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

Cover Picture

Images in Gems
'Square-eyed owl on a branch.' Partly healed cleavage in topaz.
Photograph by Spencer J.A. Currie, FGA, Auckland, New Zealand (see Photographic Competition, p. 246)

In this issue . . .

A rarity in the gem and mineral world, euclase has sometimes fooled the unwary by its similarity to aquamarine, but its higher refractive indices and specific gravity enable one to distinguish it quite readily. An affinity with the beryl group however is not confined to its colour, and the first paper describes a cut euclase from Chivor, Colombia, that not only resembles greenish-blue aquamarine from Tongafeno (Madagascar) but also contains three-phase inclusions like those found in the more famous emeralds from the Chivor mine.

The next two papers reflect the growing importance of Madagascar and describe features of sapphires from a new locality about 350 miles from Tongafeno near the southern coast. Andranondambo is a new addition to the host of multisyllabic gem sources in that country and it has already impressed itself on our minds through efforts to establish its correct spelling!

The first sapphire paper describes their geological setting and summarizes their gemmological properties. The complexity of the patterns of colour-zoning in the sapphires is explored in more detail in the second paper and features concerning inclusions, heat treatment and chemical variation are described. The range in colour zoning has significant consequences for the trade in that resemblances have been found between Andranondambo crystals and sapphires from such diverse locations as Kashmir, Sri Lanka and Vietnam.

For nearly a century, goodletite has been a name used in New Zealand to describe an ornamental greenish rock containing variable amounts of ruby and sapphire. However, this was not the source for goodletite referred to by Webster in his glossary of unusual names where he alluded to a Burmese origin. His description of a marble forming the matrix of rubies does not coincide with the New Zealand rock, but at present the allusion remains elusive and its source has not been discovered, so any ideas of establishing historical priority for the name had to be put on one side. Meanwhile, the composition of the New Zealand goodletite is described and its gemmological properties listed.

The last paper is a review of the latest gem-identification program to come on the market. It is 'Windows' based and is a subset of a much larger Adamas Advantage program comprising gem identification with diamond and coloured stone analysis reporting. The program is wide ranging and a special section contains a wealth of information which should appeal to students.

On a personal note, the loss of Bob Kammerling earlier this year has left all who knew him with a deep sense of shock and bereavement. When I last saw him in Thailand in October 1995 he was as vital and intensely concerned about gemmological issues as he had been when I first met him in the eighties. I shall miss his ready understanding and willingness to discuss a whole range of topics and his departure is a great loss to gemmological publications and to the jewellery scene worldwide.

R.R.H.

Euclase from Colombia showing three-phase inclusions

J.M. Duroc-Danner, FGA, GG

Geneva, Switzerland

Abstract

Gem quality euclase, a hydrated beryllium-aluminium silicate $BeAlSiO_4$ (OH), which crystallizes in the monoclinic system, may be fashioned into gemstones for collectors. The gemmological properties of a medium-dark greenish-blue euclase from Chivor, Colombia, are described and compared with the properties of other gemstones of similar colour with which it could be confused.

Fig. 1. Enlarged view of the 1.86 ct emerald-cut medium-dark greenish-blue transparent euclase.

Introduction

Recently the author was asked to identify a number of different faceted stones. All could be recognized from their aspect, colour and inclusions (e.g. beryl (aquamarine), trapiche emerald, parisite, peridot . . .). These were all confirmed by their gemmological properties, except for one medium-dark greenish-blue stone from Chivor, Colombia, which looked very similar to aquamarine from Tongafeno, Madagascar (Figure 1),[1] but which had different physical and optical properties.

Gemmological properties

The 1.86 ct emerald-cut medium-dark greenish-blue transparent gemstone (length 7.51 mm, width 6.60 mm, depth 1.92 mm) of vitreous lustre, is traversed by a few cleavage planes and abundant inclusions. Refractive index (RI) determinations were carried out using a Rayner Dialdex refractometer and monochromatic sodium light. The indices obtained were $\alpha = 1.654$, $\beta = 1.658$, $\gamma = 1.673$, giving a birefringence of 0.019, with optic sign (+). Under a calcite dichroscope with fibre optic illumination, a distinct to strong pleochroism in medium-dark blue; greenish-blue; colourless, was observed. When viewed through a Chelsea colour filter the stone appeared red.

The absorption spectrum was observed in dark conditions, through four spectroscopes (Aus Jena, Beck, DG-X, GEM CF), mounted on a GIA GEM spectroscope base set with a colour filter wheel, and revealed absorption bands typical of copper, iron and chromium, at 400–410, 412, 420, 453, 470, 616, 629, 641, 647, 660, 671, 684, 689, 706–708 nm. Of these absorptions, the easiest bands to locate and therefore most characteristic, were: 400–410, 412, 420, 453, 689, 706–708 nm.

The stone was examined with a Multispec combined LW/SW ultraviolet unit and remained inert.

The specific gravity (SG) was obtained by hydrostatic weighing in distilled water using a Mettler electronic PL 300C carat scale, and the stone was found to have a value of 3.11. Since the stone tested was rather small (1.86 ct) and although great care was undertaken to obtain accurate weighings, it was decided to check the specific gravity obtained. In a liquid of SG 3.05 the stone sank slowly and this is consistent with the result from hydrostatic weighing.

The inclusions were examined using a Bausch & Lomb Mark V Gemolite binocular microscope using dark field illumination or overhead lighting as appropriate. The most characteristic inclusions (apart from the cleavage planes which are visible to the naked eye), are numerous well-shaped three-phase

Fig. 2. Some of the numerous three-phase inclusions observed under the microscope. Magnification 60x.

inclusions, very similar to the ones found in emeralds from Colombia (Figure 2).

Conclusion

The physical and optical properties obtained are consistent with those for euclase.[2, 3, 4, 5, 6] Apart from the aquamarine from Tongafeno, Madagascar, which it resembles in appearance, there are two gemstones with similar properties with which this stone could be confused:

(1) green spodumene, RI 1.660–1.676(±0.005), biaxial positive, DR 0.014–0.016, and SG 3.18(±0.03);

(2) bluish-green sillimanite (fibrolite), RI 1.659–1.680(+0.004 to –0.006), biaxial positive, DR 0.015–0.021, and SG 3.24(±0.02).

Their perfect cleavages (two directions for spodumene, one direction for sillimanite), their fibrous aspect and two-phase inclusions, could also add to their confusion with euclase. The main differences between euclase and spodumene lie in the higher birefringence of euclase (0.019), and in its response to ultraviolet radiation: due to a trace content of iron it remains inert while spodumene often fluoresces.

Euclase may be distinguished from sillimanite only by its lower SG, 3.10(±0.01), compared with 3.24(±0.02) for sillimanite.

Acknowledgements

References

1. Duroc-Danner, J.M., 1989. Medium-dark blue aquamarines from Tongafeno, Madagascar, with high physical and optical properties, and showing three-phase inclusions. *Journal of Gemmology*, **XXI** (7), 423–30
2. Anderson, S.M., 1980. Euclase. *Journal of Gemmology*, **XVII**(1), 18–29
3. Bastos, F.M., 1969. Euclase from Minas Gerais, Brazil. *Journal of Gemmology*, **XI**(8), 312–14
4. Hurlbut, C.S., and Switzer, G.S., 1979. *Gemmology*. Wiley-Interscience publication, John Wiley & Sons, USA. pp 178–9
5. Liddicoat, R.T., 1989. *Handbook of gem identification*. 12th edn, 2nd revised printing. Gemological Institute of America, Santa Monica, CA., p. 185
6. Webster, R., 1987. *Gems their sources, description and identification*. 4th edn., revised by B. W. Anderson. Butterworths, London. p.322

Compositional characteristics of sapphires from a new find in Madagascar

Claudio C. Milisenda and *U. Henn***

*German Foundation for Gemstone Research (DSEF), Idar-Oberstein, Germany
**German Gemmological Association, Idar-Oberstein, Germany

Abstract

Gem-quality blue sapphires from the Andranondambo area in south-eastern Madagascar have been recently entering the gemstone market in commercial quantities. The material is recovered from altered marbles and calc-silicate gneisses of the granulite facies. The physico-chemical properties of the samples investigated are similar to those found in metamorphic-type sapphires.

Keywords: Madagascar, sapphire, geological environment, physico-chemical properties

Introduction

The island of Madagascar has long been known in the gemstone supply scene and its formidable list of gem species and stones for collectors is comparable to those found in Sri Lanka. Even before World War I, people from Idar-Oberstein went to Madagascar in order to obtain gemstones for the industry in their home town (Falz, 1939). Since then gem species such as aquamarine, emerald and other beryls (e.g. morganite), garnets (e.g. rhodolite, spessartine), tourmaline, kunzite, quartz varieties (e.g. rock crystal, amethyst, citrine, agate), feldspars (e.g. amazonite, orthoclase, labradorite), corundum (ruby, sapphire) and a number of rare collector stones (e.g. kornerupine, epidote, kyanite, hambergite

and many others) have appeared in the trade.

Lacroix (1922) summarized the island's mineralogy and showed that corundum is

Fig. 1. Geographical map of Madagascar showing the known corundum occurrences (open squares) and the new find of blue sapphire (filled square) in the Andranondambo mine.

Fig. 2.   The Andranondambo mining area in the Toliara province, south-eastern Madagascar. *Photo by E.J. Petsch*

a common constituent of the metamorphic rocks in Madagascar. However, deposits of gem-quality ruby and sapphire are sparse and the production has been limited to relatively small and low-quality samples. According to Chikayama (1989) who presented a recent survey of the gemstone deposits in Madagascar, gem-quality corundum occurs in the south-western province of Toliara at Gogogogo (ruby), Ejeda (ruby), Amboasary (sapphire) and around Antanifotsy (ruby and sapphire), some 100 km south of the capital Antananarivo (Figure 1). An unusual type of multi-coloured (polychrome) sapphire is recovered from a mining area south-west of Betroka also located in the province of Toliara (Koivula *et al.*, 1992).

A recent discovery of blue sapphire in the south-eastern part of the Toliara province now raises the possibility of significant production of sapphire from Madagascar. The occurrence is located near the village of Andranondambo approxi-mately 100 km North of Fort Dauphin (see Figure 1). There, the sapphires are recovered by using simple hand tools from numerous small square shaped gem-pits (Figure 2) which are located in residual gravels. Large quantities are apparently available and there are good prospects for commercial exploitation. In fact, a new company has been formed with investment from leading gem dealers from Thailand in order to develop the deposits in Madagascar (*ICA Gazette*, April 1995).

Geological environment
Granulite grade rocks crop out over a large area covering much of southern Madagascar. They form part of an Archaean crust which experienced its main thermo-tectonic evolution during the Pan-African event, which is known to have affected large parts of Africa, southern India and Sri Lanka (Kennedy, 1964; Kröner, 1980). In a Gondwana supercontinent notionally reassembled before conti-
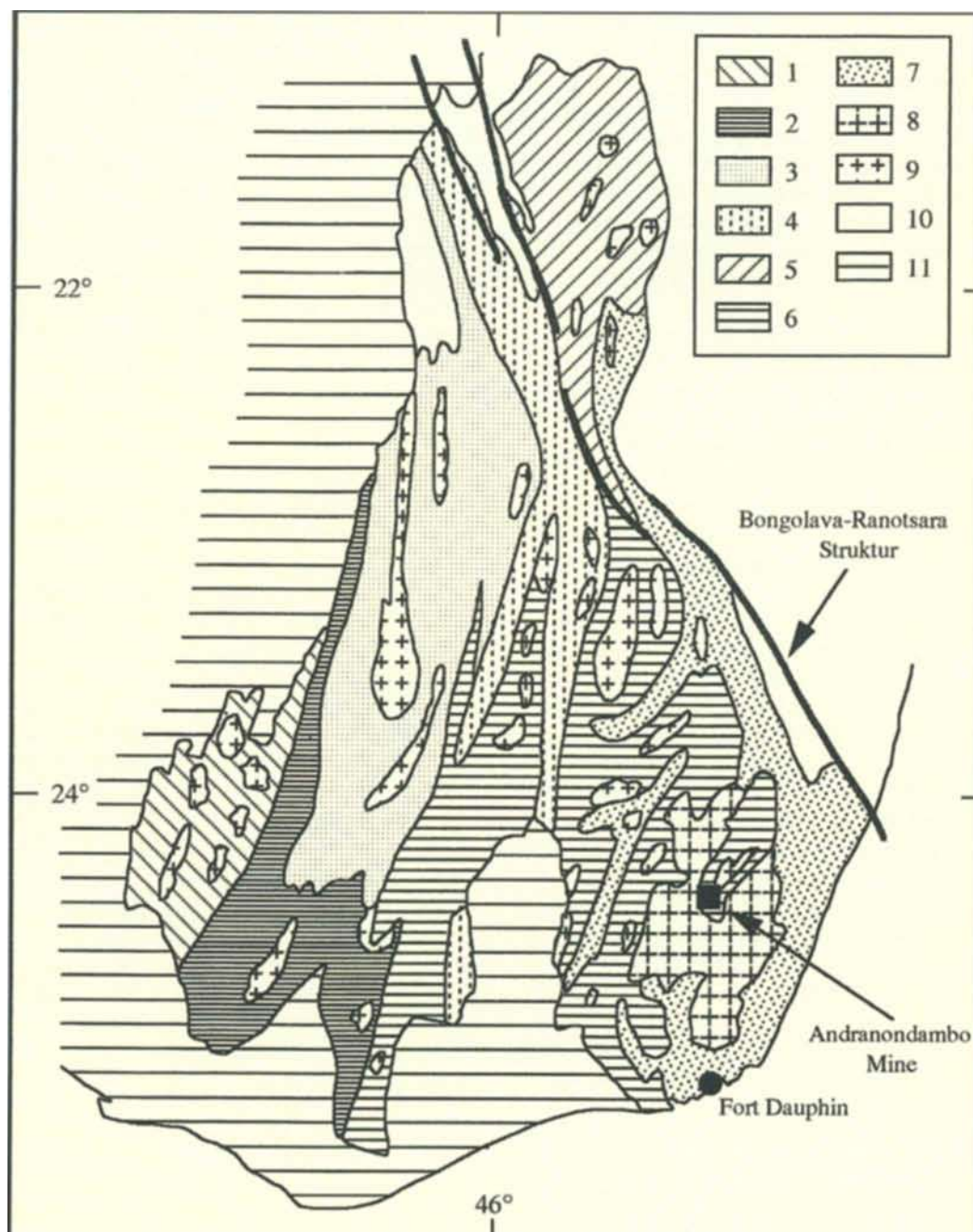
Fig. 3. Simplified geological map of southern Madagascar showing the main petrographic types (modified from Nicolett, 1990). Vohibory group: 1–Vohibory formation (amphibolite gneisses, amphibolites, marbles); Graphite group: 2–Ampanihy formation (graphite gneisses, leptynites, mafic granulites); Androyan group: 3–Horombe formation (leptynites); 4–Ihosy formation (anatectic gneisses, leptynites); 5–Tsitondroina formation (migmatites, leptynites); 6–Tranomaro formation (leptynites, cordierite gneisses, marbles, scapolite gneisses, charnockites); 7–Fort Dauphin formation (leptynites and gneisses); 8–charnockites and granites; 9–granites and orthogneisses; 10–undifferentiated Precambrian; 11–Phanerozoic.

nental drift separated the great landmasses we know today, these granulites are included in a broad belt of high-grade Precambrian rocks and marked the eastern limit of the Mozambique belt, which is regarded as a compression structure resulting from collision of East Gondwana (India-Antarctica-Australia) and West Gondwana (Africa-South America) some 600 Ma ago (Kröner, 1991; Milisenda, 1991).

Recently, Nicollet (1990) reviewed the geology and mineralogy of Madagascar. A simplified geological map is given in Figure 3. The south of Madagascar can be divided into three Archaean successions: from West to East, these are the Vohibory group which is predominantly composed of amphibolites and marbles, the Graphite group which is characterized by graphite-bearing gneisses and leptynites, a banded quartzofeldspathic granulite, as well as mafic granulites and the Androyan group which includes a large variety of granulite-facies ortho- and paragneisses (see Figure 3). Metamorphic grade increases from greenschist and amphibolite-facies in the Vohibory formation to intermediate and high pressure granulite-facies in the Androyan and Graphite group, respectively.

The new sapphire deposit is located south of the Bongolava-Ranotsara lineament (see Figure 3) which is most likely a suture that separates two chronologically distinct domains (Caen-Vachette, 1979). In the Andranondambo mining area, the sapphires are found in a suite of altered marbles and calc-silicate gneisses which form part of the 40–60 km wide Tranomaro formation, a subdivision of the Androyan group which in addition to marbles includes leptynites, banded cordierite-bearing gneisses, scapolite-bearing gneisses and charnockites (Nicollet, 1990). The Tranomaro formation or Tranomaro belt as it is alternatively called by Windley et al. (1994) closely resembles the supracrustal sequence of the Highland

Complex in Sri Lanka (Milisenda et al., 1988; 1994) and includes Archaean and Early Proterozoic rocks that have been extensively reworked in Pan-African times. Based on recent geochronological data (Andriamarofahatra et al., 1990; Paquette et al., 1993) obtained on rocks of the Tranomaro formation high-grade metamorphism took place in the Neoproterozoic ≈600 Ma ago. Because there is no evidence of either a significantly earlier or later high-grade metamorphic event in this rock unit, we conclude that this was also the time of corundum formation.

Visual appearance
The samples investigated were slightly to moderately included and commonly showed a strong, eye-visible colour zoning. In most cases an intense blue colour was concentrated in broad bands within the centre of the crystal fragments. Only a few crystals with a homogeneous colour distribution were observed. However, the distinct colour zoning can be largely obliterated and thus, the visual appearance of the sapphires can be strongly enhanced by heat-treatment.

Crystallographic properties
The Andranondambo mining area produces fragments of euhedral crystals (Figure 4) with rhombohedral and pyramidal habits. These crystal forms are typical for sapphires found in high-grade paragneisses such as marbles and are unlike the strongly etched or partly dissolved specimens that have been brought to the surface by alkali basalts. The most prominent growth planes are the hexagonal bipyramid $(11\bar{2}1)$ and the basal pinacoid (0001).

Physical properties
Refractive index and specific gravity
Using a standard gemmological refractometer, the refractive indices were determined to be $n_e = 1.761–1.763$ and $n_o = 1.769–1.771$ with a maximum birefrin-

Fig. 4. Crystal fragments of sapphires from the Andranondambo mining area, south-eastern Madagascar (weight of samples between 0.88 and 1.44 ct)

gence of–0.008. The specific gravity measured using a hydrostatic balance ranged from 3.91 to 3.98.

Pleochroism and ultraviolet fluorescence
The samples examined showed a distinct to strong dichroism with a green-blue hue perpendicular to the *c*-axis and violet-blue parallel to the *c*-axis.

All samples were inert when exposed to long wave ultraviolet (UV) radiation. Most of them were also inert to short wave UV. However, a few stones fluoresced a weak greenish-blue and one specimen a weak and uneven orange under short wave UV.

Spectroscopy
The polarized UV/VIS/NIR–spectrum of a representative sapphire specimen from the Andranondambo mining area is shown in Figure 5 and is typical for sapphires from high-grade metasedimentary sources (e.g. Poirot, 1992). They are dominated by two essential absorption mechanisms namely Fe^{3+} and the Fe^{2+}/Ti^{4+} charge transfer (e.g.
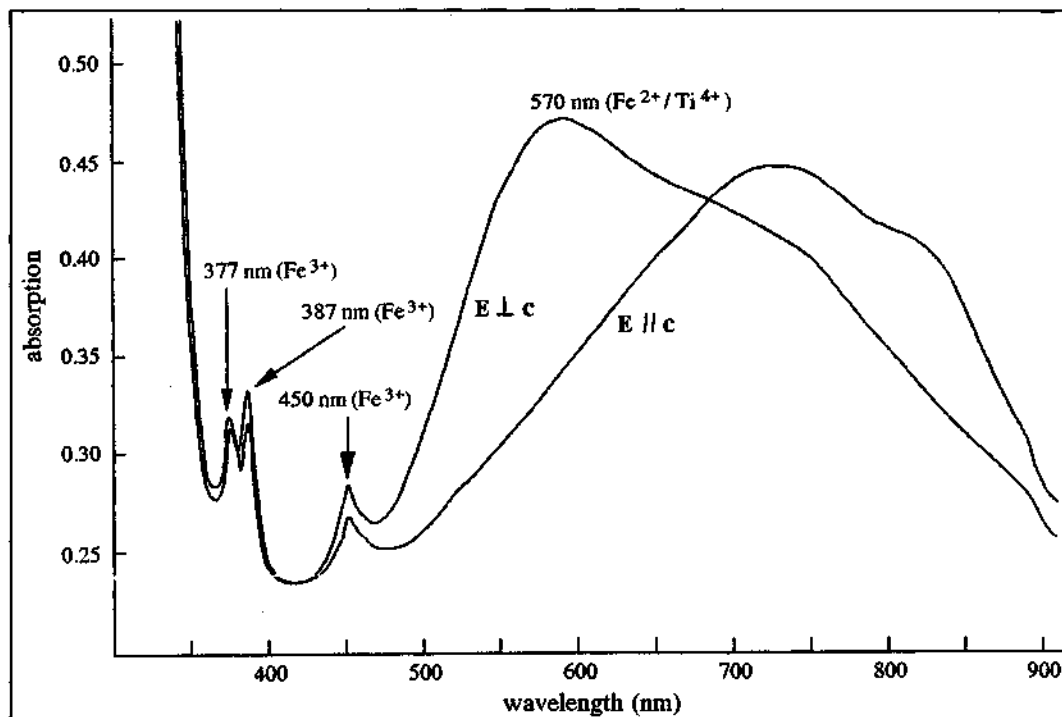

Fig. 5. Polarized UV/VIS/NIR—spectra taken on a representative sapphire specimen from the Andranondambo mining area in south-eastern Madagascar. E = vibration direction.

Schmetzer and Bank, 1980; 1981). The doublet in the ultraviolet region at 375 and 387, as well as the sharp band at 450 nm are the result of trivalent iron absorption. The broad absorption band with a maximum at 570 nm in the yellow part of the spectrum of the ordinary ray is due to an intervalence charge transfer process of the ion pair Fe^{2+} and Ti^{4+}. This absorption band is pleochroic and the maximum is closer to the near infrared in the spectrum of the extraordinary ray. It is worth noting that an absorption band in the near-infrared with a maximum at around 850 nm which is typically found in sapphires from basaltic sources (e.g. Poirot, 1992) was not detected.

Internal characteristics

As noted above, distinct colour zoning was present in the majority of the sapphires examined. In most cases, the samples showed an intense blue colour zone running parallel to the c-axis of the crystal (Figure 6). In addition, within the colour zones alternating deep to pale blue layers were observable which are oriented perpendicular to the c-axis. The colour zoning is accompanied by a strong growth zoning parallel to the basal pinacoid (0001) and/or parallel to the different bipyramidal faces of the sapphire crystal.

A number of crystalline inclusions were observed with an immersion-type microscope. Preliminary electron microprobe data indicate the presence of apatite, calcite, dolomite and a clay-mineral whose structure is yet to be determined. Apatite inclusions commonly possess a prismatic habit (Figure 7) but also occur in more equidimensional shapes which in places form a nucleus for hollow tubes oriented parallel to each other (Figure 8). Clusters of distinctly corroded, birefringent crystal
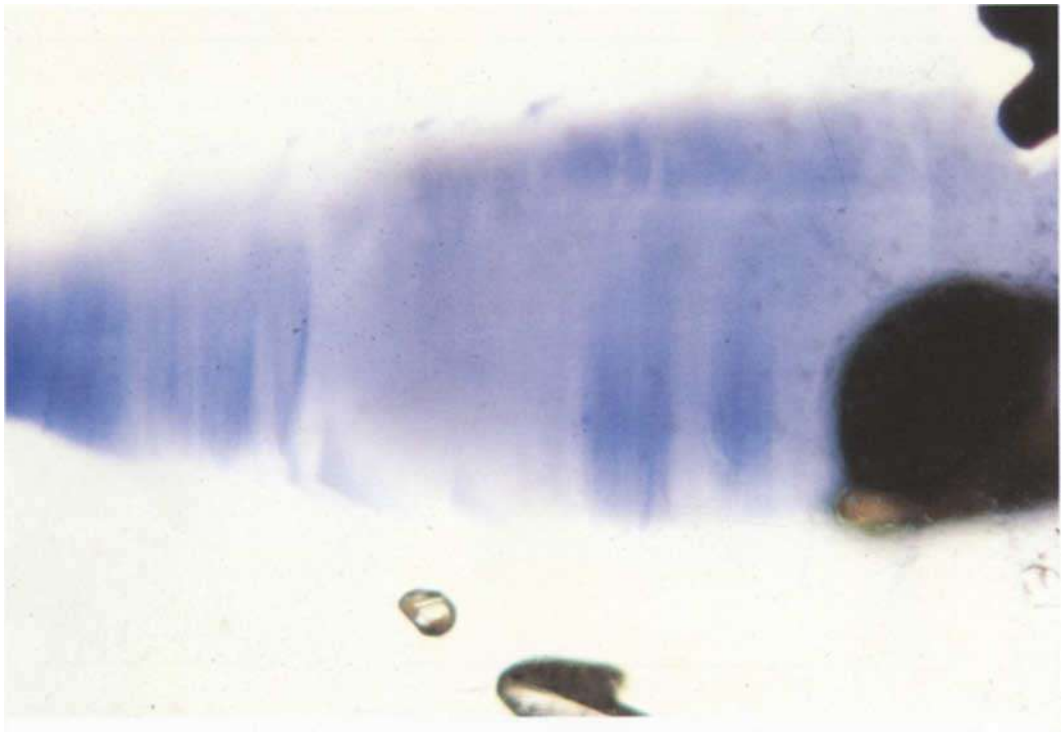

Fig. 6. An intense blue colour zone running parallel to the c-axis with alternating deep to pale blue layers oriented perpendicular to the c-axis is commonly observed in sapphires from south-eastern Madagascar. Immersion, transmitted light, 50x
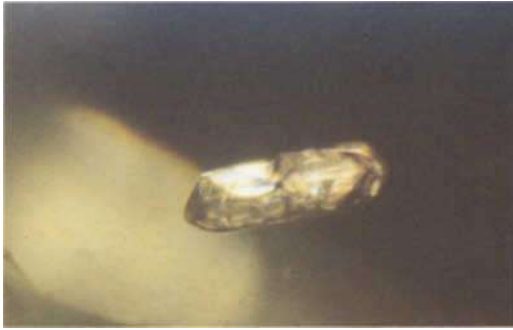
Fig. 7. Euhedral apatite crystals are common inclusions in sapphires from the Andranondambo mining area. Immersion, transmitted light, 50x
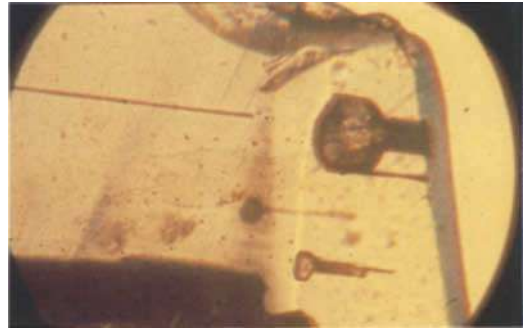

Fig. 8. Apatite inclusions located at the ends of hollow tubes which are oriented parallel to each other. Immersion, transmitted light, 40x

Fig. 9. Cluster of distinctly corroded, birefringent carbonate inclusions in front of a barely visible fingerprint-type healed crack. Immersion, transmitted light, 50x

Fig. 10. Transparent, colourless birefringent mineral platelets (probably mica) are typical inclusions in the sapphires from south-eastern Madagascar. Immersion, transmitted light, 50x

inclusions were identified as carbonates (Figure 9). Also common are transparent, colourless platelets displaying a pseudo-hexagonal habit (Figure 10); these are probably mica group minerals. In addition to the mineral inclusions mentioned above several other solid inclusions are present and probably include feldspar, diaspore, rutile and spinel. Microprobe work is continuing and a detailed chemical study of the large variety of solid inclusions in sapphires from south-eastern Madagascar will be presented in a separate paper.

A variety of negative crystals and fine networks of healed cracks (composed of minute fluid filled voids or two-phase inclusions) also form typical inclusion patterns. Lamellar twinning is present in some specimens.

Chemical properties

The chemical analyses of three sapphire specimens are listed in Table I. In addition to aluminium oxide (Al_2O_3) the electron-microprobe revealed iron oxide (FeO) as the most significant trace constituent followed by titanium oxide (TiO_2). Silicon (Si), gallium (Ga) and chromium (Cr) were also present in measurable concentrations, whereas manganese (Mn) and magnesium (Mg) were detectable in very small amounts in some crystals.

Conclusions

The compositional characteristics of the sapphires from the Andranondambo mining area in Madagascar were found to be very similar to those found in sapphires from Sri Lanka and Burma; these also were

Table I: Chemical compositions of three sapphires from the Andranondambo mine

Weight %	Sapphire 1			Sapphire 2			Sapphire 3		
	Range (3 anals)		Mean	Range (3 anals)		Mean	Range (3 anals)		Mean
SiO_2	0.02 –	0.04	0.03	0.02 –	0.04	0.04	0.02 –	0.05	0.04
TiO_2	0.06 –	0.08	0.07	0.07 –	0.14	0.10	0.03 –	0.10	0.05
Al_2O_3	99.84 –	100.28	100.09	99.48 –	100.05	99.81	99.58 –	100.35	99.93
Ga_2O_3	0.01 –	0.05	0.03	0.01 –	0.04	0.03	0.00 –	0.03	0.02
Cr_2O_3	0.00 –	0.05	0.03	0.00 –	0.07	0.02	0.00 –	0.06	0.02
FeO	0.26 –	0.30	0.29	0.45 –	0.59	0.50	0.30 –	0.31	0.31
MnO	0.01 –	0.02	0.02	0.00 –	0.03	0.01			0.00
MgO	0.00 –	0.01	0.01		<0.01	0.00			0.00
Total			100.57			100.51			100.37

formed in a sedimentary environment that underwent granulite-facies metamorphism. The new find will significantly increase the commercial importance of sapphires from Madagascar.

