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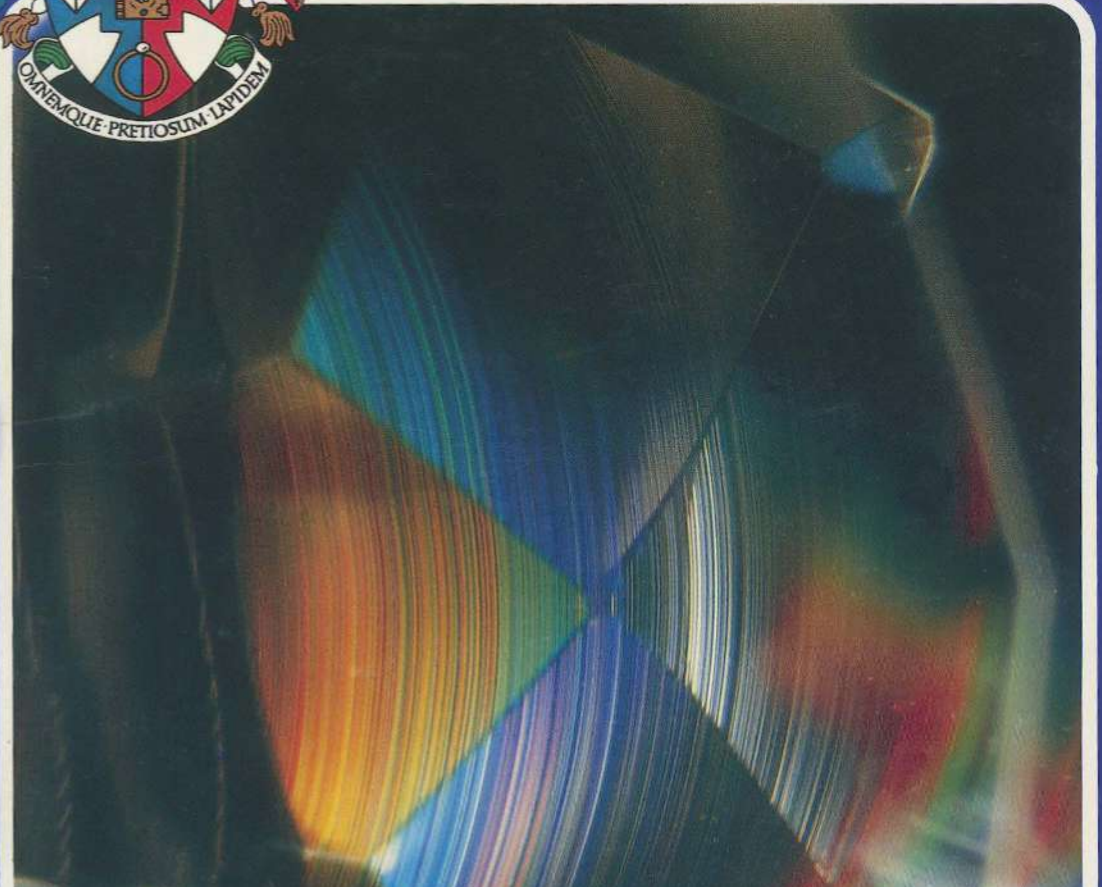

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Cover Picture

Irridescent glass with botryoidal form, exhibiting spectral colours due to interference on thin layers. (See 'Iridescent natural glass from Mexico', p.488.)

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Star sapphire from Kenya

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Abstract

Various cabochon-cut star sapphire samples from the North-West of Kenya were examined to determine all the inclusions which may contribute to cause the asterism effect.

Optical observations, electron microprobe and X-ray diffraction analyses were carried out. The inclusions recognized were: cloudy areas, acicular inclusions, 'silk', tube-like inclusions, transparent crystals, 'feathers' and healed fractures. The acicular inclusions responsible for the asterism are separated into microstriae and needle-like inclusions.

Genetic growth considerations of these star sapphires are deduced.

Introduction

The world's main sources of star sapphire, up to this time, have been Burma and Sri Lanka. Kenya is now entering the list and becoming the third country and indeed the first country in Africa to produce and supply star sapphire.

Kenya and Tanzania, in addition to the many unusual gemstones, have been known to produce corundum in all possible colours and qualities from numerous occurrences. However, none of the sources ever supplied rough which can produce star stones in commercial quantity.

Several years ago, a small lot of blue sapphires appeared on the Kenyan gem market of which some samples produced a star. However, the source was never made known and similar or larger lots never appeared on the gem market.

Now the source has been relocated, and sapphire rough has started appearing on the local market since mid 1987. Hence the rough is available in commercially acceptable quality and quantity.

Some other rough with a fair amount of transparency can be faceted to produce nice blue to bluish-green gems. Lower grade rough can be used to produce cabochons (without a star) and even beads.

Most of the rough samples are slightly worn crystals with frosted surfaces and a very low percentage (1–5%) of either completely rounded or well-shaped crystals. In the sapphire lots there are some pieces of dark brown to black obsidian, brown zircon and translucent to opaque dark green epidote.

Location and geology

Corundum appears in Kenya as patches in metamorphic rocks (gneisses) which are believed to have been desilicated by a dunite (Parkinson, 1947). The same applies to the corundum of the nepheline-syenite dyke-like bodies in the valleys (Joubert, 1966).

Usually the crystals are of dirty-brown colour and sometimes fractured.

In the North-Western region, corundum is found in Tertiary volcanic olivine basalts or in secondary deposits (Bridges, 1982).

The actual, geologically important, deposit is not identified. Sapphires are being picked up from the large desert type sandy area in the North-Western region of Kenya. This is in the Turkana district of the Northern Rift Valley Province, and lies on the West side of Lake Turkana (formerly Lake Rudolph) (Figure 1).

This region is part of the Mozambique orogenic belt extending southwards to Malagasy and Mozambique and northwards through the Sudan and Ethiopia (Bridges, 1982).

The area is in the middle of the Y-shape of the fault systems, and stretches from the turn off the main Lodwar road to the Sudan. This is a secondary road (dirt road) leading to the Ethiopian border through Murangering and Lokitaung villages (see map).

Sapphires are mined from the top soil of desert type plains (Quaternary sediments) caused by the erosion and peneplanation of hills, namely Pelekesh (1794m) and Mornerith (1438m). The primary source of the star sapphires and their original occurrence is yet to be investigated. However, areas from which sapphires are probably collected are shown by the dashed area in the map (Figure 1).

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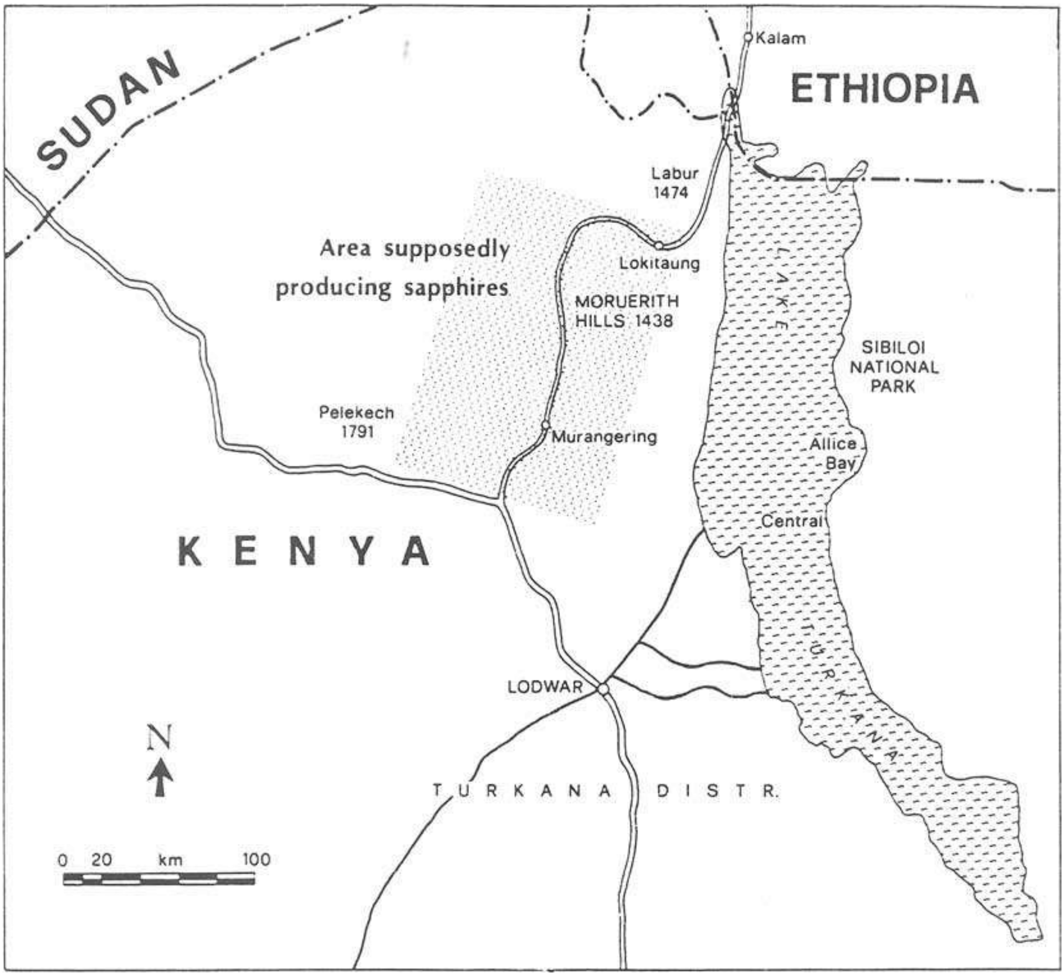

Fig. 1. This map shows the location of the star sapphires in the North-western region of Kenya. The mining area, dashed area in the map, is located in the Turkana district of the Northern Rift Valley Province on the west side of Lake Turkana.

Rough sapphire: its grading and cutting

The examined samples are in the form of ten cabochon-cut star sapphires (total weight: 1.253 gm). They cover various shades of body colour viz. blue, brownish-blue, greenish-blue, greenish-yellow, and blackish-brown.

They range in size from 3.6 × 3.8 × 1.7 mm to 5.9 × 5.3 × 3.0 mm; the weight of each specimen was measured to be a minimum 0.060 to maximum 0.782 gm.

'Silk' occurs in all the cabochons, but in eight of them it traverses the whole of the host sapphire and causes 6- and 12-rayed asterism. Nevertheless, in samples 9 and 10, the 'silk' appears densely woven, causing only 'silky-spots'.

The samples nos. 1, 2, 4, and 7 present a perfect star which displays six equally narrow rays, with characteristic angles intersecting at 60°; of equal length and brightness, extending fully in each specimen. A weak star not extending fully is displayed by the cabochons nos. 3, 5, 6, and 8.

This different behaviour is ascribable to deviations from the crystallographic arrangement of the elongated systems of inclusions in the body of the host sapphire, intergrown with the basal plane and aligned parallel to the prisms of first or second order.

Gemmological investigation

The cabochon sapphires were subjected to standard gemmological tests, and the results are discussed below.

Visual appearance and absorption spectra

The samples range in clarity and are classified as sapphires from medium transparent (diaphane) to opaque.

To the unaided eye, five cabochons, samples nos. 1, 2, 3, 4 and 6 appear a medium to excellent blue colour (Figure 2); nos. 5, 9 and 10 are dark-brownish to dark-blackish-blue (Figure 3), and Nos. 7 and 8 a pale greenish-blue to greenish-yellow.

Electron microprobe analyses carried out on the dark or brownish sapphires revealed the presence of iron: about 1-2%, and the absence of titanium. Therefore the colour hue is probably due to Fe_2O_3 dispersed in the bulk crystals (Weibel *et al.*, 1981).

The visible light absorption spectrum expressed by the lines at 450, 460 and 470 nm, is referable to iron, samples nos. 1 to 4 and 6 to 8. Instead the samples nos. 5, 9, and 10 are distinguished by a faint line at 470 nm and a single band from 450 to 460 nm.

Refractive indices, dichroism and fluorescence

Tested with gemmological refractometers, the refractive indices of the sapphire cabochons were evaluated by using the 'distant vision' method. It was possible to determine only an average value of $n_D = 1.765$ for all samples.

Using a dichroscope, various medium pleochroic colours were observed: namely shades of blue to green-blue and yellow to brownish.

Under both long- and short-wave UV radiation and through the Chelsea colour filter, the sapphires remained inert.

Specific gravity

Density was measured by means of the Berman balance. The data collected proved to be unreliable due to the peculiar characteristics of these sapphires rich with inclusions.

The results were estimated to be approximately 3.99 – 4.03 g/cm^3. Therefore the minimum value is 3.97, for sample 4, and the maximum is 4.08, for sample 10.

Micropscopic and SEM observations of the inclusions

The cabochons were examined with gemmological binocular microscopes and were tested both by by electron microprobe and X-ray diffraction procedures.

The specimen observed in immersion showed the presence of a frame of a blue colour inhomogeneously distributed in bands. Broader zones and the blue frame are made evident in the clustering of tiny needles.

A multitude of inclusions were observed and segregated into five categories:

1) Cloudy areas
2) Acicular inclusions
3) 'Silk'
4) Tube-like inclusions
5) Transparent crystals
6) 'Feathers' and healed fractures.

1) *Cloudy Areas*

Precise observations made it possible to select this type of inclusions into two groups:

- Striae
- Hazy and nebulous inclusions.

The cabochons were examined above dark field illumination and parallel striae were identified approximately orientated according to the length of the cabochon (Figure 3). However, it was difficult to discern the precise nature of this lamellar structure and the striae.

Microscopic, strongly magnified observations revealed that the unevenly spaced parallel striae are sometimes undulating and parallel to the rhombohedral faces of the crystal. These directions of weakness can probably be ascribed to lamellar twinning, also instigated by an incipient decomposition along these planes.

This hypothesis is supported by the sporadic presence of white, minute flakes, associated with the above mentioned striations.

Also present are straight-edged blue coloration and angular-growth zoning, which are referred to both multiple original growth episodes and to the hexagonal symmetry of the sapphire. (Figure 4.)

2) *Acicular Inclusions*

These inclusions form acicular systems crossing each other, and provoke the many-rayed stars (Figure 5), and may be roughly classified into two groups:

- Micro-striae
- Needle-like inclusions.

Optical observations and electron microprobe analyses were accomplished on each selected area of the samples, preferentially on the protruding terminations of the acicular inclusions. It was necessary to operate on the curved side of the cabochons, resulting in a larger degree of experimental uncertainty.

The micro-striae and the needles are apparently exactly alike, but are distinguished by means of electron microprobe analyses.

It was usually found that the former show a chemical composition as well as a pattern of minor elements similar to that of the embedding sapphire.

These micro-striae represent growth periods alternating with temperature variations during the

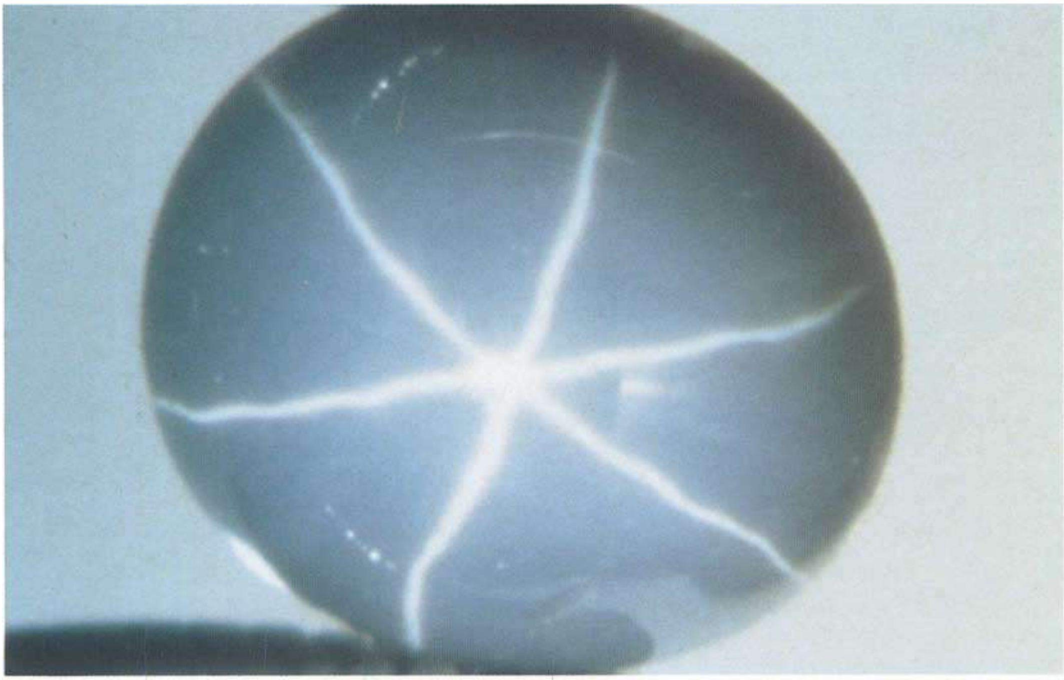

Fig. 2. A blue cabochon-cut star sapphire from Kenya displays a six equally rayed asterism. The hexagonally orientated acicular inclusions engender the six equally spaced narrow rays of same length and brightness, very sharp edged. The star effect in these gems is identical to that seen in the synthetic Linde sapphires. 10x.

Fig. 3. Dark brownish-blue cabochon-cut star sapphire from Kenya. The hue is related to the presence of hematite needles; the parallel striae are ascribed to a lamellar twinning structure. 8x.

Fig. 4. The straight-edged blue colour bands show the hexagonal sapphire symmetry and are referred to both multiple growth episodes and contemporary changes in the chemical environment. Fluid 'feather' and haloes of iron compounds create a characteristic microscopic appearance of these star-sapphires. 20x.

crystal growth.

Occasionally, an amount of titanium in the latter was ascertained, attesting the presence of rutile. The electron microprobe analyses also indicated a local enrichment of iron which would suggest the presence of needles of hematite.

The colour of the cabochons appears to be linked to these peculiar inclusions.

The excellent blue colour is preferentially ascribed to the needle-like inclusions of both micro-striae and of sporadic, acicular rutile crystals (samples nos. 1, 2, 3, 4, and 6). On the other hand, the hematite needles are responsible for the dark colour of sapphires wherever they are present (samples nos. 5, 7, 8, 9 and 10).

3) *'Silk'*

All samples show elongated thread-like needles

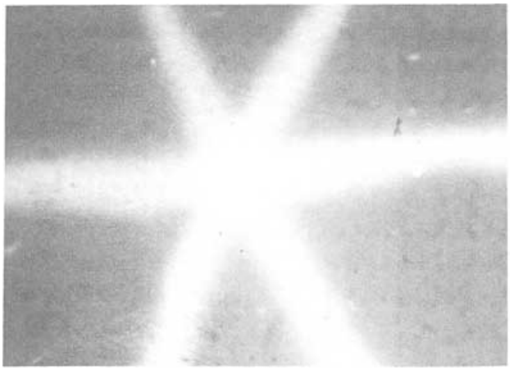

Fig. 5. Hexagonally orientated acicular systems provoke a six-rayed star in blue sapphire from Kenya. 30x.

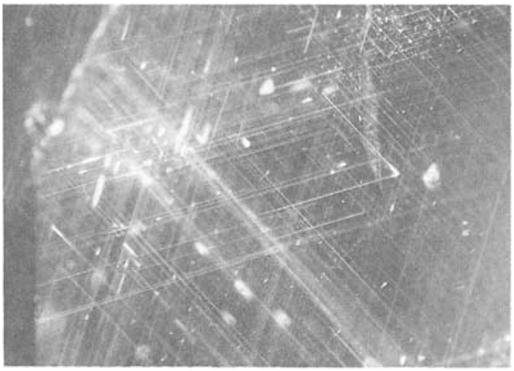

Fig. 6. The fine rutile needles constitute the 'silk', and form large or small nests. The regularly intergrown twin crystals are characterized by a re-entrant angle. 40x.

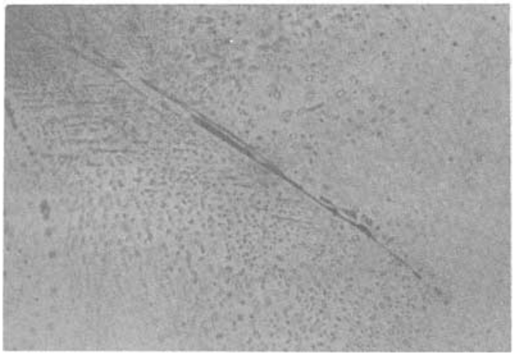

Fig. 7. A 'fingerprint' healing area is formed around a tubular cavity-filling of iron compounds. 45x.

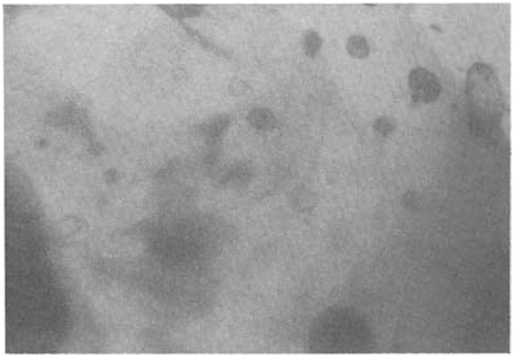

Fig. 8. Crystals of transparent and hexagonal corundum, brownish and prismatic rutile and haloes of iron compounds, are included in the host star sapphires from Kenya. 35x.

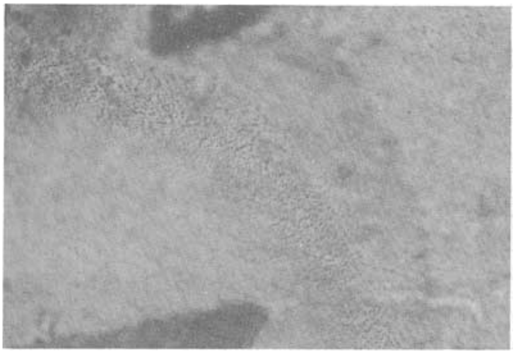

Fig. 9. Feathers of fluid inclusions, laminae of hematite and cavity fillings of iron compounds are related to the dark colour of the star sapphires from Kenya. 40x.

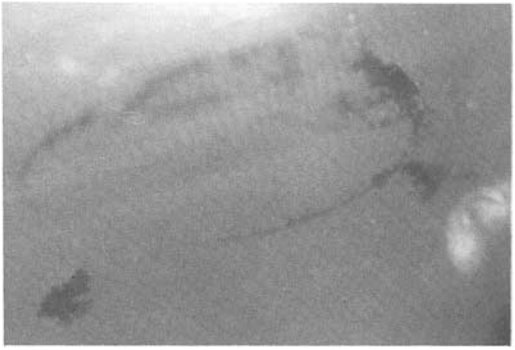

Fig. 10. The apparent ellipsoidal shape of this healed fracture is sealed off by brownish-red iron compounds. Thus they are epigenetic inclusions. 30x.

at random like particles of dust, which form the 'silk' (Figure 6).

X-ray diffraction patterns carried out on the bulk samples revealed some weak reflections referable to rutile.

A contribution to this peculiar aspect is due also to cloudy, hazy inhomogeneities, probably caused by light diffused by tiny fissures in the host.

4) *Tube-like Inclusions*

These inclusions are primary cavities which are normally caused by irregularities in growth structure of the host sapphire. Such channels, evidenced by fillings made up of scaly aggregates with a colour varying from brownish-red to yellowish and variously mixed (Figure 7).

The electron microprobe analyses showed the almost exclusive presence of iron in both the yellow and the red scales. Consequently they were ascribed to iron hydroxides or oxides.

This situation appears to be similar to the iron compounds filling the channels of scapolite (Graziani and Gübelin, 1981; Schmetzer *et al.*, 1977) and kyanite (Ghera *et al.*, 1988).

5) *Transparent crystals*

In the sapphires, sporadic, birefringent inclusions were present (Figure 8).

The transparent and colourless crystals (approx. 0.02 × 0.09 mm) are low in relief, have a 'ghost-like' nature and occur singly. They are hexagonal, tabular in shape with sharp angular corners. Analyzed with the electron microprobe they reveal a chemical composition of aluminium; therefore they are referable to sapphire.

The reddish-brown idiomorphous crystals (approx. 0.1 × 0.05 mm) of prismatic habit consist of titanium with a minor content of iron. These were identified as one of the three polymorphs of titanium oxide, and considering their morphology and high birefringence, as rutile or brookite.

Keeping in mind both the sapphire growth conditions and the unvarying appearance, these crystals are referable to rutile.

6) *'Feathers' and healed Fractures*

Analyses with the electron microprobe were carried out to attempt to clarify the nature of these inclusions. It was found that they are at least partially made up of tiny, elongated individuals (about 20 × 5 μm) whose chemical composition turned out to be aluminium and, sometimes, a little titanium. Consequently these inclusions are referable to both corundum and rutile or titanium plus aluminium compounds (Nassau, 1968). These elongated crystals constituted a kind of felt, representing the chemico-physical variations of the host crystal growth conditions and in some cases causing a hazy effect (Figure 4).

