106 log host rock + 211 was obtained. The SEM confirms that ageing produces a growth in the surface globulites and development of plate edge-like structures within the white bands. This dynamic growth of crystallites results in an increase in density. A high correlation between agate crystallite size and age of the host rock shows that the formation of wall-banded agates is penecontemporaneous with the formation of the host rock. The determination of crystallite size in such agates allows either an estimation of the approximate age of the host rock or an identification of a known agate region. R.A.H.

Tucson 2002 – Nichts ist mehr so, wie es früher einmal war!

G. Neumeier. *Lapis*, **27**(5), 2002, 35-9.

Among gem-quality minerals on display at the 2002 Tucson Gem and Mineral Show were crystals of the hackmanite variety of sodalite from Kiran in the Kokcha valley, Badakshan, Afganistan and green transparent fluorapatite crystals on stilbite, from Shird, Ahmednagar District, Maharashtra, India. M.O'D.

Vanadium-Berylle aus dem östlichen Himalaya.

G. Niedermayr, F. Brandstätter, J. Ponahlo and E. Schwarzer-Henhapl. *Gemmologie. Z. Dt. Gemmol. Ges.*, **51**(2/3), 2002, 107-14. 7 photographs, 2 tables, 2 graphs, bibl.

Vanadium beryls from a new occurrence, probably Sikkim or Bhutan, are described. Further details of their occurrence could not be established. Eight emeralds were examined, weighing 0.22–0.48 ct. They have a very low chromium content and relatively high contents of Fe and V. Although the stones contain three-phase inclusions, they are dissimilar from those offered from Russia, Africa, India, Brazil or Colombia; therefore one can assume that these stones come from a new source. E.S.

Liddicoatite von Sandnessjøen, Nord-Norwegen.

F.S. Nordrum. *Mineralien Welt*, **14**, 2003, 49-52.

Crystals of liddicoatite are described from a lithium-bearing granite pegmatite in the Sandnessjøen area of

northern Norway. Specimens found in lepidolite-rich and quartz matrixes ranged up to 5 cm and some are of ornamental or gem quality. M.O'D.

Die Seltenheit der Edelsteine aus petrologischer Sicht.

M. Okrusch and H. Bank. *Gemmologie. Z. Dt. Gemmol. Ges.*, **51**(2/3), 2002, 67-96. 7 tables, 14 photographs, 5 diagrams, bibl.

The majority of gem materials are distinguished by outstanding physical properties mostly leading to attractive optical phenomena. Diamonds, emeralds, alexandrites and rubies are used as examples to describe specific conditions and geological processes which lead to the formation of the gem material. In each of these cases the authors describe the specific conditions which have to be met and explain the subsequent rarity of the stone. E.S.

Schmucksteine aus Nussbach.

W. Oppelt. *Der Erzgräber*, **16**, 2002, 7-10.

Describes the occurrence, mining history and fashioning of a pale blue porphyry found at Nussbach, Germany. M.O'D.

Comparative study of corundum from various Indian occurrences – corundum from Kerala.

J. Panjikar. *Indian Gemmologist*, **10**(4), 2002, 23-8.

Corundum found at Noolpuzha in the Indian State of Kerala is red with a strong tint of blue. Properties are in the normal range for ruby. The most prominent solid inclusions are rounded dark brown crystals surrounded by liquid films: similar solids in Thai rubies have been identified as garnet. Twin lamellae are also prominent. M.O'D.

Basalt-Opal aus Honduras.

P. Prüfer. *Lapis*, **27**(4), 2002, 35.

Short note on a gem-quality opal found in basalt at Erandique, Honduras. The photograph shows a dark cabochon with attractive play-of-colour. M.O'D.

Einschlüsse und Begleiter der 'Schaumberger Diamanten' con Extertal, Weserbergland.

P. Prüfer. *Lapis*, **28**(1), 2003, 11-17.

Pyrite, marcasite and goethite pseudomorphs after pyrite have been noted as inclusions in well-formed clear specimens of rock crystal from Extertal, Weserbergland, Germany. The name 'Schaumberger diamonds' has been given to the crystals. M.O'D.

Classification of natural opal type 1.

J. Schellnegger. *Australian Gemmologist*, **21**(7), 2002, 270-77, 5 illus., 1 glossary, 1 reference guide, 1 table.

The author describes a practical method, devised by the Opal Advisory Service of Lightning Ridge, New South Wales, Australia, for the evaluation of natural opal. The method quantifies the positive factors that determine the value of opal (including body tone, brilliance, pattern, thickness of colour bar and colour). From these factors are deducted certain fault features (such as cracks and crazing, colour not facing, poor cut, shape and polish). Use of an associated code allows individual opals to be accurately and reproducibly described. P.G.R.

Falsche "Sternsteine": Manipulationen an Edelsteinen zur Erzeugung oder Intensivierung von Asterismus.

K. Schmetzer and M. Glas. *Lapis*, **28**(1), 2003, 22-41.

Asterism in cabochon-cut gemstones can be induced or enhanced by a variety of techniques which are described and illustrated. M.O'D.

Die berühmten Jaspachate von Giuliana/Sizilien.

R. Schmidt. *Lapis*, **27**(12), 2002, 21-37.

Fine coloured specimens of jasp-agate are described from Guiliana, Sicily. Notes on the use of the material as an ornamental hardstone are given. M.O'D.

How grey limestones become white marbles.

