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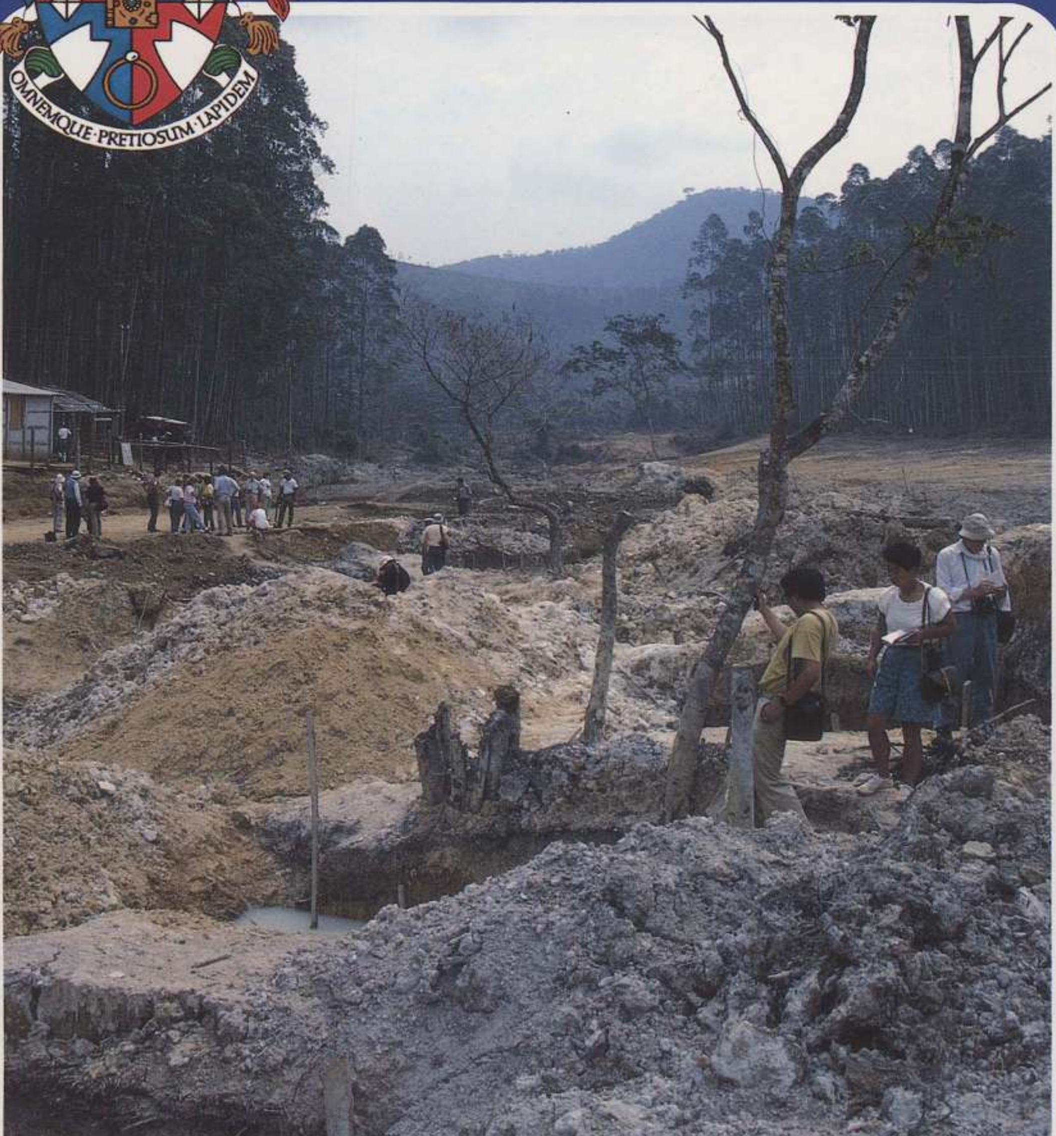

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Cover Picture

The Hematita mine in Minas Gerais in 1987 – probably the richest alexandrite concentration ever known. Note the whitish kaolinitic gravel (which carries the gem material) in the foreground, the soil profile in the centre and the valley confluence in the background. (See 'The location, geology, mineralogy and gem deposits of alexandrite, cat's-eye and chrysoberyl in Brazil' pp. 333-54)

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A method for obtaining optic figures from inclusions

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Abstract

A method for obtaining optic figures from doubly refractive inclusions in transparent gems using a standard gemmological microscope is introduced. Some useful equipment and the limitations of this technique are discussed.

Introduction

In gemmology, non-destructive testing is the norm. The vast majority of the gems encountered cannot be examined in a manner that is destructive or even potentially destructive to their appearance. The microscopic study of inclusions plays a major role in non-destructive gem identification.

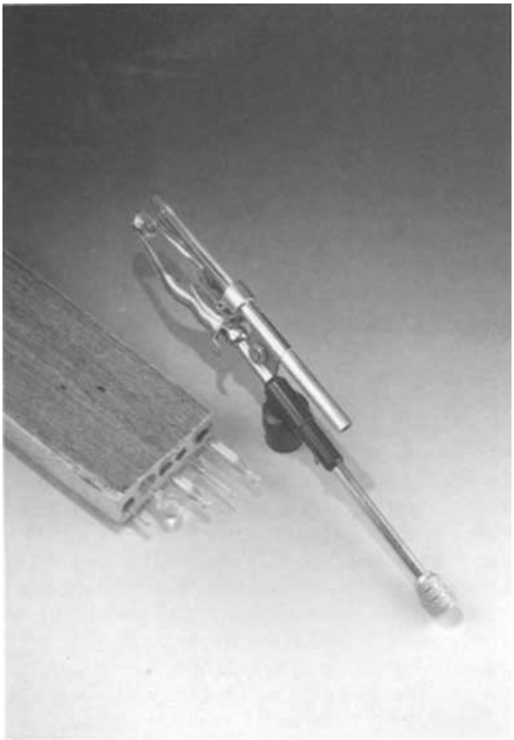

Fig. 1. The stoneholder-conoscope made by Harold Oates used to resolve optic figures from inclusions. Note the six different-sized interchangeable spherical lenses. *Photograph by Robert Weldon*

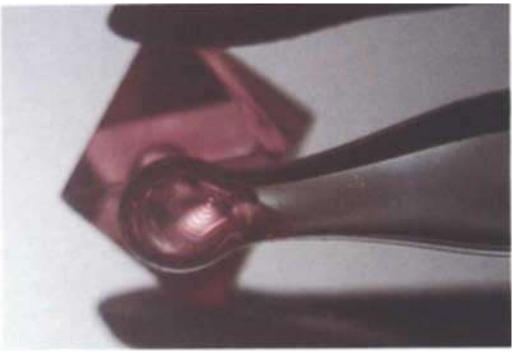

Fig. 2. One axis of a biaxial optic figure obtained by this method from an inclusion in a pink spinel octahedron from Sri Lanka. *Photomicrograph by John I. Koivula*

Inclusions exposed at the surface during the initial cutting process are ideally suited for detailed examination. However, it is rarely possible to actually grind down a gem to expose an inclusion at the surface for X-ray diffraction or chemical analysis. Yet inclusion recognition and identification is one of the more important scientific disciplines in modern gemmology. In this arena most gemmologists must work 'with their hands tied'. Although it is very important to be able to determine if a gem is natural or synthetic, and treated or untreated, this must be accomplished in ways which are not harmful to the gem itself.

At the retail and wholesale level where a great many gem identifications are done, gemmologists and appraisers do not have immediate access to testing instruments such as X-ray diffractometers, electron microprobes and Raman laser probes. Inclusion identification is generally accomplished by means of the gemmological microscope. Certain patterns and types of inclusions that have been seen before are recognized again when they are encountered. In many cases, although the overall inclusion scene presents testimony that a

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gem is natural, individual mineral inclusions within the scene remain unidentified. If such inclusions are well formed, then their external morphology gives evidence of their identity. Colour and degree of transparency are also useful in this regard. In short, any information that can be gleaned from an inclusion by means of the microscope is useful in gem identification.

With this in mind, it is apparent that polarized light would be useful in determining if an inclusion is isotropic or anisotropic. In certain cases perhaps even an inclusion's pleochroism could be ascertained.

During a polarized light examination of the inclusions in a faceted Burmese ruby, it was noticed that in a certain direction a semi-transparent inclusion that appeared to be calcite displayed ring-like patterns of bright interference colours. When a conoscope (consisting of a handle with a small glass sphere on the end) was placed over the inclusion, in contact with the surface of the ruby, a partial uniaxial optic figure was observed.

This may have gone unnoticed because ruby is also uniaxial. But it was unusual because the optic axis direction of the host ruby itself had already been determined and was approximately 40 degrees away from this viewing direction. So it was concluded that the uniaxial figure must have been generated by the inclusion and not by the ruby. Immersion in methylene iodide was then used to negate facet interference and a complete uniaxial figure was readily seen. However, an attempt at photomicrography of the effect, with the available equipment, proved to be so awkward as to be impossible.

Method

This observation and the problem with photomicrography were discussed with gemmologist Harold A. Oates of Glen Ellyn, Illinois, USA. Being a machinist as well as a gemmologist, Mr Oates manufactured a special stoneholder-condensing lens combination that secured both the gem and lens, making photomicrography of the effect possible.

The device, pictured in Figure 1, consists of a stoneholder with a flexible arm piggy-backed above it. The flexible arm can hold any one of six strain-free glass sphere-lenses. To conform to a wide range of gem and inclusion sizes, the spherical lenses themselves are of variable size (from 1 to 6 millimetres in diameter). When total immersion is not being used, a small droplet of suitable immersion oil is placed between the lens and the gem to facilitate good optical contact.

For illustration of this technique, a natural pink Sri Lankan spinel crystal containing a transparent, apparently colourless, doubly refractive crystal that measured approximately 1.5 x 1.0 millimetres was used, rather than the calcite-in-ruby described above. This was done because spinel is isotropic and there is no chance of interference from the spinel. Therefore, an optic figure resolved would have to come from the inclusion.

First the inclusion in the spinel was examined in polarized light (total extinction) to determine the most appropriate angle for conoscopic examination. Then the lens was placed in contact with the spinel immediately above the inclusion (good contact was made using a drop of methylene iodide). After a few moments of manipulation of the crystal one axis of a biaxial figure with its interference rings was noted (Figure 2). This observation immediately eliminated all uniaxial and isotropic minerals as possibilities in the identification of this inclusion and yielded information about this crystal that we would not have had otherwise.

In addition to the inclusion in this spinel, and in the ruby previously discussed, a number of other known inclusions in transparent gems have also been examined by this method. These include muscovite in topaz, apatite in spinel and corundum, and biotite in quartz.

Conclusion

Although the inclusion in spinel focused on in this paper had no recognizable external shape, its transparency, apparent lack of colour and its biaxial nature suggested that perhaps it might be albite feldspar. Albite is biaxial and has been previously identified by chemical analysis and X-ray means as a comparatively common inclusion in Sri Lankan spinels (Gübelin and Koivula, 1986).

This technique of obtaining optic figures from inclusions will not work in many cases. There are certain limitations that should be noted. First of all the host gem must be transparent, as should the inclusion (although some limited success has been had with semi-transparent gems and inclusions). The external morphology of the crystal or cut gem must not be so complex as to interfere with the spherical condensing lenses' ability to resolve an optic figure (total immersion in a properly selected liquid will help in such cases). The inclusion cannot be too deep within the host. The nearer to the surface the better. All of the inclusions successfully examined by this method so far have been within 2 millimetres of the surface of their hosts. The inclusion's orientation in the host material must be such that its optic axis (or one of its optic axes in the case of biaxial materials) can be lined up by the spherical condensing lens. The inclusion must also have some size to it (1x1 millimetre or larger is suggested). The smaller the inclusion the more difficult it is to work with. In doubly refractive host materials the optic axis of the inclusion must be sufficiently off-orientation from the optic axis of the host in order to avoid interference. Partial optic figures must be interpreted with caution. It should also be noted that this method can be very time consuming in many cases, although it is an excellent exercise for increasing microscopic skill.

One final thought concerns the possible accidental discovery of this effect by a student of gemmology. If perhaps a student were examining a gem and noticed an optic figure from an inclusion they might erroneously think that the optic figure they were observing was a property of the host material itself, and a mistake in identification could result. While this possibility is remote, it is nonetheless possible. This is in fact the way that the author discovered this effect, i.e. by accident.

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[*Manuscript recieved 28 October 1992*]

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Freshwater pearl cultivation in Vietnam

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Fig. 1. Street scene in Hanoi.

Abstract

During a visit to Hanoi, the capital city of Vietnam, the authors became aware of a freshwater pearl culturing operation on Ho Tay, a lake situated in the north-west of the capital. Whilst the industry is still young, it is self-sufficient, and further farms are planned to come into operation in the near future.

The Ho Tay farm utilizes the wild mussels found in the lake and mother-of-pearl bead nuclei cut from a species of *Unio* found in the northern rivers of Vietnam. Pearl colours are natural and are, pink, orange, brown, white, light grey, and black.

Introduction

During the authors' visits to south-east Asia in the latter three months of 1992, we heard from several sources that there was some production of 'pearls', both natural and cultured, within, and in the waters surrounding, Vietnam. A further opportunity to enter Vietnam, principally to update the situation in the Luc Yen and Quy Chau ruby deposits, arose for the authors in early January 1993. Prior to, and in between the visits to the Luc Yen and Quy Chau districts the authors stayed in an hotel on Hanoi's West Lake (Ho Tay). Whilst there, they made enquiries about pearl production in general, and were surprised to learn of a freshwater culturing farm less than a kilometre away.

It may be difficult to understand how or why it is possible for a pearl farm to exist in the centre of a city with a population of three million. However, as

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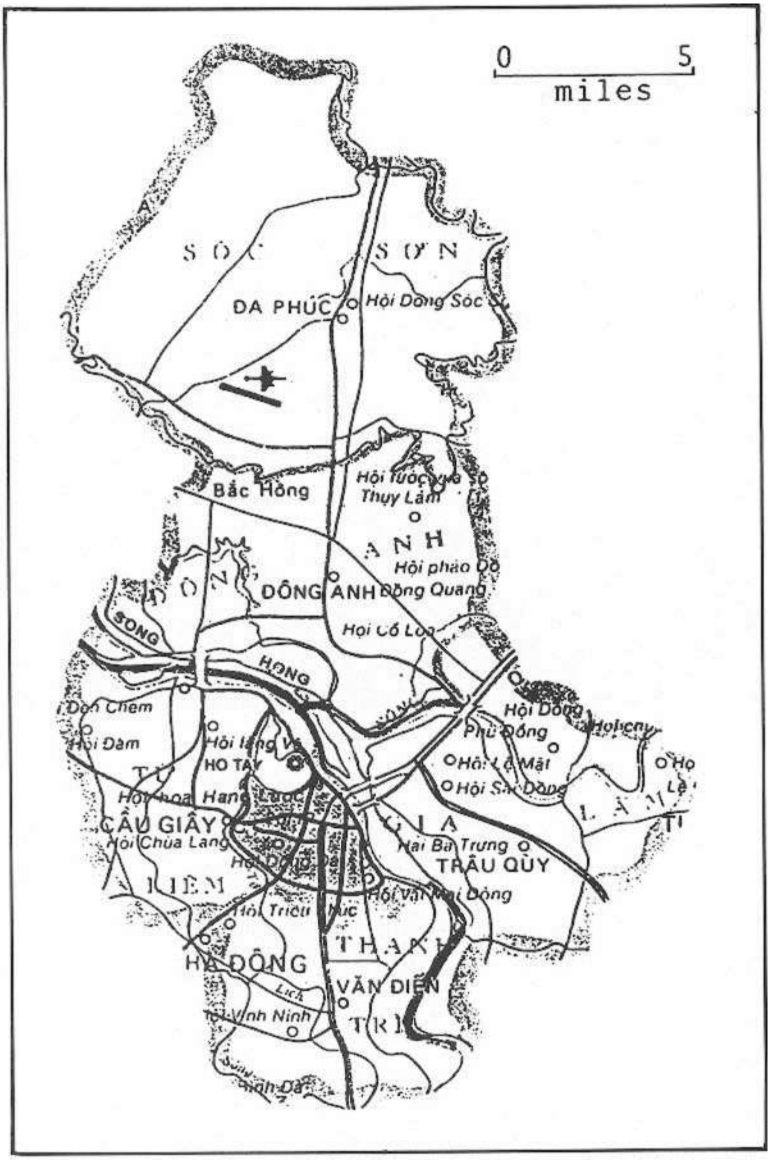

Fig. 2. Section of Hanoi city map showing the location of the Ho Tay pearl farm (shown by the 'flower' symbol) on the eastern banks of the West Lake.

is clearly evident from Figure 1, there is relatively little use of the motor car, and with the bicycle being the predominant mode of transport, not only the country, but also the capital city, is still largely unaffected by environmental pollution.

Other enquiries confirmed the possibility of orange conch (type) pearls (Scarratt, 1992) being found off shore, as well as saltwater culturing. Details concerning the saltwater culturing were difficult to obtain, and time constraints prevented the authors from visiting the locality. However, the information gained pointed to one culturing centre east of the port city of Haiphong, located either in the Ha Long bay or in the Fai Tsi Long archipelago off the north-eastern coast of Vietnam. It was further indicated that there was some involvement by a Japanese firm, although in what capacity was not made clear.

Freshwater pearl culturing in Hanoi

Enquiries about freshwater pearl farming revealed a young but blossoming industry. Apart from small operations in a number of (unidentified) Vietnamese lakes, two operations were mentioned in particular: these were in the estuary of the Red River (Song Hong) and a station in Hanoi city itself

Fig. 3. Snail harvesting in Ho Tay Lake.

Fig. 4. View across Hanoi's West Lake with the fenced-in rafts of the Ho Tay pearl farm, as seen from the main building of the Ho Tay Fish Development and Investment Company.

on Ho Tay.

At very short notice the authors were granted a visit to the facilities of the Ho Tay Fish Development and Investment Company (the company responsible for the development of pearl culturing on Ho Tay) which are located on the banks of the lake (Figure 2). This lake is situated in the northwest of the capital and is isolated from the Red River by a high-water protection dam. The water quality of the lake is apparently good since pearls appear to be farmed successfully and fishing and snail harvesting can be observed daily (Figure 3).

Development and production of the Ho Tay enterprises

The Ho Tay Fish Development and Investment Company, formerly solely occupied with fishing and fish breeding, began feasibility studies on pearl farming in 1986, consulting Japanese experts on the matter. Mr Vu Dang Khoa, director of the company, revealed to the authors that by 1989 these studies were completed.

Actual production began in 1990 when 500 pearls were produced. In 1991, 1000 pearls were harvested, followed by 3000 in 1992. It is hoped to produce 8000 pearls in 1993. The cultured pearls have only been exported to Asian countries to date. The operation witnessed by the authors is run by a small crew. The mollusc processing team consists of two individuals. The plant has several office buildings as well as a fenced-in farm containing an anchored bamboo raft of about 15 by 10 metres floating approximately 15 metres off the lakeshore (Figure 4). In each of the round wire baskets, suspended to a water depth of less than two metres from the raft, are about ten bivalves.

The Ho Tay freshwater culturing technique

The standard technique of the Ho Tay enterprise utilizes fashioned mother-of-pearl beads from freshwater shells. The use of beads in freshwater culturing is not a new technique, indeed examples are known as far back as 1761, but in modern times (post World War II) it has not been the accepted practice, ie., in the mass market product cultured in China. However, recent years have seen an increase in the use of this technique – beading appears to be applied today in some North-American and certain larger Chinese freshwater cultured pearls using Japanese-made nuclei (Man Sang, 1992). The beads used for culturing in China are often dyed and their dark colour is visible through the mostly thin nacreous coating – compare Japanese saltwater cultured pearls of low quality (Hänni, 1993).

The Ho Tay bead material used for insertion is locally cut out of the small (dimensions approximately 80 x 45 x 15mm), but comparatively thick shell of a *Unio* species found in rivers of the northern provinces. The shape of the nuclei varies from nearly spherical to elliptical or button-shaped, their hue is white, cream or light orange, and the diameters range from roughly 3 to 5mm. The non-spherical shapes were stated to be desirable for the creation of natural-looking end products and the bead colours were said to be unaltered.

The living molluscs employed for pearl culturing are of the *Cristaria plicata* species (Figure 5), reported by Jobbins & Scarratt (1990), to be used also in Chinese farms. Some authors have placed this species in the *Anodonta* genus, but this is rejected by others who retain *Cristaria*. The supply of new molluscs is provided by collecting native animals from the Ho Tay. Spatting has not been used to date. The shells roughly measure 150 x 110 x 20mm at the time of harvest and most exhibit an elegantly greyish-purple mother-of-pearl interior and large, lobular orange-brown areas of variable size.

Epithelium strips are cut from the mantle tissue of sacrificed *Cristaria* animals, fashioned into squares of approximately 3 x 3mm and dipped in an orange antibiotic liquid to prevent infection of the molluscs to be operated on. Subsequently, six to eight short cuts are placed in the epithelium of the mantle tissue (3 to 4 on each side) of the living bivalves and a corresponding number of beads inserted. To initiate nacre growth around the beads, the epithelium squares are placed on top of the already inserted nuclei.

Success rates/Production time

The success rate at present is three nucleated, nacre-coated pearls out of six to eight beads per implanted mollusc. Whilst this may appear modest the rejection of an inserted bead normally results in the production of a non-nucleated cultured pearl from the tissue implant placed with the bead. The growth period of 18 to 24 months is long in comparison with the 9 months needed for non-nucleated pearls in Chinese waters but short compared to the reported Lake Biwa conditions (up to 36 months for the first harvest). No indications were made regarding re-use of the *Cristaria* clams for a second crop (*Hyriopsis schlegeli*, for example, continue to produce pearls when returned to the waters of Lake Biwa, not requiring implantation of new tissue material, Muller-port, 1981). Nacre thickness, also being a measure of success, is discussed below.

The Ho Tay cultured pearls and their properties

Three lots of cultured pearls were shown to the authors for examination. The assemblage of these fourteen pearls looked so varied and pleasing that it was deemed worth a more detailed description. The specimens were supplemented by the addition of one yellow-banded white specimen to the top right-hand row (no.4 in Figure 6).

The nearly spherical shape of the largest pearl of the batch (no.1, upper left) is in contrast to the more familiar shapes associated with tissue-graft freshwater cultured pearls from other sources.

Typically the latter are 'semi-round' (roundish) to baroque. In fact, as can be seen from the radiograph of the fifteen undrilled pearls, only two are bead-nucleated (again no.1 on the top left in Figure 7 and no.4. All others are tissue-grafted or non-nucleated cultured pearls*. The fifteen pearls exhibit a mostly smooth surface, good lustre and a fair to good orient.

Fig. 5. *Cristaria plicata* shell with two encapsulated nuclei displaying the colour of the underlying shell (orangy pigment on the left and pinkish pigment on the right) together with the pearl batch examined.

The bead-nucleated pearls grow in 5 to 7mm sizes, with rare maximum diameters up to 12mm. The non-beaded pearls are generally smaller. The weight range of the pearl sample examined is from 2.56 ct (no.1) to 0.51 ct (no.6).

Pearl no.1 shows a nacre thickness of approximately 0.1 to 0.3mm, the lower figure being considered unacceptable by standards developed for the grading of cultured pearls by the Gem Testing Laboratory in London and the CISGEM Laboratory in Milan. The nacre coat of pearl no.4, however, has an acceptable minimum thickness of about 0.65mm.

Depending upon the structure differences of the tested pearls, there is a wide range of densities. The spherical *Unio* bead pictured in the lower right corner of Figures 6 and 7 gave a hydrostatically determined value of 2.80g/cm^3. The bead-nucleated pearls no.1 (2.56 ct) and no.4 (2.05 ct) showed densities of 2.78 and 2.65g/cm^3 respectively. These lower values can be explained by the thin nacre coat of the first and a void on one side of the bead inside the second pearl.

