



The Journal of Gemmology

Volume 25 No. 1

January 1996



President
E.M. Bruton

Vice-Presidents
A.E. Farn, D.G. Kent, R.K. Mitchell

Honorary Fellows
R.T. Liddicoat Jr., E. Miles, K. Nassau

Honorary Life Members
D.J. Callaghan, E.A. Jobbins, H. Tillander

Council of Management
C.R. Cavey, T.J. Davidson, N.W. Deeks,
R.R. Harding, I. Thomson, V.P. Watson

Members' Council
A.J. Allnut, P. Dwyer-Hickey, R. Fuller,
B. Jackson, J. Kessler, G. Monnickendam,
L. Music, J.B. Nelson, K. Penton, P.G. Read,
I. Roberts, R. Shepherd, C.H. Winter

Branch Chairmen
Midlands: J.W. Porter
North West: I. Knight
Scottish: J. Thomson

Examiners

A.J. Allnut, M.Sc., Ph.D., FGS	S.M. Anderson, B.Sc(Hons), FGA
L. Bartlett, B.Sc., M.Phil., FGA, DGA	E.M. Bruton, FGA, DGA
C.R. Cavey, FGA	S. Coelho, B.Sc., FGA, DGA
A.T. Collins, B.Sc., Ph.D.	A.G. Good, FGA, DGA
C.J.E. Hall, B.Sc.(Hons), FGA	G.M. Howe, FGA, DGA
G.H. Jones, B.Sc., Ph.D., FGA	H.L. Plumb, B.Sc., FGA, DGA
R.D. Ross, B.Sc., FGA, DGA	P.A. Sadler, B.Sc., FGA, DGA
E. Stern, FGA, DGA	Prof. I. Sunagawa, D.Sc.
M. Tilley, GG, FGA	C.M. Woodward, B.Sc., FGA, DGA

The Gemmological Association and Gem Testing Laboratory of Great Britain
27 Greville Street, London EC1N 8SU
Telephone: 0171-404 3334 Fax: 0171-404 8843

The Journal of Gemmology

VOLUME 25

NUMBER 1 JANUARY 1996

Editor

Dr R.R. Harding

Production Editor

M.A. Burland

Assistant Editors

M.J. O'Donoghue

P.G. Read

Associate Editors

S.M. Anderson	London	Dr C.E.S. Arps	Leiden
G. Bosshart	Lucerne	Dr A.T. Collins	London
Dr J.W. Harris	Glasgow	Prof. R.A. Howie	Derbyshire
Dr J.M. Ogden	Cambridge	Dr J.E. Shigley	Santa Monica
Prof. D.C. Smith	Paris	E. Stern	London
Prof. I. Sunagawa	Tokyo	Dr M. Superchi	Milan
C.M. Woodward	London		

Any opinions expressed in *The Journal of Gemmology* are understood to be the views of the contributors and not necessarily of the publishers.



Cover Picture

Typical colour zoning in a Mong Hsu ruby which has not been subjected to heat-treatment. Central violet to black zones are due to high concentrations of titanium and chromium. See 'The role of fluorine in the formation of colour zoning in rubies from Mong Hsu, Myanmar (Burma)' on pp 3-19.

ISSN: 1355-4565

In this issue...

The first paper in this volume concerns the currently fashionable Mong Hsu rubies from Myanmar and aims at explaining some of the unusual features displayed by stones from this deposit. The rubies have become famous because of their fine colour and the common occurrence of a blue core in many samples. Not the least of their attractions was the fact that this blue core could be removed by heat treatment to leave a fine red stone!

The composition of the rubies and their inclusions, and of minerals associated with the rubies in the gem gravels, are considered in modelling how the particular features of the Mong Hsu stones originated and it is concluded that fluorine played an important role. In particular a sequence of fluids variably enriched in water, CO₂, F, Cr, and Ti, is thought to be responsible for the alternating zones of ruby and sapphire.

Mention has been made before in this *Journal* of the great potential of Russia for supply of gem materials, and amber possibly having come from this source is described in Notes from the Gem and Pearl Testing Laboratory, Bahrain. The composition of strings of prayer beads and fracture-filled emerald are other topics discussed in the Notes and reflect a wide diversity of work which must be of considerable reassurance to the jewellery trade in Bahrain.

Mont Saint-Hilaire, Quebec, is a twentieth century mineralogical and gemmological phenomenon. More than 300 different minerals have been found there, 27 of them new species. Not all the new species are large enough to cut into gems, but a total of 28 species have been cut, most for curiosity but some for collectors.

Notwithstanding the original motive for cutting, all these stones become collectors' gems. An authoritative account combines the history of finds at Mont Saint-Hilaire with the major personalities involved in the discovery and cutting of the gems. With the growing economic significance in the market for specimens from some localities it is becoming more important to establish reliable and definitive criteria for their identification, and comprehensive pictures and tables provide a unique reference for the locality to mid-1995.

In the final paper, the author describes the occurrences of freshwater mussels and pearls in Bavaria and Bohemia. New interest in this subject has arisen not because a new productive strain of pearl mussel has been found but because these geologically long-lived animals are extremely sensitive to pollution and vast numbers are being studied to monitor the rivers of Europe. The fact that some of the shells will, in the fullness of time, produce pearls is a bonus!

R.R.H.

The role of fluorine in the formation of colour zoning in rubies from Mong Hsu, Myanmar (Burma)

Dr A. Peretti, FGG,¹ Dr J. Mullis² and F. Mouawad, GG³

¹P.O. Box 4028, 6002 Lucerne, Switzerland, ²Sissach, Switzerland and ³Bangkok, Thailand

Abstract

Mong Hsu rubies are characterized by a black sapphire core and a ruby rim. This colour zoning has been correlated with the presence of the trace elements Ti (violet to black) and Cr (red) (Peretti *et al.*, 1995a). Some examples of Mong Hsu rubies show a complex chemical zonation, which results in multiple zones of rubies, violet sapphires and black sapphires within one particular crystal. Rubies of this type have been studied by analyzing the solid and fluid inclusions as well as their chemical zoning. Minerals accompanying the rubies, such as tourmaline (dravite) and tremolite have also been analysed. The formation conditions of the rubies have been reconstructed following the study of mineral associations and fluid inclusion analyses. Mong Hsu rubies were formed at 2–2.5 kbars and at temperatures between 500° and 550°C. The fluids were found to be water-bearing and multi-volatile CO₂-rich (multivolatiles = composed of CO₂, CH₄ and other components, possibly N₂, H₂S and HF). Fluorite inclusions in the rubies indicate that fluids must have contained some HF. During the study of the homogenization temperatures in different populations of fluid inclusions, it was concluded that no major variations in temperature and pressure occurred during the growth of Mong Hsu rubies. However, the chemical

zonation patterns found in Mong Hsu rubies and accompanying tourmalines are indicative of variations in the composition of the fluids e.g. in contents of F, Ti and Cr. A preliminary model is proposed, which explains the cyclic growth of Mong Hsu rubies, with formation of alternating zones of ruby and sapphire by variation in HF concentration in the surrounding fluids. The possible multiple infiltration of fluids from metapelites into dolomites is discussed.

Introduction

A new source of rubies with commercial importance was declared in 1991 at Mong Hsu in the Shan state of Eastern Burma more than 200 kilometres from the classical ruby mine at Mogok (Hlaing, 1991; Jobbins, 1992; Jobbins *et al.*, 1994; Kane and Kammerling, 1992, Peretti *et al.*, 1995a). The main metamorphic rocks in the mining district are composed of metacarbonates (dolomites, marbles, calcisilicate rocks) and metapelitic rocks (schists, gneisses, phyllites) (Earth Sciences Research Division, 1977, Hlaing, 1991, 1993, 1994). Mong Hsu rubies are mined in secondary deposits (Figures 1 and 2) and in primary deposits in the dolomite marbles.

The most characteristic feature of the Mong Hsu rubies is their colour zoning, with a violet to black core (Figure 3) and a red rim. The cores consist of zones enriched in TiO₂ and Cr₂O₃ along with



Fig. 1. Ruby deposits in the Mong Hsu region showing mining activities in the secondary deposits. The picture shows the separation of the larger crystals of tremolite by sieving before the rubies are washed from soil. *Photo by U Tin Hlaing, courtesy JewelSiam*



Fig. 2. River terraces at Mong Hsu with the alluvial deposits of the rubies. Primitive mining by local people before late 1993 is shown. *Photo: anonymous miner*

Fig. 3. Non-heat-treated Mong Hsu rubies, partly with polished facets, showing black to violet cores. Rubies between 0.50 and 2.00 ct.



Fig. 4a. Typical colour zoning in a Mong Hsu ruby which has not been subjected to heat-treatment. Central violet to black zones are correlated with high concentrations of titanium and chromium (Peretti *et al.*, 1995a). Ruby cut parallel to the *c*-axis. Magnification on slide is 40x. Ruby approx. 2 ct. Photo by Dr E. Gübelin

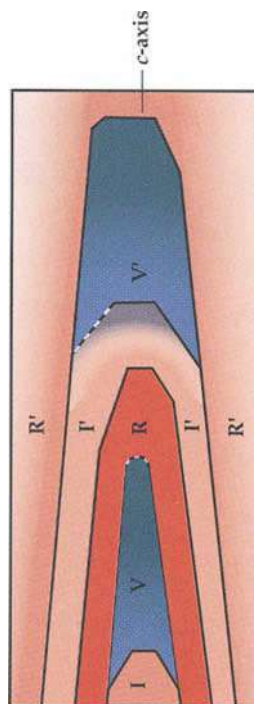


Fig. 4b. Classification of the colour zoning of the Mong Hsu ruby of Figure 4a. Growth phases are described as I, R and V. Compare with Figure 12. Sketch by Dr K. Schmetzer. Details on growth zones see Peretti *et al.* (1995a).

only small concentrations of FeO (Peretti *et al.*, 1995a). The colour zones in the Mong Hsu rubies occur in repeated cycles of violet/black and red along with changes in the crystal habit (see Peretti *et al.*, (1995a) and Figure 4a, b). The factor most relevant



Fig. 5. Heat-treated Mong Hsu rubies. The original violet to black cores have been completely removed and transformed to intense red. Rubies between 1 and 3 ct.

to the commercial importance of the Mong Hsu rubies is that the violet to black zones can be removed by heat-treatment (Figure 5) (Jobbins, 1992; Ho, 1993; Laughter, 1993). Typical examples of such heat-treated fine quality and faceted rubies are shown in Figure 6.

This study concentrates on attempting to determine the conditions under which Mong Hsu rubies were formed and on the genetic reasons for the presence of violet to black zones in the Mong Hsu rubies. A more general gemmological investigation of the properties of the Mong Hsu rubies, including the heat-treated samples, can be found elsewhere (e.g. Peretti *et al.*, 1995a,b,c).

Minerals accompanying the Mong Hsu rubies in the alluvial deposits

The materials for this study were sampled during expeditions to Northern Thailand (Mae Sai) and Burma in the summers of 1993 and 1995 (Figure 7a). However, direct field work at the primary mine in Mong Hsu was not possible because of security risks which are still pertinent (see Thailand Stone Market Report, 1995). In order to obtain further information concerning associated minerals, large parcels of mineral concentrates from the Mong Hsu ruby deposits have been checked (Figure 7). Some of the results are shown in Figure 8,



Fig. 6. A set of cut stones showing different colour shades obtainable from Mong Hsu rubies after heat-treatment. Rubies heat-treated and cut by the authors. Sizes of rubies around 1 carat each. Photo by Mouawad, Bangkok (Thailand).

Fig. 7. (a) A Mong Hsu ruby in the host rock. The ruby is formed in a vein consisting of corundum, sapphire, ruby, calcite, Mg-chlorite, fuchsite and opaque minerals. The vein itself is embedded in a dolomite marble (area of lower left corner) which shows signs of metamorphic recrystallization (equal sized dolomite crystals, 2mm in size). A calcite crystal is shown in reflected light in the figure. It is formed at the border zone of the vein, in contact between the dolomite marble and the ruby. Minerals identified by SEM-EDS analyses. Length of Mong Hsu ruby is 8 mm. Collection A. Peretti.



Fig. 7. (b) Kilos of rough Mong Hsu rubies in Mae Sai displayed in the office of a major dealer for the selection of samples for this study (left-hand side). Mong Hsu ruby lots may contain various other minerals such as tourmaline, garnet, andalusite and tremolite.

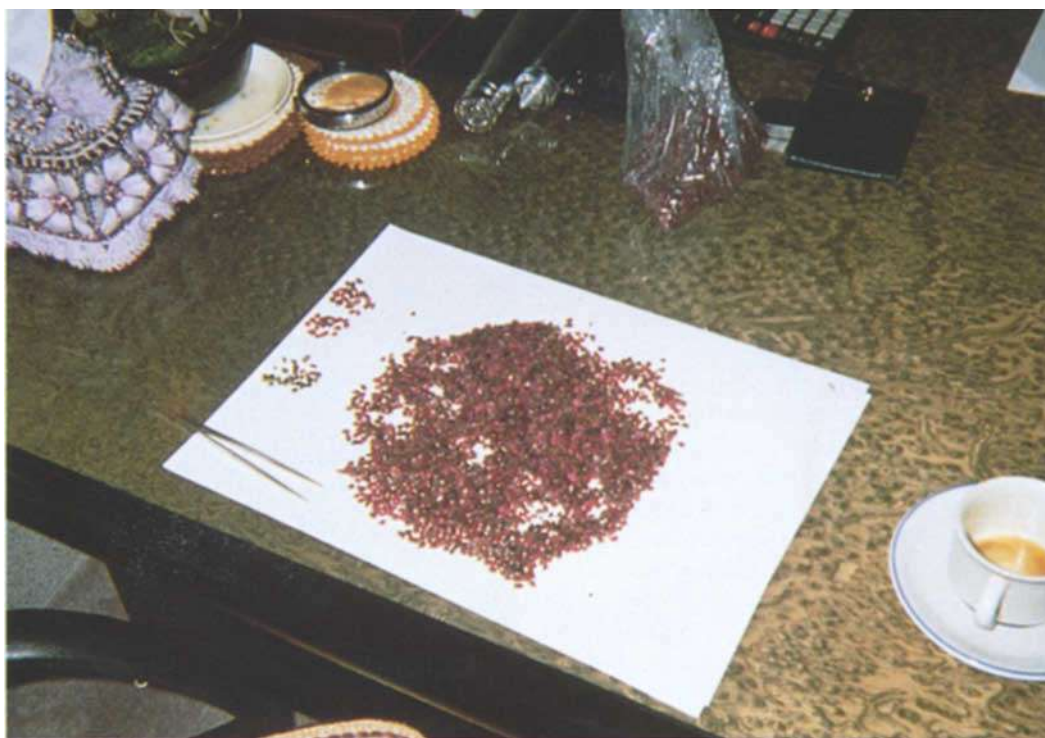




Fig. 8. Minerals found in the lots of Mong Hsu rubies including one green chromium-dravite (top), three brownish dravites (middle), andalusite (lower left corner) and two almandines (lower right side). Note that the crystals are not water-worn; length of green chromium-dravite is 6 mm. Identification by XRD.

namely, the presence of brownish-green dravite, quartz, almandine intergrown with white mica, and andalusite. Garnet, green tourmaline, white mica and quartz have already been described by Hlaing (1993), but in addition he described staurolite as a mineral that can be found in the alluvial deposits. Green tourmaline was also reported to occur as an intergrowth with ruby (Hlaing 1993). Tremolite is particularly frequent in the alluvial deposits (Figure 1).

In general, neither the Mong Hsu rubies nor the minerals accompanying the Mong Hsu rubies are water-worn (Figure 8). It is therefore most likely that the minerals occurring with the rubies in the alluvial deposits originate from the primary ruby deposits or from country rocks close to them.

In order to obtain more information about their host rock types, dravite, almandine and tremolite crystals have been chemically analyzed by means of electron



Fig. 9. Fragments of greenish tremolite from the Mong Hsu ruby mine. The green is due to Cr- and V-concentrations in the tremolite (see Table I for these and F content). Transmitted light. Length of crystal is 2 mm (Crystals immersed in epoxy, polished on one side).

microprobe analyses (Table I). Mong Hsu tremolites show traces of chromium (Cr), vanadium (V) and fluorine (F), but iron (Fe) and nickel (Ni) were below detection levels. Green tremolite from Mong Hsu is chemically zoned with some areas more enriched in V and Cr than others; these elements seem to be responsible for the variable intensities of green found in the mineral (Figure 9). Increasing Cr-concentrations in the tremolites are correlated with increasing V-concentrations with a Cr/V atomic ratio of 10:1. Furthermore, considerable concentrations of fluorine were found in the Mong Hsu tremolites. Such tremolites may be typically found in

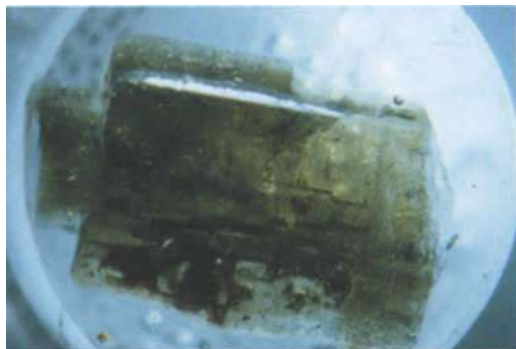


Fig. 10. Brownish-green dravite containing traces of Cr, V and F (see Table I). For the chemical profile with variations in Cr and F see Figure 11. Transmitted light. Length of crystal is 5 mm.

Table I: Chemical compositions of minerals associated with Mong Hsu rubies in comparison with those from other localities

	<i>Tremolite</i> (1)	<i>Tremolite</i> (1)	<i>Tremolite</i> (2)	<i>Almandine</i> (1)	<i>Dravite</i> (1)	<i>Dravite</i> (1)	<i>Dravite</i> (3)
MgO	24.05	24.32	24.83	1.09	12.65	13.26	13.67
CaO	13.55	13.43	12.61	0.50	2.82	1.89	2.41
Na ₂ O	0.95	1.01	0.21	0.00	1.55	1.96	1.63
K ₂ O	0.07	0.07	0.00	0.00	0.00	0.00	0.09
SiO ₂	53.07	53.31	57.88	35.15	35.46	37.57	35.96
Al ₂ O ₃	2.65	2.42	0.00	20.38	30.52	31.13	30.85
TiO ₂	0.05	0.04	0.00	0.05	0.13	0.15	0.14
FeO	0.00	0.01	1.76	42.06	0.04	0.09	0.76
MnO	0.00	0.03	0.00	0.07	0.00	0.01	not det
Cr ₂ O ₃	0.63	0.60	0.15	0.00	2.17	0.22	not det
V ₂ O ₃	0.05	0.04	bd	0.00	0.00	0.06	not det
NiO	0.00	0.00	0.07	0.00	0.00	0.00	not det
Cl	0.01	0.01	bd	0.00	0.01	0.01	not det
F	3.49	3.50	bd	0.00	1.79	1.15	not det
Total	98.57	98.79	97.51	99.30	87.14	87.50	85.51
B ₂ O ₃	not det	not det	not det	not det	not det	not det	10.73
H ₂ O	not det	not det	not det	not det	not det	not det	4.16
Notes							
not det = not determined, bd = below detection limit							
1 = Tremolite, dravite and almandine from Mong Hsu (Burma)							
2 = Malenco serpentinite (amphibolite facies metamorphism)							
3 = Brown dravite, dolomite marble, Deer Howie and Zussman (1986)							

Analytical details for Mong Hsu minerals:

Electron microprobe laboratory, IMP, Swiss Federal Institute of Technology, Zürich, Switzerland. Electron microprobe CAMECA SX-50, 5 spectrometers (2 PET crystals for Ti, Ca, K, Cr and Mn, Cl; LIF crystal for Fe and Ni; PC1 crystal for F and TAP crystal for Si, Al, Mg and Na). Standards are natural silicates and oxides. Acceleration voltage was 10 kV and 20 kV. Measuring time for trace elements 200 sec.

metasomatic veins in dolomitic marbles such as those described by Mercolli *et al.*, (1987). Chemically different from tremolites originating from marble deposits are those from metamorphosed ultramafic rocks. Their chemical composition is characterized by traces of Ni and higher concentrations of Fe but without traces of F (Table I). The most common accessory mineral found in the lots of Mong Hsu rubies was brown to green dravite. These tourmalines contain trace amounts of Cr, V and F (Figure 10, Table I).

The chemical compositions of the associated minerals give some indication of their formation in different rock types.

Almandine and white mica (as overgrowth on garnet) typically occur in a range of rocks including metapelites (metamorphosed gneisses or schists), while staurolite and andalusite occur almost exclusively in metapelites. This mineralogical assemblage is typical for regionally metamorphosed or contact metamorphosed

metapelites which have undergone amphibolite facies conditions. Additionally, the formation of tremolite is consistent with this degree of metamorphism. It is also known that tremolite can be formed under these metamorphic conditions in veins within dolomites (e.g. see Mercolli *et al.*, 1987). Cr-, V- and F-bearing dravites also probably formed in the same or similar metasomatic veins. The observed intergrowth of tourmaline with Mong Hsu rubies (Hlaing and 1993 and 1995) and their typical occurrence in other ruby deposits (Hunstiger, 1990) supports this idea.

Chemical zoning in Mong Hsu tourmaline

Strong fluctuation of the chromium content occurred during the crystal growth of green dravite, ranging from 0.2 to 2.2 wt.%Cr₂O₃ (Table I). These variations are related to the colour zoning with light green indicating low Cr-concentrations

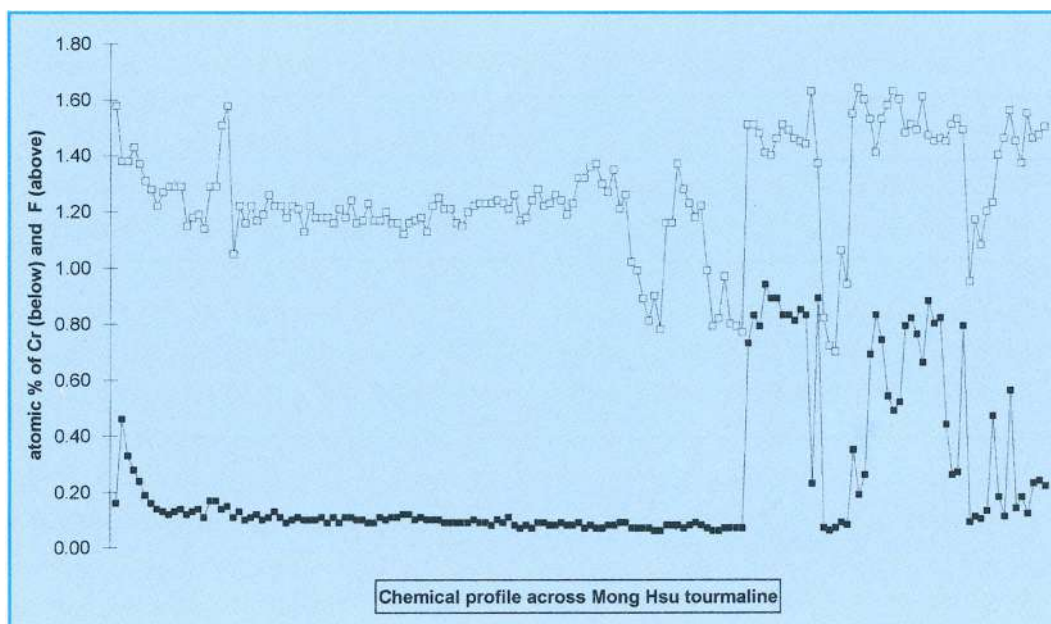


Fig. 11. Chemical profile across a green dravite originating from Mong Hsu (perpendicular to *c*-axis) showing F and Cr-concentrations. Note strong fluctuations of Cr along with F at distinct phases of growth towards the edge of the crystal. Increasing Cr-concentrations are correlated with increasing F-concentrations.

and intense green being related to relatively high Cr-concentrations. As shown in Figure 11, several abrupt changes in Cr-concentration occurred during the growth of the tourmaline crystal. Increasing Cr-concentration is correlated with increasing F-concentrations. They are also correlated with increasing V-concentrations.

Chemical zoning in Mong Hsu ruby

Figure 12 shows in an idealized way the chemical oscillations in a selected Mong Hsu ruby sample and its colour zoning as seen in the immersion microscope (Figure 4a). The concentrations of the trace elements are taken from Peretti *et al.*, (1995a). Many other samples showed a similar colour zoning, although the full sequence of growth shown in Figure 12 may not always be present. Colour zoning in

Mong Hsu ruby is correlated with different growth phases of the crystal, designated as 'I' (intermediate), 'V' (violet), and 'R' (red) as defined in Peretti *et al.*, (1995a). Growth phase 'I' is characterized by relatively low to medium Cr₂O₃-concentrations, along with relatively low or absent TiO₂-concentrations; growth phase 'V' by relatively high TiO₂ and high Cr₂O₃-concentrations; growth phase 'R' by relatively high Cr₂O₃-concentrations with no presence of TiO₂. During phase 'I', pink or violet sapphire to ruby layers are formed; during growth phase 'V' violet to black sapphire layers are formed; and during phase 'R', ruby layers are formed. This successive growth is repeated at least twice during the formation of a typical Mong Hsu ruby. A dramatic habit change in the Mong Hsu ruby crystal occurs at

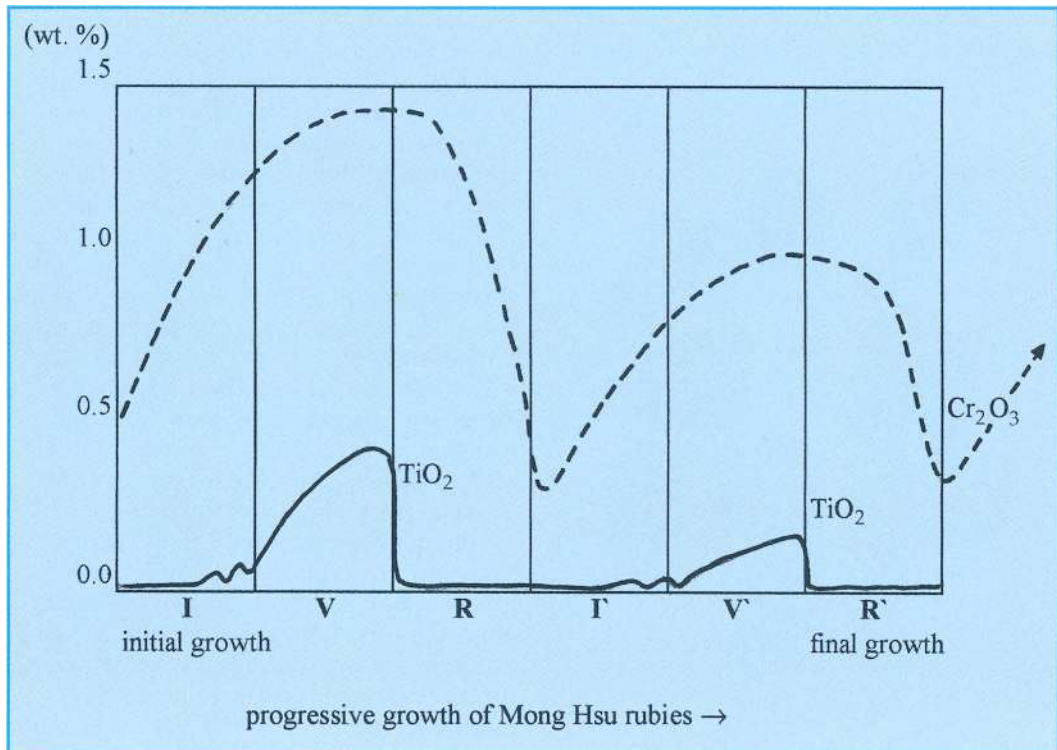


Fig. 12. Zoning patterns in Mong Hsu rubies as schematically reconstructed from colour zoning and chemical profiles; different growth stages are defined as I, V, R and are characterized by a typical trace element pattern and crystal habit (Peretti *et al.*, 1995a). I = alternation of pink sapphire and violet sapphire, V = black sapphire, R = ruby. Note the repeated oscillation of Cr and Ti during the growth history of the Mong Hsu ruby.

the transition of growth phase 'V' to 'R' and the highest vanadium concentrations are found in the 'V' zone (Peretti *et al.*, 1995a).

Solid inclusions in Mong Hsu rubies

Various minerals have been identified as inclusions in the ruby rough; these include layered silicates (white mica, fuchsite, Mg-chlorite, Figure 13), silicates (plagioclase and aluminosilicates), halides (fluorite, Figure 14a-c), oxides (rutile, Figure 15), carbonates (dolomite, see Smith and Surdez, 1994, and Peretti *et al.*, 1995a) and phosphates (apatite, see Smith and Surdez, 1994). Aluminium-hydroxide (boehmite or diaspore) has been identified as a daughter mineral in fluid inclusions and tiny dispersed diaspore inclusions occur elsewhere in the Mong Hsu rubies (Smith, 1995). Fluorite and rutile inclusions have been found in the sequence of crystal growth labelled 'R'. However, because fluorite and



Fig. 13. Mong Hsu rubies intergrown with fuchsite (top three crystals) and light green Mg-chlorite and white mica. Crystal length of lower left ruby is 9 mm (identified by means of XRD and SEM-EDS, see Peretti *et al.*, 1995a).