J. Schmidt and I. Flammer. *European Journal of Mineralogy*, **14**(4), 2002, 837-48.

In the contact aureole of the Adamello pluton, N. Italy, nearly pure calcite rocks ($CaCO_3$ > 99 wt.%) undergo a transition from dark and light grey very low-grade metamorphic limestones to white and dull white marbles close to the intrusive contact. The grey colour of the limestones is caused by as little as 0.05 wt.% finely dispersed organic carbon. On nearing the contact, the C_{org} content decreases with increasing metamorphic grade, producing a pure white to dull white marble with C_{org} < 0.02 wt.%. Grain size and grain-boundary width have a secondary effect by controlling light absorption, and thus brightness. R.A.H.

Chart of commercially available gem treatments.

C.P. Smith and S.F. McClure. *Gems & Gemology*, **38**(4), 2002, 294-300 (+ large folding chart).

A chart is included which combines a comprehensive listing of commercially available treatments for the more commonly used gem materials with an indication of the current status of their detectability. The information provided includes the use of dyes, chemical bleaching, surface coating, impregnation, thermal enhancement, diffusion treatment, irradiation and clarity enhancement. R.A.H.

Magaliesberg ist Marble Hall! Über die neuen Amethyste aus Südafrika.

K. Sprich, S. König and S. Jahn. *Mineralien Welt*, **14**, 2003, 53-9.

Gem-quality amethyst of fine quality is described from the Magaliesberg area of South Africa. The workings at Marble Hall are close to Groblersdal on route N11. Details of the local geology and mine workings are given. M.O'D.

History of the Tourmaline Queen mine, San Diego County, California.

E.R. SWOBODA. *Mineralogical record*, **33**, 2002, 409-25.

The Tourmaline Queen mine, Pala, southern California, has produced some of the world's finest crystals of tourmaline and morganite. It is still in production. The geology and mineralization of the mine are described and illustrated, and anecdotes of the discovery of major specimens accompany photographs of many of them. M.O'D.

Method for determining the cleavability of fluorite.

O. VITOV AND L. KONSTANTINOV. *Comptes Rendus de l'Académie Bulgare des Sciences*, **54**(3), 2001, 55-8.

A simple method is proposed for quantitative evaluation of the cleavability of fluorite. This method is based on statistical averaging of the numbers of differently shaped fragments of fluorite crystals and crystalline grains broken mechanically into small (~1 mm) pieces. The coefficient of 'imperfect' cleavability, K (*hkl*) and 'perfect' cleavability along (111), K(111), are introduced. In these terms, the cleavability of 'real' fluorite crystals can be presented through a point in Cartesian coordinates with abscissa K(111) and ordinate K(*hkl*). The position of this point with respect to that for a perfect single crystal of fluorite, can serve as an indication of perfection of a given crystal. This method makes it possible to classify the material for growth to CaF_2 single crystals of optical quality. R.A.

Zepterquarze und Amethyst aus dem Maltatal, Kärnten, Österreich.

S. WEISS. *Lapis*, **27**(12), 2002, 13-20.

Well-formed crystals of amethyst and rock crystal of collecting quality are described from the Maltatal, Carinthia, Austria. Sceptre habit is particularly notable. M.O'D.

Jeremejevite from Namibia.

W.E. WILSON, C.L. JOHNSTON AND E.R. SWOBODA. *Mineralogical record*, **33**, 2002, 289-301.

Cornflower-blue and water-clear crystals of jeremejevite were reported from Mile 72, north of Swakopmund, Namibia, in 1973 and the site was reworked in 1999, this time producing only colourless to pale yellow material. A location in the Erongo Mountains worked in 2001 has produced fine transparent blue crystals. Many of the Namibian crystals are of potential gem quality. The first occurrence of jeremejevite was reported in 1883 from a pegmatite on Mount Soktuy, Chitinskaya Oblast in the Nerchinsk district of Transbaikalia, Russia. M.O'D.

Instruments and Techniques

Microminerals.

Q. WIGHT. *Mineralogical record*, **33**, 2002, 337-9.

Describes a microscope lighting system devised by A.D. Morgan of the British Micromount Society. White high-intensity LEDs give light at 8000°K and use very little power. The light is towards the blue end of the spectrum but this can be compensated for by the use of the appropriate filters. M.O'D.

Stabvilisierung, Re paratur und Rekonstruktion von Mineralstufen: Was ist erlaubt?

M.L. WILSON. *Lapis*, **27**(12), 2002, 38-9.

Notes on the repair and reconstruction of mineral specimens consider techniques and propriety. M.O'D.

Synthetics and Simulants

Spectroscopic studies of coloured, synthetic corundums and spinels produced in Skawina.

M. CZAJA. *Mineralogia polonica*, **31**, 2000, 55-69.

Crystals of corundum and spinel have been produced at the Research and Development Laboratories at the aluminium plant near Kraków, Poland. Optical differences between specimens of both species are described. The main reason for colour-changes observed is the presence of more than a single colouring ion. All spinel colour varieties were non-stoichiometric with an $MgO:Al_2O_3$ ratio of 1:2.6. Results show tetrahedral coordination of Co^{2+} in the spinels and Mn^{2+} in the Al_2O_3. M.O'D.

Gemesis laboratory-created diamonds.

J.E. SHIGLEY, R. ABBASCHIAN AND C. CLARKE. *Gems & Gemology*, **38**(4), 2002, 301-9.

High-quality yellow, orange-yellow and yellow-orange laboratory-created type 1b diamond crystals up to 3.5 ct are being produced commercially by the Gemesis Corp. of Sarasota, Florida. In some samples, colour zoning (yellow and narrower colourless zones) and a weak UV fluorescence pattern (a small green cruciform zone combined with an overall weak orange luminescence) provide means of identification; when present, metallic inclusions also indicate laboratory growth. In the absence of such features, all of these Gemesis synthetic diamonds can be identified either by the DiamondView luminescence imaging system or by the presence of Ni or Co in the energy dispersive XRF pattern. Mention is also made of other kinds of synthetic diamonds produced by Gemesis. R.A.H.

