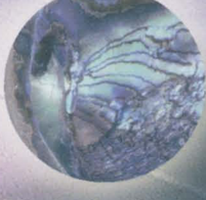
The Journal of

Gemmology

Volume 28 No. 1 January 2002



The abalone *Haliotis rufescens*

Star stones

An unusual deposit in Sri Lanka

'Kakuten' (crane crown)

The Gemmological Association and Gem Testing Laboratory of Great Britain

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.gagtl.ac.uk

Vol 28, No. 1, January 2002 ISSN: 1355-4565

Iridescence of a shell of the abalone *Haliotis rufescens* caused by diffraction

Y. Liu[1], K.N. Hurwit[2] and J.E. Shigley[2]

1. Liu Research Laboratories, 2202 Seaman Ave., S. El Monte, CA 91733, U.S.A. e-mail: yliu@liulabs.com

2. Gemological Institute of America, 5355 Armada Drive, Carlsbad, CA 92008, U.S.A. e-mail: khurwit@gia.edu; jshigley@gia.edu

ABSTRACT: The iridescent colours of bivalve mollusc shells and pearls are caused by diffraction due to the characteristic groove structure that acts as a reflection grating. The shell of the gastropod *Haliotis rufescens* also shows very strong iridescence, but scanning electron microscope (SEM) images of its surface show a tile structure arranged in a statistically regular pattern rather than a groove grating structure. This specific tile structure serves as a two-dimensional reflection grating that causes the iridescence.

Keywords: abalone, diffraction, iridescence, regular tile structure, SEM images, shell, two-dimensional reflection grating

Introduction

The inner surface of gastropod shells and the surface of pearls often show very strong iridescence. In pearls the iridescence is commonly attributed to interference caused by the aragonite layers (Nassau, 1983; Fritsch and Rossman, 1988). Liu *et al.* (1999) demonstrated that the iridescence of bivalve mollusc shells and pearls is caused by diffraction produced by the reflection grating structure.

The abalone *Haliotis rufescens* has been used to study the biofabrication of the nacre layers or 'flat pearls' (Fritz *et al.*, 1994). We were interested in studying this abalone shell because its inner nacreous layer also showed very strong iridescence (*Figure 1*), (Liu *et al.*, 1999). In order to investigate the cause of this iridescence, we took SEM images from different areas of an abalone shell from northern California. These images all showed a statistically regular tile arrangement. Our investigation indicates that the iridescence of the abalone shell is caused by diffraction, but the grating structure is different from that of the shell *Pinctada margaritifera.*

Surface structure of the shell

Haliotis rufescens (red abalone) can be found along the west coast of North America from northern California in the United States to Baja California in Mexico. Mature specimens, 8 to 10 years old, range in size from approximately 15 to 20 cm long. The outer layer of its shell appears red to brown and consists of prismatic calcite. The inner layer consists of aragonite and shows strong iridescence (see *Figure 1*). This inner layer does

ISSN: 1355-4565

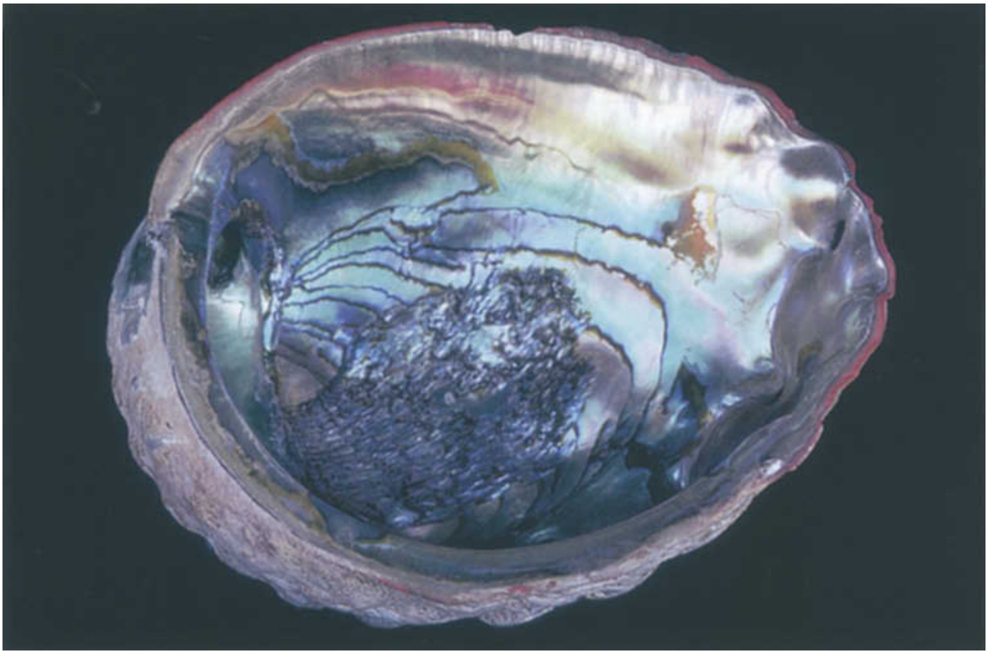


Figure 1: *Inside view of an iridescent abalone* (Haliotis rufescens) *shell (21 x 16 x 4.5 cm).*

not show the same micro-groove structure as the shell of the bivalve mollusc we had previously examined (Liu *et al.*, 1999). Instead, the aragonite tiles in the abalone shell have a structure that is arranged in a statistically regular pattern and *Figure 2a* shows the SEM image of an area of an inner layer that displays strong iridescence. Schaffer *et al.* (1997) and Addadi and Weiner (1997) have described how aragonite grows to form tiles, the size and arrangement of which are controlled by a matrix.

The aragonite tiles in the abalone nacre are relatively rough, slightly convex in cross section and much larger in size compared to those in *Pinctada margaritifera* (see *Figure 2b*). They range from 3 µm to 7 µm, averaging approximately 5 µm in long dimension. The holes in the tiles that allow the building materials to enter (so that the nacre can grow as described by Schaffer *et al.* (1997) and Liu (2001)) and the conchiolin boundaries between the tiles are also clearly visible in the SEM images. The width of the conchiolin boundaries between the tiles is of the order of 0.5 µm, which is much wider than that of 0.05 µm in *Pinctada margaritifera*. The size of the average aragonite tile (5 µm) is larger than the width of the grooves (3.38 µm) in *Pinctada margaritifera* (see *Figure 2c*). Therefore, since each groove consists of at least several aragonite tiles, the aragonite tiles of the *Haliotis rufescens* can not form a groove structure at the scale of the *Pinctada margaritifera* shell (3.38 µm).

Cause of the iridescence

Diffraction can be produced by a groove structure, and also by a two-dimensional structure such as a square array or a round array, either of which function as two-dimensional gratings (Loewen and Popov, 1997). The surface structure of the abalone nacre is formed by aragonite tiles, which although variably polygonal, can be considered to function as a rounded-corner square array, with each 'square' averaging approximately 5 µm. *Figure 3* shows a

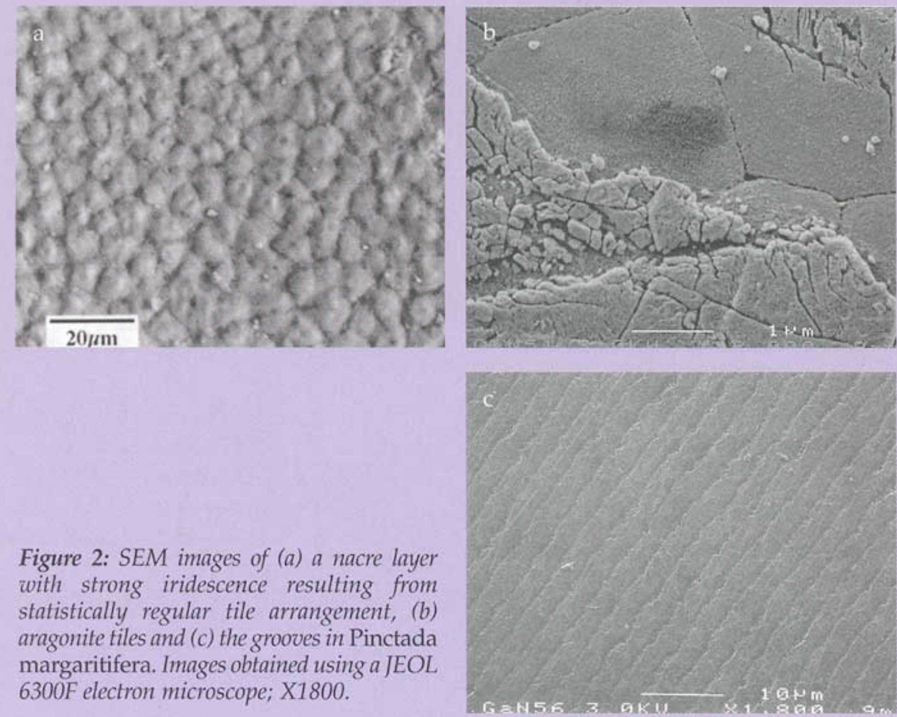


Figure 2: SEM images of (a) a nacre layer with strong iridescence resulting from statistically regular tile arrangement, (b) aragonite tiles and (c) the grooves in Pinctada margaritifera. *Images obtained using a JEOL 6300F electron microscope; X1800.*

theoretical array model of the surface structure, which functions as a 200 x 200 tiles/mm^2 two-dimensional reflection grating. When light is incident onto the surface it is reflected and diffracted. The diffracted light produces the iridescence. In any direction of observation, the iridescence is a combined effect of light from all possible diffraction orders and from different incident directions. The iridescence caused by the groove grating structure in *Pinctada margaritifera* is very directional. It cannot be observed along the groove direction. In addition, directly reflected light does not produce iridescence since it is the zero-order reflection (Liu *et al.*, 1999). In contrast, in the abalone shell with its two-dimensional grating structure, the iridescence can be observed in any direction, including the direction opposite to an incident beam, and under direct sunlight as well. The rough convex surface of the tiles also enhances this non- directional phenomenon. Depending on the alignment and smoothness of the tile array structure the colour saturation of the iridescence in the abalone nacre will vary.

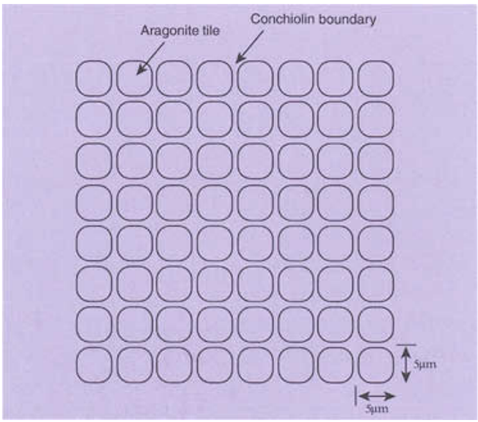


Figure 3: *Schematic model of two-dimensional square array of the surface structure of the abalone nacre.*

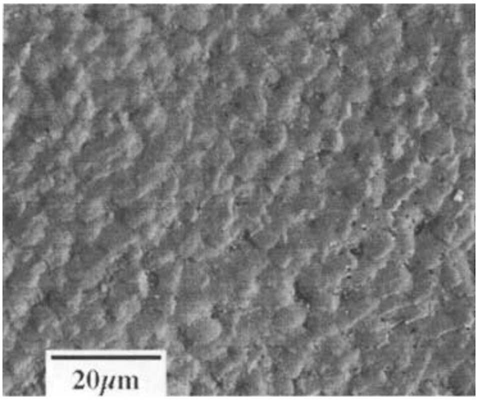
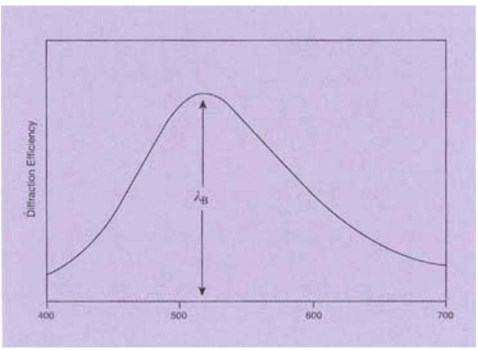


Figure 4: *SEM image of a nacre layer with irregular tiling which results in little iridescence. Equipment and conditions similar to those for Figure 2; X1800.*

At the edge of the inner shell and in some other areas in the nacre, the iridescence appears very weak or is even absent and *Figure 4* shows a typical SEM image of an area that displays a weak iridescence. Here the structure may more closely resemble the groove structure found in *Pinctada margaritifera*. The nacre tiles in *Pinctada margaritifera* are irregular in shape and size, are separated by conchiolin and are considered as being optically non-uniform. It is evident from *Figures 2* and *4* that the nacre layers in the abalone are also not optically uniform. Therefore, it is unlikely that interference is the cause of iridescence in the abalone shell.

Figure 5: *A typical diffraction efficiency curve of a reflection grating. The maximum efficiency occurs at the wavelength* λ_B.



The dominant colour

The iridescence colour of the abalone shell is commonly dominated by one or two colours. These are usually blue-green over much of the area and pink with a purple hue over a smaller area.

The dominant colour of the iridescence is caused by the uneven wavelength efficiency of diffraction of the shell. The diffraction efficiency of a reflection grating refers to the intensity of diffracted light relative to the intensity of incident light. *Figure 5* shows that the typical diffraction efficiency of a reflection grating is a curve (Palmer, 2000). The maximum efficiency of the grating occurs at the peak wavelength. The dominant colour of the iridescence corresponds to the most efficient wavelength. By inference, the most efficient wavelength of the shell is in the blue-green part of the visible range. The diffraction efficiency curve of a reflection grating corresponds to a specified diffraction order. It depends on many factors such as the material, the widths of any grooves, and the angles of both incident light and diffracted light. The hue of the dominant colour changes with a change in viewing angle. This phenomenon is caused by the peak wavelength change of the diffraction efficiency with the change of angles of incident and diffracted light.

(In fact, the efficiency of diffraction is optically similar to the efficiency of reflectance. The efficiency curve versus wavelength of diffraction is similar to the reflectance curve of a colour sample. In the case of reflectance, light may be reflected more in one wavelength range and less in another wavelength range. The hues of reflectance samples usually correspond to the wavelength at which the colour sample has the highest reflectance.)

Conclusion

The iridescence of this sample shell of the gastropod *Haliotis rufescens* is caused by diffraction of light from a reflection grating formed by a two-dimensional tile array structure. The observed iridescence is not directional due to the rough surface condition of the tiles and the irregular alignment of the tile array structure in the nacre. In effect, the iridescence is a combined effect of the diffracted light from all possible diffraction orders and different incident directions. The dominant colour corresponds to the wavelength of the peak efficiency in the visible range. The iridescence colour changes with the viewing angle. This phenomenon is caused by the shift of the peak efficiency when the angles of incidence and diffraction change.

Acknowledgement

The authors wish to thank Tish and Wes Rankin for providing the abalone shells for this study.

References and links

Addadi, L., and Weiner, S., 1997. A pavement of pearl. *Nature*, **389**, 912-15

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

Fritz, M., Belcher, A.M., Radmacher, M., Walters, D.S., Hansma, P.K., Stucky, G.D., Morse, D.E., and Mann, S, 1994. Flat pearls from biofabrication of organized composites on inorganic substrates. *Nature*, **371**, 49-51

Liu, Y., Shigley, J., and Hurwit, K.N., 1999. Iridescence color of a shell of the mollusk Pinctada margaritifera caused by diffraction. *Optics Express*, **4**(5), 177-82, http://epubs.osal.org/oearchive/ source/8639.htm

Liu, Y., Pearl, *Encyclopedia of materials: science and technology*, Elsevier Science, to be published

Loewen, E., and Popov, E., 1997. Diffraction gratings and applications. *Optical Engineering Series*. Marcel Dekker, New York.

Nassau, K., 1983. *The physics and chemistry of color*. Wiley, New York, 262-8

Palmer, C., 2000. *Diffraction grating handbook*, 4th edn. Richardson Grating Laboratory, Rochester

Schäffer, T.E., Ionescu-Zanetti, C., Proksch, R., Fritz, M., Walters, D.A., Almquist, N., Zaremba, C.M., Belcher, A.M., Smith, B.L., Stucky, G.D., Morse, D.E., and Hansma, P.K., 1999. Does abalone nacre form by heteroepitaxial nucleation or by growth through mineral bridges? *Chemistry of Materials*,. **9**, 1731-40

Diamond Education

Study diamonds at the level you choose with Gem-A

Gem Diamond Diploma Programme (DGA)

Your DGA in only four months!

Tutorials every Thursday from 10 a.m. to 5 p.m.

This course covers practical and theory tuition, providing ideal preparation for the examination. The fee of £1750 includes: tuition fees, course notes and examination fees; Gem-A membership for 2002; a basic kit, including 10x lens, stone tongs, stone cloth and a diamond model.

Course start date: **7 February 2002**

Exam date: Theory 12 June 2002 (practical on same or subsequent day)

Home Study Gem Diamond Course

Home study for Gem Diamond may be started at any time. You work at your own pace with the help and guidance of an expert tutor. You may take up to two years to complete the course. The cost of £1173 includes the six-day practical grading course in London followed by the practical examination.

Six-Day Diamond Practical Course

Monday 25 February – Saturday 2 March
(Exam - Monday 4 March)

This intensive, six-day diamond grading course plus Certificate exam, places the greatest emphasis on the use of the 10x lens. For more information on this course please contact the education office. The course covers:

- Clarity grading using a 10x loupe
- Colour grading with emphasis placed on grading by eye
- Aspects of cut including symmetry and proportions
- Simulants and treatments
- Description of rough crystals

Price £650 (Inc. VAT)

The Diamond Buying Guide

One-day workshop

Wednesday 20 March

Whether you are a first time diamond-buyer, a jewellery designer or want to improve your sales staff's knowledge of diamonds, this workshop is ideal.

An introduction to the 4 Cs – carat weight, clarity, colour and cut, this workshop will bring you up to speed. We'll show you how to assess a stone based on the 4 Cs and reveal just how different two stones of similar size and weight can be.

Gem-A Member Price £88.12 inc. VAT
Non-Member Price £99.88 inc. VAT

Courses held at the Gem Tutorial Centre, 27 Greville Street, London EC1N 8TN
For further information and a booking form contact Rachel Warner on 020 7404 3334.

A highly unusual, 7.34 ct, Fancy Vivid purple diamond

Thomas M. Moses[1], John M. King[1], Wuyi Wang[1] and James E. Shigley[2]

1. GIA Gem Trade Laboratory, 580 Fifth Avenue, New York, NY 10036-4796, U.S.A.
2. GIA Research, 5345 Armada Drive, Carlsbad, CA 92008-4602, U.S.A.

ABSTRACT: This article documents the gemmological properties of a 7.34 ct modified heart-shape brilliant-cut purple diamond. This diamond was described as 'Fancy Vivid' purple on a coloured diamond grading report issued by the GIA Gem Trade Laboratory. When viewed with magnification through the pavilion facets, the diamond exhibited banded purple colour zoning and reflective surface graining. It also exhibited unevenly distributed, weak to medium intensity yellow fluorescence when excited with UV radiation. Its visible spectrum contained a broad absorption band centred at about 550 nm, as well as increasing absorption below 450 nm. Opportunity was provided to observe the manufacturing of this coloured diamond from the rough to the polished states. Purple diamonds of this saturated colour and carat weight are quite unusual.

Keywords: colour, diamond, gemmological properties, purple, spectra

Introduction

Coloured diamonds have become increasingly popular and sought after in the jewellery trade. This popularity has been enhanced by publicized auction sales of coloured diamonds, with prices attained on repeated occasions of US $100 000 and more per carat for certain colours. The number of such diamonds brought to the GIA Gem Trade Laboratory for coloured diamond reports has increased dramatically during the past decade.

Among coloured diamonds, certain colours such as pink, blue and green are both rare and highly valued. When submitted to the GIA Gem Trade Laboratory, the documentation of these unusual coloured diamonds is an important event. Diamonds with a saturated, pure purple colour are even less common, and gemmologists have had little opportunity to study them. Brief mentions of purple diamonds have been provided in the books on coloured diamonds by Harris (1994, 172-3) and Hofer (1998, 281-93 and 678-9).

This article presents one of the few descriptions of a strongly coloured purple diamond in the gemmological literature. Our earliest experience with diamonds of this colour was in the 1970s; their reported origin was Russia (see Federman, 1995). At that time we thought that this source might provide a supply of diamonds with this colour. Since then, however, we have seen very few purple diamonds from either Russia or anywhere else. When encountered they have been small sizes and usually a pale colour.

Description

The diamond studied is a modified heart-shape brilliant-cut measuring 11.17 x 11.97 x 7.14

 ISSN: 1355–4565

Figure 1: Photograph of the 7.34 ct modified heart-shape brilliant diamond that was graded as 'Fancy Vivid' purple by the GIA Gem Trade Laboratory. Photograph by Elizabeth Schrader. © GIA.

mm in dimension and weighing 7.34 ct (*Figure 1*). According to the grading terminology used by the GIA Gem Trade Laboratory (King *et al.*, 1994), its colour description is 'Fancy Vivid purple', a terminology used to describe a limited population of coloured diamonds that are categorized by a high degree of saturation for a given colour hue. This is one of the very few, and among the most intensely coloured purple diamonds examined by the laboratory staff, since most have a pink component to their colour and are not pure purple.

Materials and methods

The gemmological properties of this diamond were documented with standard testing equipment, including a binocular microscope, a desk-model prism spectroscope, and a long- (366 nm) and a short-wave (254 nm) ultraviolet lamp unit. An absorption spectrum was recorded over the range of 360 to 760 nm with a Hitachi U-4000 spectrophotometer, with the diamond being cooled to liquid nitrogen temperature (about -196°C). Several infrared spectra were recorded with a Nexus 670 Fourier-transform infrared (FTIR) spectrometer over the range of 400 to 10500 wavenumbers (cm^{-1}). Photographs were taken with a Kodak DCS315 digital camera.

Gemmological examination

When the diamond was examined in a face-up position in the controlled colour-grading environment, the purple colour appeared to be evenly distributed (see again *Figure 1*). However, when viewed with magnification in other orientations, the purple colour was seen to occur along distinct, parallel graining planes with intervening zones that showed little if any colour (*Figure 2*). This banded coloration is typical of purple diamonds, and is similar to the colour zoning often seen in brown, brown-pink, and pink to red diamonds. Although some scientific uncertainty still exists about the details of the cause of colour, it is generally accepted that all these types of coloration result from plastic deformation while the diamonds were in the earth's mantle. The atomic-level deformation is concentrated along the same planar zones where the purple, brown, pink or red coloration is seen (Kane, 1987; Fritsch, 1998). Surface graining with an almost reflective appearance was also evident during this visual examination (see again *Figure 2*).