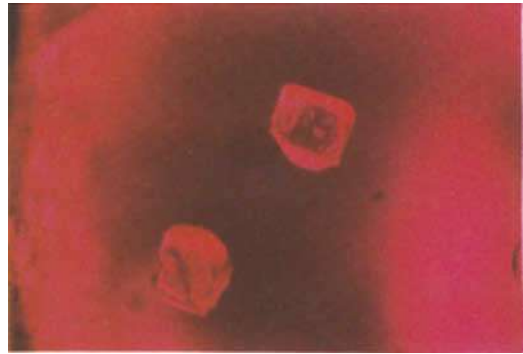


Fig. 14. (a) Fluorite inclusion, 0.2 mm across, lower left of centre occurring in a Mong Hsu ruby in transmitted and reflected light.

rutile are only found extremely rarely, it cannot yet be confirmed that they occur repeatedly in different 'R' zones in the crystals and never in the 'T' and 'V' zones. Fine dispersed diaspore occurs repeatedly in the 'R' to 'T' zones of the crystal (Figure 16 and Smith, 1995). Further study is necessary to indicate whether other hydrous silicates or even submicroscopic fluoride particles are located in these zones also. Examination of the occurrence of diaspore inclusions in the 'V' zones of Mong Hsu rubies is currently under re-examination (C.P. Smith, pers. comm.). Dolomite crystal inclusions occur in large numbers in some Mong Hsu ruby crystals and their distribution does not seem to be restricted to any particular zone.

Fuchsite, Mg-chlorite and white mica have been detected as overgrowths on Mong Hsu rubies or as inclusions in the marginal parts of the rubies, in the outer 'R' to 'T' zones (Figures 13 and 16).

Hlaing (1994) pictured Mong Hsu rubies occurring in a matrix of dolomite, with greenish minerals occurring in the contact zone. Our investigation indicates that these minerals are hydrous silicates which were formed with the ruby in veins within dolomite (Figure 7a).

Fluid inclusion analyses

Fluid inclusions are frequently present throughout a ruby, from core to rim. The

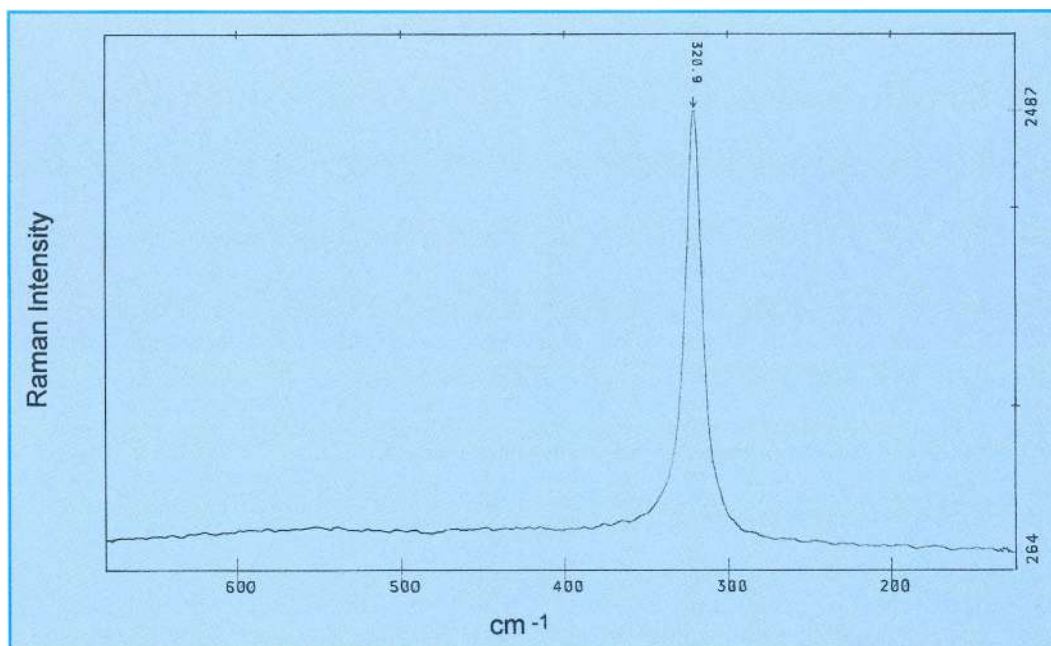


Fig. 14. (b) Raman spectrum of fluorite inclusion obtained from X-Y Dilor multichannel Raman spectrometer, Ar ion laser, 514.5nm, Type 2020 Spectra-Physics, by Dr J. Dubessy, CREGU, Nancy, France. For fluorite identification by Raman spectroscopy, see Griffith, 1987.

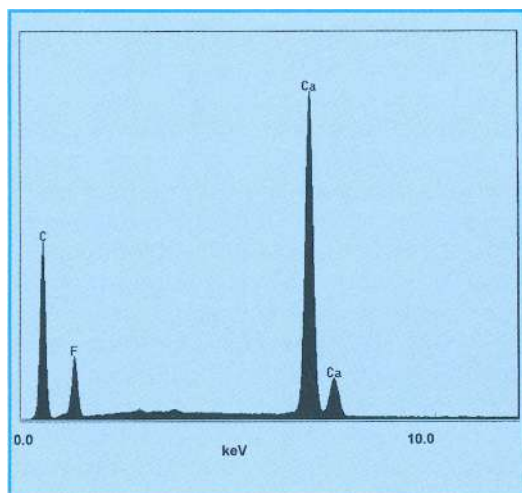


Fig. 14. (c) Analysis of fluorite by energy-dispersive technique on an electron microscope (SEM-EDX). The inclusion was exposed by recutting the ruby (C peak due to carbon coating). Analyst M. Duggelin, University of Basel, Switzerland.

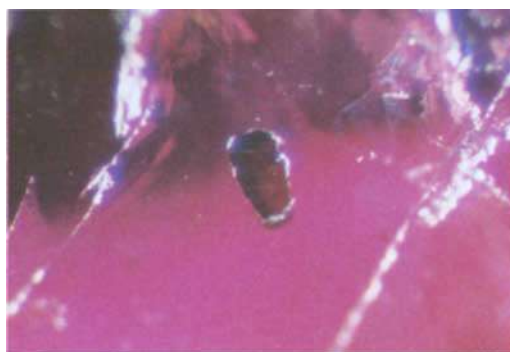


Fig. 15. Microphotograph of a rutile inclusion in a non-heat-treated Mong Hsu ruby. Note that this rutile inclusion is localized in the red portion of the ruby. Identified by Raman spectroscopy based on Capwell *et al.*, (1972). Magnification on 35 mm slide 105x.

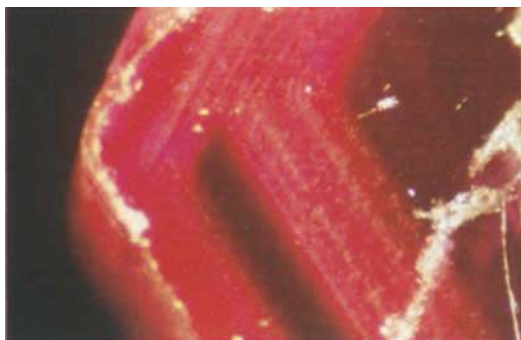


Fig. 16. Microphotograph of a non-heat-treated Mong Hsu ruby with alternating zones enriched in Ti and Cr (violet to black) and Cr (red). Note the presence of whitish reflecting inclusions in reddish zones which are most probably hydroxides such as diaspore but may possibly be hydrous silicates or fluorite. Reflected light. Fibre optic illumination. Magnification on 35 mm slide 60 \times .

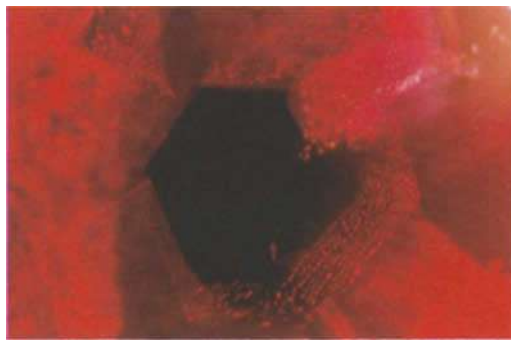


Fig. 17. Healing fissure in a rough ruby from Mong Hsu (not-heat-treated) containing fluid inclusion trails of various generations. Note 'hexagonal outline' of fluid inclusion trail around a black core in a Mong Hsu ruby. The formation of this trail is related to the early growth stage of the Mong Hsu ruby. Transmitted light, magnification on 35 mm slide 60 \times . Photo by Dr E. Gübelin

formation of fluid inclusion trails is related to cracking and subsequent healing of the ruby by fluids during its growth. Figure 17 shows an early formed fluid inclusion trail, which is located in the first 'R' growth phase of the ruby. As a result of continued growth, the secondary fluid trails are completely contained within the ruby core denoted by a hexagonal outline. This type of secondary inclusion is called pseudosecondary as the inclusions represent fluids present during a particular stage of the ruby growth. Different populations of

pseudosecondary fluid inclusions have been detected; they are related to different growth stages of the rubies.

In the single isolated tube shown in Figure 18 there are three phases present at room temperature, including a CO₂-liquid, CO₂-rich multi-volatile vapour and one daughter mineral. The daughter mineral is most probably diaspore. This conclusion is based on the habit and intergrowth within corundum found in other samples which were identified by Raman spectroscopy. In all the fluid inclusion feathers studied, similar liquid/vapour ratios were found, showing that there had been a very homogeneous fluid population. Preliminary measurements on a freezing-heating stage were carried out, in order to obtain information about the chemical composition of the fluid inclusions. Forty-four fluid inclusions were investigated in four different pseudosecondary fluid inclusion trails of different ages. The heating runs showed that the volatile-rich fluid inclusions were homogenizing from the liquid and vapour to the liquid phase, between 24 and 31 $^{\circ}$ C (temperature of homogenization = Th).

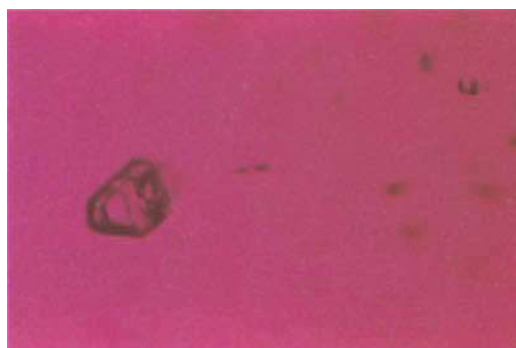


Fig. 18. Isolated fluid inclusion tubes in a secondary fluid inclusion feather of an untreated Mong Hsu ruby with a three phase inclusion (liquid, CO₂-rich multi-volatile vapour and diaspore). Microphotograph taken at approximately 25 $^{\circ}$ C. Transmitted light. Size approx. 20 microns.

Melting of CO₂ at -61 $^{\circ}$ C indicates possible contamination of CO₂ by CH₄, with one or more further components such as N₂ or

H₂S, showing that the concentration of CO₂ is greater or equal to 85 mol.% of the volatile part (Thiery *et al.*, 1994). HF may also be present as a component of the volatile part.

Because of the presence and size of Al-hydroxides as daughter minerals in the fluid inclusions, it was furthermore concluded, that minor contents of H₂O, approximately 5–10 vol.%, were also originally present in the fluids. Thus, in summary, the fluids involved in the formation of Mong Hsu rubies can be described as water-bearing multi-volatile CO₂-rich fluids.

Formation conditions

The minerals found in the alluvial deposits with the rubies, namely andalusite, almandine, white mica and staurolite can provide sensitive information concerning the metamorphic conditions in the Mong Hsu region. For the purpose of estimating these formation conditions, the stability field of almandine, andalusite and staurolite was calculated in the system FeO-Al₂O₃-SiO₂-H₂O using a computer programme of Connolly (1990). The mineral reactions that relate to the formation of almandine, staurolite and andalusite occur above 530°C. The stability field of andalusite limits the possible pressures up to approximately 4.5 kbars. Different micas + quartz are stable assemblages under these *P-T* conditions. The temperature required for tremolite to form in CO₂-rich conditions within dolomite marbles confirms the above temperature estimations (Mercolli *et al.*, 1987).

Further constraints on the formation conditions of the rubies are obtained from the fluid inclusion analyses. From the homogenization temperatures of the fluid inclusions, an isochore (Figure 19) was calculated (Bowers and Helgeson, 1983; based on *T*_h = 24°C, assuming 5 vol.% of H₂O in a CO₂-rich fluid, whose density was 0.728 g/cm³). Other minor components present in the fluids will not considerably alter the position of the isochore. The isochore

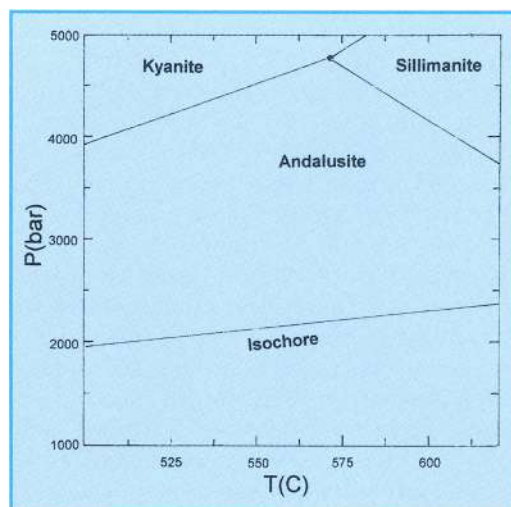


Fig. 19. *P-T*-diagram showing the stability field of andalusite, kyanite and sillimanite derived from thermodynamic data (Connolly, 1990) and the isochore determined from the fluid inclusion analyses (see text). The isochore indicates that the pressure at which the fluid inclusions formed in the rubies was 2.0 to 2.5 kbars at variable temperatures. Such conditions are within the stability field of andalusite.

defines a line in the *P* and *T* diagram (Figure 19) which indicates the possible pressures (*P*) and temperatures (*T*) under which the fluid inclusions were formed. For the estimation of the actual *P* and *T* conditions, either *P* or *T* must be determined independently. At *T* between 500 and 550°C, the likely *P* can be calculated as 2–2.5 kbars.

Titanium mobility

It has been shown by Peretti *et al.* (1995a) that the violet to black zones in the rubies are due to high concentrations of titanium (possibly Fe²⁺-Ti⁴⁺ charge transfer) and chromium. Therefore, in determining how these colour zones were formed, it is essential to know how these transition metals are transported in the fluid systems during ruby formation.

Hydrothermal fluids in the Earth's crust contain a number of complex-forming ligands (or molecules) which are important for the transportation of metals in fluid.

Some of the most important are Cl^- , OH^- , HS^- , HCO_3^- , HSO_4^- , NH_3 , F^- . Different metals tend to form ligands with different anions; Mn^{2+} , Fe^{2+} , V^{3+} , Cr^{3+} , Ti^{4+} for example, may preferably form ligands with F^- , Cl^- or OH^- (Crerar *et al.*, 1985; Brimhall and Crerar, 1987). Variations in temperature and pressure in fluid systems are also important factors. With increasing temperatures and pressures, transition metals will tend to form associated neutral metal-ligand-complexes rather than charged ionic species in the fluids (Seward, 1981).

Variations in the formation conditions such as P , T or chemical composition of the fluids will influence the type of complexes and their concentrations in the fluids.

Depending on the chemical system, the solubility of minerals in such fluids will be different and minerals may precipitate when formation conditions vary. In order to obtain detailed information on the speciation in the fluids, thermodynamic analyses are necessary (see Eugster and Baumgartner, 1987). However, because of the range of minerals occurring in the system related to the rubies, such calculations would have to be carried out in the chemical system *Si-Mg-Ca-Na-K-P-Al-Cr-Ti-V-Fe-B-C-O-H-F-N*. With so many components this is very complex and there are not yet enough thermodynamic data to do this accurately. The elements Si to P are found in the inclusions, Al to Fe are found in the ruby, and B to N occur in the fluid system.

The presence of fluorite inclusions in the 'R' growth phase of the rubies shows that F was present in the Mong Hsu solutions. From the analyses of the fluid inclusions, it was deduced that water was present in the fluids. Because there are rutile inclusions in the rubies, the concentrations of Ti in the fluids can be discussed in terms of the solubility of rutile. It is known from experiments that rutile is highly soluble in H_2O -HF fluids due to the formation of Ti-hydroxyfluoride complexes such as $(\text{Ti}(\text{OH})_{2+x}\text{F}_{2-x})$ (Barshukova *et al.*, 1979;

Ried, 1994). Variations in the solubility of rutile occur with variation in P , T , and HF-concentration in the fluids (Ayers and Watson, 1991; Passaret *et al.*, 1972; Kuznetsov and Panteleev, 1965; Barshukova *et al.*, 1979; Ried, 1994). In the T interval between 500 and 550°C and at P of 2–2.5 kbar, which are the deduced conditions for formation of the Mong Hsu rubies, the solubility of rutile in H_2O -HF-fluids increases strongly with increasing T and HF-concentrations in the fluid with only minor changes caused by variations in P (Ried, 1994). At very high P up to 30 kbars, the critical factors controlling the solubility of rutile are different (Ayers and Watson, 1991) but such conditions did not occur in the Mong Hsu area. Other complexes in the system C-O-H-S-Cl-F (Agapova *et al.*, 1989; Nabisvanet and Omel'chenko, 1986; Bright and Readey, 1987; Tolley and Testerm, 1989) may also be of importance but their presence cannot yet be proposed on the basis of our present analyses of the inclusions.

Discussion

The most characteristic feature of the Mong Hsu rubies is their colour zoning which is related to the trace contents of titanium along with small Fe-concentrations and chromium. The trace element concentrations in the Mong Hsu rubies change in a rhythmic pattern during growth and many ruby samples have Ti-rich zones with increasing Cr-concentrations as shown in Figure 12. The pattern of chemical zoning in the Mong Hsu rubies typically shows a strong phase of Cr-depletion ('T' zone) followed by an increase in Cr and this is followed by increasingly higher concentrations of Ti ('V' zone). At a certain stage of the ruby growth, mostly when the level of Cr is high, the Ti-concentrations in the ruby abruptly change to zero ('R' zone). The abrupt change may occur twice in one crystal and is always correlated with a sharp colour border between sapphire and ruby. The distinct

chemical change (from sapphire to ruby) is accompanied by a crystal habit change, as shown by Peretti *et al.* (1995a). In the different colour zones, some of the larger identifiable crystals were found to be fluorite and rutile and some of the submicroscopic minerals are hydrous (Smith, 1995).

The range of observations concerning inclusions and colour zones are interpreted as due to oscillations in the chemical composition of the fluids present during ruby formation. Indication for such variation in the chemical composition of the fluids was also obtained from the analysis of dravite from Mong Hsu. This mineral is characterized by strong oscillations in both chromium and fluorine. Based on the correlations of these elements in the tourmalines, it is concluded that the fluids which were relatively enriched in chromium were also relatively enriched in fluorine. The importance of fluorine in the system is further confirmed by the high concentrations found in the green tremolite associated with the Mong Hsu ruby and dravite.

Fluid inclusions in the Mong Hsu rubies are water-bearing, CO₂-rich and contain CH₄ with possibly N₂, H₂S and HF. Fluorine is known to play a vital role in the complexing of titanium, particularly at the *P* and *T* likely during formation of the Mong Hsu rubies, forming complexes such as (Ti(OH)_{2+x}F_{2-x}). Thermodynamic studies of the solubility of rutile, at such *P* and *T* conditions have shown that concentrations of Ti in the fluids are strongly influenced by variations in temperature and F-content. Based on experimental data, the range of concentration of Ti in the Mong Hsu fluids could be controlled by oscillations in fluorine content or by variations in temperature. However, no evidence for abrupt changes in temperature has yet been found, but indications for variations in the fluorine content are found in other minerals. So it is very possible that F is the controlling factor in the variable concentrations of Ti in the Mong Hsu rubies.

The reason for such strong variations in

fluid composition in the Mong Hsu area may be related to the infiltration of fluids from metapelites into dolomites. Fluids which are equilibrated with metapelites may be rich in certain elements such as B, C, H, O, S, N, P, F, Al, Mg, Si, Ca, Na and K, as well as Cr, V and Ti, depending on the degree of metamorphism, the rock type and type of complexing agent present in the fluids. If such external fluids come into contact with dolomites, the fluid will re-equilibrate with minerals present in the dolomites and hence dramatic changes in the fluids may be expected (Korzhiński, 1970). It is evident from the data now available from the Mong Hsu area minerals that the chemical conditions of their growth, in particular the compositions of the fluids varied and changed relatively rapidly. Repeated oscillation of Cr and Ti in the rubies as shown in Figure 12 is probably the result of the multiple influx of fluorine-bearing fluids from the metapelitic rocks into the dolomites where they reacted to the different chemical environment by precipitating at various stages hydroxides, hydrous silicates, corundum, fluorite and rutile.

It is thus proposed that *F* concentration of the metasomatising fluids migrating into the host carbonate rock was a major factor in the development of the colour zoning of the Mong Hsu rubies. According to our preliminary simplified model, relatively high F- and OH-concentrations induced complexing of Ti as well as high Ti-concentrations in the fluids. From such fluids Ti ± Fe and Cr-ions were incorporated in the corundum structure (Ti-rich Cr-rich violet to black coloured sapphire = 'V' growth phase). Decreasing F-concentrations, possibly by precipitation of fluorite, induced decreasing Ti-concentrations in the fluids (no Ti-ion incorporation in the corundum structure, medium to high Cr-bearing red ruby = 'R' growth phase). A modification of this model may be presented when more detailed data on the primary deposits become available and

thermodynamic modelling of complex systems becomes more advanced in the future.

Acknowledgements

Many thanks for their support and co-operation to: Mouawad Bangkok Co. (Thailand); Mr R. Kunkongkaphan of Mandalay Co. Ltd, Maesai (Thailand); J. Belmont, K.V.Gems Co. Ltd, Bangkok (Thailand); U Tin Hlaing, Department of Geology, University of Taunggyi (Myanmar); Dr J. Dubessy, CREGU, Raman spectroscopy Laboratory, Nancy (France), Dr K. Schmetzer, Petershausen (Germany), Prof. Guggenheim, M. Düggelin and D. Matthis, Electron Microscopy Laboratory, University of Basel (Switzerland); Dr F. Ried, Prof. T. Seward and Dr J. Connolly, Institute of Mineralogy and Petrography, Swiss Federal Institute of Technology, Zürich (Switzerland); XRD and Electron Microprobe Laboratory, Institute of Mineralogy and Petrography, Swiss Federal Institute of Technology, Zürich (Switzerland) and Prof. Dr E. Gübelin, Lucerne (Switzerland). For suggestions and discussion we thank the reviewer and the Editor.

References

- Agapova, G.F., Modnikov, I.S., and Smariovich, Ye. M., 1989. Experimental study of the behaviour of titanium in hot sulfide-carbonate solutions. *International Geology Review*, 424-30
- Ayers, J.B., and Watson, E.B., 1993. Rutile solubility and mobility in supercritical aqueous fluids. *Contributions to Mineralogy and Petrology*, 114, 321-30
- Barsukova, M.L., Kutznetsov, V.A., Dorofeyeva, V.A., and Khodakovskiy, L.I., 1979. Measurement of the solubility of rutile TiO₂ in fluoride solutions at elevated temperatures. *Geochemistry International*, 16, 4, 41-9
- Bright, E., and Readey, D., 1987. Dissolution kinetics of TiO₂ in HF-HCl solutions. *Journal of the American Ceramic Society*, 70, 12, 900-6
- Brimhall, G.H., and Crerar, D.A., 1987. Ore fluids: Magmatic to Supergene, in Carmichael, I.S.E., and Eugster, H.P., (Eds), Thermodynamic modelling of geological materials: minerals, fluids and melts. *Reviews in Mineralogy*, 17, 235-321
- Bowers, T.S., and Helgeson, H.C., 1983. Calculation of the thermodynamic data for minerals in the system H₂O-CO₂-NaCl on the phase relations in geological systems: equation of state for H₂O-CO₂-NaCl fluids at high pressures and temperatures. *Geochimica Acta*, 47, 1247-75
- Capwell, R.J., Spagnolo, F., and DeSesa, M.A., 1972. A rapid determination of low concentrations of anatase in rutile TiO₂-pigments by Raman spectroscopy. *Applied Spectroscopy*, 26, 5, 537-9
- Connolly, J.A.D., 1990. Multivariable phase diagram: an algorithm based on generalized thermodynamics. *American Journal of Science*, 290, 666-718
- Cotton, F.A., and Wilkinson, G., 1988. *Advanced inorganic chemistry*. John Wiley & Sons, 5th Edn. p. 1455
- Crerar, D., Wood, S., Brantley, S., and Bocarsly, A., 1985. Chemical controls on solubility of ore forming minerals in hydrothermal solutions. *Canadian Mineralogist*, 23, 333-52
- Deer, W.A., Howie, R.A., and Zussmann, J., 1986. *Rock-forming minerals*. Vol. 1B, 2nd Edn. Disilicates and Ring Silicates. Longman Scientific & Technical, Harlow
- Earth Sciences Research Division, 1977. *Geological map of the Socialist Republic of the Union of Myanmar 1: 1 000 000*, with brochure, 22pp
- Eugster, H.P., and Baumgartner, L., 1987. Mineral solubilities and speciation in supercritical fluids, in Carmichael, I.S.E., and Eugster, H.P. Eds. Thermodynamic modelling of geological materials: minerals, fluids and melts. *Reviews in Mineralogy*, 17, 367-98
- Griffith, P., 1987. Advances in the Raman and infrared spectroscopy of minerals, in Clark, R.J.H., and Hester, R.E. (Eds), *Spectroscopy of Inorganic-based Materials*, John Wiley & Sons Ltd, p. 137
- Hlaing, U.T., 1991. A new Myanmar ruby deposit. *Australian Gemmologist*, 17, 12, 509-10
- Hlaing, U.T., 1993. Mong Hsu update. *Australian Gemmologist*, 18, 5, 157-60
- Hlaing, U.T., 1994. A trip to Mong Hsu. *JewelSiam*, 5, 1, 54-7
- Hlaing, U.T., 1995. New extension of Mong Hsu ruby deposit. *Australian Gemmologist*, 19, 51
- Ho, H., 1993. Burma's Mong Hsu mine. Rediscovered, heat-treated rubies comparable to Mogok quality. *Jewelry Newsline*, 1, 2, 1 and 8
- Hunstiger, C., 1990. Darstellung und Vergleich primärer Rubinvorkommen in metamorphen Muttergesteinen. Petrographie und Phasenpetrologie. Teil III. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 121-45
- Jobbins, E.A., 1992. A taste of new gem deposits in South East Asia. *Gem and Jewellery News*, 1992, 2, 1, 12
- Korzhinsky, 1970. *Theory of metasomatic zoning*. Oxford University Press, London, pp. 1-159
- Kuznetsov, V.A., and Panteleev, V.V., 1965. Hydrothermal synthesis of rutile. *Physics Crystallography*, 10, 3, 369
- Kane, R.E., and Kammerling, R.C., 1992. Status of ruby and sapphire mining in the Mogok Stone Tract. *Gems and Gemology*, 28, 3, 152-74
- Laughter, T.L., 1993. Mong Hsu mix-up. *JewelSiam*, 4, 5, 34-7
- Mercolli, I., Skippen, G., and Trommsdorff, V., 1987. The tremolite veins at Campolungo and their genesis. *Schweizerische Mineralogische und Petrographische Mitteilungen*, 67, 75-84
- Nabivanets, B.I., and Omel'chenko, Yu.A., 1986. Carbonate-complexes of titanium (IV) in solution. *Zhurnal Neorganicheskoi Khimii*, 31, 356-9 (translated)
- Passaret, M., Toudic, Y., Regreny, A., Aumont, R., and Bayon, J.F., 1972. Recrystallisation de TiO₂, GeO₂, SiO₂, Si₃₋₄GeO₂

- en solutions hydrothermal fluorées. *Journal of Crystal Growth*, 13–14, 524–79
- Peretti, A., Schmetzer, K., Bernhardt, H.-J., and Mouawad, F., 1995a. Ruby from Mong Hsu. *Gems and Gemology*, XXXI, 2–26
- Peretti, A., Schmetzer, K., Bernhardt, H.J., and Mouawad, F., 1995b. Rubine aus Mong Hsu, Myanmar (Burma), ein neues Vorkommen von kommerzieller Bedeutung (Teil 1). *Goldschmiede und Uhrmacher Zeitung*, 9, 105–13
- Peretti, A., Schmetzer, K., Bernhardt, H.J., and Mouawad, F., 1995c. Rubine aus Mong Hsu, Myanmar (Burma), ein neues Vorkommen von kommerzieller Bedeutung (Teil 2). *Goldschmiede und Uhrmacher Zeitung*, 11, pp. 94–104
- Ried, F., 1994. Titanmobilität: Metasomatische titanreiche Adern am Kontakt von Dolomitmarmoren zur Bergeller Intrusion. PhD thesis, No. 10637, ETH (Swiss Federal Institute of Technology) Zürich, pp. 1–152
- Seward, T.M., 1981. Metal complex formation in aqueous solutions at elevated temperatures and pressures, in Richard, D., and Wickman, R., Chemistry and geochemistry of solutions at high temperatures and pressures. *Physics and Chemistry of the Earth*, Pergamon Press, New York, pp. 113–32
- Smith, C.P.S., and Surdez, N., 1994. The Mong Hsu ruby: a new type of Burmese ruby. *JewelSiam*, 4, 6, 82–98
- Smith, C.P.S., 1995. Contribution to the nature of the infrared spectrum for Mong Hsu rubies. *Journal of Gemmology*, 24, 5, 321–35
- Thailand Stone Market Report. Mong Hsu supply down. Emerald trade picking up (1995): *JewelSiam*, June–July, p. 53
- Thiery, R., Van den Kerkhof, A.M., and Dubessy, J., 1994. X properties of CH₄-CO₂ and CO₂-N₂ fluid inclusions: modelling for T<31°C and P<400 bars. *Eur. J. Mineral.*, 6, 753–71
- Trommsdorff, V., and Skippen, G., 1986. Vapor loss ('Boiling') as a mechanism for fluid evolution in metamorphic rocks. *Contributions to Mineralogy and Petrology*, 94, 317–22
- Tolley, W.K., and Tester, L.S., 1989. Supercritical CO₂ and solubility of TiCl₄. United States Department of the Interior. Bureau of Mines, Report Investigations No. 9216, pp 1–10

WORLD EDUCATION IN GEMS AND DIAMONDS

Worldwide Allied Teaching Centres

Learn about precious stones and how to identify them – gain confidence to buy and advise
Study diamonds and learn how they are graded – gain further insight and knowledge

Home Study Correspondence Course

Personal tutor

Flexible study programme – start at any time

Examinations

Held at centres throughout the world during January and June each year

For details apply to the Education Department, GAGTL,
27 Greville Street, London EC1N 8SU

Telephone: 0171-404 3334 (international +44-171 404 3334)

Fax: 0171-404 8843 (international +44-171 404 8843)

Notes from the Gem and Pearl Testing Laboratory, Bahrain – 5

Ahmed Bubshait and Nick Sturman

Abstract

Items of interest seen within the jewellery trade in Bahrain are discussed. An amber box and composite amber and plastic worry beads are described, and the problem of fissure filling is discussed, with a note about a fracture-filled emerald.