'Diffusion ruby' proves to be synthetic ruby overgrowth on natural corundum.

C.P. SMITH. *Gems & Gemology*, **38**(3), 2002, 240-8.

In a relatively new production of red corundum, claimed to be red diffusion-treated corundum (i.e. shallow coloration) by the lattice diffusion of Cr, the surface layer is actually an overgrowth of synthetic ruby on natural colourless or near-colourless corundum. After recutting, the overgrowth layer is seen to typically range from <0.1 to 0.3 mm thick. This material can be distinguished from red lattice-diffusion treated corundum by the presence of a boundary plane and two different types of inclusion features. R.A.H.

Le Mont Chemin.

S. ANSERMET, 2001. Musée cantonale d'histoire naturelle, Sion. pp 302, illus. in colour. Softcover ISBN 2 940145 28 8. Sfr 70.

For those readers who are also mineral collectors this attractive book is worth buying. Mont Chemin is in the Swiss canton of Valais, near the town of Martigny. The main text comprises a full descriptive mineral list arranged alphabetically and there are also sections on local geology and mineralization. The location is especially noted for fine orange crystals of wulfenite. M.O'D.

Aquamarin & Co.

Christian Weise Verlag, Munich, 2002. pp 96, illus. in colour. Softcover ISBN 3 921656 61 3 (ISSN of parent journal *Lapis* 0945-8493, *extraLapis* no. 23) Euros 17.80.

Previous numbers of *ExtraLapis* (1, revised in 21) dealt with emerald. This issue describes aquamarine, golden/yellow, pink, red and colourless beryl. As in other issues of the series the work of individual authors is submerged in the general text though there are stand-alone papers on beryl from Alpine regions and from Madagascar, and on synthetic beryls. There is a short bibliography. The quality of the colour photographs (including reproductions from early mineralogical works) is exceptional. Sets will soon be hard to acquire: the subscription to *Lapis* does not cover the monographic series. M.O'D.

The World's mineral masterpieces.

E. EQUIT, 2002. Eberhard Equit & Co., Berlin [Fehrbellinerstr 49, D-10119]. In German and English, pp 289, illus. in colour. Hardcover, in slip case. Limited Edition (700 copies). ISBN 3 930874 06 7. Euro 260.

In more than 30 years of reviewing and general familiarity with mineral and gem books from all over the world, I have seen nothing to compare with this collection of mineral and gem crystal paintings by the author. Each specimen is described by its present owner, the first ones by Bill Larson of Pala International fame and others by collectors of similar authority who in many cases describe how and where the specimens are acquired. The paintings themselves are exquisitely done with colours as close as possible to the originals, whose sizes are given. There is a short bibliography whose entries extend the material given in the descriptions.

Gemmologists will find that quite a lot of the minerals depicted are of gem quality and have been selected for that reason. They include tanzanite, ruby and blue sapphire from Myanmar and Sri Lanka, emerald from Colombia, red beryl from Utah, tourmaline from major Brazilian localities, epidote and emerald from the Habachtal, Austria, and many more. The reader should bear in mind that these specimens have been acquired by their owners in recent years and that the paintings are not of specimens already well illustrated in earlier books.

For such wealth of beauty and imaginative presentation of information the price is very reasonable: the whole production, on specially-chosen and very appropriate paper and housed in a strong slip-case will delight and inform for a lifetime. M.O'D.

Minerals of Scotland, past and present.

A. LIVINGSTONE, 2002. National Museums of Scotland Publishing Ltd, Edinburgh. pp xvi, 212, illus. in colour. Softcover, ISBN 1 901663 46 9. £35.00.

The unusual format serves very well to present this excellent survey of the minerals of Scotland, their collectors, repositories and properties. Visitors to the collections at Chambers Street will know that the presentation there is among the best anywhere and serious work continues to be carried out behind the scenes.

The book begins with a geological survey of Scotland with maps in colour and notes on its geological evolution, continuing with a history of collectors and their collections. As always, not all of them can now be located, or, rather, some individual specimens described years ago cannot now be found. Nevertheless this account is excellently presented with illustrations of some of the collectors and pages from their notebooks and catalogues.

The author now describes the major extant mineral collections in Scotland, both institutional and personal (I salute those private collectors who have allowed details of their collections to be published). The institutional collections are described extensively with some notes on their foundation and subsequent history.

From pages 93 to 130 selected minerals are described in alphabetical order with history and considerable detail; this section is followed by the colour photographs of common and unusual, species – 'The mineral album'. Here the quality is as high as the rest of the book, name, dimensions, location and provenance being given in each case. The album serves also as a display of how well minerals can now be photographed.

From pages 155-187 the entire 552 species native to Scotland are described in Appendix 1, with short entries giving name, composition, crystal system, description and localities. Appendix 2 describes the 29 species originally found in Scotland and Appendix 3 contains 33 species additional to those not already listed in previous published lists of 1981 and 1993. An excellent section of references, a bibliography and index complete the book.

Are the Scottish gemstones listed? Yes: there are details (not too specific) of the occurrence of blue sapphire at Carishader, Loch Roag, Lewis, Outer Hebrides and illustrations of a fine crystal and faceted stone from that locality. The tourmaline (a fine blue elbaite crystal) from Glenbuchat, Aberdeenshire, is also shown. M.O'D.

The physics and chemistry of color.