The densities of the non-nucleated pearls ranged from 2.71 to 2.53g/cm^3. In this group, pearls nos. 6, 2 and 12 are the most dense (in this sequence). The two lowest figures, 2.62 and 2.53g/cm^3, are caused by the biggest cavities per volume visible in pearls no.10 and no.15. There is a definite relationship between the size of the central void or tissue remainder and the pearl density: the more compact the pearl, the higher density value, as subsequently confirmed by the internal structures displayed in the X-radiograph (Figure 7).

* The terms 'non-nucleated' and 'tissue grafted' have the same meaning and refer to the same type of cultured pearl. The term 'keshi' is not used in the text, but it should be made clear that it does not apply to the non-nucleated or tissue-graft pearls referred to in the text above.

Fig. 6. The fifteen freshwater cultured pearls examined from the West Lake (Ho Tay) in Hanoi, Vietnam, lined up according to colour types (orange, white, pink, fancy). Identical arrangement as in Figure 7 for direct comparison, with one spherical *Unio* mother-of-pearl bead in the lower right corner.

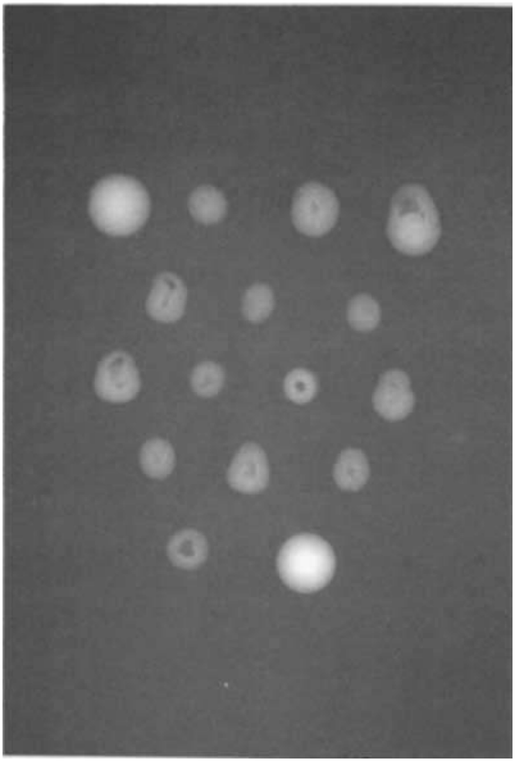

Fig. 7. X-radiograph of the fifteen Ho Tay cultured pearls and one bead, arranged as in Figure 6. Numbering in rows from top left, pearls nos. 1 and 4 are nucleated, all others are tissue-grafted or contain a void.

The colour of Ho Tay cultured pearls

As in most gem materials, colour is the outstanding property of the pearls examined. These come in a considerable range of hues, pure orange being the most unusual one. Ho Tay pearl colours were reported to be mostly pink, orange, brown and more occasionally white, light grey and almost black. This is in contrast with the three lots shown, white and pink being the predominant hues.

The present colours were measured in the reflectance mode of the Zeiss MCS 311 Multi-channel Spectrometer. This technique has been applied for many years, especially in Japan (Komatsu, 1991), for the separation of natural black cultured pearls from those dyed black with silver nitrate, ie., 'black-lip absorption' versus dyestuff absorption. Though only a preliminary colorimetric study of the Ho Tay and other known freshwater cultured pearls was conducted, it became evident that there is a positive correlation between the following hues and approximate absorption band positions:

orange	500	>	440nm
pink	440	>	550nm
purplish-pink	440	=	550nm
white	440	>	680nm

Mixed colours show the listed absorption bands roughly in the ratio of their contributing hues. It is known that the organic colouring components (porphyrine and conchiolin) of the mantle tissue as well as the aragonite platelet thickness (0.9mm in Chinese *Cristaria*, Gutmannsbauer, 1992) influence the pearl colours but the exact causes need further study.

No evidence was found to indicate other than natural colours for the examined undrilled Ho Tay pearls. This confirms the official claim that the pearls were not enhanced (i.e. not dyed, heated or irradiated). However, white and black being the preferred colours, Hanoi sources state that dying has been tested for application to off-coloured cultured pearls.

Outlook

Vietnam has the potential to become an important source of freshwater cultured pearls. It has been pointed out that there are at least three operations in various lakes, the waters of which are still largely unaffected by pollution problems, most likely because agriculture predominates over industry in all but a few urban areas.

The Ho Tay Fish Development and Investment Company plans for the Ho Tay station to become the largest such operation in Vietnam in 1993. Three additional farms will go into production this year; one in Hanoi, one in Ha Nam Ninh Province and another in Hai Hung Province, the latter two are both in the Red River delta. With increasing output figures, the Vietnamese freshwater pearls may become an important addition to the Chinese products in the future, especially if they are grown with thicker than normal nacre, as evidenced by those examined by the authors.

To encounter a pearl farm in a major metropolitan area was a great surprise. Pearls, not only from freshwater molluscs, appear to be symptomatic of the specialities and treasures that Vietnam holds in store for the world market. Conch pearl fishing in Vietnamese coastal waters, for instance, has existed for a long period, but is still not widely known. Flame-structured, natural conch-type pearls of nearly pure orange colour and sizes up to over 200 ct have come from Phu Quoc Island near the Cambodian border (Repetto, 1992, 1993) and compete with those from Thai and Burmese waters.

Acknowledgements

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Three of the authors also wish to extend special thanks to their co-author, Mr Henry Ho, for arranging the various Vietnam expeditions, to R.C. Kammerling for helpful advice and Nick Delre for artwork and photography.

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The location, geology, mineralogy and gem deposits of alexandrite, cat's-eye and chrysoberyl in Brazil

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Abstract

Alexandrite, cat's-eye and transparent chrysoberyl are the gem chrysoberyl varieties sought after in Brazil. Primary chrysoberyl deposits are a few differentiated thin granitic pegmatites emplaced in granite, gneiss and mica-schists, presently abandoned, and granitic pegmatites cutting mafic and/or ultra-mafic rocks. In the last case, a few alexandrites are associated with emeralds which are found near the contact pegmatite/wall rock (Bahia and Minas Gerais States). Currently worked chrysoberyl deposits are detrital: eluvial, high and low colluvial terraces and alluvial, the latter being the most important. These deposits are located in the Minas Gerais, Bahia and Espírito Santo States; the biggest prospects are: Córrego do Fogo, Córrego da Faisca and Hematita in the State of Minas Gerais and Córrego Alegre in the State of Espirito Santo. A detailed formation description is provided for each deposit type, and the heavy minerals associated with chrysoberyl in the fine gravel fraction are listed. Associated with chrysoberyl in the coarse gravel fractions are: amethyst, aquamarine, garnet, smoky quartz, topaz, tourmaline and, in lesser amount: andalusite, rose quartz, moonstone, rutile, sapphire and zircon. Locally chrysoberyl is a by-product of the alluvial working of other gems such as diamond, aquamarine or andalusite.

Two maps (Figures 1 and 2) show the locations of the chrysoberyl deposits, an idealized diagram illustrates the types of deposit (Figure 7) and sections are shown of a series of alluvial deposits (Figure 8).

All chrysoberyl prospects are rudimentarily worked, by means of hand dug small pits or irregular open pits, and sometimes by means of a gravel pump (dredge).

Physical properties and gemmological characteristics of Brazilian gem chrysoberyl are reported, as are the significant inclusions.

Introduction

Chrysoberyl ($BeAl_2O_4$) holds a first class position between the rarer and higher priced Brazilian gems. Owing to a hardness of 8.5 and an average density of 3.75g/cm^3, it occurs as prismatic or platy, single or twinned crystals and as sharp or rounded fragments, pebbles and gravels. The fine specimens are eagerly sought after by mineral collectors. Without industrial importance, chrysoberyl is only sought for its gem crystals of which three types are distinguished:

– chrysoberyl, golden yellow (known as 'crisolita' in Brazil). It should not be mistaken for peridot, whose local name is the same
– cat's-eye or cymophane with chatoyancy of a bright line in the translucent stones cut en cabochon
– alexandrite, greenish-blue in colour in daylight and turning red in incandescent light.

Large faceted gems and cabochons can be made from chrysoberyl and cat's-eye and samples of several tens of carats in weight are known. On the other hand, alexandrite always produces smaller cut gems.

Chrysoberyl essentially occurs in the granitic suite, that is to say: pegmatites and aplites. It sometimes occurs in mica schists and, rarely, in dolomitic or calcic skarns. Chrysoberyl deposits belong to pegmatitic, pneumatolytic-hydrothermal and hydrothermal types (Smirnov, 1977).

In Brazil, chrysoberyl is prospected for in the States of Minas Gerais, Bahia and Espirito Santo and, nowadays, only in detrital deposits. These result from the partial or total destruction of primary deposits which are granitic pegmatites, locally intruded into ultramafic rocks. Our purpose, therefore, is to describe the various types of chrysoberyl deposits (cat's-eye and alexandrite varieties being specified as appropriate), their location, the associated minerals and the produced gems, today or in the past.

Pegmatite deposits

Granite pegmatites without ultramafic rocks association

Few deposits are accessible for research and at the present time none are worked. Deposits mined in the past were few in number and frequently caved in. Records of them are kept, state by state (see the location map, Figure 1):

Espirito Santo. The Triunfo prospect (Santa Teresa township) lies 1.5 kilometres to the ESE of Itarana town. A subvertical pegmatite, one metre wide, running NW-SE and outcropping as a gossan resulting from biotite weathering, was worked

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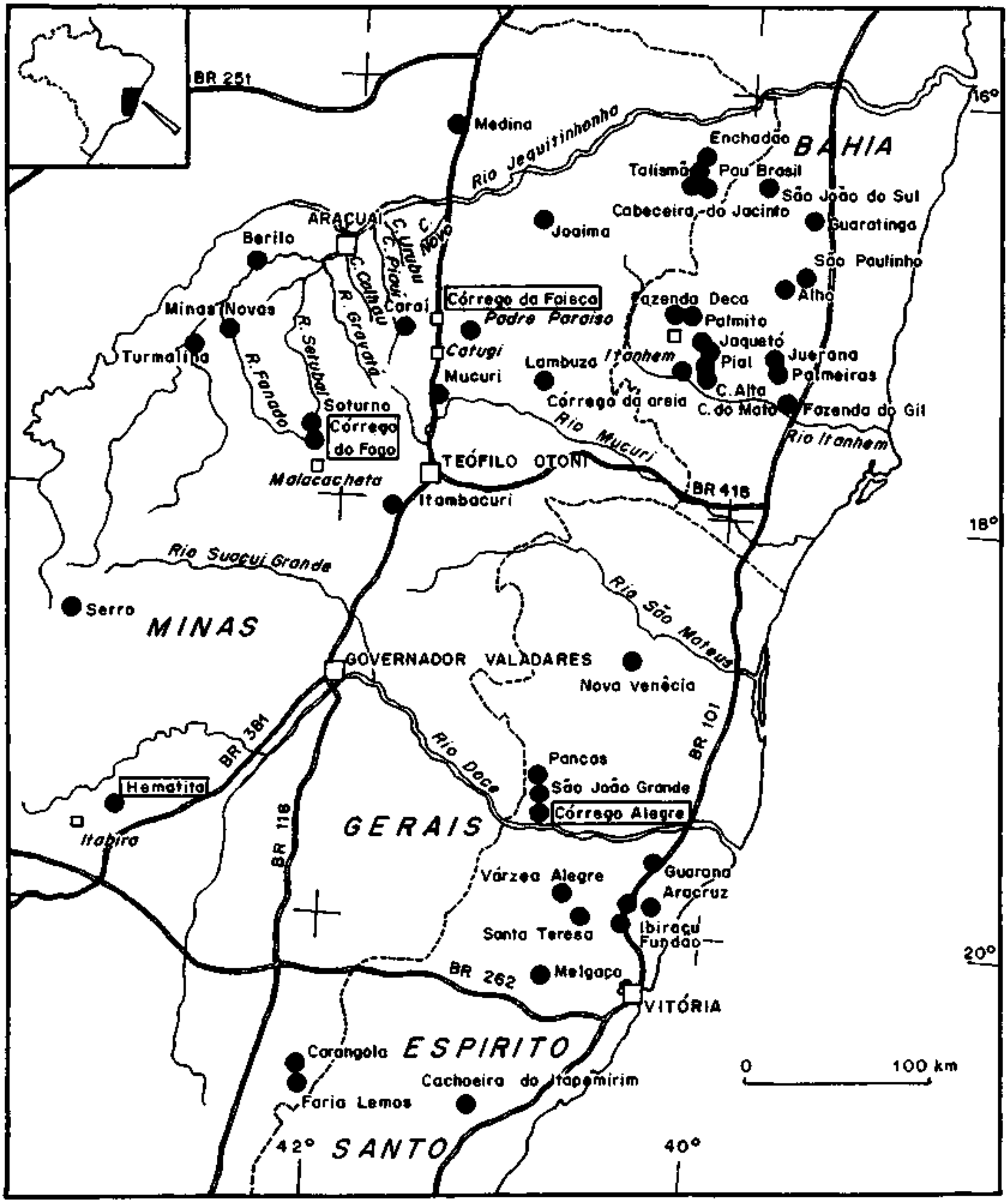


Fig. 1. Location map of the chrysoberyl deposits in Brazil.

between 240 and 270 metres in elevation. The pegmatite is zoned with a biotite-feldspar zone along the wall-rock (a granitic gneiss with feldspar phenocrysts) and a milky quartz core containing small cavities from which chrysoberyl was recovered. An 8 kilograms almost opaque V-twin is reported from this deposit.

Near Santa Leopoldina, another excavation in pegmatite produced chrysoberyl crystals reaching up to 1.5 kilograms in weight (J. Gomes, personal information). During 1940, trilling twins, several centimetres in diameter, were collected by Kaplan (Interview, 1980), from a weathered pegmatite (or its eluvium?), located in the Lavra (= mine) of Antônio Coelho (M. Luque property). These crystals are famous worldwide and commonly labelled

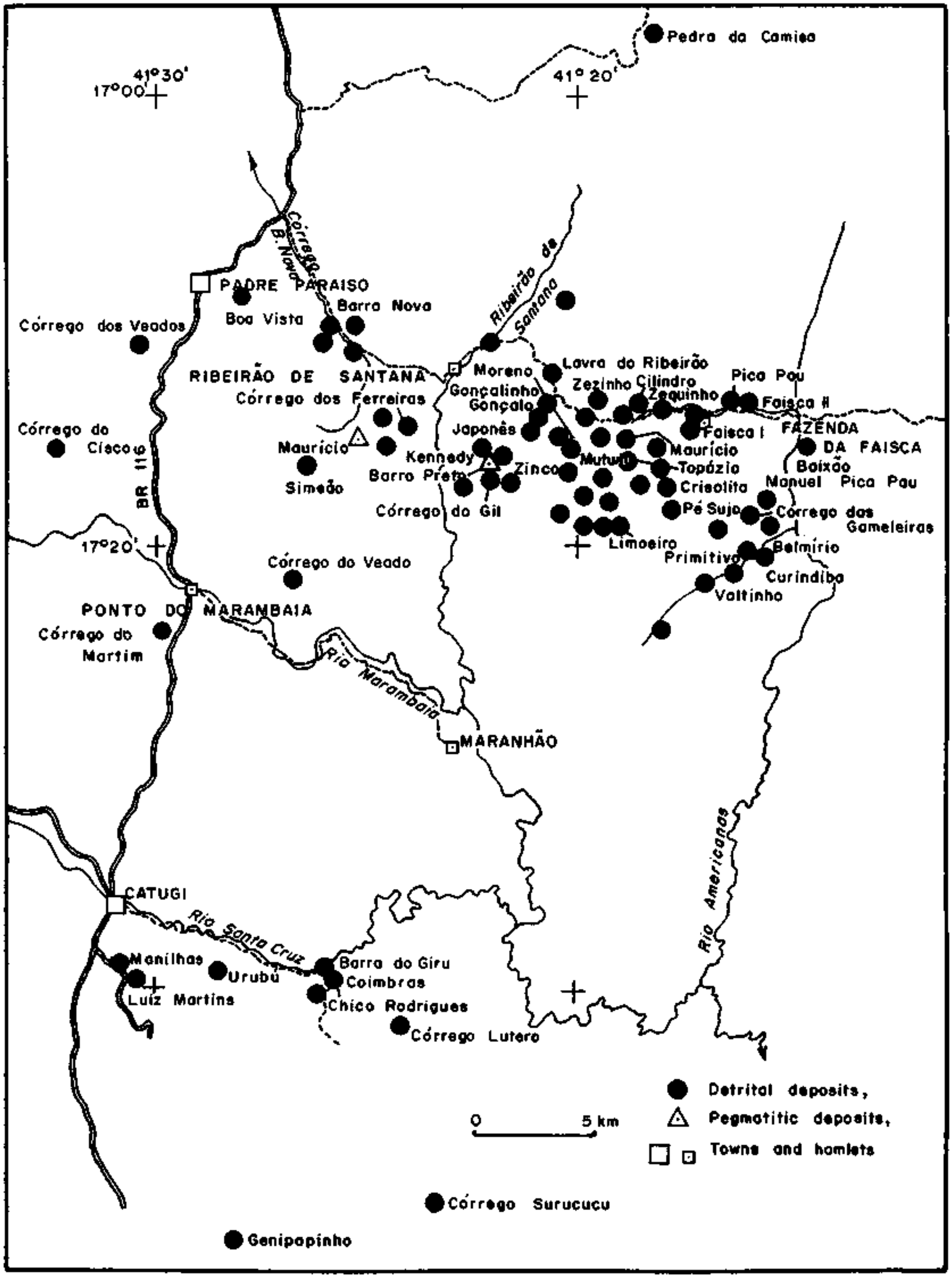


Fig. 2. Detailed map of the chrysoberyl deposits in Córrego da Faisca area.

as coming from Itaguaçu.

Chrysoberyl in quartz, near Castelinho (Cachoeiro do Itapemirim township) is briefly reported by Leonardos (1945a), and by Wohlers (1941) as being near Santa Teresa.

Minas Gerais. During 1990, on the right side of the Córrego (= creek) Barro Preto, a thin pegmatite was prospected by a trench, 50 metres in length, at the elevation of 740 metres. The occurrence is located 14 kilometres to the ESE of Padre Paraiso town (see detailed map, Figure 2), and near the top of a bald inselberg made of kinzigite with large garnets and platy sekaninaite crystals. The unzoned pegmatite, crossed by aplite veins, running N30°E and dipping 75°NW to vertical, is some centimetres wide with swellings reaching up to 0.5 metre in width. The pegmatite is composed of grey xenomorphic quartz, K-feldspar with some crystals reaching up to 15 centimetres in length, large biotite plates, green and pink fluorapatite, garnet and chrysoberyl crystals which are honey yellow to dark green in colour, thin, frequently flattened, commonly V-twinned. It is an exception if they reach up to 5 centimetres in length.

In the neighbourhood, 9 kilometres to the SSE of Padre Paraiso, another pegmatite, known as Lavra do Maurício, was partially worked in open pit on the top of a long hill made of biotitic granite, at the elevation of 800 metres. In the open pit, partially caved in, the weathered pegmatite involving many xenoliths, appears vertical, running EW and 5 to 6 metres wide. Typical minerals of the aquamarine deposits may be observed in the dumps: quartz crystals formed by three pyramids, biotite with hematite layers (Cassedanne *et al.*, 1992), muscovite, black quartz and colourless topaz. According to A. Tavares (personal communication), the pegmatite (or its eluvium?) would have produced some kilograms of greenish-yellow to greenish-grey, highly shredded, chrysoberyl crystals.

Until 1980, nine kilometres to the ESE of Coroaci town, that is to say 40 kilometres to the WNW of Governador Valadares, the Escadinha prospect was worked by small trenches and rooms, 60 metres in length along the outcrop. The deposit, located on the left side of the Grota (= gulch) do Xuxú, at an elevation of 450 metres, is a rosary-shaped pegmatite, 0 to 0.3 metre in width, running SSE-NNW and dipping 20°NE. The wall-rock is a garnetiferous mica schist. The unzoned pegmatite is made of malodorous grey quartz, kaolinized feldspar, abundant muscovite, garnet and flattened chrysoberyl crystals, frequently occurring in the quartz. Fine cat's-eyes are recorded from this deposit.

Leonardos (1945b) referred to yellow chrysoberyl in a beryl-bearing pegmatite located in the Córrego Surucucu; in Sebastião Ferreira (30 kilometres to the south of Itaipé town) and 'in various beryl-bearing pegmatites', in the Rio Mucuri basin. To the south of the State, near Manhumirim town, another pegmatite was reported as having produced chrysoberyl twenty years ago (J. Gomes, personal communication).

Bahia. Misi *et al.* (1975) report, without more information, 'simple pegmatites' chrysoberyl-bearing, in the southern part of the State. The deposits are caved in.

Rio de Janeiro. Menezes (1982) reported chrysoberyl in the Faraó de Baixo pegmatite (Conceição do Macacú township). Panning the dumps of various caved in adits, none produced chrysoberyl.

Ceará. Near the town of Fortaleza, capital of the State, and 1.6 kilometres to the east of the Cristais town, gem chrysoberyl was reported as having been found in the Caboquinho pegmatite. The deposit, running N30°W, was worked by an open pit, 120 metres in length, 40 metres in width and 20m in depth. Associated minerals are: albite, beryl, cassiterite, columbite, muscovite and spodumene (Limaverde, 1980).

From a more general standpoint, Costa Sena (1881) wrote that chrysoberyl proceeds from quartz veins and Leonardos (1945a) observed the same mineral 'in feldspar'.

The scarcity of the known deposits in rocks is highly disconcerting, even when, as it will be seen later on, chrysoberyl is broadly scattered in the detrital deposits where it is worked from many occurrences. It must be pointed out that chrysoberyl is not reported from aquamarine deposits, while the near alluvium, sometimes only several hundreds of metres away, frequently contain variable amounts of it. In order to explain this observation it was pleaded that the small size of many chrysoberyl crystals included in quartz or feldspar make them almost unperceivable, that beryl would have a different distribution in the pegmatite bodies or, in the old prospects, the belief that chrysoberyl brought bad luck caused it not to be mentioned (Elawar, 1974).

Research in numerous aquamarine-bearing pegmatites (Cassedanne *et al.*, 1992) confirmed that chrysoberyl does not coexist with aquamarine in its Brazilian primary deposits. Therefore, it may be concluded that chrysoberyl occurs in quartz (with feldspar and mica) veins and in thin pegmatites, devoid of aquamarine and judged almost without economic interest in outcrop, on account of their narrowness. According to the textural-paragenetic evolution scheme of Vlasov (1952 – modified in Cassedanne, 1990), the chrysoberyl-bearing pegmatites occur close to the base of the aquamarine producing zone.

Gem-bearing pegmatites were dated to 450-520

Fig. 3. Trilling twinned crystal (4.5 centimetres in diameter) from the Itaguaçu area (Espirito Santo State).

Fig. 4. V-twinned partly gemmy crystal (3 centimetres in length) from the Córrego da Faisca area (Minas Gerais State).

Fig. 5. Waterworn chrysoberyl crystal weighing 325 grams from Pancas area (Espirito Santo State).

Fig. 6. Large V-twinned crystals from a recent find in Córrego Alegre (Espirito Santo State). From left to right the samples weigh 1730, 830 and 880 grams. K. Elawar collection.

my old in the east centre of Minas Gerais State. They are always considered as belonging to the last phase of the Brazilian tectonic cycle, when emplaced in granites or its wall-rocks, or may have been slightly later (Correia Neves *et al.*, 1986).