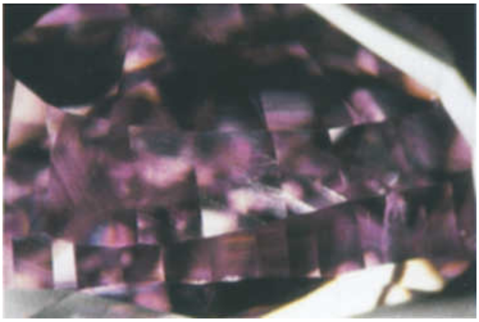


Figure 2. *When examined with magnification, this diamond exhibited banded purple coloration and reflective surface graining. Photomicrograph by Vincent Cracco; magnified 15x, copyright GIA.*

Under long- and short-wave ultraviolet illumination, this purple diamond exhibited weak to medium, and very weak, yellow fluorescence, respectively. The long-wave ultraviolet fluorescence was unevenly distributed. When viewed between crossed polarizing filters, the diamond displayed strong anomalous birefringence in the form of a cross-hatched strain pattern that was aligned with the planar colour zonation. The diamond's clarity grade was I_1 on the GIA grading scale, based on the prominent graining and a tension feather that extended into the graining plane. When examined with a desk-model spectroscope, the diamond exhibited no sharp bands in its absorption spectrum.

Visible and infrared spectra

The visible spectrum of this diamond exhibited increasing absorption below 450 nm, and a broad absorption band centred at about 550 nm (with a weak side band at about 475 nm; see *Figure 3*). This combination of absorption features produces the purple colour. The broad 550 nm absorption band is the same feature that is seen with increasing strength in the spectra of pink to red diamonds (Shigley and Fritsch, 1993; also see *Figure 4*) and is thought to be due to plastic deformation of the diamond. This deformation created colour centres capable of absorbing wavelengths of light in the region of the spectrum between about 450 and 650 nm. The direct association between the purple coloration and the banded coloured graining confirms that the cause of the colour is the same as the cause that gave rise to the graining.

Based upon the infrared spectrum (*Figure 5*), this is a type IaA diamond with a relatively high amount of nitrogen and a very low amount of hydrogen.

Manufacture

The rough crystal initially weighed 15.31 ct and had a 'blocky' shape. A slight surface coating hindered the ability of the manufacturer to readily see into the crystal to evaluate how it could best be fashioned. Although it appeared to have a dark pink colour in some directions, the diamond also displayed something different about its colour appearance. When the crystal was originally 'opened' with a few small facets to examine its clarity, it was also noted at the time that the colour was not that of a typical pink diamond. The coloration was quite unusual,

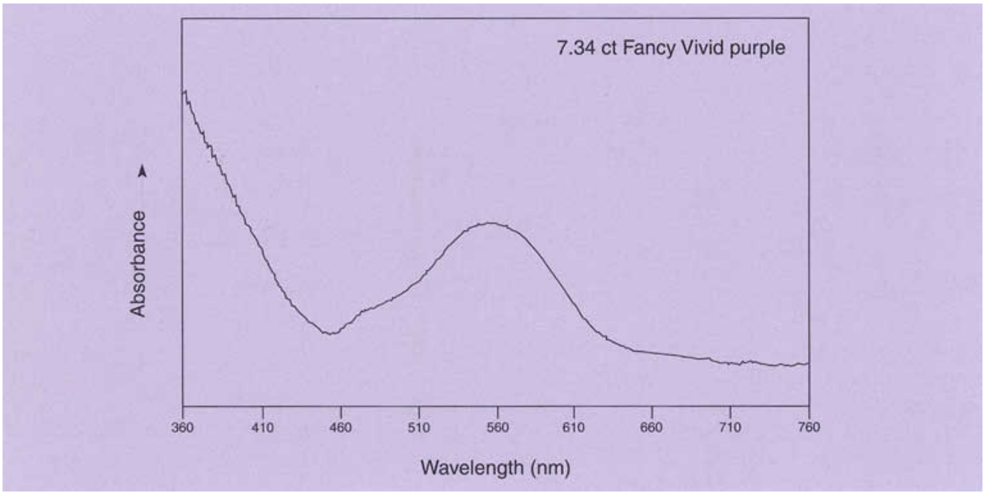


***Figure** 3. The spectrum of this coloured diamond shows increasing absorption below 450 nm, and a broad region of absorption centered at about 550 nm (with a weak side band at about 475 nm). This combination of features gives rise to the saturated purple colour.*

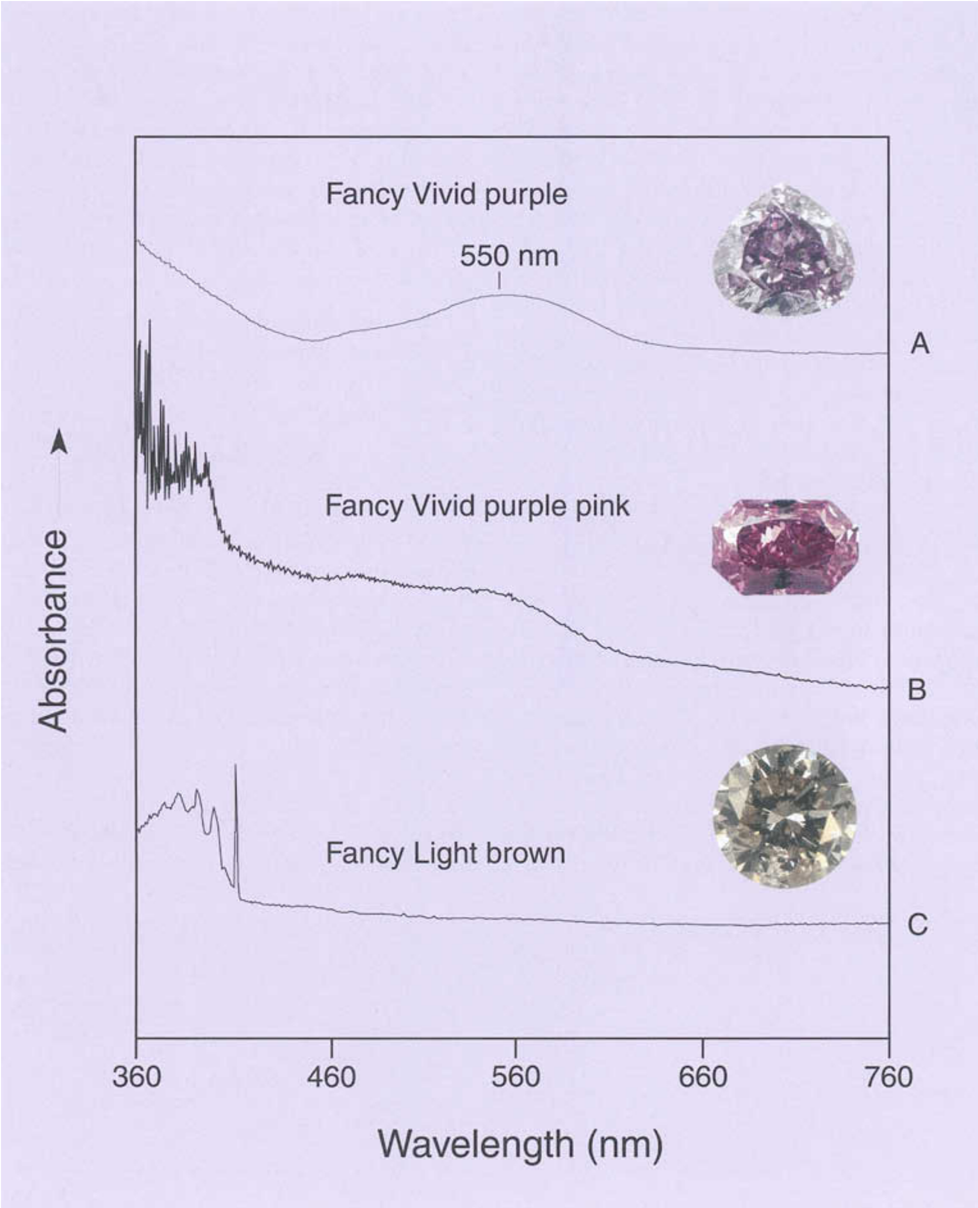


***Figure 4**: A comparison of visible absorption spectra (all recorded at liquid nitrogen temperature) for three coloured diamonds to illustrate some similarities in their spectra. From top to bottom, the spectra are for the 7.34 ct Fancy Vivid purple diamond described here (A), a 5.04 ct Fancy Vivid purplish-pink diamond (B), and a 4.60 ct Fancy Light brown diamond (C). The 550 nm band is most pronounced in spectrum (A); it is also present in spectrum (B), but is absent in spectrum (C). The 550 nm absorption is thought to be due to plastic deformation of the diamond. This deformation created colour centres capable of absorbing wavelengths of light in the region of the spectrum between about 450 and 650 nm. Photographs by Elizabeth Schrader, copyright GIA.*

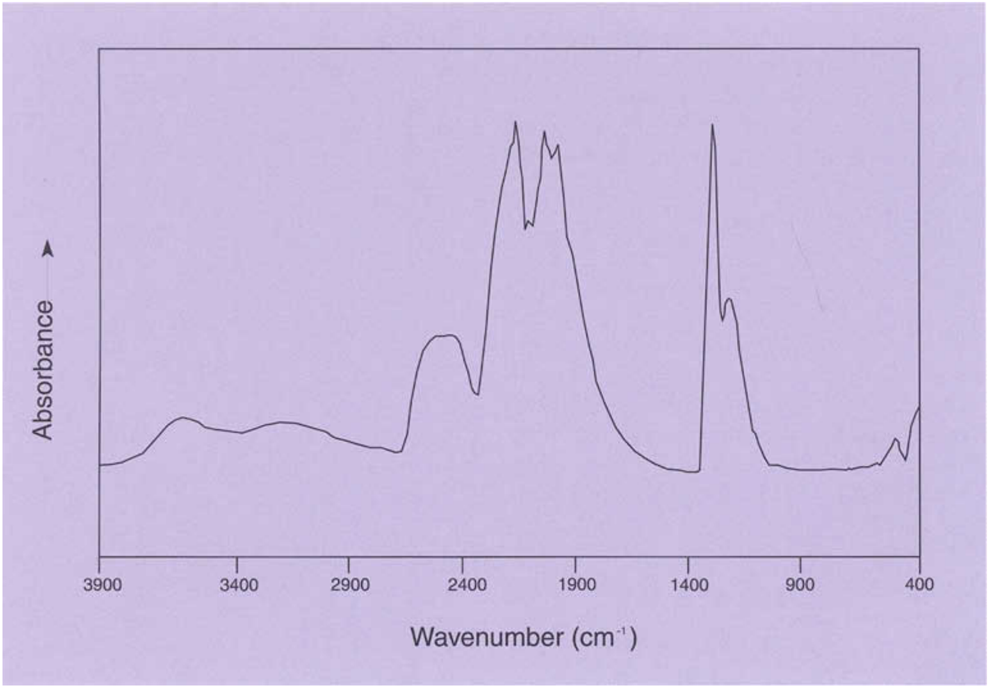


Figure 5. *The mid-infrared spectrum indicates that this purple diamond is type IaA with high nitrogen and a very low amount of hydrogen.*

and was mainly confined to slip planes. As with every rough diamond, the manufacturer had several factors to consider when deciding the shape and faceting style in which to polish it. Coloured diamonds like this further complicate this polishing problem due to their inherent colour zoning. Without the proper orientation of this colour zoning with respect to the planned faceting style, the maximum colour potential could be lost.

There were several options in manufacturing the diamond. Prior to the final decision, a traditional round brilliant and a pear shape were considered but ultimately rejected in favour of a modified heart-shape to maximise the face-up colour appearance. The purple colour zoning associated with the graining was strategically positioned so that the face-up appearance of the polished diamond was both evenly and intensely coloured. This was made even more challenging by the surface grain lines that encircled the entire diamond. With this kind of graining, optimal polishing directions may be different on the same facet, making the final polishing even more difficult. When we encounter diamonds of this colour with similar gemmological properties, they often show small tension fractures extending into the diamond along the graining planes.

Conclusion

Gem diamonds with a pure purple colour are exceedingly rare, and few have been gemmologically documented. With the exception of its saturated colour, this 7.34 ct purple diamond exhibits gemmological properties typical of other purple diamonds that we have encountered (Hargett, 1988, 1990). Its colour zoning, graining, and a visible absorption spectrum are similar to the corresponding features of brown and pink to red diamonds. The strong region of absorption centred at 550 nm in the spectrum contributes to the resulting colour, in contrast to the situation in pink and brown diamonds where the intensity of this absorption band is weaker. This is one of very few coloured diamonds examined by GIA that has a pure purple colour, and its rarity is even more astonishing given its substantial carat weight.

Acknowledgements

We thank the company of Julius Klein Diamonds Inc. in New York City for the opportunity to document this very unusual coloured diamond. Matthew Hall, Elizabeth Schrader, and Vincent Cracco of the staff of the GIA Gem Trade Laboratory helped compile spectral data and photographic images on this diamond.

References

Federman, D., 1995. Purple diamond: Russian delight. *Modern Jeweler*, **94**(9), 19-20

Fritsch, E., 1998. *The nature of color in diamonds. In. G.E. Harlow, Ed., The Nature of Diamonds*, Cambridge University Press, New York, 23-47

Hargett, D., 1988. Gem Trade Lab Notes: Diamond, grayish purple. *Gems & Gemology*, **24**(2), 112

Hargett, D.,1990. Gem Trade Lab Notes: Another purple diamond. *Gems & Gemology*, **26**(2), 154-5

Harris, H., 1994. *Fancy-color diamonds.* Fancoldi Registered Trust, Liechtenstein

Hofer, S.C., 1998. *Collecting and Classifying Coloured Diamonds: An illustrated Study of the Aurora Collection.* Ashland Press, New York.

Kane, R.E., 1987. Three notable fancy-color diamonds: purplish red, purple-pink, and reddish purple. *Gems & Gemology*, **23**(2), 90-5

King, J.M., Moses, T.M., Shigley, J.E. and Yan Liu, 1994. Color grading of colored diamonds in the GIA Gem Trade Laboratory *Gems & Gemology*, **30**(4), 220-42

Shigley, J.E. and Fritsch, E., 1993. A notable red-brown diamond. *Journal of Gemmology*, **23**(5), 259-66

Star garnets and star garnet cat's-eyes from Ambatondrazaka, Madagascar

Dr Karl Schmetzer[1], Dr Heinz-Jürgen Bernhardt[2] and Dr Lore Kiefert[3]

1. Taubenweg 16, D-85238 Petershausen, Germany
2. Central Microprobe Facility, Ruhr-University, D-44780 Bochum, Germany
3. SSEF Swiss Gemmological Institute, Falknerstrasse 9, CH-4001 Basel, Switzerland

ABSTRACT: Mineralogical and gemmological properties of star garnets from Ambatondrazaka, Madagascar, are given. All samples examined are intermediate members of the almandine-spessartine series with an appreciable pyrope component. Asterism is caused by a dense network of rutile needles that are orientated parallel to the three-fold axes of the cubic garnet hosts. In addition to the white four-rayed stars, reddish-brown cat's-eyes are present in two garnet cabochons. This additional light band is caused by orientated sillimanite lamellae. The formation of different four- and six-rayed stars in garnets is discussed.

Introduction

Asteriated garnets are known from India, Sri Lanka, and Tanzania, as well as from Idaho and North Carolina, U.S.A. Samples have been described as almandine or intermediate pyrope-almandine garnets (rhodolite), rarely also as grossular or spessartine. Cabochons with four-rayed stars (*Figure 1a, b*) are commonly observed, and garnets with both four- and six-rayed stars (*Figure 2a, b*) have also been mentioned (Rouse, 1986; Zeitner, 1986; Rohrbach, 1986; Arem, 1987; Kammerling and Koivula, 1990; Barot *et al.*, 1995; Kumaratilake, 1997; Hamer, 1998). Extraordinarily large samples are known from India (*Figure 1b*).

Asterism in garnets is caused by orientated needle-like inclusions, which are most commonly designated as rutile or rutile silk. The most frequently observed orientation of these tiny needles is parallel to the edges of the dodecahedron, i.e. parallel to the four three-fold axes <111> of the cubic system. With that particular orientation, twelve four-rayed stars can be observed on samples cut as complete spheres (Holland, 1896; Brauns, 1907; Goldschmidt and Brauns, 1911; Maier,

***Figure 1a:** Asteriated garnet cabochon from India, revealing a white four-rayed star. It measures 24.2 x 21.5 mm, and weighs 69 ct. Photograph by M. Glas.*

 ISSN: 1355–4565

Figure 1b: Asteriated garnet cabochon from India, revealing a white four-rayed star. It measures 95 x 82 mm and weighs 1.147 kg (5737 ct). Collection of the Precious Stones Museum, Antwerp, Belgium; photograph by P. Entremont.

1943; Mellis, 1966; Strunz, 1968; Barot *et al.*, 1995; Kumaratilake, 1998). Chatoyancy is rarely mentioned in garnets. It is observed in 'normal' four-rayed star garnets which are misorientated (Fryer *et al.*, 1985) or in samples that show a four-rayed star with two arms of the star being extremely weak (Fryer *et al.*, 1988).

Asteriated garnets have been offered in local markets in Madagascar since about 1997. The rough materials for these cabochons or sometimes complete garnet spheres originate from a place about 25 km north-east of the town of Ambatondrazaka which is located south of Lake Alaotra, about 160 km north-east of the capital Antananarivo. The aim of this paper is to present a mineralogical and gemmological description of these garnets, including those showing chatoyancy. These garnets from Ambatondrazaka have been determined as almandines with high spessartine components and differ from another type of asteriated garnet, a more transparent pyrope-almandine from the Ilakaka mining area in

Figure 2a: Asteriated garnet cabochon from India, revealing a white six-rayed star. It measures 27.1 x 21.0 mm, and weighs 132 ct; collection K. Fischer, Starnberg. Photograph by M. Glas.

Figure 2b: Oval cabochon of almandine garnet weighing 28.88 ct and showing a four-rayed and a six-rayed star. Source: India. Photograph by E.A. Jobbins.

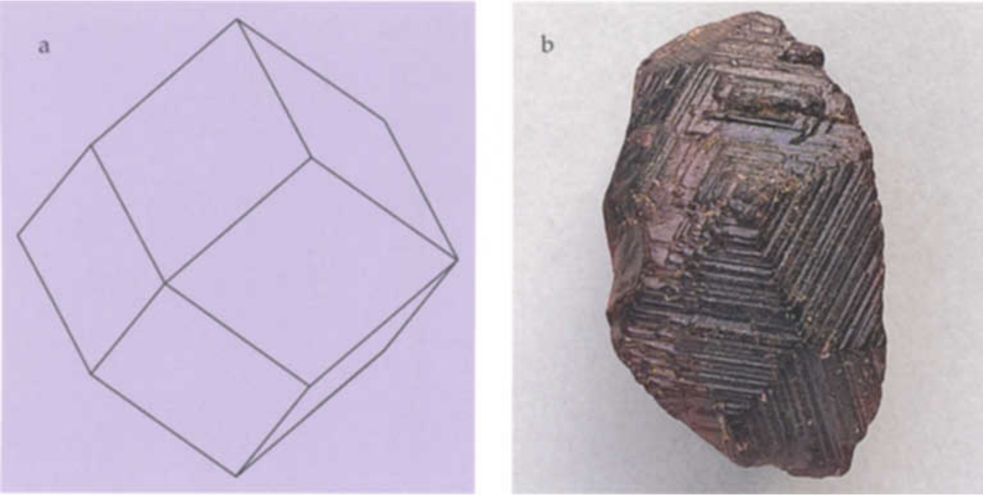


Figure 3: *Normally observed habit of garnet crystals from Ambatondrazaka, Madagascar, showing only the dodecahedron crystal form {110}:*

a) Idealized drawing (clinographic projection)

b) Fragment of a crystal showing three dodecahedral {110} faces; striations parallel to the edges <111> of the dodecahedron are also seen. Size of the sample is about 31 x 15 mm. Photograph by M. Glas.

southern Madagascar (Schmetzer and Bernhardt, 2002).

Geology of the occurrence

The region east and south-east of Lake Alaotra is one of the numerous pegmatite areas of Madagascar and is well known as a source of cyclic twins of chrysoberyl (Pezzotta, 1999). Rough garnet crystals up to 25 cm in diameter are recovered from one of these pegmatites which also contains K-feldspar, quartz, muscovite, and schorl (Pezzotta, 2001). The work in the pegmatite has been abandoned because of a landslide that covered the pits of local miners.

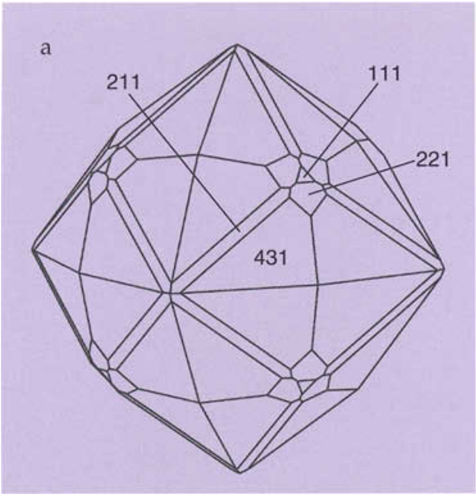
Visual appearance of rough garnet crystals and gemmological properties

The rough material available for the present study consisted of about 50 irregular fragments of garnet crystals measuring up to 8 cm in their longest dimension. In some samples, faces of the dodecahedron {110} were developed which show distinct striations parallel to <111>, i.e. parallel to the edges of the dodecahedral faces (*Figure* 3). Two crystals are strongly distorted with trigonal habit and both are elongated along one of the cubic three-fold axes (*Figure* 4). The dominant faces are the trapezohedron {211} in combination with the hexoctahedron {431}. Smaller trisoctahedral {221} and octahedral {111} faces are also present.

All samples are non-transparent and only lightly translucent with a reddish to purplish-brown colour. Refractive indices of the samples are above the limit of normal gemmological refractometers. Specific gravities of the samples lie in the range of 4.21 to 4.26.