K. NASSAU, 2002. 2nd edn. Wiley Interscience, Chichester. pp xx, 481. Hardcover. ISBN 0 471 391069. £80.50.

A welcome re-appearance of this major text enables the reviewer to recommend it to a new generation of readers. The book had just appeared as I write in December 2002 though the preface is dated 2000, but this has made no difference to topicality. In the preface Nassau in characteristic style lists several areas in which errors are consistently found in both the popular and scientific media: all of them are examined and explained. New sections and those expanded from the first edition include details on colour vision defects, the measurement and display of colour and the construction and use of colour order systems.

Gemmologists will find a description and explanation of the Usambara effect (it is found in some plastics as well as in some gem minerals) as well as the better-known causes of colour: they are all most lucidly explained. A feature of this edition is the incorporation of references into the main text as an exhaustive bibliography of the subject is not easy to handle. There is one, however, in Appendix G, *Recommendations for future reading*. As before, each chapter ends with a set of problems (answers not provided) and a central section contains 42 colour photographs, many not included in the previous edition. The quality of reproduction is excellent.

One fallacy from the 14 listed by Nassau in the preface is that for each wavelength of the spectrum there is a unique perceived colour; for example, 590 nm light is orange to everyone and at all times. If you want to find out the fallacy here this book is still, probably, the only one in which you will find it discussed. This is only one reason why gemmologists should try to obtain a copy. It has given me at least as many enjoyable hours as any book I have ever read. M.O'D.

Mogok: eine Reise durch Burma zu den schönsten Rubinen und Saphiren der Welt.

R. SCHLÜSSEL, 2002. Christian Weise Verlag, Munich. pp 280, illus. in colour. Hardcover, ISBN 3 921 65660 5, Euros 108.

Elegantly written and most beautifully produced travel guide to the Mogok area of Myanmar with intensive study of ruby and sapphire production, this book seems to indicate a very slight easing of travel restrictions in this area (cf.Themelis, *Mogok, valley of rubies and sapphires*, 2000). Whatever the reason, this book is most welcome: it deals first with the country as a whole with notes on history, religion, customs and building in a clear text which occupies approximately half of the book. The remainder takes the reader to the Mogok stone tract (good to hear this traditional name once more) and to the rubies and sapphires found there as well as to peridot, johachidolite, painite, thorite, danburite, poudrettite [potassium sodium borosilicate of the osumilite group, purple to violet] and periclase which are the only other species with full descriptions though a full name and list of gem and ornamental minerals is given (not all Myanmar gem minerals come from the Mogok area). Jadeite rough is mentioned in an earlier chapter.

The gemmological properties of ruby and sapphire have a chapter to themselves, in which the main features of specimens from other major world occurrences are also given. This section contains some excellent photographs of inclusions. Later chapters deal with fashioning, testing and certification, mounting in jewellery and one or two other major Mogok species including spinel. All the photographs come close to the best I have yet seen in a monograph. There is a glossary and a bibliography in which, though the entries are brief, a large number of items unlikely to be familiar to gemmologists are included. The only desideratum is an index.

While the book is partly intended to give pleasure and to introduce a little-known area of the Earth, it is well able to stand up as a study of the corundum gems and to act as a gemmological reference tool. M.O'D.

Smaragde der Welt.

Christian Weise Verlag, Munich, 2001. pp 96, illus. in colour. Softcover. ISBN 3 921656 58 3 (ISSN of parent journal *Lapis* 0945-8493, *extraLapis* no.21) DM39.80.

This is a new edition, by various authors, of the first *ExtraLapis* published in 1993. As always so far the different papers run together without obvious breaks and while covering the traditional emerald-producing areas the authors bring in new deposits and further details of the crystals more recently found. It is not easy to single out one particular section but I particularly admired the coverage and illustrations of the celebration of 100 years of emerald crystal growing (look at the inclusion pictures!) and of the surveys of the deposits in Nigeria (Jos Plateau), Pakistan (Swat), Russia (Malyshewo), and more traditional sites. Somalia and Namibia are added to the review of African emerald locations. There is much more but all gemmologists should buy this book (and its companions). M.O'D.

Sammlerglück: die Achatfundstelle Geisberg bei Schweighausen.

INGO STENGLER, 2000. Verlag Weissmoos, Lahr-Schwarzwald. pp 285, illus. in black-and-white and in colour. Hardcover ISBN 3 00 006801 5. DM 69. (Available through Verein der Freunde von Mineralien und Bergbau, D-77709 Oberwolfach, Germany: payment details – Kto 513003 Sparkasse Haslach-Zell, BLZ 664 515 48.)

A guide to the attractive agate specimens to be found in the central German Schwarzwald, the book is clearly a long-planned labour of love and succeeds admirably in presenting the geology and formation of the agates, nearly 70 of which are well illustrated in colour. The collector will be able to follow the author's trail and perhaps find attractive specimens too since the main areas are not too difficult to pin down from what is given in the text: I should imagine, though, that some thoughts of conservation have very properly been in the author's mind since coordinates are not provided: there is a quite adequate bibliography. Probably many readers with an

interest in agate colour and patterning will find the book of particular appeal since the author obviously likes speculation in this field and also in the history of the working of the deposits. M.O'D.

Südtirol und die Dolomiten.

Christian Weise Verlag, Munich, 2002. pp 95, illus. in colour. Softcover, ISBN 3 921656 59 1 (ISSN of parent journal *Lapis* 0945-8493, *extraLapis* no. 22) Euros 17.80.

