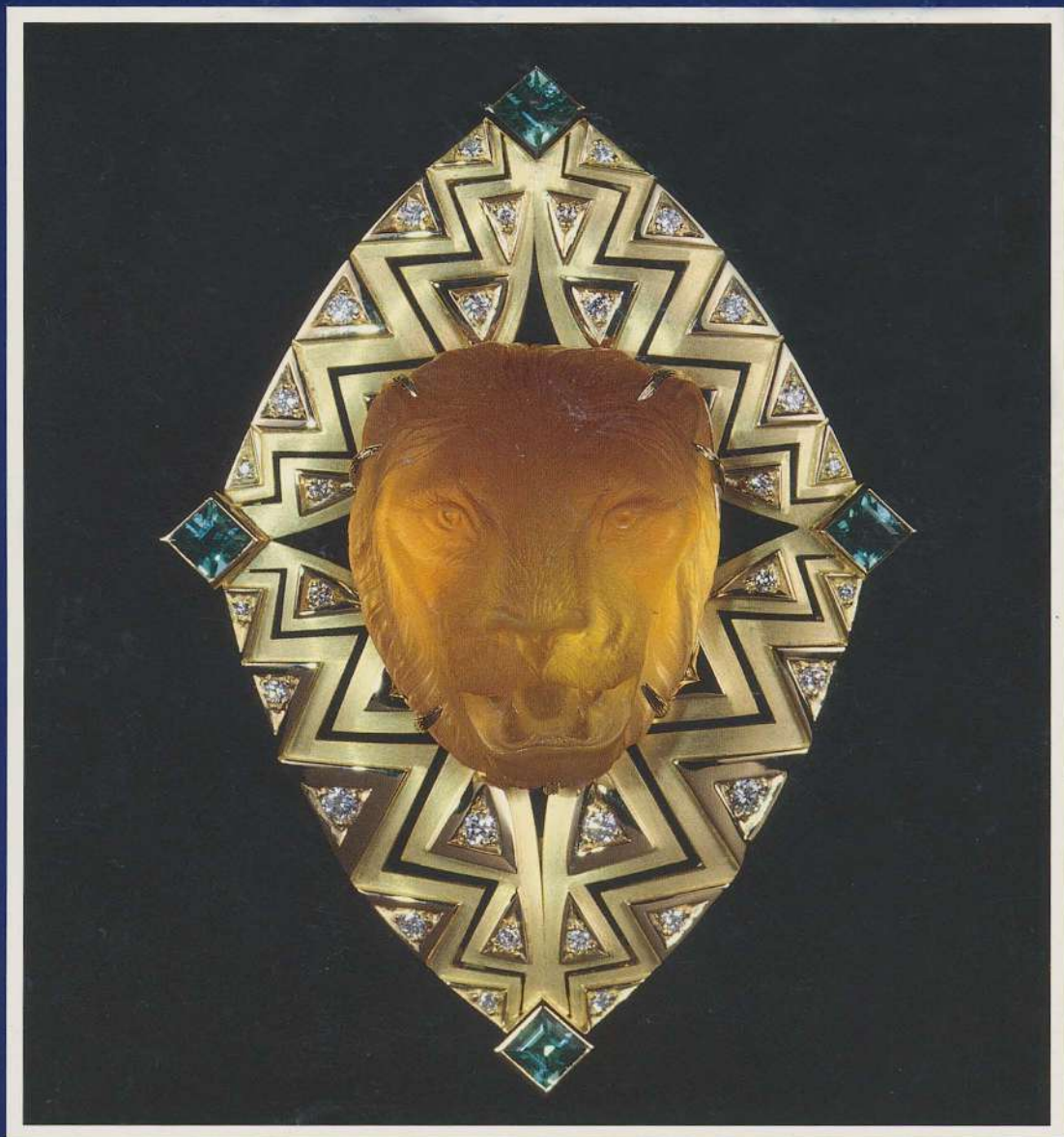
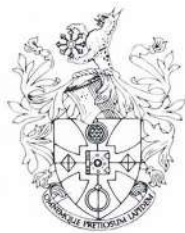




The Journal of Gemmology



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Cover Picture

Carved citrine lion face set in an 18ct gold and diamond brooch by Stephen Webster.

Photograph by Bob J. Maurer, FGA, DGA (See 'Photographic Competition' p.216)

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Editorial

Following the announcements in the April issue of the Journal the new editorial structure is now in place and I am very pleased to have the support of Michael O'Donoghue and Peter Read as Assistant Editors. They will oversee book reviews and abstracts respectively. For assessing new manuscripts submitted for publication we are at once honoured and pleased to welcome a distinguished group of Associate Editors. They hail from many parts of the world and cover a wide range of gem, diamond, pearl and trade expertise, some of which has already been put to good use in appraising the contributions in this issue.

The opening paper deals with the question of origins of gems and with the factors important in assessing how reliable origin information might be. The precise description of features in gems is paramount if there is to be clear communication, and this applies as much to origins as to the descriptions of new synthetic sapphires, moonstones, vesuvianite and the pink sapphires covered in the other contributions. A prospect of life in the wild is provided by a paper on how to pan for gem minerals and, when you bring your concentrates back to base, just apply specific gravity techniques explained by Dr Farrimond to help distinguish the gems.

It is a long-recognized fact that in order

to identify gems you should have access to the most up-to-date comparative information. But there is so much information available that it can be difficult to find what is relevant to a particular problem in a reasonable length of time. Nevertheless, we hope to assist readers in this process with an increased coverage of abstracts. To this end permission has been obtained from colleagues in related fields to reprint abstracts not normally seen by many of our members. Further, the abstracts will be arranged in the following categories: diamonds, gems, instruments, jewellery and synthetics.

The most noteworthy change of all in this issue, however, is the appearance on the inside front cover of Eric Bruton's name as President. For over three years since the death of Sir Frank Claringbull the GAGTL has been without a President and we are delighted that, on the invitation of the Council of Management, Eric Bruton agreed to become our next President and was elected at the Annual General Meeting on 13 June. A man of many talents, his gemmological contributions include the standard textbook on diamonds and it is partly in recognition of this that the GAGTL Conference in October incorporates a major diamond theme under the title 'Diamonds and modern gem developments'.
R.R.H.

Origin determination for gemstones: possibilities, restrictions and reliability

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Abstract

The gemmological 'origin' means the geographical locality of a gemstone deposit. Origin names should neither be used as a description of a colour type nor to express a certain quality. For the determination of origin in a gemmological laboratory different chemical and physical properties are considered, e.g. inclusions, colour zoning, chemical composition and spectral characteristics. Therefore, sophisticated equipment is essential and instrumentation such as spectrophotometers (UV-VIS-IR), EDXRF, SEM and optical microscopy should be applied. Some of the determined properties may be diagnostic for a definite source of gemstones. For a reliable interpretation a large collection of comparison samples of known origin and reference data are necessary. Furthermore, the knowledge has to be updated repeatedly by adding new information through research, the latest literature and by exchange of experience. Where data released from a stone are insufficient or ambiguous an opinion of origin should not be given.

Introduction

A definition of the term 'origin' as used in gemmology should logically be the starting point of this paper. 'Origin' should indicate the geographical origin of a gemstone. This is either in the primary deposit in the parent rock or in a secondary deposit resulting from transport and accumulation of gemstones after

decomposition of the parent rock.

In the trade the terms Burma, Pailin and Kashmir have been applied to what are perceived as the most desirable gems to own but since they have a geographical meaning, they should *not* be used to express a particular colour of gemstone. It is common knowledge that one deposit produces a range of colours, some of which may be found in other deposits, too.

The need in the gem trade for certification of origin seems restricted to a few varieties of gemstones only and to a small number of deposits with a high reputation. For many people the origin 'Burma' may be commercially meaningful, whereas 'Malawi' as an origin for a ruby does not create an increased interest. It should again be stressed that a certain origin does not necessarily mean that all crystals from that source are of high quality.

Some gemstones can indicate their place of origin through their physical and chemical properties, and by their inclusions and growth structures if these are clearly distinguishable from all other types. Thus, these properties must be unique by themselves or in combination. The greater the number of individual and characteristic properties found in a certain stone, the more reliable is a determination of origin. Valuable characteristics should not only positively testify a certain origin but at the same time exclude other possibilities.

Consequently in determining the origin of a gemstone the expert must be aware not only of the properties of similar stones from the locality in question, but of the whole set of properties of similar stones from all other localities (Figure 1). Only the



Fig. 1. A large collection of reference material is an important tool for recording and comparison of gemstone characteristics. It is indispensable for laboratories doing origin determination.

exclusive features, unique for a particular deposit, are called diagnostic properties! Depending on the complexity of the formation of the gemstone crystals, the geological environment, the type and number of characteristics can be quite varied.

Gemstone formation

The formation of a gemstone crystal requires a number of more or less important conditions. Some of the main conditions, causing general or individual properties of gemstones are the following:

Basic conditions pertaining to gemstone crystal formation

- availability of main constituent chemical elements, speed of growth
- type and concentration of available trace elements, variation in their concentration and relative ratio

- transport process and transport medium involved for gemstone constituents
- type of energy source for the formation (intruding pegmatite, metamorphism)
- partial pressure of free oxygen, redox situation
- cooling rate and behaviour of pressure (static or oscillating) during or after formation
- deformation history of parent rock and crystal during its period of growth

All these factors affect the individual characteristics of a gemstone crystal, and result in differences regarding the following:

Features which may impart individual characteristics to gemstones

- size and shape of crystals, growth zoning

- twinning
- colour, colour homogeneity, colour variation
- trace element mixture (including 'invisible' trace elements)
- solid inclusions (e.g. protogenetic inclusions, reflecting parent rock)
- fluid inclusions (e.g. syngenetic inclusions, reflecting transport medium and genetics of formation)
- state of healed fissures, geometry and degree of restoring
- nature of fillings in negative crystal voids

Cut Gemstones

What sort of definitive information can we collect from a cut gemstone (in respect of a determination of origin)? The following features could be studied:

Characteristic features in cut gemstones:

Microscopic features (Figure 2): colour- and growth-zoning relative to crystallography, colour inhomogeneity, twinning type, internal strain, observation of type and distribution of solid and fluid/gas inclusions, type of healing fissures temperature and pressure during formation of fluid inclusions by microthermometric measurements.

Physical and optical features: determinations of specific gravity, refractive indices, double refraction, fluorescence behaviour, cathodoluminescence reaction, absorption spectroscopy (UV,VIS,IR, see Figure 3), magnetic resonance spectroscopy.

Chemical features: main composition, trace element determination by EDSXFA, amount or relative ratio of trace elements present (e.g. Ti, Fe, Cr, V, compare Figure 4), chemical analysis of inclusions by an electron beam instrument (scanning electron microscope, or electron microprobe) or Raman spectroscopy.

The determination of origin of a cut gemstone is thus a matter which requires a number of (expensive) instruments, and a lot of experience in their use and interpre-

tation of the results. A collection of comparison stones (from all deposits, showing the variability within a population) for reference, files containing the analytical results measured over the years and a library with books and periodicals for old and new information are also very important requirements (compare list of references at the end of the article).

Analytical techniques

To register all the different features listed above requires the knowledge and application of analytical steps based on a wide field of analytical techniques. I will give a brief summary of the most recent or most important publications in this respect.

Microscopic investigation is most often done in dark field lighting, and inclusions are 'identified' by morphological comparison. *The Photoatlas of inclusions in gemstones* (Gübelin and Koivula, 1986) and *Pierres précieuses dans le monde* (Schubnel, 1972) are considered as the most important general books for inclusion reference. Growth peculiarities such as colour zoning are easier to observe in immersion, and an indication of the encountered crystal faces is possible by using a special attachment



Fig. 2. Using a Leica M8 stereo microscope for identification of internal characteristics in a gemstone. A binocular microscope with different lighting possibilities, working in air and in immersion is essential for a safe gemstone identification. An adaptor enables recording of inclusion pictures by photography or video for research and education purposes.

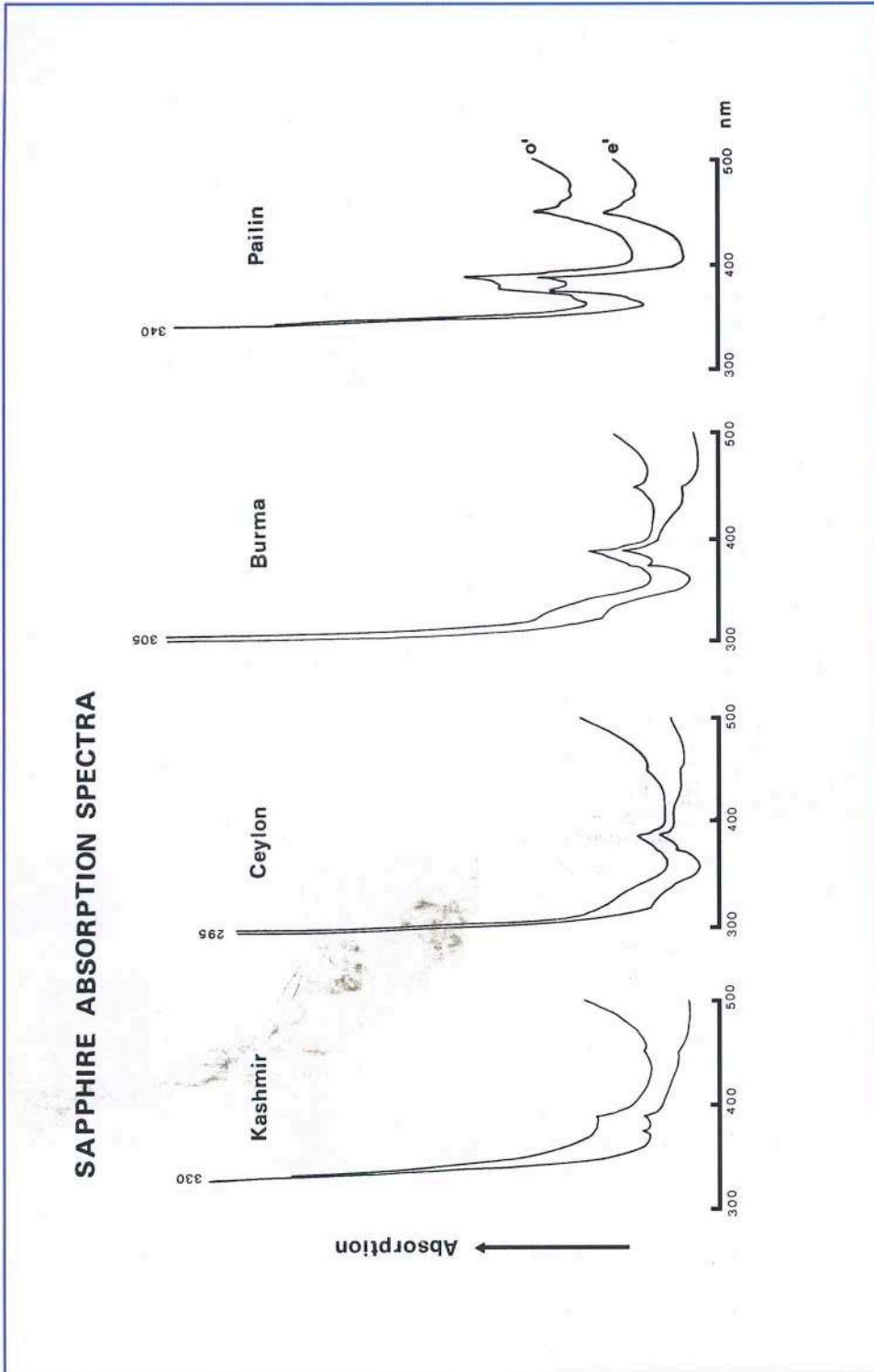


Fig. 3. Absorption spectra recording and measurement, e.g. of the Fe^{2+} features at 450 nm, furnishes important characteristics when a possible origin or heat treatment is being discussed. The above spectra may be taken as standard types for the respective origins and stones of approx. 8 mm thickness in the direction of the recorded light path.

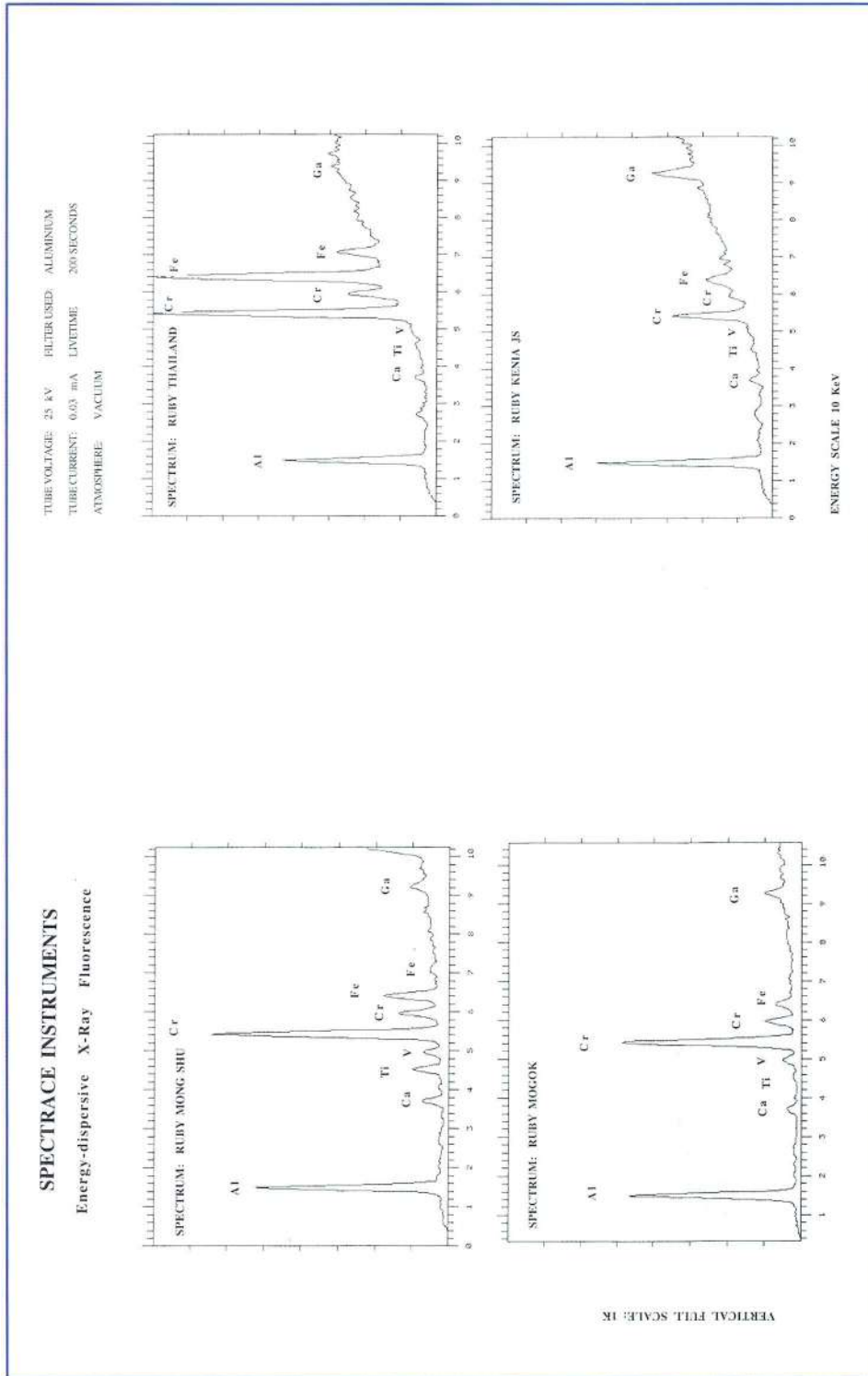


Fig. 4. EDXRF spectra reflect chemical composition for main and trace elements and allow a comparison among stones of different deposits. The above spectra are typical for rubies from Myanmar (Burma), (Mogok and Mong Hsu) Thailand and Kenya (John Saul Mine). A programmed calculation process may transform the peak intensities into semiquantitative results.

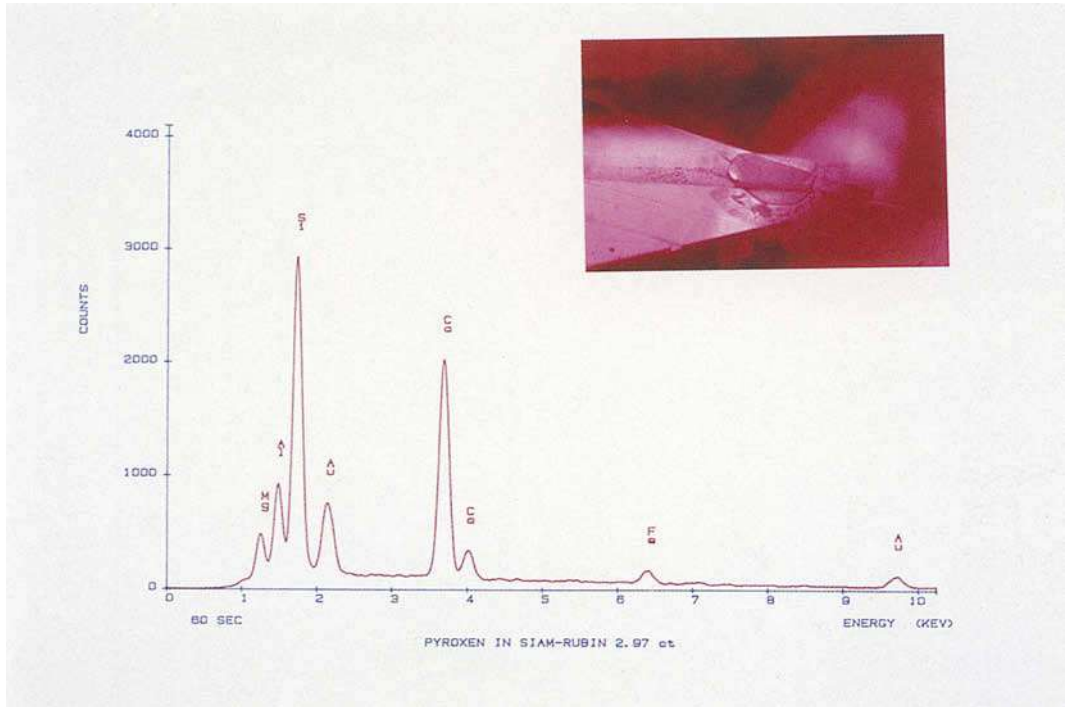


Fig. 5. The chemical composition of the inclusion in the pictured ruby has been analysed by use of the electron micro-beam of a SEM. An energy spectrum of the constituents of the inclusion has been produced and the crystal was identified as fassaite (pyroxene). This mineral is quite common as an inclusion in Thai rubies (compare Schubnel, 1972).

described by Schmetzer (1985). The application of this method is demonstrated by a characterization of sapphires from different occurrences by Kiefert (1988) and Kiefert and Schmetzer (1991). Growth characteristics may also become visible as fluorescence phenomena by cathodoluminescence as published by Lasnier *et al.* (1992) in the case of jadeite. Primary or pseudo-secondary fluid inclusions (i.e. negative crystals and fingerprints) provide important information about the conditions during the formation of a crystal. By microthermometry the fillings in these voids are analysed by their contents of gases, vapours and salts. A section by Roedder in *Photoatlas of inclusions in gemstones* (Gübelin and Koivula, 1986) is devoted to this method. For a characterization of sapphires from Kashmir, this method was used by Peretti *et al.* (1990).

Spectroscopic features are useful since they can be gathered from a very wide field of the electromagnetic wave spectrum, from the short X-rays through to the long infrared waves (Hänni, 1993). Every spectral section provides a lot of diagnostic information regarding the analyzed crystals. In their synopsis on the developments in the 1980s, Fritsch and Rossman (1990) gave a short introduction to the instrumental possibilities regarding gemstone testing.

Energy dispersive X-ray fluorescence analysis gives rapid information about surface elemental composition of a gemstone, down to trace element levels (Muhlmeister and Devouard, 1991). For a quantitative determination of major elements the electron microprobe is generally used (Dunn, 1977), a complex instrument where a fine electron beam causes an X-ray line spectrum of the excited sample ele-

ments. Microprobe analyses were used by Hänni (1982) and Stockton (1984) to differentiate chemically between the various natural and synthetic emeralds.

A related instrument is the scanning electron microscope SEM (Stockton and Manson, 1981). Although the SEM is primarily used to create highly magnified pictures of a sample surface, this instrument is also capable of producing compositional information, if it is equipped with energy dispersive system (Figure 5).

The visible and ultraviolet part of the spectrum was successfully used both for distinction of natural from synthetic rubies as well as for distinction of rubies from different localities by Bosshart (1982). Similar applications are valid for sapphire (Hänni, 1990) and emerald (Bosshart, 1991), where different types can be separated if absorption curves recorded by a spectrophotometer are investigated.

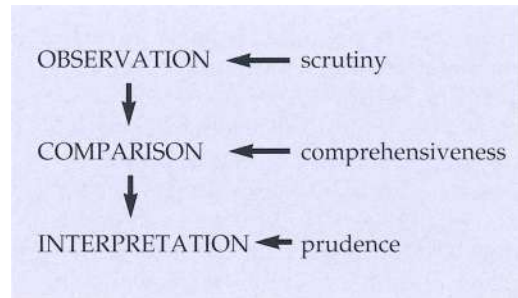
Infrared spectroscopy is a spectroscopic technique which can give information about molecules and radicals in gemstones. An introduction to the method as used in gemmology is given by Fritsch and Stockton (1987). Its applicability for emeralds is especially well demonstrated by Wood and Nassau (1968) or Goldman *et al.* (1978).

Raman spectroscopy is a very powerful and relatively new technique in its application to gemmology (Dclé *et al.*, 1980). A Raman laser probe is able to identify by comparison with reference spectra not only totally included mineral guests, but also liquid and gaseous inclusions. Plinet *et al.* (1992) have recently published a brochure with the most important Raman spectra of minerals encountered as inclusions in gemstones.

Nuclear magnetic resonance (NMR) is another non-destructive testing method but it is rarely used in gemmology (Dereppe and Morcau, 1986). Electron spin resonance (ESR) spectra can provide information about the type and position within

the crystal lattice of distinct ions. The method was successfully applied in the characterization of sapphires of different types (Troup and Hutton, 1983).

Some of the observed and registered characteristics in a gemstone may not be restricted to one deposit alone. As an example, three-phase inclusions in emeralds were regarded as characteristic for a Colombian origin for a long time. Today, such inclusions are also known in emeralds from Australia and Nigeria. Chemical information is also needed for a discrimination; together with this the inclusions may - in combination - be of diagnostic value. Those observations which are unique for a special deposit are the important diagnostic features in respect of an origin determination. For a successful determination the following steps must be taken:



Although experience, prudence and honesty are crucial in the determination of origin for cut gemstones, the result is not absolute and still expresses the opinion of the analyst. The result should reflect the most probable conclusion based on the background of the comparison stone collection and reference data. It seems clear that the education, scientific equipment and actual knowledge of the laboratory gemmologist are major points in the reliability of the origin determination. Not many laboratories have the necessary facilities in terms of equipment and staff to



Fig. 6. Vietnamese blue sapphires from the northern deposits are still new gemstones to the market and their characteristics have been discussed by only a few gemmologists. Such sapphires may exhibit a complex colour zoning, very fine and short rutile needles and they may have almost no trivalent iron, as evidenced by the absence of the 450 nm line in the spectrum.

produce consistent results over many years in this particular field. This may be one reason why CIBJO has not approved the issue of origin certificates.

How can we get reliable basic knowledge on material from a particular origin ?

The ideal procedure is to personally collect the rough gems from their geological source. In many cases this is not possible, since the source is exhausted or not accessible. Therefore we must do the next best thing and collect our reference material from a reliable source such as a museum or a well-curated old collection. Information on gemstone sources can also be obtained from books and publications. Many historical gemstone sources are treated in reference books. Geological maps give specific information on the type of deposit, and scientific publications contain the properties (including chemical analyses and inclusions) of the relevant gemstones. To be usable, all observations should be in agreement or consistent with the different facts known, e.g. trace elements with spectroscopy, inclusions with geology. A selection of books and articles with valuable information regarding origin determination is given under 'References'

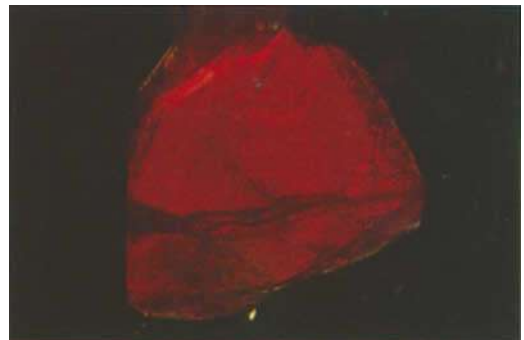
at the end of this paper.

From all this information we may gain a very complex view of a gemstone deposit and its products. The more material we investigate, the denser our network becomes. New observations will always be added to the formerly restricted set of information (Figure 6). Sharing and discussing new information with colleagues in gemmology can bring a higher degree of safety into our determinations of origin. But it is fundamental to revise and recheck our primary data regularly by basic research and literature study of publications on new sources or techniques. Stagnation is dangerous.

Limitations in the determination of origin

As pointed out at the beginning, we use differences in properties as a means of discrimination. Properties which are found in stones from more than one source are not valued as diagnostic characteristics. But they can nevertheless be helpful to exclude other localities which do not produce stones with these properties. As an example, sapphires of a particular shade of blue may not prove a certain origin, nor do those with a misty turbidity. But the misty turbidity in combination with the absence

Fig. 7. The recently discovered second mining area for corundum in Myanmar (Burma) is producing rubies with a peculiar growth pattern. A primarily blue core shows colour zoning parallel to the basal face, whereas the mantle around is formed by growth layers parallel to pyramidal faces r , n and ω (Schmetzer, 1993)



of rutile needles points towards a group of possible origins while excluding others. Within the group of possible origins we may arrive at only one, if the stone itself contains further diagnostic characteristics. It may for instance exhibit a distinct absorption curve, not seen in stones from other places. At the same time it may show included crystals (identified by an electron beam instrument) which are typical for that source only. These inclusions therefore exclude all other possibilities.

Origin determinations established do not depend on one typical characteristic only, but on at least three independent diagnostic features preferably concerning inclusions, spectroscopy and trace element contents.

The possibilities for determining an identification of origin are restricted if:

- properties observed occur in stones from several sources (they are not diagnostic)
- stones are free of diagnostic features
- the stones are set in jewellery
- not enough information about possible sources is available
- features which may be diagnostic are destroyed by heat treatment.

Sometimes gemstone deposits and therefore mining areas cross international borders, e.g. Kenya/Tanzania, Thailand/Cambodia and, conversely, large countries may contain more than one source of a particular species, e.g. Burma (Figure 7), Sri Lanka, Vietnam, Brazil. Designation of origin, therefore, must be worded appropriately.

Certain people from the gem trade seem to have rather narrow opinions on the type of material coming from one definite source. In one source the stones can vary in size, colour and transparency quite considerably, a fact that we must keep in mind when associating a certain stone with a particular group. It is certainly not the

overall aspect visible to the eye or the hand lens which is critical in determining the origin of a stone. On the contrary, origin can only be assigned following the most careful investigation of all properties by an experienced gemmologist using modern scientific equipment. And if there is any doubt or ambiguity, an independent and serious scientist would not give a definite result. When the characteristics of the stone are not diagnostic for a particular locality a report of origin cannot be issued, and it would help laboratory staff considerably if this situation could be understood by many more members of the trade.

Acknowledgements

I am indebted to Dr R.R.Harding for his critical reviewing of the script and his stylistic improvements on this article.

