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Pearl cultivation in Donggou, Ezhou, Hubei, and cathodoluminescence of cultured pearls

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ABSTRACT: The paper summarizes the cultivation in Ezhou city, Hubei, P.R. China, of freshwater pearls in four stages: (1) the choosing and rearing of parent mussels, (2) the rearing of pearl-producing mussels, (3) the grafting operation and (4) the after-care of the mussels followed by the recovery of the non-nucleated cultured freshwater pearls. Additionally, the luminescent properties of cultured pearls under cathode rays are considered. Non-nucleated cultured freshwater pearls luminesce yellow, yellowish-green and green under cathode rays, with local orangey-red areas in some specimens. In contrast, nucleated cultured seawater pearls display no cathodoluminescence. These results are related to the environments in which the respective cultured pearls grew. Dyeing and irradiation treatments were found to suppress the luminescence of freshwater cultured pearls under cathode rays. The Raman spectra of orangey-red areas in some non-nucleated cultured freshwater pearls are characterized by peaks at 281, 712 and 1085 cm^{-1}, resembling those observed in inorganic calcite. The presence of a diffuse matrix of protein, such as carotenoid, may reduce the intensity of cathodoluminescence in coloured non-nucleated cultured freshwater pearls.

Pearl cultivation in Donggou, Ezhou

It has been recorded that pearl cultivation occurred as early as 1082 during the Song Dynasty in ancient China (Pang, 1167, from Xie 1995 *et al.*), but the greatest development of the pearl culturing industry has taken place over the last 20 years (He, 1999; Shen, 2001). At present, the production of cultured freshwater pearls predominates, forming more than 90% of total world production, and is estimated to be around 1600t annually (Sun, 2001). This compares with the annual production of 15-20t of cultured seawater pearls.

The cultured pearl farm in Donggou is one of the more important cultured freshwater pearl farms in China. The town of Donggou is located on the shore of Lake Liangzi, which is the second largest lake in Hubei Province. Donggou is about 20 km away from the Wuhan-Huangshi expressway and is two hours by car from Wuhan.

The pearl culturing industry in Donggou started more than 20 years ago and a wealth of experience in rearing pearl-producing mussels and in producing pearls has been accumulated. In recent years there has been an increase in local government funds for

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Figure 1: Hyriopsis cumingi *used to produce cultured freshwater pearls in Donggou.*

the development of agriculture, which includes the pearl culturing industry. At present in Donggou there are more than 20 sites covering about 2 × 10^7 km^2 rearing approximately two hundred million pearl-producing mussels. These produce more than 90t of cultured freshwater pearls annually. The cultured pearls from the Donggou farm account for 85% of the total production of cultured freshwater pearls by weight and about 67% by value for Ezhou city.

The stages of cultivation

Choosing and rearing parent mussels

Generally, for producing cultured freshwater pearls, the mussels *Hyriopsis cumingi* and *Cristaria plicata* can be used, and in Donggou, *Hyriopsis cumingi (Figure 1)* is the preferred species. The mussels are either found wild in lakes, rivers or pools or are bred. As parent mussels, they must be healthy and strong. The adductor muscle should be strong and the shell must be of good shape. The parent mussels should be three to six years old and over 17 cm in width (Bian, 2001 a, b; Li, 2000; Wang, 2001). The male and female mussels should be from different sources in order to avoid inbreeding problems. Normally for breeding purposes the ratio of female to male mussels in a body of water is 2:1 (Bian, 2001 b). The parent mussels must be suspended in gently flowing water.

The rearing of pearl-producing mussels

The sexual glands of *Hyriopsis cumingi* mature during the last ten-day period of April and the first ten-day period of May. Normally, mature *Hyriopsis cumingi* start to ovulate when water temperature reaches 18°C. In ideal growth conditions, including suitable water temperature, full food and oxygen supplies, and a supply of fresh and flowing water, each mussel can ovulate seven to eight times annually. If the water temperature is low, the ovulation period may be delayed until September. The female mussels ovulate mature ova into their outer branchial or gill cavities, where the ova combine with the sperm discharged into the water by male mussels to form glochidiums. Since the glochidiums cannot obtain nutrition directly from water, they then must attach themselves to the fins or gills of fish, which are deliberately placed in the pools for this purpose, in order to absorb nutrition. There are two kinds of fish available to act as parasitic hosts – the yellowhead *(Pseudobagrus fulvidraco)* and the bighead (a variegated carp). In Donggou, *Pseudobagrus fulvidraco (Figure 2)* are used. On average, one fish may have 150-200 glochidiums attached. After four to fifteen days depending on the water temperature (Li, 2000), the glochidiums metamorphose to become young mussels, at which time they fall from the fishes. The young mussels are usually 0.3–10 mm long, and are transparent (*Figure* 3). Groups of 80 to 100 young mussels are placed in bamboo baskets about 40 cm × 40 cm × 11 cm in dimensions. During growth the young mussels must be fed, and protected from disease and from attack by other animals such as fishes, shrimps, ducks, water birds and other predators.

The grafting operation

When the young animals are about one year old and about 7-10 cm in length, they are lifted out of the water and are ready for

***Figure 2**: Yellowhead* (Pseudobagrus fulvidraco) *used as the parasitic host for glochidiums.*

the grafting operation. In order to produce non-nucleated cultured freshwater pearls pieces of mantle from a sacrificed mussel are inserted into the incisions made in the pearl-producing host mussel. The sacrificed mussel variety is the same as the host mussel variety, i.e. *Hyriopsis cumingi*. Normally, the mussels providing the mantle tissue are less than one year old and about 6–9 cm in length. These young mussels have mantles with a strong metabolism, which are able to secrete nacre at a high rate, which is ideal for the formation of pearl sacs.

The mantle tissue preparation is as follows (Bian, 2001c):

(a) The adductor muscle is cut and the two halves of the bivalve are opened out to reveal the fleshy organism inside.

(b) The coloured outer margin of the mantle is cut away, and then a strip of mantle with an elongate depression (along a similar depression in the shell underneath) (*Figure 4*) is removed.

(c) The strip of mantle is placed on a glass plate with the other epidermis facing upwards. The inner epidermis, which is facing downwards is sliced away.

***Figure 3**: Young mussels which have just fallen from a yellowhead* (Pseudobagrus fulvidraco).

Figure 4: The mantle from the sacrificed mussel to be removed. (1) Coloured outer margin of mantle; (2) part of mantle to be used, with the coloured outer margin cut away; (3) impression of mantle.

(d) The mucus on the outer epidermis is removed with a disinfected swab. The mantle is then cut into regular pieces of about 3.5 mm by 4 mm which becomes square due to shrinkage.

(e) A drop of disinfectant or nutrient is placed on each piece of mantle in order to avoid deaths of cells due to dehydration. The whole of this mantle tissue preparation should be finished within two to three minutes. These pieces of mantle then go to the grafting operators.

Normally, a grafting operator has a specially-designed small knife used to cut an incision in the mantle in the left hand, and a pointed tool used to pick the small pieces of mantle in the right hand.

The grafting operation takes place as follows (Bian, 2001c):

(a) The two halves of the host animal are opened and a wood wedge is inserted between the two shells. The mantle cavity is cleaned.

(b) A small piece of mantle is picked with a pointed tool. An incision is cut with a small knife from left to right, in the mantle of the mussel. The small piece of mantle is inserted into the incision in the connective tissue between the upper and lower epitheliums of the mantle, at a depth of about 0.5 cm (Zhang, 2000).

(c) The point holding the piece of mantle is removed by pressing the incision with the knife.

(d) The small piece of mantle is made round by pulling, pressing, squeezing and pushing with the point.

(e) The steps (a) to (d) are repeated until 36 to 40 pieces have been inserted in the mantle of the host mussel from upper to lower and left to right (*Figure 5*).

(f) The wedge is removed and the operated mussels are then temporarily held in containers of water with disinfectant.

The whole of the grafting operation should be complete within 3 to 5 minutes.

***Figure 5**: A piece of mantle being inserted into an incision in the mantle of a host mussel.*

After-care and recovery of pearls

The operated mussels are then suspended in fresh clear water with a gentle flow and left undisturbed for the first 15 to 30 days. After a month, the operated mussels are inspected. The surviving healthy mussels are placed in separate plastic nets and suspended in the water from plastic bottle buoys (*Figure 6*), where they are left to grow. The mussels must be supplied with various foods appropriate to the water condition, and must be protected from disease and from attack by other animals (Bian, 2001d, 2002; Li, 2000). For better quality, pearls are left to grow for three to five years before recovery. However many pearl farmers remove the

***Figure 6**: Lines of plastic bottles from which the pearl-producing mussels are suspended.*

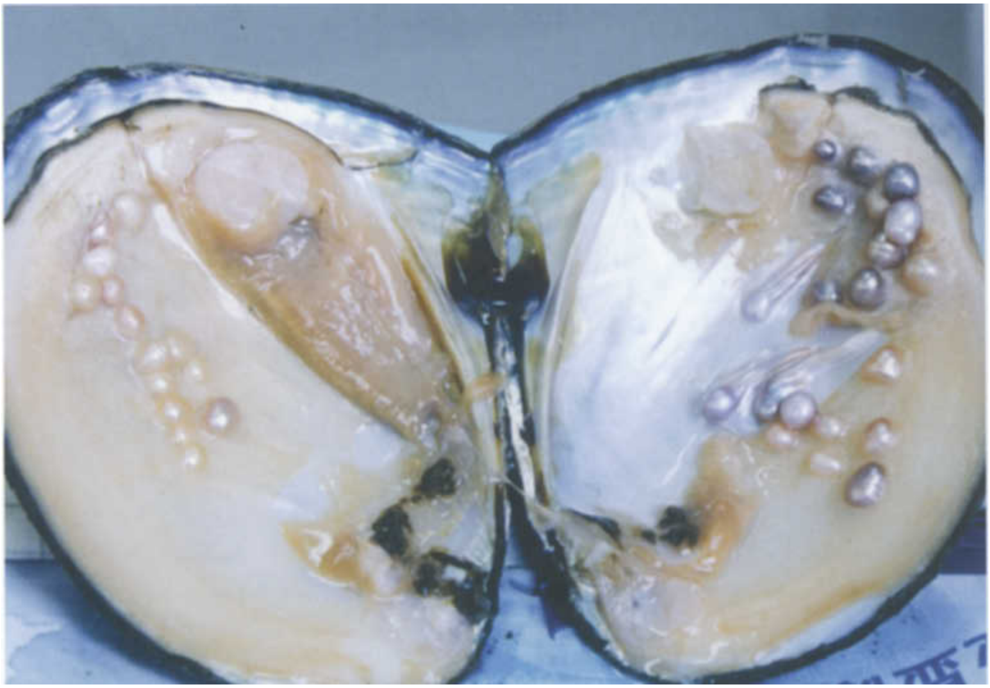

Figure 7: *An opened mussel from which pearls are obtained.*

pearls from the mussels after only one year's growth or less and these cultured pearls are of lower quality (*Figure 7*). Traditionally, cultured pearls have been recovered during the winter, but recently the pearl farmers have started to harvest the pearls at any time.

Cathodoluminescence of cultured pearls

Cathodoluminescence (CL) technology was first applied in gemmology to survey coloured stones and to identify synthetic diamonds (Ponahlo, 1992). Now, cathodoluminescence is starting to be more widely applied and with the advent of cheaper instruments and the fact that it is a non-destructive test, it is likely that it will become more and more significant in gem identification.

Pearl forms in a unique fashion compared to other gem materials. Cultured freshwater and seawater pearls contain different types and/or concentrations of trace elements, which may cause differences in the observed colour and/or intensity of luminescence under cathode rays. Cathodoluminescence therefore has the potential of providing a method of differentiating freshwater from seawater cultured pearls.

In order to understand the cause of cathodoluminescence emitted by non-nucleated cultured freshwater pearls, the Raman spectra of all were also studied. These were compared with the spectra of calcite and aragonite crystals. The Raman spectra were recorded using a Renishaw System RM-1000-type Raman spectrometer at room temperature with an Olympus BH2-type microscope and a computerized data acquisition system. The samples were excited by an Ar ion laser at a wavelength of 514 nm and focus diameter of 1μm. All samples were tested directly without pretreatment.

Instrument and Materials

The Gem Cathodoluminescence-scope (Model YJ-1) used to examine cultured pearls was developed by the Gemmological Institute of China of the China University of Geosciences (*Figure 8*). The experimental conditions were as follows: accelerating voltage, 4.5–5.0 kV, and the beam current, 0.8–1.10 mA.

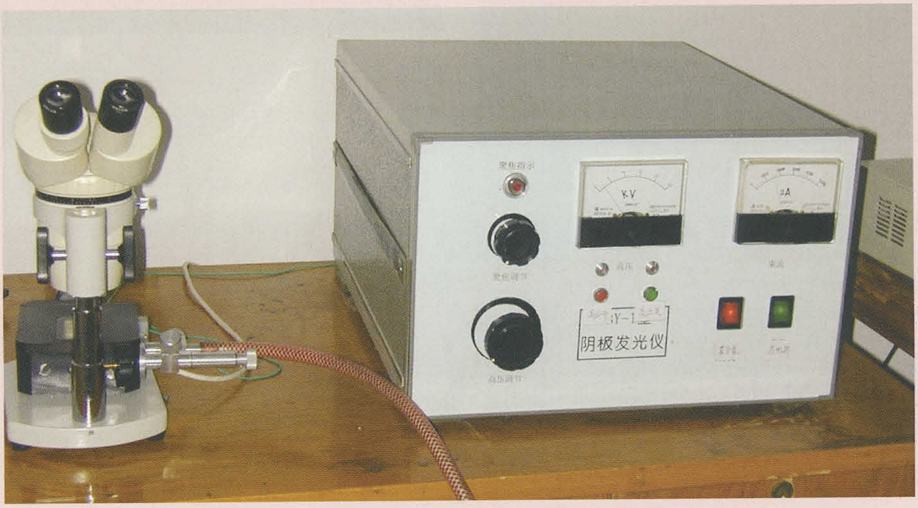

Figure 8: Gem Cathodoluminescence-scope (Model YJ-1).

This study concentrated on non-nucleated cultured freshwater and nucleated cultured seawater pearls. The non-nucleated cultured freshwater pearls were obtained from Ezhou, Hubei Province, and Zhuji, Zhejiang Province, and were of the following colours: pale purple, golden-yellow, yellowish-pink, and white and blackish-grey (this pearl is blackish-grey at one end and the colouring is about 1 mm deep). The nucleated cultured seawater pearls were obtained from the Polynesian Islands (Tahiti), Indonesia, Beihai in Guangxi and from other unknown localities, and were of the following colours: black, grey, white, pale yellow and dark grey. Additionally, two dyed black and two dyed grey nucleated cultured seawater pearls, one dyed black non-nucleated cultured freshwater pearl, one dyed pale purple with grey Mabé cultured pearl, and three irradiated greyish-black non-nucleated cultured freshwater pearls were tested. For comparison purposes two pieces of calcite and two pieces of aragonite were also studied. Thirty-six non-nucleated cultured freshwater pearls and one nucleated cultured seawater pearl were sectioned in order to observe cathodoluminescence of their interiors.

Results and discussion

Results

1. Non-nucleated cultured freshwater pearls: all the non-nucleated cultured freshwater pearls of differing colours, whether whole or sectioned, from Ezhou and Zhuji displayed yellow, yellowish-green or greenish luminescence under cathode rays (*Figures 9 and 10*).

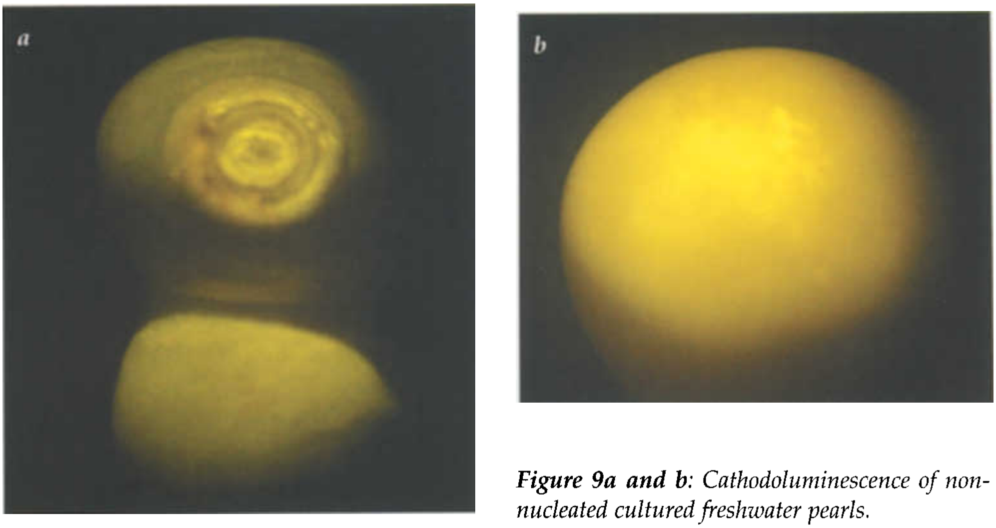

Figure 9a and b: Cathodoluminescence of non-nucleated cultured freshwater pearls.

The intensity of the luminescence varies depending on the colour of the specimens. Generally, the deeper the colour of the specimens, the weaker the intensity of luminescence displayed by the specimens. For example, white pearls display the strongest luminescence, golden and purple pearls fluoresce weaker, and blackish-grey specimens give either a very weak luminescence or are inert. On the surface of some freshwater cultured pearls rings of weaker luminescence relate to perceived growth bands of darker colour. This relationship is also observed in all the cross-sections of the freshwater cultured pearls where the differing layers of growth have different intensities of luminescence. Orangey-red

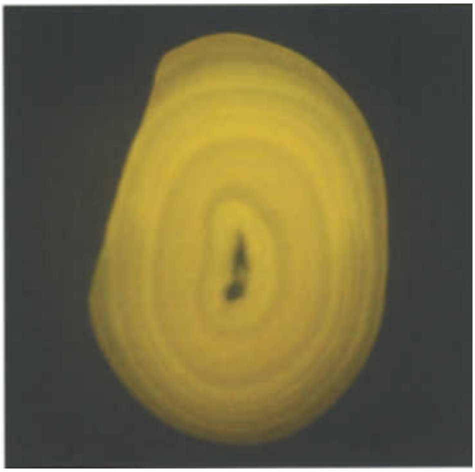

Figure 10: *Cathodoluminescence of ordered three-dimensional growth of a non-nucleated cultured freshwater pearl.*

Figure 11: *An area of a non-nucleated freshwater pearl showing orange fluorescence to cathode rays.*

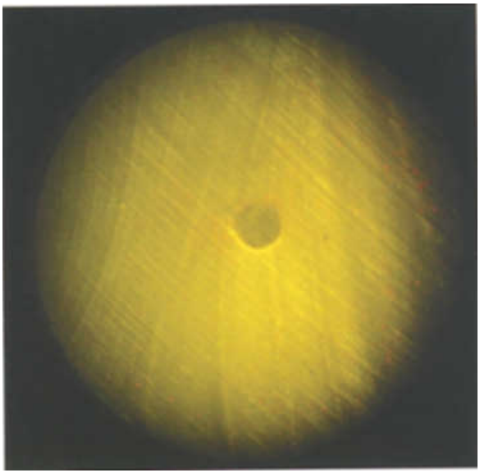

Figure 12: *Cathodoluminescence of the freshwater shell bead nucleus of a nucleated cultured pearl.*

luminescent areas (*Figure 11*) correspond generally to white areas on the surface or contained within the freshwater cultured pearls that have undergone irregular growth. In contrast the ordered three-dimensional growth of the cultured pearl in *Figure 10* reveals no orangey-red luminescence.

2. Nucleated cultured seawater pearls: all of the nucleated cultured seawater pearls were inert to the cathode rays on the surface, but when sectioned, the underlying freshwater

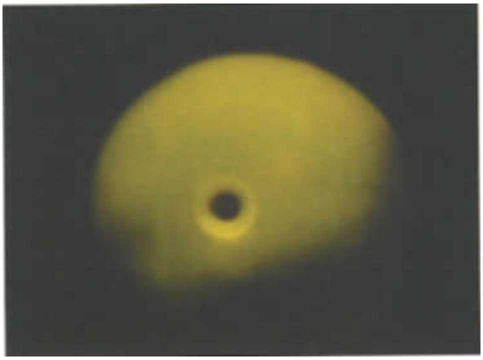

Figure 14: *Cathodoluminescence of an irradiated greyish-black non-nucleated cultured freshwater pearl.*

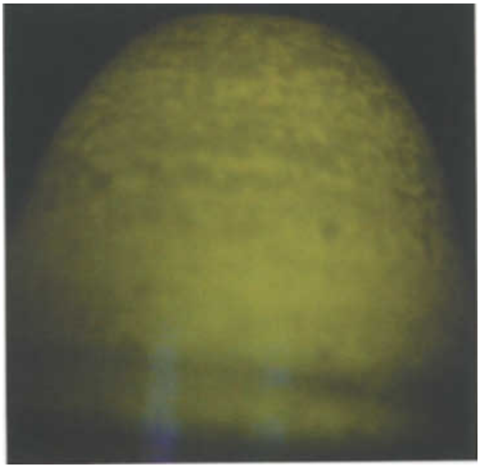

Figure 13: *Cathodoluminescence of a dyed black non-nucleated cultured freshwater pearl.*

shell bead nucleus luminesced a yellowish-green (*Figure 12*) with the thin nacreous layer remaining inert.

3. Dyed and irradiated cultured pearls: the dyed nucleated cultured seawater pearls including the dyed Mabé cultured pearl were inert to cathode rays. The stained

Figure 15: *Cathodoluminescence of a calcite crystal.*

black and irradiated greyish-black cultured freshwater pearls still showed a yellowish-green luminescence (*Figures 13 and 14*).