Seamless treatment by a number of authors (names given) of the mineral deposits of the southern Tirol, Austria. Among the species described and excellently illustrated are green crystals of sphene from the Sattelspitz and small crystals of aquamarine from the Griesferner, Pfitsch. Many of the finest crystals are micromount or thumbnail size. Maps and details of the geology and different mineralizations are given, but only six references are provided and there is no index. Nonetheless this is a beautiful book as all in this series are and it will certainly be welcomed by the many collectors focusing on this productive area. M.O'D.

Edelsteine in der Bibel.

W. Zwickel (ed.), 2002. Philipp von Zabern, Mainz am Rhein. pp vii, 99. Hardcover ISBN 3 8053 2912 1, £18.00.

It is many years since a study, however short, of the gemstones mentioned in the Bible appeared on the market and even then most of them contained few if any notable illustrations. This beautifully designed and printed study by four authors deals with selected topics and illustrates artefacts which form an exhibition planned to visit several cities in Germany.

The objects are fully described by professional archaeological standards; gemmologists will find the whole text worth serious study but the chapter on the High Priest's breastplate will probably attract the attention first as the minerals used are described and illustrated, given their proper names and shown in their rough form.

There is an extensive general bibliography and several well-presented maps help the reader to pinpoint areas of biblical significance. Biblical texts are given in all relevant places. Archival quality paper has been used. M.O'D.

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

J. (JIMMIE) K. CAIRNCROSS

A tribute by David Callaghan

Mr J. (Jimmie) K. Cairncross FGA (D.1940), family jeweller of Perth, Scotland, died on 15 November 2002 at the age of 82. Notices such as these are so abrupt, cold yet factual and tell you only the end of a life but none of the impact made during its span. Let me tell you just a little of this special man, a personal friend for over 35 years. Jimmie was born into a jewellery family, his grandfather and great uncle having founded the firm of A. & G. Cairncross, Perth, in 1869.

He began his career in the trade, training with the renowned Edinburgh firm of Hamilton & Inches just before the onset of World War II. On the outbreak of War he joined the Royal Navy where he saw action on three of the convoys to Northern Russia. After the War he entered the family firm and, not long afterwards, he was joined by his younger brother, Alastair. Together they formed a business partnership that epitomized everything that is to be admired in a family business. Alastair (D.1948) was a highly talented artist and many of the pieces of jewellery containing Scottish fresh water pearls – for which Cairncross of Perth were justly famous – were designed by him. Sadly he was to die suddenly in 1988 (obituary *J. Gemm.*, **21**(3), 1988, p. 199).

Jimmie was a man of outstanding generosity: with his friendships; his courteous manner and manners; and his wide range of interests. He was passionately interested in sports notably sailing, rugby and golf. Above all he, and Alastair, showed their generosity of spirit and purpose in the great encouragement they gave to young people. Jimmie loved the jewellery trade not only for the wonderful gifts of nature we handle, but for the people who serve it. The brothers Cairncross were great supporters of the trade, particularly the National Association of Goldsmiths (NAG) and the former GA. In recognition of this Jimmie served a two-year term as NAG President in 1987/88.

Jimmie loved his native land of Scotland and particularly his annual August 'pilgrimage' to Iona. A man of steadfast Christian faith this was not a religious outing, however; he and a group of friends were there to renew their friendship and to play golf. I think back to the many, many occasions over the years when he and I played golf, particularly in Scotland, and every one was a pleasure for me. I think I never won!

Jimmie never married and always said his friends were his family. He was a copious writer of letters and any visit, telephone call or gift resulted in a post card of thanks written in his own inimitable handwriting, so small that you could imagine that it had been written in a secret almost furtive way in case he was seen doing so! My wife, Mary, and I visited him on many occasions during our holidays in Scotland and this always prompted a card with the closing sentence *'haste ye back'*. During his last illness he received many cards, messages of good will and visitors. So numerous were these goodwill messages that one of his nurses was prompted to say to him, *"Mr Cairncross, you do seem to have an awful lot of friends."* This prompted Jimmie's reply, *"Yes I have, and I have an awful lot of friends where I'm going!"*

His life enriched that of a countless number of people all of whom will say God Bless Jimmie – rest in peace.

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The Council of Management are most grateful to the following for responding to the appeal for donations to enable the Association to extend our membership and education services. Donation levels were Diamond (£1000 and above), Ruby (£500 to £999), Emerald (£250 to £499), Sapphire (£100 to £249) and Pearl (£25 to £99). All donors will be recognized at a Gala Dinner to be held in London early next year.

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Gwyn Green, Barnt Green, Hereford and Worcester

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Richard C. Wiggin, Rapid City, South Dakota, U.S.A.

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William Windwick, Lhanbryde, Moray, Scotland

Wu Lai Ngor, Kowloon, Hong Kong

Yuko Yamashita, Sakai City, Osaka, Japan

Naomi Yokokawa, East Sheen, London

Tak Yi Yung, Shau Kei Wan, Hong Kong

Zeng Chun Guang, Singapore

GIFTS TO THE ASSOCIATION

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W. Attanayake, Kuruwita, Sri Lanka, for pink and purple corundum in granite host rock from south west Sri Lanka.

Professor Dr Hermann Bank, FGA, Kirschweiler, Germany, for a very attractive slab of polished agate.

Simon Bruce-Lockhart, FGA DGA EG, Thaigem.com, Chanthaburi, Thailand, for samples of orange sapphire.

Thomas Chatham, Chatham Created Gems Inc., San Francisco, California, U.S.A., for a large collection of Chatham Created gemstones, both rough and cut.

Christopher Cuss, FGA DGA, Cheam, Sutton, Surrey, for a collection of cut gemstones.

John R. Fuhrbach, FGA, Amarillo, Texas, U.S.A., for a petrified log of red cedar, alibates flint from Texas, and a collection of other rough and cut gemstones.