Acknowledgements

References

Andriamarofahatra, J., de la Boisse, H., and Nicollet, C., 1990. Datation U-Pb sur monazites et zircons du dernier épisode tectonométamorphique granulitique majeur dans le Sud-Est de Madagascar. *CR Acad. Sci. Paris*, 310, 1643–8

Anon., 1995. *ICA Gazette*, April.

Caen-Vachette, M., 1979. Le Précambrien de Madagascar. Radiochronométrie par isochrones Rb/Sr sur roches totales. *Rev. Geol. Dynam. Geog. Phys.*, 21, 331–8

Chikayama, A., 1989. Gemstones from Madagascar. 22nd International Gemmological Conference, Milan

Falz, E., 1939. *Von Menschen und edlen Steinen*. Idar-Oberstein

Kennedy, W.Q., 1964. The structural differentiation of Africa in the Pan-African (±500 Ma) tectonic episode. *Ann. Rep. Res. Inst. African Geol.*, Univ. Leeds, 8, 48–9

Koivula, J.I., Kammerling, R.C., and Fritsch, E., 1992. Gem news. *Gems & Gemology*, 28(4), 198–209

Kröner, A., 1980. Pan African crustal evolution. *Episodes*, 2, 3–8

Kröner, A., 1991. African linkage of Precambrian Sri Lanka. *Geol. Rundsch.*, 80, 429–40

Lacroix, A., 1922. *Minéralogie de Madagascar*. Challamel, éd., Paris, 3 tomes

Milisenda, C.C., 1991. *Development of the continental crust: a study of the high-grade terrain of Sri Lanka*. Unpubl. PhD thesis, University of Mainz, Germany

Milisenda, C.C., Liew, T.C., Hofmann, A.W., and Kröner, A., 1988. Isotopic mapping of age provinces in Precambrian high-grade terrains: Sri Lanka. *J. Geology*, 96, 608–15

Milisenda, C.C., Liew, T.C., Hofmann, A.W., and Köhler, H., 1994. Nd isotopic mapping of the Sri Lanka basement: update, and additional constraints from Sr isotopes. *Precambrian Research*, 66, 95–110

Nicollet, C., 1990. Crustal evolution of the granulites of Madagascar, in Vielzeuf, D., and Vidal, Ph. (Eds.) *Granulites and crustal evolution*. Kluwer Academic Publishers, Dordrecht, 291–310

Paquette, J-L., Nédelec, A., Monie, B., and Rakotondrazafy, M., 1993. U-Pb single zircon Pb-evaporation and Sm-Nd dating of the SE Madagascar domain: a prevailing Pan-African event. *Terra Abstr.*, 5, 393

Poirot, J-P., 1992. Spectrometry and x-ray fluorescence of sapphires. *Z. Dt. Gemmol. Ges.*, 41, 172–3

Schmetzer, K., and Bank, H., 1980. Explanations of the absorption spectra of natural and synthetic Fe- and Ti-containing corundums. *N. Jb. Min. Abh.*, 139, 216–25

Schmetzer, K., and Bank, H., 1981. Die Farbursachen und Farben der Mineralart Korund. *Z. Dt. Gemmol. Ges.*, 31, 265–80

Windley, B.F., Razafiniparany, A., Razakamanana, T., and Ackermand, D., 1994. Tectonic framework of the Precambrian of Madagascar and its Gondwana connections: a review and reappraisal. *Geol. Rundsch.*, 83, 642–59

Sapphires from Andranondambo area, Madagascar

*Dr Lore Kiefert[1], Dr Karl Schmetzer[2], Michael S. Krzemnicki[3], Dr Heinz-Jürgen Bernhardt[4]
and Dr Henry A. Hänni[1]*

1. SSEF Swiss Gemmological Institute, Falknerstrasse 9, CH–4001 Basel, Switzerland
2. Marbacher Strasse 22b, D–85238 Petershausen, Germany
3. Mineral.-Petrogr. Institut, Universität Basel, CH–4056 Basel, Switzerland
4. Institut für Mineralogie, Ruhr-Universität, D–44780 Bochum, Germany

Abstract

Sapphires from a new deposit of commercial interest in the Andranondambo area, southern Madagascar, are described. The sapphires occur primarily in pegmatitic veins consisting mainly of calcite and plagioclase which intrude pyroxenites. The crystal habit as well as internal growth structures allow a subdivision of the sapphires into three types: type I shows a dipyramidal to barrel-shaped habit, type II is prismatic, and type III reveals a distorted tabular to short-prismatic-dipyramidal habit. The sapphires show distinct, sometimes extremely complex colour zoning between almost colourless, light blue, and dark blue to extremely blue areas. Some crystals contain brownish or whitish areas. The differently coloured zones may consist of core and rim, or narrow banding throughout the stones, or a combination of both.

Apatite inclusions are common and may be accompanied by rosette-like fissures in type I or by tubes perpendicular to the growth direction in type II sapphires. Calcite and spinel inclusions were also observed. Type III sapphires commonly show three-phase inclusions parallel to the basal pinacoid, consisting of liquid and gaseous CO_2 and diaspore. Chemical analyses show that darker blue zones are richer in Fe_2O_3 than the lighter blue or almost colourless zones. They also show a somewhat increased TiO_2 content. Compared to the light blue areas, the brownish zones show significant enrichment in TiO_2 and slight enrichment in Fe_2O_3. Ultraviolet-spectra reveal absorption bands typical for sapphires of metamorphic origin. The absorption edge in heat-treated sapphires is shifted towards lower wavelengths.

Introduction

Corundum from southern Madagascar was described in 1922 by Lacroix, and subsequently by Noizet and Delbos, 1955; Rafaranalisoa, 1968; Nicollet, 1986; and Ackermand *et al.*, 1989. However, only recently in 1994 have several gem companies and the local population begun to exploit sapphires in the region of Andranondambo, southern Madagascar. Now, more and more material from this source is coming onto the market (Figure 1), and there have been several brief reports about this new Madagascar mining area and its sapphires. Piat and Bouqueau (1995) and the *ICA Gazette* (Anon., 1995) described the property situation at the

Fig. 1.   Faceted and rough sapphires from Andranondambo area, SSE Madagascar. Weight of the second stone from left: 1.88 ct.

mining area, Milisenda (1995) gave a short description of the properties of sapphires found in the south-western part of Madagascar, and Kammerling *et al.* (1995) reported more gemmological data for these sapphires without specifying the mining area. The first detailed description of the mining area and gemmological properties of sapphires from southern Madagascar was given by Hänni *et al.* (1995) and a more detailed report is presented here.

Location and mining
The sapphires are mined in the region of Andranondambo (S.24°25′,E.46°35′, district of Amboasary, SSE-Madagascar, see Figure 2). The extraction of sapphires–mainly by rudimentary means–is carried out over a relatively large area of about 200 km². The occurrence of corundum in gem quality, however, is restricted to small areas within this large region. Several mining companies (from Thailand, Switzerland, Madagascar and Israel; compare Piat and Bouqueau,

1995) and a growing number of local residents are working in the district (Figure 3).

One of the authors (MSK) recently had the opportunity to investigate the geology of the mining area during two prospecting campaigns of one month each kindly supported by W. Spaltenstein and C. Ravomanana, Multicolour and Ste. Arc-en-Ciel Gem-Corp. The sapphires from the region of Andranondambo originate from primary deposits in small pegmatite-like veins (normally 0.05–0.2 m thick, 5–50 m long). Sapphires are found directly in these veins, or in alluvial accumulations, closely related to partly eroded pegmatite-like veins. Figure 4 shows a sapphire-bearing rock consisting mainly of calcite and feldspar. The mining, e.g. by the companies Multicolour (Thailand) and Ste. Arc-en-Ciel Gem-Corp. (Sri Lanka), concentrates on these pegmatite-like veins, digging exploitation trenches with simple equipment (Figure 5). The trench-gravel is passed over a jig to separate the sapphires from other rock components (Figure 6).
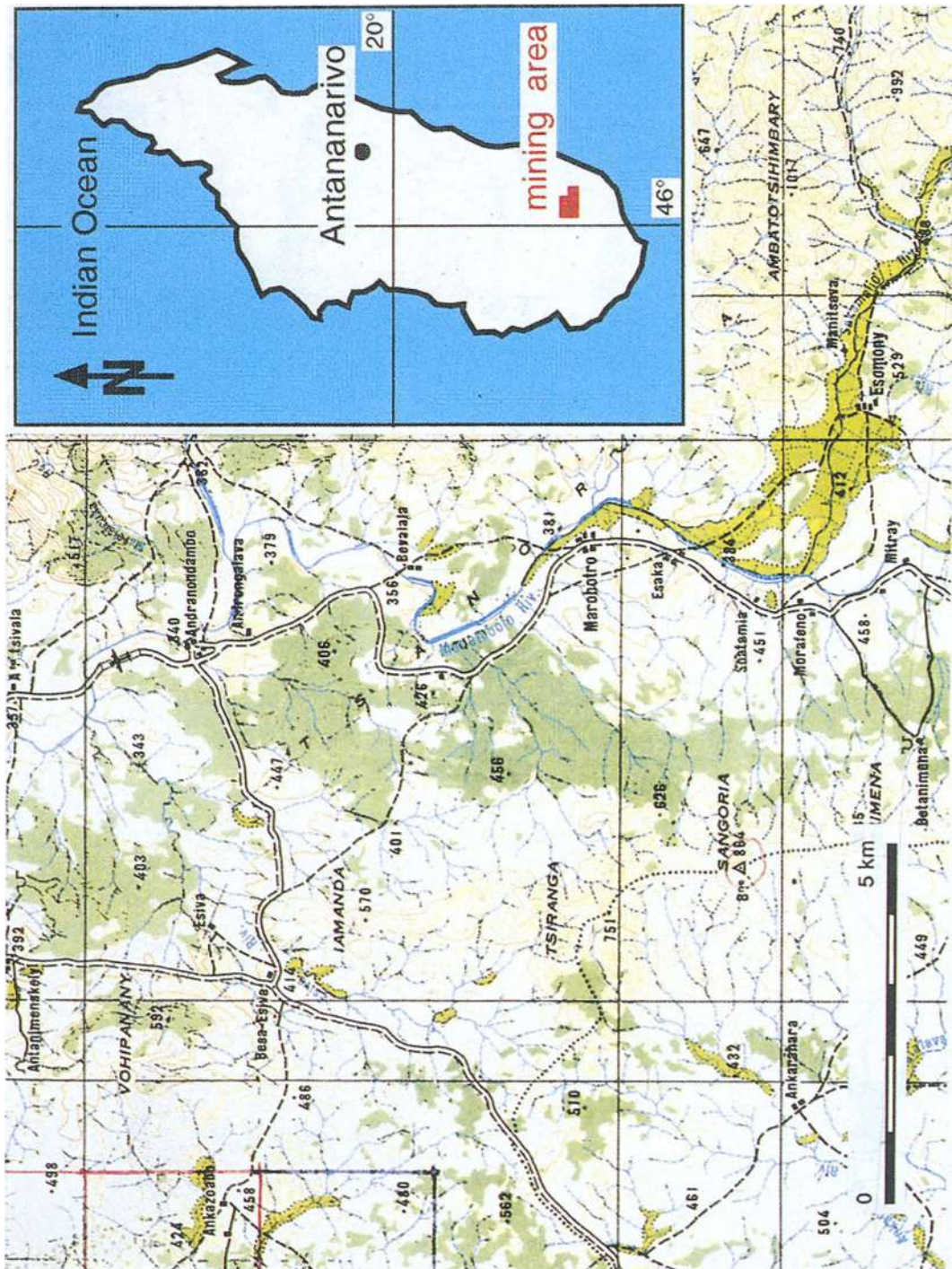
Fig. 2.   Map of the sapphire mining area of Andranondambo in SSE Madagascar.

Fig. 4. Sapphire-bearing calcareous host rock from the mining area of Andranondambo, SSE Madagascar. Length of the photographed area: 4.5 cm.

Due to evaporation in the semi-arid climate of southern Madagascar, massive limestone layers have developed on, or just below the soil-surface, and this complicates the mining operation. In addition, the development of this kind of deposit is often problematic, because the quantity of sapphires may be very unevenly distrib-

Fig. 3. Local residents dig for sapphires in the region of Andranondambo, SSE Madagascar.

Fig. 5. The mining site in southern Madagascar, near Andranondambo, showing a trench worked by the companies Multicolour and Ste. Arc-en-Ciel Gem-Corp.

Fig. 6. The sapphire-containing gravel is treated by a jig in the working area of the companies Multicolour and Ste. Arc-en-Ciel Gem-Corp.

uted throughout small veins. Thus, it is difficult to predict if mining over a longer period of time will be economic.

Regional geology

The geology of Madagascar is closely related to the geological evolution of East Africa (Dixey, 1960; Cahen and Snelling, 1984). Southern Madagascar is characterized by Precambrian basement rocks, which mainly consist of medium- to high-grade metamorphosed gneisses and metasediments (Besairie, 1971; Ackermand et al., 1989). These rocks represent terrains of continental sediments, which were accumulated and primarily metamorphosed in Archean times (~2600 Ma.). They were reactivated by the so-called Pan-African tectonothermal event (600–500 Ma.), a global phase of major metamorphic and tectonic activity. In southern Madagascar, that phase was associated with extensive magmatic activity, i.e.

granitic intrusions, granitization and pegmatite formation (pegmatites of 550–480 Ma.; Besairie, 1971). The sapphire deposits in the mining area are obviously a product of this magmatic activity. The sapphires are found in pegmatite-like veins, which cut the Precambrian basement. Corundum from such primary deposits is geologically rather unusual, although some of the most famous gem corundum mines belong to this type of deposit; for example the sapphires from Kashmir (Atkinson and Kothavala, 1983; Hänni, 1990), and the rubies and sapphires from the Umba Valley in Tanzania (Solesbury, 1967; Hänni, 1986).

As a result of the field work of one of the authors (MSK), several types of veins with varying visual appearance, mineralogy and chemistry were distinguished in the mining area of southern Madagascar. Sapphires, however, only occur in one specific type of miarolitic pegmatite-like
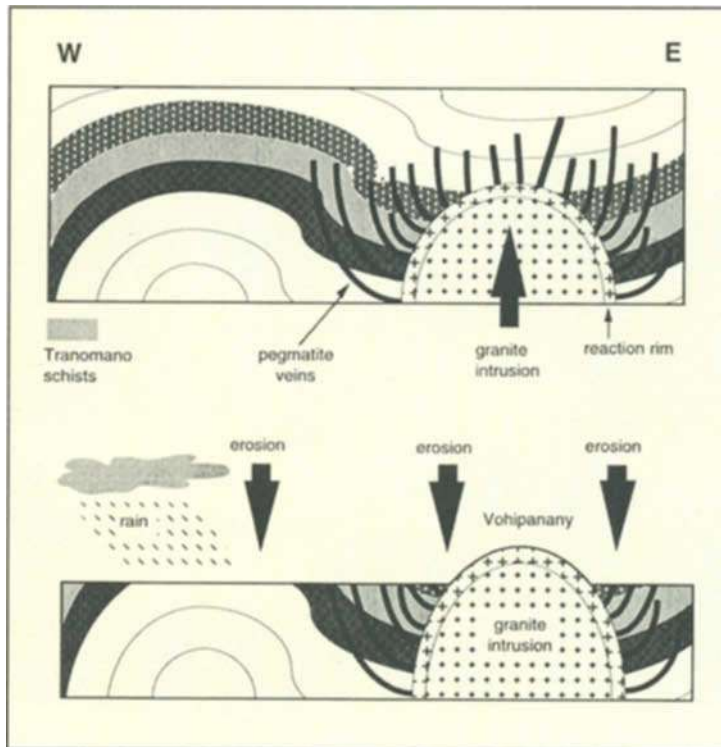
Fig. 7. Diagrammatic geological section at the mining area of Andranondambo, SSE Madagascar. Top: Pegmatites and granites intruded during the Pan-African tectonometamorphic event; bottom: situation today after 500 million years (Ma) of erosion.

(see Figure 7). The more acidic Precambrian gneisses and metasediments in the mining area contain comparable pegmatites which are, however, free of sapphires. The close connection of corundum-bearing pegmatitic rocks to basic-ultrabasic host rocks seem to be a common feature with geochemical relevance for the genesis of such a deposit (Larsen, 1928; Solesbury, 1967; Atkinson and Kothavala, 1983).

According to earlier work, the sapphire-bearing pegmatite consists mainly of calcium-rich plagioclases (bytownite-anorthite, Noizet and Delbos, 1955), and quartz only occurs in minor abundance. Hibonite $(CaAl_{12}O_{19})$, formerly only known in mete-

host rock. This type of pegmatitic rock forms a net-like pattern of rather small veins which cut the Precambrian basic rocks here consisting mainly of pyroxenites with associated marble lenses. Sapphires were not found in these pyroxenites and marble lenses until now. On the basis of the form and abundance of the sapphire-bearing pegmatite-like rocks, we suggest that they are late-stage products of the Pan-African event, possibly originating from a highly differentiated granitic magma, with a high water content. Most petrologists agree that the aqueous-fluid phase plays an important role in the generation of pegmatites (London, 1986a). The pegmatitic rocks intruded the Precambrian basement in close proximity to larger granitic intrusions, e.g. the granite of Vohipanany, 1.5 km from the mining site

orites, has also been found in these pegmatites (Rafaranalisoa, 1968). Near the surface (at several metres depth), this plagioclase is strongly altered to a white powder consisting of fine-grained clay minerals (i.e. kaolinite, saponite and montmorillonite).

At the rim of the pegmatite-like veins in the mining area, we observed a distinct mineralogical zonation, consisting of mica (mainly phlogopite and biotite), epidote, amphibole and Fe-hydroxide (Figures 8 and 9). This zonation indicates extensive metasomatic processes between the intruding hydrous aluminium-rich pegmatite-like vein and the basic host rock of the vein. The precipitation of Al-rich minerals (i.e. corundum) in pockets in the central part of the pegmatite-like veins requires either a large water/rock ratio or extensive

Fig. 8. Sapphire-bearing pegmatite-like vein with mineral zoning at its rim at the mining site near Andranondambo in SSE Madagascar. The vein cuts across the pyroxenitic rock. The heavy weathering of the whole sequence near the surface is evident.

fluid recirculation during pocket formation in the pegmatite (London, 1986b). The formation of calcite within the pegmatite and as inclusions in the sapphires probably derives from the metasomatic fluid (calcium- and CO_2-enriched) originating from the basic host rock. With this mineral composition the genetic connection of the pegmatitic rock with the local granitic rocks mentioned above is admittedly tenuous. Generally, however, the observations are consistent with descriptions of similar corundum deposits in pegmatites from other parts of the world (e.g. Larsen, 1928; Heinrich, 1949; Solesbury, 1967; Atkinson and Kothavala, 1983).

Samples and analytical methods

The authors examined more than 300 sapphires from different suppliers. Of these, 34 were rough crystals, some of which were made available before and after heat treatment and/or faceting. The rough crystals weighed up to 10 ct and some examined in this study are shown in Figure 10. The colours range from dark blue to light blue with occasional uneven colour distributions.

Morphological and crystallographical properties of the samples were determined using a standard goniometer and microscopically by the method described by Schmetzer (1986) and Kiefert and Schmetzer (1991a). Inclusions in rough and faceted sapphires and constituents of the host rock were identified by scanning electron microscopy (SEM) with a JEOL 6300F Electron Microprobe and by Raman spectroscopy (RS) with a Renishaw Raman Microscope. X-ray diffractometry (XRD) was carried out on minerals adhering to the rough crystals. Qualitative chemical data
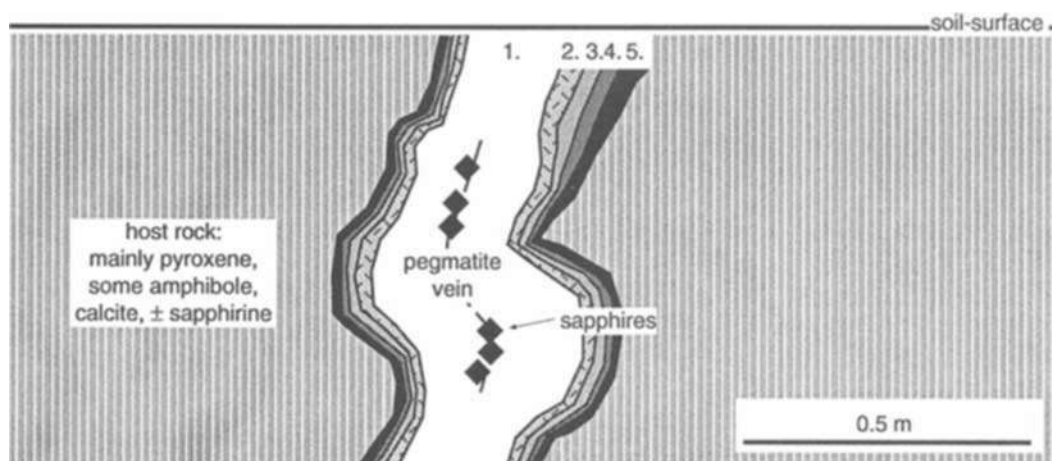

Fig. 9. Schematic diagram of a sapphire-bearing pegmatitic vein in pyroxenitic host rock from southern Madagascar. The mineral zones from vein centre to rim are (1) clay minerals (± feldspar) with some corundum in the central part of the pegmatite vein; (2) mica with clay minerals and some feldspar; (3) Fe-hydroxides, epidote and some clay minerals; (4) epidote, minor mica and clay minerals (± feldspar); (5) amphibole.

Fig. 10.   Rough sapphires from Madagascar. Weight of the largest crystal: approximately 10 ct.

were obtained with a Phillips PV9500 X-ray fluorescence spectrometer with Tracor Northern Spectrace software (XRF). The chemical compositions of 13 stones with colour zoning were determined quantitatively by electron microprobe (CAMECA Camebax SX 50) by measuring between one and three traverses of 50 to 100 point analyses each across microscopically selected areas of the samples (EMP). Spectroscopical data were recorded with a Hitachi U4001 spectrophotometer and a Leitz-Unicam SP 800 spectrophotometer between 800 and 290 nm, the characteristic range of wavelengths where absorptions from chromophore elements in sapphires are observed. Infrared spectroscopy was carried out with a Phillips PU9800 spectrometer.

Visual appearance and crystallography
The crystallographic properties of the sapphires were determined by examining the morphology of the rough crystals and combining this with microscopic examination of internal growth structures of rough and faceted samples using methylene iodide as an immersion liquid. According to their morphology, the samples can be divided into three different types, namely (I) dipyramidal to barrel-shaped, (II) prismatic and (III) distorted tabular to short-

prismatic-dipyramidal (see Figure 11). Indices of the crystal faces are given on the basis of the unit cell with a:c = 1:1.365.

Type I (dipyramidal to barrel-shaped habit): dipyramidal to barrel-shaped crystals are mostly blue, some are also whitish or greyish with a milky sheen (so-called geuda-type stones, which give nice blue colours after heat treatment). Violet stones are occasionally present, too. The crystal faces observed in this type of sapphire are the basal pinacoid c (0001), the positive rhombohedron r (10$\bar{1}$1), and the hexagonal dipyramids n (22$\bar{4}$3), w (11$\bar{2}$1), v (44$\bar{8}$3), and z (22$\bar{4}$1). These crystal faces occur in various combinations (Figure 11 a-c). Colour zoning following any of these crystal faces is common.

Type II (prismatic habit): the crystal faces observed in this type of sapphire are the basal pinacoid c (0001), the positive rhombohedron r (10$\bar{1}$1) and the hexagonal prism a (11$\bar{2}$0) (Figure 11 d). Part of these crystals reveal only c (0001) and a (11$\bar{2}$0) faces. Sapphires of the second type are often macroscopically colour zoned with a dark blue centre and a lighter blue rim. The rough stones investigated all showed a distinct whitish striation in the area confined to the rim of the basal plane with an orientation perpendicular to the hexagonal prism faces a (Figure 12).
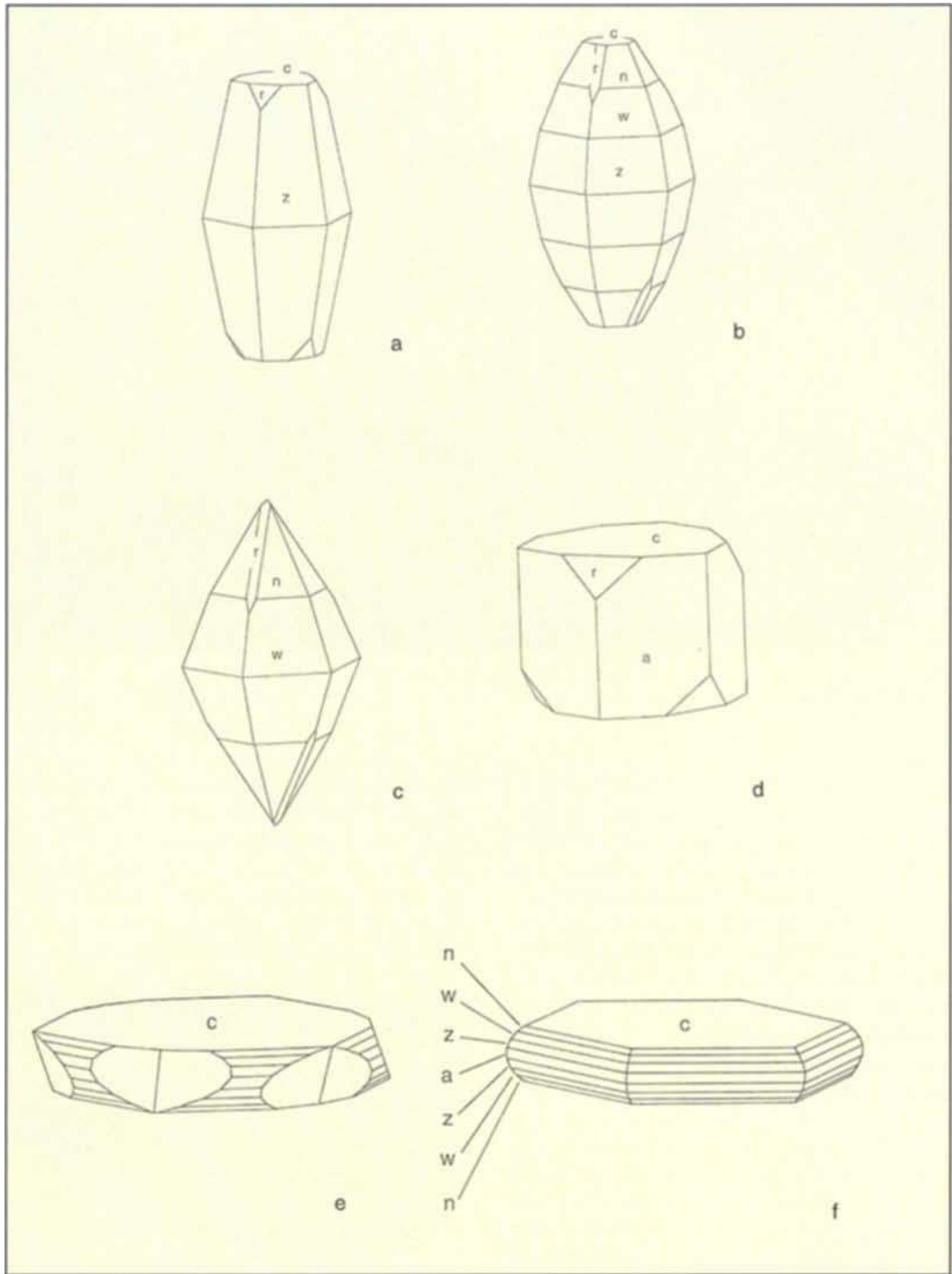
Fig. 11.   Crystal forms observed in Madagascar sapphires: a-c dipyramidal to barrel-shaped habit; d prismatic habit; e distorted tabular to short-diprismatic-pyramidal habit showing a scalenohedron face; f distorted tabular to short-prismatic-dipyramidal habit.

Fig. 12. Type II sapphire from Madagascar showing the dark blue core and lighter blue rim with white striations on the basal faces with an orientation perpendicular to the prismatic growth planes. View parallel to the c-axis. Magnification 4x.

Type III (distorted tabular to short-prismatic-dipyramidial habit): this type of sapphire shows the basal pinacoid c (0001) and the hexagonal prism a (11$\bar{2}$0) in combination with several hexagonal dipyramids such as n (22$\bar{4}$3), w (11$\bar{2}$1), v (44$\bar{8}$3), and z (22$\bar{4}$1) (Figure 11 f). The growth of the hexagonal crystal faces may be completely subdued in one or two directions, while the basal pinacoid is very prominent. In these cases distorted rhomboidal-shaped sapphires with four prism faces, or crystals with five instead of six prism or dipyramidal faces are formed (see Figure 1). Some samples of this type also exhibit a ditrigonal scalenohedron, most probably (10 2 $\bar{1}$2 3) as an additional crystal face (Figure 11 e). This type of crystal face is extremely rare in corundum (cf. Goldschmidt, 1918) and may therefore be considered a characteristic feature of type

III sapphires from Madagascar. The crystals with distorted tabular to short-prismatic-dipyramidal habit are blue with a distinct colour zoning parallel to the basal pinacoid. The colour zoning may consist of only one thin, extremely dark blue stripe through the middle of the stone or

Fig. 13. Type III rough crystals showing different colour zoning. Magnification 2x.
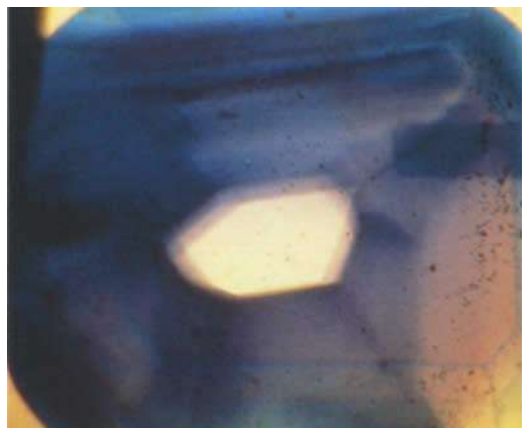
Fig. 14.   Type I sapphire from Madagascar showing a colourless core and a blue rim. View nearly parallel to the c-axis. Immersion, magnification 30x.

a broad dark blue band with lighter blue rims (Figure 13). The bands and stripes are generally orientated parallel to the basal pinacoid.