4. Inorganic carbonate minerals: calcite shows orangey-red luminescence under cathode rays (*Figure 15*), a colour which is similar to that seen in the white growth domains of cultured freshwater pearls. Aragonite, however, exhibits a very weak yellowish-green fluorescence.

5. The Raman spectra of calcite and aragonite are shown in *Figures 16* and *17*. Calcite is characterized by bands at 282, 712, 1086 and 1436 cm^{-1}, and aragonite is characterized by bands at 285, 700, 704, 1084 and 1460 cm^{-1}. The main difference between the Raman spectra of calcite and aragonite is that the former shows a peak at 712 cm^{-1}, and the latter two peaks at 700 and 704 cm^{-1}. These three bands are internal E_g modes corresponding to in-plane bending (v_4) modes of carbonate ions (Urmos *et al.*, 1991). The v_4 in-plane bending mode of the carbonate ion in aragonite occurs as a doublet consisting of bands at ~701 cm^{-1} (B_{1g}) and ~705 cm^{-1} (A_{1g}), which is in contrast to the single band at ~711 cm^{-1} band in the calcite spectra (Urmos *et al.*, 1991). The laser Raman spectra of white growth domains are characterized by peaks at 281, 712 and 1085 cm^{-1} (*Figure 18*), which are similar to those of calcite. Therefore, the orangey-red luminescence seen in white growth domains of cultured freshwater pearls may well be caused by calcite.

Discussion

It can therefore be concluded that freshwater pearls and shell will luminesce yellow, yellowish-green or green under cathode rays, with localized orangey-red luminescence in some areas relating seemingly to areas of calcite concentration. The darker the colours of the freshwater cultured pearl, whether as a whole or localized to growth rings, the lower the intensity of the cathodoluminescence perceived. The nacre deposited by seawater oysters on nucleated cultured pearls appears to be inert to cathode rays.

The trace element concentrations of manganese and strontium have been found to be different between freshwater and seawater pearls (K. Wada *et al.*, 1988, as quoted in D. Habermann, *et al.*, 2001; Xie, 1995; Li, 2001; Ma *et al.*, 1998; Zou *et al.*, 1996). Cultured freshwater pearls have higher manganese concentrations than cultured seawater pearls, averaging about three times as much according to SSEF (1998). The difference in manganese contents is proposed as the reason for the differences in X-ray fluorescence of natural, nucleated and non-nucleated cultured pearls. Habermann *et al.* (2001) have suggested that manganese is found not only in the shell, but also in the fleshy organism itself, which implies that it is involved in the biochemical secretion process. It is also proposed (op. cit.) that manganese in aragonite gives rise to green cathodoluminescence and when present in calcite causes orange luminescence.

The intensity of luminescence seen in cultured freshwater pearls may be related to organic materials. Based on the laser Raman spectra of cultured freshwater pearls, the main Raman bands of white pearls or white growth domains without orangey-red luminescence are at 702 and 1084 cm^{-1}, similar to those of aragonite. With the exception of black cultured pearls, pale pinkish, yellow, golden and purple pearls on the surface or in growth layers, show bands at 702, 1084, 1130 and 1524 cm^{-1} (*Figures 19 to 21*). Similar results were obtained by Zhang *et al.* (2001). Urmos *et al.* (1991) suggested that the peaks at 1130 and 1524 cm^{-1} are characteristic vibrational modes of the carotenoid pigment. The fundamental Raman band at 1524 cm^{-1} (v_1) is produced by the stretching vibrations of -C=C- double bonds, and that at 1130 cm^{-1} (v_2) is produced by the stretching of -C-C- single bonds. This indicates that the presence

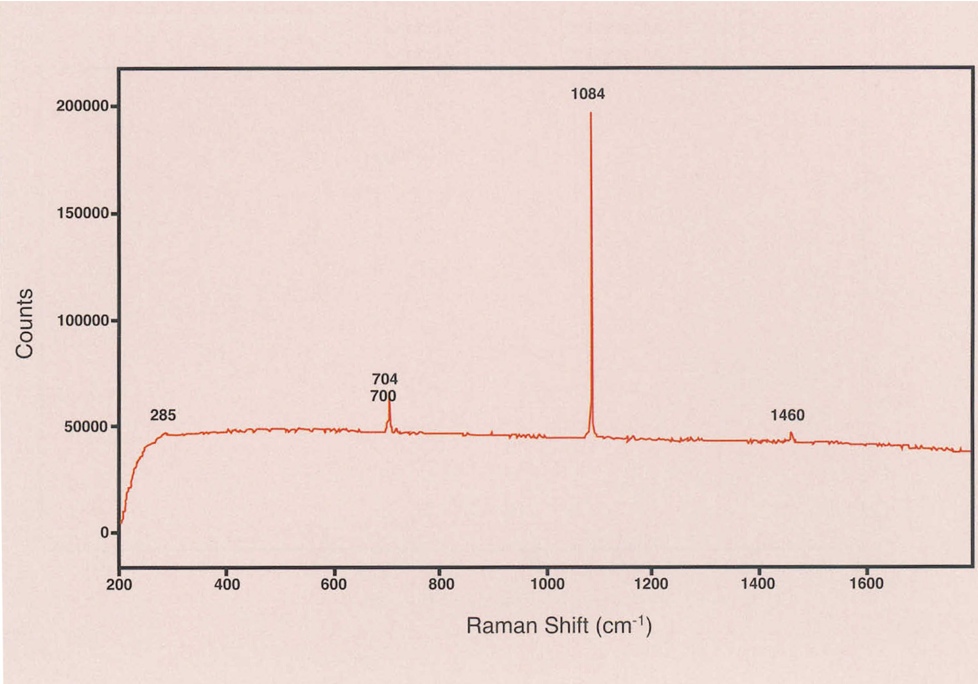

Figure 16: Raman spectrum of an aragonite crystal.

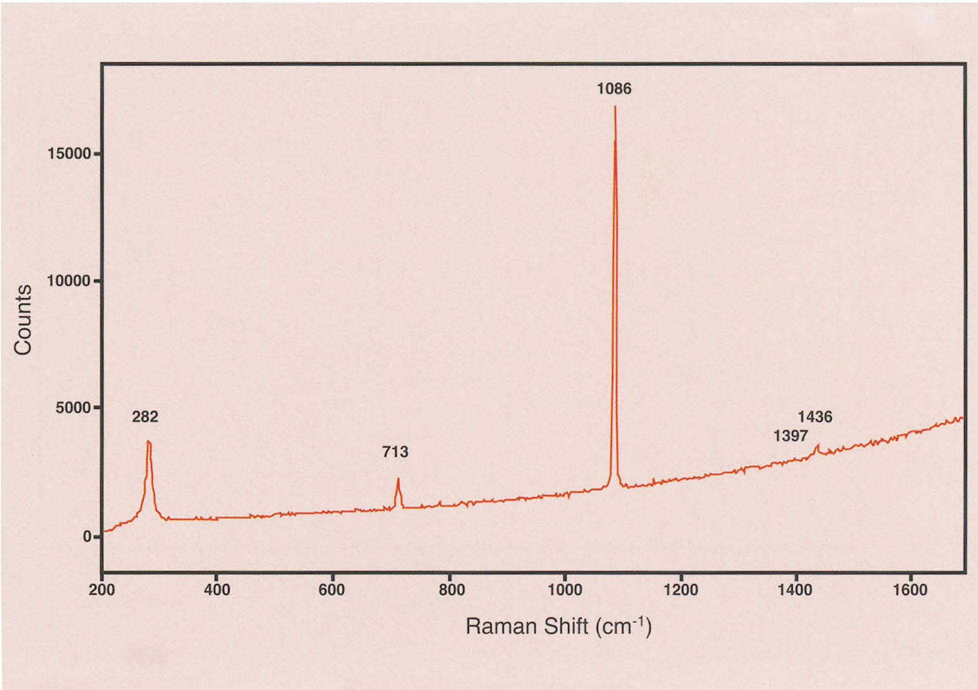

Figure 17: Raman spectrum of a calcite crystal.

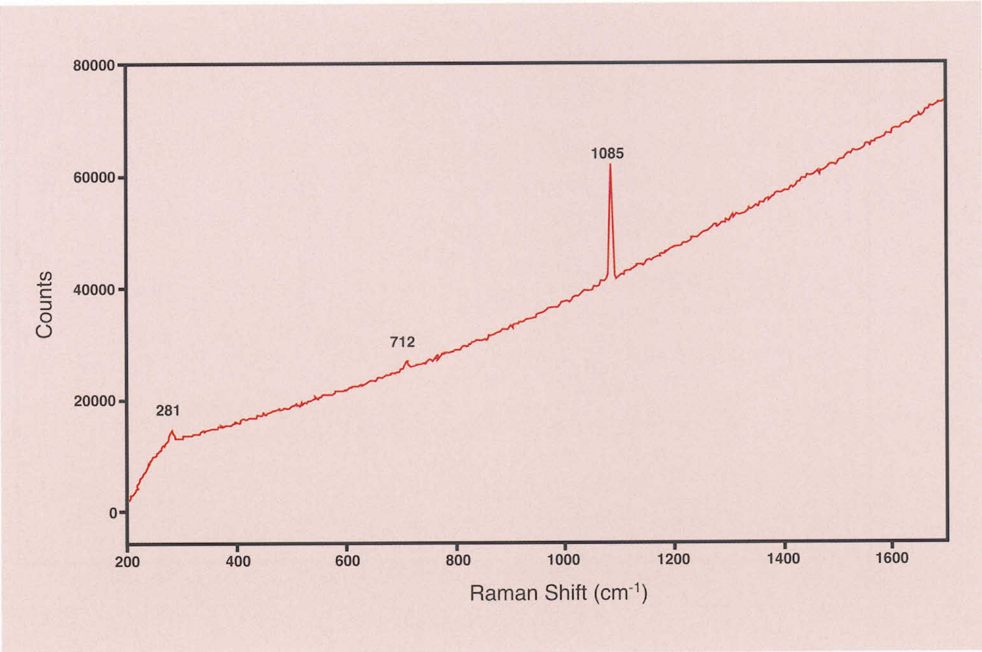

Figure 18: Raman spectrum of the orangey red luminescent area in the non-nucleated cultured freshwater pearl shown in Figure 11.

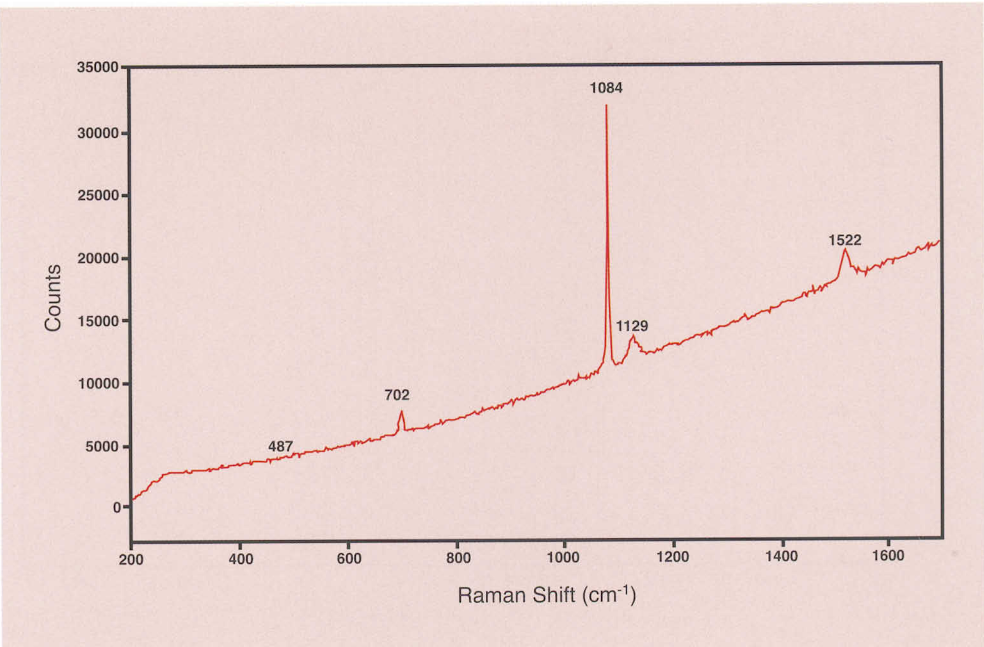

Figure 19: Raman spectrum of a golden yellow non-nucleated cultured freshwater pearl from Ezhou, Hubei Province.

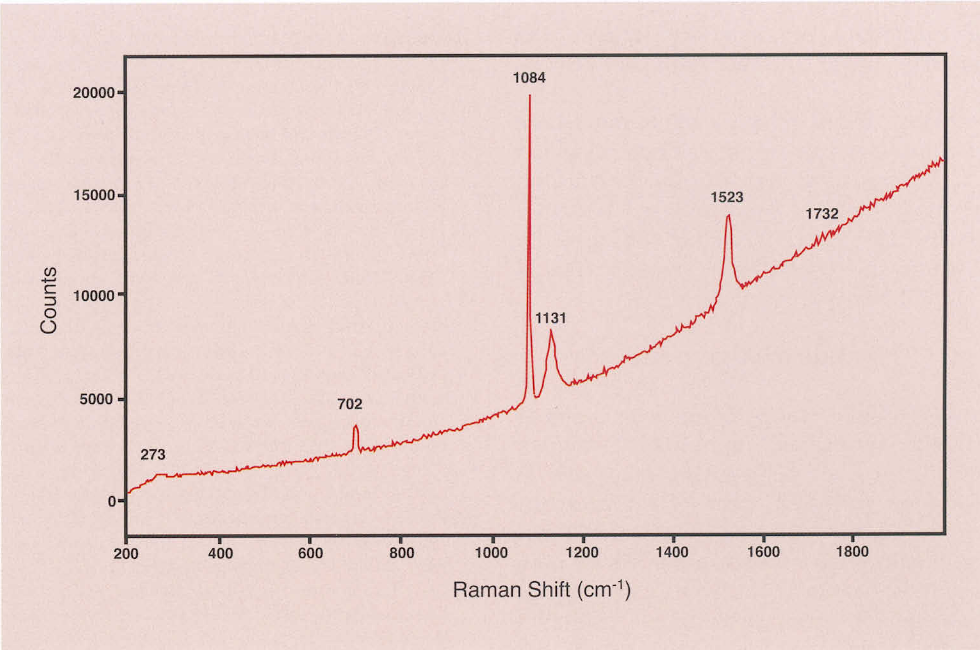

Figure 20: *Raman spectrum of a pale purple non-nucleated freshwater pearl from Ezhou, Hubei Province.*

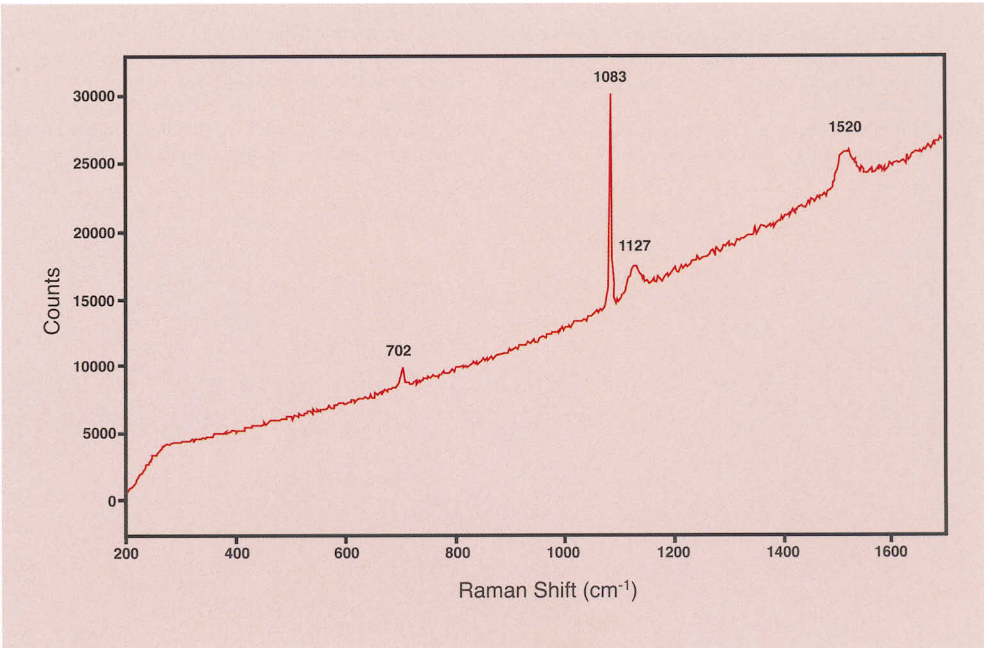

Figure 21: *Raman spectrum of a pale purple non-nucleated cultured freshwater pearl from Zhuji, Zhejiang Province.*

of carotenoid pigment may reduce the luminescence of cultured freshwater pearl.

Many factors influence the luminescence of cultured pearls under cathode rays, and CL can be used to distinguish cultured freshwater pearls from cultured seawater pearls. However, it cannot be used to distinguish untreated from treated cultured pearls.

Acknowledgements

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Nephrite jade from Sestri Levante, Italy

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ABSTRACT: In the vicinity of Sestri Levante, deposits of nephrite jade are intimately associated with serpentinized peridotite in an Apennine ophiolite complex of Jurassic age. The nephrite jade bodies are mainly thin veins and occasionally podiform nodules that formed within serpentinite, chloritite or rodingite near contact alteration zones between serpentinite and metagabbro. Predominant colours of the nephrite jade are of uneven greyish-green hues and surface lustre is dull. Grain size varies from fine- to medium-grained and subordinate constituents of apatite, diopside, magnetite, picotite, sphene and talc have been recorded. The nephrite jade formed as a result of metasomatism and high pressure effects following the emplacement of the ultrabasic rocks and serpentinization. Although the deposits are frequently cited in the literature, doubts remain in relation to their prospectivity. Surface exploration has failed to identify a single mass of nephrite of sufficient size to warrant mining operations and so far, exploitation has been limited to collecting material from outcrops and fossicking for nodules in the regolith. The small pieces found are scarcely ever fashioned by lapidaries except for minor items of costume jewellery. Nevertheless, the deposits remain of considerable geological and historical interest.

Introduction

The existence of nephrite jade in the Ligurian Apennines of Italy has been known for around a century and the locality is widely referred to in the extensive literature on jade. Indeed, it is frequently cited as the largest deposit of nephrite jade in Europe (e.g. Kolesnik, 1970; Frey and Skelton, 1991). Surprisingly however, commercial exploitation has failed to eventuate. In addition, few specimens of the nephrite are displayed in major mineral collections and the history of the deposits remains shrouded in mystery.

The nephrite jade locality lies some 40 km east of the city of Genoa in Northern Italy and near the picturesque town of Sestri Levante on the Riviera Ligure (*Figure 1*). Here, the Northern Apennines meet the coast and create steep terrain with spectacular cliffs and rugged mountains. Recorded occurrences of nephrite jade lie almost entirely within the Cinque Terre Regional Park.

The writer carried out field investigations at Sestri Levante during October 2002 as part of a wider study of nephrite jade in Europe. This paper provides a review and a description of the geological setting of the deposits and comments on the exploration potential of the district.

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Figure 1: Orientation map.

Historical background

In a landmark paper, Kalkowsky (1906) first reported the discovery of primary deposits of nephrite jade in the vicinity of Sestri Levante. He described the principal deposit near Monte Bianco and identified ten other occurrences within a belt stretching from Sestri Levante for almost 25 km in a south-eastwards direction to Monterosso al Mare (*Table I* and *Figure 2*, Sites 1-11 inclusive). (This Monte Bianco should not be confused with the mountain on the border between Italy and France which is also known as Mont Blanc.) The area was later visited by Steinmann (1908) who confirmed the findings of Kalkowsky (1906) and also identified three further occurrences (*Table I* and *Figure 2*, Sites 12–14 inclusive). More recently, Antofilli *et al.* (1983, p.167) mentioned Sites 1, 5 and 9 in a general account of the geology and mineralogy of the Ligurian region.

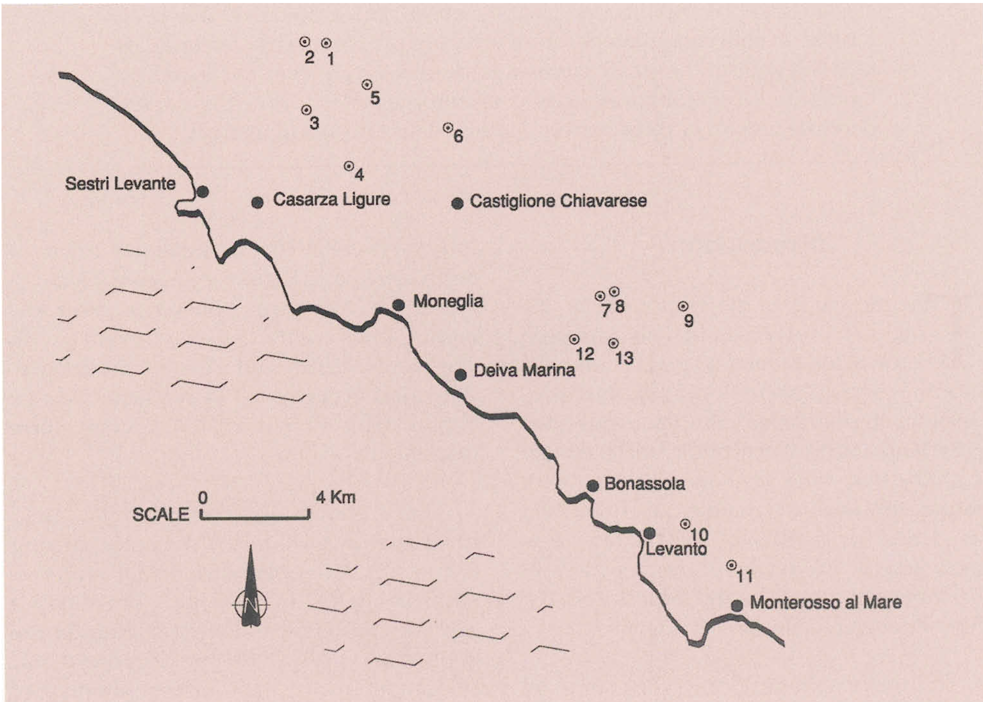

Figure 2: Nephrite jade occurrences between Sestri Levante and Monterosso al Mare (see Table I).