Asterism and chatoyancy

For the present study, 40 cabochon-cut garnets up to 50 ct in weight and 15 samples cut as complete spheres were available. Samples cut as cabochons revealed distinct asterism forming sharp four-rayed white stars (*Figure* 5). According to the orientation of the surfaces of an individual cabochon, up to three of these four-rayed stars may be present (*Figure* 6). Garnet crystals cut as



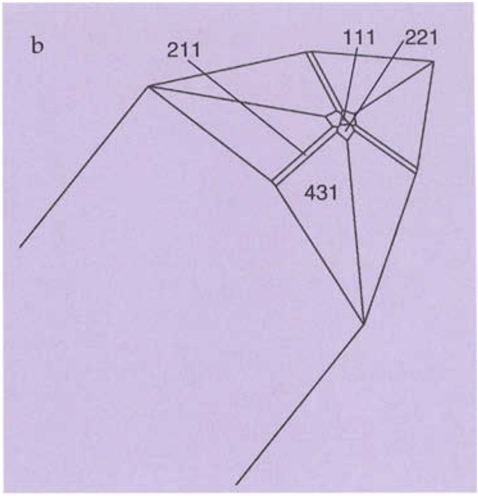


Figure 4: *Trigonally distorted garnet crystal from Ambatondrazaka, Madagascar:*

a) Idealized drawing (clinographic projection) of an undistorted cubic crystal showing the trapezohedron {211} in combination with the hexoctahedron {431} as dominant crystal forms; subordinate faces are the trisoctahedron {221} and the octahedron {111}.

b) Idealized drawing (clinographic projection) of a trigonally distorted crystal, the sample is elongated parallel to one of the three-fold axes <111> of the cubic garnet crystal (faces designated as in (a) above.

c) Photo of the trigonally distorted crystal drawn in (b) above, rotated compared with the idealized drawing.

Size of the sample is about 24 x 15 mm; photograph by M. Glas.

complete spheres (*Figure 7a, b*) showed 12 four-rayed stars on their surfaces, the centres of which were observed in a direction parallel to the six cubic two-fold axes <110>, i.e. in a view perpendicular to one of the twelve dodecahedral {110} faces.

One exceptionally large garnet sphere (*Figure 8a, b, c*) measuring 67.8 mm in diameter weighs 676 grams (3380 ct after recutting and repolishing in Germany). This sphere also revealed sharp four-rayed asterism in directions parallel to all of the cubic two-fold axes and is regarded as one of the largest

Figure 5: *Asteriated garnet cabochon from Ambatondrazaka, Madagascar, revealing a white four-rayed star. It measures 19.5 x 15.4 mm and weighs 34 ct. Photograph by M. Glas.*

Figure 6: *Asteriated garnet cabochons from Ambatondrazaka, Madagascar, revealing white four-rayed stars. The light bands of the four-rayed stars appear at different angles according to the orientation of the two-fold axis of the garnet in relation to base and dome of the cabochon. The cabochon in the centre is cut with a base perpendicular to a three-fold axis and shows the light bands of three four-rayed stars. Sizes of the samples are 19.5 x 15.4 mm to 11.1 x 8.9 mm, and weights vary from 34 ct to 5 ct. Photograph by M. Glas.*

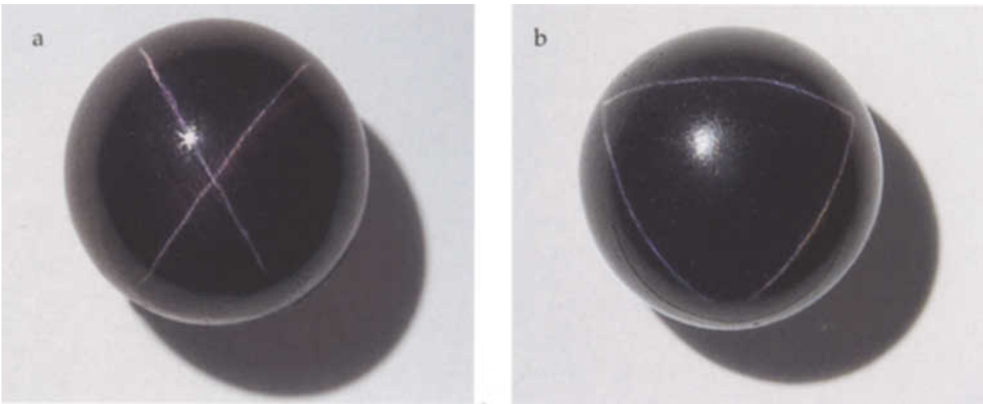


Figure 7: *Garnet from Ambatondrazaka, Madagascar, cut as a complete sphere: a) In a view parallel to one of the two-fold axes a four-rayed star is observed. b) In a view parallel to one of the three-fold axes, the light bands of three four-rayed stars are observed. The diameter of the sphere is 13.0 mm, weight 18 ct. Photographs by M. Glas.*

Figure 8: *Garnet from Ambatondrazaka, Madagascar, cut as a complete sphere:*

a) In a view parallel to one of the two-fold axes a four-rayed star is observed.

b) In a view parallel to one of the three-fold axes, the light bands of three four-rayed stars are observed.

c) In a view inclined to one of the two-fold axes a four-rayed star is observed.

The diameter of the sphere is 67.8 mm, weight 676 grams (3380 ct). Photographs by M. Glas.

asteriated garnet spheres known to date (see e.g. Brauns, 1907; Sinkankas, 1959).

In addition to the commonly observed asterism of the material from Ambatondrazaka, two of the garnet cabochons weighing 32.74 and 19.76 ct show a distinct reddish brown cat's-eye (*Figure 9*). The orientation of this additional light band is oblique to the different light bands forming the commonly observed white four-rayed stars of these samples.

Chemical composition

Microprobe analyses of three samples are given in *Table I*. These data represent average concentrations measured in scans of 20 point analyses each across the plane bases of the samples. In these scans, no distinct chemical zoning was observed.

The garnets are members of the almandine-spessartine series with almandine components of 70-73 mol.% and high spessartine components in the range of 18-21 mol.%. Appreciable pyrope percentages between 7 and 9 mol.% were also determined, and a small grossular component of 1-2 mol.% was also present. Calculating the garnet composition for 12 oxygens and for both iron valencies, iron in the trivalent state is always present in small amounts (between 0.035 and 0.045 Fe^{3+} atoms per formula unit). These data indicate a small component of about 1-2 mol.% of andradite in the garnet samples.

Table I: Composition of almandine-spessartine garnets from Ambatondrazaka, Madagascar; electron microprobe analyses.

Sample (wt%)*	1	2	3
MgO	2.17	1.90	2.00
CaO	0.60	0.36	0.47
MnO	8.02	8.60	8.96
FeO**	32.48	32.50	31.71
V_2O_3	0.01	0.01	0.02
Cr_2O_3	0.02	0.01	0.01
Al_2O_3	20.90	20.87	20.93
SiO_2	36.50	36.28	36.32
TiO_2	0.14	0.06	0.04
Total	100.84	100.59	100.46
Cations based on 12 O			
Mg	0.263	0.231	0.243
Ca	0.052	0.032	0.041
Mn	0.551	0.594	0.618
Fe	2.202	2.215	2.161
V	0.001	0.001	0.001
Cr	0.002	0.001	0.001
Al	1.997	2.005	2.009
Si	2.959	2.957	2.959
Ti	0.008	0.004	0.003
Mol. % end-members			
Pyrope	8.57	7.51	7.94
Grossular	1.69	1.03	1.33
Spessartine	17.96	19.34	20.18
Almandine	71.78	72.12	70.55

** Each composition reported is an average of 20 analyses.*
*** Total iron is given as FeO.*

Figure 9: *Asteriated garnet cabochon from Ambatondrazaka, Madagascar, revealing a white four-rayed star and a reddish-brown cat's-eye. It measures 19.2 x 17.2 mm, and weighs 33 ct. Photograph by M. Glas.*

Microscopic properties observed in thin sections and determination of acicular inclusions

For the examination of needle-like inclusions in the slightly translucent samples, and especially for the evaluation of the causes of asterism and chatoyancy, we prepared four polished thin sections of rough fragments of garnet crystals. These sections were not cut parallel to specific faces or according to specific crystallographic orientations.

Figure 10: *Dense network of rutile needles in an orientation parallel to two edges of the dodecahedron. Thin section, width of the sample about 0.45 mm.*

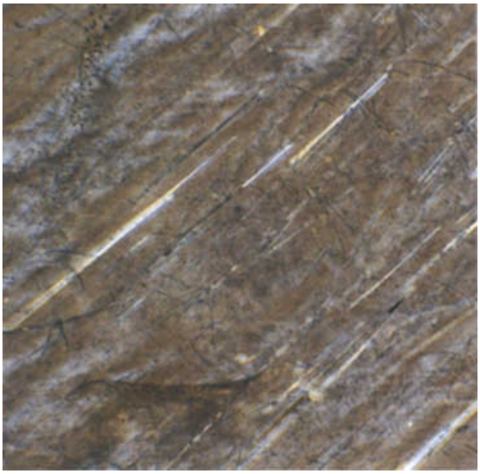


Figure 11: *Lamellar inclusions of birefringent sillimanite crystals in garnet from Ambatondrazaka, Madagascar. Thin section, crossed polarizers, width of the sample about 1.75 mm. Photograph by O. Medenbach.*

All samples showed a network of fine needle-like inclusions (*Figure 10*). In one of the four thin sections, the needles are somewhat thicker than in the other three and were large enough to be analysed by electron microprobe. Only titanium was found as a major component of these needles, and this is consistent with the results from micro Raman spectroscopy, which indicated the needles to be rutile.

In all four thin sections a variable concentration of a second type of microscopic lamellar inclusion was also observed (*Figure 11*). These birefringent lamellae are orientated in one direction which in every instance, differed from the orientation of the rutile needles. Occasionally, the lamellae are slightly inclined or bent. In one of the four thin sections that revealed a relatively high concentration of this second type of acicular inclusion, several lamellae could be measured quantitatively by electron microprobe. The analyses gave the exact composition of Al_2SiO_5 with iron contents in the range of 1.5 to 1.7 wt.% Fe_2O_3. Additional examination of these lamellae by micro Raman spectroscopy indicated that they are sillimanite.

Formation of asterism in garnets

In specific orientations of garnet hosts, asteriated samples typically show six and/or four-rayed stars formed by dense networks of needle-like inclusions. In both cases the stars are formed by bands of light which are orientated perpendicular to the needle axes. In the first case, a four-rayed star is observed in each direction of view perpendicular to a dodecahedral face. In the second case, a six-rayed star is observed in each direction of view perpendicular to an octahedral face. In a view perpendicular to a cube, the arms of six-rayed stars intersect and thus form a four-rayed star (Maier, 1943; Strunz, 1968; Kumaratilake, 1998).

In samples which show only four-rayed stars, the stars are formed by needles which are orientated parallel to <111>, i.e. parallel to the edges of the dodecahedron (*Figure 12a*). In a view perpendicular to a dodecahedral face, a rhomb with angles of 70° and 110° is seen, the edges of which are parallel to two <111> directions. The light bands causing asterism are oriented perpendicular to these edges. Consequently, four-rayed stars are observable in each view perpendicular to one of the twelve {110} faces. The stereographic projection (*Figure 12b*) shows the four light bands and their intersection points. On the surface of garnet crystals that are cut as complete spheres (*Figure 12c*), the centres of the stars are located at the positions of the two-fold axes <110>, that are perpendicular to the dodecahedral faces {110}. Turning a sphere through a certain angle α causes the light bands to move through an angle of 2α. Consequently, the spherical triangles of light bands observable on the surface of a garnet sphere are double the size of the spherical triangles drawn in *Figure 12c*.

In samples which show both four and six-rayed stars, the stars are formed by needles that are oriented parallel to <110>, i.e. parallel to the edges of the octahedron (*Figure 13a*). In a view perpendicular to an octahedral face, a triangle with three equal 60° angles is seen that is formed by three <110> directions, i.e. by three sets of needles. The light bands

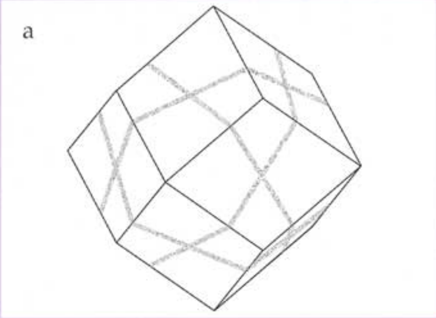
Four-rayed stars

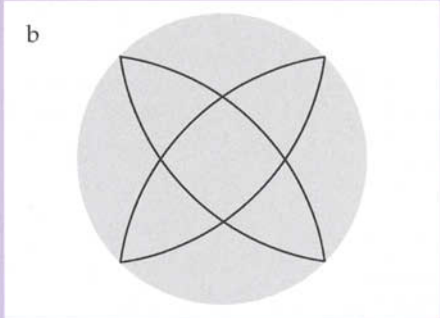
Figure 12: With an orientation of needle-like inclusions parallel to the edges of the dodecahedron, i.e. parallel to the four three-fold axes of garnet, four-rayed stars are formed in directions perpendicular to the dodecahedral faces; the arms of the stars are perpendicular to the long axes of the inclusions.

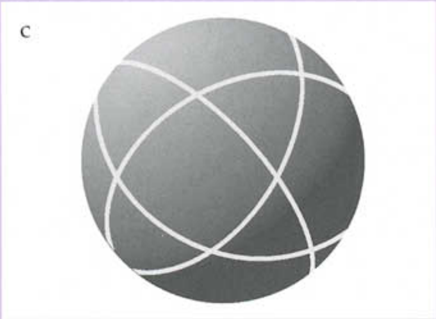
a) Clinographic projection of a cubic crystal with dodecahedral faces {110}, the theoretical positions of light bands perpendicular to the edges of the {110} faces are also shown.

b) The stereographic projection shows four intersection points of four light bands on the upper part of the projection sphere, four additional intersection points are found at the equatorial line of the sphere and another four intersection points are located on the lower half of the sphere (not shown).

c) Three dimensional view of a garnet sphere with four-rayed asterism caused by four light bands perpendicular to the cubic three-fold axes (orientation according to (a) above); the four light bands intersect at the dodecahedral faces. In a view of a sphere in different orientations, only two or three of these intersection points are seen (Figures 6, 7, 8). In a view parallel to one of the two-fold axes (Figures 7a, 8a) two intersecting light bands are observed. With a fixed orientation of the sphere, all intersection points are observable with an incident light rotated around the surface of the sphere.







causing asterism are orientated perpendicular to these edges. Consequently, six-rayed stars are observable in each view perpendicular to one of the eight {111} faces. In a view perpendicular to a cube {100}, two sets of needles intersect at right angles. Consequently, six four-rayed stars with their centres at the position of the cubic four-fold axes <100> are seen. The stereographic projection (*Figure 13b*) shows the six light bands and their intersection points. On the surfaces of garnet crystals that are cut as complete spheres (*Figure 13c*), eight six-rayed stars are observable with the centres of the stars at the position of the cubic three-fold axes <111>, that are perpendicular to the octahedral faces {111}. In addition, six four-rayed stars are observable with the centres of the stars at the position of the cubic four-fold axes <100>.

Six- and four-rayed stars

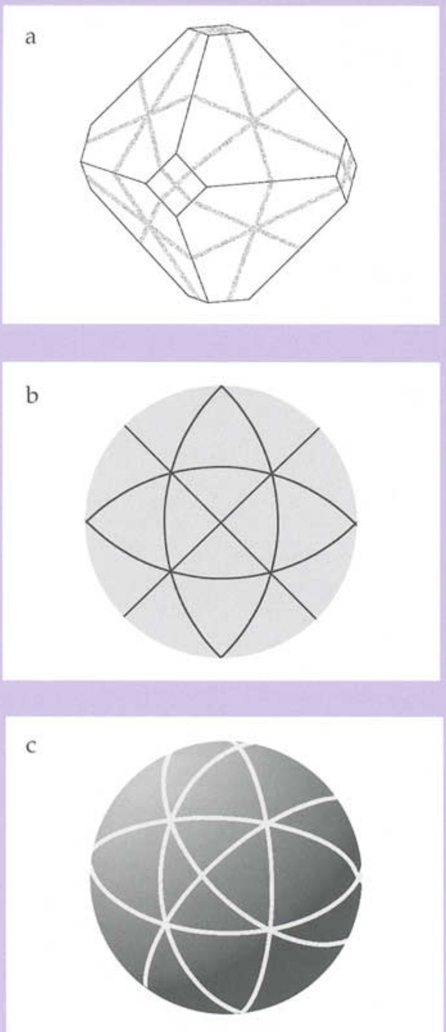


Figure 13: With an orientation of needle-like inclusions parallel to the edges of the octahedron, i.e. parallel to the six two-fold axes of garnet, six-rayed stars are visible in directions perpendicular to the octahedral faces. Viewed in directions perpendicular to cube faces, four-rayed stars are formed by intersecting arms of six-rayed stars. The arms of both types of star are perpendicular to the long axes of the inclusions.

a) Clinographic projection of a cubic crystal with octahedral faces {111} and cube faces {100}, the theoretical positions of light bands perpendicular to the edges of the {111} faces are also shown.

b) The stereographic projection shows four intersection points of three light bands on the upper part of the projection sphere; four identical intersection points are located on the lower half of the sphere (not shown); four additional intersection points of two light bands are found at the equatorial line of the sphere, one intersection point is located in the upper pole of the sphere and another one in the lower pole of the sphere (not shown).

c) Three-dimensional view of a garnet sphere with six- and four-rayed asterism caused by six light bands perpendicular to the cubic two-fold axes (orientation according to a) above); the six bands that intersect at the octahedral and at the cube faces form six- and four-rayed stars (see also the detailed explanation of Figure 12).

As well as the two types of star-forming needles parallel to <111> and parallel to <110> mentioned above, a third type of orientated needles in garnets is also described in the literature (Holland, 1896; Mellis, 1966; Strunz, 1968). These needles are found parallel to the cubic four-fold axes <100>, i.e. perpendicular to the cubic planes of garnets from India and Madagascar. Until now, star garnets with this particular orientation of needles have not been described, probably because the needles in this orientation do not form a dense silk-like network that is necessary for the formation of asterism.

Conclusions

Asteriated garnets from Ambatondrazaka near Lake Alaotra, Madagascar, are almandines with high spessartine and somewhat lower pyrope contents. The ordinary asterism of the samples is caused by orientated rutile needles forming white four-rayed stars. Additional chatoyancy is due to orientated lamellae of sillimanite. To our knowledge, this is the first report of garnet cat's-eyes that show a certain type of acicular inclusion in one single orientation only. The formation of different six- and/or four-rayed stars in garnets is explained by the intersection of light bands that are formed perpendicular to dense networks of acicular inclusions.

References

Arem, J.E., 1987. *Color Encyclopedia of Gemstones.* 2nd edn. Van Nostrand Reinhold Company, New York, 248pp

Barot, N.R., Graziani, G., Gübelin, E., and Rettighieri, M., 1995. Cat's-eye and asteriated gemstones from East Africa. *Journal of Gemmology*, **24** (8), 569-80

Brauns, R., 1997. Lichtschein bei Granat, Zirkon und Sapphir, *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, **1907** (I. Band), 13-20

Fryer, C.W., Crowningshield, R., Hurwitt, K.N. and Kane, R.E., 1985. Gem Trade Lab notes. Garnet: almandite, exhibiting both chatoyancy and asterism. *Gems & Gemology*, **21** (1), 44

Fryer, C.W., Crowningshield, R., Hurwitt, K.N., and Kane, R.E., 1988. Star (or cat's-eye?) almandite garnet. *Gems & Gemology*, **24** (2), 112

Goldschmidt, V., and Brauns, R., 1911. Über Lichtkreise und Lichtknoten an Kristallkugeln. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, **31.** Beilage-Band, 220-42

Hamer, M., 1998. Almost heaven. *Lapidary Journal*, **52** (9), 69-72

Holland, T.H., 1896. On the acicular inclusions in Indian garnets. *Records of the Geological Survey of India*, **29**, 16-19

Kammerling, R.C., and Koivula, J.I., 1990. Star rhodolite garnet from Tanzania. *Journal of Gemmology*, **25** (1), 16-18

Kumaratilake, W.L.D.R.A., 1997. Gems of Sri Lanka: a list of cat's-eyes and stars. *Journal of Gemmology*, **25** (7), 474-82

Kumaratilake, W.L.D.R.A., 1998. Spinel and garnet star networks: an interesting asterism in gems from Sri Lanka. *Journal of Gemmology*, **26** (1), 24-8

Maier, W., 1943. Experimenteller Asterismus. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie*, **78** (3), 283-380

Mellis, O., 1966. Die nadeligen Einschlüsse in Pyralspitgranaten. 44. Jahrestagung, *Deutsche Mineralogische Gesellschaft*, München 1966, Referate, 2 pp

Pezzotta, F., 1999. Madagascar. Das Paradies der Mineralien und Edelsteine. *In:* Glas, M. (Ed.), *extraLapis*, 17, Christian Weise Verlag, München, 98 pp

Pezzotta, F., 2001. Pers. comm.

Rohrbach, R.P., 1986. Stars and stripes forever. *Lapidary Journal*, **40** (7), 20-30

Rouse, J.D., 1986. *Garnet*. Butterworths, London, 134 pp

Schmetzer, K., and Bernhardt, H.-J., 2002. Star Garnets from Ilakaka, Madagascar. *Australian Gemmologist* (in press)

Sinkankas, J., 1959. *Gemstones of North America.* Van Nostrand Reinhold Company, New York, 285-6

Strunz, H., 1968. *Atomare Struktur, Eigenschaften und Klassifikation der Edelsteine.* In: Mackowsky, M-T. (Ed.) Edelsteine. Aufschluβ, 18. Sonderheft, 68- 102

Zeitner, J.C., 1986. Phenomenal gems. *Lapidary Journal*, **40** (7), 32-6

Gem-A Education

Short courses and Workshops

20 February	**Ruby and sapphire – the inside story** *Gem-A Member price £99 + VAT. (Non-Member price £110 + VAT)*
13 March	**The hitchhiker's guide to inclusions** *Gem-A Member Price £99 + VAT. (Non-Member Price £110 + VAT)*
20 March	**The diamond buying guide** *Gem-A Member price £75 + VAT. (Non-Member price £85 + VAT)*
27 March	**Emeralds – the inside story** *Gem-A Member price £99 + VAT. (Non-Member price £110 + VAT)*
10 April	**The rocks we wear** *Gem-A Member price £75.00 + VAT. (Non-Member price £85.00 + VAT)*
17 April	**Bead-stringing workshop** *Gem-A Member price £108 + VAT. (Non-Member price £118 + VAT)*
27 and 28 April	**Stone faceting workshop** *Price £175 + VAT.*
1 May	**Gemstones for jewellers** *Gem-A Member price £75 + VAT. (Non-Member price £85 + VAT)*
8 to 10 and 13 to 15 May	**Six-day Diamond Practical Course (exam 16 May)** *Price £650 including VAT*
2 July	**Photographing jewellery** *Price £134 + VAT.*

Student Workshops

15 to 17 April	**Three-Day Preliminary Workshop** *Gem-A student price £120 +VAT. (Non-student price £156.00 + VAT)*
20 to 23 May	**Four-day Diploma workshop** *Gem-A student price £199 + VAT.*
25 to 26 May	**Weekend diamond grading revision** *Gem-A student price £120 + VAT.*
25 to 26 May	**Two-day Diploma practical workshop** *Gem-A student price £120 + VAT.*

All workshops held at the Gem Tutorial Centre, 27 Greville Street, London EC1N 8TN
For further information and a booking form contact Rachel Warner on 020 7404 3334.