Gemmological properties

Densities and refractive indices of all types of Madagascar sapphires do not differ from those of sapphires from other deposits. Measured densities vary between 3.99 and 4.01 g/cm^3. Refractive indices range from 1.761 to 1.763 for ε and 1.769 to 1.771 for ω, with a birefringence of 0.008. The blue sapphires are inert to short wave and long wave UV light, while the few purplish stones examined exhibit a distinct red fluorescence. Pleochroic colours of the blue sapphires are light greenish-blue parallel to the optic axis (ε-vibration) and dark violet-blue perpendicular to the optic axis (ω-vibration).

Microscopic features

Microscopic features can be studied in various kinds of lighting, in air or immersion. Therefore, the observed peculiarities may appear or be described differently, according to the illumination conditions. It is perhaps timely to point out that mineral dust appears different in dark-field and in transmitted light. What may be described

as a zone of whitish dust in dark field illumination would probably appear to be brown in transmitted light in immersion (see Figures 21a and b). The Tyndall effect and scattering of light may explain the different appearance in relation to the observation technique.

Since the growth characteristics of the Madagascar sapphires were investigated in immersion (compare Schmetzer, 1986; Kiefert and Schmetzer, 1991a), in the following paragraphs growth sectors with mineral dust (rutile?) that appear whitish through a Gemolite binocular microscope with dark-field illumination, appear brown or brownish in immersion and are described accordingly.

Type I sapphires (dipyramidal to barrel-shaped habit)
Growth structures and colour zoning: The dipyramidal to barrel-shaped stones often vary in colour from core to rim. Three different types of colour variation were observed. Sapphires with: (a) a colourless core and a blue rim (Figure 14), (b) a dark blue, zoned core and a light blue rim (Figure 15) and (c) a brown (whitish) core with a blue rim (Figure 16). The cores are defined by various crystallographic planes

Fig. 15.   Type I sapphire from Madagascar showing a dark blue inner core and nearly colourless rim. The zonation of the blue area is parallel to the basal plane. View perpendicular to the c-axis, the c-axis runs horizontally. Immersion, magnification 40x.
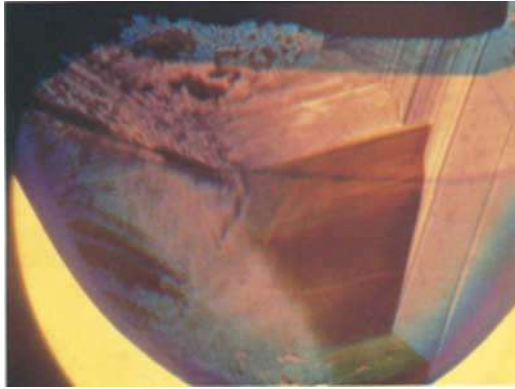
Fig. 16. Type I sapphire from Madagascar showing a brown core and light blue rim. View perpendicular to the *c*-axis, the *c*-axis runs almost vertically, the dark brown core is confined by one *c* and one *r* face. Immersion, magnification 50x.

which are parallel to the macroscopically observed crystal faces. The brown cores show mostly a homogeneous, unzoned colour, but in some cases minute particles were observed.

The zones around the cores and the complete samples (of stones without a distinct colour zoning between cores and rims) show strong light and dark blue, sometimes extremely complex colour zoning parallel to all macroscopically observed crystal faces *c, r, n, w, v,* and *z*

Fig. 19. Type I sapphire from Madagascar showing colour zoning related to two dipyramidal faces *n* and *n'* and the negative rhombohedron *r*. View inclined approximately 30° to the *c*-axis. Immersion, magnification 50x.

(Figures 17–19). In some crystals, oscillatory growth of different faces has formed mosaic-like patterns, occasionally throughout the crystals (Figure 20). These structures consist of various growth planes such as *c, r, n, w, v,* and *z*, sometimes in combination with crystal planes which are not observed macroscopically in this type of sapphire, e.g. the hexagonal prism *a*.

Brownish areas were not only observed in the core (Figure 16), but also as brown stripes in the outer rim of some sapphires. These brown stripes are usually very thin layers, and sometimes show a concentration of fine brownish particles. The brown colour is visible when the stone is viewed in transmitted light in immersion. Without

Fig. 17. Type I sapphire from Madagascar showing zones of lighter blue and darker blue. View almost perpendicular to the *c*-axis, the light blue zone is related to *c*-growth zones, the darker blue areas (left and right) are related to two *n* growth zones. Immersion, magnification 32x.
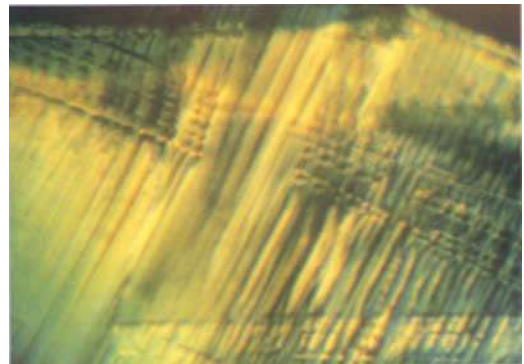

Fig. 20. Mosaic-like growth pattern in type I sapphires from Madagascar. Immersion, magnification 50x.
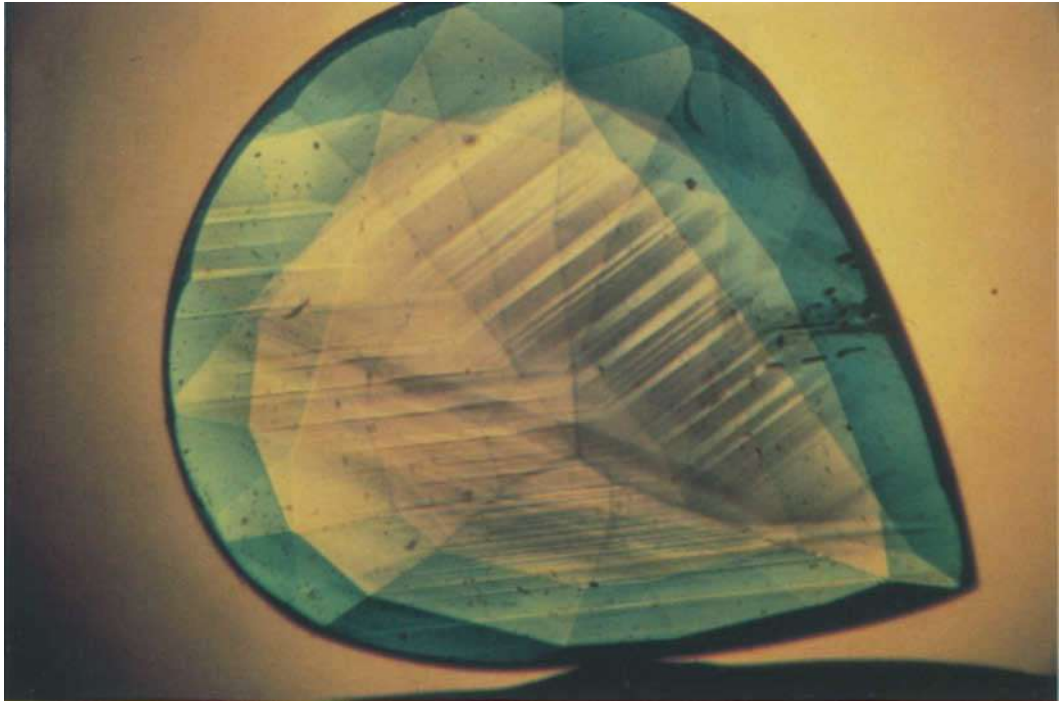
Fig. 18.   Type I sapphire from Madagascar showing colour zoning related to the forms *r* and *n*. View inclined approximately 30° to the *c*-axis. Immersion, magnification 30x.

immersion, the brown areas appear white due to scattering of light by the small particles. In general, the thin brown stripes are orientated parallel to one single crystal face (Figures 21a and b, 22), but sapphires with brown stripes parallel to two or three crystal faces were also observed (Figure 23).

These thin brown stripes were apparently formed by oscillating growth of one of the dominant faces such as *c, r, n, w, v,* and *z* with subordinate faces, which are not present macroscopically in this type of sapphire. Occasionally, this subordinate face was identified as the prism *a* ($11\bar{2}0$), and in
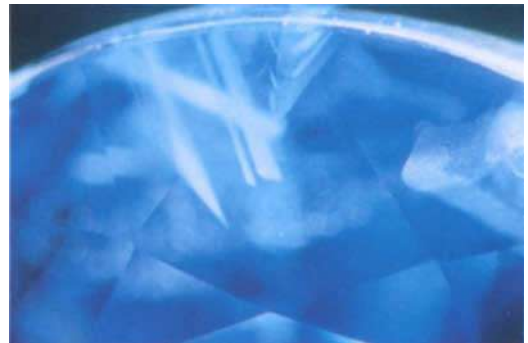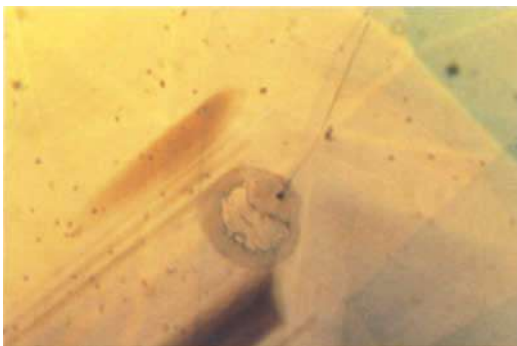
Fig. 21.   (a) Parallel brown stripes in type I sapphire from Madagascar. At the centre of the photo is a tiny apatite crystal surrounded by a two-phase liquid/gas rosette, with the gaseous component in the centre of the rosette. Immersion, magnification 60x. (b) Similar stripes appearing white in reflected dark-field illumination. Magnification 30x.
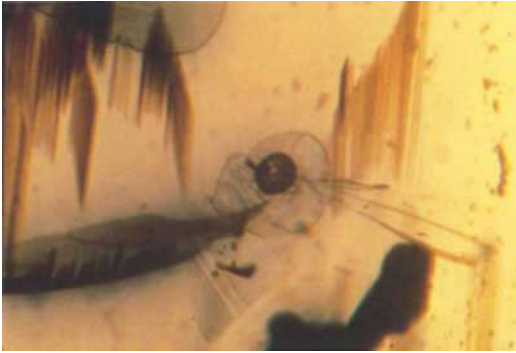
Fig. 22. Parallel brown stripes in type I sapphire from Madagascar. The centre of the photo shows a rounded calcite crystal with rosette-like fissure. Immersion, magnification 50x.
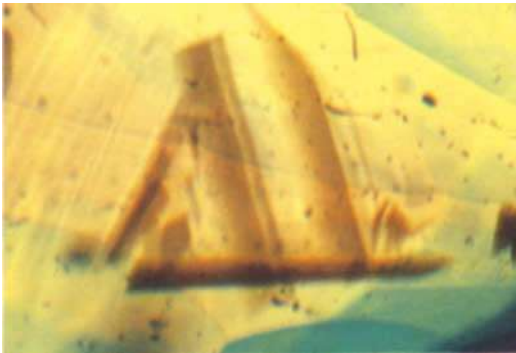

Fig. 23. Brown stripes parallel to three different growth planes in type I sapphire from Madagascar. Immersion, magnification 50x.

one crystal brown stripes were confined by the dominant dipyramid n (22$\bar{4}$3) and located in a growth area of a subordinate dipyramid o (22$\bar{4}$5). In all cases, the brown stripes were related to the growth area of the subordinate face e.g. parallel to a and o.

Twinning was not commonly observed in any of the examined sapphires.

Inclusions: Untreated as well as heat-treated type I sapphires from Madagascar frequently show rounded apatite crystals with rosette-like liquid/gas feathers (Figure 21a), which were determined with Raman Spectroscopy (RS) in the majority of the analysed samples. Further, calcite crystals with rosettes were also identified in some sapphires (Figure 22). Four calcite

crystals which could be found on the surface of broken crystals were also identified by XRD. Typical solid inclusions in type I sapphires are therefore apatite, calcite, and small brown particles in cores and stripes. On the surface of a rough crystal which showed the basal pinacoid c and the negative rhombohedron r as dominant crystal faces, dark green spinel inclusions were identified by Raman Spectroscopy (Figure 24). Spinel was also identified in the host rock by SEM.

Healed feathers are commonly present in heat-treated and untreated stones (Figure 25). Some of the heat-treated sapphires obtained from the trade also show fissures with an unidentified foreign substance, which spreads into the fissures with a dendritic pattern (Figure 26).
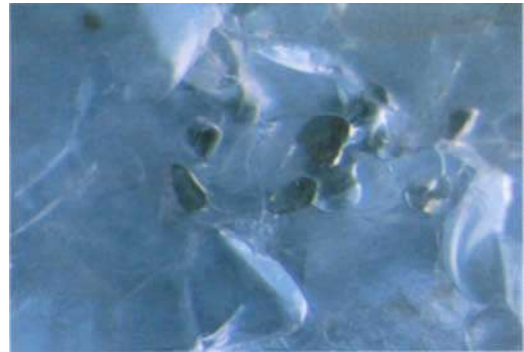

Fig. 24. Spinel inclusions on a broken surface of a type I sapphire from Madagascar. Magnification 30x.

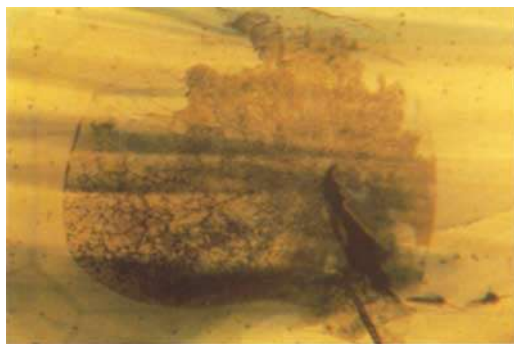Fig. 25. Healed feather in sapphire from Madagascar. Immersion, magnification 50x.

Fig. 26.   Dendritic substance in healed feather in a heat-treated sapphire from Madagascar. Immersion, magnification 40x.

Similar looking patterns in emerald have been identified previously in the SSEF laboratory as organic fillers.

Type II sapphires (prismatic habit)
Growth structures and colour zoning: The crystals with prismatic habit possess an intense colour zoning with a dark blue core and a lighter blue outer zone (see Figure 12). There is a distinct boundary between the dark blue core and the light blue rim, which is generally orientated parallel to the hexagonal prism a $(11\bar{2}0)$, or occasionally in combination with the positive rhombohedron r. The core often shows narrow colour banding parallel to the basal pinacoid c. In some of the cores of this type of sapphire uniform dark blue trigonal pyramidal areas are observed which are terminated by the basal plane c and the rhombohedral faces. Within the rim colour zoning was observed parallel to the basal plane and to the prism faces. More complex zoning is also present and visible in oblique dark-field illumination.

Inclusions: Sapphires of the prismatic type frequently contain well rounded apatite crystals (RS) as solid inclusions accompanied by tubes (Figure 27). From their distribution (Figure 28) it is obvious that the apatite crystals were included first, and then subsequently, when the host sapphire continued growing, the tubes were formed in a direction perpendicular to the growth front (i.e. the prism face). Healed

feathers were also observed in this type of sapphire. The contents of the tubes and the whitish substance forming striations on the basal planes of the rough crystals await identification.

Type III sapphires (distorted tabular to short-prismatic-dipyramidal habit)
Growth structures and colour zoning: This type of sapphire reveals a distinct growth and colour zoning parallel to the external growth planes. Blue and colourless zones alternate in narrow bands mostly parallel to the basal plane. Three different growth patterns were observed: (a) the whole stone shows thin alternating colour zones (Figure 29); (b) the centre of the crystal is

Fig. 27.   Rounded apatite crystals with subsequent tubes in type II sapphires from Madagascar. Magnification 40x.
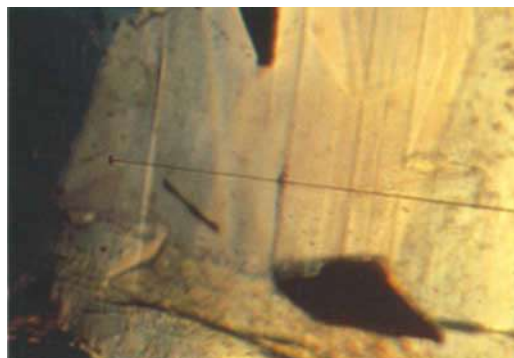

Fig. 28.   Small rounded apatite crystal with a tube extending perpendicular to prismatic growth planes in type II sapphire from Madagascar. Immersion, magnification 50x.
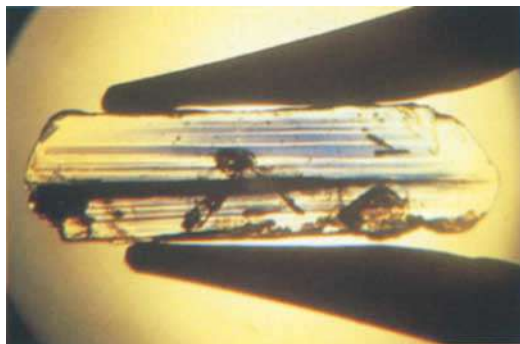
Fig. 29. Colour zoning parallel to the basal plane in type III sapphire from Madagascar showing a dark blue stripe in the centre. View perpendicular to the c-axis, the c-axis runs vertically. Immersion, magnification 20x.
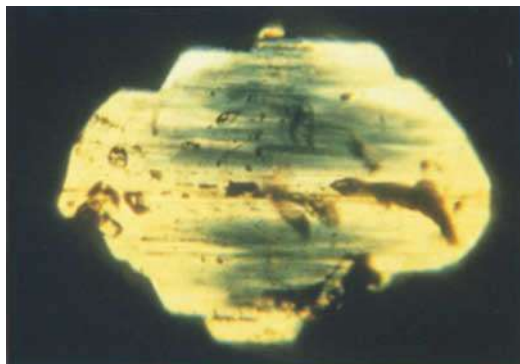

Fig. 30. Colour zoning with a colourless centre in type III sapphire from Madagascar. View perpendicular to the c-axis, the c-axis runs vertically. Immersion, crossed polarizers, magnification 25x.

zoning parallel to the basal pinacoid c, colour zoning with alternating light blue to colourless areas was also observed parallel to other crystal faces, e.g. parallel to the prism a and/or parallel to dipyramidal faces.

Inclusions: These sapphire crystals often contain three-phase inclusions, which are oriented parallel to the basal faces. Due to improved analytical techniques, three-phase inclusions such as shown in Figure 31 can now be analysed on a non-destructive basis by Raman spectroscopy. The Raman spectra revealed that these inclusions consist of liquid and gaseous CO_2 and diaspore needles (Figure 31). Figure 32 shows a combined Raman spectrum of all phases contained in the inclusion. Similar inclusions have already been described in sapphires from Sri Lanka (Schmetzer and Medenbach, 1988). Flat calcite crystals with corroded edges (Figure 33), identified by Raman spectroscopy, are also oriented parallel to the basal plane of the sapphires. Other birefringent mineral inclusions (Figure 34) were identified as apatite and zircon by XRD and Raman spectroscopy.

Chemical composition

Qualitative chemical analyses by EDS-XRF of a range of samples from all three types

more or less colourless and narrow alternating colour zones occur only at the basal pinacoid rim (Figure 30); and (c) the centre of the crystal shows alternating light blue to colourless banding while the outer zones are colourless.

In half of the stones, one additional extremely dark coloured layer parallel to the basal plane, which runs through the centre of the crystal, was observed (Figure 29). This thin colour zone gives the sapphires a medium blue colour when viewed parallel to the optic axis, even when the main body of the crystal is almost colourless. In addition to these different types of
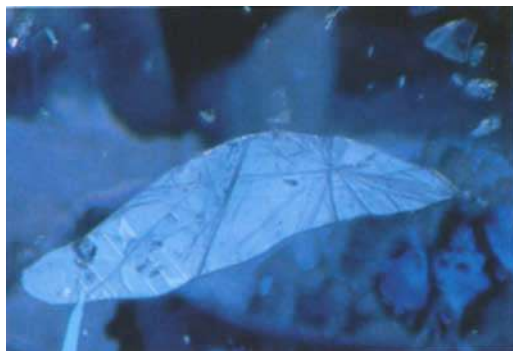

Fig. 31. Three-phase inclusions in type III sapphire from Madagascar oriented parallel to the basal plane and showing liquid and gaseous CO_2 and diaspore needles. View parallel to the c-axis. Magnification 50x.
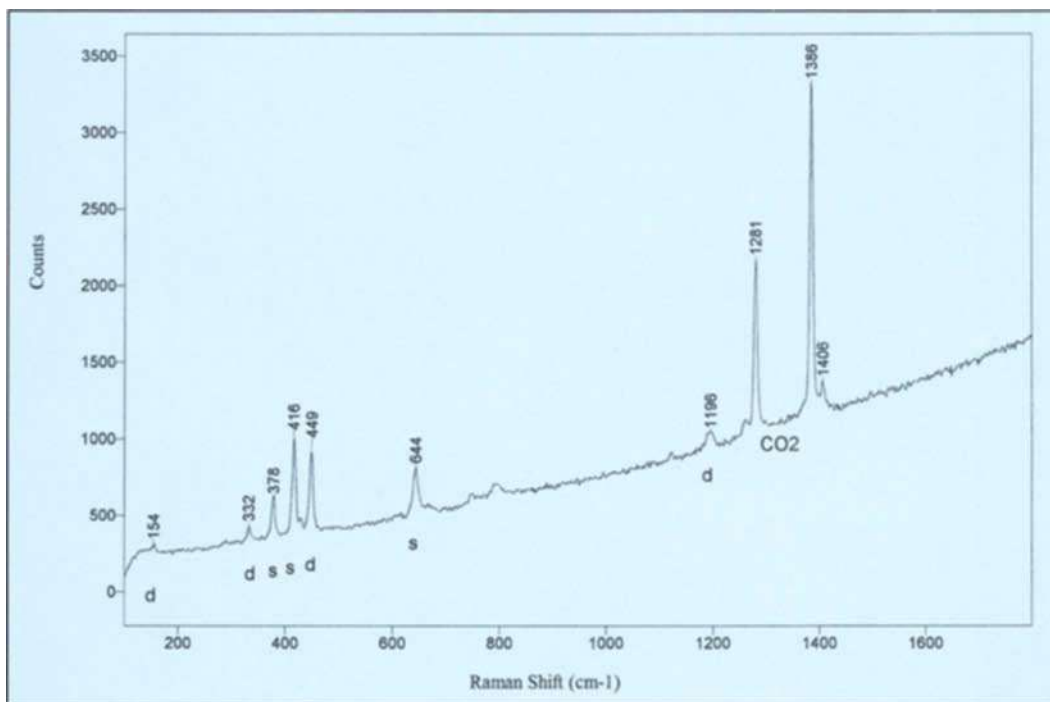
Fig. 32.   Raman spectra of the phases in a three-phase inclusion in type III sapphire from Madagascar. The peaks are assigned to corundum (s), diaspore (d) and liquid and gaseous CO_2, and were obtained from a Renishaw Raman system.

of Madagascar sapphires show different bulk contents of the trace elements Fe and Ti. Differences in Fe- and Ti-concentrations were observed in detail between darker and lighter blue zones of macroscopically colour zoned samples, e.g. between a dark blue core and light blue rim of a type II

sapphire (Figure 35). Distinct differences in different coloured areas have also been described from rubies from Mong Hsu, Myanmar (Peretti et al., 1995). In order to quantify the chemical variations, 13 stones (8 of type I, 1 of type II and 4 of type III) were microscopically selected to cover the
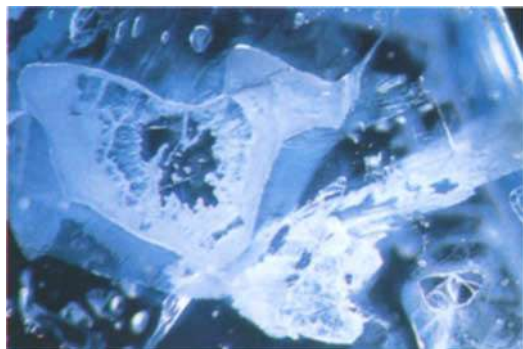

Fig. 33.   Flat inclusion with calcite crystals parallel to the basal plane in a type III sapphire from Madagascar. View parallel to the c-axis. Magnification 40x.
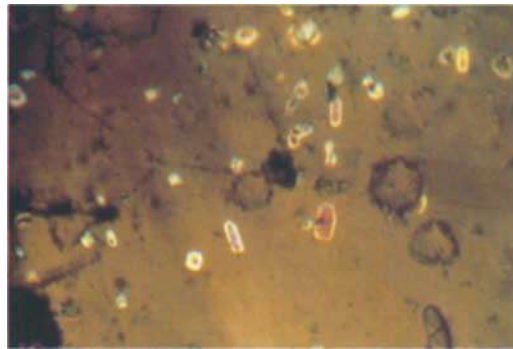

Fig. 34.   Birefringent apatite inclusions in type III sapphire from Madagascar. Immersion, crossed polarizers, magnification 50x.

Table I: Chemical composition of sapphires from Madagascar

Sample number	Sample description	Number of analysis points	Al_2O_3	V_2O_3	Weight % oxides Cr_2O_3	MnO	Fe_2O_3	TiO_2
S1 (type I)	fine complex colour zoning, faceted, table ‖ basal plane, heat-treated	50	98.5–99.4	0.01–0.03	0.00–0.02	0.00–0.02	0.18–0.24	0.07–0.20
S4 (type I)	fine complex colour zoning, faceted, table ‖ basal plane, heat-treated	50	98.3–99.5	0.00–0.03	0.00–0.02	0.00–0.02	0.15–0.29	0.05–0.10
S9 (type I)	fine complex colour zoning, faceted, table ‖ basal plane, heat-treated	50 + 50	98.9–99.5	0.00–0.03	0.00–0.03	0.00–0.02	0.11–0.23	0.05–0.25
S20 (type I)	fine complex colour zoning, faceted, table ⊥ basal plane, heat-treated	50 + 50	98.5–99.3	0.01–0.03	0.00–0.02	0.00–0.02	0.43–0.62	0.03–0.16
H1.88 (type I)	faceted with dark blue core, lighter blue rim, table ‖ basal plane, heat-treated	29 (dark blue) 71 (lighter blue)	98.4–99.6	0.00–0.03	0.00–0.03	0.00–0.02	0.22–0.29 0.11–0.15	0.10–0.14 0.02–0.06
S27 (type I)	faceted with dark blue core, lighter blue rum, table ‖ basal plane, heat-treated	40 (dark blue) 10 (lighter blue)	98.7–99.4	0.00–0.03	0.00–0.02	0.00–0.02	0.31–0.40 0.24–0.26	0.05–0.10 0.04–0.06
S5 (type I)	faceted with brown core and blue rim, table ‖ basal plane, heat-treated	5 (brown) 45 (blue)	98.2–99.7	0.00–0.03	0.00–0.03	0.00–0.01	0.25–0.28 0.22–0.29	0.10–0.13 0.04–0.09

Table I: Chemical composition of sapphires from Madagascar (*Continued*)

Sample number	Sample description	Number of analysis points	Al_2O_3	V_2O_3	Weight % oxides Cr_2O_3	MnO	Fe_2O_3	TiO_2
S7 (type I)	faceted with brown core and blue rim with brown stripes, table ‖ basal plane, heat-treated	15 + 3 (br. core) 1+1+1 (br. stripe) 36 + 46 + 49 (blue)	98.4–99.7	0.01–0.03	0.00–0.02	0.00–0.02	0.28–0.34 0.26–0.29 0.24–0.33	0.09–0.15 0.22–0.27 0.04–0.09
H1 (type II)	rough piece, dark blue core and light blue rim, polished ‖ basal plane	12+20 (dark blue) 36+80 (light blue)	98.4–99.8	0.01–0.03	0.00–0.01	0.00–0.01	0.20–0.23 0.13–0.18	0.06–0.08 0.01–0.06
H3 (type III)	rough crystal, light blue core and colourless rim, polished ‖ basal plane	100+90	98.1–100.2	0.01–0.03	0.00–0.03	0.00–0.02	0.30–0.54*	0.00–0.04
H5 (type III)	rough piece, almost colourless	100+100	98.5–99.8	0.00–0.03	0.00–0.03	0.00–0.02	0.22–0.32	0.00–0.03
H2 (type III)	rough crystal, very intense blue layer ‖ c and almost colourless rim, polished ⊥ basal plane	2 (intense blue) 48+50 (colourless)	98.1–99.5	0.01–0.03	0.00–0.02	0.00–0.02	0.77–0.86 0.33–0.45	0.23–0.24 0.01–0.04
H4 (type III)	rough crystal, very intense blue layer ‖ c, almost colourless rim, polished ⊥ basal plane	2+3 (intense blue) 47+47 (colourless)	98.1–99.5	0.01–0.03	0.00–0.02	0.00–0.02	0.67–0.97 0.39–0.47	0.13–0.22 0.01–0.03

* Fe_2O_3 was somewhat higher in the light blue core compared to the almost colourless rim.
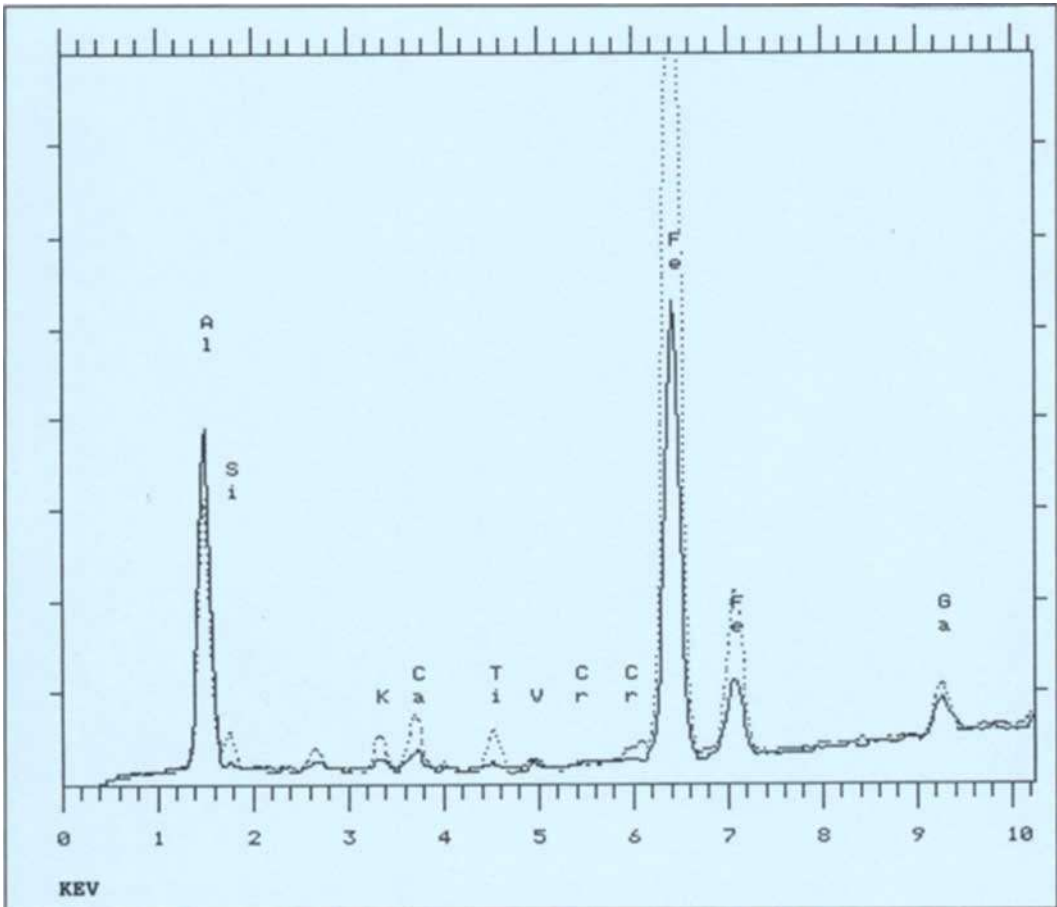
Fig. 35.   Energy-dispersive X-ray fluorescence spectrum showing the chemical composition of a type II sapphire from Madagascar. Solid line, light blue prism face representing the rim of the crystal; dotted line, dark blue basal pinacoid representing the core.

different types of colour zoning and quantitatively analysed by electron microprobe. Between one and three traverses of 50 to 100 point analyses each were measured across the differently coloured areas of the samples. These analyses showed a marked zoning of Fe and Ti in all three types of stones, while the other elements showed a common range within differently coloured zones (Table I).