***Table I**: Nephrite jade occurrences between Sestri Levante and Monterosso al Mare (see Figure 2).*

Ref No	*Locality name*	*Nephrite occurrence*	*Grid ref.*
1	Monte Bianco	main deposit; veins and nodules	5357 9081
2	Domenico Pass	patches and swirls in rodingite	5353 9080
3	Libiola Hill	veins in chloritite	5354 9058
4	Gallinaria Mine (Casarza Ligure)	vein in serpentinite	5372 9038
5	Casa di Bonelli (Monte Tregin)	vein network in serpentinite	5380 9065
6	Casa di Monte Pu	irregular bands	5406 9046
7	La Spezia Road A	irregular patches	-
8	La Spezia Road B	angular block at roadside	-
9	Mattarana	patches in serpentinite and talc	-
10	Levanto	pebbles in riverbed	-
11	Monterosso al Mare	patches in serpentinite	-
12	La Baracca-Castagnola Path	deformed vein in serpentinite	5455 8980
13	Monte Guaitarola Road	veins in roadside cuttings	5470 8980
14	Aulla-Bibola (Val Magra)	veins (16 km NE of La Spezia)	-

Although the discoveries of nephrite jade at Sestri Levante aroused widespread interest and the potential for exploration in the surrounding area appeared encouraging, further information on the deposits in the technical literature is singularly lacking. This seems rather surprising because despite certain restrictions throughout the war years due to the strategic importance of the region for naval purposes, the area appears reasonably accessible.

Geological setting

Ophiolite complexes are widespread along the Northern Apennines. They basically consist of associations of serpentinized peridotite, gabbroic rocks, and basalts overlain by marine sedimentary sequences, including radiolarian cherts and limestones, the whole having been affected by mild metamorphism. These ophiolitic complexes are interpreted as remnants of Jurassic oceanic crust and upper mantle, formed in a palaeo-Apennine basin that

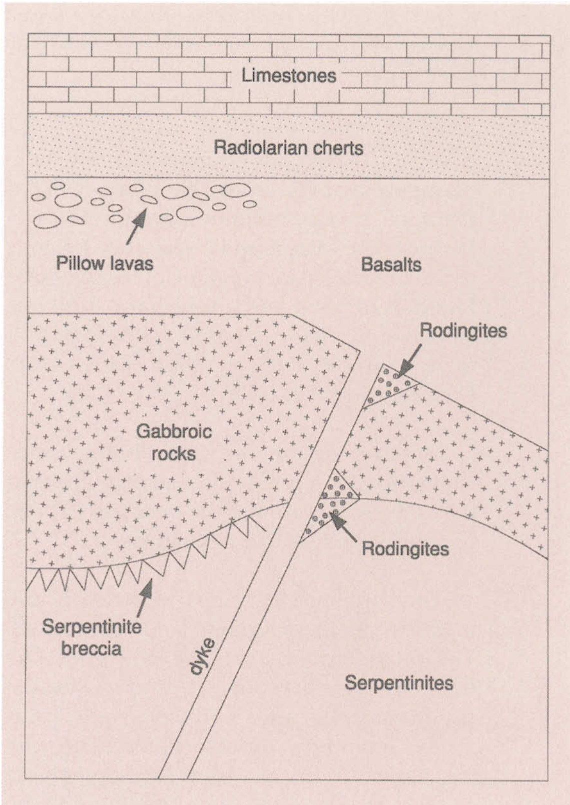

***Figure 3**: Schematic section through Apennine ophiolite showing stratigraphic setting.*

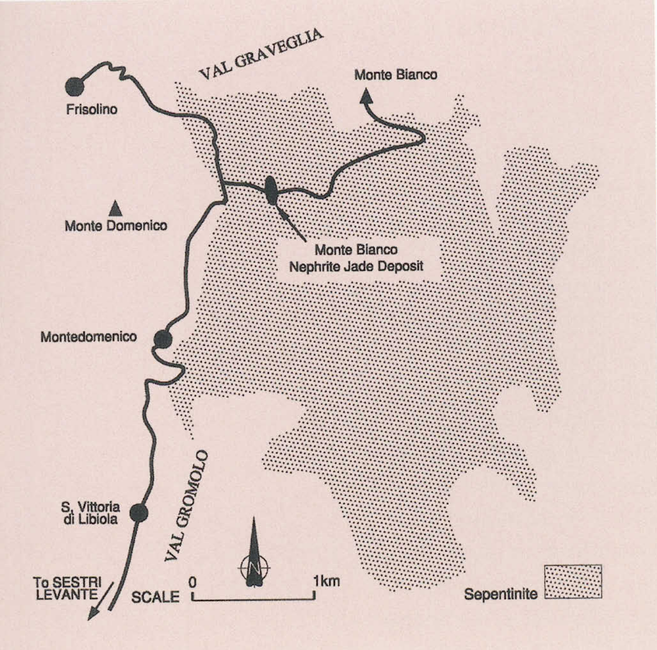

Figure 4: Monte Bianco nephrite jade deposit. Locality and geology plan (after Decandia and Elter, 1972).

closed in Cretaceous to early Tertiary time (Rampone and Piccardo, 2000, and references therein). In the neighbourhood of Sestri Levante, the stratigraphic sequence belongs to the Bracco-Val Graveglia Unit of the Inner Ligurian Domain and a schematic synthesis is shown in *Figure 3*, based on the work of many authors (Abbate and Sagri, 1970; Decania and Elter, 1972).

Massive serpentinite, metagabbroic rocks, rodingite and serpentinite melange underlie the hilly ground around the principal deposit of nephrite jade at Monte Bianco.

The serpentinite ranges from black and massive to dark green and brecciated. The main constituents of the rock are lizardite, chrysotile and bastite pseudomorphs after orthopyroxene, plus minor quantities of chlorite, brucite and magnetite. In places, sheared serpentinite appears to grade into chloritite. In addition, closely spaced veins composed of calcite are commonplace.

The gabbroic rocks (mainly troctolite to olivine-bearing gabbro) comprise discrete intrusive bodies and dykes emplaced within the serpentinite. They are variably altered and crop out mainly as small, scattered outcrops. According to Tribuzio *et al.* (1997), they also have a complex metamorphic and deformational history.

The rodingite is a distinctive hard and compact rock with highly variable composition. Common mineral constituents include albite, chlorite, diopside, epidote, garnet, prehnite, pumpellyite, sericite, vesuvianite and zoisite. According to Bezzi and Piccardo (1969) and Rösli *et al.* (1991), the rodingite is metasomatic product associated with interaction between gabbro and serpentinite.

The Monte Bianco deposit

The main deposit of nephrite jade is situated on the south facing slope of Monte Bianco in the upper Gromolo Valley (*Figure 4*). From Sestri Levante, access to the site is northeastwards for 8 km via Santa Vittoria di Libiola to the village of Montedomenico thence northwards for 1.7 km along Frisolino Road to the col and eastwards by track for 0.5 km.

The nephrite site occupies an area some 150 m long by up to 40 m wide and elongated down the hillslope. It is characterized by stony ground and vegetation of Mediterranean scrub (*Figure 5*). Serpentinite comprises the dominant rock type subcropping on the hillside although chloritite and rodingite are abundant in places. Rock relationships are unclear due to poor exposure.

The nephrite jade bodies chiefly comprise either networks of veinlets or more commonly single, steeply dipping veins typically 2–5 mm wide that cut through the serpentinite (*Figure 6*). In places, some bodies

Figure 5: *Monte Bianco nephrite jade deposit. The site appears in the central part of the picture. View looking north.*

form irregular masses of lensoid to podiform shape ranging from 10 to 200 mm across though most are much smaller. The larger pods give rise to rounded nodules. Kalkowsky (1906) reported nodules and masses of larger dimensions that may subsequently have been removed from the site. Importantly, most of the pod shaped masses are heterogeneous and contain significant quantities of other minerals. Not uncommonly, the nodules feature a core of leucocratic rodingite, an inner rim of mixed diopside and chlorite and an outer rim of nephrite that graduates almost imperceptibly into the internodular serpentinite (*Figure 7*).

Using the Munsell notation (Rock-Colour Chart Committee, 1980), the nephrite jade ranges from pale green (10G 6/2) and pale yellowish-green (10GY 7/2) through greyish-green (5G 5/2 and 10G 5/2) to dusky green (5G 3/2) and dusky yellow-green (5GY 5/2) but is predominantly greyish-green (10G 5/2). Localized zones contain an unusual

Figure 6: *Vein of green nephrite jade alongside pen. Host rock is serpentinite with white calcite veining. Monte Bianco site.*

Figure 7: Cut and polished specimen of a typical nodule. Core of leucocratic rodingite, inner rim of mixed diopside and chlorite and outer skin of nephrite. Size approximately 100 mm across. Monte Bianco site.

variety of nephrite of medium bluish-grey (5B 5/1) colour with light bluish-grey (5B 7/1) mottles. Colours generally are patchy and uneven and surface lustre typically appears dull and somewhat sheared.

X-ray and petrographic examinations of an array of samples obtained from outcrops and a roadside cutting has revealed that the nephrite jade consists of microcrystalline tremolite-actinolite that is intimately associated with appreciable but variable quantities of chlorite and diopside and to a lesser extent talc. The majority of the tremolite-actinolite shows incipient preferred orientation and occurs as very fine fibrous crystals, less than 0.005 mm in width.

Certain specimens are porphyritic or contain distinct inclusions. Kalkowsky (1906) identified the following list of minor coexisting minerals – apatite, chlorite, diopside, garnet, hematite, magnetite, picotite and sphene.

Nephrite classification and origin

Almost invariably, the nephrite jade localities in the vicinity of Sestri Levante are intimately associated with mafic and ultramafic rocks. Based on the field relationships between the nephrite bodies and the ophiolite belt as well as the association of rodingite within contact alteration zones, the deposits are classed as ortho-nephrite in type (Nichol, 2000).

Following the discovery of nephrite jade in the Sestri Levante district, controversy arose on the origin of the deposits and at least two schools of thought evolved. The first group led by Kalkowsky (1906) considered that the nephrite originated entirely within serpentinite as a result of tectonic movements combined with hydrothermal modifications. The second group led by Steinmann (1908) rejected the concept of tectonic control over nephrite genesis and maintained that the transformation process resulted from pressures induced by the volume increase of 15–20% associated with the alteration of olivine to serpentine. Steinmann also contended that the process operated predominantly in the contact alteration zone between serpentinite and metagabbroic rocks. Although the latter gained widest acceptance, our understanding of the formation of ortho-nephrite has seen great progress since that time. We now attribute the origin of the mineral to contact or infiltration metasomatism of silicic rocks by serpentinite fluids or a blackwall-like boundary reaction between silicic rocks and Ca-Mg-rich aqueous fluids from serpentine (see Karpov *et al.*, 1988; Suturin, 1986). Nevertheless, the insights of these early workers based on their observations at Sestri Levante provided profoundly significant contributions to the theories on the subject.

Figure 8: *Cabochon brooch fashioned in nephrite jade from Monte Bianco site.*

Production and exploration potential

No commercial development of the nephrite jade deposits at Sestri Levante has been recorded. This was probably due to the dispersed distribution of the material through the serpentinite and the apparent lack of a single mass of sufficient dimensions to warrant mining operations or to encourage deeper exploration beneath the ground surface. Consequently, output has been limited to intermittent fossicking for nodules in the regolith and prising small pieces from outcropping veins. These fragments are suitable only for small crafted items (*Figure 8*).

Another consideration is quality which appears generally low for most gemmological purposes with the proportion of monomineralic material estimated at less than 5 per cent. Moreover, the material lacks the vitreous lustre usually associated with nephrite and typically, the size of stone is too small to be used for ornamental and hardstone carvings.

Although surface indications of nephrite are widely scattered in the region, the historical records and desultory production suggest a lasting story of small size and low quality. However, despite the lack of workable deposits to date, the region appears to remain under-explored for nephrite. The full potential may not have been realized because of inadequate support for prospecting and geological studies. As far as can be determined, no subsurface investigations have been carried out and potential exists for possible improvements in the quality of the material at deeper levels in fresh rock. This could be tested at the Monte Bianco site by a modest programme of investigations involving a series of inclined boreholes through the deposit to obtain core samples of subsurface material. However,

Figure 9: *Polished specimen of nephrite jade from Sestri Levante. Approximate size 70 × 40 mm. Kalkowsky collection, Museum für Mineralogie und Geologie, Dresden.*

special permissions and restrictions may apply because the site lies within a designated Regional Park.

Museum collections

Three small specimens of nephrite jade from the neighbourhood of Sestri Levante are held in the Tiragallo collection at the Museo Civico di Storia Naturale 'G. Doria' in Genoa but they are not on public display.

The largest collection of nephrite jade specimens from the Sestri Levante district is held in the Museum für Mineralogie und Geologie, Dresden. It comprises some 70 cut and uncut rock samples including several polished pieces (*Figure 9*). Interestingly, the collection was assembled by Ernst Kalkowsky while he held the positions of Professor of Mineralogy and Geology at the Technical University of Dresden as well as that of Director of the Museum für Mineralogie und Geologie, Dresden (Mathé, 1993). One of the specimens from the collection appears on public display at the Schatzkammer Museum in the Zwinger, Dresden.

A general survey of other museum collections throughout Europe failed to disclose any further noteworthy specimens.

Conclusions

At Sestri Levante in Italy, nephrite jade is associated with contact alteration zones between serpentinite and metagabbro. As well as nephrite jade, the alteration zones also contain sheared serpentinite, chloritite, talc and rodingite.

The nephrite jade is categorized as an ortho-nephrite and occurs mainly in narrow veins and small lensoid to podiform bodies. Colour is predominantly greyish green (10G 5/2), texture ranges from fine- to medium-grained and surface lustre is typically dull.

Specimens of nephrite jade from Sestri Levante are held in only a few museum collections and the material is scarcely ever fashioned by lapidaries except for minor items of costume jewellery.

Although surface indications of nephrite are widely scattered throughout the region, the occurrences generally appear small in size and poor in quality. No commercial production is recorded and doubts remain in relation to Sestri Levante being regarded as a significant nephrite jade province. However, scope exists for further exploration work in the district: in particular, at the Monte Bianco site where subsurface investigations are needed to examine the distribution and quality of the nephrite at deeper levels in fresh rock.

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The author is grateful to Herr Herbert Giess for considerable assistance with the interpretation of technical literature in the German language. I wish to thank Angelo Stagnaro of Museo Parma Gemma at Casarza Ligure for hospitality and guidance during my field visit to Sestri Levante. I also wish to thank Professor Dr Klaus Thalheim, Curator of Mineralogy, Museum für Mineralogie und Geologie, Staatliche Naturhistorische Sammlungen Dresden for kindly making arrangements for me to examine the nephrite jade specimens in the Kalkowsky collection at the museum. The X-ray diffraction analyses were carried out by X-Ray Mineral Services Ltd, Penmachno, North Wales and the diagrams were prepared by Angela Hughes.

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Chemical fingerprinting of some East African gem rubies by Laser Ablation ICP-MS

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ABSTRACT: Laser Ablation ICP-MS is a suitable method for determining the trace element chemistry of gem rubies because of its sensitivity (ppm levels) and high spatial resolution (less than 100 μm^3). The method is best described as *Quasi non-destructive* because of laser damage induced during the ablation process. Analyses of gem rubies from the Longido and Chimwadzulu deposits of Tanzania and Malawi respectively show that Mg, V, Cr, Fe, Ga, Cu and often Ca, are typically above detection limits. The Ga, V and Cu (0.001 to 0.05 wt.%) and Ca values (0.03 to 0.5 wt.%) show good 'within sample' reproducibility and similar ranges for both deposits. In contrast, the Mg values (0.0001 to 0.49 wt.%) are highly variable and show poor 'within sample' reproducibility. The Fe and Cr values, respectively, are typically from 0.027 to 1.1 wt.% and from 0.084 to 0.71 wt.% (but up to 2.53 wt.% in two samples). These elements show marked differences between the two deposits. Together with Ga they define different areas on published Cr/Ga vs. Fe/Cr discriminant plots, but there is some overlap with fields defined for Burmese and Thai rubies. Combined with published data for Kenyan and Madagascan samples, the Chimwadzulu and Longido samples define a broad 'East African Trend' probably reflecting their similar geological setting within the Proterozoic Mozambique Metamorphic Belt.

Keywords: chemical composition, East Africa, Laser Ablation ICP-MS, ruby

Introduction

The gemmological and inclusions characteristics of rubies and sapphires may be used to help identify their likely source or geographical location (Hughes, 1997). This is important for a number of reasons. Firstly, gemstones from certain localities attract a much higher price than others. Secondly, the information can help archaeologists to establish the provenance of artefacts containing gems, and thirdly, these features can also assist geologists and mineralogists in their understanding of the geological controls on gem formation.

A wide variety of solid and fluid inclusions have been reported in sapphires and rubies from a number of different

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localities and deposit types (e.g. Gübelin and Koivula, 1986; Hughes, 1997). However, even when present, the inclusions are not always readily identifiable because of either their small size or their inaccessibility deep within the sample.

An alternative approach in recent years has been to use the trace and minor element chemistry of gemstones as indicators of both their provenance and genesis. These so-called 'chemical fingerprints' are present either as atomic substitutions in the crystal lattice, (e.g. Cr, Fe and Ga), or as components of solid and liquid inclusions (e.g. Zr from zircon). Previous authors have used chemical data to help discriminate between natural and synthetic rubies (e.g. Tang *et al.*, 1989; Joseph *et al.*, 2002), to identify the provenance of rubies in jewellery and historical artefacts (e.g. Calligaro *et al.*, 1998, 1999), and to characterize corundums from different geological environments (Sutherland *et al.*, 1998; Schwartz *et al.*, 2000).

Systematic trace element analyses of rubies and sapphires from specific localities may also reveal broad geographical (and perhaps geological) differences. Osipowicz *et al.* (1995), for example, elaborating on earlier work by Tang *et al.* (1988), showed that there are marked differences between the Ti, V, Cr, Fe and Cu contents of Burmese and Thai rubies. Calligaro *et al.* (1999) used a database of some 200 analyses of rubies from nine different regions to define three main groupings based on a simple Cr versus Fe discriminant plot, and Schwarz and Schmetzer (2001) used a Cr/Ga versus Fe/Cr discriminant diagram to define different fields for rubies from Burma, Thailand- Cambodia and Madagascar.

To date, X-ray fluorescence (XRF), electron microprobe analysis (EMPA) and proton induced X-ray emission (PIXE) spectroscopy have been the preferred methods of gem analysis, because of their sensitivity and non-destructive nature. But they all have their limitations. To be effective, EMPA needs to be carried out on a flat polished surface, the instrumentation required for PIXE is very expensive, and XRF is generally less sensitive and usually requires bulk samples.

Laser Ablation Inductively Coupled Plasma Mass Spectrometry (L-ICP-MS) is a recently developed, alternative method with the required sensitivity (Jarvis and Williams, 1993). It involves ablating a small sample area (*c*.100 microns^2) down to a depth of about 10 microns, using a laser focused on the surface of the sample through a microscope. The ablated material is swept into a plasma, held at about 10,000 K, via a stream of argon where it is completely ionized. The charged particles are then passed into a mass spectrometer which is capable of determining the quantities of different elements (and their isotopes) depending on their different mass to charge (m/e) ratios. Instrumentation is now widely available, little sample preparation is required and sensitivities are high – simultaneous multi-element analyses can be carried out even if contents are low (in the $\mu g\ g^{-1}$ range or less) within minutes. Inevitably, some laser damage will occur on the surface. This is undesirable in faceted stones, unless analyses are carried out on the underside or edges. However, in a recent study Guillong and Gunther (2001) successfully applied L-ICP-MS to the systematic analyses of Cr, Fe, Ga, V, Ti in 25 sapphires from five unspecified localities with minimal laser damage to the extent that they considered the technique to be *Quasi 'non-destructive'*.

In this paper we report on the L-ICP-MS analyses of trace elements in gem rubies from the Chimwadzulu and Longido deposits of East Africa, which are comparable in terms of their broad geological settings. The main objectives are to:

1. Assess the extent to which trace elements show significant variations between different stones from the same locality.

2. Compare the overall data sets from the two localities with published data from other major ruby localities, worldwide, to

determine whether they can be used as geographical or genetic discriminants.

Geological setting, sample description and preparation

The Chimwadzulu and Longido gem deposits (*Figure 1*) are located within the Proterozoic Mozambique Metamorphic (Mobile) Belt, which is a major structure extending south to north from Mozambique to Arabia. As summarized by Levitski and Sims (1997), late Proterozoic sediments were subjected to several phases of folding and suffered amphibolite to granulite facies metamorphism, with localized alkali metasomatism and granitization. Graphitic gneisses, schists and marbles are locally abundant, and ultramafic rocks occur in belts within gneisses adjacent to their contacts with marbles. On a regional scale, the primary ruby deposits of East Africa and Madagascar are generally associated with ultrabasic rocks (Mercier *et al.*, 1999).