Granite pegmatites associated with ultramafic rocks

Chrysoberyl (alexandrite) from these deposits is a by-product of emerald mining. See Schwarz (1987) for more details regarding this gem and its deposits.

In the large Carnaiba mine, 30 kilometres to the south of Campo Formoso town (Pindobaçu township, State of Bahia) located on the western slope of the Serra de Jacobina, alexandrite is associated with emerald mainly in the Marota and Lagarto prospects. In another, called Mundeú, chrysoberyl is found in biotite schist lenses in which it occurs as flattened trilling twins measuring up to 5 centimetres in diameter, but almost without translucent parts (Bruni, 1976). The Serra de Jacobina is made of a quartzite sequence with schist intercalations and ultramafic rocks sills (where chromite deposits are worked), intruded by a granite batholith and its pegmatite vein satellites. Emerald is found near the contact of the pegmatites. It is in a micaceous rock called sludite made of phlogopite, a little quartz, apatite, biotite, molybdenite and minor scheelite and alexandrite. The deposit, the production of which reaches some hundreds of tons of emerald of greatly variable quality, is hand worked by means of shafts and adits. The scattered prospects cover several square kilometres.

In the Socotó mine, to the NE of Campo Formoso town, a steeply dipping, running NNE-SSW sequence is made of gneiss, quartzites and talc-schists associated with peridotites and serpentinites, cut by thin granite pegmatites. As is done in Carnaiba, emerald is worked in the sludite lenses. Alexandrite and chrysoberyl are rare, sometimes associated with large rounded milky phenakite crystals.

Lastly, a very little alexandrite sporadically appears in the Belmont emerald mine, near Itabira (State of Minas Gerais).

Detrital deposits

A series of physical and chemical superficial phenomena take place in the primary deposits which lead to the formation of gem-bearing alluvium. Various types of deposits may be correlated to intermediate stages during this formation.

In tropical countries a number of pegmatite minerals are unstable under superficial conditions, at least on geological time scale. Some minerals change into clay (feldspars, spodumene), others decompose (biotite, magnetite, garnet) leading to the disintegration of the pegmatite body, while chemically stable or practically insoluble compounds such as chrysoberyl, beryl, topaz or tourmaline, remain unaltered and concentrate with heavy minerals such as cassiterite, ilmenite, monazite, niobotantalite, rutile and zircon. When the weathering-resistant products stay plumb with or very near to the pegmatite, they are either scattered in a reddish-brown sandy clay or are submitted to a light grade increase, by elimination of fine particles, caused by meteoritic water action, forming the so-called *eluvial deposits*. The previous detritus may slide down the slopes, forming *colluvium* deposits before reaching the bottom of the valley, where they are picked up, transported and deposited several times by the running waters. This process allows gems and resistant heavy minerals to concentrate, by elimination of light particles, and leads to the formation of *alluvial deposits* (placers or flats). If the preceding cycle is repeated at different levels, distinct in time, its result will be the construction of superimposed *terraces* (see Figure 7).

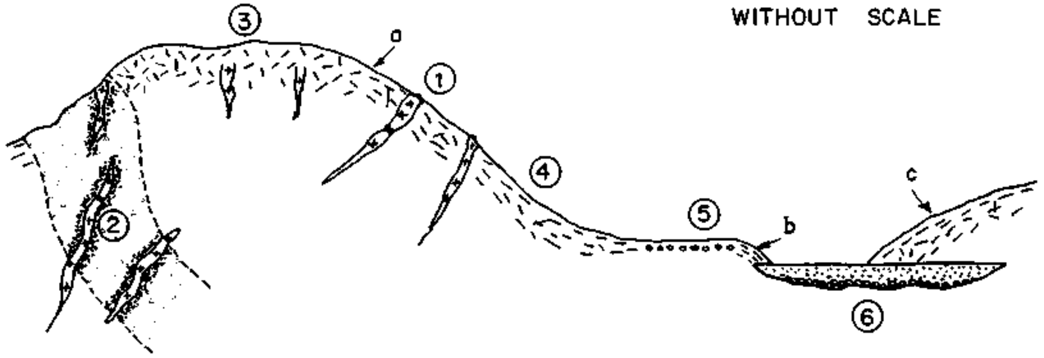
The chrysoberyl detrital deposits are remarkably developed in the north-east of the Minas Gerais State, south of the Bahia State and west of Espirito Santo State, the area belonging to the 'Eastern pegmatite Province' of Paiva (1946).

Outliers of an old peneplain occur at the summit of some inselbergs to the north of Teófilo Otoni town and near the frontier with the State of Bahia, as extensive high plains preserved in clayey and sandy Cenozoic sediments. The peneplain, that culminates between 800 and 900 metres in elevation, belongs to the South American erosion cycle, dated lower Cenozoic (King, 1956) and extends to the south of the State of Bahia and near the frontier between the States of Minas Gerais and Espirito Santo.

The South American peneplain was dissected during new erosion cycles, with steeply sided valleys more than 300 metres in depth. The down cutting, related to the Rio das Velhas (Upper Cenozoic) and Paraguaçu (Pleistocene) cycles, was spasmodic with short accretion and planation periods. The accretion phases are marked by shreds of terraces remaining perched upon the high slopes. Commonly these very old terraces are buried by colluvium and only appear by chance, when artificial work cuts the slope. Other lower, but very extensive, terraces occur in the Rio Doce tributaries and various small coastal rivers (Rio Mucuri, for instance). The important preceding morphological features commonly are dated Upper Pleistocene – Lower Holocene (Meis *et al.*, 1981) and explain the importance of erosion in the dismantling of the primary chrysoberyl deposits.

In the south of the Bahia State, the newer erosion cycle appears as vast pediments gently sloping down towards the Atlantic ocean, but lightly rising up from south towards north. Broad valleys, where almost all chrysoberyl prospects are located, gashed the preceding pediments before being partly filled. In the interior, hanging valleys, sited upstream were thresholds of resistant granitic rocks which produced waterfalls and acted as traps for the chrysoberyl and heavy minerals (Cachoeira do Mato,

Fig. 7. Types of chrysoberyl deposits in an idealized section.



1 - Granitic pegmatite,

2 - Granitic pegmatite associated with mafic and ultramafic rocks,

3 - Eluvium,

4 - Colluvium. a/high colluvium, b/gem-bearing low colluvium, c/barren low colluvium covering a flat,

5 - Terrace,

6 - Alluvium with gem-bearing gravel (flat).

Jaquetó, Pau Brasil, etc.): erosion migrating towards the heads of the rivers did not have sufficient time to level the streams after the falling to the last base level.

Eluvial deposits

In the eluvium, commonly lateritic, the rough or slightly rounded gems are preserved in the soil, their surfaces being coated by ferriferous plastic reddish clay. The deposits, also called 'Chapada' (= high plain or plateau), as well as those of the high colluvium, are located upon the outliers of the South American peneplain or upon later piedmont slopes or planation surfaces. These deposits, of which superficial extension may reach tens of hectares, were extensively worked by means of irregular pits, small shafts of variable section and large irregular excavations. All were haphazardly dug because no superficial clue exists to guide the research. No well defined mineralized horizon occurs, but deposits of variable thickness composed of brown to reddish, sandy argillaceous layers with erratically distributed gems, associated with many milky quartz fragments, are found (Córrego da Faisca). Locally gem bearing layers become individualized in the eluvium, as thin discontinuous lenses. Mineralogically speaking, the eluvium deposits are poor, with some variably martitized magnetite granules, limonitic pisolites and quartz, associated with the chrysoberyl in the coarse fraction of the soil. The mass of the fine heavy fraction is made of magnetite and its alteration products, associated with ilmenite and a very small amount of biotite, garnet, leucoxene, monazite, muscovite, niobotantalite, tourmaline, xenotime and zircon.

It is impossible to date precisely the eluvial deposits, all old in age, because their formation continued after the peneplanation of the surface development which characterize them. This very long exposure to superficial weathering explains their broad extension, caused by multiple very small lateral movements of their resistant components, as well as their mineralogical paucity resulting from an exhaustive chemical weathering. Discovery of eluvial deposits is always fortuitous: loose gem chrysoberyl collected during a road or trench opening, fitting up of a wire fence, etc. Without delay a garimpeiros' (= diggers) rush follows the discovery, sometimes involving hundreds of diggers. They turn the soil of the deposit upside down before leaving it, regarding it as a worked out area. It remains, at first sight, a lunar or undulating bombarded landscape. The excavations are almost always hand dug, with vertical walls dependent on the eluvium stability. The brown to red colour of their wastes is typical, contrasting with the white or pale grey colour of pegmatite dumps. Sorting of the gems is made during the excavating, sometimes with screening of the finer sized overburden.

Colluvial deposits

By slow creep eluvium imperceptibly passes to *high slope colluvium*. The limit between the two types is merely conventional and only founded on their topographic situation. Mineralized high slope colluvium is always hand worked.

Colluvium is generally of low economic importance, the gems becoming diluted among a great deal of barren detritus sliding down the slope.

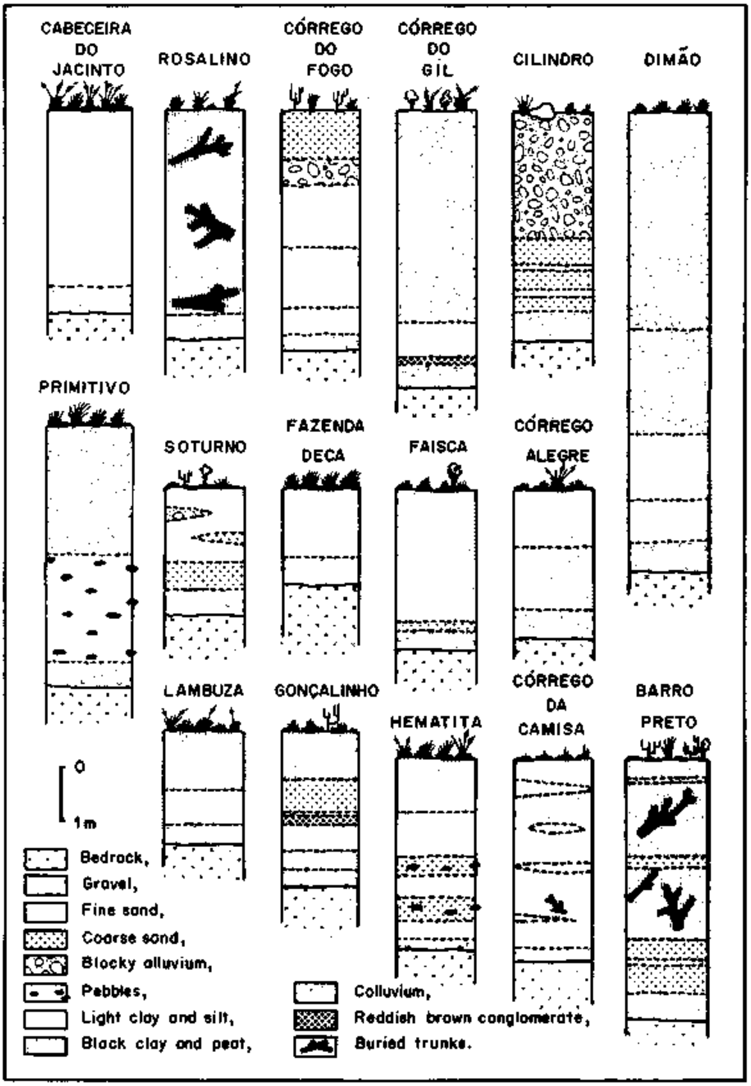
The *low slope colluvium* represents, in the vicinity of the alluvium, the result of the slight creep phenomena. This creep is accompanied by important mineralogical changes: the reddish-brown to reddish soil of the high slopes changes in the foothills to ochre or light brown in colour. Likewise, decrease of the magnetite and its alteration products, is counterbalanced by increase of ilmenite and/or monazite percentage in the heavy minerals fraction. Resistant mineral reloading occurs locally. In a sandy argillaceous soil reaching up to 10 metres in thickness, with some detrital quartz fragments, the chrysoberyl crystals and fragments are disseminated and worked by way of large irregular excavations, with vertical walls, always hand dug, as in the Curindiba prospect.

When no chrysoberyl occurs in the upper layers, barren colluvium of variable thickness may cover the gem-bearing outer alluvium (Córregos do Gil and do Fogo, Belmírio, etc.). For instance, at the Dimão prospect and vicinity, near São João Grande (Espirito Santo State), working of the mineralized gravel leads the diggers to search for its lateral extension until the riverside of the early creek is reached, that is to say below the slipped barren colluvium. This, 6 to 8 metres thick, was stripped with the help of a bulldozer during 1990 and 1991, allowing the discovery of magnificent large, partly gem-quality, V-twinned chrysoberyl crystals, some of them reaching up to 2 kilograms in weight.

Alluvial deposits

The so-called 'brejo' (= food plain) deposits are located at the bottoms of valleys, frequently occurring as swampy plains where the streams meander. The alluvial deposits vary from a few hundred metres to more than 2 kilometres in length, with a width of from some tens to some hundreds of metres. They are oval-shaped and may succeed one another, like a string, along one stream. Crosswise, the valleys show a flat bottom leaning by a nick against the lower slopes. In section, the alluvial deposits are usually characterized by a gravel bed lying upon the bedrock and overlaid by fine grained sediments. See some sections of alluvial deposits as

Fig. 8. Sections through various alluvial chrysoberyl deposits.



are shown in Figure 8.

The bedrock is variable, but invariably weathered below the placers and altered into a more or less plastic grey, beige or yellowish mass. The bedrock surface is undulating, showing pot holes, canyons more than 2 metres in depth (Córrego do Fogo) and large transverse ridges, or is asymmetrical, compared with the valley axis. Frequently, at both flat ends, the sole plate rises, forming a series of large elongated basins, where gravel was deposited, between rock thresholds which are passed by cascades and waterfalls. The resulting morphology leads to a series of high steps where hanging gravel beds are preserved. After gravel sedimentation, weathering of the bedrock took place. In order to explain this observation it must be kept in mind that the bedrock morphology is typical of hard rock river erosion. The argilization took place later, below the alluvial overburden resulting from weathering under a tropical climate.

The gravel, commonly fairly rounded, frequently contains medium to small sized, rare to abundant pebbles. It is an exception for multi-decimetre sized boulders to occur (Cilindro, southern tributaries of the Córrego do Fogo). After a few kilometres, the gravel grain-size distribution downstream quickly decreases and the fragile components disappear. Sometimes small boulders or coarse sand beds occur in the gravel. Moreover, what may be observed locally is a partial or entire iron hydroxide concretion of ferricrust type resulting from a tropical climate (Belmiro, Soturno) or a marked silicifica-

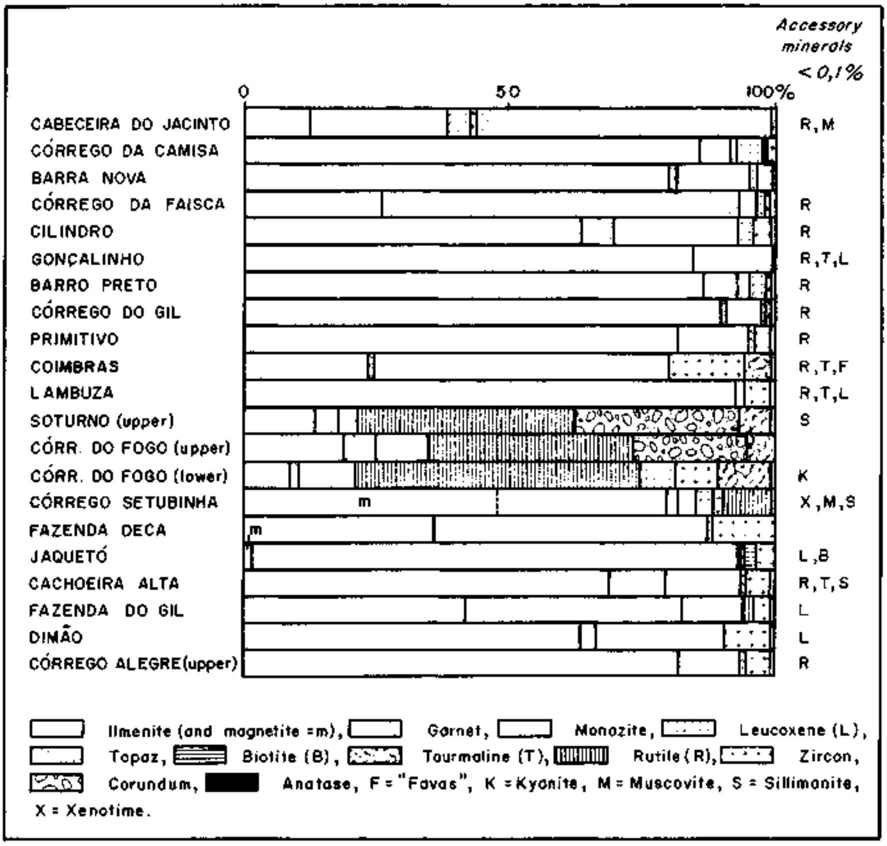


Fig. 9. Heavy minerals in some Brazilian chrysoberyl-bearing gravels.

tion corresponding to paleosoils (Primitivo, Córrego do Gil). The gravel is a few decimetres thick and it is an exception for it to reach up to 0.8 metre.

The gravel is invariably made of milky quartz, some of it being translucent to transparent or smoky quartz, associated with rock fragments, clay galls, feldspar in very variable amounts and, sometimes, a little muscovite and pisolites, in a poorly developed sand and clay matrix. In the coarse fraction (more than 2 millimetres in size) the chrysoberyl is associated with: aquamarine, garnet, schorl (locally with indicolite or rubellite), topaz, amethyst, smoky quartz, rose quartz and, in lesser amount, andalusite, iron oxides, niobotantalite, rutile, sapphire, zircon and moonstone. Research upon the fine fraction of panned heavy minerals (Figure 9) resulted in the finding of: anatase, andalusite, apatite, biotite, beryl, cassiterite, chrysoberyl, chrysocolla, cordierite, corundum, gahnite, garnet, hematite, hornblende, ilmenite, kyanite, leucoxene, 'limonite', magnetite, malachite, muscovite, nontronite, niobotantalite, pyrite, rutile, sillimanite, staurolite, rare-earths coatings, topaz, tourmaline, wolframite, xenotime and zircon. See for more details Cassedanne *et al.* (1984).

The overburden, barren and always fine grained in contradistinction to the gravel, lies abruptly upon the gravel. It is made of greyish, beige, yellowish or whitish coloured, more or less sandy clay, argillaceous sand and silt, irregularly superimposed, typical of flood plains. Interbedded locally are rich bluish-grey to blackish organic matter, plastic layers (Soturno, Barro Preto) with or without buried trunks, testifying to old turf-moors established in ox-bows (Rosalino) where pyrite neoformation sporadically occurs (Córrego do Fogo). Sometimes thin beds of cross-bedded coarse sand attest to short renewed torrential erosion periods (Barro Preto). Sandy or sand-free, kaolin layers and beige argillaceous brown mottled horizons evoke paleosoils. A mantle of large boulders descending from the steep slopes overhanging the streams, is rarely present (Cilindro). The overburden is always thicker than the gravel, reaching up to 4 metres in thickness. It grows thinner towards the heads.

Thus, the alluvial deposits correspond to more or less sorted torrential layers belonging to an old erosion period, abruptly overlain by finer sediments of a more even regime. Frequently the proximity of the gem-bearing source rocks may be inferred from field observation: large chrysoberyl crystals point out the proximity of more or less broken down pegmatites which, apparently, have never been sought after by prospectors (São João Grande, Jaquetó or Córrego da Faisca). Frequently the nearness of pegmatites may even be inferred by: the abundance of sharp-edged topaz and muscovite crystals (Cabeceira do Jacinto), metre sized blocks of roze quartz (Alto Lagoa), almost unaltered biotite (Pau Brasil) or quartz from the graphic pegmatitic zone (Rosalino). However, it must be pointed out that, frequently, the chrysoberyl and some associated minerals are more rounded than the rest of the gravel. This observation demonstrates the importance of the relatively long transit creeping, accompanied by the red clay abrasion between the source rocks and the alluvium.

The main geomorphological features of the present relief were in the same position from the beginning of the alluvial deposits formation. In the valleys subjected to tropical and arid climates, in potholes, canyons and basins developed between the falls, which were remainders of former erosion cycles. From turbulent mud flows, the gravel deposition probably took place during local violent floods of short duration. Unsorted fragments coming down from the sparsely wooded adjacent slopes, or resultant from previous floods, were transported a short distance. Towards the end of every flood, a vanning of the finer particles took place. During this period, mechanical erosion augmented a weak chemical erosion. As consequence of a rapid climatic change, the earlier conditions were reversed: a predominantly dry climate may follow a tropical one where, under a thick forest, the chemical erosion predominates. Assisted by a deep rock weathering, this erosion will supply fine and argillaceous sediments to the valleys. During this period, marshes settle in the bottoms, where important terrigenous sedimentation and euxenic lens formation takes place, after the sudden decrease of the stream flow. Locally, temporary accidents disturb the terrigenous sedimentation. The chrysoberyl-bearing gravels probably were deposited during a dry climatic period approximately 40,000 years ago (Turcq *et al.*, 1987).

The search for alluvial deposits empirically is made by means of short pits haphazardly sunk in the flats. If gems are unearthed, the swampy or uninhabited valley converts into a diggers ant hill after a garimpeiro's rush. They turn the flat of the new deposit upside down before leaving it, regarding it as a worked (or not) area. Commonly working is done by a reduced garimpeiros team. A timbered square pit, a few metres in size, is sunk down to the bedrock, the overburden being indiscriminately dumped roundabout. When the gravel is reached, it is piled up on the flat surface, near the pit, the argilized bedrock being carefully cleaned up. Ever

Fig. 10. Two stage excavation of a pit. Soturno alluvial deposit (Minas Gerais State).

present seeping water is removed by small motor pumps. Finally, the gravel is washed upon a coarse sieve and the residue thrown into the now flooded pit. The sorting by hand of the highly coloured gems, among the prevailing milky quartz, is easy. Sometimes, part of the overburden is scraped by bulldozer (Córrego da Faisca, Córrego do Fogo, São João Grande), after draining of the flat by some deep trenches, or diverting the stream. Ground sluicing is rarely used (Córrego Topázio, tributary of the Córrego da Faisca).

Locally, working is done using a 'dredge', a small horizontal gravel pump set upon a steel pontoon. After building a dam, part of the deposit is flooded, then the overburden is pumped out as mud and rejected downstream below the dam, where a new flat is reconstituted. Locally buried trunks make dredging difficult. When the gravel is almost outcropping, a pit is sunk to the bedrock and water supplied by a stream deviation. The gravel is shovelled into the pit and mixed with a lot of water, before pumping and discharging upon a tilted sieve with a 3 to 5 millimetre aperture. The undersize passes through the sieve towards the dumps, but gravel and pebbles are secured and hand sorted. When gravel cannot be exposed, because water is too abundant, it is directly pumped out from the

Fig. 11. Removing a peat horizon in the overburden. Córrego do Fogo alluvial deposit (Minas Gerais State).

Fig. 12. Washing and sorting the chrysoberyl-bearing gravel. Rosalino prospect in the Córrego do Fogo alluvial deposit (Minas Gerais State).

Fig. 13. Working an alluvial deposit by means of a small dredge, near Teófilo Otoni town (Minas Gerais State).

bottom of the flooded excavation. This way leads to a variable loss of gems during the gravel dredging and consequently to a lower chrysoberyl recovery.