Type I sapphires (dipyramidal to barrel-shaped habit): The sapphires of Type I could be subdivided into three groups: 4 stones (samples S1, S4, S9 and S20) show a fine and, in places, an extremely complex

colour zoning; 2 stones (samples H1.88 and S27) have dark blue cores with lighter blue rims; and 2 stones (samples S5 and S7) have brown cores with blue rims. One of the latter two stones also shows brown stripes in the rimming area around the blue core where some of the stripes were cut by the table of the faceted stone.

The samples with complex colour zoning show a wide range of Fe_2O_3 and especially of TiO_2 concentrations. Fe_2O_3 concentrations vary from a minimum of 0.11 wt.% in the lighter zones of the sample to a maximum of 0.62 wt.% in the darker blue zones of the sample. TiO_2 values range
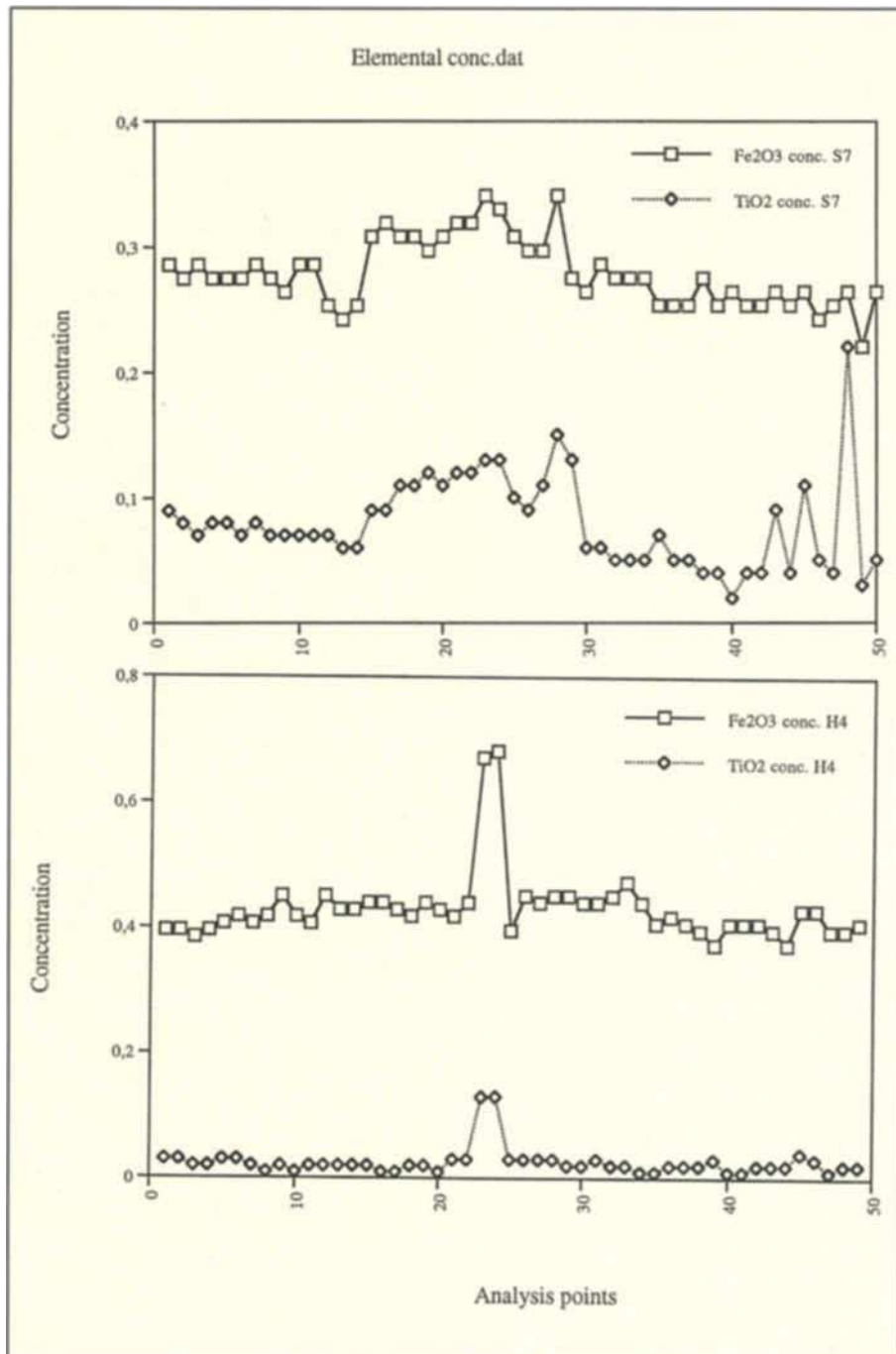
Fig. 36.   Fe₂O₃ and TiO₂ contents of sapphires in traverses across colour zones: (a) type I sapphire: higher Fe₂O₃ and TiO₂ values are present in the brown core area, between analysis point No. 15 and 30. Analysis points 43, 45 and 48 show extremely high TiO₂ contents which are coincident with brown stripes in the rim of the stone; (b) type III sapphire: higher Fe₂O₃ and TiO₂ contents were measured across a thin, extremely dark blue stripe (analysis points 23 and 24).

from 0.03 to 0.25 wt.% in comparable zones (Table I).

The two samples with dark blue cores and lighter blue rims both contain higher Fe_2O_3 and TiO_2 in the darker cores compared to the lighter blue rims (Table I). While darker blue areas in the samples mentioned above are characterized by both higher Fe_2O_3 and TiO_2 values, the brown areas (cores and stripes) and blue rims of samples S5 and S7 show only minor differences in Fe_2O_3 content but there are marked differences in TiO_2 values (Table I and Figure 36a). The highest difference in TiO_2 content was found in the brown stripe outside the core which was high compared to that of the surrounding blue area (Table I). The high TiO_2 values are an indication that the composition of the fine particles is probably rutile, i.e. the brown zones with mineral dust are likely to contain extremely small rutile crystals.

Type II sapphires (prismatic habit): Only one of the type II sapphires (sample H1) was available for quantitative chemical analysis. The sample shows slightly higher values of both Fe_2O_3 and TiO_2 in the dark blue core compared to the outer light blue areas (Table I), which is in agreement with the qualitative chemical analyses (Figure 35).

Type III sapphires (distorted tabular to short-prismatic-dipyramidal habit): Sapphires of type III are characterized by medium Fe_2O_3 and very low TiO_2 concentrations in the lighter blue and almost colourless areas (samples H2, H3, H4 and H5). The very intense dark blue, extremely thin layers parallel to the basal pinacoid through the centres of the crystals show relatively high Fe_2O_3 concentrations (up to 0.87 wt.%), and TiO_2 concentrations are higher in these bands when compared to the dark blue areas of type I and II sapphires (Table I). Figure 36b shows the distribution of Fe and Ti content in a traverse through a sapphire with a dark blue stripe. In all three types of sapphires from Madagascar distinct amounts of Ga_2O_3 are present.

Spectroscopic data
Visible and ultraviolet (UV) spectroscopy.
During the course of the study, UV-VIS spectra of 25 rough and three faceted sapphires were recorded. The rough, untreated samples show one common type of spectrum in the visible and UV range which can be considered characteristic for this occurrence. The Fe^{2+}/Ti^{4+} absorption bands resemble the ones observed in sapphires from Myanmar, Sri Lanka, Umba, Tanzania or Kashmir, all sapphires from pegmatitic or metamorphic sources (Figure 37a; see also Schmetzer and Kiefert, 1990). The absorption edge lies between 340 and 325 nm, which is a higher wavelength than usual for sapphires from metamorphic origins (see also Hänni, 1994). Violet stones show a distinct Cr^{3+}-component, which is superimposed on the blue sapphire spectrum.

Figure 37b shows a spectrum of a so-called geuda-type sapphire before heat-treatment. The sample shows a low Fe^{2+}/Ti^{4+} absorption, but bands in the Fe^{3+} area and the absorption edge are similar to the spectrum shown in Figure 37a. The spectra of heat-treated sapphires differ distinctly from untreated samples (Figure 37c). After heat treatment, the absorption spectra reveal a strong Fe^{2+}/Ti^{4+} absorption and a significant change in the 500 to 300 nm range. The Fe^{3+} absorption bands become very low and the absorption edge is stifled to a range below 300 nm. The low intensity of Fe^{3+} absorption bands in heat-treated samples may be explained by the conversion of trivalent iron to bivalent iron in connection with the dissolution of rutile particles as described by Schmetzer and Kiefert (1990). Absorption spectra of this type have so far been considered typical for heat-treated Sri Lankan sapphires (Schmetzer and Kiefert, 1990; Hänni, 1994).

Infrared spectroscopy: IR spectra of sapphires from Madagascar do not show the sharp OH-absorption lines in the 3000 to 3500 cm^{-1} range observed in some other corundum, e.g. in rubies from Mong Hsu,
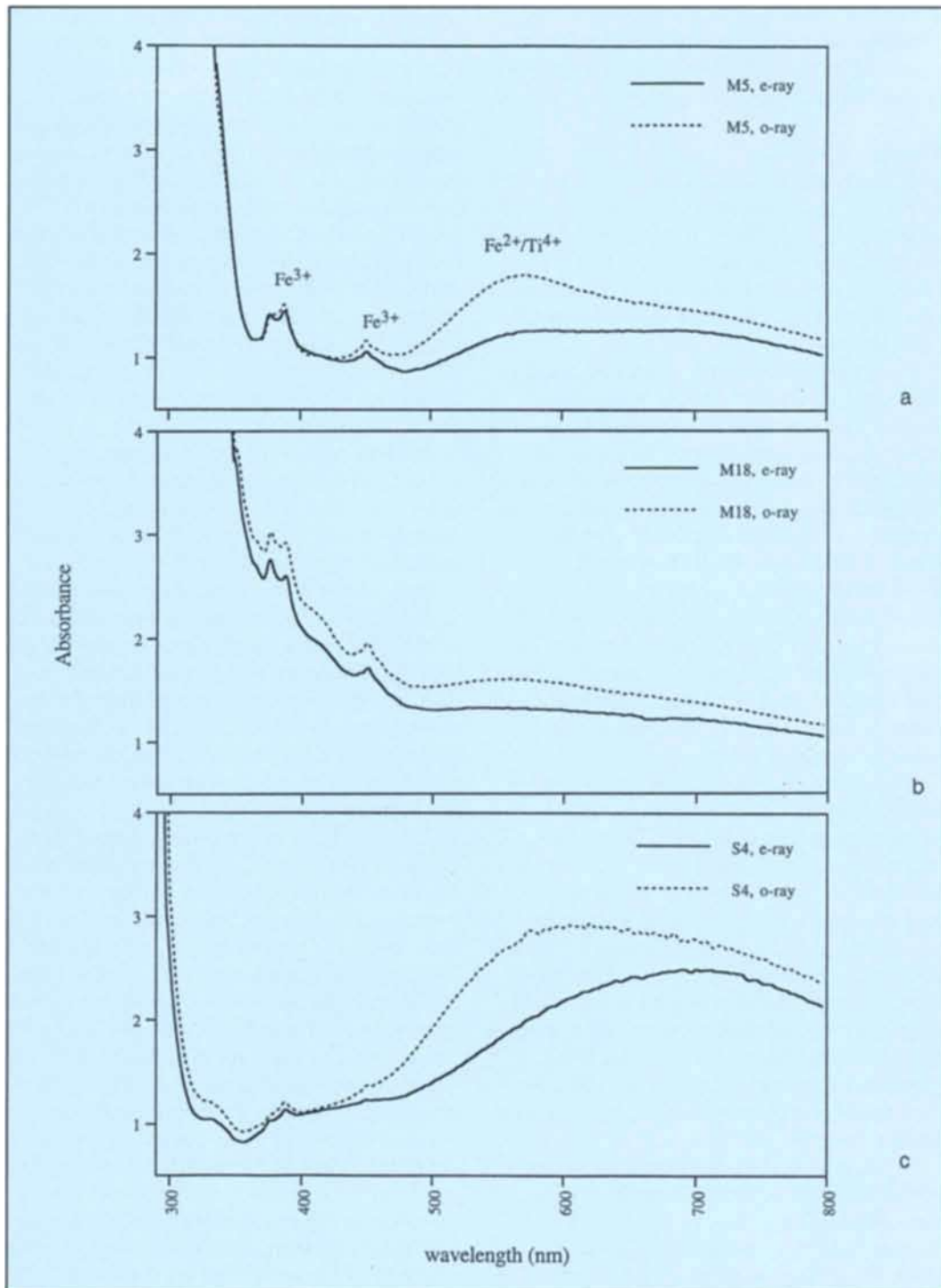
Fig. 37.   UV-VIS spectra of sapphires from Madagascar: (a) untreated type II sapphire; (b) untreated type I sapphire (geuda-type); (c) heat-treated type I sapphire.

Myanmar (Peretti *et al.*, 1995; Smith, 1995). The samples only show the two absorption lines at 2930 and 2855 cm^{-1}, which are typical for corundum.

Conclusions
Sapphires from Madagascar show a variety of properties, most of which are also observed in sapphires from other deposits. A certain number of characteristics are, however, diagnostic for sapphires of the new deposit near Andranondambo, southern Madagascar.

The growth structures observed allow a division into three different types of stones. The first type is dipyramidal to barrel-shaped. Sapphires with this habit are observed at many other sapphire localities, e.g. Sri Lanka and Australia, while the second type with prismatic habit is frequently found in Montana, USA (Kiefert, 1987). The third type of sapphire from Madagascar varies in its morphology and consists mostly of distorted crystals which are formed of a prominent basal pinacoid and narrow dipyramidal and prismatic faces. Some of these crystals may also exhibit a scalenohedron.

Sapphires of all three types show strong colour zoning reflecting important fluctuations of growth conditions during the formation of the crystals. This colour zoning may be blocky and show a colourless core and blue rims, or a dark blue or brown core and light blue rims. Narrow colour zoning, sometimes irregular, is also present. Some of the colour zoning observed in cut stones may resemble colour zoning from Kashmir sapphires (Hänni, 1990), Vietnam sapphires (Smith *et al.*, 1995) or Sri Lankan sapphires (Kiefert, 1987; Kiefert and Schmetzer, 1991b).

Type I sapphires are the most abundant of the three types. Some contain fine particles, most likely rutile, in areas which appear brown in transmitted light, and these brownish areas may form the core or some small banded growth structures in the outer areas. This feature, especially the relation of the brown stripes to subordinate growth areas, can be considered as diagnostic for Madagascar sapphires. Although similar brown growth zones are also found in Sri Lankan sapphires, the brown areas in Sri Lankan sapphires are, however, always related to dominant growth zones. Diagnostic growth features of type II sapphires may be the dark blue cores confined by the hexagonal prism *a* and the basal pinacoid *c*, and, less commonly, the positive rhombohedron *r*. Type III sapphires generally contain extremely dark blue thin stripes, mostly parallel to the basal pinacoid *c*.

Solid inclusions in type I Madagascar sapphires are mainly calcite and apatite; the latter are commonly altered during heat treatment and surrounded by rosette-like feathers. The prismatic-type sapphires frequently show well rounded apatite crystals with hollow tubes extending perpendicular to the prismatic growth planes. Sapphires of type III contain apatite, zircon, and abundant three-phase inclusions or flat calcite crystals parallel to the basal plane. Similar three-phase inclusions with liquid and gaseous CO_2 and diaspore also occur in Sri Lankan sapphires.

The Madagascar sapphires contain a range of Fe_2O_3 and TiO_2 contents which cause different types of colour zoning and a variety of spectroscopic features. Light blue areas are generally low in Fe_2O_3 and TiO_2, while the dark blue areas show high Fe_2O_3 and TiO_2 contents. The brown cores and stripes contain Fe_2O_3 values almost comparable to the dark blue areas, but TiO_2 is enriched in these areas. The data observed lie within the range of compositions of sapphires from metamorphic origins and origin determination based only on chemical composition is not reliable unless other diagnostic features, such as the scalenohedron face, brown (resp. whitish) areas, or apatite crystals with tubes, can be taken into account.

Acknowledgements

References

Ackermand, D., Windley, B.F., and Razafiniparany, A., 1989. The Precambrian mobile belt of southern Madagascar. In: Daly, J.S., Cliff, R.A., and Yardley, B.W.D. (Eds), *Evolution of Metamorphic Belts*. Geol. Soc. Special Publication, London, No. 43, pp 293–6

Anonymous, 1995. Thai Company to mine in Madagascar. *ICA Gazette*, April 1995, p. 6

Atkinson, D., and Kothavala, R.Z., 1983. Kashmir sapphires. *Gems & Gemology*, 19, pp 64–76

Besairie, H., 1971. Madagascar. In: Baker, B.H. (Ed.) *Tectonique de l'Afrique*. UNESCO, Paris, Sciences de la Terre, 6, pp 549–57

Cahen, L., and Snelling, N.J., 1984. *The geochronology and evolution of Africa*. Clarendon Press, Oxford, 511 pp

Dixey, F., 1960. The geology and geomorphology of Madagascar, and a comparison with Eastern Africa. *Quarterly Journ. Geol. Soc.*, 116, pp 255–68

Goldschmidt, V., 1918. *Atlas der Kristallformen. Band V. Kainit-Margarosanit*. Carl Winters Universitätsbuchhandlung, Heidelberg

Hänni, H.A., 1986. On corundums from Umba valley, Tanzania. *J. Gemm.*, 20, pp 278–84

Hänni, H.A., 1990. A contribution to the distinguishing characteristics of sapphire from Kashmir. *J. Gemm.*, 22, pp 67–75

Hänni, H.A., 1994. Origin determination for gemstones: possibilities, restrictions and reliability. *J. Gemm.*, 24, pp 139–48

Hänni, H.A., Kiefert, L., Krzemnicki, M., Schmetzer, K., and Bernhardt, H.-J., 1995. The deposit and sapphires from Southern Madagascar. *Proc. 25th Internat. Gemmol. Conf., Rayong, Thailand* (in press)

Heinrich, E.W., 1949. Pegmatites of Montana. *Econ. Geol.*, 44, pp 307–35

Kammerling, R.C., Koivula, J.I., and Fritsch, E. (Eds), 1995. Gem News. Sapphires from Madagascar. *Gems & Gemology*, 31, pp 132–3

Kiefert, L., 1987. Mineralogische Untersuchungen zur Charakterisierung und Unterscheidung natürlicher und synthetischer Sapphire. Diplomarbeit, Universität Heidelberg, 203 pp

Kiefert, L., and Schmetzer, K., 1991a. The microscopic determination of structural properties for the characterization of optical uniaxial natural and synthetic gemstones. Part 1: General considerations and description of the methods. *J. Gemm.*, 22, pp 344–54

Kiefert, L., and Schmetzer, K., 1991b. The microscopic determination of structural properties for the characterization of optical uniaxial natural and synthetic gemstones. Part 3: Examples for the applicability of structural features for the distinction of natural and synthetic sapphire, ruby, amethyst and citrine. *J. Gemm.*, 22, pp 471–82

Lacroix, A., 1922. *Minéralogie de Madagascar*. Tome 1, A. Challamel, Paris. pp 247–55

Larsen, E.S., 1928. A hydrothermal origin of corundum and albitite bodies. *Econ. Geol.*, 23, pp 398–433

London, D., 1986a. Magmatic-hydrothermal transition in the Tanco rare-element pegmatite: evidence from fluid inclusions and phase-equilibrium experiments. *Am.Min.*, 71, pp 376–95

London, D., 1986b. Formation of tourmaline-rich gempockets in miarolitic pegmatites. *Am. Min.*, 71, pp 396–405

Milisenda, C.C., 1995. Saphire aus Madagaskar. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 44, pp 3–4

Nicolett, C., 1986. Saphirine et staurotide riche en magnésium et chrome dans les amphibolites et anorthosites à corindon du Vohibory Sud, Madagascar. *Bull. Minér. Franç.*, 109, pp 599–612

Noizet, G., and Delbos, L., 1955. Etude géologique des schistes cristallines de l'Androy Mandrareen. *Travaux du Bureau Geologique Madagascar*, Nr. 65

Peretti, A., Schmetzer, K., Bernhardt, H.-J., and Mouawad, F., 1995. Rubies from Mong Hsu. *Gems & Gemology*, 31, pp 2–26

Piat, C.D., and Bouqueau, M.-P., 1995. En direct de ... Madagascar. *Revue de Gemmologie*, 123, pp 12–13

Rafaranalisoa, E., 1968. Données nouvelles sur la Hibonite (CaAl$_{12}$O$_{19}$) de Madagascar. Thèse, Acad. De Paris, Univ. P. et M. Curie

Schmetzer, K., 1986. An improved sample holder and its use in the distinction of natural and synthetic ruby as well as natural and synthetic amethyst. *J. Gemm.*, 20, pp 20–33

Schmetzer, K., and Kiefert, L., 1990. Spectroscopic evidence for heat treatment of blue sapphires from Sri Lanka–additional data. *J. Gemm.*, 22, 80–2

Schmetzer, K., and Medenbach, O., 1988. Examination of three-phase inclusions in colourless, yellow, and blue sapphires from Sri Lanka. *Gems & Gemology*, 24, pp 107–11

Smith, C.P., 1995. A contribution to understanding the infrared spectra of rubies from Mong Hsu, Myanmar. *J. Gemm.*, 24, pp 321–35

Smith, C.P., Kammerling, R.C., Keller, A.S., Peretti, A., Scarratt, K.V., Khoa, N.D., and Repetto, S., 1995. Sapphires from Southern Vietnam. *Gems & Gemology*, 31, pp 168–86

Solesbury, F.W., 1967. Gem corundum pegmatites in NE Tanganyika. *Econ. Geol.*, 62, pp 983–91

Goodletite – a beautiful ornamental material from New Zealand

Grahame Brown* and Hylda Bracewell**

*ALLGEM Services, 14 Allamanda Crescent, Albany Creek, Qld 4035, Australia
**P.O. Box 6055, Mitchleton, Qld 4053, Australia

Abstract

Goodletite is an informal name used in New Zealand to describe a rare rock, of undetermined origin, that is found as small alluvial cobbles and pebbles in the gold-bearing alluvial gravels of rivers that drain the Westland district of the South Island of New Zealand. It is a greyish-green mottled ornamental rock consisting of a mixture of ruby (that in places grades into blue sapphire) and pinkish-grey corundum in a fine-grained greyish-green matrix of green tourmaline and translucent chrome-rich green micas. The literature is reviewed and the gemmological properties of goodletite are given.

Fig. 1. Sawn slab of New Zealand goodletite.

Keywords: goodletite, New Zealand

Introduction

A collector of rare and exotic gem materials or a New Zealand gemmologist might be familiar with the existence of a rare and attractive New Zealand ornamental material called goodletite. A measure of goodletite's rarity is that for over a century after its discovery a comprehensive gemmological description of this ornamental rock has not been available.

Goodletite, sometimes called locally 'ruby rock' or 'treasure stone', is a rare ultrabasic rock that displays considerable potential as an ornamental material. When slabbed or carved its polished surfaces can be attractively patterned by a random mosaic of pink to purplish-red, pinkish-grey and occasional blue areas that contrast strongly with the dark greyish-green to green matrix of this rock (Figures 1 and 2).

Goodletite in the literature

A literature search for previous descriptions of goodletite was not particularly rewarding. Older textbooks of gemmology such as Bauer's two volume *Precious stones* (1896),[1] Smith's *Gemstones* (1912),[2] Weinstein's *Precious and semi-precious stones* (1929),[3] and Spencer's *A key to precious stones* (1946),[4] failed to mention this material. However, in the Glossary [of unusual names] of the first (1962) edition of *Gems*, Robert Webster[5] did define goodletite as 'Marble forming the matrix of rubies (Burma)'. An attempt at tracing the source of Webster's definition by searching the available literature on the occurrence of ruby in Burma failed to find any reference to goodletite.

Fig. 2.   Cabochon of New Zealand goodletite weighing 27.94 ct.

One of the few books published on the gemstones of New Zealand, L. and R. Cooper's *New Zealand gemstones* (1966),[6] was equally uninformative with respect to goodletite. However, the third (1967) edition of W.M. Campbell's *Minerals and gems of Maoriland*[7] contains the following entry on goodletite:

'Ruby: real ruby, dark red, H 9, SG 4, is found with dark green olivine crystals in goodletite or "treasure rock" at Rimu Flat, Westland. It is small and fragmentatious. Sir James Hector thought better quality awaited finding.'

However, a description of goodletite by A. Neithe, in B. Myatt's 1972 publication *Australian and New Zealand gemstones: how and where to find them*[8] stated that goodletite was:

'... not good lapidary rock because of the variable hardness of its composition, but its extreme rarity makes it a highly desired mineral specimen ... goodletite is so rare that it is not sold by any of the dealers, but is sometimes traded by fortunate owners.'

In addition Neithe suggested that goodletite was a rock which was formed from ruby and sapphire in a matrix of chrome mica (fuchsite) and tourmaline, but had never been found *in situ*. Instead, it is recovered 'as fragments' from gold sluicings at Rimu Flat, south of Greymouth on the west coast, in the rugged mountains to the east and in Whitcombe Pass (through which the Whitcombe River flows) (see Figure 3).

Further information on goodletite was obtained from Minerals of New Zealand, *New Zealand Geological Survey Bulletin*, **104**, 1990.[9] Railton and Watters state on p.53 that goodletite is an informal name given to a rock found as boulders at Rimu, Kaniere and Kaniere Forks (Westland), but not found *in situ* (see Figure 3). This attractively patterned rock also has been recorded as occurring in boulders of muscovite-serpentine rock at Olderog Creek, Arahua Valley (see Figure 3). In addition, Figure 34 (p.18) of *Bulletin* **104** illustrates a petrological thin section of goodletite (from a boulder in Whitcombe River, Westland). The caption of this colour photomicrograph states that the constituent minerals of goodletite are ruby grading into blue sapphire, green tourmaline and chromium-bearing muscovite.