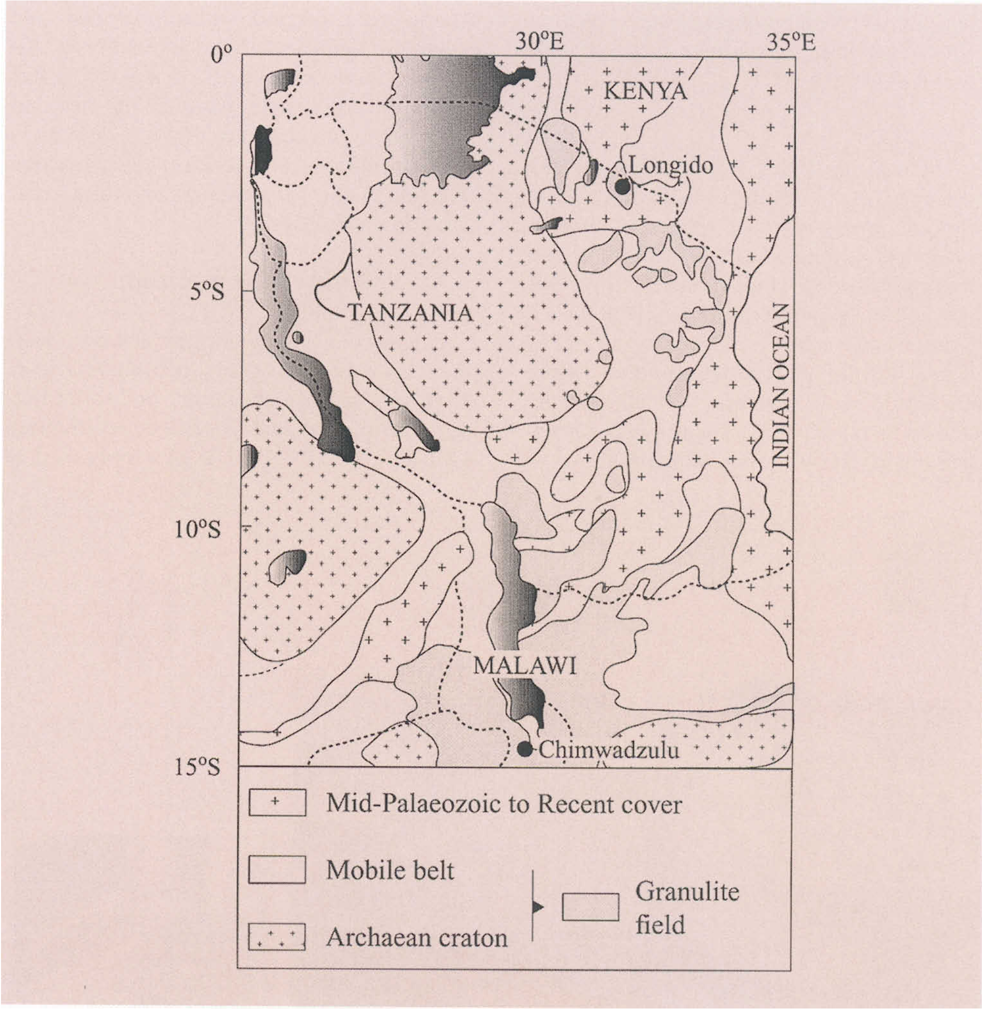

Figure 1: *Simplified geological map of East Africa and Madagascar (after Mercier et al., 1999) showing the location of the Longido and Chimwadzulu ruby deposits in relation to Proterozoic granulite terrains within the Mozambique mobile belt.*

Figure 2: Uncut rubies from Chimwadzulu mounted on double-sided sellotape ready for introduction into the ablation chamber of the Laser ICP-MS system.

The Chimwadzulu rubies, recently described by Rankin (2002), have been worked from surface eluvial deposits associated with a weathered and metamorphosed (amphibolitic) ultramafic body within a metasedimentary sequence of gneisses and schists. The Longido rubies occur within a chrome-green zoisite-amphibole rock (Game, 1954), locally referred to as 'anyolite'. The anyolite forms a zone about 1 m wide and some 500 m long within a weathered ultrabasic rock intruded into a sequence of metamorphic rocks, including marbles (Hughes, 1997).

Samples of gem rubies were collected *in situ* from mine workings. The selected rubies were deep to fresh-blood-red in colour, up to 1.5 cm in size and with variable, but usually tabular, shapes. Individual crystals, containing areas as free as possible from visible mineral inclusions, were chosen for study (*Figure 2*). Most analyses were carried out on natural crystal faces and cleavage planes, while others were carried out on lapped and polished surfaces. Prior to analysis the samples were washed in de-ionized water, buffed dry and then cleaned with acetone. Some Longido rubies contain rounded blebs of Fe-sulphide on the surface, and particular care had to be exercised in avoiding these areas during analysis.

Analytical methods

Batches of up to 15 samples at a time were placed inside a specially constructed laser ablation chamber mounted on an optical light microscope with a camera attachment. A CETAC™ Nd: YAG UV laser operating at

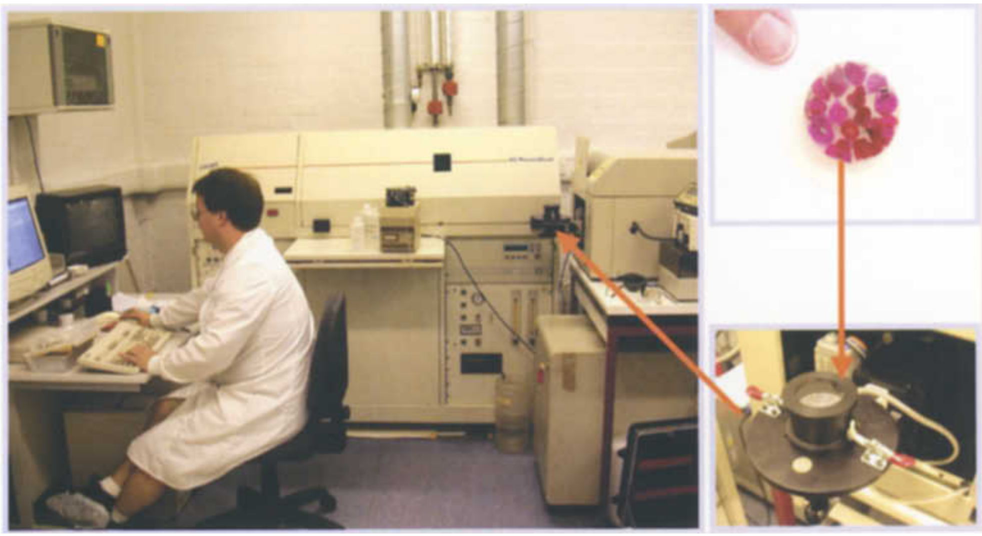

Figure 3: General view of the NERC Laser-ICP-MS system showing close-up views of the ablation chamber and a batch of Longido rubies prior to analysis.

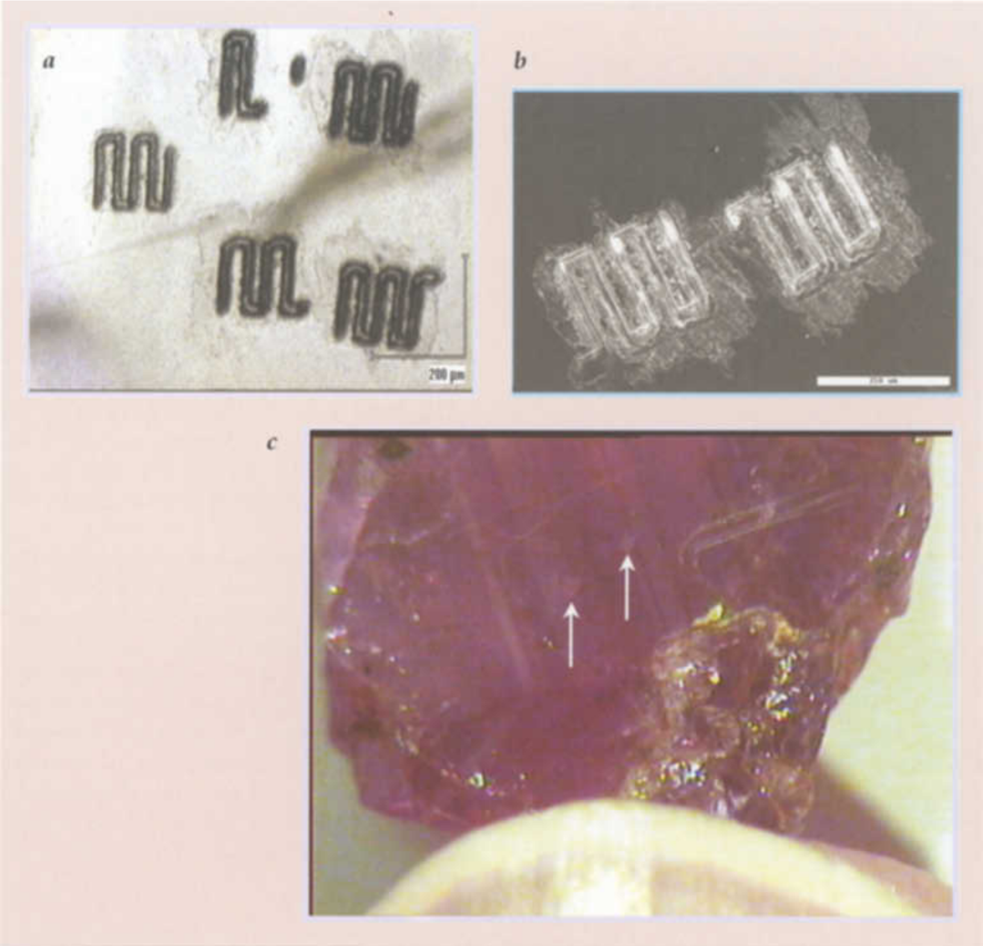

***Figure 4**: Laser ablation tracks on the surfaces of rubies (a) in transmitted light showing the traverse lines of the lasers and surrounding patchy damage caused from right to left by low, medium and high laser energies and (b) under a scanning electron microscope showing surrounding sputter zones produced under normal operating conditions (80% laser power); (c) at approximately ×10 magnification showing the barely visible tracks (arrowed). Note thumbnail for scale.*

266 nm, and with an output power of 2 mJ, was focused through the microscope onto the surface of the sample. The power was adjusted both to optimize elemental response and to avoid excessive spallation and damage to the sample. Ablated material was transferred into the inlet system of a Thermo Elemental Plasma Quad™ ICP-MS instrument, via a stream of argon carrier gas (*Figure 3*).

The ablation process was carried out along linear tracks some 10 μm wide and 10 μm deep over a distance of some 500 μm (*Figure 4*). Elemental data were acquired sequentially along the track over three, 30-second intervals, and the data reported here for each element represent the mean of these three runs. Duplicate sets of data were collected from two separate areas of each crystal. Altogether, duplicate analyses were obtained from different areas within 10 Chimwadzulu and 14 Longido ruby crystals.

***Table I**: Detection limits (3 x standard deviation) in μg/g (ppm) for selected elements analysed by Laser ICP-MS in three batch runs.*

Element	*Batch 1*	*Batch 2*	*Batch 3*
Ni	401	147	369
Ca	269	269	81
Ti	58	46	49
Fe	11	6.4	8.0
Cu	3.0	12.7	5.2
Mn	3.3	2.8	0.8
Mg	1.8	3.2	2.5
Cr	1.4	1.2	1.1
V	1.4	0.4	0.4
Ga	0.7	0.6	0.7
Zr	0.8	0.7	0.8
Y	0.3	0.4	0.8
Ce	0.04	0.14	0.11

Gas blanks were used to determine the detection limits for each element at regular intervals (*Table I*). Calibration was carried out using the internationally recognized NIST 610 glass standard based on an average Al_2O_3 content of 98.1% for the host rubies, as determined by EMPA. Further details of the L-ICP-MS method and procedures are provided by Jarvis and Williams (1993) and Mason *et al.* (1999).

Results

The data are summarized in *Table II*. The elements Mg, V, Cr, Fe, Ga and Cu are usually present in concentrations significantly above background in samples from both localities. Ca and Mn are above background levels in only a few samples. Ce has only been detected in one sample from each locality, but Ti, Zr, Ni and Y are characteristically below their detection limits.

In general, the duplicate analyses for Mg, V, Cr, Fe, Ga and Cu on different areas of the same crystal (*Figure 5*) are in good agreement and plot close together, except for Mg which shows a much greater variability compared to other elements (*Figure 5*). For clarity, error bars, estimated from the standard deviation of the mean of three analyses of scanned areas for each sample, are omitted from these plots. However, the errors are generally better than 50% RSD except for Mg which are

***Table II**: Summary of Laser ICP-MS trace element data for Chimwadzulu and Longido ruby samples (wt.%) compared with some ranges reported in Hughes (1997)*

Element	*Chimwadzulu (n=20)*	*Longido (n=20)*	*Other data (PIXE) (Hughes 1997, p. 50)*
Fe	0.350-1.099	0.024-0.439	0.049-0.545
Cr	0.084-0.204	0.153-2.530[(b)]	0.148-0.870
Ga	0.002-0.004	0.003-0.014	
V	<.001-0.003	0.004-0.055	0.002-0.046
Cu	<.002-0.008	<.001-0.013	
Mg	<.001-0.071	0.001-0.049	
Ca	<.08-0.81[(a)]	<0.03-0.40	0.013-0.069

Values with a < sign are below the detection limit (see Table I)
Notes: (a) One data point at 1.03% rejected because duplicate was below detection (<.08%)
(b) Except for three values at 2.27, 2.43 and 2.53 wt.%, the maximum value is 0.721 wt.%

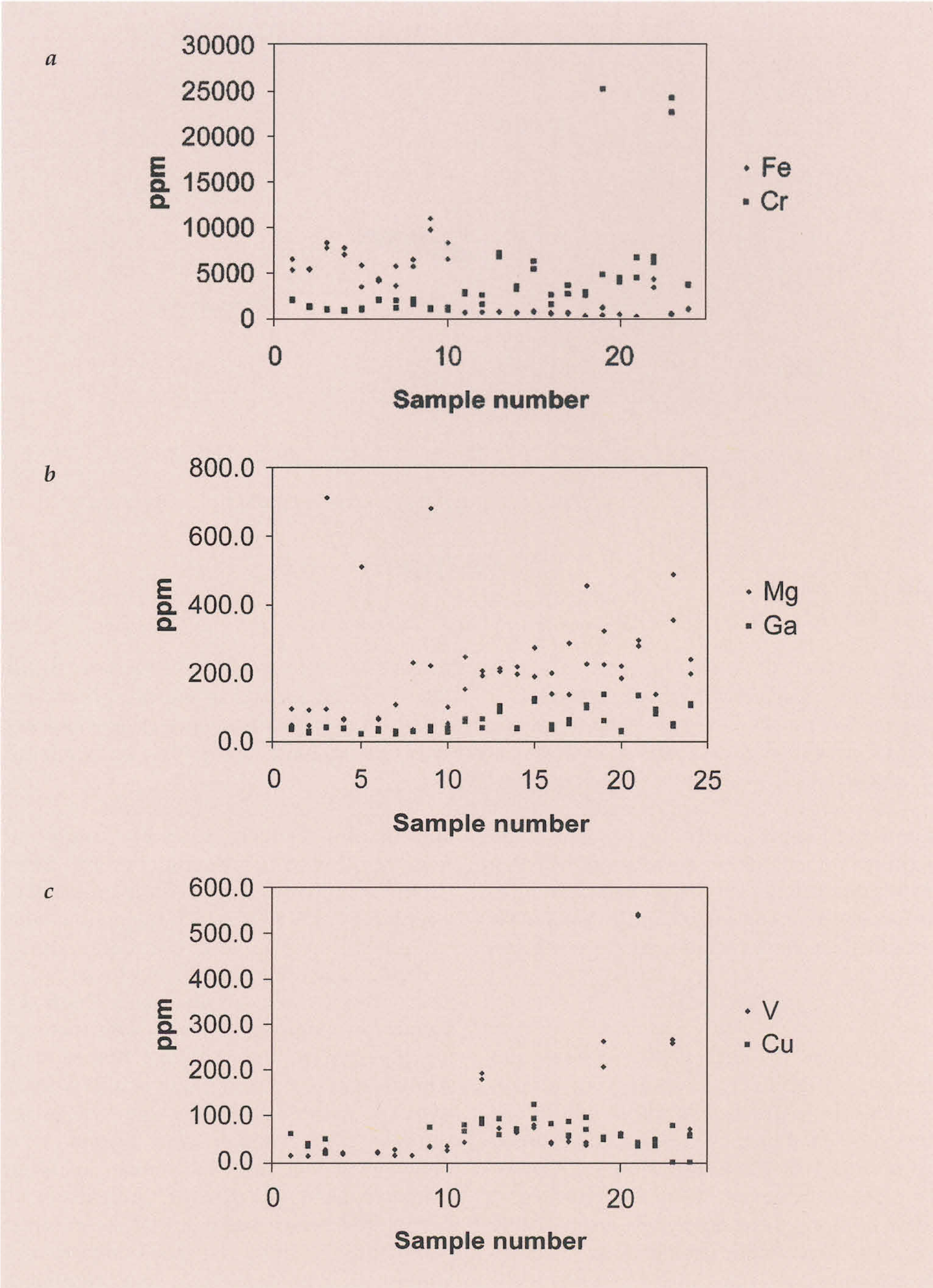

***Figure 5**: Duplicate analyses of (a) Fe, Cr; (b) Mg, Ga; (c) V and Cu in different areas of 24 rubies from Chimwadzulu (samples 1-10) and Longido (samples 11-24). The paired data illustrate 'within' and 'between' sample variability. In many cases (notable Cr, Fe and Ga) within sample variability is low (sometimes indistinguishable). In others (e.g. most Mg results; Cr data for sample 19) it is significant.*

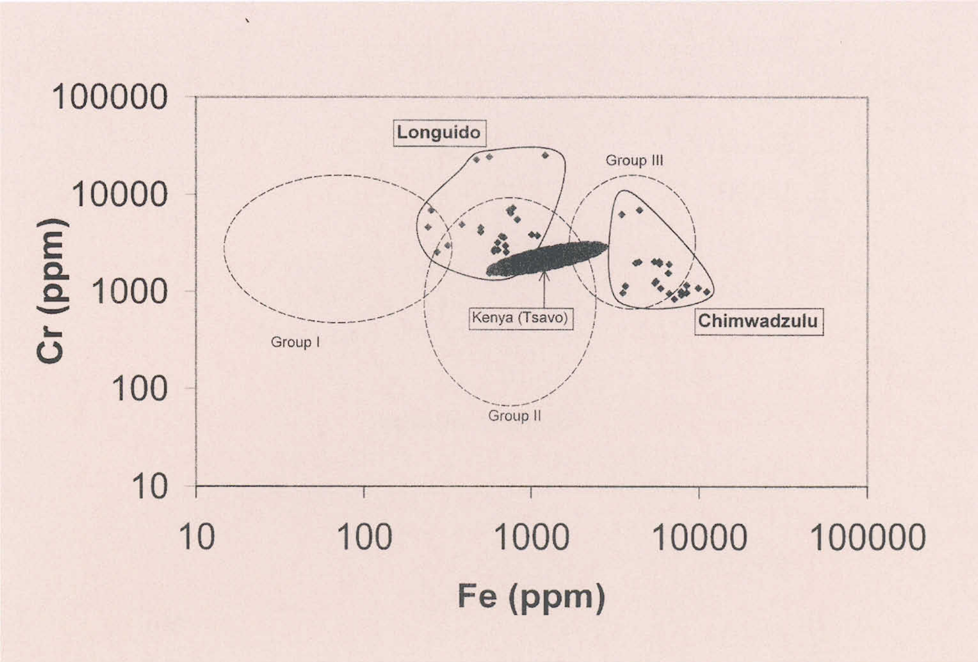

Figure 6: *Plot of Cr vs. Fe contents in ppm for Longido and Chimwadzulu rubies superimposed on the three main groupings defined by Calligaro et al. (1999) based on analyses of 64 rubies from nine geographical regions. Data from Tsavo, Kenya (the only East African samples analysed by these authors) plot within a separate field between those for Longido and Chimwadzulu; together they define a broad E. African trend straddling the recognized groupings.*

sometimes significantly higher and may account for the poor correlation between duplicate analyses for this element. No plots are presented or considered for Ca, Mn and Ce because data above background are too sparse.

Discussion

Calligaro *et al.* (1999) carried out comprehensive PIXE analyses on a number of rubies from different localities worldwide and showed that they defined three broad groupings (I, II and III) on a simple Cr versus Fe plot, as shown in *Figure 6*. According to these authors, these groupings are probably linked to three main geological occurrences or environments. The L-ICP-MS data for the Longido and Chimwadzulu samples show clear separation on this plot. This is somewhat surprising in view of their similar geological occurrence in association with amphibolites which probably represent metamorphosed ultramafic bodies. Most Chimwadzulu samples lie within group III of Calligaro *et al.* (1999), which mainly includes samples from Thailand/Cambodia, India and Madagascar. Most Longido samples, apart from three anomalously high Cr values, lie in group II which also includes samples from Sri Lanka, Kenya and Afghanistan. However, there is also a small overlap with group I which comprises samples from Vietnam and Burma. It is noteworthy that the five Kenyan analyses, extracted from the data of Calligaro *et al.* (1999), and which occur in the same broad geotectonic setting as the Longido and Chimwadzulu deposits, also define a separate area. When considered together, all three data sets for Chimwadzulu, Longido and Tsavo appear to define a broad 'East African' grouping.