There are no reliable reports upon possible reserves, production or chrysoberyl gravel grade, whatever the prospect type. However, the chrysoberyl must be valued roughly as a few grams at most per cubic metre of gravel, of which gemmological properties are highly variable. Frequently eluvial and colluvial grades are far lower. Locally some coloured gemstones are recovered as by-products of the alluvium treatment: aquamarine, garnet, tourmaline; but industrial mineral is never recovered, although locally comprising a substantial part of the heavy undersize, particularly rutile (Córrego do Fogo) or monazite.

Location of the chrysoberyl detrital deposits

Minas Gerais

This State was the first chrysoberyl producer. From the eighteenth century the gem has been worked in the Rio Araçuaí basin, near the town of the same name (formerly Calhau) and in the tributaries of the river: Calhau, Gravatá, Lufá, Rabelo, Urubu, dos Neves (Costa Sena, 1881), Novo (Leonardos, 1945a) and Santa Maria (Arena, 1956). Presently these deposits, where chrysoberyl was associated with andalusite, sillimanite, spodumene and coloured tourmalines, have been worked out or abandoned and are mainly of historical interest.

The actual output proceeds from the Padre Paraiso-Americanas, Malacacheta and Itabira areas, where almost all active prospects are located.

Between *Padre Paraiso and Americanas*, about 90 kilometres to the NNE of Teófilo Otoni town, a great number of prospects, some worked for more than 50 years, comprise the larger concentration of chrysoberyl workings in Brazil, making out a WNW-ESE trend. The Córrego Barra Nova flows to the east, the Córrego da Faisca to the west and the Ribeirão de Santana in the centre, the last two being tributaries of the Rio Mucuri. The main deposit, near the elevation of 550 metres, is located at the Córrego da Faisca Fazenda (= farm) de R. Zimmer and its small tributaries, with various prospects: Cachoeira do Gato, Crisolita, Filuca, Córregos do Marcolino, Limoeiro and Topázio; Gameleira, Topazinho and Topazão. The area is mountainous with bald garnet-rich kinzigite inselbergs, looking down on deep valleys. The deposit produces chry-

Fig. 14. Discharging the pumped chrysoberyl-bearing gravel. Gravel and pebbles are retained by the sieve before hand sorting. Medina alluvial deposit (Minas Gerais State).

soberyl and cat's-eye associated with aquamarine, amethyst, smoky quartz (= morion), topaz and tourmaline with a little andalusite and very rare alexandrite. Garnet is abundant in the heavy panned fraction.

Towards the west a series of prospects exists, part of which is abandoned (see Figure 2 – in part after Vargas, 1992): Barra Nova 1 and 2, Boa Vista, Argimírio Gonçalves, Fazenda A. Tavares (Lavra do Bejú), Antônio Ramos, Córrego dos Veados, Córrego do Cisco, Córrego do Martim, Simião, Córrego do Veado, Córrego do Gil (more than 2 kilometres long flat located ESE of the Ribeirão de Santana hamlet and worked for twenty years), Barro Preto (working alluvium caught between kinzigite fallen blocks, in one Córrego do Gil affluent), Lavra do Ribeirão, Gonçalinho, Mutum, Moreno, Zinco, Cilindro and Zequinha (working a long narrow flat between blocks fallen in from the surrounding steep slopes). To the east and south are: Faisca 1 and 2, Baixão, Crisolita, Manoel Pica Pau, Fazenda João Edilberto (Córrego das Gameleiras), Belmírio Poaiá, Curindiba (Arlindo Miranda and Abílio Preto), Primitivo Moreira and Valtinho. This region, where many gems were produced in the past from alluvium, terraces and low colluvium, is also known as Americanas or Americaninhas, the name of a nearby hamlet. (See Proctor (1988) for historical data and detailed description of some deposits.) Output was mainly of chrysoberyl, with a lesser amount of cat's-eye, both associated with aquamarine, morion, topaz and tourmaline with rare garnet and andalusite. It is an exception to find alexandrite in this area.

About twenty kilometres to the ENE of Padro Paraiso, in the important outlying Pedra (or Córrego) da Camisa prospect, more than 300 diggers were actively working during 1990. The flat extends about 800 metres along the stream, a little before its junction with the Rio Anta Podre, and produces chrysoberyl and cat's-eye associated with much schorl, morion and topaz, with a little garnet, andalusite, amethyst and moonstone.

Fig. 15. After removing the thick reddish barren colluvium caused by sliding, workers found large V-twinned chrysoberyl crystals in the alluvial gravel of this flat in the Córrego Alegre (Dimão prospect – Espirito Santo State). See the 3 crystals in Figure 6.

In the south, after an hiatus corresponding to the Córregos Marambaia and Santa Cruz basins, famous world-wide for their great aquamarine production, exists another series of prospects, almost all abandoned. The Lavra dos Coimbras which produced fine small alexandrites from a wide flat of the Rio Comprido must be noted. The Chico Rodrigues, Córrego Lútero and Genipapinho prospects are located nearby.

The *Córrego do Fogo* deposit, 15 or so kilometres to the NNW of Malacacheta town, discovered about 1975, is one of the more important in Brazil. There, between 830 and 870 metres in elevation, along the full length of the stream which runs ESE-WNW in a narrow valley, as in its southern tributaries and the Córrego Setubinha (to which flows the Córrego do Fogo), a series of prospects succeed one another (Garimpos Rosalino, da Safira, João Rodrigues, do Baiano, Abel, etc.). The deposit produces chrysoberyl and alexandrite and a few small sapphires associated with aquamarine, rubellite and some garnet and andalusite. Alluvium is rutile-rich, with large rose quartz boulders and, locally, pyritic peat horizons.

About 10 kilometres to the north, still in the Rio Setubal basin, the Soturno prospect works, at nearly 830 metres in elevation, in a narrow valley, a WNW-ESE running flat, one kilometre in length. The production is the same as that at the Córrego do Fogo. Small hematite roses are common in the gravel.

Approximately 20 kilometres to the north-west of the Santo Antônio do Jacinto town, various prospects are almost abandoned: Pau Brasil, Cabeceira do Jacinto, Talismã and Enchadão. They produced chrysoberyl associated with much colourless topaz with a few cat's-eyes and aquamarines.

The Lambuza prospect, to the SSW of Pavão town, is re-working a wide flat which produced aquamarine in the past (while chrysoberyl was not sought). Cat's-eye and alexandrite associated with the same minerals occurring in other nearby prospects are recovered.

The *Hematita mine* (also called Nova Era and Itabira), 4 kilometres to the SSW of the homonymous hamlet and 20 kilometres to the ESE of the Itabira town, is probably the richest alexandrite concentration in the world, located near the junction of two creeks that flow into the Córrego da Liberdade. The flat, 200 metres in length and 150 metres wide, encloses a kaolinitic gravel, probably an eluvium or colluvium almost unsorted, in which the alexandrite grade is exceptionally high. The alexandrite fragments, with many faces, subangular, are frequently centimetre sized. After two diggers invasions following the discovery in 1986, the deposit is presently mechanically worked by a sole mining society, but is in the process of closing because of the exhaustion of the detrital reserves. A few occurrences are sited in the neighbourhood.

Fig. 16. Córrego da Camisa alluvial deposit, near Padre Paraiso town (Minas Gerais State).

Various other chrysoberyl localities are mentioned, without details, and commonly lost: Serro (Ferraz, 1929), Rio Mucuri tributaries (Leonardos, 1945b), Caraí, Itambacuri, Joaima, Medina, Mucuri (Abreu, 1963), Santa Luzia de Carangola (Serra dos Arrependidos) and Fária Lemos (Franco *et al.*, 1972), Pouso Alegre (Rio Sapucaia Mirim), Rio Suaçuí Grande, Minas Novas, Turmalina (Rio Itamarandiba) and Berilo (Schobbenhaus *et al.*, 1984).

Fig. 17. Working a chrysoberyl-bearing pegmatite, during 1990, near Barro Preto (Minas Gerais State). The pegmatite may be seen along the small brown step in the foreground.

Bahia

Chrysoberyl deposits are smaller than those of Minas Gerais State, mostly abandoned and located in the south-eastern region of the State (see Cassedanne, 1984, for more details). In the northern area of the aforesaid region, the prospects of São João do Sul (Olavo, Fazenda E. Motta), Guaratinga (Lavra da Libidinosa, Fazenda Monte Carmelo), São Paulinho, Alho (Fojó Velho, Cacheado), Imbauba (near São João da Prata), Córrego da Queixadá, Lavra da Copacabana and Lavra do Corró (Itanhém) are practically abandoned, and the Jaquetó prospect (Salomão, where a very pale V-twinned alexandrite crystal, 6250 grams in weight, was unearthed) is in the process of closing.

Near Itamaraju, to the east of the São João da Prata hamlet, small prospects in the flats of the Fazenda Deca (Bom Jesus) and Palmito, between 90 and 100 metres in elevation, are located along tributaries of the Rio do Sul. There chrysoberyl and alexandrite are associated with a few cat's-eyes, aquamarine, garnet, andalusite, tourmaline, rose quartz, amethyst and zircon.

To the ENE, near Medeiros Neto town, two prospects are in reduced activity: Cachoeira do Mato at an elevation of 290 metres and Cachoeira Alta at 330 metres, both in hanging valleys overlooked by inselbergs. The output is made up of chrysoberyl with very little alexandrite, associated with aquamarine and tourmaline and a little garnet and rose quartz. The prospects of Pial (São José do Prado), Córrego da Areia (Medeiros Neto) and Juerana (Teixeira de Freitas) are abandoned. The latter two produced aquamarine and chrysoberyl.

In the neighbourhood of Santo Antônio de Alcobaça, the Palmeiras prospect, in process of closing, worked at an elevation of nearly 150 metres, a 2 kilometres long flat cut into a broad pediment. There, alexandrite and chrysoberyl are found in association with garnet and amethyst and rare aquamarine. The nearby prospects of Coité and Cachoeira are abandoned.

A deposit discovered in 1983, in the Fazenda do Gil, 500 metres from the riverside of the Rio Alcobaça, works a flat more than 1 kilometre in length, and produces chrysoberyl and alexandrite associated with aquamarine, garnet, tourmaline and rose quartz.

Chrysoberyl is also reported, without details, in Jacunda and Mata Verde.

Espirito Santo

The greatest deposit is that of the Córrego Alegre (Dimão, Minguinho, Nelson Costa, etc.), near São João Grande, 20 or so kilometres to the northwest of the Colatina town. There, a string-shaped flat, more than 3 kilometres in length, occurs through low hills with inselbergs above, between 100 and 120 metres in elevation. The production is made up of chrysoberyl and cat's-eye. Crystals of the former with numerous faces, frequently V-twinned and reaching more than 2 kilograms in weight, characterize the output of this region, where the medium size of the crystals, as a whole, is always greater than in the aforesaid prospects. Moonstone fragments are common in the gravel as are aquamarine, garnet and amethyst. In the neighbourhood, the São João Pequeno prospect is abandoned as is that of Pancas which produced chrysoberyl and fine cat's-eye.

The other prospects: Vargem Alta (Franco & Campos, 1965), Santa Teresa area (Tancredo), Vargem Alegre, Ibiraçu, Fundão (Córrego das Piabas), Cachoeiro do Itapemirim and Córrego Melgaço (Putzer, 1956), are practically abandoned.

Sao Paulo

This is the only other State where alluvial chrysoberyl is reported, but without details. In the Serra de Taquaxiara (near São Paulo city), it occurs in the gulches that flow into the Rio M'Boi Mirim (Knecht, 1934).

Fig. 18. Partial view of the Córrego do Fogo alluvial deposit (Rosalino prospect) where chrysoberyl is associated with some sapphire (Minas Gerais State).

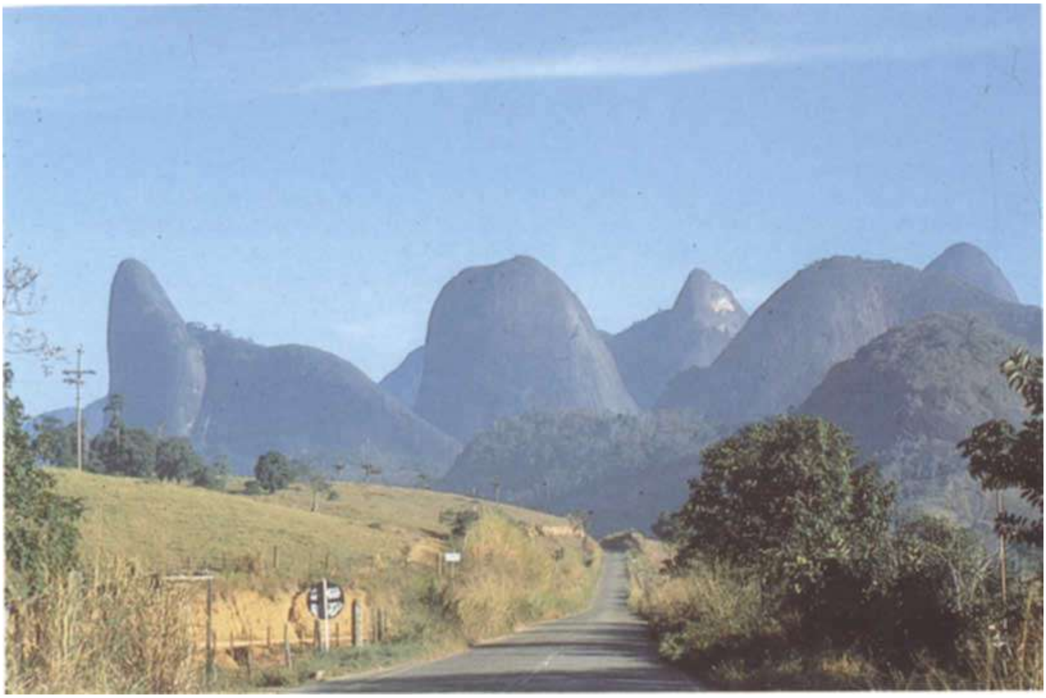


Fig. 19. Typical 'inselberg' landscape of the chrysoberyl-bearing areas. Road from Colatina to Pancas (Espírito Santo State).

Chrysoberyl associated with other gems

Chrysoberyl is frequently associated with other gems worked in alluvium, such as diamond, beryl and andalusite. It is locally recovered as a by-product.

Chrysoberyl from the diamond-bearing gravels is considered a common fellow-traveller mineral (Arena, 1956). It is reported from the State of Bahia in Lençois, Andaraí, Rio Paraguaçu (near Bandeira de Melo town) and Camaçari (cat's-eye) by Hussack (1917) and in Limões (Arena, op. cit.). In the State of Minas Gerais, chrysoberyl was observed in several flats in the Jequitinhonha valley, associated with andalusite, pyrope and hessonite (Bastos, 1962), particularly near Diamantina (Hussak, op. cit.), Lavrinhas (Cassedanne, 1971) and Três Ilhas. Chrysoberyl is reported from the São Paulo State by Hussak (1917) in the Patrocínio do Sapucaí township (Rios Santa Bárbara and Canoas, tributaries of the Rio Grande), in the Goiás State (Rio Claro) and in the Mato Grosso State (Rio Coxim, associated with sapphire). Limaverde (1980) reports chrysoberyl in the diamond gravel of the Rio Jauru, in the same State.

A little chrysoberyl is commonly associated with the aquamarine in its alluvial deposits, mainly in the State of Minas Gerais: Serrinha near Medina (with some alexandrite), Rios Marambaia (Córrego do Felipe) and Santa Cruz (Lavra das Manilhas, Urubu) valleys, among others. Chrysoberyl is also scattered in the aquamarine-bearing gravel of Juerana and Jaquetó deposits, in the far southern Bahia State, as in Fazenda Antônio Boffi (near Guaraná) and near Nova Venécia, both in Espirito Santo State.

Lastly, chrysoberyl is an accessory component of the gem andalusite-bearing gravels in the neighbourhood of Santa Teresa town (Serra do Prego, Ribeirão Caldeirão) in the Espirito Santo State.

The gems

Chrysoberyl belongs to the orthorhombic system. In alluvium it occurs as rounded or sub-rounded grains, chips and variably sized fragments, sometimes as crystals. These are long or wide with right-angled or sub-square section, or else platy, with longitudinal grooves upon the larger faces. Twins are common, frequently V-shaped with or without re-entrant angles, formed by two prisms or flat crystals. Hexagonal wheel-twins, crenellated or not, are not rare, but quite often small. In the gravel, crystals are millimetric to centimetric in size, rarely reaching up to 10 centimetres in length, partly rounded (head of the Córrego da Faisca), in elongated prisms or V-twinned. The Córrego Alegre deposit near Colatina town (Espirito Santo State), has been world famous for a long time for its large, partly gem quality, crystals many reaching more than one kilogram in weight. Recently a series of V-twinned crystals, with marked grooves, lightly rounded with sides exceeding 15 centimetres in length, olive green to dark green, were unearthed at São João Grande. The splendid, wonderful, translucent crenellated wheel-twins, yellow to olive green in colour, reaching up to 8 centimetres in diameter, from Ituaçu (Espirito Santo State), belong unfortunately to history. The Carnaiba emerald deposit produced flat opaque hexagonal twinned crystals, several centimetres in diameter.

Crystals found in pegmatites are commonly platy or V-twinned (Padre Paraiso), many being heavily shredded as a result of growing among micaceous minerals.

Hardness is 8.5. The fracture is conchoidal to uneven and the single poor cleavage is seldom observed.

Chrysoberyl is transparent to translucent, sometimes turning opaque due to very small black or brown inclusions. It is colourless (Barra Nova), milky (if so, not collected), pale yellow, vivid yellow, golden yellow, greenish-yellow, greenish, greenish-grey, dark green, beige or brown, sometimes grey, bluish-grey or blackish. The last three shades are common in the sand fraction, but infrequent in the gravel, and seldom collected. Locally opalescent (tributaries of the Ribeirão Americanas), the chrysoberyl often displays chatoyancy with a sharp line, occurring as cat's-eye with a more or less dark colour, golden and honey hues being the most sought after. Alexandrite appears greenish-blue, bluish-grey, dark green or brown in daylight, turning pale pink, reddish, reddish-brown or purple when examined for transparency before an incandescent light. The Hematita alexandrite shows a 'fabulous' colour-change according to Koivula (1987): bluish-green to greenish-blue passing to pink, raspberry, 'rhodolite' or ruby in colour, while other Brazilian alexandrites recovered in the past change only from green to violet or pink.

Lustre is vitreous to almost pearly, the streak colourless to pale beige. As crystals are frequently large and partly transparent, faceted chrysoberyl may be more than 100 carats in weight, as compared to the usually small faceted alexandrites. Yellow cat's-eye may weigh more than 40 carats, whereas cat's-eye alexandrites are extremely rare and seldom weigh a few carats.

Mean density of yellow chrysoberyl and cat's-eye is $3.68 g/cm^3$, higher and lower measured densities being 3.72 and $3.62 g/cm^3$. Density of brown chrysoberyl showing various shades varies from 3.75 to $3.80 g/cm^3$. Alexandrite density is 3.68 to $3.70 g/cm^3$.

Chrysoberyl is biaxial (+) with 2V near 70°. Typical refractive indices of pale yellow, golden and greenish chrysoberyl are: α = 1.744-1.745 β = 1.746-1.749 γ = 1.753-1.754. Exceptionally, samples associated with gem andalusite, from the Santa Teresa area (Espirito Santo State), gave: α = 1.747 β = 1.749 γ = 1.757. Typical indices of alexandrite are: α = 1.745-1.747 β = 1.748-1.749 γ = 1.755-1.756. Some pale alexandrites from Córrego do Fogo show: α = 1.745-1.746 β = 1.748-1.749 γ = 1.754-1.755, and a sample from Carnaiba gave: α = 1.747 β = 1.748 γ = 1.756. A 0.008 to 0.010 birefringence is deduced from the previously reported indices.

Chrysoberyl and cat's-eye show a distinct pleochroism in the yellow and brown shades. Alexandrite, on the other hand, displays a marked pleochroism: dark red/orange to yellow/green.

The gravel grain surfaces are frequently pitted or show impact figures from which wavy cracks commonly diverge. Triangular positive (Pau Brasil) or negative marks may be observed upon some crystal faces. Gravel fracture is sometimes furrowed by parallel or divergent scratches. Because of their alluvial transport, many grains show large, impact, divergent, undulated, flat or conchoidal cracks and fissures, frequently producing iridescence, or are invaded by iron oxides. The latter, under microscopic examination and an adequate incident angle, present a golden gleam. Some small bayonet or grid-shaped fissures occur in some crystals (Santa Teresa).

Many pale yellow, golden yellow or greenish chrysoberyl grains are totally free of inclusions or imperfections under microscopic examination. In other grains, the most frequent inclusions are fissures with very small bubbles (Córrego do Gil) or, more often, finger prints (Córrego da Faisca). Small negative crystals are scattered or concentrated in parallel lines upon the inner crystal planes (Belmírio). When very small inclusions are thickly gathered upon conchoidal inner fractures, the crystal turns milky. Large two-phase inclusions are locally present (Lambuza). Unusable parts of many crystals are due to regular or no alternation of thick milky bands (caused by very small inclusions arranged in strips) and thinner transparent ones.

Little grey metallic plates, probably ilmenite, are common just underneath the faces of some crystals, and are easily eliminated during the cutting process. When present throughout the rough, the crystals turn opaque and are therefore useless as gems (Barro Preto).

Golden rutile needles, irregularly distributed and without preferential orientation are sometimes abundant (São João Grande), recalling those occurring in quartz crystals. Gübelin *et al.* (1986) reported goethite fibres in chrysoberyl from Bahia State.

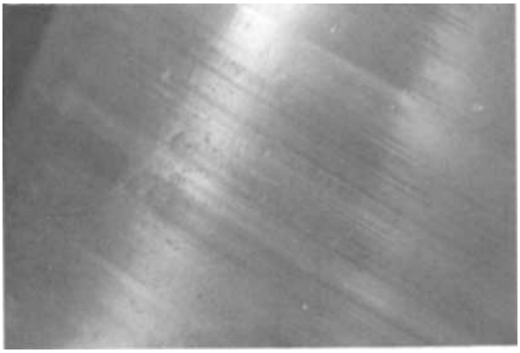


Fig. 20. Fine tubes in a cat's-eye from the Córrego da Faisca area (Minas Gerais State).

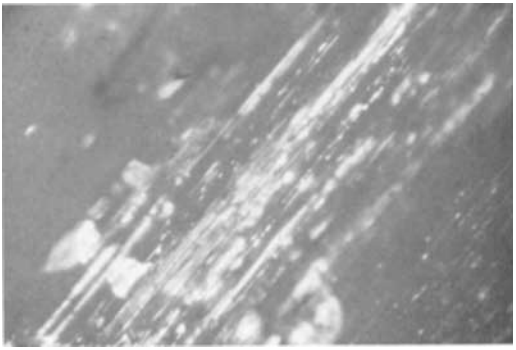


Fig. 21. Large tubes in a cat's-eye from the Córrego Alegre area (Espirito Santo State).

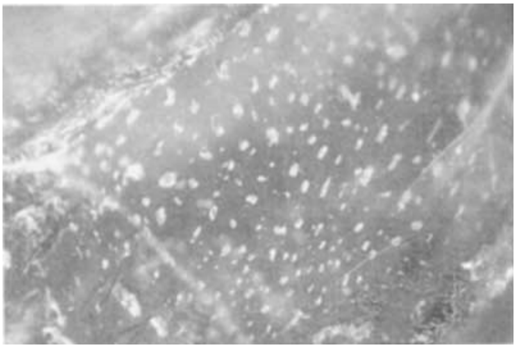


Fig. 22. Small two phase inclusions forming veils in a chrysoberyl from the Córrego da Faisca area (Minas Gerais State).