The healing areas are often sealed off and evidenced by feathers of fluid inclusions (Figure 9) and by yellow or brownish-red matter (Figure 10). The electron microprobe analyses showed the almost exclusive presence of iron, and consequently they were ascribed to iron hydroxides or oxides (Schmetzer *et al.*, 1977).

Conclusions

The cabochon-cut sapphire samples examined, which have identical genetic conditions, are remarkable for the presence of the same type of inclusions. These, however, are variously distributed in each specimen.

Indeed, the acicular inclusions, particularly the microstriae and also the needles both of rutile and hematite, decorate the sapphires with a crystallographically-dictated arrangement of minute lines, and represent the main cause of the asterism.

It is remarkable that the perfect star with sharp edges extending fully, samples nos. 1, 2, 4 and 7, is similar to the six-rayed asterism present in the Linde synthetic cabochon-cut star sapphires.

Nevertheless, the straight-edged angular-growth zoning caused by the hexagonal symmetry of the sapphire, and especially the absorption lines at 450, 460 and 470 nm, represent distinguishing features between these natural sapphires and synthetic sapphires.

Sporadic alterations of the physico-chemical conditions tended to produce straight-edged colour bands, growth-zoning and the formation of inclusions of corundum, rutile and hematite crystals. They document different episodes of the host crystal's growth.

Subsequently the mother-fluid penetrated into fractures of the embedding crystal, and iron compounds have been segregated.

The irregular contour of the channels and their fillings of yellowish and brownish-red matter can be generally correlated.

Furthermore, the presence of haloes, often surrounding the healing areas sealed by mother fluid, suggest a possible sequence of transformation of these iron compounds due possibly to the dehydration of iron hydroxides and the consequential formation of iron oxides, referable to an increase of the environmental temperature.

Considerations on the brookite-rutile equilibrium allow a hypothesis on high temperature and high-pressure sapphire crystal growth conditions (Dachille *et al.*, 1939). The presence of iron hydroxides and oxides, as well as hematite, suggests that the utmost temperature of crystallization was in any case higher than 500°C (Kulp *et al.*, 1951).

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The Brazilian emeralds and their occurrences: Carnaíba, Bahia

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1. Introduction

The emerald occurrences of Carnaíba and Socotó in the state of Bahia are located at a distance of about 40 kilometres from each other. The first one belongs to the county of Pindobaçu, the latter to the county of Campo Formoso (Figure 1). Campo Formoso is developing an infrastructure that is changing it into the regional trade centre for the gemstones mined in the state of Bahia (besides emerald, others include amethyst, citrine, aquamarine, diamond, sodalite and ruby). Actually it is the transfer point for the emeralds produced in the Carnaíba and Socotó mining fields. Starting from Salvador or Feira de Santana, Campo Formoso can be reached using first the BR 324 road going northwest up to Capim Grosso and after that using the BR 407 to Senhor do Bonfim. The distance between Salvador and Campo Formoso is about 400 kilometres.

The mining region of Carnaíba, located about 30 kilometres south of Campo Formoso, covers an area at the western border of the north-south extending mountains of the Serra de Jacobina (Figure 2). It has an extension of about 200 km^2 and lies between the villages of Pindobaçu, Saúde and Mirangaba, all located near the Serra de Jacobina. It was discovered in 1963 and has been the most important emerald mining region in Brazil until the discovery of the Santa Terezinha occurrence in the Gioás state. Mining activities began towards the end of 1963 in the sector known as Braúlia (Figure 3). In the following year, the mineralizations of Marota (Carnaíba de Baixo) have been found and only in 1972 were discovered those of the Trecho Novo in Carnaíba de Cima. After having reached its lowest production rate in 1981, when the discovery of the Santa Terezinha deposit resulted in the migration of many garimpeiros out of the region, the production has been increasing somewhat during the last few years.

Because of the necessity of moving the mining activities forwards with the aim of reaching the deeper layers and because of the growing production costs, a positive development of this mining region in the future can be expected only if the mining methods, which are quite primitive now, are replaced by a systematic exploitation with modern mining techniques.

2. Geology

The following remarks concerning the regional and local geological situation in the Carnaíba region are based on the works of Griffon *et al* (1967), Barbosa (1973), Santana *et al* (1980), Santana *et al* (1981), Couto and Almeida (1982), Moreira and Santana (1982), and Couto (1985). They were complemented by our observations made during our field works.

2.1 Regional Geology

The geological situation in the Carnaíba region is marked by the intrusion of granite batholiths (Figure 2) into lithologic units of the Serra de Jacobina. The rocks of the Serra de Jacobina were subdivided by Couto *et al* (1978) into the Jacobina Group and the Itapicuru Complex.

The Jacobina Group consists of an ultrabasic basement unit (with an age of 2.4 to 2.7 billion years) which, together with the granite, is of major importance for the formation of the emerald occurrence. To the east, stratigraphically above, follows the Itapicuru Complex, consisting mainly of phyllites, schists and itabirites. Between the formation of these two rock units and the granite intrusions occurred two metamorphic phases resulting mainly in the mineral parageneses of the greenschist facies.

The lithologies important for the emerald formation are:

a) Granites

They ascended probably along the tectonic western boundary of the Serra de Jacobina and partially intruded the rocks of the Jacobina Group. They

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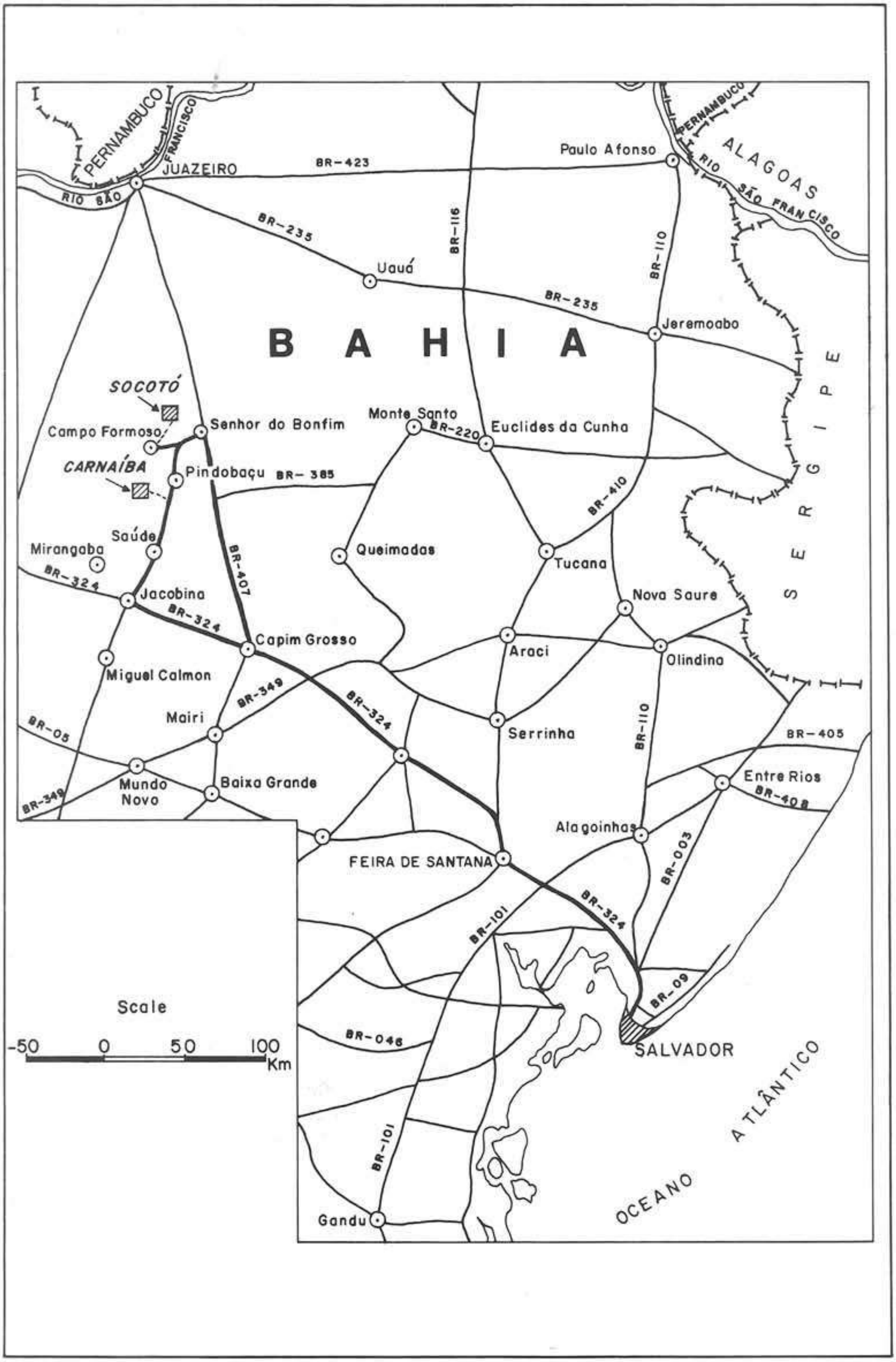
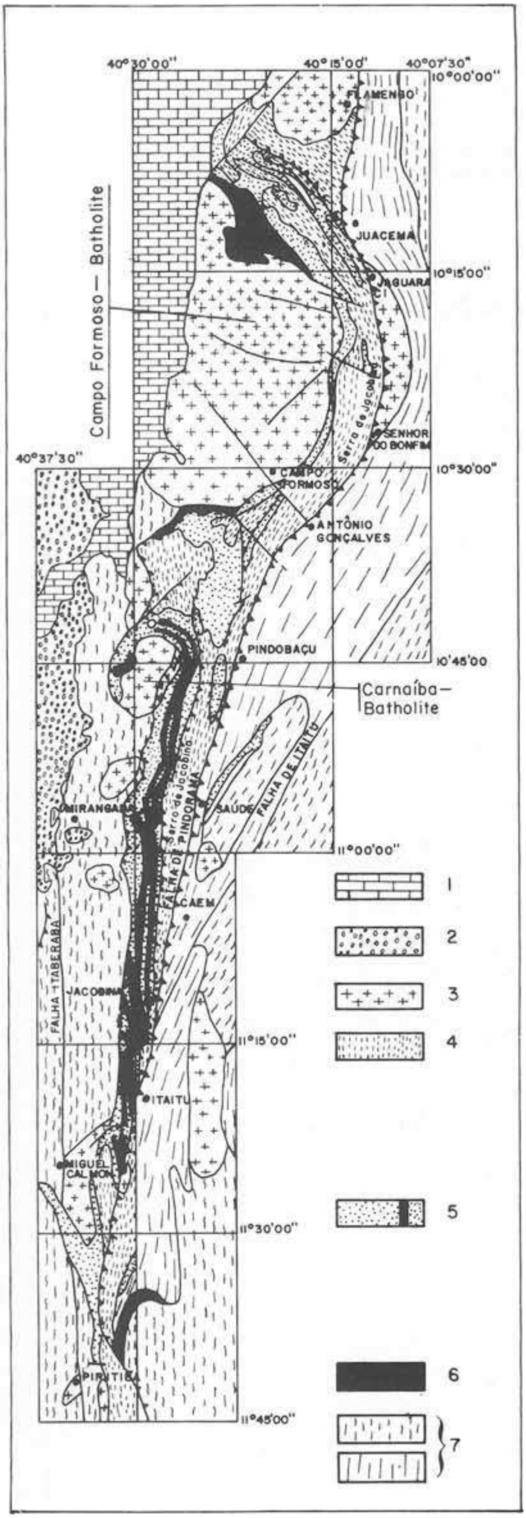


Fig. 1. Geographical map of the northeastern region of the Bahia state.



are associated with pegmatites and, with regard to their mineralogical composition, show similarities to lithologies of the metamorphic-migmatitic complex surrounding the Serra de Jacobina. Their average mineralogical composition is: oligoclase (20–70%), microcline (26–50%), quartz (22–30%), muscovite (up to 5%), and biotite (up to 5%). Rb/Sr age dating gave results ranging from 1.1 to 1.9 billion years (with emphasis on 1.9 billion years). This corresponds to one of the final tectono-magmatic phases of the Transamazonic Cycle during which the rocks of the Jacobina Group were deformed (Santana *et al*, 1980).

b) Ultramafites

Mainly Cr-rich serpentinites and peridotites which were intruded by pegmatites. In the immediate contact area, a metasomatic transformation into biotite/phlogopite schist took place.

The ultramafites can be observed: (1) as enclaves in the Carnaíba granite (the garimpos* called Bode, Gavião, Lagarta, and Formiga are located within such enclaves; compare Figure 3); (2) in strips up to an extension of 200 metres which are separated from the granite by migmatitic gneisses (garimpos of Braúlia and Marota); and (3) as stratiform lenses which were enclosed in quartzites during tectonic activities (garimpos of Trecho Velho and Trecho Novo in Carnaíba de Cima as well as Munde).

c) Quartzites

Intensively recrystallized, they are of light green colour passing into grey when in contact with pegmatites. In Carnaíba de Cima, ultramafites were enclosed within the quartzites during tectonic activities.

*Garimpo = mining area with shafts, pits and trenches, the exploitation is made using primitive methods only

Fig. 2. Geological map of the Serra de Jacobina showing the batholiths of Carnaíba and of Campo Formoso (the latter with the Socotó mining region) (in Inda & Barbosa, modified after Couto *et al.*, 1978).
1– Metasediments of the Una Group
2– Metasediments of the Espinhaço Super Group
3– Granitic rocks
4– Complexo Itapicuru (volcanoclastic sequence): feldspar-quartzites, phyllites and schists, amphibolites, metabasites, and serpentinites. Formations Água Branca (Tab), Serra da Algria (Tsl), Cruz das Almas (Tca), and mica schists with aluminium silicates (Tal)
5– Jacobina Group (clastic sequence): metaconglomerates, orthoquartzites, intercalated serpentinites. Formations Rio do Ouro (Tro) and Serra do Córrego (Tsc)
6– Basic and ultrabasic rocks
7– Basement (i.e. mainly archaic migmatites and gnaisses)

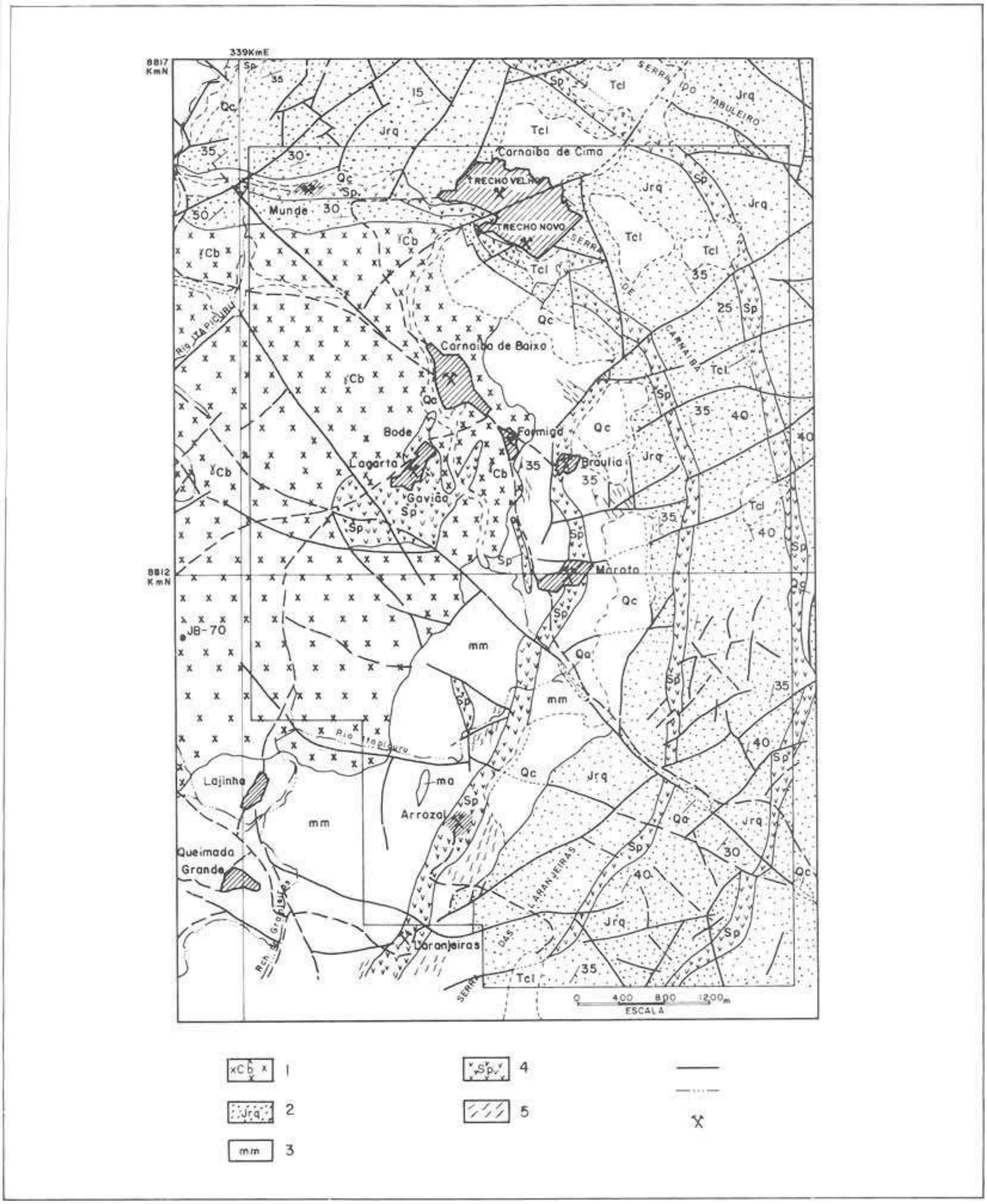


Fig. 3. Geological map of the Carnaíba region

1– Carnaíba granite	faults	
2– Jacobina Group	lithologic and/or	
3– Migmatites	stratgraphic contact	
4– Serpentinites		
5– Cataclastic rocks	emerald	mineralizations

(in: SME – CBPM, Salvador 1978)

d) Pegmatite veins

These have a thickness of not more than two metres and consist mainly of oligoclase and muscovite. Quartz can be found in varying amounts and sometimes forms veins of its own.

e) Metasomatic rocks

They consist almost exclusively of phlogopite or biotite/phlogopite and are in direct contact with the pegmatite- and quartz veins. The micas are oriented mainly parallel to the vein walls and show a lepidoblastic texture which gives the rock a schist-like appearance. The rock is called mica-schist or 'sludite' and is the emerald host rock. The emeralds occur either in form of aggregates or as single crystals. Associated minerals are molybdenite, quartz, apatite, schorl, alexandrite, pyrite, pyrrhotite, chalcopyrite, rutile and scheelite. In a transition zone between the mica-schist and the ultrabasic rocks, masses of talc with phlogopite and some still unweathered serpentinite can be observed.

Fig. 4. a) The 'Carnaíba de Cima' mining field (Upper side on the left).

2.2 LOCAL GEOLOGY AND GENETIC ASPECTS

In Carnaíba de Cima, the emerald host rock can be found in two horizontal levels as well as in several vertical layers. In Carnaíba de Baixo, occur vertical layers as well. The emeralds coming from different mining zones show different qualities (i.e. different colours and density of inclusions). Griffon *et al* (1967) give some processes explaining the formation of new minerals during the transformation of the ultra-basic rocks into mica-schists: $KAlSi_3O_8$ (K-feldspar) + $Mg_6Si_4O_{10}(OH)_8$ (serpentine) = $KMg_3Si_3AlO_{10}(F, OH)_2$ (phlogopite) + $Mg_3Si_4O_{10}(OH)_2$ + $2H_2O$ (talc)

Near the contact zone with the pegmatite, talc is also transformed into phlogopite:

$KAlSi_3O_8$ (K-feldspar) + $Mg_3Si_4O_{10}(OH)_2$ (talc) = $KMg_3Si_3AlO_{10}(F, OH)_2$ (phlogopite) + 3 SiO_2 (quartz)

Phlogopite (sometimes passing into biotite depending on the iron contents of the initial basic rock) forms a monomineralic zone. The great number of quartz veins associated with the mica-schist can be explained by the great amounts of liberated silica and water.

The following hypothesis concerning the genesis of the emerald mineralizations in the region of Carnaíba may be postulated. Metasomatic processes accompanying the intrusion of pegmatite bodies into the surrounding ultrabasic rocks are responsible for the formation of emerald and alexandrite. The appearance of molybdenite and scheelite gives a rough idea concerning the PT-conditions during the metasomatic reactions. Molybdenite and scheelite are typical formations of the final phase of the pegmatitic stadium. Griffon *et al* (1967) settle the geochemical processes resulting in the Carnaíba mineral association in the temperature range of 600–800°C. Other authors suppose an emerald formation in the rothermal-pneumatolytic boundary region with temperatures of about 500°C.

1. Regional tectonics leading to the formation of faults during the metamorphic phases prior to the granite intrusion.
2. Fracture tectonics as a result of the intrusion of the granite body (the longitudinal narrowing of the Serra de Jacobina is probably related to the granite intrusion).

Thus, the Carnaíba deposit confirms the observations made in other emerald deposits showing that the emerald mineralizations are preferably related to the zones of strongest tectonic activities (often presenting mylonitization effects). This can

Fig. 4. b) The 'garimpo' Formiga in the 'Carnaíba de Baixo' mining field.

Griffon *et al* (1967) emphasize the complexity of the structural elements in the area of the emerald deposit. This is the result of several superimposed tectonic phases which are correlated either with the local tectonics (folding of quartzites, formation of faults, filling of fissures with quartz) or with the regional tectonic events of the Serra de Jacobina. Probably, the fault system was there prior to the granite intrusion. It was enlarged by the intrusion of the granite body, creating in such a manner good conditions for the migration of the pegmatitic solutions.

Schematically, the following events can be outlined:

be explained by the fact that within these zones of weakness the mobility of the solutions responsible for the material transport, is considerably increased. Genetically, Carnaíba belongs to the classic type of formation which is characterized by the association of mafic-ultramafic rocks or their metamorphic derivatives (Cr/Fe source rocks) with pegmatites (provide Be).

After Couto (1985) there exist three zones in the mining area which distinguish themselves by their productivity (Figure 3):

1. The 'schistified' ultramafic intercalations in the quartzites (Carnaíba de Cima with Trecho Velho and Trecho Novo).

Table 1. Refractive indices and birefringence of Carnaíba emeralds.

n_e	n_o	Δ_n	References
1.580–1.583	1.587–1.590	0.005–0.007	Bank (1969)
1.582	1.588	0.006	Eppler (1973)
1.566–1.575	1.572–1.582	0.006	Mumme (1982)
1.582	1.588	0.006–0.007	Gübelin (1974)
1.578±0.002	1.584±0.002	0.006–0.007	Sauer (1982)
1.577–1.582	1.582–1.589	0.005–0.008	Schwarz (1987)

Table 2. Microprobe analyses of Carnaíba emeralds. Total iron as FeO. CaO content < 0.01 Wt%.

Sample	CAR-P	CAR-T	CAR-8	CAR-12/1	CAR/FOR-5	CAR-12/2
N°	1	2	3	4	5	6
SiO_2	66.92	63.92	66.49	66.34	66.16	63.99
Al_2O_3	15.43	15.63	16.12	14.92	15.80	15.19
Cr_2O_3	0.73	0.61	0.0	0.37	0.20	0.42
V_2O_3	0.0	0.0	0.08	0.03	0.07	0.0
FeO	0.69	0.78	0.52	0.67	0.65	0.74
MgO	1.87	1.92	1.63	2.34	1.82	2.45
Na_2O	1.29	1.57	1.47	1.85	1.53	1.89
K_2O	0.01	0.0	0.02	0.02	0.02	0.0
Total	86.94	84.43	86.33	86.54	86.25	84.68
Mineral formula (normalized: Si = 6)						
Si	6.000	6.000	6.000	6.000	6.000	6.000
Al	1.680	1.730	1.714	1.604	1.690	1.679
Cr	0.052	0.045	0.000	0.027	0.014	0.030
Mg	0.250	0.268	0.219	0.319	0.246	0.341
Na	0.225	0.285	0.257	0.330	0.269	0.343
Fe^{2+}	0.052	0.062	0.039	0.050	0.049	0.059

2. The less 'schistified' ultramafic belt in the contact region between the Carnaíba granite and the quartzites at the base.
3. The ultrabasic, somewhat granitized rock body intercalated into the Carnaíba granite.

The latter two zones are situated in Carnaíba de Baixo, number 3 also includes the sector of Formiga which had the highest production rates in 1984/85 and of which the emeralds are characterized by a quality above the average. Systematic investigations carried out on request of the Secretaria das Minas e Energia, performed by the Companhia Baiana de Pesquisa Mineral in 1978, led to estimates on reserves of about 2.000 tons of green beryl, including emerald. Of these, 990 tons came from Carnaíba de Cima and the rest from the different sectors of Carnaíba de Baixo.

3. Optical and chemical properties of the Carnaíba emeralds

Table 1 gives the optical data of Carnaíba emeralds determined by different authors. The measured density values range between 2.70 and 2.72 g/cm^3.