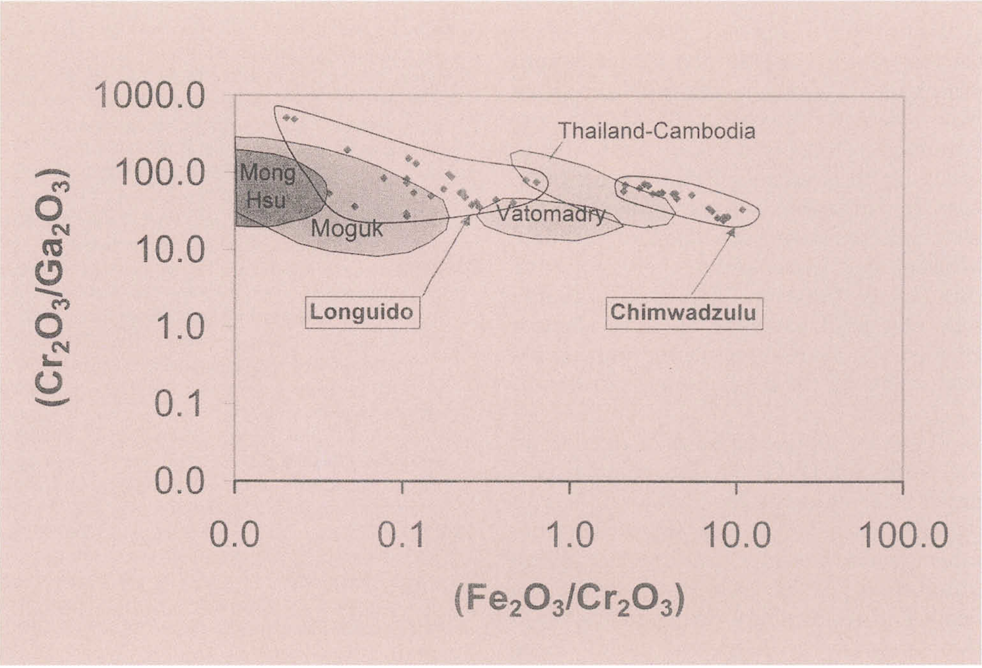

***Figure 7**: Plot of Cr/Ga vs. Fe/Cr ratios (wt% oxides) for Longido and Chimwadzulu samples in relation to fields for rubies from some other geographical localities as defined by Schwarz and Schmetzer (2001). There is clear separation of many Longido and Chimwadzulu samples, but some overlap with other areas. As with Kenyan samples in Figure 6, the Vatomandry (Madagascar) samples straddle these two main fields, reinforcing the concept of a broad E. African grouping related to the Mozambique mobile belt.*

Discriminant plots of Cr/Ga versus Fe/Cr ratios, based on XRF analyses of rubies from similar world occurrences, have also recently been presented by Schwarz and Schmetzer (2001). *Figure 7* shows the L-ICP-MS data for the Longido and Chimwadzulu rubies compared to the groupings indicated (op.cit) for rubies from these other localities. It can be seen that these plots are more effective at separating the Chimwadzulu from the Thai/Cambodian rubies, but that the overlap between Burmese and Longido samples is enhanced. Interestingly, the field for Madagascan (Vatomandry) samples, as with the Kenyan (Tsavo) samples, which also occur in the same broad, geotectonic setting, also straddles the data sets for Longido and Chimwadzulu samples, again defining a broad East African trend as previously suggested.

Conclusions

These initial studies have shown that L-ICP-MS is an appropriate and effective method for determining the trace element contents of natural gem rubies. Laser damage, though small, is still significant and care must be taken to avoid analyses on the upper surface of polished stones and to restrict analyses to less visible areas. For consistency and reproducibility care must be taken to avoid analysis of areas containing admixed solid phases.

A number of trace elements have been detected in the range normally expected for rubies from other worldwide localities. The elements Cr, Fe and Ga are present in levels consistently above background but their ranges are quite different to those reported in synthetic rubies (Tang *et al.*, 1989). Plots of Cr, Ga and Fe for Longido and Chimwadzulu samples, in comparison with published data from Kenya (Tsavo) and Madagascar (Vatomandry), show a broad 'East African grouping'. It is suggested that this defines a broadly comparable geological (amphibolitic/ultramafic?) environment within the Proterozoic Mozambique Metamorphic Belt, with the differences between deposits probably reflecting local variations in trace element chemistry of the host rocks and/or the fluids responsible for the crystallisation of ruby.

There are significant areas of overlap on the published Cr, Ga, Fe discriminant plots between samples of the four east African deposits considered here and those from other world localities. Additional criteria (notably types of inclusions) would be needed to confirm any distinction between these deposits as suggested by the trace element data. Conversely, the trace element signatures would be particularly helpful in distinguishing rubies from different east African localities where the inclusion assemblages are very similar. This is illustrated in *Figure 7*, with reference to Chimwadzulu and Vatomandry (Madagascar) rubies where the chemical fingerprints are quite distinct even though their inclusion characteristics, notably the presence of zircon clusters, are very similar (Schwarz and Schmetzer, 2001; Rankin, 2002).

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A Verneuil synthetic ruby showing diverse veil-like 'fingerprints'

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ABSTRACT: Although 'fingerprints' have been observed sporadically in synthetic Verneuil corundums, the novelty here consists of numerous veil-like 'fingerprints', some of which resemble those observed in Mong Hsu (Myanmar) rubies, while others proved similar to those frequently observed in sapphires from Myanmar or to those seen in flux grown synthetics (e.g. corundum and emerald). The gemmological properties and characteristics of this synthetic Verneuil ruby are described.

Introduction

Recently the author was asked to inspect a parcel of rubies for determination of origin, amongst which was a 2.60 ct oval-shaped red stone (*Figure 1*). With all the concern there is nowadays to recognize the treatments undergone by gemstones, one tends to overlook the danger of a synthetic stone finding its way into a parcel of natural stones. Such is the case of a flame fusion Verneuil synthetic ruby, displaying 'fingerprints', which was found in a parcel of natural rubies.

The measurements, weight and gemmological properties of this stone are described below.

Gemmological properties

The 2.60 ct oval-shaped red transparent gemstone (length 9.01 mm, width 7.28 mm, depth 4.60 mm) displayed a vitreous lustre.

The refractive index (RI) determinations were carried out using a Rayner Dialdex refractometer and monochromatic sodium light. The indices obtained from the table facet were ω = 1.773, ε = 1.765, giving a birefringence of 0.008, with optic sign negative. A uniaxial interference figure indicating the *c*-axis was obtained using a glass sphere between crossed polars and proved to be inclined to the girdle plane at about 45°.

Figure 1: *Oval Verneuil synthetic ruby of 2.60 ct.*

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***Figure 2:** Curved growth lines readily visible through the table facet of the Verneuil ruby (dark field illumination 15×).*

***Figure 3:** Numerous twisted wispy veil-like 'fingerprints' in the 2.60 ct Verneuil ruby, similar to those present in some Mong-Hsu (Myanmar) rubies (dark field illumination 30×).*

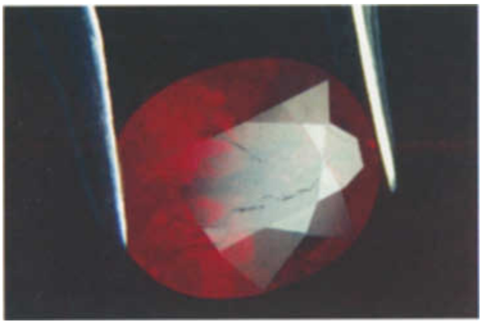

***Figure 4:** Several sinuous cracks breaking the surface of the 2.60 ct Verneuil ruby marking the positions of the 'fingerprints' (dark field illumination 10×).*

Under a calcite dichroscope, with fibre optic illumination, a strong dichroism in pale yellowish-red to deep red was observed through the stone's table facet.

The absorption spectrum was observed in daylight conditions, through a Beck spectroscope, and revealed a spectrum typical of chromium: a fluorescent line in the red at 695 nm, a very strong broad absorption band from the yellow to the bluish-green at about 610 to 490 nm, with two fine sharp lines visible in the blue at 480 and 474 nm, and a very strong broad band from the blue to the violet at 460 to 400 nm.

The stone was examined with a Multispec combined LW/SW ultraviolet unit and fluoresced a strong brick red to SW and a less strong darker red to LW.

The specific gravity (SG) was obtained by hydrostatic weighing in distilled water using a Mettler PL 300C carat scale, and the stone was found to have a value of 4.00.

The stone was immersed in methylene iodide between crossed polars and observed along the optic axis direction to see if 'Plato striations' (Liddicoat, 1989) were present but none were found.

The inclusions were examined using a Bausch & Lomb Mark V Gemolite binocular microscope using dark field illumination or overhead lighting as appropriate.

The main features encountered in the 2.60 ct oval-shaped stone were:

- numerous and very apparent curved growth lines visible through the table facet (*Figure 2*);
- small groups or clouds of pinpoint gas bubbles trapped between curved growth lines, confined in two zones on one side of the crown, near the edge of the girdle;
- numerous twisted, wispy veil-like 'fingerprints', similar to those observed in Mong-Hsu (Myanmar) rubies (Peretti *et al.*, 1995), readily observed through the crown (*Figure 3*);

Figure 5: Some 'fingerprints' found with a glassy dark red substance (healing flux?), in the 2.60 ct Verneuil ruby (dark field illumination 35×).

Figure 6: A flat 'fingerprint' showing large net-like patterns, resembling the 'fingerprints' in some flux grown synthetics (dark field illumination 40×).

- several of these 'fingerprints' breaking the surface of the stone (*Figure 4*);
- some 'fingerprints' filled with a glassy dark red substance which is possibly flux healing reflecting red from the stone's saturated colour. (*Figure 5*);
- a flat surface 'fingerprint' showing large net-like patterns (*Figure 6*), reminiscent of the 'fingerprints' currently observed in flux grown synthetics (Gübelin and Koivula, 1986);
- a small flat surface 'fingerprint' displaying a formation of 'folds' (*Figure 7*) similar to those typical of Myanmar sapphires (Gübelin, 1974; Gübelin and Koivula, 1986);
- some parallel straight polishing lines meeting at an angle at a facet junction (*Figure 8*).

Figure 7: Verneuil ruby with a flat surface 'fingerprint' showing 'folds' similar to those in some sapphires from Myanmar (dark field illumination 50×).

Composition and spectroscopy

The composition was determined using a Philips PV 9500 EDXRF spectrometer with an X-ray tube voltage of 25 kV and a current of 200mA. In addition to the corundum's aluminium (Al), and the colouring agent (Cr), the only significant trace element recorded was iron (Fe).

Infrared absorption spectra (FT-IR) were obtained for this stone using a Nicolet Magna-IR ESP System 560 spectrometer. The IR spectrum is compared with those of two

Figure 8: Parallel straight polishing lines intersecting at a facet junction (dark field illumination 20×).

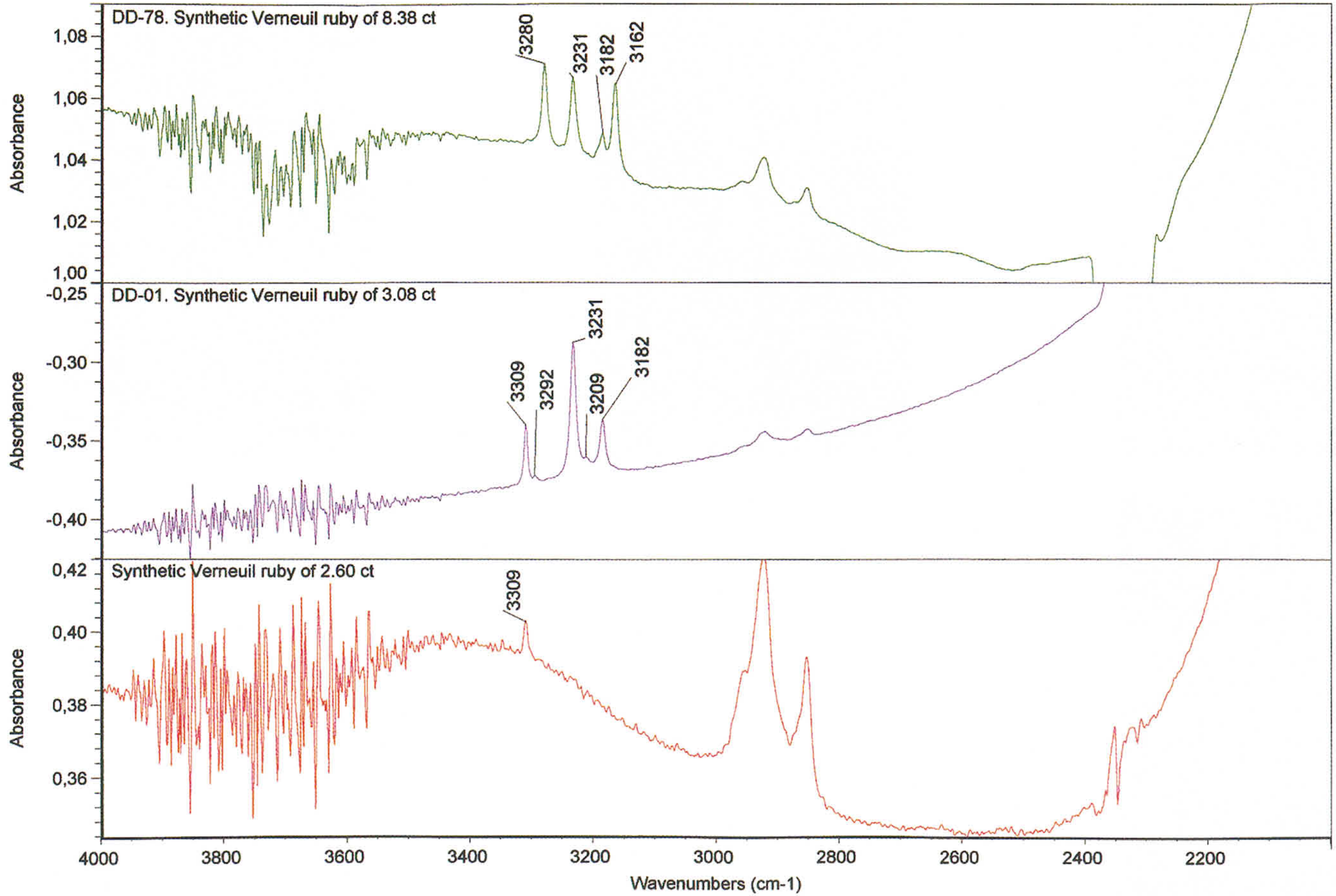

***Figure 9**: Infrared spectra of 2.60 ct Verneuil ruby with two other Verneuil ruby spectra for comparison.*

other Verneuil synthetic rubies in *Figure 9*. They all display two sets of absorption peaks. A first set is at ± 2850, ± 2921 and ± 2950 cm^{-1} (not indexed in *Figure 9*) and these are due to Blu-tack supporting the sample, to finger grease, or to residues of plastic or resin; therefore they are considered as an artefact (David and Fritsch, 2001). The second set generally comprises three peaks with one or several minute shoulders, or less often a single peak at 3309 cm^{-1}. The strongest is usually that at 3309 cm^{-1}; this peak is caused by an OH-dipole linked to a pair of atoms of iron and titanium inside the corundum lattice (David and Fritsch, 2001) . It must be said here that similar spectra may be displayed by basaltic rubies and sapphires; heat-treated non-basaltic rubies and sapphires may also show the 3309 cm^{-1} peak like the synthetic ruby described in this paper (Duroc-Danner, 2002). Although the presence of titanium (Ti) is indicated, its concentration is below the detection limit of the EDXRF equipment.

Discussion

If 'fingerprints' are not usually observed in Verneuil synthetics, it is nevertheless well-known that these can be induced by the process of 'quench-crackling' (Koivula, 1983; Schmetzer and Schupp, 1994). Since many of the 'fingerprints' seen in this stone break the surface, this clearly points towards such a treatment. The danger of the twisted veil-like 'fingerprints' observed in this Verneuil synthetic ruby lies in their similarity to those seen frequently in Mong-Hsu (Myanmar) rubies.

The flat surface 'fingerprint' showing large *net-like* patterns, similar to those encountered in flux-grown synthetics, and the small flat surface 'fingerprint' exhibiting a formation of 'folds' similar to those typical of Myanmar sapphires, shows how diverse 'fingerprints' can be, even in a single specimen, and why one should be careful not to jump too rapidly to a conclusion.

The induced 'fingerprints' that mask the otherwise too-apparent curved striae, and the polishing lines on the facet surface which visually interfere with the curved striae (*Figure 7*), could be created intentionally to fool a potential buyer. Viewing these with a 10× lens, and wrongly interpreting them as natural 'fingerprints' and angular growth zones would lead to a wrong conclusion.

To give a pink to red colour to the synthetic corundum, only 1 to 3 per cent of the chromium oxide (Cr_2O_3) are added to the alpha form of aluminium oxide (Al_2O_3) (in accordance with the intensity of the pink-to-red desired). Iron should be avoided, since even a small addition will produce a brownish ruby (Nassau, 1980), but small amounts can be present – possibly contamination from the blowpipe.

Conclusion

The physical and optical properties, and the curved striae and gas bubbles observed in the 2.60 ct oval-shaped ruby, are characteristic of synthetic Verneuil corundum, variety synthetic ruby.

The fact that the Plato lines were not detected is not surprising since these are not always visible (Elen and Fritsch, 1999). Heat treatment of flame-fusion synthetics can also make these Plato lines less apparent (Nassau, 1981) and it appears that this stone has undergone heat treatment and quench crackling to induce 'fingerprints' in the created cracks. Such inclusions and the curved growth lines are still more reliable indicators of the origin of a stone than the infrared spectra.

Acknowledgements

The author is indebted to Professor E. Fritsch, of the Institut des matériaux Jean Rouxel, Nantes, France, for providing stimulating discussions and comments.

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A note on the directions of maximum double refraction divergence (DD) in uniaxial and biaxial stones

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ABSTRACT: A method of visualizing the significant directions related to DD in uniaxial and biaxial stones is presented. Explanations are specifically tailored for a non-mathematical understanding, although mathematical justifications are included.

1. Introduction

In a recent paper, Cartier (2002, p.225) summarized the factors relating birefringence (BI) and double refraction and commented on the directions of maximum double refraction divergence (DD) in crystals. Maximum DD is discussed in more detail in 2 below; this is followed by the relationships of angles in section 3, and construction and equations of the ellipse in section 4.

2. Directions of maximum DD in uniaxial and biaxial stones[1]

The angle of 45° has been offered as a reasonable approximation of the direction of maximum DD for the uniaxial case[2], although the actual angle depends on the proportions[3] of the ellipse[4] in the birefringent wave front. These proportions correspond to the ratio[5] of the extreme velocities of light or to the inverse of the ratio of the two refractive indices. When the ratio is larger, the angle differs more significantly from 45°, but as the ratio approaches unity (when the ellipse would become a circle) the angle to the wave-normal direction of maximum DD approaches 45°.

The variation from 45° will be in the direction that tilts the wave-tangent plane toward the major axis of the ellipse. This then tilts the wave-normal for the direction of maximum DD toward the minor axis, which is the vibration direction for the lowest RI (α). It is helpful to merge uniaxial and biaxial concepts and consider lowest RI as α and highest RI as γ with the uniaxial case being considered an extreme biaxial case with β, the RI of the optic axis, coinciding with either α or γ.

It is interesting to note that it is RI ratio, not BI, which controls the maximum DD. The RI ratio for any gemstone is generally only slightly greater than unity even for cases of extreme birefringence. For malachite and smithsonite the RI ratios are

1. Explanation of summary; Birefringence vs. double refraction divergence. Cartier, 2002. *Journal of Gemmology*, **28**(4), 225
2. Doubling of images in gemstones. Sturman and Back, 2002. *Journal of Gemmology*, **28**(4), 210-22
3. Ellipse formulae actually use the square of the ratio, but "depends on the proportions" is fair comment.
4. The author would like to thank Doug Mabee of Toronto for helpful guidance regarding the mathematics of the ellipse.
5. The larger number divided by the smaller number is presumed for ease of discussion. If the smaller number is divided buy the larger, the ratio would, of course be less than one and we would need to talk about departure from unity rather than size.

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1.1535 and 1.1406 respectively, but the more common extremely birefringent stone rhodochrosite (which at 1.816-1.597 has higher BI than the renowned calcite), would have the RI ratio of 1.1371 for faceted specimens. This ratio sets the direction of maximum DD at 48.7° from the major semiaxis of the ellipse, which direction is 3.7° toward the optic axis because of the negative optic sign. Other stones will be nearer to 45°.

The following visualizations of the significant directions for the uniaxial and the biaxial cases are offered, which many will find more easily understandable than mathematics formulae. The word 'direction' when unqualified in this explanation means 'wave-normal direction' which is the direction 90° to the wave front. The expression '~45°' is intended to mean 'the angle near 45° established by the ratio of the refractive indices as the wave-normal direction of maximum DD'.

The directions of maximum DD for the uniaxial case are in a ~45° cone around the optic axis. For the biaxial case, if you imagine a ~45° cone around each optic axis with the vertex of each cone at the intersection of the optic axes, the linear directions of maximum DD will be where the cones stand proudest from the optic plane. Clearly, the directions on each cone that lie in the optic plane will be of intermediate DD because they are nearer to the principal vibration direction (either α or γ) where DD is nil. The greater the 2V angle[6], the greater will be the difference in DD between the maximum in the directions along the cone in a plane perpendicular to the optic plane, and the minima in the directions along the cone within the optic plane. The smaller the 2V angle, the less will be the difference in DD between the maximum at the spot on the edge of the cone proudest from the optic plane and the minima within the optic plane. As the 2V angle approaches 90° (optically neutral) the DD minima in each cone approach nil. As the 2V angle approaches 0° the difference in DD between the minima and maxima in each cone reduces to nil and the medium approaches the appearance of being uniaxial.

For those with some facility for mathematics, general equations of the angular relationships can be expressed using standard RI symbols with differing lower case Greek letters used as symbols to represent the significant angles. By convention α (alpha) means the lowest RI, β (beta) means the RI of the optic axis, and γ (gamma) means the highest RI. We can use θ (theta) to represent the wave-normal angle to the major axis, ϕ (phi) to represent the DD angle (between the wave-normal and the ray), and ζ (zeta) to represent the ray angle to the major axis. The prefix '*tan*' means the numerical tangent of the subsequently named angle. Then, for any elliptical wave front of light, the following two equations show the relationship between the extreme RI values and those three angles: first $\theta = \phi+\zeta$ and then $((\gamma^2/\alpha^2)-1)\ tan\zeta)\ /\ ((\gamma^2/\ \alpha^2)tan^2\zeta+1) = tan\phi$. (A derivation of this equation is presented in Section 4.) One can use these equations with tangent values looked up in standard tables to run a series of calculations for various ray angles (ζ) from the ellipse's centre[7] (for any material with known refractive indices) to find the wave-normal angle (θ) that yields the highest DD. This angle θ is the angle ~45°.