A check of references cited in *Bulletin* **104** revealed that in Bell and Fraser's 1906 paper,[10] ruby rock, then already known as goodletite, had been found as loose boulders in the gold-bearing drifts of Rimu, Kaniere and Kaniere Forks, and in the Whitcombe Valley. Apparently a search had failed to locate any outcrops of the rock, so the authors postulated that it had been derived from serpentines located in the catchment area of the Hokitika River (see Figure 3).
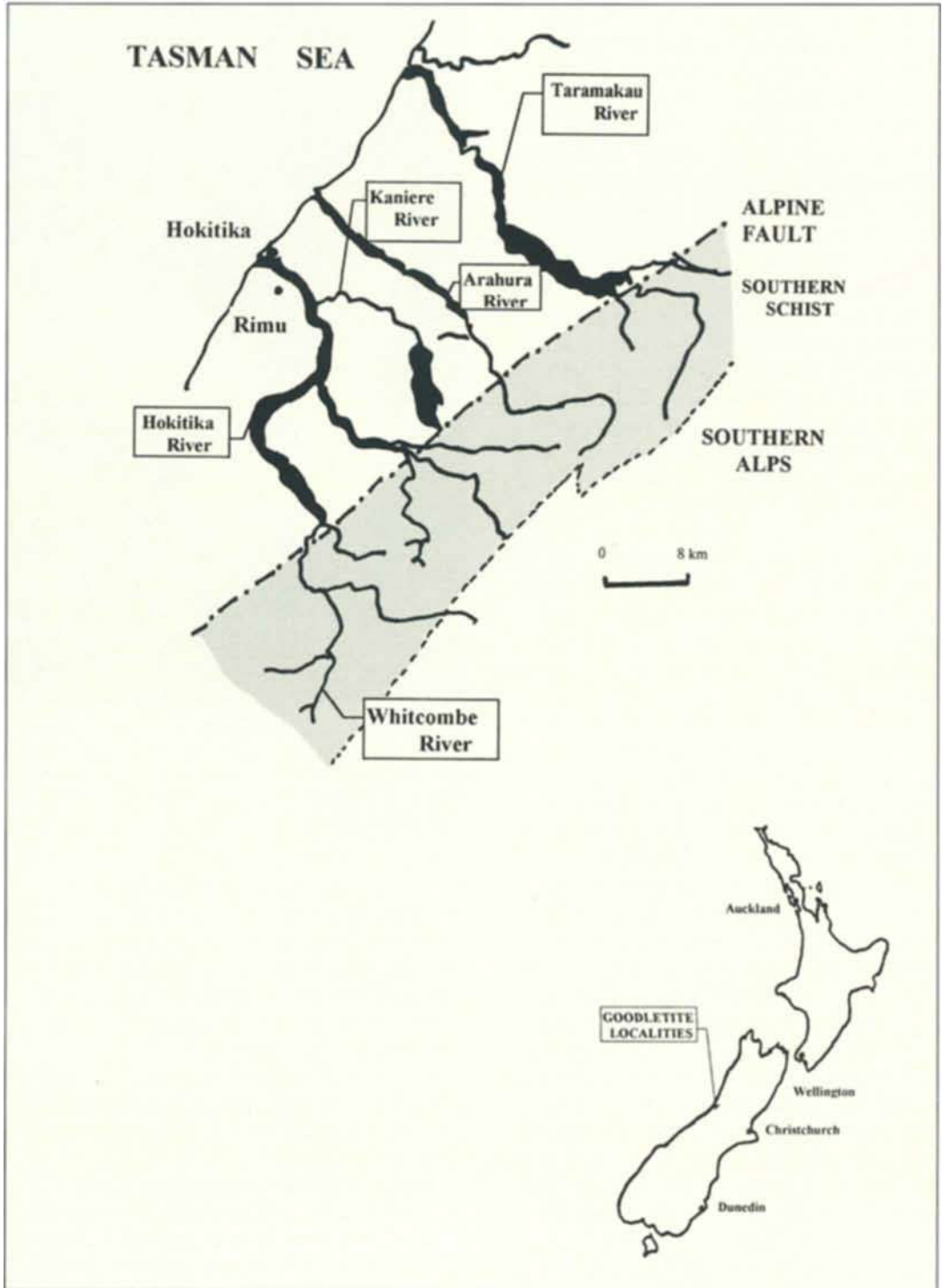
Fig. 3. Localities from which goodletite has been recovered (after Warren. G. (1967), Sheet 17, Hokitika[18]]

According to the same authors,[10] the first specimen of goodletite was obtained in 1891 by a geologist named A. McKay. According to McKay, [11] it was he who first submitted the rock for identification to the then Colonial Analyst William Skey. Subsequently Skey informed McKay that the rock contained ruby. Unfortunately (for McKay) the results of this analysis were never published.

Some time later William Goodlett, then a Laboratory Assistant in the Department of Geology, took specimens of this rock to Professor Ulrich, Professor of Geology at Otago University, Dunedin. Ulrich determined that the rock contained 'oriental rubies of fine colour', and it is likely that goodletite was named for William Goodlett (H.N. Jacobs, 1987).[12]

In 1908 Morgan[13] described the 'ruby rock' as dark green chrome mica and altered olivine containing fractured ruby that occasionally graded into blue sapphire. Morgan also suggested that the Hokitika Glacier was a possible transporter of the 'ruby rock'.

In 1976 Campbell[14] was well aware of the occurrence of ruby in green micaceous margarite and fuchsite at Rimu Flat (Hokitika), Kaniere Forks and Olderog Creek in Whitcombe Valley, but he did not identify the rock as goodletite.

Some eighty years after the first chemical analysis of goodletite was published, Mason[15] indicated that goodletite was a rock consisting of 'granular red and blue corundum intergrown with a green mica' that was 'a fine grained mixture of margarite and muscovite'. Mason's analysis was based on 'a fist-sized piece collected some years ago from the Rimu dredge tailings near South Beach, Hokitika' and he made no mention of the presence of green tourmaline in this rock. The specific gravity of 3.54 suggested to Mason that the rock consisted of about 70 per cent corundum and 30 per cent mica. In thin section, microprobe analyses of the corundum revealed Cr_2O_3 contents ranging from
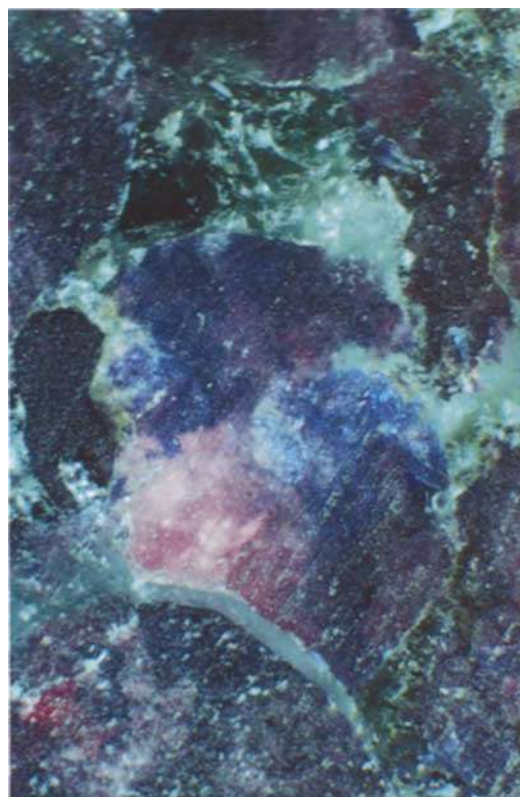

Fig. 4. Hand lens characteristics of goodletite illustrating an anhedral grain of ruby-blue sapphire and anhedral grains of corundum in a matrix probably consisting of a mixture of green chrome-rich micas and tourmaline.[17] Magnification 20×.

0.93–3.36 wt % (mean 1.85 wt %), Fe_2O_3 contents of 1.0–2.0 wt %, and TiO_2 contents of 0.2–0.3 wt %. Mason further postulated that the rock originated from the Haast (Southern) Schist in probable association with the chromium-containing Pounamu Ultrabasics (see Figure 3).

In response to Mason's paper, two New Zealand geologists, Grapes and Palmer, represented data in an article 'Goodletite further re-examined'.[16]

The authors' analyses showed that goodletite was a chrome-rich metasomatic rock, with a bulk rock content of 1.49 wt % Cr_2O_3. The rock was formed from green Cr-margarite, green Cr-muscovite, green tourmaline with a content of 1.9 wt %

Table I: Gemmological properties of goodletite	
Colour	Variegated, having a random pattern of dark pinkish-grey, pink, red, purplish and blue grains that are surrounded by anastomosing veins of light to dark green matrix.
Hardness (Mohs)	Variable: grey, purple or blue patches (9), green to greyish matrix (6 to 3). Polished surfaces undercut due to the comparative softness of the micaceous matrix.
Degree of transparency	Opaque
Lustre	Waxy
Specific gravity	3.53
'Spot' refractive index	Three relatively indistinct 'spot' refractive indices of 1.74, 1.64 and 1.57 were obtained from various areas on the cabochon.
Fluorescence: LWUV SWUV	Pale yellow patches Few very small whitish specks

Cr_2O_3, ruby with an average content of 5 wt % Cr_2O_3 but containing thin lamellae with a very high Cr_2O_3 content of up to 10.2 wt %, and blue corundum with a maximum Cr_2O_3 content of 3.2 wt % and some TiO_2. The authors further postulated that, when eventually it was found in situ, goodletite was likely to occur in metasomatic muscovite zones developed within quartzofeldspathic schist near contacts with Pounamu ultramafic lenses.

In summary it would appear that goodletite is the informal name that, for over a century, has been used to describe small water-worn greenish-grey pebbles and cobbles that have been and still are occasionally recovered from gold-bearing alluvial gravels of the westerly flowing Hokitika, Kaniere and Whitcombe Rivers of the South Island of New Zealand. Goodletite is a coarsely granular rock poor in silica (SiO_2 = 20.90%), consisting of a mixture of anhedral grains and rarer euhedral crystals of red to blue and pinkish-grey corundum set in a fine-grained matrix of green chrome-rich margarite-muscovite mica and minor chromian tourmaline. The rock has not been found in situ.

The gemmology of goodletite
The gemmological features reported in this study of goodletite were determined on a thin slab (Figure 1), provided by the late Bryan Harford of Lightning Ridge, and a 30.5×21.8 mm low domed cabochon of 27.94 ct (Figure 2).

When examined with the naked eye, the slab of goodletite (Figures 1 and 2) has a very characteristic appearance. It is opaque, with globulose, decidedly mottled pinkish to dark grey (corundum) matrix that is attractively patterned by random 'specks'
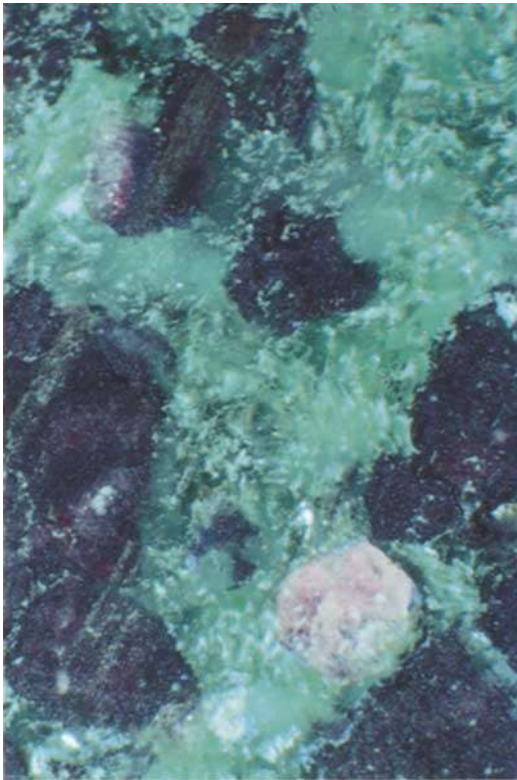
Fig. 5. Hand lens characteristics of goodletite illustrating the cross section of a ruby crystal and anhedral corundum in a matrix probably consisting of a mixture of green chrome-rich micas and tourmaline. Magnification 20×.

of pink to purplish corundum, and anastomosing veins of light green translucent mica and darker green tourmaline.

When examined at 10× magnification, goodletite was found to consist largely of a random mixture of anhedral grains of pink, pinkish-red, purplish-red ruby (some of which occasionally graded into blue sapphire), pinkish flecked dark grey corundum, and occasional euhedral crystals of opaque ruby of up to 1 mm cross-section. These occur as granular masses of various shapes and sizes, generally globulose, and set in a matrix of dark green tourmaline and fine-grained translucent emerald-green mica (Figures 4 and 5) which, in hand specimen, give the impression of sinuous veins.

Table I lists the properties of goodletite derived from the two specimens studied. It should be noted that the SG in other goodletite specimens may differ from that given in Table I because the mineral proportions of corundum, mica and tourmaline could be different.

As goodletite is a rock, for gemmologists outside the laboratory its identification must rely essentially on its distinctive hand specimen appearance. While superficially goodletite could be mistaken for other jade-like green to greyish materials – such as agalmatolite, serpentine, chalcedony, steatite or dyed calcite – none has either the gemmological properties (see Table I) or distinctive hand-lens characteristics (see Figures 1, 2, 4 and 5) of goodletite. For additional discriminatory data for possible imitations of goodletite readers are referred to Gübelin (1985).[17]

Discussion
Goodletite was named for William Goodlett, a Laboratory Assistant at Otago University, who in the early 1890s arranged for specimens of this rock to be analysed by Professor Ulrich, the Professor of Geology at Otago University, Dunedin.

Both the literature review that preceded this investigation and the investigation itself have confirmed that goodletite is a rock that has quite variable gemmological properties but with characteristics readily identifiable under the hand lens. The principal constituents of this coarse grained rock are ruby (some crystals of which grade into blue sapphire), pinkish-grey corundum, with lesser amounts of green chrome micas and green tourmaline.

Priority for the first use of the term appears to belong to McKay (1893).[11] The present authors could find no source, either in the literature or in terms of specimens, from which Webster might have derived the definition included in his book.

References

1. Bauer, M., 1896. *Edelsteinkunde.* Leipzig (translation by L.J. Spencer published in 1904 and republished with additions in 1968 by Dover Press, New York)
2. Smith, G.F.H., 1912. *Gem-stones.* Methuen, London
3. Weinstein, M., 1929. *Precious and semi-precious stones.* Sir Isaac Pitman & Sons Ltd., London
4. Spencer, L.J., 1946. *A key to precious stones.* 2nd edn. Blackie & Son Ltd, London
5. Webster, R., 1962. *Gems,* 1st edn. Butterworths, London. p.757
6. Cooper, L and R., 1966. *New Zealand gemstones.* A.H. & A.W. Reed, Wellington
7. Campbell, W.M., 1967. *Minerals and gems of Maoriland.* 3rd edn. Unity Press, Auckland. p.39
8. Myatt, B., (ed.), 1972. *Australian and New Zealand gemstones: how and where to find them.* Paul Hamlyn, Sydney. pp. 190-1
9. Railton, G.T., and Watters, W.A., 1990. Minerals of New Zealand. *New Zealand Geological Survey Bulletin,* 104, 18, 53
10. Bell, J.M., and Fraser, C., 1906. Geology of the Hokitika sheet, North Westland Quadrangle. *New Zealand Geological Survey Bulletin,* 1, 123-4
11. McKay, A., 1893. Geological exploration of the northern part of Westland. New Zealand Mines Department Report C-3, p.151
12. Jacobs, H.N., 1987. Personal communication
13. Morgan, P.G., 1908. The geology of the Mikonui subdivision, North Westland. *New Zealand Geological Survey Bulletin,* 6, 77
14. Campbell, W.M., 1976. *Minerals and gems of Maoriland,* 4th edn. Unity Press, Auckland. p.31
15. Mason, B., 1989. Goodletite re-examined. *Geological Society of New Zealand Newsletter,* 84, 66
16. Grapes, R., and Palmer, K., 1989. Goodletite further examined. *Geological Society of New Zealand Newsletter,* 85, 31
17. Gübelin, E., 1985. Properties of ornamental stones and their identification. *Australian Gemmologist,* 15, 335-86
18. Warren, G., 1967. Sheet 17, Hokitika. *New Zealand Geological Survey*

The Adamas Advantage Gem Identification Kit 1.2e – a review

P.G. Read

Bournemouth

Abstract

The Adamas Advantage Gem Identification Kit 1.2e is a program requiring Windows 3.1, a 386 processor, 4Mb of RAM, 6Mb of free Hard Disk, a VGA/SVGA Monitor and a mouse. The program is excellent for students and suggestions for improving some aspects are made.

Introduction

When I was asked by Martin Haske of the Adamas Gemological Laboratory to review his gem identification computer program, I was pleasantly surprised as he knew that my own program GEMDATA, now in its sixth update, is a competitor in the same market. No doubt his reason for nominating me for this task was that I would be well aware of the necessary functions and programming complexities of such a product.

The program

The Adamas Advantage Gem Identification Kit 1.2e for Windows is a 'subset' of the much larger Adamas Advantage program, which is a DOS based package for gem identification, plus diamond and coloured stone analysis and reporting. The Kit is contained on two 3.5-inch diskettes. It is a Windows version with the minimum system requirements of Windows 3.1, a 386 processor, 4Mb of RAM, 6Mb of free Hard Disk, a VGA/SVGA Monitor, and a mouse.

Instructions for the installation of the program in the Windows environment are minimal and are easily implemented. Within a few minutes of my responding to the on-screen instructions, the Adamas icon appeared in the Main section of the Windows display and the program was ready for use.

On the title page of the program (Figure 1) there are six options (including Exit). Choosing 'Scan Data Base' gives direct access to data pages on each of the 524 gem materials in the database (selection is by double clicking the mouse on the chosen gem name). If 'Run Gem Identification' is chosen from the title page, the main ID menu is displayed (Figure 2).

Initially, the complexity of the menu screen seems rather daunting, as it contains some twenty-six input options for the various test parameters, all activated by clicking the mouse on the open box to the left of each parameter. However, it is only necessary to activate as many parameters as are relevant to the gem under test. For example, with a ring-mounted stone, colour, transparency, RI(s), and optic character (single/double refraction) may well be sufficient.

Before starting an identification, perhaps the most important choice to be made is how much of the database should be searched to find a match for the values of the chosen parameters. The first option labelled 'A Chart only', enables a search to be made for a match among a group of 66 of the more common gem materials. Unless the gem under test is thought to be
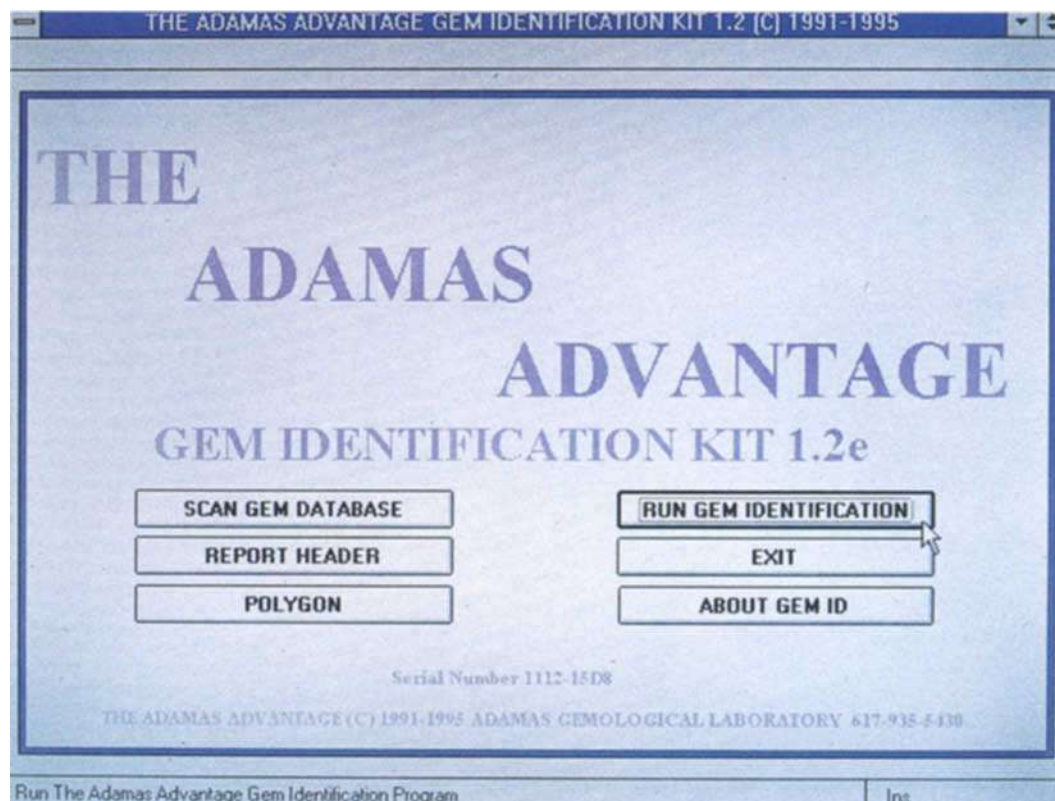

Fig. 1. Title page of the Adamas Advantage Gem Identification Kit.

something unusual, this is probably the best first choice. A second option labelled 'A + B Charts' adds in some less common gems to bring the total up to 133 materials, while the third option involves the complete database of 524 materials (many of these being minerals well outside my experience but no doubt forming a valuable asset to any mineralogist using the program!).

The next important decision is in the selection of the tolerance ranges for the search. These are set by clicking the mouse on 'Update Match Tolerances' to bring up a separate screen. For comparison purposes, I set the RI, DR and SG tolerances to my own program's 'Narrow Search' values of ±0.005, ±0.003 and ±0.02 respectively.

If a modest set of input parameters is chosen and entered (e.g. colour, transparency, optic character, lowest and highest RIs, and SG) and database option 'A' is chosen, the time taken by the program to search and find a match is around four seconds (the display box labelled 'Matched Table' then indicates those gems which fall within the tolerance ranges of the input values; if more than three gems are identified, these can be scrolled into view in the ID display box). However, if the complete database is chosen for the search, this can take up to thirty seconds. These items were logged on my 486SX based computer. (Slower processors such as the 386 specified as a minimum requirement would take proportionally longer.)

After the various test parameters have been keyed in, initiation of the search

Fig. 2. The parameter menu page indicates the number of possible identifying constants and features which can be included in an identification search of the database.

process can be done either by clicking the mouse button on the 'Search' facility in the display, or by selecting the 'Auto Gem ID Search' facility. If the latter method is chosen, the program will search the database each time a parameter is modified, added or deleted – a useful feature when exploring alternative identifications.

If an identification becomes necessary on a gem whose RI is above the range of the standard critical-angle refractometer, the 'OTL' box alongside the 'Lower RI' parameter can be activated to exclude all gems with an RI lower than 1.81 from the identification (this is similar to an input option in GEMDATA). Information on any of the parameter boxes can be viewed by clicking on that box and data field with the mouse and then pressing key F1 on the

computer (clicking on just the box will, with the exception of the 'OTL' feature, only display a standard message).

Evaluation of the program
During my evaluation of the program, I first checked out a few of the more common gem minerals such as quartz, corundum, topaz and diamond, all of which were promptly identified using the 'Chart A' section of the database. When employing the complete database, additional materials are often included in the ID. For example, Cape diamond, synthetic diamond and yellow diamond are listed in addition to diamond.

Feeling more adventurous, I set up the colour, transparency, optic character (DR) and RIs for meliphanite using the full database. It was here that I ran into my

Fig. 3. When the constants for meliphanite are set up and optic character 'doubly refracting' is included, this gem is missing from the materials identified.

first problem when the 'Matched Table' display identified two gems, amblygonite and natromontebrasite, but omitted to list meliphanite (Figure 3). I activated the program's 'Scan' facility and checked out the constants of meliphanite (called melinophane) in the database. These were the same as the values I had input. Then I noticed that there was no mention of birefringence under the 'Optic Character' section of the database 'Scan' page, although the appropriate RI and DR values were listed.

When I went back to the Gem Identification screen and de-activated the 'Optic Character' input, melinophane was then displayed together with the other two gem materials (Figure 4). It seemed that melinophane was not being identified because its optic character (uniaxial positive) was missing from the database.

I then checked the optic character of all the gems from Achroite to Azurite in the database and found that five birefringent gems (albite feldspar, algodonite, andesine, anhydrite and ankerite) were also not listed as doubly refracting. Because of this, these gems could not be identified when this feature was included in the 'Optic Character' section of the parameter menu page. On a random browse through the rest of the alphabet, I found many other birefringent gems with this omission.

Although more irritating than major, this problem will need to be addressed in future versions of the Gem Identification Kit, as there are occasions when 'doubly refracting' becomes a necessary ID parameter (e.g. when a polariscope test indicates that a gem is birefringent, but
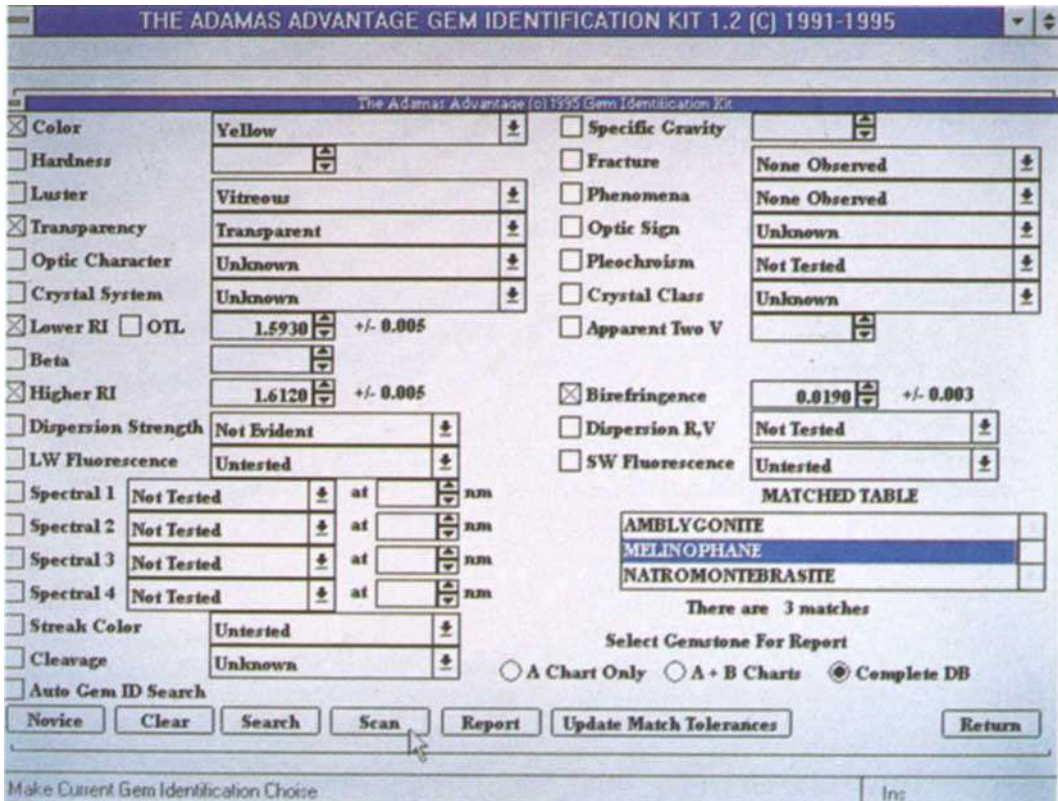
Fig. 4. If one optic character 'doubly refracting' is deleted (open parameter selection box near top on left-hand side), melinophane is included in the gems selected.

only one index can be measured on the refractometer).

Another characteristic of the program, which could easily be corrected, is the fact that when 'Run Gem Identification' is selected on the title screen, the program goes immediately into its search program. When the parameter menu page is finally displayed, the 'Auto Gem ID Search' feature is already activated (as can be seen in the bottom left-hand corner of Figure 2). It would be preferable if the user had the initial choice of selecting either the 'Auto' feature or the single 'Search' function.

Once a gem, or a set of gems, has been displayed in the 'Matched Table', it is then possible (as indicated earlier) to access the complete gem constants and characteristics on the selected material by clicking the mouse on the 'Scan' button (Figure 5). This information is derived from the database, and includes a 'View Gemstone Comments' feature which when activated displays further details including book references with page numbers.

After a gem identification, all of the selected parameters can be reset by activating the 'Clear' button. However, the first three gems in the selected section of the database remain displayed in the 'Matched Table' box. It would be more logical if this box was also cleared of any gem names prior to each ID operation.

Another aspect that could be reconsidered is that if the mouse indicator arrow is left on the 'Search' or 'Clear' button after this feature is chosen, the program stays in the search mode and displays its 'Computing' message until the
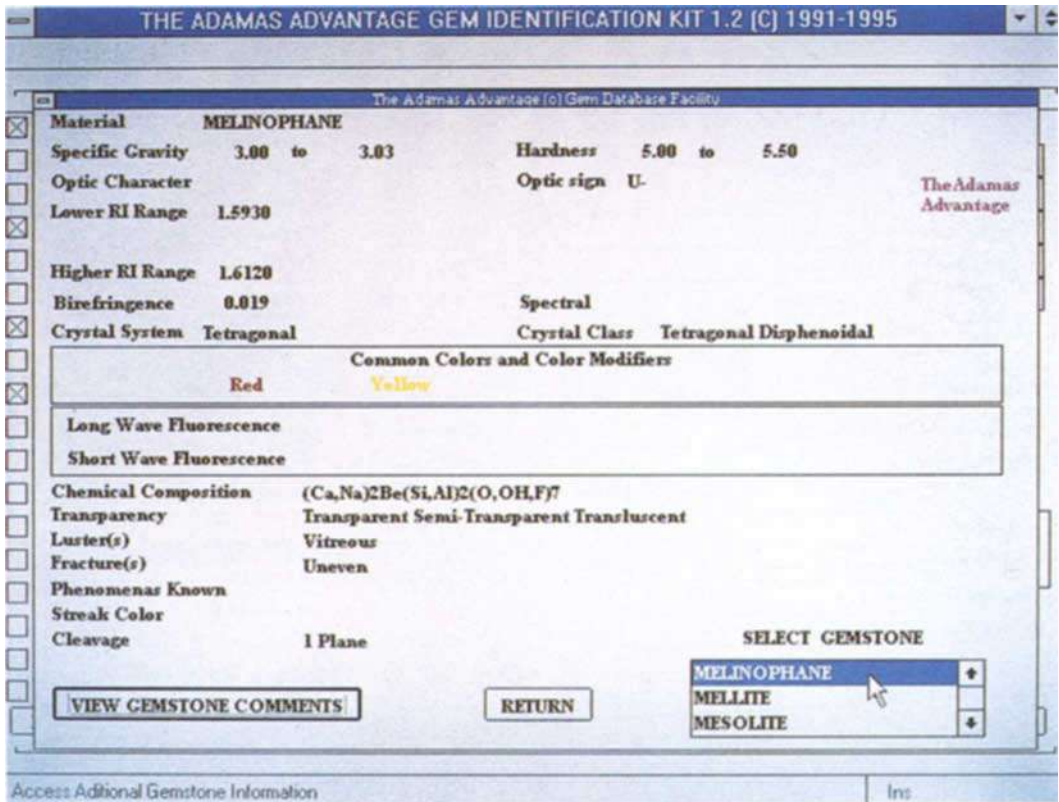
Fig. 5. After identification, further information on a gem is available from the database.

arrow is moved away. Under the colour selection parameter pink could be added to the colours to help separate highly saturated red gemstones from the pinks of smithsonite, kunzite, rhodochrosite, etc., and the term 'colourless' should replace 'clear'.