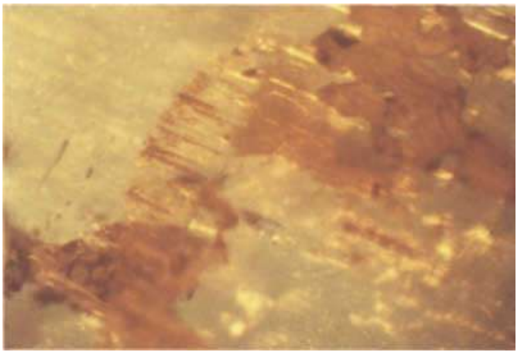


Fig. 23. Iron oxides filling a fissure in a chrysoberyl from the Córrego da Faisca area (Minas Gerais area).

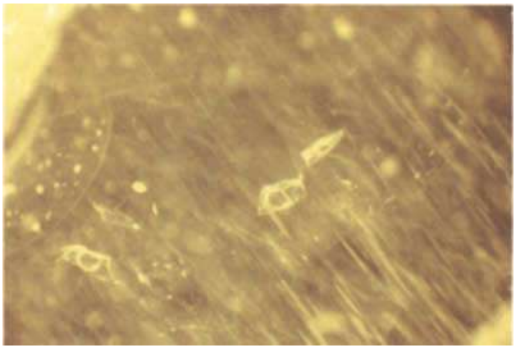


Fig. 24. Two phase inclusions in a cat's-eye from Lambuza (Minas Gerais State).

Fig. 25. A fine cat's-eye cabochon from Córrego da Faisca (Minas Gerais State).

Fig. 26. A fine banded cat's-eye cabochon, 23.51 cts in weight.

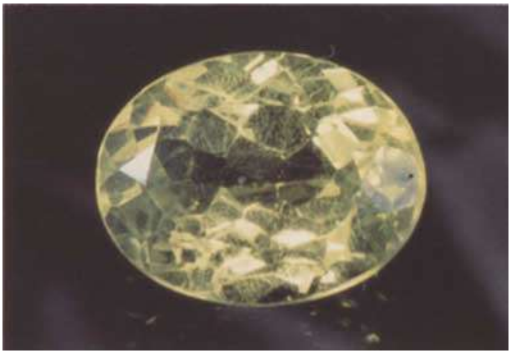


Fig. 27. Large faceted transparent chrysoberyl.

Fig. 28. Fine faceted Hematita alexandrite seen in incandescent light.

Fig. 29. Large two phase inclusions in a chrysoberyl from Lambuza (Minas Gerais State).

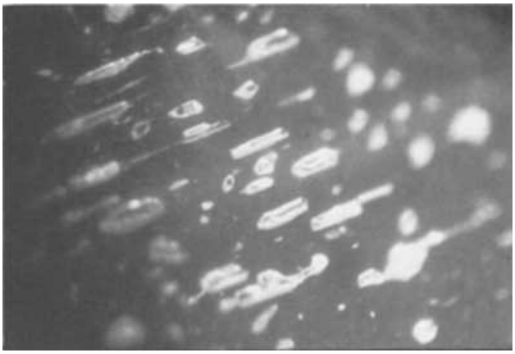


Fig. 30. Rutile needles in a chrysoberyl from São João Grande area (Espirito Santo State).

With the exception of Hematita, no deposit has revealed characteristic inclusions, although small crystals may be commonly observed in many gems under microscopic examination (the aforesaid cited prospects were only a few examples among many). According to Koivula *et al.* (1988) fluorite would be typical of the Hematita alexandrite, associated with apatite. Henn (1985) determined the following inclusions, for which chemical analyses are reported, in Brazilian chrysoberyls of imprecise location (because various prospects are known in each location): muscovite, andalusite and orthoclase at Três Barras; orthoclase and albite at Malacacheta; actinolite, talc and anthophyllite at Córrego do Fogo; albite, oligoclase, anorthite and andalusite at Água Fria; andalusite at Jaquetó; the examined samples from Colatina were inclusion-free. Lastly, Gübelin (1974) records radiating amiant fibres, sea-urchin like and biotite plates (Gübelin *et al.*, 1986) in Brazilian alexandrites of unknown origin.

Growth zones appear as narrow stripes with different hues (Juerana). Twin planes may be sporadically observed.

Tubes varying in length and diameter, hollow or not, are constantly present in cat's-eye and sometimes in yellow or greenish chrysoberyls, but very rarely in alexandrite; they are parallel to the crystal elongation.

All chrysoberyl varieties are free of radioactivity and are subject to very little deterioration. That property explains the easy preservation in alluvial gravels.

Colourless, yellow and greenish chrysoberyls and cat's-eyes are not fluorescent. Alexandrite, when light coloured, is inert under UV light (Córrego do Fogo), but has a weak orange/red when its body colour is darker (Carnaiba).

Yellow and greenish chrysoberyls and cat's-eye show a wide absorption band centred at 445 nm (440-450) and weak lines at 485 and sporadically at 505 nm (Lambuza). Light alexandrite from Córrego do Fogo shows a band between 680-690 (doublet), a partial absorption between 620 and 545 nm and total absorption beyond 470 nm. The weak additional lines reported by Anderson (1971) were not registered.

Trace elements (Ti, Sn, Fe) of the Americanas area chrysoberyls, are identical to those of the Trivandrum chrysoberyls (India – Soman *et al.*, 1986). It must be pointed out that in four Brazilian alexandrites analyzed by Otteman *et al.* (1978) gallium reaches up to 1200 ppm associated with tin which diadochically substitutes for aluminium following the equation: $2\ Al^{+3} \rightarrow Sn^{+4} + Fe^{+2}$. Like alexandrite, colourless chrysoberyl contains gallium (Vogler, 1986), although Schmetzer (1985) reports otherwise. A partial analysis of Hematita alexandrite gave 0.30-0.44 wt% Cr_2O_3, 1.11-1.59 wt% Fe_2O_3 and 0.01-0.03 wt% V_2O_3 (Proctor, 1988 – quoting Bank & Schmetzer).

Conclusion

According to Elawar (1974) the total monthly Brazilian chrysoberyl output would be in the order of 10 kilograms in weight, only 10% of which is gem quality grade: 1% top, 3% average commercial and 6% lower commercial grades. The remainder is sold as by-product. Production probably increased with the opening of new prospects, as was the case of the Córrego do Fogo, before decreasing to the current one kilogram monthly (Elawar, personal communication, 1992) as a result of the abandoning and closing of many workings. No official record of the present or recent output is available, but it is possible to warrant that the exhaustion of Brazilian chrysoberyl reserves is not to be foreseen in the near future.

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[*Manuscript received 20 September 1992*]

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Jaspers from Swierki near Nowa Ruda, Lower Silesia, Poland

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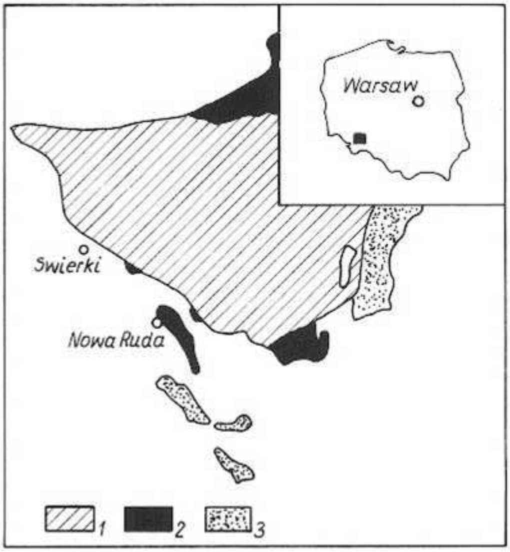
Abstract

The paper presents the results of mineralogical-petrographical and geochemical studies of jaspers occurring among Permian melaphyres (weathered basalts, often amygdaloidal (mandelstones)) and porphyries in the vicinity of Swierki near Nowa Ruda. Jaspers form a layer up to 1.8m thick. They mainly consist of silica represented by chalcedony, opal and quartz, as well as some admixtures of dolomite and micas. They are very interesting as a decorative material. Their origin appears related to low-temperature hydrothermal silification of sedimentary rocks occurring among melaphyres.

Introduction

Jasper is one of the more attractive and fairly common ornamental stones. This fine-grained massive rock contains marked amounts of iron oxides admixtures which may, in extreme cases, well exceed 20%. Its principal constituent silica is developed as chalcedony – either fibrous or spherulitic. Jaspers have a smooth and even fracture and their colour ranges from brick-red to blue. Besides occasional idiomorphic quartz concentrations, chlorite and opaque mineral inclusions are very frequent.

Fig. 1. Occurrence of rocks in the vicinity of Swierki: 1. gneisses; 2. serpentinites, gabbros and amphibolites; 3. old crystalline series.



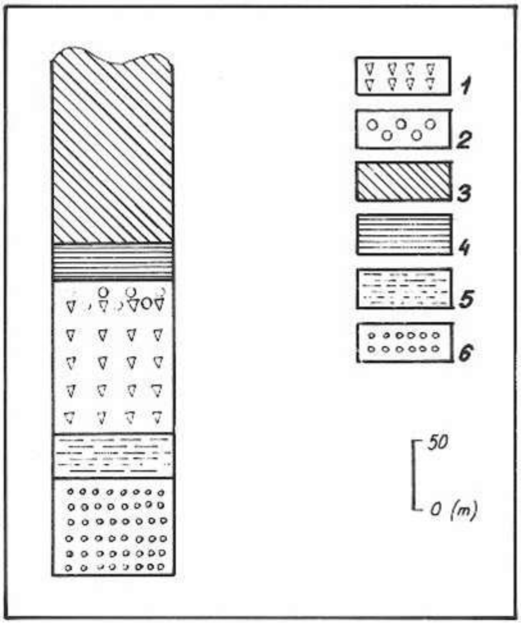


Fig. 2. Lithological profile of Permian rocks from the vicinity of Swierki: 1. compact melaphyres; 2. mandelstone; 3. porphyries; 4. schists intercalated with jasper layer; 5. clay shales; 6. sandstones.

Geology of the deposit

The jasper occurrence at Swierki near Nowa Ruda (Figure 1) is associated with melaphyres classified into the lower portion of the eruptive complex. This complex is underlain by shales occurring in the top part of the sandstone series (Figure 2). The melaphyre complex of Swierki is about 80m thick and composed of extensive lava flows partly of sub-volcanic nature. An amygdaloid-

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al zone has been identified in its upper part on the contact with the overlying shales above which a porphyry complex occurs classified into the second magmatic cycle.

Jasper occurring on the first level in the quarry forms a thick bed up to 1.5m dipping to the north at angles of 3-15° and showing distinct tectonic disturbances. The accompanying shales are thermally metamorphosed and distintegrated and the melaphyre is heavily fractured and altered. On the second exploitation level jasper is best exposed in the uppermost portion of the southern wall where it appears as a regular bed up to 1.8m thick. Also in this part of the quarry jasper is surrounded by thermally metamorphosed shale. The jasper bed is fairly compact and can be easily worked into blocks. Large blocks the size of several cubic metres are found at the foot of the wall on level two.

Jasper varieties found in the deposit

Varieties found in the jasper deposit at Swierki are cherry-red, red-grey, brick-red, creamy-green and green. They all have streaky hematite concentrations visible in hand specimens. The individual colour varieties form streaks or nest-like concentrations imparting an attractive colour pattern to the entire rock mass. The most common are red-grey jaspers while the green ones belong to the rarest and most prized varieties.

The red-grey jasper is dense and can be easily polished. Under the microscope it reveals a parallel, fluidal or unoriented texture. Its main chemical constituent is silica (Table 1) reaching up to 77% by weight and usually developed as chalcedony, usually fine-grained. Locally it is accompanied by spherulitic or fibrous forms. The rock also contains opal and quartz sometimes filling fissures and voids. The quartz is very often idiomorphic and then forms druses. All the constituents described above are unevenly scattered throughout the rock.

A constituent second in quantity is dolomite occurring in single rhombohedrons or filling fissure. Its amount does not exceed 15% by weight. Iron minerals are represented chiefly by hematite dispersed throughout the rock. Sometimes, however, their individuals, up to 0.01mm in size, show a linear arrangement accentuating the wavy structure. The amount of iron calculated as Fe_2O_3 does not exceed 0.6% by weight. But this amount is sufficient to impart to the rock a distinct coloration. Locally, in some voids and fissures the actual mineral succession can be easily traced: chalcedony attached to the wall is overgrown by quartz which in turn is overgrown by dolomite. As evidenced by the fact that dolomite veinlets cut all the other mineral concentrations this mineral is the final crystallization product.

Most often larger occurrences of green jasper are found close to the contact between the jasper bed and melaphyre. It is dense and uniformly coloured and can be polished easily. Under the microscope it is homogenous, fine-grained and shows an unoriented texture. Occasionally it contains minor dolomite amounts in the form of veinlets or rhombohedral individuals. Small opal concentrations are also present. In this variety the quartz content is 77,89% by weight (Table 1). Chemical results reveal the presence of 0.002% copper which is likely to be responsible for the green colouring. Rare mica scales and iron in the form of minute goethite pigment have also been identified under the microscope.

X-ray analysis

X-ray data were obtained from TUR 61 equipment within 0-25° range, with filtered CoKα radiation, goniometer and recorder speeds being 2°/min. and 600mm/h respectively.

X-ray data (Figure 3) reveal that both colour varieties differ only slightly in their chemical composition. In the X-ray diffraction patterns quartz reflections predominate for d_{hkl} = 4,25, 3,34, 2,45, 2,28, 2,24 and 2,13 Å. Also, as evidenced by reflections for d_{hkl} = 2,57 and 2,39 Å, minor

Table 1: Chemical composition (average) of jaspers from Swierki near Nowa Ruda in % by weight.

	Red-grey jasper	Green jasper
Fe_2O_3	0.59	1.85
SiO_2	77.79	77.89
TiO_2	0.12	0.34
CaO	4.15	0.43
MgO	3.29	2.05
Al_2O_3	4.44	8.96
Na_2O	0.28	0.34
K_2O	1.95	3.48
H_2O^+	0.39	1.97
H_2O^-	0.34	1.19
Loss of mass	7.01	3.63
Total	100.35	101.86

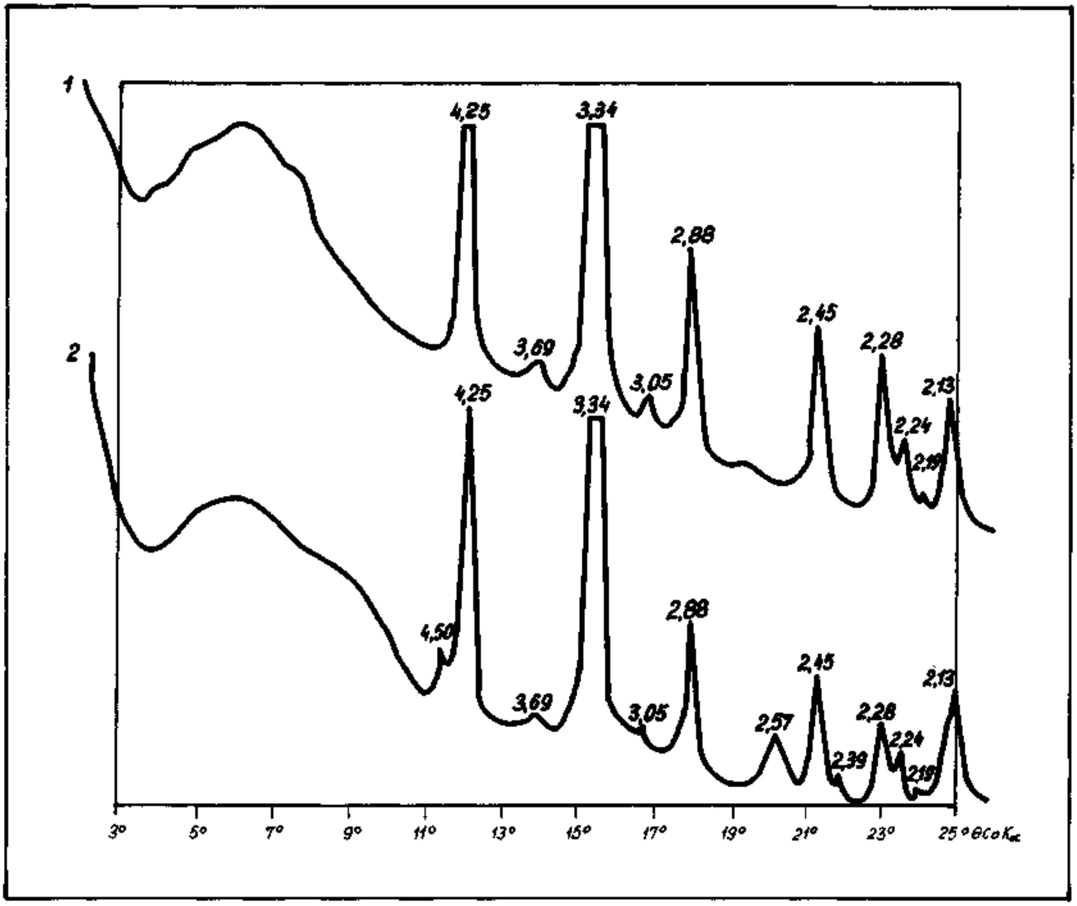
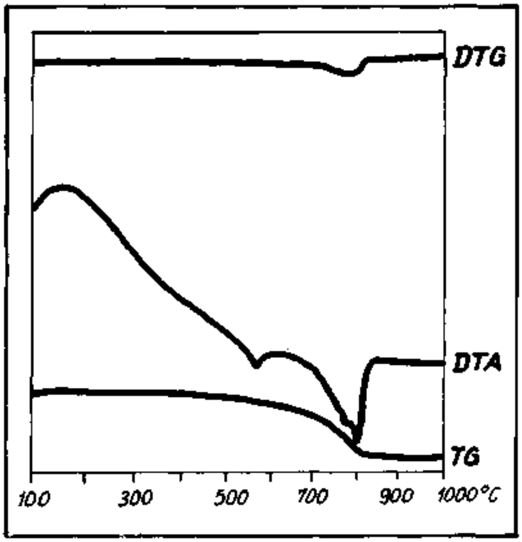


Fig. 3. X-ray diffractographs of jaspers: 1. red-grey; 2. green.

Fig. 4. DTA curves of cherry-red-grey jasper.



tenorite amounts may be present. The X-ray diffraction patterns for both coloured varieties show an elevated background within the 5-10 Å interval due to the presence of poorly ordered opal silica. The occurrence of poorly crystallized mixed-layer aluminosilicates cannot be excluded.

Thermal analysis

The thermal analysis was conducted within the 20-1000°C range using a Hungarian-made derivatograph, with 500mg samples and sensitivities DTG 1/3, DTA 1/3 and TG 100.

Thermal data (Figure 4) confirmed the presence of minerals identified previously. The DTA curve shows a weak endothermal effect at about 570°C related to polymorphic quartz transformation. The approximate 3% weight loss of the sample is due to dolomite dissociation as confirmed by two endothermal effects on the DTA curve at 780 and 800°C respectively.

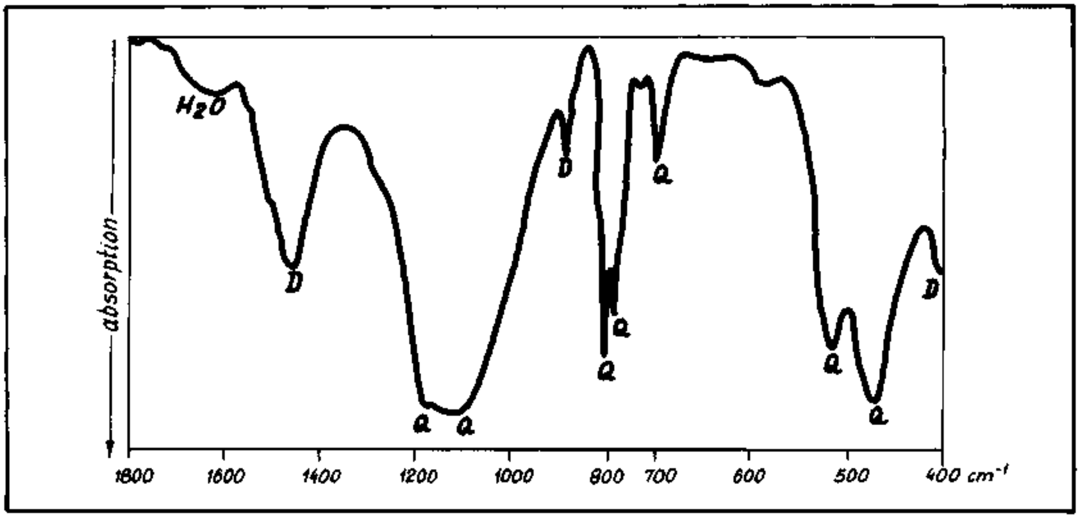


Fig. 5. IR absorption curve of cherry-red-grey jasper: D-dolomite; Q-silica (quartz and chalcedony).

IR spectrophotometric analysis

For IR spectrophotometric determinations within the 400-1800cm^{-1} range tabletized samples with KBr were used.

IR spectrophotometric data (Figure 5) for the jaspers examined point to the presence of small amounts of water with vibrations around 1650cm^{-1}. In addition, the absorption curve shows maxima distinctive of quartz (Q) and of dolomite (D). Vibrations around 1100cm^{-1} confirm the presence of opal. A small aluminosilicates admixture is indicated by vibrations within the 580-600cm^{-1} range.

Summary

Examinations discussed above revealed that jaspers from Swierki, Lower Silesia are built chiefly of silica developed as chalcedony and accompanied by minor amounts of opal and quartz. The rock also contains dolomite, hematite, aluminosilicates and trace amounts of copper minerals. Genetically the jaspers are connected with low-temperature silicification of shaly sediments by fluids migrating from the underlying melaphyres. Most probably silicification was accompanied by simultaneous hematitization, while the crystallization of dolomite and minor quartz amounts occurred after silicification.

Test Report on the Hanneman Mini-cube II

Peter G. Read, C.Eng., MIEE, FGA, DGA.

Bournemouth

The benefits gained by the immersion inspection of gemstones have been well documented[1]. To summarize, when a gem is immersed in a liquid whose refractive index is close to that of the gem, surface reflections are much reduced and light is able to penetrate the stone and reveal internal features. Immersion also helps in the identification of composite stones, as the differing refractive indices of the component parts of, for example, a garnet topped doublet will show contrasting outlines.

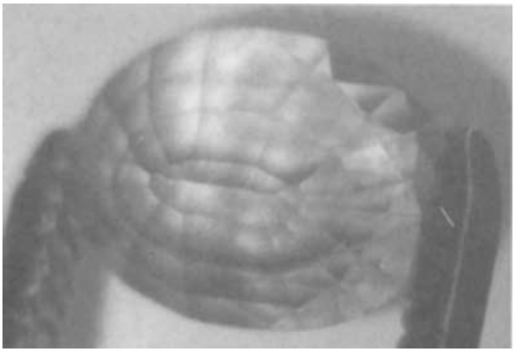


Fig. 1. Diffusion-treated Sri Lankan sapphire showing the spider-web effect produced by the concentration of colour at the facet edges

While in Sri Lanka in 1980, I was shown a sapphire which had come under suspicion because of its unusual evenness of colour. When immersed in water the colour concentration along the faceted edge became apparent (Figure 1), revealing the stone as one of the early diffusion-treated corundums. This effect, sometimes referred to as a spider-web, is made more obvious if the stone is immersed in a high-RI contact fluid such as di-iodomethane (methylene iodide).