References

- Bauer, M., 1896. *Edelsteinkunde*. C.H.Taunitz, Leipzig
- Bosshart, G., 1982. Distinction of natural and synthetic rubies by ultraviolet spectrometry. *Journal of Gemmology*, XVIII, 2, 145-60
- Bosshart, G., 1991. Emeralds from Colombia. *Journal of Gemmology*, 22, 6, 355-61 (part 1); 7, 409-25 (part 2); 8, 500-503 (part 3)
- Delé-Dubois, M.L., Poirot, J.P., Schubnel, J.J., 1980. Différentiation entre les gemmes naturelles et les matériaux synthétiques par microspectrométrie Raman à Laser. *Revue de Gemmologie aff.*, 88, 13-14
- Dunn, P., 1977. The use of the electron microprobe in gemmology. *Journal of Gemmology*, XV, 5, 248-58
- Fritsch, E., Rossman, G., 1990. New technologies of the 1980s: their impact in gemmology. *Gems & Gemmology*, 26, 1, 64-75
- Goldman, D.S., Rossman, G.R., Parkin, K.M., 1978. Channel constituents in beryl. *Phys. Chem. Minerals*, 3, 225-35
- Gübelin, F.J., Koivula, J.L., 1986. *Photoatlas of inclusions in gemstones*. ABC Editions, Zurich
- Hänni, H.A., 1982. A contribution to the separability of natural and synthetic emeralds. *Journal of Gemmology*, XVIII, 138-44
- Hänni, H.A., 1990. A contribution to the distinguishing characteristics of sapphire from Kashmir. *Journal of Gemmology*, 22, 2, 67-75
- Hänni, H.A., 1990. Letter to the Editor. *Journal of Gemmology*, 22, 4, 250-1
- Hänni, H.A., 1993. Spectroscopy and its application in gemmology. *Journal of the Gemmological Association of Hong Kong*, XVI, 16-22
- Hughes, R.W., 1990. A question of origin. *Gemmological Digest*, 3, 1, 28-31
- Hughes, R.W., 1990. *Corundum*. Butterworth-Heinemann Ltd., London
- Kane, R.E., McClure, S.F., Kammerling, R.C., Khao, N.D., Mora, C., Repetto, S., Khai, N.D., Koivula, J.L., 1991. Rubies and fancy sapphires from Vietnam. *Gems & Gemmology*, 27, 136-55
- Kazmi, A.H., Snee, L.W., 1989. *Emeralds of Pakistan*. Van

- Nostrand Reinhold, New York
- Keller, P.C., 1990. *Gemstones and their origins*. Van Nostrand Reinhold, New York
- Kiefert, L., 1988. Mineralogische Untersuchungen zur Charakterisierung und Unterscheidung natürlicher und synthetischer Sapphire. Diplomarbeit, Universität Heidelberg
- Kiefert, L., Schmetzer, K., 1991. The microscopic determination of structural properties for the characterization of optical uniaxial natural and synthetic gemstones. Part III: Examples for the applicability of structural features for a distinction of natural and synthetic sapphire. *Journal of Gemmology*, 22, 8, 471-82
- Lasnier, B., Poirot, J.P., Smith, D.C., 1992. Intercroissance de jadéite de différentes compositions dans les jades relevées par cathodoluminescence. *Revue de Gemmologie afg.* 113, 8-11
- Muhlmeister, S.M., Devouard, B., 1991. Trace element chemistry of natural and synthetic rubies, in A.S. Keller (ed.) *Proceedings of the 1991 International Gemological Symposium*, Gemological Institute of America, Santa Monica, CA
- Peretti, A., Mullis, J., Kündig, R., 1990. Die Kaschmir-Saphire und ihr geologisches Erinnerungsvermögen. *Neue Zürcher Zeitung (Forschung & Technik)* 187; 15. Aug. p.59
- Plinct, M., Smith, D.C., Lasnier, B., 1992. Utilité de la microsonde Raman pour l'identification non destructive des gemmes. Association Française de Gemmologie afg., *La microsonde Raman en gemmologie*, volume spéciale, 11-61
- Poirot, J.P., 1992. Spectrométrie de fluorescence X, des aides pour la détermination de types de gisement de saphir. *Revue de Gemmologie afg.* 110, 7-9
- Schmetzer, K., 1985. Ein verbesserter Probenhalter und seine Anwendung auf Probleme der Unterscheidung natürlicher und synthetischer Rubine sowie natürlicher und synthetischer Amethyste. *Z. Dt. Gemmol. Ges.*, 34, 29 - 46
- Schmetzer, K., 1993. personal communication
- Schubnel, H.J., 1972. *Pierres précieuses dans le monde*. Horizons de France, Paris
- Stockton, C.M., 1984. The chemical distinction of natural from synthetic emeralds. *Gems & Gemology*, 20, 3, 141-5
- Stockton, C., Manson, D.V., 1981. Scanning electron microscopy in gemology. *Gems & Gemology*, Summer, 72-7
- Troup, G., Hutton, D.R., 1983. The use of spin resonance spectroscopy to distinguish synthetic from natural gemstones. *Journal of Gemmology*, XVIII, 421-31
- Van Landingham, S.L., 1985. *Geology of world gem deposits*. Van Nostrand Reinhold Book Company Inc., New York
- Wood, D.L., Nassau, K., 1968. The characterization of beryl and emerald by visible and infrared absorption spectroscopy. *American Mineralogist*, 53, 777-800

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An examination of Chatham flux-grown synthetic pink sapphires

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Abstract

This article reports on the gemmological, spectroscopic and chemical characteristics of the new flux-grown synthetic pink sapphires produced by the firm Chatham, Inc. of San Francisco, California, USA. The material is essentially a lighter-toned version of the firm's well-known synthetic ruby that has been available for many years. Gemmologically, the pink synthetic sapphires differ from the synthetic ruby in their ultraviolet fluorescence behaviour and in the presence of a grid-like flux inclusion pattern not previously documented in the synthetic rubies.

Introduction

Synthetic ruby is one of the more important of the commercially-produced man-made gem materials. It is also the one that has been produced by perhaps more methods of synthesis than any other. In terms of quantity, the vast majority of material is produced by the melt techniques of flame-fusion and Czochralski 'pulling' (Nassau, 1980). Another melt technique that has been used is floating zone. This was used briefly in the early- to mid-1980s by Suwa Seikosha (Seiko Watch) Company Ltd. of Japan (Koivula, 1984). More recently, a variation of this method, described by the producers as 'horizontal growth' has begun to be employed commercially in Russia (W. Barshai, *pers. comm.*, 1993). Russia is also

the source of hydrothermal synthetic rubies that are now available in small quantities (Peretti and Smith, 1993).

Flux-growth methods have also been used by a number of manufacturers to synthesize ruby; among them (both past and present) are Chatham (Reinecke, 1959), Kashan (Huffer, 1981), Knischka (Gübelin, 1982) and Ramaura (Kane, 1983); among the more recent entries are the Douros product from Greece (Smith and Bosshart, 1993) and one from Russia (Henn and Bank, 1993).

In spite of the many manufacturers of flux-grown synthetic rubies, until recently none of these firms has marketed flux-grown synthetic pink sapphires (although some of the material marketed in the past as synthetic ruby, for example, some of the lower-quality Kashan material has lacked sufficient depth of colour to be called ruby). This has changed recently with the introduction of a synthetic pink sapphire by Chatham, Inc., of San Francisco, California, USA, a firm that produces and markets flux-grown synthetic rubies, emeralds and sapphires (both blue and orange). This report will describe the authors' recent examination of samples of this new flux-grown product.

Materials and methods

The test sample consisted of four faceted stones ranging in weight from 2.73 to 4.19 ct (Figure 1). Also examined for microscopic features was an 884 ct crystal (Figure 2).



Fig. 1. These four faceted flux-grown synthetic pink sapphires comprised the test sample on which complete gemmological testing was performed for this study. Photo by Maha DeMaggio © GIA



Fig. 2. Also examined for microscopic features was this 884 ct crystal. Photo by Maha DeMaggio © GIA

The microscopic examination was performed using GIA GEM Instruments Mark VII binocular gemmological microscopes in conjunction with darkfield and supplemental fibre-optic illuminators. Refractive indices were determined using a Duplex II refractometer and a near sodium-equivalent light source. Ultraviolet luminescent reactions were observed under a dual, 4-watt long-wave/short-wave unit in a viewing cabinet at distances of approximately 5 to 10 cm from light source to test sample. Absorption features were observed with a Beck prism spectroscope mounted on a GIA GEM illuminator base.

Pleochroism was documented using a calcite dichroscope. Specific gravity determinations were made through the hydrostatic weighing method on a Mettler AM 100 electronic balance equipped with suitable attachments. Chemical analyses were performed using a Tracor X-ray Spectrace 5000 energy-dispersive X-ray fluorescence (EDXRF) system.

Gemmological properties

Appearance:

All four faceted specimens are transparent. Their body colours range from medium light to medium purplish pink of fairly high saturation, with the colour quite evenly distributed in all samples. The crystal has comparable hue and saturation but due to its very large size is medium dark in tone. Two of the faceted pieces as well as the crystal exhibit some eye-visible inclusions.

Refractive indices:

RI values are very constant from one faceted stone to another, all exhibiting 1.768 for the ordinary ray and 1.759 for the extraordinary ray, with a birefringence of 0.009.

Pleochroism:

The dichroic colours are purplish pink for the ordinary ray and orange-pink for the extraordinary ray.

UV Luminescence:

All specimens fluoresced when exposed to both long- and short-wave ultraviolet radiation. The reaction was essentially identical under both wavelengths: a strong orange-red that was evenly distributed and possessed a weak to moderately chalky overtone. There was no phosphorescence after exposure to either wavelength.

In the crystal, large flux inclusions located near the surface fluoresced green, while those located deeper within the crystal appeared to fluoresce yellow. This

latter reaction is probably the result of the inclusion's inherent green fluorescence being observed through the red-fluorescence of the host material, as green light combined with red light results in yellow light.

Chelsea colour filter:

All test samples appeared a strong red when viewed through the colour filter.

Optical absorption spectra:

Absorption features observed with a desk-model prism spectroscope were consistent with those previously reported in the literature for rubies and pink sapphires, both natural and synthetic, with lines at 468.5, 475-476.5 (doublet), 659.2, 668, 692.8 and 694.2 nm (see, e.g., Liddicoat, 1989).

Specific gravity:

Three of the faceted stones had SG values of 3.99; a value of 4.00 was determined on the fourth.

Microscopic features:

Magnification revealed a number of internal features in the sample specimens. Most prevalent were flux inclusions, both primary and secondary. Primary flux inclusions ranged from large masses revealing their distinctly granular texture and white to light brown body colour (Figure 3) to series of many minute droplets arranged in rows along growth steps (Figure 4). In two of the faceted stones what appeared to be minute primary flux inclusions were delicately arranged in neat, intersecting rows that formed a grid-like pattern and created an unusual inclusion scene (Figure 5). This is a type of inclusion pattern that to our knowledge has not previously been observed in any synthetic gem material. It is, however, very similar to the patterns of tiny negative crystals observed in some natural spinels (Cübelin and Koivula, 1986). Secondary flux inclusions noted

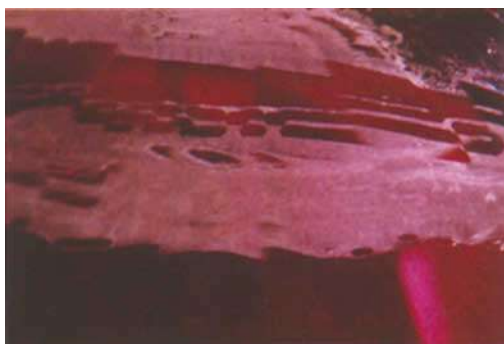


Fig. 3. These large primary flux inclusions in a Chatham flux-grown synthetic pink sapphire exhibit a distinctly granular texture. Photomicrograph by John I. Koivula © GIA. 10x



Fig. 4. Some of the primary flux trapped in the synthetic pink sapphires occurred as rows of minute particles trapped along growth steps. Photomicrograph by John I. Koivula © GIA. 10x



Fig. 5. Delicately arranged in neat intersecting rows producing a grid-like pattern, what appear to be minute primary flux inclusions created an unusual inclusion scene in two of the flux-grown synthetic pink sapphires. Photomicrograph by John I. Koivula © GIA. 10x

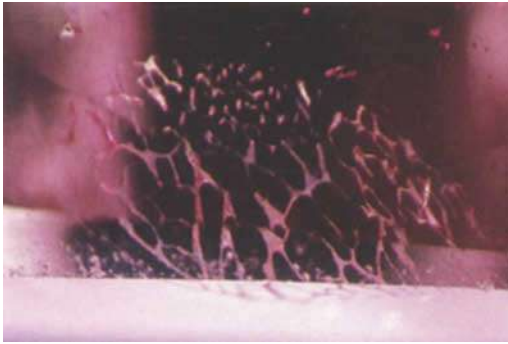


Fig. 6. This planar flux 'fingerprint' inclusion provides evidence of partial fracture healing. *Photomicrograph by John I. Koivula © GIA. 30x*

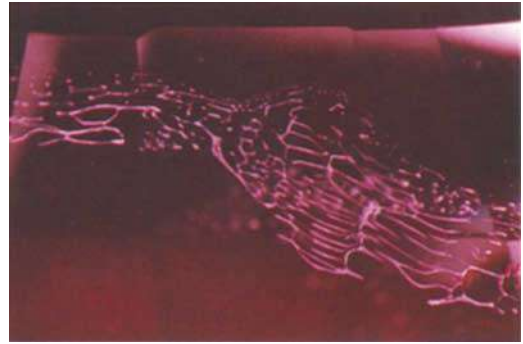


Fig. 7. Secondary flux inclusions in the specimens commonly exhibited an undulating form, as seen here. *Photomicrograph by John I. Koivula © GIA. 25x*

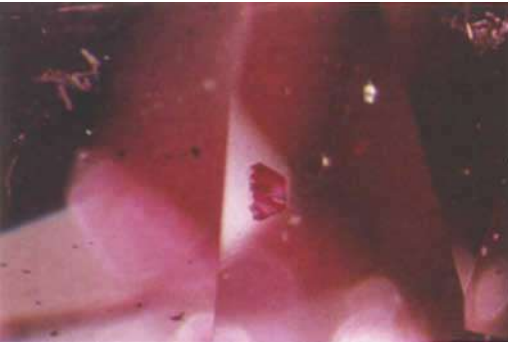


Fig. 8. A small number of relatively large, individual platelets of platinum like those seen here were observed in the test samples. *Photomicrograph by John I. Koivula © GIA. 20x*



Fig. 9. Dense clusters of small rods and platelets were typical of the platinum inclusions noted. *Photomicrograph by John I Koivula © GIA. 35x*

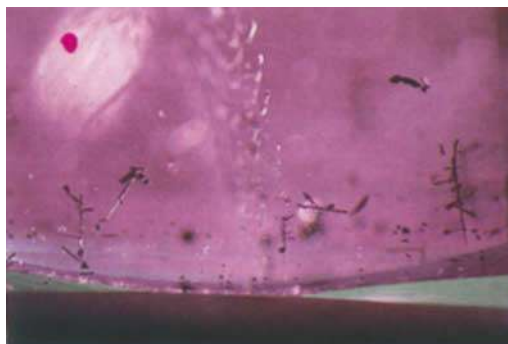


Fig. 10. Dendritic formations were another typical pattern noted for the platinum inclusions. *Photomicrograph by John I. Koivula © GIA. 25x*

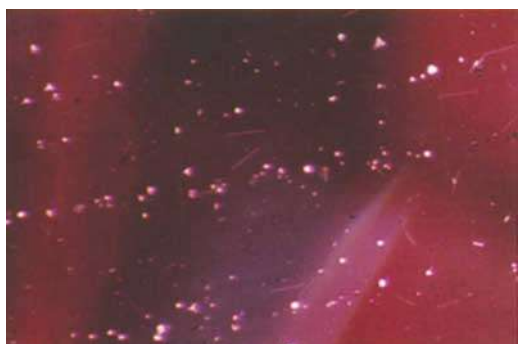


Fig.11. One of the test samples contained this phantom layer of tiny triangular and hexagonal platelets just under the table facet. *Photomicrograph by John I. Koivula © GIA. 30x*

Table I: Summary of gemmological properties

Diaphaneity	Transparent
Colour	Medium light to medium purplish pink of fairly high saturation (faceted stones); medium dark purplish pink (large crystal)
RI	1.768 (ω), 1.759 (ϵ); 0.009 birefringence
Pleochroism	Purplish pink (ϵ) and orangey-pink (ω)
UV luminescence	Weakly to moderately chalky, strong orangey-red (LW and SW); no phosphorescence
Chelsea filter	Strong red
Absorption spectrum	Lines at 468.5, 475, 476.5, 659.2, 668, 692.8 and 694.2 nm
SG	3.99-4.00
Inclusions	Primary flux as large, granular masses and lines of small droplets; secondary flux in 'fingerprint' patterns, both planar and undulating; platinum as large, individual platelets, clusters of small rods and platelets and complex dendritic formations

were in the form of partially healed 'fingerprints'. While some of these were quite planar in attitude (Figure 6), the majority showed an undulating form (Figure 7).

Angular metallic inclusions tentatively identified as platinum on the basis of their morphology were also noted in a number of forms. Least common were large, single platelets (Figure 8). Relatively common, however, were both dense clusters of small rods and platelets (Figure 9) and complex dendritic formations (Figure 10). In addition, one of the four faceted specimens contained a phantom layer of minute, triangular to hexagonal platelets under its table facet (Figure 11).

The gemmological properties noted are summarised in Table I.

Chemistry

As with Chatham flux-grown synthetic rubies, the synthetic pink sapphires contain very little in addition to the corundum's aluminium and the chromium colouring agent. The only other elements detected were a trace of iron and a weak to moderate amount of platinum. This latter element

can most likely be attributed to the crucible in which the material was grown and confirms the identification of the metallic-appearing inclusions (see 'Microscopic features,' above).

The chromium concentration varies widely from one test specimen to another, ranging from 0.027 to 0.200 % wt. Cr_2O_3 . There did not appear to be any obvious correlation between the colour of the samples and their chromium content, even when variations in size are taken into account. Examination of additional specimens in the future may shed additional light on this issue.

Discussion and conclusion

The refractive indices, birefringence, specific gravity and inclusions of the four faceted specimens of Chatham flux-grown synthetic pink sapphires were generally consistent with those of other flux-grown synthetic corundums produced by this firm, including their synthetic blue sapphires and synthetic orange sapphires as reported by Kane (1982). These properties were also generally consistent with those

noted by the authors in Chatham flux-grown synthetic rubies. Additionally, the optical absorption features noted in the test sample were consistent with those previously observed in both Chatham flux-grown synthetic orange sapphires and synthetic rubies.

One interesting property noted in the pink material was its reactions to long- and short-wave ultraviolet radiation which were of essentially equal intensity. This is unlike the reactions of Chatham flux-grown synthetic rubies which typically luminesce more strongly to the long-wave than to the short-wave lamp. We have noted a similar luminescence behaviour in Czochralski 'pulled' synthetic pink sapphires coloured by chromium, reactions we therefore surmise are due to the presence of a moderate amount of chromium in an otherwise pure corundum. Also of note in the synthetic pink sapphires were the grid-like patterns of flux inclusions which the authors have not previously documented in any of the other Chatham flux-grown products or those of other flux-grown synthetics.

As is the case with other flux-grown synthetics—both those of the Chatham and of other firms—inclusions prove diagnostic in separating them from their natural counterparts.

Acknowledgements

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References

- Gübelin, E.J., 1982. New synthetic rubies made by Professor P.O. Knischka. *Gems & Gemology*, 18, 3, 165-8
- Gübelin, E.J., Koivula, J.I., 1986. *Photoatlas of inclusions in gemstones*. ABC edition, Zurich, Switzerland, p. 375
- Henn, U., Bank, H., 1993. Flux-grown synthetic rubies from Russia. *Journal of Gemmology*, 23, 7, 393-6
- Huffer, II., 1981. Why do Kashans fool so many? *Jewelers' Circular-Keystone*, 152, 1, 118-20
- Kane, R.E., 1982. The gemological properties of Chatham flux-grown synthetic orange sapphire and synthetic blue sapphire. *Gems & Gemology*, 18, 3, 140-53
- Kane, R.E., 1983. The Ramaura synthetic ruby. *Gems & Gemology*, 19, 3, 130-48
- Koivula, J.I., 1984. Gem news: Seiko growing synthetic gemstones by the floating-zone method. *Gems & Gemology*, 20, 1, 60
- Liddicoat, R.T., 1989. *Handbook of Gem Identification*. Gemological Institute of America, Santa Monica, California, U.S.A., Chapter 13
- Nassau, K., 1980. *Gems Made by Man*. Chilton Book Company, Radnor, Pennsylvania, USA, Chapters 6 and 7
- Peretti, A., Smith, C.P., 1993. An in-depth look at Russia's hydrothermal synthetic rubies. *JewelSiam*, 4, 2, 96-102
- Reinecke, C., 1959. The new rubies of Carroll Chatham with a discussion of rubies in general. *Lapidary Journal*, 13, 4, 528, 530 and 532
- Smith, C.P., Bosshart, G., 1993. New flux-grown synthetic rubies from Greece. *JewelSiam*, 4, 4, 106-14

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Exploration gemmology

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Fig. 1 Prospectors recovering pan concentrates from small stream in the Bell Hill Exploration Licence Area, Westland, New Zealand.

Abstract

Microscopic examination of heavy mineral samples from stream sediments is a quick method for initially assessing the mineral potential of selected watersheds. Application of gemmological techniques provides a check on conventional geochemical prospecting and gives information not otherwise obtainable. The collection and study of pan concentrates is a novel occupation for the gemmologist.

Introduction

The gold pan used with a couple of screens (6 and 3 mm) is the gear of the prospector. It is effective for mineral prospecting in areas where there is running water.

In geologically youthful terrains, e.g. New Zealand and Southern Chile, mining companies sometimes use a 'pan concentrate' method to explore a large area, often several 100 sq km, that may include many watersheds (Bates, 1987; Taylor and Utting, 1984, 1988). Samples of the screenings and/or heavy residue are systematically recovered from the stream

bed at regular intervals of a kilometre or less, and all tributaries are sampled.

The samples may be analysed for a few or for a dozen or more metals and elements by an appropriate chemical or physical method, e.g. XRF (X-ray fluorescence), AA (atomic absorption), NAA (neutron activation analysis).

The analytical results are plotted on a map of the area to give an overall picture of the survey and show up any anomalies from background levels.

The role of the microscope

Most rock-types have distinctive accessory minerals, or heavy minerals, of a few per cent or less down to mere traces. Often they are characteristic of the particular rock. Sandstones and arkoses may have magnetite with garnet, zircon and xenotime. The weathering of granite will produce its suite of heavy minerals and so too will gneiss, schist and volcanics.

When streams join up to form rivers you get a blend of heavy minerals from all the rock-types occurring in the watershed that have been subject to erosion. By using a binocular microscope to examine the pan concentrates, you can test what rocks might lie ahead. Hopefully, with luck and skill, you may detect traces of an orebody undiscovered in your licence area.

When prospecting, black sand is a welcome sight as it shows there is heavy residue in the sample of gravel; if not present, you may have to dig deeper.

Black sand is usually composed of tiny grains of the opaque iron minerals, magnetite and ilmenite, either one or the other or both; sometimes chromite is encountered. It is useful to know the ratio of magnetite to ilmenite since they tend to originate from different rock-types. When the black sand is dry, run a magnet through it (covered with tissue paper). If the black grains all leap to the magnet then it is composed of magnetite (Fe_3O_4); if only a few are strongly attracted, the bulk of it could possibly be ilmenite (FeTiO_3), the

titanite of iron, which is almost nonmagnetic. Chromite (FeCr_2O_4) is feebly magnetic. Next examine the black sand with a binocular microscope and see for yourself what it is.

Magnetite belongs to the cubic system and commonly occurs as tiny octahedra, either alone or as crystal intergrowths. On the other hand, ilmenite is trigonal and like sapphire may occur as shiny, hexagonal platelets or thicker, rounded tablets.

Examination under the microscope (up to x40) confirms which mineral is which and use of the magnet is a quick way to test roughly the ratio of these two iron minerals.

The black sand can be the result of erosion of the rocks contained in the watershed being prospected, but not always! In recent volcanic terrains there is the possible source from weathering of soils, having wind-blown volcanic ash, which invisibly coats the landscape.

When prospecting, it is advantageous to get quick results and so direct the field activity to concentrate on regions of greatest promise. This is where the binocular microscope comes into its own for producing important initial information with later assay results being used as valuable supplementary information.

The detection and estimation of gold, tin (cassiterite) and tungsten (scheelite) in a pan concentrate is quickly and reliably done using a binocular microscope (Taylor and Utting, 1988).

The tail sands of a pan concentrate usually range in grain size from 0.1 to 1 or 2mm. Optically, there are two extremes in mineral grains - the transparent and the opaque when viewed with oblique lighting. The grains may be single or multi-mineralic (rock fragments), single crystals, or poly-, micro- or micro-crystalline as with conventional gem material. All the physical properties of minerals (e.g. habit, cleavage, refractive index, colour, dichroism, etc) are important in order to identify what is present. This is

where a knowledge of gemmology is an advantage. But with the ore minerals, such as cassiterite and scheelite, you have to be certain of a correct identification and with these minerals it is necessary to do simple microchemical tests to prove their presence (Hutton, 1950).

The sparkly white crystals often encountered in the tail sands are usually tiny (0.2mm) prisms of zircon, which occur as tetragonal prisms capped with pyramid faces; they have a high RI and sparkle well if the faces are not water-worn. The purple/pink variety of zircon is often found. The prismatic habit of zircon distinguishes it from the pink/red/orange garnets, which are isometric (isotropic) and may occur as very angular fragments or

broken parts of a dodecahedron. The deep red pyrope garnet is an important indicator mineral used in diamond prospecting as its source is usually the kimberlite pipes or lamproite dykes that produce diamonds.

The tail sands of your gold pan are like a jeweller's window; with the binocular microscope you may find apatite, epidote, tourmaline, zircon, rutile, topaz, sapphire, diopside, pyrite, hematite and a host of other gem materials (but not beryl or emerald), all in miniature.

Just as the source rock for diamond is associated with distinctive indicator minerals that are more abundant and therefore easier to find than diamond, e.g. pyrope garnet, chrome diopside, picroilmenite (Atkinson *et al.*, 1990), so too can the metals



Fig. 2. Geologists use an old bathtub to pan-off concentrates at small alluvial goldmine at Bell Hill, Westland, NZ

Fig. 3. Typical one-man operation of a deep lead alluvial goldmine at Bell Hill, Westland, NZ. A backhoe is used to feed a rotating trommel, which screens the gravel and allows the fines to flow over inclined tables to trap the heavy minerals and gold. Concentrates from such operations are worth studying closely because of the great quantity of gravels processed.





Fig. 4. Aluminium sluice box used to recover gold from the heavy mineral concentrate accumulated at an alluvial gold mine, Bell Hill, Westland, NZ. After a week's operation of the gold recovery plant, there is always an interested audience to see how much gold is produced.

and ores (gold, platinum, cassiterite, scheelite, etc) be associated with a suite of minerals distinctive of a particular occurrence or rock-type. Once on the trail of gold, tin or whatever, you have to study all the clues and trace the metal or mineral to its source to see whether its occurrence is significant.

Today, undiscovered ore bodies are hidden and not easily found. A mineralised zone may be well weathered and covered by soil and forest, or sometimes may exist beneath later surface deposits such as river gravels, glacial till, loess, lava flows and volcanic ash beds. Erosion of these superficial deposits will also contribute a heavy mineral residue to the streams, and this source must be recog-

nized as being distinct from the bedrock. Perhaps the watershed being prospected does not penetrate deep enough to gain erosion products from the bedrock? In this case, pan concentrate prospecting is not suitable, or your objective needs changing. Maybe the overlying material contains something of value?

On gold

Gold, once seen in the pan is easily recognized, even the tiniest yellow speck of 0.1mm size or less. The binocular microscope allows you to pry deeply into its varied forms and so read its history. A gold particle has much to tell about itself which may hopefully reveal its source, and a possible economic deposit.

One scenario for a hard-rock gold deposit is to contain irregularly shaped or granular gold particles of 0.1 to 1mm size. Erosion of the mineralised zone will shed the gold into the stream gravels.

In an active mountain stream it takes only 2 or 3 km of buffeting travel to result in the flattening of the grains to larger flakes. A further 30 to 100 km of travel may shred the gold to small flakes until eventually, on reaching the sea, it may concentrate on the beaches. The very fine flaky beach gold is difficult to pan off from the black sand, and amalgamation is usually resorted to for recovery.

Besides this mechanical abrasion and battering of the gold particles, there are also the processes of solution and crystal growth of gold by reaction with the groundwater, particularly when the particles stop travelling. A solution surface tends to be dull and rounded, whereas a growth surface is often bright, with shiny faces and sharp edges. When gold particles become stagnated in a terrace or deep lead occurrence, it is possible for the larger particles to grow at the expense of the small ones. It may take

thousands of years to produce detectable results.

In the Victorian goldfields, the deep leads have existed for many tens of millions of years. Although much of the original reef gold was coarse, the frequent occurrence of nuggety alluvial gold in Victoria and West Australia is exceptional by world standards (Flett, 1979).

In New Zealand, where the alluvial goldfields are probably no more than a few million years old, since the topography is so youthful, gold nuggets are rare. Even so, microscopic evidence can be found of growth surfaces on gold particles found in terraces and deep leads.

Gold particles may have quartz or some other gangue mineral attached to them, which is indicative of their origin.

A few red herrings

It is not unusual to find in the pan silvery particles, like platinum, that are as heavy as gold. This is amalgamated gold or gold particles coated with mercury. Heating the sample in a flame will drive off the mercury and reveal the true gold; so too will heating in nitric acid.

Mercury may originate from some gold-mining or battery site contamination located upstream. However, natural amalgamated gold is sometimes found, particularly if cinnabar is known to occur in the vicinity.

Metallic lead pellets from shotguns are often found in heavy residues. If you assay samples without microscopic tests, your lead anomalies could be misleading. Pellets are now also made from steel and bismuth in order to prevent lead pollution of the environment.

Tiny spheres of metallic iron, highly magnetic, can be found in heavy residues. These are not micrometeorites from outer space - but quite probably upstream someone has been welding a bridge girder or iron pipe and the welding sparks have contaminated the stream sediments.

Detecting cassiterite

Cassiterite, or tinstone (SnO_2), is often black and opaque, sometimes brown to deep red. It is a heavy mineral (SG 6.8), usually exhibiting no crystal form, when encountered in the pan. It is not recognizable for sure on sight, when present in small amounts or as small grains. So how do you identify cassiterite?

A simple chemical test for cassiterite is to place the specimen in a beaker with dilute hydrochloric acid and a piece of metallic zinc. The nascent hydrogen produced by the zinc dissolving in the acid reacts with the tin oxide and reduces it to metallic tin. Thus your cassiterite specimen becomes tin-coated and 'silvery' in appearance (Hutton, 1950; Lever, 1965).

To check pan concentrates for tin, a microchemical test based on this reaction was used successfully to show the presence of even one grain of 0.1mm size in a pan of gravel. The tail residue was put into a zinc beaker (made from half a dry cell battery) and dilute hydrochloric acid added for c. 30 seconds. Any cassiterite grains present develop a tin coating. The residue is then transferred to a specially prepared 'iodine paper' in order to pinpoint the tin-coated grains, since they produce a noticeable white spot on the blue paper. The iodine paper was prepared by spraying KI and iodine solution onto a filter paper soaked in starch, hence it is a dark blue colour. When in contact with metallic tin, the iodine in the paper is reduced to colourless iodide and makes a white spot much larger than the original grain, which is immediately noticeable.

Detecting scheelite

Scheelite is the ore of tungsten, composition calcium tungstate, CaWO_4 , a heavy mineral (SG about 6.0). It may be found in the heavy residues of river sands and even sea beaches, at quite some distant from its original source, but in tiny grains of 0.2mm size or less.

It is important to be able to positively identify scheelite in a pan concentrate. The grains tend to be translucent to transparent, either colourless or white to creamy, so they do not stand out when the residue has appreciable milky or clear quartz grains present.

The method used by CRA Exploration Ltd in their prospecting for scheelite in the Southern Alps of New Zealand was to examine the residues with a short-wave ultraviolet light, whereupon any scheelite grains were detected by their natural bluish fluorescence. This requires a special dark box for operation in the day time.