An unusual gem deposit (man-made) at Pallebedda, Sri Lanka

M.D.P.L. Francis[1] and P.G.R. Dharmaratne[2]

1. *Department of Earth Resources Engineering, University of Moratuwa, Sri Lanka*
2. *National Gem and Jewellery Authority, Colombo, Sri Lanka*

ABSTRACT: An unusual gem deposit (man-made) lies in the remote village of Pallebedda in Sri Lanka. This deposit is known as 'walankatu illama' which lies within the bund or embankment of an abandoned tank called Kandiyapalle (alias Bisokotuwa). Second rate material from a jewellery industry of ancient times was included probably at the time of its construction. This deposit contains many archaeological artifacts including many varieties of beads, rough gems, gem carvings, glass and coins, but it is mined by villagers mainly for the precious stones because they can be most easily marketed.

Keywords: beads, bund, cameos, carving, clay utensils, intaglios, tank

Introduction

Sri Lanka is renowned for its wide variety of fine quality gemstones such as sapphire, ruby, chrysoberyl, alexandrite, spinel and beryl. Most of these gems are found as alluvial deposits in ancient buried or existing stream beds and low-lying areas. There are several primary outcrop deposits but the gems found in them are commonly not of the best quality, other than those found at the moonstone deposit of Meetiyagoda.

Gem deposits in Sri Lanka are classified according to their distance of transportation from the source, by the shapes and sizes of the rock and mineral fragments found. Gem-bearing beds where angular minerals and rocks have been deposited in situ are named as residual gem deposits. Gem-bearing layers found on the hill slopes with minerals and rock fragments that are semi-rounded or rounded are termed eluvial gem deposits. The third type of gem deposit is alluvial, which is by far the most prevalent in Sri Lanka. These deposits generally lie in old stream beds, far away from their sources and are characterized by the presence of well rounded heavy minerals, indicating longer distances of transportation (Dhanayake, 1980) (*Figure 1*).

In Sri Lanka there is currently no scientific approach towards gem exploration. Established gem miners who can afford to invest in land, to purchase a licence to prospect for gems and other expenses, always follow the trails of illicit gem miners. Some people find gems during their day-to-day activities such as construction of a well or while ploughing their farmlands.

 ISSN: 1355–4565

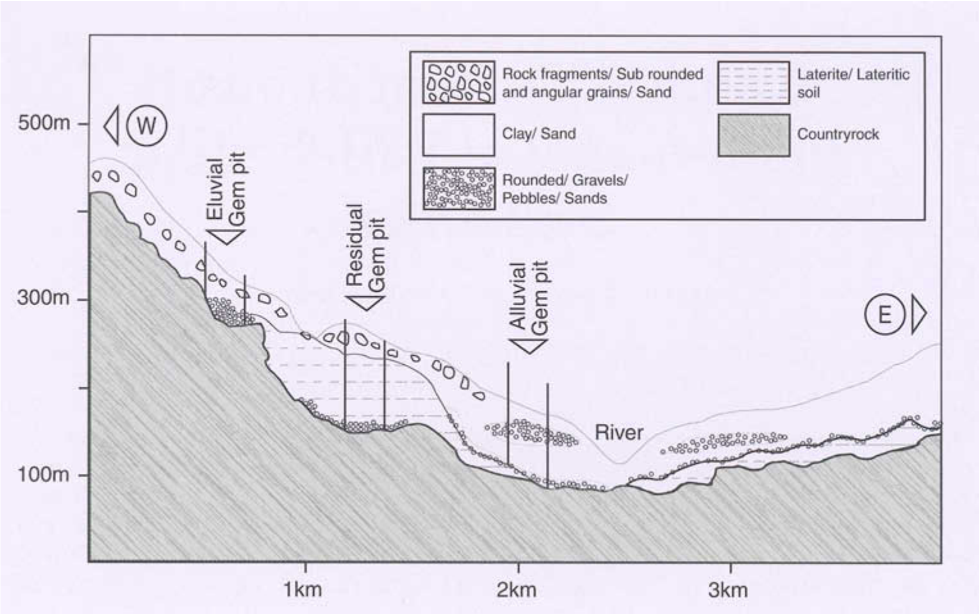


Figure 1: *Schematic cross section showing different modes of occurrence of gemstones (modified after Dhanayake, 1980).*

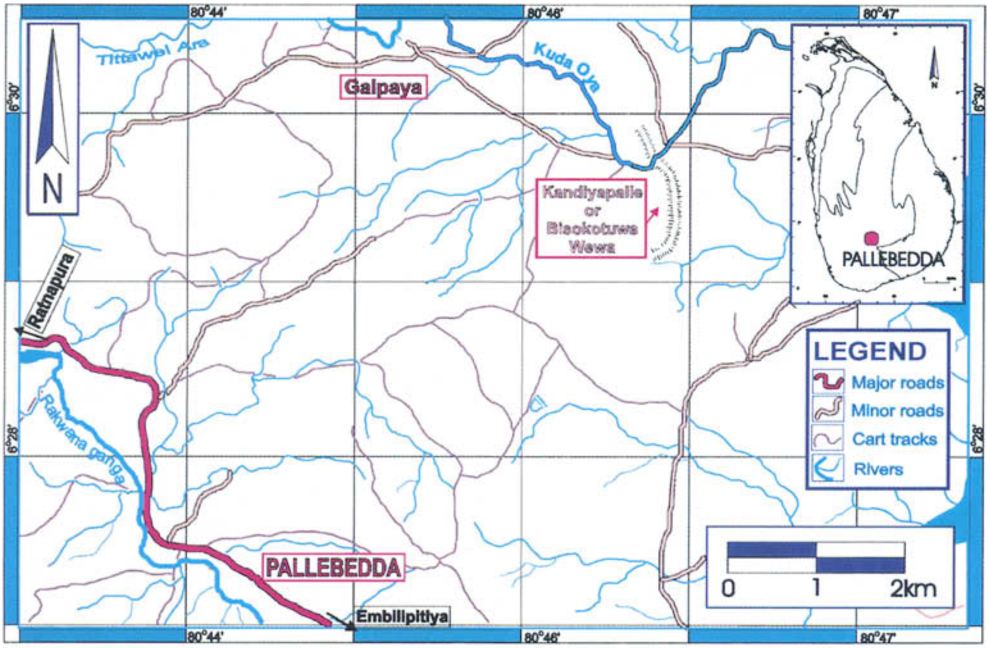


Figure 2: *Location of Pallebedda and the abandoned tank called Kandiyapalle alias Bisokotuwa (source: Survey Dept. 1:63360 topographic map of Timbolketiya).*

However, the type of gem deposit to be discussed in this paper is somewhat different to the three kinds of deposit outlined above.

Along the Ratnapura-Embilipitiya road, 21 km from Embilipitiya, is the village of Pallebedda, a gem-trading centre, which has existed since ancient times. Six km north east of Pallebedda is the small village of Galpaya, with an abandoned tank named Kandiyapalle alias Bisokotuwa Wewa (*Figure 2*). The bund (embankment) which encloses the tank contains hidden treasure consisting of a variety of gems, beads and carvings made of different materials. These artifacts and gems occur in a layer in the bund, 60 to 180 cm thick, which local people call 'walankatu illama'. In Sinhalese, 'walankatu' refers to pieces of earthenware and 'illama' refers to gem deposit. The artifacts bear witness to how knowledgeable the ancient civilization of Sri Lanka was and to their standard of living. The gem carvings exhibit the most intricate and delicate workmanship and provide evidence of a sophisticated technology of the time.

Historical records

According to several authors there is evidence that this area was once a flourishing agricultural village. R.L. Brohier, Surveyor General during colonial times, describes this tank with reference to a Mr Collins and a Mr Mitford who was Assistant Government Agent, Sabaragamuwa Province in 1848. According to the quotes this tank was quite beautiful at the time and had watered nearly a thousand acres of paddy fields (Brohier, 1934). There is an ancient stone pillar situated in the village with an inscription dating to the tenth century AD, which indicates that

Figure 3: *Cross section of the gem-bearing layer showing the embedded pieces of earthenware (walankatu illama).*

Figure 4: Various types of beads found in the deposit.

the village was called Girimandula (Nichal, 1979). It is not certain as to who built the tank but according to folklore the builder was King Vijayabahu I (1055–1110).

Materials found

For the villager, 'walankatu illama' is merely a gem deposit, unique because artifacts were found among the buried potsherds. This deposit is located along the tank bund that extends for more than 3.2 km (two miles). At a depth of 60 to 120 cm from the top surface lies the layer called the 'walankatu illama' with an abundance of potsherds. The thickness of the layer ranges from 60 to 180 cm (*Figure* 3). The layer is easily identified and the material is washed as usual in large wicker baskets to extract the gem material. A general idea as to the percentage of the earthenware material contained in the illama can be formed from the heaps of debris found in the vicinity of the washing sites. The miners are interested only in the gems, carvings and beads that fetch high prices. The highest prices are obtained for gems such as sapphire, geuda, pushparaga (yellow sapphire), chrysoberyl, etc. Even among these gems there are instances of finding stones with drill holes to indicate that they were once discarded as valueless, owing to imperfections detected during the process of drilling. Other than these, various kinds of objects have been found within the area, and these include many kinds of beads, clay utensils, glass bangles, stone cameos, intaglios, coins and bones.

The illama contains many types of large and small beads in a variety of shapes. These include glass, carnelian, agate, amethyst, terracotta, garnet, feldspar, rock crystal, chrysoberyl and zircon (*Figure* 4). These stones are called 'mukkaru gal' by the

Figure 5: *Corundum bead (specimen of National Museum of Sri Lanka, No. 56-2-32).*

Figure 6: *Amethyst bead.*

villagers, because most have drill holes which identify them as the raw material of a trade practised for a living by a segment of society known as mukkaru. The most sought-after beads (mukkaru gal) were the beads made of gem materials such as corundum (*Figure* 5) or amethyst (*Figure* 6).

At this site agate beads and clear glass beads have also been found in large quantities. According to archaeological dating, clear glass was made at a later date than coloured glass. As in many other places, carnelian beads of many shapes and sizes found at this site are believed to be from India. Pieces of beads broken during production, unfinished beads and discarded second-rate material suggest that there had been jewellery workshops here during ancient times.

Terracotta beads of various shapes and sizes are very common, the majority being disc-shaped; the larger ones are embedded with a tiny copper wire to strengthen the bead – an example of the ingenuity of the ancient craftsmen.

Figure 8: *Several drill holes in a spinel as a result of testing the gauges of drill bits.*

Figure 7: *Drill hole through a bead showing slight disorientation in the middle.*

Figure 9: *Chrysoberyl carved with the figure of an elephant (1.8x).*

Figure 10: *(a) Carnelian carved with the figure of a hunter along with his weapon and the dead animal (22 mm). (b) Carnelian carved with the figure of a female dancer (16 mm). (c) Carnelian carved with the figure of a reclining cow (13 mm). (d) Rock crystal carving depicting three cows drawn similar to the manner shown in Egyptian frescos (18 mm). (e) Rock crystal carving depicting a seated posture of Buddha in meditation (19 mm). (f) Carnelian carved with the figure of a woman adorned with masks, meant to be either a dancer or more probably a goddess (22 mm). (g) Scratched drawing on a rock crystal depicting a man dragging a child bound with ropes ('Wessantara jatakaya', a parable of Buddhism) (20 mm).*

Almost all the beads show clear evidence of how they were drilled. The abrasion marks indicate that they were drilled from both ends to meet in the middle, and commonly this resulted in a slight disorientation in the centre (*Figure 7*).

The question arises as to how they drilled tiny holes through these very hard substances. Some are of the opinion that emery powder and iron drill bits were used. If this is the case, how were the hard materials like sapphires drilled? Even for other gem species, it could have taken a very long time using this method to drill a single bead. Large numbers of beads found in the area suggest that the drillers were experts. Is it possible that they could have used diamond drill bits exported from India for the purpose of drilling? According to Henry Parker the bow-driven drill was familiar to locals in Sri Lanka from the second century BC onwards (Parker, 1981). So it is a fair assumption that they used this type of drill along with diamond drill bits to drill with ease large quantities of beads and to cope with the harder gems such as sapphire. A number of stones of hard materials such as sapphire and spinel that contain multiple drill holes of the same gauge or different gauges have been found. This could have happened as a result of testing the gauges of drill bits on these stones (*Figure 8*).

The most interesting materials found in this deposit are not the beads or the clay utensils but the most intricately carved cameos and intaglios. These carvings are mostly in materials such as carnelian, rock crystal and coloured glasses, and very rarely in other types of material – one such rare type is chrysoberyl (*Figure 9*). Some carvings depict a cow in a seated position (*Figure 10c*) and three cows carved are similar to an ancient painting of an Egyptian goddess (*Figure 10d*). The human figures carved are of both males and females. The female figures are mainly of dancers (*Figure 10b*) and of a semi-nude woman meant to be either a dancer or more probably a goddess adorned with masks (*Figure 10f*). Male figures include a hunter with his weapon and a dead animal (*Figure 10a*), a seated Buddha in meditation (*Figure 10e*) and a man dragging a child bound with ropes, scratched on rock crystal ('Wessantara jatakaya', a parable of Buddhism) (*Figure 10g*).

Conclusion

These materials are much older than the date of construction of the dam, and this layer found within the dam was the fill material for the bund excavated from the nearby ancient work sites, where the clay utensils, beads and other carvings were manufactured. According to many experts, the materials can be dated from the first to the twelfth century AD. Therefore the assumption is that at the time the mukkaru people lived and worked in this vicinity in large numbers. The artifacts are of very good craftsmanship although they were made using the most primitive methods and instruments. In terms of the intricacy of the carvings and the quality of the drill holes in the sapphire they are not inferior to today's standards. They are also remarkable aesthetically.

This is an unusual gem deposit because it contains artifacts that had been once discarded by people who were only interested in gems of value (precious material). Sometimes a villager who has found a carved artifact of a precious stone may try to erase the carving by grinding it on a lap to make a faceted gem. This would find a more ready market than the carvings, which are considered as archaeological artifacts and cannot be sold on the open market.

Acknowledgements

The authors would like to thank Mr Ruwan Fonseka for supplying the photographs of cameos and intaglios, the Director of the National Museum for granting permission to photograph the specimens, Mr Rohan Perera for preparation of the location map, and Mr Harsha Waidyasekera for scanning some of the photographs.

References

Brohier, R.L., 1934. *Ancient irrigation works in Ceylon.* Government Press of Ceylon Publication, 17

Dhanayake, K., 1980. Modes of occurrence and provenance of gemstones of Sri Lanka. *Mineralium Deposita*, **15**, 81-6

Nichal, C.W., 1979. *Historical Topography of Ancient and Medieval Ceylon.* Ceylon Branch of the Royal Asiatic Society Publication (Sinhala Edition), 148

Parker, H., 1981. *Ancient Ceylon.* J. Jetley for Asian Educational Services, New Delhi (ISBN 8120602080), 558-9

'Kakuten' (crane crown), an 'ojime' made from the tooth of a grass-eating animal

Ichiro Sunagawa[1], Yasushi Takahashi[1], Ikuko Kimura[2] and Toshio Sakae[3]

1. Yamanashi Institute of Gemmology and Jewellery Arts, Tokoji-machi 1955-1, Kofu, 400-0808 Japan

2. Department of Clinical Pharmocology, Toyama Medical and Pharmaceutical University, Sugitani 2630, Toyama, 930-0194 Japan

3. Faculty of Dentistry at Matsudo, Nihon University, Sakae-cho 2-870-1, Matsudo, 271-8587 Japan

ABSTRACT: 'Kakuten' is a kind of 'ojime', an ornamental craft product of the Edo era used to tighten the connecting strings between a 'netsuke' and an 'inro', or between a cylindrical container of khsier (a tobacco pipe) and a pouch for shredded tobacco. These craft products have attracted world-wide attention owing to their exotic motifs and delicate craftsmanship. 'Kakuten' has been highly praised as a magical ornament and was believed to consist of the red crown of the Japanese crane. Gemmological data obtained on a sample of 'kakuten' has now discredited this origin. Textural observations and micro-area FTIR spectroscopy have been applied to selected areas of a 'kakuten' showing a featureless white band and a porous band stained vermilion. The tests indicated that the 'kakuten' is made of an animal tooth. The white featureless bands correspond to enamel, and the porous vermilion bands correspond to the dentine part of an animal tooth. The texture of the tooth indicates that it is from a grass-eating animal but the species has not yet been identified.

Introduction

'Netsuke' and 'ojime' are small ornamental craft products of the Edo era and have been regarded as Japanese magical jewels by collectors[1]. 'Ojime' is smaller than 'netsuke' and usually spherical or die-shaped and engraved in exotic design, and used to tighten strings connecting a 'netsuke' and an 'inro'. 'Netsuke' is an ornamental craft product engraved in symbolic or exotic figures on various materials, and 'inro' is a set of lacquered portable boxes containing pills for an emergency. 'Ojime' is also used to tighten strings connecting a pouch for shredded tobacco and a cylindrical container that contains a 'khsier' (a tobacco pipe, consisting of two metal ends for bowl and mouthpiece, connected by a bamboo pipe-stem). All these items have attracted the enthusiastic interest of mainly European and American collectors, owing to their delicate craftsmanship and exotic motifs, and many went abroad after Japan opened up during the Meiji period. High quality examples of these craft

 ISSN: 1355–4565

Figure 1: *A set comprising a tobacco pouch (A), an 'ojime' ('kakuten') (B), a 'khsier' container (C) and strings. The size of the 'kakuten' is 2.1 cm across.*

Figure 2: *A collection of 'kakuten'. Bar indicates 1.0 cm. By courtesy of Ms Reiko Fujita.*

products may be seen these days mainly in European and American museums, such as the British Museum and the Victoria and Albert Museum in London, but not in Japan. There are books describing art, magic and materials used in 'netsuke' and 'ojime', and also clubs or societies which concentrate on collections and studies[1,2]. *Figure 1* shows a good example of a set, and the mutual relations between a tobacco pouch, a 'khsier' container and an 'ojime' (in this case 'kakuten').

A wide variety of materials have been used to make 'ojime' and 'netsuke'[1] and the most frequently used are ivory, narwhal, stag antler, amber, ebony, agate, malachite, silver, red copper, nickel and brass. Problems of weight, abrasion and fragility have restricted the number of materials practical for 'netsuke', but because of their comparatively smaller size, 'ojime' have been largely exempt from such limitations. The materials used for 'ojime' include coral, amber, ivory, vegetable ivory, fossilized mammoth tusk, narwhal, rhinoceros horn, stag antler, shell of mother-of-pearl, boxwood, rosewood, teak, sandal wood, mahogany, ichii (Japanese yew, *Taxus cuspidata*), bamboo, gold, silver, iron, brass, red copper, nickel silver, cloisonne, stained glass, ceramic, agate, tiger's-eye, jade, malachite, serpentine,

Figures 3a and b: *Two views of the 'kakuten' sample investigated; it is 1.7 cm in diameter.*

goldstone and turquoise[1,2].

Among the various materials used for 'ojime', 'kakuten' whose literal translation is a head (red crown) of a Japanese crane, has attracted particular interest among collectors. 'Kakuten' is fashioned in a small ball ca. 1.2 to 2.0 cm diameter with a hole, and shows an irregular pattern of alternating white and vermilion (or dark brown to reddish-brown) bands. It is also said that there are 'kakuten' with black and white or brown and white irregular bands. In *Figure* 2, a collection of 'kakuten' is shown.

In the oldest book of the Edo era published in 1781[3] describing how ornamental craft products were used to decorate swords, 'soken-kisho' (literal translation – highly praised ornamental crafts of swords), the word 'ho-ten' was used instead of 'kakuten'. 'Ho' is a Chinese imaginary bird such as a phoenix, and 'ten' is a crown or casque, a process on the upper mandible or on top of the head. The casque of the extinct helmeted hornbill (*Rhinoplax vigil*), an unusual substitute for ivory of bird origin, has an alternative name of 'ho-ting'[4], which also originated from China. The pronunciations of 'ho-ten' in Japanese and 'ho-ting' in Chinese apply to the same Chinese characters. It follows from this that the word 'kakuten' most probably originated from 'ho-ten' or 'ho-ting', a casque of an extinct species of bird that once lived in Borneo. The particular interest in and high praise for 'kakuten' are due to this fact.

One of the authors (I. Kimura) is a collector of 'ojime', particularly of 'kakuten', and considered it necessary to investigate the material of her collection to give a correct description. So she offered a sample for testing to I. Sunagawa. Gemmological tests of specific gravity (SG) and refractive index (RI) by Y. Takahashi revealed that the sample can neither be the red crown of a Japanese crane, nor the casque of a helmeted hornbill. So the sample was submitted for further investigation to check the texture under higher magnifications and the composition by micro-area FTIR spectroscopy; these were carried out by T. Sakae and I. Sunagawa. From these data, it has been concluded that the 'kakuten' is made of the tooth of a grass-eating animal. Since ornamental objects made from the teeth of animals are very rare and not recorded in gemmological textbooks, we considered it worthwhile to report the results in this journal.

Table I: *Gemmological properties of 'kakuten'*

RI (by spot method)	Dark brownish part	1.57
	Vermilion band (reddish-brown)	1.58
	White band	1.60
	Mean	1.58
SG (by hydrostatic method)		2.176
Fluorescence	The white band displays dull bluish-white fluorescence under long wave UV. The white band displays dull yellowish-white fluorescence under shortwave UV. The vermilion bands are inert.	
Spectroscopy	No absorption peaks in the UV-visible range of the spectrum.	
Chelsea colour filter	Colour reduction is observed only in the vermilion band. Ivory stamps that used the classical cinnabar inkpad show similar behaviour.	
Specific point	The vermilion dyestuff is partially soluble in distilled water and traces of colour were seen during the SG measurements.	