Colin Nunn, Worth Matravers, Dorset, for a collection of coloured pastes.

OBITUARY

Professor Pieter C. Zwaan FGA (D. 1954 with Distinction), Leiden, The Netherlands, died on 7 November 2002.

MEMBERS' MEETINGS

Midlands Branch

On 31 January a Quiz and Bring and Buy Sale were held at the Earth Sciences Building, University of Birmingham, Edgbaston.

On 28 February at the Earth Sciences Building, Michael Houghton gave a talk entitled 'Pearls of wisdom' and ran a pearl workshop.

On 28 March at the Earth Sciences Building, Stephen Whittaker gave a talk entitled 'An auctioneer's lot is not a happy one'.

North West Branch

On 26 March at Church House, Hanover Street, Liverpool 1, Richard Slater gave a talk entitled 'Jewellery at auction'.

Scottish Branch

On 15 January at Jury's Hotel, Great Western Road, Glasgow, Colin Towler gave a talk entitled 'Diamonds at Finsch – bullets in Angola'.

On 26 February at Jury's Hotel Alan Hodgkinson gave a talk and hands-on session entitled 'Gem surprises'.

On 25 March at the British Geological Survey, Murchison House, West Mains Road, Edinburgh, Doug Morgan gave a talk entitled 'Some gemmological and lapidary diversions'.

South East Branch

On 6 April at Christie's, South Kensington, Peter Wates and Colin Winter gave a presentation entitled 'Tucson 2003'.

GEM DIAMOND EXAMINATION

In the Gem Diamond Examination held in January 2003, 53 candidates sat of whom 26 qualified including three with Distinction and four with Merit. The names of the successful candidates are listed below:

Qualified with Distinction

Chen Xiumei, Wuhan, Hubei, P.R. China
Marlow, Carol C., Sutton Coldfield, West Midlands
Ross, Alexander, Bath, Somerset

Qualified with Merit

Cheung Shuk Han, Alice, Kowloon, Hong Kong
Li Kun, Wuhan, Hubei, P.R. China
Pace, Michael, Elk Grove, California, U.S.A.
Wong Ying, Shatin, Hong Kong

Qualified

Akintonde, Olubunmi, Woolwich, London
Chalmers, Marie L., Redditch, Worcestershire
Champetier, Marie-Pierre, London

Chan Pui-Sze, Percy, Sheung Shui, Hong Kong
Chaudhary, M. Ali, London
Cheung Suk Yin, Kowloon, Hong Kong
Cheung Yee Ming, New Territories, Hong Kong
Giannakakis, Vasileios, Athens, Greece
Hu Jiahao, Wuhan, Hubei, P.R. China
Ka Tsz Man, Kowloon, Hong Kong
Kwok Ling, New Territories, Hong Kong
Lee Chun Ming, New Territories, Hong Kong
Nei Xiaomei, Wuhan, Hubei, P.R. China
Okada Hiroko, Birmingham, West Midlands
Tominaga, Masami, West Finchley, London
Tse Shim Fong, Kowloon, Hong Kong
Wong Ching Man, Discovery Bay, Hong Kong
Zhang Dingzhi, Wuhan, Hubei, P.R. China
Zhou Tie, Wuhan, Hubei, P.R. China

EXAMINATIONS IN GEMMOLOGY

In the Examinations in Gemmology held worldwide in January 2003, 125 candidates sat the Diploma Examination of whom 69 qualified, including one with Distinction and nine with Merit. In the Preliminary Examination, 115 candidates sat of whom 88 qualified. The names of the successful candidates are listed below:

Diploma

Qualified with Distinction

Xie Jing, Shanghai, P.R. China

Qualified with Merit

Ayer, Elizabeth C., Cambridge
Barnett, Catherine Elizabeth, Balham, London
Guillaud, Pauline, Montreal, Quebec, Canada
Hing, Michael E., London
Houghton, Agnes, London
Lam Koon-Wah, Francis, Kowloon, Hong Kong
Ma Hongyu, Wuhan, Hubei, P.R. China
Pennington, Susan E., Bickerstaffe, Lancashire
Ruckel, Daphne, London