Conclusion

However, none of these criticisms detract from what is a very wide ranging and excellent gem identification program in which even the student is well catered for

in a 'Novice' section containing a wealth of information. This ranges from a selection of basic equipment (including the yet to be marketed Brewster-angle meter) to a detailed description of the use of the critical-angle refractometer, plus a list of recommended gemmological text and reference books.

Both the Adamas Advantage program and the Gem Identification kit are available from the Adamas Gemological Laboratory, The Brook House C609, 77 Pond Avenue, Brookline, MA02146, USA.

Letters

From Dr T. Farrimond

Dear Sir

When making hydrostatic determinations of SG (*J. Gemm.*, 1994, **24**, 3) I also carried out a series of measurements of surface tension (ST), using initially the method advocated by most writers on the subject (e.g. Webster, R., 1983, *Gems*, p. 654; Sinkankas, J., *Gemstone and mineral data book*, p. 124.). For example, Sinkankas suggests adding a drop of detergent the size of a pin head to the surface of one litre of water. In my experiments I used de-ionized water with a temperature range between 16 and 17°C.

Ten ST readings were made in order to establish the accuracy of the procedure and gave the following values:- Mean 73.8 dynes/cm; standard deviation $\sigma_{(n-1)}$ 0.16 where n = number of measurements (in this case 10).

In the first series of tests, one drop of detergent of the *non-foaming variety* (supplied for wet or dry vacuum cleaners) was added to the surface of 150 ml of de-ionized water and ST readings were made at approximately 20 second intervals for a period of 50 minutes, giving a total of 150 readings. It was noticed that the readings were initially low, but showed a variation with time, producing a pattern resembling a damped oscillation.

Then the tests were repeated and the same effect occurred. The patterns were so similar that the results of the two tests were combined and a graph plotted for the total of 300 readings (Figure 1, Graph B). Adjacent readings were averaged to produce Graph B, which shows 45 ST values at approximately one minute intervals. Each point on the graph is, therefore, the average of about six readings.

From the $\sigma_{(n-1)}$ values for plain water, the variation due to experimental error should not be more than $\pm$ 1 dyne/cm. The effects shown in graph B do not appear to be random variations. It is noticeable when carrying out the measurements that each reading varies only slightly from the previous one and that the changes are progressive. The ST falls rapidly, after adding the detergent, to a value of 33 dynes/cm and then climbs slowly over a period of 20 minutes to 66 dynes/cm, after which a fluctuation occurs which gradually diminishes in amplitude over the next half hour.

When the liquid was allowed to stand for 15 hours, the first reading was low, at about 36 dynes/cm, but values rose rapidly so that after 8 minutes the levels were only slightly lower than for plain water. The 26 points shown in Figure 1 (Graph A) are based on 96 readings over a 50 minute period.

Figure 1 (Graph C) shows the effect of adding one drop of *concentrated dishwashing detergent* to the surface of 150 ml of de-ionized water. Surface tension falls abruptly to 29 dynes/cm but rises slowly to around 43 dynes/cm over a 20 minute period after which it settles down to a level of about 37 dynes/cm.

It seems from the graphs that hydrostatic measures of SG may reflect the variability of surface tension values. SG measurements obtained in the first minute after
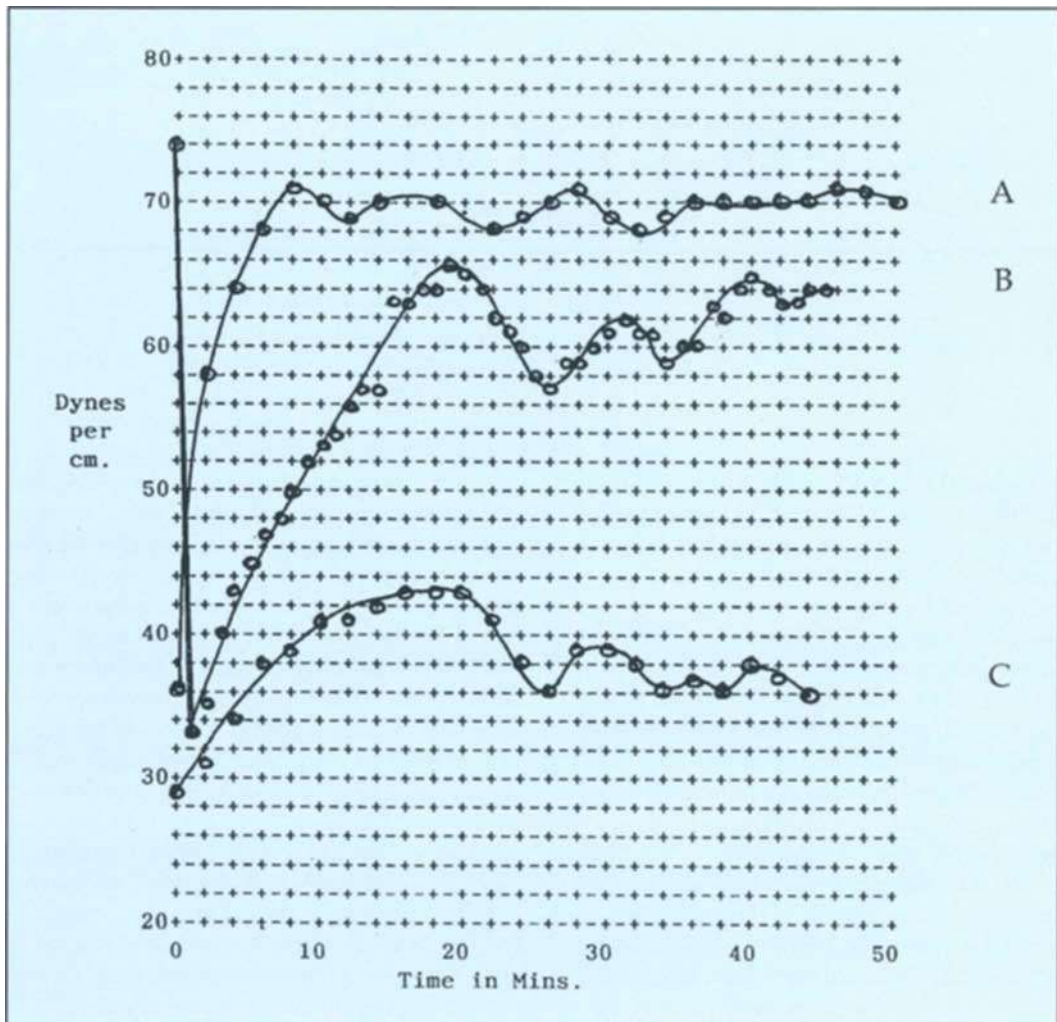
Figure 1

adding detergent may differ from those obtained after 20 minutes.

I am aware that ST would act not only on the suspension wire, but would also affect the tendency for bubbles to form on the stone and its holder beneath the surface. There appears to be a need to ascertain the percentage of detergent which should be added to water to determine what is optimal for the lowest values of ST at the surface and also beneath it.

Further tests were carried out with *non-foaming detergent* in which *increasing*

amounts of detergent were added to 10 ml of water at 17°C followed by careful mixing and subsequent testing. The results are shown in Figure 2 (upper graph). The optimum concentration would seem to be a 10 per cent solution. An approximate ST level for toluene (dotted line) is also shown for comparison.

The lower graph in Figure 2 shows the effect of mixing *concentrated kitchen detergent* with 150 ml of de-ionized water. An amount of 2–3 drops appears to be optimal (that is about 14 drops per litre).
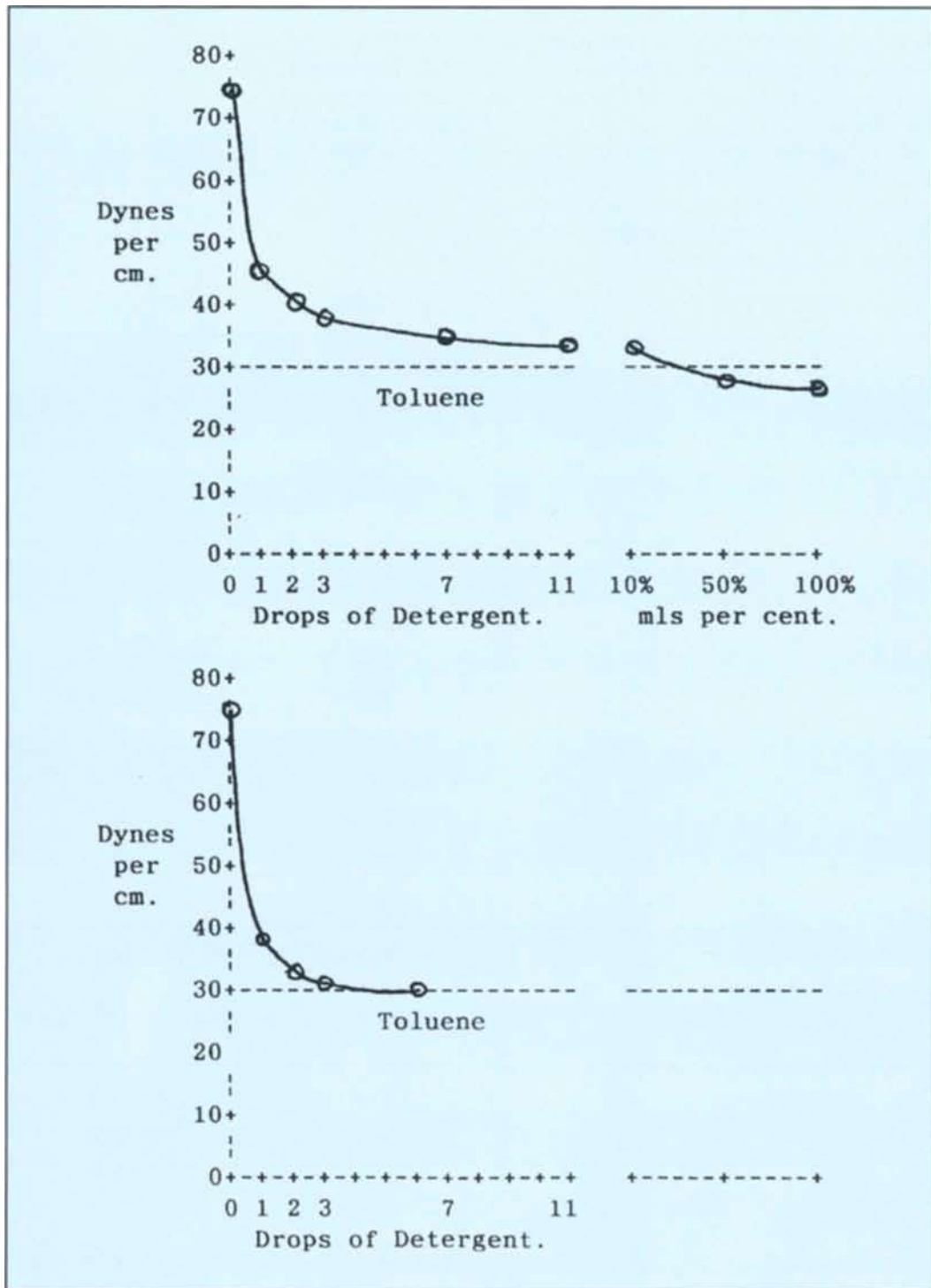
Figure 2

The values on which these graphs are based are shown in Table I. Each point on the two graphs is based on ten readings and the $\sigma_{(n-1)}$ values show the spread about the mean.

It is suggested that higher concentrations of detergent may be more effective (when measuring the SG of small stones hydrostatically) than the one drop on the surface previously advocated.

Yours etc.

Dr T. Farrimond
Cambridge R.D.1
New Zealand.
19 March 1996

Table I: Surface tension(ST) values for detergent mixed in 150 mls de-ionized water.

Non-foaming detergent added:			Mean ST	$\sigma_{(n-1)}$
drops		mls %		
0			74.6	0.18
1			46.2	0.26
2			39.2	0.21
3			36.9	0.46
7			35.0	0.16
11			34.0	0.14
		10	33.3	0.52
		50	28.5	0.25
		100	28.0	0.25
Concentrated kitchen detergent added: drops			Mean ST	$\sigma_{(n-1)}$
0			73.8	0.16
1			38.1	0.50
2			31.9	0.21
3			31.1	0.25
6			30.1	0.18

N.B. Each value based on 10 readings

Abstracts

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

Diamonds

Conversion of platelets into dislocation loops and voidite formation in type IaB diamonds.
T. Evans, I. Kiflawi, W. Luyten, G. van Tendeloo and G.S. Woods, *Proceedings of the Royal Society, Mathematics & Physical Sciences*, 449(1936), 1995, 295–313.

Experiments are described in which platelets in natural diamonds are converted to dislocation loops by annealing at > 2400°C under high P. Conversion occurs most readily when the annealing conditions are in the graphite-stable region on the C phase diagram. At 2650°C there is an increase in the rate of conversion of about three orders of magnitude, attributed to the instability of the diamond structure. Linked to the conversion is the disappearance of the B local-mode platelet peak, the D spectrum and the X-ray spikes, which have been associated with platelets. Voidites on and inside the dislocation loops were produced, suggesting that voidites with these loops are formed during the conversion of platelets to dislocation loops. IR spectra and electron micrographs illustrate these results. TEM shows that platelets are converted to interstitial $\frac{1}{2}a$ (011) dislocation loops.   R.K.H.

A history of diamond sources in Africa: part 1.
A.J.A. Janse. *Gems & Gemology*, 31(4), 1995, pp 228–55, 25 illus., 7 in black-and-white, 18 in colour.

This review covers diamond and kimberlite discoveries in Africa spanning nearly 130 years from children playing with bright pebbles on the De Kalk farm to highly sophisticated exploration and mass excavation of desert sand at Orapa and Jwaneng in the Kalahari. During this time all but two of the largest economic kimberlite pipes in the world were discovered. In the period 1872–1959 Africa produced 98 per cent of the world's diamonds by weight and 96 per cent by value. Although most diamonds have been produced by alluvial diggings along waterways in South Africa, Angola and Zaire, and by large kimberlite pipes in the Kimberley area and in Botswana, diamonds from the coastal deposits off the Atlantic coasts of Namibia and Namaqualand promise to be the industry's greatest future resource.

The earliest official finds were made from 1867 in the sands and gravels of the Orange and Vaal Rivers in South Africa and subsequently in the hard rock kimberlites and more recently in off-shore deposits along the western coast of South Africa and Namibia. Further important discoveries in many African countries such as Angola, Botswana, the Central African Republic, Ghana, Namibia and Zaire qualify them for inclusion with South Africa among the top diamond-producing countries in the world. The histories of these discoveries in southern and central Africa

from the nineteenth century to the present are examined in a systematic way.

The early history of diamond discovery has been well documented but not all the stones can be substantiated, and the reviewer has the advantage of hindsight to put these events into perspective. The result is a fascinating and authoritative review.   R.J.P.

New find of diamond bearing gravel horizon in Payalkhand area of Raipur District, Madhya Pradesh.
S.K. NEWLAY AND J.K. PASHINE. *Journal of the Geological Society of India*, 45(3), 1995, pp 309–12.

Some 200 kg of gravel from this area contained ~ 2% pyrope with minor quartz and two off-coloured diamonds (0.88 and 0.29 ct).   R.A.H.

A chart for the separation of natural and synthetic diamonds.
J.E. SHIGLEY, E. FRITSCH, I. REINITZ AND T.M. MOSES. *Gems & Gemology*, 31(4), 1995, pp 256–65, 1 table, 64 illus. in colour.

The chart itself is comprehensive, lucid and supplied with a profusion of coloured photographs. The information and testing is well within the scope of most gemmologists, and the recommended testing pattern uses everyday equipment. It was pleasing to note that where photomicrographs were shown the magnification was quoted.

The testing sequence was in the order (a) examination of the stone under magnification looking for inclusions, colour zoning and graining (b) ultraviolet radiation including both long and short wave (c) spectroscopic examination in the visible region (d) checking a suspected synthetic with a strong magnet and (e) observing possible strain patterns between crossed polarizers. The most useful gemmological properties of three groups of natural and synthetic stones were considered, yellow, blue and colourless to near colourless. The authors think that cathodoluminescence will soon be used routinely for examining diamonds.

Synthetic diamonds typically contain traces of flux metals such as iron or nickel both of which are ferromagnetic and will be attracted to a strong magnet (e.g. the neodymium-iron-boron magnet). Information was not included to cover cases where natural diamonds had a synthetic coating placed on them to change their colour or weight.   R.J.P.

Analysis of diamonds and indicator minerals for diamond exploration by laser ablation-inductively coupled plasma mass spectrometry.
R.J. WATLING, H.K. HERBERT, I.S. BARROW AND A.G. THOMAS. *Analyst*, 120(5), 1995, pp 1357–64.

A method has been developed, using LA-ICP-MS, for the semi-quantitative determination of 43 elements in diamonds, chromites and garnets. Samples of diamonds from five different countries and the interrelationship between their trace elements gives distinctive patterns for each source. This should allow the tracing of stolen diamonds and can also be used to establish the trace element distribution in indicator minerals for diamond exploration, such as garnets and chromites. The relative distribution of the *REE*, Ta and Hf indicate a consistent inter-element relationship for garnets associated with diamondiferous kimberlites; the trace element partitioning patterns of chromites can be used to establish a kimberlitic or non-kimberlitic provenance of this mineral.   R.A.H.

Gems and Minerals

Gemmologie aktuell. Gemmological news.
H. BANK, U. HENN AND C.C. MILISENDA. (*Gemmologie – Zeitschrift der Gemmologischen Gesellschaft*, 45(1), 1996, pp 1–4.

This deals with various items of gemmological interest. Green crystal fragments were submitted from an unknown source in Asia and were found to be demantoid garnet. An unusually large specimen of gahnite from Brazil weighing 8.54 ct and of intense green colour was examined, as were star-scheelite from Sri Lanka: yellowish-brown, weighing 61.73 ct, showing a distinct four-rayed star due to oriented needle-like inclusions. A larger variation of RI than previously described was found in garnets from Mali; some crystals can be as large as 15 cm in diameter; in cases of sufficient transparency it is possible to facet bicoloured stones.

Yellowish-green to yellowish-brown chatoyant specimens of opal cat's-eyes from Brazil are described—the cat's-eye effect is caused by parallel fibres of chrysotile. A new opal imitation is offered from Australia under the name of 'opalus'; it is composed of plastic foil in a colourless plastic material cemented onto a black background. Quartzes with a thin golden-yellow film were offered on the market as golden beryls; the layer could easily be removed by a solvent.   E.S.

Amethysts and their occurrences.
H. BANK AND C.C. MILISENDA. *Australian Gemmologist*, **19**(4), 1995, pp 175–7, 6 illus. in colour.

Amethyst, the violet to purple variety of macrocrystalline quartz crystallizes in the trigonal system. Its colour is caused by a radiation-induced colour centre associated with an iron impurity. Pliny (AD 23–79) recounts amethyst amulets being used to protect their owner from excessive alcohol consumption and the word is derived from the Greek *amethustos* meaning 'not drunken'.

Since the fifteenth century amethyst has been mined and fashioned in Idar-Oberstein where it occurs as druses in mafic eruptive lava flows of Permian age (about 250 million years old). Brazilian amethyst also occurs in druses but from a slightly younger basaltic rock in the southernmost state of Rio Grande do Sul. These have been exploited commercially by traders and cutters from Idar-Oberstein since 1834. Amethysts from Bahia are transformed on heating into yellow citrine. Latterly another deposit from Minas Gerais has yielded amethyst which turns green (prasiolite) on heating. Bicoloured violet and yellow quartz (ametrine) comes from the Anay mine in Bolivia. In North America amethysts have been found in North Carolina, California, Colorado, Maine, Pennsylvania, Texas and Virginia. In Africa the largest occurrence was discovered in 1956 in the Kalomo district of Zambia where it occurs in hydrothermal veins in granulitic gneisses.

In France, amethyst has been mined since the seventeenth century from geodes in volcanic rocks in the Auvergne. Swiss alpine deposits are well known but the most important source in early times was Russia where amethyst was found in early Paleozoic quartz-chlorite and mica schists in the southern Polar Urals. Other deposits occur in many other countries including Japan, China and Australia.   R.J.P.

Siberian jade.
R. BECK AND S. LEAMING. *Bulletin of the Friends of Jade*, **9**, 1996, pp 8–10, illus.

A short account of a visit paid to the (nephrite) jade fields in the East Sayan mountains of southern Siberia in August 1994, with notes on prospecting and occurrence of nephrite which is found as boulders.   M.O'D.

Gems around Australia.
H. BRACEWELL. *Australian Gemmologist*, **19**(4), 1995, pp 182–4, 1 illus. in black-and-white, 6 in colour.

A visit to Western Australia's Wyloo amethyst deposit is described. A detailed description of the colourful history of the Great Australian Amethyst Mine makes interesting reading. So does the account of the author looking for complete crystals whilst fellow fossikers were intent only on obtaining faceting rough smashed crystals without concern.   R.J.P.

La citrine de Campo Belo (second part).
J. CASSEDANNE. *Revue de gemmologie*, **126**, 1996, pp 7–9, illus. in colour.

Continues the description of citrine from Campo Belo, Minas Gerais, Brazil, with notes on the geology and mineralogy of the occurrence and on the gemmological properties of the citrine. Cut gemstones have been found to contain minute two-phase inclusions, dendritic crystals of goethite, various types of fissures and negative crystals.   M.O'D.

Confucius. The essence of jade as told by Confucius in the *Li Ki*. Translated from the Couvreur's French translation by Herbert Geiss and Bob Frey with translations in French and Latin by Couvreur and the original Chinese text by Confucius. *Bulletin of the Friends of Jade*, **9**, 1996, pp 117–21, illus.

The *Li Ki* or *Memories on the propriety and the rites*, by Confucius, contains a definition of the essence of jade whose translation, with the original Chinese text, is given here.   M.O'D.

What's new in minerals.
M.P. COOPER. *Mineralogical Record*, **27**, 1996, pp 137–48, illus. in colour.

Fluorite was a theme mineral at the 1995 Munich show and a wide range of specimens was exhibited from major museum collections. Crystals of particular interest and colour are described, with emphasis on British occurrences. An exhibit of crystal models also attracted considerable attention. Fine crystals of yellow beryl from Zelatoya Vada, Pamir mountains of Tajikistan and a group of brazilianite crystals on quartz, from near Mendes Pimentel, Minas Gerais, Brazil featured at other recent mineral shows.   M.O'D.

Trois portraits du XVIIIe siècle en saphir.

M. DUCHAMP. *Revue de gemmologie*, **126**, 1996, pp 17–20, illus. in colour.

Portraits of Louis XIV, the Grand Dauphin and the Princess Palatine, fashioned as cameos in blue sapphire, are described with notes on their history.   M.O'D.

The causes of color in garnets.

E. FRITSCH AND G.R. ROSSMAN. *Mineralogical Record*, **24**(1), 1993, p 63.

In most natural garnets colour is due to several superimposed absorption mechanisms. The common red colour in many garnets is caused by Fe^{2+} in a site with distorted cubic co-ordination. Mn^{2+} in this site produces the orange colour seen in many spessartines. Mn^{3+} in the octahedral site occasionally gives a pink colour to hydrogrossular, while Fe^{3+} in octahedral co-ordination produces the pale yellow-green colour of some andradites. Charge transfer absorptions involving Ti and Fe commonly contribute a yellow to orange to black colour component depending on Fe-Ti concentrations. Low concentrations of V^{3+} in octahedral co-ordination in grossular produce the yellowish green variety, tsavorite, and low concentrations of Cr^{3+} in andradite, also in octahedral co-ordination, produce the emerald-green variety, demantoid. Cr^{3+} in octahedral co-ordination gives the green colour to uvarovite and high-Cr content pyrope. Some purple garnets coloured by both Cr^{3+} and Fe^{2+} show a remarkable colour change to green when heated to about 200°C. An 'alexandrite effect' may be caused by Cr^{3+} and V^{3+} in octahedral co-ordination, generally in conjunction with Mn^{2+}. Occasionally, various physical mechanisms such as diffraction also cause colour in garnets.   G.W.R.

Coraux (Coelenterata) australiens.

R. GARCÍA GIMÉNEZ, M.A. FERNÁNDEZ RODRÍGUEZ AND P. DA SILVA. *Revue de gemmologie*, **126**, 1996, pp 13–16.

Examples of corals from waters around Australia are briefly described and illustrated.
                                                    M.O'D.

Nouvelle structure d'empilement compact dans de l'opale noble du Brésil.

J.-P. GAUTHIER, J. CASEIRO, S. RANTSORDAS AND D. BITTENCOURT ROSA. *Comptes Rendus de l'Académie des Sciences, Série II*, **320**(5), 1995, pp 373–9, (French with abridged English version).

A precious opal from Pedro II, NE, Brazil, shows a rare structure consisting of silica spheres of two different sizes regularly arranged, with a radius ratio $\gamma = r/R \sim 0.75$. From SEM images, it is possible to describe the periodic array, its stoichiometry, the unit cell including the 'atomic' positions and the symmetry group, $Fd\bar{3}m$. This cubic packing corresponds with a new AB_2 type structure, not described previously in bidisperse opals. The spheres of radius R occupy tetrahedral cavities of a face-centred cubic packing of spheres of radius r, and themselves display a diamond-like sublattice. The stability of the structure requires that the large spheres become slightly flattened, in order to eliminate 'rattling' of the structure. The large spheres are indeed flattened.   M.L.

Structural mechanisms for light-element variations in tourmaline.

F.C. HAWTHORNE. *Canadian Mineralogist*, **34**, 1996, pp 123–32.

While Si, B and OH and F are well known to be variably present in minerals of the tourmaline group, their stereochemical details are still not fully understood. Proposals are made for the reallocation of site labelling.   M.O'D.

Gemmologische Kurzinformationen. Short gemmological notes.

U. HENN, H. BANK, J. HYRSL AND C.C. MILISENDA. *Gemmologie – Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **45**(1), 1996, pp 23–8.

The first item is by U. Henn and H. Bank and describes trapiche-like corundums from Myanmar. Red, blue and grey prismatic corundum crystals (ruby and sapphire) from Myanmar are described which showed a trapiche-like six-rayed inclusion pattern when viewed along the *c*-axis; the inclusions are probably carbonates.

The second item is by J. Hyrsl and C.C. Milisenda and describes eudialyte from the Kola peninsula in Russia. The specimens are intense red and of gem quality. Eudialyte is a complex trigonal cyclosilicate with RI n_e 1.614–1.615, n_o 1.610–1.611, DR 0.004, SG 2.91. There is colour and growth zoning and typical liquid feather inclusions.

The third and last item concerns new emerald manipulations and is by C.C. Milisenda. Two types of 'manipulations' are described. The first specimen, probably of Colombian origin, was

offered from Russia, weighed 5.62 ct and was overgrown with a 2.5 mm thick layer of green artificial glass. The second type concerned emerald crystals from Brazil which had been hollowed out and filled with a green plastic; strong tabby extinction under crossed nicols, swirl marks and air bubbles were also visible.   E.S.

Inclusions in amethyst from Eonyang, Korea.
WON-SA KIM. *Canadian Gemmologist,* **17**(1), 1996, pp 8–13, illus.

Amethyst from Eonyang, Korea, has been found to contain acicular and dendritic crystals of hematite with two- and three-phase inclusions with gas bubbles, liquid and halite crystals.
M.O'D.

Inclusions in garnets.
J.I. KOIVULA. *Mineralogical Record,* **24**(1), 1993, p.64.

Garnets are host to a variety of inclusions which reflect their somewhat diverse geological environments. The work required to correctly identify inclusions is time-consuming, specialized, and often difficult. Although 14 species are currently recognized as members in the garnet group, only five of these, almandine, andradite, grossular, pyrope and spessartine (and chemical solid solutions of these) have been studied for their inclusions. Almandine garnets are primarily a product of schists and gneisses. The most common mineral inclusions so far identified in almandine are apatite, biotite, ilmenite, monazite, rutile and zircon. Chromium-bearing transparent green andradite garnets, known by the name demantoid, are found in chlorite schists and serpentinites. These garnets often contain distinctive acicular groups of white-to-yellow tremolite-actinolite that radiate outward from a central crystalline core of chromite. Grossular garnets are produced by the contact and regional metamorphism of impure calcareous rocks. A wide variety of inclusions have been observed in these garnets such as actinolite, apatite, calcite, diopside, graphite, pyrite and scapolite. Peridotites and kimberlites are the chief source rocks of pyrope. Most of the pyrope that we see, however, is recovered from sands and gravels produced by weathering of these rocks. Inclusions recognized in pyrope garnets so far are diopside, forsterite and rutile. Diamond has even been noted as an inclusion in pyrope garnets from a kimberlite in South Africa. Granitic

pegmatites are the primary source rocks for spessartine garnets. Spessartines reflect this environment in that they are the only garnet to commonly contain liquid and gaseous two-phase and three-phase fluid inclusions.   G.W.R.

Nouvelles données sur la zincite synthétique.
E. LANDAIS AND J.-P. POIROT. *Revue de gemmologie,* **126**, 1996, pp 11–12, illus. in colour.

Synthetic zincite crystals in green and orange colours have been faceted as gemstones. Their formation is said to be a by-product of zinc oxide preparation at a location in Silesia, Poland. Properties are given.   M.O'D.

Cu-bearing tourmaline from Paraíba, Brazil.
D.J. MACDONALD AND F.C. HAWTHORNE. *Acta Crystallographica,* **C51**(4), 1995, pp 555–7.

Two crystals of tourmaline, containing 0.81 and 0.38 wt.% CuO have been studied by single crystal XRD. The octahedrally co-ordinated Z site is completely occupied by Al, whereas the X and Y sites both contain more than two scattering species [(Na, Ca, $\square$) and (Li, Mn, Cu, Al) respectively]. The occupancy of these two sites by cations of very different size and charge causes a significant degree of positional disorder, especially on O1 and O2.   P.F.S.