Table II: *RI and SG values of various ivories, 'kakuten' and adult human teeth.*

		RI	*SG*
Elephant		1.535	1.70-1.90
Hippopotamus		1.545	1.90-1.95
Walrus		1.560	1.95-2.00
Narwhal		1.560	1.95
Cachalot		1.560	1.95
Bone		1.54	2.60
Vegetable ivory:	Corozo nut	1.54	1.40-1.43
	Egypt nut	1.54	1.38-1.40
Helmeted hornbill		n.f.	n.f.
Keratin (main constituent of helmeted hornbill)		ca. 1.54	ca. 1.26-1.35
'Kakuten'		1.57-1.60	2.176
Adult teeth (mean)	as a whole, after drying		2.12
	Enamel	1.62	2.92
	Dentine	n.d.	2.26
	Cement	n.d.	2.11

N.B.: Data cited from references 4 and 5. n.d. = not determined, n.f. = not found

Sample description and gemmological investigation

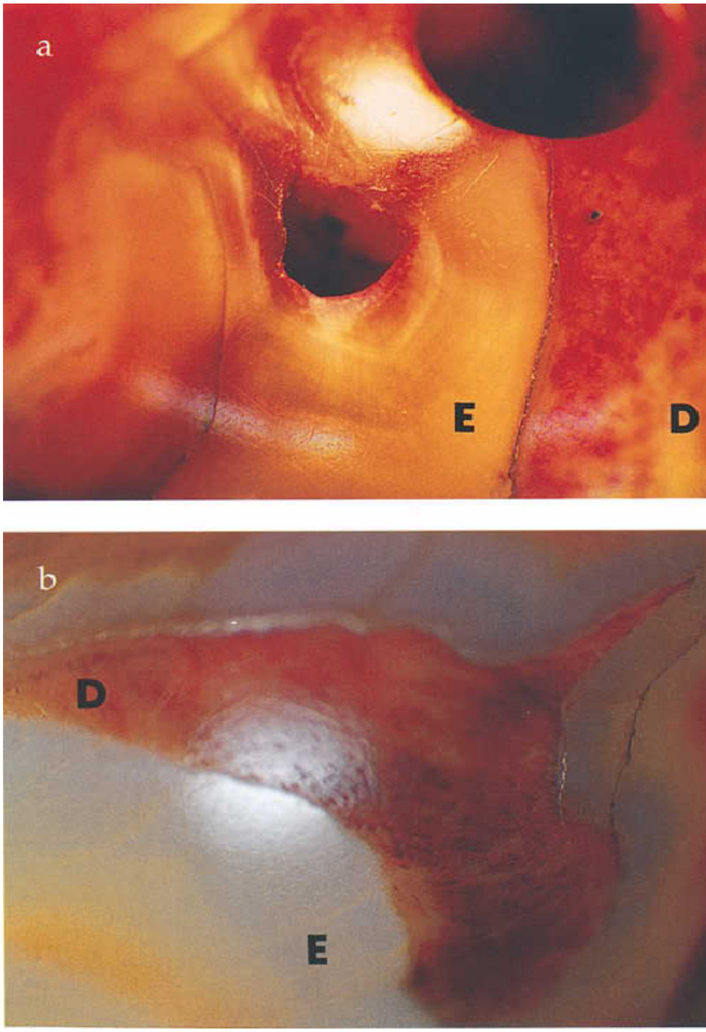
The sample is a polished spherical bead, 1.7 cm in diameter, and has a hole (*Figure 3*). It shows an irregular pattern of alternating white and vermilion (or dark brownish to reddish brown) bands, and is reasonably similar to other 'kakutens' (compare *Figures 2 and 3*).

Standard gemmological tests were applied to the sample, and the data are shown in *Table I*. The data indicate that the 'kakuten' is not made of any known ivory or ivory-like materials, including the casque of the helmeted hornbill (see *Table II*). SG and RI values of the 'kakuten' are markedly different from those of any kind of ivory. Although no RI and SG data have been reported for the casque of the helmeted hornbill, or for the red crown of a Japanese crane, the values are assumed to be in the range given in *Table II*, since the material is essentially a keratin. Keratin is a major protein constituting hard skin, horn, nail and hair; it is tough and elastic, chemically stable, and insoluble in water.

The specific point in *Table I* also indicates that the vermilion bands of the sample are stained. Comparison of the appearance of the vermilion bands of the 'kakuten' under the Chelsea Colour Filter with the classical cinnabar inkpad indicate a close similarity and it is probable that the dyestuff used is cinnabar ink.

Texture and micro-area FTIR spectroscopy

Under higher magnification the white bands and the bands stained vermilion show distinctly different textures. *Figures 4a and b* show higher magnification photographs showing these differences in texture. The white bands are nearly featureless, with a fine and compact texture, and not being stained, faint features due to the internal scattering of light can be seen in the interior. In contrast, the vermilion bands are porous, with many spots selectively stained. The spots are only a few µm across, and the



Figures 4a and b: *Photomicrographs of white (E) and stained vermilion (D) bands of 'kakuten', showing differences of texture. Bar indicates 200 µm.*

vermilion colour diffuses around them. The texture of the vermilion bands closely resembles the textures of dentine in mammalian teeth including those of humans. Stained spots correspond to the outcrops of dentinal tubules. White, featureless bands without any stain appear to correspond to the enamel portions of these teeth. The correspondence of respective

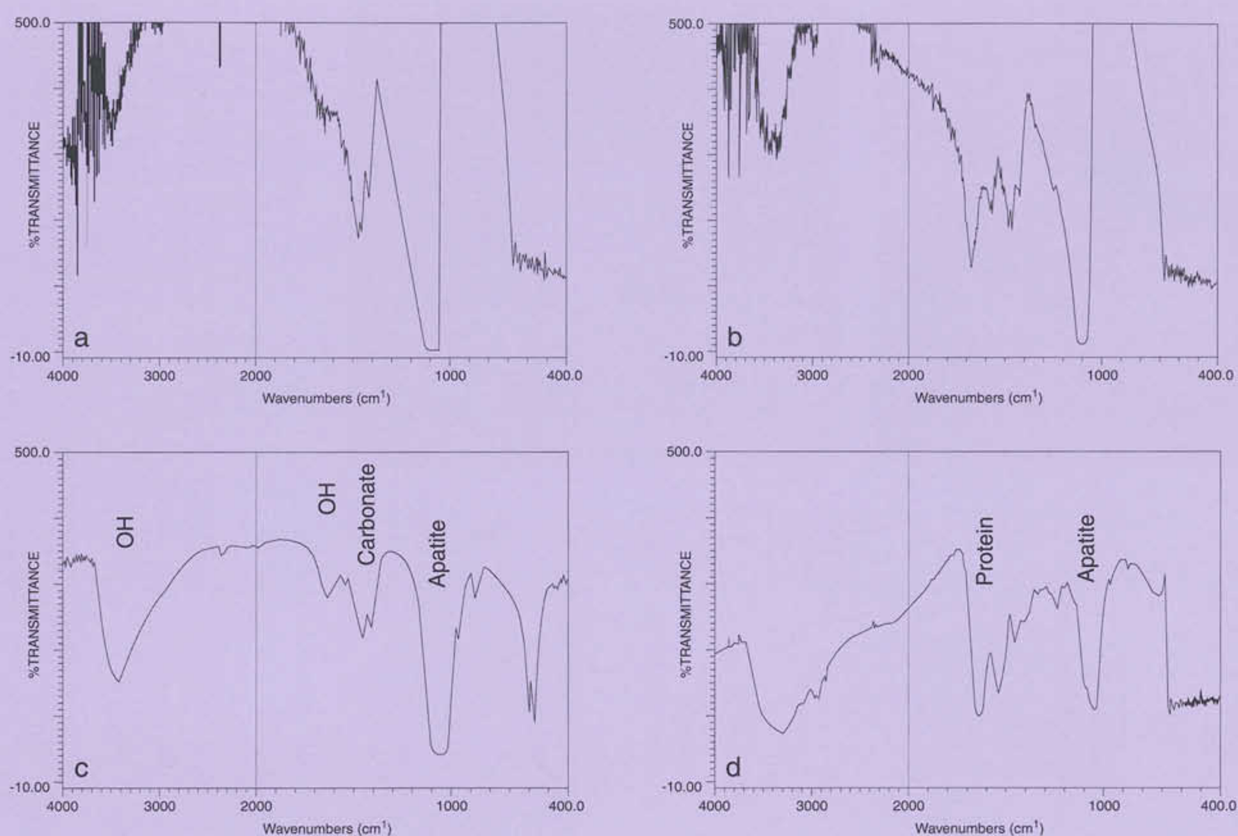


Figure 5: *Micro-area FTIR spectra of a white band (a) and a vermilion band (b) of 'kakuten', and an enamel portion (c) and a dentine portion (d) of healthy adult human teeth. Spectra of (a) and (b) are K-K transformed spectra from reflected light measurement, and those of (c) and (d) are obtained by the powder KBr method. In (c) and (d), the absorption peaks are assigned on the basis of references 6-8.*

bands between 'kakuten' and tooth material is based on the long experience of one author (TS) as a dental anatomist. Faint internal features observable in the white bands are attributed to internal light scattering at grain boundaries of hydroxyapatite crystals which constitute the enamel portion.

It is well known among dental anatomists that the teeth of mammals, irrespective of species, consist of enamel, dentine and cement components. Cement is a smaller and less important component than enamel and dentine. Enamel and dentine differ in composition, texture and function[6]. Irrespective of species, the enamel portions consist of 97 to 98% of hydroxyapatite and 2% protein, plus a small amount of carbonate and water, whereas dentine consists of ca. 30% hydroxyapatite and ca. 70% protein and water with no carbonate[6,7]. Hydroxyapatite crystals in enamel are much larger than those in dentine, and adopt well-formed hexagonal platy or prismatic habits. The average width of hydroxyapatite crystals in the enamel of adult human teeth is ca. 70 nm, the thickness is ca. 26 nm, and the length is commonly as long as 50 µm, occasionally attaining 100 µm. Hydroxyapatite in the dentine is much smaller, being less than 1 µm in length; it shows an ill-formed platy form and is poorly crystalline. The dentine contains dentinal tubules ca. 1 µm in cross section. These data are for healthy adult human teeth but essentially the same composition, constituents and functions, and sizes and forms of hydroxyapatite crystals are applicable to the teeth of any mammal[5–8]. The only difference among different species is the texture. Grass-eating and flesh-eating mammals show very different textures. Among grass-eating mammals detailed textures, i.e. form, thickness, distribution and proportion of enamel and dentine portions are different depending on species[9].

To confirm whether the 'kakuten' investigated is really made from the tooth of a mammal or not, micro-area Fourier Transform Infrared (FTIR) spectroscopy was applied to selected small areas (ca. 30 µm^2) of white and vermilion bands. A micro FTIR spectroscope manufactured by Horiba, Kyoto, Model FT-530 was used to obtain direct spectra by reflected light, since sectioning of the specimen was not permitted. The conditions of measurements were reflected light, selected area 30 µm^2, liquid nitrogen temperature, range 4000 – 750 cm^{-1}, resolution 2 cm^{-1}, time for measurement 100 sec. The direct reflected light spectrum can be transformed to a transmission spectrum by means of a computerized Kramers-Kroning (K-K) transformation, installed in the apparatus. In *Figure 5* K-K transformed FTIR spectra of white (a) and vermilion (b) bands are shown respectively. For comparison, transmission FTIR spectra of enamel and dentine portions of adult human teeth (taken by the KBr powder method and using the same spectroscope) are shown in *Figures 5c and d*, respectively, where the absorption peaks assigned to hydroxyapatite, protein, carbonate and OH are indicated. These assignments are well established in dental anatomy[6–8]. One may clearly notice the difference of composition between enamel and dentine in adult human teeth. By comparing (a) and (c) one immediately notices their close similarity, and the same applies to (b) and (d). From these observed similarities we may conclude that the white bands of the 'kakuten' correspond to enamel and the vermilion bands to the dentine portion of human teeth. Combining the SG and RI data, texture observations and micro-area FTIR spectroscopy, it is therefore concluded that 'kakuten' is made from the tooth of some species of mammal, and not from one of the better-known kinds of ivory or the casque of the helmeted hornbill.

From the viewpoint of biomineralization the enamel corresponds to the well crystallized (matured) component and the dentine to the poorly crystallized (prematured) component of the tooth. Irrespective of species, the enamel consists of larger and well-formed hydroxyapatite crystals, whereas the dentine is made of much smaller, poorly crystalline and ill-formed hydroxyapatite crystals. The different texture and function of these two components are due to this difference which is attributed to differences in the proteins. It should also be noted that composition, constitution and texture of teeth themselves are essentially the same throughout all species of mammals. However, distribution of the enamel and dentine components in a tooth (which cause the different textural patterns) must be different depending on what food is eaten. The teeth of flesh-eating and grass-eating animals should have different patterns of distribution of enamel and dentine and in Hilton's book on teeth[9], patterns formed by distributions of enamel and dentine portions are illustrated for a variety of animals. The teeth of grass-eating animals show more complicated patterns than those of flesh-eating animals. Judging from the complicated patterns of distribution of the white and vermilion bands seen in 'kakuten', we consider that the tooth must be that of a grass-eating animal. To identify the species, investigation in detail of the distribution of the two bands, and comparison and correlation with the patterns recorded by Hilton[9] and other literature, would need to be undertaken. For this purpose the specimen would have to be sectioned which was not allowed, so the species could not be determined. It was suggested (G. Brown, pers. comm.) that the tooth may be from a hippopotamus. But the published SG and RI values (see *Table II*) are different, and questions would be raised about whether such teeth were imported into Japan during the Edo era.

In conclusion, this rare 'kakuten' has been identified as part of a tooth of a grass- eating animal.

Acknowledgements

Mr J-P. Poirot of Paris is acknowledged for information on the collections of the Musee Fragonard d'Alfort, Mr H. Fukushima of the Gemmological Association of All Japan for information on ivory and its substitutes, Dr K. Suzuki of Nihon University for information on FTIR spectroscopy and Dr G. Brown of the Australian Gemmological Association for the suggestion of a possible species origin for the 'kakuten'.

References

1. Kinsey, R.O., 1991. *Ojime, magical jewels of Japan*. H.N. Abrams Inc., New York
2. Nihon Netsuke Kenkyu-kai. *20th Anniversary Publication, 1995. Netsuke: The flower of delicate crafts of Edo era*. Nihon Netsuke Kenkyu-kai. Nihon Netsuke Kenkyu-kai 25th Anniversary Publication, 2000. *Dew drops from Netsuke*. Nihon Netsuke Kenkyu-Kai (both in Japanese)
3. Inaba, T., 1781. *Soken-Kisho* (highly praised ornamental craft products for swords). Vols. 7 and 8 (in Japanese)
4. Espinoza, E.O., and Mann, M.J., 1992. *Identification guide for ivory and ivory substitutes*. World Wildlife Fund
5. Suga, S., Taguma, S., and Sasaki, T., (Ed.), 1973. *Methods of investigation of teeth, structure and composition*. Ishigaku Syuppan Co. (in Japanese)
6. Elliott, J.C., 1994. *Structure and chemistry of the apatites and other calcium orthophosphates. Studies in inorganic chemistry*, 18, Elsevier, Amsterdam
7. Le Geros, R.Z., 1991. *Calcium phosphates in oral biology and medicine. Monograph in oral science*. Vol. 15, Karger, Basel
8. Nishikida, K.,and Nishio, E., 1990. *FTIR spectra seen on charts*. Kodan-sha (in Japanese)
9. Hilton, S., 1986. *Teeth, Cambridge manuals in archaeology*. Cambridge University Press, Cambridge

Fake asterism – two examples

Dr Karl Schmetzer[1] and Martin P. Steinbach[2]

1. Taubenweg 16, D-85238 Petershausen, Germany
2. Postfach 250 145, D-50517 Köln, Germany

ABSTRACT: Two cabochon-cut natural gem materials with artificially produced asterism are described. The light bands of the imitation stars are caused by sets of parallel scratches on the surfaces of the cabochons. A reddish-brown garnet of the pyrope-almandine series and a black tourmaline (schorl) are examples of this new type of imitation asterism.

Introduction

A new type of artificially produced asterism in natural gem materials was recently described by McClure and Koivula (2001). The optical phenomenon is caused by a series of man-made parallel scratches on the surfaces of cabochon-cut gemstones. Although the artificial production of asterism by oriented scratches in metal plates has been generally known since the middle of the nineteenth century and was described and explained in detail by Maier (1943), a similar technique has not been applied to natural gem materials until recently. The following minerals with artificially produced fake asterism were described by McClure and Koivula (2001): sinhalite, cassiterite, chrysoberyl, garnet, rutile and samarskite (?). Details of the production process are not known.

Garnet and tourmaline

The examination of two natural cabochon-cut gemstones with asterism which were purchased by one of the authors recently in Europe revealed that their asterism was artificially produced. Both cabochons were said to originate from Sri Lanka or India and they are described briefly.

The first gemstone of 3.08 ct (*Figure 1*) was determined as reddish-brown garnet. Absorption spectroscopy showed the common iron spectrum known for members of the pyrope-almandine series. Microscopic examination of the completely transparent garnet revealed only a few rutile needles in orientations, oblique to the surface of the cabochon. In these orientations, and especially in the low concentration present, a possible contribution to the asterism observed in the sample could be excluded. The star itself consisted of nine sharp rays (*Figure 1*) which were produced by several sets of parallel scratches on the surface of the cabochon.

Figure 1: *Asteriated reddish-brown garnet of 3.08 ct; the star consists of nine sharp rays. Diameter of the sample 7.7 mm. Photograph by M. Glas.*

ISSN: 1355–4565

Figure 2: Asteriated black tourmaline of 15.04 ct; the star consists of six sharp rays and two 'satellite' lines. Diameter of the sample 14.1 mm. Photograph by M. Glas.

Figure 3: Several sets of parallel scratches on the surface of the asteriated black tourmaline pictured in Figure 2. Photograph by M. Glas.

The second gemstone of 15.04 ct (*Figure* 2) was non-transparent and identified as black tourmaline. The high refractive indices of 1.625 to 1.646 indicate a relatively high iron content, i.e. an iron-bearing black member of the tourmaline group (schorl). The star shows six sharp rays at angles consistent with the trigonal symmetry of tourmaline. One of these six light bands, however, is accompanied by a strong and sharp 'satellite' line emanating from the centre of the cabochon to about half its diameter (*Figure* 2). A second somewhat weaker 'satellite' line was also observed in association with another light band of the six-rayed star. Again the surface of the cabochon showed various sets of parallel scratches (*Figure* 3).

Detection of fake stars

To date the recognition of artificially produced asterism is straightforward using simple visual observation of the unusual appearance of the star followed by microscope examination. A certain number of light bands and/or a symmetry of the star that does not fit with the symmetry of the gem material may be the first warning that the star is not natural. The presence of incomplete and/or misoriented 'satellite' lines is also indicative of man-made asterism as is the microscopic observation of oriented sets of scratches on the surface of an asteriated cabochon.

References

Maier, W., 1943. Experimenteller Asterismus. *Neues Jahrbuch für Mineralogie, Geologie und Paläontologie,* **78**(3), 283-380

McClure, S.F., and Koivula, J.I., 2001. A new method for imitating asterism. *Gems & Gemology* **37**(2), 124-8

Abstracts

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

Diamonds

Diamond genesis, mantle fractionations and mantle nitrogen content: a study of δ¹³C-N concentrations in diamonds.

P. Cartigny, J.W. Harris and M. Javoy. *Earth and Planetary Science Letters*, **185**(1-2), 2001, 85-98.

δ¹³C-N data from well-characterized diamonds show a correlation of the maximum diamond N content and δ¹³C, those with low δ¹³C have low N contents (~ 0ppm at δ¹³C < -30‰), those with high δ¹³C have variable N contents (~ 3500 ppm at δ¹³C = -4.5‰). Slow growth produces diamonds with N contents lower than the maximum value, and these are interpreted as having fractionated the N/C ratio relative to their growth medium. Since the limit sector is applicable to every diamond paragenesis, this implies every diamond type may be derived from a similar isotope source. Assuming a mantle δ¹³C of -4.5‰, it is shown that the initial C/N value of mantle melts that crystallize diamonds is 200-500; similar to that for MORB. Subcontinental and oceanic mantles give samples with similar δ¹³C, δ¹⁵N and C/N, suggesting an overall homogeneity of volatiles within these parts of the Earth since the Archaean. If N is incompatible during partial melting, a mantle N content of ~ 2 ppm could be expected, provided the mantle C content is ~ 40 ppm. However, evidence presented in this study shows that N is not completely incompatible, and a higher mantle N content (≤ 40 ppm) is preferred. J.F.

Chemical heterogeneity in carbonado, an enigmatic polycrystalline diamond.

S. De, P.J. Heaney, E.P. Vicenzi and J. Wang. *Earth and Planetary Science Letters*, **185**(3-4), 2001, 315-30.

Carbonado, a polycrystalline variety of diamond, has unusual C isotope compositions, with bulk δ¹³C values clustering at -23 to -30‰ (PDB); significantly lighter than harzburgitic diamond (-1 to -10‰), and near the lower extreme for eclogitic diamond (+3 to -34‰). Studying textural and inclusion data and these isotope compositions has caused some workers to re-investigate whether carbonado originated in the mantle or the crust. Previous carbonado studies showed a bimodal grain size distribution that correlates with CL emissions, and is believed by these authors to result from a two-step growth process. Ion microprobe analyses of a Central African carbonado show a bimodal distribution of δ¹³C (-24 to -26‰; instrumental precision ± 0.29‰). Also, secondary ion MS analyses show this δ¹³C distribution coincides with variations in N abundance and both of these chemical zonations correlate with CL emission signatures. 1D analysis of self-diffusion of C in diamond suggests isotopic homogenization is extremely slow, even under upper mantle conditions. While the microscale distribution of C isotopes in carbonado does not constrain the *T*, *P* or t of carbonado formation, it does provide a geochemical signature that recorded the dynamics of the growth process. J. F.

Implications of the carbon isotope and mineral inclusion record for the formation of diamonds in the mantle underlying a mobile belt: Venetia, South Africa.

P. Deines, F. Viljoen and J.W. Harris. *Geochimica et Cosmochimica Acta*, **65**(5), 2001, 813-38.

Analyses are presented of 199 diamonds from the Venetia kimberlite for δ¹³C (range from -2.23 to -18‰) PDB; samples were grouped on the basis of previous chemical analysis of inclusions, by Viljoen *et al.*, (*Proc. VIIth Int. Kimberlite Conf., Cape Town*, 1998, pp 888- 895). Analyses are also presented of inclusions - chromites, olivines and garnets for δ¹³C and major constituents. δ¹³C distribution of these diamonds which includes a few highly δ¹³C depleted samples, is similar to that of diamonds from kimberlites of the central Kaapvaal craton, and this supports the concept that the Limpopo belt is underlain by old, thick craton. The results support the hypothesis that the diamond suite represents several mantle environments that underwent several petrogenetic processes in which C of variable isotopic composition formed diamond. On the basis of chromite and olivine inclusions, fo_2 values are 2.9-3.5 orders of magnitude below that of the QFM buffer extending to 5.8 orders below QFM; large δ¹³C variations would not be produced in diamond formation. The inclusions from the lowest δ¹³C value

Abstractors

J. Flinders	J.F	M. O'Donoghue	M.O'D.	I. Sunagawa	I.S.
R.K. Harrison	R.K.H.	P.G. Read	P.G.R.	R. Van Tassel	R.V.T.
R.A. Howie	R.A.H.	E. Stern	E.S.	P.M. Whelan	P.M.W.
P.B. Leavens	P.B.L.				