Structural and chemical considerations as well as the calculated mineral formula coefficients (Table 2) indicate that the following substitutions are present:

(a) Al^{3+} (octahedral) = $(Mg,Fe)^{2+}$ (octahedral) + Na^+ (channel site)
(b) Al^{3+} (octahedral) = $(Cr,Fe)^{3+}$ (octahedral)

In case of a coupled exchange of the substitution type (a), channel positions are occupied by Na^+, thus compensating the charge difference between Al^{3+} and $(Fe,Mg)^{2+}$.

The representing points shown in the formula coefficients diagram of (Mg + Fe) v. Na (Figure 5) lie below the line corresponding to a gradient of 1, demonstrating a slight excess of (Mg + Fe) over Na. This can be explained by a small amount of Fe^{3+} which needs no compensation by Na^+ in terms of electrical charge. Chromium, which is found in concentrations up to 0.73 Wt% Cr_2O_3, is incorporated in the crystal structure according to substitution type (b).

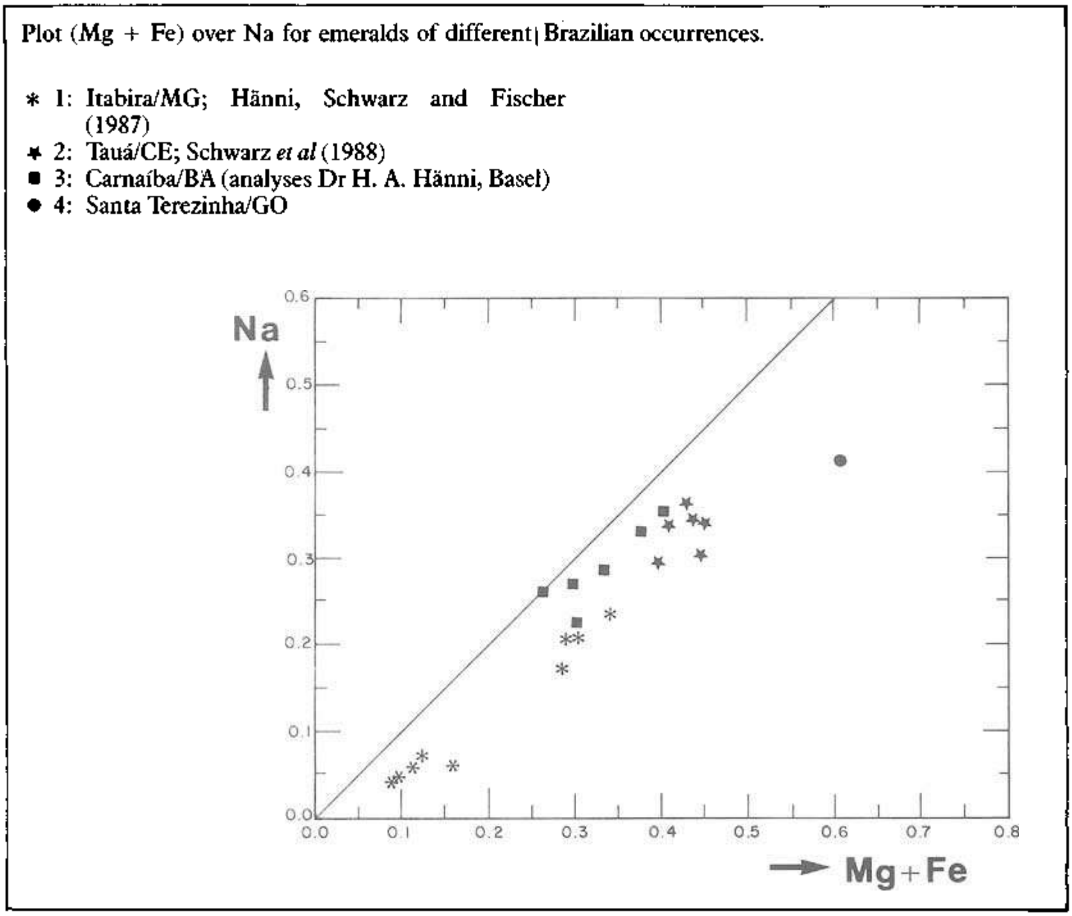


Fig. 5. Mineral formula coefficients Na v. (Mg + Fe) of Brazilian emeralds from different localities.

4. Inclusions

The most frequent inclusions in the Carnaíba emeralds are the so-called 'flocs' and 'stars' (Figures 6 and 7). When examined in the gem microscope – using an immersion liquid and transmitted light – they appear grey to black. Using high magnification (> 50x), it becomes obvious that these formations are composed of tiny particles (Figure 8) which are mostly cavities with a one-phase filling or with a 'l-g' two-phase filling. The flocs and stars are sometimes arranged like pearls on a string and they can also be seen within healed fractures. The particles themselves often form more or less compact agglomerations (clouds) or populate healed fractures where they represent the remnants of healing solutions. Sometimes these particles accompany larger inclusions with two-, three- or multi-phase fillings (Figure 9). The existence of great amounts of these inclusions is responsible for the lack of transparency of the majority of the emeralds from this occurrence (Figure 10).

Apart from mica, mineral inclusions are relatively rare in the Carnaíba emeralds. The most frequent inclusion mineral is a mica of biotite/phlogopite composition (see Table 3) which is represented mainly by two types of different appearance:

a) Plate-like crystals which possess no preferred orientation and present irregular/rounded outlines. These mica plates which obviously are protogenetic inclusions (Figure 11) generally show a more or less intensive brown colour.
b) Crystals showing an uncommon board- or lath-like form (Figures 12a and 12b). They also have no preferred orientation, show different shades of brown and are of protogenetic origin.

Other mineral inclusions, besides biotite/phlogopite, are muscovite and chlorite. The minerals described hereafter were observed only occa-

Table 3. Microprobe analyses of a feldspar inclusion (a), and of two mica crystals (b) in a Carnaíba emerald (Wt%).

	(a) Feldspar		(b) Phlogopite/biotite	Muscovite
SiO_2	69.85	SiO_2	40.22	50.07
TiO_2	0.0	Al_2O_3	13.63	29.14
Al_2O_3	19.83	Cr_2O_3	0.43	–
Cr_2O_3	0.0	FeO	5.42	4.02
V_2O_3	0.0	MgO	20.45	2.85
FeO	0.0	K_2O	9.96	8.22
MnO	0.0	Na_2O	0.37	0.41
MgO	0.18			
CaO	0.57			
Na_2O	11.54			
K_2O	0.01			
F	0.0			
Total	101.98		90.48	95.01

sionally during the examination of more than 600 rough and cut Carnaíba emeralds: tourmaline, albite (Figure 13), molybdenite, lepidocrocite (Figure 14), goethite, beryl (emerald), tremolite/actinolite (Figure 15), apatite (Figure 16), quartz (Figure 17), as well as pyrite and allanite (?) (Figure 15), (Schwarz, 1984).

Tourmaline appears in form of brown-black prismatic crystals which become somewhat transparent only when submitted to strong transmitted light. Tourmaline inclusions have been described several times in emeralds from other occurrences, e.g. from the Habachtal (Morteani & Grundmann, 1977), the Ural Mountains (Sinkankas, 1981), Zambia (Koivula, 1982), and Madagascar (Hänni & Klein, 1982).

Albite forms transparent tabular crystals (Figure 13) or irregular grains ranging from colourless to light brown. The microprobe analysis (Table 3) shows that it is an almost pure albite.

The small, opaque molybdenite plates have irregular rounded or hexagonal outlines and show typical lead-coloured or bluish-grey reflexes in incident light.

Lepidocrocite is characterized by the intense red-orange colour of its aggregates (Figure 14). Goethite occurs in the form of opaque aggregates which resemble splashes of ink, and settle mainly in fissures.

In a few samples we observed transparent tremolite/actinolite rods (Figure 15) as well as extremely fine, curved needles, probably of allanite (Figure 15). Partially, these needles have a hair-like appearance and generally they are not evenly distributed but form clusters and aggregates within the host crystal.

Apatite (Figure 16) forms prismatic, colourless-transparent crystals, partly exhibiting well developed outlines. The chemical analysis showed an F-content of 6.68 Wt%.

Quartz (Figure 17) occurs as prismatic crystals which are distributed all over their host crystal without showing a specific crystallographic orientation.

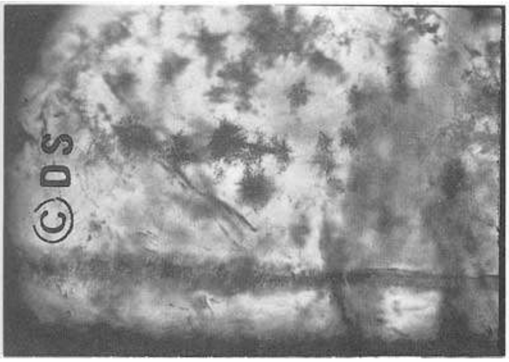
Pyrite grains, with their typical yellow metallic lustre, when seen in incident light, are also irregularly distributed within the host crystal.

Other crystalline inclusions are fragments or protogenetic chips of beryl (emerald) that have been described also by Gübelin (1974) in Colombian emeralds. In normal transmitted light, these inclusions are extremely difficult to detect because they generally are of the same colour and the same refractive index as their host crystal. They become clearly visible, however, when using crossed polarizers, because their dark position is usually different from the dark position of the host crystal.

Growth phenomena are a common inclusion type in the Carnaíba emeralds, they can be observed in a diversity of forms:

a) A concentric striation parallel to the prism faces (looking in the direction of the *c* axis).
b) Growth pyramids forming zig-zag lines (Figure 18) similar to those frequently seen in Colombian emeralds. They correspond to pyramid faces which are formed during certain growth

Note: The magnification of the inclusion photographs is given by the optical unit, composed of microscope objective, ocular, camera distance, etc. All photographs were taken using an immersion liquid.



Figs. 6 and 7. The 'flocs' and 'stars' in the Carnaíba emeralds consist of tiny cavities with one- or two-phase fillings. 35x

Fig. 8. Under high magnification, single particles are visible which compose the floc- or star-like formations. 70x

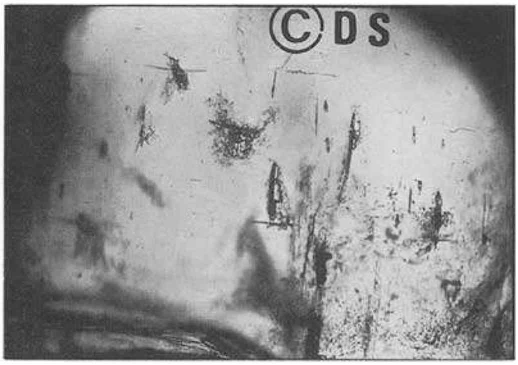


Fig. 9. Larger cavities with two-, three-, or multi-phase fillings, accompanied by numerous tiny cavities with one- or two-phase fillings. 50x

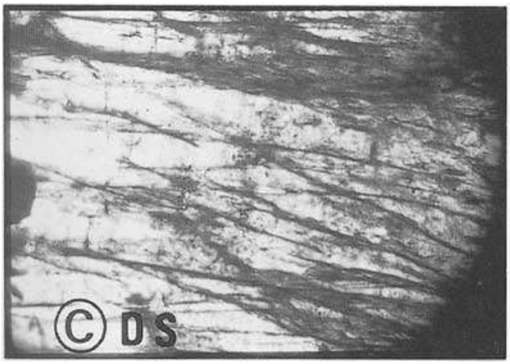


Fig. 10. Most Carnaíba emeralds are of low transparency. This is due to the great number of tiny particles (cavities with one- or two-phase fillings) forming dense clusters (clouds) or being concentrated within healed fractures. 35x

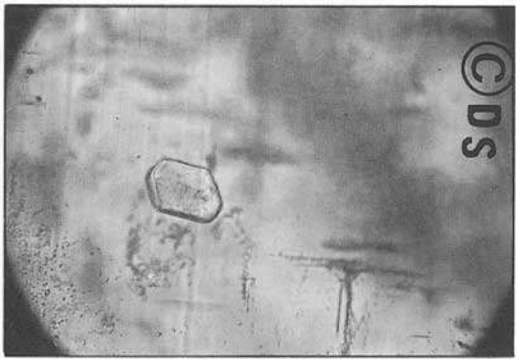


Fig. 13. Tabular, well-developed albite crystal. 50x

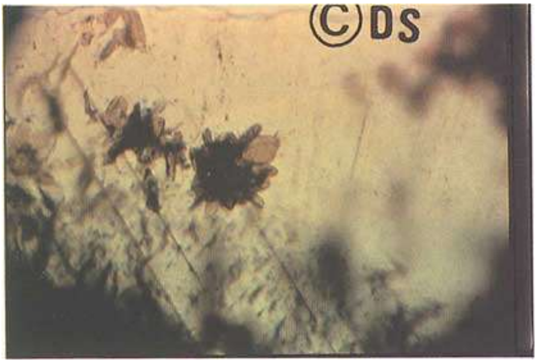


Fig. 11. Protogenetic mica crystals showing irregular outlines. 35x

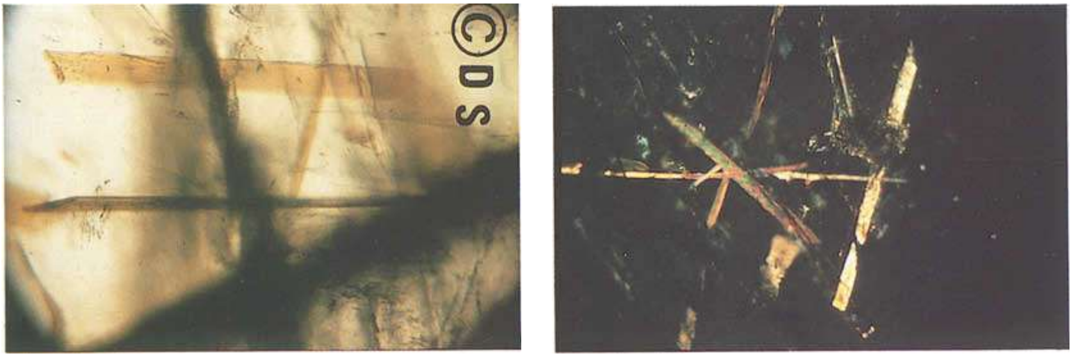


Fig. 12. Mica crystals showing an uncommon 'board'- or 'lath'-like form. a) transmitted light; b) using crossed polarizers, emerald host crystal in dark position. 50x

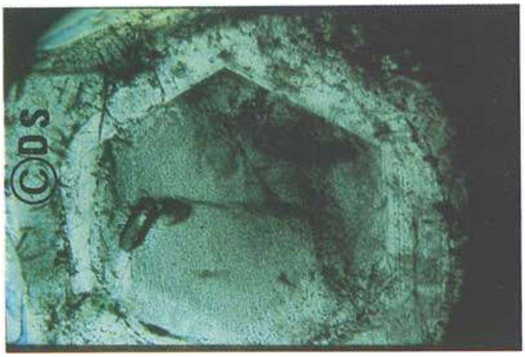


Fig. 17. Besides a sharply limited colour field indicating the hexagonal symmetry of the emerald a prismatic quartz crystal can be seen. 35x

Fig. 19. Typical growth striae (growth layers) with internal structure. 50x

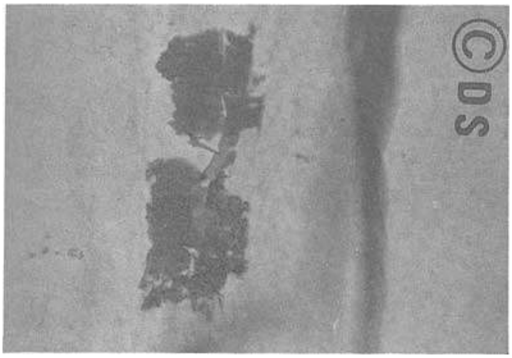


Fig. 14. Aggregates of lepidocrocite showing a strong red-orange colour. 70x

Fig. 15. Transparent-colourless tremolite/actinolite rods and hair-like crystals of a dark brown to black-brown colour (allanite?). 50x

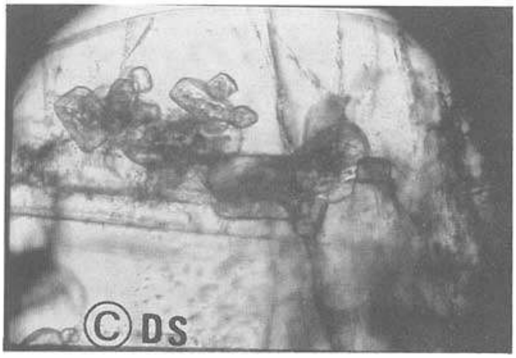


Fig. 16. Prismatic, partly well-formed, apatite crystals. They are distributed in the host crystal without a preferred crystallographic orientation. 35x

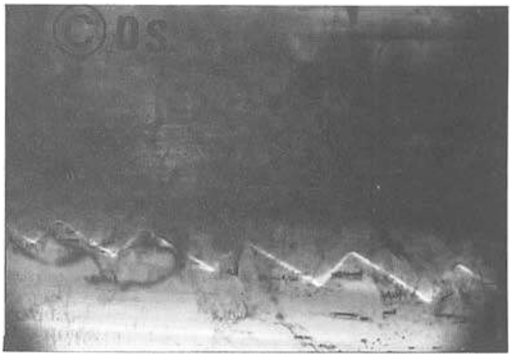


Fig. 18. Growth pyramids forming zig-zag lines. 35x

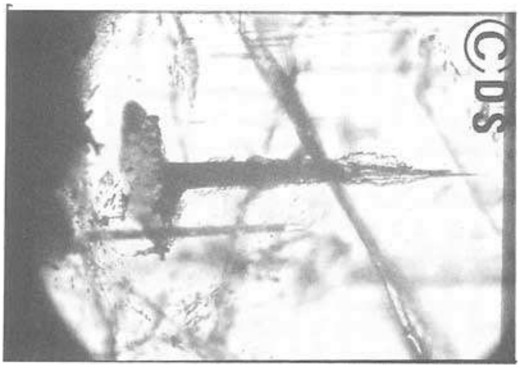


Fig. 20. Conically shaped growth tube, starting from a crystal inclusion. 70x

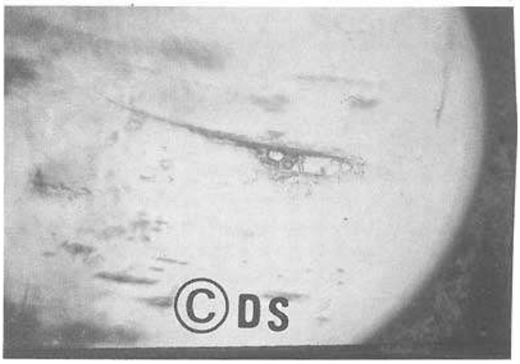


Fig. 21. Cavity with multi-phase filling. 70x

phases but are usually not observed macroscopically.

c) Growth striae or growth layers (Figure 19) which can occur in all directions parallel to both the basal face and the prism faces as well as in directions that are not observed macroscopically. Growth striae as such are common inclusion features both in natural emeralds of different localities and also in synthetic emeralds. Therefore, their appearance normally is only of restricted value as a distinctive mark. In the Carnaíba emeralds, however, features are often observed which can be considered as diagnostic of natural emeralds. The growth layers display an internal structure that remembers pyramids arranged side by side or one after another, or showing a fish scale effect. The formation of this internal structure is due to changing formation conditions during crystal growth. It gives the growth striation a somewhat diffuse (blurred) appearance which is distinctly different from the generally sharply developed growth striae in synthetic emeralds.

Besides the inclusions mentioned above, fine growth tubes are (relatively often) found in Carnaíba emeralds. These growth tubes sometimes start from crystal inclusions (Figure 20). Two-phase inclusions ('l-g' type), three-phase inclusions ('s-l-g' type) and, very rarely, multi-phase inclusions (Figure 21) occur further.

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Iridescent natural glass from Mexico

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Abstract

Transparent brownish 'iris opal' from San Luis Potosí (Mexico) was found to be a natural glass exhibiting layered and botryoidal textures. SEM studies on these layers indicate that they give rise to the iridescent effect, which occurs by interference on layers each of approx. 2μm thickness. An X-ray diffraction pattern shows the material to be amorphous. Infra-red spectroscopy revealed the presence of SiOH groups, but no evidence of water. Microprobe analyses indicated a composition which includes the elements Si, Al, Cs, K and Na as main constituents, and Rb and Fe occur in trace amounts. DTA analysis up to 1200°C resulted in an ignition loss of 0.9% above 900°C.

Introduction

As far back as 1964, transparent light brown stones were mentioned in a gemmological publication (Barbour, 1964), and these are the subject of the present study (Figure 1). In a later report (Sinkankas, 1966) they were called *iris opal*. Leiper (1965) had already noted the presence of spherulitic inclusions. Electron microscopy (TEM) revealed the thin-layered texture, which was thought to be responsible for the iris effect. Viewed under strong illumination (Figure 2 and cover picture) and at the correct orientation, the stones exhibit specific colour effects due to optical interference.

Nowadays, it is known that the play of colours in gem opal represents a colour effect due to the diffraction of white light on a regular pattern of minute spheres (Sanders, 1964). This phenomenon, caused by a 3-dimensional diffraction lattice, needed to be compared with the apparently different mechanism in 'iris opal'. The terms hyalite, hyaline, opal, etc., used in the trade were also thought questionable, and initiated interest in the undertaking of this present study.

The *Iris Effect* as an interference phenomenon at at thin layers has been known to gemmologists for a long time, but not however, in the case of opal! The iris agate mentioned by Webster (1983) exhibits iridescence colours because of interference at thin layers. We wish to differentiate between interference at thin layers (2-dimensional) and diffraction in spatial (3-dimensional) lattices as the cause of colour in gemstones. The first (Iris Effect) can be considered to be a special case of the second (play of colour).

Both the iris effect and play of colour can occur in silica minerals, especially in iris quartz, the various opals and the variety hyalite, as well as in chalcedony and agate. The question arises as to which of these classes the studied material belongs.

Depending on origin and structure of coloured opals, they can be classified into distinguishable mineralogical types (Flörke *et al.*, 1985[2]). In general, it can be said that opal can be formed at low temperatures from aqueous gels. This type exhibits an amorphous character to X-ray diffraction, as shown in opal from some sedimentary rocks from Australia. Opal can also form at higher temperatures and contain crystalline components in the form of cristobalite and/or tridymite within the amorphous mass. It can occur in cavities in volcanic rocks. This opal is not amorphous to X-ray diffraction, but exhibits diffraction patterns representing the crystalline SiO_2 minerals present.

A recent publication (Gübelin 1987, see Figures 21 and 22), which describes black opal from Lightning Ridge, shows scanning electron micrographs. Figure 21 shows the familiar spatially ordered spherical packing, which can cause opalescence. Figure 22, on the other hand, shows a distinct layered structure. The accompanying text describes the material as 'glassy hyaline opal'. The 'sporadic and few cristobalite and tridymite spheres' mentioned cannot be seen in the figure, and as they do not represent dense, ordered patterns, they cannot produce the play of colours. For this reason, the narrow layers would therefore seem to play a more important role in explaining the opal-like behaviour of the 'hyaline opal'. Discussions with the author (Gübelin, 1988) clearly indicate that the latter material is most probably identical to the glass from Mexico examined in this study.

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Fig. 1. A number of specimens of natural iridescent glass from Mexico. Rear left: natural untreated material; rear right: a frothy specimen of the glass after heating to 1200°C. The largest of the faceted stones weighs 3.2ct.

Origin and type of material

Our study material originates from the Tepetate and Lourdes area in the state of San Luis Potosí in Mexico (Koivula, 1988). Sinkankas (1966) also mentions a location near Durango. The host-rock is described as volcanic, probably a rhyolite, in whose cavities topaz and droplet-like to crusty forms of the studied glass occur. Reniform to grape-like masses are often called botryoidal forms. The iridescent glass occasionally forms caps on crystals of topaz, thus indicating a certain genetic relationship. Under the hand lens, the surfaces of the glass bodies (up to cm-large) and crusts can be seen to be composed of very fine step-like layers as sometimes seen on pearls, however in the case of the glass, some wedge-like features are often seen (Figure 3). Older natural surfaces are often pitted, and may be either the result of corrosion or are larger open pores.

Gemmological and optical characteristics

The following studies were carried out on eight stones, some of which are faceted or polished, the remaining uncut. Their colour varies between light yellowish- and greenish-brown, and the form of all stones is botryoidal, identical to that of hyalite.

Note should be made here of the similarity of the surface to that of artificial glass. The fine botryoidal layers can be easily mistaken for 'swirl marks' in artificial glasses, and the stress-induced birefringence exhibited between polarizing filters and the low values for density and refractive

Fig. 2. Iridescent glass with botryoidal form, exhibiting spectral colours due to interference on thin layers.