Gems and gemmology in Sri Lanka: the early history.
M.M.M. MAHROOF. *Australian Gemmologist,* **19**(4), 1995, pp 169–74, 1 illus. in black-and-white.

Gems have been associated with the older name of Ceylon for many centuries and apart from emerald and diamond, examples of most gem species have been recovered from the island. The Roman historian Pliny wrote much about the gems in Sri Lanka and even Sinbad's narrative has connection with the island. The precious stones were under the direct control of royalty who underpinned the gem trade of ancient Ceylon.

Between the fifth and eleventh centuries AD gold jewellery became intricate and beautiful but the art of lapidary appears to have regressed. During the Middle Ages the gem trade was in the hands of the King and the great value of these gemstones ensured that the King retained his power. Nevertheless, in 1620 a Dutch admiral visiting Sri Lanka, landed at Trincomalee and reported the ready sale of gemstones before pro-

ceeding to the capital at Kandy. Evidently the King's edicts were not so effective since independent trading some distance from the capital was carried on. In medieval Ceylon a knowledge of gemstones was a necessary adjunct of the accomplished young man.   R.J.P.

Minerals of the Sawtooth batholith, Idaho.
M.A. MENZIES AND R.C. BOGGS. *Mineralogical Record*, 24(3), 1993, pp 185–202.

The Sawtooth batholith is an anorogenic Tertiary granite pluton with miarolitic cavities, small pegmatite dykes and pegmatitic segregations containing both interesting and unusual minerals. Some of the miarolitic cavities have produced gem-quality crystals of aquamarine < 18 cm, topaz crystals < 12 cm and rare helvite crystals < 2.5 cm. Large crystals of smoky quartz, microcline and albite are abundant. The cores of some of the topaz crystals fluoresce bright yellow in long wave UV light; its cause is presently unknown. The predominant mica in the miaroles is a dramatically zoned zinnwaldite/masutomilite. The crystallization of spessartine is probably responsible for the abrupt change from zinnwaldite to masutomilite back to zinnwaldite. EPMA gave MnO 9.37%, making this the most Mn-rich masutomilite yet reported. The identification of carpholite from several pockets is the first reported from the USA. One of the carpholites has the unusual composition $(K_\chi(Mn^{2+}_{2-\chi},Li_\chi)Al_4Si_4O_{12}(OH,F)_8$, and may be a new mineral species.   G.W.R.

Saphire aus einem neuen Vorkommen in Madagaskar.
C.C. MILISENDA AND U. HENN. *Gemmologie— Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 45(1), 1996, pp 13–22, bibl. 2 tables.

The commercially available blue sapphires were recovered from the Andranondambo mining area in the south-east of Madagascar and occur in altered marbles and calc-silicate gneisses. The specimens were found to be similar to those from Sri Lanka and Myanmar. Most stones were colour zoned, and homogeneously coloured examples were extremely rare. The general appearance of many of these sapphires can be improved by heat treatment.   E.S.

La saga peregrina (second part).
B. MOREL. *Revue de gemmologie*, 126, 1996, pp 4–6, illus.

•Continues the story of the celebrated pearl which formed part of the French crown jewels up to the time of the Revolution.   M.O'D.

California jade: a geological heritage.
A. PASHIN. *California Geology*, 48(6), 1995, pp 147–54, illus. in colour.

Both jadeite and nephrite occur in California and some of the principal deposits are briefly described with notes on specimen quality and local geology.   M.O'D.

Blue quartz from the Antequera-Olvera ophite, Málaga, Spain.
J.C. SILVA ROMERO. *Mineralogical Record*, 27, 1996, pp 99–103, illus. in colour.

Crystals of blue quartz are reported from an ophite near Málaga, Spain. Some of the crystals appear large and translucent/transparent enough to facet: they occur in an ophite (diabase with ophitic texture) found in the Triassic rocks located between the Antequera and Olvera regions of Andalusia. The blue colour is attributed to inclusions of aerinite, a calcium aluminium iron magnesium silicate carbonate of hydrothermal formation. The blue quartz crystals show an apparently dipyramidal habit whose formation is not yet accounted for.   M.O'D.

Mineraleinschlüsse—Indikatoren metamorpher Reaktionen. Mineral inclusions—a clue to metamorphic reactions.
W. SCHUBERT. *Gemmologie – Zeitscrift der Deutschen Gemmologischen Gesellschaft*, 45(1), 1996, pp 5–12, 8 photomicrographs, bibl.

Detailed studies of relict mineral inclusions can document the process of mineral-forming reactions during monometamorphic or polymetamorphic events. Petrological phase analyses and thermodynamic calculations will yield information about pressure and temperature conditions and activities of water and CO_2. Various examples are given, such as prograde formation of staurolite, garnet, kyanite and corundum + albite.   E.S.

Water-rock interaction on Zabargad Island, Red Sea – A case study: II. From local equilibrium to irreversible exchanges.
P.F. SCIUTO AND G. OTTONELLO. *Geochimica et Cosmochimica Acta*, 59(11), 1995, pp 2207–13.

Reaction kinetics in the quasistationary state of the alteration paragenesis of the peridotites in

this island are tentatively assessed. The highest (-ve) reaction rates of olivine gem formation occur in the zone of the thermal maximum coupled with a high (+ve) rate of chrysotile dissolution and (-ve) tremolite production; dolomite is near a balancing condition throughout the process.   R.K.H.

To the problem of nephrite-bearing properties of folded areas.
A.P. SEKERIN, N.V. SEKERINA, Y.A. LASHCHENOV AND YU.V. MENSHAGIN. *Bulletin of the Friends of Jade*, 9, 1996, pp 147–50, 1 map.

Commercial deposits of nephrite may be either apohyperbasite nephrite whose colours are various shades of green, or apocarbonate nephrite which shows white to light green colours. Notes are given on Russian nephrite deposits in the folded framework of the Siberian platform, accompanied by a nine-entry bibliography of Russian papers.   M.O'D.

The light-coloured nephrite of East Sayany.
N.V. SEKERINA, A.P. SEKERIN, YU.V. MENSHAGIN, AND V.A. LASHENOV. *Bulletin of the Friends of Jade*, 9, 1996, pp 143–6.

Light-coloured nephrite (white with various shades) occurs in the Sayan-Baikal Mountain area of Russia, in South Australia and in China, with a small deposit in the Kuraminski mountains of Uzbekistan. The alluvial deposits of China were once the main source of light-coloured material but they are now almost exhausted. Today the best qualities from the above locations are reported to be those specimens found in the Middle-Vitim Mountain area where deposits occur in the mid-flow of the Vitim River.

A promising nephrite source in Russia is East Sayan which is geologically favourable. Notes on this and on other Russian nephrite deposits are given, with a short bibliography including six papers in Russian.   M.O'D.

Recent gemstone production in North America [first part].
J. SINKANKAS. *Canadian Gemmologist*, 17(1), 1996, pp 18–22.

In a paper presented at the CGA Conference in Vancouver, Ontario, in October 1995, the author assesses the production and resources of gem material on the North American continent, including Mexico. In this portion of the paper

amber, ammolite, azurite/malachite, benitoite, beryl, calcite, coral, corundum, diamond, feldspar, fluorite, garnet, ivory, the jade minerals and lapis lazuli are discussed.   M.O'D.

Notes from a Singaporean laboratory.
TAY THYE SUN. *Australian Gemmologist*, 19(4), 1995, pp 178–81, 20 illus. in colour.

A white conch pearl known locally as a 'coconut pearl' displayed the typical 'flame' patterning on a smooth porcellanous surface. A rare elephant pearl (unattached denticle), claimed to have been recovered from inside the tusk of a Sri Lankan elephant, was 18.90 mm × 16.47 mm nearly void and weighing 24.93 ct. It had an SG 1.80, a spot RI value of 1.53 and showed a chalky white fluorescence of moderate intensity to long wave ultraviolet light. An amber imitation was readily recognized as plastic and even sported a modern ant as an inclusion. A polished water-worn pebble was an aggregate containing the rare Burmese jade-like mineral kosmochlor (formerly ureyite), spot RIs of 1.54 to 1.65 and an SG 2.72 were obtained and it was inert to ultraviolet light. A thin wafer of coloured jadeite had been coated with nail polish. A star sapphire looked natural but contained gas bubbles and curved colour banding indicating a Verneuil synthetic. Synthetic cubic zirconia melee resembled diamond but the single cut stones were chipped and poorly polished; a diamond probe gave a non-diamond reaction. A diffusion-coated ruby was claimed to be manufactured in Sri-Lanka.   R.J.P.

A history of pietre dure.
T. TROIANI. *Australian Gemmologist*, 19(4), 1995, pp 186–9, 8 illus. in colour.

Pietre dure (hard stones) are mosaic pictures or patterns made from gem materials commonly siliceous substances with a Mohs hardness of 6 or 7. Examples include jasper, chalcedony, quartz, agate, petrified wood, granite and porphyry, all of which were commonly used on Florentine mosaics. This art form was developed by the Opificio delle Pietre Dure which is now the National Museum in Florence, Italy.

At the time of the Renaissance, Florence was ruled by the Medici family who controlled the city from the fifteenth century to 1737 amassing a vast collection of jewels and works of art including mosaics. Mosaics from pre-Colombian Central America had turquoise as the favourite

working material, whilst one of the oldest modern mosaics, the 'Fight of the Macedonians and Persians' was found in Pompeii and identified as a copy of a lost painting by Philoxenus in about 300 BC. The Florentine mosaics reached such perfection that not only were the joins invisible but the finished product was sometimes indistinguishable from the brush strokes of an oil painter.

Created on 3 September 1588 the large building of the Opificio delle Pietre Dure is still in existence carrying on the operation of creating and restoring works in pietre dure.   R.J.P.

Jade in China.
CHUNYUNG WANG. *Bulletin of the Friends of Jade*, **9**, 1996, pp 121–42, 3 maps.

Up-to-date survey of the nephrite deposits of China with notes on the history of nephrite use and fashioning followed by a survey of Chinese deposits which are listed and described as carbonate-type or serpentine-type. Details of current nephrite production are given with particular references to Khotan jade, Manus jade, Altun jade and other deposits. A number of occurrences are described in relation to their geology and mineralogy and there is a bibliography containing references to 35 papers in Chinese, many of which are as yet unpublished, as well as Western-language items.   M.O'D.

Jade in Canada.
F. WARD. *Bulletin of the Friends of Jade*, **9**, 1996, pp 1–7.

A short survey of jade deposits in Canada with particular reference to deposits, recovery and sale of nephrite from British Colombia. Useful notes on marketing are given.   M.O'D.

Check-list for rare gemstones: kämmererite.
W. WIGHT. *Canadian Gemmologist*, **17**(1), 1996, pp 14–17, illus.

Review of the composition, properties, mode of occurrence and locations for the chromian clinochlore, kämmererite, occasionally cut as a gemstone.   M.O'D.

Zhou-Li.
References to jade in the *Zhou-Li* or Rites of Zhou, translated and assembled from the first French version...1851, by Herbert Giess. *Bulletin of the Friends of Jade*, **9**, pp 58–117.

[This is an analytical entry, the name given to a complete separate work published within an issue of a journal.]

The title-page of volume 1 of the first French translation published by Edouard Biot in 1851, precedes the complete text of the book in which small editorial changes have been carried out by the Editor of the *Bulletin*. The text deals with religious rituals in which jade ornaments played a significant part.   M.O'D.

Instruments and Techniques

The hazardous effects of refractometer contact fluid. A note.
T. LINTON. *Australian Gemmologist*, **19**(4), 1995, p. 185.

The recent replacement of the Anderson and Payne refractometer fluid in the UK and USA appears to be centred on the toxic and carcinogenic nature of the tetra-iodoethene component although di-iodomethane is also extremely toxic. Liquids containing halogeno-hydrocarbons must be treated with great care and this code of practice should be advertised and ideally learnt. A liquid with a refractive index of 1.81 is said to be stable and is currently undergoing evaluation tests in Victoria.   R.J.P.

Australian (1.81) refractometer fluid.
T. LINTON AND B. NEVILLE. *Australian Gemmologist*, **19**(5), 1996, pp 221–3.

During the past two years many Australian gemmologists have had to use a refractive index fluid with RI 1.79 and the recent marketing of a liquid with RI 1.81 to the original Anderson and Payne formulation has led to this appraisal. The fluid is made by saturating di-iodomethane with sulphur followed by mixing with tetraiodoethene. The mixture is filtered and washed with sodium carbonate to remove any residual acidic component which reduces the risk of etching the refractometer glass. The present liquid is light-stabilized by the addition of copper to the mixture to prevent the liquid from turning black. The toxicity of both di-iodomethane and tetraiodoethene have been examined and a code of practice drawn up for the use of liquids containing these compounds. Correct handling techniques should be taught to all users and the recommended use of disposable protective gloves appears to be highly appropriate.   R.J.P.

Metastable diamond synthesis—principles and applications.
C.-P. KLAGES. *European Journal of Mineralogy*, 7(4), 1995, pp 767–74.

Diamond chemical vapour deposition (CVD) technology has progressed considerably in the last 30 years; a multitude of deposition processes are now available to grow diamond films, and textured and hetero-epitaxial (on Si) deposition also has been achieved. New technological applications of diamond films, making use of their outstanding physical properties, are continuing to emerge. Simultaneously, there has been rapid progress in the understanding of which molecular species and physicochemical processes are relevant for CVD growth in the metastable diamond phase, mainly due to the development of data-bases of chemical gas phase reactions in C-H-O systems using the results of research on flames and combustion. The various growth processes and different applications of diamond films are reviewed.

R.A.H.

BOOK REVIEWS

Geology of Pakistan.

F.K. BENDER AND H.A. RAZA (eds), 1995. Gebrüder Borntraeger, Berlin. Distributed by E. Schweizerbart'sche Verlagsbuchhandlung, Johannesstr 3A, D–70176, Stuttgart. pp x, 414, illus. and with 5 loose folding maps in colour, hardcover. DM248.00, US$178.00. ISBN 3 443 11025 8. (*Beiträge zur regionalen Geologie der Erde.* 25.)

Following the excellent *Geology of Burma* (vol 16, 1983), Pakistan takes its place in this major series for whose outstanding components the publishers deserve great credit. While gemstones have their own section, [9.4] the text in general needs to be read to find out why Pakistan has produced so many gem-quality minerals. While the text is aimed at post-graduate level or at professional geologists rather than at undergraduates, and still less at gemmology students, nonetheless it is written sufficiently clearly for all to gain something useful on a slow and careful reading. The standard of illustration (incorporating Landsat images in colour) is first-class and the large-scale loose maps go a long way towards making up for the lack of Pakistan maps in the general market. The book is divided into eleven major chapters, each with its own author.

This type of overall country coverage falls into traditional order with mineral resources coming well after preceding chapters in which regional geology and tectonic units are described. Pakistan is uniquely blessed with dramatic beginnings, arising from the collisions of the Arabian plate in the south-west with the Eurasian plate in the north and north-west and the Indo-Pakistan plate in the south-east. From these tectonic events the Pakistan portions of the Karakorum, the western Himalaya, the Pamirs and the Hindu Kush mountain ranges were formed, giving the country some of the highest peaks in the world and surrounding areas particularly difficult to access.

The volcanic activity accompanying plate movement is the prime source of the mineralization in the Northern Areas of Pakistan and it is in these areas that emerald, aquamarine, ruby, spinel, tourmaline, garnet, epidote, turquoise, moonstone and some topaz are found. The very fine deep pink to purple topaz, a naturally occurring colour unique so far to Pakistan, is found in the North West Frontier Province. We can confidently expect further species to turn up, as did peridot a year or two ago, again from a very difficult site in the Northern Areas. The recovery of many species, particularly ruby, is still at a stage where fine-coloured but small crystals or larger heavily-included ones seem to be the rule: it is very likely that fine larger crystals will appear. The present reviewer, who in 1990 co-authored the standard book on Pakistan gemstones* with Dr Ali H. Kazmi, a major contributor to the present work, was very pleased to see mention of sites visited and explored at that time and also to note how many more sites had been worked.

A good guide to the usefulness of any book is the size and content of the bibliography. Here is an exceptionally good and welcome example, covering fifty pages and including many papers of gemmological interest. I strongly recommend visiting those (few) libraries which will buy this book.   M.O'D.

Minerales de las comunidades autónomas del país Vasco y Navarra.

M. CALVO REBOLLAR, F. GASCÓN CUELLO AND J.M. CAVIA ORTEGA, 1993. Museo de Ciencias Naturales de Alava, Vitoria (Alava). pp 156, illus. in colour, hardcover. Price on application. ISBN 84 7821 145 4. (*Monografías del Museo de Ciencias Naturales de Alava.* 2.)

Not all locality mineral books provide much for the gemmologist but this example is not only beautifully produced and illustrated, but includes photographs of crystals of some minerals that ought to be familiar. The crystals are shown in a manner that a gemmology text will never have space for: those who can find a copy of the book should look for the sphalerite crystal groups, for the calcite crystals and for crystals of amethyst. Perhaps best of all are the dark crystal diagrams which are included to illustrate important forms.

*[Kazmi A.H. and O'Donoghue, M., *Gemstones of Pakistan*, 1990]

The area covered lies in the eastern Pyrenees of Spain and the geology and mineralogy are fully described, with an excellent bibliography.

M.O'D.

Platinum by Cartier: triumphs of the jeweler's art. (*Translation of Cartier: joaillier du platine,* 1995.)
F. COLOGNI AND E. NUSSBAUM, 1996. Harry N. Abrams Inc., New York. pp 279, illus. in colour, hardcover. £65.00. ISBN 0 8109 3738 7.

This large and heavy book somehow suggests large, ornate and heavy pieces of jewellery made from platinum and set with the finest gemstones. The suggestion is borne out by the useful text and very high-quality colour photographs which reproduce many Cartier pieces set in platinum. The text is arranged chronologically, beginning with the garland style from its origins to 1914 and continuing with Art Deco jewellery and its geometric forms from 1915 to 1925. The next chapter describes Cartier's development of the *tutti frutti* style and of white Art Deco, together with a synthesis of eastern and western forms.

From 1940 to 1967 Cartier made naturalism one of their major themes with jewellery representing flowers and animals. Finally the new era period from 1968 towards the end of the century is marked by Cartier's use of platinum to an even greater degree and by the firm's line of new jewellery and of watches.

The book is a beautiful production, with excellent layout: there is a most useful chronology and a short bibliography. Students of jewellery design will find the colour reproduction of many Cartier designs of particular interest.   M.O'D.

Wonders within gemstones: the elusive beauty of gemstone inclusions.
A. DE GOUTIÈRE, 1996. Gemworld International Inc., 630 Dundee Road, Suite 235, Northbrook, IL 60062-2750. pp vii 135, illus. in colour, hardcover. US$49.95. ISBN 0 9641733 2 8.

There is a great deal of scope for many more books on inclusions and they do not all need to instruct. This one aims to delight and succeeds very well. Over 100 large colour photographs show inclusions in a variety of gem species. The arrangement appears to follow no particular pattern and since the captions are brief, readers need only turn through the pages to interpret the scenes in any way they like. Students in particular will find the book a lift to their imaginations,

a pre-requisite for any learning.

Readers interested in gemstone photography will welcome the details given by the author, who gives magnification and type of illumination for each picture and an account of technique and instruments used at the end of the main text. A brief classification of inclusions is also provided but is not really much help as the true story is far more complicated than gemmologists imagine. The list of references takes the reader a little further. One or two careless misprints do not spoil the excellent general effect and very reasonable price.   M.O'D.

New frontiers in diamonds: the diamond revolution.
D. DUVAL, T. GREEN AND R. LOUTHEAN, 1996. Rosendale Press, London. pp 175, hardcover. £30.00. ISBN 1 872803 21 0.

In recent years more areas have been prospected for diamonds than ever before and stories of 'the new boom locations' have proliferated, expanded and sometimes been denied. The book first considers diamond prospecting and recovery throughout the world and then turns to Canada, where new locations are being pursued with vigour. The third section is concerned with diamond prospecting and mining on the Australian continent and asks where the successors to the Argyle enterprise may be. Finally the authors ask about trends in diamond sales and project them to the year 2000. Appendices detail total rough diamond supply, diamond production at the major mines, a forecast of world diamond supply and demand, and Antwerp prices index.

This is a well-written and provocative book with clear signs of the journalistic background of the three authors. Co-operation among diamond producers is thought to be the way in which the diamond mining world will evolve over the next few years. On the marketing side the expansion of the Asian market is cited as one of the best things to have happened to the world diamond trade, which looks reasonably healthy to the authors in 1996.   M.O'D.

Amber, window to the past.
D.A. GRIMALDI, 1996. Harry N. Abrams in association with the American Museum of Natural History, New York. pp 216, illus. in colour, hardcover. £36.00. ISBN 0 8109 1966 4.

Although in size and general appearance the

book might be assumed to have a slight and insignificant text, this is not the case and the book successfully combines zoological, botanical, palaeontological and gemmological information, most of which has been brought up-to-date by specialists in those fields. While not setting out to be a gemmological textbook, the student will be stimulated to find out more about a material which is often not well covered by standard texts and the connoisseur will find delight in the items depicted in the first-class colour and black-and-white photographs. The book first discusses the nature and properties of amber and introduces non-amber resins from the start: there is a good deal of information on contemporary resins and I found this part useful.

The text then describes the major amber deposits of the world covering Mesozoic, Tertiary, Baltic, Dominican Republic and Mexican material: the tree species involved in amber production, the insect and other populations of amber and the topical discussion of DNA from amber inclusions are all worked through before amber imitations and forgeries are described.

The second section describes the use of amber in art and proceeds in chronological order from the Mesolithic period through the Bronze Age to classical, medieval, renaissance and 17th–19th century artefacts. There are sections on the Amber Room and on Asian ambers.

The book ends with a quite useful bibliography. It can be recommended for a wide readership and the price is by no means high for a book of so high a standard. M.O'D.

Vases and volcanoes. Sir William Hamilton and his collection.

I. JENKINS AND K. SLOAN, 1996. British Museum Press for the Trustees of The British Museum, London. pp 320, illus. in colour, softcover. £25.00. ISBN 0 7141 1766 8.

Sir William Hamilton is known to connoisseurs for his collections, formed in Naples where he was British Ambassador, and to the public at large for his second wife Emma who eventually became the mistress of Horatio, Lord Nelson. Hamilton's time in Naples coincided with a flowering in that city of all kinds of cultural activities. At that time, too, eruptions of Vesuvius and the discovery of the buried city of Pompeii resulted in the discovery of antiquities on a large scale. Hamilton made collections which included objects recovered from Pompeii together with a large number of artefacts of all kinds: they were offered to the British Museum in 1772 for £8,400, a large sum for those days. So large an acquisition helped to broaden the collections of the Museum which had hitherto been richer in written and printed materials and in natural history. Hamilton's gifts to the Museum continued for many years and the objects he brought there became one of the sources of a growing interest in classical times and their artistic productions.

While the catalogue contains examples of polished rocks and lava from Vesuvius, gemmologists and historians of ornament will take considerable interest in the items of jewellery that Hamilton collected. His first bequest included a few cameos though more came to the Museum later on. From the latter group James Tassie selected some items for reproduction in both sulphur and white glass impressions: the catalogue illustrates some of the finest original cameos and also two trays of sulphur impressions attributed to Tassie. The collections also contained groups of Egyptian scarabs and sealstones as well as of hardstones set in rings and of intaglios.

Each item described in the catalogue is well illustrated with the expected high standard of photography and reproduction. Details of size, type and provenance are given and full references are made to supporting literature. The book ends with a glossary and a general bibliography. This is an excellent starting-point to any study of British interest in classical antiquities. M.O'D.

Mineralogy of Maine. Vol. 1. Descriptive mineralogy.

V.T. KING AND E.E. FOORD, 1994. Maine Geological Survey, Department of Conservation, Station #22, Augusta, Maine 04333, USA. pp xi. 418, illus. in colour, softcover. US$40.00. inclusive of postage.

While this account of the minerals of Maine needs consideration as a location mineralogy, gemmologists will (or should) equate Maine with tourmaline and purple apatite and sure enough a photograph of apatite from the Pulsifer quarry at Auburn is on the front cover. Turning to the illustrated section, the book breaks new ground by including a set of excellent black-and-white pictures of mineral specimens, among which are crystals of a number of gem species. The colour photographs naturally include Mount Mica and Dunton quarry (Newry) tourmalines and show once more what beautiful

crystals they are. Gemmologists once having seen the pictures should look for a bibliography and here we have a very comprehensive one.

The bulk of the text is occupied by the descriptive section in which Maine mineral species are arranged and described in alphabetical order. While name and chemical composition are given, details of properties are not exhaustively covered, the text giving copious details of Maine occurrences and references instead. This is a wise decision since locality information of this quality might very well not find an alternative outlet and access to papers in which a particular species is fully described should not be too difficult. For elbaite there are 25 pages of occurrence description! Where crystal morphology is of particular interest, however, the entries include diagrams.

There is an index and an alphabetical list of townships down to the smallest identifiable places: the list is accompanied by a map on which the print is rather small – my only criticism of an excellent book whose second part I await eagerly.   M.O'D.

Le diamant dans tout son éclat.
F. KOSTOLANY, 1992. Hachette, Paris. pp 159, illus. in colour, hardcover. £33.50. ISBN 2010166183.

A general survey of diamond with examples of set jewellery, loose stones and crystals, the whole book well-illustrated in colour but with an overall dark appearance which begins with the end-papers showing colourless faceted diamonds against a black background. From stories of diamond in the East the text ranges over the properties which make the stone desirable, famous diamonds and the diamond market, to accounts of important pieces of diamond-set jewellery. The last chapters deal briefly with imitations of diamond and ends with a quiz with interesting and useful questions. There is a very short bibliography.

While the book is one of many such, the presentation is attractive and the illustrations good.
                                                                                      M.O'D.

Collectable beads: a universal aesthetic.
R.K. LIU. 1996. Ornament Inc, Vista, California [distributed in the UK by Thames and Hudson]. pp 256, illus. in colour, hardcover. £30.00. ISBN 0 9641023 0 7.

The study of beads has been helped by more than one book published in the last few years

and while they have been of variable quality, all have contained useful text and attractive pictures. This example is particularly well illustrated and the text concise and carefully matched to the photographs. The coverage is arranged by area: thus Africa, China and Taiwan, the Indian sub-continent and its near neighbours, the Pacific countries, the Middle East and North Africa, Precolumbian Americas, the Americas and Europe. The book ends with illustrations of contemporary necklaces and beads, with fakes and simulations and with notes on bead collecting. There is a really first-class bibliography, a useful glossary and a short list of bead-collecting organizations, not confined to the United States.

At the price you could hardly do better than this: while the text is naturally not aimed at the scholar, some readers will be sufficiently inspired to take their studies further and while one or two entries in the glossary are not quite accurate, the mistakes are slight and the book as a whole is well worth buying.   M.O'D.

The Amber Room. [A novel.]
C. MATTHEW, 1995. Sinclair-Stevenson, London. pp 390, hardcover. £14.99. ISBN 1 85619 447 7.

Some interesting and probably accurate details are given of the history of the Amber Room, once a feature of Pushkin, Russia. Included among descriptions of the fairly hectic activities taking place are notes on amber as an ornamental material, on its various imitations and how they may be detected.   M.O'D.

Environmental geology.
B.W. MURCK, B.J. SKINNER AND S.C. PORTER, 1996. John Wiley & Sons Inc., New York. pp xviii, 535, illus. in colour, softcover. £19.99. ISBN 0 471 30356 9.

Gemmologists looking for a textbook which explains geological formations on Earth, the solar system and planetary evolution, the dynamic Earth, mineral formation and properties, volcanic eruptions, energy resources and how to make use of them and a whole range of allied topics will find an excellent coverage in this undergraduate-level textbook whose main theme is the environment. Readers should not be put off by the title: in the various sections, some at first sight not immediately applicable to minerals, let alone ornamental species, is a great deal of information of the 'I always wanted to know

what that meant' kind. As so often happens, consulting a foreign topic enlightens dark areas of your own field of study. The study of gemstones can easily become a parochial subject – there is an Earth outside.   M.O'D.

Diamond ring buying guide. [fifth edition.]

R. NEWMAN, 1996. International Jewellery Publications, Los Angeles. pp 140, illus. in colour, softcover. US$14.95. ISBN 0 929975 24 3.

This book improves on its predecessors, which are also of high quality, by the inclusion of chapters on the filling of diamond and on synthetic gem-quality diamonds. The colour photographs, too, have been revised and now include examples showing how diamonds are graded – these are the best I have seen – and of a selection of setting styles. As always, chapters end with some pertinent questions (all placed together at the end this time), there is a useful bibliography and the author displays a genuine talent for spotting just the points you want to know, unlike most computer manuals which invariably miss just that one thing!   M.O'D.

The gold jewelry buying guide.

R. NEWMAN, 1993. International Jewelry Publications, Los Angeles. pp 172, illus. in colour, softcover. US$19.75. ISBN 0 929975 19 7.

Another book by Renée Newman in the excellent *Newman's Gem guides* series, this study of the buying and selling of all types of gold jewellery should join its companions on the counter and in the loftiest of salerooms. Few books can be read from end-to-end but I found it possible to do so in this instance. Gemmologists will find the wealth of information on gold and on the setting of stones in and with gold fills a serious gap left by almost all gemmological texts.

The book begins with a survey of gold as a precious metal, describing systems of weighing, a brief note on hallmarks, a list of terms used for imitation gold, followed by descriptions of nugget gold jewellery and decorative finishes. The chapter ends with a quiz, an arrangement used in all the *Newman's Gem guides* and very useful.

The next chapter describes manufacturing methods, including lost-wax casting, stamping, electroforming, hand fabrication and handmade jewelry and succeeding chapters deal with judging the mounting and the setting and with gold chains. Gemmologists will be interested on 'real gold or fake?' and in determining carat value.

Final sections of this first-rate book cover gold colours, gold coin jewellery, valuing gold jewellery and how to look after it. There is a short bibliography, and the coloured and black-and-white pictures are workmanlike. If you don't know which type of chain is the most difficult to repair properly (I didn't know) you should buy this book. Gemmologists should buy it anyway.
M.O'D.

Chaumet, master jewellers since 1780.