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

ISSN: 1355–4565

samples do not indicate an unusual low fo_2 that might be expected in an organic source of diamond. R.K.H.

Metamorphic diamonds: mechanism of growth and inclusion of oxides.

L.F. Dobrzhinetskaya, H.W. Green II, T.E. Mitchell and R.M. Dickerson. *Geology*, **29**(3), 2001, 263-66.

A detailed series of EM observations are reported of metamorphic microdiamonds included in and separated from garnets and zircons from a single specimen of garnet-biotite-feldspar gneiss from the Kokchetav massif, Kazakhstan. The morphology of the diamonds ranges from skeletal forms composed of thin {111} plates to cuboid and octahedral forms. Included within the diamonds is a diverse suite of nanometric oxides, suggesting that the C-O-H fluid from which the diamonds grew may have carried chemical components derived from both the sediments and the mantle. The spectrum of morphologies and their abundant tiny inclusions can all be explained by a simple model based on the ratio of the rate at which {111} plates grow and the rate of random nucleation of new plates at their edges. P.B.L.

Diamond in its primary rocks with special reference to the diamond deposits of Mbujimayi, East Kasai, Zaire.

M.R. Fieremans and C.L. Fieremans *Geologie. Bulletin de la Société belge de Géologie*, **101**(1-2), 1992, 9-39.

The kimberlitic formations are described on the basis of recent data available for the kimberlite- and lamproite clans of rocks. The lower crust and mantle xenoliths are essentially eclogites. Megacrysts show unusual rutile- silicate intergrowths. The inclusions in Kasai diamonds suggest a peridotitic paragenesis. R.V.T.

Evidence for the transition zone origin of some [Mg, Fe]O inclusions in diamonds.

T. Gasparik. *Earth and Planetary Science Letters*, **183**(1-2), 2000, 1-5.

Inclusions of [Mg, Fe]O (fPc, ferropericlase, magnesiowüstite) occur in natural diamonds from several localities. Whilst fPc is typically absent from upper mantle assemblages, the expectation that it is common in the lower mantle in assemblages with [Mg, Fe]SiO_3 perovskite led to proposals that the inclusions originated in the lower mantle. Results from new experiments that produced fPc-bearing assemblages at 20-24 GPa and 1800-2000°C, suggest some fPc inclusions could have originated at the base of the transition zone if the mantle *T* were >1800°C. If so, reaction of garnet with fPc could cause a seismic discontinuity at ~ 660 km. J.F.

In situ discovery of shock-induced graphite-diamond phase transition in gneisses from the Ries Crater, Germany.

A. El Goresy, P. Gillet, M. Chen, F. Künstler, G. Graup and V. Stähle. *American Mineralogist*, **86**(5-6), 2001, 611-21.

Reflected-light microscopy and fine-scale laser micro-Raman spectroscopy of shocked garnet-cordierite-sillimanite gneisses in suevites of the Ries meteorite impact crater, Germany, has led to the discovery of impact diamonds in their pristine graphite-diamond assemblages. Graphite diamond textural relations permit a clear determination of the solid-state nature of the formation of diamond from graphite, which is estimated to have occurred at a peak shock *P* between 30 and 40 GPa. Shock-induced transformations were promoted in only unkinked and undeformed graphite booklets at the graphite-garnet, graphite-sillimanite, or graphite-rutile interfaces, where the difference in shock impedance is very high. Reverberations of shock waves with short wavelengths similar to the grain sizes at the phase boundaries are probably important constraints for dynamic graphite-diamond phase transformation. Raman spectroscopic investigations of hard transparent carbon platelets intercalated between fine-grained diamond and deformed graphite revealed the platelets to be Raman inactive. The platelets are either dense amorphous carbon or an unknown dense crystalline carbon phase that is Raman inactive. P.M.W.

Timing of eastern North American kimberlite magmatism: continental extension of the Great Meteor hotspot track?

L.M. Heaman and B.A. Kjarsgaard. *Earth and Planetary Science Letters*, **178**(3-4), 2000, 253-68.

Twenty-nine new U-Pb perovskite ages for kimberlite and other CO_2-rich ultramafic rocks from five localities in E North America (Rankin Inlet, Attawapiskat, Kirkland Lake, Timiskaming and Finger Lakes), show at least five distinctive periods of Mesozoic kimberlite magmatism, four of which at 196, 180-176, 148-146 and 142-134 m.y., were previously unrecognized. The detailed emplacement history of Kirkland Lake Jurassic kimberlites indicates magmatism occurred over a period of 13 m.y. (165-152 m.y.) with approximately half the kimberlites emplaced in <2 m.y. (156.9-155.3 m.y.). These U-Pb results show a NW-SE Triassic-Cretaceous age progression in kimberlite magmatism that extends more than 2000 km from Rankin Inlet through to the Attawapiskat, Kirkland Lake and Timiskaming fields. This is interpreted in part as the continental expression of magmatism associated with the Great Meteor mantle plume hotspot track. If correct, the timing and location of this magmatism more rigidly constrains the position of the hotspot, and the relative direction and rate of North American plate motion during the Mesozoic opening of the North Atlantic Ocean. J.F.

Brine inclusions in diamonds: a new upper mantle fluid.

E.S. Izraeli, J.W. Harris and O. Navon. *Earth and Planetary Science Letters*, **187**(3-4), 2001, 323-32.

Microinclusions in cloudy diamonds from the Koffiefontein kimberlite in the S Kaapvaal craton, South Africa, are either silicates, carbonates or brine. The silicates, of either eclogitic or peridotitic paragenesis, are associated with carbonates and brine. The brine has composition $(K, Na)_8(Ca, Fe, Mg)_4SiO(CO_3)_4Cl_{10}\,(H_2O)_{28\text{-}44}$, and differs from fluids trapped in fibrous diamonds mainly by its high Cl and low SiO_2. Average mass proportions are 30-42% H_2O, 19-22% Cl, 14-17% Na and K, 22-25% Fe-Ca-Mg-carbonates and 3-4% SiO_2.The close association of C-bearing brine, silicate minerals and diamonds suggests such brines are important for diamond growth in eclogitic and peridotitic environments, and the similar composition of the brine in both environments, and the similar composition of the brine in both environments implies diamonds of both suites grew in a single event.

J. F.

Electric lithosphere of the Slave craton.

A.G. Jones, I.J. Ferguson, A.D. Chave. R.L. Evans and G.W. McNeice, *Geology*, **29**(5), 2001, 423-6.

The Archean Slave craton in NW Canada is an ideal natural laboratory for investigating lithosphere formation and evolution, and has become an international focus of broad geoscientific investigation following the discovery of economic diamondiferous kimberlite pipes. Three deep-probing magnetotelluric responses reveal an unexpected and remarkable anomaly in electrical conductivity, collated with the kimberlite field that is modelled as a spatially confined upper mantle region of low resistivity (<30 m) at depths of 80-100+ km, and is interpreted to be due to dissolved hydrogen or carbon in graphite from. This geophysically anomalous upper mantle region is also spatially coincident with a geochemically defined ultradepleted harzburgitic layer. The tectonic processes that emplaced this structure are possible related to the lithospheric subduction and trapping of overlying oceanic mantle at 2630-2620 m.y.

P.B.L.

Gem news international.

B.M. Laurs. *Gems & Gemology*, **37**(2), 2001, 138-59.

Items include an update on the Ekati diamond mine in the North West Territories of Canada, which in 2000 produced ~ 2.6 million ct of rough with an average value of US$ 170/ct, representing ~ 2.5 % of world production by weight and 5% by value. At least 250 additional occurrences of kimberlite, many diamond- bearing, have been found in the Slave Province.

R.A.H.

Nitrogen distribution in diamonds from the kimberlite pipe No. 50 at Fuxian in eastern China: a CL and FTIR study.

F.-X. Lu, M.-H. Chen, J.-R. Di and J.-P. Zheng. *Physics and Chemistry of the Earth. Part A: Solid Earth and Geodesy*, **26**, 9–10, 2001, 773-80.

Cathodoluminescence (CL) and Fourier transform infrared techniques were used to study the internal structure, variable nitrogen contents, and state of aggregation of diamonds from kimberlite pipe # 50 at Fuxian, Liaoning Province, China. Single-stage growth, multi-stage complex growth and a rare agate-like structure were identified; most of these diamonds show complex growth histories. Diamonds with bright blue CL have higher nitrogen contents than those with dark green or green-blue CL. One diamond (LC35), a brown octahedron of 0.26 ct (3.2 x 3.6 mm), that had experienced at least four growth stages, has N varying in the range 244–679 atom ppm. Sharp increases and decreases at the growth-stage boundaries imply different conditions during crystallization. Before 1.3–1.4Ga, unstable conditions produced a rapid rate of growth, whereas after that time stable conditions gave a slower growth rate and enhanced fluid activity.

R.A.H.

Short gemmological notes.

C.C. Milisenda. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 61-4, 8 photographs.

A number of intense greenish-yellow diamonds each weighing approx. 1 ct were identified as HPHT treated. They showed green fluorescence under long wave ultraviolet light, they also showed discoidal tension cracks and black inclusions probably resulting from graphitization during treatment.

E.S.

Gem Trade Lab notes.

T.M. Moses, I. Reinitz, S.F. McClure and M.L. Johnson. *Gems & Gemology*, **37**(2), 2001, 130-38.

Items noted included a natural 14.07 ct elongated diamond with a black area in the middle and colourless, twinned portions at each end, representing different stages and conditions of growth.

R.A.H.

Gems and Minerals

Esperienze tra Pakistan ed Afganistan.

G. Agozzino. *Rivista Mineralogica Italiana*, **25**, 2001, 86-95.

Minerals encountered during a visit to Pakistan and Afghanistan include a number of gem species, especially from pegmatite deposits. Areas described include the Hunza valley, the Dassu area around Haramosh, Shengus and Skardu.

M.O'D.

The current status of Chinese freshwater cultured pearls.

S. Akamatsu, L.T. Zansheng, T.M. Moses and K. Scarratt. *Gems & Gemology*, **37**(2), 2001, 96- 113.

Although Chinese freshwater cultured pearls are assuming a growing role in the gem market, it is difficult to obtain information on quantities produced, in what qualities and the culturing techniques used. Recent visits to Chinese pearl farms in Hanzou Province examined the latest pearl culturing techniques being used there, both in tissue nucleation and, much less commonly, bead (typically shell but also wax) nucleation. With improved techniques, using younger *Hyriopsis cumingi* mussels, pearl cultures are producing freshwater cultured pearls in a variety of attractive colours that are larger, rounder and with better lustre. Tissue-nucleated examples can be distinguished from natural and bead-nucleated pearls by using X-radiography.

R.A.H.

Schleifwürdiger grüner Lazulith aus Pakistan.

M. Andrut, V.M.F. Hammer, C.L. Lengauer, T. Ntaflos and G.J. Redhammer. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 65-74.

In 1998 some gem-quality deep green lazulite from the Gilgit district in Pakistan came on the market; originally these were only expensive samples for collectors, but in 2000 large crystals the size of a fist were on the market for about US $500 per ct. Hardness 5.5-6, SG.3.12, RI between 1.61 and 1.64, from yellow-green to blue-green with strong dichroism, almost iron-free.

E.S.

Rhodochrosit aus Kassel, Nordhessen.

K. Belendorff. *Lapis*, **26**(9), 2001, 21-6.

Rhodochrosite of at least ornamental quality is described with other minerals from Kassel, northern Hesse, Germany. Some notes on the mining history of the area are given. M.O'D.

'Alpine' Bergkristalle von Piramida im Polar-Ural.

J.V. Burlakov and J.A. Polenov. *Lapis*, **25**(5), 2001, 27-31.

Rock crystal of alpine cleft type is described from Piramida in the Polar Urals of Russia. Details of the occurrence are given with examples of the crystal forms shown. Other minerals from the location are mentioned.

M.O'D.

Kämmererit 'kirmizi rüya' – der rote Traum.

R. Dietrich and M. Dietrich. *Mineralien Welt*, **12**(2) 2001, 40-53.

Fine quality dark red crystals of chrome-rich clinochlore (kammererite) are described from several locations in Anatolia, Turkey. Some crystals have been faceted despite their very easy cleavage. Notes on the geology and mining practices in the area are given, together with a descriptive mineral list. M.O'D.

Achat-Fundstellen in der Slowakei.

R. Dud'a and B. Baláz. *Mineralien Welt*, **12**(4), 2001, 28-34.

Details of ornamental-quality agate are given for a number of sites in Slovakia. The modes of occurrence are described. M.O'D.

Spectral reflectance and fluorescence characteristics of natural-color and heat-treated 'golden' South Sea cultured pearls.

S. Elen. *Gems & Gemology*, **37**(2), 2001, 114-23.

A comparison study is reported between the yellow and white nacre of the gold-lipped *Pinctada maxima* oyster shell and 65 yellow cultured pearls, both natural and treated colour, made from this mollusc. The yellow nacre has a characteristic absorption feature in the UV region between 330 and 385 nm; the strength of this feature increases as the colour becomes more saturated. White shell nacre fluoresces very light blue or very light yellow to long-wave UV radiation, whereas yellow nacre fluoresces greenish to brownish yellow or brown. Natural-colour yellow cultured pearls from *P. maxima* show absorption and fluorescence characteristics similar to those of the yellow shell nacre. In contrast, the absorption feature in the UV was either weak or absent in yellow cultured pearls reportedly produced by a method involving heat treatment, and their fluorescence was generally very light blue or light yellow. R.A.H.

La 'Rogerley mine' (Weardale, Durham, Inghilterra).

J. Fisher and L. Greenbank. *Rivista mineralogica italiana*, **25**(3), 2001, 150-65.

Geological and mineralogical survey of the Rogerley mine in Weardale, County Durham, north-east England, with notes on the exceptionally transparent green fluorite found there. The earliest mining records from the Northern Pennine Orefield date back to the 12th century. A table of rare earth contents in the fluorite and notes on mining history up to the present day are given. M.O'D.

Cala Francese, Sardinien.

A. Gamboni and T. Gamboni. *Lapis*, **25**(12), 2000, 33-41.

The granite quarries on the island of La Maddalena (Sassari) in north-east Sardinia produce especially large crystals of quartz. Specimens are illustrated and other species from the area described. M.O'D.

The fluid inclusions of pegmatites with lithium mineralisation of the Araçuaí pegmatite district (eastern pegmatite province, Minas Gerais, Brazil).

I. Gatter, C. Preinfalk and G. Morteani. *Chemie der Erde: Geochemistry*, **59**(4), 2000, 307-27.

Araçuaí district pegmatites are economically significant because of their Li, Be, Nb and Ta mineralization, and gemstones (tourmaline, aquamarine, morganite, kunzite). Fluid inclusions within the highly differentiated and zoned LCT-type pegmatites of Urubu, Barreiro, Maxixe and Morro Redondo, are either type-A, aluminosilicate-rich melt ± CO_2, type-B, mostly CO_2 but with variable, low H_2O contents, or type-C, H_2O with occasional daughter minerals. *Th* (fluid), *Te* (Tc) and Tm_{ice} were determined for type-C, and $ThCO_2$ and $TmCO_2$ for type-B inclusions. Pegmatite fluids evolved from a very H_2O- poor, CO_2-bearing aluminosilicate-rich melt, to an H_2O- dominated hydrothermal fluid. This change in fluid composition during early pegmatite crystallization resulted from early crystallization of tourmaline, which reduced H_2O solubility in the silicate melt. Increasing inclusion salinity with decreasing pegmatite crystallization *T* results mainly from incorporation of water into late (secondary) micas. J.F.

L'exploitation des mines d'émeraude D'Autriche et de la haute Egypte à l'époque Gallo-romaine: mythe ou réalité?

G. Giuliani. *Revue de gemmologie*, **143**, 2001, 20-4.

Study of the working in classical times of the emerald mines in Austria and Upper Egypt with particular reference to the chemical composition of emeralds in artefacts from a number of museum collections. M.O'D.

La composition isotopique de l'oxygène des émeraudes de la mine de la Pita.

G. Giuliani, *Revue de gemmologie*, **143**, 2001, 13-14.

Details are given of the isotopic oxygen content of emeralds from a new location at La Pita, Colombia.

M.O'D.

Aluminium in quartz as an indicator of the temperature of formation of agate.

J. Götze, M. Pötze, M. Tichomirowa, H. Fuchs and J. Pilot. *Mineralogical Magazine*, **65**(3), 2001, 407-13.

An Al-thermometer was applied to agates from volcanic rocks, the *T* being calculated from the concentrations of $[AlO_4]^\circ$ centres as determined by e.p.r. measurements. The calculations for agate bands in some cases yield *T* of ≤ 655°C assumed to be invalid (the result of non-equilibrium crystallization processes). In contrast, the formation *T* (60-198°C) estimated for associated quartz encrustations within the agate geodes are in good accord with those calculated from the $\delta^{18}O$ data. Direct estimation of the formation *T* of agate is problematic. It is considered that the most useful results are those obtained by analyses of associated phanerocrystalline quartz encrustations. R.A.H.

Twenty years in minerals: mineral collecting.

D.I. GREEN. *UK Journal of mines and minerals*, **21**, 2001, 2-8.

Overview of the changing role of the mineral collector, museum collections and associated research, the mineral and gem trade and of useful recent publications. M.O'D.

Twenty year in minerals: Ireland.

D.I. GREEN AND S. MORETON *UK Journal of mines and minerals*, **21**, 2001, 29-36.

Blue beryl from two locations in the Mourne Mountains of Northern Ireland is described and illustrated in a general survey of mineral collecting in Ireland over the past 20 years. M.O'D.

Twenty years in minerals: Scotland.

D.I. GREEN AND J.G. TODD. *UK Journal of Mine and Minerals*, **21**, 2001, 9-27.

Illustrated survey of mineral species, varieties and notable specimens found in Scotland over the last 20 years. Items illustrated include elbaite from Glenbuchat, Grampian Region, aquamarine from northern Arran, amethyst from the Dalbeattie area of Dumfries and Galloway, agate from Broughty Ferry, Tayside. A comprehensive bibliography is appended. M.O'D.

Rubine aus neuen Vorkommen in Madagascar.

H.A. HÄNNI, C.C. MILISENDA AND U. HENN. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 89-94.

The latest deposit was found in the north-eastern province of Taomasina; there seem to be two mines, one near Vatomandry, east of the capital Antananarivo, known as the 'Charlyne Mine', the other, known as 'Zwtkoff Mine', is in the north-east of the island, south of the Alaotra Sea. This district also yields very beautiful yellow chrysoberyl trillings. Both deposits have great potential. Cut stones up to 12 ct have been seen. Inclusion patterns with clusters of zircons resemble these found in corundum from the Umba Valley in Tanzania and from the fancy coloured sapphires from the Ilakaka area in South-western Madagascar. The colour is purple-red and requires heat treatment. E.S.

Sapphirin aus Sri Lanka.

U. HENN. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 112-15.

Various faceted sapphirines and a rough specimen were examined. The cut stones weighed up to 0.69 ct each, colour varied from blue to grey-blue and came from Sri Lanka, near Kolonne, not far from Embilipitya; SG 3.42–3.51, RI 1.701–1.711, DR 0.006–0.007. An iron content of 2.04% FeO is responsible for the colour. There were healing cracks and zircon with tension cracks as inclusion patterns. E.S.

Lapis lazuli – Eigenschaften und Vorkommen, Imitationen und kuenstliche Eigenschaftsveraenderungen.

U. HENN AND C. BRAUN. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 95-108.

Lapis lazuli is one of the oldest known gemstones. It is largely an aggregate of lazurite but diopside, calcite and pyrite may be present. Commercially important occurrences are in Afghanistan, Chile, Russia and Tajikistan. There are several imitations on the market which are not easily distinguishable from the natural material. Unset stones can be identified by their RI and SG, stones set in jewellery are best identified by using infrared spectroscopy. E.S.

Stabilisierter gruener Tuerkis aus China.

U. HENN AND I. QUINTENS. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 109-11.

Apple-green turquoise has been on the market for some months. The apple-green colour is caused by a distinct iron content. Infrared spectroscopy showed the turquoise to be impregnated with artificial resin. E.S.

Batiferrit, ein neues Mineral aus der Eifel.

G. HENTSCHEL. *Lapis*, **25**(5), 2001, 37-8.

Small crystals of batiferrite are reported from the Eifel region of Germany where three distinct locations are identified. The flattened crystals, up to 2 mm across, show a dark metallic lustre with a pronounced cleavage parallel to {2001}. The composition is given as $Ba(Fe^{2+}, Mg, Mn^{2+})_2Fe_8^{3+}Ti_2^{4+}O_{19}$. M.O'D.

The Gem Emporium in Myanmar.

U.T. HLAING *Australian Gemmologist*, **21**(3), 2001, 117-9.

Myanmar's unique method of selling its gemstones consists of a combination of tender and bidding processes. Periodic 'Gem Emporiums' organised by the Myanmar Gem Enterprise (MGE) and by the Union of Myanmar Economic Holding Limited (UMEHL) are held in a hall next to the Gemstone Museum, Yangon. The MGE Emporiums started in 1964 and soon became popular with foreign gem merchants. The UMEHL began holding its own gem sales in 1994 and remains popular with local gem merchants. The paper briefly describes the differences between the sales of the two Gem Emporiums. P.G.R.

Rare earth element chemistry of zircon and its use as a provenance indicator.

P.W.O. HOSKIN AND T.R. IRELAND. *Geology*, **28**(7), 2000, 627- 30.

Sedimentary mineral assemblages commonly contain detrital zircon crystals as part of the heavy-mineral fraction. Age spectra determined by U-Pb isotopic analysis of single zircon crystals within a sample may directly image the age composition – but not the chemical composition – of the source region. *REE* abundances have been measured for zircons from a range of common crustal igneous rock types from different tectonic environments, as well as kimberlite, carbonatite and high-grade metamorphic rocks, to assess the potential of using zircon *REE* characteristics to infer the rock types present in sediment source regions. Except for zircon with probable mantle affinities, zircon *REE* abundances and normalized patterns show little intersample and intrasample variation. To evaluate the actual variation in detrital zircon *REE* composition in a true sediment of known mixed provenance, zircons from a sandstone sample from the Statfjord formation (North Sea) were analysed. Despite a provenance including high-grade metasediment and granitic rocks and a range in zircon age of 2820 m.y., the zircon *REEs* exhibit a narrow abundance range with no systematic differences in pattern shape. These evidences show zircon *REE* patterns and abundances are generally not useful as indicators of provenance. P.B.L.