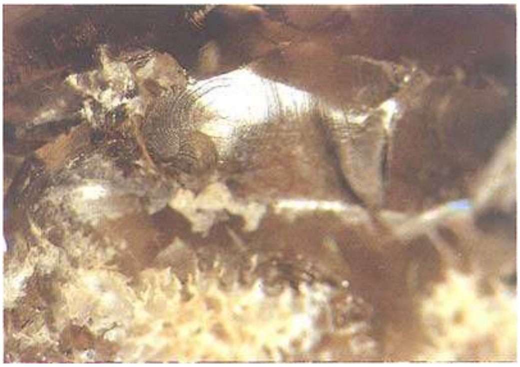

Fig. 3. Natural surface of iridescent glass, showing concentric layered structure. Magnification 10x.

indices are also similar to those expected in glasses. Spherical inclusions also resemble the gas bubbles or vesicles seen in many glasses. However, closer optical study reveals the presence of conical segments of fine and bent layered stacks, slightly tilted one to another, which make up the single crusts and clumps. This is an unknown phenomenon in artificial glasses. The description of the hyalite structure (Flörke *et al.*, 1985) as a consequence of a 'layer-by-layer deposition from droplets, which have built up cone-like common contact surfaces' also fits iridescent glass accurately.

Small, spherical forms (spherulites) are found as inclusions, from which short cracks radiate, or which are surrounded by foliated fissures. The spherulites are amorphous (Figure 4).

The stones are isotropic under polarized light, although in thicker layers, stress-induced birefringence becomes evident (Figure 5). Using fibre optics, spectral colours are produced which follow the thin-layered texture when the stone is tilted (Figure 2). Density and refractive index data are presented in Table 1.

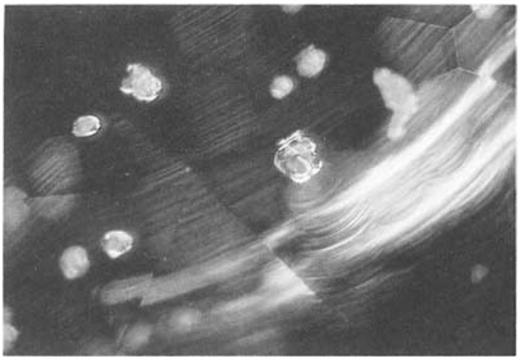

Fig. 4. Spherical inclusions (amorphous) with a 'wreath' of fine fissures, and finely layered botryoidal texture. Magnification ca. 20x.

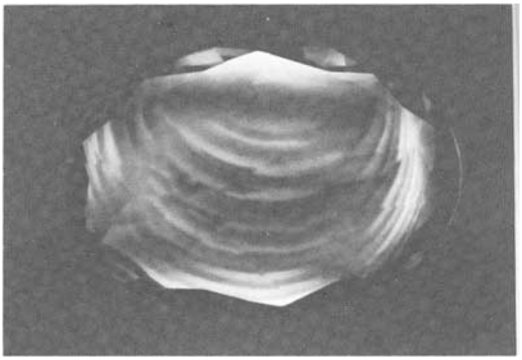

Fig. 5. Birefringence produced due to stress. Iridescent glass between crossed polarization filters.

Table 1: Physical data for iridescent glass from San Luis Potosi (Mexico)

Density	2.241–2.270 g/cm^3
(Sinkankas 1966:	2.257)
Refractive index	1.462–1.467
(Sinkankas 1966:	1.4625)

The absorption spectrum contains no identifiable lines. It is characterized by a slight increase of the absorption from 900 to 450nm. From there, the curve becomes steeper and attains a maximum at 430nm. This confirms the findings of Liddicoat (1985), who noted additional bands at 495 and 460nm, and compared the spectrum with that of a uranium glass described in Webster (1983).

The iridescent glasses exhibit a weak to medium strong greenish fluorescence under long-wave ultra-violet radiation.

Comparison of the data with that for density and refractive indices of artificial glasses in the Bannister diagram (Webster, 1983) shows that the values fall in the region of the so-called opal glasses, without the iris glass specimens exhibiting the milkiness of these artificial products.

Scanning electron miscroscopy (SEM) study

Fracture surfaces of the iridescent glass were studied with a Philips 515 SEM with an attached energy-dispersive analyser (Tracor). Using this equipment images were formed and energy-dispersive X-ray spectra produced. As the technique requires a conducting surface, the specimen surfaces were coated with a thin layer of gold.

The SEM micrographs plainly show the finely-layered texture of the material, and the bent form of the individual layers is also clearly visible (Figure 6). The wedge-like features can be seen in detail where the individual sectors and cones touch each other. At higher magnification, layered structures, each only 2.5μm thick, are recognisable on a fracture surface (Figure 7). This observation agrees remarkably well with the figures and data in Sinkankas (1966), who reports an average width of the bands of 2.24μm. At these dimensions, the stacked layers exhibit interference in ultraviolet radiation (Jones, 1952), and the phenomenon of iridescence is adequately explained.

The numerous minute cracks seen in Figure 7 could possibly represent a partial structure, or could be interpreted as shrinkage cracks.

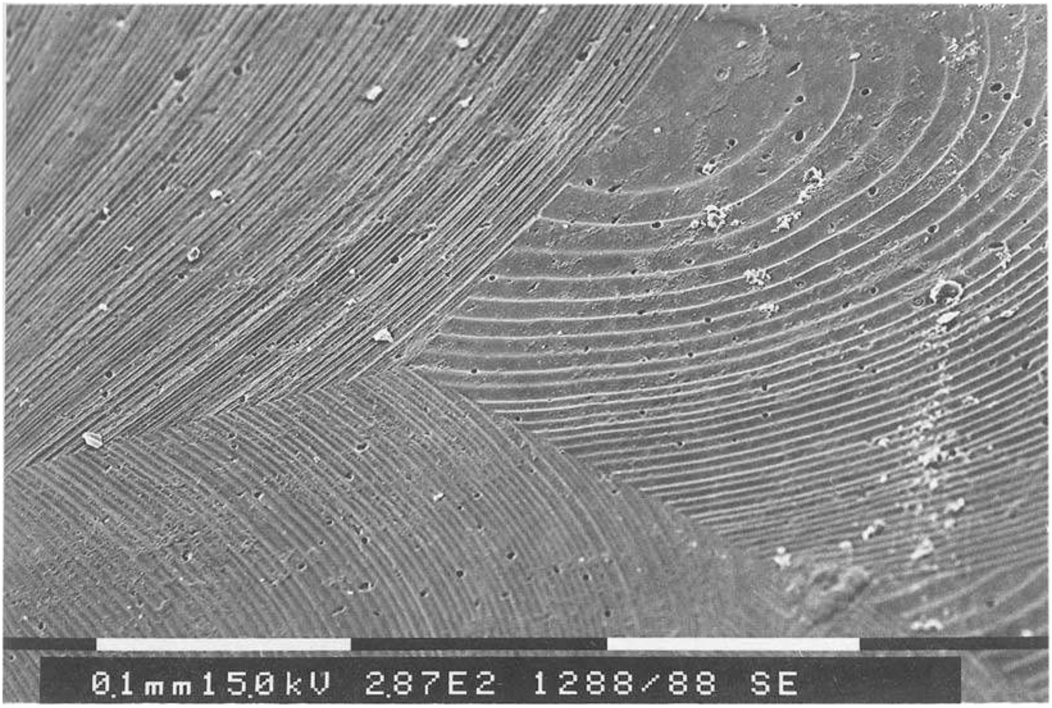

Fig. 6. SEM micrograph of the surface of a raw sample of iridescent glass revealing thin and bent layers as well as a few holes. White scale bar is 0.1mm long.

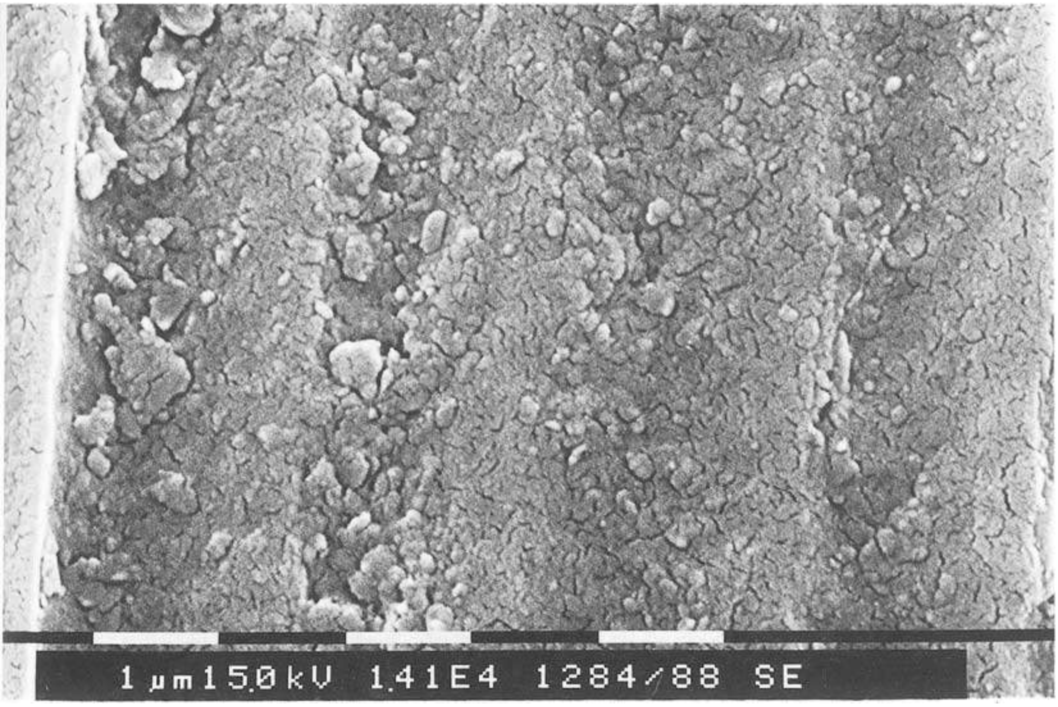

Fig. 7. SEM photograph of the surface showing the stepped nature caused by the emergence of the steeply inclined 2µm thick layers. The small crooked openings may be 'shrinkage cracks'. White scale bar is 1µm long.

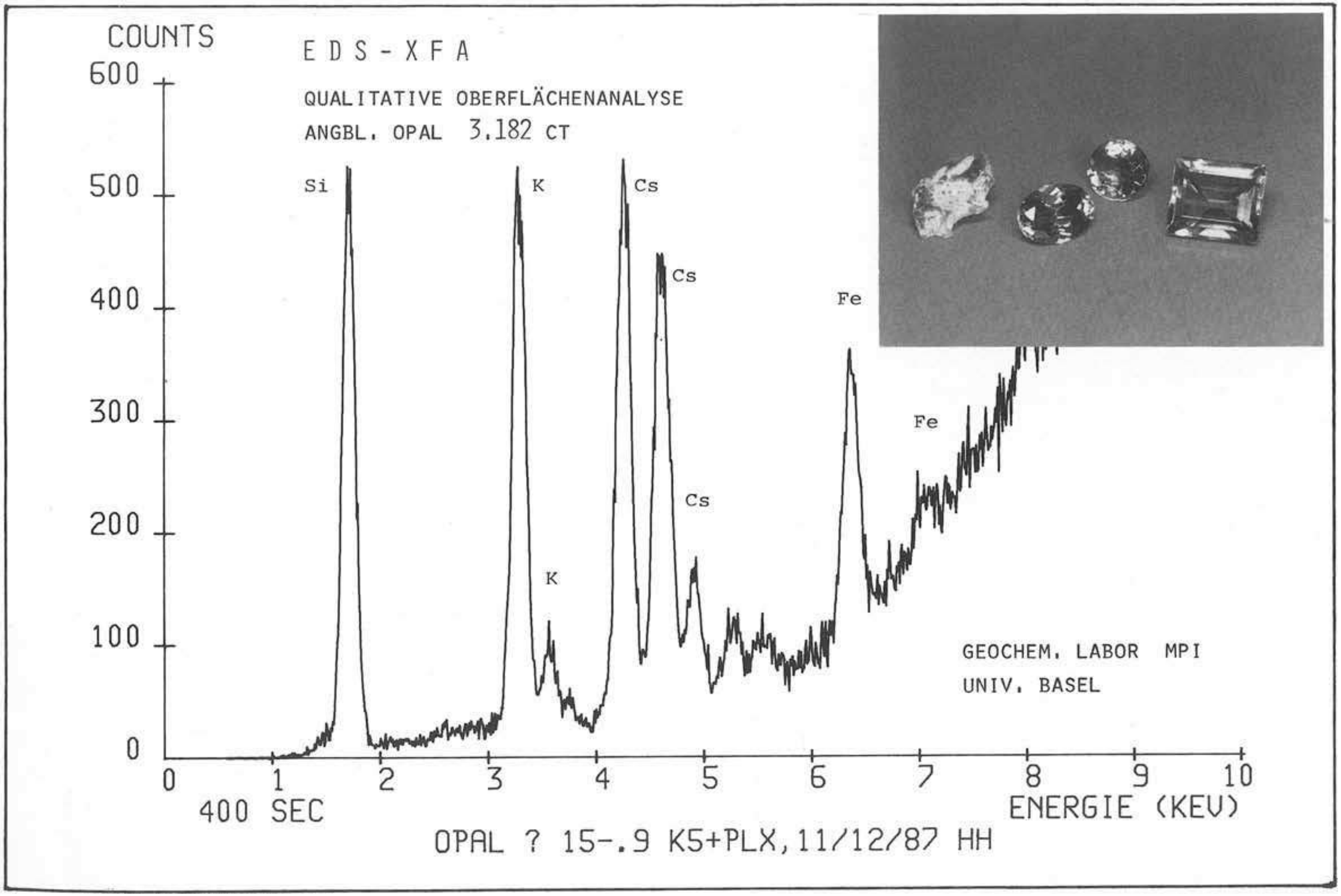

Fig. 8. General EDS-XRF spectrum of iridescent glass. The instrument conditions chosen only reveal the presence of the medium heavy elements.

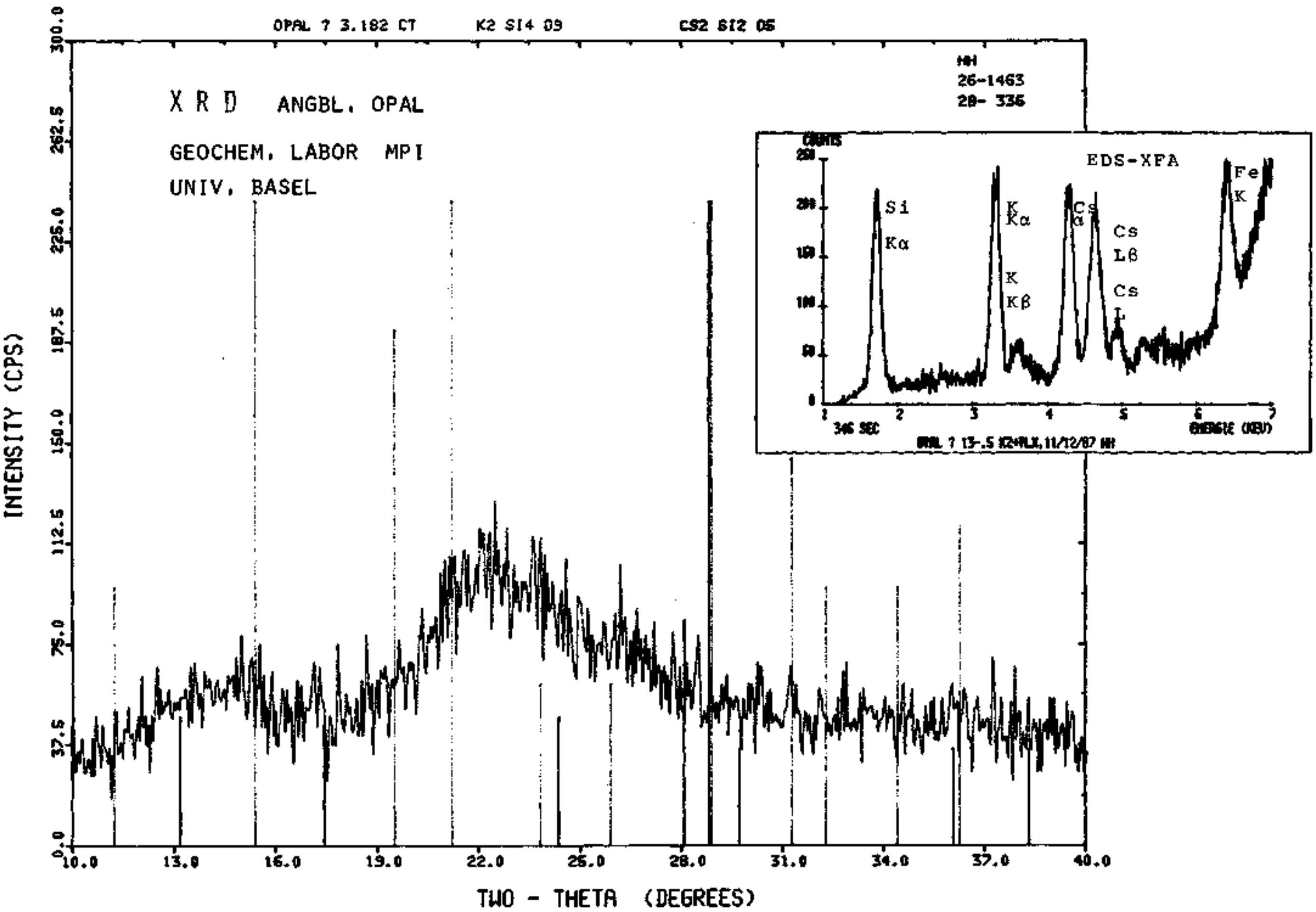

Fig. 9. X-ray diffractogram of iridescent glass from Mexico, showing the absence of crystallinity, thus indicating the amorphous character of the sample. The box (upper right) shows the EDXRF spectrum of Fig. 8.

Chemical study

No chemical data is presented in the publications cited. Our chemical study of iridescent glass was undertaken in a number of stages. Energy-dispersive X-ray fluorescence analysis (EDS-XFA) has been used in gemmology for some time now with success (Stern and Hänni, 1982). Qualitative analyses were undertaken using EDXRF (Figure 9). The spectra show the presence of elements which are for opal, to say the least, unusual. Apart from Si, K and Cs as major to minor elements, Fe, As and possibly U occur as trace elements.

The quantitative analysis of the major and minor components was undertaken with an electron probe microanalyser (Jeol JXA-8600), using a combination of EDS/WDS-analysis (Schwander and Gloor, 1980). The results of the quantitative analysis are presented in Table 2, supplemented by the semi-quantitative analysis for Cs, calculated from the SEM-EDS spectrum. Light elements and volatile components such as Li, B, Be, H_2O, CO_2, were omitted due to analysis problems encountered by such components. The fine-layered texture observed under the microscope appeared to be chemically homogeneous under the electron microprobe and no chemical zoning was indicated. However, chemical variations may exist, but lie below the resolution of the electron microprobe (EPMA).

Table 2: Chemical composition of iridescent glass from San Luis Potosí (Mexico)

SiO_2	87.90 Wt.%
Al_2O_3	3.64
Cs_2O	2.0
K_2O	1.93
Na_2O	0.55
Fe_2O_3	0.02
	96.02%

Light elements with Z<11 (e.g. Li, Be, B etc.) could not be analysed by EPMA.

A partial (EPMA) quantitative analysis in 1977 (pers. comm. Gübelin, 1988) was undertaken, most probably on the same material ('yellow hyaline', Mexico), and the contents of Si, Al, K, Na and Fe were similar to those given in Table 2. Values for Cs and Rb, however, are absent. From the analysis, the material thus cannot be regarded as opal nor as hyalite.

As opals (and hyalites) contain up to >99% SiO_2 (Flörke *et al.*, 1985[1]), the Mexican material (which contains 12 Wt.% other elements) cannot by definition be considered to be opal.

X-ray diffraction studies

A powder diffraction film contained no lines and the material is thus amorphous. An X-ray diffraction study using a Siemens Kristalloflex diffractometer revealed a weak and broad intensity maximum at 22° 2θ [CuKα] and a second even weaker one at about 15° 2θ (Figure 8). Such weak 'bulges' of the background can be explained by the presence of an unordered network of SiO_4 tetrahedrons. The proven amorphous character of the material indicates the absence of C/T opal (with cristobalite and tridymite), which often occurs in some volcanic areas of Mexico. An X-ray study of one of the spherulitic inclusions (powder technique, Bradley camera) again resulted in the absence of any diffraction lines, indicating the amorphous nature of the inclusions.

Infra-red spectroscopy (IRS)

IRS is used when the presence of certain molecules, organic groups or water has to be determined. As all opals contain 1–12% water occurring mainly as molecular water, this specific study was of particular significance. The IR spectra did not show the presence of any molecular water. Spectral bands seen at 3600 and 4450 cm^{-1} are assigned to Si-OH groups (Langer and Flörke, 1974). The content is <0.1 wt. %. A similar 'OH spectrum' is exhibited by certain silica glasses, which occur naturally as Libyan desert glass. A measurable hydrogen-content in the form of silanol groups (Si-OH) and the absence of molecular water (H_2O) are thus apparently characteristic of the Mexican iridescent glass and distinguish it from opal.

Thermal study

A thermo-gravimetric study using a Mettler thermobalance TA 3000 gave information on mass changes in the material when heated to 1200°C. Any water present will be expelled and the change in mass relative to temperature can be monitored. Heating the sample at 10°/minute initially revealed no change in mass until >900°C, at which stage a mass loss was registered attaining 0.92% at 1200°C. After heating, the appearance of the material had altered considerably and resembled a coarsely-blistered foam or froth. This behaviour is markedly different to that of opal, not only with the low ignition loss but also in this conversion to foam-like material. A subsequent study of the crystallinity showed that the material was still amorphous, and no cristobalite was formed as would have been the case with opal. Further studies are planned to determine the actual composition of the 0.92% material expelled during heating, using a heating arrangement in vacuum with a coupled mass spectrometer.

Discussion of results

The study has furnished much information which conflicts with the original idea that the Mexican material was hyalite or another variety of opal. A review by Flörke *et al.* (1985[2]) presents the non-crystalline and micro-crystalline SiO_2 minerals and their aggregates, known at that time, and hyalite is a specific sub-type and an amorphous variety of opal. The SiO_2 minerals and aggregates listed by Flörke *et al* are chemically very pure in comparison with the iridescent glass studied in this publication and which contains about 12 % wt. of other elements. The 3% alkali metals are of particular interest. Some Li could well be present since the analytical total of 96% (EPMA) leaves 4% unaccounted for. Although hyalite contains 3-5% molecular water and about 1% silanol (Flörke *et al.*, 1985[1]), less than 0.1% silanol was found in the Mexican glass. Thermal analysis of hyalite reveals a maximum weight loss around 275°C. This occurs only at >920°C with iridescent glass. On the basis of these substantial differences, iridescent glass cannot be considered to belong to the SiO_2 family, although some features similar to those of hyalite are observed: particularly the glassy appearance, the botryoidal form of the crusts, and possibly the large pore-like 'holes' (Figure 6), (Flörke *et al.*, 1985[2]). The occurrence and habit of the material is strongly reminiscent of hyalite.

The 'shrinkage cracks' seen in Figure 7 raise the question of whether these could have been formed by the migration or diffusion of molecular water originally present.

Finally, the question on the genesis of these unusual natural glasses is raised. We are used to linking the term 'glass' with a magmatic origin, but the extremely fine layers and the botryoidal texture would tend to discount this possibility. Thus we are left with the possible formation of this amorphous material from late-magmatic vapours, steams or aqueous solutions. The formation of iridescent glass is most plausibly explained by rhythmic deposition from steams, mainly indicated by the finely-layered texture. The latter may have been formed by successive deposits of chemically very different 2μm thick layers. In theory, therefore, a rhythmic deposition of (water-free?) opal with layers of alkali-rich substances is quite feasible. A steam phase could – in the rhyolitic area where the glass is found – quite easily have transported the alkalis. In future investigations, the precise composition of the steam must be determined and its function during formation of the glass and its subsequent disappearance explained.

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J. Gemm., 1989, 21, 8

A jade moon?

R. Keith Mitchell, FGA

I wonder how many readers will agree with me in thinking that this picture looks remarkably like a full moon in a star-lit sky.

But it is in fact a disc of orange-veined yellow jadeite, just 2mm thick, photographed by transmitted light between two sheets of crossed polaroid simply because it shows to a very marked degree the fibrous structure of the material. The polaroids do increase the contrast, but only by a very little. I have used them mainly because they provide a nice background while allowing me to light the disc from the back. Such a multi-crystalline plate does not extinguish between polaroids.

One side was flat enough to give a reasonably good RI of 1.66, but I was not able to find any trace of the normally expected 437nm absorption when I used the spectroscope. The whole disc fluoresced slightly under LWUV, with the paler area at the bottom showing the most reaction. Close examination of surface reflection using a 10x lens revealed the expected 'orange peel' effect due to under-cutting when it was polished. Nephrite does not show this effect to the same degree.

Oh yes! The 'stars' in this 'night-sky' picture are minute dust particles between the two sheets of polaroid. Much household dust consists of cotton or other fibres which happen to be birefringent. Most, if not all, fabric fibres are!