Amber box

Figures 1 and 2 show an amber box submitted for testing by a local customer. The box was being offered for sale as amber by a 'Russian' client.

On preliminary examination the majority of pieces used to construct the box appeared to be amber and this was duly confirmed by basic gemmological testing. However, the interesting point about this piece was that the orange-brown inlaid rectangular area and the scrolled area of the same colour on the lid of the box, proved to be fashioned from pressed amber. Proof that these two areas were not natural amber was obtained by using polarized light to inspect the internal structure under the microscope. Between cross polars a typical pattern of interference colours (Bubshait and Sturman, 1993) was seen and swirly smoke-like inclusions con-



Fig. 1. Side view of the amber box.

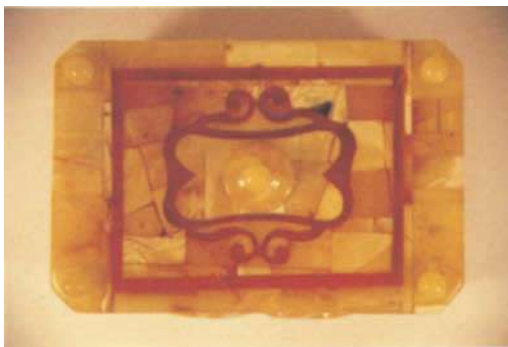


Fig. 2. View of the lid with darker orange-brown rectangular and central scrolled pressed amber areas showing.

sisting of minute brown to black impurities were seen in places; the latter structure is typical of some types of pressed amber. Although identification was fairly straightforward, it was made harder because the maker of the box had mixed a reddish-brown dye with the adhesive to fix the pressed amber pieces in position. This layer prevented most of the light from passing through the pressed amber freely and it was only in the patches where there were bubbles in the adhesive that we could observe the interference pattern between crossed polars and look at the inclusions with greater clarity. These bubble areas, being free of the reddish-brown dye, showed the true paler yellow colour of the pressed amber used and allowed the light to pass through with little obstruction.

Plastic and amber worry beads

Worry or prayer beads are widely used in the Middle East. Traditionally they were used in mosques and were made up of either 99, 66 or 33 beads, strung with two spacers and a long cylindrical terminating 'bead'. The number of beads corresponded to the number of times short Arabic phrases had to be recited after prayer. The Catholic faith's rosary beads are used in a similar fashion.

Today most strings of worry or prayer beads consist of 33 beads and are mainly

used as fashion accessories. The bead in Figure 3 was one of 33 in a row of worry beads that we were asked to examine recently. The beads were being offered as amber and our customer decided to have them checked. Although not a member of the trade, he was aware that some materials sold as amber are not genuine and they looked suspicious to him. The identity of the beads was partly correct when described as amber but, as can be seen from the photograph, the beads used in this particular set of worry beads look 'wrong' on first impression and indeed they are. Each bead is actually made up of amber pieces, embedded within a plastic bead frame and clearly shows a central line (typical of some pieces of moulded plastic and glass) where the two adjacent pieces of plastic meet.

We have encountered worry beads such as these before, but it is the first time we have had the opportunity to photograph a set.

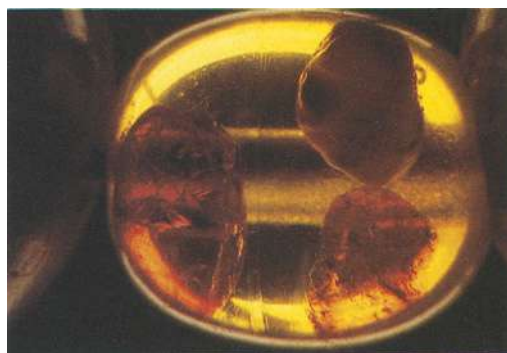


Fig. 3. One of the plastic beads with included amber pieces.

A resin-filled natural emerald

An ongoing concern in the international jewellery trade today is the fracture filling of various stones (Levy, 1995). Diamonds, corundum (mainly ruby) and emerald are the main stones to be treated in this way. However, some in the jewellery trade would appear to consider emerald separately and argue that oil (generally accepted by all) or resin (not so widely

accepted) should both be considered as accepted practices. On the other hand, some say any filling should be disclosed. The trade generally agrees that filled fractures and cavities in stones other than emerald should be disclosed. It is good to see that this problem is being addressed at various international meetings and whatever the reader's personal opinion, this will continue to be a matter for discussion (*Gem and Jewellery News*, 1993–94) until a firm stance is taken. Valid points have been made for and against disclosing oiled and resin-filled fractures in emeralds.

Customers have the right to know and decide for themselves. In practice, many think that when they purchase a stone they are being told everything relevant to them at the time (*Gem and Jewellery News*, 1993). Should all filled stones, no matter what the filler is, be openly disclosed to customers so that they can decide for themselves? If you were the customer, would you like to be told the 'whole truth and nothing but the truth' wherever possible? In the laboratory, it is not yet possible to *prove* the identity of a specific filler, such as Opticon resin No. 224 (even with infrared spectrometers and other sophisticated equipment available to some of us) without destructive testing but it is possible to indicate in general terms whether oil or resin is present.

Recently a number of resin-filled natural emeralds have been examined in the laboratory and, although most of the stones appear to be of Colombian origin and show weak to distinct signs of resin filling, one stone described here is possibly of 'Russian origin' (customer's opinion) and contained quite distinct evidence of filling. The colour flashes within the fractures were very pronounced (even vivid at some angles) and the filler was easily visible throughout the fractures.

We believe that this particular stone was filled by a resin other than Opticon 224, possibly Araldite No. NU471, Dobeckot No. 505 or Novogen No. P40 (Nassau,



Fig. 4. The distinct orange colour seen in the fractures of a resin-treated emerald.



Fig. 5. The blue colour seen in the fractures of the same emerald as Fig. 4.

1994), first because the colours were extremely strong, comprising orange (Figure 4) which was the most distinct, blue (Figure 5) and yellow and purple (depending on the angle); and secondly due to its unusual reaction when examined under both long- and short-wave ultraviolet light. A fracture running parallel to the table fluoresced a moderate yellow/white and exhibited a fairly persistent yellowish phosphorescence when exposed to SWUV light, whilst another fracture produced a strong yellow/white fluorescence and a very short-lived phosphorescence under LWUV. This is the first time resin fillers exhibiting these fluorescent characteristics have been observed in this laboratory. Because no 'sweating' was observed from any of the surface-reaching fractures in the

stone, the filler in this stone was probably sealed in with a hardener. A Colombian stone examined earlier showed the more characteristic resin-filled features and also showed pronounced 'sweating' from some of its surface-reaching fractures, so therefore this stone probably had no hardener applied to it. As part of its disclosure policy, the Bahrain laboratory adds a final explanatory paragraph on emerald reports, to inform customers about the filling of fractures in emeralds with various substances. However, because precise identification of the fillers is not yet feasible, we also give the customer a verbal opinion (when all agree) as to whether the filling is a natural oil/resin or an artificial epoxy type resin. The two customers who owned the stones mentioned above chose to act on both the laboratory report and verbal opin-

ion. One chose not to purchase the stone (he would have done so if it were oiled and not filled with artificial resin) and the other customer purchased the resin-filled stone to see whether he could sell it as a treated emerald in the market. In both cases the customer had all the relevant laboratory information available and the decisions were made accordingly.

References

- Bubshait, A., and Sturman, N.P.G., 1993. Notes from the Gem and Pearl Testing Laboratory, Bahrain - 2. *Journal of Gemmology*, 23, 7, 398-401
- Gem and Jewellery News*, 1993-94. Trade notes and letters in issues 2, 2, to 3, 3
- Gem and Jewellery News*, 1993. Treated gems. 2, 2, 20
- Levy, H., 1995. Around the trade. *Gem and Jewellery News*, 4, 4, 51-2
- Nassau, K., 1994. *Gemstone enhancement* (2nd edn). Butterworth-Heinemann Ltd, London. pp 64-6

Gemmological Association and Gem Testing Laboratory of Great Britain

✱ Gem Tutorial Centre ✱

YOUR GAGTL HOME STUDY RE-TAKE PROGRAMME

This re-take programme provides you with a second chance to gain your Diploma in Gemmology by continuing with the help of your correspondence tutor.

You will be issued with a new set of homework assignments

Preliminary retake: £385.00

Diploma retake: £515.00

Start whenever you like - all examinations are available twice a year in January and June. Fee includes an appointed correspondence tutor for a maximum period of two years for each part of the course, and examination fees.

Telephone 0171-404 3334 or Fax 0171-404 8843 and ask us for latest information and details or write to GAGTL, 27 Greville Street, London EC1N 8SU

The gems of Mont Saint-Hilaire, Quebec, Canada

Willow Wight

Research Division, Canadian Museum of Nature, Ottawa, Ontario, Canada

Abstract

The quarries at Mont Saint-Hilaire, Rouville County, Quebec, have been visited by mineral collectors for over 30 years. The total number of minerals found there stands at over 300, with 27 new species described from the locality. Gems have been cut from at least 28 mineral species. Since many of the minerals are rare and difficult to iden-

tify even as crystals, there are significant problems in identifying the gems. There has also been confusion about which gems come from Mont Saint-Hilaire, and this has been exacerbated by an increasing demand and thus increasing prices put on these rare gems. Two tables list and describe all gems documented from Mont Saint-Hilaire as of April 1995.

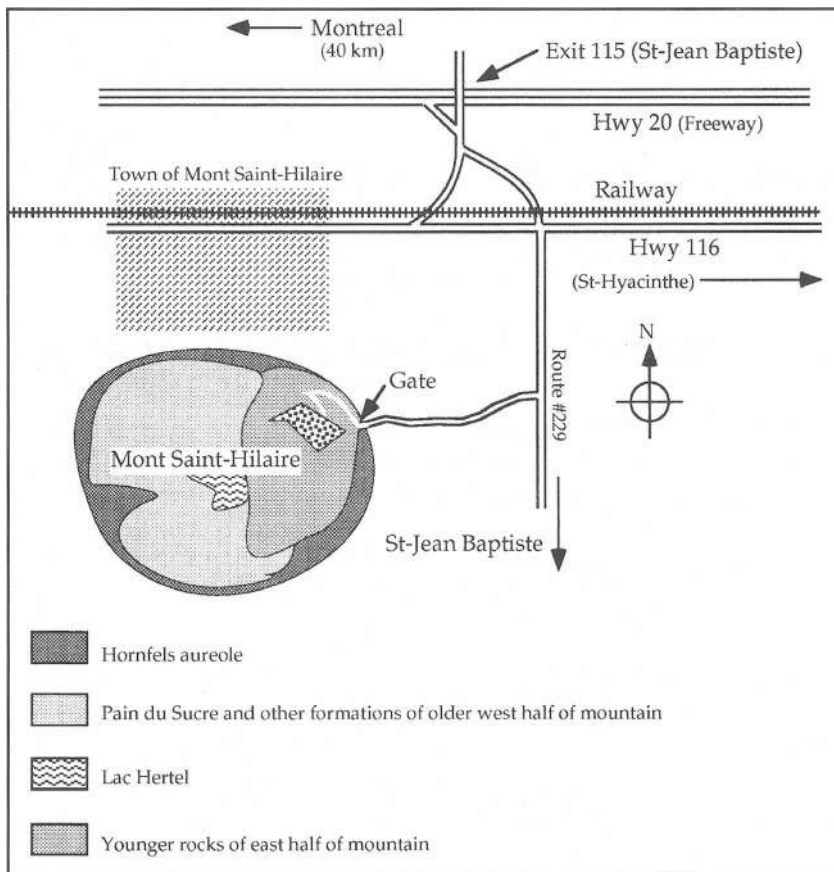


Fig. 1. Locality map of Mont Saint-Hilaire quarries. Computer graphic by Q. Wight.



Fig. 2. Mont Saint-Hilaire from the north on highway 20, 28 May 1995. *Photo: Q. Wight.*



Fig. 3. Quarries on north-east side of Mont Saint-Hilaire from highway 229, 6 August 1994. *Photo: Q. Wight.*

Introduction

The quarries of Mont Saint-Hilaire, Quebec, have been a Mecca for mineral collectors, especially micromounters, for over thirty years. The number of minerals found at the locality now stands at over 300, with minerals new to science being described regularly. Mont Saint-Hilaire is the type locality for 27 mineral species, and there are still unknown species to be identified and described.

This large number of minerals, many of which are rare or unique, is even more remarkable considering the small size of the locality. The quarried area of Mont Saint-Hilaire is relatively small, a mere 30 or so hectares (<0.5 km²). In contrast, the 340 minerals at the classic mineral locality of Franklin/Sterling Hill, New Jersey, came from mines spanning an area of at least 7 km².

Mont Saint-Hilaire lies about 40 km east of Montreal in Rouville County; it is one of

the ten Monteregian Hills (see locality map, Figure 1). About 350 m in height and about 3km in diameter, the roughly circular pluton rises abruptly above the surrounding flat, St Lawrence lowlands (Figure 2). The nearby village on the bank of the Richelieu River is also called Mont Saint-Hilaire. At one time there were three adjoining quarries on the north-east face of the mountain – the Poudrette on the east and the Demix, formerly known as the Desourdy and Uni-Mix quarries, on the west – operating to provide crushed rock for construction and road work. Steady expansion over the years has resulted in one large pit, operated today by R. Poudrette Inc. (Figures 3 and 4).

Access for collecting in the quarry is strictly controlled, with regularly scheduled field trips being organized by the Club de Minéralogie de Montréal (usually five trips each summer).

Several comprehensive articles on Mont



Fig. 4. Looking into the south corner, 6 August 1994. Field trips are arranged for mineral collectors five times each year. Only about one-quarter of the quarry is visible here. Photo: W. Wight.

Saint-Hilaire and its minerals have been published, notably Horvath and Gault (1990), and Wight and Chao (1986, 1995). The book *Monteregian Treasures* was produced in 1989 by Mandarino and Anderson. References cited in these works will not usually be repeated here.

Geology

Mont Saint-Hilaire is a small, alkaline complex that intruded the Palaeozoic rocks of the St Lawrence Lowlands during the Cretaceous period; there were probably three intrusions, between 134 and 120 million years ago. Some indication of the geology is shown in Figure 1. The quarries are on the eastern side of the mountain, where the dominant rocks are nepheline syenite and sodalite syenite.

The complex contains some rare agpaite rocks, those in which the alkali content is very high relative to aluminium. It is thought that the development of so many rare minerals at Mont Saint-Hilaire is related to the high alkalinity that allowed the liquid magma to incorporate more of the zirconium, titanium and rare earth elements that have been found in so many of the species. Furthermore, the material that makes up such rocks may have originated at great depth (perhaps 70 km) in the crust of the Earth, where the ratios of the elements to each other are not necessarily the same as those found in the relatively lighter rocks of the continental material above. The abundance of sodalite has been attributed to the reaction of the rising East Hill suite magmas with chlorine-bearing brines. Further geological information can be obtained from Horvath and Gault (1990), Wight and Chao (1995) or references in those comprehensive articles.

The minerals for which Mont Saint-Hilaire is famous occur in a large number of geological environments. Collectors refer to several readily recognizable host rocks, such as unaltered pegmatites, altered pegmatites, miarolitic cavities in nepheline syenite, marble xenoliths,

sodalite xenoliths, igneous breccias, hornfels breccias and so on, in the three main rock types in the quarry – nepheline syenite, sodalite syenite and hornfels. Different environments, of course, foster the growth of different minerals.

History

When mineral collectors first began to visit the quarries in the early 1960s, Frank Melanson found an unusual orange-pink crystal about 5 cm long. Since he could not identify it, he took it to Dr Guy Perrault of the Ecole Polytechnique in Montreal. Perrault identified it as serandite, a rare sodium manganese silicate, previously found only as cleavage fragments from the island of Rouma, Los Archipelago, Guinea, off the west coast of Africa. Since then serandite has been found in other localities, but the crystals from Mont Saint-Hilaire are the best in the world (Figures 5 and 6). They have been found in sufficient quantities for almost every mineral museum in the world to have one. Three major finds in 1972, 1981 and 1988 are chronicled in detail in Horvath and Gault (1990).

The unusual and very attractive orange-pink colour of serandite led to the preparation of a cabochon by Sam Ronson of Montreal about 1964. Melanson kindly loaned this, the first polished serandite, for a photograph (Figure 7).

The first gems from Mont Saint-Hilaire

Over the years 'Canada's Magic Mountain' has become of great interest also to collectors of rare gemstones. This is partly because of the promotion of Canadian gemstones by the Canadian Museum of Nature (CMN). In 1975–76, the then National Museum of Natural Sciences mounted a temporary exhibit called 'Gemstones', consisting of 18 cases of minerals and gems, which was shown in Ottawa and then in Toronto at the Royal Ontario Museum (ROM). One case featured Canadian gemstones and included



Fig. 5. Superb large serandite crystal (CMN#37124; 22 x 10 cm) with the typical intense orange-pink colour, found in 1972. *Photo: CMN, G. Robinson.*



Fig. 6. Particularly lustrous pink serandite crystals were found in 1988 (CMN#54046; 6.0 x 3.5 cm). *Photo: CMN, G. Robinson.*



Fig. 7. The first polished serandite cabochon, 22.3 x 8.2 x 3.5 mm, loaned by F. Melanson. *Photo: Q. Wight.*

the four minerals from Mont Saint-Hilaire that had been faceted at that time: serandite, sphalerite, willemite and natrolite (Figure 8).

The serandite gem, on loan from the ROM, was the first faceted serandite. The 3.14 ct salmon-coloured, translucent, step-cut stone was faceted by G. Grant Waite of Toronto in 1974 from rough purchased by the ROM from Bernard Beaudin in 1973.

The natrolite and willemite in the exhibit were faceted from transparent pieces in the collection of the CMN by an amateur faceter, E.G. Letourneau of Ottawa. The 8.70 ct natrolite gem, largest of three that he produced in 1976, has still not been surpassed in beauty, although there are now slightly larger natrolite gems in the National Gem Collection. The blue willemite at 6.75 ct is the largest known; it is unlikely that any more will be found. Willemite of this blue colour is not found elsewhere (see Figures 9 and 10).

The sphalerite, a light green brilliant weighing 1.61 ct, was the gift of Wilfrid Jonasch of Montreal, who collected and faceted it himself.

The search for serandite

Serandite provided the same impetus for gem collectors as for mineral collectors.



Fig. 8. The first gems from Mont Saint-Hilaire exhibited by the CMN in 1976. Back, left to right, serandite (ROM; 3.14 ct), sphalerite (CMN#20045; 1.61 ct), willemite (CMN#20353; 6.75 ct) and in front, natrolite (CMN#20238; 8.70 ct). Photo: CMN, G. Runnells.

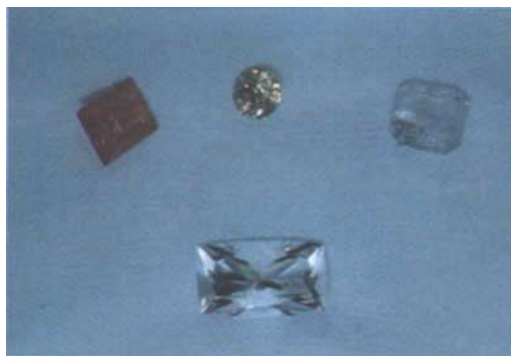


Fig. 9. Natrolite (CMN#20238; 8.70 ct) faceted from Museum rough in 1976 by E.G. Letourneau in a modified gavotte cut that brings out the best from this usually undistinguished looking material. Photo: CMN, W. Wight.



Fig. 10. Blue willemite (CMN#20353; 6.75 ct) was found only rarely in the 1970s at Mont Saint-Hilaire. This is the first and still largest gem, faceted in 1976 by E.G. Letourneau. Photo: CMN, W. Wight.

After the exhibition of the four gems in 1976, interest gradually grew with almost every collector looking for transparent pieces of the very attractive, orange-pink serandite. Some pieces tend to be more pink; others more orange. The CMN purchased its first serandite gem in 1981, a transparent orange beauty of 0.95 ct (Figure 11). Other stones were later faceted and cabochon-cut from Museum-collected rough by Art Grant. The National Gem Collection now has five gems, four being transparent, and one an exceptional orange translucent, pear-shaped cabochon of 19.65 ct (Figure 12).

A faceted serandite of 14.62 ct is known to exist in a private collection. Recent references to the species include Henn *et al.*, (1991) and Koivula *et al.*, (1992a and b).



Fig. 11. Faceted serandite acquired by the CMN in 1981, the first of several (CMN#20852; 0.95 ct). Photo: CMN, W. Wight.



Fig. 12. A large cabochon (CMN#22137; 18.65 ct) showing the pinkish orange colour typical of the best serandite, cut from rough already in the CMN by A. Grant in 1981. Photo: CMN, W. Wight.

Historical development

One of the important aspects of the production of gems from Mont Saint-Hilaire has been the role of the amateur faceter. The first gems were all cut by 'amateurs', who took the time to study these minerals, and found the proper angles and designs that would bring out their beauty. Skill and patience in the actual faceting are also very important, since many of these gemstones are soft, have cleavages and are difficult to polish. Special techniques were developed to facet water-soluble minerals such as villiaumite.

The great success in 1976 of Ernie Letourneau in providing attractive gems from the natrolite and willemite rough in the Museum's collection led to consideration of other possible gems from Mont Saint-Hilaire. The light blue colour of the willemite was attractive (and very unusual for willemite), but the natrolite gem, a modified gavotte cut, was truly surprising. It is remarkable that Letourneau was able to produce a beautiful gem (Figure 9) with a very bright appearance from natrolite, a colourless mineral with a very low refractive index, cleavages and a hardness of only 5. Attention to the proper angles and proportions are essential when working with such materials. Most natrolite gems appear dull and uninteresting.

Wilfrid Jonasch of Montreal faceted the first sphalerite gem on his own. He then produced four siderite gems in 1984 from Museum rough (Figure 13), the largest two weighing 2.25 and 2.60 ct.

Arthur Grant of Martville, NY, was at that time an amateur faceter very interested in soft and unusual gem materials (Wight and Wight, 1989). Over the years, his skills added villiaumite (1981) (Figures 14 and 15), rhodochrosite (1982) (Figures 16 and 17), catapleite (1983), fluorite (1983), analcime (1987), microcline (1987) and narsarsukite (1987) to the National Gem Collection. Villiaumite (sodium fluoride) was a special challenge; it is water

soluble and required the development of special faceting techniques.

Gradually gem collectors interested in oddities learned about Mont Saint-Hilaire, and the demand for the faceted gems increased as had the demand for its rare and unusual minerals. Gems from Mont

Saint-Hilaire now have a profitable, if limited, market. Table I gives details of the 28 minerals which we know to have been cut and polished as of April 1995. Table II gives a description of the gemstones with their properties and references that may be helpful in identification.

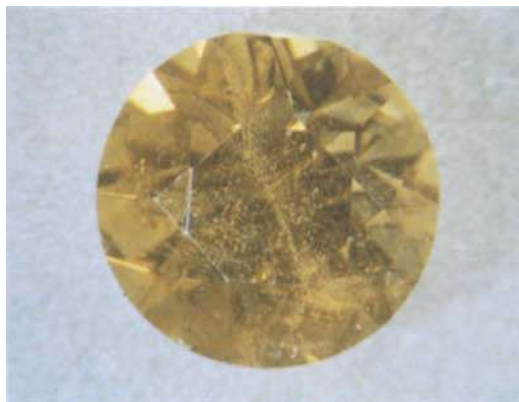


Fig. 13. Siderite (CMN#22201; 2.60 ct) faceted from rough already in the CMN in 1984 by W. Jonasch. *Photo: CMN, W. Wight.*



Fig. 15. Villiaumite (CMN#21544; 0.92 ct) faceted by B. Wilson in 1993. The first villiaumite was faceted from rough already in the CMN in 1981 by A. Grant (CMN#22134; 0.27 ct). *Photo: CMN, W. Wight.*



Fig. 14. Typical red cubes of villiaumite in white sodalite/analime *Specimen and photomicrograph, Q. Wight.*

Table I: Some documented gems from Mont Saint-Hilaire

<i>Mineral</i>	<i>Gem sizes</i>	<i>Dates first cut¹</i>	<i>Remarks¹</i>
Albite	1 ct light pink	1987 (GH rough 1985)	only stone known Apr 1995
Analcime	0.82 ct 1 to 4.98 ct	1987 (CMN rough)	AG (list 95: 10 stones) BW 1994: 4.98 ct
Apophyllite	1.13 ct	1994	only stone known Apr 1995
Cancrinite	mauve cab 3.43 ct	1994 (CMN rough)	only stone known Apr 1995
Carletonite	0.04 to 1.48 ct	1988 (GH rough)	AG (list 95: 6 stones)
Catapleiite	0.45 to 2.48 ct	1983 (CMN rough 1972)	AG (list 95: 27 stones); BW 91
Cryolite	0.20 to 2.25 ct	1991	AG (list 95: 11 stones)
Eudialyte	0.19 ct	1991 (GH rough)	only stone known Apr 1995
Fluorite	G 0.38 ct; V 1.06, 1.23 ct; C 2.94 ct; lt B 3.47, 14.6 ct; lt G 26.90 ct	1983 green (CMN rough acquired 1972)	AG (list 95: 6 stones) BW 1992
Kogarkoite	0.34 ct	1993 (GH rough 1992)	only stone known Apr 1995
Leifite	0.72 to 2.82 ct	1992 (GH rough found 1989)	AG (list 95: 7 stones) BW (2 stones) only stones known Apr 1995
Leucophanite	lt G 1.49 ct; Y 0.30, 0.47 ct	1987 (GH rough found 1987)	AG (list 95: 3 stones) only stones known Apr 1995
Manganotychite	lt Y 0.16 to 0.32 ct; lt O 0.47 ct	1993 (GH rough found Sept 1992)	AG (list 95: 5 stones) only stones known Apr 1995
Microcline	0.56 ct; lt grey cab 16.26 ct	1987 (CMN rough collected 1984)	AG; BW cab only stones known Apr 1995
Narsarsukite	0.14 to 0.32 ct	1987 (CMN rough collected 1984)	AG (list 95: 3 stones) only stones known Apr 1995

Table I continued

Natrolite	8.70, 3.60, 3.05, 9.65; up to 10.60 ct	1976 (CMN rough collected 1973)	EL 1976 (3 stones) AG (list 95: 8 stones); BW
Pectolite	0.85 ct	1992 (GH rough)	only stone known Apr 1995
Quartz	0.22 ct	1994	AG (list 95: 1 stone)
Remondite-(Ce)	1.72 to 6.62 ct; 7.27 ct	1992 (GH rough 1991)	AG (list 95: 30 stones) BW 95
Rhodochrosite	0.21 to 1.16 ct; 3.91 to 5.66 ct	1982 (CMN rough 1972)	AG BW 95 (4 stones)
Serandite	0.95 to 2.80; cabs 6.40 to 18.65; others up to 14.62 ct	1964 cabochon 1974 Waite/ROM; 1981 (CMN rough)	AG (list 95: 37 stones)
Shortite	0.35 to 3.52 ct	1991 (CMN rough 1991)	AG (list 95: 16 stones)
Siderite	0.70, 0.95, 2.25, 2.60 ct	1984 (CMN rough 1972)	only stones known Apr 1995
Sodalite	cab; 0.12 ct transparent B	1978 cab 1994	BW 1994
Sodalite var. Hackmanite	3.32, 9.77 ct; up to 15.33 ct	1988 (GH rough found 1988)	AG (list 95: ~90 stones)
Sphalerite	G 1.61 to 24.74 ct; dk R 6.03 ct; dk G 42.16, 55.62 ct; Y 25.45 ct	1976 (WJ) 1984 (from CMN rough collected 1983)	AG (list 95: 31 stones) MG 1991 (red) BW 1994 (B-G) and others
Ussingite	0.11, 0.53 ct	1995 (GH rough)	AG (list 95: 2 stones) BW 1995 (3 small) only stones known Apr 1995
Villiaumite	0.27 to 35.0 ct 5.01 tricolour (1988)	1981 (CMN rough acquired 1972)	AG (list 95: 19 stones)
Willemite	0.30, 1.02, 6.75 ct	1976 (CMN rough collected 1971-72)	EL (6.75 ct, 1976) AG (list 95: 2 stones 1987) only stones known Apr 95

¹Faceters; AG = Arthur T. Grant; BW = Bradley S. Wilson; EL = Ernest G. Letourneau; MG = Michael Gray; WJ = Wilfrid Jonasz

Collections: CMN = Canadian Museum of Nature; GH = Gilles Haineault

Abbreviations used for colour description: V = violet; B = blue; G = green; Y = yellow; O = orange; R = red; C = colourless; W = white; lt = light; dk = dark