Quartz-Zwillinge nach dem Japaner-Gesetz aus Bolivien und Peru.

J. Hyrsl and A. Petrov. *Mineralien Welt*, **12**(4), 2001, 46-9.

Large quartz crystals displaying Japan-law twinning and of collectors' or near ornamental quality are described from locations in Bolivia and Peru. M.O'D.

Fluorapatit und seine Begleitmineralien vom Cerro del Mercado in Durango, Mexico.

M. Jurgeit. *Mineralien Welt*, **12**(4), 2001, 56-60.

Transparent yellow apatite of gem quality is described from the Cerro del Mercado mine in the state of Durango, Mexico. Notes on the mineralization of the occurrence are given. M.O'D.

Macro and micro anatase-rutile combinations in quartz.

J. I. Koivula, *Australian Gemmologist*, **21**(3), 2001, 129-31.

Both rutile and anatase can occur as inclusions in quartz. Although these inclusions are both polymorphs of titanium oxide and crystallize in the tetragonal crystal system, they can be identified by their appearance (long thin needles for rutile, slightly elongated octahedrons for anatase). Another factor which separates rutile and anatase is their formation temperature (high for rutile, low for anatase). Their presence as interconnected inclusions in the same quartz host helps to define that host's paragenesis, their physical relationship indicating which started growing first as the temperature rose or fell.

P.G.R.

Gem news international.

B.M. Laurs. *Gems & Gemology*, **37**(2), 2001, 138-59.

Items include a 2.12 ct orange stone from Afghanistan/Pakistan represented as bastnäsite was identified as sphene, and canary-yellow tourmaline is reported from Malawi (heat treated to remove the brown colour component). A crystal of Nigerian tourmaline had a purplish-pink rim of Ca-rich elbaite on a pale orange- pink core of liddicoatite; it also had Bi_2O_3~0.3 wt.% in the core and ≤ 1.23 wt.% in the rim. R.A.H.

A new method for imitating asterism.

S.F. McClure and J.I. Koivula, *Gems & Gemology*, **37**(2), 2001, 124-8.

Several gemstones recently examined showed stars with an unnatural appearance or an unusual number of rays. In some of the species represented, asterism is very rare or had not been reported previously. Microscopic examination revealed that these 'stars' were produced by apparently using a rough polish to scratch lines in an orientated fashion onto the upper surface of the cabochons. R.A.H.

Gem Trade Lab notes.

T.M. Moses, I. Reinitz, S.F. McClure and M.L. Johnson. *Gems & Gemology*, **37**(2), 2001, 130-38.

Items noted included a 40 ct cabochon of orthoclase (moonstone) with chrome diopside inclusions and a gibbsite bead dyed to imitate nephrite. R.A.H.

Mostre Verona 2000.

Rivista Mineralogica Italiana. **25**(1), 2001, 42-53.

Among specimens on show at the 2000 Verona mineral show were aquamarine and transparent colourless beryl from Erongo, Namibia, light green tourmaline from Pech, Afghanistan and fine blue apatite crystals from Minas Gerais, Brazil. M.O'D.

Les nouvelles mines de La Pita (Colombie)

J-C. Michelou. *Revue de gemmologie*, **143**, 2001, 9- 12.

Emerald is reported from a site known as La Pita, close to the municipality of Maripi which is situated between Muzo and Coscuez, approximately 100 km north-west of Bogota, Colombia. The site lies in an area known locally as El cinturon esmeraldifero occidental, in the eastern cordillera of Colombia. The emeralds occur in the Paja formation which consists of a thick series of dark schists intercalated with gravelly clays. Details of the establishment of the mine and its method of functioning are given: crystals up to 1563 ct have been recovered.

M.O'D.

Nouvelles de Bogota.

J-C. Michelou. *Revue de gemmologie*, **143**, 2001, 8.

Emerald production at the Muzo mines in Colombia has been in decline over the past few years, productive areas having been worked for the last 500 years. Brief details of the mines and workings are given.

M.O'D.

Edelsteinvorkommen und Plattentektonik.

C. C. Milisenda. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 75-88.

The genesis of a large variety of gemstones is associated with the development of the lower continental crust, i.e. the bottom half of the continental crust. Rocks from deep crustal levels are restricted either to granulite-facies terrains at the earth's surface or xenoliths carried in alkali basaltic magmas. Virtually all corundum deposits are found in these two types of environments. A good example of the correlation of gemstone occurrences and plate tectonics is the Mozambique belt, which includes Madagascar, Sri Lanka and Southern India. In Africa, the Mozambique belt can be traced to the north in Ethiopia and Somalia and south to Mozambique. These countries have a potential for gem occurrences that have not yet been realised. Also where continents collided and sedimentary assemblages were buried to lower crustal levels and then uplifted (e.g. the Himalayas), gemstones are and will be found. E.S.

Short gemmological notes.

C. C. MILISENDA. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 61-4.

Bi-coloured ametrine from the Yuruty mine, near the Anahi mine, Bolivia, has been on the market for some time. From the same source 'aluminium quartz' is offered, the name probably derived from the fact that the smoky quartz layers are aluminium enriched which by natural irradiation gives rise to the smoky quartz colour. Some intense yellow beryls from Nigeria were examined. A stone of 8.61 ct is illustrated showing an attractive inclusion pattern; the radially arranged needles have not yet been identified, but resemble goethite. E.S.

Ste Marie-aux-Mines 2001.

G. NEUMEIER, *Lapis*, **26**(9), 2001, 43-5.

Among gem-quality mineral specimens on display at the St Marie-aux-Mines mineral show held in 2001 were fine crystals of pink and green tourmaline from the Pedernerira mine, 100 km north of Governador Valadares and green tourmaline associated with transparent blue apatite from Paraîba, Brazil. M.O'D.

Bastnäsit aus Pakistan-ein neuer Schmuckstein?

G. NIEDERMAYR. *Mineralien Welt*, **12**(3), 2001, 51.

Transparent dark orange-brown bastnäsite-(Ce) of potential gem quality is reported from Pakistan. A faceted stone of around 8 ct is illustrated and shows needle- or channel-like inclusions. M.O'D.

Spektakuläre Funde von väyrynenit aus Nuristan, Afghanistan.

G. NIEDERMAYR. *Mineralien Welt*, **12** (3), 2001, 52-3.

Fine dark pink crystals of vayrynenite up to 1 cm long and of potential gem quality are described from pegmatites at the Afghanistan-Pakistan border. Some crystals are associated with green gem-quality tourmaline. M.O'D.

Achate aus der Lausitz.

R. NOACK. *Mineralien Welt*, **12**(5), 2001, 40-5.

Attractively-patterned polished agates are described and illustrated from the Lausitz area of eastern Germany. A short bibliography is appended. M.O'D.

India: alcuni minerali della provincia vulcanica del Deccan. Parte II.

B. OTTENS. *Rivista Mineralogica Italiana*, **25**(1), 2001, 4-24.

While this paper concentrates on mineral species available to collectors in the traprocks of the Deccan, India, collectors of unusual gemstones may welcome the opportunity to find out more about yugawaralite (which has sometimes been faceted) and fine crystals of calcite. M.O'D

Ätzfiguren und Auflösungserscheinungen an Fluoritkristallen.

P. RUSTEMEYER. *Lapis*, **25**(12), 2001, 11-23.

In an illustrated review of etch and dissolution marks on fluorite crystal faces theories of formation are discussed with reference to large and attractively-coloured specimens from a number of localities. M.O'D.

Spinelle aus Ilakaka, Madagascar.

K. SCHMETZER. *Lapis*, **26**(2), 2001, 33-4.

Gem-quality spinel of different colours is described from Ilakaka, Madagascar. Red and pink stones are coloured by chromium, cobalt and iron in conjunction colour blue to blue-violet specimens and bluish-green to greenish-blue specimens are coloured by Fe and a charge transfer $Fe^{2}+/Fe^{3+}$. Details of the absorption spectra are given. M.O'D.

Zwölfstrahliger Sternsaphir aus Bang-kha-cha, Thailand.

K. SCHMETZER AND M. GLAS, *Lapis*, **26**(11), 2001, 40- 42.

12-rayed star sapphires with dark body colours are described from Bang-kha-cha, Thailand. Diagrams illustrate the light paths involved when the crystals are cut en cabochon. M.O'D.

Ti-Fe mineral inclusions in star sapphires from Thailand.

S. SRINAKHARINWIROT. *Australian Gemmologist*, **21**(3), 2001, 125-8.

Black star corundums occur in Bang Kacha in more abundance and in larger average sizes than elsewhere in Thailand. The use of an electron probe microanalysis-wavelength dispersive spectrometer (EPMA-WDS), and the techniques of element mapping and spot analyses, produced results suggesting that the exsolved 'needles' causing the star are not rutile or hematite as indicated in the literature, but probably a mineral of the ilmenite-hematite series, ilmenite or a spinel. P.G.R

Porkura-ein klassischer Amethystfundort in Rumänien.

W. STÖHR, *Lapis*, **26**(9), 2001, 13-20.

Amethyst, some of fine gem-quality colour, is found in crystal groups at Porkura in west-central Rumania. Details of the local geology and mineralization are described with some notes on mining history in the district. M.O'D.

Clinopyroxene-corundum assemblages from alkali basalt and alluvium, eastern Thailand: constraints on the origin of Thai rubies.

C. SUTTHIRAT, S. SAMINPANYA, G.T.R. DROOP, C.M. B. HENDERSON AND D.A.C. MANNING. *Mineralogical Magazine*, **65**(2), 2001, 277-95.

A clinopyroxene xenocyst with an inclusion of ruby, in alkali basalt from the late Cainozoic Chanthaburi-Trat volcanic rocks of E Thailand, is found to be chemically similar to clinopyroxene inclusions in rubies from nearby alluvial gem deposits, suggesting a common origin for both types of occurrence. The clinopyroxene is fairly sodic, highly aluminous and magnesian (mg>0.9); sapphirine and garnet also occur as inclusions in the alluvial rubies. Thermodynamic calculations on the equilibrium 2Di + 2Cor = 2 CaTs + En constrains the T of clinopyroxene + corundum crystallization to between 800 and 1150 ± 100°C. Other equilibria indicate a limit on P of crystallization of 10-25 kbar, implying depths of between 35 and 88 km. The rubies are presumed to have crystallized in rocks of mafic composition, i.e. garnet clinopyroxenites or garnet pyroclasites, within the upper mantle. R.A.H.

Les inclusions en double hélice dans les émeraudes de Colombie.

P. VUILLET AND J. ROTLEWICZ. *Revue de gemmologie*, **143**, 2001, 15-19.

Double screw inclusions are described from Colombian emeralds: the cause of the phenomenon is not yet understood. M.O'D.

Notes from the Museum - focusing on travertine.

G. WEBB, *Australian Gemmologist*, **21**(3), 2001, 124.

A brief description of the composition, formation, appearance and use of the decorative rock travertine, examples of which can be seen in the mineral section of Sydney's Australian Museum. P.G.R.

Onyx im Mainzer Becken.

H. WEYGANDT. *Lapis*, **26**(2), 2001, 26-31.

Fine banded black and white onyx is described from the Mainz basin, Germany, and notes on its formation and that of differently coloured banded agate specimens from the same area are given. Jasper and carnelian are also described. M.O'D.

An overview of China's pearl industry.

H. XIE AND L. LI, *Australian Gemmologist*, **21**(3), 2001, 120-3.

The Chinese were the first to learn how to cultivate pearls about 900 years ago. China's modern pearl culturing industry began during the 1950s to 60s. Later, under the reforming policies of the People's Republic Chairman Deng Xiaoping, the cultured freshwater pearl industry flourished, reaching its peak in 1987 with a production of over 300 tons of pearls. As a result of this over-production, the price of pearls fell and by the end of the '80s China's pearl industry had become severely depressed. By 1990 production was rising again and eventually hit a new high with exports exceeding US$100 million. This serious over- production caused a second crisis, which resulted in the implementation of output control and an improvement in farming techniques. By 1998, the production and marketing of Chinese freshwater cultured pearls were in balance with demand, and the sale price had stabilized. On November 18, 2000, the Chinese National Pearl Association was founded in Beijing. This new organisation, drawing on the lessons of the past, will ensure that market order is maintained while establishing effective trade standards and setting up a competitive system for the cultivation and marketing of Chinese pearls. P.G.R.

A fluid inclusion study of an amethyst deposit in the Cretaceous Kyongsang Basin, South Korea.

K.H. YANG, S.H. YUN AND J.D. LEE, *Mineralogical Magazine*, **65**(4), 2001, 477-87.

The Eonyang deposit is considered to be spatially and temporally related to biotite granite of the Kyongsang Basin. Euhedral quartz crystals in cavities in the aplite which intrudes the granite are white at their base to amethystine at the top. Examination of fluid inclusions in these crystals and in rock-forming quartz in the granitic rocks showed three types of primary inclusions and three isochores for inclusions of each type were constructed. The intersection of the isochore representing the early fluid inclusions with solidus T of the host granite indicates initial quartz formation at ~600°C and 1.0-1.5 kbar. Intermediate quartz associated with high salinity inclusions occurred at ~ 400°C and 1 kbar, and the amethystine quartz formed from H_2O-CO_2-NaCl fluids at 400-280°C and ~ 1 kbar. The host granitic rocks including amethystine quartz probably crystallized in the root zones of porphyry-type systems. R.A.H.

Synthetics and Simulants

Conversion of silicon carbide to crystalline diamond-structured carbon at ambient pressure.

Y. GOGOTSI, S. WEIZ, D.A. ERSOY AND M.J. MCNALLAN. *Nature*, **411**(6835), 2001, 283-7.

The synthesis is reported on nano- and microcrystalline diamond-structured C with cubic and hexagonal structure, by extracting Si from SiC and Cl-containing gases at ambient P and < 1000°C. H_2 in the gas mixture leads to a stable conversion of SiC to diamond-structured C of average grain size 5–10 nm. Hardness values of >50 GPa, and Young's modulus < 800 GPa are reported for the nanocrystalline coatings. R.K.H.

New routes for the preparation of ultramarine.

CH. GURRIS, C. MIGOWSKI AND J. CH. BUHL. *Applied Mineralogy* (Rotterdam, Balkema), D. Rammlmair *et al.* (eds.), 2000, 787-90.

The alkaline transformation of kaolinite in the presence of sodium rhodanide produced a basic hydrosulphide sodalite $Na_8[AlSiO_4]_6(SH)_{1.3}(OH)_{0.7}.0.7H_2O$, which after heating at 1093-1153 K gave a pure blue sodalite. The Raman spectra are presented. R.A.H.

[Effect of oxygen partial pressures on the growth of oxide single crystals by the floating zone method.] (In Japanese with English abstract.)

M. HIGUCHI AND K. KODAIRA. *Journal of the Japanese Association for Crystal Growth*, **27**(5), 2001, 288- 92, 4 figs.

Rutile single crystals are grown under a low oxygen partial pressure of about 10^3 Pa to avoid formation of low-angle grain boundaries. Zr-doping is effective to grow rutile single crystals without low-angle grain boundaries and bubble inclusions at a high growth rate of 10 mm/h under a high oxygen partial pressure of 10^5 Pa. Cr^{4+}-rich Cr-doped forsterite single crystals are grown under a high oxygen partial pressure of 1-2 x 10^5 Pa. This was not possible by the conventional Czochralski method using an Ir crucible. I.S.

Short gemmological notes.

C.C. MILISENDA. *Gemmologie. Z. Dt. Gemmol. Ges.*, **50**(2), 2001, 61-4, 8 photographs.

An oval translucent, green cabochon of 2.20 ct, RI 1.50, SG 2.55 was shown to be a glass-jadeite-glass triplet. E.S.

BOOK REVIEWS

Rock-forming minerals. 2nd edn. Vol. 4A, Framework silicates: feldspars.

W.A. Deer, R.A. Howie and J. Zussman, 2001. The Geological Society, London, 2001. pp x, 972. Hardcover ISBN 1 86239 081 9. £50 (to Fellows of the Geological Society).

Geologists and mineralogists will find no difficulty over one mineral group having a whole, large volume to itself when it is the feldspar group! Of course the feldspars were dealt with in the previous edition of 1962 but, as expected, the present work includes a very much larger body of data, due almost entirely to the development of modern analytical techniques, including electron probe microanalysis and computer modelling among many others. Differences between this and the previous edition include the provision of bibliographies at the end of major chapters rather than a single very large listing in one place – this makes for ease of consultation – and the inclusion of more data on diffusion, chemical alteration and surface studies. Gemmologists straying into the text will find that alkali and plagioclase feldspars occupy the major sections and that both have a sub-section on optical and physical properties that will be found useful and very interesting. Those with an interest in crystals will find profuse, well-drawn diagrams. Readers should try to get a sight of the book which is very reasonably priced for today. M.O'D.

French jewellery of the nineteenth century: a loan exhibition.

Wartski, London, 2001,. pp 72, illus. in colour. Soft-cover. £7.00.

The exhibition was held to mark the publication of a translation of Vever, *La bijouterie française au XIXe siècle* and includes beautifully ornate and imaginative pieces, many of the Art Nouveau style. The catalogue descriptions are brief but entirely adequate and the whole publication is excellently produced. Provenances are given. M.O'D.

Elba: die klassische Urlaubinsel der Mineralogie.

Christian Weise Verlag, München, 2001. pp 96, illustrated in colour. Softcover. ISBN 3 921656 57 5 [ISSN of parent journal *Lapis* 0945 8492] *extraLapis* no 20. DM 34.80.

Elba is important to gemmologists as fine specimens of tourmaline are found there, many distinguished by black terminations on differently- coloured crystals. Tourmaline occurrences and types are extensively discussed in this multi-author monograph in the now accepted *extraLapis* style and presentation, both being first class. Fine orange crystals of spessartine occur with tourmaline and albite from the Rosina mine and both aquamarine and morganite are found in the Monte Capanne area. Colourless petalite has been faceted. Details of the Elba pegmatites are very useful and there are excellent maps and crystal diagrams. M.O'D.

Christie's guide to jewellery.

S. Hue-Williams, 2001. Assouline Publishing, New York. pp 95, illustrated in colour, hardcover. ISBN 2 84323 302 X. US $18.95.

Very pleasing small guide to the kinds of jewellery the reader might very well encounter in the major auction houses and especially in Christie's whose catalogues have provided the excellent illustrations. After a short conspectus of jewellery styles and periods the text takes the major gemstones, describing them and illustrating them usually but not invariably set in jewellery. Comments on precious metals, a brief note on the history of Christie's and short biographies of some of the major jewellery designers complete the book. M.O'D.

Kremlin gold: 1000 years of Russian gems and jewels.

Harry N. Abrams Inc., New York. 2000. pp 204, illustrated in colour, hardcover. ISBN 0 8109 6695 6, about £30.

This is an exhibition catalogue in which each individual item is not described minutely but in which the history of Russian jewellery and gemstones are presented as a background to the country's history. The pieces, selected from the Kremlin Museums in Moscow, were taken for display to the Houston Museum of Natural Science and to the Field Museum in Chicago. The illustrations are first-rate and a pleasing section at the end of the main text gives a short account, illustrated with paintings of some gem crystals, of the gem species found in Russia. The captions are informative and the general production very good: authors are in the main drawn from the leading Russian museums. M.O'D.

Pearls, a natural history.

N.H. Landman, P.M. Mikkelsen, R. Bieler and B. Bronson, 2001. Harry N. Abrams Inc., New York. pp.232, illus. in colour, hardcover. ISBN 0 8109 4495 2. US $49.50.

There are not many books about pearls and recent ones have not been especially good starting-points for the student, though they have often been attractively produced. This one, with general supervision by the senior author, a staff member of the Division of Palaeontology of the American Museum of Natural History, New York, comes close to filling this awkward gap. Illustrated by many beautiful photographs, the text opens with a description of pearl-producing molluscs with illustrations of the creatures involved – the first time I have seen anything like this. Not only does the reader feel that they could be recognized in the street from the pictures but from the insides too – 'so this is how pearls get formed' [or, at least, where]. This is a quite excellent start to what continues as a really good effort to make pearls understandable and accessible.

Succeeding chapters cover the mechanisms of pearly lustre, pearls in human history (divided into European and non-European), the recovery of pearls, pearl culture and the preservation of pearl-producing molluscs. Each chapter has its own list of references and these are a lot better than usual. At last, a reasonable academic/popular study of a difficult subject. M.O'D.

Handbook of Raman spectroscopy from the research laboratory to the process line.

I.R. Lewis and H.G.M. Edwards (Eds), 2001. New York: Marcel Dekker. pp xiii, 1054, hardcover. ISBN 0 8247 0557 2 (Practical spectroscopy series. vol. 28) US $225.00.

A most useful and up-to-date multi-author coverage of what has become one of the most powerful tools in specimen determination. Gemmologists will first turn to the paper by Kiefert, Hänni and Ostertag, *Raman spectroscopic applications to gemmology*. Emphasizing the need for a powerful but non-destructive testing method for gemstones it outlines several applications: analysis on a lot of gemstones; analysis on taaffeite and musgravite; analysis on a purple jadeite consisting of jadeite and albite; analysis on stones set in a reliquary cross from the Basel Cathedral. The authors then describe the usefulness of the technique in the identification of inclusions and in treatments where the nature of filling materials can be determined. Examples are the analysis of impregnated jadeite; analysis of dyed quartzite to imitate jadeite; analysis of artificially coloured pearls; analysis of fissure fillers in emerald where the spectra of several types of oils and artificial resins are presented. There is a useful list of references.

This paper is not the only one with relevance to gem and ornamental materials. Apart from introductory descriptions of the theory of Raman spectroscopy and why it is so powerful an investigative tool, there are notes on its application to the characterization of archaeological materials and to crystals: Smith and Carabatos-Nédelec introduce crystal structures for the general reader and then proceed to describe Raman analysis of solid solutions and ways in which the techniques can be used to identify Bravais lattices (space lattices). Raman analysis can also be employed in crystal optics. Useful examples are given along the way: spectra from a Roman intaglio show that it was made from chrysoprase with some moganite [chalcedony polymorph] and contains a microinclusion of zircon.

Though the book is not intended in the first instance for non-scientific readers it certainly should be looked into by those concerned with the identification of unknown solids of any kind. Each chapter has its own list of references but the subject has already extended too widely for a general bibliography to form a part of what is already a very large work. The book is well printed and appears adequately bound: the price is not excessive for the work that has been devoted to its compilation.

M.O'D.

Diamond ring buying guide.

R. Newman, 2002. Los Angeles: International Jewelry Publications. Sixth edition. pp 156, illustrated in colour, softcover. ISBN 0 929975 32 4. US $17.95.