Alternatively, a microchemical test can be used. The heavy residue tail contained in a glass beaker can be carefully heated on a hot plate with aqua regia (a mixture of nitric and hydrochloric acid this will dissolve any gold hence it is the last test to be done). Any scheelite present develops a bright yellow coating of tungstic oxide, which will dissolve in ammonia solution, thus confirming the presence of tungsten.

The results of these chemical reactions are studied with the binocular microscope - hence the name 'microchemical test'.

Conclusions

Pan concentrate surveys are an effective way of evaluating the mineral potential of areas that are subject to active erosion by running water. Use of the binocular microscope to examine the heavy concentrates

enhances the information obtained and provides a check on the geochemical assay data.

The collection and study of pan concentrates is within the broad scope of gemmology, it may be seen as dealing with micro-jewels, rather than macro-jewels.

Wherever you live, be it England, Zimbabwe or Patagonia, get out your pan or kitchen dish and recover a sample of the heavy residue from a nearby stream (with the permission of the landowner of course!). Examine it with your binocular microscope. You will be surprised. You will enter a new World and learn much. Maybe you will find clues to a mineral deposit hidden nearby.

References

- Atkinson, W.J., Smith, C.B., Danchin, R.V., Janse, A.J.A., 1990. 'Diamond Deposits of Australia', *Geology of the mineral deposits of Australia and Papua New Guinea*. AusIMM, Melbourne pp 69-76
- Bates T.E., 1987. Final Report to the Ministry of Energy (NZ) on Exploration Licence 33-279 Terawhiti. Mineral Resources Ltd
- Plett, James, 1979. *The history of gold discovery in Victoria*. The Poppet Head Press. pp 25-6
- Hutton, C.A., 1950. The mineralogy of heavy detrital minerals of New Zealand. *Bull. Geol. Soc. Am.* 61: 647
- Lever, R.R., 1965. The detection of small amounts of cassiterite in pan concentrates. CSIRO Ore Dressing Investigation Report
- Taylor, A.M., Utting, B.S., 1984. Final Report to the Ministry of Energy (NZ) on Exploration Licence 33-198 Terawhiti. Sigma Mining Co. Ltd
- Taylor, A.M., Utting, B.S., 1988. Final Report to the Ministry of Energy (NZ) on Exploration Licence 33-316 Bell Hill, Westland. Titan Resources Ltd

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Hydrostatic measurement of specific gravity

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Abstract

The hydrostatic method has been found to give reasonably accurate specific gravity values for stones down to about five points. A major advantage of the method is its speed and convenience, and the fact that, as opposed to heavy liquids, there is no upper limit to the value of SG which may be determined.

According to Webster (1983) 'even with an accurate balance, the method of hydrostatic weighing is hardly worth using with stones of a carat or under and heavy liquids have to be pressed into service'. Anderson (1990) states that 'if it is desired to obtain the best possible results with small stones (say under 3 carats), it is desirable not to use water but some other fluid having a lower surface tension. Toluene is a stable and fairly inexpensive liquid which can be recommended for the purpose'. In view of the above comments, it might be supposed that the hydrostatic method involving water is of little value for stones of less than 3 carats. In this paper, the practicability of using water for determining the SGs of stones down to 0.035 ct is considered. It is axiomatic that knowing the SG of a stone is of considerable value; it is also evident that using heavy liquids is an unpleasant and often noxious way of establishing SG. If the relatively innocuous hydrostatic method is to be used, it is important to know its limitations and benefits.

Method

Stones ranging from 0.035 ct to 2.62 ct were tested to determine the smallest weights which would give reasonable accuracy. Tests were carried out using the following equipment:

1. a Sartorius single pan balance weighing to 0.0001 gm (0.0005 ct).
2. a 9 ct gold stone carrier in the form of a small dish to which is attached a suspension wire of 0.6mm diameter (Figure 1).

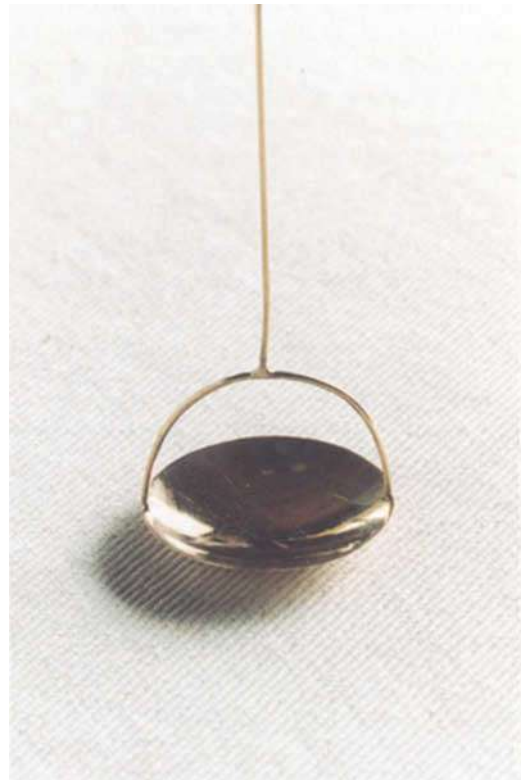


Fig. 1. The 9ct gold dish constructed to hold the stones; it remains relatively bubble-free in water with detergent.

This carrier was used in preference to a wire cage, since cages are notorious bubble traps; the dished surface of the carrier is remarkably free from bubbles in comparison. The water used was drawn from the mains supply and not boiled or distilled. However, it was left to stand for several hours to reach room temperature and occasionally stirred to remove dissolved air bubbles before use. A non-foaming carpet shampoo of the type used in wet and dry vacuum cleaners was found to be an ideal detergent, but five drops were used rather than the one drop often recommended in the literature. The water container had a working volume of 450mls. Since the balance had a tare weight facility, the scale could be adjusted to read zero with the carrier suspended in the water. Six stones were used in the SG determinations, two diamonds of 0.035 and 0.053 ct and four synthetic corundum stones of 0.25, 0.46, 0.91 and 2.62 ct respectively. They were first tested without detergent and then with detergent. The values obtained are shown in Table I.

Results

As a check on the test-retest variation to be expected in the weighing technique, the SG of a twinned quartz cut stone of 3.42 carats was obtained in ten successive weighings. The stone was tested, dried and retested (and inevitably dropped on occa-

sion) in order to determine the variations created by dust particles, air bubbles, response of the balance, etc. The results were:- mean SG 2.662, standard deviation $\sigma^{n-1} = .0065$. This shows that the technique is reasonably consistent. Using the same procedure, ten measurements of SG, using an untwinned quartz cut stone of 6.707 ct, gave a mean SG of 2.650, and $\sigma^{n-1} = .0029$.

Comments

With heavy liquids it is of course possible, when stones of particular SGs are to be detected, to make up a liquid of the same SG as the stone (providing that a sufficiently dense liquid is available), but when a number of different stones are to be tested it is necessary to use a series of liquids with SGs such as 2.65, 3.06, 3.33 (and 4 if you have a fume cupboard and suitable equipment to deal with Clerici solution - it is not recommended for use outside the laboratory). In this case, unless the stone happens to remain suspended in the liquid, since its SG coincides with that of the liquid, it is only possible to locate its SG somewhere between two values, for example 4.0 and 3.3, corresponding to the liquid in which it floats and that in which it sinks. For stones down to 0.053 ct, such approximate estimations of SG are also obtainable, using the hydrostatic method. The 0.053 ct diamond would be credited with an approximate SG of 3.45 similar to

Table I. Weights, SGs and errors in measurements of stones tested.

Stone	Weight in carats	With detergent		Without detergent	
		SG	% Error	SG	% Error
Diamond	0.035	3.12	-11.4	3.0	-14.8
Diamond	0.053	3.45	-2.0	3.16	-10.2
Corundum	0.25	3.94	-1.2	3.87	-3.0
Corundum	0.46	4.01	+0.5	4.04	+1.2
Corundum	0.91	3.97	-0.5	3.99	0
Corundum	2.62	3.97	-0.5	3.96	-0.75

NB: Errors are related to theoretical SG values of 3.52 for diamond and 3.99 for Corundum (Arem)

that provided by the four heavy liquids.

For stones in excess of 0.25 ct hydrostatic determinations become more accurate and at about 0.46 ct the error is only 0.5 per cent. The advantage of using the hydrostatic method for such stones is that there is no upper SG limit as for heavy liquids, and for the determination of accurate SGs the hydrostatic method is far quicker than modifying the SG of a heavy liquid to obtain a match.

The water used in the tests was relatively pure, but water samples from other localities may require greater quantities of detergent for the best results. Water has a surface tension of 74 dynes per cm and in tests carried out by the writer using a platinum wire loop, it was found possible to reduce the surface tension (by adding detergent) to a value approaching that of toluene at 28 dynes per cm. There is thus apparently little point in using toluene, particularly since it varies in SG as its temperature changes and temperature correction tables would have to be used; for example at 5°C its SG is 0.8787, but at 25° it has fallen to 0.8587, representing a change of 2.3 per cent. Since water only changes by about 0.02 per cent between 4° and 70°C, no compensation needs to be made.

Surface tension increases proportionally with the contact made by the suspension at the water's surface. Therefore the results could have been improved by using a

thinner wire. The wire used in these tests was 0.6mm in diameter. If the diameter had been reduced to 0.05 mm the surface tension would fall to about one tenth, so improving accuracy, particularly for smaller stones. However, the thicker wire was used since it provided greater rigidity and made removal of stones from the dish much easier.

Conclusions

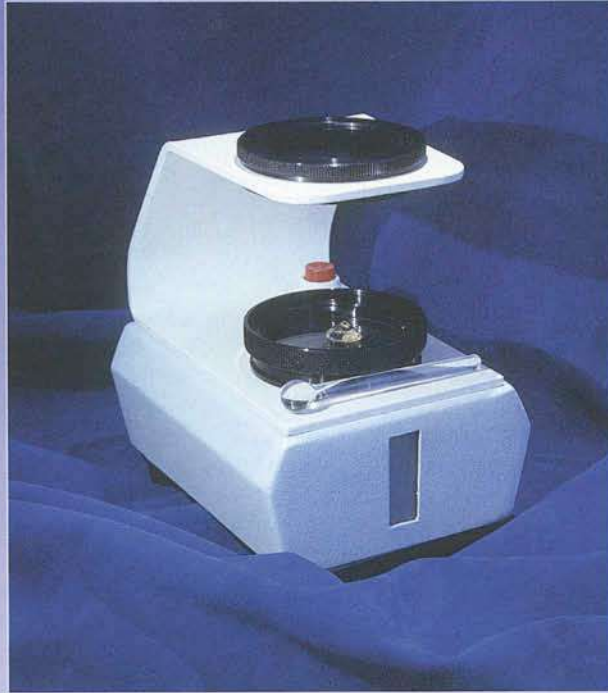
Hydrostatic measures of specific gravity, using a sensitive balance, appear to be suitable for obtaining accurate values of SG for stones over 0.25 ct. For stones down to 0.05 ct, the method still gives approximate values such as are obtained when using a series of heavy liquids. The hydrostatic method, using water, was found to be quicker and more pleasant and, in contrast with heavy liquids, there is no upper limit to the value of SG which may be determined.

References

- Anderson, B.W., revised by F.A. Jobbins, 1990. *Gem testing*. 10th edn. Butterworth & Co., London. p.62
Arent, J.E., 1987. *Colour encyclopedia of gemstones*. Van Nostrand Reinhold Co., New York, p.222
Webster, R., revised by B.W. Anderson, 1983. *Gems*. 4th edn. Butterworth & Co., London. p.652

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Pink corundum from Kitui, Kenya

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Abstract

A new source of pink corundum in the eastern foothills of Mount Kenya is described. The corundum occurs in gravels overlying rocks of the Mozambique orogenic belt which comprises ancient basement and metamorphosed volcanic and sedimentary rocks.

Corundum has been extracted since 1989 using simple open-pit mining techniques with a work force of 30 to 50. After sieving and washing, about 50-100 kilograms of corundum are recovered each week.

The corundum is light to medium pink, translucent, and suitable for cabochons and beads. Most material is exported to India but 1-5 per cent of the yield is good quality and the stones are cut in Kenya or in Germany.

Corundum beads dyed red in India could well have been fashioned from material obtained from the new deposit at Kitui.

Introduction

The north end of the East African gemstone belt lies in northern Somalia next to the Red Sea. The belt extends southwards through Ethiopia, through north-west to south-east Kenya and across Tanzania to Mozambique. In geological terms this assemblage of rocks is known as the Mozambique orogenic belt and here it forms the eastern margin of the great rift valley.

The gemstones from this region of East

Africa are as ancient and spectacular as their environment. They occur in and are derived from ancient basement rocks and overlying volcanic and sedimentary rocks which have been modified by several episodes of metamorphism. Some of these episodes involved intense heat and pressure leading to partial melting, and the resulting movement of these fluids caused reaction, dissolution and recrystallization of new mineral assemblages, some containing gem species.

The concentration of gem materials is such that now this East African 'gem belt' is blessed with proven producing areas such as the following: Lodwar and Garbatula for sapphire; Taita Taveta and Kasigau for ruby, tsavorite, tourmaline and garnet; Arusha-Moshi for tanzanite, tsavorite, chrome tourmaline and rhodolite; Longido for ruby in zoisite; the Umba River valley for fancy sapphire, garnet and other gems; Mpwapwa near Dodoma for scapolite and kyanite; and Mgorogoro for ruby and spinel.

The latest addition to this catalogue of gem localities is a hitherto unknown area east of Mount Kenya. Preliminary investigations have indicated deposits of pink corundum and this paper outlines the geology, gemmological investigations, and potential for production, marketing and manufacturing.

Location and access

The north Kitui area broadly covers the area just south of the equator, 50 miles east of Mount Kenya and about the same distance north of Mwingi.

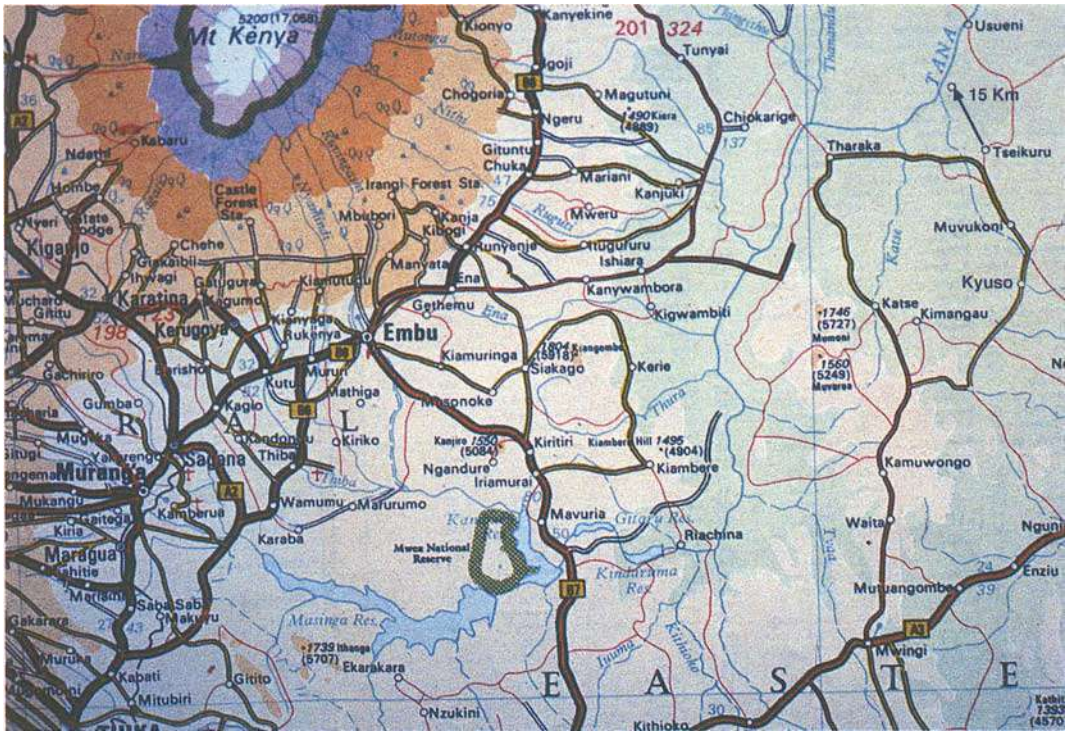


Fig. 1. Map and localities.

The claim known as Taawajah ($0^{\circ}13'S$, $38^{\circ}11'E$) (shown on Figure 1) is at an elevation of about 1900 metres above sea level and situated in the eastern foothills of Mount Kenya (elevation 5200 metres). The River Tana (500 metres west of the claim) flows all year round providing a good source for permanent water. Tsaikuru is the nearest village with a population of about 500 people.

In order to reach Taawajah, take the Thika road from Nairobi and then the A3 highway to Mwingi (approximate time 2 hours). From Mwingi turn left (Marrom Road) and pass through Waita, Kamuwongo (approximately 15 kms) then turn right to pass through Kyuso, Mavukoni and on to Tsaikuru. After that turn left onto a bush track in a north-west direction for about 15 kms to arrive at the claim Taawajah (three hours from Mwingi).

Geology

The geological succession in the north Kitui area consists of the Basement System (Precambrian in age) overlain by younger sediments and volcanics of Tertiary and Recent age.

The Basement System consists of an assemblage of quartzites, marbles, calc-silicate rocks, amphibolites and heterogeneous gneisses, some graphitic, with minor granitic and basic intrusive rocks. The quartzites typically contain magnetite, epidote, diopside, wollastonite and garnet. The marbles are generally salmon-coloured. In the alumina-rich rocks, metamorphism was sufficiently intense to produce sillimanite. The intrusive rocks include pegmatites and peridotites.

Near Kitui, 120 miles east of Nairobi, the Mutito fault zone, in which the rocks are intensely sheared and crushed, was devel-

Fig. 2. Crystals and cabochons of reddish-pink sapphire from Kitui, Kenya. *Photo: N. R. Barot*



Fig. 3. Crystals, cabochons and necklace of reddish-pink sapphire. *Photo: N. R. Barot*

oped first in the early Precambrian (Archean) along a north-north-westerly direction, and then was probably rejuvenated in Lower or Middle Pleistocene times about 2 million years ago. This produced what is now known as the Mutito escarpment and is part of the African Rift System. Further details of the geology of this area may be found in Dodson (1955) and

McConnell (1972). Dodson reports (1955, p.26) the alleged recovery from the Giluni river bed of a corundum crystal weighing about 3.5 kg but subsequent search revealed no further evidence of corundum.

Mining and production

In 1969 prospecting in the Taawajah area revealed pink corundum but due to the



Fig. 4. Cabochon weighing 7 ct of Kitui reddish-pink sapphire showing colour zoning. *Photo: R. R. Harding*

lack of demand the area was not developed. In 1988 the area was again surveyed and was registered in 1989.

Since then open-pit mining using simple techniques has been employed.

The deposit is processed using compressor and pneumatic drills, picks and shovels, and the ore is washed and sieved before hand picking of the gem material. Most gem corundum comes from the top 30 cm of gravel but depths up to 4.5 m have been exploited. There is a work force of between 30 and 50.

Weekly production of gem corundum generally varies between 50 and 100 kg but occasionally reaches 200 kg if a favourable area is being worked. More than 2 tonnes of corundum were extracted during 1989-1991, and from early 1992 to September 1993 a further 2 tonnes have been mined.

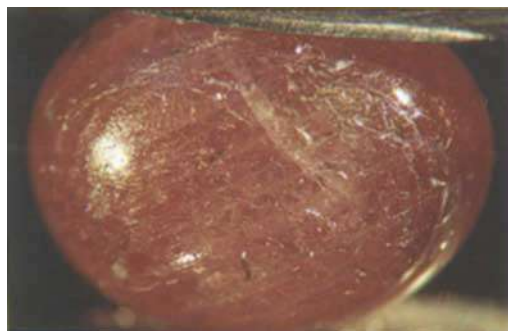


Fig. 6. Parting and fissures in a cabochon, 4.10 ct. *Photo: R. R. Harding*

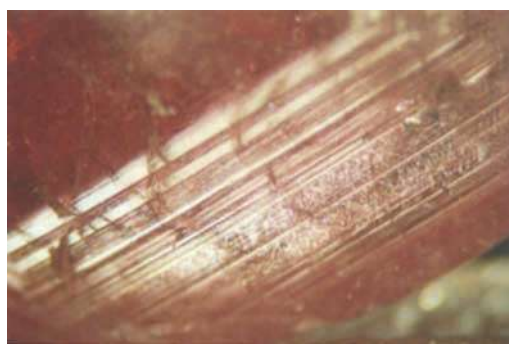


Fig. 5. Close up of colour zoning in cabochon illustrated in Figure 4 showing variation in coarseness of rutile needle inclusions. *Photo: R. R. Harding*

Most of the gem corundum is pink or reddish-pink and is recovered from the upper levels of the deposit, largely free of decomposed host rock. Below 1.5m the corundum forms part of composite rocks with white, grey, dark green or black minerals. This profile indicates that much, if not all, the corundum is eluvial in origin, derived from rocks in the immediate area, with probably some local re-working.

Marketing and manufacturing

Most of the rough corundum is sold and exported to India through various Kenyan dealers. Between 1 and 5 per cent of production is of good quality and is either sold to Germany or cut and polished into cabochons in Kenya (Figure 2). The cabochons are usually light to medium pink, translucent with a good polish and range from 2 to 20 carats.

In India the corundum rough is cut and polished into cabochons or beads; some of these are dyed red and sold locally or exported to various parts of the world (Figure 3).

Gemmological investigation

a) Description of material

Samples of rough weighing 1080g and comprising crystals and mineral aggregates up to 30 mm across were examined in London. Representative selections from the

range of material were made for detailed analysis.

The samples examined comprise small prismatic crystals with basal parting, rhombohedral parting or both, and chipped or broken to some degree. Some crystals remain undamaged but most have been abraded and now show rounded edges and impact fractures. Abrasion, however, has not removed all traces of host rock and about 10 per cent of the crystals have dark green chlorite, amphibole or mica, or white feldspar or margarite adhering. The crystals range in weight up to 20g (including partial skins of the above minerals).

Iron oxide or hydroxide stains which penetrate along cracks in the crystals, give rise to an orange or brown cast to the colour

Most crystals are bright reddish-pink overall but sections can reveal some complexity in an apparently homogeneous overall colour. Colour zoning inside the crystals is common and often discontinuous in shades of red. Some crystals contain regions of blue which have gradational edges where they merge through purple into the red host.

Cut and polished samples of natural corundum examined in this survey comprise cabochons ranging from purplish-pink to reddish-pink. They range in weight from 3 to 7 carats and are up to 12 mm in length. Rutile silk is present in some crystals and cabochons and it may show a considerable range in coarseness between colour zones (Figures 4 and 5). They contain numerous fissures (Figure 6), twin planes and some contain small sub-rounded colourless crystal inclusions (Figure 7). In addition, dyed corundum cabochons and faceted beads were examined. The cabochons are a bright red and range from 1.2 to 2.7 ct in weight and up to 9 mm in length (Figure 8). The faceted beads are a deeper duller red up to 9 mm across and weigh between 2.7 and 5.9 ct; they are crudely drilled inwards from two

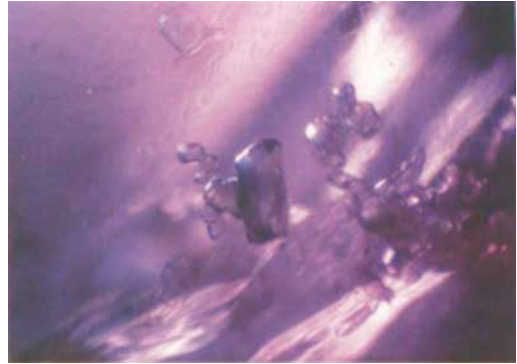


Fig. 7. Colourless crystal (?apatite) inclusions in Kitui pink corundum. *Photo: N.R. Barot*

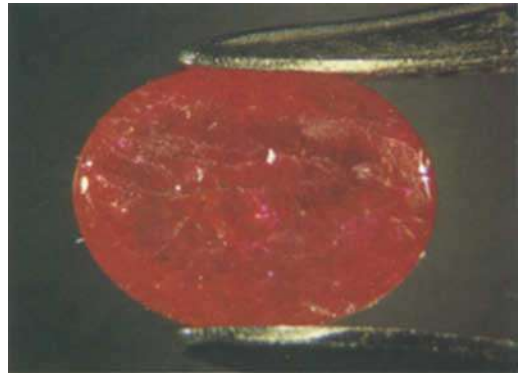


Fig. 8. Treated corundum cabochon, 1.22 ct. *Photo: R. R. Harding*



Fig. 9. Treated corundum faceted bead, 2.85 ct. *Photo: R.R. Harding*

directions (Figure 9).

(b) Dichroism and fluorescence

The reddish-pink crystals and cabochons show moderate dichroism from a purplish-red to red with an orange tinge. In many samples, however, the numerous fissures and some twin planes make it difficult to see. Paler crystals and cut stones have correspondingly less distinct dichroism.

Dichroism is very faint or absent in the dyed cabochons examined but in the dyed faceted beads there appeared to be faint purplish-orange dichroism in some samples.

Fluorescence of untreated crystals and cabochons under long-wave ultraviolet radiation (LWUV) at 365 nm is orange-red and strongest in the most translucent crystals. Increasing degrees of opacity or of blueness in colour correspondingly dampen the fluorescence. Behaviour of any of the rubies under short-wave ultraviolet (254 nm) is a duller version of that under LWUV.

In both the dyed cabochons and faceted beads the response under long- and short-wave ultraviolet is orange-red. It comes mainly from the fissures and is more obvious in the beads than in the cabochons.

(c) Chemical analyses

Analyses by Geoscan electron microprobe at the British Geological Survey were carried out to determine the composition of the ruby in its various shades of colour and to identify the black, dark green, grey and off-white minerals adjacent to the ruby in the mineral aggregates.

The compositions of eight positions on a red cabochon showed major aluminium and minor chromium and iron; total iron reported as FeO, ranged from 0.26 per cent to 0.44 per cent while chromium (as Cr₂O₃) varied between <0.10 per cent and 0.16 per cent. In a purplish-pink cabochon the FeO range was 0.18 per cent to 0.39 per cent, and Cr₂O₃ <0.10 per cent to 0.21 per cent. Analyses of a polished section across a

ruby prism showed similar ranges of values. Some round polished and faceted beads have been stained to resemble better quality ruby (see below). One was analysed and contained no detectable chromium (<0.10 per cent Cr₂O₃) and between 0.44 per cent and 0.75 per cent FeO.

Two orange-red fragments in the ruby concentrate were found to be garnet with approximately equal contents of almandine and pyrope; there are also minor grossular and trace spessartine components. Analyses of seven spots on the two fragments gave a mean composition for the garnet of Py₄₅Al₂Gr₁₁Sp₂.

The mineral aggregates from deeper levels of the deposit consist of red corundum, grey-brown corundum, amphibole, feldspar and micaceous minerals. The grey-brown corundum contains no detectable chromium and up to 0.7 per cent FeO. The black lustrous amphiboles are the calcic variety hornblende with the composition (Na_{0.11}K_{0.05}Ca_{1.64})(Fe_{1.01}Mg_{0.31}Ti_{0.03}Al_{1.13})(Si_{6.37}Al_{2.63})O₂₃(OH). The off-white minerals sampled are oligoclase feldspar (An₂₆Ab₇₂Or₁) and quartz. Dark green minerals, probably largely chlorite, form at the margins of the hornblende.

(d) Spectral features

Spectra in the range 250-750 nm (UV-VIS) were measured on specimens of natural corundum (two pink cabochons, one purplish-pink cabochon and a polished slice) and five treated specimens (two cabochons, one half-cabochon and two faceted beads).

The natural untreated corundum displays a small peak at 692 nm, a broad absorption between 490 and 600 nm centred about 550 nm, very small peaks at 474 nm, 466 nm and 448 nm, and a major sharp peak at 386 nm. Each specimen also showed total absorption at wavelengths which ranged from 310 nm in the pale corundum to 350 nm for the more intensely

coloured purplish-pink cabochon. In comparison with published spectra for rubies and sapphires (see for example Schmetzer et al., 1992, and Themelis, 1992) the preliminary work on the Kenyan stones has revealed no obvious distinguishing characteristics.

The spectra of the treated stones can be considered in two groups. The cabochons and half-cabochon display spectra similar to the untreated stones except that peaks recorded for untreated stones at 474, 466 and 448 nm are weak or non-existent. The second group comprises the faceted beads. They display no absorption at 692 nm, a broad peak centred about 550 nm and a distinct peak at 450 nm with a minor peak on the longer wavelength shoulder at 458 nm.

This preliminary survey has thus shown that the treated cabochons have spectra similar to those of Kenyan rubies, but at the same time have not shown obvious spectral differences between untreated and treated stones. However, the differences between the spectra of the treated cabochons and treated beads indicate that the beads are made from corundum with no detectable chromium.

(e) *The dyed corundum*

At first glance the dyed cabochons and faceted beads look like ruby (Figures 8 and 9) but careful examination under a microscope in appropriate lighting conditions reveals patchy and sometimes dense concentrations of colour in the fissures. The dye is orange red in transmitted light but tends to have a purplish hue if the fissure/polished surface intersection is viewed in reflected light, perhaps because the dye has reacted with the air.

Immersion of the cabochons (Figure 10) and faceted beads (Figure 11) in water did not appear to affect the dye, but there is some dissolution in benzyl benzoate which is easily seen as a pink residue when the dyed material is dried with white tissue. In ethyl alcohol and amyl acetate the dye in



Fig. 10. Treated corundum cabochon immersed in water; red dye along fractures is easily visible. Photo: R. R. Harding

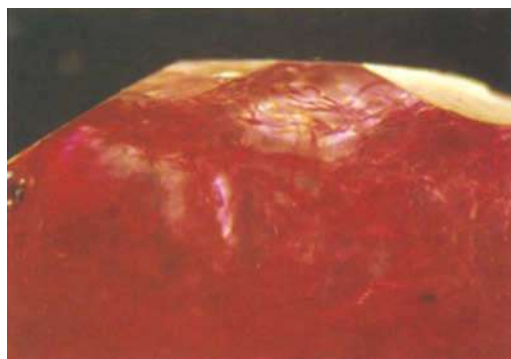


Fig. 11. Treated corundum bead immersed in water; red dye along fractures may be seen near the facet surfaces. Photo: R. R. Harding

the cabochons was slightly soluble, and that in the faceted beads was readily soluble, making the white tissue distinctly pink. The dye in both kinds of stone appeared to be less soluble in methylene iodide (di-iodomethane) with only faint tinges of pink on the tissue resulting. The apparently 'stronger' behaviour of the faceted beads in the solvents may merely be an indication of a higher density of dye-filled fissures.

We can conclude that it is a simple matter to detect dyed faceted beads using ethyl alcohol or amyl acetate where a rapid appearance of colour on white material might be expected. A little more perseverance may be necessary to check the

cabochoons if they have relatively few fissures.

In addition to the above organic solvent test, Schmetzer *et al.* (1992) have discussed a method of detecting dye in a dyed corundum using ultraviolet spectroscopy and microphotography.

Discussion

We may draw the following conclusions:

(a) pink and reddish-pink gem quality corundum from a new locality at Kitui in Kenya has been described. The best material is a bright attractive colour but the stones contain numerous fissures and to date the production has been most suitable for cutting into cabochoons;

(b) chemically, the corundum contains small amounts of chromium and slightly higher contents of iron, features confirmed in the spectra obtained from a sample of cabochoons and crystals;

(c) samples of corundum cabochoons, dyed red and emanating from India, yield identical spectra to those from untreated corundum from Kitui. Kitui is therefore a possible source for this Indian material. Samples of faceted beads, also dyed red and emanating from India, are cut from corundum with different spectra from those of the examined Kitui material and the source of the corundum is not known;

(d) both dyed cabochoons and dyed faceted beads may be detected and distinguished from un-dyed ruby and sapphire by application of a solvent such as ethyl alcohol or amyl acetate on a white tissue and observing the colour of the residue when it dries.

Acknowledgements

We would like to thank Ana Castro and Stephen Kennedy for assistance in the Laboratory and for useful discussions. Thanks also go to Dr. M. T. Styles of the British Geological Survey for use of the Geoscan electron microprobe, and to him, D. Bland and Paul D. Wetton for technical assistance.