Table II: Description and properties of gemstones from Mont Saint-Hilaire

Mineral	Description ¹	Optical Properties ²	Physical Properties ²	Composition and Crystal System; Absorption Spectrum ⁰	Ref. ³
Albite	light pink (colourless)	B(+) $\alpha = 1.528$ $\beta = 1.532$ $\gamma = 1.539$	H: 6 to 6.5 SG: 2.59 Cleavage: perfect Fluoresces cherry R in SWUV	NaAlSi ₃ O ₈ Triclinic	(1) (2)
Analcime	colourless Lustre: vitreous but less so than garnet	I n = 1.487 mean (meas.) (range 1.486 to 1.489) (may appear anisotropic)	H: 5 to 5.5 SG: 2.23 (meas.) May fluoresce G LW & SW UV	Na(AlSi ₂ O ₆ ·H ₂ O) Cubic	(1) (2)
Apophyllite (probably fluorapophyllite)	colourless (light grey, light green, light yellow, light pink) Lustre: vitreous, pearly on cleavage	U(+) $\omega = 1.530-1.536$ $\epsilon = 1.532-1.538$ DR 0.001-0.002; may appear isotropic	H: 4.5 to 5 SG: 2.4 Cleavage: perfect May fluoresce Y LW, bright G-SWUV	KCa ₄ Si ₈ O ₃₀ (F,OH)8H ₂ O Trigonal	(1) (2)
Cancrinite	light, greyish purple (yellow to orange, violet)	U(-) $\omega = 1.512$ $\epsilon = 1.489$ (meas.) Opaque to transparent	H: 5 to 6 SG: 2.45 (meas.) Cleavage: perfect	Na ₆ Ca ₂ Al ₃ Si ₆ O ₂₄ (CO ₃) ₂ Hexagonal	(1) (2)
Carletonite	intense blue (blue, pink, white, grey, colourless; Lustre: vitreous to pearly, slightly waxy on long exposure to air	U(-) $\omega = 1.521$ $\epsilon = 1.517$ (meas.) Pleochroism: weak, blue/pinkish brown (in blue material)	H: 4 to 4.5 SG: 2.45 (meas.) Cleavage: perfect	KNa ₄ Ca ₄ Si ₈ O ₃₈ (CO ₃) ₄ (OH,F)·H ₂ O Tetragonal	(1) (2) (3) (4)
Catapleite	colourless, greyish (light brown)	B(+) $\alpha = 1.588$ $\beta = 1.591$ $\gamma = 1.624$ (meas.) DR 0.036 gems 1.593 - 1.629	H: 5.5 SG: 2.77 to 2.81 (meas.) Cleavage: perfect May fluoresce G LW & SW UV	Na ₂ ZrSi ₃ O ₉ ·2H ₂ O Monoclinic (pseudo-hexagonal)	(1) (2) (5) (6)

Cryolite	nearly colourless	B(+) $\alpha = 1.338$ $\beta = 1.338$ $\gamma = 1.339$ DR 0.001	H: 2.5 SG: 2.97	Na_3AlF_6 Monoclinic	(1) (2)
Datolite	gems not confirmed; (pale yellow, white)	B(-) $\alpha = 1.625$ $\beta = 1.653$ $\gamma = 1.670$	H: 5 to 5.5 SG: 3.00	$\text{CaBSiO}_4(\text{OH})$ Monoclinic	(1) (2)
Eudialyte	brownish red (brown, red, orange)	U(±) $\omega = 1.598 - 1.628$ $\epsilon = 1.605 - 1.625$ (meas.)	H: 5.5 SG: 2.88 to 3.07 (meas.) Cleavage: indistinct	$\text{Na}_{16}(\text{Ca})_6\text{Fe}_3\text{Zr}_3(\text{Si}_3\text{O}_{12})_2(\text{Si}_4\text{O}_{27})_2(\text{OH},\text{Cl})_4$ Trigonal Abs. sp.: lines at 523, 527, 595nm	(1) (2) (7) (23)
Fluorite	colourless, violet, green, blue (pink, tan)	I $n = 1.435(1)$ meas.	H: 4 SG: 3.08 meas. Cleavage: perfect octahedral. May fluoresce. V-B LW, weak B SWUV	CaF_2 Cubic	(1) (2) (5)
Genthelvite	gems not confirmed (colourless, light yellow, greenish yellow, orange-tan) Lustre: vitreous; greasy on broken surface	I $n = 1.741$ to 1.745 (meas.) Translucent	H: 6 SG: 3.63 to 3.66 (meas.) Cleavage: none Fluoresces bright G LW & SW UV; phosphoresces YG	$\text{Zn}_4\text{Be}_3(\text{SiO}_4)_3\text{S}$ Cubic	(1) (2)
Kogarkoite	light blue (pale blue, white) Lustre: vitreous to waxy after exposure to air	B(+) $\alpha = 1.439$ $\beta = 1.439$ $\gamma = 1.442$ DR (0.003) Translucent	H: 3.5 SG: 2.679 Slightly water soluble Fluoresces W LW, pale B SWUV	$\text{Na}_3(\text{SO}_4)\text{F}$ Monoclinic	(1) (24)
Leifite	light violet, (white to colourless, light yellow) Lustre: vitreous to silky	U(+) $\omega = 1.515$ $\epsilon = 1.519$ (meas.) Translucent to transparent	H: 6 SG: 2.57 (meas.) Cleavage: distinct May fluoresce G SWUV	$\text{Na}_6\text{K}_3(\text{Si}_3\text{Al}_3)(\text{BeF})_2\text{O}_{39}$ Trigonal	(1) (2) (8) (25)

Table II continued

Leucophanite	light yellow to light green (yellow, green and white)	B(-) $\alpha = 1.565$ $\beta = 1.590$ $\gamma = 1.593$ (meas.)	H: 4 SG: 2.97 to 3.06 (meas.) Cleavage: perfect Some fluoresces pink or blue in LW & SW UV	(Na,Ca) ₃ BeSi ₃ (O,OH)F ₇ Orthorhombic	(1) (2)
Manganotychite	light rose	I n = 1.552 (meas.)	H: 4 SG: 2.83 (meas.) Water soluble	Na ₆ (Mn,Fe) ₂ (CO ₃) ₄ SO ₄ Cubic Abs. sp.: sharp band at 414 nm	(8) (9)
Microcline	colourless to greyish (white, grey)	B(-) $\alpha = 1.514 - 1.529$ $\beta = 1.518 - 1.533$ $\gamma = 1.521 - 1.539$	H: 6 to 6.5 SG: 2.56 Cleavage: perfect	KAlSi ₃ O ₈ Triclinic	(1) (2)
Narsarsukite	olive green (pale to bright yellow, green, grey, tan, brown)	U(+) $\omega = 1.610 - 1.614$ $\epsilon = 1.644 -$ 1.647 (meas.) DK 0.033	H: 6 to 7 SG: 2.72 - 2.83 (meas.) Cleavage: perfect	Na ₂ (Ti,Fe)Si ₄ (O,F) ₁₁ Tetragonal	(1) (2)
Natrolite	colourless, (light pink, yellowish brown)	B(+) $\alpha = 1.479$ $\beta = 1.485$ $\gamma = 1.491$ (meas.) gems 1.478 - 1.490	H: 5 SG: 2.25 (meas.) Cleavage: perfect May fluoresce white LW & SW UV	Na ₂ Al ₂ Si ₃ O ₁₀ ·2H ₂ O Orthorhombic	(1) (2) (5) (10)
Pectolite	colourless	B(+) $\alpha = 1.592 - 1.610$ $\beta = 1.603 - 1.615$ $\gamma = 1.630 - 1.645$	H: 4.5 to 5 SG: 2.91 (meas.) Cleavage: perfect May fluoresce pink, O-pink LW & weak pink SWUV	NaCa ₂ Si ₃ O ₈ (OH) isomorphous series with serandite Triclinic	(1) (2)
Quartz	colourless to smoky	U(+) $\omega = 1.544$ $\epsilon = 1.553$	H: 7 SG: 2.65 May fluoresce Y-O LW & SW UV	SiO ₂ Trigonal	(1) (2)

Remondite-(Ce)	orange (colour-change); greenish yellow in fluorescent light to yellowish orange in incandescent light	B(+) $\alpha = 1.632$ $\beta = 1.633$ $\gamma = 1.638$ (meas.) DR 0.006 gem 1.630 - 1.632 (0.002)	H: 3 to 3.5 SG: 3.43 (meas.), gem 3.53 (meas.) May fluoresce weak pink LW & SW UV	$\text{Na}_3(\text{Ca}, \text{Ce}, \text{La}, \text{Na}, \text{Sr})_3(\text{CO}_3)_5$ Monoclinic UV/Visible trans- mission sp: sharp lines at 444, 488, 510, 522, 578 nm; others at 636, 678, 740, 800, 874 nm	(11) (12)
Rhodochrosite	pinkish red, orangish red	U(-) $\omega = 1.810$ $\epsilon = 1.598$	H: 3.5 to 4 SG: 3.51 to 3.67 meas. Cleavage: perfect rhombohedral	MnCO_3 Trigonal	(1) (2) (5) (13)
Serandite	orange, pinkish orange, pink	B(+) $\alpha = 1.668$ $\beta = 1.671$ $\gamma = 1.703$ (meas.) DR 0.035 gems 1.674 - 1.708 Pleochroism: moderate pink/O	H: 5 to 5.5 SG: 3.34 (meas.) Cleavage: perfect	$\text{Na}(\text{Mn}, \text{Ca})_2\text{Si}_3\text{O}_8(\text{OH})$; isomorphous series with pectolite Triclinic Abs. sp.: absorbed up to ~420 nm, strong band centred at ~520 nm	(1) (2) (5) (8) (14)
Shorlite	intense yellow, greenish yellow	B(-) $\alpha = 1.531$ $\beta = 1.555$ $\gamma = 1.570$ DR 0.039 Pleochroism: moderate Y/G/grey	H: 3 SG: 2.60 Cleavage: distinct Decomposed by water	$\text{Na}_2\text{Ca}_2(\text{CO}_3)_3$ Orthorhombic	(1) (8) (15)
Siderite	golden brown (light to dark brown)	U(-) $\omega = 1.816 - 1.875$ $\epsilon = 1.592 - 1.633$; 1.623 (meas.) DR 0.240 gems $\epsilon = 1.61 - 1.63$, $\omega > 1.81$	H: 4 SG: 3.92 (meas.) Cleavage: perfect rhombohedral	FeCO_3 Trigonal Abs. sp.: broad line 485 nm, weak bands 450 and 510-520 nm	(1) (2) (5) (16)
Sodalite	blue (white, grey)	I $n = 1.483$ (meas.) Transparent to opaque	H: 5.5 to 6 SG: 2.22 (meas.) Some fluoresces bright O LW & SW UV; phosphoresces Y-W	$\text{Na}_4\text{Al}_3(\text{SiO}_3)_2\text{Cl}$ Cubic	(1) (2) (5) (17)

Table II continued

Sodalite var. hackmanite	Light yellow/pink after exposure to UV; rarely pink	as sodalite Transparent gems 1.483 (meas.)	as sodalite	$\text{Na}_4\text{Al}_3(\text{SiO}_3)_3\text{Cl}$ Cubic	(1) (2) (18) (19)
Sphalerite	yellow green, brownish green, dark red (colourless; brown, black) Lustre: resinous to adamantine	I $n = 2.37$ to 2.40 Dispersion: 0.156	H: 3.5 SG: 4.07 (meas.) Cleavage: perfect dodecahedral. May fluoresce Y-O LW, weak Y-O in SWUV	ZnS Cubic Abs. sp: sometimes 3 bands in red at 690, 667, 651 nm	(1) (2) (5) (8) (20)
Sugilite	gems not confirmed (light purple)	U(-) $\omega = 1.595 - 1.611$ $\epsilon = 1.590 - 1.607$ Pleochroism: weak, shades of purple	H: 6 to 6.5 SG: 2.74 to 2.79 Inert to UV	$\text{KNa}_2(\text{Fe,Mn,Al})_2\text{Li}_3\text{O}_{30}$ Hexagonal Abs. sp: broad band at ~420 nm	(1) (8)
Ussingite	light pink (colourless)	B(+) $\alpha = 1.504$ $\beta = 1.508$ $\gamma = 1.543$	H: 6.5 SG: 2.46 - 2.50 Cleavage: perfect 2 directions	$\text{Na}_2\text{AlSi}_3\text{O}_8(\text{OH})$ Triclinic	(1) (2)
Villiaumite	colourless to pink to very dark red; some bi- or tri-coloured stones	I $n = 1.326$ (meas.)	H: 2 to 2.5 SG: 2.78(2) (meas.) Cleavage: perfect Very soluble in water May fluoresce weak R SWUV	NaF Cubic	(1) (2) (5) (21)
Willemite	light blue (grey, pale yellow, pink, colourless) Lustre: vitreous to resinous	U(+) $\omega = 1.689$ $\epsilon = 1.716$ (meas.) gem 1.693 - 1.722 (0.029)	H: 5.5 SG: 4.26 (calc.) Fluoresces G LW & bright G SWUV, phosphoresces G	Zn_2SiO_4 Trigonal	(1) (2) (5) (22)

¹ Colours in parentheses are also found at Mont Saint-Hilaire, but not known to be faceted.

² Whenever available, data are given for Mont Saint-Hilaire specimens, and designated (meas.).

References:

- (1) Horvath and Gault, 1980 (2) Mandarino & Anderson, 1989 (3) Chao, 1971 (4) Wight, 1993a (5) Wight, 1986 (6) Wight, 1992b (7) Wight, 1994 (8) Kammerling *et al.*, 1995 (9) Khomyakov *et al.*, 1990 (10) Wight, 1992a (11) Kovvula *et al.*, 1992c (12) Van Velthuizen *et al.*, 1995 (13) Wight, 1985 (14) Wight, 1991a (15) Wight, 1993b (16) Wight, 1992c (17) Wight, 1989 (18) Wight, 1993c (19) Kovvula & Kammerling, 1989 (20) Wight, 1991b (21) Wight, 1992d (22) Wight, 1991c (23) Nickel & Nichols, 1991 (24) Palst & Sharp, 1973 (25) Petersen *et al.*, 1994



Fig. 16. Rhodochrosite at Mont Saint-Hilaire may be rose pink (CMN#20894; 1.61 ct). *Photo: CMN, W. Wight.*

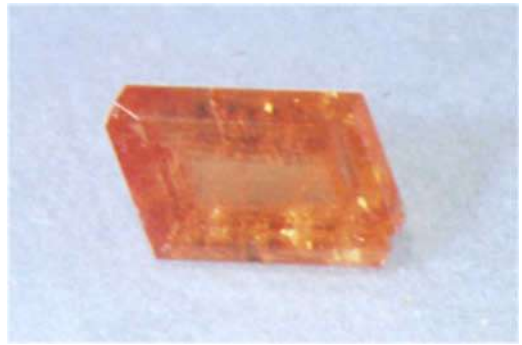


Fig. 17. Rhodochrosite may also be orange pink, similar in colour to some serandite (CMN#22136; 0.48 ct). *Photo: CMN, W. Wight.*



Fig. 18. Superlative yellowish green sphaerite (CMN#22212; 24.74 ct) faceted in 1980 by A. Grant. The combination of colour and cut has resulted in a stone whose true beauty is elusive and difficult to record in a photograph. *Photo: CMN, G. Robinson.*

Some gemstones will be discussed in more detail.

Sphalerite

The 1980 Rochester Mineralogical Symposium was considerably brightened by the sight of an exceptional gem sphalerite (Figure 18). It was faceted by Art Grant for Dr George Robinson, who had obtained the rough from someone who had collected it in the early 1970s. Previous sphalerite gems in shades of yellowish- to brownish-green had been attractive, but not large. This yellowish-green, 24.75 ct, pear-shaped, brilliant-cut gem was fashioned from an ugly, black-coated lump, showing that, indeed, the beauty of a gem owes much to the skill of the faceter. This glorious gem came to the CMN when Robinson took up an appointment as Associate Curator in 1982.

In 1991 a very rare, red sphalerite (6.5 ct step-cut) was acquired; it came from the rind of a green piece (see Figure 19).



Fig. 19. Very rare red sphalerite (CMN#21420; 6.03 ct) faceted in 1991 by M. Gray. Photo: CMN, W. Wight.

Recently larger greenish sphalerites have been cut by Art Grant for Gilles Haineault (25.45 ct yellow, 42.16 ct light green and 55.62 ct dark green) and others. The green of these stones is darker and not quite as attractive as the earlier 24.75 ct stone.

Carletonite

Carletonite is just one of the minerals first described from Mont Saint-Hilaire (Chao,

1971, 1972), which is so far the only known locality for the mineral. It was named after Carleton University in Ottawa, where Dr Chao is Professor of Mineralogy. In the period 1982–87, larger crystals up to about 5 cm in length were found. These vary in colour from colourless to light pink and from light to intense blue. Some small transparent pieces of a beautiful, intense blue colour have been faceted into stones weighing from as little as 0.02 ct up to 1.48 ct (Figures 20 and 21).

The first carletonite gem (0.34 ct) was shown at Tucson in 1988 and is pictured in the *Mineralogical Record* (Wilson, 1988).

Sodalite

Sodalite is a rock-forming mineral at Mont Saint-Hilaire. Nepheline syenite and sodalite syenite are common, and some sodalite containing rock was first cut as a cabochon showing blue crystal outlines in a white matrix. This rock has been called *beloeilite*, after the nearby town of Beloeil. Recently one tiny, transparent, blue gem was cut by Bradley S. Wilson for G. Langelier.

The hackmanite variety of sodalite, which can be yellow to pink to reddish-purple (photochromic), is also common at Mont Saint-Hilaire as massive, opaque material. In 1992, transparent light yellow hackmanite was found and some was faceted into amazing gems (Figures 22a, b, c). They become raspberry pink after about 15 minutes exposure to ultraviolet light. The colour fades gradually to the original light yellow, but the process is repeatable. These were first exhibited by Art Grant (who faceted them) and Gilles Haineault (who found the hackmanite) at Tucson and Rochester in 1989 (Koivula and Kammerling, 1989). Since then, a few pieces having a stable pink colour have been found.

The causes of colour, fluorescence and photochromatism in sodalite and its hackmanite variety are complex; some references are given in Wight, 1993c.



Fig. 20. Carletonite crystals, at 10x. *Specimen and photomicrograph: Q. Wight.*



Fig. 21. Carletonite gem (CMN#21464; 0.04 ct) at 20x. *Photomicrograph: CMN, W. Wight.*

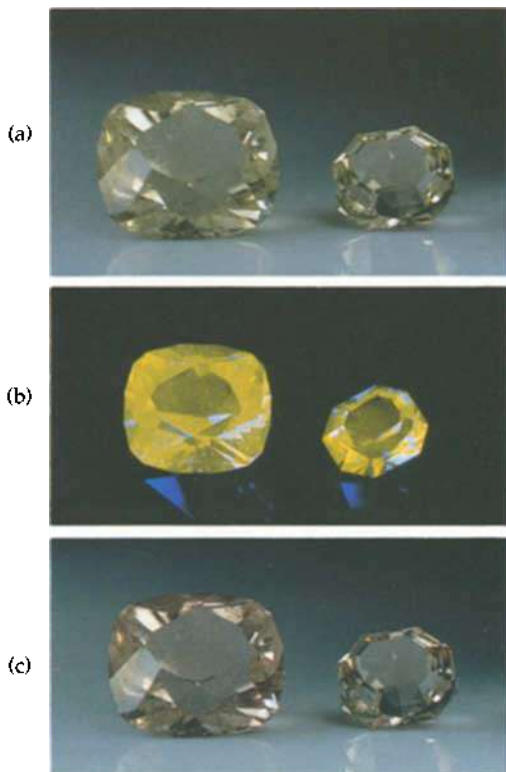


Fig. 22. Sodalite var. hackmanite gems (CMN#22363; 9.77 ct and CMN#22364; 3.32 ct) (a) light yellow in daylight; (b) showing orange fluorescence in ultraviolet light; (c) raspberry pink after irradiation with ultraviolet light. *Photos: CMN, G. Robinson.*



Fig. 23. The first shortite gem, faceted from rough already in the CMN by A. Grant in 1991 (CMN#21467; 1.04 ct). The intense yellow colour is distinctive. Photo: CMN, W. Wight.

Hackmanite from Mont Saint-Hilaire probably exhibits all possible reactions: some will appear bright pink when a rock is split open in the quarry and fade to white after a few minutes in daylight; some is found pink and remains pink; yet other pieces are white or light yellow until exposed to ultraviolet light, when they become pink temporarily, but fade in light.

Remondite-(Ce)

In 1991, Gilles Haineault found fragments of transparent orange crystals, which were first identified as burbankite. Small crystals of burbankite-group minerals had been found earlier, but these were large in comparison. The broken pieces were faceted by Art Grant into about 30 stones, weighing up to 6.62 ct. After being shown at the Tucson Show in February 1992, they were reported by Koivula *et al.*, 1992c. The most interesting property of these gems is their strong colour-change from orange or yellowish-orange in incandescent light to greenish-yellow in daylight. The colour-change is thought to be caused by the presence of rare-earth elements such as cerium and neodymium. New work on the burbankite group of minerals indicates that the gems are remondite-Ce, and not burbankite itself (Van Velthuisen *et al.*, 1995; see also Cesbron *et al.*, 1988). The

name remondite-Ce indicates that cerium is the predominant rare-earth element.

Present situation

In the last few years, there has been a small but steady stream of new faceted rarities from Mont Saint-Hilaire: leucophanite (1987), cryolite (1991), shortite (1991) (Figure 23), leifite (1992), pectolite (1992), kogarkoite (1993) and manganotychite (1993). At the Rochester (New York) Mineralogical Symposium in April 1995, faceted ussingite (0.53 ct) was shown for the first time (Figure 24).

By April 1995, 28 mineral species from Mont Saint-Hilaire had been cut and polished. Transparent pieces of others have been collected (datolite, genthelvite and sugilite) and are awaiting the attention of a faceter. Despite the fact that the majority of the above species are not traditional gemstones, the demand for gems from Mont Saint-Hilaire has increased to the point where faceters (no longer amateurs) are competing for the very limited supply of facetable material.

Identification

It can be very difficult to identify the minerals of Mont Saint-Hilaire, especially since many of them are very small (microcrystals). In addition, the habit of a mineral from Mont Saint-Hilaire may be unlike the habit of that mineral from other localities. X-ray diffraction or electron microprobe analyses are often necessary to confirm identity. There have been many instances over the years of the incorrect identification of commercially available specimens, especially microcrystals.

Because of the fierce interest, and the resulting high price put on the limited number of gems available, it is very important to confirm the identity and true source of a gemstone. If one is paying a premium for a 'locality piece', there is the potential for misleading labelling. For instance, eudialyte gems labelled 'Canada' commonly come from Kipawa, Quebec, and



Fig. 24. Ussingite crystals, at 10x (CMN#54851). Photomicrograph: Q. Wight.

not Mont Saint-Hilaire. Although there is eudialyte at Mont Saint-Hilaire, it is not generally suitable for faceting. There is only one documented eudialyte gem (0.19 ct); it is in the collection of G. Haineault. Reports of gems cut from colourless scheelite, wulfenite and grossular are unconfirmed, and seem unlikely according to expert mineralogists and published literature. Scheelite and wulfenite do occur at Mont Saint-Hilaire, but only as a small number of microcrystals (Horvath and Gault, 1990).

It can be especially difficult to identify these rare gemstones since most of them are not described in the usual gemmology textbooks. And, of course, one must be aware of the existence of a gemstone in order to identify it. To help with that problem, some Mont Saint-Hilaire gemstones have been featured in the 'Check-list for Rare Gemstones' series published between

1985 and 1994 in *The Canadian Gemmologist* by W. Wight.

Conclusion

Mont Saint-Hilaire is a scientific treasure house of the rare and unusual. Only a few of its 311 identified mineral species have been cut and polished to date. The interest of mineralogists, mineral collectors and gem collectors in the treasures from this locality continues unabated.

Acknowledgements

The author would like to thank her colleagues at the Canadian Museum of Nature, particularly Dr Joel Grice and Robert Gault, for a critical reading of the manuscript and many helpful discussions. Thanks are also due to Marga Abear for laboratory assistance. Information provided by Dr Robert Gait of the Royal Ontario Museum, Arthur Grant, Gilles Haineault, Guy Langelier, Frank Melanson and Bradley S. Wilson has been invaluable. Special thanks are due to my husband, Quintin Wight, whose passion for Mont Saint-Hilaire has resulted in our spending many hours in the quarries since 1969.

References

- Cesbron, F., Gilles, C., Pelisson, P., and Sauges, J.-C., 1988. Remondite-(Ce), a new rare earth carbonate in the burbankite group. *C.R. Acad. Sci. Paris*, series II, 915-920 (in French); *American Mineralogist*, 1990, 75, 433, abstract
- Chao, G.Y., 1971. Carletonite, $\text{KNa}_2\text{Ca}_2\text{Si}_8\text{O}_{18}(\text{CO}_3)_4(\text{F},\text{OH})\cdot\text{H}_2\text{O}$ a new mineral from Mont Saint-Hilaire, Quebec. *American Mineralogist*, 56, 1855-66
- Henn, U., and Redmann, M., 1991. On the physical and chemical properties of serandite from Mont Saint-Hilaire, Quebec, Canada. *Canadian Gemmologist*, 12, 4, 105-8
- Horvath, L., and Gault, R.A., 1990. The mineralogy of Mont Saint-Hilaire, Quebec. *Mineralogical Record*, 21, 4, 285-352 (comprehensive article with many references)
- Kammerling, R.C., Koivula, J.L., Fritsch, E., (eds), 1995. Gem News - faceted sphalerite and other collector stones from Canada. *Gems & Gemology*, 31, 1, 65-7
- Khomyakov, A.P., Bakhchisaraitsev, A. Yu., Martynova, A.V., and Parashenko, T.M., 1990. Manganotychite $\text{Na}_2\text{Mn}_2(\text{SO}_4)(\text{CO}_3)_4$ - a new mineral (in Russian). See *Mineralogical Abstracts* 92M/2074
- Koivula, J.L., and Kammerling, R.C., 1989. Gem News - hackmanite: a remarkable variety of sodalite. *Gems & Gemology*, 25, 2, 112-13 and 25, 3, 245
- Koivula, J.L., Kammerling, R.C., and Fritsch, E. (eds), 1992a. Gem News - rare gemstones from Mont Saint-Hilaire. *Gems & Gemology*, 28, 1, 62 (cryolite, pectolite, leucophanite, serandite, burbankite)
- Koivula, J.L., Kammerling, R.C., and Fritsch, E. (eds), 1992b. Gem News - rare gemstones from Quebec. *Gems & Gemology*, 28, 2, 134 (villiaumite, carletonite, hackmanite, natrolite, sphalerite, catapleite, serandite, albite, pectolite, burbankite, shortite, cryolite)
- Koivula, J.L., Kammerling, R.C., and Fritsch, E. (eds), 1992c. Gem News - color-change burbankite-related mineral from Mont Saint-Hilaire, Quebec. *Gems & Gemology*, 28, 4, 270-71 (remondite-(Ce))
- Koivula, J.L., Kammerling, R.C., and Fritsch, E. (eds), 1993. Gem News - miscellaneous fashioned curiosities. *Gems & Gemology*, 29, 1, 60 (leifite)
- Mandarino J.A., and Anderson, V., 1989. *Monteregian Treasures*. Cambridge University Press, Cambridge. Comprehensive to 1988, with many properties measured on Mont Saint-Hilaire specimens
- Nickel, E.H., and Nichols, M.C., 1991. *Mineral reference manual*. Van Nostrand Reinhold, N.Y.
- Pabst, A., and Sharp, W.N., 1973. Kogarkoite, a new natural phase in the system Na_2SO_4 -NaF-NaCl. *American Mineralogist*, 58, 116-27
- Petersen, O.V., Rønsbo, J.G., Leonardsen, E.S., Johnsen, O., Bollingberg, H. and Rose-Hansen, J. (1994) Leifite from the Ilmaussaq alkaline complex, South Greenland. *N. Jb. Miner. Mh.*, Jg. 1994, H.2, 83-90
- Robbins, M., 1994. *Fluorescence: gems and minerals under ultra-violet light*. Geoscience Press, Phoenix, Arizona
- Schlüter, J., and Gebhard, G., 1993. Natrolith von St. Hilaire, Quebec, Kanada. *Z. Dt. Gemmol. Ges.*, 42, 1, 43-5
- Van Velthuizen, J., Gault, R.A., and Grice, J.D., 1995. Calcioburbankite, $\text{Na}_3(\text{Ca},\text{REE},\text{Sr})_3(\text{CO}_3)_6$, a new mineral species from Mont Saint-Hilaire, Quebec and its relationship to the burbankite group of minerals. *Canadian Mineralogist*, in press
- Wight, Q., and Chao, G.Y., 1986. Mont Saint-Hilaire revisited. *Rocks & Minerals*, 61, 182-97
- Wight, Q., and Chao, G.Y., 1995. Mont Saint-Hilaire revisited, part 2. *Rocks & Minerals*, 70, 90-103 and 131-8
- Wight, Q., and Wight, W., 1989. Art Grant: a cut above the rest. *Canadian Gemmologist*, 10, 4, 98-101
- Wight, W., 1985. Check-list for rare gemstones - rhodochrosite. *Canadian Gemmologist*, 6, 3, 78-81
- Wight, W., 1986. Canadian gems in the National Museums of Canada. *Canadian Gemmologist*, 7, 2, 34-45, 50-5
- Wight, W., 1989. Round and about. *Canadian Gemmologist*, 10, 4, 93-4 (hackmanite)
- Wight, W., 1991a. Check-list for rare gemstones - serandite. *Canadian Gemmologist*, 12, 2, 46-9
- Wight, W., 1991b. Check-list for rare gemstones - sphalerite. *Canadian Gemmologist*, 12, 3, 78-81
- Wight, W., 1991c. Check-list for rare gemstones - willenite. *Canadian Gemmologist*, 12, 4, 110-13
- Wight, W., 1992a. Check-list for rare gemstones - natrolite. *Canadian Gemmologist*, 13, 1, 14-17
- Wight, W., 1992b. Check-list for rare gemstones - catapleite. *Canadian Gemmologist*, 13, 2, 46-9
- Wight, W., 1992c. Check-list for rare gemstones - siderite. *Canadian Gemmologist*, 13, 3, 78-81
- Wight, W., 1992d. Check-list for rare gemstones - villiaumite. *Canadian Gemmologist*, 13, 4, 110-13
- Wight, W., 1993a. Check-list for rare gemstones - carletonite. *Canadian Gemmologist*, 14, 1, 14-17
- Wight, W., 1993b. Check-list for rare gemstones - shortite. *Canadian Gemmologist*, 14, 2, 46-9
- Wight, W., 1993c. Check-list for rare gemstones - sodalite. *Canadian Gemmologist*, 14, 3, 78-81
- Wight, W., 1994. Check-list for rare gemstones - eudialyte. *Canadian Gemmologist*, 15, 1, 14-17
- Wilson, W.E., 1988. What's new in minerals? *Mineralogical Record*, 19, 3, 209

River pearls from Bavaria and Bohemia

Horst Hahn

Idar Oberstein, Germany

Translated and amended with the author's permission by Dr J Kanis from a paper published in *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, March 1995.