It is perhaps worth mentioning that such fibres are often to be found abraded from the silk in the drill-holes of pearls or other beads. I recall an occasion at Chelsea Polytechnic more than forty years ago when a very knowledgeable gemmologist was temporarily foxed by such doubly refracting fibres found in a scraping taken from the drill hole of an emerald bead. They can be quite a surprise unless one is aware of the possibility of finding them.

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Cambay's indigenous silica powder for polishing ruby, sapphire and emerald

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Abstract

Through the ages the lapidary of Cambay has invented many indigenous materials for gem cutting. One such material is the polishing powder, a by-product derived while perforating the silica beads by using diamond tipped bow-drill. This silica powder is refined by wet sieving and heating to make it suitable for polishing hard stones like ruby, sapphire and emerald.

Key words

Lapidary, hard stone, chalcedony, bow-drill, perforation, polishing powder.

Introduction

Cambay (Khambhat: 22°19′N and 72°38′E) in Gujarat is an important centre for gem cutting in India. It has a long tradition of lapidary work that may be traced much before two millennia (Mehta, 1968, Shukla, 1972). Over the centuries, stones processed here were traded in many parts of the world (Arkell, 1936, Janaki, 1980). The methods followed for manufacturing ornamental stone beads have been explained by many authors (Possehl, 1981, Francis, 1982, Karanth, 1988). However, the technology of cutting and polishing coloured stones has not been explained adequately. Ingenuity of the lapidary of Cambay lies in becoming self sufficient in the process of gem cutting. The instruments used for gem cutting are fabricated locally. In fact, some of the lapidary techniques like tumbling were originated in Cambay. An important material produced indigenously is the fine powder used for polishing highly precious stones, viz. ruby, sapphire and emerald. Many authors have listed several kinds of powder for polishing gemstones all over the world (Baxter, 1950, Sparingen, 1950, Sinkankas, 1962). However, none of them has recorded the type of silica powder produced indigenously in Cambay.

Material

Silica powder under study is a by-product obtained while perforating the ornamental beads. By and large the decorative beads produced here belong to silica group, in particular the cryptocrystalline varieties (agate, etc.). The latter accounts for over 95% of the beads manufactured, as chalcedony varieties are mined extensively in nearby Ratanpura-Jhagadia in Bharuch district. The Cambay lapidary follows several steps to produce silica beads, one such step being driving a hole through the bead. Perforation of silica beads is carried out by a very primitive, nevertheless, very effective bow-drill method. The details of bead making and construction and mechanism of bow-drill has been explained in an earlier publication (Karanth, 1988).

The bow-drill unit essentially consists of a wooden shaft, fitted with a steel rib having diamond bits at the drilling end. The drill shaft is rotated with the help of bow-string (Figure 1). First, the place for perforation is marked with single diamond bit drill, and further, the full length perforation is carried out with the help of double diamond bit drill. The drilling is operated from both the ends which ultimately meet to produce a tubular hole. While drilling, the scooped out silica powder from the bead falls down with a thin stream of water (coolant) supplied through a long steel rib attached to a pot of water. Silica powder thus produced is collected in a bowl kept below the scaffold that holds the bead and taken for further processing to make it suitable for polishing.

Processing

Wet silica powder collected in the bowl is poured into a large container of water. After stirring and mixing the paste thoroughly in water, the coarser particles are allowed to settle at the bottom for some time. The upper part of water, ie, water with suspended fine particles is decanted and filtered through a fine cloth for removing the stray coarser particles and floating materials. Suspended fine particles are allowed to settle completely for a day or two. The paste of silica powder collected at the base is rolled into ovoidal balls of about 3–4 cm

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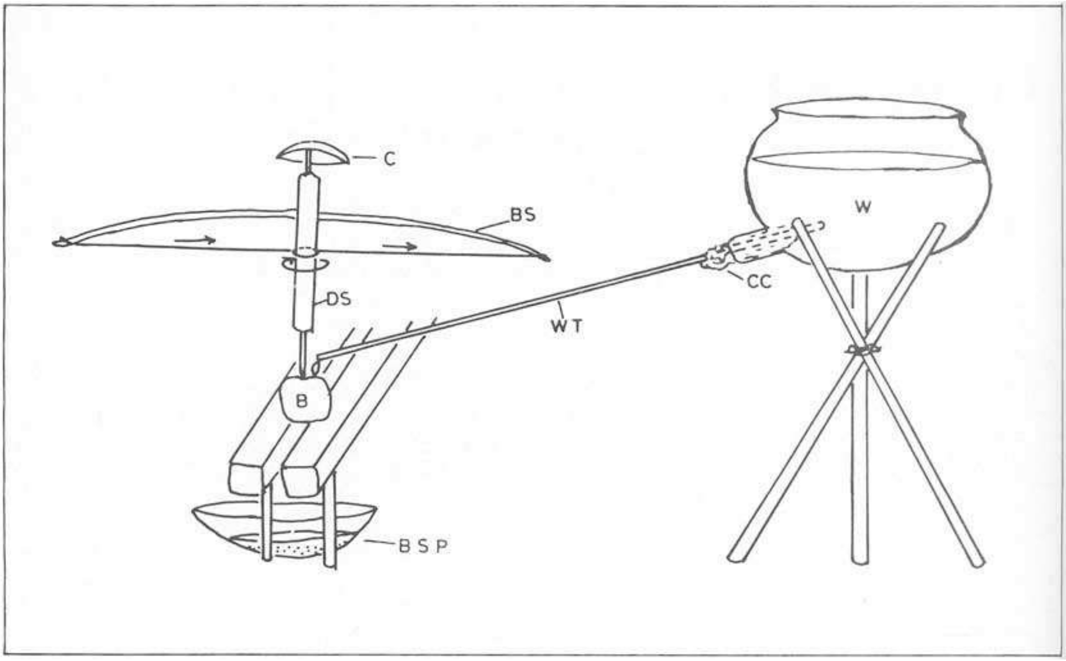

Fig. 1. Bow-drilling unit for perforation (B – silica bead, DS – drill shaft, C – Coconut shell for protection of hand while drilling, BS – bow-string, WT – Water transport, CC – cotton cloth for regulating water flow, W – water pot, BSP – bowl to collect silica powder).

diameter. After drying, these lumps are further placed in a heap of cowdung cake or saw dust and burnt overnight. This process appears to help in driving off intergranular/interfibre water molecules of chalcedony powder and makes the cryptocrystalline silica powder crumple further into much finer particles. The final product obtained is the lump of milky white silica powder, ready for polishing. Often the silica powder lump is used directly without burning.

Grain size

Grain size of silica was analysed for two samples in SACPZ Schimadzu Particle Size Analyser. The samples were run at 500 RPM for a period of 150 minutes. A majority of particles of both the samples measured about one micrometre (Table 1). Sample 1 supplied was more carefully filtered through a much finer cloth than Sample 2. This fact is adequately reflected in the data obtained. According to the lapidaries of Cambay this powder is highly effective for polishing hard stones.

Polishing

Varieties of corundum, chrysoberyl and beryl can be polished efficiently with the silica powder. However, Cambay lapidaries prefer different laps for different stones, as listed below: (i) natural corundum (ruby and sapphire HM* = HL** = 9): copper rich bronze lap; (ii) synthetic ruby – sapphire (HM = 9, HL = little less than 9) and chrysoberyl (alexandrite and cat's eye, HM = 8.5, HL = 8.5–8.8): copper lap; (iii) beryl (emerald and aquamarine, HM = 7.5–8, HL = 7): tin lap.

For polishing emerald, absolutely finer powder without any larger particle is preferred, while the lapidary would not mind a few larger particles (not more than 5–10 μm) for polishing corundum, as the latter is much harder than the former. In the case of emerald even a single large grain could spoil the smoothness of a facet by creating an ugly scratch. On the contrary, in the case of ruby-sapphire, Cambay lapidaries believe that the larger particle might help in removing prepolish irregularities of a facet (Mr. Mulchand Zaveri, personal comm.).

* HM = Mohs scale of hardness
** HL = Apparent lapidary hardness
Except the synthetic corundum, the values of hardness are after Sinkankas (1962).

Table 1. Particle size distribution of silica powder

Diameter in μm	Sample 1 cumul. %	Sample 2 cumul. %
10.0	0.0	0.0
8.0	0.0	0.3
6.0	0.0	0.3
5.0	0.0	0.3
4.0	0.0	0.3
3.0	0.0	0.3
2.0	0.0	23.9
1.0	62.4	79.8
0.8	75.5	88.9
0.6	87.1	NA
0.4	NA	NA

(NA – not analysed)

Discussion and conclusion

High efficiency of the silica powder obtained from bow-drilling has made the Cambay lapidary not to go for modern ultrasonic method of perforation. As mentioned earlier in the case of bow-drilling, the boring operation is executed from both the ends of a bead and is planned to meet at one place to produce a continuous hole. However, quite often the holes drilled from either sides meet irregularly making the operation of driving thread difficult. In the international market, this forms a main objection for the beads produced in Cambay. On the contrary, from the more efficient ultrasonic drill, a continuous, smooth hole can be obtained from one end itself. But from this method, the scooped out silica powder gets mixed with the abrasive powder (emery: coarse grit) used for boring and this mixture can not be used further for any purpose. Though a few ultrasonic perforators have been installed in Cambay, the majority of lapidaries are sticking to the ancient method because of the valuable by-product.

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Some inexpensive improvements to existing instruments

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In putting together my modest gemmology lab I did a lot of comparison shopping and adapting of various equipment to keep my costs down. The polariscope (Figure 1) for example, was a piece of PVC sewage pipe (new, of course) which had an access port cut in the side and two rings made by cutting a chunk from a slice of the same tube which then supported the filters. There were $7.00 polarizing camera filters used in it. The 49mm filters used happened to fit the GIA immersion cell perfectly and furnished me with a very useful polariscope at low cost. While all gemmologists could build such a tool fairly easily, there were several items that I thought worth sharing with your readers.

First is the method of spot readings from the Rayner refractometer suggested by Dr R. M. Yu in the *Journal of Gemmology*[1]. He suggested using a divergent lens[2] over the eyepiece of the refractometer which makes spot readings far easier. I found that stacking two lenses one on top of the other made the readings easier still on my Dialdex and even allowed spot estimates of birefringence in some cases (Figures 2 and 3). I cut the bottom of a plastic container of pills which fitted the eyepiece of the instrument perfectly and glued the lenses to it after cutting a hole in the bottom. This enabled me to install and remove the lens arrangement rapidly and has proved very useful in practice. The divergent lenses bring both refractive index shadow and Dialdex shadow bar into sharp focus at the same time. I believe that this combination gives greater accuracy for such tests than is possible on standard refractometers.

Second is an adaptation of the Hanneman specific gravity balance which increases its already very high accuracy to the point that it easily gives the correct SG reading for stones as small as 0.25ct, substantially better than with a glassed in chemical balance. It should be noted that I usually use an average of three readings. I also check the balance before and sometimes during use with a known sample to make sure all is well with it.

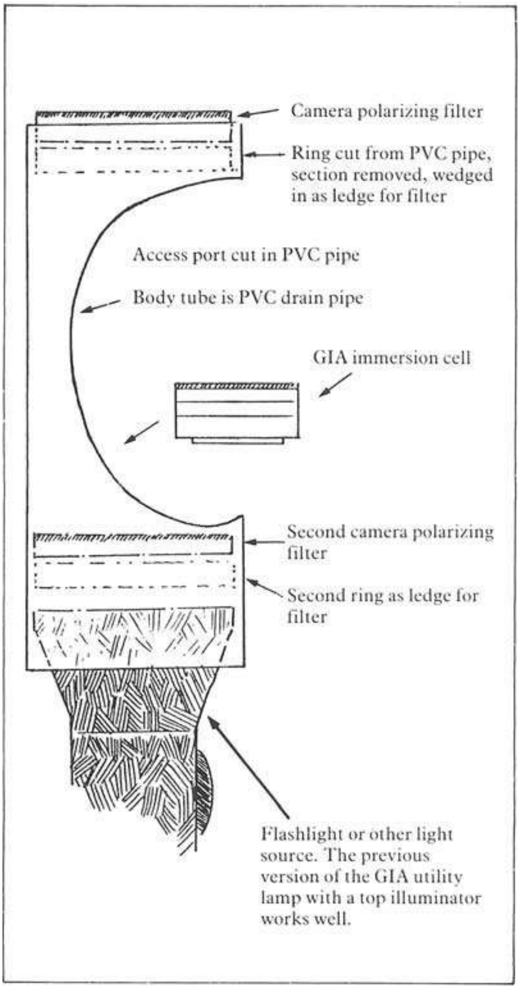

Fig. 1. A home-made polariscope.

[1]Yu, R. M. 1984, Improvements on the Rayner Refractometer, *The Journal of Gemmology*, **XIX**(1), 62–4.
[2]Divergent lens available from Edmund Scientific USA and Efston Scientific in Canada. The catalog number is #94,425.

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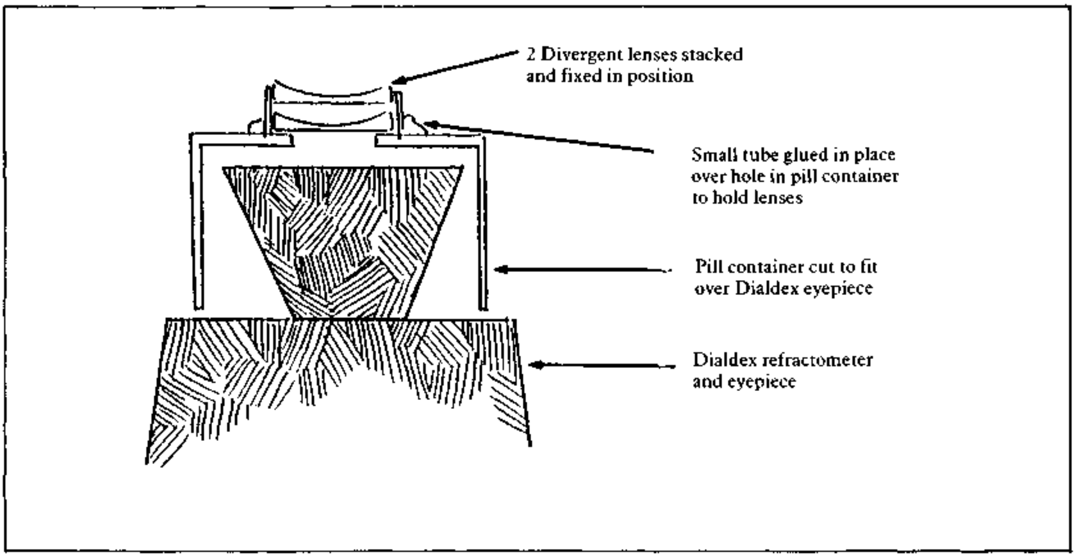


Fig. 2. Lens arrangement for improving spot readings on the Rayner refractometer.

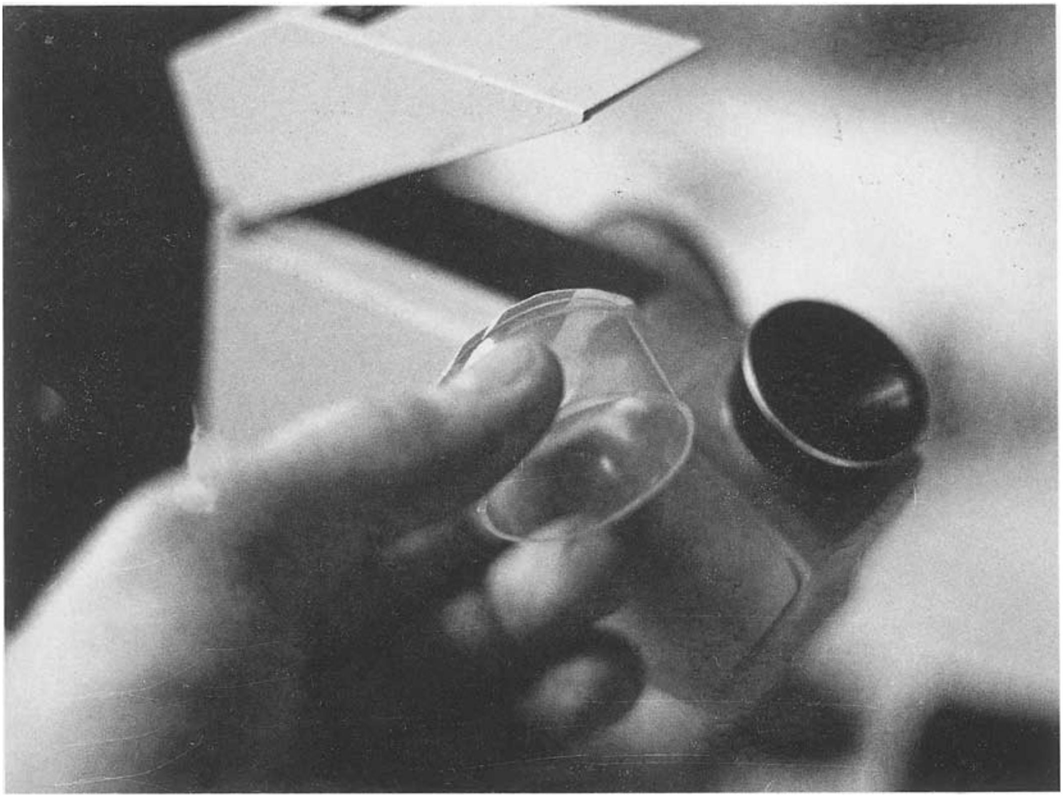


Fig. 3. Pill-box 'cover' for Dialdex eyepiece; open side in view, lenses on the other side away from view.

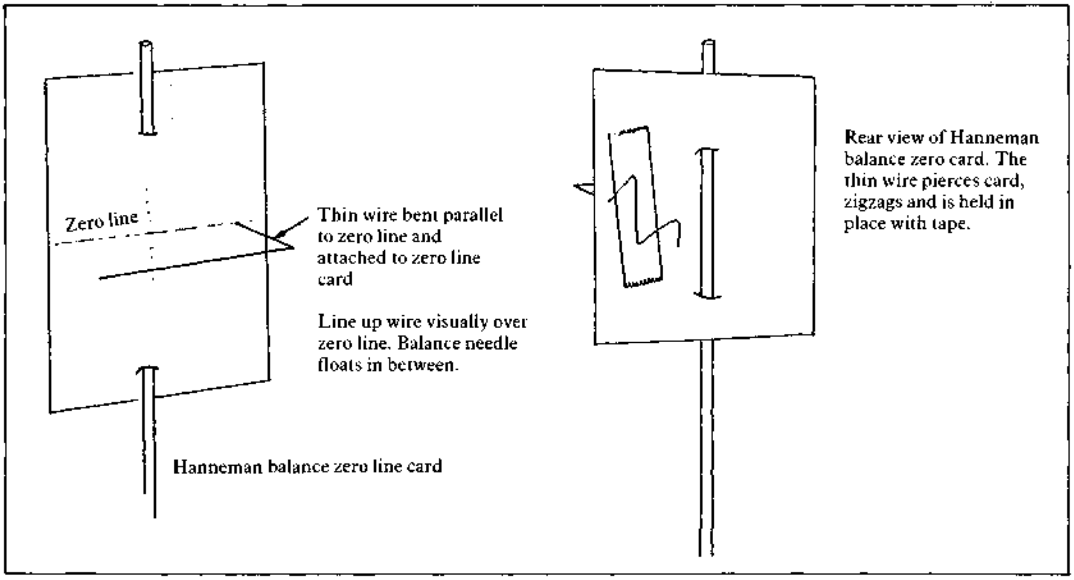


Fig. 4a, b. Improvements to the accuracy of the Hanneman specific gravity balance.

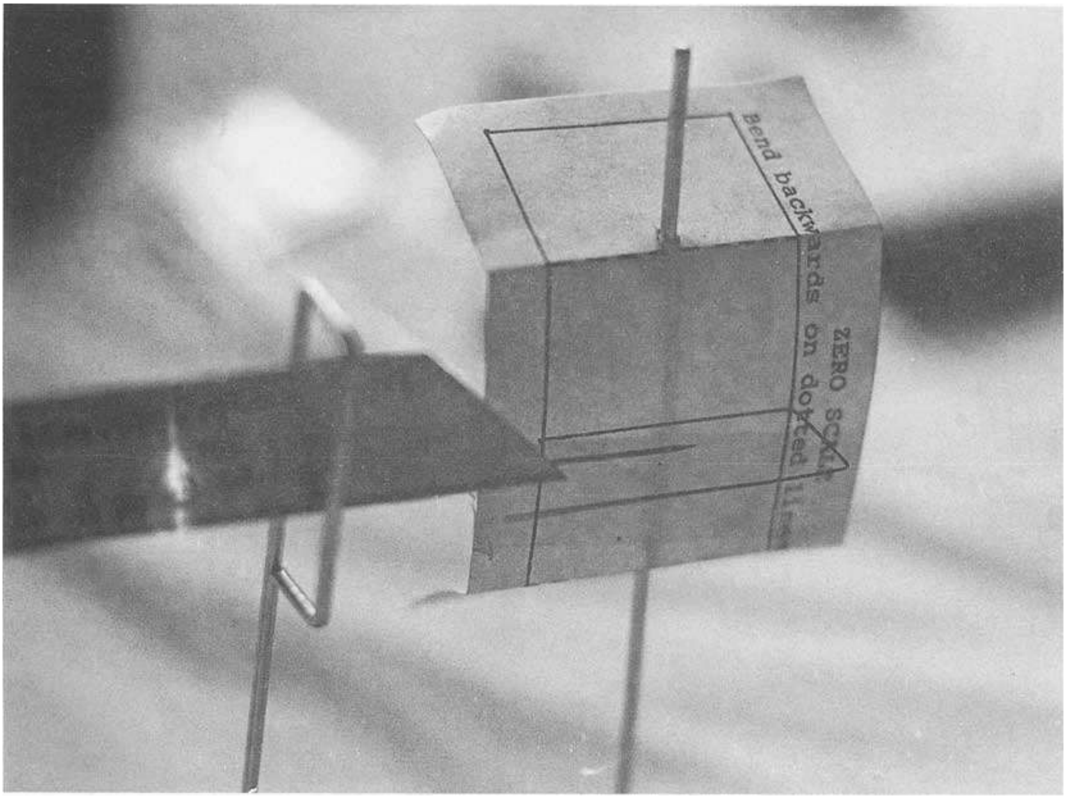


Fig. 5. View of Hanneman balance adaptation with balance arm needle floating between zero card and wire.

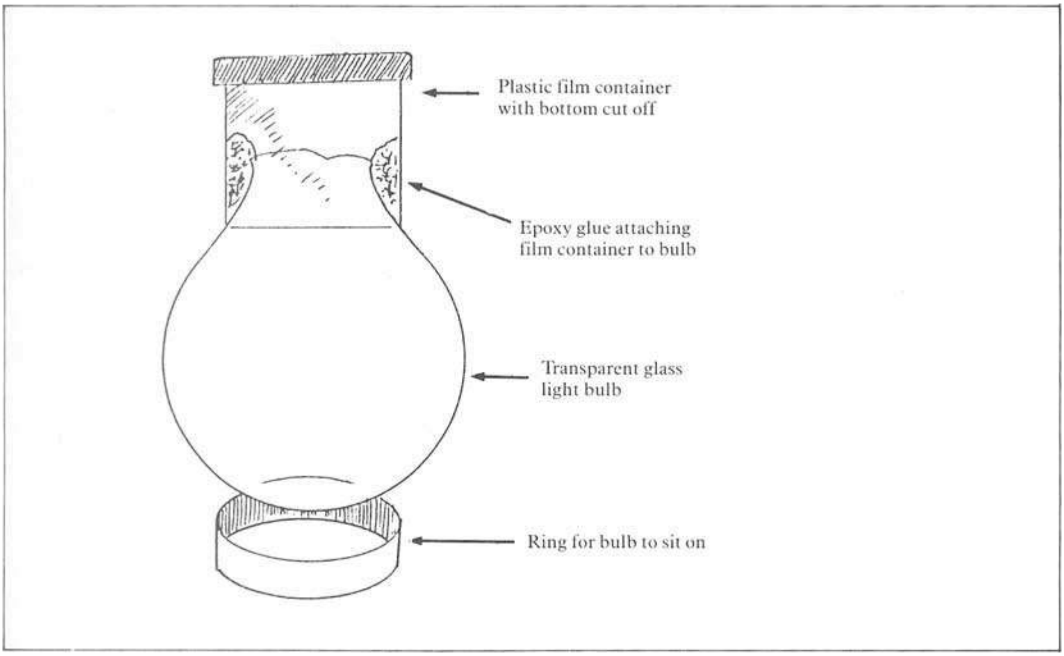


Fig. 6. A clear light bulb adapted for use as a round bottomed flask.