References

- Barot, N. R., 1993. Gem deposits discovered in Ethiopia and Somalia. *Gem News, ICA Gazette*, p.4
- Bridges, C., 1982. Gemstones of East Africa. *International Gemmological Symposium Proceedings*, pp. 263-75
- Crowningshield, G.R., Reinitz, I., 1992. Dyed sapphire as a ruby imitation, in *Gem Trade Lab Notes*, C. W. Fryer (ed.) *Gems and Gemology*, 28, 3, 196-7
- Dodson, R.C., 1955. Geology of the North Kitui area. *Geological Survey of Kenya*, 27 pp, 1 map.
- McCornell, R. B., 1972. *Geological Society of America Bulletin*, V, 83, pp. 2549-72
- Schmetzer, K., Hänni, H. A., Jegge, E.P., Schupp, F.-J., 1992. Dyed natural corundum as a ruby imitation. *Gems and Gemology*, 28, 2, pp. 112-15
- Themelis, T., 1992. *The heat treatment of ruby and sapphire*. Gem Lab Inc., Florida, USA

[Revised manuscript received 5 January 1994]

Vesuvianite from Bellecombe and Montjovet (AO Italy): a material of gemmological interest

Massimo Nozaga

Milan, Italy

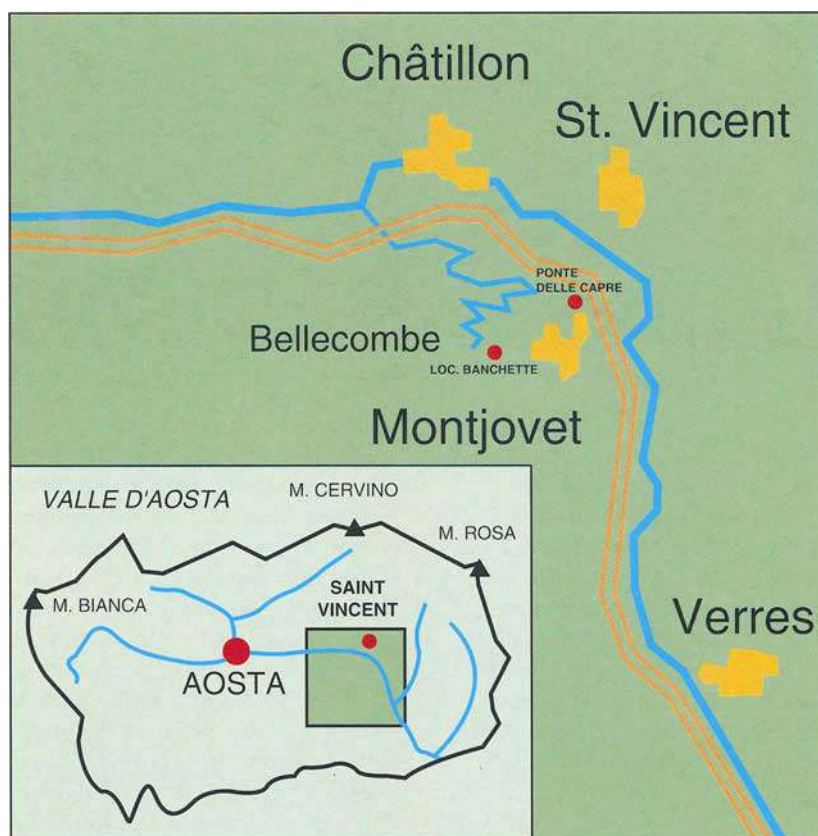


Fig. 1. Map showing the vesuvianite research area in the Valle d'Aosta region, Italy.

Abstract

Gem quality vesuvianites from Cretaceous rodingite veins near Bellecombe and Montjovet (AO Italy) have been analysed. Chemical analyses and refractive index measurements allow distinction of two kinds of vesuvianite: type A with $n=1.724-1.736$ and type B with $n=1.715-1.720$; densities between 3.35 and 3.40 g/cm³ were recorded. Transparent vesuvianite from this locality is good gem material but, because the vesuvianite is not uniformly distributed in the rodingite rock, the occurrence is not an economic prospect.



Fig. 2. Massive vesuvianite rock and serpentinites in the Bellecombe area

Introduction

Vesuvianite or idocrase is a calcium aluminium silicate classed as a sorosilicate and is present generally in rodingite rock. Rodingites, which are common in Liguria (Voltri group) at Bric Camula and in other parts of the Valle d'Aosta, are associated with peridotites and serpentinites (Dal Piaz, 1966). The aim of this work, comprising, geological fieldwork and laboratory analysis, is the study of the petrology and gemmology of vesuvianite and an investigation of its economic potential.



Fig. 3. Veins of vesuvianite rodingite rock near the road from Ussel to Bellecombe.

Location and petrology

The area studied covers 12 square kilometres lying north-east and north-west of Bellecombe, and is occupied by massive serpentines (Figure 1). The metamorphic rodingite-vesuvianite rocks from Bellecombe are of Cretaceous age and were formed as a result of the action of serpentinizing fluids on ultrabasic massifs (see Dal Piaz, 1966) (Figure 2). Generally the rodingite-vesuvianite rocks are present as brown or pink fine-grained veins and lenses. These calc-silicate rocks consist of diopside and augite, epidote, garnet and chlorite, with vesuvianite enclosed in a garnet matrix: indeed the rodingite rock has been called 'garnetite'.

Veins of rodingite rock are easily visible in the serpentines, both in the mines and quarries near Montjovet (Figure 3) and in outcrops near the road from Ussel to Bellecombe. Massive rodingites also occur at Banchette. A characteristic feature of rodingite veins in these localities is the chlorite border at each margin which effectively defines the veins.

Table I. Chemical analyses of vesuvianite from Bellecombe and Montjovet, Valle d'Aosta, Italy

<i>Weight per cent</i>	<i>Range</i>	<i>Mean</i>
SiO ₂	36.53 - 37.40	36.95
Al ₂ O ₃	15.12 - 17.74	16.43
FeO	2.66 - 3.94	3.3
MgO	2.04 - 2.62	2.33
CaO	35.78 - 36.50	36.14
Na ₂ O	abs - 0.09	0.02
TiO ₂	0.035 - 2.05	1.04
MnO	abs - 0.12	0.06
Cr ₂ O ₃	0.02 - 0.06	0.04
Total		96.85

N.B. 'abs' means below the detection limits of this method of analysis

Table II. Optical and physical analyses of vesuvianite from Valle d'Aosta, Italy

<i>IGI inventory number</i>	<i>Locality</i>	<i>Indices</i>		<i>Birefringence</i>	<i>Density g/cm³</i>
		ϵ	ω		
Type A					
2909	Ponte delle Capre	1.724	1.728	-0.004	3.35±0.025
2910	Ponte delle Capre	1.731	1.736	-0.005	3.38±0.045
2911	Ponte delle Capre	1.731	1.736	-0.005	3.36±0.020
Type B					
2760	Loc. Banchette	1.715	1.718	-0.003	3.40±0.055
2761	Loc. Banchette	1.714	1.717	-0.003	3.38±0.050
2904	Bellecombe	1.719	1.722	-0.003	3.39±0.050
4119	Bellecombe	1.718	1.720	-0.002	3.36±0.035
Unit cell parameters					
Sample	1	2	3	4	5
a (Å)	15.566	15.538	15.588	15.533	15.546
c (Å)	11.859	11.816	11.848	11.878	11.831



Fig. 4. Vesuvianite crystal.

Characteristics of vesuvianite

Vesuvianite from Banchette and Bellecombe has prismatic habit, is greenish-brown (DIN 24,5:4:6) and reaches 3 cm in length (Figure 4) that from Ponte delle Capre is yellowish-brown. Chemical analyses of vesuvianite crystals were performed

by Scanning Electron Microscope with energy dispersive attachment (Table I). Since minor elements and water were not determined, the oxides do not total 100 per cent. Optical data and density measurements are given in Table II.

Refractive indices and densities

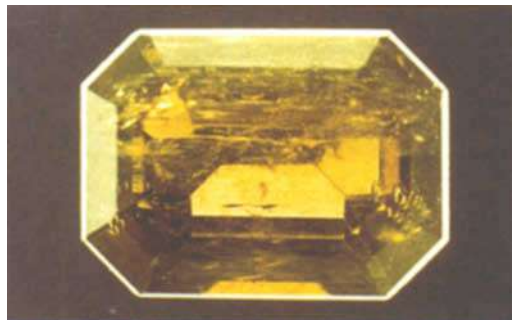
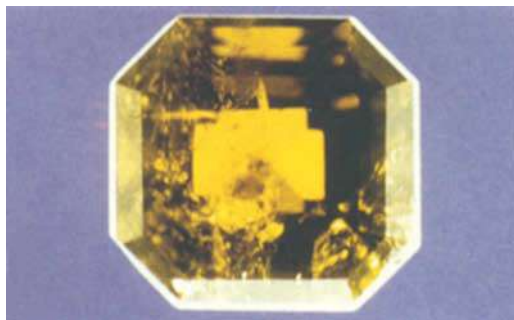
Gemmological examinations were performed on seven cut samples (two of which are illustrated in Figures 5 and 6), which weighed between 1.2 and 3.1 ct. These samples have been divided into two types designated 'A' and 'B'. Type A presents refractive indices in the range 1.724-1.736 and densities $3.35 \pm 0.025 - 3.36 \pm 0.020$ g/cm³; type B is characterized by refractive indices of 1.714-1.722 and densities of $3.36 \pm 0.035 - 3.40 \pm 0.055$ g/cm³. The reasons for these differences probably lie in chemistry related to the diversity of the host rodingite rock.

Spectra

Using a Zeiss prism spectroscope, the spectra of all samples showed an absorption line at 471 nm, which is the most important identification feature of vesuvianite (Anderson, 1987).

Inclusions

Under the immersion microscope, the gems may be seen to contain abundant inclusions, the most frequent of which are fluid inclusions in small tubes or channels and in negative crystals (Figure 7).



Figs. 5 and 6. Samples of faceted vesuvianite.

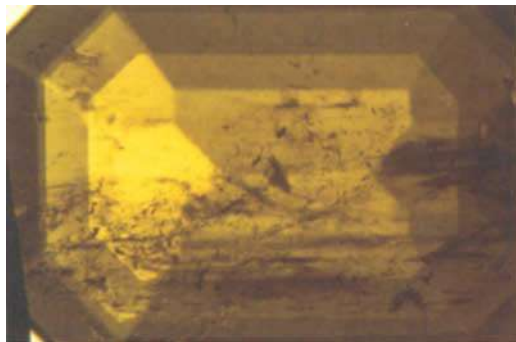


Fig. 7. Fluid inclusions in small tubes and fractures, and various crystals. Immersion microscope.

Dichroism

Dichroism, observed with a calcite dichroscope, indicates that the Ponte delle Capre samples range from brown to yellow or green, while the Loc. Banchette and Bellecombe samples tend to show a yellow to green range.

Conclusions

The rodingite veins in the serpentinites around Bellecombe and Montjovet have yielded some gem quality vesuvianite. However, the rodingites are heterogeneous rocks (Vuagnat, 1965; Dal Piaz, 1966) and economic extraction of vesuvianite from this area of Valle d'Aosta is not feasible. Moreover this area is now protected by the Valle d'Aosta regional authority.

References

- Anderson, B.W., 1987. *Gemmologia pratica*. IGI, Milan. p.551
 Biesalski, E., 1975. *Pflanzenfarbenatlas nach DIN 6164*. Musterschmidt Verlag, Göttingen. p.283
 Dal Piaz, G.B., 1966. *Le granatiti nelle Serpentine delle Alpi Occidentali Italiane*. Memorie Societa Geol. It., 6, 267-313
 Vuagnat, M., 1965. *Alcune riflessioni sulle ofioliti e sulle rodingiti*. Rendiconti Soc. Min. It., 23, 471-81

[Revised manuscript received 8 April 1994]



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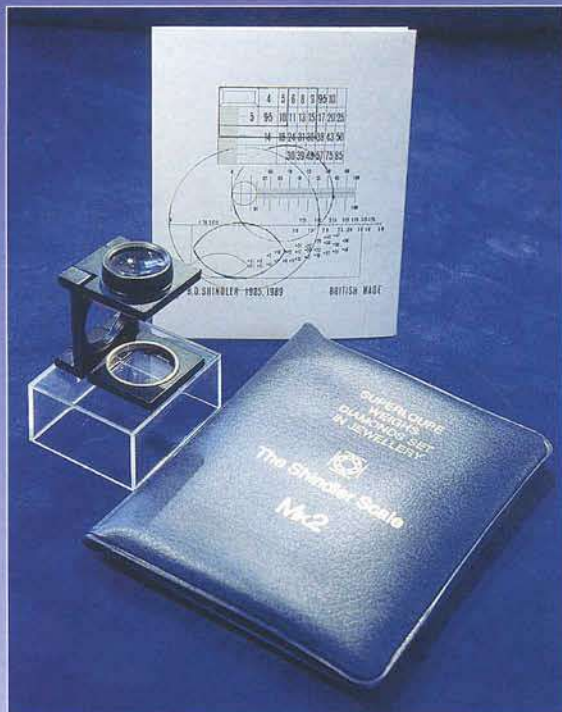
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Smoky moonstone: a new moonstone variety

H. Harder

Göttingen, Germany

Abstract

The blue sheen of moonstone is enhanced by a dark body colour. It is proposed to call moonstones with a grey body colour 'smoky moonstone'. The colour can be attributed to divalent iron content.

Introduction

The beauty of moonstones is due to both the body colour and the blue or white sheen (adularescence). The moonstone sheen is mobile and is best seen in particular crystallographic directions.

Moonstones are generally colourless but can also occur in many colour shades.

Some south Indian moonstones, for instance, have a strong body colour in green, yellow, beige, pink, red or brown and even in black or grey, but most Sri Lankan moonstones are colourless and transparent or white and translucent.

The blue sheen in some Sri Lankan moonstones is well known (Spencer, 1930) and is caused by a high sodium content (Harder, 1992a). Only a small proportion of stones show a strong sheen, but a weak sheen may be emphasized by a darker body colour and appear much more beautiful.

Location

Moonstones with a dark body colour have been found in the last few years in

Table I. Moonstone qualities of Sri Lanka with different body colours and sheens

Moonstone body colour	<i>Colourless moonstones</i> Water clear Colourless cloudy	<i>Smoky moonstones</i> Smoky clear or Cloudy translucent
Moonstone sheen Blue	Crystal blue ¹ Normal blue Muddy blue	'Royal blue' ² Normal blue Muddy blue
Semi blue	Top semi blue ¹ Normal semi blue Muddy semi blue	Crystal semi blue Normal semi blue Muddy semi blue
White	Crystal white ¹ Silvery/pearly white ³ Normal white Muddy white	Crystal white Normal white Muddy white

1 Only in Metiyagoda

2 Only in Imbulpe

3 Less in Metiyagoda and more from Embulipitiya, a new moonstone locality on a bank of the river Walawe Cianga in south Sri Lanka

Table II. Chemical composition of colourless and smoky moonstones from Sri Lanka

Weight %	Colourless – Metiyagoda semi-blue sheen		Smoky – Imbulpe	
			blue sheen dark smoky	semi-blue sheen light smoky
SiO ₂	66.2		66.5	66.4
TiO ₂	0.004		0.02	0.02
Al ₂ O ₃	18.8		19.0	19.1
Fe ₂ O ₃	0.007		0.014	0.003
FeO	0.014		0.094	0.06
MgO	<0.00		<0.00	0.005
PbO	≈0.02		0.00	0.00
BaO	0.004		0.04	0.03
CaO	0.3		0.74	0.64
SrO	0.02		0.05	0.05
Na ₂ O	3.7		5.9	5.34
Rb ₂ O	≈0.07		≈0.013	≈0.009
K ₂ O	10.1		7.7	8.41
Ign. loss at 950°C	0.16		0.0	0.03
Total	99.399%		100.071%	100.097%
Other trace elements:	Cr ₂ O ₃ 0.02-0.003	MnO 0.03-0.01	Ga 0.002	
Feldspar components:				
Orthoclase	63		45	49
Albite	35		52	48
Anorthite	2		3	3

the Central Mountains of Sri Lanka near Imbulpe, east of Ratnapura (Harder, 1992b), and in the region of Balangoda, near the road to Haputale in the Sabaragumuba Provinces. The flash of the blue or white sheen emanating from the dark smoky body makes the beauty more apparent. It is proposed to call this new variety of moonstone 'smoky moonstone'.

In the Sri Lankan trade, there is now a much greater variety of moonstones. Qualities from a number of new mines are cut together with the well-known moonstone from Metiyagoda (see Table I). The locality in Imbulpe has produced some smoky moonstones with an unusually strong blue sheen and locally this top quality is called 'royal blue'.

Composition

Top blue moonstones even in smoky qualities are albite rich; i.e. an albite, which contains only up to 45 per cent potassium feldspar (orthoclase). The chemical composition of two smoky moonstones from Imbulpe are presented in Table II and are compared with an analysis of a moonstone from Metiyagoda with a quality called 'semi-blue'. The SiO₂ and Al₂O₃ contents were determined by means of gravimetric analyses. The K₂O, Na₂O, CaO and MgO contents were analysed by atomic absorption, Fe by spectrophotometric investigation and the trace elements Mn, Ba, Sr, Rb and Cr by X-ray fluorescence.

Although the values of the main and trace element contents between samples



Fig. 1. The strong blue moonstone sheen is visible from a smoky body colour. The stones range from 2 to 10 cts and are of reasonable quality.



Fig. 2. Range of qualities of cut smoky moonstone from Imbulpe.



Fig. 3. Poor quality smoky moonstone from Imbulpe with cleavages, cracks and inclusions; cut as a paper weight. Size 50/30mm.



Fig. 4. The smoky body colour of this moonstone is apparent in front of a white sheet.

are very similar, the Fe_2O_3 and especially the total iron content of the smoky moonstone samples are distinctly higher than in colourless Metiyagoda moonstones. A higher Fe^{2+} content and the charge transfer of Fe^{2+} to Fe^{3+} is the chemical reason for the smoky body colour of the moonstone. The blue sheen is more visible the darker the stone.

In the smoky moonstone deposits in Imbulpe a range of qualities is recovered from pegmatites. The moonstones are mined from the pegmatite surface on the slopes of the mountains and show some weathering. Some of these moonstones present brownish or yellow colours, which probably formed through recent weathering processes. Although these muddy

colours are not appreciated in the trade, the most important defects which affect gem quality are the numerous mineral inclusions. Most inclusions are clay minerals, such as swelling chlorite, which is probably a recent result of weathering of biotite. The inclusion-rich moonstones may have some interest for collectors but for the moonstone dealers this 'quality' is a disadvantage. The first smoky moonstones were cut at the end of 1990 and their intensive blue sheen has attracted some Sri Lankan sapphire dealers. The trade in sapphires has tolerated inclusions, indeed they are a useful indication of natural origin. The prices of the new variety of smoky moonstones are extremely high even though they are difficult to sell.

Moonstones on the market

The mining in Imbulpe is illegal and the activity is not regular. In the years 1992 and 1993 better material with a stronger blue was cut. But most cut stones contain inclusions, and only a small percentage is inclusion-free. This inclusion-free material with a strong blue sheen should be expensive, but it is not sufficiently well-known in the jewellery trade so the clear Metiyagoda moonstones are preferred. The present market situation of smoky moonstones may be compared with the introduction to the trade of black opals. At first the beauty of black opals was not recognized by the public, but now their prices are extremely high compared to white opals. It is the author's opinion that the trade and public will grow to accept smoky moonstones and that values will rise.

Other localities

John Sinkankas (1959) describes the body colour of 'the finest moonstones in North America' (Black Range in Grant County, New Mexico) as 'a very distinctive smoky grey or brown'.

'The strong bright blue adularescence ... rivals that observed in Ceylon moonstones. Most of the material is cracked

and veiled with inclusions and large flawless gems are impossible to obtain.'

The material from New Mexico seems to be similar to the smoky moonstones of Imbulpe. But in Sri Lanka a few cut stones are free of inclusions and possibly the Sri Lankan quality may be slightly higher.

It is to be hoped that more smoky moonstones in other parts of the world can be found in qualities which the gem trade will accept.

Acknowledgements

It is a pleasure for me to express my thanks to several friends in Sri Lanka. Talks with well-informed moonstone merchants were very helpful in preparations for this paper, especially the information from S.H.M. Mohideen (Jeiser), Hajee M.T.M. Nazurdeen and John Sinkankas of San Diego, USA.

References

- Harder, H., 1992a. Moonstone. Mining in Sri Lanka – new aspects. *J. Gemm.*, 23, 1, 27-35
 Harder, H., 1992b. Rauchmondsleine, eine neue Mondstein Varietät. *Z. Dt. Gemmol. Ges.*, 41, 69-84
 Sinkankas, J., 1959. *Gemstones of North America*. D. Van Nostrand Co. Inc., New Jersey
 Spencer, E., 1930. A contribution to the study of moonstone from Ceylon and other areas and of the stability-relations of the alkali-feldspars. *Miner. Mag.*, XXII, 291-367

[Manuscript received 27 March 1993]

Letters

From Dr Kurt Nassau, PhD, FGA

Dear Sir

On Diamond-filling Glasses and Nelson's Speculations

I was surprised by the speculations of J.B. Nelson¹ on the possible nature of the glasses used in the fracture filling of diamonds and on a possible apparatus for performing this operation. First, Nelson ignored the stated limitation of the analyses used by Koivula *et al.*² and therefore missed the important boron content of these glasses. Secondly, he also ignored the large literature on low melting glasses, including solder glasses. And, thirdly, he hypothesized a possible £5000 apparatus for fracture filling when a £5.00 arrangement would do as good a job. As a result, while his discussion is actually not often wrong, much of it is irrelevant.

The type of analyses used by Koivula *et al.*² as well as that shown in Figure 2 of Nelson's paper is not able to detect the presence of boron, as was clearly stated by Koivula *et al.* (ref. 2, p.79). They also reported that the chloride content seemed to approximate the sum of lead and bismuth and that a major amount of oxygen was also present. Nelson¹ repeated these statements but ignored their logical consequence, namely that there must be present another cation in major amounts to correspond to the oxygen content and that boron is the only practicable (and indeed expected) candidate. Since Koivula *et al.*² reported that bismuth was present in some, but not all, of the analyzed fillings and E. Fritsch (unpublished data) observed the presence of bromine in one fracture-filled diamond, the fracture-filling glasses are thus quite variable, including both lead-boron-oxy-

halides and lead-boron-bismuth-oxyhalides.

Lead-boron-oxide glasses are well known, with melting temperatures as low as 500°C, and so are lead-boron-bismuth-oxide glasses (ref. 3 p.169; ref. 4 pp 447, 465-9; ref. 5, pp 177, 185, 218, 251). The addition to oxide glasses of halides, such as bismuth and lead chlorides and bromides are also widely described (ref. 3 pp 225-6; ref. 4 pp 562-5; ref. 5 p.183).

Multicomponent oxyhalide glasses can have extremely low melting points (even lower than 300°C) and are widely used, e.g. as 'solder glasses' to seal glass covers to digital (alphanumeric) semiconductor displays. Such glasses do not usually show devitrification unless specifically designed and processed to do so, thus allaying one of Nelson's concerns.

Incidentally, Nelson's suggestion of pouring molten glass into mineral oil should not be tried - such a process is an extreme explosion and fire hazard! Why not merely pour the melted glass onto a cold metal plate in the customary manner?

A very simple apparatus often used by scientists to mix substances in vacuum is shown at *a* in Figure 1.

Since the fracture-filling glasses are so low melting, a fused silica (or even pyrex?) container is suitable for their melting. The diamonds are placed at A, the glass at B, and a vacuum is applied at a temperature less than the flow temperature of the glass for baking out. The temperature is then raised and rotation about the ground glass joint C into the dashed position now causes the glass to flow onto the diamonds. After fracture filling, a further rotation permits draining the excess glass through screen D. To remove the diamonds, one merely breaks the inexpensive tube (if it has not fractured by itself on

cooling).

If one does not insist on performing the draining step in vacuum, then the even simpler test-tube arrangement at *b* in Figure 1 can be used, where lumps of glass E are placed on top of the diamond F. After baking out at a lower temperature, the glass is melted to flow over the diamonds. For this arrangement a furnace is not needed since a gas burner will do; the excess glass is melted away on a wire screen in the ambient atmosphere.

Finally, one should point out the impossibility of the precision polishing required

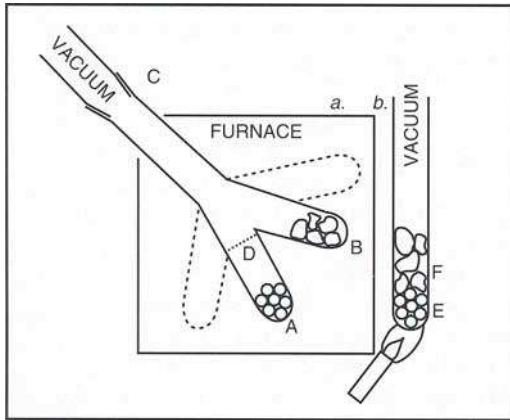


Fig. 1. Two ways of filling fractures in diamonds with low melting glass in a fused silica (or pyrex?) apparatus.

by Nelson¹ in his Figure 6. When a soft glass is adjacent to extremely hard diamond, the well-known 'undercutting' just cannot be avoided, even if the heat of cutting does not cause the glass to ooze.

My aim here has been to caution the reader and to provide Nelson with additional data and some entry references into the glass literature²⁻⁴, where he will find many additional relevant references; this should give him a factual basis for his speculations.

Yours etc.
Kurt Nassau
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Lebanon, NJ 08833, USA.

References

1. Nelson, J.B., 1994. The glass filling of diamond: Part 2: a possible filling process. *Journal of Gemmology*, 24, 94-103
2. Koivula, J., Kammerling, R.C., Fritsch, E., Fryer, C.W., Hargett, D., and Kane R.E., 1989. The characteristics and identification of filled diamond. *Gems and Gemology*, 25, 68-83.
3. Kreidl, N.J., 1983. Inorganic glass-forming systems in Uhlmann, D.R., and Kreidl, N.J., eds, Academic Press, New York. *Glass: science and technology*; vol. 1
4. Volf, M.B., 1984. *Glass science and technology*, 7; chemical approach to glass, Elsevier, New York
5. Takamori, T., 1979. Solder glasses in Tomazawa M., and Doremus R.H., eds, *Treatise on materials science and technology*; vol. 17: glass II, Academic Press, New York

From Professor Cornelius S. Hurlbut

Dear Sir

I write in reference to the article by T. Farrimond in the *Journal of Gemmology* (1994, 24, 2), 'A device to facilitate the measurement of birefringence in gemstones'. This paper was of particular interest to me for several years ago I constructed, for my own use, an almost identical device for use with a GIA GEM Duplex II refractometer.

However, the device itself is not what prompted this letter but rather the reference to the Gemeter Digital 90. It is perfectly correct that the difference between the highest and lowest readings determined on any facet with a Dialdex is the birefringence. Since a similar device is mentioned, and illustrated, for the Gemeter, it implies that the birefringence can also be measured with this instrument. Assuming accurate readings, only with special crystallographic orientations of the table can birefringence of a gemstone be determined with a Gemeter. The special condition for uniaxial gemstones is when the table is parallel to the optic axis. If the table were perpendicular to the optic axis, all readings would be the same as the stone is rotated. For biaxial gemstones the rarely encountered special condition is that the vibration directions of both the alpha and gamma indices lie in the table. For a random crystallographic orientation of the table of both uniaxial and biaxial gemstones different readings would be obtained on turning the stone, but the dif-

ference of the maximum and minimum would never be the full birefringence.

Yours etc.

Cornelius S. Hurlbut
Professor of Mineralogy, Emeritus
Department of Earth and Planetary
Sciences, Harvard University, Cambridge,
Mass 02138, USA

Response from Dr T. Farrimond

20 May 1994

Dear Sir

I appreciate the comments made by Professor Hurlbut pointing out the problems of measuring birefringence using a device such as the Jemeter Digital 90. In my article, the reference I made to it en passant was simply to illustrate the convenience of using a mechanical rotation device for the Jemeter. I find it much easier, when using mechanical rotation, to retain a stone balanced on the 4.5mm diameter truncated cone platform of the Jemeter. My reference was not intended to imply similarity of function to critical angle refractometers.

I am pleased Professor Hurlbut has drawn attention to my footnote since the distinction between the different types of instruments is made clearer.

Yours etc.

Tom Farrimond
Thornton Road, Cambridge, New Zealand
11 June 1994

From Richard M. Hughes

Dear Sir

I would like to comment on two articles in the *Journal of Gemmology*. First, 'A Note from the Bahrain Laboratory' (1992, 23, 4, pp 223-4), featuring a discussion of treated amber. In this article, the authors noticed a concentration of colour at the surface of a necklace of amber beads, and came to the

logical conclusion that the beads had been treated to darken their colour.

In the mid-1980s I had occasion to cut some rough amber (probably of Baltic or Dominican Republic origin) in Bangkok. In the rough, the colour was a rich golden brown, but the resulting cabochons came out a pale yellow, similar to the colour of the average, tasteless, American beer. The stones were put into a stone paper and promptly forgotten. Several years later I examined those same stones and was surprised to discover that their colour had darkened considerably, despite the fact that they had remained in pitch darkness the whole time.

From the above experience I was able to conclude one thing without doubt ...

* The colour of amber may darken over time.

However, being the good scientist I pretend to be, I must consider mitigating factors. These lead me to the following postulate ...

* The colour of amber may very well darken over time. But with the paint-warping pollution levels what they are in Bangkok, it is entirely possible that such a colour change should be seen as a form of providential treatment (er, enhancement).

Perhaps this is the real secret to Thailand's success at gem treatments. Not to worry though. If pollution is found to influence the colour of gemstones, I am sure CIBJO can find a historical precedent, so customers need not be informed.

The second item is 'Myanmar and its gems - an update' (1994, 24, 1, pp 3-40). In this article (which was excellent), the Black Prince's Ruby and the Timur Ruby are said to possibly be of Burmese origin (p.4). I would like to point out the existence of historical evidence which suggests that most of the red spinels of yore were actually mined in Badakshan, along what is now the Afghanistan-Tajikistan border. The terms *balas ruby*, formerly used to describe spinel, is a garbled version of *Balakhsh*, an old pro-

nunciation of Badakshan.¹ To me, Timur is an obvious reference to King Timur, who ruled over Samarkand early in the fifteenth century. And the Timur ruby does feature Persian inscriptions on it.

While the above evidence is circumstantial, it is no more than the inclusion evidence. Until such a time as documented specimens are collected from the Badakshan mines, and inclusion studies performed, it is impossible to say whether or not their inclusions are similar to those of Burmese spinels.

In closing, I would like to leave you with the following from one of Ireland's finest, Valentine Ball [1843-1895], former head of the Geological Survey of India and Tavernier biographer ...

‘There is good reason for thinking that many of the large historical spinels, both of the East and Europe, may have come from

the locality in Badakshan, or possibly even from Afghanistan, rather than from the better known localities of Ceylon and Burmah.’


Valentine Ball (1893)


A description of two large spinel rubies, with Persian characters engraved upon them. *Proceedings of the Royal Irish Academy, Third Series, 3, 1*, pp 380-401. Reprinted in *Gemological Digest, 1990, 3, 1*, pp 57-68.


Yours etc.
Richard W. Hughes
Boulder, CO 80301-3980, USA
28 May 1994


1. For an excellent description of this term, see Yule, H. and Cordier, H. (1921) *The Book of Ser Marco Polo*. Reprinted by Dover, 1993, London, Murray, 3 vols.


Abstracts

 Diamonds

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Diamonds

Possibly diamond-bearing mantle peridotites and podiform chromitites in the Luobusa and Donqiao ophiolites, Tibet.

W.-J. BAI, M.-F. ZHOU AND P.T. ROBINSON. *Canadian Journal of Earth Science*, **30** (8), 1993, pp 1650-9, 3 maps.