3. Relationships of angles and dimensions

Imagine that a single-point light source inside the medium produces a momentary flash of light, somewhat like a pinpoint size photographic flash bulb. Using our imagination to stop time a little while after our pulse of light is produced, we can picture the shape of the wave front at any particular

6. The 2V angle is the acute angle between the two optic axes.
7. It has been suggested in peer review of this article that the value of zeta that maximises DD can be directly calculated by application of a little calculus. Independent derivation of a suitable formula would be welcomed. The intention of the author of this article is to offer explanations accessible to a readership that may not be mathematically adept.

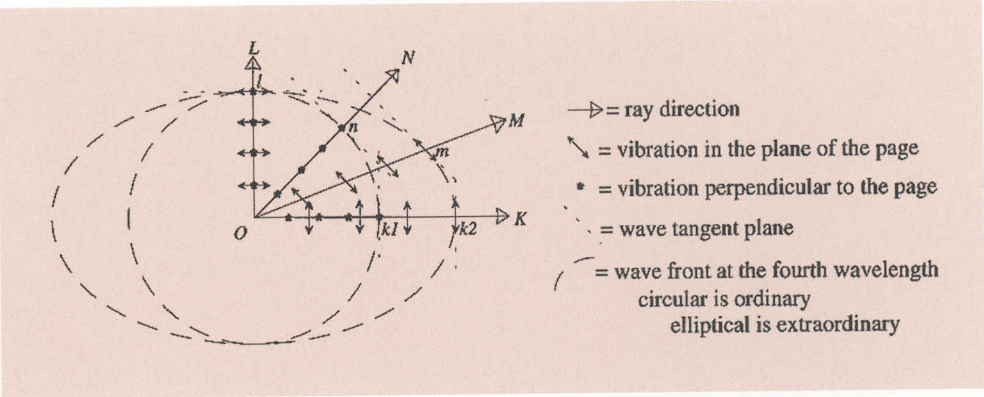

***Figure 1**: Uniaxial negative wave fronts, with optic axis top to bottom in the plane of this page*

moment as it progresses through the medium. The three-dimensional shape of the progressing wave front(s) is called the ray velocity surface in optics jargon. *Figure 1* depicts a centre section through unixial negative wave fronts. The wave front section for all ordinary rays is circular and the wave front section for all extraordinary rays is elliptical.

The ray-velocity surface of a birefringent medium will have unequal dimensions that give cross-sections with various circular and elliptical shapes. The most pronounced ellipse is in the optic plane, which is that centre section through the ray-velocity surface that contains both the fastest and the slowest rays for all possible ray directions through the medium.

To calculate the divergence of the extraordinary ray, we must consider the relationships to the elliptical wave front. *Figure 2* shows the relationships between the angles and dimensions used in the equations cited in section 2 above.

The first equation, $\theta = \phi + \zeta$, shows the simple geometric relationship between the three angles. This relationship is based on the fundamental geometric principle that the sum of the three interior angles of a plane triangle must always equal 180°, and the sum of the two different angles formed by the intersection of two straight lines must also always equal 180°.

The second equation, $((\gamma^2/\alpha^2)-1)tan\zeta) / ((\gamma^2/\alpha^2)\ tan^2\zeta+1) = tan\phi$ incorporating the square of the RI ratio, arises from

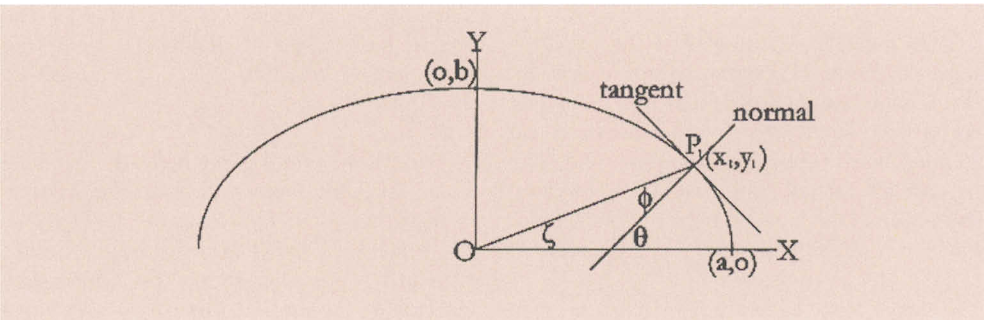

***Figure 2**: Positions of ϕ, θ and ζ in the ellipse.*

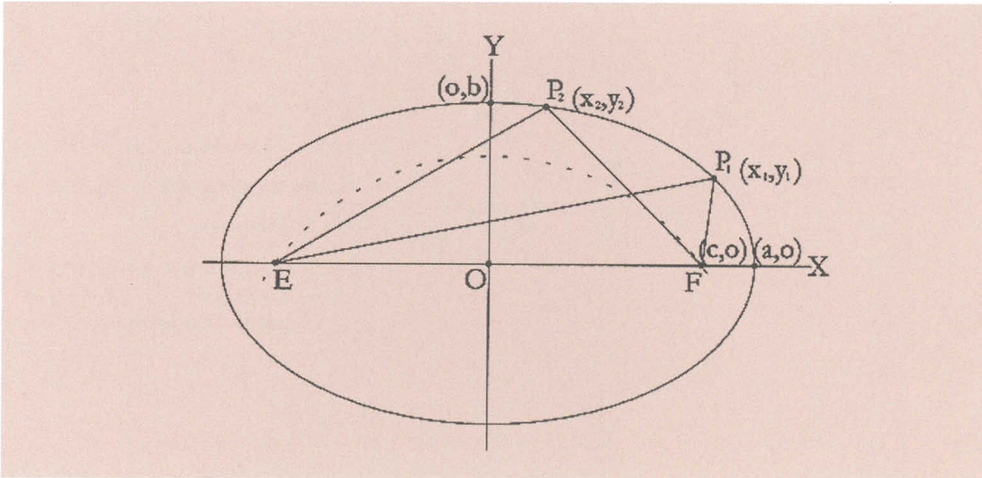

***Figure** 3: Foci and coordinates of the ellipse.*

substitution of γ for the major semiaxis 'a' together with the substitution of α for the minor semiaxis 'b' in the equation $((a^2/b^2)-1)\tan\zeta)/((a^2/b^2)\tan^2\zeta+1) = \tan\phi$ derived from the standard general equation for an ellipse (for derivation see section 4).

Given the understanding that velocity of light is the reciprocal of the refractive index, it is easy to understand that the length and width of the ellipse can represent the distances the rays travelled, can represent the velocities of the extreme rays (because the time component of velocity is identical for all rays), or can represent the highest RI and the lowest RI because the ratio of $a/b = 1/(\alpha/\gamma) = \gamma/\alpha$.

With a calcite example (RI 1.486-1.658) ... if we are going to imagine stopping time to observe the size and dimensions of the wave fronts, we can decide to measure in millimetres and choose to stop time when the distance the fastest light travels is 1.658 mm. The distance the slowest light travels is then (1.658 mm multiplied by α/γ) = 1.486 mm.

Clearly, the RI values γ and α can legitimately replace 'a' and 'b' in an equation of the ellipse.

4. Construction and equations of the ellipse

An ellipse is an out-of-round shape with special characteristics (*Figure* 3). The line across the greatest dimension of an ellipse is called the major axis and the line across the least dimension is called the minor axis. The major and minor axes intersect at the centre, which is called the origin, usually labelled O. A semiaxis is from the origin to one end of the axis.

The dimension of the major semiaxis is 'a' and the dimension of the minor semiaxis is 'b'. An arc centred at the end of a minor semiaxis with radius a will intersect the major axis at distance c each side of the origin. Each point at distance c along the major axis (E and F in *Figure* 3) is a focus of the ellipse.

For every point on an ellipse, the distance from that point to one focus plus the distance to the other focus is a constant. In *Figure 3*, $EP_1 + P_1F = EP_2 + P_2F$ and this holds for any arbitrarily chosen point on the ellipse. The bisector of the angle formed by those lines from the foci to the point on the ellipse is normal to the ellipse.

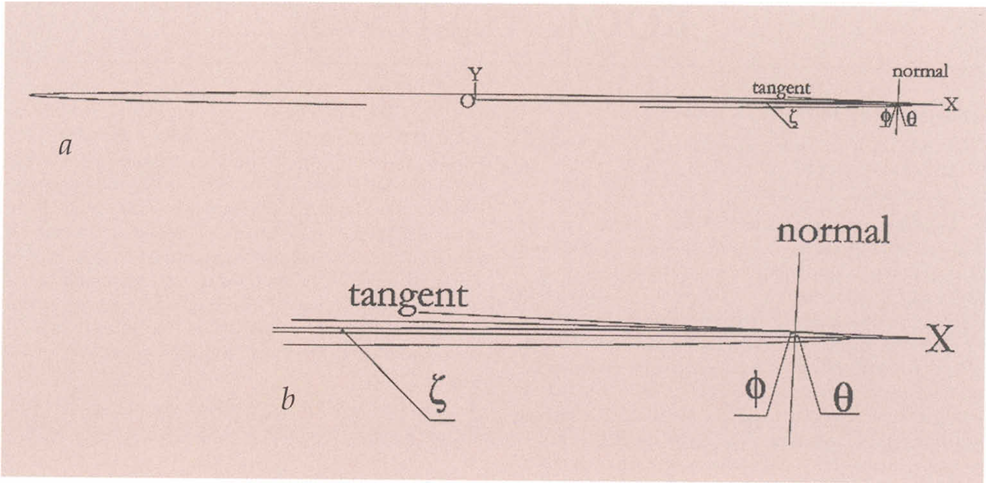

***Figure 4**: (a) Ellipse with extreme length to width ratio. (b) Detail of Figure 4a.*

Points in the plane of the ellipse can be precisely located in a grid coordinate system with distance along the major axis being the X direction and distance along the minor axis being the Y direction. In *Figure 2* and *Figure 3* any X coordinate to the right of the origin O is positive while to the left is negative. Any Y coordinate above O is positive while those below are negative. For an ellipse a>b; a, b, and the (x, y) coordinates conform to the basic equation of the ellipse:

$$b^2x^2+a^2y^2 = a^2b^2 [1]$$

The slope of the normal at P_1 (the bisector of angle E-P_1-F) is ...

$$(a^2y_1)/(b^2x_1) = \tan\theta \; [2]$$

From [2] → $(a^2/b^2)(y_1/x_1) = \tan\theta$ [3]

As was pointed out earlier ... $\theta = \phi+\zeta$ [4]

From [4] → $\tan\theta = \tan(\phi+\zeta)$ [5]

Conforming to the definition of a tangent...

$$\tan\zeta = y_1/x_1 \; [6]$$

From [3, 5] → $(a^2/b^2) \tan\zeta = \tan(\phi+\zeta)$ [7]

[7] → $(a^2/b^2) \tan\zeta = (\tan\phi + \tan\zeta) / (1 - \tan\phi\tan\zeta)$ [8]

[8] → $(a^2/b^2-1) \tan\zeta = (a^2\tan^2\zeta+b^2)\tan\phi$ [9]

In section 3 it was concluded that RI values can appropriately replace semiaxis dimensions, so replacing a and b with γ and α in [9] → $((\gamma^2/\alpha^2)-1) \tan\zeta) / ((\gamma^2/\alpha^2)\tan^2\zeta+1) = \tan\phi$ [10]

This series of combinations and transformations of equations gives the final equation suggested previously in section 2 for testing ray angles (ζ) to find the one that yields the maximum $\tan\phi$. From standard tables, $\tan\phi$ can be looked up to get ϕ. Then ζ and ϕ will add together to give θ, the wave-normal direction for maximum DD. Alternatively, the angle ζ that yielded maximum $\tan\phi$ can be used to calculate $\tan\theta$ by the formula $(\gamma^2/\alpha^2)\tan\zeta = \tan\theta$ [11], then $\tan\theta$ used to look up θ.

In an ellipse with an extreme length to width ratio, angle ϕ can approach 90° (*Figure 4*). Elliptical wave fronts in birefringent media, however, usually have an a/b ratio less than 1.14 so angle $\theta_{max\phi}$ is never more than a few degrees away from 45° to the major axis of the ellipse.

Gems and gem industry in India.

R.V. KARANTH, 2000. Geological Society of India: Memoir 45, Bangalore, xii 405 pp. ISBN 81-85867-41-0. Price on application.

India has a strong tradition of gem cutting, with the total value of exports of gemstones and jewels amounting to nearly 20% of the country's total exports, much of it consisting of imported raw diamonds cut and set in jewellery, and employing some 500,000 people. Written for the Indian market, this book provides an introduction to the chemical, physical and optical properties of the hundred or so species of minerals used as gemstones, with particular reference to Indian gemstones. Details are also provided of inclusions and other internal features, synthetic stones and gem cutting, before descriptions of the principle gem materials, grouped into isotropic, uniaxial and biaxial gems. There is an inset of colour plates and a geographical index detailing the latitude and longitude of localities, and in addition to subject and author indexes there is a geographical index listing the latitude and longitude of localities mentioned. R.A.H.

Gem identification made easy.

A. MATLINS AND A.C. BONANNO, 2003. Third edn. Woodstock, VT, USA. pp xxii, 330. Illus. in black-and-white and in colour. Hardcover ISBN 0 943763 34 7. £28.90.

Since the first edition of this useful guide aimed specifically at the jeweller and dealer was published in 1978 with a second edition some years afterwards, a number of important developments have had to be added to a cheerful, homespun text which is easy to follow. HT/HP diamonds, new diffusion techniques for treating near-colourless sapphires are some of the new additions.

While the text is very readable it may sometimes be hard to find some items in the index which for some reason I found difficult to work with because of its layout and the typeface used. Some of the books recommended for further reading would be hard to obtain now and there are much better ones around. I found a number of statements which need further investigation (the account of the operation of the diamond wand, for example) and I couldn't track down in the text what is new about 'chromium-type emeralds' from North Carolina [I described them in the 1970s] which are mentioned in the preface.

None the less this is a keenly priced and useful book, though it needs to be read with caution. M.O'D.

A student's guide to spectroscopy.

C.H. WINTER, 2003. Leatherhead: OPL Press, Leatherhead, Surrey. pp 85. Illus. in colour. Softcover ISBN 0 9544853 0 0. £9.99

Attractively produced, accurate and very reasonably priced guide to the use of the direct vision spectroscope in the testing of gemstones. After some remarks on the construction of the OPL [Orwin Products Ltd] hand spectroscope and on the nature of absorption spectra in the visible region, the book's main section describes the spectra of the gem species which can be tested by using the spectroscope.

Most examples are illustrated in colour and the reproduction is easily the best that I have seen so far – idealized representations in earlier textbooks do not always help students as they expect to see a clearer effect than is usually possible. This book is more reasonable in this area and the accompanying remarks will help in the resolution of difficult cases. M.O'D.

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

E. Alan Jobbins

We send our congratulations to E. Alan Jobbins in celebration of his forthcoming 80th birthday.

Alan is an Honorary Life Member of Gem-A, and was for many years Editor of *The Journal of Gemmology* and Chairman of the Board of Examiners.

Alan Jobbins has made a major contribution to gemmology during his career and we acknowledge his continuing involvement in the world of gemstones.

GEM DIAMOND EXAMINATION

In the Gem Diamond Examination held in June 2003, 133 candidates sat of whom 75 qualified, including seven with Distinction and nine with Merit.

The **Deeks Diamond Prize** for the best candidate of the year in the Gem Diamond Examinations has been awarded to Lu Lili of Wuhan, Hubei, P.R. China.

The **Bruton Medal** was not awarded.

The names of the successful candidates are listed below:

Qualified with Distinction
Lu Lili, Wuhan, Hubei, P.R. China
McKenzie, Wilma A., South Surrey, British Columbia, Canada
Pennington, Susan E., Bickerstaffe, Lancashire
Rafter, Jacinta, Kensington, London
Wells, Miranda E.J., Hartlebury, Worcestershire
Whitehouse, Keith P., Marston, Stafford
Winter, Nikki, Chiswick, London

Qualified with Merit
Brown, Mary Josephine, Bangkok, Thailand
Dash, Sandra Y., London
Huang Jin, Wuhan, Hubei, P.R. China
Lam, Victoria L., Carnforth, Lancashire
Nessi, Veroniki, Athens, Greece
O'Leary Al-Khayaali, Dominique, London
Phillips, Paul, Bulkington, Warwickshire
Xu Sha, Beijing, P.R. China
Zhang Ao, Beijing, P.R. China

Qualified
Allsopp, Christopher J., St Saviour's, Guernsey, Channel Islands
Appadoure, Basile, London
Aubert, Rebecca, Islington, London
Chan So-Ha, Anna, Hong Kong
Choi, Daeshik, Incheon, S. Korea
Chu Hon Chung, New Territories, Hong Kong
Deligiannis, Marios, Athens, Greece
Douvis, George, Athens, Greece
Facey, Emma L., Shirley, West Midlands
Firmin, James H., Burley on the Hill, Rutland
Georma, Titika, Athens, Greece
Godfrey, Kay, Halstead, Essex
Hadley, John, Stratford-upon-Avon, Warwickshire
Haycock, Ian P., Sheldon, West Midlands
Hayward, Johnathon D., Oldbury, West Midlands
Hui Chau Ming, Kowloon, Hong Kong
Jiang Weiwei, Wuhan, Hubei, P.R. China
Kalischer, Janice, Finchley, London
Ke Jia, Beijing, P.R. China
Kelly, Christopher, High Wycombe, Buckinghamshire
Koraki, Christina, Athens, Greece
Lee Ka Yan, Audrey, New Territories, Hong Kong
Lee Lok Chi, Simon, New Territories, Hong Kong
Leung Ka Lok, Kowloon, Hong Kong
Leung Ka Yi, Kowloon, Hong Kong
Li Chen, Beijing, P.R. China
Li Heung Hung, Kowloon, Hong Kong
Liao Wei-Ching, Ping Tong, Taiwan, R.O. China
Manchanda, Anu Dippal, Smethwick, West Midlands
Marsh, Claire L., Wollaston, Stourbridge, West Midlands
Miller, Steve, Crawley, West Sussex

 ISSN: 1355–4565

Najda, Marina, London
Ng Pui Wa, Joe, New Territories, Hong Kong
O'Dwyer, Michael, Dun Laoghaire, Co. Dublin, Ireland
Randhawa, Sukhwant Singh, Hounslow, Middlesex
Riedel, Richard W., Lewes, East Sussex
Roussou, Zoi-Kiriaki, Athens, Greece
Rynhold, Emma N.C., London
Sanchez Sierra, Maria F., Tooting, London
Sarri, Santino, Brighton, East Sussex
Sheikh, Musa M., Norbury, London
Shi Lei, Beijing, P.R. China
Singh, Harjit, Bilston, West Midlands
Sipson, Ian, Trowbridge, Wiltshire
Somaiya, Kaushal Kirti, Finchley Central, London
Song Jie, Beijing, P.R. China
Spear, Paul M., Maidenhead, Berkshire
Suen Ka Kwan, Athena, Kowloon, Hong Kong
Townsend, Rachel E., Tamworth, Staffordshire
Tse Chui Yin, Angela, Causeway Bay, Hong Kong
Velliniati, Ekaterina, Athens, Greece
Watanabe, Tomoko, Mitsukaiudo-shi, Ibaraki, Japan
Wenwei Kong, Wuhan, Hubei, P.R. China
Williams, Adrienne V., Chesham, Buckinghamshire
Williams, Benjamin J., Moreton-in-Marsh, Gloucestershire
Yao Lin, Beijing, P.R. China
Yip Siu Ling, New Territories, Hong Kong
Yung Mou Cheung, Shau Kei Wan, Hong Kong
Zhang Runbei, Beijing, P.R. China

EXAMINATIONS IN GEMMOLOGY

In the Examinations in Gemmology held worldwide in June 2003, 265 candidates sat the Diploma Examination of whom 88 qualified, including two with Distinction and ten with Merit. In the Preliminary Examination, 189 candidates sat of whom 139 qualified.

The **Anderson Bank Prize** for the best non-trade candidate of the year in the Diploma Examination has been awarded to Jessica Banks of London.

The **Christie's Prize for Gemmology** for the best candidate of the year in the Diploma Examination who derives his main income from activities essentially connected with the jewellery trade has been awarded to Xie Jing of Shanghai, P.R. China.

The **Anderson Medal** for the best candidate of the year in the Preliminary Examination and the **Preliminary Trade Prize** for the best candidate of the year who derives her main income from activities essentially connected with the jewellery trade has been awarded to Antoinette Jackson of London.

The **Tully Medal** was not awarded.