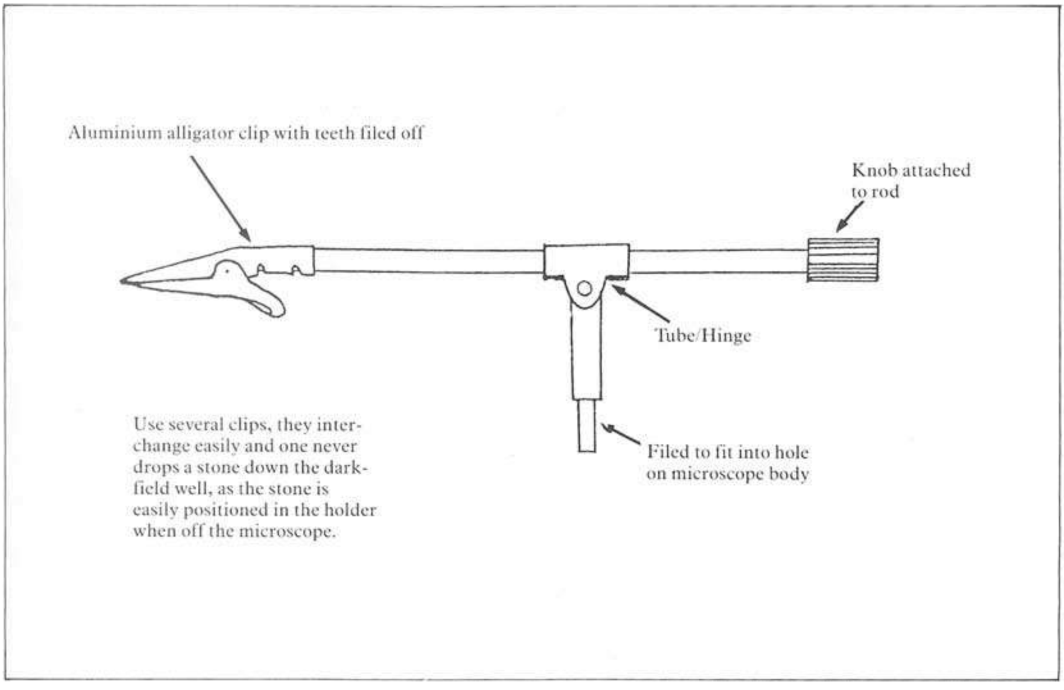


Fig. 7. Alligator clips adapted for use as stone holders.

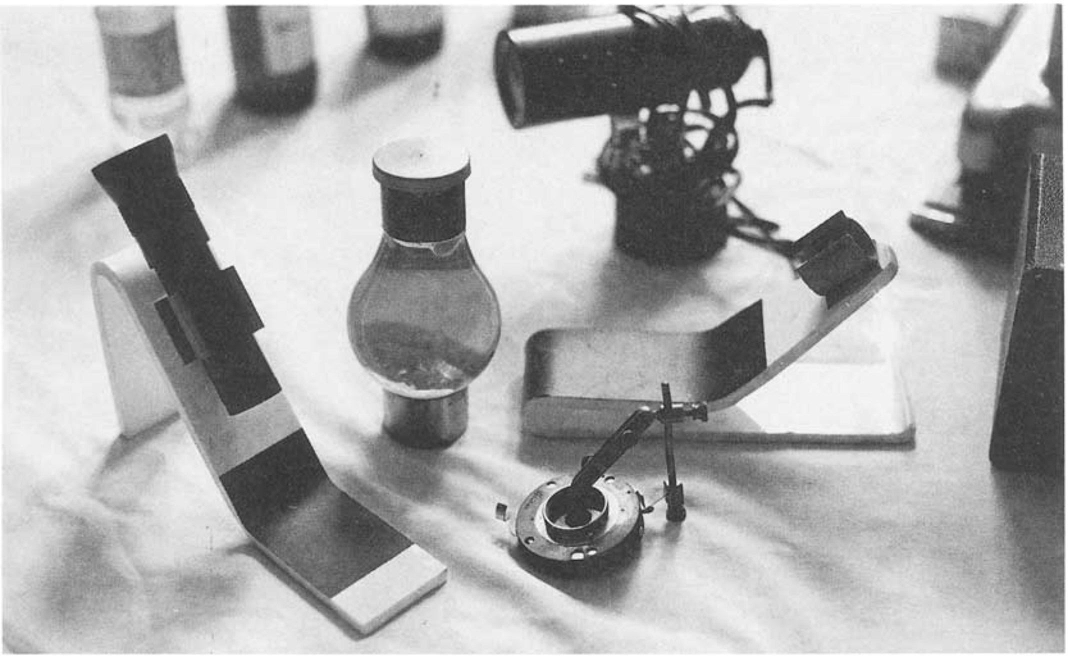


Fig. 8. Home-made spectroscope stands in plexiglass; camera lens iris diaphragm and stone holder for transmitted light spectroscopy and light bulb flask of copper sulphate solution.

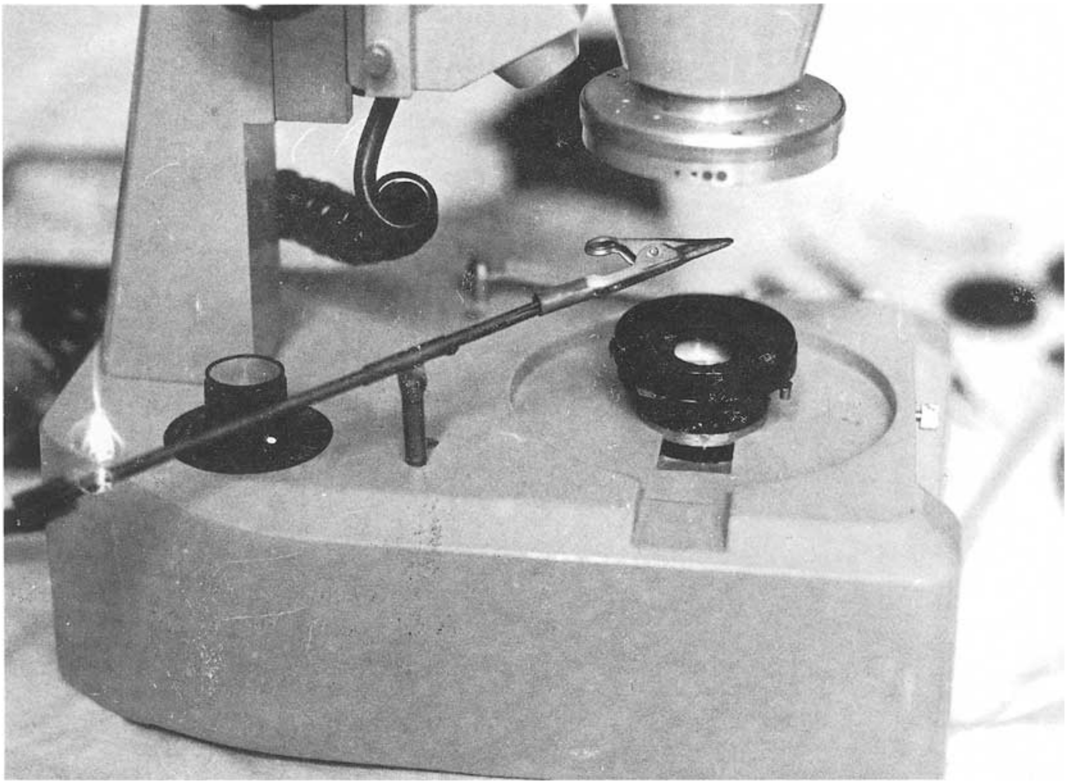


Fig. 9. Lewton-Brain, view of binocular microscope with used camera lens iris diaphragm as a dark-field well and interchangeable alligator clip stone holder.

One of the problems with the balance is that if one moves one's head during weighings one may be off on the reading. The improvement consists of a thin straight wire which is attached to the zero card of the balance so that it is parallel to the zero line on the card and about 1in (2.5cm) out from the card (Figures 4a, b and 5). The needle of the balance arm floats between the wire and the card. When you line up the wire and the zero line (the wire covers the zero line) then one's head is automatically in the same place relative to the balance. One can detect minute differences in needle placement using this method. Remember to use a very thin wire. I used thin iron binding wire which I straightened by placing one end in a vice, holding the other end with a pair of pliers and pulling. The wire stretches somewhat and is perfectly straight after this treatment.

Other adaptations included a clear light bulb (Figure 6) transformed into a round bottomed flask for copper sulphate solution and using alligator clips with all the teeth filed off as interchangeable stone holders (Figure 7) on my microscope. This latter arrangement is far more pleasant than commercial stone holders and one never drops a stone into a light well as the stone is put in the holder before the holder is in place on the microscope (Figure 8). Oh yes, old iris diaphrams may be had for free from camera repair shops and can be used for spectroscopy as well as, in my case, for constructing a dark field well for my binocular microscope (Figure 9).

Of the above perhaps the most useful is the Hanneman balance adaptation. I hope that this information may prove useful to gemmologists and students.

Clamps for spectroscope stands may be had from: Small Parts Inc, PO Box 381736, Miami, Florida, 33138. In USA called cable clamps.

[*Manuscript received 17 March 1989.*]

Gemmological Abstracts

Balfour, I., 1989. Famous diamonds of the world, XLI. Penthièvre. *Indiaqua*, 53, (1989/2), 149-52.

The 10 carat yellow oval-cut Penthièvre takes its name from Louis-Jean Marie de Bourbon, Duke of Penthièvre, heir to the last of the legitimate sons of King Louis XIV of France. Although there is no record of the provenance of the rough stone, it is thought to have been mined in either India, Brazil or possibly Borneo. Much of the article is to do with the lineage of the Duke and the mystery surrounding one of his descendants, Louis Philippe, who became King of France. Although never worn by her, the Penthièvre can be identified as being part of the jewellery owned by Marie-Amélie, consort of Louis Philippe, and the stone subsequently survived at least two robberies. It is now on display as the principal gem in a large oval motif on a flat bandeau in the Condé museum at the Chateau de Chantilly. P.G.R.

Bancroft, P., 1989. Record Russian spinels. *Lapidary Journal*, 43, 4, 41, 1 fig. in colour.

Large purplish spinels from the Pamirs, USSR, have been cut. Some reach sizes up to 28 ct as depicted. The location can be worked only in times of reasonable weather. M.O'D.

Bowersox, G.W., Anwar, J., 1989. The Gujar Killi emerald deposit, Northwest Frontier Province, Pakistan. *Gems & Gemology*, 25, 1, 16-24, 14 figs in colour.

Describes deposits, mines, geology and gemmology of emeralds from the remote Swat river region of the Indus headwaters of Northern Pakistan. High iron and chromium content gives emeralds of dark colour and skilled cutting is required to produce acceptable stones. RI 1.589-1.599, DR 0.010, SG 2.72, strong absorption spectrum, with many inclusions and some healed cracks which are described as 'veil-like', hopefully not to be confused with the 'twisted veils' associated with synthetic emerald. R.K.M.

Bracewell, H., 1989. Gems around Australia, Part 2. *Australian Gemmologist*, 17, 2, 60-2, 64, 15 coloured figs.

The promised continuation of Mrs Bracewell's account of gems seen on their long autotrek around that vast continent. The area of Mt Isa, one of the largest mines for silver and lead, with zinc and copper as considerable by-products, is renowned for its variety of mineral specimens including actinolite, amethyst, beryl, calcite, dravite, epidote, feldspars, garnet, iolite, malachite-azurite, mica, quartz, rutile, scapolite, schorl, staurolite, etc. Ornamentals inculde jaspers, zig-zag amethyst, mudstone, gooseberry agate, spinifex stone, green fluorite, and torbernite (radio-active, not a gem mineral) and fossil trilobites. Other areas for petrified woods, pyrope, serpentine, transparent labradorite, etc., etc., are mentioned. The Bracewells must have had quite a time! R.K.M.

Brown, G., 1989. Quality assessment of Thai gem corundum. *Wahroongai News*, 23, 5, 15-17.

An extract from a Siam Science Bulletin dated 1947, by U. Guhler, titled 'Studies of precious stones in Siam', is sufficiently rare to warrant abstraction. It covers some of the gemmology of the material, occurrence and recovery of stones and the factors influencing values of rubies, sapphires and zircons. Only 1% of fine sapphires are above 4 carats. Mr Brown suggests that these factors are as valid today as they were in '47. Abstractor doubts this! R.K.M.

Brown, G., 1989. Siliciophite: Australian 'cat's-eye opal'. *Australian Gemmologist*, 17, 2, 48-51, 10 coloured figs.

Chrysotile asbestos fibres in a common opal matrix, when correctly oriented, cuts to give attractive cat's-eyes in yellowish-green or brown, with eyes of varying sharpness. RI and SG are right for opal but H is given as 6. Colour and appearance identifies. R.K.M.

BROWN, G., BRACEWELL, H., SNOW, J., 1989. Gems of the Mud Tank carbonatites. *Australian Gemmologist*, **17**, 2, 52-5, 17 coloured figs.

[Carbonatites are comparatively rare marble-like rocks which are of magmatic origin rather than sedimentary, and are sources of important included minerals.] In the Strangway Range, NE of Alice Springs, they were found to contain brown, reddish-brown, pink and purple high-type gem zircon, possibly with little uranium, so absorption lines are weak in pale specimens and absent in darker ones. Yellowish apatite of cabochon grade also found. R.K.M.

BROWN, G., CALLAWAY, P., 1989. Black-dyed synthetic opal. *Australian Gemmologist*, **17**, 1, 24-6, 5 figs in colour.

A Gilson white synthetic opal was found too porous to cut and polish well so the owner used sugar/acid dyeing to enhance the material, with very satisfactory results which showed up the highly characteristic distribution of colour. R.K.M.

BROWN, G., KELLY, S.M.B., 1989. Australian colour-changing sapphire. *Australian Gemmologist*, **17**, 2, 47-8, 4 coloured figs.

A sapphire changed from bluish in daylight to purplish in incandescent light, due to patch of strong orange in base of the stone. R.K.M.

BROWN, G., SNOW, J., 1989. Gemmological study club lab reports. *Australian Gemmologist*, **17**, 1, 27-33, 18 figs in colour.

Reports are given on Finnish spectrolite; ox-eye labradorite from Malagasy; ornamental wurtzite material; cultured blister pearls from Broome, Western Australia; Ramaura synthetic ruby; Oregon labradorite sunstone; two different types of 'emerald' doublet; a modern whalebone scrimshaw; Mount Isa 'scapolites' which are now recognized as feldspar pseudomorphs of scapolite crystals. R.K.M.

BROWN, G., SNOW, J., BRACEWELL, H., 1989. Gemmology Study Club report. *Australian Gemmologist*, **17**, 2, 65-8, 13 figs, some in colour.

Describes two opals, one with a bubble-like formation and the other with a U-shaped colour distribution; a Sumitomo synthetic diamond octahedron with trigons and lamella [grooved edge] growth etc.; a yellow one with flux inclusions; dyed paua shell from New Zealand; and faceted cuprite from Namibia; red clarified amber with sun spangles; proliferated bubbles in synthetic spinel [these are usually called 'profiled' bubbles because their edge outline can look rather like the human face in profile]; howlite stained to imitate turquoise; other turquoise imitants; Pilbora 'jade', a decorative serpentine; and amethyst burned to prasiolite (green quartz) by the heat of the sun. All are illustrated. R.K.M.

BROWN, G., BRACEWELL, H., 1989. Greenbushes spodumene-quartz (a new Australian lapidary material). *Australian Gemmologist*, **17**, 1, 14-17, 3 maps, 4 figs in colour.

This variegated pink-grey rock from Greenbushes in SW Western Australia, is mined as a source of lithium, but it is suggested that the deposit has gem potential for kunzite. The bimineral rock is also promising as an ornamental material. R.K.M.

CAMPBELL, I.C.C., 1989. The physical appearance of rutile in a Sri Lankan grey asteriated corundum. *South African Gemmologist*, **3**, 2, 17, 3 figs.

Photographs of coarse rutile needles in a grey Sri Lankan star corundum show the difference between natural and synthetic star corundum in this context. M.O'D.

CASSEDANNE, J.P., 1989. The Ouro Preto topaz mines. *Mineralogical Record*, **20**, 3, 221-33, 21 figs (10 in colour).

Topaz and other minerals are described from the Quadrilátero Ferrífero in central Minas Gerais, Brazil. Geology and mining history are described and an alphabetical list of minerals given. The area is the type locality for euclase which occurs with topaz in loose single crystals, partly gem quality and pale blue, pale green or colourless. Topaz crystals show a wide range of colours and are usually singly terminated and some show a weak milky orange fluorescence. M.O'D.

COLDHAM, T.S., 1989. Hexagonal zoning and coarse needles in heat-treated sapphire. (Letter.) *Gems & Gemology*, **25**, 1, 42.

Disputes belief that sapphires with coarse rutile needles have necessarily not been heat-treated. Stones so treated to improve colour were found to retain some of their silk. R.K.M.

COY-YLL, R., 1986. Luminescence in tourmaline. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.*

A pale pink tourmaline crystal, apparently closely related to the elbaite pole and a deep blue crystal close to the schorl pole showed interesting luminescent effects from sections cut perpendicularly to the *c*-axis. The specimens were heated to 500°C to observe possible thermoluminescent effects. Following each TL run the sample was heated again to obtain the black-body background. The pink specimen showed a natural TL of three broad glow-peaks centred at 210, 310 and 360°C. The natural TL from the blue specimen includes six well-resolved glow-peaks at 160, 170, 185, 280, 300 and 380°C. M.O'D.

DIRLAM, D.A., MISIOROWSKI, E.B., COOK, J.L., WELDON, R., 1989. The Sinkankas Library. *Gems & Gemology*, 25, 1, 2-15, 16 figs in colour.

At the beginning of 1988 the Gemological Institute of America bought the vast and unique library of gemmological, gem and jewellery related works collected over some 40 years by John and Dorothy Sinkankas, the largest and most complete such collection in existence. Comprising something like 14,000 items, there are many extremely rare books dating from such works as Pliny's *Natural History* with translations into several languages, and complete runs such as all 14 editions of G.F. Herbert Smith's *Gemstones*, to innumerable other extremely rare and valuable books both ancient and recent, and a vast collection of pamphlets, periodicals in a variety of languages. The paper can scarcely begin to cover the full import of this vast accumulation of facts on every aspect of these subjects.

The incorporation of this collection as part of the Richard T. Liddicoat Information Centre is extremely reassuring, for such a remarkable library should be preserved intact once brought together, and never dispersed by piecemeal sale. The GIA is taking precautions against disasters such as fire and earthquake, ones which have to be reckoned with in California. Within limits imposed by security the library will be accessible to students, and to the public. The wisdom of this intelligent disposal by Captain and Mrs Sinkankas has to be applauded, but abstracter wonders whether they miss all those books, desperately? – or with relief?

R.K.M.

DOWNING, P.B., 1989. An Australian love affair. *Lapidary Journal*, 43, 3, 32-40, 8 figs (3 in colour).

An account of life and opal mining at Lightning Ridge, New South Wales, Australia. M.O'D.

FRIESE, B., 1989. Einschlüsse in Edelsteinen als diagnostisches Kennzeichen zur Bestimmung und Unterscheidung. (Inclusions in gemstones as diagnostic characteristics for determination and investigation.) *Aufschluss*, 40, 4, 221-9, 10 figs in colour.

Inclusions characteristic of a variety of gem minerals are illustrated by photomicrographs. A history of the study of inclusions is given. M.O'D.

FRYER, C.W., (ED.), CROWNINGSHIELD, R., HURWIT, K.N., KANE, R.E., HARGETT, D., 1989. Gem Trade Lab notes. *Gems & Gemology*, 25, 1, 35-41, 18 figs in colour.

A dark green 8 ct faceted brilliant was identified as a new variety of augite, RI 1.682-1.702, SG about 3.20 by heavy liquids, faint absorption at 500nm. X-ray diffraction confirmed augite rather than other monoclinic pyroxenes [not illustrated].

A dark opaque 'indigo' blue covellite was identified by sight, often veined with pyrite, sub-metallic lustre, SG about 4.6, vague spot RI 1.45, H 1.5 to 2.

East Coast Lab reports resurgence of coated diamond fakes, such deceptions generally die out once they are exposed in trade press. Roof-like arrangements of parallel needles intersecting at 90° were found in a diamond, while another had a dense bundle of laser drillings aimed at eliminating [?] one inclusion.

A natural freshwater pearl in a necklace dated 1858 is thought to be among the earliest of American Unio pearls 'because Scotland was largely worked out by this time'. [?] Two black three-quarter cultured pearl pendants were claimed by the jeweller to have been whole cultured at one time – another mystery?

A large crystal of rarely seen fine quality bluish-green phosphophyllite weighed 220 grams, size and colour gave a 448nm absorption not usually present in smaller and paler stones, RI 1.595-1.616, SG 3.10, H 3 to 3.5, SUV gave strong violet, an unusual specimen beautifully illustrated. Straight twin-planes gave the appearance of needles in a synthetic flame fusion ruby. A 204.39 ct star sapphire of 'pure' blue colour was examined and found to be entirely natural in colour. Another star sapphire was an unusual greyish-green colour, possibly from Thailand, although the absorption was reminiscent of Australian green stones. Attractive purplish-pink spinel from the Pamirs, USSR, showed close zoning and striation under magnification, a crystal of the same material had sugary grains, possibly calcite, and some mica-like flakes.

More examples seen of antique jewellery 'improved' by substituting cultured pearls, or synthetic sapphires in pieces dating from periods well before either were available; in the second case lack of re-setting damage suggests that the piece was in fact a reproduction, although the diamonds were old-cut. R.K.M.

GAUTHIER, J.P., AJACQUES, J.-M., 1989. La perle au microscope electronique. (Pearls under the electron microscope.) *Révue de Gemmologie*, 99, 12-17, 21 figs (5 in colour).

Pearl structures as seen with the electron microscope are described and illustrated. M.O'D.

Ghera, A., Graziani, G., Lucchesi, S., 1986. Genesis of vanadium-bearing beryls. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.* **p.110.**

An examination of vanadium-bearing beryl from Salininha, Brazil, suggests that the vanadium may have derived from bituminous sediments. The nature of the inclusions found seems to indicate that pressure-temperature conditions can be referred to metasomatism in dolomitic limestones. M.O'D.

Ghera, A., Lucchesi, S., 1987. An unusual vanadium-beryl from Kenya. *Neues Jahrbuch für Mineralogie, Monatshefte,* 6, 263-74, 6 figs.

A vanadium-bearing beryl crystal from Kenya had inclusions of talc, phlogopite, calcite, quartz and apatite, and was believed to have been formed as a result of metasomatic activity, referable to a pegmatitic intrusion in the pre- existing graphite-rich calc-silicate rocks and marbles of the Pre-Cambrian basement of southern Kenya. The mineral inclusions suggest the temperature and pressure of formation to be between 475-380°C at about 2-3kbar. M.O'D.

Gibbs, R.B., 1989. The Magdalena District, Kelly, New Mexico. *Mineralogical Record,* **20,** 1, 13-24, 16 figs (11 in colour).

The Kelly mine, no longer in operation, was celebrated for its fine specimens of botryoidal blue-green smithsonite, several of which are illustrated. The geology and mineralogy of the mine are discussed. M.O'D.

Graeser, S., 1989. Phenakit im Binntal. (Phenakite in Binntal.) *Schweizer Strahler,* **8,** 5, 189-96, 5 figs.

Phenakite is reported from the Binntal in Central Switzerland. The mineral is rare for this location, celebrated for its sulfosalts. Crystal forms are described. M.O'D.

Hänni, H.A., Bosshart, G., 1988. Danneggiamenti subiti dai diamanti tagliati. (Damage suffered by cut diamonds.) *La Gemmologia,* **13,** 1/2, 17-23, 10 figs in colour.

The various ways in which cut diamonds can be damaged are outlined. M.O'D.

Hansen, N.R., 1989. Hong Kongs jademarked pa Canton Road. (The Hong Kong jade market on Canton Road.) *Gem Bulletinen,* 1, unpaged, 6 figs.

The famous open-air jade market is described. M.O'D.

Harris, C., 1989. Oxygen-isotope zonation of agates from Karroo volcanics of the Skeleton Coast, Namibia. *American Mineralogist,* **74** (3-4), 476-81.

Oxygen-isotope profiles through six agates show $\delta^{18}O$ variation from 20.4 to 28.9‰, consistent with low temperatures of formation. Systematic differences in $\delta^{18}O$ exist beteween coarsely crystalline quartz bands and mycrocrystalline quartz within the same agate, with the coarse quartz being, on average, 3‰ lighter; this is consistent with crystallization of the coarse zones from H_2O vapour and the microcrystalline quartz from H_2O liquid at about 120°C. R.A.H.

Hawthorne, F.C., 1987. The crystal chemistry of the benitoite group minerals and structural relations in (Si_3O_9) ring structures. *Neues Jahrbuch für Mineralogie, Monatshefte,* 1, 16-30, 7 figs.

Structures discussed are pabstite and bazirite as well as benitoite with which they are both isostructural. M.O'D.

Heflik, W., Kwiecinska, B., Natkaniec-Nowak, L., 1989. Colour of chrysoprase in light of mineralogical studies. *Australian Gemmologist,* **17,** 2, 43-6, 58-9, 11 figs, map.