With the increased production of diffusion-treated sapphires[2], immersion inspection has become one of several important screening methods in the detection of these stones. To meet this requirement, W.W. Hanneman, a pioneer in

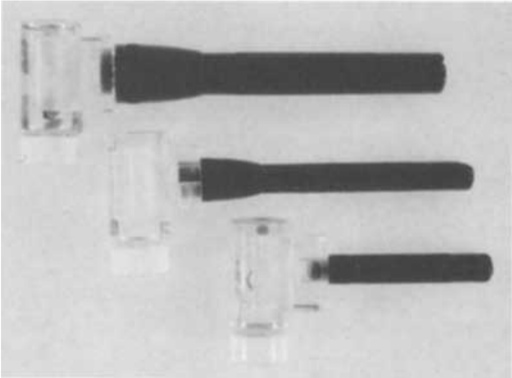
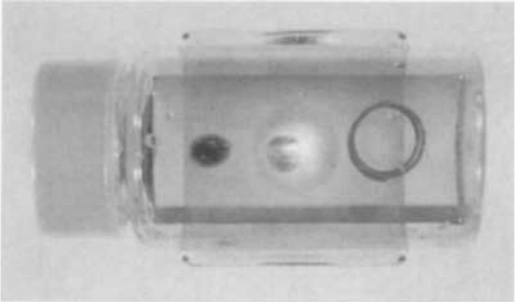


Fig. 2. Versions of the Mini-cube II designed for specific Mag-lite flashlamps. In the basic model, a black plastic mounting ring is fitted which has a 13mm diameter hole for a standard pen torch (the hole can be enlarged for other light sources)

the production of inexpensive gemmological test equipment, has produced the Mini-cube II. This instrument consists of a small glass cell with a screw top, a block of acrylic plastic milled out to take both the diameter of the cell and any suitable light source (e.g. a pen torch - see Figure 2). The milled surface of the plastic cell holder is left unpolished and acts as a diffuser for the light source.

Fig. 3. The immersion cell, illuminated from the rear by a pen torch fitted in the plastic mount, contains a sapphire immersed in di-iodomethane (the copper wire ring is to prevent discoloration of the liquid)



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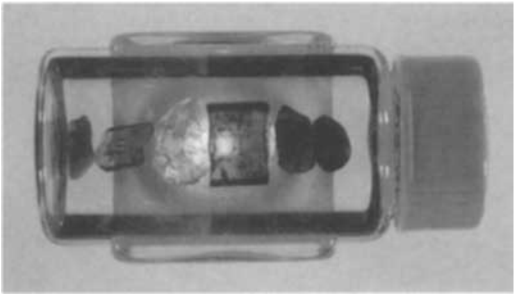

Fig. 4. Pieces of faceting-grade rough gem material being evaluated while immersed in baby oil

Figure 3 shows a horizontally positioned mini-cube containing a sapphire immersed in di-iodomethane. The coil of copper wire is provided to prevent darkening of the immersion liquid. In Figure 4, several pieces of faceting rough have been immersed for evaluation purposes, this time using baby oil as an alternative to the less pleasant high RI liquids (a concept introduced by A. Hodgkinson).

When used in conjunction with a pen torch and a 10X hand lens, the Mini-cube II forms a useful portable means of immersion inspection of quite sizeable gems (the cell neck diameter is 16mm) and immersion liquids can be safely left in the cell without danger of leakage. The Mini-cube II is marketed by Hanneman Gemological Instruments of PO Box 2453, Castro Valley, CA 94546, USA.

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1. Read, P.G., 1990. Reflections on reflectivity. *Journal of Gemmology*, **22**, 2, 97-102.
2. Koivula, J.I., *et al.*, 1992. Gem news - Update on diffusion-treated sapphires. *Gems & Gemology*, **28**, 1, 62-3.

Notes from Tucson '93

Eric C. Emms, B.Sc., FGA, DGA

Gemmological Association and Gem Testing Laboratory of Great Britain, London

Each year some 20,000 gemstone enthusiasts from around the world congregate in the city of Tucson, Arizona, in the south west of the United States. Starting in the mid-1950s with a small group of Tucson mineral dealers exhibiting their stock, the Tucson Gem Show is now not one but twenty different shows of varying size located at different hotel sites scattered around the city. The first fortnight of February is designated 'Tucson Gem and Mineral Days'.

Each show is organized by a different committee catering in the main for a particular market - for example fossil and mineral dealers would choose to exhibit at one show, while gemstone merchants would be attracted to another show. At the busy budget motels strung along a road close to the freeway, individual dealers, specializing in one type of gemstone, occupied the small bedrooms where they lived, slept, exhibited and dealt. A Hungarian would be dealing in East European minerals in one room, next door an Afghan would be selling his lapis lazuli, whilst a dealer showing his Baltic and Dominican amber would be in the next room. Such is the scale of the event that a visitor cannot hope to see and take in all that is on offer at Tucson.

The GAGTL decided to return to Tucson by exhibiting at the American Gem Trade Association (AGTA) GemFair - the prestigious coloured stone show housed in the modern, spacious Convention Center. Our aim was to promote our overseas membership and market our ever popular Diploma in Gemmology leading to the FGA. It was gratifying to learn from American gemmologists that the FGA is considered the pinnacle of gemmological education and that many Graduate Gemmologists wish to continue their studies by taking the FGA. The Gem Diamond Diploma leading to the DGA aroused interest, particularly in gemmologists from Canada and South East Asia. The Gem Testing Laboratory was highlighted by an illustrated talk I gave on gemstones recently seen in the Laboratory.

The topic of gemstone treatments was much discussed at the GemFair, especially diffusion treated sapphires, the prevalence and durability of fracture filling of emeralds and how these treatments should be explained and described to the consumer.

The shows appeared well attended and although some exhibitors were disappointed with the business conducted, others reported good sales. I was impressed with the quantity, quality and popularity of tourmalines on display, especially the red variety. The Paraíba tourmalines in a wide range of colours were more in evidence than I expected, accompanied by the similar colours of apatite. Tanzanite in strong to deep saturation and large sizes (over 10ct) was abundant, as were good-coloured peridot from the US and Burma. Peridot from China and Kenya was also in evidence.

The large number of red spinels from Burma impressed, at attractive prices in comparison to fine coloured Burma rubies on display. Pinkish-red Vietnamese rubies were for sale, one certified at over 8ct, although most dealers I spoke to indicated that Burmese material is currently easier to obtain than stones from Vietnam.

It was interesting to learn more of the present state of the mining of Montana sapphires and to see recent production of unheated and heat-treated stones. Three sources in the state are said to be producing small, flat crystals in many colours. The stones I saw had a light saturation of blue and were of good clarity. With large reserves rumoured to exist, the future for this native US gem looks encouraging.

Turning to synthetic stones, I was struck by the absence of anything new and exciting at the shows. Coloured cubic zirconia continues to be popular, with much rough in various colours being abundant. I was able to secure examples of recent US production of flux grown rubies and sapphires. Current Moscow production of flux grown syn-

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thetic spinel, synthetic opal and green GGG, together with Russian hydrothermal synthetic emerald, were obtained.

Garnet was the theme of the Tucson Gem and Mineral Show. Here nomenclature of the six gem garnets was well explained and illustrated by exhibitors displaying large crystal specimens of each species; large uvarovite crystals from Finland, orange spessartine garnets from Namibia and iridescent andradite from a new source in Mexico were particularly striking. A twenty kilogramme example of Libyan glass (the natural silica glass found in North Africa) and the Thompson diamonds (three pear-shaped brown diamonds cut from a 264ct rough stone) attracted the eye. Unusual quartzes included cabochon-cut transparent pink quartz (not to be confused with rose quartz) and crystals of ametrine (quartz with purple, colourless and brown colour zones), reputedly from Bolivia, characterized by the rhombohedral faces meeting at the basal pinacoid.

GAGTL is committed to expanding the opportunities for home and overseas students to study our FGA and DGA courses, and each year more of our Allied Teaching Centres are established for this purpose. The Tucson gem shows provide the opportunity to discuss with our overseas friends matters of interest and mutual concern, to emphasize our educational plans and to clarify perceptions of our future strategy.

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Gemmological Abstracts

ASHBAUGH III, C.E., 1992. Gamma-ray spectroscopy to measure radioactivity in gemstones. *Gems & Gemology*, **28**, 2, 104-111, 8 figs.

Gamma-ray spectroscopy to determine the radionuclides used to colour a yellow-green diamond (bought as radium-treated) and a deep blue topaz. The diamond had been treated with americium-241, a product of bombarded uranium-238 which coloured the surface and left radio-activity which would decline to a legally acceptable level for sale in rather more than three thousand years [not a very sound commercial proposition!]. The (London blue) topaz is a better bet and should reach a safe level in about two years. [Tests for radionuclides obviously call for expensive equipment and the ethics and sense of such treatment are highly questionable]. The author gives the half life of cobalt-60 gamma-ray signatures as 5.27 years and europeum-152 as 13.5 years (both have been used to colour diamonds), and says that it would take decades for even these fast faders to decline to a point where they were undetectable. Not all radiation, however, leaves such prolonged radio-active signatures. R.K.M.

BANK, H., 1991. In Partien natürlicher Rohedelsteine synthetische Rohsteine beobachtet. (Synthetic rough found in natural rough gemstone lots.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 40, 4, 253-5, bibl.

The author enumerates a number of instances where synthetics have been found amongst rough gem lots. In a lot of emeralds from Zambia, Chatham emeralds were found, a lot from Colombia contained glass, a lot from Nigeria yellowish fluorites. Rubies contained Verneuil products, alexandrite from Brazil some synthetic Russian alexandrite, glass masqueraded as tourmaline and aquamarine as well as amethyst which also contained some synthetic amethyst. The author also warns of quartzes which have been treated with green oil and sold as emeralds, and glass instead of diamond crystals. E.S.

BIANCHI POTENZA, B., DE MICHELE, V., LOBORIO, G., RIZZO, R., 1991. Le olivine della Sardegna: un materiale di interesse gemmologico. *La gemmologica*, **16**, 1, 17-28, 13 photos in colour, 2 figs, 1 map.

Green transparent olivines from Sardinian alkali basalts have gem potential. All major properties are described with a note on their occurrence. The basalts are of Plio- Pleistocene age and occur near Pozzomaggiore, Sassari, Sardinia. M.O'D.

BLANKENBURG, H.-J., LOTTNER, S., 1991. Achate aus einem temporären Ignimbritaufschluss bei Chemnitz. *Aufschluss*, 42, 275-383, 7 photos (5 in colour), 3 figs.

Agate is found in a disintegrated ignimbrite near Chemnitz, Germany. M.O'D.

BLANKENSHIP, D., 1992. The color of jade. *Bulletin of the Friends of Jade*, 7, 48-55.

The cause of colour in both nephrite and jadeite is reviewed; several areas where jade is found are covered. M.O'D.

BLANKENSHIP, D., 1992. Two stones. *Bulletin of the Friends of Jade*, 7, 24-8.

A short review of the two jade minerals with notes on some of their commoner imitations. M.O'D

BODE, R., KLAUS, D., 1992. Neue Rhodochrosit-Funde in der Sweet Home Mine bei Alma/Colorado. *Mineralien Welt*, **3**, 6, 43-5, 13 photos (12 in colour), 1 map.

Further production of rhodochrosite at the Sweet Home Mine, Alma, Colorado, USA, is reported. M.O'D.

CAMPBELL, I.C.C., 1992. A short note on the appearance of some inclusions seen in a number of blue sapphires from Bo Ploi, Thailand. *South African Gemmologist*, **6**, 2, 24-5, 4 photos in colour.

Blue sapphires from Bo Ploi, Thailand, were found to contain liquid feathers and possible plagioclase crystals as well as wool-like rutile crystals and negative inclusions. The inclusions distinguish the sapphires from their Burmese counterparts. M.O'D.

CASSEDANNE, J-P., ALVES, J-N., 1992. L'aigue marine au Brésil (part 2). *Revue de gemmologie*, **111**, 11-14, 2 photos (1 in colour).

The second part of the paper discusses the classification and formation of pegmatites containing aquamarine. Simple, complex and intermediate types are postulated and described. M.O'D.

CASSEDANNE, J-P., ALVES, J-N., 1992. L'aigue marine au Brésil (part 2). *Revue de gemmologie*, **112**, 7-11, 2 photos (1 in colour).

The paper describes prospecting for aquamarine in the pegmatites of Brazil and discusses pegmatite age and formation. M.O'D.

COZAR, J.S., GARZON, J., 1992. Fluoruro de magnesio sintetico, en esmeralda sintética hidrotermal rusa. *Boletin del Instituto Gemológico Español*, **34**, 70-2, 5 photos in colour.

Tetragonal crystals of MgF_2 have been found in Russian hydrothermal emeralds. Energy-dispersive X-rays are used to demonstrate their presence. M.O'D.

COZAR, J.S., IBARRA, A., 1992. Centros de color en espinelas. *Boletin del Instituto Gemólogico Español*, 34, 42-52, 8 figs (1 in colour), 5 photos in colour.

Defects and impurities in $MgAl_2O_4$ are discussed with reference to natural and synthetic stones. M.O'D.

CURTO MILA, C., FABRE FORNAGUERA, J., 1992. Fluorite and associated minerals from Asturias, Spàin. *Mineralogical Record*, **23**, 1, 69-76, 14 photos (12 in colour), 1 map.

Some of the fluorites from a number of mines in Asturias, Spain, are of gem or ornamental quality. Details of the geology, mineralogy and associated minerals are given. M.O'D.

DE ALDECOA, M.A.I., SAPALSKI, C., 1992. Joyas españolas en la historia: siglos XVII y XVIII. *Boletin del Instituto Gemológico Español*, **34**, 63-9, 13 photos in colour.

Spanish jewels of the 17th and 18th centuries are described, examples being taken from a number of museums in Spain and abroad. M.O'D.

DIRLAM, D.M., MISIOROWSKI, E.B., TOZER, R., START, K.B., BASSETT, A.M., 1992. Gem wealth of Tanzania. *Gems & Gemology*, **28**, 2, 80-102, 27 figs.

Deals in some detail with diamond, Mwadui (formerly Williamson) Mine; ruby: Longido, Umba River and Morogoro; sapphire: all colours and change of colour, Umba River; zoisite: Merelani Hills, the purplish blue tanzanite and some yellow, reddish-brown and recently transparent green zoisite from the same area; garnet, including malaia (reddish orange) from Umba valley; tsavorite from the Tsavo National park in Kenya and from several Tanzanian sites including the Merelani Hills; rhodolite from many localities and colour-change pyrope/spessartine (blue-green daylight and purple-red in incandescent light) from Umba, other colour changes also known and illustrated; tourmaline in various types and many colours including the 'chrome' green now known to be due to vanadium, from various northern and eastern sites including Umba; emerald from Lake Manyara and Sumbawanga.

Other gems listed are actinolite, *alexandrite*, amblygonite, *amethyst*, andalusite, apatite, aquamarine, bronzite, chrysoberyl cat's-eye, chrysoprase, agates, etc., diopside, enstatite, epidote, euclase, feldspar, fluorite, hypersthene, idocrase, iolite, kornerupine, kyanite, malachite, pearls, peridot, phenakite, prase opal, quartz, rhodonite, *scapolite*, sillimanite, sinhalite, sphene, *spinel*, topaz, turquoise and *zircon*. Those italicized are dealt with briefly in this paper.

Writers suggest that the considerable gem potential could build to the great benefit of this impoverished country, but the health problem of the spread of HIV virus and AIDS challenges that effort. R.K.M.

DUCARRE, C-J., 1992. Gemmologie en Savoie (part 1). *Revue de gemmologie*, **111**, 3-4, 1 map, 4 figs.

Mineralization of the French Savoy Alps is discussed with particular reference to geological processes and mountain building. M.O'D.

DUCARRE, C-J., 1992. Gemmologie en Savoie (part 2). *Revue de gemmologie*, **112**, 3-6, 3 photos in colour, 1 fig.

Blue beryl, axinite, epidote and quartz from the Savoy area of France are described. M.O'D.

FREY, R., 1992. Jade and science. *Bulletin of the Friends of Jade*, 7, 56-69.

The development of modern methods of gem testing is described with particular reference to the two jade minerals and their commoner simulants. M.O'D.

FRITSCH, E., WU, S-T., MOSES, T., MCCLURE, S.E., MOON, M., 1992. Identification of bleached and polymer-impregnated jadeite. *Gems & Gemology*, **28**, 3, 176-87, 14 figs.

Jadeite, bleached of iron-staining and impregnated with acrylic resin, possibly with added colour, to conceal cracks, is being offered in quantity in Taiwan and Hong Kong as natural coloured, RI and spectrum are right for jadeite, SG rather low and most treated stones will float in 3.32 liquid, while most untreated stones sink. Heat probe melts or burns filler. A spot of hydrochloric acid on an untreated stone will produce sweating near that spot.

Treated stones fluoresce faint bluish-white in LUV, white areas of untreated stone fluoresce yellow. Infrared spectrometry provides definitive test since acrylic filler gives sharp lines at 2900cm^{-1} and in the near infrared. Bleached/filled stones may fade. R.K.M.

FRYER, C.W., CROWNINGSHIELD, R., MOSES, T., HURWIT, K., KANE, R.E., 1992. Gem Trade lab notes. *Gems & Gemology*, **28**, 2, 123-8, 19 figs.

A fracture-filled diamond damaged by mount-repair heat confirmed prediction that sooner or later someone would fall into this trap. Diamonds without fillings may take repair heat but filled ones can suffer disastrously; this stone still had tell-tale 'flash-effect' even after it was damaged; filling material contains lead which is opaque to X- rays.

A 22.28 carat stone was the largest example of a chameleon type diamond (temporary change of colour on moderate heating) so far seen in the NY lab. A 'black' diamond with good polish proved to be an irradiated very dark green stone, polish too perfect for a natural black one, residual radio-activity would need some 36 years to reduce to US Nuclear Regulatory Commissions's low level requirement for legal sale.

A 5.56 carat 'emerald' with 'jardin' inclusions was a green YAG synthetic, singly refractive off-the-scale RI and SG 4.55 should have made the fraud obvious, 'jardin' was a mass of bubbles; crown glass imitations of crystals have been offered as 'healing stones' ['Crystal healing' is a health fad probably with little basis in fact]; a 'turquoise' with pitted surface was shown to be glass; a parcel of amethysts was found to contain a significant proportion of good paste, chalky-blue fluorescing, imitations with RI close to those of quartz (which did not fluoresce).

A black natural pearl was found off the coast of Baja California (La Paz, Mexico, formerly noted for such pearls, but not recently - the return of this type of oyster is obviously welcome); black dyed mabe blister pearls were proved by lifting colour with a swab of very weak nitric acid, LUV gave dull orange-red fluorescence, silver bromide was the colourant; nine large 'Geneva rubies' (early flame-fusion synthetics) were an unusual find for the NY lab; a sapphire with rubbed facet edges was a diffusion treated stone which would lose colour if repolished - the heat process is thought to make the surface brittle and more prone to wear, successive heatings, which are common with this treatment could increase this tendency; curved striae in synthetic orange or yellow sapphires, normally difficult to see, can be made more obvious by using a blue filter on the microscope light. R.K.M.

FRYER, C.W., CROWNINGSHIELD, R., MOSES, T., HURWIT, K., MCCLURE, S.F., 1992. Gem trade Lab Notes. *Gems & Gemology*, **28**, 3, 192-7, 18 figs.

Polymer-filled cavity in pavilion facet of alexandrite described and illustrated; in up-date of fracture filling in diamond new flash colours are noted; 6.90ct diamond, fractured in cutting, was filled but needed second and third treatment before polishing was complete, then two hour spell in ultra-sonic cleaner shattered and removed most of the filling, leaving flaw extremely visible; light pink diamond had ribbon-like etch features similar to laser holes but entrances were square, not round like laser drilling, and had to be inherent to the stone [transverse striation of holes also argues natural origin], stone graded I2 for lack of clarity.

A pair of jadeite earclips splice-repaired, cement fluoresced under UV; cat's-eye yellow opal had anomalous RIs of 1.45 and 1.47, X-ray diffraction showed cristobalite with amorphous background.

A shark pin made from an odd-shaped blister pearl was probably unbacked; large drop pearl was also hollow, filled with composite material; another large hollow pearl was the body of a gold and diamond owl pendant-seal; a black mabe pearl had been dyed with silver nitrate and had a crystalline filling.

A three-row necklace of 'ruby' beads was low-grade sapphire, crackle-dyed red, no chromium absorption, but sapphire bands at 450 and 380nm were seen and another at 560 probably due to dye; a 125 carat greyish-green cabochon zircon, claimed to be world's largest, had a superbly sharp cat's-eye and exceptionally strong absorption spectrum. R.K.M.

GENDRON, F., 1992. 1492-1992 Les El Dorados gemmologiques américains. *Revue de gemmologie*, **110**, 15-16.

Materials used for ornament in the Americas from the 16th century are briefly discussed. M.O'D.

GROAT, L.A., HAWTHORNE, F.C., ERCIT, T.S., 1992. The chemistry of vesuvianite. *Canadian mineralogist*, **30**, 19-48, 23 figs.

Crystal chemistry and chemical variations in vesuvianite are studied from 76 samples from 54 different localities. A proposed general formula for boron-free vesuvianite is given as $X_{19}Y_{13}Z_{18}O_{68}W_{10}$ where X are cations occupying [8]- co-ordinate sites, Y are cations occupying [6]- and [5]- co-ordinate sites, Z are cations occupying [4]- co-ordinate sites and W are monovalent and divalent anions. M.O'D.

GÜBELIN, E., 1992. Dans la vallée des rubis. *Revue de gemmologie*, **111**, 5-8, 4 photos (2 in colour).

Mining operations in the Mogok region of Myanmar and details of rubies are discussed. M.O'D.

GÜBELIN, E., 1992. Green zoisite. (Letter). *Gems & Gemology*, **28**, 2, 140.

An objection to the use of the name 'green tanzanite' for the facetable green zoisite, reported in the Spring issue of The Journal, rightly points out that the Tiffany name 'tanzanite' belongs exclusively to the blue zoisite, and 'green tanzanite' is a horrible confusion of names. 'Green zoisite' is sufficient. R.K.M.

HÄNNI, H.A., 1992. Identification des fissures traitées. *Revue de gemmologie*, **110**, 10-12, 4 photos in colour.

Filled fissures in emeralds can be detected by a variety of tests which are summarized and illustrated. [Translated from the English]. M.O'D.

der Deutschen Gemmologischen Gesellschaft, **41**, 1, 17-19, 3 photomicrographs, 1 table, bibl.

The red garnets from Malawi (exact location of occurrence not known) were shown to be almandine-spessartine-pyrope-grossular mixed crystals. The garnets had unusual spherical aggregates as inclusions in the centre of the crystal, which were identified with the help of a scanning electron microscope as quartz and ilmenite. E.S.

HENN, U., BANK, H., 1991. Aussergewöhnliche Smaragde aus Nigeria. Exceptional emeralds from Nigeria. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 181-7, 1 photo in colour, 4 photomicrographs, 1 graph, bibl.

The emerald crystals from Nigeria are unusually well crystallized, some examples being crystallized at both ends. RI 1.569-1.576, DR 0.005-0.006, SG 2.65-2.67. chromium content of 0.06-0.11 weight % Cr_2O_3. The green colour is caused by a broad absorption spectrum band of Cr^{3+} as well as Fe^{2+} and Fe^{3+}. Beside distinct growth zoning two and three phase inclusions have been observed, the latter similar to those in Colombian emeralds. E.S.

HENN, U., BANK, H., 1992. Über die Eigenschaften von im Flussmittelverfahren hergestellten synthetischen roten und blauen Spinellen aus Russland. (About the properties of flux-grown synthetic red and blue spinels from Russia.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **41**, 1, 1-6, 8 photomicrographs, 1 table, 1 graph, bibl.

The values for RI are 1.716-1.719 and SG = 3.58-3.62, well within the limits of natural magnesium spinels. The colour is caused in the red stones by Cr^{3+}, in the blue by Co^{2+} which can be seen in the spectra. Microscopic studies show growth lines and tabby extinction as well as flux residues of different types and arrangements, some being of metallic origin, some being similar to the Lechtleitner and some producing two-phase inclusions. E.S.