The Luobusa ophiolite of the Yarlung-Zangbo (S Tibet) suture zone and the Donqiao ophiolite of the Bangong-Nujiang (N Tibet) suture zone are allochthonous bodies that contain possible diamond-bearing mantle peridotites and podiform chromitites. The mantle sections in both massifs consist chiefly of harzburgite and diopside-bearing harzburgite with abundant lenses of dunite and chromitite. These ultramafic rocks are more strongly depleted than typical abyssal peridotites and their geochemistry suggests formation above a subduction zone. An unusual mineral association (diamond, SiC, graphite, native chromium, Ni-Fe alloy, Cr²⁺-bearing chromite), indicating a high-*P*, reducing environment, occurs in both the peridotites and chromitites. To date, > 100 diamond grains have been recovered from the two massifs; most are 0.1–0.2 mm in diameter but some are > 0.5 mm. Those in the Luobusa massif are colourless, whereas those from the Donqiao massif are yellowish green to dark green. It is suggested that these ophiolites were generated originally in a

ABSTRACTORS

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suprasubduction zone environment and were later carried deep into the mantle along a second subduction zone, at which time the diamonds and other high-*P* minerals were formed. It is not yet clear whether the diamonds formed by high-*P* metamorphism of the oceanic crust or by crystallization from mantle melts, but their occurrence in chromitites and harzburgites suggests a metamorphic origin. During the collision of India with the Eurasian plate, the mantle sections were tectonically emplaced at shallow crustal levels rapidly enough to preserve the diamonds. R.A.H.

Find of eclogite with two diamond generations in the Udachnaya kimberlite pipe.

A. M. BEZBORODOV, V. K. GARANIN, G. P. KLDRYAVISEVA, J. PONAHLA AND E. YAGOUTS. *Akademia Nauk USSR, Doklady Earth Sciences Section*, **317**(3), 1993, pp 190-3.

The problem is defined and the diamond-bearing rocks are described. The chemical data are tabulated. CL curves and IR spectra are shown. The authors conclude that natural diamond formation is a discrete process. K.A.R.

Low-calcium garnet harzburgites from southern Africa: their relations to craton structure and diamond crystallization.

F. R. BOYD, D. G. PEARSON, P. H. NIXON AND S. A. MERTZMAN. *Contributions to Mineralogy &*

For further information of many of the topics referred to consult *Mineralogical Abstracts* or *Industrial Diamond Review*.

Petrology, **113**(3), 1993, pp 352-66.

Low-Ca garnet harzburgite xenoliths contain garnets that are deficient in Ca relative to those that have equilibrated with diopside in the lherzolite assemblage. Minor proportions of these harzburgites are of widespread occurrence in xenolith suites from the Kaapvaal craton and are of particular interest because of their relation to diamond host rocks. The harzburgite xenoliths are predominantly coarse, but one specimen from Jagersfontein and another from Premier have deformed textures similar to those of high-*T* peridotites. Equilibration *T* and depths calculated for the harzburgites have the ranges 60-1400°C and 50-200km. Garnets and associated minerals in harzburgite xenoliths differ from minerals of the same assemblage that are included in diamonds in that the latter are more Cr-rich, Mg-rich and Ca-poor. Coarse crystals of low-Ca pyrope with the compositional characteristics of diamond inclusions commonly occur as disaggregated grains in diamondiferous kimberlites. Their host rocks are presumed to have been harzburgites and dunites. The differences in composition between the disaggregated grains that are similar to diamond inclusions and those comprising xenoliths imply some differences in origin. P.Br.

A graphite-cohenite-iron mineral association in the core of a diamond from the Twenty Third Soviet Communist Party Congress Pipe.

G. P. BULONAVA AND N. V. ZAYAKINA. *Akademia Nauk USSR, Doklady Earth Sciences Section*, **317A**(3), 1993 pp 126-30.

The diamond was studied with optical, X-ray, and EPMA methods. The X-ray powder data are tabulated and five photomicrographs are shown. The data are discussed in detail. It is concluded that the diamond was formed in nature from graphite. K.A.R.

Thin film diamond growth mechanisms.

J. E. BUTLER AND R. L. WOODIN. *Philosophical Transactions of the Royal Society: Physical Sciences and Engineering*, **342**(1664), 1993, pp 209-24.

The principal chemical mechanisms relevant to the growth of diamond from gaseous hydrogen and hydrocarbon species are discussed. The

kinetic processes during activation and transport of the gaseous species to the growing surface are described, with the key processes being the generation and subsequent reactions of gaseous atomic hydrogen. R.K.H.

Evidence of kimberlite magmatism in the eastern part of the East European craton.

V. G. CHAYKIN AND A. V. TULZAKOVA. *Akademia Nauk USSR, Doklady Earth Sciences Section*, **314**(1-6), 1992, pp 62-4, 1 map.

Most believed that kimberlite magmatism is confined to cratons. The widespread rifting caused widespread mafic and ultramafic activity including traprock, trachybasalt, and kimberlite(?). This is confined to the west Urals where diamonds are found in Palaeogene deposits. However, all attempts to find bedrock sources of diamonds in the Urals have failed. The authors reinterpret aeromagnetic data to derive a sequence of events for the Urals, and conclude that known and presumed kimberlite bodies are in areas E of the White Sea and W of Timan as well as in the Timan and Cisural region. K.A.R.

Diamondiferous kimberlite in Saskatchewan, Canada – a biogeochemical study.

C. E. DUNN. *Journal of Geochemical Exploration*, **47**(1-3), 1993, pp 131-41, 1 map.

Kimberlite was first reported in this area in 1988. Subsequently more kimberlite pipes have been discovered and the total diamond yield is now 160, of which some are macro-diamonds of gem quality. An investigation was made in 1989 of the kimberlite outcrop at Sturgeon Lake, at that time the only known kimberlite in central Canada, to characterize its biogeochemical signature and assess the value of biogeochemistry in future exploration activities. The vegetation is dominated by *Populus tremuloides*, *Cornus stolonifera*, and *Corylus cornuta*. Although no geobotanical expression of the kimberlite was found, tissue samples of the three species showed a spatial relationship to the kimberlite in enrichment in Ni, Rb, Sr, Cr, Nb, Mg and P, and depletion in Mn and Ba. The Ni content of *C. stolonifera* twigs was much higher than that of twigs of the other species near the kimberlite; all three species were enriched in Rb and Sr relative

to sites on the surrounding Cretaceous and Quaternary deposits. It is suggested that Rb may be derived from the phlogopites within the kimberlite, and mobilized during weathering as its highly soluble carbonate. It seems that biogeochemical studies of the distribution patterns of, especially, Ni, Rb and Sr, may help in locating kimberlite at shallow depth, particularly if there is upward movement of groundwaters to bring these elements to the root systems of the plants.

R.E.S.

Gem Trade lab notes.

C.W. FRYER, G.R. CROWNINGSHIELD, T. MOSES, K. HURWIT AND S.F. McCLURE. *Gems & Gemology*, 28(4), 1992, pp 262-7, 15 figs.

A diamond with zig-zag etched dislocation channels is described and illustrated; an Argyle yellow diamond exhibited characteristic etch feature rather like a wheel abrasion; another diamond had long blade-like parallel inclusions reflecting kaleidoscopically when stone was face up; a deep brown octahedral diamond crystal was set in a medieval ring mount.

R.K.M.

[Spectroscopic characteristics of yellow and green fancy colour diamond prepared by Koss.] (Japanese)

M. HAYASHI. *Journal of The Gemmological Society of Japan*, 17 (1-4), 1992, pp 43-4, 4 figs.

FTIR spectroscopic investigations of yellow and green fancy colour diamond prepared by Koss Co. have been made. Based on the results, the annealing temperature of yellow diamond was evaluated to be 900°C, and that of green diamond a slightly higher temperature. FTIR spectroscopy reveals characteristic peaks more clearly than ordinary spectroscopy.

I.S.

[Characterization of diamond synthesized from gas phase.] (Japanese with English abstract)

M. KAMO. *Journal of The Gemmological Society of Japan*, 17 (1-4), 1992, pp 24-30, 10 figs.

This paper reports an outline of diamond synthesis from a gas phase and some properties of diamond prepared by the microwave plasma method, based on the results of Raman, absorption and cathodoluminescence spectroscopies, and secondary ion mass spectroscopy (SIMS) analyses. Single crystals of diamond grown from

the gas phase have good crystalline quality, but polycrystalline films grown under the same conditions contain an appreciable amount of double bonds and strains. Contamination of elements from substrate holder can not be neglected for the diamond obtained. Hydrogen and oxygen contents are negligibly small. Other impurities in higher concentration than those found in natural diamond were not detected.

I.S.

[Recent studies on impurities in large synthetic diamonds.] (Japanese with English abstract)

J. KANDA. *Journal of The Gemmological Society of Japan*, 17 (1-4), 1992, pp 16-23, 9 figs., 1 table.

This paper summarizes the results of recent studies on the synthesis of large gem quality diamond crystals (the largest in the world so far reported is 15mm across) and on atomic scale impurities, which may influence the colour and optical properties) in both natural and synthetic diamonds. Large diamond crystals of gem quality can be synthesized by temperature gradient method using a seed crystal. By adding appropriate metals, such as Ti, into the solvent metal system, which act as a nitrogen getter, colourless diamond can be synthesized. Growth temperature and annealing temperature are also parameters which control the concentration and state of nitrogen in diamond structure. Boron is easily incorporated into diamond, producing a blue colour whose intensity depends on the type of metals used and the boron concentration. Nickel is also incorporated in the crystal, inducing green and brown colours. These impurities are located selectively depending on growth directions, thus producing growth sectors discernible even by the naked eye. The concentrations of these impurity elements are in general the highest in the {111} growth sectors, followed by the {100}, and then by {110} and {113}. The morphology of large synthetic crystals is principally cubo-octahedral, but often associated with {110}, {113}.

I.S.

CL and optical microtopographic studies of Argyle diamonds.

K. KANEKO AND H.R. LANG. *Industrial Diamond Review*, 53 (6), 1993, pp 334-7.

External surfaces and polished sections of dia-

monds from the Argyle deposit, Western Australia, have been examined by cathodoluminescence topography and optical micrographic techniques, revealing radiation damage on natural surfaces, complex growth histories and post-growth plastic deformation. Spatially fine-scale variations in nitrogen impurity content correlate closely with differences in abrasion resistance. Lattice misorientations may result from the lattice distortions and rotations generated when closely-spaced slip bands lying on different octahedral planes intersect. R.A.H.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, 28 (4), 1992, pp 268-79, 14 figs.

Potential diamondiferous pipe found at Ciralia, W. Australia; a deep etch cavity in a small diamond resembled a statue of President Lincoln, trigons were present; an update on gem diamond synthesis is given; Tanzania is exploring Lake Victoria region for diamonds; Zimbabwe diamond processing plant at River Ranch reports 5000 carats in three month test. R.K.M.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, 29 (1), 1993, pp 52-64, 24 figs.

Headed Tucson '93, this paper reports on:-

Diamonds: including natural green transmitters; chameleon stones (colour changes with temperature); Indian briolettes and diamonds with clarity enhancement disclosed. A Swiss company is offering fine five-pointed star-cut diamonds in a variety of colours. R.K.M.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, 29 (2), 1993, pp 130-41, 24 figs.

Diamonds: a 446ct diamond is reported from Botswana; De Beers market quality high-pressure industrial diamonds with numerous metallic inclusions, 1 to 4ct cost effective, largest 34.80ct, 600 hours in production; quality synthetic diamond films also reported; the Flanders brilliant, a new octagonal-cut, is described and illustrated; Sakha (Yakutia) is building diamond reserves independent of Moscow; Venezuelan diamond production up almost 50 per cent. R.K.M.

Diamond nucleation by hydrogenation of the edges of graphitic precursors.

W. R. L. LAMBRICHI, C. H. LEE, B. SEGALL, J. C. ANGUS, Z. LI AND M. SUNKARA. *Nature*, 364(6438), 1993, pp 607-10.

Calculations suggest that diamond films can nucleate by the initial condensation of graphite and subsequent hydrogenation of the (1100) prism planes along the edge of the graphite particles. R.K.H.

Diamond sources and production: past, present and future.

A. A. LEVINSON, J.J. GURNEY AND M.B. KIRKLEY. *Gems & Gemology*, 28(4), 1992, pp 234-54, 19 figs.

An exhaustive account of diamond availability from 1600 to 1990, amply illustrated by maps and tables to provide a fascinating paper heavy with significance of vast craton areas as yet scarcely touched. Some figures are rather dark and detail has suffered. R.K.M.

[Identification of natural and synthetic diamonds by a cathodoluminescence method.] (In Japanese with English abstract)

T. MINYATA AND M. KITAMURA. *Journal of The Gemmological Society of Japan*, 17 (1-4), 1992, pp 10-15, 9 figs., 1 table.

Cathodoluminescence topography using scanning electron microscopy has been applied to visualize internal heterogeneity of both rough and brilliant-cut natural diamonds and Sumitomo synthetic rough diamonds. It has been shown that (1) growth sectors of natural diamond consist of flat {111} with or without curved {100} faces, whereas those of synthetic diamond are characterized by flat {111} and {100} faces, and (2) each stone exhibits different patterns of growth sectors, and growth banding indicating the applicability of the method for both identification of natural and synthetic diamonds and finger printing of a cut stone. A convenient index system to arrange the zoning patterns is also presented. I.S.

Two treated-colour synthetic red diamonds seen in the trade.

T.M. MOSES, I. REINITZ, E. FRITSCH AND J.E. SINGLEY. *Gems & Gemology*, 29(3), 1993, pp 182-90,

1 table, 10 illus. in colour.

Microscopic examination revealed distinct colour zoning showing square shaped and superimposed yellow areas surrounded by large red areas. The narrow light zones were seen at four locations around the girdle separated by ninety degrees when viewed through the girdle. Metallic opaque inclusions were identified as nickel and iron by EDXRF chemical analysis. Both diamonds were attracted by a simple magnet. Ultraviolet luminescence was striking both in the long- and short-wave. An intense green fluorescence corresponding to the narrow yellow areas showed squares and crosses which phosphoresced the same colour when the short wave UV lamp was turned off. Under long-wave UV radiation there is only a small reddish orange fluorescence at an isolated point near the girdle but this extends to all the large dark red areas under short-wave UV.

Spectroscopy in the visible region showed numerous sharp absorption bands at liquid nitrogen temperatures, several of which could be seen by hand held spectroscope, particularly at 637 and 658nm. In addition there was increased absorption towards the violet and a broad absorption region extending from 500-640nm. Mid-infrared spectra showed that both diamonds were a mixture of types Ib + IaA + IaB and bands at 1050, 1450 and 1502cm⁻¹ were present, the latter two due to annealing.

Examination of the visible and infrared spectra showed the lines were due to nickel, iron and nitrogen aggregates. The cause of the colour is almost certainly due to increased absorption towards the UV and the broad absorption band between 450 and 650nm (due to the 'N-V' centre) is a result of laboratory treatment. The orange UV luminescence is most likely due to irradiation and heating. Previous reports of a yellow to greenish-yellow fluorescence to short wave UV radiation refers to yellow untreated synthetic diamonds of pure type Ib in contrast to natural yellow Ib diamonds which rarely show this reaction.

In comparison with natural diamonds, some natural pink diamonds are type IIa with orange fluorescence; no known treated pink diamonds are of this type. Increasing number of pink/red

natural diamonds are of type Ia with blue UV fluorescence but none of these showed any type Ib character. Thus all known natural pink to red natural diamonds are readily distinguishable from the stones described. (Unfortunately there is no evidence as to where they might have been treated.) R.J.P.

[Inclusions of sodium fluoride and high-alkali silicate glasses within a xenogenic diamond from granulites.] (Russian with English abstract)

M. I. NOVGORODOVA, N. V. TRUBKIN, M. A. AKHMEDOV AND M. KH. SATVALDIEV. *Proceedings of the Russian Mineralogical Society*, 122(1), 1993, pp 88-96.

Inclusions of silicate glass are reported in diamonds from a pipe-like body (100-150 m diameter) with siliceous cement, cutting through granitic rocks of the Badaytagsky massif, Kuramin Mts, central Tien Shan. The chemical composition of the silicate glass inclusions are tabulated; Na₂O ranges 2.90-20.86, and K₂O ranges 0.69-4.36 wt.%. The alteration of villiaumite under the electron microdiffraction beam is recorded. Comparisons are made with glasses from other diamonds from Zambia, Botswana and Yakutia. R.A.H.

Petrology of a diamond and coesite-bearing metamorphic terrain: Dabie Shan, China.

A.I. OKAY. *European Journal of Mineralogy*, 5(4), 1993, pp 659-75, 2 maps.

The Dabie Shan complex is a large gneiss-granite terrain in the E part of the Qinling orogen in central China; it represents part of the lower continental crust of the Yangtze plate subducted during the Triassic continental collision and consists of several welded gneiss terrains with different metamorphic grades. An eclogite zone is sandwiched between two amphibolite-facies terrains, and consists of a >25 km thick sequence of leucocratic, granoblastic gneiss with eclogite, marble and minor ultramafic bands and lenses. Two subzones with different P-T regimes are tentatively distinguished in the eclogite zone. In the hot eclogite zone in the N the eclogites contain garnet, omphacite, zoisite, kyanite; phengite ± Ca-amphibole ± quartz, rutile and very rare coesite as inclusions in garnet. Eclogites also

occur in marble bands where they contain diopside pyroxene and grossular-rich garnet with coesite, K-feldspar and diamond inclusions. The eclogite mineral assemblages record T of $800 \pm 50^\circ\text{C}$ and P 18-34 kbar; the presence of coesite and diamond indicate minimum P of 29 and 38 kbar, respectively. The ultra-high P metamorphism appears to have been regional and to have affected both the eclogites and the host gneisses. The coesite and diamond-free cold eclogite terrain in the S tectonically overlies the hot eclogite terrain and is characterized by the absence of marble-eclogite horizons and by the presence of eclogites with sodic amphiboles (crossite). The mineral assemblage indicates P - T conditions of $635 \pm 40^\circ\text{C}$ and 18-26 kbar. The retrograde P - T path of the hot eclogite terrain appears to be very steep down to < 10 kbar when it was juxtaposed with the cold eclogite terrain R.A.H.

Diamonds and associated minerals in kimberlites and loose sediments of Tersky shore (Kola Peninsula). (Russian with English abstract)

L. V. POLYAKOV AND M. M. KALINKIN. *Proceedings of the Russian Mineralogical Society*, 122(1), 1993, pp 96-101, 1 map.

Diamond-bearing kimberlite pipes have been discovered on the Tersky shore of the White Sea. Haloes of diamond-associated minerals were found by prospecting in unconsolidated sediments of the area. Chemical compositions for garnets from kimberlites, melilitites and the sediments are reported ($\text{Cr}_2\text{O}_3 < 6.97\%$). An estimate is made of possible diamond mineralization being of more widespread occurrence in the terrain. R.A.H.

Catodoluminiscencia (CL) y espectros de catodoluminiscencia de diamantes sintéticos experimentales De Beers.

J. PONAHO. *Boletín del Instituto Gemológico Español*, 35, 1993, pp 25-38, 8 figs (21 col.), 2 tables.

Synthetic gem-quality diamonds manufactured by De Beers show geometrically-patterned colour zoning under cathodoluminescence. Polarization figures induced by stress have been observed as well as large euhedral crystals of unknown composition. Colours induced by cathodoluminescence are a greenish yellow and

blue. Growth lines can be seen in different sectors of the stones. M.O'D.

Famous diamonds.

K.T. RAMCHANDRAN AND B. PORWAL. *Indian Gemmologist*, 4(1), 1994, pp 20-3.

Thirty-three of the world's most celebrated diamonds are briefly described. M.O'D.

De Beers near colourless-to-blue experimental gem-quality synthetic diamonds.

T. ROONEY, C.M. WELBOURN, J.F. SHIGLEY, E. FRITSCH, I. REINHIZ. *Cems & Gemology*, 29(1), 1993, pp 38-45, 10 figs.

Five small boron-doped diamonds had diagnostic features not previously reported in synthetic diamond, internal zones of blue, yellow and near colourless gave near colourless to greenish-blue and blue face-up tints in faceted stones. Could be confused with natural diamond if made commercially, but fluorescence and inclusions should detect them. R.K.M.

Diamond growth history from in situ measurement of Pb and S isotopic compositions of sulfide inclusions.

R. L. RUDNICK, C. S. ELDRIDGE AND G. P. BULANOVA. *Geology*, 21(1), 1993, pp 13-16.

The S and Pb isotopic compositions of mantle sulphide encapsulated within diamonds from under the Siberian craton were determined and the results compared with those of African counterparts. $\delta^{34}\text{S}$ values of the Siberian sulphides do not deviate significantly from the mantle value, but Pb isotopic compositions are highly variable confirming the compositional differences between peridotitic and eclogitic suite inclusions in African diamond inclusions. The large variation in Pb isotopic compositions of sulphides within a single peridotitic suite diamond documented three stages of diamond growth: 1) crystallization of the core near 2000 m.y., 2) growth of its outer zone in an environment with high U/Pb ratio similar to that of eclogitic diamond, 3) growth of the rim near the time of kimberlite emplacement. L.C.H.

Relación del grado de color de los diamantes con la banda de absorción N3 (415.5nm) y con

su respuesta a la luz ultravioleta.

L. SARMIENTO AND C. SAPALSKI. *Boletín del Instituto Gemológico Español*, 35, 1993, pp 50-6, 9 tables.

5298 faceted gem-quality diamonds examined gave rise to the conclusions that nitrogen was present in 88 per cent of the specimens. The N absorption was the N3 type with absorption at 415.5nm and showed in 53 per cent of D grade stones and in more than 90 per cent of stones graded G or lower. There was evidence of a direct relationship between the intensity of the yellow colour and the intensity of the N3 absorption. Only 32 per cent of the specimens responded to UV and no clear relationship between colour grade and fluorescence was established. M.O'D.

Contrasting kimberlites and lamproites.

B. H. SCOTT SMITH, *Exploration & Mining Geology*, 1(4), 1992, pp 371-381, 1 map.

Over the past 20 years lamproites have joined kimberlites as the only two known primary sources of economic quantities of diamonds. Here the petrography, primary and xenocrystic mineralogy, and pipe geology of these petrogenetically separate rocks types is contrasted. The petrographic discrimination of kimberlites and lamproites from each other, as well as from other rock types found during prospecting, is discussed. Kimberlites and lamproites can be classified texturally and mineralogically, highlighting the differences between, and among, lamproites and kimberlites. The implications of these differences for diamond exploration programmes are discussed, with particular emphasis on the application of petrography. R.E.S.

Two near-colourless General Electric type-IIA synthetic diamond crystals.

J.E. SHIGLEY, E. FRITSCH AND I. REINITZ. *Gems & Gemology*, 29(3), 1993, pp 191-7, 7 illus. in colour.

Isotopically pure ^{12}C diamonds were synthesized for use as heat sinks in telecommunications and integrated circuits. Unlike previous synthetic diamonds the source material was a thin polycrystalline layer of synthetic diamond grown from ^{12}C methane gas by a low pressure chemical vapour deposition. This new method also uses a

transition metal flux which removes nitrogen and boron impurities.

The colour was L-M a faint yellow. No colour zoning was seen. Microscopy revealed clusters of tiny triangular or lozenge shaped tabular inclusions. These are possibly metallic as the stones were attracted to a simple magnet. Such inclusions are virtually unknown in the natural stones. The stones showed anomalous strain birefringence between crossed polars, and although the stones were inert to long-wave UV radiation, they fluoresced a weak yellowish orange to short-wave UV. This greater response to short wave UV is a distinctive property of some synthetic diamonds. Both stones showed cathodoluminescence when exposed to X-rays in a vacuum chamber.

Further studies on type IIa diamonds will be required to confirm these preliminary identification criteria. R.J.P.

The gemological properties of Russian gem-quality synthetic yellow diamonds.

J.E. SHIGLEY, E. FRITSCH, J.I. KOIVULA, N.V. SOBOLEV, I.Y. MALINOVSKY, Y.N. PALYANOV. *Gems & Gemology*, 29(4), 1993, pp 228-47, 2 tables, 24 illus. in colour.

Seven as-grown samples and three treated by post-growth annealing at high pressure and high temperature (HPHT) revealed distinctive gemological properties including colour and luminescence zoning, metallic inclusions, grain-ing and sharp absorption bands in the visible. Although easily identifiable some properties differed from previous yellow synthetics *viz.* UV luminescence and optical absorption spectra. All but one fluoresced to long-wave UV and the HPHT-treated stones fluoresced stronger to long-wave UV radiation than to short-wave UV radiation (typical of fluorescing natural diamonds). Thus UV luminescence (i.e. short wave stronger than long wave) can no longer be considered diagnostic for synthetic yellow diamonds. Additionally HPHT treated stones showed a moderate to strong yellow phosphorescence to UV radiation. Most of the samples showed a green luminescence to visible light. These synthetic diamonds showed a distinctive spectrum, and HPHT treated stones showed additional

sharp bands visible at low temperature with a handheld spectroscope. It may be difficult to establish simple identification criteria for gem-quality Russian synthetic diamonds. R.J.P.

Dependence of the cathodoluminescence of diamond films on deposition temperature.

Y. H. SHENG *ET AL.* *Journal of Applied Physics*, 71 (12), 1992, pp 6036-8 (Jun 15), 4 figs.

The deposition temperature dependence of the cathodoluminescence (CL) of diamond thin films grown by microwave plasma-assisted CVD has been investigated. Depositions were made in the temperature range of 400 to 750°C at a pressure of 10 Ton, with a gas mixture of 5% CII_4 and 5% O, in hydrogen. The intensity of the luminescent peak at 430nm was used as a measure of diamond quality for the film. This peak was found to be a maximum above 600°C. Examination of the intensities of CL emissions associated with nitrogen and silicon impurities at 530, 560 and 740nm indicate incorporation of these impurities is more efficient at temperatures above 600°C. Film quality was thus found to be an optimisation of competing mechanisms, i.e. improvement of diamond quality as evidenced by the intensity of the 430nm peak, with the apparent activation of impurities and vacancy defects at elevated temperatures. J.H.

[Kimberlite magma evolution and diamond genesis.] (Russian with English abstract)

V.S. SHKODZINSKII AND V.V. BESKROVANOV. *Zapiski Vses. Min. Obsheh*, 121 (6), 1992, pp 21-32.

Results of quantitative modelling of the evolution of kimberlite indicate that: (1) it was formed by compression-dissipative remelting with the squeezing and extrusion of a substratum of sub-melted kimberlite composition from asthenospheric depth through tectonic fault zones; (2) the formation of the diatreme and most of the kimberlite breccia is a result of explosive disintegration of the upper part of the magmatic column under the influence of excessive P in the fluid phase preserved by decompression hardening of the melt during its ascent; (3) the best conditions for diamond conservation are in the explosive breccia because of the rapid decrease in

T (through several hundred degrees) due to adiabatic dilation of gas and heat expansion within xenoliths of sedimentary rocks; (4) diamond crystallizes as a solid-phase product of incongruent melting during the ascent of the kimberlite magma, according to a reaction of the type $\text{CO}_2 + \text{CH}_4 + \text{solid phases} \rightarrow \text{melt} + \text{C}$. This mechanism of diamond genesis is confirmed by the presence of three zones (central, intermediate, peripheral) within most of the diamond crystals. The parameters of these zones testify to the gradual dilution of the media during the growth of the crystals, with a decrease in its oversaturation with carbon and increase in T. R.A.H.

Nd and Sr isotopes from diamondiferous eclogites, Udachnaya Kimberlite Pipe, Yakutia, Siberia: evidence of differentiation in the early Earth?

G. A. SNYDER, E. A. JERDE, L. A. TAYLOR, A. N. HALLIDAY, V. N. SOBOLEV AND N. V. SOBOLEV. *Earth & Planetary Science Letters*, 118(1-4), 1993, pp 91-100.

Nd and Sr isotopic data from diamond bearing eclogites in the Udachnaya Kimberlite are interpreted as indicating an early (> 4000 m. y.) differentiation event, whereby the mantle split into complementary depleted and enriched reservoirs. Reconstructed whole-rock $^{87}\text{Sr}/^{86}\text{Sr}$ ratios (present-day) range from 0.70151 to 0.70315 and are consistent with a mantle origin for these rocks. The Nd isotopic evolution lines of four samples (U-5, U37, U-41 and U-79) converge at 2200-2700 m.y. Sample U-5 is unique in exhibiting the most enriched signature of any of the samples (present-day ϵ_{Nd} of -20), and this sample points unequivocally to an old, enriched component. A complementary depleted mantle component is suggested by samples U-86 and U-25 which yield ϵ_{Nd} values (at 2200 m. y.) of +13 and +7, respectively. The two mantle reservoirs may have formed before 4000 m.y., and evolved separately until 2200-2700 m.y. At that time, the reservoirs were melted, forming eclogites both as residues (from the enriched reservoir) and as partial melts of peridotite (from the depleted reservoir), resulting in demonstrably different histories for eclogites from the same locality.

R.A.H.

A diamond-bearing xenolith of garnet peridotite from the 'Mir' kimberlite pipe.

Z. V. SPERSIUS, *Akademia Nauk USSR, Doklady Earth Sciences Section*, 313(1-6), 1992, pp 200-203.

The xenolith nodule is described, and its mineralogy is given and discussed. The chemical composition is tabulated, and two electron micrographs are shown. The diamonds are described. The work supports the hypothesis that diamonds in kimberlites are xenogenic. K.A.R.

[Basic concept for the identification of natural and synthetic diamonds.] (Japanese with English abstract)

I. SUNAGAWA. *Journal of the Gemmological Society of Japan*, 17 (1-4), 1992, pp 3-9, 8 figs., 1 table.

This is a paper discussing the fundamental concept to be based in the forthcoming necessity of identification between natural and synthetic diamonds. The main difference between natural and synthetic diamonds is the difference of solvents in which diamond single crystals grow; natural diamond grew from silicate solution, whereas synthetic diamond grows from metallic solution. The difference leads to a distinct difference in their morphological characteristics and growth processes. Spiral and layer growth can occur only on {111} surface and never on {100} in the case of natural diamond, whereas they can be expected on both {111} and {100} surfaces in synthetic diamonds. The difference comes from the difference of solvents, which may modify solid-solution interface structure. Due to this difference, natural and synthetic crystals exhibit different internal morphologies, i.e. growth sectors, growth banding etc., which can be used as diagnostic features to differentiate between the two, if appropriate methods are used to visualize such heterogeneities and imperfections in single crystalline cut stones. Polarization microscopy, cathodoluminescence tomography, laser beam tomography, X-ray topography, etc., are useful methods for such purposes. I.S.

The diamond deposits of the Mandala Basin, SE Guinea, West Africa.

D.G. SUTHERLAND. *Transactions of the Royal Society of Edinburgh*, 84(2), 1993, pp 137-49, 4 maps.

This drainage basin in the central part of the West African craton, immediately to the S of the regional watershed contains numerous intrusions of kimberlite dykes. The kimberlites range in grade from being apparently barren to having a high diamond content. The presence of other undiscovered kimberlites can be inferred from the distribution, chemistry and abundance of kimberlite indicator minerals and variations in diamond size and character. Secondary diamond deposits are widespread with the main concentrations in the present and former Mandala valley bottoms; tributaries have lower diamond contents. Systematic variations in the alluvial diamond characteristics can be explained in terms of diamond sources as well as transport of the diamonds away from these sources. Since the Pliocene or early Pleistocene the Mandala has been rejuvenated with incision of the main channel by < 26m, which has led to flushing of the tributaries and storage of sediment, including diamonds, in the principal channel. The abundance of diamonds ranges from 1 to 37 stones/m³, with average weights of 0.18ct but with individual stones > 1ct constituting > 17 per cent of the diamonds, e.g. where the Mandala crosses the Bourou dyke zone. R.A.H.