Abstract

Freshwater pearls have been found in Europe for centuries and important sources of supply in the past have been various rivers in Bavaria, Bohemia, Russia, Scandinavia, Scotland, Spain, Lorraine and Brittany, as well as Lüneberg Heath and in Saxony. Because of increasing pollution, pearl fisheries in Europe are now unimportant and today it is only in Scotland where a few rivers yield a significant amount of mussel pearls.

The author describes the propagation of the mussels and gives a survey of the occurrences of freshwater pearls in Bavaria and Bohemia. In addition it is pointed out that, very recently, some 150 000 mussels derived from Russian sources have been placed in Bavarian rivers. The reason for this is not the production of pearls but for research into the behaviour of the mussels in response to various kinds of pollution.

Introduction

Since ancient times salt-water molluscs and their pearls have been widely known. In contrast our knowledge of pearls from the freshwater mussel *Margaritifera margaritifera* is relatively recent and much research has still to be done (Figure 1).

Some animals propagate very slowly, others much faster, and it is interesting to note that animals with a long life span normally produce fewer young than animals with a short life span.



Fig. 1. *Margaritifera margaritifera* (L.) with pearls, from a stream in Saxony.

With *M. margaritifera*, however, we have a different situation, and although they can grow to be a greater age than many other animals, they propagate in enormous numbers – an unusual process in the animal world.

During the Middle Ages freshwater pearls were fished in abundance from streams in Germany and other countries. For instance, according to interesting old documents (Reger, 1981), between 1814 and 1887 at least 158 000 pearls came from streams in the Bavarian Forest. Pearl fishing was of importance not only in Bavaria, but also in Bohemia, as well as in the



Fig. 2. Russian Maria Ikon (copy of Smolensk Madonna Ikon) embroidered in Munich in 1580 with 700 Bavarian river pearls. In Schatzkammer, Munich.

Lüneburg Heath district, Saxony, Lotharingen, Scandinavia, Spain, Brittany and Russia. In particular Scottish pearls should also be mentioned.

But where have all these freshwater pearls gone? High society, churches and monasteries obtained most of them and some beautiful specimens can now be admired in museums. To mention a few, the Schatzkammer of the Munich Residenz, the Bavarian National Museum (see Figure 2) and the Grüne Gewölbe in Dresden where a beautiful necklace from the time of August the Strong contains freshwater pearls from the River Elster (Figure 3).

In the St Petersburg Hermitage Museum a few valuable jewellery pieces with freshwater pearls are exhibited and in the

Bavarian pilgrim village of Altötting there is an altar decorated with 3000 pearls.

Although some pieces are still in private hands and disappeared from the pearl trade long ago, the best and biggest freshwater pearls can be admired in the Hohenzollern jewellery. In particular the state crown with insignia (in the Schatzkammer in Vienna) and the Habsburg crown are richly decorated with pearls.

It is difficult to find out what has happened to the many pearls which were fished and recovered from Bohemian rivers and streams during the last few centuries. Until recently it was believed that nearly all river mussels in Europe yielding pearls had become extinct, but lately some interesting items of information have come to light.

Margaritifera margaritifera

The mussel *M. margaritifera* thrives only in very clean calcium-poor waters, but does not prosper in streams without any calcium. They are bisexual, which means that a sex change of the female mussel is possible. They can reach an age of 120 years and can grow up to 14 cm across. Their circulation system makes it possible for the animal to expand its foot up to 7–8 cm, to extend it from the shell and to move. This is, however, very slow at one metre a day. Their food consists of micro-organisms and algae, which are transported to the inner part of the mussel by millions of fast moving flagella. It is also known that this mussel variety has been with us for at least 130 million years and has outlived Dinosauria and many other animals.

Mussels of the species *M. margaritifera* are genetically identical everywhere and occur only in the northern hemisphere. They propagate as follows: during the spawn time in July–August up to four million eggs leave the ovary (the size of the eggs is approximately 0.04 mm) and move to the gill-leaves. Immediately thereafter – probably because of slight changes in

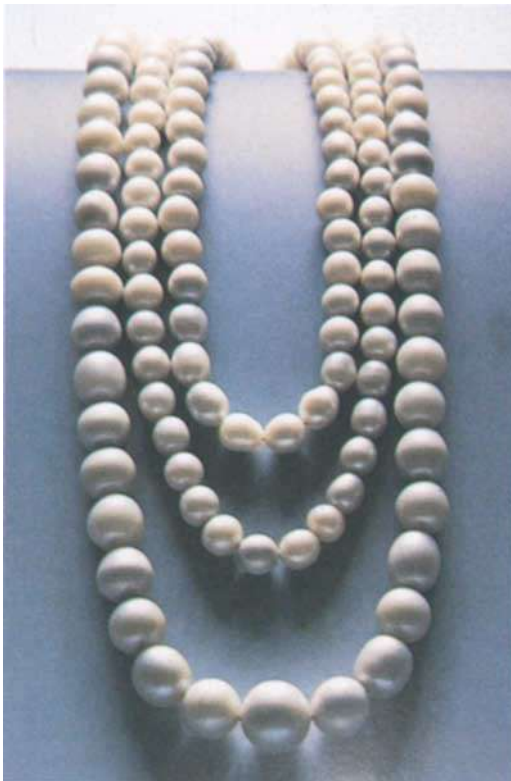


Fig. 3. Pearl necklace with 117 pearls from the Elster river in Saxony, eighteenth century. 'Grüne Gewölbe', Dresden.

water temperature – the male mussels produce sperm which is then absorbed by the female mussel during the intake of water. During the course of evolution it would appear that the freshwater mussels must have developed some form of communication system because they appear to know whether they are alone, or whether other mussels occur upstream. In some environments the female mussel may change sex, perhaps where no males are present and reproduction is in danger.

Research in Sweden and by Dr Bauer of Bayreuth University proved that the larvae produced by the female mussel can only continue to grow in the gills of a particular variety of river trout 'Bachforellen' *Salmo trutta fario* (Reger, 1981). It takes three years for the young mussels to grow large enough to be recognized in the streams. The river trout are normally 'infected' only once with larvae and after that they develop an antibody which rejects the larvae.

It has also been established that among the millions of larvae are a few male mussels. The reason for this is that, although the female mussels are bisexual, a few male mussels in the group ensure that no degeneration takes place as a result of inbreeding which could occur if the female mussels exclusively depended upon self-fertilization. Male mussels cannot change sex (Reger, 1981).

Although this mussel variety has survived for millions of years through the complicated technique of survival outlined above, present ecological changes in water conditions and in general environmental pollution could eventually threaten the mussel's existence.

History

Recently the Förderverein Perlfischerei has obtained old documents from the former Bohemia, which are little known in western Europe; they include reports about river pearls in Bavaria in the sixteenth and seventeenth centuries in the Bavarian State Archives.

In 1560, the Swiss scientist Konrad Geszner wrote about the abundance of pearls in Bohemia and mentioned, among others, the rivers Moldau and Wottava. In particular good quality pearls in a range of colours were supposed to come from the Moldau. In the past, pearl dealers would specially mention Moldau pearls from Bohemia for their beautiful lustre. The author found this description in one of his grandfather's business books of 1888 of a grey-rosé coloured Moldau pearl of 9½ grains (4 grain equal 1 carat) that had been sold for 70 Gulden.

Most probably these pearls came from the upper course of the Moldau river because as rivers become larger downstream, the quantity of mussels diminishes, perhaps due to changes in plankton and other food, or to a lower calcium content of the water, or to a combination of factors.

The upper course of the small Bohemian river Schwarzach (Czech = Svarcavan) was well known for its abundance of mussels, but it is not known whether pearls have been found on the Bavarian side of the border. No pearls have yet been found in either Slovakia or Hungary, but during a trip to Hungary the author saw in the Schatzkammer of the Cathedral of Echtergom an old choir robe which was entirely embroidered with pearls. This is a Greek Byzantine piece of art, however, and the pearls came from the Orient.

Another piece of Greek-Byzantine origin in the famous Loretto church treasures in the Prague Hradschin, is the monstrance and this is decorated with large river pearls. Also, Bohemian pearls are found on a robe and a monstrance in the former monastery of Hohenfurt, and beautiful pearl-embroidered items can be admired in the Prague Cathedral Treasury.

Before the First World War most of the Bohemian river pearls were traded in the small town of Rosenberg where a large Jewish community has lived since the thirteenth century. The centre of the Bohemian pearl trade before the wars was, of course,

Prague, which has had a flourishing jewellery industry since the Middle Ages.

In 1933 a book on 'Pearl mussel and its occurrence' was published by a teacher named Ottokar Schubert, a Sudeten-German. Another local Sudeten-German, Arno Ritter, a textile merchant, studied river pearls and published various articles in magazines, and at the beginning of the 1930s he wrote:

'The industrialization of the last few years with its materialistic views has created conditions whereby these rare creatures are in danger of extinction. It is feared that all good intentions in Bohemia and Bavaria will disappear in bureaucratic paper and "paragraph-sausage" and that the biological gem will be totally extinct within a few decades.'

Pearl fishermen have also reported that, during the nineteenth century, the opening of mussels in certain streams was officially allowed only once in eight years.

Many an experienced fisherman believed that it was a good sign when many pearls came from mussels with curved and dented shell surfaces. They believed that rougher and more deformed shells promised larger pearls. However, the author does not believe that this is the case. For some time it has been known that natural pearls originate from an epithelial tumour and not due to pressure or injury. Arab and Indian pearl divers agree with this. Healthy, strong mussels normally carry more and better pearls, but in some rare cases deformed shells can produce a larger pearl which is often irregular and described as baroque.

Protection of the freshwater pearl mussel

Eight years ago a new society was founded with the assistance of the Bavarian Ministry of Agriculture, namely Förderverein Perlfischerei-Museum. The president, Karl-Heinz Reger, is the author of a book on pearl fisheries in Bavaria. In addition he started a data bank on freshwater pearls and their documentation. The

honorary president, Otto von Habsburg, as a representative on a European committee for ecology and health, has with the help of committee members from Germany and other countries, stressed the importance of freshwater pearls as environmental indicators. Where they can survive the surroundings are still alright and other animals and plants can also flourish, which makes the need for other research and environmental improvements, possibly expensive, unnecessary.

The ecological problem of dying mussels is not confined to small regions and therefore the European Commission committee members have demanded immediate action to protect *M. margaritifera* from extinction. This is now the task of the Bavarian agriculture and forestry ministry and funds have been made available.

In particular, the newly founded Förderverein Perlfischerei is active and is, together with the University of Bayreuth, in contact with other European countries such as Sweden, France, Spain, Scotland and Russia.

During the last few years the present occurrences of *M. margaritifera* have been registered and one still finds these mussels in various streams in the Bavarian Forest, Scotland, Scandinavia, Spain and in a small area in Brittany. On the border of Saxony and the Czech Republic, in so-called no man's land, are two streams with healthy mussels, which shows that Nature can recuperate when people do not interfere! In Slovakia there are no recorded mussel occurrences, nor have pearls been used in the jewellery contained in museums or churches in that country.

During the 1980s a Czech-Bavarian border committee was formed, as some Czech scientists realized that freshwater pearl mussels are perhaps the best environmental indicators we have. This led to an agreement whereby some streams are cleaned and are not subject to untreated sewage from local establishments. This is perhaps not much, but it is a good start

and during the last two years there has been good cooperation.

Present status

Scientists are now making discoveries and collecting data which can form the basis for certain protection measures. Since 1991 the Bavarian agriculture ministry has been installing automatic equipment to check pH-values in streams and rivers. Some results are surprising: for example they found that during the cold season the mussels reduce their metabolism considerably and polluted waters cause less harm than in summer. A particularly harmful period seems to be spring when the melt waters from snow swell the rivers, but as a long research period is required to obtain reliable data (pers. comm.), no results have yet been published.

In one stream, Dr Bauer of Bayreuth University has discovered a potentially worrying situation. About 10 000 mussels live in this stream whose channel is completely covered with them. They are in a healthy condition, i.e. the females produce a very large amount of larvae every summer, which develop, thanks to the Bachforellen, into young mussels. But for the last few years the young mussels have been dying and therefore the mussel community is becoming too old. The remedy for this malaise has not yet been discovered.

In 1988–89 authorities in the former USSR offered their cooperation to the Bavarian authorities and informed them that they estimated that between 50 million to 150 000 million *M. margaritifera* mussels lived in Karelian streams. 150 000 mussels were then transported to Bavaria and placed in certain streams to complement low mussel populations; Bachforellen, essential for their reproduction, were also present.

However, this exercise was only partly

successful, as not sufficient Bachforellen lived there. It took some time to realize that in addition to placing *M. margaritifera*, it is also necessary to introduce sufficient 'infected' Bachforellen at the same time. This was then done in a second trial, which now will be repeated in Bohemia, Saxony, Scotland, Spain and France. Again, these trials are being carried out because this mussel is a good indicator of the cleanliness of environmental conditions; it is considered a bonus that after 20–30 years they may produce pearls.

The Bavarian agriculture and environmental ministries have been able to keep the streams in question free from additional pollution. Further efforts at improvements will be made in the triangular area north of Rehau between Bavaria, Bohemia and Saxony.

Researchers at Bayreuth University and in particular Swedish scientists have described the presence of strontium and caesium in one of the latest year rings of the *M. margaritifera*; this is a result of the Chernobyl catastrophe and the consequent release of these elements into the atmosphere. Other Swedish investigations reveal that the fallout from large nuclear tests can be detected in mussels and convincing results will be published at a later date (pers. comm.). Future research on freshwater mussels is designed to provide important data regarding the mechanics of environmental catastrophes, and particularly to help solve problems concerning dying forests and the acidity of stream and river waters.

Reference

Reger, Karl Heinz, 1981. *Perlen aus bayerischen Gewässern*. Hugendubel Verlag, Munich.

Further reading

Woodward, Fred, 1994. *The Scottish pearl in its world context*. Diehard publ., Edinburgh.

SPECTROSCOPES



- High quality
- Reasonably priced

<i>Model</i>	<i>Price*</i>
Diffraction spectroscope	£27.50
SP 100 prism, fixed slit with focusing adjustment	£70.00
SP 150 prism, adjustable slit and focus	£105.00
SP 200 prism, adjustable slit, focus and wavelength scale	£225.00

* Prices quoted are exclusive of VAT, postage and packing
Remember your membership number for your 10% discount.

Gemmological Instruments Limited

◆ SECOND FLOOR, 27 GREVILLE STREET (SAFFRON HILL ENTRANCE), LONDON EC1N 8SU ◆

Tel: 0171-404 3334

Fax: 0171-404 8843

Abstracts

Diamonds

Gems and Minerals

Instruments and Techniques

Synthetics and Simulants

Diamonds

The formation of diamond.

G.P. BULANOVA. *Journal of Geochemical Exploration*, 53, 1995, pp 1-23, 11 photos (10 in colour), 8 figs.

Study of the formation of commercial-sized diamonds from kimberlites has produced a very large amount of data which are summarized with fresh theories on the growth of diamond from kimberlites at Yakutia, Russia. It is proposed that all primary genetic information is collected from large single crystals and collated. Main primary features studied have been inclusion paragenesis, internal morphology, growth mechanism and evolution of the growth environment. Diamonds from kimberlitic rocks are concluded to have originated from a variety of mantle rock source environments. Photoluminescence photographs are used to show growth zones.

M.O'D.

Vacancy-related centres in diamond.

G. DAVIES AND OTHERS. *Physical Review B*, 46(20), 1992, pp 13157-70.

Vacancies in diamond migrate, during annealing, primarily in their neutral charge state, with an activation energy of 2.3 ± 0.3 eV. Negative vacancies are destroyed by first converting to neutral centres in a reversible charge transfer process. In relatively pure diamonds (type IIa)

and in type I diamonds containing large concentrations of nitrogen, effectively all the vacancies in the samples after irradiation can be accounted for in their neutral (V^0) and negative (V^-) charge states. In nitrogen-rich diamonds, the vacancies are predominantly trapped during annealing at the nitrogen. In common natural (type Ia) diamonds, variations of absorption linewidths during annealing imply that ~40 per cent of the vacancies are created within a few atomic sites of the nitrogen impurity, and direct observation confirms that vacancy production is enhanced in these diamonds. About half of the vacancies, including those near the nitrogen, anneal at each $T \sim 12$ times faster than those vacancies whose creation is not correlated with the nitrogen.

R.A.H.

Applications of the SHRIMP I ion microprobe to the understanding of processes and timing of diamond formation.

C.S. ELDRIDGE, W. COMPSTON, I.S. WILLIAMS, J.W. HARRIS, J.W. BRISTOW AND P.D. KINNY. *Economic Geology*, 90, 1995, pp 271-80, 12 figs.

Using the ion microprobe, problems on the timing, materials, sources and processes involved in diamond formation in African kimberlites have been addressed in the course of a study combining uranium-lead isotope dating, rare earth element fingerprinting and sulphur plus lead isotope tracing. Results obtained are

ABSTRACTORS

R.K. Harrison	R.K.H.	M.O'Donoghue	M.O'D.	R.E. Samson	R.E.S.
J. Hewitt	J.H.	R.J. Peace	R.J.P.	E. Stern	E.S.
R.A. Howie	R.A.H.	S.A.T. Redfern	S.A.T.R.		

For further information on many of the topics referred to consult *Mineralogical Abstracts* or *Industrial Diamond Review*. For a further 9 papers concerning diamond sources the reader should consult the *Journal of geochemical exploration*, 53, 1995.

of value towards the study of carbon isotope heterogeneity of eclogitic diamonds. Data can be reconciled with a simple model in which the introduction of crustal material into the mantle triggers both generation of the kimberlite and diamond growth. Plate tectonic studies are vitally important in locating economic diamond reserves.

M.O'D.

The origin of diamonds in western Minas Gerais, Brazil.

G.M. GONZAGA, N.A. TEIXEIRA AND J.C. GASPAR. *Mineralium Deposita*, 29(5), 1994, pp 414–21, 2 maps.

Important diamond-mineralized alluvium/colluvium occurs in WMG in the 700–450 m.y. old Brasília orogenic belt. Diamonds are geographically related to glacial and periglacial sediments, wadi and debris flow conglomerates, and ultramafic alkaline rocks (intrusive and extrusive, including kimberlites, leucites, kamafugites, carbonatites, etc.). Petrological data indicate that the rocks, originally classified petrographically as kimberlites, have mineralogical, chemical and isotopic differences from group I and II kimberlites, and more closely resemble kamafugites. The Brasília orogenic belt has features of a Wilson cycle, implying that WMG does not fulfil the geotectonic and geothermometric requisites to host primary diamond sources. An analysis of field relations and sedimentology in WMG shows that the majority of the diamonds have been transported by glacial events from the São Francisco craton further E.

R.E.S.

Diamondiferous eclogites from Siberia: remnants of Archean oceanic crust.

D. JACOB, E. JAGOUTZ, D. LOWRY, D. MATTEY AND G. KUDRJAVTSEVA. *Geochimica et Cosmochimica Acta*, 58(23), 1994, pp 5191–207.

Analyses by EMP are presented of mineral separates for major elements and trace elements, together with O, Sm-Nd and Rb-Sr isotopes from a suite of eight diamond-bearing eclogite xenoliths from the Udachnaya mine, Siberia. Chemically and petrographically these eclogites are similar to the eclogite suite from Roberts Victor or Bellsbank mines, South Africa, in age (2760 m.y.) and $\delta^{18}\text{O}$ values that deviate from mantle values. But no samples of eclogite with $\delta^{18}\text{O}$ lower than mantle values have yet been found, and Cs contents of the Siberian eclogites

are lower than those from Roberts Victor. A model indicates an origin of the Siberian eclogites from Archean oceanic crust altered prior to subduction to mantle depths, and this is extrapolated to global eclogites from kimberlites despite the differences between samples from different cratons.

R.K.H.

Catalogue of worldwide diamond and kimberlite occurrences: a selective and annotative approach.

A.J.A. JANSE AND P.A. SHEAHAN. *Journal of Geochemical Exploration*, 53, 1995, pp 73–111, 9 maps.

Primary host rock occurrences of diamond on Earth are believed to number approximately 5000: 500 of these have been found to contain diamond with 50 being mined and 15 being large active mines. The validity of Clifford's Rule is upheld: this holds that economic kimberlites are found only on Archons (cratonic regions underlain by Archean basement) while economic lamproites occur on some Protons (Proterozoic mobile belts adjacent to Archons). Diamond and kimberlite occurrences are catalogued for all continents, the data including co-ordinates.

M.O'D.

Gem trade lab notes.

R.C. KAMMERLING AND C.W. FRYER. *Gems & Gemology*, 31(2), 1995, pp 120–27, 1 illus. in black-and-white, 17 illus. in colour.

A diamond showed high-order strain through crossed polars in the shape of an octahedron showing a dark line through the vertex and a dark plane perpendicular to it. The phantom did not affect the clarity (VVS) or the natural intense yellow colour.

Treated-colour pink diamonds. These have been found to have characteristic strong orange fluorescence to both LW and SW ultraviolet radiation. In addition they consistently show a diagnostic visible spectrum with sharp lines at 595, 617 and 658nm and an emission line at 575nm.

An unusual diamond crystal (13.24ct) of irregular shape with a large 'tunnel' etched through the centre was shown to be a single crystal.

R.J.P.

A visual guide to the identification of filled diamonds.

S.F. MCCLURE AND R.C. KAMMERLING. *Gems & Gemology*, 31(2), 1995, pp 114–19, 60 illus. in colour.

All filled diamonds to date have shown flash effects in a variety of colours. In addition there is evidence of flow structure, trapped bubbles, incomplete filling at the surface, crackled texture, an apparent colour to the filler, cloudy filled areas and surface residue. The authors have recognized the inadequacy of descriptive text in this subject and have resorted to the unusual step of providing a chart of over fifty photographs covering most aspects of diamond filling, together with photographs showing misleading features found in unfilled diamonds.

Emphasis is placed on the responsibility of jewellery professionals to be aware of diamond treatments as mistakes can be damaging both financially and to reputations. Lighting is important particularly in the use of darkfield and brightfield illumination where complementary colours are seen in the flashes. R.J.P.

Basic principles of alluvial diamond exploration.

T.R. MARSHALL AND R. BAXTER-BROWN. *Journal of Geochemical Exploration*, 53, 1995, pp 277-92, 3 figs.

No single method of target selection for alluvial diamond deposits has yet been suggested. Data needed to be assimilated before field exploration is begun include regional geological features of the drainage basin, the constituent lithologies of the gravel being prospected for, geomorphic and climatic factors affecting the exploration area, the type of deposit sought and information on post-depositional processes which may have affected the deposit considered for exploration. M.O'D.

The role of petrography and litho-geochemistry in exploration for diamondiferous rocks.

R.H. MITCHELL. *Journal of Geochemical Exploration*, 53, 1995, pp 339-50, 2 figs.

A combination of transmitted light petrography, back-scattered electron imagery and energy-dispersive X-ray spectrometry is used to assess rock samples collected during diamond exploration. M.O'D.

Pathfinder sampling techniques for locating primary sources of diamond: recovery of indicator minerals, diamonds and geochemical signatures.

M.T. MUGGERIDGE. *Journal of Geochemical Exploration*, 53, 1995, pp 183-204, 8 figs.

Direct evidence of the presence of a diamond source may be given by other minerals (pathfinder minerals). Sampling techniques for the handling and identification of these minerals are described. M.O'D.

The morphology and nature of primary diamondiferous occurrences.

P.H. NIXON. *Journal of Geochemical Exploration*, 53, 1995, pp 41-71, 4 maps, 13 photos, 10 figs.

The role of kimberlite and lamproite pipes as sources for diamond are reviewed together with notes on other types of occurrence, in particular the kimberlite pyroclastic ejecta deposits interstratified in the Albian Cretaceous sediments of Saskatchewan, Canada. Diamonds from Tibetan ophiolites are still being studied. M.O'D.

Sampling and statistical evaluation of diamond deposits.

L. ROMBOUS. *Journal of Geochemical Exploration*, 53, 1995, pp 351-67, 12 figs.

The statistical distribution found by a sampling programme of the average grade of deposit and average value of the diamonds found is an important item in the evaluation of a diamond deposit. Techniques are described. M.O'D.

Archean mantle heterogeneity and the origin of diamondiferous eclogites, Siberia: evidence from stable isotopes and hydroxyl in garnet.

G.A. SNYDER, L.A. TAYLOR, E.A. JERDE, R.N. CLAYTON, T.K. MAYEDA, P. DEINES, G.R. ROSSMAN AND N.V. SOBOLEV. *American Mineralogist*, 80, 1995, pp 799-809, 9 figs.

The O isotopic composition of clinopyroxene and garnet, the C isotopic composition of diamond and the OH⁻ content of garnet from eclogite xenoliths transported to the surface in the Udachnaya kimberlite pipe, Yakutia, Siberia are presented as data which prompt the proposal that the eclogites may derive from an ultra-depleted mantle at approximately 2.9Ga. It is possible that ancient crustal material may have participated in the formation of the Udachnaya eclogites though the mantle C isotopic values of associated diamonds and the low OH⁻ content of the minerals suggest low or no participation of crustal material. M.O'D.

Occurrence of diamond in the mantle: a case study from the Siberian Platform.

Z.V. SPETSUS. *Journal of Geochemical Exploration*, 53, 1995, pp 25-39, 4 photos, 8 figs.

Diamond crystals from diamondiferous xenoliths and some kimberlite pipes at Yakutia, Russia, are described. Photoluminescence and infrared light absorption studies of crystals from mantle xenoliths, together with their morphology, allow differentiation to be made between diamonds from the peridotitic and eclogitic parageneses. Crystals from mantle xenoliths and from kimberlites are compared on the basis of their physical properties and morphology. It is shown that most diamonds in kimberlites are derived from mantle peridotite and eclogite, and were released into the kimberlite when the xenoliths disintegrated. M.O'D.

Thermal conductivity of isotopically modified single crystal diamond.

L. WEI, P.K. KUO, R.L. THOMAS, T.R. ANTHONY AND W.F. BANHOLZER. *Physical Review Letters*, 70(24), 1993, pp 3764–67 (Jun 14), 3 figs, 1 table, 18 refs.

Experimental results on the thermal conductivity of isotopically enriched ^{12}C diamond crystals at low temperatures are presented. As far as is known, the measured value for a 99.9% ^{12}C crystal at 104 K, 410 W/cm K, is the highest measured thermal conductivity for a solid above liquid nitrogen temperature. The temperature dependent conductivities measured for the isotopically enriched diamond and natural abundance diamond specimens in the experiments are well described by Callaway's theoretical model. It is predicted that the thermal conductivity of a 99.999% ^{12}C diamond crystal should exceed 2000 W/cm K at ~80 K. J.H.

Infrared spectra of type IaB diamonds.

G.S. WOODS, I. KIFLAWI, W. LUTYEN AND G. VAN TENDELOO. *Philosophical Magazine Letters*, 67(6), 1993, pp 405–11 (Jun), 6 figs, 18 refs.

It is shown that the infrared absorption spectra of pure type IaB diamonds, namely those that on cursory examination show only a B one-phonon component and neither A nor D, and the complete absence of a B' localized-mode platelet absorption peak, may be divided into two subgroups. The defect content of specimens of one of these subgroups has been studied before and comprises slip dislocations and voidites in random homogeneous distributions unconnected with the transformation of platelets to dislocation loops. Electron microscopy of a specimen of the other subgroup, which may be recognised by

the presence of weak additional one-phonon absorption near 1100cm^{-1} , shows a population of dislocation loops resulting from the complete transformation of a former platelet population, plus accompanying voidites. It is suggested that the extra absorption is caused by the dislocation loops. Observation of the way in which loops and voidites are distributed suggests that voidite production and platelet transformation may not, after all, be interlinked phenomena, but parallel independent processes both promoted by the same unknown conditions. J.H.

Gems

Fluorit. Liebling der Sammler.

ANON. *Mineralientage München. Offizieller Katalog 1995*, 1995, pp 30–110, illus. in colour.

Every year the Munich mineral fair has a theme mineral and fluorite fills the role in 1995. Fluorite's colour, geology, mineralogy, occurrence and recovery are described with notes on outstanding specimens, significant locations (including the Blue John site) and some paintings of fluorite crystals. M.O'D.

Pierres naturelles at matières synthétiques utilisées dans la joaillerie égyptienne.