Never behind the times, Newman unerringly hits the right spot once more. This time it is with diamond treatments (HPHT stones among others), the growing interest in coloured diamonds and how they are to be graded. There is also a commentary on the diamond pricing system: here the 4 Cs as the only criteria for judgement come under unfavourable comment - read the book to find out why. There are more photographs in colour and a piece on the detection of synthetic moissanite. I like the questions (I look at the answers to try and find out what the question was) and the general style just as much as I ever have and the pictures even more.

M.O'D.

Diamond Grading ABC – The Manual.

Verena Pagel-Theisen, 2001. 9th new revised and enlarged edition. £39.50.

This much enlarged edition of the *Manual* includes an introduction to the history of the diamond trade and the occurrences and mining of rough diamonds. But it is the chapters dealing with the evaluation of colour, clarity, cut and weight of cut and polished diamonds which make this handbook essential for every diamond laboratory, grader and gemmologist as a reference book. These chapters are exceedingly well illustrated and explain the grading procedure carefully and in detail. A particularly useful chapter deals with modernizing old cuts and re-cutting damaged stones. The newer techniques of treating diamonds, like HPHT, are described and discussed. There are informative chapters on fancy cuts and fancy colours and there is a survey of imitations and simulants and their identification. Many instruments and tools of the trade are discussed.

Altogether there are 750 photographs and figures with a number of useful tables. The book is dedicated to Dr E.J. Gübelin, who has also written the preface. Extensive bibliography. E. S.

Gemstones, quality and value. Volume 3 Jewelry.

Y. Suwa, 2001. Sekai Bunka Publishing Inc., Tokyo, Japan. pp. 144, illustrated in colour, hardcover. ISBN 4 418 01902 2. £75.

This is in every way a worthy successor to the two previous volumes which dealt with the classic gem species with detailed notes on how values were arrived at and what were considered the finest colours and styles of fashioning. The present book does the same thing for jewellery and is the only one I know in which the design, construction, appearance and stones used are all considered in minute detail so that the reader will be able to follow these stages in the creation of, for example, a diamond necklace and see just how some stones are preferred to others. Colours are compared once more as in the two earlier books and the matching of stones is illustrated. Large and clear diagrams show the different parts of pieces of jewellery and convertible pieces are also described. The photographs rank with the finest I have seen in this area of jewellery study and the book closes (?) a superb trio. M.O'D.

Emeralds. Revised edition.

F. Ward, 2001. Gem Book Publishers, Bethesda, MD, U.S.A. pp 63, illus. in colour, softcover, ISBN 1 887651 05 5 [*Fred Ward gem series*] 2001. £9.95.

Just as I had begun to wonder when another Fred Ward short colourful guide would come out, two more appeared in revised editions, this one and *Jade*. First published in 1993, *Emeralds* now covers a world in which a great deal has been happening. Fred still includes his experiences in Colombia but also updates such vital areas as the work of emerald crystal growers – his remarks on synthetic gemstones are absolutely correct – if the customer cannot try to learn about something for which he is willing to pay a great deal of money it is his own fault if he comes to grief (what Fred actually said was that synthetic gemstones fill a real need [they do and are beautiful as well] but the intention is there). As always the pictures are first-class and some show areas very little photographed, in Pakistan and Afghanistan. M.O'D.

Jade. Revised edition.

F. Ward, 2001. Gem Book Publishers, Bethesda, MD, U.S.A. pp. 64, illus. in colour, softcover, ISBN 1 887651 06 3 [*Fred Ward gem series*]. £9.95.

A welcome revision of the text first published in 1996, *Jade* now includes fresh as well as the original material with particular reference to some of the jade found from 1998 in Guatemala where jade of different colours occurs. The pictures, as expected, are excellent and the book gives a good introduction to the jade minerals for the student and the connoisseur. M.O'D.

Jades of Mesoamerica.

F. Ward, 1997. Gem Book Publishers, Bethesda, MD, U.S.A. pp 16, illus. in colour. Softcover ISBN 1 887651 00 4 [*Fred Ward Gem Books*]. £9.95.

Short but delightful guide to the jades of the Pre-Columbian period in central America, the text largely subsumed into the second edition (2001) of *Jade* (reviewed above). M.O'D.

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

90TH BIRTHDAY

Our Vice President, R. Keith Mitchell, celebrates his 90th birthday on 28 February 2002. We congratulate him and wish him good health in the coming years.

APPOINTMENT OF NEW VICE PRESIDENT

At a meeting on 12 December, the Council of Management unanimously appointed Noel Deeks a Vice President of the Association. The appointment is for life and he joins Alec Farn, Bob Howie, David Kent and Keith Mitchell.

Noel has supported the Association for nearly 40 years and, in the last ten of those, has been particularly active in overseeing the day-to-day financial activities of the company. He obtained his FGA in 1969 while working in the jewellery trade, and after passing what was then the Diamond Certificate, started teaching the diamond course with Alec Pickett at the Sir John Cass College, and the summer diamond courses with Eric Bruton.

He was chairman of the Education Committee at the National Association of Goldsmiths for eleven years and has maintained his strong interest in course development, chairing the Diamond Committee that led to the Gemmological Association's correspondence course for gem diamonds.

Trained as a watchmaker, he has maintained an active interest in gem testing instruments and collaborated with Peter Read on the Brewster Angle meter; he has also developed his own synthetic moissanite tester.

OBITUARY

Michael S. D'Arcy FGA DGA (D.1967), Holt, Norfolk, died on 24 December 2001.

MEMBERS MEETINGS

Gem-A Conference 2001

The Annual Conference was held on Sunday 4 November at the Barbican Centre, London. A full report was published in the December 2001 issue of *Gem & Jewellery News*.

London

On 10 October at the Gem Tutorial Centre, 27 Greville Street, London EC1N 8TN, Moya Corcoran gave an illustrated lecture entitled 'A portrait of jewels'.

On 21 November at the Gem Tutorial Centre Professor David Smith gave lectures entitled 'Analysis of precious stones under thick glass by Mobile Raman Microscopy' and 'Compositions of jade and garnets by non-destructive Raman Microscopy'.

On 6 December at the Gem Tutorial Centre, Michael O'Donoghue gave a talk on the 'Literature of gemstones'. Those present had the opportunity to examine many of the books held in the Gem-A library.

 ISSN: 1355–4565

GIFTS TO THE ASSOCIATION

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

Mrs M. Bird, Ransey, Isle of Man, for her late husband's gem collection of crystal models, crystals and cut stones.

Maggie Campbell-Pedersen, London, for *Amber* by the Danish Amber Museum.

Professor Akira Chikayama, Tokyo, Japan, for peridot crystals from three different localities, together with maps of the mines.

The Diamond Trading Company, London, for the permanent loan of a DiamondSure ™1.

H. Gerald Stonley, Haddenham, Buckinghamshire, for a wide range of cut stones typical of the market over 40 years.

Pierre Vuillet, Villards d'Heria, France, for photographs of screw inclusions in Colombian emeralds and topaz from Pakistan; also for a cut and polished synthetic berlinite.

Julia Woods, Spetisbury, Dorset, for a collection of stones.

Midlands Branch

On 28 September at the Earth Sciences Building, University of Birmingham, Edgbaston, Richard Taylor gave a talk on 'The implications and problems of gemstones in jewellery valuations'.

On 26 October at the Earth Sciences Building John Wheeler of Tamborine, Queensland, Australia, gave a talk entitled 'Beautiful opals, Australia's national gemstone'. His presentation included a video of opal mining at Lightning Ridge and a display showing top-quality black opal, boulder opal and white opal specimens.

On 30 November at the Earth Sciences Building Alan Hodgkinson spoke on the characteristics and identifying features of natural, synthetic, treated and composite emeralds.

The 49th Annual Dinner of the Branch was held at Barnt Green on 8 December.

North West Branch

On 19 September at Church House, Hanover Street, Liverpool 1, Charles Preston gave a talk entitled 'Reading silver hallmarks'.

On 17 October at Church House Ray Rimmer spoke on 'Pawnbroking throughout the 20th century'.

The Branch AGM was held on 21 November at Church House, at which Deanna Brady, Ray Rimmer and Eileen Franks were elected Chairman, Secretary and Treasurer respectively. The AGM was followed by a social evening.

Scottish Branch

On 24 September at the British Geological Survey, Murchison House, West Mains Road, Edinburgh, Roger Key gave a talk on 'Gemstones and geology of South Central Africa'.

On 17 October at the British Geological Survey, Clive Burch gave an illustrated lecture on 'Inclusions: highlights from twenty years of gemstone photomicrography'.

On 20 November at the British Geological Survey, Rosamond Clayton gave a talk entitled 'Jade then and now'.

South West Branch

A meeting of the Branch was held during the afternoon of 25 November at the Royal Literary and Scientific Society Institute, Bath. A video-microscope demonstration was given by Doug Garrod entitled 'Everything included', and Marcus McCallum gave a hands-on demonstration on pearls.

PRESENTATION OF AWARDS

The Presentation of Awards gained in the 2001 examinations was held at Goldsmiths' Hall, Foster Lane, London EC2 on Monday 5 November. Professor Alan Collins, President of Gem-A, presided and welcomed those present, particularly those students who had travelled from as far away as Canada, China, Japan, Korea, Hong Kong and the U.S.A., as well as many European countries. He announced that in January and June 2001, a total of 760 students and entered the Preliminary and Diploma Gemmology and Gem Diamond Diploma examinations. A total of 143 students had qualified in the Gemmology Diploma examination and 121 in the Gem Diamond.

Professor Collins then introduced Raymond Sancroft-Baker, Senior Director of the Jewellery Department at Christie's, who presented the awards.

(a) *Raymond Sancroft-Baker (right) presentating the Christies's Prize for Gemmology to Ian Sipson of Trowbridge, Wiltshire. © Peter Dyer Photographs Ltd.*

(b) *Dong Lan of Wuhan, PR. China, receiving the Anderson-Bank Prize. © Peter Dyer Photographs Ltd.*

Mr Sancroft-Baker delivered his address (see below) and a vote of thanks was given by Vivian Watson, who also thanked the Goldsmiths' Company for kindly permitting Gem-A to hold the ceremony at the Hall.

A Reunion of Members was held following the ceremony, attended by over 200 members and students.

Raymond Sancroft-Baker's address

"It gives me great pleasure to be standing here presenting the awards for 2001. I do know how difficult it is to obtain these diplomas and how proud you all must be feeling – and that the many many hours of hard work are soon forgotten.

"The qualifications you now have give you a head start in the world of jewellery; being

(c) *Karen McKinley of Northampton receiving the Preliminary Trade Prize. © Peter Dyer Photographs Ltd.*

(d) *Allyson Thomas of Birmingham receiving the Deeks Diamond Prize. © Peter Dyer Photographs Ltd.*

(Left to right) Vivian Watson, Raymond Sancroft-Baker, Dr Roger Harding and Professor Alan Collins at the Presentation of Awards ceremony. © Peter Dyer Photographs Ltd.

qualified is vital for the analysing and grading of jewellery which becomes more complicated with simulants and treatments reaching new heights of sophistication. This situation inevitably raises questions of ethics; for instance, when sapphires are sold should it be stated that they are heat treated, and are glass-filled rubies, rubies at all? It should be remembered that many Mong Hsu rubies are often heated to 1600°C in order to eradicate the inner blue core and heating more gently can remove inclusions – especially silk – from corundum, as well as giving the stone a more even distribution of colour. Should it be compulsory for laser-drilled diamonds to be so described on both sides of the Atlantic? I certainly think so.

"The use of Opticon has had a huge effect on the value, and confidence in emeralds. It is difficult to know where to stop, as tanzanite is brown when found and only becomes its vibrant blue colour when heated. I find it amazing that a New York firm who sell treated diamonds (high pressure, high temperature), say that it does not really matter as nobody can tell the difference. It is the same in many spheres of life; people are just trying to get something for nothing and this is certainly nothing new. Now at least you will be able to know how to go about the problems that gemstones present.

"I know there are moves afoot to create a jewellery centre in Hatton Garden and I am very much in favour of such an enterprise. it could become a real attraction not only from people just looking but also buying, especially if they could actually see a diamond or indeed any gemstone being cut and polished. London also lacks a museum devoted to 20th century jewellery and all there is to see are the wonderful galleries in the Victoria and Albert Museum that specialize in antique jewellery without much concern for more modern creations. People do need to be educated and I know from having organized short jewellery and gemmology courses that there is a great thirst for knowledge by not only members of the public but also those belonging to the trade. I just hope that sufficient funds are available as projects such as these inevitably absorb more money, time and resources than were envisaged at the outset. Hopefully there are people in this room that will help in this exciting idea.

"What I have said reinforces the need for London to have an effective and efficient gemmological laboratory that can grapple with the complex puzzles of today's jewellery world. Its importance was brought home to me in my first week in the Jewellery Department at Christie's. I had been in the Coin Department for 18 years but this was a small hobby getting smaller and I was lucky enough to be offered the opportunity of becoming the administrative director of Jewellery. During the first week of my new vocation in January 1988, a man came to our front counter with a large sapphire which he claimed to be Burmese and wanted the appropriate price; but my colleague thought it was from Ceylon which upset the client and he demanded to see the Director. I remember going down the lift chanting ruby red, emerald green, sapphire blue. After a close examination of the sapphire I said that while I was sure he was right, my colleague was of a sensitive nature and maybe the best solution was to send it to the famous gem lab for certification.

"I was asked to explain the role of the auctioneer in today's fast changing world. Some people think that I spend my time with dowager duchesses selecting a few baubles for our next auction. I can assure you that the vast majority of old family jewellery has already been sold. It is true that once this country was a huge repository of wealth but with two World Wars and high taxation there is little left; our sales are filled to some extent from what people can't wear any longer because jewellery in general makes people nervous either from the insurance angle or they fear that they might be mugged. In recent years as less jewellery has come from the public more has been consigned by the trade as we can reach a huge audience compared with a shop in Manchester, Milan or Madrid. Particularly if the piece they are thinking of selling is of a specialist nature. The dealers know they would have their jewellery shown in New York and Geneva before being sold in London. The 4000 catalogues that are printed reach a huge audience and in a recent sale we had 144 different buyers from 28 different countries which gives you an idea how international the business is today. It does give me great pleasure to put together an entire sale of Cartier jewels or an auction solely devoted to Art Deco as this involves research which leads to new knowledge. I feel that the auction houses have an obligation to educate as well as just sell jewellery. In fact one of your examiners, Sarah Hue-Williams, and I have produced a small book called *Christie's Guide to Jewellery* to answer the most common questions I am asked. The most common problem that I have come across is in the area of valuation. What is a piece of jewellery worth? This of course depends on whether it is for sale or insurance or indeed is it going to be replaced by making an exact replica? The price of a piece of jewellery is inevitably much higher in a retail shop in Bond Street as they have a great number of expensive overheads. But at the end of the day you are paying for choice as they have a large selection from which to choose, and at auction we only have what we are given and often this is not the most attractive of pieces, but the trade and the auction houses do get on well as they have become interdependent on each other.

"I would like to finish by wishing you all the very best in your future endeavours and to keep looking at gemstones be they with a dealer or at auction and never stop learning!"

MEMBERSHIP

Between 24 September and 12 December 2001 the Council of Management approved the election to membership of the following:

Fellowship (FGA)

Alexanders, David, Karlsruhe, Germany. 1993
Amliwala, Panna, Shirley, Solihull, West Midlands. 2001
Armstead, John Miller, Ealing, London. 1958
Bi Yuliang, Guilin, Guangxi, P.R. China. 2001
Biuokzadeh, Hossein, Toronto, Ontario, Canada. 2001
Bolter, Rachel Louise, Chisledon, Swindon,

Wiltshire. 2001
Cao Yuan, Guilin, Guangxi, P.R. China. 2001
Chater, Melanie Dawn, Spratton, Northamptonshire. 2001
Downes, Lisa Elaine, Handsworth Wood, Birmingham, West Midlands. 2001
Elder, Maureen, Vancouver, B.C., Canada. 2001
Epa, Widanagamage, Malabe, Sri Lanka. 2001
Faustmann, Alexandra M., New Manilla, Quezon City, Philippines. 2000
Hassan, Fatima Chamade, Totteridge, London. 2001
Hoshino, Takako, Vancouver, B.C., Canada. 2001
Howard, Avrom E., Toronto, Ontario, Canada. 2001
Huang Zhan, Guilin, Guangxi, P.R. China. 2001
Hynes, Lola, Monkstown, Co. Dublin, Ireland. 2000
Keung Chan Chi, Shatin, Hong Kong. 1995
Long Zhen Xing, Liuzhou, Guangxi, P.R. China. 2001
Mariani, Geoffry, Toronto, Ontario, Canada. 2001
Minner, Loren M., Belen, New Mexico, U.S.A. 1987
Morrish, Rachel, Manor Hill, Sutton Coldfield, West Midlands. 2001
Sipson, Ian, Trowbridge, Wiltshire. 2001
Smith, Dana L., Port Perry, Ontario, Canada. 2001
Thouvenot-Villie, Fabienne, Levallois-Perret, France. 2001
Trudel-Decelles, Maureen, Hudson, Quebec, Canada. 2001
Wong Vina, Hong Kong, 2001

Diamond Membership (DGA)

Alderman, Chris, Ripley, Woking, Surrey. 2001
Amarasinghe, Ashan Sudeera, Hounslow, Middlesex. 2001
Browning, Matthew, Brighton, East Sussex. 2001
Hackett, Helen, London. 2001
Holdsworth, Isabel Dorothy Durley, Surbiton, Surrey. 2001
Koundouraki, Evagelia, Katerini, Greece. 2001
Ndemumana, Zarina, Edmonton, London. 2001
Pecku, George Otu, London. 2001

Ordinary Membership

Alvarez, Patricia, Belgravia, London
Eastwood-Barzdo, Elizabeth, Vinzel, Switzerland
Fajobi, Adeniyi Akanmu, Palmgrove, Lagos, Nigeria
Govindara Julu, Suresh, Ilford, Essex
Ingridsson, Anna-Lis, Lannavaara, Sweden
Jojie-Oberoi, Mirjana, London
Jose, Kadavi Francis, Ilford, Essex
Karimjee, Farida Noordin, Chingford, London
Kaushal, Opinder J. Singh, Reading, Berkshire
Kawasaki, Masayuki, Sayama, Japan
La Fontaine, Ralph, Isleworth, Middlesex
Luo Xuan, Matthew, Glasgow, Scotland
Malinowska, Rossita, Beckenham, Kent
Mehdi, Jonathan, London
Morikawa, Satoshi, Nishikasugai-gun, Aichi, Japan
Ng Ka Kit, New Territories, Hong Kong
Ola-Oye, K., London
Richards, Justin, Lower Loxley, Uttoxeter, Staffordshire
Smeets van der Berg, W.R., Wassenaar, The Netherlands
Sutthisakorn, Siriwan, Reading, Berkshire
Yaddanapudi, Pratima, London

Laboratory Membership

Chard (1964) Ltd., 521 Lytham Road, Blackpool, FY4 1RJ
N M Solden Ltd., PO Box 1108, Barnet, Herts. EN5 42T
QVC The Shopping Channel, South Boundary Road, Knowsley Ind Est, Liverpool L70 2QA

Errata

In *J.Gemm.*, 2001, 27(8), p. 506, second column, third line, 'Gandusio, SU.S.A.nna' should read 'Gandusio, Susanna'. We apologize for the error.

We look after all your insurance PROBLEMS

Established in 1887, T.H. March have been arranging insurance cover for the Jewellery trade for over 100 years, and we are the appointed brokers to the National Association of Goldsmiths, and the British Jewellery and Giftware Federation. We offer specialised policies for the Retail, Wholesale, Manufacturing and Allied Jewellery Trades, and we would help you with all aspects of your Business insurance, and can also take care of other insurance problems such as car, boat, and home insurance. Our staff are experienced in security matters, and would be delighted to visit your premises if required to give advice and a quotation without obligation.

Please contact us at our Hatton Garden Head Office address shown below.

T.H.MARCH INSURANCE

T.H. March and Co. Ltd.
10-12 Ely Place, London EC1N 6RY
Telephone 020 7405 0009 Fax 020 7404 4629
Also at Birmingham, Manchester, Glasgow, Plymouth and Sevenoaks.

You can't beat Experience

FORTHCOMING EVENTS

20 February	**North West Branch.** *The Chairman's mantra: don't forget the speakers.* *Irene Knight*
22 February	**Midlands Branch.** *An orgy of organics. E. Alan Jobbins*

Midlands Branch

A day in celebration of fifty years of gemmology

A one-day conference, including celebration lunch, to be held on Sunday 24 February at Barnt Green near Birmingham

Speakers will include:

Professor Dr Henry Hänni

E. Alan Jobbins

Ian Mercer

For further information contact Gwyn Green (details below)

5 March	**London.** Visit to the Diamond Information Office at the DTC.
6 March	**Scottish Branch.** *Poking in gemmological corners.* ***Alan Hodgkinson***
20 March	**North West Branch.** Visit to the Geology and Archaeology Room at the Liverpool Museum.
29 March	**Midlands Branch.** *The art of the goldsmith and silversmith. Martyn Pugh*
9 April	**London.** Private viewing and guided tour by *Geoffrey Munn* of the *TIARAS* exhibition at the Victoria and Albert Museum.
17 April	**North West Branch.** *Gems in the collection of the Natural History Museum, London. Dr Roger Harding*
26 April	**Midlands Branch.** *The importance of the microscope in Gem ID. Gwyn Green and Kate Hopley*
3 May	**London.** Lecture by Joseph Tenhagen of Miami, Florida.
15 May	**North West Branch.** *Diamonds – the fourth dimension (cut). Rosamond Clayton*
19 June	**Midlands Branch. Gem Club.** *Photomicroscopy* with *Doug Morgan and David Larcher*
19 June	**North West Branch.** Bring and buy.
22 June	**Midlands Branch.** Supper Supper Party.

Contact details

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

London:	Mary Burland on 020 7404 3334; e-mail gagtl@btinternet.com
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 cm@scotgem.demon.co.uk
South West Branch:	Bronwen Harman on 01225 482188; e-mail bharman@harmanb.freeserve.uk

Gem-A Website

For up-to-the-minute information on Gem-A events visit our website on www.gagtl.ac.uk

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.

Volume 28 No. 1 January 2002

Contents

The Journal of Gemmology

Cover Picture

Three coloured diamonds: Fancy Vivid purple, Fancy Vivid purplish-pink and Fancy Light brown. (A highly unusual, 7.34 ct, Fancy Vivid purple diamond, pp. 7-12).

Registered Office: Palladium House, 1–4 Argyll Street, London W1V 2LD

ISSN: 1355–4565

Designed & Produced by Harley UK