Working on Polish deposits authors seem to have gone to a lot of trouble to show that the green colour of chrysoprase is due to nickel oxide in the form of bunsenite. [NiO has been recognized as the colouring agent in this stone for more than a century.] R.K.M.

Heppe, S., 1989. Un grenat vertila tsavorite. (A green tsavorite). *Révue de Gemmologie,* 99, 5-7, 6 figs (4 in colour).

A review of the discovery, occurrence and properties of green transparent grossular. Raman spectra for the calcium garnets are illustrated and there is a graphic summary of chromium and vanadium content. M.O'D.

Hicks, W.H., 1989. Editorial *Australian Gemmologist,* **17,** 2, p48.

There are apparently 'no legally enforceable definitions of gems' in Australia, so that a synthetic emerald can be sold simply as 'refined' emerald without further qualification and without offending any laws. There is no Customs or Tax 'requirement to differentiate between natural stones and synthetics'. CZ simulants of diamond were offered with diamond emphasized and scarcely a mention of their true nature. The Victorian Department of Consumer Protection apparently showed little interest. The AG editor is concerned that tourists and others should be protected and should actually receive what they think they are buying. R.K.M.

HISS, D.A., 1989. Chrysoberyl: the phenomenal gem-spinel: so misunderstood. *Jewelers' Circular Keystone*, **159**, 4, 233-30, 20 figs in colour.

Brief descriptions of the chrysoberyl and spinel gemstones with notes on their current marketability. [Similar accounts by the same author on other species can be found in other issues of this Journal.] M.O'D.

HODSON, K., 1989. Mining rainbows. *Lapidary Journal*, **43**, 3, 41-3, 2 figs in colour.

A brief description of the Rainbow Ridge opal mine, Virgin Valley, Humboldt County, Nevada, USA. M.O'D.

HOLLIS, J.D., SUTHERLAND, F.L., 1986. Relationships between colour, crystallography and origins of gem zircons in E. Australia. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA*. p.127.

Large gem quality zircon crystals from some Australian deposits derived from alkaline volcanic activity in the eastern part of the country. Zircons from three locations are examained and their colour correlated with the crystal forms displayed. M.O'D.

HUISHU, W.A., 1986. A mineralogical study of amber in the XIXIA region of Henan PRC. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA*.

Amber is found in a red sand conglomerate formation of the Upper section of Mesozoic age in Henan province. Specimens are white, yellow, orange, red and reddish-brown and the RI is 1.5426-1.5549. Varying luminescence is shown; the SG is 1.113. M.O'D.

KAMPF, A.R., FRANCIS, C.A., 1989. Beryl gem nodules from the Bananal mine, Minas Gerais, Brazil. *Gems & Gemology*, **25**, 25-9, 5 figs in colour.

This mine, near Salinas, has yielded fine large aquamarine crystals with morganite cores. The morganite fades from orange to a more desirable pink on exposure to sunlight. Much material is good carving quality, with some of excellent facet grade. R.K.M.

KOIVULA, J.I., 1989. Ancient millipedes. *Australian Gemmologist*, **17**, 1, 14-17, 2 figs in colour.

Millipedes in amber are quite rare and those trapped are usually smaller species. [Monster tropical ones presumably had the strength to struggle free!] R.K.M.

KOIVULA, J.I., KAMMERLING, R.C., 1989. 'Opalite': plastic imitation opal with true play-of-color. *Gems & Gemology*, **25**, 1, 30-4, 5 figs in colour.

Polystyrene imitation opals of Japanese origin cannot be separated visually from natural or synthetic opals. Specimens purporting to be 'new', under the name 'Opalite' were examined and found to be assembled, i.e. with signs of a distinct basal layer of another plastic, probably acrylic resin. RI is 1.51, SG estimated at 1.20 ± 0.05, too high and too low respectively for true opal. A false claim that these imitations will not scratch or chip as easily as natural opal is belied by the hardness of about 2.5. Far warmer to touch than opal. If doubt still exists the infrared absorption is completely typical of Japanese plastic imitation opal. Alternative name is 'Opal Essence' and it is available world-wide. Virtually identical with other Japanese imitation opals. R.K.M.

KOIVULA, J.I., KAMMERLING, R.C., 1989. Gem News. *Gems & Gemology*, **25**, 1, 45-51, 14 figs in colour.

Angelite, a 'new' light bluish-grey opaque stone seen at the Tucson Show, is in fact anhydrite. Many fine African rhodolites, and dark red almandines from Orissa, India, were seen; also stones with man-made inclusions, either electrically deposited dendrites, or drilled and filled quartz. Mother of pearl gambling chips of Chinese 18th or 19th century origin were offered mounted or loose. Plastic one-piece imitations of cameos were offered. Hydro-thermal amethyst, citrine and rock-crystal were plentiful, while bi-colour purple-red/yellow-green tourmalines from Nigeria were available.

Coloured Stones.

A new and beautiful form of orthoclase from the Harts Range in Northern Territory, Australia, sold as 'Rainbow Lattice Sunstone', is illustrated. A new emerald deposit yielding yellowish-green stones found near Itabira, at Nova Era, Minas Gerais. A 708 ct polished spessartine garnet of fine quality, found 16 years ago, and thought to have come from Brazil, may be the largest polished transparent red gem in the world. A star almandine is reported from Idaho, and a star rhodolite from Tanzania is illustrated, the latter a new find. A light greenish-grey opaque wollastonite, suitable for carving, is mined at Viola, near Caliente in Nevada.

Instrumentation.

The Discan, a new spectroscope produced in conjunction with the GIA, is coupled to a liquid crystal display of the wavelength of each absorption as it is centred on a crosshair scanner. Another instrument couples a small fixed-slit diffraction instrument with a video camera to give an on-screen display of the spectrum. [This would be useful in teaching!]

Synthetics.

Sumitomo are now producing yellow synthetic gem diamond crystals in the 5 ct range. Minute diamond crystals have been found in the residual soot from TNT explosions. A two kilogram 'synthetic diamond' reported in USSR in 1983 is now known to be an unusually large top-quality piece of cubic zirconia, Russian words for 'simulant' and for 'synthetic' do not distinguish clearly between them, error was in translation and not an attempt to deceive. Once more quartz crystals faked to look like emerald have been found; superficially convincing to the eye, the two crystals purchased in 'Southern Africa' involved the buyer in considerable financial loss. [Illustration shows a rhombohedral face and transverse striations on the prism, both typical of quartz and not of emerald.] Dark purple massive lepidolite artificially shaped to resemble crystals have apparently also been darkened by heating. 'Diamond' octahedra faked from cubic zirconia have been sold in Swakopmund, Namibia, while street pedlars have offered green bottle-glass fragments as tsavorite.

Porous azur-malachite from Arizona is being bonded with plastic, under pressure, to make workable blocks which cut and polish well as cabochons, with no intent to deceive. R.K.M.

Koivula, J.I., Kammerling, R.C., 1989. The gemmology of Kyocera's new synthetic star ruby. *South African Gemmologist*, **3**, 2, 5-14, 4 figs in colour.

A natural-looking star ruby has been manufactured by the Kyocera Corporation, Kyoto, Japan. A strong fluorescence under LWUV and characteristic inclusions of a high-temperature melt process show that this is an artificial product. The trade name is Inamori. M.O'D.

Kostov, R.I., 1986. A complex classification of gem minerals. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.* p.144.

The existing classifications of gemstones on physico-chemical grounds is criticized and an alternative scheme proposed. This would classify gem minerals on the basis of morphological status, art status (e.g. rough material or fashioned), genetic or locality status, optical, crystallographic or historical status or utilization status. M.O'D.

Kozlowski, A., Metz, P., Estrada Jaramillo, H.A., 1988. Emeralds from Somondoco, Colombia: chemical composition, fluid inclusions and origin. *Neues Jahrbuch für Mineralogie, Abhandlungen*, **159**, 23-49, 11 figs.

Emeralds from the Somondoco district of Colombia were analyzed by electron microprobe, colorimetry, emission spectrography, thermogravimetry and infrared absorption. Inclusions are illustrated. M.O'D.

Landmesser, M., 1988. Experimente zur Petrologie edelsteinbildender Prozesse: Chalcedon/Achat. (Studies on the petrology of gemstone-forming processes: chalcedony/agate.) *Kurzmitteilungen aus dem Institut für Edelsteinforschung*, **4**, 3/4, 13-24, 10 figs.

Work on the experimental synthesis of cryptocrystalline silica is described. M.O'D.

Leguey, S., Gimenez, G., Morante, M., Medina, J.A., 1986. Opals of gemological interest in the Neogene basin of Madrid. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.* p. 153.

Both black and white opal of gem quality occur in a siliceous rock in the Neogene basin of Madrid, Spain. Black opal shows RI 1.420-1.428 and SG 1.898-2.054, and white opal RI 1.436-1.449 with SG 1.886-1.891. The black material has a pleasing lustre while the white stones are translucent and highly fluorescent. M.O'D.

Li Ping, Peng Mingsheng, 1986. The study of the spectroscopy and the color nature of some gem minerals. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.* p.155.

Aquamarine, blue sapphire and lazurite are examined with a view to establishing the cause of their colour. Blue sapphire is reported from Hainan, Guangdong, People's Republic of China. The sapphire, which is found with spinel, zircon and olivine, all of gem quality, is pale blue with 0.73% Fe and 0.03% Ti. M.O'D.

Malley, J., 1988. Synthetischer Alexandrit aud der UdSSR. (Synthetic alexandrite from the USSR.) *Kurzmitteilungen aus dem Institut für Edelsteinforschung*, **4**, 3/4, 21.

Synthetic alexandrite grown in the USSR was found to contain gallium, with bismuth and sulphur in the flux feathers. These are clear evidence of artificial origin. M.O'D.

MINSTER, D., 1989. A practical diamond grading technique. *South African Gemmologist*, **3**, 2, 20-1, 4 figs in colour.

Polarized light is used to locate small imperfections in cut diamonds. M.O'D.

MONCORGE, P., 1989. 'Thaïlande-Kanchanaburi Bo Phloï': une page se tourne. (Thailand-Kanchanaburi Bo Phloi: a page turns.) *Révue de Gemmologie*, 99, 3-4, 7 figs (3 in colour).

Gem-quality blue sapphire is found near the town of Bo Phloi in Thailand and is recovered from alluvial deposits. Seven small basaltic hills are in the vicinity. M.O'D.

MOORE, P.B., SEN GUPTA, P.K., SCHLEMPER, E.O., 1989. Kornerupine: chemical crystallography, comparative crystallography, and its cation relation to olivine and to Ni_2In intermediate. *American Mineralogist*, **74**, 642-655, 2 figs.

Kornerupine from Mautia Hill, Tanzania, is discussed in relation to its chemical composition and crystallography. M.O'D.

NASSAU, K., 1989. DR JOHN SINKANKAS. *Lapidary Journal*, **43**, 4, 42-9, 5 figs (3 in colour).

The gift by John and Marge Sinkankas of their large gemmological library to the Gemological Institute of America is marked by a short biography. M.O'D.

NASSAU, K., 1989. Opal treatment. *Lapidary Journal*, **43**, 3, 44-51, 2 figs in colour.

The various ways in which opal can be treated, stabilized or improved are described. Notes on identification are given. M.O'D.

NASSAU, K., 1986. The physics and chemistry of the thirteen causes of color in minerals. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA*. p.184.

The author summarizes the 13 causes of colour in minerals from his monograph *Physics and chemistry of color*, 1983, Wiley. M.O'D.

NOGUES-CARULLA, J.M., VENDRELL-SAZ, M., ARBUNIES, M., LOPEZ-SOLER, A., 1986. Photometric study of UV- luminescence of cut diamonds and its relationship with their colour classification. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA*. p.187.

UV-luminescence from cut diamonds has been measured in the visible range and the points display a linear distribution corresponding to a dominant wavelength of 484nm. The transmission curves of the diamonds were obtained between 400 and 700nm. The colour coordinates and colour saturation were calculated and the points of x and y adjusted to a straight line whose dominant wavelength corresponds to 578nm. The comparison of the two photometric results shows that the observed colour is the addition of both transmission and visible range emission luminescence. M.O'D.

NUNAN, T.J., 1989. The mining of sapphires. *Australian Gemmologist*, **17**, 1, 7-12, 18-9, 7 figs in colour.

A comprehensive paper on this general subject, but largely concerned with mining areas of Queensland and NSW. So far mining has been from alluvial areas and volcanic ash. Writer suggests that other sources should be sought. The economics of cutting in Australia are compared with the far lower costs in Sri Lanka and Bangkok. R.K.M.

OTTAWAY, T.L., WICKS, F.J., 1986. Characteristics and origin of the Muzo emerald deposit, Colombia. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA*. p.193.

Emeralds occur in a stockwork of albite + calcite + dolomite ± barite veins cross cutting Cretaceous shales and limestones. There is no direct evidence of igneous activity either at Muzo or at other localities in the emerald belt of the Cordillera Oriental. Thermal metamorphism has not been seen in the vicinity of the vein systems. M.O'D.

POUGH, F.H., 1989. Carletonite. *Lapidary Journal*, **43**, 4, 16-18.

Details of carletonite are given along with other ornamental minerals from the nepheline syenites of Mt St Hilaire, Quebec, Canada. The other minerals described are serendibite and catapleite. M.O'D.

POZZI, A., 1988. Gemme della Tanzania. (Gemstones from Tanzania.) *La Gemmologia*, **13**, 1/2, 25-37, 8 figs in colour.

An up-to-date summary of gem minerals found in Tanzania, with a short bibliography and a map. M.O'D.

RODIONOV, A. YA, SOLNTSEV, V.P., 1986. Gem varieties of beryl, chrysoberyl and phenakite grown by chemical vapour transport. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA*. p.213.

Coloured varieties of beryl, chrysoberyl and phenakite, were grown by chemical vapour transport in closed halogen- bearing systems. Several colour varieties were obtained for each species with appropriate dopants. M.O'D.

ROMBOUTS, L., 1987. Geology and evaluation of the Guinean diamond deposits. *Annales de la Société Géologique de Belgique*, **110**, 1, 241-59, 5 maps.

Nineteen Cretaceous kimberlite pipes, classified into three types, with area surfaces from 1100 up to 95,000 m^2, and alluvial diamond deposits are located in Upper Guinea, in the area bounded by Kissidougou, Kerollane and Macenta. The kimberlites, which seem all diamond-bearing, are intruded into the Archaean craton of the Guinea Rise and are closely related to the break-up of Gondwana. About 1700 diamonds, $\leqslant$ 10 ct, were examined for their crystallography and colour. Octahedra, dodecahedra and their twins are best represented, while cubes are very rare. White and yellow colours predominate over brown, grey and green. In the alluvial deposits of the Gbenko-Banankoro area 93% of the stones are of gem quality. R.V.T.

ROSSMAN, G.R., 1986. The hydrous component in garnets. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.* p.216.

Results suggest that a 'hydro' substitution in garnet is common but that the amount of H_2O is usually small. Most garnets have 1/100 the hydro content of classical hydrogarnets. M.O'D.

RYKART, R., 1989. Amethystfarbige Zepterquarze, grosse Barytkristalle und Fadenquarzaggregate aus dem Val Giuv, Tavetsch GR (Neufund). (Amethyst-coloured sceptre quartz, large baryte crystals and quartz aggregates with a central opaque portion from Val Giuv, Tavetsch, Grisons, [Switzerland].. New find.) *Schweizer Strahler*, **8**, 5, 196-201, 8 figs in colour.

Fine crystals of amethyst sceptre quartz with large baryte crystals and quartz aggregates with opaque centres have recently been found in the Val Giuv, Tavetsch, Grisons, Switzerland. Some of the quartz crystals have smoky portions. M.O'D.

SAADI, J.A., 1988. Rodocrosita argentina para la ciencia y el arte. (Argentinian rhodochrosite in science and art.) *Boletin del Instituto Gemológico Espanõl*, 30, 8-20, 36 figs in colour.

Rhodochrosite from the Capillitas location in Catamarca Province, Argentina, is described and illustrated. M.O'D.

SCHMETZER, K., 1988. Zur Charakterisierung von synthetischen, im Hydrothermalverfahren gezüchteten russischen Smaragden. (On the characterization of Russian synthetic emerald made by the hydrothermal method.) *Goldschmiede und Uhrmacher Zeitung*, **86**, 11, 97-192, 27 figs (in colour).

A large number of characteristic inclusions patterns are depicted for the Russian hydrothermally-produced synthetic emerald. SG is in the range 2.68-2.70 and RI 1.580-1.586 for the ordinary ray and 1.573-1.579 for the extraordinary ray. The DR is 0.006-0.007. Among the inclusions are very fine parallel needles and hexagonal flattened crystals which may be hematite. M.O'D.

SCHMETZER, K., 1988. Thermal stability of yellow colour and colour centres in natural citrine. *Neues Jahrbuch für MIneralogie, Monatshefte*, 2, 71-80, 2 figs.

Two types of colour centre are identified in natural citrine. The yellow colour centre of natural untreated citrine is bleached by heat treatment at temperatures between 450 and 550°C and this type of colour centre is not restored by gamma or neutron irradiation. The second type with lower thermal stability is produced in bleached and unbleached citrines by subsequent gamma irradiation and is stable up to about 300°C. Additional defect centres causing absorption maxima in the red or violet range as well as smoky colour centres are also discussed. M.O'D.

SNOW, J., BROWN, G., 1989. Optronix® gemmological instruments. *Australian Gemmologist*, **17**, 1, 3-4, 2 figs.

The Multi View II is a quartz-halogen fibre-optic light source for microsopy, spectroscopy and other optical purposes.

The Omni View is an up-dated version with many in-built facilities, including polariscope, UV luminescence, etc. Made in Bangkok, both are heavy instruments, 4.6kg and 7.7kg respectively, and quite costly. Electrical safety and some design factors are criticized. R.K.M.

STOCKTON, C.M., MANSON, D.V., 1986. The chemical and spectral characteristics of gem garnets from East Africa. *Abstracts from the Proceedings of the 14th General Meeting of the International Mineralogical Association, 13-18 July 1986, Stanford, CA, USA.* p.239.

Gem garnets from East Africa do not always fit existing classification schemes. The new colour types are discussed and referred to their composition. M.O'D.

SUTHERLAND, M.B., 1989. Sinhalite – golden gem of Sri Lanka. *South African Gemmologist*, **3**, 2, 15-16.

Brief account of the testing of a sinhalite. M.O'D.

SWARTZ, D., 1989. The discovery of a new emerald occurrence in Brazil: Capoeirana (Nova Era), Minas Gerais. *Australian Gemmologist*, **17**, 1, 4-5, 1 map.

Material similar in all respects to that from nearby Belmont mine has been found. R.K.M.

THOMAS, A., 1989. An update on the availability of hydro-grossular garnet. (Letter.) *Gems & Gemology*, **25**, 1, 43-4, 1 fig. in colour.

Disputes statement that this is now a scarce material, or that it is as common as an earlier letter from Dr Schreuders claimed. Recent finds have been sporadic, finer colours no longer available, but opaque greyish-green material is still found in quantity, most shipped to Far East. A superb multi-coloured hydro-grossular necklace, [from material found much earlier] is illustrated. R.K.M.

VIMOVA, E.S.E., ZAKHARCHENKO, O.D., SOBOLEV, N.V., MAKLIN, A.I., 1989. (Inclusions in diamonds from some kimberlite pipes.) *Zapiski Vses. Min. Obshch.*, **118**, 2, 74-6. (Russian wih English abstract.)

The problem of the abundance of kimberlitic diamonds which contain solid mineral inclusions is discussed. Microprobe analyses are reported for inclusions in pyrope-almandine, omphacite, magnesiochromite and chrome-diopside. R.A.H.

WILSON, W.E., 1989. The Anjanabonoina pegmatite, Madagascar. *Mineralogical Record*, **20**, 3, 191-200, 17 figs (8 in colour).

The Anjanabonoina pegmatite has produced exceptional crystals of liddicoatite, danburite, phenakite and pink beryl rich in caesium. The history and geology is described and an alphabetical list of minerals is given. Less prominent are spessartine and hambergite. Fine kunzite crystals are found in a reddish-coloured alluvium. M.O'D.

YAKHONTOVA, L.K., SOBOLEVA, T.V., NERADOVSKY, YU.N., BARZHITSKAYA, S.M., RUNDQUIST, T.V., 1989. (Turquoise from Tekhutskoe deposit: mineralogy and genesis.) *Zapiski Vses. Min. Obshch.*, **118**, 2, 83-93. (Russian with English abstract.)

Two morphological types of turquoise are distinguished from the Tekhutskoe deposit, Armenia. One has a streaky appearance and occurs in association with quartz and pyrite, while the other occurs as isolated nodules in quartz-mica-kaolinite weathering material from the quartz diorite host rock. Colloform turquoise gives a diffuse XRD pattern and IR spectrum; disseminated turquoise is better crystallized. The results of 31 chemical analyses for this turquoise are tabulated and the results plotted on a Cu–Al–Fe^{3+} diagram. IR spectra show the presence of $[HPO_4]^{2-}$ anions; the formula may be given as
$CuAl_6[PO_4]^{3-}_2[HPO_4]^{2-}_2(OH)_{10}.4H_2O$.

R.A.H.

ZECCHINI, P., MARTIN, F., 1988. Studio del corindone per mezzo della spettroscopia. (A study of corundum using the spectroscope.) *La Gemmologia*, **13**, 1/2, 7-15, 15 figs.

A spectroscopic study of the infrared regions of natural and synthetic corundum suggests that it might be possible to distinguish one type from another. M.O'D.

ZEITNER, J.C., 1989. Opals that made history. *Lapidary Journal*, **43**, 3, 23-30, 5 figs in colour.

An overview of the history of opal as a gemstone and of its occurrence in literature. M.O'D.

ZEITNER, J.C., 1989. Opal, anyone? *Lapidary Journal*, **43**, 3, 52-6, 1 fig. in colour.

Notes are given on the fashioning of opal.

R.K.M.

ZEITNER, J.C., 1989. Green as in emeralds. *Lapidary Journal*, **43**, 4, 22-40, 3 figs in colour.

A useful overview, aimed at the amateur, on the origin, history and properties of emerald. M.O'D.

ZEITNER, J.C., 1989. Crystal shapes. *Lapidary Journal*, **43**, 4, 53-6, 4 figs.

Crystal-like rose quartz formations are reported from the Black Hills of South Dakota. M.O'D.

Book Reviews

CHAUVET, M., 1989. *Frédéric Cailliaud*. Editions ACL-Crocus. pp.371. Illus. in black-and-white and in colour. F.295.

This book was written by a Nantais, to commemorate the bicentenary of one of Nantes' famous sons: the naturalist and egyptologist Frédéric Cailliaud (1787-1869). The author painstakingly retraces the expeditions of his compatriot in Egypt and the Sudan, covering the period 1815-1822.

Although primarily of interest to the student of egyptology, it will be remembered that M. Cailliaud also held the position of mineralogist to the Khedive, Mehemet Ali, and in this connection Chaps. 3 and 5 – dealing with Cailliaud's rediscovery of the ancient 'lost' emerald mines of Zabara and Gebel Sikait – are of particular, and historic, interest to the gemmologist.

Illustrations are from original prints of the period complemented by present-day photographs and there is a fold-out map of the country. N.C.

MANDARINO, J.A., ANDERSON, V., 1989. *Monteregian treasures*, Cambridge. pp.xiii, 281. Illus. in colour. £60.00.

This magnificent book describes the many mineral species found in the nepheline syenite of Mont St Hilaire, east of Montreal, Quebec, Canada. At the time of writing 221 species had been identified with a further 25 still to be identified. Most crystals are small and thus make excellent micromounts but one or two have been cut as gemstones; probably the best-known of these is serandite, a beautiful orange-red sodium magnesium calcium silicate. There are many beautiful photographs of minerals that in many cases have not been illustrated in colour before, tables and an excellent bibliography. M.O'D.

RYKART, R., 1989. *Quarz*. (Quartz.) Ott Verlag, Thun, Switzerland. pp.413. Illus. in black-and-white and in colour. DM69.00.

The book deals in the main with the various forms taken by quartz crystals from a wide variety of localites. Particular attention is paid to European occurrences, a valuable and surprisingly rare feature in mineral books. There is an extensive bibliography and apart from the excellent photographs, many illustrations in the text. Each of the colour illustrations has an extensive caption. This is a well-produced book and amazingly good value for the price. M.O'D.

STRONGE, S., SMITH, N., HARLE, J.C., 1989. *A golden treasury: jewellery from the Indian subcontinent*, Victoria and Albert Museum, London. pp.144. Illus. in colour. £20.00.

This is the catalogue of an exhibition which was staged in London during June 1989. It is also an authoritative treatise on the use of gold in the subcontinent where it has always been venerated and used in many decorative and social contexts. The first section deals with jewellery in Indian sculpture and is followed by a study of jewellery of the Mughal period. The third and final section, called 'The darker side of gold', gives an interesting and valuable account of the commercial handling of gold and the way in which it has been the object of smuggling and crime. Between the three sections is the catalogue proper with each object illustrated in colour with notes on its provenance, date, materials and size. M.O'D.