D. SCARISBRICK, 1995. Alain de Gourcuff Editeur, Paris. Distributed by Art Books Distributors Ltd, P.O. Box 281, Lincoln, LN1 2AT. pp 366, illus. in colour, hardcover in lidded and hinged box. £125.00. ISBN 2 909838 10 2.

Drawing on the rich archives of the firm, this is the scholarly study *par excellence* of a major jewellery house. Chaumet's account books date back to 1836 and the archives also contain drawings, models and pieces of jewellery. The firm were jewellers to Napoleon, who enabled a slightly obscure jeweller and watchmaker, Marie-Etienne Nitot, to become one of Europe's greatest nineteenth-century craftsmen and retailers. Beginning with a commission to catalogue the jewels and other ornamental possessions of Marie-Antoinette, Nitot later asked that confiscated valuables should be kept as teaching examples for the jewellery makers. This successful suggestion shows Nitot's rise from a position of influence from 1793, the date of the commission, to that of the acknowledged Napoleonic jeweller: his commission to make the consular sword marked a point from which he never looked back. His parures, Scarisbrick tells us (and the illustrations emphasize the message) were outstanding for their brilliance, using gemstones and pearls in profusion: he was able to draw on the Trésor de la Couronne, formerly dispersed and later largely reunited on Napoleon's orders and he also acquired a number of stones, celebrated at the time, by shrewd bargaining with officials and trade rivals, his progress continuing to attract the interest and patronage of the Emperor.

This wonderful beginning sets the scene for a series of celebrated productions – the Consular Sword and jewels for the Empress Josephine and her successor the Empress Marie-Louise. But Nitot did not only create magnificent jewels for French Imperial and aristocratic wearers: his reputation led to commissions for a tiara for Pope Pius VII and for Maximilian I of Bavaria's crown.

Such progress could not have been possible without the recruitment of the best craftsmen and Nitot clearly recognized excellence in this field when he encountered it. With this and with judicial marriages the firm retained the premier position as jewellers to the Empire until it ended in 1814.

The end of the Empire also marked the firm's transfer by bequest to Fossin, the head of the workshop. Jean-Baptiste Fossin and his son Jean-Jules François Fossin continued to produce fine jewellery over the period from the Bourbon restoration to the fall of the July Monarchy. Sculptors as well as jewellers, the Fossons served the new aristrocracy well and opened a branch in London which was to be visited by Queen Victoria in 1849 when some sales were made by its owner, Jean-Valentin Morel, who had followed his father Prosper, successor to Jules Fossin. The branching-out of the business away from France was due not only to London's preeminent position in the trading world but to a decline in French sales during and after the revolution of 1848.

In 1875 Marie Morel married Joseph Chaumet, thus introducing a name inevitably destined to become associated with the concept of the finest jewellery. Chaumet was a jewellery craftsman of the highest order who made a serious study of gemstones and pearls. The work of Chaumet quickly increased its sales world-wide and the firm prospered until the war of 1914 which slowed business down. After 1918 there were not many years in which to aim for pre-war levels of prosperity and the depression in 1929 forced the closure of the New York office which had opened only five years before. The London shop re-located to cheaper premises but gradually things improved, designs keeping in touch with changes of fashion and managing to achieve a simplicity which matched that of contemporary clothes.

A similar slow-down and regeneration followed the second world war. In 1987 Jacques and Pierre Chaumet resigned from their joint managing directorships and the company is now controlled by an international financial group: its present name is Chaumet International SA. Fine jewellery is still made and sold.

This is a magnificent account of one of the world's great jewellers. The text is uniformly lucid and the illustrations, depicting both jewels, designs and personages are the best quality possible today: the type-face is especially readable.

There are exhaustive references to both pieces and archives and there is a good bibliography.

In its attractive lidded box, the book could almost be one of Marie-Etienne Nitot's own productions.　　　　　　　　　　　　M.O'D.

Exploring Australia's mining heritage. A visitor's guide.

W.G. SHACKLETON AND M.N. BINNIE, 1995. Osmond Earth Sciences, P.O. Box 658, Kent Town, South Australia 5071. pp 118, illus. in black-and-white, softcover. Overseas orders US$14.95 plus US$5.50 economy airmail or US$3.40 sea mail. ISBN 0 949116 05 X.

The title somewhat conceals a very useful directory of Australian mine sites and mining museums, arranged by state and then alphabetically. Each entry gives means of access, telephone number, contact names and telephone numbers, hours of opening and other facilities. Many sites are illustrated. Among those likely to be of interest to gemmologists are several in the Anakie sapphire district in Queensland, the Lightning Ridge and White Cliffs opal districts in New South Wales and the Andamooka and Coober Pedy opal mine sites in South Australia. Mineral collectors will find almost all the entries useful, many dealing with gold mines. The book concludes with a chronological table of significant dates in Australian mining history, a glossary of mining and mineral treatment terms and a short bibliography. A second edition is promised for mid-1996 and will certainly be welcome, since there must be far more sites to cover! This is a well-produced book and very competitively priced.　　　　　　　　　M.O'D.

Jewelry in Europe and America: new times, new thinking.

R. TURNER, 1996. Thames and Hudson, London. pp 144, illus. in colour, softcover. £14.95. ISBN 0 500 27879 2.

Published to mark the occasion of the exhibition *Jewelry in Europe and America: new times, new thinking*, this book briskly covers the periods 1940-1980 in America, 1945-1970 in Europe (recovery and reconstruction), 1970-1980 (crosscurrents in Europe) and finally the present time – 'in pursuit of savage luxury'. These headings suggest an idiosyncratic choice of pieces, a choice made all the more critical by the relatively small size of the book. A preliminary section introduces and explains the choice of items included, which are well reproduced. There is a

comprehensive bibliography and brief biographical notes on the artists whose work is included in the exhibition. As a study of jewellery trends this is a good starting-point.   M.O'D.

Fabergé in America.

G. VON HABSBURG, 1996. Thames and Hudson, London. pp 366, illus. in colour, hardcover. £32.00. ISBN 0 500 01699 2.

An exhibition *Fabergé in America* was organized by the Fine Arts Museums of San Francisco and the Fabergé Company during 1995 and is scheduled to tour the United States during 1996. The present book is a catalogue of the exhibition (celebrating the 150th anniversary of the artist's birth) and contains a great deal of biographical and commercial information as well as the catalogue itself.

In the catalogue each item is illustrated in colour, the entry giving provenance, bibliography, exhibitions, details of the work and materials used, name of maker and workshop, date of manufacture and size. The quality of the illustrations is excellent. Two most valuable appendices deal with 'Fauxbergé' (forged artefacts) and how to recognize them (the New Brunswick Museum received a gift of 100 such items in the 1980s and was caught out, later displaying false and genuine items side-by-side as a courageous comeback). Some of the false objects are illustrated here. The second appendix describes acquisitions made by Americans at Fabergé's London shop 1907–1917.

American readers will of course find the book essential but at the very competitive price I can recommend it to all students of jewellery.
M.O'D.

Fashion beads.

S. WITHERS, 1996. Thames and Hudson, London. pp 128, illus. in colour, hardcover. £12.95. ISBN 0 500 01697 6.

A pleasantly-written and well-illustrated book which covers its subject in a painless and imaginative way. The aim is that readers will learn to make their own decorative beadwork and jewellery on the basis of 45 designs taken from the jewelled artefacts of different periods and civilizations and in this the author succeeds. The standard of illustration is good, especially for the very reasonable price.   M.O'D.

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

PHOTOGRAPHIC COMPETITION

The third GAGTL Photographic Competition on the theme 'Images in gems' attracted a record entry with a large number of beautiful pictures. After considerable deliberation the judges awarded the three prizes as follows:

First Prize –   Mr S.J.A. Currie, FGA, of New Zealand

Square-eyed owl on a branch (see front cover)

Second Prize –   Mrs H. Hubberstey, FGA, of Northern Ireland

'Hummingbird' in amber

Third Prize –   Mr R.J. Maurer, FGA, DGA, of Redhill

Flower carved in amethyst

The three prize winners receive awards of £100.00, £75.00 and £50.00 respectively and plans are advanced to include these pictures and a selection of other fine entries in the 1997 GAGTL calendar.

Second prize

Third prize

OBITUARY
Antonio C. Bonanno FGA, MSA, MGA

We are sad to report the death on 28 March of Antonio C. Bonanno after a long illness. He was 79 and for more than 50 of those years was a leader in the field of gemmology. 'Tony' Bonanno was one of America's best loved and most respected gemmologists.

His accomplishments reflect a lifelong love of gems and jewellery, a passion for scientific research and education, and a commitment to honesty, integrity, and high standards. During World War II he created a special vocational training programme teaching lapidary and gemmology to disabled veterans. A native Washingtonian, he founded one of the country's first schools of gemmology over 40 years ago, Columbia School of Gemology in Washington, DC, and one of the country's first gem testing laboratories, National Gem Appraising
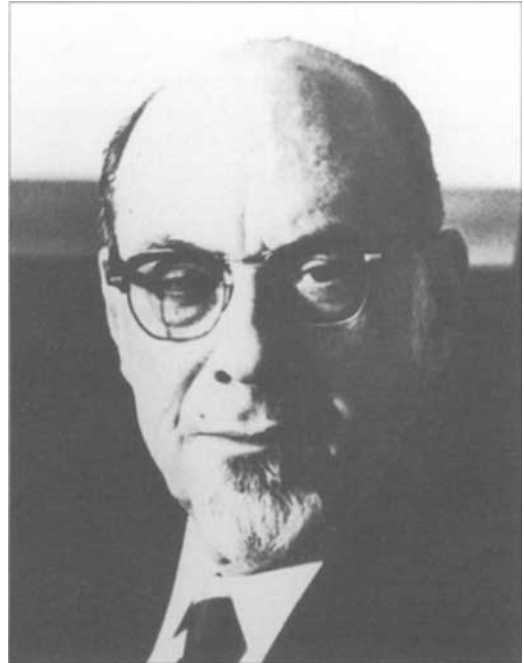
Laboratory. He served as Director of both until the onset of his illness. He appraised and taught beyond the call of duty, giving his precious, valuable knowledge to anyone who asked for it. In addition to the laboratory and school, he was Co-Editor of the Gemology Column for *National Jeweler* magazine from 1986–1994, and co-authored four highly acclaimed books in the field. He was a specialist in forensic gemmology and was active in many local, national, and international gem, mineral and lapidary organizations. In 1974 he founded the Accredited Gemologists Association (AGA), a national organization committed to expanding education and establishing standards of professional and ethical conduct in the field of gemmology. A distinguished Fellow of the Gemmological Association of Great Britain and Master Gemologist Appraiser of the American Society of Appraisers, he was also a chemist, photographer and appreciated the great outdoors.

He is survived by his wife Ruth Bonanno of Fredericksburg, VA, two sons, four daughters, one granddaughter, four grandsons and two great-granddaughters.

This tribute was assembled from contributions by Anne Ferrara Dale and Stuart Matlins.

Miss Jillian Glen, FGA, DGA (D. 1980, DGA 1981), London, died on 20 April 1996.

Mr Frederick E.J. Hewitt, FGA (D. 1956), Ormskirk, died on 1 May 1996.

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

Joris Hofelt, FGA, of Utrecht, The Netherlands, for hyalite from the Czech Republic.

Mrs Ameena Kaleel, FGA, D.Gem.G., of Mount Lavinia, Sri Lanka, for specimens of corundum, sinhalite, rutile, kornerupine, spinel, quartz and tourmaline.

Yasushi Takahashi, FGA, Kofu, Japan, for anorthite crystals from Miyake Island, Tokyo, and Yoichi, Hokkaido, Japan.

Jesse Williams for garnet, rough and faceted, from northern Idaho, USA.

NEWS OF FELLOWS
After ten years working in the laboratory, Nick Sturman is leaving the GAGTL to take up a position with the Bahrain Government in their gem testing laboratory. For the past four years Nick has been seconded to the Bahraini laboratory from the GAGTL and has been a regular contributor to the *Journal* with his Notes from the 'Gem and Pearl Testing Laboratory, Bahrain'.

Michael O'Donoghue gave a talk on synthetic and treated gemstones to the Wessex branch of the National Association of Goldsmiths on 24 April 1996.

MEMBERS' MEETINGS
London
On 3 April 1996 at the Gem Tutorial Centre, 27 Greville Street, London EC1N 8SU, Arthur Woolgar gave an illustrated talk entitled 'Bringing gems to the market place'.

On 30 April at the Gem Tutorial Centre Mr S. Akamatsu of K. Mikimoto & Co. Ltd. gave an illustrated talk entitled 'Cultured pearls: past present and future'. A report of the talk was published in *Gem and Jewellery News*, 1996, 5, 3.

On 8 May at the Gem Tutorial Centre Dr Jamie Nelson gave a talk and demonstration entitled 'Identifying inclusions within gemstones'.

On 10 June at the Gem Tutorial Centre the Annual General Meeting was held, followed by a Reunion of Members and Bring and Buy. A full report of the AGM will be published in the October issue of the *Journal*.

On 14 June the Annual Trade Luncheon was held in the Portland Suite of the Langham Hilton Hotel, Portland Place, London W1. The speaker was Mr Naim Attallah, formerly Group Chief Executive of Asprey's. A report of his address will

appear in the September issue of *Gem and Jewellery News*.

Midlands Branch

On 26 April at the Discovery Centre, 77 Vyse Street, Birmingham 18, the Annual General Meeting was held at which Gwyn Green and Elizabeth Gosling were elected Chairman and Secretary respectively. The AGM was followed by a talk by Mr D.H. Ariyaratna.

On 19 May members visited the Dolgellau Gold Mine in north Wales.

Gem Clubs were held on 14 and 28 April and 5 May.

North West Branch

On 15 May at Church House, Hanover Street, Liverpool 1, Rosamond Clayton delivered an illustrated presentation entitled 'Jade past and present' to a packed house. The opening notes were on the ancient history of jade, its uses in acts of worship, power, status, ritual activities (4000 BC to AD 1000), and on the proper excavation of jadeite (eighteenth century). Amongst exceptional pieces of jewellery with fine carvings shown on slides were necklets, bangles, hair ornaments and brooches. Auction prices for some of the pieces ranged from £650 to above £120,000. Items dated from as early as 221 BC to the present time.

Retailers, registered valuers, students and other interested persons attended the talk. Some of those present had brought items to determine their authenticity, and some pieces were passed around for closer inspection of particular features.

Scottish Branch

A weekend of Scottish gemmology was held in Perth on 19 to 21 April. The Annual General Meeting was held on 20 April when Brian Jackson and Joanna Thomson were elected Chairman and Secretary respectively. Talks and practical sessions were given by Alan Hodgkinson and the weekend culminated in a field trip to quarries near Dundee where members were able to collect agates and quartz specimens. A full report of the weekend was published in *Gem and Jewellery News*, 1996, 5, 3.

On 19 May a lapidary session was held at the National Museum for Scotland Research Centre, Edinburgh, when members had the opportunity to cut the specimens they had collected on the field trip.

1996 CALENDAR

On the October page of the 1996 calendar we regret that an error occurred in the caption to the illustration, which should read 'Carved rubellite lip perch brooch by Stephen Webster. Photograph by Robert J. Maurer, FGA, DGA'. We apologize for this confusion.

ANNUAL REPORT
The following is the report of the Council of Management of the GAGTL for 1995.

The Gemmological Association and Gem Testing Laboratory of Great Britain (GAGTL) is a company limited by guarantee and is governed by the Council of Management. E.M. Bruton continued as President, and A.E. Farn, D.G. Kent and R.K. Mitchell are Vice Presidents. The activities of the company benefited greatly from the contribution of other major Councils and Committees; Dr G. Harrison Jones continued as Chairman of the Board of Examiners, D.G. Kent retired from the Board after sixteen years' service and three new appointments were made: Ms A. Good, Mrs C.J.E. Hall and Mrs G. Howe. C. Winter continued as Chairman of the Members' Council and D. Gann took over the Chair of the Trade Liaison Committee from J. Kessler. The annual Education Review Meeting provided a very useful forum to exchange information between teachers, examiners and staff of the Association and is of great benefit in monitoring progress.

During 1995 the GAGTL continued to grow and can report a successful financial year. The Laboratory was completely refurbished and a new X-ray machine was installed to maintain and develop its world-renowned expertise in pearl identification. The licence to issue GIA diamond grading reports came to an end in September and a programme to promote the London Diamond Report has commenced; in addition the Laboratory continues to issue CIBJO reports. Identification and origin reports for rubies, sapphires and emeralds continue to form a significant part of the Laboratory's work. After 16 years with the Laboratory E.C. Emms resigned from GAGTL at the end of November to pursue his own interests and the Council wishes him every success in the future.

The GAGTL staff member N. Sturman, seconded to the Gem and Pearl Testing Laboratory in Bahrain, continues to provide a valuable, fully active service and, in collaboration with staff of that Laboratory, produced an account of highlights of their work which was published in the *Journal of Gemmology*.

The gemmology courses established in 1994 at the Gem Tutorial Centre in Greville Street are fully subscribed for the academic year 1995–6. The members' evening study and research group, led by M.J. O'Donoghue, is also expanding and a very successful members' tour of Idar Oberstein was conducted in March. Travelling workshops were held in Scotland, Ireland and England, and an expanded programme is planned.

There was an increase of 8 per cent in students entering for the examinations in 1995 and pass rates in the preliminary Gemmology and Gem Diamond examinations were higher than in 1994. In contrast, the Diploma in Gemmology examinations produced lower than average results and the Tully Medal was not awarded.

Gemmological Instruments Limited occupies a designated area on the second floor of the Greville Street building where visitors can buy and receive advice on the instruments, stones and books on display. Turnover compared with 1994 showed a slight increase, and it is felt that there is room for expansion; a shop window has been installed at street level and efforts will be made to increase both home and overseas business by mail order.

The GAGTL again exhibited at the American Gem Trade Association Fair in Tucson, Arizona, and also at the International Jewellery Fair in Basle, Switzerland. Education staff also attended the Hong Kong jewellery Fair in September before visiting the Allied Teaching Centre in Wuhan, People's Republic of China, where I.F. Mercer presented diplomas to candidates successful in the GAGTL examinations.

The theme of the GAGTL annual conference in October was 'Gemmology in Britain'. Alan Hodgkinson opened the conference with 'The Gemstones of Scotland'

FORTHCOMING MEETINGS

London

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

4 September	**The importance of gems in Brazil's development**	John Kessler
20 November	**The mystery of opal**	David Gallaghan
4 December	**Burmese gems at the Natural History Museum**	Cally Hall

GAGTL Conference
Exceptional Gems

The 1996 Annual Conference is to be held on Sunday 13 October at the Scientific Societies Lecture Theatre, New Burlington Place, London W1.

Extraordinarily beautiful and rare gemstones and methods of cutting to produce a truly outstanding specimen have inspired the theme of this year's Conference 'Exceptional gems'. The keynote speaker will be Dr H. Bank from Idar-Oberstein, Germany.

As well as a full programme of lectures, delegates will be able to enjoy displays of the gemmology of exceptional stones.

For further details contact Mary Burland on 0171–404 3334.

Midlands Branch

Monthly meetings will be held at the Discovery Centre, 77 Vyse Street, Birmingham 18 (directions to the Sunday Gem Club available on request). Further details available from Gwyn Green on 0121–445 5359.

27 September	**The Beta appraiser; a new computer program for valuers**	
		John Henn
25 October	Talk by Eric C. Emms	

North West Branch

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

18 September	**Brush up your gemmology**	Deanna Brady
16 October	**Second-hand and antique jewellery, and all you need to know about it**	Richard Digby
20 November	**Annual General Meeting**	

Scottish Branch

For details of Scottish Branch meetings contact Joanna Thomson on 01721–722936 or Ruth Cunningham on 0131–225 4105.

and the British theme was continued by Helen Fraquet with the 'Amber of East Anglia' and then David Lancaster on 'Victorian gem-set jewellery'. Stephen Kennedy described the new X-ray set and its use in the London Laboratory and Ian Mercer reviewed the early days of gemmology in England. With 'Gemmological eye-openers', Alan Hodgkinson rounded off a full day's programme attended by members and visitors from 14 countries.

The presentation of awards was again held at the Goldsmiths' Hall by kind permission of the Worshipful Company of Goldsmiths. The President, E.M. Bruton, was in the chair, and the successful students in the gemmology and gem diamond examinations received their diplomas and prizes from the author and well-known gemmologist P.G. Read.

A revived Scottish Branch commenced its meetings programme in the spring and they, the Midlands and the North West Branches have all had a successful year.

Gem and Jewellery News, the joint production of GAGTL and the Society of Jewellery Historians, continues to be a lively forum for news of interest to our members, and the *Journal of Gemmology* continues to attract and publish papers on new materials and ideas in gemmology. Volume 24 was completed in October and with 624 pages is the largest to date.

The 1995 GAGTL photo competition produced a very good response and, again, what were judged to be the best contributions were reproduced in the calendar for 1996, which was distributed free to all members. Membership continues to increase and at 31 December stood at 3600.

The Council of Management wishes to thank all the staff for their dedication and hardwork throughout the year, and is indebted to all those who volunteered their time and expertise so willingly to serve on the many committees.

GEM DIAMOND EXAMINATIONS

In January 1996 19 candidates sat the Gem Diamond Examinations overseas of whom 12 qualified. The names of the successful candidates are listed below:

Chan Kwok Keung, Kowloon, Hong Kong.
Cheng Tak Min, Kowloon, Hong Kong.
Cheung Sung, NT, Hong Kong.
Francis Chow Chun Wai, Kowloon, Hong Kong.
Jin Lunwen, Wuhan, China.
Lam Kwai Fat, NT, Hong Kong.
Lee Yuan, Wuhan, China.
Li Liping, Wuhan, China.
Li Zihui, Wuhan, China.
Lo Lai Shan, Kowloon, Hong Kong.
Ng Wai Man, Kowloon, Hong Kong.
Yip Yick Hing, Brenda, Kowloon, Hong Kong.

The UK candidates who qualified were published in the April issue of the *Journal*.

EXAMINATIONS IN GEMMOLOGY

The names of the successful overseas candidates, additional to those published in the April issue of the Journal, who sat the Examinations in Gemmology held in January 1996, are as follows:

Qualified with Distinction
Ding Qian, Suzhou, China.
Liu Xu, Wuhan, China.
Mao Yanying, Wuhan, China.
Wu Yaoxing, Wuxi, China.

Qualified
Yik Pun Chan, Hong Kong.
Chan Kar Ming, Grace, Kowloon, Hong Kong.
Chan Yue Kwan, Joyce, NT, Hong Kong.
Binghui Chen, Guangzhou, China.
Chu, Terry, Kowloon, Hong Kong.
Guan Zichuan, Wuhan, China.
Hao Hui, Wuhan, China.
He Lin, Wuhan, China.
Ho Suk King, Betty, Kowloon, Hong Kong.
Hsieh, Chung Wei, Taipei, Taiwan, ROC.

GAGTL GEM TUTORIAL CENTRE

27 Greville Street (Saffron Hill entrance), London EC1N 8SU.

9 October — **Preliminary Workshop**
A day of practical tuition for Preliminary students and anyone who needs a start with instruments, stones and crystals. You can learn to use the 10x lens at maximum efficiency, to observe the effects and results from the main gem testing instruments and to understand important aspects of crystals in gemmology.
Price £47.00; GAGTL students £33.49 (including sandwich lunch)

10 October — **Introduction to Gemstones**
A day to look into the beautiful world of gemstones. Hold the gems in your hand and discover the individual qualities and characteristics that make them so prized.
The price is only £47.00 for the day (including sandwich lunch)

30 October — **Enquire Within : Emerald**
A valuable and concentrated look at all aspects of emerald: natural rough and cut stones, treated, synthetic and imitation stones.
Price £111.63 (including sandwich lunch)

5 and 6 November — **Synthetics and Enhancements Today**
Are you aware of the various treated and synthetic materials that are likely to be masquerading amongst the stones you are buying and selling? Whether you are valuing, repairing or dealing, can you afford to miss these two days of insights, tips and practical investigation?
Price £223.25 (including sandwich lunches)

20 November — **Review of Diploma Theory**
A day for Gemmology Diploma students to review their theory work and to prepare for the Diploma theory examinations. Find out about our tips on the consolidation and revision of facts, figures, principles, practical techniques and instruments.
Let us help you to review your examination technique with the help of past questions. This review would help students who intend to enter the Diploma examination in 1997.
Price £33.49 (including sandwich lunch)

27 November — **Enquire Within : Ruby and Sapphire**
A day looking at all aspects of these gems – natural, treated, synthetic and imitation.
Price £111.63 (including sandwich lunch)

7 and 8 December — **Weekend Diamond Grading Revision**
This intensive weekend course has been designed for all students about to take the Gem Diamond Diploma. This workshop will include a mock examination to help students gain familiarity and confidence with examination conditions.
Price £129.25

NOTE: All prices include VAT at 17.5%
Please ring the Education Office (0171–404 3334) for further information

Lam Yiu Ming, Tsing Yi, Hong Kong.
Leung Siu Ha, Sue, Mongkok, Hong Kong.
Liao Zongting, Shanghai, China.
Lim Sau Kuen, Hong Kong.
Lin Xuefang, Wuhan, Hubei, China.
Luo Huabao, Wuhan, Hubei, China.
Ma, Annie Yiu-Chu, Hong Kong.
Ma, Sui Shan Tina, NT, Hong Kong.
Ma, Lien-Chen, Taiwan, ROC.
Qiu, Zhili, Guangzhou, China.
Tang, Deping, Wuhan, China.
Tian, Liangguang, Wuhan, China.
Xu, Hainan, Wuhan, Hubei, China.
Yan Chun Wai, Danny, NT, Hong Kong.
Yang, Ruzeng, Wuhan, China.
Yao, Teng-Long, Taipei, Taiwan, ROC.
Yeh, Chen-Mei, Taipei, Taiwan, ROC.
Yuyan, Yuan, Wuhan, Hubei, China.
Zeng, Chunguang, Shanghai, China.

MEETINGS OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 10 April 1996 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Transfers – FGA to FGA/DGA

Chan, Kwok Keung, Kowloon, Hong Kong. 1994/1996
Lee, Yuan, Wuhan, Hubei, China. 1995/1996

Transfer – DGA to FGA/DGA

Chan, Yik Pun, Hong Kong. 1996/1995

Fellowship

Can, Cao, Anhui, China. 1995
Clay, Gretchen, Boston. 1995
Crawley, Annette, Thingwall,Wirral. 1975
Dempster, Stuart, Glasgow. 1996
Fleischner-Zois, Krista, Athens, Greece. 1996
Grondin, Magali, Geneva, Switzerland. 1996
Lam, Yiu Ming, Hong Kong. 1996
Luo, Yi Guang, Xi, China. 1995
Ma, Sui Shan, Tina, NT, Hong Kong, 1996

Mathon, Andries Petrus Theresia, Oosterhout, The Netherlands. 1996
Morris, Clive Raphael, Berkhamstead. 1961
Song, Gyu Bong, Kyungnam, Korea. 1996
Yan, Chun Wai, Danny, NT, Hong Kong. 1996

Transfers – Ordinary Membership to FGA

Ma, Annie Yiu-Chu, Hong Kong. 1996
Yao, Teng-Long, Taipei, Taiwan. 1996

Ordinary Membership

Chan, Lam Wing, Hong Kong.
Fahller, Ingegerd, Lulea, Sweden.
Hopley, Katharine, Coventry.
Huysser, Isabelle, Vught, The Netherlands.
Lodge, Tim, London.
Lundin, Margareta, Taby, Sweden.
Quintner, Flora, Grays.
Ramirez-Achinelli, Soledad, Skogas, Sweden.
Satariano, Lee, Msida, Malta.
Shaikh, Zakir, London.

Laboratory Membership

Marcus McCallum, London EC1N 8JY.

At a meeting of the Council of Management held on 15 May 1996 at 27 Greville Street, London EC1N 8SU, the business transacted included the election of the following:

Diamond Membership

Fukushima, Katsue, London. 1995
Lam, Kwai Fat, Hong Kong. 1996
Lo, Lai Shan, Kowloon, Hong Kong. 1996

Diamond Membership and Fellowship

Lewis, Rachel, Stockport. 1988/1989

Fellowship

Ang, Zen Yi, Singapore. 1996
Chan, Kar Ming, Grace, Kowloon, Hong Kong. 1996
Chan, Yue Kwan, Joyce, Hong Kong. 1996
Chu, Yin Yee, Terry, Kowloon, Hong Kong. 1996
Cunningham, DeeDee Cecilia, Toronto, Ont., Canada. 1996

Guo Xiaodan, Beijing, China. 1995
Leung, Siu Ha, Sue, Kowloon, Hong Kong. 1996
Lim, Sau Kuen, Hong Kong. 1996
Limaye, Mukund Dattatraya, Calcutta, India. 1996
McFarlane, Iain Scott, Chesham. 1996
Warren, Philip Arthur, Bolton-le-Sands. 1967
Welch, Lizanne, Taunton. 1991
Yeh, Chen Mei, Taipei, Taiwan. 1996
Zhang, Liangju, Guilin, China. 1990

Ordinary Membership
Batchelor, Philip Stephen, Dartford.
Campbell, Suzan, Morden.

Charles, Bruce, Llanelli, Dyfed.
Fenemore, Gerald, London.
Feng, Hsiu Yun, Taichung, Taiwan.
Godoy Ranirez, Aura, Madrid, Spain.
Hooke, Gina Marie, Cullompton.
Hoskins, Robert, Falls Church, VA, USA.
Hugo, Philippe Antoine M., Kortryk, Belgium.
Iannicelli, Marco, London.
Lin, Chief, Kaohsinng, Taiwan
López Sedó, Javier, Madrid, Spain.
Martini de Brum, Tania Mara, Rio Grande do Sul, Brazil.
Vafai, Khatereh, Tehran, Iran.
Wang, Chien-Ling, Taichung, Taiwan.

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

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

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

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

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

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

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

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

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

A This is a first level heading

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

B *This is a second level heading*

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

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

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

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

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

Notes and References Authors may choose one of two systems:

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

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

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

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

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

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

The Journal of
Gemmology

Contents