The names of the successful candidates are listed below:

Diploma

Qualified with Distinction
Banks, Jessica, London
Jackson, Antoinette, London

Qualified with Merit
Conejero, Jennifer H., Boston, Lincolnshire
Domec, Cedric, Forest, Belgium
Firmin, James H., Burley on the Hill, Rutland
Inagaki, Yuko, Kawaguchi-shi, Saitama-Ken, Japan
Lee Tsung Han, Taipei, Taiwan, R.O. China
Phillips, Patrick E., Toronto, Ontario, Canada
Richmond, Sonia, London
Shikatani, Kohei, Yudogawaku, Osaka, Japan
Tuen Sai Hing, Shau Kei Wan, Hong Kong
Wong Ying, Shatin, Hong Kong

Qualified
Ahde, Petra M.E., Helsinki, Finland
Balabhadra, Naga V.R.S., Hyderabad, India
Breuer, Lisa, London
Chen Xiumei, Wuhan, Hubei, P.R. China
Cherchi, Sonia, Zurich, Switzerland
Cheung Wing Man, Cynthia, New Territories, Hong Kong
Ching Mei Kit, Jennifer, Kowloon, Hong Kong
Cho Young Mi, Nam-Gu, Incheon, Korea
Dash, Sandra Y., London
Deprez, Guillaume, London
Ecknauer, Marc, Stein, Switzerland
Eguchi, Yumi, Fukuoka City, Fukuoka Pref., Japan
Fisher, Abigail, London
Fitzgerald, John, Peoria, Illinois, U.S.A.
Fleuranceau, Annie M., Brossard, Quebec, Canada
Fujii, Eiko, Bunkyo, Tokyo, Japan
Guo Tianshun, Wuhan, Hubei, P.R. China
Hayashida, Shoko, Minato-ku, Tokyo, Japan
Henry-Stogdon, Sarah A., West Norwood, London
Hiraoka, Kenji, Suginami-ku, Tokyo, Japan
Holmes, Lissa, Balham, London
Hotson, Peter J., Berkhamsted, Hertfordshire
Huang Chi-Hua, Taipei, Taiwan, R.O. China
Kuo Chi-Cheng, Taipei, Taiwan, R.O. China
Lau Chun Kit, Shatin, New Territories, Hong Kong
Lau Siu Ying, Emily, Hong Kong
Lee Hsiang Ju, Taichung, Taiwan, R.O. China
Lee Young Ji, Ealing, London
Leung Suk Kay, Hong Kong

Li Cheung, Alex, New Territories, Hong Kong
Li Dandan, Wuhan, Hubei, P.R. China
Li Hui, Guilin Guangxi, P.R. China
Liang Liang, Shanghai, P.R. China
Liang Yuhui, Wuhan, Hubei, P.R. China
McCrabbe, Julie A., Hackney North, London
McMillan, Emma L., Leamington Spa, Warwickshire
Mathiesen, Lisbeth S.G., Virum, Denmark
Mathur, Chetna, Indore, India
Milton, Paul R., Liverpool, Merseyside
Mo Bixun, Shanghai, P.R. China
Mo Yu, Guilin, Guangxi, P.R. China
Munawar Mirza, Sohail, Angered, Sweden
Nilsson, Annica H., Uppsala, Sweden
Pang Bowen, Guilin, Guangxi, P.R. China
Park Chung Hyun, Daegu, Korea
Pearson, Isabel J., Tilehurst, Berkshire
Phillips, Gregory J., Toronto, Ontario, Canada
Phyu Thin Khine, Yangon, Myanmar
Plantagenet, Ian, Heaton, Bradford, West Yorkshire
Pui Pui Tsoi, Karen, Kowloon, Hong Kong
Pumphrey, Jessica K., London
Ren Yuan, Guilin, Guangxi, P.R. China
Rutter, Fay, Walsall, West Midlands
Sai Kyaw Kyaw Win, Yangon, Myanmar
Sanchez Sierra, Maria, Tooting, London
Schwabe, Arnold R., Burnaby, British Columbia, Canada
Shang Wenjing, Shanghai, P.R. China
Shaw, Sinead, London
Smith, Anna, Pinner, Middlesex
Sykes-Gomez, Heidi M., Cornelius, North Carolina, U.S.A.
Taylor, Louise, Gresford, Clwyd
Thornhill, Helen V., Greenhill, South Yorkshire
Tsuor Wai Hing, Shatin, Hong Kong
Velez Melendez, Ana Maria, Bogota, Colombia
Wang Chenchun, Shanghai, P.R. China
Wang Duo, Guilin, Guangxi, P.R. China
Wang Liang, Guilin, Guangxi, P.R. China
Watanabe, Tomoko, Mitsukaido-shi, Ibaraki, Japan
Wei Wei, Guilin, Guangxi, P.R. China
Wenham, Diana L., North Harrow, Middlesex
Westling, Jonny, Stockholm, Sweden
Wijetunga, Lettietia C., Colombo, Sri Lanka
Williams, Cara M., Jefferson City, Missouri, U.S.A.
Xu Wenxing, Wuhan, Hubei, P.R. China
Yang Yang, Guilin, Guangxi, P.R. China
Ye Dong, Wuhan, Hubei, P.R. China

Preliminary

Qualified

Ahlgren, Anne M., Espoo, Finland
Anderson, Judith S., Manchester, New Hampshire, U.S.A.

GIFTS TO THE ASSOCIATION

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

Chang He Ok FGA DGA, Rio de Janeiro, Brazil for two samples of irradiated fluorite.

Alexandros Sergoulopoulos FGA DGA, Athens, Greece, for five rough diamond crystals.

Manfred Szykora, Munich, Germany, for three issues of extraLapis, Aquamarin & Co, and the English translations of Tourmaline and Calcite; also for three samples of Russian synthetic opal.

Christine Woodward FGA DGA, London for a selection of dyed beads.

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Carter, Yonita, South Woodford, London
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Chan So-Ha, Anna, Hong Kong
Chan Wai Fong, Hong Kong
Chan Chi Wai, Hong Kong
Chandhok, Jasmeet Singh, New Delhi, India
Chaudry, Mohamed Ashraf, Rochdale, Lancashire
Chen Chen Miao, Taichung, Taiwan, R.O. China
Chen Liang Chih, Taipei, Taiwan, R.O. China
Chen Zheng Tang, Taipei, Taiwan, R.O. China
Cheng Shiu Wan, Lina, Kowloon, Hong Kong
Cheng Wai Ping, New Territories, Hong Kong
Cheung Wai Shan, Rosita, New Territories, Hong Kong
Cho Young Mi, Incheon, Korea
Choon Luen Mei, New Territories, Hong Kong
Chow, Queenie, Lindfield, New South Wales, Australia
De Silva, Dayasiri W., Dagenham, Essex
Derada, Herve, Montmollin, Switzerland
Donovan, Kathleen, Carlsbad, California, U.S.A.
Fan Yu-Hsiang, Taipei, Taiwan, R.O. China
Fleuranceau, Annie M., Brossard, Quebec, Canada
Forbert, Maile M., Vallejo, California, U.S.A.
Gadd, Craig A., Horfield, Bristol, Avon
Gaskin, Clare K., Wimbledon, London
Gemmill, Tanya C., Hampstead, London

DONATIONS

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

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

Sapphire Donations

Manfred Szykora, Munich, Germany

Pearl Donations

Robert B.R. Gau, Taipei, Taiwan, R.O. China

Alice Lui, Richmond, British Columbia, Canada

Michael D. Rennes, New Cross, London

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Kontos, Panagiotys, Athens, Greece
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Kosonen, Emilia, Helsinki, Finland
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Lai Lok Yan, Kowloon, Hong Kong
Lai Wing Yee, New Territories, Hong Kong
Lal, Sumit Kumar, Siliguri Bazar, West Bengal, India
Lam Shun Kwong, New Territories, Hong Kong
Lam Wa Fei, Kowloon, Hong Kong
Lee Young Ji, Ealing, London
Lee Lai Ha, New Territories, Hong Kong
Leondaraki, Eleni, Athens, Greece
Leung Kam Ping, Sai Kung, Hong Kong
Li Sze Man, Tai Wai, Hong Kong
Li Po Man, North Point, Hong Kong
Liontakis, Antonis, Athens, Greece
Liu Hing Tze, Olivia, Tseung Kwan, Hong Kong
Lo Pui Sze, Anny, Kowloon, Hong Kong
Lo Pui Fan, Amy, Kowloon, Hong Kong
Lo Chun Kin, James, Tin Shai Wai, Hong Kong
Lovelock, Justina E., Barnes, London
Lyons, Annabel, London
Ma Yaw Lam Hsiung, Ruth, Hong Kong
Mahmood, Zahid, Aston, Birmingham, West Midlands
Manchanda, Anu D., Smethwich, West Midlands
Marsh, Claire L., Stourbridge, West Midlands
Matoba, Ayumi, Minoo City, Osaka, Japan
Matsumoto, Yoshihiro, Kofu City, Yamanashi Pref., Japan
Miao Fu-Chiang, Taipei, Taiwan, R.O. China
Michalcova, Silvia, Finchley, London
Moe Tin Tin, Yangon, Myanmar
Mohamed, Ahmed, Lannavaara, Sweden
Mok Chi Wang, Sha Tin, Hong Kong
Moutier, Frederique, Montreal, Quebec, Canada
Murakami, Kayo, Hammersmith, London
Ng Yee Kar, Carolina, Chai Wan, Hong Kong
Okada, Manjo, Kofu City, Yamanashi Pref., Japan
Okako, Mayumi, Kamifukuoka City, Saitma Pref., Japan
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Pang Shing Kwan, New Territories, Hong Kong
Pang Miu King, Winnie, New Territories, Hong Kong
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Park Chung Hyun, Daegu, Korea
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Stumpf, Harry, Oakmont, Pennsylvania, U.S.A.
Su Min Hui, Taipei, Taiwan, R.O. China
Tammilehto, Eero J., Helsinki, Finland
Tchakerian, Silva, Montreal, Quebec, Canada
Tenhunen, Henriikka, Helsinki, Finland
Tooth, Helen J., Keresley, West Midlands
Trevanion, Christina H.J., Shrewsbury, Shropshire
Turku, Jenni J., Helsinki, Finland
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Wai Yee Tak, Elise, New Territories, Hong Kong
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Welton-Cook, Elsa M., West Kensington, London
Werattarakul, Tanawut, Bangkok, Thailand
Westwood, Lauren, Godalming, Surrey
Williams, Benjamin J., Moreton-in-Marsh, Gloucestershire
Wold, William, Joure, The Netherlands
Wong Chung Yan, Kowloon, Hong Kong
Wong Hing Yee, New Territories, Hong Kong
Wu Pei Hua, Taipei, Taiwan, R.O. China
Xu Ping, Shanghai, P.R. China
Yu Po Ching, Shanghai, P.R. China
Yung Suk Hing, Tung Chung, Hong Kong
Zhu Jia, Shanghai, P.R. China

MEMBERS' MEETINGS

London

On 9 September 2003 at 27 Greville Street, London EC1N 8TN the Annual General Meeting was held, a report of which will be published in the January 2004 issue of *The Journal*. The AGM was followed by an illustrated talk by David Callaghan entitled 'Jewellery of the Art Nouveau period'.

Midlands Branch

On 26 September at The Earth Sciences Building, University of Birmingham, Edgbaston, PC Terry Lewis of the West Mercia Constabulary gave a talk on 'Crime prevention in the jewellery industry'.

North East Branch

The inaugural meeting of the North East Branch was held on 10 October at Gem-Ro Associates, Millshaw, Leeds. Neil Rose, Jane Howe and Helen Prior-Chappell were elected Chairman, Secretary and Treasurer respectively.

The evening began with a wine and buffet reception followed by a talk by John Benjamin entitled 'Jewellery from Elizabeth I to Elizabeth Taylor'.

The evening was generously sponsored by Tracy Jukes of e-jewel Ltd.

North West Branch

On 17 September at Church House, Hanover Street, Liverpool 1, Brian Jackson gave a talk entitled 'Scottish minerals'.

Scottish Branch

On 24 August members of the Branch gathered at Tyndrum where gold panning expert Bob Sutherland demonstrated panning techniques.

On 11 September at the British Geological Survey, Murchison House, West Mains Road, Edinburgh, Alan Jobbins gave a lecture entitled 'Organics in ornamentation'.

South East Branch

On 27 July at the County Club, Guildford, Alan Jobbins gave an illustrated talk entitled 'Fifty years of gemmology'.

On 7 September at Christie's South Kensington Colin Winter presented a 'Spectroscope workshop'. This included an illustrated talk, a practical demonstration and a quiz.

South West Branch

On 17 September at the Bath Royal Literary and Scientific Institution, Bath, Stephen Kennedy gave a talk entitled 'Insider Trading'.

ANNUAL REPORT

The following is the Report of the Council of Management of the Gemmological Association and Gem Testing Laboratory of Great Britain for year ending 31 March 2003.

Officers, councils and committees

Gem-A The Gemmological Association and Gem Testing Laboratory of Great Britain is a company limited by guarantee and is governed by a Council of Management. In August 2002 Council member and acting Chief Executive Officer T.M.J. Davidson accepted the full-time position of CEO.

Professor A.T. Collins was re-elected President of the Association. Vice Presidents N.W. Deeks, A.E. Farn, R.A. Howie, D.G. Kent and R.K. Mitchell continued in office. Council member

Name	*Position*	*Activities*	*Advisory/Consultative Bodies*
Terry Davidson	CEO	Marketing and PR Office Services	
Ian Mercer	Director of Education	Courses Examinations	Board of Examiners Education Review Board
Stephen Kennedy	Director of Laboratory	Diamonds Coloured Stones Pearls Consultancy Editorial	Trade Liaison Committee
Mary Burland	Director of Commerce	Membership Events Publications	Members' Council Editorial Boards
Y J Thien	Director of Office Services	Accounts Personnel Premises Security	
Alan Clark	Director of Gemmological Instruments Ltd	Books Instruments	T.M.J. Davidson and R.R.Harding are also Directors of GIL

Dr R.R. Harding who at the age of 65 was due to retire in February 2003 has at the request of the CEO agreed to continue in the roles of Company Secretary and as Editor of *The Journal of Gemmology* and to remain on the editorial board of *Gem & Jewellery News*. C.M. Woodward and E. Stern continued as Chairman and Vice-Chairman respectively of the Board of Examiners. J Kessler and W. Roberts continued as Chairman and Vice-Chairman respectively of the Trade Liaison Committee. C. Winter and P. Dwyer-Hickey continued as Chairman and Vice-Chairman respectively of the Members' Council. P.G. Read resigned from the Members' Council and has been thanked for the support he has given Gem-A as a Council member. We are fortunate that Mr Read is to continue as a correspondence course tutor and as an assistant editor of *The Journal of Gemmology*.

Gem-A

The financial year 2002–2003 has been interesting and challenging. We had drawn up a strategic plan for the years 2002/3 – 2004/5. We have redefined the roles and responsibilities of the senior staff (see organigram above). There is now in place an open and informed system of management with regular monthly meetings with department directors and quarterly meetings with all staff members.

We applied for and were most grateful to receive a grant of £50,000 from the Worshipful Company of Goldsmiths which has enabled us to replenish and purchase equipment for use in education and by the laboratory.

Gem-A Board of Directors 2002/3

The body with legal responsibility for directing and managing the Association is the Council of Management. The Council has delegated day-to-day running of the company to the CEO and the Board of Directors (see organigram above) who remain responsible to the Council.

Education

The last year has again seen the gemmology and gem diamond courses fully subscribed, attracting students from many different disciplines and professions, and from many countries. A first in the history of Gem-A occurred in July when at the JA Show in New York Gem-A gemmology course scholarships, sponsored by EGL USA and the *National Jeweller*, were awarded to five lucky winners selected from over 40 applications. A wide range of courses and tutorials are held at the Greville Street Gem Tutorial Centre, including bead stringing and jewellery sketching. Custom built tutorials have been held for firms in the jewellery trade such as de Beers, Christie's and SWAG with D.J. Garrod travelling to Norway and giving gemmology lectures on board a ship!

This report covers two examination sessions for a total of 831 students who sat the gemmology and gem diamond papers in June 2002 and January 2003. In gemmology the pass rate for the preliminary examination was 78%, slightly higher than the previous year; the diploma pass rate was 46%, the same as the previous year. For the gem diamond examination the pass rate was 54%. The Anderson Bank Prize was awarded to S. Hudson, Ealing, London. The Christie's Prize for Gemmology (Diploma Trade Prize) was awarded to N.L. Arachchige, Kandy, Sri Lanka. The Anderson Medal was awarded to N. Sehgal, New Delhi, India. The Preliminary Trade Prize was awarded to A. Verma of New Delhi, India. The Deeks Diamond Prize was awarded to J. Read, Goole, East Yorkshire. Neither the Tully nor the Bruton Medal was awarded.

The Presentation of Awards was again held at Goldsmiths' Hall where the President, Professor A. Collins, presided and welcomed the successful students and their families and friends, who had travelled from as far afield as China, Hong Kong, India, Japan, Korea, Sri Lanka and the USA, as well as those from the UK and Europe. Vice-President Noel Deeks presented the awards.

On the recommendation of the Board of Examiners G.M. Green was appointed an examiner for diploma theory, and M.A. Medniuk a diploma practical examiner. P.A. Sadler resigned as an examiner. The education review meeting was held in November and provided a valuable forum for discussion and exchange of views between tutors, lecturers, examiners and staff of the education department.

Two new projects were introduced in the Autumn when Gem-A ran a course and a workshop at the Gilbert Collection in Somerset House. 'A practical introduction to precious stones' was held on Tuesday afternoons for eight weeks, and included tours of the Gilbert Collection. A one-day family workshop 'Exploring precious stones' for both adults and children to discover more about gemstones in a fun environment was held in November 2002 and repeated in March 2003.

The last year has been spent putting the final touches to the Foundation Course, consolidating existing and negotiating potential new Allied Teaching Centres and Allied Gem Tutorial Centres.

Laboratory

Diamond grading continued to grow with an increase of 9% year on year. Gem identification showed an increase of 12% with 45% tested for origin and heat treatment. S. Kennedy attended and represented Gem-A at the gem industry and laboratory conference in Tucson. S. Kennedy regularly writes articles on gemstone testing and identification in the trade publication *The Jeweller* and has attended branch meetings where he has given updates on what is happening in the laboratories. With part of the grant received from the Worshipful Company of Goldsmiths the laboratory has been able to replace three microscopes, the UV-VIS and FTIR spectrometers, purchase a digital camera and update IT. The diamond and gemstones reports have been redesigned and 'branded' in our corporate colour, and have met with approval from the trade.

Gem-A USA

Gem-A USA was formally launched at the Tucson Gem Fair in February 2003 with an inaugural dinner. The renowned diamantaire Gabi Tolkowsky was the guest speaker. Anne Dale, Director of Gem-A USA, is supported by an advisory council comprising leading figures in the American jewellery industry and they meet four times a year. Over the last twelve months a lot of PR, hard work on the laying of a strong foundation for Gem-A USA has taken place ranging from a champagne and chocolate book signing to lectures given by D. Garrod and S. Kennedy. We also exhibited at the JCK Show Las Vegas show and Gem-A USA has given workshops in Atlanta.

Trade fairs and shows

Gem-A has also exhibited at International Jewellery London 2002 at Earls Court in September with D. Garrod giving three lectures. I. Mercer and L. Stather represented Gem-A at their stand at the Hong Kong Jewellery Show in September. Three staff members, A.J. Clark, D.J. Garrod and L.F. Stather, spent four weekends promoting Gem-A at Rock 'n' Gem Shows at Kempton Park, where they answered enquiries on membership and education, and sold books and instruments.

In common with many non-profit association and learned societies, we lack the funds for capital expenditure to maintain and improve standards in membership and education. We therefore launched an appeal for funds to improve our in-house teaching and computer facilities to extend our membership and education services, and for the acquisition of rough and polished diamonds to expand teaching and exam sets. Through the generosity of our members by the end of the financial year we had raised £10,000.

Visits

During the current financial year there were two visits organized by D.J. Garrod to Idar-Oberstein, Germany, once in April 2002 and again in March 2003. These trips are always appreciated and enjoyed by the participants. The visits to the gem cutting workshops, the mine and museums, never fail to impress.

Membership

There was a slight increase in Fellow, Diamond and Ordinary membership during the year, with Laboratory membership remaining static.

The Gem-A Branch network was expanded in 2002 with the launch of the South East Branch which held its inaugural meeting at Christie's South Kensington on 8 December. The Midlands Branch held eight meetings as well as their Summer Supper Party in June and a Celebration 50th Anniversary Dinner in December. The North West Branch held seven meetings. The Scottish Branch held seven meetings at venues in both Edinburgh and Glasgow, and their Annual Conference in Perth in May with T. Themelis as the keynote speaker, which attracted a record attendance. The South West Branch held two meetings in Bath which included talks and practical sessions. An informal members' group established in Belgium in 2002 held their first meeting in October when they visited the Living Diamonds exhibition in Antwerp's new diamond museum. This event was followed in the New Year by visits to the Europalia exhibition of gold from archaeological finds in Bulgaria and to Diamscan and Diamondland in Antwerp. Council is most grateful to the Branch Officers and Committee Members who work so hard to present interesting and varied programmes of activities each year.

In London guest lectures were given by two visiting gemmologists. J. Tenhagen gave two presentations, 'New aspects of cut in round brilliant-cut diamonds' (May) and 'Emeralds of Colombia' (October), and R. Hughes 'Burma ruby and new corundum treatments' (June). Private viewings and curatorial tours of the Tiaras exhibition at the Victoria and Albert Museum with G. Munn were held in April and May.

The Annual Conference moved to a new venue in 2002; the event was held at the Kempton Park Racecourse during the late autumn Rock 'n' Gem Show giving delegates the opportunity to browse and buy at the Show during the lunch break. The keynote lecture 'The significance of inclusions in garnets' was presented by Professor Dr E. Gübelin of Lucerne, Switzerland. Professor A. Rankin gave a talk entitled 'Inclusion and chemical fingerprints for sapphires and rubies', Dr R. Symes spoke about sites of precious minerals in England and Wales and jewellery designer S. Webster described the growing influence of women purchasing their own jewellery. A curatorial tour of the Jewels of JAR, Paris, exhibition, at Somerset House and a private viewing of the Crown Jewels at the Tower of London with Crown Jeweller D. Thomas were arranged for the conference delegates.