A. BOUQUILLON, G. QUERRE AND J.-P. POIROT. *Revue de gemmologie*, 124, 1995, pp 17–22. Illus. in colour.

Three pectorals in the collection of the Musée du Louvre, Paris contain natural and artificial stones whose identity was determined by a variety of techniques which are described. M.O'D.

History of pearling in La Paz Bay, South Baja, California.

M. CARINO AND M. MONTEFORTE. *Gems & Gemology*, 31(2), 1995, pp 88–105, 16 illus. in colour.

The history of Baja California, the peninsula in North West Mexico, is closely linked to the exploitation of pearl resources for the past 400 years. Pearls from this source can be found in many religious treasures and royal jewellery collections. The two pearl oysters indigenous to the area are *Pinctada mazatlanica* giving typical baroque or semi-baroque pearls and *Pteria sterna* which produces smaller but rounder natural pearls.

Although pearling was known before the

arrival of the Spaniards in 1533, the area was exploited until the 1680s and for the next sixty years the grounds replenished themselves. Following thousands of oysters being cast onto the northern shores of the Gulf in 1740 the grounds were again exploited and a permanent settlement was established. By 1756 the grounds were again impoverished but the political independence of Mexico in 1821 coincided with a natural replenishment coupled with an influx of foreign investment. Combier, a French businessman started the export of oyster shell in 1836 and from 1840 the value of this was greater than that from pearls. During 1850–1925 pearl finishing increased and the pearl fleets were increasingly owned by local people. Later the Mangara Exploration Company became the main operator but did great damage to the grounds by routinely using explosives. Following the revoking of the Mangara Contract in 1912, the world's first pearling station was established by Gaston Vives and the C.C.C.P. company.

For spat collection wooden incubators were used and several million young oysters were harvested by hand. In San Gabriel Bay the inlet was transformed into a lagoon where the oysters were grown and protected from predators. After three years the oysters 16–18cm in diameter were collected and examined for pearls. Whereas Mikimoto's work pioneered pearl culturing, that of Vives was centred on pearl-oyster cultivation.

Today, cultivation techniques are being carried out by CIBNOR, a pearl-oyster research group incorporating many of the factors considered by Vives. Although on a limited scale the anticipated harvest by March 1996 is approximately 1000 cultured blister pearls of which 70 per cent should have the rich distinctive colours of Baja California pearls. R.J.P.

Eclogites and jades as prehistoric implements in Europe. A case of petrology applied to cultural heritage.

C. D'AMICO, R. CAMPANA, G. FELICE AND M. GHEDINI. *European Journal of Mineralogy*, 7(1), 1995, pp 29–41, 1 map.

Eclogites and 'jades' [Na-pyroxenitic stones lacking garnet] are the raw material of many prehistoric polished axes found in N Italy and in a great part of the rest of Europe. In sites near the Western Alps, eclogites prevail over jades, whereas outside this region, jades become dominant. The petrography of European axes is

similar to that of the N Italian axes and they were probably derived from the same source; only a few ceremonial jade axes of high quality in NW Europe do not correspond with a NW Alpine provenance. R.A.H.

The Merelani graphite-tanzanite deposit, Tanzania: an exploration case history.

C. DAVIES AND R.J. CHASE. *Exploration & Mining Geology*, 3(4), 1994, pp 371–82, 2 maps.

This deposit occurs in NE Tanzania, 14 km south of Kilimanjaro International Airport and close to the towns of Moshi and Arusha. The graphite mineralization is hosted by relatively undeformed linear Proterozoic meta-sedimentary gneisses, several of which have been subjected to hydrothermal alteration resulting in tanzanite mineralization. The graphite has been shown to be of unusually coarse flake-size, crystallinity and high purity. Studies have shown the deposit to be economically viable with a measured resource to 50m of $> 9 \times 10^6$ t assaying at > 8 per cent graphitic C. Production was due to start at the end of the first quarter of 1994 with the processing plant design capacity initially set at 15 000 t/y. Tanzanite will also be produced by selective mining within the graphite open pit in the upper horizon and from underground workings within the lower horizon. This deposit will be the first major ore body to be exploited by private funding since Tanzania gained independence. R.E.S.

Zum Fluorit. Eigenschaften und genetische Aspekte.

M.A. GÖTZINGER. *Mineralien Welt*, 6(6), 1995, pp 26–32, illus. in colour.

The structure, cause of colour, luminescence, geology, occurrence and internal world of fluorite are discussed. A list of references is provided. M.O'D.

Petrology of jadeite metagranite and associated orthogneiss from the Malpica-Tuy allochthon (northwest Spain).

J.I. GIL-IBARGUCHI. *European Journal of Mineralogy*, 7(2), 1995, pp 403–15, 2 maps.

Jadeite occurs in plagioclase pseudomorphs of porphyritic veins associated with corona-bearing granodioritic orthogneiss SW of Cabo Ortegal, NW Spain. Igneous textures and the igneous composition of plagioclase and biotite,

as well as high-*P* assemblages with sodic pyroxene, Ca-rich corona garnets, Si-rich phenigite and rutile are preserved in the least deformed zones of jadeite-bearing and related rocks. Almandine- and grossular-rich coronitic garnets show conspicuous asymmetric zoning (e.g. Alm₇₆Gro₁₁Pyr₁₃ to Alm₅₄Gro₄₁Pyr₅ across a <100µm thick garnet rim). Estimated peak metamorphic conditions for jadeite-bearing and related rocks, ~640°C, >1.6 GPa, are consistent with those deduced from eclogites within the same structural unit. R.A.H.

Kristallglasschalen von Carl Fabergé.

J. GRAF VON FRANCKEN SIERSTORPF. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 61–3, 2 photos. in colour, bibl.

Two Carl Fabergé cut glass bowls with silver rims and round silver handles are described as are the typical hallmarks giving the silver content. The bowls are dated 1890. E.S.

Ein neues Vorkommen von Smaragd, Alexandrit, Rubin und Saphir in einem Topas-führenden Phlogopit Fels von Poona, Cue District, West Australien.

G. GRUNDMANN AND G. MORTEANI. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 11–31, 3 maps, 13 photos in colour, 2 diagrams, bibl.

In August 1994 first alexandrite then ruby was discovered in the Murchison Province, Western Australia. The green alexandrite and the ruby occur in tabular crystals or as strongly altered fragmented crystals together with deep blue sapphires, colourless topaz, light green emeralds, pink fluorite, margarite, muscovite and quartz in schists typical of those hosting the emerald deposits of Poona. The host rock is a medium grained phlogopite. Until now little cuttable material has been found, but further discoveries are likely. E.S.

Ein neues Vorkommen von Feueropal in Brasilien.

U. HENN AND R. BALZER. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 43–6, 3 photos in colour, bibl.

A new occurrence of fire opals has been discovered in the Brazilian state of Rio Grande do Sul, near the village of Campos Grande within the agate and amethyst mining areas of southern

Brazil. The fire opal is found in a sedimentary layer just below the agate-bearing lavas. The rough is partly rounded and weighs up to 50–70 grams. They are orange-red to fire-red. RI 1.440 (±0.001), SG 2.01 (±0.02). Under the microscope one can see swirl-like structures and colour zoning. E.S.

Rote berylle aus Utah, USA-neue beobachtungen.

U. HENN AND G. BECKER. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 55–60, 3 photos. in colour, 4 photomicrographs in colour, bibl.

The beryls come from south-western Utah, particularly the Wah Wah Mountains. They are found in so-called steam holes in rhyolites. The tubes which have penetrated the rhyolites and transported some post-volcanic gases are significant for the study of transportation of substances necessary for the formation of manganese containing red beryls. Fluid inclusions as well as interesting growth and colour zoning perpendicular and parallel to the *c*-axis of the beryls are shown. E.S.

Gem trade lab notes.

R.C. KAMMERLING AND C.W. FRYER. *Gems & Gemology*, 31(2), 1995, pp 120–7, 1 illus. in black-and-white, 17 illus. in colour.

Azurite and antlerite rock. A variegated blue and green cabochon effervesced with dilute hydrochloric acid whilst a substance present in surface cavities melted on the approach of a hot needle suggesting azur-malachite. X-ray powder diffraction showed the blue and grey material to be azurite and quartz. The green material proved to be antlerite whilst the coloured foreign material was probably a polymer.

Jadeite with misleading inclusions. Small white crystals were seen in the white areas in an especially clear mottled green and white carving. All the properties were consistent with natural-colour jadeite.

An opaque mottled green and white carved mask gave only a vague RI reading of 1.62 and was inert both to LW and SW ultraviolet radiation. X-ray powder diffraction showed it to be omphacite, a pyroxene group mineral intermediate in composition between jadeite and diopside.

A cultured pearl showed on radiography a central void containing free pieces of a shattered bead.

A translucent mottled green cabochon resembling fine quality jade had a spot RI of 1.55 with dye in the fractures and a characteristic 'dye' band centred at about 650nm; it was dyed quartzite. Infra-red spectroscopy revealed a key absorption feature at 2900cm^{-1} similar to that of opticon resin.

A synthetic ruby with curved striae also showed fingerprint inclusions and a moderate star both of which must have been induced.

A green-blue sapphire showing chatoyancy which is described as rare had no acicular rutile needles but a series of nearly-planar, parallel, liquid-filled 'fingerprints'. Diffuse colour halos around the crystal inclusions showed that the stone had been heat treated. R.J.P.

An update on the Ural emerald mines.

A.F. LASKOVENKOV AND V.I. ZHERNAKOV. *Gems & Gemology*, 31(2), 1995, pp 106–13, 12 colour illustrations.

The Ural emerald mines have been worked almost continuously since 1831; up to 1930 emerald and green beryl production sometimes reached 2.5 million carats annually and exceeded that of Colombia. During the 1939–45 War mining concentrated on beryllium ore production. Contrary to popular belief emerald production from this source has barely been interrupted.

During the 1940s and 1950s emerald production reached as high as 3–4 million carats as a by-product in beryllium production but the discovery of further beryllium deposits shifted attention back to emerald production with an annual production as high as 8–10 million carats. Malysheva Mines Management developed a sophisticated mining complex but cutting was not quite as sophisticated and only 20 000 carats of well cut emeralds were produced. After a cessation in cutting between 1987 and 1991, a Russian-Panamanian-Israeli venture ensured that Russian emeralds were cut using the latest technology.

Although there are significant reserves, only the Mariinsky deposit is currently being mined for emeralds using special low impact explosives. The deposits are located about 100km north-east of Ekaterinburg and are found in schists within amphibolite zones.

Uralian emeralds are mainly bluish-green, the intensity varying due to chromium content. Internal features are characterized by zoning, mineral and two-phase inclusions. The nature of

the mineral inclusions depends on the nature of the enclosing rock. Several very large emeralds have been found including the 11 000 carat crystal named Kochubey's emerald found in 1831 and latterly the 3 370 carat emerald named Glorious Ural Stone found in 1978. In 1990 two rare beautiful emeralds were mined, the 4 400 carat New Year's stone and the 37.5 carat faceted Vitaly emerald. R.J.P.

Zinnober und antiminit: ausgezeichnete kristalle und ihre fundstellen in China.

G. LIN. *Lapis*, 20(10), 1995, pp 33–43, 2 maps.

Included in the paper which describes Chinese locations for fine cinnabar and antimonite crystals is a list of gem minerals found in that country, giving species and province name only. M.O'D.

The crystal chemistry of Si \rightleftharpoons Al substitution in tourmaline.

D.J. MACDONALD AND F.C. HAWTHORNE. *Canadian Mineralogist*, 33, 1995, 849–58.

The structure of nine gem-quality vanadian uvites on analysis with the electron microprobe proved to have a Si content of significantly less than 6 atoms per formula unit: assignment of ^{14}Al sufficient to fill the Si site gives a linear relationship between {Si-O} and ^{14}Al content. Recent work on tourmaline structure refinement shows no well-defined relationship between {Z-O} and constituent Z-cation radius. On the other hand there is a linear relationship between {Y-O} and constituent Y-cation radius. Site-scattering refinement shows F to be strongly to completely ordered at the O(1) site with no significant positional disorder at the O(1) or O(2) sites. M.O'D.

Metasomatism at a granitic pegmatite-dunite contact in Galicia: the Franqueira occurrence of chrysoberyl (alexandrite), emerald and phenakite.

A. MARTIN-IZARD, A. PANIAGUA, D. MOREIRAS, R. ACEVEDO AND C. MARCOS-PASCUAL. *Canadian Mineralogist*, 33, 1995, pp 775–92, 2 maps.

The first documented example of a gem-quality chrysoberyl, emerald and phenakite deposit in western Europe is situated at Franqueira in the north-western part of the Iberian peninsula, Spain. The deposit is in the Galicia-Tras os Montes zone which is formed of two domains, one of schistose rocks and one of

granitic rocks. Granite pegmatite bodies intrude both schists and granite rocks. The geology and mineralization of the chrysoberyl (alexandrite) emerald and phenakite occurrences are discussed. The contact between a pegmatite body related to heterogeneous granites and ultramafic rock of dunitic character has developed a metasomatic zone in which the dunite has been almost completely altered to phlogopite at the contact. The phlogopite-rich metasomatic rocks contain the gem minerals. A genetic model is proposed in which emplacement of pegmatite and associated mobile elements (Be, B, P) into dunite takes place with subsequent metasomatism of the dunite into phlogopite and tremolite rocks near the pegmatite body. Chrysoberyl may be formed through its sharing structural features with the olivine so that epitactic nucleation on olivine relics could take place. Emerald is the last Be-bearing mineral to form, partially replacing chrysoberyl and phenakite, perhaps from the reaction $\text{chrysoberyl} + \text{phenakite} + \text{quartz} \rightarrow \text{emerald}$, until exhaustion of the quartz occurs.

M.O'D.

Situation géologique des émeraudes de Ianapera, province de Tuléar (Madagascar).

P. MARCHAND. *Revue de gemmologie*, 124, 1995, pp 13–16, illus. in colour, 3 maps.

Emerald has been discovered at Ianapera, Tuléar province, Malagasy Republic. The site is in the south of the island and crystals occur in tremolite-actinolite schists. The crystals are dark green in the main and reach 10g maximum. Most are heavily fractured and contain mica inclusions.

M.O'D.

Fluoritfundstellen in Kanada.

F. MELANSON. *Lapis*, 20(11), 1995, pp 33–5, illus. in colour.

Fine examples of gem-quality fluorite have been found at a number of locations in Canada. Brief notes are given for the major locations.

M.O'D.

Peridot aus Pakistan.

C.C. MILISENDA, H. BANK AND A. HENN. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 33–42, 3 photos in colour, 2 photomicrographs in colour, 1 map, 3 diagrams, 1 table, bibl.

The gem quality peridot is found 15 000 ft above sea level in the Nanga Parbat region of

Pakistan Kashmir, most probably in veins in serpentized peridotite. The crystals are in part well crystallized. There are some large crystals that are eye-clean and yield stones weighing more than 100ct. The authors examined a cut stone of 309.90ct. RIs range n_x 1.648–1.653, n_y 1.663–1.671 and n_z 1.683–1.689, and birefringence from 0.035–0.038. SG 3.29–3.37. The absorption spectrum showed typical bands characteristic of Fe^{2+} . When immersed, feathers of small fluid inclusions as well as growth structures could be seen. Some rope-like inclusions of the Ludwigite-Vonsenite solid solution series were seen which have not been reported in peridot from other sources.

E.S.

Gemmologische kurzinformationen.

C.C. MILISENDA. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 3–9, 8 photos in colour.

New gemstone finds in Afghanistan include golden beryls and brownish-yellow tourmalines from the Laghman district near Nuristan. The beryls show etch figures and have SG 2.7, RI 1.569–1.580, DR 0.008. Some cavansite was found near Poona, India, this is blue to bluish-green, turquoise-like and cut as cabochons; it has RI 1.54, SG 2.24–2.27, hardness 2%.

A massive natrolite was found in northern Bohemia; it is yellow-brown and looks like opalised wood; it has RI 1.48, SG 2.15, hardness 5.

An imitation of demantoid was offered on the market, but on examination turned out to be YGG (yttrium-gallium-garnet). A diffusion treated red corundum of 7.38ct was examined; it has RI 1.762–1.770, DR 0.008; the rim was relatively dark.

Some diamond beads on the market are yellow-brown, greenish-brown, weighing more than 10ct. The stones are bruted and show polishing marks. Weight loss is said to be about 50%. The technique was developed in Antwerp in 1989.

E.S.

Ammolite, ein organischer Schmuckstein aus Alberta, Kanada.

G. NIEDERMAJR. *Mineralien Welt*, 6(6), 1995, pp 41–6, illus. in colour.

The name ammolite has been given to an ornamental fossil material with an opal-like play of colour, found in the area of St Mary's river in southern Alberta, Canada. Maps and details of the occurrence are given.

M.O'D.

Mondstein als Schmuckmaterial.

G. NIEDERMAYR. *Der Staoansuacher*, 9(2), 1995, pp 18–24, illus. in colour.

A description of the feldspar gemstones with particular reference to the moonstone effect in orthoclase and other feldspar group members, to the coloration of labradorite and to the coloration and phenomenal effects in gemstones generally. M.O'D.

World review of mineral discoveries 1993–1994.

G.W. ROBINSON, V.T. KING, J. SCOVIL AND F. CURETON. *Mineralogical record*, 26(5), 1995, pp 475–99, illus. in colour.

Among mineral discoveries reported during 1993–94 are bicoloured red and green elbaite from the Himalaya mine, Mesa Grande, California, where in 1994 a series of pockets were found: pale lilac to dark royal-purple amethyst from the Intergalactic mine, Maine and facetable blue-green elbaite from the Mount Mica quarry, Paris and multi-coloured green to crimson tourmaline crystals at the Bennett mine, Buckfield, in the same state: fine green facet-grade fluorite from the re-opened William Wise mine, Westmoreland, New Hampshire.

Outside the United States are reports of: lazurite from mines in the Kokscha Valley, Afghanistan and gem elbaite from the Gusalaka mines near Pech, Kunar in the same country; other gem quality tourmalines have been reported from the Klugal mine near Paprok and from another locality in the vicinity; many of the crystals reported from Afghanistan at this time are a fine blue; large morganites are reported from Resplendor, Minas Gerais, Brazil, the colour bleaching from a peachy-orange to pure pink; relatively few of the diamond crystals found near Lac de Gras, approx. 300 km NE of Yellowknife, NW Territories of Canada are of gem quality; gem quality opal has been found near Vernon, British Columbia; the Mengyin area of Shandong Province, China, is producing small diamond crystals in matrix; from Russia have come elbaite and liddicoatite but buyers are warned to check their specimens as there has been some indiscriminate labelling; Na-liddicoatite is reported from the Malchan pegmatite field [Kraznoy Chikoy]; some of the kimberlites found in eastern Finland contain diamonds; gemmy orthoclase is coming from South Betroka, Malagasy Republic; large yellow-green to brown grossular-andradite crystals are reported from a site near Sandara, Niore du

Sahel, Mali; fine peridot crystals are being found in Pyaung Gaung, Myanmar, as is bright green tourmaline (V-uvite is considered to be the appropriate name for this material); Namibia (the Otjua mine, Karibib) is continuing to produce large, often doubly-terminated rubellite crystals; red to green tourmaline is also reported from an alluvial ruby deposit at Thac Ba Lake, Yen Bai province, north Vietnam; pink beryl is reported from a site near Drot-Balachi, Shengus, Pakistan and the same country is producing peridot from Kohistan – quality is very fine. Also from Pakistan are blue crystals of phenakite (from Apaligun) and zircon crystals from Bulbin, Wazarat district. From Sri Lanka a 27 ct 2 cm crystal of sinhalite is reported from Niriialla near Ratnapura, Sabaragamuwa province and sharp sapphire crystals are coming from Galbkkka, near Vallivaya, Uva province. Pink zircon occurs as terminated crystals at Amlilipitiya, near Kataragama. M.O'D.

Topas aus dem Untersulzbachtal, Österreich.

W. SCHÄFER, S.-A. JAKOBS AND R. HOCHLEITNER. *Lapis*, 20(9), 1995, pp 13–19, illus. in colour, 1 map, 2 figs.

Well-formed colourless topaz crystals which could be fashioned into faceted stones are found in the Untersulzbachtal area of southern Austria, one of the main sites lying between the Stockeralm and Leutachkopf mountains. Quartz and sphene are sometimes found with the topaz as characteristic Alpine cleft minerals. M.O'D.

Gem minerals in early Arabic literature.

W.J. SERSEN. *Mineralogical Record*, 26(4), 1995, pp 43–8, 3 figs.

While much Arabic writing on gemstones has not been translated, the original texts are mostly available in major libraries around the world. The author cites several topics dealt with in early Arabic literature, including the distinction of ruby from red spinel by specific gravity testing, the emerald versus peridot question as it concerns Egyptian sites, fluorescence in gem species from Afghanistan and Arab remarks on corundum. Brief details of early sources and their availability are given. M.O'D.

Regional mineralogies of the world.

A.E. SMITH. *Mineralogical record*, 26(4), 1995, pp 113–134.

A bibliography of topographical mineralogies arranged in alphabetical order of country or

state, including citations of papers in journals as well as monographs. M.O'D.

Étude comparative sur les principaux traitements de l'émeraude.

D. SIRAKIAN AND D. RUSKONÉ. *Revue de gemmologie*, 124, 1995, pp 6–8, illus. in colour.

Examples of different types of treated emeralds are presented with brief notes on identification. M.O'D.

Der Edelstein-Bergbau in Afrika.

K.C. TAUPITZ. *Gemmologie – Zeitschrift der Deutschen Gemmologische Gesellschaft*, 44(2/3), 1995, pp 47–54, 3 maps, 1 diagram, 1 table.

Survey of gem mining in Africa, diamond being the most important, but during the last 10–15 years emerald, ruby, sapphire, tourmaline, aquamarine, amethysts, tanzanite, tsavorite and others have increased in importance. Easing of currency restrictions has had a positive effect on trading, as has also the diminishing influence of drug dealing combined with illegal dealing. Some geological interrelations are pointed out. E.S.

The saga of *Mineral digest*.

L. ZARA. *Mineralogical Record*, 26(4), 1995, pp 135–42, 11 photos.

An account of the conception and publication of the journal *Mineral digest* which ran to eight issues only over an eight-year period from 1970 and which included many gemstones in its subject-matter and lavish colour photographs. Sets of the journal are keenly sought by collectors. All eight covers are reproduced. M.O'D.

Instruments and Techniques

Automated engraving with Syndite PCD.

B. AUGENSTEIN. *IDR*, 55(2), 1995, pp 66–7, 5 illus. in colour.

The author describes an engraving machine suitable for mass production in the jewellery and coin stamping industry. Diamond tools work to extremely close tolerances, provide high surface finish and provide flexibility. As an example of an individual piece the author describes agate of diameter 100mm which was to be engraved with a wine-making scene; the tool used was a four-edged PCD cutter. The work was finished in approximately 48 hours. E.S.

Modelling the X-ray diffraction pattern of opal-CT.

G.D. GUTHRIE, JR., D.L. BISH AND R.C. REYNOLDS, JR. *American Mineralogist*, 80, 1995, pp 869–72, 3 figs.

It is suggested that H₂O in opal is probably not present on a specific crystallographic site within the opal structure but may be located along the boundaries between the 10–35nm grains. This proposal is derived from the modelling of X-ray diffraction patterns of opal-CT [cristobalite/tridymite] using a recursive calculation technique allowing for ordered and disordered intergrowths of planar units. M.O'D.

Rho und Phi, Omega und Delta: die Winkelmessung in der Mineralogie.

O. MEDENBACH, P.W. MIRWALD AND P. KUBATH. *Mineralien Welt*, 6(5), 1995, pp 16–25, 15 photos (14 in colour).

Short account of the part played by the goniometer in the history of mineral identification. Several models of instrument are illustrated. M.O'D.

Historische Entwicklung der Kristallmodelle.

L. TOURET. *Mineralientage München. Offizieller Katalog 1995*, 1995, pp 25–8.

Brief survey of the art of crystal modelling with particular reference to Häüy and other early crystallographers. M.O'D.

Diamond laboratory techniques.

N.J. TOWIE AND L.H. SEET. *Journal of Geochemical Exploration*, 53, 1995, pp 205–12, 1 fig.

For the location of possible diamond sources discrete mineral grains need to be extracted from primary source rock. Grain size needs to be greater than 0.1mm in diameter: laboratory techniques for the handling of grains are described. M.O'D.

Synthetics

Premières études sur les émeraudes synthétiques hydrothermales japonaises AGEE.

H.A. HÄNNI AND L. KIEFERT. *Revue de gemmologie*, 124, 1995, pp 9–12, illus. in colour.

Examination of hydrothermal emeralds produced by the Japanese firm AGEE shows that small liquid- and gas-filled inclusions and undulating veil-like structures are helpful in identification. Energy-dispersive XRF shows chlorine to be present. M.O'D.

Growth temperature effects of impurities in HP/HT diamonds.

H. KANDA AND S.C. LAWSON. *IDR*, **55**(2), 1995, pp 56–61, 1 table, 1 graph, 9 photomicrographs in colour, bibl.

Diamond crystals have been grown by the temperature gradient method under high temperature and pressure conditions, using Co and Ni catalysts with or without the use of Ti. A distinct green or brown coloured stripe caused by the incorporation of nickel appeared in sample regions formed during decreases in the growth temperature, but not in regions corresponding to increases in temperature. This suggests that the concentration of nickel depends on growth rate rather than on the growth temperature, in contrast to the case for nitrogen and boron. E.S.

New nickel-related optical absorption in high-pressure synthetic diamond.

S.C. LAWSON, H. KANDA AND M. SEKITA. *Philosophical Magazine B*, **68**(1), 1993, pp 39–46 (Jul), 4 figs, 10 refs.

Diamonds grown by the temperature-gradient method using a nickel catalyst and sufficient nitrogen getter to produce barely detectable nitrogen absorption in the defect-induced one-phonon region have a deep brown colour which has been found to result from continuum absorption whose threshold lies around 1.7 eV. In these diamonds, the presence of a zero-phonon structure lying between 1.2 and 1.25 eV has been observed for the first time in the near-infrared spectral region of the absorption spectrum. This structure exhibits interesting photochromic effects, and a correlation between partial decay of the 1.40 eV system (whose transition has previously been ascribed to nickel) and growth of the new zero-phonon structure has been observed. Like the 1.40 eV system, the new zero-phonon structure shows strong polarisation effects and is confined exclusively to the {111} growth sectors of diamond. From these results, it is proposed that the new structure results from a different charge state of the 1.40 eV nickel system. J.H.

Optical absorption spectroscopy of synthetic tourmalines.

M.N. TARAN, A.S. LEBEDEV AND A.N. PLATONOV. *Physics & Chemistry of Minerals*, **20**(3), 1993, pp 209–20.

The optical absorption spectra of tourmaline solid solutions containing Fe, Fe + Ti, Cr, Ni, Cu, Co, Mn chromophoric centres have been

measured in the range 26316–5000cm⁻¹ at 297K and in the range 26316–9090 cm⁻¹ at 77K. In Fe²⁺, Fe³⁺-bearing specimens intense σ -polarized absorption bands caused by exchange-coupled Fe²⁺, Fe³⁺ pairs in Y- and Z-sites occur. The colour and spectroscopic properties of the Fe²⁺, Mn³⁺ and Cu²⁺ containing tourmalines are significantly affected by the presence of even the smallest Li-contents. The results suggest that Fe²⁺, Cu²⁺, Co²⁺, Ni²⁺ ions occupy, predominantly, Y sites of the tourmaline structure, whereas the Cr³⁺ ions enter the smaller Z octahedra.

S.A.T.R.

The effect of isotopic changes on the {001} platelet infrared absorption in diamond.

G.S. WOODS, I. KIFLAWI, H. KANDA AND T. EVANS. *Philosophical Magazine B*, **67**(5), 1993, pp 651–658 (May), 3 figs, 3 tables, 29 refs.

Normal synthetic diamonds consist of 99% ¹²C with 1% ¹³C in the host lattice, with dispersed ¹⁴N as the main impurity. Two variants have been produced by changing natural isotopic abundances, in one case of the atoms of the host lattice and in the other of the nitrogen impurity. These, together with normal specimens, were treated under a stabilising pressure at a temperature sufficiently high to produce {001} platelets and the associated B' localized-mode infrared absorption peak. No isotopic effects were observed when B' peaks in ¹²C diamonds with a substantial proportion of the nitrogen (up to about 67 per cent) present as the ¹⁵N isotope (the balance being ¹⁴N) were compared with the B' peaks in ¹²C diamonds containing only ¹⁴N. This implies either that nitrogen atoms, if present, are a minor constituent of the platelets or that such atoms, if a major species, remain stationary in the vibrational mode responsible for the B' absorption peak. Specimens consisting almost entirely of ¹³C, with the nitrogen impurity present as ¹⁴N, showed a shift in the wavenumber of the B' peak. Using simple harmonic theory, and taking into consideration the experiment described above which shows no influence of nitrogen atoms on the B' peak, this shift would be expected to be in the ratio of about (12/13)^{1/2}, caused by the change in the carbon mass only. The observed shift was, however, smaller than expected. It is suggested that this anomalous shift is caused by anharmonic effects, enhanced by the proximity of the B' local mode energy to the Raman energy. It would be valuable if a theoretical study could be made to test the validity of this suggestion. J.H.

The centre of
Excellence...

... for diamonds

The London Gem Testing Laboratory was founded in 1925 and from the start established a reputation for integrity and excellence.

Diamond grading services were established in 1980 and the Laboratory has built up an enviable international reputation for consistency and quality.

The London Diamond Report is based on harmonized grading for colour and clarity of diamonds and gives the most essential and up-to-date information required by the trade.

The Laboratory is also proficient in the grading of fancy-cut diamonds and in colour origin determination.