Proceedings of the Gemmological Association of Great Britain and Association Notices

OBITUARY

Dr Walter Campbell Smith (1887-1988) An Appreciation

Fellows and friends who attended the Association's lectures at Goldsmith's Hall from the late 1940s onwards may well recall the spare, upright, elderly figure of Dr Walter Campbell Smith, who took much pleasure in his appointment in 1947 as an Honorary Fellow of our Association, and gave support and encouragement by his presence at those meetings for so many years.

Now with great regret I have to report that this dear and kindly man died peacefully at his home in Goudhurst, Kent, on December 6th of last year, a few days after reaching the quite remarkable age of 101. A great petrologist, he was Keeper of the Department of Mineralogy at the British Museum (Natural History) from 1937 to 1952.

Graduating brilliantly at Cambridge in Crystallography, Mineralogy, Geology and Petrology, Campbell Smith joined the staff of the Department of Mineralogy in 1910. A petrologist was needed so he fitted ideally into that groove in time to deal with the enormous task of assimilating into the collections some 10,000 world-wide specimens which were handed over by the Geological Society's museum in 1911.

Already a member of the Territorial Army, Campbell Smith was mobilized in the Artists Rifles as a lance corporal at the outbreak of hostilities in 1914 and served with considerable distinction on the Somme and other battlefields throughout that war, eventually emerging with the Military Cross and the rank of Lieutenant-Colonel in 1919.

He had already worked on rock and mineral specimens collected by the ill-fated Terra Nova Antarctic Expedition, led by Captain Robert Falcon Scott in 1912, and now returned to continue this work and to a long association with Antarctic Research and the Scott Polar Research Institute at Cambridge.

Dr W. Campbell Smith

Further research into rare carbonatites from Nyasaland (Malawi) brought the realisation that these were magmatic rocks and not sediments as had been thought.

Valuable studies over the years on a great range of subjects were recorded in some 100 articles covering, among many other things, meteorites, oceanic island geology, feldspars and the origins of beautiful Neolithic green jadeite axe heads found in this country and in western Europe. His work over the years brought him a ScD degree from Cambridge.

The second war again deflected his energies, first to planning for the safety of the immensely important and valuable collection which was now his responsibility, then when war was done, to organizing the long task of restoring the collection to its orderly places in a gallery which first needed repair after bomb-damage, and then the re-opening of the latter to public access. Although already in his fifties he served the Artists' Rifles again as second in command of the 163 OCTU until 1941.

He was appointed a CBE in 1949 and retired officially from the Museum in 1952, but was then re-employed to work part-time on a considerable number of projects and articles which culminated in a long paper based largely on his personal knowledge of 'Seventy Years of Research in mineralogy and crystallography in the Department of Mineralogy – under the Keeperships of Story-Maskelyne, Fletcher and Prior: 1857-1927' which was published in 1982 when he was 94.

Campbell Smith in his exceptionally long life was held in the greatest esteem for his total application, loyalty and integrity. My own experience of him was of a good and most kind friend who once, when living in a very pleasant first floor flat in Sevenoaks, was still able to get down stairs with remarkable speed to let me in, despite the fact that he was already well into his nineties. But with characteristic honesty he owned that going up again did take a little longer. A distinguished scientist, he had held many appointments of considerable importance and honour in various earth science societies over the years. A wise and intellectually brilliant man to the very end of his days, he had seen vast changes in the techniques of the sciences he served so well for most of his long lifetime, and had indeed contributed to those changes himself in no small measure.

In 1936 he married Dr Susan Finnegan, a senior member of the Department of Zoology at the Museum, a devoted, accomplished and delightful lady who, with a son and daughter and seven grandchildren, now survives him.

Regrettably my own contact with him was slight, and I am indebted to an obituary by Dr A.C. Bishop, the recent Keeper of Mineralogy, for most of the biographical detail in this appreciation. But that does not alter in any way my personal feeling of deep respect and admiration when writing about Dr Campbell Smith. He found time in a long and busy life to befriend and encourage our specialized science of gemmology and we were most grateful for his interest. R.K.M.

It is with great regret that we announce the death of **Mr F. E. Lawson Clarke, FGA** (D.1943), Treasurer of the Association from 1951 to 1983. A full obituary will appear in a future issue of the *Journal*.

Mr George A. Massey, FGA (D.1973), Sheffield, died in May 1989. Mr Massey was Chairman of the South Yorkshire Branch of the Association, and a full obituary will appear in a future issue of the *Journal*.

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to the following for their gifts:

Mr M. Kammerling, FGA, Idar Oberstein, West Germany, for three unique sapphire doublets.

Mr H. Tamiya, President of Cosmo Ltd, Japan, for a book on jadeite by Hisui.

MEMBERS' MEETINGS

London

On 12 July 1989 at the Flett Theatre, Geological Museum, Exhibition Road, South Kensington, London SW7, following the Annual General Meeting (see p.519), the film 'Considering crystals' was shown. Members were then able to view the new Exhibition 'The Natural History Museum Rock Festival' (see p.519). These events replaced the Gemmological Forum which had to be cancelled because of a train strike.

Midlands Branch

On 15 September 1989 at the Society of Friends, Dr Johnson House, Colmore Circus, Birmingham, Mr Richard Taylor of Professional Jewellery Services of Shrewsbury gave a talk on valuations.

EXECUTIVE MEETING

At a meeting of the Executive Committee held on 1 September 1989 at Saint Dunstan's House, Carey Lane, London EC2, the business transacted included the election to membership of the following:

Fellowship

Becker, Kim A., Francistown, Botswana. 1988
Jayawardena, Palihawadana A.J.L.P., Wattala, Sri Lanka. 1979
Thornton, Shirley E., Bangor, N. Ireland. 1989

Ordinary Membership

Barckley, Lucia, M., San Diego, Calif., USA.
Broadley, Michael, Walton On Thames.
Colomb, Nanette, D., Epsom.
Hoggett, Jane E., Gateshead.
Inkpen, Michael S., Kingsbridge.
Kim, Park J.S., Singapore.
Kneale, Janette, Maidenhead.
Lau, Clement H., London.
Leary, Ronald, Liverpool.
Mansell, Rosalind, London.
Mushtaq Ahmed, Muslim, Faisalabad, Pakistan.

Nangia, Rani, North Harrow.
Papaeliopoulos, George A., London.
Pattni, Dipesh S., Loughborough.
Pelham, David A., Colwyn Bay.
Ravona, Haim, Hadera, Israel.
Razvi, Abdul Q., Slough.
Reeve, Barbara H.C., Cambridge.
Rukbankerd, Poonsri, Bangkok, Thailand.
Simonis, Frank J., Long Beach, Calif., USA.
Swenson, Darrell R., Spring Valley, Calif., USA.
Taylor, Shelley C., Santa Monica, Calif., USA.

COUNCIL MEETING

At a meeting of the Council held on 11 September 1989 at the Royal Automobile Club, Pall Mall, London SW1, the business transacted included the following:

(1) the subscription rate for 1989 for Fellows and Ordinary members was increased to £33 for UK members and $90 for those overseas;
(2) The election to membership of the following:

Fellowship
Andrews, Suzanne, Cheadle Hulme. 1989
Douglas Marshall, Anna T., Cambridge. 1989
Fuller, Mark R., London. 1989

Ordinary Membership
Laidler, James, Cardiff.
Patel, Kokila R., Harrow.
Robertson, David, Edinburgh.

ANNUAL GENERAL MEETING 1989

The 58th Annual General Meeting of the Association was held on 12 July 1989 at the Flett Theatre, Geological Museum, Exhibition Road, London SW7.

The Chairman, Mr David Callaghan, FGA, presided and welcomed members to the meeting.

It was reported with regret that Mr Eric Bruton had decided to retire from the Council. Mr. Callaghan thanked him for the many years of service that he had given to the Association, particularly in connection with the Gem Diamond course.

Mr Callaghan thanked the Officers and Council for their help and support during the year, particularly Nigel Israel and Noel Deeks who had done a tremendous amount of work.

He thanked Secretary Jonathan Brown and his team for all they had done. He said that there had been many problems during the year to challenge Jonathan but he had never failed to respond.

Mr Nigel Israel, Treasurer of the Association, presented the audited accounts for the year ended 31 December 1988. The adoption of the Report and Accounts was duly proposed, seconded by Mr David Kent, and carried.

Sir Frank Claringbull, Mr David J. Callaghan, Mr Noel W. Deeks and Mr Nigel B. Israel were re-elected President, Chairman, Vice Chairman and Honorary Treasurer respectively. Dr A.J. Allnutt, Dr R.R. Harding, Mr D.M. Larcher, Dr J.B. Nelson, Mr W. Nowak and Mr C.H. Winter were re-elected and Mr R.J. Peace and Mr C. Burch elected to the Council.

Messrs Ernst and Whinney were reappointed Auditors, and the proceedings then terminated.

CRYSTAL HAUTE COUTURE AT 'THE NATURAL HISTORY MUSEUM ROCK FESTIVAL'

A new exhibition opened at the Natural History Museum on 6 July 1989 and looks at the many faceted world of the crystal. Alongside spectacular natural crystal formations and fantastic science-fiction comic art there is a collection of contemporary jewellery by leading French designers Jean Vendome, Kurt Neukomm, Laurent Stoll and Anne Silbermann (collectively known as Karenage). The exhibition runs at the Museum until 15 January 1990.

DR NASSAU RETIRES

Dr Kurt Nassau is retiring at the end of 1989 after 30 years with A T & T Bell Laboratories, Murray Hill, New Jersey.

In his technical research on crystal growth, lasers, semiconductors, glasses, and high temperature superconductors, among others, Dr Nassau has over two hundred technical publications and fifteen patents. He has published the textbook *The Physics and Chemistry of Color* (Wiley, 1983) and an Encyclopaedia Britannica article on 'Colour' for the 1988 and subsequent editions. He was awarded the Distinguished Technical Staff Award for Sustained Achievement by Bell Laboratories in 1988, consisting of an honorarium, a metal sculpture, and other benefits.

Dr Nassau is well-known in the field of gems and minerals for his gemmological research, reported in over one hundred and fifty articles and his two popular books, *Gems Made by Man* (GIA, Santa Monica, CA, 1987) and *Gemstone Enhancement* (Butterworths, Boston, 1984). He is on the board of governors of the Gemological Institute of America.

In his retirement in his recently-completed home in Tewksbury, NJ (mailing address 154A Guinea Hollow Road, Lebanon, NJ 08833; Tel: 200-832-2499), Dr Nassau intends to continue writing and expand his consulting and teaching activities.

THE GUILDFORD GEM, MINERAL AND LAPIDARY CLUB

The Guildford Gem, Mineral and Lapidary Club was inaugurated on 18 May 1989. The object of the Club is to interest, inform and entertain its members and to include within its scope such subjects as gemmology, mineralogy and mineral collecting, lapidary work (ornamental and gemstones), geology, precious metals and jewellery making, fossils, and similar related subjects. Monthly lectures or demonstrations are arranged, as well as field trips to collecting sites, visits to museums, shows and collections.

Full details of the Club may be obtained from the Secretary, Ms Pat Lapworth, 9 Trinity Churchyard, Guildford, GU1 3RR.

CORRIGENDA

On the front inside cover of *J.Gemm.*, 1989, **21**, 7, Mrs E. Stern, FGA, is omitted from the list of Members elected to Council

On p.450 above, first column, line 26, for 'Dahu', read 'Oahu'

On p.440 above, the refracted ray shown in Figure 5 should read r° and not i°. Also, the general incident ray i° should have appeared within the EON angle and in a similar position to the corresponding reflected ray (= i°)

Letters to the Editor

From R. Keith Mitchell
Gemmological Association of Great Britain

Dear Sir,

WHAT IS HAPPENING TO OUR SOUTH KENSINGTON MUSEUMS?

Following considerable public concern at new management's drastic changes in the Victoria and Albert Museum, involving the removal of several heads of departments, we now hear, via the July-August issue of *Geology Today*, that 'The Geological Museum is being strangled. In fact, in one sense it is already dead', a statement based on the monthly *Events* leaflets issued by a controlling BMNH which since March of this year have shown a slow eclipse of the Geological Museum – in printed space allotted, in events and lectures forecast and even in the use of its name.

The magazine investigated further and found that that name has already been dropped unofficially, a move which only awaits Government ratification to make it official; that some GM staff are now redundant; that schoolchildren are now considered to be the primary audience of the NHM; that aid to teachers in the earth sciences is to stop; that adult education within the museums is to be abandoned and other retrograde steps taken.

Once again a new management must be regarded as responsible for changes which cause geology and allied subjects to be regarded 'merely as a branch of natural history'.

We now hear rumours that the NHM is sending staff to study the showmanship of Disneyland, possibly with the object of instilling such methods into the museum presentation.

But perhaps of greater concern to the gem trade and to gemmology is the suggestion that thought is being given to moving the world-renowned collection of superb cut gems and gem minerals from its dominant main hall position in the Geological Museum to a cramped and less frequented space on the first floor gallery.

That collection has been assiduously built up in excellence of display and in content to become a major attraction for the general public and for overseas visitors for more than forty years. To move it now to a less accessible area, possibly at the same time dispensing with the very successful and much admired non-reflecting showcases, would seem to be the height of folly!

The Geological Museum name should be preserved. The famed and quite remarkable gem collection should remain in its present readily accessible position unless a convincing and rational case can be made for its re-siting. The keynote should not be 'Change for the sake of Change'.

Yours etc.,
R. Keith Mitchell,
Vice President.

11 August 1989
Orpington, Kent.

From Dr Karl Schmetzer

Dear Sir,

In an article dealing with irradiation effects and colour changes of hydrothermally- and flux-grown synthetic emeralds by H.-W. Schrader (*Journal of Gemmology*, **21**, 1988, 237-51), a conversion of flux-grown synthetic emeralds from green to violet colours as well as a conversion of hydrothermally-grown synthetic emeralds from green to smoky colours is described. The irradiation treatment of the synthetic emeralds was performed during six hours in a running nuclear reactor with a thermal fluence rate of 7 × 1011 neutrons/cm^2.sec (Schrader, Dissertation, Universität Mainz, 1987). After an exposure of violet samples to daylight for five months, the violet colour centres were bleached and the synthetic beryls turned smoky.

According to Schrader, the colour changes described are due to neutron radiation causing additional absorptions in the visible range of the spectrum which are superimposed to the normal chromium absorption bands of emerald. The smoky colour is due to an absorption band centred in the ultraviolet, the low energy tail of which extends to the visible area. The violet coloration is produced by an absorption maximum in the green range between 520 and 530 nm. In analogy to quartz colour centres, the absorption band in the ultraviolet was assigned by Schrader to a more stable smoky type $[AlO_4]^{4-}$ colour centre and the absorption band in the range of 520 to 530 nm was assigned to a less stable amethyst type $[FeO_4]^{4-}$ colour centre, with both, aluminium and iron, replacing silicon in tetrahedral lattice sites of beryl. However, these assignments as well as the assumption of neutrons as colour causing radiation are highly speculative.

First, it is common that in a running nuclear reactor in addition to neutrons extremely high dose rates of gamma radiation are also efficient during a radiation treatment of six hours. The smoky colour centres of hydrothermally- and flux-grown synthetic emeralds can also be produced by X-rays (Lind, Henn and Bank, 1986, *Z. Dt. Gemmol. Ges.*, **36**, 51-60; Schmetzer, unpublished data), and both violet and smoky colour centres were described for synthetic beryl irradiated with gamma rays from a Co-60 unit (Solntsev, 1981, *Tr. Inst. Geol. Geofiz., Akad. Nauk SSSR, Sib. Otd.*, **499**, 92-140). Consequently, gamma rays are also regarded as a colour causing radiation for smoky and violet colour centres of synthetic emerald.

Furthermore, the violet colour centre found in synthetic beryl after Co-60 radiation, which reveals an absorption maximum in the green area at about 520 to 530 nm, was characterized by Solntsev using electron paramagnetic resonance. The EPR signals were assigned to an O-electron hole centre confined to an Al^{3+} substituting for Si^{4+} in tetrahedral sites. This $(AlO_4]^{4-}$ colour centre, which is closely related to the smoky colour centre of quartz, is bleached after heating up to 80°C, i.e. both the absorption band in the green range as well as the EPR signals disappeared after heat treatment at 80°C. This assignment of the violet colour centre of irradiated flux-grown synthetic emerald to aluminium related colour centres, however, is consistent with the chemical data of Schrader, who found remarkable Si-deficiencies only in flux-grown synthetic emeralds.

The assignment of the ultraviolet absorption band, which causes a smoky coloration in irradiated hydrothermally- and flux-grown synthetic emerald, is more difficult. According to Solntsev, this type of absorption produces a yellow to brown colour in almost chromium-free synthetic beryl. Natural iron-bearing, almost colourless beryls are commercially irradiated with gamma rays, mostly from Co-60 units, in order to produce an intense yellow coloration. This type of irradiated beryl reveals a similar or identical absorption band centred in the ultraviolet, the low energy tail of which extends to the visible range. At present, it is unknown if those particular colour centres causing an intense yellow to brownish coloration in chromium-free natural beryls and those ones producing a smoky coloration in synthetic emeralds and a yellow to brown coloration in chromium-free synthetic beryls are identical. However, according to the fact that iron-bearing natural beryls turn a more intense yellow than almost iron-free natural beryls using identical gamma dose rates (Schmetzer, unpublished data), the yellow colour centres of natural beryls or at least part of them may be related to traces of iron.

Yours etc.,
K Schmetzer,

19 May 1989
Heidelberg, West Germany.

From A.E. Farn

Dear Sir,

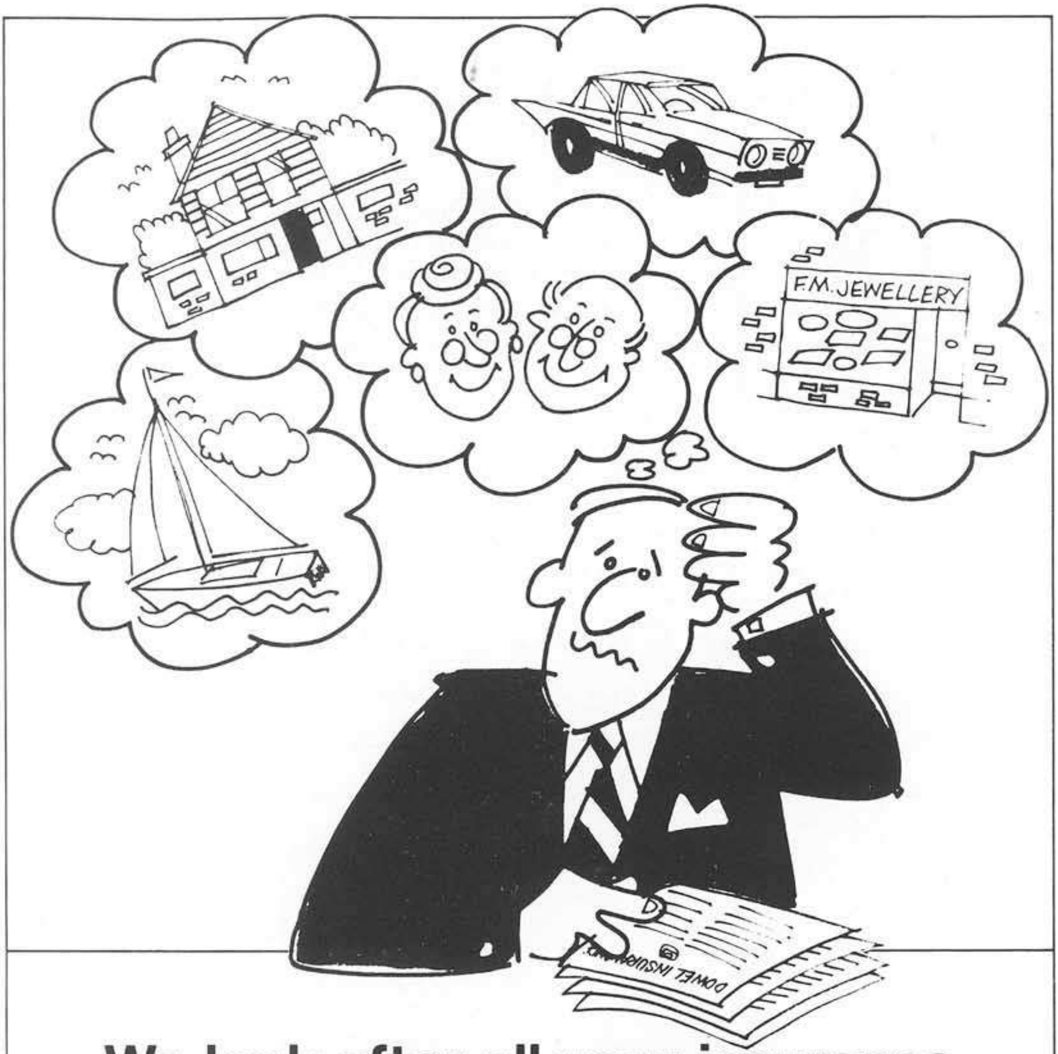
I read with interest and admiration Kenneth Scarratt's lucid exposition of absorption curves as opposed to line drawings depicting what is seen in the hand held spectroscope (Notes from the Laboratory – 14, *Journal of Gemmology*, 1989, 21, 6, 339-46). As K. Scarratt states, the hand held spectroscope still serves us well in immediate identification for ordinary gemmologists (and most of us are).

A laboratory such as The Gem Testing Laboratory of Great Britain needs its sophisticated equipment to maintain its position in the forefront. However, my memories are of the tall figure of B.W. Anderson poised over the old brass microscope (used solely as a light gathering source), and the smell of scorched woodwork from the asbestos lined 500 watt lamp housing. His amazing accuracy with a hand held measuring spectroscope serve to reinforce and reiterate for me some of his basic observations.

For the ordinary gemmologist there are still the delights of discovery with the 10x lens and the hand spectroscope. Whilst not denying in any manner the importance for laboratories to possess every possible item of sophisticated equipment, we can be encouraged by the words of the man who made most things possible by his researches. B.W. Anderson was not just a pioneer gemmologist, among many other accomplishments he had the use of and command of words. The opening chapter of his book *Gemstones for Everyman* is entitled, 'What exactly is a gemstone?'. The book ends with the lines, '...and let it not be thought that efficient gem testing today must always depend upon sophisticated apparatus. A very important proportion of the work needs only two ingredients for its performance – a good gemmologist and a 10x lens'. Between these two excerpts Anderson encompasses a world of encouragement, explanation and enjoyable gemmology for us, 'the vast majority'.

Yours etc.,
A. E. Farn,

1 July 1989
Blatchington Green, Seaford, E. Sussex BN25 3HP.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GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

The Arms and Crest of the Association, conferred by a grant of Arms made by the Kings of Arms under royal authority. The cross is a variation of that in the Arms of the National Association of Goldsmiths of Great Britain and Ireland. In the middle is a gold jewelled book representing the study of gemmology and the examination work of the Association. Above it is a top plan of a rose-cut diamond inside a ring, suggesting the scrutiny of gems by magnification under a lens. The lozenges represent uncut octahedra and the gem-set ring indicates the use of gems in ornamentation. The lynx of the crest at the top was credited, in ancient times, with being able to see through opaque substances. He represents the lapidary and the student scrutinizing every aspect of gemmology. In the paws is one of the oldest heraldic emblems, an escarbuncle, to represent a very brilliant jewel, usually a ruby. The radiating arms suggest light diffused by the escarbuncle and their tips are shown as jewels representing the colours of the spectrum.

Historical Note

The Gemmological Association of Great Britain was originally founded in 1908 as the Education Committee of the National Association of Goldsmiths and reconstituted in 1931 as the Gemmological Association. Its name was extended to Gemmological Association of Great Britain in 1938, and finally in 1944 it was incorporated in that name under the Companies Acts as a company limited by guarantee (registered in England, no. 433063).

Affiliated Associations are the Gemmological Association of Australia, the Canadian Gemmological Association, the Gem and Mineral Society of Zimbabwe, the Gemmological Association of Hong Kong, the Gemmological Association of South Africa and the Singapore Gemologist Society.

The *Journal of Gemmology* was first published by the Association in 1947. It is a quarterly, published in January, April, July, and October each year, and is issued free to Fellows and Members of the Association. Opinions expressed by authors are not necessarily endorsed by the Association.

Notes for Contributors

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

Papers should be submitted in duplicate on A4 paper. They should be typed with double line spacing with ample margins of at least 25mm all round. The title should be as brief as is consistent with clear indication of the content of the paper. It should be followed by the names (with initials) of the authors and by their addresses. A short abstract of 50–100 words should be provided. Papers may be of any length, but long papers of more than 10 000 words (unless capable of division into parts or of exceptional importance) are unlikely to be acceptable, whereas a short paper of 400–500 words may achieve early publication.

Twenty five copies of individual papers are provided on request free of charge; additional copies may be supplied, but they must be ordered at first proof stage or earlier.

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Compiled by Judy Israel

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above and *below* indicate that the reference is to another subheading under the same heading, not a separate heading.
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