Qualified

Caron, Marie-Chantale, Montreal, Quebec, Canada
Chang Chi Fu, Kowloon, Hong Kong
Chen Chen, Wuhan, Hubei, P.R. China
Chen Zhao, Wuhan, Hubei, P.R. China
Chung Yee, Donna, Kowloon, Hong Kong
Du Congyan, Wuhan, Hubei, P.R. China
Epelboym, Marina, Brooklyn, New York, U.S.A.
Fisher, Fiona J., Dublin, Ireland
Gao Bo, Wuhan, Hubei, P.R. China
Gao Boqian, Guilin, Guangxi, P.R. China
Geng Yunying, Beijing, P.R. China
Giancola, Maria Luisa, Milan, Italy
Gregory, Pauline A., Bishop Auckland, Co. Durham
Henri, Martyne, Montreal, Quebec, Canada
Hillstrom, Anders, Lannavaara, Sweden
Hu Zhikun, Shanghai, P.R. China
Jia Nan, Beijing, P.R. China
Jiatao Wu, Wuhan, Hubei, P.R. China
Jones, Lorraine D., Farnworth, Greater Manchester
Kanaan, Dominique, London
Knight, Jennifer J., Selby, North Yorkshire
Kuang Chung Lee, Taichung, Taiwan, R.O. China
Lee (a) Ting Yu, Michelle, Yangon, Myanmar
Lee Hin Chi, Cheung Chau, Hong Kong
Li Wenjian, Guangzhou, P.R. China
Li Xinyan, Guilin, Guangxi, P.R. China
Li Yaoyao, Wuhan, Hubei, P.R. China
Liu Lili, Guilin, Guangxi, P.R. China
Luo Lulu, Wuhan, Hubei, P.R. China
Maeland, Egil, Sandnes, Norway
Mak Sio In, Hong Kong
Moger, Adam D.D., Little Raveley, Cambridgeshire
Ng Wai Ling, Kowloon, Hong Kong
Okazaki, Maki, London
Parnell, Alexander J., Finchley Central, London
Pe Thu Aung, Yangon, Myanmar
Randhawa, Sukhwant Singh, Hounslow, Middlesex
Selvamani, Parvathi, Ilford, Essex
Shen Shaoqin, Guilin, Guangxi, P.R. China
Su Chen Hui, Taichung, Taiwan, R.O. China
Tan Ke, Wuhan, Hubei, P.R. China
Thin Thin Hlaing, Yangon, Myanmar
Tse Yiu Yu, Stephen, Kowloon, Hong Kong
Tun, U Myint, Lannavaara, Sweden
Tyrrell, Siobhan A., New Cross, London
Valia, Tulsi, London
Van Rooij-Roeloffzen, Almere Buiten, The Netherlands
Vyas, Meenu B., Mumbai, Maharashtra, India
Wang Ying Ling, Taichung, Taiwan, R.O. China
Wang Dan, Wuhan, Hubei, P.R. China
Wang Minmin, Wuhan, Hubei, P.R. China
Whalley, Joanna, Walthamstow, London
Xi Xingshu, Shanghai, P.R. China
Xing Yuan, Beijing, P.R. China
Ye Jing Yin, Shanghai, P.R. China
Yu Ying, Wuhan, Hubei, P.R. China
Zhao Jinglong, Wuhan, Hubei, P.R. China
Zhou Wei Yong, Shanghai, P.R. China
Zhu Juntao, Guilin, Guangxi, P.R. China

Preliminary

Ahren, Anna, Johanneshov, Sweden
Akashi, Nana, Highgate, London
Anderson, Ian, Heaton, Bradford, West Yorkshire
Avakian, Sevan, Los Angeles, California, U.S.A.

Baciocco, Leona T., San Bruno, California, U.S.A.
Banks, Jessica, London
Behennah, Andrew C., Didcot, Oxfordshire
Breuer, Lisa, London
Canisius, Alexandra, London
Champetier, Marie-Pierre, London
Chan Pak Lin, Tsuen Wan, Hong Kong
Chan Yuk Yee May, Kowloon, Hong Kong
Cheng Chong Chuen, Tsuen Wan, Hong Kong
Chung Yim Ling, Mandy, Kowloon, Hong Kong
De Souza, Luciano P., London
Domec, Cedric, Forest, Belgium
Doyle, Cindi, Carlsbad, California, U.S.A.
Drijver, Joyce M-L., Utrecht, The Netherlands
Ecknauer, Marc, Wood Green, London
Firmin, James H., Burley-on-the-Hill, Rutland
Garner, Robert B., Pinner, Middlesex
Glasgow, Sarah A., Fulham, London
Greenstein, Saul, London
Hirst, Catherine, Harborne, Birmingham, West Midlands
Holman, Meryan, London
Hotson, Peter J., Berkhamsted, Hertfordshire
Huang Teng Feng, Taichung, Taiwan, R.O. China
Huang Chi-Hua, Taipei, Taiwan, R.O. China
Hui Siu Fan, Gloria, Yuen Long, Hong Kong
Ino, Shinji, Moseley, Birmingham, West Midlands
Jackson, Antoinette, London
Kelly, Jennifer Liu, London
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Lu Yi Fen, Taichung, Taiwan, R.O. China
Ma Cho Ping, Kowloon, Hong Kong
Mai Zhiqiang, Guangzhou, P.R. China
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Moore, Katherine H., Glasgow, Scotland
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Shih Ming Chih, Taichung, Taiwan, R.O. China
Shih Meng Hsin, Taichung, Taiwan, R.O. China
Shikatani, Kohei, London
Sillem, Hayaatun, London
Sue-A-Quan, Dona M., Yangon, Myanmar
Sykes-Gomez, Heidi, Belsize Park, London
Sylvester, Sheila E., Brussels, Belgium
Tolliss, Jonathan C., York, Yorkshire
Tuen Sai Hing, Shaukei Wan, Hong Kong
Tun Zaw Myo, Yangon, Myanmar
Tung Boon-Ngai, Kowloon, Hong Kong
Vyas, Meenu B., Mumbai, India
Walker, Guy, Southwark, London
Wang Ying Ling, Taichung, Taiwan, R.O. China
Wang Chenchun, Shanghai, P.R. China
Wang Duo, Guilin, Guangxi, P.R. China
Wang Jun, Shanghai, P.R. China
Wang Liang, Guilin, Guangxi, P.R. China
Watanabe, Tomoko, London
Webb, Stephen C., Nelson, New Zealand
Wei Wei, Guilin, Guangxi, P.R. China
Wills, Emily, London
Wong Sau Han, Branda, Kowloon, Hong Kong
Wong Sheung Ling, Shirley, Kowloon, Hong Kong
Wood, Naoko Wakabayashi, Kensington, London
Yang Yang, Guilin, Guangxi, P.R. China

MEMBERSHIP

Between 28 January and 31 March 2003 the Council of Management approved the election to membership of the following:

Fellowship and Diamond Membership (FGA DGA)

Birrell, Andrew T., St Heliers, Auckland, New Zealand. 1992, 1996
Glover, David G.B., Chelsea, London. 1987/1988