[Reactor irradiation and heat treatment examinations on diamonds.] (Japanese with English abstract)

I. UMEDA AND K. LIDA. *Journal of the Gemmological Society of Japan*, 17 (1-4), 1992, pp 31-6, 7 figs.

Absorption spectroscopic investigations were made to trace how spectrographs of sample diamond crystals changed by irradiating the samples in a research reactor, and the subsequent heat treatment so that the optimum conditions for dose intensity and annealing temperature may be found quantitatively. A range of dose, 10¹⁴ ~ 10¹⁶ fast neutrons/cm², and of annealing temperature, 300 ~ 700°C were investigated. An experiment of very high dose irradiation (10¹⁶ ~ 10¹⁷ fast neutrons/cm²), which changes the colour to black was also performed. In this case, the black colour changed to orange, through light red, and brown by subsequent heat treatment at 600 ~ 700°C. I.S.

Nano-structures on polished diamond surfaces.

W.J.P. VAN ENCKEVORT, M.S. COUTO AND M. SHAL. *Industrial Diamond Review*, 53(6), 1993, pp 323-7.

Despite many debates in the past, the actual mechanism of diamond polishing is still unclear. To obtain more information on this, the morphologies of polished surfaces of several semiconducting diamonds have been examined by scanning tunnelling microscopy. The results of this topographic study are presented and provide essential new insights into the process of diamond polishing, but further questions arise. Abrasion along the hard directions proceeds via fracture and chipping on a nanometre scale; material removal in the softer directions seems to take place by single pass grooving by diamond particles at supercritical loads followed by a polishing action by particles at subcritical loads. Problems to be solved include the actual mechanism of 'plastic' grooving and how the extreme dependence of polishing rate on crystal orientation can be explained now that the Tolkowsky cleavage model must be abandoned. R.A.H.

Micas in diamond-bearing metamorphic rocks of northern Kazakhstan.

M. A. VAVILOV, N. V. SOBOLEV AND V. S. SHATSKIY. *Akademia Nauk USSR, Doklady Earth Sciences Section*, 319A(6), 1993, pp 177-182.

The petrography and mineralogy of these diamond-bearing, metamorphic rocks are described. Representative chemical analyses are tabulated and plotted. It is concluded that the data on the micas support the earlier conclusion that diamond in some metamorphic rocks crystallized in the thermodynamic stability range with $P > 40$ kbar. K.A.R.

Implanted radiogenic and other noble gases in crustal diamonds from northern Kazakhstan.

A.B. VERCHOVSKY, U. OTT AND F. BEGEMANN. *Earth and Planetary Science Letters*, 120(3-4), 1993, pp 87-102.

Noble gases were extracted in steps from grain-size fractions of microdiamonds ($< 100 \mu\text{m}$) from the Kokchetav Massif, N Kazakhstan, by pyrolysis and combustion. The amount of ^4He in the diamonds themselves (liberated by combus-

tion) shows a $1/r$ dependence on grain size (r). For grain diameters $> 15 \mu\text{m}$, the amount also decreases with the combustion step. Both results are evidence that ^4He was implanted into the diamonds from α -decaying elements in the surrounding matrix. The saturation concentration of ^4He ($5.6 \times 10^{-4} \text{ cm}^3 \text{ STP/g}$) is among the highest observed in any terrestrial diamonds. Fission xenon from the spontaneous fission of ^{238}U accompanies the radiogenic ^4He ; the $^{136}\text{Xe}/^4\text{He}$ ratio of $(2.5 \pm 0.3) \times 10^{-9}$ agrees well with the production ratio of 2.3×10^{-9} expected in a reservoir where $\text{Th}/\text{U} \sim 3.3$. Radiogenic ^{40}Ar is predominantly ($> 90\%$) set free upon combustion; it also resides in the diamonds and appears to have been incorporated into the diamonds on formation. On the other hand, ^3He is mainly released during pyrolysis and hence is apparently carried by 'contaminants'. The amount in the diamonds proper is of the order of $4 \times 10^{-12} \text{ cm}^3 \text{ STP/g}$, with a $^3\text{He}/^4\text{He}$ ratio of 1×10^{-8} . Excess ^{21}Ne , similarly, appears to be present in contaminants as well as in the diamonds themselves. These two nuclides in the contaminants must have a nucleogenic origin, but it is difficult to explain their abundance. R.A.H.

Dynamics of the crystal lattice of lonsdaleite.

M. F. VIGASINA. *Akademia Nauk USSR, Doklady Earth Sciences Section*, 317(2), 1993, pp 188-90.

This is a hexagonal wurtzite-like polymorph of diamond. The vibrational frequencies are tabulated and the unit cell is sketched. The Raman spectra are plotted. The measurements were done on a synthetic specimen prepared by explosion. The results permit the identification of fine lamellae in diamond monocrystals. Also the study leads to physical models for the force fields of other compounds similar to diamond. K.A.R.

Large $\langle 110 \rangle$ -segmented helical dislocations in natural diamond.

J.C. WALMSLEY AND A.R. LANG. *Philosophical Magazine Letters*, 65(3), 1992, pp 159-65.

Helical dislocations composed of very straight $\langle 110 \rangle$ line segments (helical shape due to climb from original screw orientation) have been observed by TEM in a region of diamond where

growth had occurred on non-faceted, near $\{100\}$ orientation surfaces. Of the six $\langle 110 \rangle$ segments forming each turn of the helix, the two which are pure edge segments normal to the helix axial Burgers vector are 10x longer than the others, thereby producing strong flattening of the helix in the cube plane containing the axis of the helix. Detailed study of one of 30 such helices revealed that the axis of the helix was marked by a line of vesicles, diameters 20-130nm, producing matrix strain contrast attributed to fluid under pressure within the vesicles.

R.A.H.

Carbon in the core.

B. J. WOOD. *Earth and Planetary Science Letters*, 117(34), 1993, pp 593-607.

Although C is extremely abundant in the solar system (10 x Si, 20 x S) and in C1 carbonaceous chondrites (3.2 wt.%) and it dissolves readily in liquid Fe at low P (4.3 wt.% at 1420 K), it is rarely considered as a potential light element in the Fe-rich core, because it is volatile even at low T as CO. Carbon volatility is shown to be a strongly P -dependent phenomenon that is important only during condensation from a solar gas ($\sim 10^{-3}$ atm), and not at the P and T generated during planetary accretion and differentiation (0.01-5 GPa). Thus, impact heating and degassing of the protoearth should have led to an Fe-rich melt with $\sim 2-4$ wt.% C, compared to the 0.01-0.6 wt.% in iron meteorites and 0.3-3 ppm C predicted to be present in Fe condensed from the solar gas. Experiments (to 9 GPa) and thermodynamic calculations on the systems Fe-C and Fe-C-S show that C solubility in Fe melt increases slightly with P but that C could not conceivably constitute more than half the light element content of the core. However, the addition of even very small amounts of C (< 1%) to liquids containing Fe and a light element such as S has a dramatic effect on the properties of the system. At 330 GPa (inner core - outer core boundary) 0.3% of C is sufficient to stabilize Fe_3C , rather than $\epsilon\text{-Fe}$, as the first phase to crystallize in melts with $\sim 10\%$ S. Given probable inner core T of $\sim 5000-6000$ K, both $\epsilon\text{-Fe}$ and the higher P $\alpha\text{-Fe}$ are too dense to explain the inner core D of 12.85 g/cm^3 . The stability of iron carbide provides a possible solution and is shown to acquire the inner core D in the right P - T range.

R.A.H.

Gems and Minerals

Reactor-irradiated green topaz.

C.E. ASHBOUGH III AND J.E. SHIGLEY. *Gems & Gemology*, 29(2), 1993, pp 119-21, 6 figs.

So-called 'Ocean Green' topaz is identified as reactor irradiated, probably at higher temperatures than the 'London blue' material. These green stones have residual radio-activity and are prone to fade rapidly in bright sunlight.

R.K.M.

L'aigue-marine au Brésil [final part].

J.-P. CASSEDANNE AND J.-N. ALVES. *Revue de gemmologie*, 118, 1994, pp 21-3.

Appendix in the form of a table listing occurrences and related properties of Brazilian aquamarine. Entries are arranged by state then by individual mine. Notable years of production are given as well as geographical coordinates, size of deposit, type of working and host rock.

M.O'D.

Emerald dating through $^{40}\text{Ar}/^{39}\text{Ar}$ step-heating and laser spot analysis of syngenetic phlogopite.

A. CHEILLETZ, G. FÉRAUD, G. GIULIANI AND G. RUFFET. *Earth and Planetary Science Letters*, 120 (3-4), 1993, pp 473-85, 1 map.

Emerald in K-metasomatic rocks at the contact of the Carnaíba leucogranite with serpentinite, Bahia State, Brazil, gave ages of 1951 ± 8 and 1934 ± 8 m.y. for the Trecho Velho and Braulia occurrences, respectively. The procedure combines step-heating and spot fusion on two types of phlogopite crystals: (1) bulk samples and individual grains extracted from the enclosing metasomatic host rocks and (2) syngenetic solid inclusions precipitated along growing zones of the emerald host crystals. A second procedure uses in situ laser probe measurements on rock sections. Chemical analysis of an emerald crystal from Trecho Velho gave SiO_2 64.52, TiO_2 < 0.01, Al_2O_3 16.80, Fe_2O_3 0.57, MnO < 0.01, MgO 1.18, CaO 0.25, Na_2O 1.20, K_2O 0.038, Rb_2O 0.0038, H_2O 2.42, BeO 13.26, Li 0.0684, Cs 0.1045, V 0.0068, Cr

0.0480, Zn 0.0050, = 100.47; EPMA results are given for a muscovite and for phlogopites both outside and inside emerald. All these results are consistent with the fast cooling of the whole granite hydrothermal system and place the age of the Carnaíba granite-related emerald deposits as being within the Transamazonian orogenesis.

R.A.H.

Single-crystal NMR studies of low-concentration hydrous species in minerals: grossular garnet.

H. CHIO AND G.R. ROSSMAN. *American Mineralogist*, 78 (11-12), 1993, pp 1149-64, 4 tables, 16 figs. in black-and-white.

Garnets containing low (OH) levels were examined by detailed solid-state proton NMR. Stones examined included a colourless and a pale orange grossular from Asbestos, Quebec, and a colourless grossular from the Lelatema Hills, Tanzania. These crystals showed a broad line at 40kHz with a weaker feature superimposed. Examination of multiple-quantum spectra shows that in the asbestos specimen the dominant cluster size is two protons whereas in the Tanzanian specimen there was a mixture of two proton and four proton clusters. An average interproton separation for the grossular samples was 1.69Å; the low levels of (OH) were 0.2-0.3wt% as H₂O.

M.O'D.

Rainbow Garnet: Das Geheimnis der irisierenden Andradite aus Mexico.

G. CLARK. *Lapis*, 19 (4), 1994, pp 23-6, 6 illus. in colour.

A variety of andradite displaying colourful iridescence is reported from the Sierra Madre area of Mexico. The andradite is found in schists in the western part of the Sierra Madre. Cut stones show iridescent colours against a blue-green or yellow-orange background. One star stone is illustrated and comparisons with spectrolite are made.

M.O'D.

Aplicación de técnicas de microanálisis de rayos X al estudio de inclusiones en gemas.

J.S. CÓZAR. *Boletín del Instituto Gemológico Español*, 35, 1993, pp 40-8, 13 illus. in black-and-white, 20 in colour, 7 figs.

Inclusions in sapphire, quartz, emerald, topaz and ruby were studied by various X-ray techniques applied to microanalysis. The analysis of F, O, N and C was made possible by the use of an ultrafine window in the detector. Sapphire from Sri Lanka was found to contain negative crystals filled with iron hydroxides, aluminium hydroxides and colloidal silica: quartz from La Unión, Cartagena, was found to contain manganoan calcite in radiating fibres and dendritic sulphur compounds with Fe, Pb and Sb: Brazil emerald showed spearhead-like twinned crystals of rutile: Brazilian colourless topaz showed almandine-spessartine: Thai ruby was found to contain microcavities in veils, the cavities filled with concretions of calcium carbonate.

M.O'D.

A prospector's guide map to the gem deposits of Sri Lanka.

C.B. DISSANAYAKE AND M.S. RUPASINGHE. *Gems & Gemology*, 29(3), 1993, pp 173-81, 2 tables, 6 illus. in colour.

Sri Lanka has probably the widest variety of gem minerals of any country and the greatest proportion of land underlain by gem deposits. Although haphazard prospecting has been reasonably successful for over two thousand years, this is the first occasion when a scientific map has been compiled. Criteria include lithology and topography, stream-drainage density, presence of alluvium and the nature and abundance of heavy metals. Gem potential was divided into four classes. As expected most of the new probable areas surround existing known deposits. Analysis of heavy minerals in stream sediments showed that garnets, spinels and zircons were the most useful indicators of gem potential.

It is suggested that large amounts of gem minerals have been washed into the sea particularly in the south west regions and future targets should be the mouths of rivers and their near-shore regions.

R.J.P.

Heat treating the sapphires of Rock Creek, Montana.

J.L. EMMETT AND T.R. DOUTHIT. *Gems & Gemology*, 29(4), 1993, pp 250-71, 2 tables, 25 illus. in colour.

A large percentage of pale blue, pale green or

near-colourless sapphires could be converted into well saturated blue and yellow colours. Oxidizing conditions which were tolerant of time and temperature easily produced yellow hues. Blue colours resulted under reducing conditions but high iron concentrations increased the possibility of hercynite precipitation. Samples of exact size with parallel polished sides were specially produced to enable accurate before and after treatment studies to be carried out. The theoretical background to reduction/oxidation conditions was very thoroughly covered.

The strong yellow colours produced under oxidising conditions previously thought to be due to Fe³⁺ absorption was shown to be the result of a broad absorption band extending from 600nm to the shortest visible wavelengths. The suggested cause is divalent ion-hole pairs or colour centres in the crystal. Blue coloration was due to rutile dissolution in the presence of dissolved iron, followed by reduction of some of the iron.

The authors concluded with a timely warning of the explosive nature of reducing gases when mixed with air or oxygen.

R.J.P.

Gem trade lab notes.

C.W. FRYER, G.R. CROWNINGSHIELD, T. MOSES, K. HURWIT, R.C. KAMMERLING AND S.F. MCCLURE. *Gems & Gemology*, 28(4), 1992, pp 262-7, 15 figs.

Lechleitner type 'emeralds' in a brooch had been polished very lightly if at all, characteristic reticulation seen at junction layer. A pink cabochon of hydro-grossular had low RI (1.69) and SG (3.30); a black opal with a truly black background, and a 12mm pinkish purple pearl from Chattahoochee River, Alabama, are illustrated and described synthetic green quartz, purporting to be natural from Brazil, submitted for testing.

An unusual sapphire zoned in pink and orange is illustrated and described; a heat-diffusion treated sapphire had abraded facet edges as if paper-worn, does this treatment leave some stones more prone to wear? A heat-treated yellow sapphire showed yellow fluorescence to SUV, due to complex combination of orange and blue fluorescence; a synthetic purple star sapphire was unusually translucent; a bi-colour

green and blue zoisite owed green to Cr and blue to V.

R.K.M.

Gem trade lab notes.

C.W. FRYER, G.R. CROWNINGSHIELD, T. MOSES, K. HURWIT, R.C. KAMMERLING AND S.F. MCCLURE. *Gems & Gemology*, 29(1), 1993, pp 46-51, 17 figs.

A synthetic alexandrite with slightly curved colour banding and short acicular inclusions was thought to be Czochralski-pulled; a green beryl gave a red reaction through the emerald filter but colour was due to a coating on the pavilion facets; yellow-green beryls had Maxixe-type absorption suggesting irradiation; a black fingerprint-like inclusion was seen in a blue electrically-conducting diamond; another diamond had laser drilled holes to provide for setting; other diamonds had been notched below their girdles to allow invisible setting; another had been laser drilled to facilitate filling a fracture; a greenish-yellow diamond was found to have been irradiated with americium and has a legal safety date in the States some 4500 years in the future.

A possibly Russian synthetic emerald had been cut unusually as a cabochon; an earlier report on a phlogopite ceramic imitation of lapis lazuli is updated; and a large faceted lazulite and a yellow cat's-eye orthoclase are reported, as was an unusually metallic lustred pair of abalone pearls.

R.K.M.

Gem trade lab notes.

C.W. FRYER, G.R. CROWNINGSHIELD, T. MOSES, K. HURWIT, R.C. KAMMERLING AND S.F. MCCLURE. *Gems & Gemology*, 29(2), 1993, pp 122-8, 19 figs.

Clarified amber, heat-treated to improve surface colour, faded under strong light and fluoresced unusually orange; a diamond had extensive difficult-to-see filled fractures like low-relief fingerprints; an unusual V-shaped iridescence seen in another diamond; small diamonds set in plastic gave 'simulant' readings on thermal conductivity meter, UV fluorescence proved them real; an irradiated green diamond was radio-active and illegal for US sale until 2192.

A carved head of Emperor Nero as a child was identified as emerald by SG and chrome absorption; a deep blue-green euclase gave chrome

absorption lines; a fine suite of turquoise jewellery contained some examples of the rare 'bone turquoise' odontolite.

A natural black cultured pearl had a dimpled surface like a golf ball [or an orange]; a badly eroded cultured earstud gives rise to advice on pearl care; the back of a large half pearl illustrated the natural concentric layer structure very effectively.

R.K.M.

Gem trade lab notes.

C.W. FRYER, G.R. CROWNINGSHIELD, K. HURWIT, R.C. KAMMERLING AND S.F. MCCLURE. *Gems & Gemology*, 29(3), 1993, pp 198-205, 19 illus. in colour.

A necklace of baroque amber 'nuggets' showing heat induced spangles which darkened on exposure to strong light possibly due to oxidation; a brown-pink diamond showing rare 'green graining' was shown to be natural by its spectrum; a light violet-grey diamond explained as an optical combination of grey and pink zones shown to be of type IIa and IIb; a light yellow diamond showing a clear octahedral strain phantom defined by first-order interference colours; an unusual tablet reminiscent of a mass of actinolite crystals proved to be devitrified glass; a treated jadeite pendant was shown to have natural colouring but an infra-red spectrum denoting polymer treatment; a grey pearl set as a brooch with a bird motif was shown to be natural-colour cultured pearl containing two beads; a string of cultured pearls showed severe erosion by skin contact and lack of after-wear care; a colour-zoned pink quartz showing a UV absorption spectrum similar to that of amethyst and traces of iron by EDXRF analysis was simply reported as pink quartz; an imitation of a water-worn ruby crystal was shown to be synthetic by EDXRF analysis which showed a typical melt-produced trace element composition; a pair of earrings set with invisibly mounted square cut rubies were shown to be flame-fusion synthetics.

R.J.P.

Gem trade lab notes.

C.W. FRYER, G.R. CROWNINGSHIELD, K. HURWIT, R.C. KAMMERLING AND S.F. MCCLURE. *Gems & Gemology*, 29(4), 1993, pp 278-84, 17 illus. in

colour.

A brownish-yellow carving allegedly sixteenth century proved to be cubic zirconia; A cyclotron-treated round diamond showed an asymmetric umbrella effect which was thought due to treatment by an old cyclotron at Columbia University; a natural fancy dark yellowish-brown diamond showed unusual brown radiation stains; a greyish-green diamond showed numerous brown radiation stains and an unusual 'melted' cavity; a faceted yellow synthetic diamond exhibited features of a synthetic and suggested a Russian origin; an emerald with large filled etch channels had been treated with a synthetic resin and an attempt made to polymerize the surface but the interior was fluid as shown by a movable bubble; filled fractures in garnets were detected by the careful use of a hot point needle; a necklace of iridescent beads was shown to be orthoamphibole 'Nuummite'; a carved mask in rock contained one or more orthopyroxenes. A multi-stranded necklace containing both natural and cultured pearls showed 'hammering' effects on the natural pearls which appeared to have been inflicted with a ball peen hammer; synthetic ruby rough was easily identified by the curved striae shown using a brightfield/immersion technique; a set sapphire appeared to show curved striae on exposure to short-wave UV radiation but its uniform colour caused a re-examination of the unset stone which then showed evidence of altered silk and the striae under immersion were normal parallel growth planes. Another sapphire showed diffusion treatment obscured by the mounting; a dark green YAG showed elongated gas bubbles sheathed in fine layers of blue colouration with slightly curved parallel graining and scattered small crystals with stress fractures.

R.J.P.

Les perles rouges de *Pinna nobilis*.

J.-P. GAUTHIER, J. CASEIRO AND B. LASNIER. *Revue de gemmologie*, 118, 2-4, 1994, 6 photos, 4 in colour.

Pearls of a pinkish-red colour are retrieved from *Pinna nobilis*, a bivalve found at depths between 3 and 30m in the Mediterranean. Specimens may reach nearly 20mm in length and have a mainly calcitic content. Sections of the

pearls show a radiating fibrous structure.

M.O'D.

The difference between the solubility of quartz and chalcedony: the cause?

S. R. GÍSLASON, P. J. HEANEY, D. R. VELEN AND L. K. T. LIVI. *Chemical Geology including Isotope Geology*, 107(3-4), 1993, pp 363-6.

Chalcedony is a mixture of quartz and moganite, a little known silica polymorph. Possible causes for the enhanced solubility of chalcedony include small crystal size, high defect concentration due to pervasive Brazil twinning and the incorporation of moganite. The solubility of moganite and its surface free energy are unknown, but indirect evidence suggests that it is more soluble than quartz.

R.A. H.

Die aussergewöhnlichen Eigenschaften von Kascholong-Opal aus einem Neuentdeckten Vorkommen im Oman.

I. GUBA. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(4), 1993, pp 141-8, 1 diagram, 6 illus. in colour, bibl.

A new deposit of rare opal varieties cashalong and prasopal has recently been discovered in the ophiolites of the Oman mountains near Muscat/Oman. Similar but smaller deposits have been known in Poland and Mexico. Both varieties are intergrown and grading into each other. The extraordinary characteristic of cashalong in particular is its high porosity and capillary wettability. The stone is easily polished and engraved and its use for cameos and in composition stones is suggested. Because of its porosity it will retain perfumes for a long time and can be used as a combined piece of jewellery and perfume flask. It is easily dyed and can therefore be used as simulant for turquoise, malachite, amber, coral, etc. Other uses suggested are in aromatherapy, filter or absorption medium, slow coolant and possibly as implant (?).

E.S.

A cobalt-rich spinel inclusion in a sapphire from Bo Ploi, Thailand.

J. GUO, W.L. GRIFFIN AND S.Y. O'REILLY. *Mineralogical Magazine*, 58(2), 1994, pp 247-58, 1 map.

A gem-quality blue sapphire from Bo Ploi contains a composite inclusion consisting of Co-rich

spinel (~200 µm) and a glassy phase. A combination of EPMA and proton microprobe techniques gave the composition of this spinel as Al₂O₃ 48.18–61.27, CoO 19.7–22.84, Cr₂O₃ 0–12.28, FeO 8.64–9.67, MgO 6.04–6.89, TiO₂ 0.49–0.73%, Ni 2251–2532, Zn 335–371, Mn < 177–849, Ga 113–153, Nb 24–1252, Zr < 4–167, Sn 22–428, As < 4–56, Sr < 4–59, Ag 13–64 ppm. Transitional elements decrease in abundance from core to rim of the spinel while the other elements increase. Crystal chemical considerations suggest that a vacancy-creating substitution mechanism may be operative in the Co-rich spinel: $3\text{Co}^{2+} = 2\text{Al}^{3+} + \text{V}^{\text{IV}}$. The coexisting glassy phase may be the product of heating by the host basaltic magma. This unusual spinel [with average composition near (Co_{0.8}Mg_{0.7}Fe_{0.9})(Al_{1.5}Cr_{0.2})O₃] is considered to be the result of a complex magma mixing process in the lower crust.

R.A.H.

Sapphires from Changle in Shandong Province, China.

J. GUO, F. WANG, G. YAKOUMELOS. *Gems & Gemology*, 28(4), 1992, pp 255-60, 7 figs.

Significant quantities of sapphire have been found in situ in basalt in Changle [Chang-Lee?] county, colours ranging through dark blue, blue, greenish-blue and yellow. Area has produced alluvial sapphire for some time but this basalt deposit is considered to be unique in size. Some stones strongly zoned. At present a small operation, mining is largely by hand, but mechanization is planned and potential appears to be large. Constants as normal for sapphire, little dichroism, red zircon, columbite, feldspar, ilmenite and spinel were seen as inclusions.

R.K.M.

Gemmologische Kurzinformationen.

U. HENN AND H. BANK. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(2-3), 1993, pp 163-67, 1 table, 4 illus. in colour, bibl.

The first note deals with a new ruby find in Myanmar, in the Mogok district, at Mong Hsu, east of Mandalay. The rough is on the dark side and may be lightened by heating with borax and sodium hydrogen phosphate, remains of which can be found in cracks and fractures, RI 1.762-

1.770, DR 0.008, SG 3.98.

The second note describes spessartines from Namibia, which were offered in Tucson as 'hollandine' (because of their orange colour). The stones are found as rhombododecahedra near a river on the border with Angola. They have RI 1.790-1.796, SG 4.04-4.15. The largest cut stone weighed 55.4ct.

The rest of the notes mention triphylite and triplite from Brazil (the first being greenish-blue lithium phosphate, the second a complex phosphate black with blue sheen and cat's-eye effect); synthetic diamonds from Russia (yellow rough, the largest crystal weighing 0.86ct); synthetic rubies from Russia and beryl/beryl triplets and blue adhesive layer as imitation for Paraíba tourmalines, found in a parcel of tourmalines. E.S.

Geschliffene grünlich-braune Hornblende aus Sri Lanka.

U. HENN AND H. BANK. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(4), 1993, pp 163-9, 1 table, 4 illus. in colour, bibl.

Three transparent, greenish-brown specimens came from a district about 75km south-east of Ratnapura in Sri Lanka and were identified as parasitic hornblende. RI 1.620-1.642, birefringence 0.022, SG 3.12. The colour is caused by iron; inclusions are healing cracks, hollow tubes and mica platelets as well as growth structures. Some crystals show cat's-eye effect. E.S.

Gemmologische Kurzinformationen.

U. HENN, H. BANK AND C.C. MIJISENDA. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(4), 1993, pp 137-40, 4 photomicrographs in colour.

The most detailed note of this report deals with filled diamonds and how to recognize these treated stones.

A new synthetic ruby from Greece is now commercially available under the name of 'Douros'; RI 1.762-1.770, DR 0.008, SG 3.98. There is also a new synthetic ruby from Russia that can be identified by dendritic remains of the flux.

A new occurrence of dendritic opals has been found on lake Kariba, Zambia. The material is brownish-yellow and shows definitive dendritic inclusions; RI 1.459, SG 2.15.

From the Kola peninsula in Russia comes a quartz with a stick-like bronze-coloured inclusion which has been shown to be astrophyllite (a type of complex layered silicate). E.S.

Aquamarin aus Irfersgruen, Sachsen.

G. HOLZHEY. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(2-3), 1993, pp 123-7, 4 photomicrographs, 1 table, 1 graph, bibl.

The only known German source of aquamarine in Irfersgruen in Saxony occurs in local pegmatites. The aquamarines have low RIs of 1.565-1.570. The absorption spectra can be seen at 810nm and 225nm and there is a transmission maxima at 485nm. Two-phase inclusions can be seen parallel to the crystallographic *c*-axis. E.S.

Das strahlende Blau der behandelten Topase.

M.F. HUEGL. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(2-3), 1993, pp 91-9, 6 photographs, bibl.

A review of the colour and its causes by different treatment methods of blue topaz. The blue colour is due to structural defects which radiation can turn into colour centres. In natural blue topaz the radioactivity of the host rock causes colour saturation. The artificial colour can be caused either by irradiation by gamma-rays or electrons or bombardment with neutrons. The risks of transformation of trace elements into radioactive isotopes are explained. Reliable proof of treatment is only possible by laboratory methods. E.S.

Rare stones.

A. JAVIERI. *Indian Gemmologist*, 4(1), 1994, pp 15-16.

Stones chosen for a brief description are rhodochrosite and thomsonite. M.O'D.

Emeralds and green beryls from Upper Egypt.

R.H. JENNINGS, R.C. KAMMERLING, A. KOVALTCHOUK, G.P. CALDERON, M.K. EL BAZ AND J.I. KOIVULA. *Gems & Gemology*, 29(2), 1993, pp 100-15, 19 figs.

A report on a visit to the Red Sea Hills near Marsa Alam and the examination of historic mine sites and emeralds. Believed to be the oldest known sources of emerald, these are worked only sporadically today. A radio navigation

system enabled the accurate mapping of these difficult wadis during the expedition. Quality of emerald mined today is generally low. R.K.M.

Examination of a glass imitation of jade from Vietnam.

R.C. KAMMERLING AND G.P. CALDERON. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(4), 1993, pp 171-7, 2 illus. in black-and-white, 2 in colour, bibl.

The bowl of yellowish-green (apple-jade) with semi-translucent, whitish areas was obtained in Ho Chi Minh City, Vietnam. RI 1.51 and found to be partially devitrified glass, but distinct from the Japanese product known as 'Meta-Jade'. The material was shown to be not entirely amorphous. E.S.

Identificación de zafiros tratados por difusión.

R.E. KANE, R.C. KAMMERLING, J.I. KOIVULA, J.E. SINGLEY AND E. FRITSCH. *Boletín del Instituto Gemológico Español*, 35, 1993, pp 7-23, 2 tables, 27 illus. in colour, 3 figs.

Paper on the identification of blue diffusion-treated sapphires first published in *Gems & Gemology*. M.O'D.

Testa Nera: die trauernden Turmaline von Elba.

D. KLAUS. *Lapis*, 19(1), 1994, pp 54-5, 4 photos in colour.

Tourmaline crystals of various colours but with black or dark tops are characteristic of Elba. Some examples and locations are described.

M.O'D.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, 28(4), 1992, pp 268-279, 14 figs.

Uruguay has large deposits of agate and amethyst at Artigas; reports on blue amber from Dominican Republic and on Baltic amber, including plan to pump direct from seabed at Gdansk; an unusual aragonite from south Peru resembled blue pectolite; a faceted remondite-Ce had colour change from greenish-yellow (day) to yellowish orange (incandescent) due possibly to neodymium; dumortierite quartz beads from S. Africa are illustrated; a turquoise simulant seen in Egypt was mixture of amphibole and feldspar,

colour due to copper. Fine golden cultured pearls, reportedly from Okinawa, are illustrated and described; individual gem mining continues on a small scale at Elahera, Sri Lanka; another update on Sri Lanka from Gordon Black says that decline in production is due to threat of terrorism, some pink sapphires have been irradiated to padparadscha colour but change is unstable, chatoyant kornerupines, rutiles and a 114 carat chrysoberyl twin also reported, an iron-rich chrysoberyl had high RIs; a 33 carat taaffeite was seen in Hong Kong; an update from Vietnam reports increased production of pink sapphire/ruby at Luc Yen, various finds reported; green zoisite reported from Skardu, Pakistan.

Enhancements: Filled pique diamonds offered in Perth W. Australia without clear statement that they are filled; rough diamonds are being fracture filled to defraud, since glass fillings will not stand heat of cutting; black irradiated diamonds said to become non-radioactive after boiling in acid; a sandstone teapot stained by tea is illustrated. R.K.M.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, 29(1), 1993, pp 52-64, 24 figs.

Headed Tucson '93, this paper reports on unusual multi-coloured iris agates; Baltic amber; Uruguayan amethyst; amethyst-citrine from Bolivia; dark blue and blue-green apatite from Bahia and bright green-blue apatite from Madagascar; a 10.90ct alexandrite from Brazil and another of 7.55ct from Orissa were seen. Various materials cut to display natural surfaces are described; yellow-green beryl from Ukraine; deep yellowish-green Zambian emeralds with fewer inclusions than usual; gem materials ranging from pallasitic meteorite to moldavite and other tektites and silica glass were shown. Among large stones exhibited were a 240ct sinhalite and several Sri Lankan sphenes; a 673ct pink fluorite; iolites up to 110ct and a 600ct opal from Tintenbar, NSW. Some Siberian jadeite was shown; and a strangely aventurescent zircon. Basaltic opal from British Columbia; cultured pearls from Tahiti, Australia and China were offered. Chinese reported to be trying to develop

spherical pearls by tissue nucleation. Natural river Unio pearls were shown from a Quebec source which can reach -40°C in winter; one man exhibited peeled black cultured pearls which had been worked on with little more than a knife [does this expose the dyed conchiolin layer?]. Opaque red quartz owed its colour to included chalcotrichite; small Ethiopian peridots similar to those from Arizona and China were seen; briefly described but not illustrated were faceted ezcurrence, probertite, mooreite, brucite and leifite; Colorado yielded some spectacular large faceted rhodochrosites.