HENN, U., BANK, H.,1992. Klar durchsichtiger, roter Labradorit aus Oregon, USA. (Clear transparent red labradorite from Oregon, USA.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **41**, 1, 49-51, 1 yellow, or yellow-red to reddish-brown and red. RII n_o =1.558, n_z=1.563, n_y=1.555, DR 0.008. SG 2.70. The chemical composition is 50.5% anorthite, 46.5% albite, 3% orthoclase. The deep red colour is caused by Fe, absorption band at 565nm. E.S.

HENN, U., REDMANN, M., 1991. Geschliffener, klar durchsichtiger, farbloser Katapleit von Mont Saint Hilaire, Kanada. (Cut transparent colourless katapleite from Mount St. Hilaire, Canada.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 197-200, 1 photo under crossed nicols, 2 tables, bibl.

Katapleite is a hydrous sodium zirconium silicate which under normal temperatures crystallizes monoclinically and at 139°C hexagonally, Hardness 6, perfect cleavage; if calcium rich the colour is light yellow to brown, otherwise colourless to bluish. SG 2.72. RI 1.590-1.629, DR 0.039. Has an oily appearance under the microscope and shows irregular interference under crossed nicols. E.S.

HYRS, I.J., 1992. Die Mineralien der Alpin-Paragenese aus dem Nordural/Russlang. *Mineralien Welt*, **3**, 6, 59-62, 8 photos in colour, 1 map.

Minerals from Pripoljarnyi in the Urals include gem quality sphene and axinite as well as large specimens of phantom quartz. M.O'D.

KANE, R.E., KAMMERLING, R.C., 1992. Status of ruby and sapphire mining in the Mogok stone tract. *Gems & Gemology*, **28**, 3, 152-74, 26 figs.

A well illustrated account of this important source of gem corundum, dealing with history, geology, geographic location, nationalization, mining techniques (twinlons {narrow pits}, hmyawdwins {trenches}, loodwins {cavities in marble}), mechanisation including tunnelling, recovery, central crushing plant, production, manufacture and distribution, and other ruby occurrences in Myanmar. A valuable paper. R.K.M.

KOIVULA, J.I., KAMMERLING, R.C., FRITSCH, E., 1992. Gem news. *Gems & Gemology*, **28**, 2, 129-39, 17 figs.

Diamonds

Reports on diamond-claim rush at Lac de Gras in Canada's Northwest Territories; a diamond technical symposium in Israel; diamond bearing kimberlite pipes in Ukraine; small industrials near Tashkent; De Beers/Republic of Sakha (Yakutia) sales agreement; R.E. Kane's visit to alluvial diamond mines at Longlands, SA; agreement on prospecting and mining between De Beers and Tanzania; Zaire output reduced by a third, regulations tightened to reduce smuggling.

Coloured Stones

Californian exhibit of exotic beetles showed 107 different iridescent species which may be used in jewellery in one part of the world or another; cat's-eye golden beryl, possibly irradiated, is illustrated; a Cairo museum exhibits garnet-set Greco-Roman jewellery; largest jadeite boulder weighing estimated 33 tonnes is displayed outside Myanmar Gems Enterprise in Yangon (Rangoon); further reports on Vietnam rubies; iron nickel meteorite is sliced, etched and mounted as jewellery; black mabe 'pearls' made from nautilus shell are again on offer; a visit to Mont St Hilaire quarry, near Montreal, for red-brown villiaumite, carletonite, hackmanite, natrolite, sphalerite, catapleiites, orange serandites, albites, pectolites, burbankite, shortite, cryolite, and colourless vesuvianite [idocrase]; Tajikistan, (Pamirs), now independent, is to develop gem potential, including fine marble, spinel and lapis lazuli.

Enhancements

Acrylic spray coating for stones which do not take a good shine results in unnatural glassiness especially in recessed carving, coatings can be scraped off or dissolved by acetone; massive beryl/quartz is being heat-quench dyed to resemble charoite, sugilite, turquoise or coral, dye concentrated in surface fissures easily seen; aquamarine and other beads enhanced by dyeing the string and the stringing hole and by heat-quench dyeing; a 'concrete' Andamooka sandstone opal is blacked by sugar/acid treatment and then toughened with a plastic; silver nitrate, smoke and black plastic have also been used to give a black ground to porous opal; a local preference in Egypt for greenish turquoise is met by oiling the blue material to the required colour.

Synthetics and Simulants

Another sawn and hollowed beryl crystal (from Bogota) filled with green liquid and cemented together again, was detected when a cutter tried to saw it and it bled green; more information on Russian opaque CZ gives RIs about 2.14 to 2.165; bicolour red CZ is described and illustrated; many glass imitations of Paraíba tourmaline crystals have been encountered, one from Bogota is illustrated; Vietnamese parcels of blue sapphire rough have been found to contain large crystals of blue spinel, and parcels of ruby rough continue to be found with significant admixtures of 'water-worn' Verneuil synthetics, immersion tests are essential for both rough and cut parcels; synthetic sodalite was among several synthetics from Academia Sinica (China), this is colourless but irradiates to a good blue.

Instrumentation

Hanneman Gemological Instruments are offering a cheaper simulant of the expensive quartz wedge used to determine optic sign in microscopic work. R.K.M.

KOIVULA, J.I., KAMMERLING, R.C., FRITSCH, E., 1992. Gem news. *Gems & Gemology*, **28**, 3, 198-209, 22 figs.

Diamonds

New extraction plant near Alexander Bay, S. Africa, operates on sea-water; at Lac de Gras, Canada, a 160 ton sample of ore yielded 101 carats of diamond, 25 per cent gem quality; British Crown Jewels, including Cullinan I [and II] and Koh-i-Noor diamonds, are to be brought up to ground floor level in the Tower of London in 1994; India is to increase diamond mining in collaboration with Australia; mining at Jwangeng, Botswana, is to expand; alluvial diamonds found near Momeik and Theindaw, Myanmar, are being cut in Yangon; Venetia mine, N. Transvaal, is operating and forecasts 5 million carats of rough a year; Belgian owned Hai Duong diamond factory, Vietnam, is polishing ready-sawn rough for return to Antwerp.

Coloured Stones

An amber is illustrated with 'insect inclusion' engraved on its base; Russians marketing heat-improved Baltic amber in Hong Kong; 'Glory Blue' chalcedony is reported from Montana; a Madagascan crystal had a corundum centre covered concentrically with green spinel and blue sapphirine; green crystals from Merelani Hills, home of tanzanite and green zoisite, were chrome diopside; opalized iron-stone is being used for carvings; an egg of rare mansfieldite, a new ornamental rock from Algeria, has been cut in Germany, looks like variscite.

Pearl shell is reported from Baja, California; also pearls from a Spanish galleon, badly damaged by long immersion; a liquid-filled cultured pearl reported earlier is now illustrated; Venezuelan investigations towards pearl cultivation have begun, using good nacre producing *P. radiata* oysters.

Longido ruby from Tanzania usually suitable only for cabochons, but a small deep red faceted brilliant is illustrated, about 6 carats of such stones may be expected from 20 tons of rough; Iankaroka, Madagascar, is producing parti-coloured sapphires in pale blue and orange-brown, some of them magnetic; small crystals of green sphalerite [blende] were found in Pennsylvania; a green tourmaline from Paraíba had a cascade of metallic yellow inclusions.

Enhancements

Large Thai parcels of 'natural coloured' cabochon sapphires are being salted with diffusion treated stones; at Tucson a kit was offered for fracture-filling emeralds with green dye; update on crackle-dyed emerald-green quartz reports they are convincing table-up but cracks easy to see base-up over white card, test as quartz, dye thought to be green Opticon which gives absorption from 660-690nm, no chromium lines; a ruby crystal was coated with amorphous red spinel, SG about 3.75, strong red luminescence in UV, RI and spectrum [surprisingly] typical of corundum.

Synthetics and Simulants

A new Czochralski-pulled 'alexandrite' is marketed as Allexite, colour-change bluish-green to reddish-purple similar to fine Brazilian alexandrite, curved striae seen, RI 1.740-1.749, SG 3.72, red luminescence very marked; green glass made from fused rock from Mt St Helens with added colorants is still being offered; scratched assembled stone looked like badly oriented alexandrite, had red centre enclosed by green glass; flame-fusion synthetic rubies, offered as natural stones at Mae Sot on the Thai/Burma border, have been quench-fractured and crudely cut to aid deception; an imitation opal with moulded plastic 'faceted' crown, backed by patterned diffraction foil was offered at recent gem show; about 100 specimens were seen in Germany of a composite crystal consisting of a zoned tourmaline slice cemented to coloured glass. R.K.M.

KUMARATILAKE, W.L.D.R.A., RANASINGHE, U.N., 1992. Unusual corundum bearing gem pockets at Avissawella and Getahetta, Sri Lanka. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **41**, 1, 7-16. 2

maps, 2 photos, 4 diagrams, bibl.

For the last four decades peculiar kinds of corundum bearing pockets have been found in various localities, the main one being at Thalduwa in Avissawella in church premises. Extraction is primitive. There are two types of these pockets, corundum bearing pockets and hollow type pockets, the former yielding mainly patchy sapphires (which could probably be heat treated and turned into blue), some yellow and a few blue sapphires, while the latter only yields iron pyrite. The corundum bearing pockets also yield iron pyrite and dark orange brown tourmaline crystals. E.S.

LAFON, J-M., COLLYER, T.A., SCHELLER, T., 1991. Datierung der Smaragdmineralisationen der Granite von Campo Formoso und Carnaíba, Bahia. (Dating of emerald mineralization of the granites of campo Formoso and Carnaíba, Bahia. First results). *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 241-6, 2 maps, 1 graph, 1 table, bibl.

An age of 1851 +/- 48 Ma has been obtained for five samples of phlogopites associated with the emerald mineralization of Campo Formoso and Carnaíba granitic bodies. This agrees with the radiometric ages obtained from these granitic rocks. Furthermore, the age of the phlogopites represents a cooling temperature of about 400°C which is the maximum temperature for the crystallization of gem quality emeralds. E.S.

LASNIER R., POIROT, J-P., VIDAL P., 1992. Essais de datation et détermination de l'origine des eméraudes par la méthode rubidium-strontium. *Revue de gemmologie*, **110**, 27-9, 1 fig.

Rubidium-strontium dating techniques are applied to the identification and characterization of emerald from different localities and of synthetic emerald. M.O'D.

LI YINGPING, 1992. Jade mining at Khotan from Chinese historical records. *Bulletin of the Friends of Jade*, 7, 29-39.

Jade mining at Khotan has taken place over the centuries and Chinese records have been used for this short study. Mining goes back at least 3,000 years; a list of references is given. M.O'D.

LYCKBERG, P., 1992. Eine reise zu den klassischen Edelstein-pegmatiten von Mursinka und Alabaska sowie zu den Smaragdvorkommen im Bereich von Takovaja im Ural. *Mineralien Welt*, **3**, 6, 68-79, 18 photos (10 in colour), 1 map.

As Russian gem-bearing areas are gradually opened up once more, details are given of some of the locations and of the species that are found at them. They include beryl, topaz, tourmaline, amethyst as well as a variety of minerals for the collector. Geological details are briefly given. M.O'D.

NASSAU, K., 1991. The seven types of yellow sapphire and the proposed Ponahlo test. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 247- 51, bibl.

The fading behaviour of yellow sapphire with respect to light can be quite variable, depending on the nature of material and origin of colour. The author lists the seven different types of sapphires and shows that the cathodoluminescent test proposed by J. Ponahlo can only predict the fading behaviour of some types of yellow sapphire. E.S.

NASSAU, K., ROSSMAN, G.R., WOOD, D.L., 1992. Unstable radiation-induced yellow-green colour in grossular garnet. *Gems & Gemology*, **28**, 3, 188-91, 3 figs.

Pale grossularites from a few African localities were irradiated to a light to medium yellowish-green, a colour which faded rapidly in daylight and in about two months in the dark. Mechanics of the fade are explained. Colour too fugitive to have commercial significance. R.K.M.

NIEDERMAYR, G., 1992. Das Einschlussbild von Smaragden aus Serpentinit-Randgesteinsserien (Smaragde vom Typus Habachtal). *Mineralien Welt*, **3**, 5, 46-7, 4 photos in colour.

Habachtal emerald contains hornblende and biotite crystals as well as a variety of colour patterns and cracks. The relationship between the emerald and its host rock is discussed. M.O'D.

PERNY, B., EBERHARDT, P., RAMSEYER, K., MULLIS, J., PANKRATH, R., 1992. Microdistribution of Al, Li and Na in quartz: possible causes and correlation with short-lived cathodoluminescence. *American mineralogist*, 77, 534-44, 5 photos (3 in colour), 8 figs.

Secondary ion mass spectrometry has been used to identify the distribution of Al, Li and Na in natural quartz crystals looking at individual growth layers which are identified by cathodoluminescence and artificial γ irradiation.

Changes of trace element concentration by more than 3 orders of magnitude were observed on a scale of a few tens of micrometres. Zones showing intense but short-lived blue luminescence contain the highest Al and Li concentrations with no luminescence shown by regions with low concentrations. The pronounced variability in the phenomena is attributed to conditions of growth (fluctuations of temperature, pressure, pH and composition of growth fluids during growth). M.O'D.

PLATONOV, A.N., SACHANBINSKI, M., WROBLEWSKI, P., IGNATOV, S.I., 1992. Natural prasiolite from Lower Silesia, Poland. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **41**, 1, 21-7, 1 photo, 4 graphs, bibl.

Prasiolite is the green, transparent holocrystalline variety which can be obtained by heating certain varieties of quartz up to 400-600°C. Naturally occurring prasiolites were discovered in quartz agate geodes in trachybasalts in the sedimentary-volcanic complex of Lower Silesia. The green colour is distributed unevenly throughout the stone and is caused by Fe seen in the absorption band at 725nm. When heated to 400-500°C the green colour turns to brown. The authors suggest that the colour is primary as a result of specific physico-chemical parameters in the quartz forming solution. E.S.

POIROT, J-P., 1992. Spectrometrie et fluorescence X, des aides pour la détermination de types de gisement de saphirs. *Revue de gemmologie*, **110**, 7-9, 15 figs.

X-ray spectroscopy and X-ray fluorescence have been used to determine the origin of sapphires from different localities, which include Burma, Sri Lanka, Kashmir, Vietnam, Madagascar, Thailand, Australia and France. Heated sapphires are also cited. [Translated from the English]. M.O'D.

PONZONE, A., 1991. Studi termici sulle inclusioni fluide in corindoni di Sri Lanka. *La gemmologia*, **16**, 1, 7-16, 10 photos in colour.

Chemical composition and physico-chemical properties of Sri Lanka corundum are investigated on the basis of thermal treatment of inclusions. M.O'D.

READ, P.G., 1991 - 1992. A four-part series of articles on gemstone enhancement methods. *Canadian Jeweller*.

Part 1 - Foiling, dyeing and impregnation. October 1991. 24. Covers historic enhancement techniques, and more recent wax, plastic and oil impregnation methods.

Part 2 - Heat treatments can enhance color. January/February 1992. 24-5. Describes the standard centuries-old heat treatment processes and the more recent high-temperature methods employed with geuda corundum and its detection.

Part 3 - Not all enhancement techniques are equal. March 1992. 24-5, 1 fig. This section includes the less permanent colour enhancement techniques employed with surface-diffused and irradiated corundum. Permanent irradiation methods including those used for topaz and diamond are also discussed.

Part 4 - Artificially-coloured diamonds can be detected. April/May 1992. The final part of the series deals with the irradiation/heat treatment, glass filling and lasering of diamonds, and its detection. (Author's abstracts) P.G.R.

ROBERT, D., 1992. Reseau cristallin des grénats. *Revue de gemmologie*, **110**, 23-4, 1 fig., 2 photos in colour.

A synthetic garnet with the trade name Oulongolite is discussed. Specimens have the YAG or GGG composition with various dopants. M.O'D.

SALERNO, S., 1992. Minéraux et pierres de Madagascar. *Revue de gemmologie*, **111**, 9-10, 1 photo in colour.

Polychrome sapphires are reported from Madagascar. First thought to be alexandrite, the zoned crystals (green and red) had RI 1.770-1.778 and 1.762-1.770 for the ordinary and extraordinary rays respectively with a birefringence of 0.008-0.009, and a specific gravity of 4.0. The mine is in the Betroka area; the corundum occurs with cordierite, tourmaline and biotite. Extraction of the corundum crystals without damage is said to be very difficult. M.O'D.

SAPALSKI, C., GOMEZ, F., 1992. Estudio de la esfalerita de la mina de Aliva, Santander (España). *Boletin del Instituto Gemólogico Español*, **34**, 29-39, 27 photos in colour, 2 maps.

Sphalerite of gem quality in colours ranging from light yellow and green to red is found at the Aliva Refuge mine, Camaleño, Cantabria, Spain. The sphalerite occurs with calcite.

Gemmological tests are used to identify the material which very frequently contains colour zoning, negative crystals and a variety of liquid inclusions. M.O'D.

SCHÄFER, W., HENN, U., SCHWARZ, D., 1992. Smaragde aus de Kesselklamm, Untersulzbachtal, Osterreich: Vorkommen und Eigenschaften. *Aufschluss*, **43**, 231-40, 3 maps, 4 figs, 3 photos in colour.

The Untersulzbachtal, celebrated for many years for fine crystals of epidote from Knappenwand, has produced some emerald. It was found in 1988 in a serpentine-talc lying to the south west of an already known beryl-producing area (Leckbachrinne). It is accompanied by biotite and muscovite and actinolite/tremolite crystals appear as inclusions together with them. Constants are given as n_e 1.580-1.582, n_o 1.588-1.590, DR 0.008, SG 2.72-2.73. Cr_2O_3 content varies from 0.01 to 0.38. M.O'D.

SCHLEE, D., PHEN HOCK CHAN, DORANI, J., FOOK KUNG VOONG, 1992. Riesenbernsteine in Sarawak, Nord-Borneo. *Lapis*, **17**, 9, 13-23, 23 photos (19 in colour).

Ornamental quality amber has been found with coal deposits in Sarawak, North Borneo, Malaysia. Specimens illustrated show long subparallel flow lines and colours range from white through colourless, pink, orange, red, yellowish-green, blue, violet, brown and black. Between 5-10% of the amber recovered is suitable for fashioning. M.O'D.

SCHLÜSSEL, R., 1991. Die Saphir-Lagerstätte von Bo Ploi in der Provinz Kanschanaburi, Thailand. (The sapphire occurrence at Bo Ploi in the Province of Kanchanaburi, Thailand.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 165-80, 2 maps, 4 photographs, 10 photomicrographs, 1 table, bibl.

The occurrence of sapphires in Bo Ploi has been known since 1920; these were worked in small scale workings rarely larger than 15-15 sq.m. and varying in depth from 4 to 20 metres using similar methods to those used in most primitive gem producing countries. In the last fifteen years, however, the district has been worked more mechanically and the sapphires are found over an area of 100 sq.km. Today this is the most important production of sapphires in Thailand. Bo Ploi lies roughly 120km east-north east of Bangkok, near the border and near to the River Kwai bridge. The sapphires are dark to middle blue and do not require heat treatment. They are found together with black spinel. 46 rough and 135 faceted stones were examined. Mineral inclusions were mainly of colourless, tabular prismatic elongated crystals of feldspar surrounded by a halo; partly recrystallised healing fissures produce triangle shaped patterns; healing fissures and liquid-filled feathers can show interference colours. Oriented rutile needles have also been observed. E.S.

SCHLÜSSEL, R., 1992. L'identification au microscope des diamants aux cavités artificiellement colmatées à l'aide d'une substance vitreuse. *Revue de gemmologie*, **111**, 15-17, 5 photos in colour.

Methods of identifying glass-filled cavities in diamonds are discussed. M.O'D.

SCHMETZER, K., HÄNNI, H.A., JEGGE, E.P., SCHUPP, F-J., 1992. Dyed natural corundum as ruby imitation. *Gems & Gemology*, **28**, 2, 112-15, 6 figs.

A new imitation ruby was made from pale or colourless natural corundum with dye-filled heat and quench cracks. Early examples had colourless areas easily seen by eye; improved specimens need immersion and magnification to detect colour in cracks, and uncoloured areas.

No fluorescent line at 695nm, but iron bands were seen in the blue and ultraviolet regions; dye fluoresced a strong orange-yellow in LUV but was inert in SUV; acetone swab did not lift it. Corundum probably from Umba in Tanzania. R.K.M.

SCHWARZ, D., 1991. Geologie und Genese der Smaragdvorkommen in der Cordillera Oriental/Kolumbien. (Geology and genesis of the emerald occurrences in the Eastern Cordilleras, Colombia). *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 201-31. 2 maps, 2 schematic sketches, bibl.

The author gives a detailed description of the regional and local geological conditions of the eastern Cordilleras in Colombia. Different genetic models of the emerald mineralisation are discussed. There are still some questions open for discussion, i.e. the temperature and composition of the mother solution and the origin of the element Be or of the Be-carrying solution (syn- or epigenetic). E.S.

SCHWARZ, D., 1992. Die chemischen Eigenschaften der Smaragde IV. Kolumbien. (The chemical properties of emeralds IV. Colombia). *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 41, 1, 29-47, 7 tables, 6 graphs, bibl.

The emeralds examined were from Muzo, Coscuez, Yacopi, Chivor, Gachala and some other not specified occurrences. Ninety emeralds were subjected to a microprobe. The results of the chemical analyses are discussed and correlated. The amount in variation and concentration of chromium, vanadium, iron, magnesium and sodium in these Colombian emeralds are summarised. They seem to have the lowest iron and magnesium content of all examined emeralds. E.S.

SHERNAKOW, W.I., LASKOWENKOW, A.F., 1991. Grosse Smaragdkristalle aus den Gruben des Ural, UdSSR. (Large emerald crystals from the mines in the Urals, USSR). *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 40, 4, 189-95, 1 photo, 1 geological map, 1 crystallographic diagram, bibl.

The Ural emeralds usually have a hexagonal, prismatic habit - the hexagonal crystals being somewhat distorted. The colour is a rich green with bluish and yellowish hues, the intensity of the colour being dependent on the chromium content. A few especially large and beautiful emerald crystals are described in details, such as the 3369.5 ct. weighing 'Slavnyi Uralaski', eighty per cent of which are of gem quality; the 6.55 kg heavy crystal group 'Miner's Glory', the particularly beautiful 'Nowogodni' and 'Swesdar' and a number of other famous emeralds. Together with the emeralds alexandrites, phenakites and chrysoberyls are found. There are also some rare minerals such as brommelite, euclase, bertrandite and bowenite. E.S.

SHIGLEY, J.E., FRITSCH, E., REINITZ, I., MOON, M., 1992. An update on Sumitomo gem-quality synthetic diamonds. *Gems & Gemology*, **28**, 2, 116-22, 9 figs.

Two 5 carat slices of Sumitomo synthetic diamond, from cube and octahedral crystals respectively, revealed colour zoning, graining, strain and luminescence reflecting their initial crystal habits. Crystal morphology is thought to affect the properties. Material is used for industrial heat-sinks, etc., and is not intended for jewellery use. Both samples were inert to LUV but gave weak orange-yellow under SUV, a reaction which may be seen in type Ib natural diamonds. Cathodoluminescence emphasizes growth patterns. The cube sample was type Ib. The octahedral sample was found to be a mixture of types Ib+IIa+IIb diamond, so far not seen in natural diamond. R.K.M.

SOSSO, F., ROMAN E., 1002. Les améthystes d'Artigas (Uruguay). *Revue de gemmologie*, **110**, 13-14, 3 photos (2 in colour).