Fellowship (FGA)

Balzan, Patrick A., Fairfax, California, U.S.A. 2002
Goumaz, Benoit, Geneva, Switzerland. 2002
Griffiths, Victoria, Cradley Heath, West Midlands. 2002
Kumarasuriar, Krishna, Los Angeles, California, U.S.A. 1983
Lei Jiali, Guilin, Guangxi, P.R. China. 2002
Mackay, Collin, Catford, London. 1996
Myint, Kyaw, Hounslow, Middlesex. 2002
Ogden, Benjamin J., High Birstwith, Harrogate, N. Yorkshire. 2002
Phillips, Paul, Bulkington, Warwickshire. 2002
Sehgal, Neha, New Delhi, India, 2002
Soe Moe Tun, Yangon, Myanmar. 2002
Wei Xiaoling, Guilin, Guangxi, P.R. China. 2002

Xu Banghui, Guilin, Guangxi, P.R. China. 2002
Zhu Xulei, Guilin, Guangxi, P.R. China. 2002
Zuo Xin Mo, Guilin, Guangxi, P.R. China. 2001

Diamond Membership (DGA)

Collins, Steven John, Letchworth, Herts. 2002
Greer, Paul, Chatham, Kent. 2002
Li Cheung, Alex, Hong Kong. 2002

Ordinary Membership

Ahren, Anna, Johanneshov, Sweden
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Kavazis, Constantinos, London
Kendirci, Yasin, Stone, Staffordshire
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Moore, Katherine, Glasgow, Scotland
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Okano, Makoto, Iwatsuki City, Saitama Pref., Japan
Parry, Susannah Tamsin, London
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Souza, Luciano Pablo, Notting Hill, London
Takeda, Naoki, Yamagata City, Yamagata Pref., Japan
Thomas, Robert, Morrisville, North Carolina, U.S.A.
von Fullman, Paul John Edmund, Chiswick, London
Warde-Norbury, Lucianne Claire, London
Xu Bin, Hackney, London
Ynal, Izzet, Stone, Staffordshire
Yoshioka, Yumi, Minato-Ku, Tokyo, Japan

Corrigendum

J.Gemm., 2003, **28**(5), p. 310, South East Branch. Sally Hudson was elected Branch Secretary and not Sally Everitt as stated.

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Tel 01732 462886 Fax 01732 462911

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FORTHCOMING EVENTS

2 to 5 May	**SCOTTISH BRANCH CONFERENCE** **Queen's Hotel, Perth.** The ill treatment of corundum. Old and new facts about diamonds. *Professor Dr Henry Hänni* Jewellery of the Art Nouveau Period. *David Callaghan* From imagination to manufacture. *Dorothy Hogg* Notes from the Gem Laboratory. *Stephen Kennedy* The DTC Gem Defensive Programme. *Dr Paul Spear* Emeralds of Sandawana. *Dr Hanco Zwaan* Workshop sessions and social events
15 May	**London.** The Gem market of Chanthaburi and the heat treatment of gems in Thailand. *Prof. Theerapongs Thanasuthipitak, Anuphap Chinudompong and Prajak Angkahiran*
18 May	**Midlands Branch. ONE-DAY CONFERENCE** Gemmological diversions. *Doug Morgan* Thai heat-treatment experts. A team headed by *Dr Bill Gaskarth* Gem identification competition.
21 May	**North West Branch.** A jade tour. *Ian Mercer*
18 June	**North West Branch.** Crystal care. *Wendy Simkiss*
8 June	**South East Branch.** Valuation today. *Peter Buckie*
18 June	**Scottish Branch.** Amber – yellow, orange, green, blue, red: the ins and outs. *Vanessa Guest*
21 June	**Midlands Branch.** Midsummer Supper
July/August	**South East Branch.** Fifty years plus of gemmology. *E. Alan Jobbins* (date to be confirmed)
7 September	**South East Branch.** Workshop – spectroscope. *Colin Winter*
9 September	**Gem-A ANNUAL GENERAL MEETING**
17 September	**North West Branch.** Scottish minerals. *Brian Jackson*
15 October	**North West Branch.** Notes from the laboratory – detection, disclosure and false description. *Stephen Kennedy*
15 October	**Scottish Branch.** The Cheapside Hoard. *James Gosling*
19 October	**South East Branch.** Jem Jumble (non-trade)
2 November	**Gem-A ANNUAL CONFERENCE.** Kempton Park Racecourse

Contact details

(when using e-mail, please give Gem-A as the subject):

London:	Mary Burland. 020 7404 3334; e-mail mary@gem-a.info
Midlands Branch:	Gwyn Green on 0121 445 5359; e-mail gwyn.green@usa.net
North West Branch:	Deanna Brady 0151 648 4266
Scottish Branch:	Catriona McInnes on 0131 667 2199; e-mail scotgem@blueyonder.co.uk
South East Branch:	Colin Winter on 01372 360290; e-mail ga_seb@hotmail.com
South West Branch:	Richard Slater on 01635 553572; mobile 07801 666172; e-mail rslater@dreweatt-neate.co.uk

Gem-A Website

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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.

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 centred on a separate line.

B *This is a second level heading*

Second level headings are in italics and are flush left on a separate line.

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. Collins, 2001, 341). References are listed alphabetically at the end of the paper under the heading References.

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

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

Papers Collins, A.T., 2001. The colour of diamond and how it may be changed. *J.Gemm.*, **27**(6), 341-59

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

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

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Cover Picture

A multi-star quartz from Sri Lanka cut as a complete sphere. (See 'Multi-star quartzes from Sri Lanka' pp. 321-332.)

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