With a London Diamond Report your diamond's prestige is assured



The Gem Testing Laboratory

GAGTL, 27 GREVILLE STREET,
LONDON EC2M 8SU, UK

Tel: +44 (0) 171-405 3351
Fax: +44 (0) 171-831 9479

BOOK REVIEWS

Faux gems and jewels circa 1700 to 1930. An exhibition and sale [held by and at Sandra Cronan Ltd].

V. BECKER, 1994. Sandra Cronan Ltd, London. pp 36, illus. in colour, softcover.

A useful and attractive guide to a sale-exhibition held during 1994 with many colour photographs, some of which have reproduced rather darkly. The author speeds through the use of foiled and glass imitation gemstones and succeeds in making them objects of interest and desire, as indeed they were meant to be. There is a short list of references and the book in no sense aims at completeness, but anyone interested should try to get a copy before the print run is exhausted.

M.O'D.

Ringe. Rings. Die Alice und Louis Koch Sammlung. Vierzig Jahrhunderte durch vier Generationen gesehen. The Alice and Louis Koch collection. Forty centuries seen by four generations.

A.B. CHADOUR, 1994. Maney, Leeds. pp 663, illus. in colour, hardcover, £200.00. ISBN 0 901286 45 1. In German and English. Slip case provided.

This very large book (it measures 35 x 25cm) is a full *catalogue raisonné* of the collection of rings formed by Alice and Louis Koch (1862–1930). The Kochs formed collections of other materials too, notably in the field of music, but antiquaries would place their collection of faience high in the list of major cabinets of that material. The Koch family were jewellers in Frankfurt am Main, Germany, and the firm was one of the leading German jewellery enterprises. Since the development of the business coincided with the rise of Art Nouveau, followed by Art Deco, the creations of the Kochs became important in those fields. The pieces made by Robert Koch (d.1902) are not often seen in the saleroom and when Louis Koch died in 1930 no one was left to carry on the name. The property was expropriated by the Nazi régime and, after the war when it had changed hands more than once, the business never regained its pre-eminence, closing down finally in 1987. The archives, mostly of jewellery designs, are in the Deutsches Goldschmiedehaus, Hanau.

The ring collection, now comprising 1980 items, is in the care of Louis Koch's great-grandchildren and contemporary jewellery designers have been helped by having their works included in it.

After a short biography of the Koch family and the formation of their art collections, the book devotes some pages to the history of the ring both in history and in the collection. The note covers the chronological development of the ring as an ornament, from classical antiquity up to the present. The descriptive portion of the catalogue then occupies the remainder of the text. Here items are arranged chronologically, each entry containing a colour photograph of good quality; most of necessity are small though there are short sections in the front of each volume for which larger photographs are selected. The rest of the entry gives inventory number, dimensions, description of metal and stone where appropriate, designer, publication and general comment. As in the remainder of the book both German and English are used side-by-side.

The book ends with an 18-page bibliography, notable for the inclusion of many rare German and European items; it is followed by a glossary, a general index and an index of firms and artists.

It is inevitable that most copies of this magnificent book will be purchased by libraries, since the price is naturally high for the private scholar. Nonetheless it will clearly be one of the most notable additions to ring scholarship for many years and will be of great interest to the historian of gemmology and its applications (a race yet to evolve).

M.O'D.

Fifth international kimberlite conference, Araxá, Brazil, 1991.

COMPANHIA DE PESQUISA DE RECURSOS MINERAIS-CPRM, RIO DE JANEIRO, 1994. pp 495, 388, 2 vol., illus. in black-and-white, softcover. Price on application to and available from the Mineralogical Society of America. CPRM *Special publication* 1/A.

The first volume of this major work on kimberlites and diamond sources deals with kimber-

lites, related rocks and mantle xenoliths and contains papers on the Arkhangelsk diamond-kimberlite province as well as a great deal of material on other types of kimberlite, lamprophyre and carbonatite occurrences. The second volume is entirely devoted to diamonds, their characterization, genesis and exploration. The 29 papers in this volume will all be of interest to academic gemmologists and the student may also find at least some of the text a stimulus toward further study. Each paper has its own list of references. M.O'D.

100 famous diamonds.

DE BEERS, 1995. London. pp 18, illus. in colour, softcover.

Free publicity pamphlet describing and illustrating 100 of the best-known cut diamonds with notes on the weight, source of name, colour, date and source of discovery and weight of the original rough where known. The pamphlet is quite well produced but the text is marred by the recurring and sometimes mystifying reference to 'weight of original diamond' (not the rough) and by the use of unspecific adjectives ('extraordinary colour') where specific ones would have told the reader something useful. M.O'D.

Les grenats.

J. DEVILLE, 1995. *Minéraux et fossiles*, Paris. pp 67, illus. in colour, softcover. Price on application. ISSN (of the parent serial) 0335-6566. *Minéraux et fossiles*. Hors série no 1.

This is a very attractive, well-produced and informative guide to the garnet group, aimed primarily at the collector but of considerable use to the gemmologist. After a brief introduction to the mineralogy of the garnet group the group members are discussed in alphabetical order. Particular attention is paid in the remainder of the book to garnets from France, the relationship of garnets to metamorphism, the synthesis of garnets (this short item includes YAG but also true garnets, which have been synthesized in very small sizes) and garnets as gemstones. For those collectors interested in non-gem members of the garnet group there is some brief but useful information. The book lacks a bibliography but otherwise is an excellent production. M.O'D.

The Paris salons.

A. DUNCAN, 1994. Antique Collectors' Club, Woodbridge. pp 349, 305, illus. in black-and-white and in colour, hardcover. £45.00. ISBN 1

85149 159 7.

Consisting largely of black-and-white photographs, the book records about 3 000 pieces of jewellery displayed at the Paris Salons from 1895 to 1914. This period saw the development and growth of Art Nouveau, a style brought to an end by the start of the war and not revived afterwards. For this reason the period represents a spirit of decoration concentrated into a few years and perhaps because of this flowering more exotically than it might have done otherwise. Jewellers represented include Lalique, Fouquet, Gaillard and Boucheron as well as many other important designers. Four Salons including jewellery exhibits were held each year, those of the Société des Artistes Français, the Société Nationale des Beaux-Arts, the Société des Artistes Decorateurs and the Salon d'Automne. In addition the two major exhibitions, the Exposition Universelle of 1900 and the Exposition de la Parure of 1908 are also included in the survey.

The two volumes thus give a very full record of a major French design period and while most of the photographs are in black-and-white they show up well. Each piece is briefly described and the author has found it possible to provide attributions hitherto lost. Entry is in alphabetical order of artist and the major descriptive text follows a short general introduction in which trends perceived in Art Nouveau jewellery are elaborated. A short index of jewellery designers is given at the end of the second volume. Students of jewellery will need to have this book. M.O'D.

Jewelry in America 1600-1900.

M.G. FALES, 1995. Antique Collectors' Club, Woodbridge. pp 447, illus. in colour, hardcover. £35.00. ISBN 1 85149 223 2.

While the productions of this publisher are always attractive and informative, this book is particularly well-prepared and covers a subject which has often been attempted on a smaller scale. The top of the dust-cover shows a necklace of Maine tourmalines - I can think of nothing so calculated to draw out my interest - the necklace is in the Harvard Mineralogical Museum. The book, too, has a particularly useful bibliography.

Whether or not the pieces included were made in the United States or imported there, the author has attempted to identify and provide accurate descriptions of as many major items of

jewellery with an American connotation over the period 1600–1900 as can be found. The arrangement is in chronological order and many descriptions are taken from contemporary letters in which the jewels were mentioned by their owners or makers.

The book is arranged in four sections: colonial jewellery from 1600–1775; federal jewellery from 1775–1825; introduction [from outside the United States] 1825–1875; and introduction 1875–1900. Each of the four sections concludes with a discussion of the work and influence of individual jewellery of the time.

The illustrations are well-captioned and provide description, size, provenance and present location. The standard of the photography is high. For the gemmologist there is a good deal of relevant information with Kunz and Hamlin credited with many threads of influence; there is as much for the jewellery historian and the historian of costume. This is a first-class book and sells at a most reasonable price.

M.O'D.

Goldsmiths review 1994/95.

1995. Worshipful Company of Goldsmiths, London. pp 64, illus. in black-and-white and in colour.

Articles include silver in the National Museum of Wales, the career of Robert Welch, the new School of Jewellery, Birmingham, the jewellery designer Stephen Webster and his work, the making of fine jewellery, the Goldsmiths Group and its retail outlets, the arrangement of jewellery galleries in shops and the wine cups in the collection of the Court of Assistants, Company news occupies the last part of the issue.

M.O'D.

Edelsteine und Schmucksteine.

R. HOCHLEITNER, 1994. Gräfe und Unser Verlag, München. pp 160, illus. in colour [*GU Naturführer*]. ISBN 3 7742 2131 6.

Pocket-sized, beautifully illustrated guide to gem materials with sections on synthetics and imitation products. One or two of the chemical compositions given are not accurate; for example hydroxyl is omitted from the composition of topaz and feldspar group minerals are too simply presented in the chemical context. These are small points and the book can be highly recommended for the German-speaking gemstone student.

M.O'D.

Tangerine green. [A tale.]

W.D. JAMES, 1995. University Editions, Huntingdon, West Virginia. pp 303, softcover. US\$10.00. ISBN 1 56002 529 8.

A set of assorted characters, few if any likely to be highly-placed on my dinner-party list, are involved in the search for a blue diamond reputedly stolen long ago from Shah Jahan in India. The search 'takes them through several continents' as such enterprises usually do and their miscellaneous adventures are described in a spirited if familiar railway-bookstall style. There are some accounts of gem centres and dealings. Division of the text into 55 chapters speeds the action along and the tale is a fair example of its genre.

M.O'D.

Gediegen Silber: das Erz der Münzen, das Metall des Schmuckes, das Element mit dem Glanz.

VARIOUS AUTHORS, *EXTRALAPIS* 8, 1995. Christian Weise Verlag, München. pp 96, illus. in colour, softcover. DM47 (including postage). ISBN 3 921656 34 6.

A set of papers dealing with the geology, mineralogy, current mining and mining history, fashioning and lore of native silver. The concluding paper lists and briefly describes the known silver compounds and lists are also given of the known silver mines in antiquity with dates of their period of production and notes of other elements found. The paper on major silver artefacts includes a list of references and the whole book is well up to the now-expected *extraLapis* standard.

M.O'D.

Granat. Die Mineralien der Granat-Gruppe: Edelsteine, Schmuck und Laser.

EXTRALAPIS 9, 1995. Christian Weise Verlag, München. pp 96, illus. in colour, softcover. DM 34.80. ISBN 3 921656 35 4.

The text covers all the garnet group minerals but pays most attention to the ornamental ones. In the first section group members are briefly described and illustrated: then comes a more detailed discussion of garnet minerals, their chemistry and structure, with the different species being taken in alphabetical rather than chemical order. As with the remainder of the sections, each page includes many colour photographs of the very highest quality, as readers of *Lapis* now expect. Look especially at the Pakistan spessartine!

Geological and mineralogical notes follow, special attention being paid to European deposits. Other sections include descriptions of Bohemian garnet, of some European garnet-set artefacts and a very useful and well-illustrated note on the synthetic garnets. The book ends (or nearly ends) with the question 'why are there no blue garnets?'. For an answer, get the book. In small letters could I add that a bibliography would have been welcome!

M.O'D.

Il libro delle gemme.

E. LEONE, A. LEONE AND G. PROVERA, 1995. Edizioni AISG, Valenza. pp xv, 494, illus. in colour, hardcover. L290,000.

This is a beautifully-produced book with a comprehensive text arranged around a great number of high-quality colour photographs. So many of these show inclusions that the book might be used primarily as a source for some of the latest information about the internal inhabitants of gemstones. It is certainly time that fresh photographs appeared since the importance of inclusions grows daily.

The book begins with an introduction to petrology and mineralogy, dealing with the lithosphere, rocks and minerals, mineral formation and location types. Elementary crystallography follows with coverage of physical properties and the role played by chemistry in crystal formation. The fourth chapter introduces optical properties, including the use of the spectroscope and of ultra-violet sources in gem testing.

Chapter five introduces gemmology as a system of gemstone identification and includes such diverse topics as gemstone nomenclature, gem fashioning and treatment, the synthesis of gem materials and the nature of colour.

Much of the remainder of the book, from page 94 to the end, is devoted to gemstone descriptions. These are arranged in order of crystal class (see below for comment on this) so that diamond is the first material to be described. This section, of 54 pages, covers mining, the properties of diamond, fashioning and examples, with diagrams, of diamond grading. Diagrams of a number of celebrated diamonds are also provided. Descriptions of other gem materials follow the same form: synthetic counterparts of natural stones are included with them and very useful colour photographs of their inclusions, as well as those seen in treated stones need to be looked for under the name of the material. There is a lot to be said for including these features in one place.

Imitation gemstones, where no particular major stone is simulated, are placed in their appropriate crystal families after the natural species have been covered. Thus we find YAG, strontium titanate and cubic zirconia in the cubic crystal system section. Glass is placed in the amorphous section. Altogether this arrangement works quite well since there is no ideal to be aimed at.

Those materials less often seen as fashioned gemstones appear in their appropriate crystal section. Quite a lot of species are described, making the book valuable for the growing number of collectors.

Organic materials are described after opal and glass and again the coverage is very thorough and the photographs original and arresting. Simple identification tables, quite a useful bibliography and both species and general indexes complete the book.

In so large a text there are bound to be some errors and areas less well handled than others. I found that the bibliography included some out-of-date items and some critical notes ought to be included in any bibliography today. Mere lists do not help. Rather more confusing is the arrangement of species by crystal system. Only three classes are used, monometric, dimetric and trimetric. Monometric is the cubic system while dimetric includes tetragonal, hexagonal and trigonal species: the rest are grouped under trimetric. This will appear eccentric to experienced gemmologists and beginners will find it hard to turn from this method of arrangement to more acceptable ones used elsewhere. I would strongly suggest that in a second edition an alphabetical arrangement is used.

Nonetheless, this is a very good, beautiful and important book, well in keeping with traditional Italian excellence of production. All serious gemmologists should buy it.

M.O'D.

Fascination of gemstones.

H.J. MÜLLENMEISTER, 1995. [Published by the author] Markt Schwaben. pp 224, illus. in colour. DM49.50 plus postage. ISBN 3 9801925 1 2.

The author embarks on the perilous course of trying to explain or even justify his addiction to the study of gemstones, taking a number of different topics to illustrate those areas which he finds of greatest interest. He succeeds admirably, not least through the selection of subject areas but also in the choice of first-class colour photographs. Themes include historical diamonds, the physics of coloured diamonds, ruby, emerald

and their synthetic counterparts, details of stones in the crown jewels (in the Hofburg, Vienna) and a great deal on inclusions, well-illustrated by excellent photographs which in fact make the book worth recommending for inclusion study.

I found the addiction completely justified in terms of the book and would recommend it for general reading. For such a colourful production the price is reasonable for today. M.O'D.

La gemmologie, notions, principes, concepts. 2e édition.

F. PAYETTE, 1995. Fischer Presses, Sillery, Québec. pp 227, illus. in black-and-white.

This is a pleasantly-produced and simple book which would suit the student or beginner very well but will not attract the curious customer despite the attractive coloured front cover which depicts cut and rough villiaumite, of all rare stones! As villiaumite has been described as 'only partly water-soluble' it seems appropriate to describe the book as 'only partly satisfactory' for it is without colour photographs! Nonetheless the actual text is fair and the figures are notably clear and accurate. It can be recommended for the French-speaking gemmologist.

M.O'D.

Amber: the golden gem of the ages.

P.C. RICE, 1993. The Kosciuszko Foundation, New York (3rd printing with revisions). pp x, 289, illus. in black-and-white and in colour, softcover. £19.95. ISBN 0 917004 22 1.

This pleasant book was first published in 1980 by Van Nostrand Reinhold and the recent update takes into account the work of George O. Poinar Jr at the University of California, Berkeley, best known for providing some of the impetus for the film *Jurassic Park*. Other additions include some rather fruitless speculations on the present whereabouts of the Amber Room, formerly in St Petersburg, and, more usefully, additional entries to the bibliography. At the softcover price this is still a book gemmologists should possess.

M.O'D.

Photo masters for diamond grading.

G. ROSKINS, 1994. Gemworld International Inc, Northbrook, IL, USA. pp 94, illus. US\$95.00, £49.50.

This reviewer has been grading diamonds in a laboratory environment and teaching the subject

since 1979. In that time he has seen few books published which cover the practical element of diamond grading and which can be used as teaching aids. The chapters covering grading in *Diamonds* by Bruton are a useful introduction but are now in need of revision *Diamonds and diamond grading* by Lenzen is out of print leaving *ABC of diamond grading* by Pagel-Theisen as the sole available text.

In this book Roskins draws on his experience as a diamond grader at the GIA Gem Trade Laboratory to review the history of the GIA clarity scale and provides a brief, rare glimpse of the workings of a grading laboratory. The value of the book to a diamond student lies in its presentation of over 200 excellent photomicrographs illustrating all the clarity grades accompanied by clear descriptions of the clarity characteristics responsible for the given grade. Common inclusions, symmetry and polish grades, girdle thicknesses and culet sizes are also illustrated.

Roskins correctly states that diamond grading is a subjective process with consistency only being achieved through the regular examination of many stones of different sizes. This book could help the tyro grader reach such a consistency. The author and publisher deserve much credit in producing such clear illustrations but the high cover price may deter all but serious students from acquiring this welcome book.

E.C.E.

Quartz-Monographie. Die Eigenheiten von Bergkristall, Rauchquarz, Amethyst, Chaledon, Opal und anderen Varietäten (2, überarbeitete auflage).

R. RYKART, 1995. Ott Verlag, Thun. pp 462, illus. in colour, hardcover. DM69.00. ISBN 3 7225 6204 X.

This now standard work on the occurrence and crystal forms of the major varieties of silica makes a welcome re-appearance with additional colour plates and a really exhaustive bibliography. As always the emphasis is upon quartz for the collector and a large amount of information has been compiled upon the wealth of crystal forms reported from locations worldwide. This is the book to consult if you want to know what quartz from a particularly celebrated site looks like and in covering this ground the author naturally brings in a wealth of data on inclusions, colour varieties and citations of papers with a slant towards those in German and other European languages.

Fine objets d'art in rock crystal are illustrated and some of the romantic side of crystal collecting in the Alps is included with notes on the life of the strahlers. Later sections describe the formation and colouration of chalcedony, the formation of opal and how its play of colour arises. A small separate section of colour photographs at the end of the text illustrates particularly notable specimens of the silica varieties covered by the book: the present location of the specimens is given along with their size (most if not all colour photographs in the main text of the book have the specimen size in their captions). A first-class book and don't let there be a language barrier!

M.O'D.

Tudor and Jacobean jewellery.

D. SCARISBRICK, 1995. Tate Publishing, London. pp 104, illus. in colour, softcover. £8.95. ISBN 1 85437 158 4.

Much of the evidence for the nature of jewellery from Tudor and Jacobean periods is derived from portraits and indeed the study of pictures for details of artefacts is rapidly becoming an independent branch of art scholarship. This short guide presents a series of portraits, very well reproduced in colour, each depicting items of jewellery and arranged in four sections, patrons, makers and materials, themes and the jewels themselves. There is a short bibliography and at the price the book is very good value. Perhaps the casual viewer of a portrait does not always understand the symbolism or other significance of a piece of jewellery; the choice of stone, where the jewel was worn and on what occasion, the choice of one item of jewellery rather than another. In its small compass this book is an excellent starting-point.

M.O'D.

Structure of crystals.

B.K. VAINSHTEIN, V.M. FRIDKIN, V.L. INDENBOM, 1995. Springer-Verlag, Berlin. pp xx, 520, illus. in black-and-white and in colour, hardcover. Second, enlarged edition (*Modern crystallography*. 2). DM 119.00. ISBN 3 540 56848 4.

With the publication of the second volume of the second edition of *Modern crystallography* mineralogists and gemmologists again have an up-to-date text to back those areas of crystallographic importance in which work constantly

continues to refine crystal structures once accepted as less complex than they now prove to be. While gemmologists will not often meet quasi-crystals and high-temperature superconductors, many will be interested in advances made in the study of crystal surfaces. From the first edition, published in 1982, the list of references has been greatly expanded and since the work is written by Russian crystallographers it is not surprising, though very welcome, that Russian and Soviet papers are strongly represented. In all, 21 pages are devoted to citations.

Gemmologists will probably find the sections on chemical bonding, the principal types of crystal structures and the advances in structural crystallography the most interesting though it must be said that the treatment, inevitably, is strongly mathematical. Nonetheless, since larger university libraries will have copies, the serious student will find many items of interest rigorously treated and some questions settled.

M.O'D.

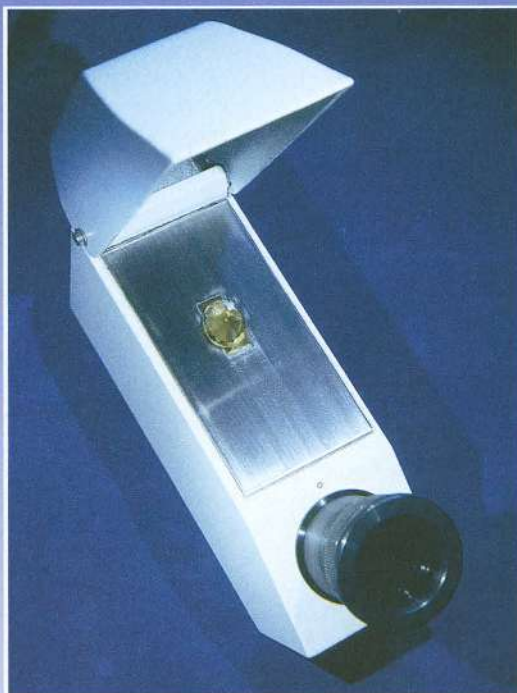
Geology and mineralogy at Oxford 1860-1986: history and reminiscence.

E.A. VINCENT, 1994. Published by the author, Department of Earth Sciences, University of Oxford. pp 245, illus. in black-and-white, softcover. £10.50.

Gemmologists should take the opportunity to learn how one at least of its 'parent' sciences has been organized at a major university and how the specific subject of mineralogy has changed in emphasis during this century: up to 1941 it merited its own chair but from that date the Waynflete Professorship of Mineralogy and Crystallography was abolished, being then made part of the Department of Geology and Mineralogy. Both the work and the personalities of some of the leading Oxford earth science figures are described and, as always in academic history, there are accounts of making do with what accommodation was available and with the vagaries of temperament exhibited by some influential figures. Readers should visit the mineral display at the University Museum; the specimens are very well displayed and excellently curated and form an impressive background to one of the larger British earth science departments.

M.O'D.

REFRACTOMETER



- Easy to read scale
- Fine definition readings
- Wide prism for large stones
- Built-in monochromatic filter

Comes with travel case, RI liquid and polarizing filter

£275.00 plus VAT, postage and packing

Members are entitled to a 10% discount.

Remember to quote your membership number

Gemmological Instruments Limited

◆ SECOND FLOOR, 27 GREVILLE STREET (SAFFRON HILL ENTRANCE), LONDON EC1N 8SU ◆

Tel: 0171-404 3334

Fax: 0171-404 8843

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

OBITUARY

Mr T.H. Bevis Smith, FGA (D.1936), Epsom, died suddenly on 22 October 1995. Mr Bevis Smith served as a member of the Council of the Gemmological Association from 1954 to 1976.

Mr Harold Cox, FGA (D.1934), Windsor, died recently.

Mr John J.W. Laurie, FGA (D.1988), Bluche, Switzerland, died on 25 September 1995 after a short illness.

Mr Aaron N. Levy, FGA (D.1990), London, died recently.

Mr Edward Arthur (Ted) Thomson, Hon. FGA, London, died in December 1995. A full obituary will appear in a future issue of the *Journal*.

Mr George Lindley, FGA (D.1937), Sutherland, Scotland, died on 27 November 1995. A full obituary will appear in a future issue of the *Journal*.

GIFTS TO THE ASSOCIATION

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

Professor Yuri Aroutiounov, Moscow, Russia, for the illustrations of Russian lacquer boxes and a paste-set crown badge.

Dr Keglim Belloso-Laufer, London, for diamond crystals.

Biron International Ltd for synthetic emeralds.

Mr Tom Chatham of the USA for synthetic emeralds and rubies.

The Cultured Pearl Company, London, for a Tahitian cultured pearl, 18.73ct, 13.8mm, drilled.

Rak Hansawek, M.Sc., GG, Bangkok, Thailand, for tektites from NE Thailand, one faceted stone and one cabochon.

Mr John A. Kessler, London, for emerald crystals in matrix.

Ms Ou Yang C.M., Hong Kong Institute of Gemmology, for four cabochons of jet from Wusun, NE China, and a book on jade by Ms Ou Yang.

Mr Julius Petsch, Idar-Oberstein, for sapphire crystals from Madagascar.

Mr Xui Zhili, Zhongshan University, Guangzhou, China, for two gemmology textbooks by Mr Xui Zhili.

NEWS OF FELLOWS

Alan Hodgkinson carried out an extensive lecture programme during 1995. As well as speaking at the GAGTL Conference in London (as reported in *Gem and Jewellery News*, 1995, Vol. 5, No. 1) and other localities in the UK, Alan gave presentations in Australia, Canada, Hong Kong and New Zealand.

On 4 October 1995 Peter Read gave an illustrated talk to the Bournemouth Natural Science Society in their Christchurch Road premises on the subject of 'Diamonds and De Beers'. Included in his presentation was a display of gemmology books, diamond testing instruments and replicas of famous diamonds.

FORTHCOMING MEETINGS

London

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

28 February	The art and science of valuation	Rosamond Clayton
3 April	Bringing gems to the market place	Arthur Woolgar
8 May	Identifying inclusions within gemstones	Jamie Nelson
10 June	Annual General Meeting and Reunion of Members	

Midlands Branch

Monthly meetings will be held at the Discovery Centre, 77 Vyse Street, Birmingham 18 (for directions to the Sunday Gem Club Venue contact Gwyn Green on 0121 445 5359). Further details from Mandy MacKinnon on 0121 624 3225 or Neil Rose on 0161 483 8919.

18 February	Gem Club – Talk on history of pearl buttons and bead-stringing workshop	
23 February	Jades	Alan Jobbins
4 March	Visit to Birmingham Assay Office	
24 March	Gem Club – Silversmithing activity day	
29 March	Lavriotike: treasure house of Attika	Edgar Taylor
14 April	Gem Club	
26 April	Annual General Meeting followed by a talk by D.H. Ariyaratna	
28 April	Preliminary Gemmology Seminar	
5 May	Diploma Gemmology Seminar	
19 May	Gem Club – day visit to Dolgellau Gold Mine	

North West Branch

Meetings will be held at Church House, Hanover Street, Liverpool 1. Further details from Joe Azzopardi on 01270 628251.

20 March	Introduction to gemmology	Deanna Brady
15 May	Jade, past and present	Rosamond Clayton
19 June	Jewellery in the auction world	David Lancaster

Scottish Branch

For details of Scottish Branch meetings contact Ruth Cunningham on 0131 225 4105.

7 February	A Lab Night at Telford College, Edinburgh	
22 March	Quiz Night and Bring and Buy	

MEMBERS' MEETINGS

London

On 1 October 1995 the GAGTL Annual Conference was held at the Scientific Societies Lecture Theatre, New Burlington Place, London W1. A full report was published in *Gem and Jewellery News*, 1995, Vol. 5, No. 1.

On 16 October at 27 Greville Street, London EC1N 8SU, Howard Vaughan gave a presentation illustrated by slides and a video entitled 'Recent developments in the diamond industry'.

On 30 November at 27 Greville Street, Dr John L. Emmett, a principal of Crystal Research, Pleasanton, California, gave an illustrated lecture entitled 'The heat treatment of corundum: a view from the laboratory'.

Midlands Branch

On 29 September 1995 at the Discovery Centre, 77 Vyse Street, Birmingham 18, Mr Philip Stocker gave an illustrated lecture entitled 'Jewellery valuations and their attendant problems'.

On 27 October at the Discovery Centre Mr Stephen Kennedy of the GAGTL laboratory gave an illustrated lecture entitled 'Pearls – production and identification'.

On 24 November at the Discovery Centre the speaker was Mr James Gosling. His topic was 'Jewels in the hand, a celebration of Elizabethan and Jacobean miniatures'.

On 2 December the forty-third anniversary dinner was held at Barnt Green.

North West Branch

On 20 September 1995 at Church House, Hanover Street, Liverpool 1, Dr John Franks gave an illustrated talk entitled 'Natural History of jewellery'.

On 18 October at Church House a gemmology evening was held for members and guests. Those attending were invited to bring along interesting items of jewellery for examination and discussion.

On 15 November at Church House the Annual General Meeting was held at which Irene Knight and Joe Azzopardi were re-elected Chairman and Secretary respectively.

Scottish Branch

On 19 September the Scottish Branch held its first outing which was a tour of the British Geological Survey unit in Edinburgh.

On 20 October at Newliston House, Newbridge, Edinburgh, Doug Garrod of the GAGTL gave a talk on traditions and superstitions connected with gemstones.

PRESENTATION OF AWARDS

The Presentation of Awards gained in the 1995 examinations was held at Goldsmiths' Hall, Foster Lane, London, on 6 November. The President, Mr Eric Bruton, presided and welcomed those present, including visitors from India, Japan, Korea, Norway and Taiwan. He reported that a total of 1095 students sat the Gemmology and Gem Diamond examinations in 1995, 619 of whom had been successful which represented a pass rate of just over 56 per cent. Students from 26 countries in all five continents qualified in this year's Diploma Examination.

The awards were presented by Peter Read and his address is set out below. The vote of thanks was given by Ian Thomson and in conclusion Eric Bruton thanked the Goldsmiths' Company for once again allowing the GAGTL to hold the ceremony at the Hall.