Updates on rubies and sapphires from a number of sources are given; intense orange spessartine garnets from Namibia were offered as 'Hollandine'. Paraíba blue-green tourmalines were again offered and some from Minas Gerais which do not heat-treat so well; parti-coloured green/blue zoisites were also seen.

Enhancements: An apparatus for filling emerald fractures with coloured oil was offered from Israel. R.K.M.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*, 29(2), 1993, pp 130-41, 24 figs.

Coloured stones: Blue cancrinite reported from Greenland (RI 1.499-1.493, SG 2.43, H 5-6, fluoresces red to dark purple); Big Crab-Tree Mountain, N. Carolina, 'only source US emeralds', now mining matrix material for cabochons and quartz-topped doublets; a 30cm globe using gem slabs of representative minerals for countries was seen at Tucson, also a large quartz cabochon had been cut to include 3-phase 'fingerprint'; Tucson also offered volcanic glass with striking range of iridescent colours.

Orissa, India, is now a significant gems source with rhodolite garnet, alexandrite, aquamarine, ruby, tourmaline, hessonite and chatoyant sillimanite seen at Tucson; cultured freshwater pearls in various colours are reported from Ho Tay Lake, Hanoi; a small quantity of Zabargad peridot was shown at Tucson, as were an ornamental porphyry from British Columbia and a natural fossil resin from Colombia, S. America, containing numerous insect and plant inclusions; alluvial ruby workings at Ruvu, near Mahenge,

Tanzania, by Thai companies, producing mainly cabochon material.

Enhancements: RI of opticon filler varies between 1.545 and 1.560 giving variable optical relief as RI of host also differs; turquoise oiled to improve colour may fade as oil evaporates.

Announcements: The S.R. Perren Gem and Gold Room at the Royal Ontario Museum, Toronto, opened in July featuring a 1625ct peach-coloured beryl, a 193ct star sapphire and a natural blue topaz of some 3000ct, among nearly 1000 gem and gold exhibits. R.K.M.

[Amethyst. A geological-mineralogical and gemmological essay.] (Bulgarian with English abstract)

R. I. KOSTOV. Sofia (Private Edition), Price 29 Levs, 1992, 250 pp.

The book consists of the following chapters: Etymology, Historical notes, Crystal morphology (structure, morphology, polycrystalline varieties and ontogenetic studies), Physical properties (specific gravity, permittivity, magnetic susceptibility, refractive index, nature of colour and hues, homogeneity, zonality, optical spectroscopy, thermoluminescence, X-ray and gamma luminescence, thermal influences, IR spectroscopy, e.p.r. and nuclear magnetic resonance), Chemical composition and inclusions, Geographical distribution and production (Europe, Asia, Africa, America, Australia and Oceania), Genetic types of the deposits, Synthesis, and Role in human culture. The rich literature cited serves as a specific to amethyst bibliography with sources in different languages. R.K.

A new gem beryl locality: Luumäki, Finland.

S.I. LAHTI AND K.A. KINNUNEN. *Gems & Gemology*, 29(1), 1993, pp 30-7, 12 figs.

Pale yellow, green and (rarely) blue, heavily etched crystals of beryl have been found in a pegmatite quarry. Decrepitated fluid inclusions are characteristic. Constants typical of beryl. Greens are not emerald. R.K.M.

U-disequilibrium dating of corals in southern Taiwan by mass spectrometry.

T. LEE, J. H. CHEN, C. F. DAI & J. J. SHEN, *Journal of the Geological Society of China*, 36(1), 1993, pp 57-

6, 1map.

Uplifted corals in this area were dated by $^{230}\text{Th}/^{234}\text{U}$ using MS. For Holocene samples the results are in agreement with earlier studies but with better precision than conventional nuclear counting, and better than ^{14}C dating. There is the potential to date samples as young as 30 yr and as old as 500,000 yr, though careful selection of samples and thorough field studies are required. To investigate the possibility of dating palaeoseismic activity four coral samples from Hou-Bi-Hu, Kenting, were analysed. The results suggest that complex coral assemblages and the studied samples may not be suitable for dating such activity. The dating of other samples is discussed. R.F.S.

Spessartine aus Namibia.

T. LIND, H. BANK AND U. HENN. *Neues Jahrbuch für Mineralogie. Monatshefte*, 12, 1993, pp 569-76, 3 figs.

Gem-quality spessartine from Namibia has SG 4.09-4.15 and RI 1.790-1.797. The specimens are ascribed to a near-binary solid solution series pyrope-spessartine with spessartine content between 80 and 90 per cent. With the spectroscopy a nearly pure spessartine composition is indicated with bands corresponding to Mn^{2+} , the only ones found in the visual spectrum. A small amount of hydrospessartine is found by using NIR spectroscopy. M.O'D.

Stable-isotope, fluid-inclusion, and mineralogical studies relating to the genesis of amethyst, Thunder Bay Amethyst mine, Ontario.

J.R. McARTHUR, E.A. JENNINGS, S.A. KISSIN AND R.L. STERLOCK. *Canadian Journal of Earth Sciences*, 30(9), 1993, pp 1955-69, 1 map.

This mine exploits a vein system in which the main zoned sequence consists of chalcedony, colourless quartz and three to four stages of amethyst. The main sequence surrounds fragments of a brecciated earlier sequence with chalcedony, colourless quartz and prasiolite, which appears to be thermally bleached amethyst. The vein system is in a fault in Archaean granodiorite and is associated with a zone of chloritic and hematite alteration. Main-stage fluid inclusion T_c are in the range 91.2 to

40.9°C (mean 68.4°C) in amethyst, whereas in colourless quartz the T_c range is 146.5-114.7°C (mean 132.1°C); eutectic T_c indicate an $\text{NaCl}-\text{CaCl}_2-\text{H}_2\text{O}$ system and salinities are 22.9 to 15.3 eq.wt.% NaCl. trace sulphide and other mineral inclusions indicate a trend of decreasing Eh and pH from a rather oxidized (sulphate stable) to a reduced (sulphide stable) condition during deposition. The ^{34}S values for pyrite and chalcopyrite are -0.4 to 1.4‰; $\delta^{18}\text{O}$ in quartz range +12 to +17.1‰, corresponding with $\delta^{18}\text{O}(\text{H}_2\text{O})$ -2.1 to -12.8‰ using fluid-inclusion T_c . The quartz monzonite wall rock does not appear to have been involved isotopically; rather, mixing of local meteoric water with a basinal brine appears to explain the observed trend. The amethyst deposits are believed to have been formed by basinal brines expelled from Proterozoic Sibley group sediments; the brines dissolved silica by alteration processes accompanying their passage through granitic basement rocks. The T_c interval for amethyst formation appears to be restricted to < 90°C; T_c for thermal bleaching of amethyst are as low as 145°C. R.A.H.

Update on diffusion treated corundum: red and other colours.

S.F. McCLURE, R.C. KAMMERLING AND E. FRITSCHE. *Gems & Gemology*, 29(1), 1993, pp 16-28, 20 figs.

Diffusion-treated red and pink corundums were examined prior to commercial release. Such stones cannot be assumed to start as rubies and so must not be called 'diffusion-treated rubies'. Of 43 stones examined only 12 were 'ruby colour' while a further 15 were light pink or purple. These 27 stones were examined gemmologically in detail. The remaining 16 stones were unsatisfactory products of earlier experiments, patchy or wrong in colour.

RI's were abnormally high in many stones and some showed a second set above 1.80 when tested on a cubic zirconia refractometer. Some pleochroism and luminescences were unusual, the latter particularly in SUV; absorption spectra weak for colours tested. Magnification showed disrupted inclusions expected in heat-treated stones; uneven patchy colour due to thin colour layer or to excessive polishing more obvious

when stones immersed. In methylene iodide these stones showed greater facet relief than similar naturally coloured stones or synthetics, some gave blue or purple outlines. [There appears to be an element of coating in some specimens which surely needs to be declared.]

An important paper which suggests that these experimental reds are detectable. Experiments are continuing in an endeavour to improve the products. R.K.M.

Achate aus dem Geschiebe der nordischen Vereisungen.

R. MENDE. *Aufschluss*, 45, 1994, pp 43-7, 8 photos.

Some examples of agate from the northern area of Germany are described and illustrated.

M.O'D.

Application of structural geology in the exploration for residual gem deposits of Sri Lanka.

D.P.J. MENDIS, M.S. RUPASINGHE AND C.B. DISSANAYAKE. *Bulletin Geological Society of Finland*, 65(1), 1993, pp 31-40, 4 maps.

Geological investigations have shown that corundum deposits are generally associated with axial plane areas of tight, doubly plunging synclinalia and anticlinalia where crystalline limestones and pegmatites occur. Corundum deposits also occur at sites of heavy structural disturbances such as discontinuities, faults, folds, joints, lensing and necking zones, etc. if marbles and/or intrusions of granite and pegmatites are present. Alluvial gem deposits do not necessarily exist close to their place of origin, though most concentrations of alluvial gem beds still remain close to their source. Examples are given of areas of high potential (Opanayake and Hattota Amuna), moderate potential (Bogawantalawa and Pubbiliya) and areas with significant potential. Sketch maps are given of the four areas mentioned, which in addition to sapphire yield spinel, tourmaline, zircon and garnet. R.A.H.

What's new in minerals?

T. MOORE. *Mineralogical Record*, 25(1), 1994, pp 57-63, 1 illus. in black-and-white, 9 in colour.

Gem minerals reported from a number of shows include fine elbaite from Pakistan, a

country which also provided specimens of aquamarine, spessartine and epidote. Orange sphene has also been reported from Pakistan, the actual location being Alchuri village, Shigar Valley, Baltistan. Some green-pink water-melon tourmaline is reported from Pakistan. Gem-quality datolite has been found at Dalnegorsk in the far eastern part of Russia and fine rhodochrosite continues to appear from the Sweet Home mine in Colorado. Fine green uvite from a site 'near Mogok', Myanmar, is reported to be found about 15km from the Thai border. M.O'D.

Rb-Sr dating of sphalerites from Mississippi Valley-type (MVT) ore deposits.

S. NAKAI, A.N. HALLIDAY, S. E. KESLER, II. D. JONES, J. R. KYLE AND T. E. LANE. *Geochimica et Cosmochimica Acta*, 57(2), 1993, pp 417-427, 1 map.

Rb-Sr elemental and isotopic data are presented for sphalerites and their fluid inclusions from NW Territories and Newfoundland, Canada, and E Tennessee and N Arkansas, USA. The value of the Rb-Sr method for dating sphalerites is assessed and can be useful in elucidating the genesis of MVT and other types of ore deposits. But isotopic inhomogeneity of ore brines limits the accuracy of sphalerite dating. Rb and Sr appear to be hosted mainly in the sphalerites rather than in silicate inclusions the sites of Rb and Sr atoms in the sphalerites are uncertain but they are probably associated with crystal defects. Sphalerites with very low Sr contents are difficult to date since their Sr isotopic compositions are affected by minor silicate inclusions. Results for the four groups of samples are discussed. R.K.H.

Edel-und Schmucksteinvorkommen in Nepal.

G. NIEDERMAYR, F. BRANDSTAETTER AND V.M.F. HAMMER. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42, 1993, pp 69-89, 1 map, 7 photographs, 4 tables, 5 graphs, bibl.

Gemstones found in Nepal include corundum (ruby and sapphire), dravite, almandine garnet, iolite, alkali feldspar-moonstone, rock crystal and smoky quartz, aquamarine, tourmaline, spessartine garnet, amazonite, danburite and hambergite. Most of these are not commercially mined, partly because of their local situation.

The corundums are mainly pink and violet sapphires from Ganesh Himal, north-west of Kathmandu. The aquamarines are often light blue, the dravite dark brown to orange-brown. The high quality tourmalines are in shades of pink, green, brown to orange and pure yellow; these come from the pegmatites near Manang, the rough crystals being up to 16cm long. The Mn content of these tourmalines can be as much as 9.2 per cent of their weight. Mining is difficult. One of the promising tourmaline mines in eastern Nepal can only be reached after three days on foot. Explosives cannot legally be used by private persons. E.S.

Almandin.

G. NIEDERMAYR. *Mineralien Welt*. 5(1), 1994, p.17, 2 illus. in colour.

Short account of the occurrence of almandine in metamorphic rocks with notes on characteristic inclusions. M.O'D.

Comparative study of beryl from various Indian occurrences - beryl from Jammu and Kashmir.

J. PANJIKAR. *Indian gemmologist*. 4(1), 1994, pp 3-8, 3 tables, 10 figs, 1 map.

The structure and properties of the beryl varieties are described with particular reference to beryl from Jammu and Kashmir. M.O'D.

Fluid evolution in the H₂O-CH₄-CO₂-NaCl system during emerald mineralization at Gravelotte, Murchison Greenstone Belt, north-east Transvaal, South Africa.

Y. Y. NWE AND G. MORIFANI. *Geochemica et Cosmochimica Acta*, 57(1), 1993, pp 89-103, 1 map.

Microthermometry and laser Raman microprobe spectrometry are used to study complex fluid inclusions present during the formation of emeralds and associated phenakites. In the system, H₂O + CH₄ were dominant in the earliest stages of formation; minor C₂H₆, N, and H₂S were also detected. The early type 1 fluids, trapped in the phenakites and beryls, which are low-salinity with <18 mol.% CH₄, developed during albitization/alkali metasomatism of a pegmatite body. With increasing interaction with the host rocks, progressive crystallization of the emeralds

occurred, the fluids becoming less CH₄-rich and more saline. P-T conditions for the earliest inclusions in the phenakites were ~450-500°C and 4 kbar. Phenakite was converted to emerald as Al₂O₃ activities in the system increased. R.K.H.

A study of gem varieties of corundum from parts of Tumkur and Mysore Districts, Karnataka.

J. PANJIKAR, H. CHANDRASHEKHAR, M. MUNISWAMIAH AND N. AHMED. *Journal of the Geological Society of India*. 43, 1994, pp 311-15.

A brief account of gem corundum occurrences in southern Karnataka, India, is given with notes on the complex geological environments involved, specially referring to the margins of the Clospet pluton. Geological and gemmological characteristics of gem corundum from parts of Tumkur and Mysore districts are given. M.O'D.

A tentative classification of heat-treatable corundum (Geuda) stones.

M.S. RUPASINGHE, R.A.P. RUPASINGHE, C.B. DISSANAYAKE AND O.A. IJEPERUMA. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*. 42(2-3), 1993, pp 115-21, 4 photographs, 1 table, bibl.

Heat-treatable low quality corundum (Geuda) exhibit a wide range of properties and the local gem trade (Sri Lanka) identifies these stones mainly on the basis of their appearance. Local names for the different varieties are explained, including such names as diesel geuda (oily), milky geuda (these include blue milky, red milky and yellow milky), silky geuda, ottu geuda (indicator for other stones probably to be found, i.e. unevenly developed, patchy or spotted stones) and dhum geuda (smoky). E.S.

[Structural-mineralogical peculiarities of lazurite from the South-Western Pamirs.] (Russian with English abstract)

A. N. SAPOZHNIKOV, V. G. IVANOV, V. I. LEVITSKY AND L. F. PISKUNOVA. *Proceedings of the Russian Mineralogical Society*, 122(1), 1993, pp 108-115.

Associated isotropic and anisotropic lazurites from the Luadzhvardarite lazurite deposit, together with an isotropic lazurite from near the town of Ishkashima (SW Pamirs) have been studied. The commensurate and incommensurate modulations of the lazurite structure were

established by XRD; they are related to non-stoichiometry, causing local changes in occupation of structural sites. This, in turn, seems to be related to changes during secondary crystallization after the primary phase of growth. EPMA data, n values and XRD powder reflections are tabulated for three Pamir lazurites and compared with lazurites from Baikal and Afghanistan. Indexed powder data are given for an anisotropic lazurite; this has a reflection at $d=12.2\text{\AA}$. R.A.H.

Saphir vom Seufzergründel in Sachsen.

F. WAGENKNECHT. *Lapis*. 18(12), 1993, p.46, 1 fig., 1 photograph in colour.

Ruby and sapphire, not of gem quality, are reported from the Seufzergründel near Hinterhermsdorf, Saxony, Germany. Associated minerals include almandine, zircon (high type) and apatite. M.O.D.

Garnets from Altay, China.

F. WANG AND Y. LIU. *Gems & Gemology*. 29(4), 1993, pp 273-7, 1 table, 9 illus. in colour.

Spessartine (wrongly described as spessartite in this paper) and grossular garnets of gem-quality are being mined commercially. The material is cut in China and sold internationally through Hong Kong. Chemical composition and physical constants are normal for these species. The deposits are in mountainous terrain close to the borders of Kazakhstan and Mongolia. Access is limited to six months each year and is difficult. R.J.P.

Queensland boulder opal.

R.W. WISE. *Gems & Gemology*. 29(1), 1993, pp 4-15, 16 figs.

An exhaustive account of black opal found in ironstone in Central Queensland, a variety largely disregarded at first but now increasingly valued. Impressively illustrated and well written. R.K.M.

[Gem scapolite from the Eastern Pamirs and some general constitutional features of scapolites.] (Russian with English abstract)

A.A. ZOLOTAREV. *Zapiski Vsesoyuznogo Mineralogicheskogo Obchestra*, 122(2), 1993, pp 90-102.

Gem scapolite from the Kukurt deposit, E

Pamirs, can be distinguished from other scapolites by its chemical composition, cell parameters and other properties. Chemical analyses and cell parameters are given for eight scapolites with Me % 5.4—34.0. IR, optical absorption and EPR spectra are presented. The data suggest the existence of a hitherto unrecognized solid solution between marialite and Ca-marialite. The nature and cause of the lilac colour of the Kukurt scapolite is of particular interest, but additional investigations are needed. R.A.H.

Instruments and Techniques

Radioactivity revisited (Letter).

W.W. HANNEMAN. *Gems & Gemology*. 29(2), 1993, p.80.

Points out inconsistencies in US regulations affecting irradiated gems, and suggests that the restrictions are political rather than practical.

R.K.M.

[The weight of a round brilliant cut by calculation] (Japanese with English abstract).

M. HAYASHI AND Y. HORIKAWA. *Journal of The Gemmological Society of Japan*. 17(1-4), 1992, pp 37-42, 9 figs.

A new equation is proposed to calculate the weight of a round brilliant cut diamond, which is applicable under less limited conditions than any of the hitherto proposed equations. For this calculation, the diameter of the girdle, D , the depth of the pavilion, P , the thickness of the girdle, G , the height of the crown, H , the length between the vertical point of the star facet and the girdle, U , that between the vertical point of the lower girdle facet, L , and the diameter of the table, T , are necessary factors. The equation appears rather complicated, but the calculation is easy with the help of a calculator. I.S.

Kathodolumineszenz (KL) und KL-Spektren von Edelsteinen. (Ausgewählte Beispiele) Teil II.

J. PONAHL. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(2-3), 1993, pp 101-13, 6 photomicrographs, 6 graphs, 1 illus., 2 tables, bibl.

The article describes some CL phenomena and results of CL microspectrophotometric measurements to differentiate between natural and synthetic coloured stones. The following examples are given: blue sapphire, red topaz and spinel, natural and synthetic emerald, red and violet taaffeite. E.S.

Kathodolumineszenz (KL) und KL-Spektren von Edelsteinen. (Ausgewählte Beispiele) Teil II.

J. PONAHO. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 42(4), 1993, pp 149-162, 6 illus. in colour, bibl.

In the second part of his paper the author describes the cathodoluminescence of red and violet spinels, chrome-containing taaffeites, feldspars, apatite cat's-eye and a leuco sapphire from Sri Lanka. E.S.

Magnetic field-induced rotation of diamagnetic gem crystals.

C. UYEDA. *Science Reports of the College of General Education, Osaka University*. 41(1-2), 1992, pp 23-8.

The rotation induced by a magnetic field is reported for natural gem-quality crystals of quartz, topaz, beryl, olivine and spodumene. This rotation was observed when the restoring force of the string suspending the crystal became negligible compared to the diamagnetic anisotropic energy. The diamagnetic principal axis of the crystal gradually changed its orientation towards the direction of the applied magnetic field. The values of diamagnetic anisotropy ($\Delta\chi$) estimated ($\times 10^{-6}$ emu/mol) were: quartz 0.12, (*b-c* axis) 16.4, beryl 58.3, olivine (*a-c* axis) 4.50 and spodumene (*a-b* axis) 4.33.

R.A.H.

Stone polishing - measurement of surface finish.

D. N. WRIGHT AND C. ROUSE. *Industrial Diamond Review*, 53(1), 1993, p 10-13.

Values obtained for different types of polished granite using a portable instrument, where a stylus measures the surface texture, and a gloss meter are compared. The effects of mineral grain size and 'pull-out' have to be taken into consid-

eration when analysing the results. R.A.H.

Monodite used in engraving jewellery.

Industrial Diamond Review, 53(6), 1993, p. 316, 5 photos, 1 diagram, bibl.

Single point diamond cutting tools made from De Beers blank monodite, a single crystal, synthetic diamond product, are used by a Birmingham manufacturer of rings, bracelets, earrings, clock faces and picture frames, which are engraved with intricate patterns. E.S.

Jewellery

Methods of determining the gold content of jewelry metals.

M.E. MERCER. *Gems & Gemology*, 28(4), 1992, pp 222-33, 11 figs.

Without a rigorous hallmarking system, the assessment of gold quality in the USA presents many difficulties. Officially they have 10 carat, 14 carat, 18 carat and 22 carat, but these can apparently be interpreted somewhat widely.

Ms Mercer has investigated four methods of assessment; density (the least reliable since lead is also a heavy metal); touch-stone and acid (complicated by acid dilution, but more reliable); testing with a pen-like detector (not usable on curved surfaces); and X-ray fluorescence (an expensive test which still does not come within their legal requirement (known rather quaintly as Plumb Laws) of ± 3 parts per thousand accuracy. Plated or colour flashed goods could be deceptive. Author says much more research is needed. [In abstractor's opinion the time is ripe to institute a proper hallmarking procedure, perhaps on British lines.] R.K.M.

Jewels of the Edwardians.

E.B. MISIOROWSKI AND N.K. HAYS. *Gems & Gemology*, 29(3), 1993, pp 152-71, 20 illus. in colour.

This detailed review covers the period 1880-1915 and records the introduction of platinum as a precious metal. With its non-tarnishable nature together with its great strength and hardness compared with silver it led to the creation of the light

and lacy garland style. Women from the uppermost echelons of society favoured extravagant jewellery to demonstrate their wealth and rank with the tiara as an essential item.

The Edwardian age was shattered by World War I which not only changed the social structure in Europe but paralysed both the gem and jewellery trades. The former by De Beers who closed down diamond production and the latter by platinum being classified as a strategic metal [a chemist could argue that without platinum, explosives production would have been insufficient to continue the conflict]. When the war was over it was impossible for society to revert to the self-indulgent lifestyle of the Belle Epoque. R.J.P.

Synthetics

Growth of crystals of beryllium oxides and silicates using fluxes.

G.V. BUKIN. *Growth of crystals*. 19, 1993, pp 95-110, 8 illus. in black-and-white, 8 figs.

Work over 25 years at the Institute of Geology and Geophysics and the Special Design and Technology Office of Single Crystals of the Siberian Branch of the USSR Academy of Sciences has dealt with the experimental mineralogy of Be oxides and silicates. The present paper deals particularly with the synthesis and crystallization conditions of analogues of natural beryllium minerals. Work on emerald and chrysoberyl is described and there are also notes on bromellite. Further investigation may enable crystal growers to accomplish the growth of taaffeite and cordierite. M.O'D.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*. 28(4), 1992, pp 268-79, 14 figs.

An update on crystal synthesis reports fluoride crystals of more than 100kg, combined flux and pulling methods improve size and quality of crystals, yttrium silicate and yttrium vanadates, etc., have been produced for laser and super-conductor purposes; attractive three part gem of rhodolite, topaz and iolite was offered as 'rhodiolopaz'; Durafourge of Switzerland are cutting

CZs in sizes down to 500 per carat; Bifra of Vicenza are marketing synthetic stones ready set in gold findings; possibly the largest hydrothermal synthetic ruby weighs 1930 carats; an imitation of water melon tourmaline proved to be stained red quartz surrounded by other mineral fragments and cement encased in slices of blue/green tourmaline. R.K.M.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*. 29(1), 1993, pp 52-64, 24 figs.

Headed 'Tucson '93' this paper reports on: Synthetics and simulants: reconstituted amber (pressed); several 'pulled' synthetic materials; miscellaneous emerald simulants are described and discussed. R.K.M.

Gem News.

J.I. KOIVULA, R.C. KAMMERLING AND E. FRITSCH. *Gems & Gemology*. 29(2), 1993, pp 130-41, 24 figs.

Synthetics and simulants: synthetic corundum marketed as Imperial topaz simulant; Russian flux-synthetic emerald cut in Bangkok under name 'Crystural-created emerald'; opal simulants using holography image or interference imaged film to give play of colour, and other plastic imitation opals; triplet apatite and tourmaline simulants of Paraíba tourmaline; blue synthetic quartz; non-transparent synthetic quartz and German synthetic spinel are all described and illustrated. R.K.M.

Flux-grown synthetic red and blue spinels from Russia.

S. MUTHMEISTER, J.I. KOIVULA, R.C. KAMMERLING, C.P. SMITH AND E. FRITSCH. *Gems & Gemology*, 29(2), 1993, pp 81-98, 19 figs.

An in-depth investigation of these relatively new synthetics with suggestions for identifying them by absorption spectra, flux inclusions when present, or by detection of more zinc in natural spinels by energy dispersive X-ray fluorescence. Other colours have been made. R.K.M.

Flux growth and properties of oxide crystals.

V.I. VORONKOVA, V.K. YANOVSKIY, I.V. VODOLAZSKAYA AND E.S. SHLEBENTSOVA. *Growth of*

crystals. 19, 1993, pp 111-27, 2 illus. in black-and-white, 7 figs.

Growth of crystals using low-temperature fluxes allows crystals to be prepared from compounds melting with decomposition. Choice of an appropriate flux has always been an important part of crystal growth work and this paper outlines growth methods of a number of materials including corundum and lithium niobate. Crystallization of ruby from a flux of alkali and

alkaline-earth tungstates and molybdates enables isometric single crystals to be prepared with hexagonal bipyramidal shape. Growth from these solvents takes place most effectively in a fixed temperature gradient on seeds when rates of about 0.5mm/day give single crystals up to 25mm in size from 50-100ml of melt. For large single corundum crystals the Verneuil or Czochralski methods are still the most efficient.

M.O'D.



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Book Reviews

Beautiful Australian opals

L. CRAM. 1994. Robert Brown & Associates, Coorparoo, Queensland. pp 80. Illus. in black-and-white and colour. Soft cover. Price AUS\$9.95. ISBN 1 86273 075 X.

Len Cram is now well-known as a writer of most attractive books on Australian opal, very competitively priced and with a good deal of information not published previously. The text is divided into three parts, dealing with black opal, boulder opal and light opal with illustrations of some fine stones and of mining scenes and methods. The text includes mining anecdotes, folk-lore and details of present-day mining and exploitation. I have rarely seen such good opal photographs and I recommend all opal lovers to buy the book. M.O'D.

Gemstones.

C. HALL. 1994. Dorling Kindersley, London. p.160. Illus. in colour. Soft cover. Price £10.99. ISBN 0 7513 1026 3.

Part of the publishers' Eyewitness handbooks this book is most attractively produced with colour photographs on virtually every page. I would certainly recommend it as a starter and present and since stimulus of the imagination is the essential first part of learning it could even be used in the early stages of a gemmology course. Material is arranged with the usual introductory chapters followed by separate descriptive sections covering major and rarer species. There are tables and a glossary but no bibliography which would have been useful for the next stage of learning. But this is a small point in a book which ought to spend a lot of its life on the bedside table. M.O'D.

The new alchemists: breaking through the barriers of high pressure.

R.M. HAZEN. 1993. Times Books, New York. pp xvi.286. Price US\$22.50. ISBN 0 8129 2275 1.

So much of this excellent semi-popular study of how scientists have been able to overcome the difficulties of high pressure experiments deal

with the successful synthesis of diamond that it should be required reading for all gemmologists. In fact it would be fair to say that this is at least two-thirds a study of diamond synthesis since the last part of the text is a more cursory survey of the structure and nature of the earth, of superconductivity and of the very recent discovery of buckminsterfullerene, a new form of carbon with the possibility of transforming to diamond at room temperatures under pressures of 200,000 atmospheres. The material is so lucidly presented that it is easy to read and easy to (think you) understand! Beginning with the famous peanut butter to diamond transformation by Wentorf in 1955, the book goes on to outline the ways in which high pressures were achieved and their subsequent employment in materials structure analysis. On the way we stop at early attempts at diamond synthesis, the work of Percy Bridgman, the final harnessing of high pressure and the manufacture and application of diamond thin films grown by chemical vapour deposition. These topics are given sufficient detail to make them both a stimulus to the imagination and a source of information. Anecdotal material is well-chosen and not overdone; the occasional black-and-white picture helps the text along as do the diagrams, especially those depicting diamond synthesis.

The text, once fully read, brings the participants to life as well as to work. The workers on diamond synthesis were as subject to human emotions and jealousies as anyone else; scientists also need the trappings of peer recognition and our brief acquaintance with the characters in this particular play makes us feel that we know them well. M.O'D.

Antero aquamarines: minerals from the Mount Antero-White Mountain region, Chaffee County, Colorado.

M.I. JACOBSON. 1993. L.R. Ream Publishing, Coeur d'Alene, Idaho. pp xvi.126. Price US\$19.85 (paper) US\$34.95 (cloth). ISBN 0 928693 07 4.

Interesting geological-mineralogical-anecdotal account of the pegmatites of Mount Antero, Colorado and their contents, the most significant of which is aquamarine. Crystals reach gem quality in some instances and some faceted stones are illustrated in colour. There is a really useful bibliography and chapters deal with the genesis of pegmatites and with geochemistry as well as with local conditions. A model of a local specialized guide which will appeal to several classes of reader. M.O'D.

Designer jewellery.

C. MAZLOUM. 1993. Gremese International, Rome. p.189. Price £12.95. ISBN 88 7301 021 0.

A review of some of the work of currently-operating Western-style jewellery designers, chosen apparently at random, this book, while quite attractively produced and certainly well illustrated, comes close to advertising the products displayed and their designers. The text is inflated, containing little more than platitudes, and there is no attempt at any kind of critical review. As the 'collaborators' listed on the title-page are the same as the designers whose work is included, perhaps this is to be expected. A number of mistakes in the lists of journals and museums does not increase confidence. M.O'D.

International Conference [on] New Diamond Science and Technology, Washington DC, 1990.

R. MESSLER, J.T. GLASS, J.E. BUTLER, R.ROY (eds). 1991. Materials Research Society, Pittsburgh, PA. pp xx, 1128. Illus. in black-and-white. Price £58.00.

This very stout but reasonably-priced book covers a wide field of diamond research, beginning with an account of the resurgence in work on diamond synthesis (together with cubic boron nitride (BN) and related materials): chemical vapour deposition techniques have initiated considerable advances in the synthesis of very hard materials. The text is divided into 13 parts and most of these deal with various aspects of vapour-grown diamond crystals and films. Gemmologists will probably find most to interest them in part 8 which deals with properties: optical, vibrational, Raman. Here there is a paper by Collins on optical centres in synthetic

diamond; this is a review paper and is followed by Fritsch, Scarratt and Collins on optical properties of diamond with an unusually high hydrogen content. Other papers in this section cover cathodoluminescence, spectroscopic studies and features of diamond films. Part 10 describes the effect of doping with boron and with various electrical properties. The final two parts deal with diamond-like materials and with cubic boron nitride.

There is a very large amount of information in this book and as each chapter has its own list of references readers will find pointers in any direction of further study. Perhaps this is not a book for the general gemmologist but all should know of its existence. M.O'D.

Diamond grading ABC (11th revised, enlarged edition).