Amethyst from Artigas, Uruguay, is described with notes on its occurrence and properties. [Translated from the English]. M.O'D.

SUPERCHI, M., 1992. Trésors de l'art italien. Analyse gemmologique. *Revue de gemmologie*, **110**, 17-19, 4 photos in colour.

Three jewelled artefacts made in Italy are discussed gemmologically. M.O'D.

TOURET, L., 1992. Les pegmatites de Volhynie (Ukraine). *Revue de gemmologie*, **110**, 25-6.

Pegmatites of the Volhynie area of the Ukraine produce feldspar, quartz, yellow beryl and blue and pink topaz. M.O'D.

WANG TAO, 1992. Recent discoveries and research of ancient jade in PR China. *Bulletin of the Friends of Jade*, 7, 38-41.

A report that suggested that jadeite may have been found in Eastern Zhou tombs in Luoyang but a loose usage of the Chinese word yu shows that this is not the case. Poor documentation of sites hinders work on mineral or artefact occurrences. M.O'D.

WEIDINGER, W.A., 1992. More on alcohol damage to amber (Letter). *Gems & Gemology*, **28**, 2, 140.

Provides three further references to amber damaged by alcohol, ether and similar solvents (hair-sprays, perfume, etc.). R.K.M.

ZABINSKI, W., 1991. Transvaal 'Jade'. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **40**, 4, 233-9, 2 tables, 1 graph, bibl.

The name Transvaal jade is given to a green grossular/hydrogrossular with some vesuvianite; the pink material consists also of grossular/hydrogrossular with different lattice parameters. The green is caused by the presence of Cr, the pink by Mn. E.S.

ZWAAN, P-C., 1992. La kornerupine d'Embilipitiya, Sri Lanka. *Revue de gemmologie*, **110**, 5-6, 2 photos in colour, 1 map.

Kornerupine is found at Embilipitiya in the south of Sri Lanka. SG=3.284, RI=1.660, 1.672. Black and red rutile crystals are found as inclusions in cut stones. [Translated from the English.] M.O'D.

Book Reviews

BALFOUR, I., 1992. *Famous diamonds.* Second edn. NAG Press, Colchester. pp. 245, illus. in black-and-white and in colour. £29.00.

The first edition of this book was well received and as so often happens sparked off the discovery of several more outstanding stones! Considerable attention is given to the superb Centenary diamond, weighing in its cut form 273.85ct and the largest diamond to be cut by the application of the most modern techniques. The colour picture of the faceted stone shows, as few diamond photographs do, some of the dispersion of this beautiful stone. It was found in 1986 at the Premier mine and weighed 599ct in the rough.

Other stones, such as the pink Kirti-noor have only recently come to public attention (it is a Golconda stone and has been in a private collection in India until recently). Some, such as the 'Unnamed Brown' have no name (this stone is now a modern fire-rose cushion shape of 545.67ct from a rough crystal weighing 755.50ct; the cut stone is a very high 72.2 per cent of the original weight).

As in the previous edition the text surrounds black-and-white and coloured photographs and the price is most reasonable for so interesting a book. M.O'D.

HOOVER, D.B., 1992. *Topaz.* [Butterworths Gem Books.] Butterworth-Heinemann, Oxford. pp. xiv, 207, illus. in black-and-white and in colour. £35.00.

Some topaz may be triclinic and some physical and optical values may be more dependent on locality and formation than upon colour. This study of topaz is particularly readable with a lucid style and very extensive references. Many new concepts similar to those opening this review are presented with sustainable evidence.

The book opens with a study of the derivation of the word 'topaz' and of the occurrence of the mineral in historical accounts. Large and notable topaz gemstones and crystals are described before an account of topaz chemistry, crystal structure, optical properties, physical properties, colour and luminescence. Next comes a description of topaz crystal morphology and of inclusions. Topaz geology and a summary of world sources complete the book.

Early on the author discovered that the substitution of the hydroxyl ion for fluorine in the topaz structure affects the crystallography and properties in hitherto unrealized ways and this theme is followed throughout this book which all gemmologists should possess.

M.O'D.

JOYCE, K., ADDISON, S., 1992. *Pearls, ornament and obsession.* Thames and Hudson, London. pp. 253, illus. in black-and-white and in colour. £38.00.

An uninformative introduction by Sumiko Mikimoto precedes a very attractive, illustrated book with a fairly general text. The survey covers the use of pearls in a variety of contexts with emphasis on costume; this is well illustrated by a number of reproductions of portraits in which pearls are prominent. The historical material has to be selective but is well put together and interesting to read. There is a reasonably useful bibliography and a much less useful glossary. Read the book for the pictures at least; the flowery style disguises quite a lot of valuable information and has to be waded through.

M.O'D.

KOCKELBERGH, I., VLEESCHDRAGER, E., WALGRAVE, J., 1992. *The brilliant story of Antwerp diamonds.* MIM n.v., Antwerp. pp. 303, illus. in black-and-white and in colour. BF2,895.

A book illustrating the history of Antwerp in celebration of its position as Cultural Capital of Europe 1993 and forming part of the 'Ortelius' series gives a great deal of information on the history of the city. The text is easy to read, with several pictures on each page: they include reproductions of significant documents and of portraits with many illustrations of famous diamonds. The diamond trade has done much to maintain Antwerp's favourable trading position and although work on small goods has largely moved to India the presence in the city of the Diamond High Council will help to ensure the continuance of Antwerp's domination of the European diamond handling and polishing trade. M.O'D.

MARSHALL, D.J., 1988. *Cathodoluminescence of geological materials.* Unwin Hyman, Boston. pp. xiv, 146, illus. in black-and-white and in colour. £65.00.

Over the past few years cathodoluminescence has been advocated as a useful gemmological test. Here the whole range of geological materials, including gemstones, has been subjected to energetic electrons and the most significant results are detailed in a way which is easy to understand. History and instrumentation of the method are outlined first with definitions and a survey of the results obtained from some common minerals arranged by classes. The cathodoluminescence of the feldspar and quartz group is extensively described, each group having a chapter of its own; the carbonates are similarly treated. The cathodoluminescence of gemstones has a page of its own; there is an appendix outlining the photographic methods used in the various tests. An excellent bibliography completes the book.

Even though the treatment of gemstone cathodoluminescence is small, the general text contains much to interest the gemmologist. Not least in importance is the description of the ways in which different types of luminescence are caused and the review of a large number of individual species under test. M.O'D.

NABARRO, F.R.N. (ed.), 1992. *Dislocations and disinclinations. Dislocations in solids.* North-Holland, Amsterdam. Vol. 9, pp. x, 424, illus. in black-and-white. US$208.50.

With chapter numeration continuing from the first eight of the series, this volume deals with a summary of the advances in the electron microscopy of dislocations, the study of internal friction derived from kinks in dislocations lying in Peierls valleys, dislocation dynamics in face-centred cubic and body-centred cubic metals. An overview of rotational deformation is given with an exhaustive bibliography. Many of the topics discussed will be of great interest to crystal growers. M.O'D.

ROCK, N.M.S., 1991. *Lamprophyres.* Blackie, Glasgow. pp. viii, 285, illus. in black-and-white. Approximately £60.00.

From a gemmological point of view lamprophyres sprang into prominence with the discovery that the supposed kimberlite pipe, which provides many gem and industrial quality diamonds at Kimberley, Western Australia, is a lamprophyre now known as the Argyle pipe.

The first section of the book offers a history of the term lamprophyre; the suffix -phyre is correctly used in this context to denote a porphyritic character. The term was first used in 1874 for a rock characterized by glistening phenocrysts first described from the German Fichtelgebirge. Recent studies have begun to suggest that lamprophyres form a vital insight into the deep mantle and mantle processes and thus into the formation of materials such as diamond and gold. The term lamproite was coined in 1923 to describe extrusive rocks of lamprophyric aspect. Lively discussion of the nature of lamprophyres continues and several classifications have been postulated; in one hierarchical scheme kimberlites are placed with four other rock types in the first order, within which many other smaller categories are distinguished. From the mineralogical aspect the assemblage of minerals is probably that part of the lamprophyre topic of greatest interest; lamprophyres carry essential amphibole and/or biotite-phlogopite and also abnormal amounts of minerals rich in F, Cl, SO_3, CO_2 and H_2O. Mg-rich mafic minerals such as diopside and forsterite are found with Na-K feldspars and some quartz. Tremolite actinolite phases, for example, found in some igneous rocks, are not found in lamprophyres. Chapter 9, dealing with economic geology, will be found particulary interesting to gemmologists as it includes a table of diamondiferous lamprophyres excluding kimberlites. At the time of writing, some kimberlites at least, had been reclassified as lamproites and the premise made that lamprophyric rocks are the only confirmed magmatic sources of diamond.

There are other chapters of interest but the main feature is a very extensive bibliography. There is also a table of confirmed occurrences of different types of lamprophyres. This type of work, which will inevitably attract considerable discussion and amendment, is the type of study upon which our gemmological investigations ultimately depend, particularly at the prospecting and recovery end. M.O'D.

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

GIFTS TO THE GAGTL

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

Miss Mary J. St Amand, FGA, of Sausalito, California, for moonstone from Mexico.

Mary Burland for synthetic rubies.

MEMBERS' MEETINGS

London

The following meetings, that have been held in the GAGTL's new Gem Tutorial Centre on the second floor at 27 Greville Street, London EC1N 8SU, have proved very successful and have attracted a 'full house' on every occasion.

On 25 January 1993 Michael O'Donoghue gave a talk on 'Gems of Pakistan'. A number of the gems mentioned were on display for the evening.

On 8 February 1993 Ana I. Castro and Stephen Kennedy gave an illustrated talk on 'Emeralds in the Laboratory'.

On 24 February Peter Read gave a talk entitled 'New gem testing instruments'.

On 8 March 1993 Dr Alan Collins gave an illustrated talk on the 'Colour in diamonds', bringing those present up-to-date with current research on the subject.

On 31 March 1993 David Callaghan gave a talk entitled 'From gem to jewel'.

Midlands Branch

On 27 January 1993 at Dr Johnson House, Bull Street, Birmingham, Edgar Taylor gave a talk entitled 'Fossicking in Wales'.

On 26 February 1993 at Dr Johnson House, Robert Campbell-Legg spoke to members on 'The art of the engraver'.

On 26 March 1993 at Dr Johnson House, Peggy Stock gave a talk entitled 'Crystal healing'.

North West Branch

On 20 January 1993 at Church House, Hanover Street, Liverpool 1, David Pelham gave a talk on 'Mines and mineral deposits of South Africa'.

On 17 February 1993 at Church House the video 'Gemstones of America' was shown.

On 17 March 1993 at Church House, Richard Digby gave an illustrated talk on 'Cameos and intaglios'.

GEMSTONE INCLUSIONS

A set of 30 display pictures of gemstone inclusions is available for sale. Recently they formed a travelling exhibition and consist of 40 x 29 cm prints mounted in glass/hardwood frames (67 x 54 cm) with explanatory captions.

For full details contact C.R. Burch, FGA, at 4 West Moor Drive, Cleadon, Nr Sunderland, Tyne and Wear SR6 7TW. Telephone 091-536 2386.

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 13 January 1993 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Fellowship

Bakker, Frederik C.S., Zwaagdijkwest, The Netherlands. 1992
Leung, Florence Lai Ping, Hong Kong. 1992
Spanbok, Gary, Edgware. 1992
Winkelmolen, Karin, Beesel, The Netherlands. 1992
Zaveri, Pragnesh, Bombay, India. 1992

Ordinary Membership

Cho, Eun-Kyung, Seoul, Korea.
Crane, Simone, London.
Kalischer, Janice, London.
McIntosh, Robert P., Penicuik.
Ruhmer, Fiona, Brackenbury Village, London.
Woodbridge, Roger, Upminster.

At a meeting of the Council of Management held on 17 February 1993 at 27 Greville Street,

GAGTL GEM TUTORIAL CENTRE

27 Greville Street, London EC1N 8SU

Diamond Grading Weekend Course
8-9 May 1993
For retailers, valuers and those involved in trading diamonds, who need an insight into gem diamond grading, simulants and treatments.
Price £210.00 + VAT

Identifying hardstone carvings
11 May 1993
Price £90.00 + VAT

A day of pearls
12 May 1993
Price £90.00 + VAT

Preliminary questions and answers
14 May 1993
The chance for Preliminary examination candidates to find out from tutors and examiners what is required of them in the examination.
Price £15.00 including VAT

A day of beads and stringing
20 May and 8 July 1993
For anyone who wishes to investigate the great variety of beads, natural or artificial, and the intricate methods for stringing beads or pearls.
Price £90.00 + VAT (inclusive of materials)

Diploma Workshop
1-2, 5-6, 8-9 and 19-20 June 1993
Two days of intensive practical tuition for students approaching examinations, with a mock exam; also suitable for those who need intensive gem therapy.
Price £125.00 + VAT for two days
GAGTL students £85.00 + VAT

Enquire within - Ornamental rocks
15 July 1993
A day looking at all aspects of ornamental rocks. Includes a short walk around the Hatton Garden area discovering materials used in buildings.
Price £90.00 + VAT

Enquire within - Organic gem materials
22 July 1993
A day looking at all aspects of organic gems, natural, treated and imitation.
Price £90.00 + VAT

Two days of diamonds
15-16 September 1993
For an insight into the gem diamond origins, grading, simulants and treatment.
Price £190.00 + VAT

Preliminary Workshop
12-14 October 1993
One-day practical tuition for Preliminary students and anyone who needs a start with instruments, stones and crystals.
Price £38.00 + VAT
GAGTL students £27.00 + VAT

For further information contact the GAGTL Education Department on 071-404 3334.

London EC1N 8SU, the business transacted included the election of the following:

Fellowship

Bruciak, Thomas M., Venice, Fla., USA. 1986
De Ruiter, Jacoba E., Waddinxveen, The Netherlands. 1992
Kim, Jong Pil, Seoul, Korea. 1992
Lu, Milton R.K., Taipei, Taiwan. 1983
Sohn, Jeong Sun, Seoul, Korea. 1992
Tenhagen, Joseph W., Miami, Fla., USA. 1969
Wong, Min Wan, Kowloon, Hong Kong. 1992

Ordinary Membership

Aikawa, Atsuko, Heusenstamm, Germany.
Beesley, C.R., New York, NY., USA.
Bell, Martin, Albuquerque, N.Mex., USA.
Bendingham, Michiko, Tokyo, Japan.
Boehm, Edward, Carlsbad, Calif., USA.
Bruns, Frederik H., Tucson, Ariz., USA.
Crevoshay, George, Upton, Mass., USA.
Gaskell, Benjamin H., London.
Guest, Vanessa A., Arnold, Nottingham.
Harada, Kayoko, Kanagawa Pref, Japan.
Ikuta, Miwa, Kyoto, Japan.
Inoue, Keiko, Osaka, Japan.
Ishida, Masako, Osaka, Japan.
Kanamori, Tomohiro, Osaka, Japan.
Kaneda, Kenichiro, Hyogo Pref, Japan.
Kashi, Kenya, Osaka, Japan.

FORTHCOMING MEETINGS

London

Throughout 1993 there is a programme of meetings on the second floor at 27 Greville Street. Refreshments will be available from 6.00 p.m. and lectures will start at 6.30 p.m.; these will be followed by discussion and closing about 7.45 p.m. The charge for a member will be £3.50 and, as places are limited to 55, entry will be by ticket only, obtainable from GAGTL.

11 May	'Engraved Gems'	Christopher Cavey
14 June	Reunion of Members, AGM and 'Bring and Buy'	
20 September	'Photographing minerals and gems'	Frank Greenaway
6 October*	'Diamonds in the Laboratory'	Eric C. Emms
8 November	'Thai evening'	Amanda Good and Martin Issacharoff
22 November	'CIBJO matters' - the gem trade in Europe	Harry Levy
7 December*	'Pearls in the Laboratory'	Ana I. Castro and Stephen Kennedy

* PLEASE NOTE: 'Diamonds in the Laboratory' is one week later and 'Pearls in the Laboratory' is one day earlier than previously scheduled.

Midlands Branch

30 April Annual General Meeting followed by a gem collection talk

The meeting will be held at Dr Johnson House, Bull Street, Birmingham. Further details from Gwyn Green on 021-445 5359.

North West Branch

19 May	'Lalique jewels, from the 1992 Paris Exhibition'	Dr J. Franks
16 June	Members and friends evening. Bring and buy: crystals, books and instruments, and exchange of views	
15 September	Jonathan Condrup from Sotheby's	
20 October	'Minerals in the Bronze Age'. The Great Orme Mine.	Tony Hammond
17 November	Annual General Meeting	

Meetings will be held at Church House, Hanover Street, Liverpool 1. Further details from Joe Azzopardi on 0270-628251.

Kimura, Michihoko, Hiroshima Pref, Japan.
Kitawaki, Hiroshi, Saitama Pref, Japan.
Kitawaki, Junko, Osaka, Japan.
Kobayashi, Masahide, Osaka, Japan.
Kodama, Aki, Osaka, Japan.
Kokubu, Ozusa, Tokyo, Japan.
Lahogue, Pascale, Tervuren, Belgium.
Lee, Kyung Hae, Fukuoka Pref, Japan.
Nakamura, Maya, Hyogo Pref, Japan.
Nihira, Hiroko, Tokyo, Japan.
Ninomiya, Tsuyosho, Fukuoka Pref, Japan.
Nishizawa, Takako, Osaka, Japan.
Ogihara, Shigenori, Saitama Pref, Japan.
Ohki, Kuniyuki, Osaka, Japan.
Okada, Takayuki, Osaka, Japan.
Okuda, Etsuko, Osaka, Japan.
Otomo, Ryoko, Miyagi Pref, Japan.
Oyama, Yumiko, Shiga Pref, Japan.
Purkiss, Christopher R., London.
Reay, Kenneth, Worplesdon.
Reynolds, Stephen, Cleeve Hill, Cheltenham.
Richardson, Andree J., Alverstoke.
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Transfer to Fellowship and Diamond Membership
Bakagianni-Sabou, Aristea, Nikea-Piraeus, Greece. 1993
Gofa, Sophia, Athens, Greece. 1993
Hare, Rebecca, Fleet. 1993
Prior, Louise, London. 1993
Scott, Kenneth M., Cleghorn. 1993

Diamond Membership
Lupton, Elaine, Paddock Wood. 1992

Fellowship
Koetsier, Anya, Maida Vale, London. 1992
Van Keulen, Simone J.C., Amsterdam, The Netherlands. 1992

Ordinary Membership
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Bollack, Josee, Strasbourg, France.
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Jones, Donald, London.
Karmali, Amin, Wembley.
Levinson, Alfred A., Calgary, Alberta, Canada.
Pattni, Himat H., Chilwell, Nottingham.
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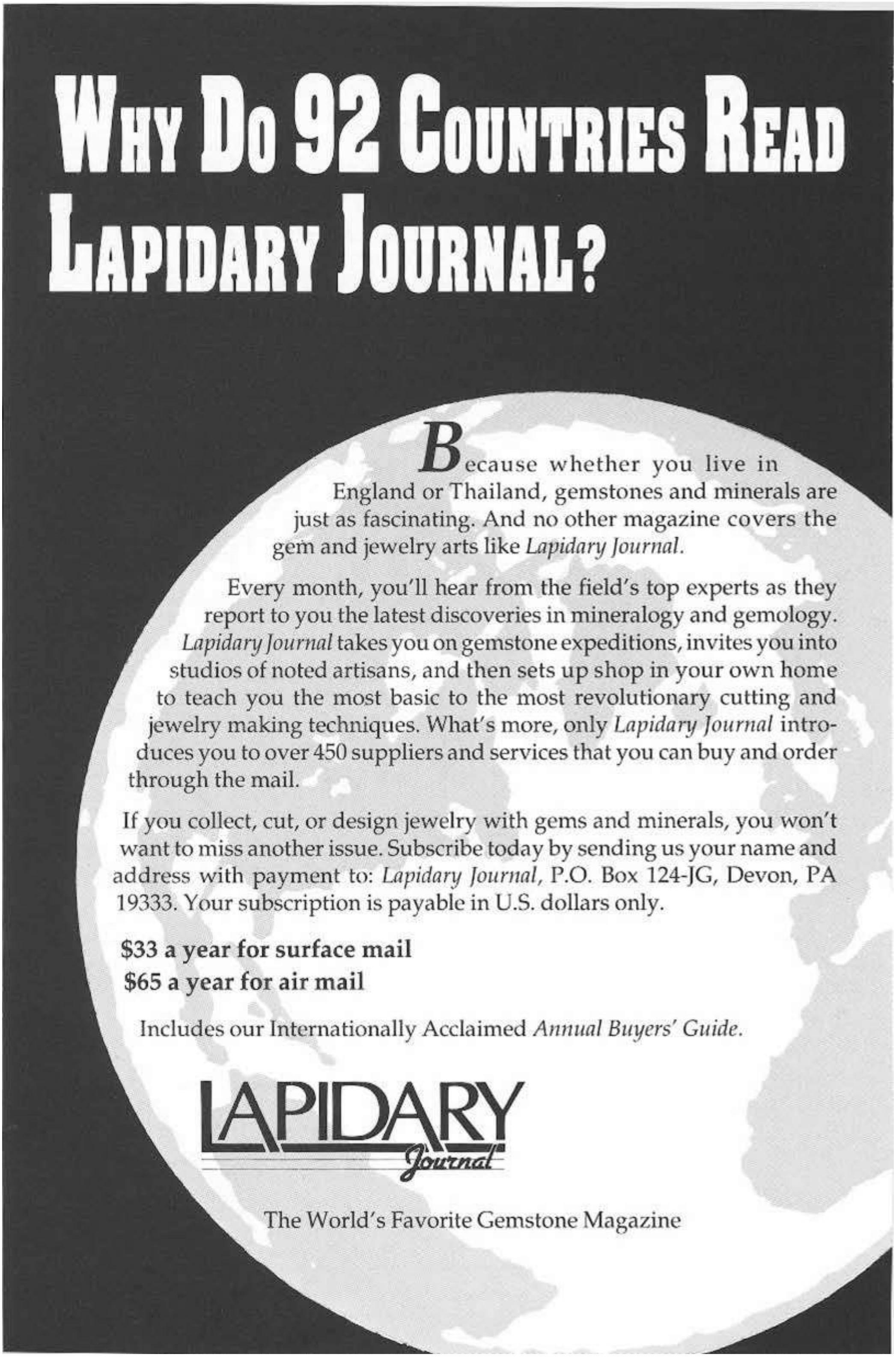
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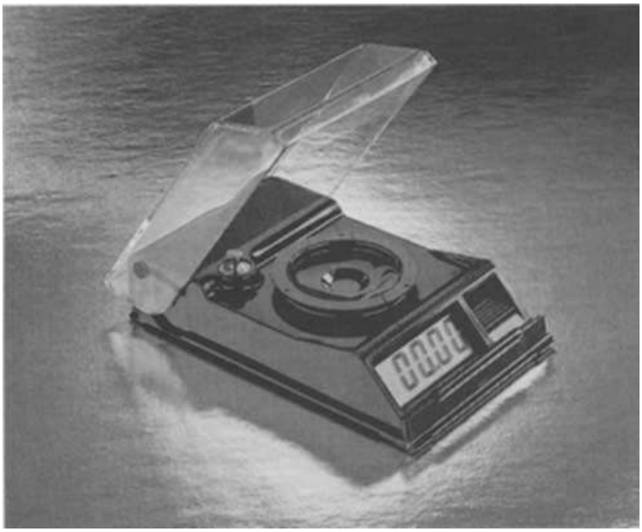

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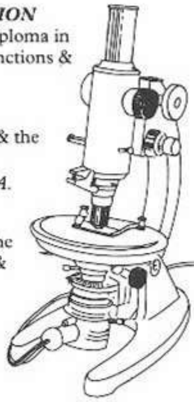

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