Publications

In the period April 2002 to March 2003, 22 papers were published in The Journal of Gemmology with topics ranging from garnets in Madagascar to amethyst in Brazil, from diode light sources in gem instruments to concave faceting of gems, and from zircons in corundum to synthetic moissanite. Abstracts totalled 110 and there were 27 book reviews; M. O'Donoghue is warmly thanked for his major contributions to these sections of the Journal and E. Stern, P.G. Read and R.A. Howie are also thanked for supplying a steady stream of abstracts. The Associate Editors are warmly thanked for their support through their academic and technical expertise. The Mineralogical Society is thanked for their permission to reprint mineralogical abstracts that are relevant to gemmology. R. Coleman (of Harley, UK) continued to provide fresh and attractive covers and design for the *Journal*.

Gem & Jewellery News is published jointly with the Society of Jewellery Historians and in 2002/3 contained a wide range of lecture and exhibition reviews, comments on new books, reports on activities of the Gem-A branches, and conference reports. In addition, Harry Levy is thanked for his 'Around the Trade' column which kept everyone up-to-date with the gem scene and, at international level, the Kimberley Process.

Photographic Competition

The 2002 competition on the theme 'Out of the Ordinary' drew a record number of images of unusual cut stones and crystals, and several were selected to grace the 2003 calendar. The winner was B. Maurer of London with runners-up M. White of Birmingham and J. Harris of Carlisle. Council is most grateful to Harley (UK) for their sponsorship of the three prizes and for their contributions to conference expenses.

Finance

For this report and in the future our financial year is from 1 April through to 31 March. One must remember when comparing figures that year 2001/2 was for a fifteen month period. Prior to the writing of the strategic plan we reviewed the charges made for our services. As a first stage for the financial year 2002/3, we increased the prices for education courses and margin of Gemmological Instruments Ltd. We budgeted to break even for 2002/3 and with rigid control of expenditure we have managed to turn round a deficit for Gem-A of £62,874 into a surplus of £124,823, and for Gemmological Instruments Ltd a deficit of £14,759 into a surplus of £15,330. The accounting system installed to date is now functioning and has contributed to improved reporting. However, we need to link it into the other departments. This will incur an investment in additional computer software, and will take place as funds become available.

Staff and Supporters

Two of the laboratory staff left to travel round the world. They have been replaced with two new members of staff, both with FGA and DGA qualifications, who have settled in very well. One member of staff retired and another left to work in the new de Beers store in Bond Street. This year's surplus figures are due in no small way to the hard work of a compact dedicated team and the Council of Management wish it to be known that they are very much aware of this contribution to the Association's success. We are also fortunate to have worldwide support which is identified by the generous donations of gemstones and the response we had from members to our appeal.

Gemmological Instruments Ltd.

Gemmological Instruments Ltd is a wholly-owned company of Gem-A. It supplies gem-testing equipment of good quality at competitive prices and ranging from stone tweezers to top-of-the-range microscopes, books on gems, gemmology and gem-set jewellery, and a range of thematic sets of gems for students. Introduced in 2002/3 were a new electronic 500 ct balance, a lower-prized thermal tester for diamond, and well-designed and equipped portable gem kits. Following the loss reported in the 2002 accounts, profit margins were reviewed in order to generate more resources for the company. This met with some success with a profit for the year of £15,330, but the world market is extremely competitive and continuing efforts are made to find better equipment at lower prices.

The Council of Management

MEMBERSHIP

Between 1 June and 30 September 2003 the Council of Management approved the election to membership of the following:

Fellowship and Diamond Membership (FGA DGA)

Stevens, Peter, Swanage, Dorset. 1972/1973

Fellowship (FGA)

Boyens, Christine P., Virginia Water, Surrey. 1994
Henri, Martyne, Montreal, Quebec, Canada. 2003
Horikawa, Yoichi, Tokyo, Japan. 1982
Pe Thu Aung, Yangon, Myanmar. 2003
Richmond, Sonia, London. 2003
Simonian, Siran, Krimpen a/d Ijssel, The Netherlands. 2002
Takeuchi, Tomoko, Takarazuka-city, Hyogo Pref., Japan. 1971
Tyrrell, Siobhan, London. 2003

Diamond Membership (DGA)

Champetier, Marie-Pierre, London. 2003
Gandhi, Amar A., Stanmore, Middlesex. 1998
O'Dwyer, Michael, Dun Laoghaire, Co. Dublin, Ireland. 2003

Associate Membership

Abbot, Janetta, Edinburgh, Scotland
Akintola, Akinjide, Catford, London
Anderson, Tricia, Montreal, Quebec, Canada
Arai, Kie, Sandwich, Kent
Bae Sang Hee, Kingston-upon-Thames, Surrey
Bassi, Balvinder Singh, Canary Wharf, London
Bedimo Ngomba-Morin, Emmanuelle, Streatham, London
Berthault, Alexandra, London
Blanco, Bea, St. John's Wood, London
Burnapp, John Edward, Welwyn, Hertfordshire
Callaghan, Neil, Sidcup, Kent
Castel, Anne, London
Clarke, Carl, Seaford, East Sussex
Collins, Shelley E., Sandwich, Kent
Davila, Marc, London
Dawson, Jane M., Ashbourne, Derbyshire

Desai, Yunus, Bradford
Drexler, Steven, Palo Alto, California, U.S.A.
Drummond, Jean, Farnham, Surrey
Fairhurst, Holly, Tarporley, Cheshire
Faysal, Aamin, London
Fitzgerald, Addrianna M.E., Dublin, Ireland
Garfield, Emma-Rose, Banbury, Oxfordshire
Gibson, Suzanne Peplo, London
Haythornthwaite-Shock, Lucy P., Bristol, Avon
Hislop, Donna, London
Howe, Jane, Millshaw, Leeds, West Yorkshire
Klimek, Karina S., Truro, Cornwall
Lee, Young Shin, Ealing, London
Lesetedi, Madichaba Maria, Billesley, Warwickshire
Levine, Gail Brett, Rego Park, New York, U.S.A.
Maranhao, Priscilla P., London
Rebmann, Olivier, Geneva, Switzerland
Nilaratanakul, Chiraphong, Bangrak, Bangkok, Thailand
Owen, Deborah Louise, Crewe, Cheshire
Prior-Chappell, Millshaw, Leeds, West Yorkshire
Richart, Christian, Candlor, North Carolina, USA
Rowley, Elaine, London
Sowa, Ali Med, Tilbury, Essex
Szymanska, Zofia, London
Trikha, Shashi, Weybridge, Surrey
Ye, Hui Hui, Preston, Lancashire

Laboratory Membership

Spicer-Warin Antiques, London

TRANSFERS

Fellowship to Fellowship and Diamond Members (FGA DGA)

Allsopp, Christopher J., St Saviour's, Guernsey, Channel Islands
Appadoure, Basile, London
Aubert, Rebecca, Islington, London
Brown, Mary Josephine, Bangkok, Thailand
Choi, Daeshik, Incheon, South Korea
Douvis, George, Athens, Greece
Hui Chau Ming, Kowloon, Hong Kong
Kalischer, Janice, Finchley, London
Lam, Victoria Lucy, Carnforth, Lancashire
McKenzie, Wilma A., South Surrey, British Columbia, Canada
Nessi, Veroniki, Athens, Greece
Pennington, Susan E., Bickerstaffe, Lancashire
Phillips, Paul, Bulkington, Warwickshire
Roussou, Zoi-Kiriaki, Athens, Greece
Sipson, Ian, Trowbridge, Wiltshire
Townsend, Rachel E., Tamworth, Staffordshire
Liao Wei-Ching, Ping Tong, Taiwan, R.O. China
Whitehouse, Keith P., Marston, Staffordshire
Winter, Nikki, Chiswick, London

SUBSCRIPTIONS 2004

The following are the membership subscription rates for 2004. Existing Fellows, Diamond Members and Associate Members will be entitled to a £5.00 discount for subscriptions paid before 31 January 2004.

	Fellows, Diamond Members and Associate Members	Laboratory Members
UK	£70.00	£250.00 + VAT
Europe	£77.00	£250.00
Overseas	£82.00	£250.00

Associate to Fellowship and Diamond Membership (FGA DGA)

Sanchez Sierra, Maria F., Tooting, London
Firmin, James H., Burley on the Hill, Rutland

Diamond Membership to Fellowship and Diamond Membership (FGA DGA)

Li Cheung, Alex, New Territories, Hong Kong
Plantagenet, Ian, Bradford, West Yorkshire
Pui Pui Tsoi, Karen, Kowloon, Hong Kong
Rutter, Fay, Walsall, West Midlands

Associate Membership to Fellowship (FGA)

Banks, Jessica, London
Breuer, Lisa, London
Conejero, Jennifer H., Boston, Lincolnshire
Eguchi, Yumi, Fukuoka City, Fukuoka Pref., Japan
Fisher, Abigail, London
Hayashida, Shoko, Minato-ku, Tokyo, Japan
Henry-Stogdon, Sarah A., West Norwood, London
Hiraoka, Kenji, Suginami-ku, Tokyo, Japan
Hotson, Peter J., Berkhamsted, Hertfordshire
Jackson, Antoinette, London
Lee Hsiang Ju, Taichung, Taiwan, R.O. China
Lee Young Ji, Ealing, London
Milton, Paul R., Liverpool, Lancashire
Munawar Mirza, Sohail, Angered, Sweden
Nilsson, Annica H., Uppsala, Sweden
Pearson, Isabel J., Tilehurst, Berkshire
Pumphrey, Jessica K., London
Shaw, Sinead, London
Taylor, Louise, Gresford, Clwyd
Wenham, Diana L., North Harrow, Middlesex
Williams, Cara M., Jefferson City, Missouri, U.S.A.

Associate Membership to Diamond Membership (DGA)

Chan So-Ha, Anna, Hong Kong
Godfrey, Kay, Halstead, Essex
Miller, Steve, Crawley, West Sussex
Najda, Marina, London
Riedel, Richard W., Lewes, East Sussex
Sarri, Santino, Brighton, East Sussex
Watanabe, Tomoko, Mitsukaiudo-shi, Ibaraki, Japan

ISLAND OF GEMS

The eighth exhibition of the gems and gem industry of Sri Lanka is to be held in London on 15 and 16 November. The venue for this year's event is the Kensington Close Hotel, Wright Lane, London W8 5SP (nearest underground High Street Kensington).

The exhibition will be opened by His Excellency the High Commissioner for Sri Lanka in London, Mr F. Musthapa PC, and Terry Davidson, Chief Exeutive Officer of Gem-A.

The entrance fee, which includes a souvenir brochure and a sample gemstone, is £5.00 (children under 12 years of age free of charge).

For further details contact Don Ariyaratna on 020 8807 8252; e-mail sri@lankagems.co.uk website: www.lankagems.co.uk

OBITUARY

Nikola Kielty-Lambrinides FGA RSM, BWG (1924-2003)

A tribute by Alexandra Krikos

Nikolas Kielty-Lambrinides was without a doubt one of the most important figures of Hellenic gemmology and glyptography. His passing has left a vacuum that is unlikely to be filled by one single person. I vividly recall his unique amber collection and his ivory antiques, rubies, emeralds, melanites, enstatites, moldavites, bowenites, elbaites, rhodonites, apatites, nephrites, calcites and eilat stones flooding the classrooms of Athens, captivating our interest during the first round of gemmology lectures he gave in Greece at the end of the seventies and beginning of the eighties. Until their revival through these lectures, gemmology and glyptography were forgotten words in Greece. At the time Nick, as his friends called him, worked closely with Goulandris Natural History Museum and the Hellenic American Union in Athens.

Nikola Kielty-Lambrinides

The Birth of an Era

Of Irish Greek descent, N. Kielty-Lambrinides' background was from Constantinople (now Istanbul) where his grandfather was a diamond and precious materials merchant in the Cheshli street market. His family moved to Manchester where, during the Second World War, Nick completed his school education and developed a passion for miniature sculpture. He did his National Service in the British Army before attending Chelsea Polytechnic to study Gemmology (1958/61). He continued to study gemmology at Manchester Polytechnic while attending studies in silversmithing/goldsmithing, design and retail jewellery. He then went on to read Philosophy and Theology (1964/68) at the University of Athens. He believed that to understand art one had to study the culture and milieu in which the art was created. He is quoted as saying in the magazine *The Greek Jeweller* "How can a person understand Spanish or Byzantine Art, without having understood the religion of those areas?". He deepened his understanding of glyptic arts and antiques by travelling throughout the world and conducting research in places as far apart as India, the Far East, Spain, Italy and Greece.

On returning to England he completed his seven years' apprenticeship and furthered his studies in glyptography and glyptology under the tutelage of Cecil Thomas OBE 'Master of Mint' who also introduced Nick to the methodologies employed by his colleague and famous Master of the Fabergé House, Alfred Lyndhurst Pocock. At about this time Nick was also close with the well known Beth Bento Sunderland from America. Nikolas Kielty-Lambrinides became successor of both Master Glyptographers after their deaths, continuing traditions dating back to the 14th century.

Lambrinides also worked at the central administrative office in the House of Lords. On completion of these duties, there was plenty of time left in the afternoons and evenings for other responsibilities, such as restoration and repair of art objects for his Kensington High Street antique business, which was booming at the time. Michael Theodosius Hatiris was brought on board in 1965 to aid in the buying and selling of antiques in the capacity of a business partner.

N. Kielty-Lambrinides, a full member with following Licentiate of the Royal Society of Miniature Painters Sculpters and Gravers (RSM) and also a full member of the Brothers of Art Workers Guild (AWG), believed that his duty as a Master Glyptographer was to found an Academy of Glypotography, so that traditional methods could be revived and enriched by the development of new ones.

Nick Lambrinides returned to Greece to realize his goal. He reasoned that Greece was the cradle of European glyptography and so the rightful home of such a school, and he began lecturing in gemmology, antiques, archaeogemmology and glyptography. The influence that Cecil Thomas had on him was profound. Cecil Thomas had thoroughly researched themes through Ancient Greek tradition and also the subjects of crystal carvings and engravings, working with Sir Arthur Evans the renowned Minoan civilization archaeologist who discovered the treasures of Knossos in Crete. During this initial campaign for the reintroduction of the above-mentioned subjects to the academic world, Lambrinides was also in close contact with certain well-known Greek jewellers such as Ilias Lalaounis, M. Athiniotakis and co-worked with the late P. Tsaktanis, president of the Athens Retail Jewellers and Watchmakers Association. Tsaktanis inaugurated the first seminar ever for jewellers in Greece and it was Lambrinides who was called upon to deliver the inaugural lecture in Rhodes. This was followed by a six-month seminar in Athens under the auspices of EOMMEX, the Hellenic Organization for Small/Medium Sized Enterprises and Handicraft. These activities led to long lists of applicants for the gemmology and glyptography seminars all over Greece, which marked the beginning of the materialization of the Lambrinides' vision which was, as we have stated, the re-establishment and development of gemmology and glyptography in Greece. In addition to lecturing, Lambrinides founded a Center of Gemmology and Glyptography, which was run with assistance from Eric Bruton, Alan Clark, Alan Jobbins, Roger Harding, Ian Mercer and many more.

The movement that Lambrinides inspired and founded in Greece has grown from humble beginnings to the size it is today. Many of Lambrinides' students are now respected lecturers and specialists in their fields, and have taken up the gauntlet that he laid down to take the movement forward. Many of these students and Nick himself, the representative for the Gemmological Association of Great Britain in Greece, have lectured in the schools of Athens, Volos, Crete, Larissa, Salonica and elsewhere. This group has also been teaching at his ATC (Allied Teaching Centre) for the Gem-A classes and has prepared students for the gemmology exams under the aegis of GNHM which were held until 1997 at the EOMMEX centre in Athens, where he was the Director of Studies.

The culmination of all this effort was the foundation of the Gemmological Association of Greece. This achievement was realized by the first group's communal effort and Lambrinides rightfully became the first president. The ATC for Gemmology in Greece, was by then well established, as was Gem-A under the aegis of the British Council. Teaching of gemmology in the Greek language has started, and Gem-A exams were held until 2002 at ELKA's (Hellenic Silver and Goldsmith Centre) laboratory, housed at the EOMMEX building, where Nick Lambrinides was Director of 'Gemmology, Diamondology and Glyptography Studies' until June 2003, while co-working with EIMA A. Krikos – R. Hopper Ltd, which has become the Gem-A examination centre. In his spare time he organized activities for the Greek Irish Society as a founder member.

The man and his creative work

As a person N. Kielty-Lambrinides was a calm and collected man, as a tutor he was a strict task master and was uncompromising in his demand for excellence from his students as any of them will tell you. We all enjoyed his classes – while lecturing about tusk and tooth dentine ivory he once asked, "How many teeth has a sea lion?" After all it is a lion, so ... a hundred or at least thirty two, stated some students with a wary smile. "The answer is none ... only a moustache!", he replied. "You must always engage and even intrigue your students, let them experiment with the magnetism of the pyrope garnet for example." Lambrinides compiled the first bilingual (Greek-English and English-Greek) dictionary of gemmology, and the books *Notes of Gemmology and Elements of Glyptography*. He wrote countless books, papers and magazine articles on the above subjects, and gave information on a wide range, with a variety of themes such as jewellery, crystal and herbal alternative therapy.

Nick Lambrinides' carvings, at times three-dimensional figures, "... portraying such details as worry lines and smiling eyes, or unfriendly mouths ... have been on display in the V and A's man-made exhibition. He made a Queen Victoria's 1½ inch head from a piece of white topaz which was on show in the Geological Museum, London", as Adam Joseph published in the *Evening Standard* in January 1977. A male hologlyph smoky quartz head and other pieces are permanently on display in the Mineralogy and Petrology Museum of Athens University.

A unique Glyptography exhibition was held at EOMMEX in 1985 where his pieces and those of his students were displayed together. This exhibition received widespread public recognition. Other exhibitions of his work in galleries in London and Athens, and demand for pieces that have been acquired by private collections, demonstrate how sought-after his craftsmanship and the great works of art he skilfully achieved in small scale have become.

The end of an era

His teaching attracted the interest of both professionals and amateurs alike. Lambrinides lectured and carried out workshop demonstrations in such places as the Geological Museum and Natural History Museum (where his pieces were on display since 1975), the Victoria and Albert Museum, the Polytechnic of Isleworth, London, at EOMMEX, and at the Department of Mineralogy and Petrology, Faculty of Geology, National and Kapodistrian University of Athens, School of Sciences, where gemmology was taught by him and his assistants as an applied part of the mineralogy studies course. Nick could also be found on 'search and rescue' missions in flea markets or gemstone shops, or carrying out other tasks, such as testing the acoustics of the new lecture room at 1 Agias Irinis Street, Athens, now home of the Gem-A examinations. He would devote hours of research to organic precious metals while stroking his beloved Siamese cat.

Many students, 'his family' as his friends referred to us, visited our 'Thaskalos' (Master), just before his passing. He gave creative input to each and every one of us and patiently discussed each of our future careers.

He managed to study and practice the art of science and the science of art, as Leonardo Da Vinci suggested. Nick Lambrinides, operating with the vigour and passion of an 18-year-old, the drive and determination of a 25-year-old, the professionalism and precision of a 50-year-old, and with the wisdom that only a man of his advanced years could attain, and having the desire throughout his career that everything should continue to operate unimpeded and smoothly, will be dearly missed.

Acknowledgements

The author is grateful to Yannis Arnaoutelis for supplying the photo of N. Kielty-Lambrinides, Michalis Theodosious Hatiris for supplying most of the data, Andrew Clements for his assistance and Barbara McConnell from the Greek Irish Society.

* * *

Christopher R. Masters FGA (D.1960), Bispham, Lancashire, died recently.

Erratum

In *J.Gemm.*, 2004, **28**(7), p. 411, in the caption to the photograph winning third prize in the Photographic Competition, for 'Mabe pearl' read 'Blister pearl'

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FORTHCOMING EVENTS

17 November	**Scottish Branch.** *Tales of a gemstone dealer: thoughts from a broad.* *Tracy Jukes*
19 November	**North West Branch.** AGM and social evening.
28 November	**Midlands Branch.** *British gemstones with a Scottish flavour.* *Brian Jackson*
6 December	**Midlands Branch.** *51st Anniversary Dinner.*
7 December	**South East Branch.** Cartier: the 20th century. *Terry Davidson*

2004

20 January	**Scottish Branch.** Some unusual and historical synthetics. *Michael O'Donoghue*
30 January	**Midlands Branch:** Annual Bring and Buy and Team Quiz
January	**South East Branch:** New Year's Celebration (date and venue to be announced)

MIDLANDS BRANCH ONE-DAY CONFERENCE

22 February – Barnt Green
Keynote speaker: Stephen Dale
Carl Fabergé – a Russian Revolution

18 February	**North West Branch.** *Gems in space – an introduction to the world of meteorites.* *Alan Bowden*
27 February	**Midlands Branch.** The latest from the SSEF and the University of Basel. *Professor Henry Hänni*
25 February	**South East Branch.** Tavernier and his stones. *Nigel Israel*
17 March	**North West Branch.** Nineteenth-century jet. *Peggy Hayden*
26 March	**Midlands Branch:** The hallmark. *Chris Tarratt*

SCOTTISH BRANCH CONFERENCE

30 April to 3 May – Lovat Hotel, Perth

Speakers will include:

John I. Koivula – Keynote speaker
Peter Buckie, Alan Hodgkinson, Elisabeth Strack and Colin Trowler

Contact details

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

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Gem-A Website

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

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

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

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

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

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

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

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

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

A **This is a first level heading**

First level headings are in bold and are centred on a separate line.

B *This is a second level heading*

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

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

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

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

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

Notes and References Authors may choose one of two systems:

(1) The Harvard system in which authors' names (no initials) and dates (and specific pages, only in the case of quotations) are given in the main body of the text, (e.g. Collins, 2001, 341). References are listed alphabetically at the end of the paper under the heading References.

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

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

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

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

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

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Cover Picture

A natural Malawi ruby, 2.70 ct, mounted in a ring. (See 'Chemical fingerprinting of some East African gem rubies by Laser Ablation ICP-MS', pp 473-82)

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