V. PAGEL-THEISEN. 1993. Rubin & Son bvba, Antwerp. p.308. Illus. in black-and-white and colour. Soft cover. Price £25.00. ISBN 3 9800434 1 1.

Since its first appearance in the early 1970s this book has deservedly become a useful handbook for the diamond grader. Over the years production and presentation have kept pace with improving standards and the clarity grading text is illustrated in eye-catching black and red, making the inclusions much easier to see.

Chapters deal with colour first, followed by clarity, cut and weight. The last section deals with diamond imitations. A good deal of attention is paid to instruments and styles of cutting are clearly described; this section has been updated to take new styles into account; other additions to the text include details of filling practices and the lasering of stones.

There is a useful bibliography and the book is very reasonably priced. M.O'D.

The Coronation ceremony of the kings and queens of England and the crown jewels.

T. ROSE. 1992. HMSO, London. p.134. Illus. in colour. Hardback. Price £9.95. ISBN 0 11 701361 7.

The varying rituals of English coronations are briefly described with passing notes on items of the regalia. Though the pictures of the regalia and the reproductions of pictures and MSS are

very well done the text jumps about rather uncomfortably, mingling accounts of the most recent coronation with those of earlier ones so that the reader does not always know which one is meant. Accounts of the various items are not always accurate; for example, the colobium resembles the present-day alb rather than the dalmatic; though a pair of gloves is said to be worn for the reception of the two sceptres, the photograph on page 112 shows only one being worn; after retiring the sovereign removes the mantle as well as the dalmatic and supertunica - if this is not done she would be wearing two heavy robes! On page 95 the white shift worn for the anointing is worn over the dress, not beneath the Parliamentary robes which have been removed before this point. The bracelets worn by the Sovereign are known as armills rather than armillas, however correct the latter name may be. The illustration on page 53, showing the two ends of the stole, is not captioned clearly.

Despite the support of 'seven distinguished scholars' the author appears to have no real depth of knowledge of her subject and the whole text reads as a hasty throw-together of items from popular journals. It is a pity that so ancient a ceremony and magnificent paraphernalia are not better served. For gemmologists, the text is of no greater value than previous accounts. M.O'D.

La microsonde Raman en gemmologie.

H.-J. SCHUBNEL, M. PINEI, D.C. SMITH AND B. LASNIER. 1992. Association française de gemmologie, Paris. p.60. Illus. in black-and-white and in colour. Price FF100.00. ISBN none: uses ISSN of *Revue de gemmologie* which is 0396-9011.

Raman microprobe techniques enable non-destructive testing of gemstones to be carried out by comparison with established mineral and gemstone standards. Using a laser beam Raman-diffused light is converted to a computerized

spectrum with peaks denoting specific atoms in vibration within specific molecular environments. After an introductory section by Schubnel describing developments in Raman techniques with particular reference to inclusion determination the remainder of the book details gem minerals in chemical order with their Raman spectra, notes on major inclusions and other properties and constants. The book is well illustrated and will be a very useful laboratory tool, giving the first set of examples to serve as standards in the future. M.O'D.

Fabergé: imperial jeweller.

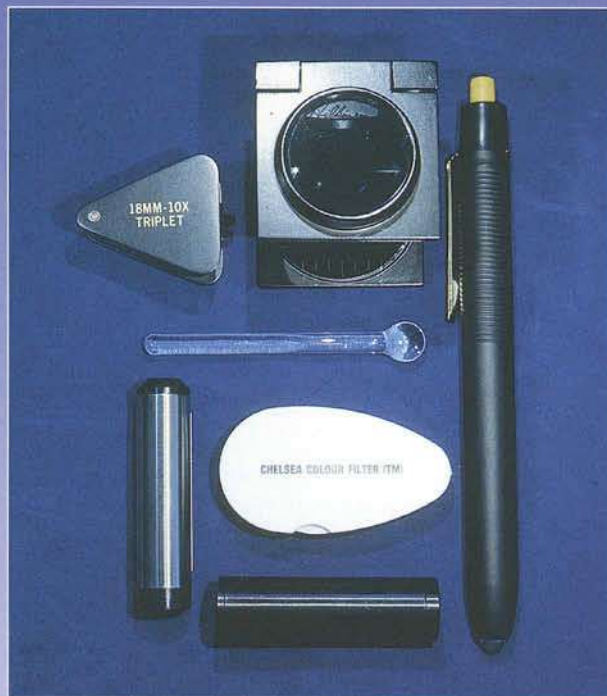
G. VON HABSBURG, M. LOPATO. 1993. State Hermitage Museum, Fabergé Arts Foundation, St Petersburg Museum and Washington DC and St Petersburg. p.476. Illus. in black-and-white and colour. Paperback. Price £30.00. ISBN 0 88397 110 0.

This is a well-produced catalogue of an exhibition of Fabergé pieces ranging from enamels to gold to large silver presentation pieces. Though few pieces of jewellery are included, readers will find the text most useful as it gives a considerable amount of the history of the Romanov royal family as well as many details of the Fabergé workshop, its masters and its methods of production. Those readers who then visit the exhibition will find especially fine examples of nephrite and at least two fine aquamarines.

The exhibition was shown in London and Paris during 1993-94 and began at the State Hermitage Museum in St Petersburg, whose staff contributed considerably toward the compilation of the catalogue. With many reproductions of Fabergé working drawings, photographs of the Romanov family and notes on marks, added to a useful bibliography, the catalogue should be required reading for all Fabergé students.

M.O'D.

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

PHOTOGRAPHIC COMPETITION

The Association's first photographic competition for members attracted 18 entrants and a total of 93 prints or transparencies in the two categories 'Macro' and 'Micro'.

The winner of the 'Macro' category is Mr Bob J. Maurer of Redhill, Surrey, with a fine picture of a gold and diamond brooch with a carved citrine in the centre (designer Stephen Webster). The brooch is shown on the front cover of this issue of the *Journal*.

In the 'Micro' category, the winner is Mr Anthony de Goutière of Victoria, British Columbia, and his picture of an inclusion (?cavity) in quartz is reproduced opposite.

Each winner receives a prize of £100.00. The entries covered a wide range of aspects of gemmology, from the mechanical effects of magnification in gems, to interference effects of light both on surfaces and through crossed polars, to gemmologically informative or artistically attractive inclusions, to rare gem minerals and cameos. A selection will be published in future issues of the *Journal*.

OBITUARY

Claire Elizabeth Parker, FGA, DGA, GG, jewellery expert and cataloguer, died on 10 April aged 36.

Everyone who met Claire admired her impeccable manner, her warm, selfless composure, as well as her professional expertise.

She will be greatly missed by her colleagues at Sotheby's and all her friends in the Laboratory and jewellery trade.

A rare pure spirit. *Requiescat in Pacem.*

Ana I. Castro

Mr Yoshio Asano, FGA (D.1976), Tokyo, Japan, died recently.

Mr N.P. Jameson Bennett, FGA (D.1967), Plymouth, died recently.

GIFTS TO THE GAGTL

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

Vanessa Guest for 15 cut tourmalines.

R. Holt & Co. Ltd, London, for cut zircons and garnet-topped doublets for teaching purposes.

John Kessler, London, for a parcel of rough emeralds from Brazil.

Pentti Merranto, Kalhonkyla, Finland, for spectrolite and hypersthene with a sheen from Mantyharjo (per Riitta Spencer).

Bernard Silver, FGA, London, for a stained cultured 'black' pearl.

NEWS OF FELLOWS

Peter Read was invited to speak at the Swedish Gemmological Association's Annual Meeting held in Stockholm on 19 and 20 March 1994. He gave two talks entitled 'The Brewster Angle Refractometer' and 'GEMDATA Update 5'. Following the talks he made provision for participants to try out an experimental refractometer (using a miniature solid-state laser in a Dialdex case) and to use his latest GEMDATA computer program.

Michael O'Donoghue gave a talk to the Wessex Branch of the National Association of Goldsmiths on 27 May 1994. The subject was 'Gemstones of Pakistan' and a number of stones and maps were on display.

Michael O'Donoghue also leads the Wednesday group which meets in the evenings at the GAGTL. Members of the group choose their own subjects of study and several useful projects are under way, backed by GAGTL and outside resources.

ANNUAL GENERAL MEETING

The Annual General Meeting of the GAGTL was held on 13 June 1994 at 27 Greville Street, London EC1N 8SU.



Photographic Competition - Winner of the Micro category.
Inclusion in quartz showing a combination of flat and rounded boundaries to a cavity. *Photograph by Anthony de Goutière.*

The meeting was chaired by Ian Thomson who opened by welcoming those present. The Annual Report and Accounts were approved and signed.

Memorandum and Articles

It was reported that when the merger between the Gemmological Association of Great Britain and the Gem Testing Laboratory of Great Britain took place, the Memorandum and Articles had been assembled from those of the two organizations. Most requirements for the new Association were satisfactorily dealt with but a few aspects were not covered. The following amendments to the Memorandum and Articles were proposed and approved:

1. Article 10 states 'No business shall be transacted at any General Meeting unless a quorum of members is present at the time when the meeting proceeds to business; save as herein otherwise provided, two members present in person shall be a quorum.'

It was agreed to delete 'two' and insert 'ten'.

2. The wording in Articles 26 and 27 concerning the proxy forms relate to companies; it was agreed that the following wording would also apply to single members:

'I/We... of (address or company)... in the County of... being a member/members, hereby appoint (name)... of (address or company)... as my/our proxy to vote for me/us or my/our behalf at the Annual/Extraordinary General Meeting of the Company to be held on the... day of , 19 , and at any adjournment thereof. Signed... this day of , 19 .'

3. Amendment concerning the President and Vice-president:

President

'32 - On the nomination of the Council of Management, the President shall be elected by the members of the Association at a General Meeting. The term of office of the President shall run from the election at a General Meeting for two years until the re-election or a successor is elected at the appropriate General Meeting. Subject to the discretion of the Council of Management and the membership, a President would not normally be re-elected more than once. The President shall, ex officio, be entitled to attend meetings of the Council of Management and be entitled to vote.'

Vice-President

'33 - On the nomination of the Council of Management a member may be elected a Vice-president of GAGTL at a General Meeting, provided however that at no time shall the number of Vice-presidents exceed six. A Vice-president, duly elected, shall be entitled to hold that office so long as he or she continues to be a member of the Association.'

To take account of these two additional Articles, the following Articles should be renumbered accordingly.

4. The wording of Article 32 stated that the General Meeting could determine the salaries of members of Council. It is felt that the spirit of the Article is to reimburse Council members for necessary expenses and not to restrict the management function of the Council, which must always have a majority of non-executive members. It was agreed therefore to reword the Article thus:

'34 - The members of the Council shall be paid all reasonable travelling, hotel and other expenses properly incurred by them in attending and returning from meetings of the Council or any committee of the Council or General Meetings of the Company or in connection with the business of the Company.'

5. Since members receive at least 21 days notice of the General Meeting, it was agreed that if a member wishes to nominate a member for the Council of Management, notice should be registered with the office of the Association 35 days before the Meeting; it was also agreed that the notice should contain the names and signatures of the proposer, the seconder and a statement of willingness to stand of the proposed. The agreed wording replacing Article 43 is:

'45 - No person not being an officer or other member of the Council of Management retiring at the meeting shall, unless recommended by the Council for election, be eligible for office on the Council of any General Meeting, unless at least thirty five days before the day appointed for the meeting, there shall have been delivered to the office notice in writing by members duly qualified to be present and vote at the meeting for which such notice is given, of the intention to propose and second such person for election, and also notice in writing, signed by the person to be proposed, of their willingness to be elected.'

FORTHCOMING MEETINGS

London

Meetings are held in the GAGTL Gem Tutorial Centre, 2nd Floor, 27 Greville Street, London EC1N 8SU (entrance in Saffron Hill).

The charge for a member is £3.50. Entry will be by ticket only, obtainable from GAGTL.

19 September	'The gem materials of Zimbabwe'	Susan Anderson
28 September	'Diamonds and the retail trade'	Alan Clarke
22 November	To be announced.	
5 December	'Sapphires in the Laboratory'	Stephen Kennedy

GAGTL Annual Conference

Diamonds and Modern Gem Developments

The 1994 GAGTL Annual Conference is to be held on Sunday 23 October at the Great Western Royal Hotel, Paddington, London. A full programme has been arranged to include lectures by Professor I. Sunagawa from Japan, A.T. Collins, David Callaghan, Peter Read and Eric Emms, as well as a Forum to discuss 'Implications for the trade of gemstone treatments'.

For further details and a booking form contact Roger Harding at the GAGTL on 071-404 3334.

Midlands Branch

30 September	'Poking about in gemmological corners'	Alan Hodgkinson
28 October	Bring and Buy - rock swap, instrument demonstration, 'Do-it-Yourself'	
6 November	Autumn Seminar at the Cobden Hotel, Hadley Road, Birmingham	
25 November	'How to buy gemstones'	Grenville Millington
3 December	Annual Dinner	

The meetings will be held at Dr Johnson House, Bull Street, Birmingham. Further details from Mandy MacKinnon on 021-444 7337.

North West Branch

21 September	'Pearls in the Arabian Gulf'	Stephen Kennedy
19 October	A visit to the Liverpool Museum of Geology, specimen mineral and instruments	
16 November	Annual General Meeting	

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

6. At the meeting of the Members' Council on 8 April 1994 it was agreed that to fulfil the functions summarized in Article 56a section (f) the current arrangement for a quorum could sensibly be reduced from half the membership of the Members' Council to that of four members. Membership of the Members' Council was determined to be a maximum of twenty and a minimum of twelve. In view of the change to the quorum it would be appropriate to reduce the minimum membership to eight.

It was therefore agreed that in Article 58a (the revised 56a), section (a) the minimum number of 'twelve' be replaced by 'eight'; and 58a section (f) should read: '(f) A quorum for any meeting of the Members' Council shall be four.'

7. In order to make Article 64 consistent with Article 67 and to eliminate irrelevant wording, clarification concerning UK members and deletion of references to debenture holders was agreed, the Article to read:

'66 - A copy of every balance sheet (including every document required by law to be annexed thereto) which is to be laid before the Company in General Meeting, together with a copy of the auditor's report, and Council's report, shall not

less than twenty-one days before the date of the meeting be sent to every member of the Company with an address in the UK. Provided that this article shall not require a copy of those documents to be sent to any person whose address is unknown to the Company.'

Roger Harding and Vivian Watson were re-elected to the Council of Management and the election of Eric Emms was confirmed.

The Chairman announced that Adrian Klein had retired from the position of Company Secretary and had been succeeded by Roger Harding. He expressed the Association's gratitude to Adrian for holding the post, which is an important job with many responsibilities laid down by law.

It was announced that George Harrison Jones and D. Warren had expressed their wish to retire from the Members' Council. Keith Penton was elected and I. Roberts, R. Velden and C. Winter were re-elected to the Members' Council.

Messrs Hazlems Fenton were re-appointed Auditors.

Election of President

Ian Thomson outlined the desirability and



Eric Bruton, FGA, DGA (right) being congratulated on his election to the Presidency of GAGTL by Ian Thomson, Chairman at the AGM.

prestige of having a President. It had been decided, when the merger between the Gemmological Association and the Gem Testing Laboratory took place in 1990, that the Chairmanship of the Council of Management meetings would rotate alphabetically, whilst David Callaghan would retain the title of Chairman. When David retired from Council in 1993 it was decided that the position of President, which had been vacant since the death of Sir Frank Claringbull in 1990, should now be filled. The criteria for the position were that the candidates should be internationally recognized, to have contributed to gemmology in a significant way and be someone that the Association would be proud to have as its figurehead. The position would be primarily ceremonial, and would be held for two years, renewable for a further two years by agreement, after which a successor must be appointed. The position may again be held by the retiring President at some time in the future.

'We are fortunate in our organization', Ian continued, 'to have many internationally renowned personalities which have been recommended by the membership to fulfil this post, but after much heart-searching the Council agreed that Eric Bruton should be approached to become President, and I am very pleased to say that he is willing to be nominated.'

The nomination was unanimously carried and Eric Bruton was presented with the Presidential Badge of Office.

Eric thanked the Chairman for his kind words and said that he had been both surprised and delighted to be nominated and that he felt it was a great honour to have been elected.

Eric concluded, 'When John Major was elected as Prime Minister he said "Who would have thought it!" - I feel a bit like that myself!'

Photographic Competition and Bring and Buy

The AGM was following by a Bring and Buy sale, with many members bringing along an assortment of items including mineral specimens, beads, books and second-hand instruments.

During the evening a selection of the entries for the Photographic Competition was displayed as well as the two prizewinning photographs (see details on p.216).

MEMBERS' MEETINGS

London

The following meetings were held at 27 Greville Street, London EC1N 8SU:

On 13 April 1994 Dr Jack Ogden gave a lecture entitled 'Time and money: natural and deliberate alteration of ancient gem materials'.

On 26 April Dr George Harrison Jones gave a lecture on 'Cutting it fine'.

On 11 May, Ian Mercer gave a lecture entitled 'Spreading gem knowledge'.

On 13 June the Annual General Meeting was held, a report of which appears on p.218.

Midlands Branch

On 29 April 1994 the Annual Meeting of the Branch was held at Dr Johnson House, Bull Street, Birmingham, at which Jim Porter and Mandy MacKinnon were elected Chairman and Secretary respectively. The AGM was followed by a talk by Richard Taylor entitled 'Diamonds and their value'.

On 8 May a practical seminar was held for students.

North West Branch

On 18 May 1994 at Church House, Hanover Street, Liverpool 1, David Callaghan gave a lecture entitled 'Touching gold and silver'.

On 15 June at Church House a 'Bring and buy' and a business buzz were held.

GEM DIAMOND EXAMINATIONS

In January 1994 13 candidates sat the Gem Diamond Examination worldwide, of whom 3 qualified. The names of the successful candidates are as follows:

Larkins, Barry, London.

Mistry, Dharmesh, London.

Stratigos, Harry G., Pittsburgh, Pa., USA.

EXAMINATIONS IN GEMMOLOGY

In the Examinations in Gemmology held in January 1994 126 candidates sat for the Preliminary examination of whom 71 qualified, and 120 for the Diploma examination of whom 52 qualified, 3 with Distinction. The names of the successful candidates are as follows:

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Naresh, Deora, Jaipur, India.
 Hong, Ji-Youn, Seoul, Korea.
 LeRose, David Charles, Redondo Beach, CA,
 USA.

Qualified

Ahn, Eun Sook, Seoul, Korea.
 Bao, Deqing, Wuhan, P.R. China.
 Bartfai, Tunde, Schoonhoven, The Netherlands.
 Batis, David, Athens, Greece.
 Blancardi-de Jong, Iris, Schoonhoven, The
 Netherlands.
 Brom, Reinier W., Schoonhoven, The
 Netherlands.
 Brown, Elizabeth Anne, Lindford.
 Capper, Beverley Anne, Bath.
 Chau Kit Yee, Fion, Hong Kong.
 Conley, Curtis D., Fairplay, Co, USA.
 Guptill, Martin, Los Angeles, Ca, USA.
 Hui, King Chuen, Hong Kong.
 Human, Tracey D., Toronto, Ont, Canada.
 Im, Un San, Seoul, Korea.
 Jack, Johanne C., Bangkok, Thailand.
 Johnson, Philip F., Wirral.
 Jordan, Steven L., Boston.
 Kim, Byung-Bae, Kyung Gd-do, Korea.
 Kim, Kyoung-Soo, Taegu, Korea.
 Kim, Taek Joong, Seoul, Korea.
 Kim, Jin-Gu, Kyung Gi-Do, Korea.
 Kim, Sang Hee, Seoul, Korea.
 Kim, Sung-Mo, Seoul, Korea.
 Ko, Hyun Seung, Seoul, Korea.
 Kweon, Hyun Jun, Seoul, Korea.
 Lam, Denys Tai Sing, Hong Kong.
 Lee, Chang-Hun, Kyung B K-Do, Korea.
 Leung, Irene Yuk Ping, Hong Kong.
 Li, Zhaocong, Wuhan, P.R. China.
 Livingstone, Sheena S., Dundee.
 McCarthy, Edward J., Cambridge.
 McLelland, Jonathan Neil, Bradford.
 Meropi, Kaminara, Athens, Greece.
 Michaelides, Maria G., Athens, Greece.
 Mitchell, Gisela Charlotte, London.
 Nayer, Ranjit Kaur, Nairobi, Kenya.
 Oh, Sook-Hoe, Pusan, Korea.
 Orner, Miri, London.
 Park, Mi Kyeong, Pusan, Korea.
 Rodrigues, Lourdes, London.
 Saito, Masumi, Bangkok, Thailand.

Seong, Wun-Mo, Daejon, Korea.
 Shin, Jae-Hyuk, Seoul, Korea.
 Stratmann, Rudolf W., The Hague, The
 Netherlands.
 Takahashi, Yasushi, Kofu, Japan.
 Utagawa, Sayuki, London.
 van Gils, Heleen, Overveen, The Netherlands.
 Vaughan, John W., London.

Preliminary*Qualified*

Ahn, Eun Sook, Seoul, Korea.
 Anastasiou, Pavlos, Athens, Greece.
 Bowman, Helene, Epping.
 Carpenter, Emma, Gillingham.
 Chakravarti, Lisa M., Hong Kong.
 Ching, Joanne Chan Wai, Kowloon, Hong
 Kong.
 Chang Jin Han, Seoul, Korea.
 Chao, Tan-Chi, Taipei, Taiwan.
 Chen, Chin-Ho, Taipei, Taiwan.
 Chen, Debbie Chu-Jueh, Taipei, Taiwan.
 Cheng, Lap Fan, Hong Kong.
 Cheng, Su Chen, Taipei, Taiwan.
 Cheung, Losanna Lai Ha, Hong Kong.
 Choi, Gyoung-Ho, Seoul, Korea.
 Choi, Ik Jin, Seoul, Korea.
 Chow, Kam Lun, Kowloon, Hong Kong.
 Chui, May Mui-Ching, Kowloon, Hong Kong.
 Chung, Luk-Mui (Ivy), Kowloon, Hong Kong.
 Deora, Naresh, Jaipur, India.
 Florian, Claudia, New York, NY, USA.
 He, Wei, Wuhan, P.R. China.
 Ho, Jolanda Cheuk-Wah, Kowloon, Hong Kong.
 Hong, Ji-Youn, Seoul, Korea.
 Hu, Hai, Wuhan, P.R. China.
 Huang, Yin-Ching, Taipei, Taiwan.
 Im, Un San, Seoul, Korea.
 Jin, Yi, Wuhan, P.R. China.
 Johnston, Dale Raymond, Durham.
 Kam, Roma Mei Lin, Hong Kong.
 Kaushik, Suresh Kumar, Jaipur, India.
 Kim, Byung-Bae, Kyung Gd-do, Korea.
 Kim, Hyun Ok, Daejon, Korea.
 Kim, Hyang-Mi, Kyung Ki-do, Korea.
 Kim, Jin-Gu, Kyung Gi-do, Korea.
 Kim, Nam Soon, Kyung Di-do, Korea.
 Kim, Sang Hee, Seoul, Korea.
 Ko, Hyun Seung, Seoul, Korea.
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 Kweon, Hyun Jun, Seoul, Korea.

Lam, Yiu Ming, Hong Kong.
 Lamahewa, Nilanthi, Colombo, Sri Lanka.
 Lee, Jae Yong, Seoul, Korea.
 Lin, Hsin-Pei, Taipei, Taiwan.
 Lord, Karen Wendy, Lutterworth.
 Louie, Miu Man, Hong Kong.
 Lu, Yi, Wuhan, P.R. China.
 Lu, Yung Ching, Taipei, Taiwan.
 Mourtzanos, S., London.
 Mun, Eun Kyung, Kyunggi-do, Korea.
 Nisell, Ann, Lidings, Sweden.
 Pit, Tino, Groningen, The Netherlands.
 Sarkinen, Marianne, Stockholm, Sweden.
 Shi, Dan, Wuhan, P.R. China.
 Shin, Kyoung-Ok, Seoul, Korea.
 Shu, Xingying, Wuhan, P.R. China.

Stather, Lorne Francis, Hong Kong.
 Sung, Min Jun, Taegu, Korea.
 Tao, Du, Wuhan, P.R. China.
 Tzung, Chiu-Yen, Taipei Hsien, Taiwan.
 Vingback, Roland, Vittangi, Sweden.
 Wang, Tai-Hwan, Taipei, Taiwan.
 Weng, Li Li, Taipei, Taiwan.
 Wong, Gary Ming Leung, Hong Kong.
 Woo, Jee, Seoul, Korea.
 Xu, Hong, Wuhan, P.R. China.
 Yoo, Bo-Young, Seoul, Korea.
 Yu, Ni Wen, Taiwan.
 Yuen, Flora Tsz Wai, Hong Kong.
 Zhang, Bing, Wuhan, P.R. China.
 Zhou, Jie, Wuhan, P.R. China.
 Zhu, Meidi, Wuhan, P.R. China.

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Transfer DGA

Mistry, Dharmesh, London, 1994.

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Larkins, Barry, London, 1994.

Transfer FGA

Brown, Elizabeth A., Lindford, 1994.
 Jack, Johanne C., Bangkok, Thailand, 1994.
 Jordan, Steven L., Boston, Lincs., 1994.
 McCarthy, Edward J., Cambridge, 1994.
 Rodrigues, Lourdes, London, 1994.
 Stratmann, Rudolf W., The Hague, The Netherlands, 1994.
 Vaughan, John W., London, 1994.

Fellowship

Parsons, Richard F., Chorleywood, 1970.

Ordinary Membership

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 Cham, Ansumana Ali, London.
 Cooper, Tamasin Louise, Oxford.
 Fantis, Charoulla, London.
 Habern Jr., Michael Wayne, Tx, USA.
 Lin, Shung-Shan, Taipei, Taiwan.
 Mamo, Charles, Wanstead.
 Perera, Sreemal, Hounslow.
 Prince, John L.N., Westbury on Severn.
 Sanderson, Michael David, London.
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 Bartfai, Tunde, The Hague, The Netherlands, 1994.
 Batis, David, Athens, Greece, 1994.
 Chau, Kit Yee, Fion, Hong Kong, 1994.
 Conley, Curtis, Fairplay, Ca, USA, 1994.
 Duguid, Keith Bruce, Kadoma, Zimbabwe, 1984.
 Guptill, Martin, Los Angeles, Ca, USA, 1994.
 Hui, King Chuen, Hong Kong, 1994.
 Johnson, Philip Frederick, Pensby, Wirral, 1994.
 Kim, Taek Joong, Seoul, Korea, 1994.
 Le Rose, David, Redondo Beach, Ca, USA, 1994.
 Livingstone, Sheena S., Dundee, 1994.
 McLelland, Jonathan Neil, Thackley, Bradford, 1994.
 Mitchell, Gisela, Hong Kong, 1994.
 Nayer, Ranjit Kaur, Nairobi, Kenya, 1994.
 Takahashi, Yasushi, Kofu, Japan, 1994.
 Utagawa, Sayuki, Tokyo, Japan, 1994.
 van Gils, Heleen, Santpoort Noord, The Netherlands, 1994.

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Boocock, Allan, Shepley, Huddersfield.
 Duggan, Rory, Phetchabun, Thailand.
 Dykhuis, Luella Woods, Tucson, Az, USA.
 Fawcitt, Tony, London.
 Govindasamy, Paramasivam, Selangor Darul Ensan, Malaysia.
 Hughes, Nicholas, Stevenage.
 Huston, Jane, Kilkenny, Ireland.
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 Novaga, Massimo, Milan, Italy.
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 Boyd, Warren, Ontario, Canada, 1979.
 Saito, Masumi, Bangkok, Thailand, 1994.
 Sinclair, Anne Louise, London, 1988.

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Kim, Kyoung-Soo, Taegu, Korea, 1994.
 Leung, Irene Yuk-Ping, Chaiwan, Hong Kong, 1994.

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 Chow, Michelle, Epsom.
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 Lin, Hsin-Pei, Taipei, Taiwan.
 Lu, Yung-Ching, Taipei, Taiwan.
 Mackenzie, Nicola-Jane, Southport.
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CORRIGENDA

On p.91 above the captions to Figures 8 and 9 should read as follows:

Fig. 8: A twin boundary extends from the lower left to the upper middle of the photograph, 20x.

Fig. 9: A twin boundary extends from the lower middle to the upper left of the photograph, 30x.

The Journal of Gemmology

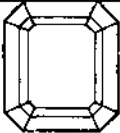
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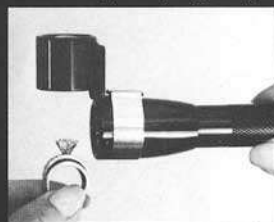
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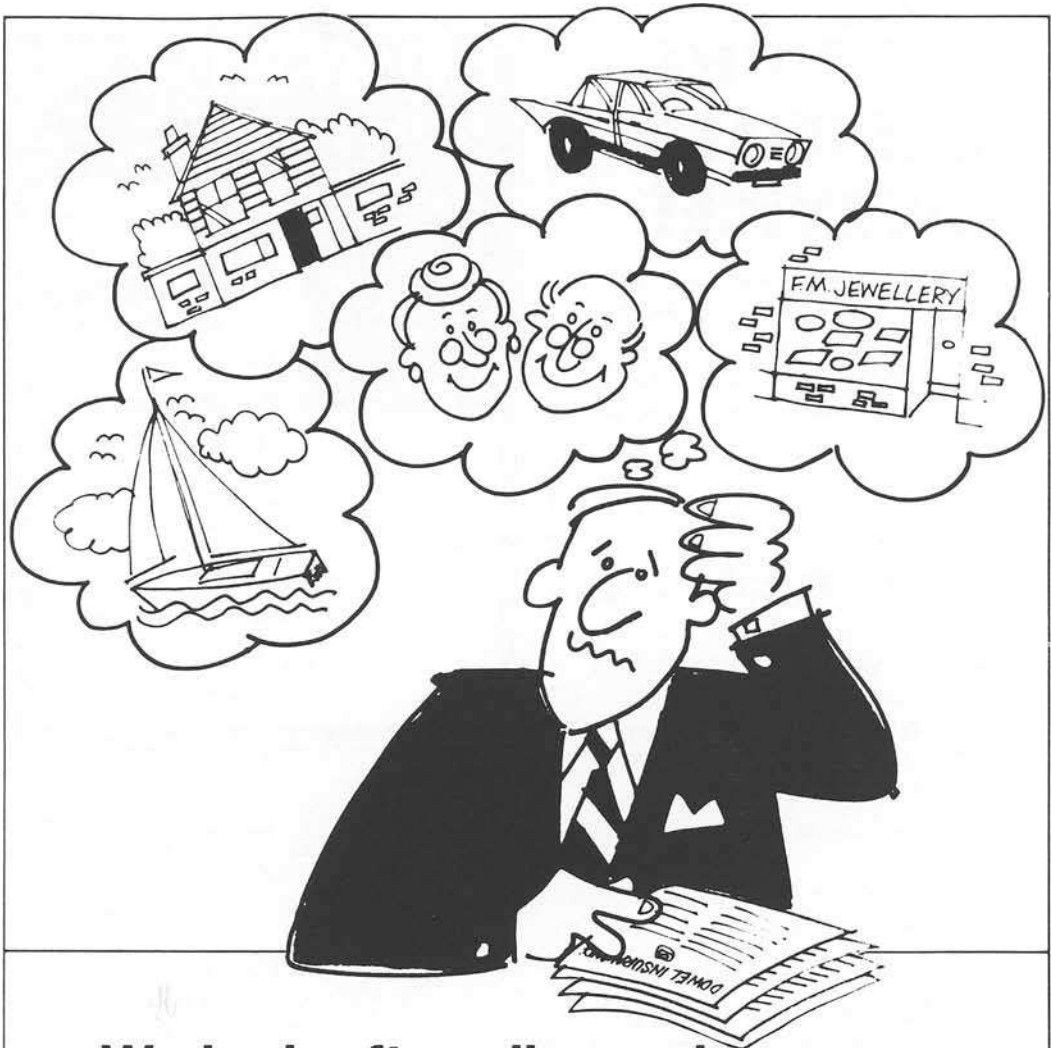
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