Address by Peter Read

It's a great pleasure to be here tonight addressing you in this impressive and historic Goldsmiths' Livery Hall. My greetings and congratulations are also especially directed to all those students who have just received their richly deserved diplomas – as a former student I'm well aware of the

effort you have made in achieving this goal.

Looking around the Hall earlier this evening reminded me of my own attendances here some twenty years ago. I'm not referring to those pleasant occasions when I too was the recipient of the Gemmological Association's Diplomas, but to the much more stressful hours I spent in this very Hall sitting the Association's theory and practical examinations under the watchful eye of Robert Webster. Among a group of around 45 other budding gemmologists, I still remember the rising tension during the final minutes of the three-hour practical exam as some of us literally ran between the various test instruments to identify the last few stones in the list. Inevitably the very last stone was dropped on the floor by a nervous student – this was not, surprisingly, yours truly – my speciality was knocking over the bottle of contact fluid! On this occasion Robert Webster was quickly on the scene and went down on his hands and knees to search for the missing gem. As you can appreciate, the lighting in the hall was not ideal for this task and someone offered a pen torch. By now the hands of the clock were indicating that the exam's three hours were up, and two of us were still waiting to test the missing stone. But with Robert in charge we need not have worried – the stone was quickly found and we were awarded an extra five minutes of 'injury time' to complete our tests! Little did I imagine then, that one day I would have the honour of returning to this same Hall and presenting the awards to another generation of graduate gemmologists.

Unlike many of my contemporaries who have been closely associated with the jewellery trade for most of their working lives, I discovered the fascinating world of gemmology much later in life. The main benefit of this tonight is that any reminiscences I might be tempted to indulge in will of necessity be reasonably brief.

Strictly speaking, my contact with the gem world only really started in 1970 when I joined De Beers Central Selling



Diploma Trade Prize winner, Johanna Carlsson, receiving her prize from Peter Read.

Organization in London to set up their first engineering development department. Prior to that time I had been a technical author and an electronics development engineer with companies such as the GEC, Iliffe publishers, Plessey, and Johnson Matthey the precious metals specialist.

Some of you may be wondering at this point why De Beers were in need of an electronics engineer and a development department. Well, the sale of rough diamonds at the CSO had increased enormously in the post war years, and this had meant a similar increase in the number of diamond sorters. With more and more people handling the diamonds, De Beers decided that it made sense to begin automating some of

the less skilled sorting processes such as sieving and weighing.

One of my projects at Johnson Matthey had been the development of an automatic gold grain weighing system for the production of 10 tola currency bars. When I was offered the opportunity to move less than a hundred yards down Hatton Garden and take on the problems of automatic diamond weighing at De Beers, I readily agreed – a move from precious metals to gem diamonds was a chance not to be missed. As De Beers newly appointed Technical Manager my brief was first to set up a small development department. During the following years my department designed and installed computer-controlled automatic weighing systems in London, Kimberley and Botswana. We also introduced many other sorting aids including high-speed diamond counters, automatic diamond sieving machines and television shape sorting. During this period I became aware that evening classes in gemmology and gem diamond were being held in the Sir John Cass Institute at Aldgate (now called the London Guildhall University). As I was in the privileged position of seeing thousands of carats of rough diamonds passing through the various sorting departments each day, the gem diamond course seemed an ideal way to learn more about this stone. Unfortunately, it was not possible in those days to take the diamond course and sit the exam without first taking the gemmology course. Undaunted, I signed on for the gemmology course. Because of my lack of contact with gemstones other than uncut diamonds, I spent much of my exam preparation time in the Geological Museum's mineral gallery. So much time in fact that I had the feeling that the staff were beginning to follow me around – perhaps they thought I was casing the joint!

By 1976 my three years of evening study spent at the Cass Institute were finally over, and I was at last the proud possessor of both the gemmology and gem diamond diplomas. I must confess, however, that the

amount of work I had to put in to ensure a comfortable pass far exceeded anything I had experienced in qualifying as a Chartered Engineer. This, of course, is why the FGA qualification is held in such high esteem around the world.

When I eventually left De Beers to start my own consultancy company, I also began writing articles for the trade magazines and for the *Journal of Gemmology*. The particular aspect of gemmology I chose to write about was one that as an engineer I found particularly interesting – gemmological instruments. Eventually I persuaded Butterworths to let me write a book on the subject. After this was published they suggested that I turned a series of articles I had written on gemmology into a paperback entitled *Beginner's guide to gemmology*. This slim volume appeared to find favour with students over the following years. In retrospect, perhaps this was because both author and reader were the 'Beginners'! The next book to be published was my *Dictionary of Gemmology* and, in 1991, after several reprints, *Beginner's guide* was finally replaced by my more comprehensive text book *Gemmology*.

Back in 1979 I had been fortunate enough to be chosen by the Rayner Optical Company as their consultant and over the next few years designed several gem test instruments for them. Perhaps the most important of these was the UK's first thermal diamond tester, in which endeavour I was encouraged by Harry Wheeler, who was secretary of the Gemmological Association from 1973 to 1982. With the introduction of cubic zirconium oxide as a diamond simulant, particularly in sizes smaller than the testing capability of the reflectance meter, Harry had foreseen the usefulness and the growing demand for such an instrument.

Because of my involvement with computers at De Beers, it seemed a logical step to write a computer program containing gemmological data. The result was GEMDATA, the world's first commercial computer pro-

gram for gemstone identification. This has just been released in its sixth update version.

Over the last two years, with the backing of the Gemmological Association, I have developed a new instrument using the Brewster angle of polarization. This has the advantage over the standard model of a range which covers refractive indices from 1.40 to around 3.3 – and without the need for contact liquid.

When, in 1986, I became a tutor for the Gemmological Association's correspondence courses, I was also running adult education courses in gems and gemmology at West Dean College near Chichester and in Bournemouth. This latter activity, of course, was all part of a cunning plan to introduce the general public to the exciting world of gemstones, and at the same time make them aware of the Gemmological Association's courses!

In an extension to this method of subliminal advertising, I have also followed the precedent set several years ago by our President Eric Bruton, and published two gemmological novels *Diamond mine* and *The Peking diamonds* – whoever said gemmology was dull!

I often find that memories are triggered by smells. Perhaps you do too. For me the smell of resin-cored solder takes me back to my electronic engineering days, while the all pervading smell of heavy liquids reminds me of happy evenings spent identifying gems at the Cass Institute. Unfortunately, the aroma of methylene iodide (or di-iodomethane as it's called today) is not so welcome in the home. Even with my study door firmly closed, it takes only a few minutes for my wife to become aware that I'm using my refractometer, or that I've unstoppered my heavy liquids to check the SG of a stone. If sodium polytungstate ever replaces the smelly organic liquids, gemmology will not seem the same!

In ending my reminiscences I will borrow part of one of Churchill's phrases and remind tonight's successful candidates that

being awarded the Diploma is not the *end* of the learning process. It is not even the end of the beginning. For you the most exciting part of the great gemmological experience is just about to start, as it did for me twenty years ago.

Finally, I can do no better than quote the words that my De Beers friend and former colleague Jeremy Richdale used in his Keynote talk at the Italian GemFest '95... 'There has never been a better time to be a gemmologist or a student of gemmology, and the future for the science of gemmology has never been more promising.'

Thank you – and may I wish tonight's award winners the best of luck in their careers.

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 20 September 1995 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Transfers – DGA to FGA, DGA
 Bray, Betty A., Abilene, Tex., USA. 1995
 Everitt, Sally Ann, London. 1995
 Yoshida, Miyuki, Hong Kong. 1995
 Zhou, Min, Wuhan, China. 1995

Transfers – FGA to FGA, DGA
 Carroll Marshall, Anne E., Hong Kong. 1995
 Cassarino, Paul R., Rochester, NY, USA. 1995
 Fan, Siu Kam, Kowloon, Hong Kong. 1995
 Fantis, Charoulla, London. 1995
 Farion, Jean-Christophe, South Kensington. 1995
 Fung, Wai Yin, Hong Kong. 1995
 Hamp-Gopsill, David, Burton-on-Trent. 1995
 Hui, Sze Wai, Kowloon, Hong Kong. 1995

Hung, Vivian Chi Ling, Hong Kong. 1995
Kwan, Wai Shun, Kowloon, Hong Kong.
1995

Lai, Mui Guk Margaret, Hong Kong. 1995

Lakhtaria, Yashwin, London. 1995

Nicholson, Charles J.R., London. 1995

Papadopoulos, Iraklis, Athens, Greece.
1995

Pegg, Delia, Petts Wood. 1995

Ruhmer, Fiona J., Hammersmith. 1995

Smyth, Lesley J., London. 1995

Spooner, Carole, Wokingham. 1995

Wakefield, Melanie, Horsham. 1995

Williams, Jason F., West Byfleet. 1995

Transfers – Ordinary Membership to DGA

Hofer, Peter M., Northwood. 1995

Hung, David Lam Chiu, Kowloon, Hong
Kong. 1995

Mamo, Charles, Wanstead. 1995

Transfer – Ordinary Membership to FGA

Cadby, John H.V., Trowbridge. 1995

Cadby, Sarah, London. 1995

Chen, Jyh-Shyang, Taipei, Taiwan, ROC.
1995

Dokken, Aarrynne D.C., Sutton. 1995

Ho, Hsiung-Chien, Taipei, Taiwan, ROC.
1995

Iwata, Kaoru, Kanagawa, Japan. 1995

Kathoon, Junaida, Singapore. 1995

Kawamura, Toshiko, Sakurai City. 1995

Kleiser, Alwen M., Holyhead. 1995

Lin, Fiona, Taipei, Taiwan, ROC. 1995

Owens, Suzanne, Dublin. 1995

Purkiss, Karen A., Colchester. 1995

Rabstein, Wolf Isidore, London. 1995

Smallenburg, M.A., Amsterdam, The
Netherlands. 1995

Sotolongo, Sachiko Kashiba, London. 1995

Tada, Reiko, Osaka, Japan. 1995

Tanaka, Daisuke, Kobe City, Japan. 1995

Thornton, Timothy J., Kettering, 1995

Turner, Caroline, Southwold. 1995

Whipp, David, Thornton Heath. 1995

White, Michele, Moseley, Birmingham.
1995

Diamond Membership and Fellowship

Bratton, Tim, London. 1976/1977

Wilson, Andrew Robert, Worthing.
1980/1986

Diamond Membership

Allberg, Mauritz, Stockholm, Sweden. 1995

Badibanga, Carine, London. 1995

Garland, Annette Joy, London. 1995

Kassam, Sultan Mohamed, London. 1995

Keating, Elaine, London. 1995

Tsoi, Chung Ho, Hong Kong. 1995

Wan, Stephen, Hong Kong. 1995

Fellowship

Ajani, Shilpa Chetan, Bombay, India. 1985

Buxani, Naina Mahesh, Kowloon, Hong
Kong. 1993

Carr, John Raymond, Cheltenham. 1995

Cheng, Ming Chi, Hong Kong. 1995

Day, Stephen J., Peterborough, Ont.,
Canada. 1995

Haitioniemi, Mia Maria, Kuusankoski,
Finland. 1995

Ho, Tung Tak, Hong Kong. 1995

Leung, Stephen Ping-Kwong, Thornhill,
Ont., Canada. 1995

Moore, Julie Lyn, Swadlincote. 1995

Rickard, Sarah, Market Harborough. 1995

Rosier, Wendy Julia, Stanley, Hong Kong.
1995

So, Che Shing, Kowloon, Hong Kong. 1995

Yates, David Hayman, Whatstandwell, Nr
Matlock. 1995

Ordinary Membership

Aslanian, Mehran Artin, Tettenhall.

Battiscombe, Bridgid, London.

Birtwhistle, John Percy, Telford.

Clarkson, James D., Reno, Nev, USA.

Dagermark, Sofa, London.

Fielding, Geoffrey Ian, Bury.

Foote, David Stuart, Reading.

Forbes, Victoria Elizabeth, Portadown.

Grondin, Daniel, Geneva, Switzerland.

Harvey, Mark Anthony, Hinckley.

Hegi, Matthieu M.M., Geneva,
Switzerland.

GAGTL GEM TUTORIAL CENTRE

Synthetics and Enhancements Today

14-15 February

Are you aware of the various treated and synthetic materials that are likely to be masquerading amongst the stones you are buying and selling? Whether you are valuing, repairing or dealing, can you afford to miss these two days of insights, tips and practical investigation?

Price £223.25 (including sandwich lunches)

Enquire Within : Emerald

6 March

A valuable and concentrated look at all aspects of emerald: natural rough and cut stones, treated, synthetic and imitation stones.

Price £111.63 (including sandwich lunch)

Preliminary Workshop

13 March

A day of practical tuition for Preliminary students and anyone who needs a start with instruments, stones and crystals. You can learn to use the 10x lens at maximum efficiency, to observe the effects and results from the main gem testing instruments and to understand important aspects of crystals in gemmology.

Price £47.00; GAGTL students £33.49 (including sandwich lunch)

Enquire Within : Ruby and Sapphire

20 March

A day looking at all aspects of these gems - natural, treated, synthetic and imitation.

Price £111.63 (including sandwich lunch)

Two-Day Diploma Practical Workshop

25-26 May and 1-2 June

The long-established intensive practical course to help students prepare for the Diploma practical examination or for those in the trade or elsewhere to brush up on technique. This is the course to help you practise the methods required to coax the best results from gem instruments. The course includes a half-length mock exam for you to mark yourself.

Price £160.39 (£111.04 for GAGTL registered students) - includes sandwich lunches

NOTE: All prices include VAT at 17.5%

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

Ho, Yan Yee Winnie, Hong Kong.
 Jama, Abdillahi, Cardiff.
 James, Anthony Harcourt, Ipswich.
 Joseph, Elizabeth, Hale Barns.
 Khairallah, Theresa, London.
 Kim, Myung Suk, London.
 Kritikou, Eleni, London.
 Lee, Dongjae, London.
 Lorking, Derek, Walthamstow, London.
 Matza, Eynat, London.
 Mewani, Ashok, Montego Bay, Jamaica.
 Mitchell, Christopher Hagon, Leigh-on-Sea.
 Mitteregger, Unni, London.
 Monje, Lucy, London.
 Omine, Mitsunobu, Stanmore.
 Pepprell, Eija-Liisa, London.
 Riddell, Vanessa Stella, Harrow.
 Rizwan, Babar, Ilford.
 Schutt, Alan W., Bristol.
 Silverio, Ma Rita, Mandaluyong City, Philippines.
 Slattery, Bozenna, London.
 Starreveld, Francis M.M., Hilversum, The Netherlands.
 Stern, Sara, Arlington, Va, USA.
 Swaffer, Hugh, Brighton.
 Torrent, Denise, Geneva, Switzerland.
 Torto, Augustine Bockaire, London.
 Vernon, Penny Ann, High Wycombe.
 Vivian Smith, Marina Lea, Quan, Vietnam.
 Whiteson, Sarah Jane, London.
 Yap, Hui Ling, Penang, Malaysia.
 Yasuma, Kaori, Tokyo, Japan.

Laboratory Membership

Andre Messika S.A., Paris, France.
 Morelle Davidson Ltd., London.

At a meeting of the Council of Management held on 17 October 1995 at 27 Greville Street, the business transacted included the election of the following:

Diamond Membership

Chan, Yuk Fan Anna, Kowloon, Hong Kong. 1995

Fellowship and Diamond Membership

Eggleston, Avrina, London. 1995/95
 Jones, Karen, Caernarfon, Gwynedd. 1985/86

Fellowship

Carlsson, Johanna A., London. 1995
 Dillimuni, Dayananda, Colombo, Sri Lanka. 1978
 Diserens, Myriam, Paudex, Switzerland. 1994
 Hawken, Diana Blair, Hong Kong. 1995
 Lee, Sau Mui Angela, Kowloon, Hong Kong. 1995
 Mak, So Yi, Hong Kong. 1994
 Papadopoulos, Dimitrios, Athens, Greece. 1995
 Schmidt, Simon Peter, London. 1991
 Shetty, Vaju Krishna, Bombay, India. 1995
 Soo, Hoi Leung, Hong Kong. 1995
 Stead, Graham Scott, Tillsonburg, Ont., Canada. 1995

Ordinary Membership

Caspi, Daniel R., London.
 Davis, Roberta Kay, Harborne.
 Hargreaves, David, London.
 Haria, Aarti Vipul, Nairobi, Kenya.
 Johnson, Helen Louise, Edinburgh.
 Khashkovskaia, Tatiana, St Petersburg, Russia.
 Patel, Ajay, Reading.
 Rönkkö, Veera Viktoria, London.
 Söderström, Jenny, Lannavaara, Sweden.
 Urm, Tanel, Voru, Estonia.
 Warren, Glynn Mark, Lindford.
 Wong, Yik Shih, Wimbledon.

Laboratory Membership

Raymond Lyons & Co Ltd, Croydon.

Мир Камня World of Stones

- *The only Russian popular science mineralogical journal*
- *Mines, minerals, museums and much more!*
- *Printed in English with supplementary sheet of text in Russian, volume 80pp*
- *One year subscription (4 issues) \$52, including postage*

You may subscribe at any time. Back issues are available.

Send your subscription details and cheque to:

UK: Don Edwards, Tideswell Dale Rock Shop, Commercial Road, Tideswell, Derby SK17 88NU, UK
Please make cheque payable in £ Sterling to Don Edwards

Germany: L. Schneider, Hemmersweiher 5, 66386 Sr-Ingbert BRD.
Please make cheque payable in DM to L. Schneider.

USA: H. Obodda, Box 51, Short Hills, NJ 07078, USA
Please make cheque payable in US \$ to H. Obodda

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

ADVERTISING IN THE JOURNAL OF GEMMOLOGY

The Editors of the Journal invite advertisements from gemstone and mineral dealers, publishers and others with interests in the gemmological, mineralogical, lapidary and jewellery fields.

Rates per insertion, excluding VAT, are as follows:

Whole page	£180
Half page	£100
Quarter page	£60

Enquiries to Mrs M. Burland,
Advertising Manager,
Gemmological Association,
27 Greville Street,
London EC1N 8SU

- GEMMOLOGY
- INSTRUMENTS
- CRYSTALS
- CUT SPECIMENS
- STUDY TOURS

Genesis
Ltd.



● **WORLD LEADERS IN PRIVATE GEMMOLOGICAL EDUCATION**

We specialize in small group intensive tuition, from scratch to F.G.A. Diploma in 9 months. We are able to claim a very high level of passes including Distinctions & prize winners amongst our students.

● **GEMMOLOGICAL STUDY TOURS**

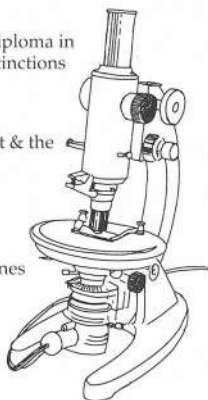
We organise a comprehensive programme of study tours for the student & the practising gemmologist to areas of specific interest, including :- **ANTWERP, IDAR- OBERSTEIN, SRI LANKA, THAILAND & CHINA.**

● **DEALERS IN GEMSTONES/DIAMONDS & CRYSTALS**

We buy & sell cut and rough gemstones and diamonds, particularly for the F.G.A. syllabus, and have many rare or unusual specimens. Gemstones & Diamonds also available for commercial purposes.

● **SUPPLIERS OF GEMMOLOGICAL INSTRUMENTS**

We offer a comprehensive range of gem testing instruments, including inexpensive Petrological & Stereo-zoom Microscopes, Refractometers, Hand Lenses, Pocket U/V Lights, S.G. Liquids, the world famous OPL Spectroscope, and many other items including Books & Study Aids.



Illustrated:

*Petrological
Microscope.*

*Mag. 20x - 650x, with
full range of oculars &
objectives, wavelength
filters, quartz wedge,
Bertrand lens, iris
diaphragms, graticules
etc.*

*From ONLY £650 +
VAT &
Delivery/Carriage*

For further details of these and our other activities, please contact-

*Colin Winter, F.G.A. or Hilary Taylor, B.A., F.G.A. at GENESIS, 21, West Street, Epsom, Surrey. KT18 7RL England
Tel. 01372 742974 or Fax 01372 742426*

The Journal of Gemmology

Back issues

Individual back issues of volumes 23 and 24 are available at £10.00 each.

Issues up to and including volume 22 are £4.00 each. Most issues are available.

Members of GAGTL are eligible for a 10% discount.

When an order is received an invoice will be sent showing cost including postage and packing.

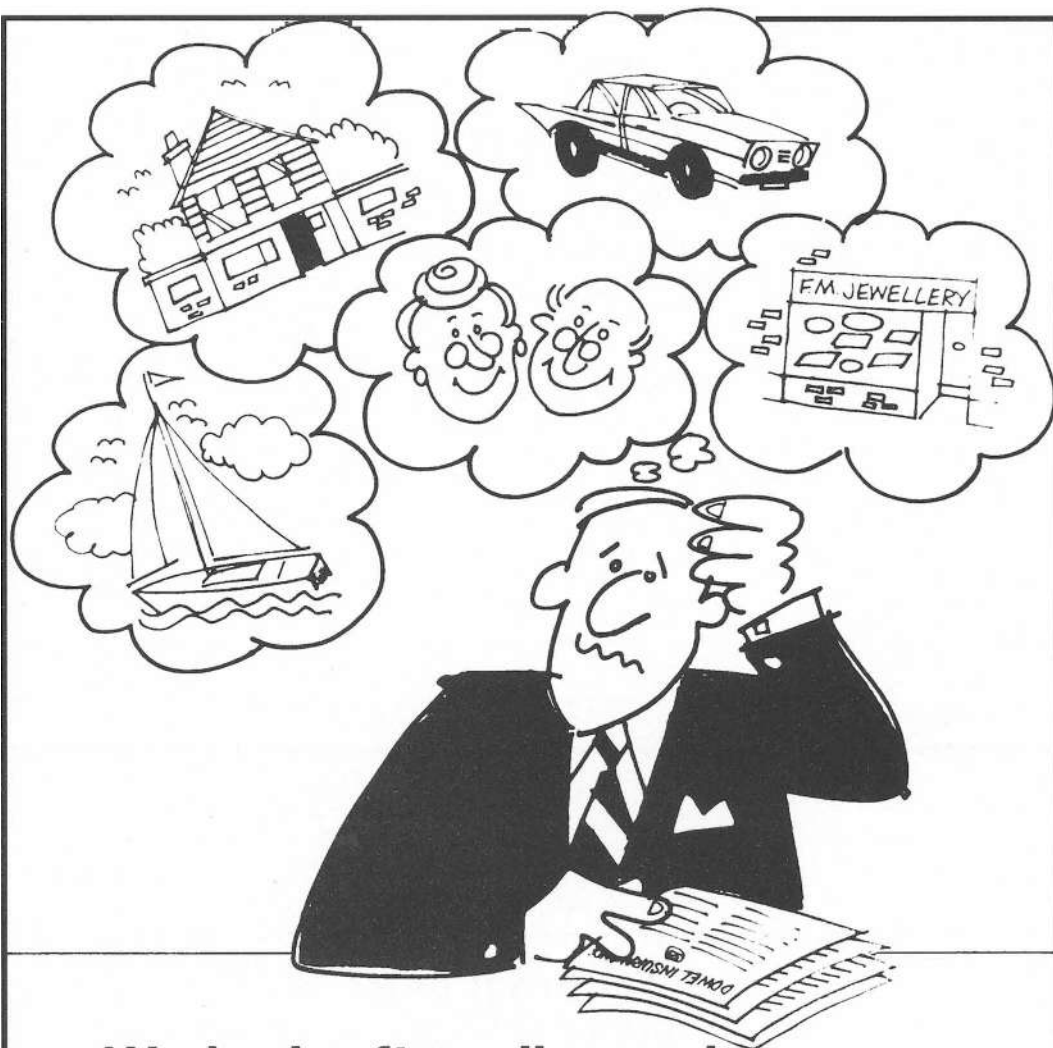
Please contact:
Mary Burland

Gemmological Association and Gem Testing Laboratory of Great Britain

◆ FIRST FLOOR, 27 GREVILLE STREET (SAFFRON HILL ENTRANCE), LONDON EC1N 8SU ◆

TEL: 0171 404 3334

FAX: 0171 404 8843



We look after all your insurance **PROBLEMS**

For nearly a century T. H. March has built an outstanding reputation by helping people in business. As Lloyds brokers we can offer specially tailored policies for the retail, wholesale, manufacturing and allied jewellery trades. Not only can we help you with all aspects of your business insurance but we can also take care of all your other insurance problems,

whether it be home, car, boat or pension plan.

We would be pleased to give advice and quotations for all your needs and delighted to visit your premises if required for this purpose, without obligation.

Contact us at our head office shown below.



T. H. March and Co. Ltd.

Saint Dunstan's House, Carey Lane,
London EC2V 8AD. Telephone 0171-606 1282
Also at Birmingham, Manchester, Glasgow and Plymouth.
Lloyd's Insurance Brokers

*You can't beat
EXPERIENCE*

Museums, Educational Establishments, Collectors & Students

I have what is probably the largest range of genuinely rare stones in the UK, from Analcime to Wulfenite. Also rare and modern synthetics, and inexpensive stones for students. New computerised lists available with even more detail. Please send £2 in 1st class stamps refundable on first order (overseas free).

Two special offers for students:
New Teach/Buy service and free stones on an order.

A.J. French, FGA
82 Brookley Road, Brockenhurst,
Hants SO42 7RA
Telephone 01590 623214

PROMPT LAPIDARY SERVICE!

Gemstones and diamonds cut to your specification and repaired on our premises.

Large selection of gemstones including rare items and mineral specimens in stock.

Valuations and gem testing carried out.
Mail order service available.

R. HOLT & CO. LTD

98 Hatton Garden, London EC1N 8NX
Telephone 0171-405 0197/5286
Fax 0171-430 1279

.... In 1992 we wrote the book "The Heat Treatment of Ruby and Sapphire"[†]
Now we manufacture top-quality furnaces designed for heating rubies/sapphires

Gemlab Model-181 furnace


- *Continuous operation to 1800°C
- *Vertical muffle configuration
- *Bottom loading/unloading design
- *Digital microprocessor technology
- *Fully automated; easy to operate
- *Atmospheric control (air, oxid-reduc)
- *Can be used with or without fluxes
- *compact, desk-top, and portable
- *Measures only (14"W 14"D 36"H)
- *Capacity to 800 cts of ruby/sapphire
- *Operates in any 208/240Vac 10A outlet
- *Low maintenance and operating costs
- *Heating processes are fully reproducible
- *Pretuned, ready for immediate operation
- *Moderately priced to fit any budget



[†]Available from your GAGTL bookstore

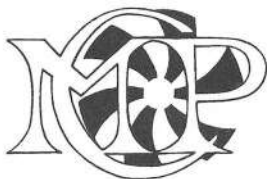
GEMLAB Inc. POB 570023, Houston Texas 77257, USA TEL/FAX: (713) 626-5005

• AMETHYST • AMBER • BERYL • CHRYSOBERYL • CITRINE • TOPAZ • RUBY •
 • SAPPHIRE • IOLITE • AQUAMARINE • CAMEOS • PERIDOT •
 • CORAL • OPAL • GARNET • EMERALD • PEARLS •



E. A. Thomson (Gems) Ltd.
 Precious stone merchants
 also representing:
 Morris Goldman Gems Ltd
 Chapel House, Hatton Place,
 Hatton Garden
 London EC1N 8RX, England.
 Tel: 0171-242 3181
 Telex: 27726 THOMCO-G
 Fax: 0171-831 1776

GEMSTONES OF THE WORLD



MAGGIE CAMPBELL PEDERSEN
 ABIPP, FGA

JEWELLERY & GEMSTONE
 PHOTOGRAPHY

Tel: 0181-994 8341
 Fax: 0181-723 4266

LUMI-LOUPE

Dark Field Illumination

at your fingertips

3 Position lens
 gives you fast
 and efficient
 inclusion
 detection on any
 size stone
 mounted or not
 & folds up to fit
 in your pocket



2 MODELS

Both with the same high quality fully corrected 10X triplet lens

LUMI-LOUPE	15mm lens	\$90.
MEGA-LOUPE	21mm lens	\$115.

ADD: \$16. for shipping outside the continental USA
 \$6. for shipping inside the continental USA

Write for price list and catalog

NEBULA

P.O. Box 3356, Redwood City, CA 94064, USA
 (415) 369-5966

Patented

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

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

Typescripts Two copies of all papers should be submitted on A4 paper (or USA equivalent) to the Editor. Typescripts should be double spaced with margins of at least 25mm. They should be set out in the manner of recent issues of *The Journal* and in conformity with the information set out below. Papers may be of any length, but long papers of more than 10 000 words (unless capable of division into parts or of exceptional importance) are unlikely to be acceptable, whereas a short paper of 400–500 words may achieve early publication.

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

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

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

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

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

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

A This is a first level heading

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

B This is a second level heading

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

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

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

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

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

Notes and References Authors may choose one of two systems:

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

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

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

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

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

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



The Journal of
Gemmology

Contents

The role of fluorine in the formation of colour zoning in rubies from Mong Hsu, Myanmar (Burma) <i>A. Peretti, J. Mullis and F. Mouawad</i>	3
Notes from the Gem and Pearl Testing Laboratory, Bahrain - 5 <i>A. Bubshait and N. Sturman</i>	20
The gems of Mont Saint-Hilaire, Quebec, Canada <i>W. Wight</i>	24
River pearls from Bavaria and Bohemia <i>H. Hahn</i>	45
Abstracts	52
Reviews	64
Proceedings of the Gemmological Association and Gem Testing Laboratory of Great Britain and Notices	71

Copyright © 1996

The Gemmological Association and Gem Testing Laboratory of Great Britain

Registered Office: Palladium House, 1-4 Argyll Street, London W1V 1AD

ISSN: 1355-4565