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Cover Picture

A crystal of emerald on calcite from Muzo, Colombia, from The Mineral Collection,
Federal Institute of Technology, Zurich, presented and photographed by Dr E. Gübelin
of Meggan, Switzerland.

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Sir Frank Claringbull 1911-1990



It is with great regret that we report the death, on 23 November 1990, of Sir Frank Claringbull, an Examiner from 1938 to 1970 and President of this Association from 1972. He had been in ill-health for some years.

Gordon Frank Claringbull, B.Sc., Ph.D., F.Inst.P., FGS, Born 21 August 1911, was educated at Finchley Grammar School and then at Queen Mary College, University of London, where he gained first class honours in geology. This was followed by the award of Ph.D. for his study of igneous rocks in the Balmoral area, Aberdeenshire. He joined the staff of the British Museum (Natural History) in 1935 and worked there, apart from the war years, until his retirement in 1976. Initially he worked under Dr Campbell Smith on curatorial duties with the rock collections and continued his studies of Scottish rocks.

During the war he moved to Birmingham where he worked on the crystallography and the development of explosives for the Special Operations Executive.

Following his return to the Museum in 1945 he worked with Dr F.A. Bannister on the development of X-ray diffraction methods for the identification of minerals. After his appointment as Keeper of Minerals in 1953 he ensured that his department

was well equipped for the rapid analysis of minerals and rocks. X-ray diffraction was followed by X-ray fluorescence and with great prescience he sent one of his staff to Cambridge to collaborate in the development of the electron-microprobe for use on minute mineral grains.

In many of his scientific papers Claringbull worked with Dr M.H. Hey, the Museum expert on microchemical analyses; he also collaborated with B.W. Anderson and C.J. Payne of the Gem Testing Laboratory. In 1951 this quartet elucidated the nature of the spinel-like mineral, taaffeite, which had been found as a gemstone by Count Taaffe in a jeweller's junk box in Dublin. In 1952 Claringbull and Hey announced the discovery of the new mineral, *sinhalite*, which had previously lurked as a 'brown olivine' gemstone and had been viewed with suspicion by Anderson and Payne and by G. Switzer of the US National Museum in Washington. In 1956 Claringbull, Hey and Payne announced the discovery of another new mineral, *painite*, found as a crystal by A.C.D. Pain at Mogok in Burma and named in his honour. Claringbull worked on many other minerals and this is reflected in a series of papers in the mineralogical journals. *Claringbullite*, a new hydrated copper chloride mineral, was named in his honour in 1977.

In 1968 Claringbull was appointed Director of the Museum, and his experience in the reopening of the famous Mineral Gallery (now threatened with closure) stood him in good stead. The attention to detail, so necessary in that exhibition, was to be of immense value in the wider tasks ahead. The 'Hall of Human Biology', opened in 1977, was the first of the 'new' exhibitions developed under his direction; it was widely popular, especially with the young who did not mind the somewhat cramped viewing space and the paucity of natural specimens.

Claringbull was a man of bustling activity with a constant desire to finish the work in hand as soon as possible. As Secretary of The Mineralogical Society for many years he was immensely efficient and a great stickler for punctuality at meetings. He was eminently fair and one former member of the old Geological Museum staff can recall being in a somewhat tense dispute in the Keeper's room with four members of the BM staff when Claringbull observed that 'four of us to one of him' was not fair odds.

His wife, Enid, son and daughter survive him.

E.A.J.

Pocahontas

A.E. Farn

Seaford, East Sussex

I voted for the merger of The Gemmological Association with The Laboratory because it seemed inevitable and, frankly, sensible. I did so, though, not without regret at the passing of two distinct yet analogous bodies. Both were very important in my working life as a trade gemmologist. When I retired, a previous chairman of The Precious Stone Trade Section said that it was the end of an era, i.e. Anderson, Payne, Webster and Farn. I felt the same way about the merger. Now we have a new beginning and fresh fields to conquer.

Setting about a clearance of many old papers of the now defunct GA, I came across the minutes of a GA council meeting on 28 February 1989. One of the matters discussed was *The Journal*; the third and last paragraph contained the following:—

“Mr Jobbins also requested more contributions from the membership for *the Journal*, promising that all would be looked at sympathetically and they need not be too ‘learned’ or contentious to be included.”

I took considerable heart from this refreshing aspect of the *Journal's* reading matter and felt ‘not too learned’ and hopefully not very contentious.

The longer one is separated from the gemmological scene and the less one practises gem testing, the sooner accumulated knowledge disappears. Be that as it may, I have been thinking, not of gemstones, but of pearls and some interesting parallels or connections with them. It seems I made a literary contact with an aspect of their history when I received a book from a favourite aunt on my ninth birthday. The book was entitled ‘*Captain John Smith*’. My aunt was a maiden lady named Emily Chatterton (the name E. Chatterton is of interest). The book was written by E. Chatterton but at the moment of writing there is no immediate importance to be attached to the coincidence. The book's content at the time was above my head even though I was an omnivorous reader for my age. I let it be for a couple of years and then enjoyed it.

About sixty years later, in retirement, I was approached to write a monograph on pearls. It was something that I had never seriously contemplated.

I felt, somewhat righteously, that I was really a coloured stone man and had only undertaken pearl testing because of the retirement of Anderson, Payne and Webster. The new staff had no experience with pearls and so it was inevitable that I did the pearl testing – which became my metier – and, of course, the book. I sought as many references as possible, not just on pearls, but on equipment, X-ray production and the biology of oysters (scallops really). Being a pearl tester, however efficient, doesn't make one into a marine biologist. A good editor is most useful since grammar, punctuation and nomenclature, all make their demands. I was working at home and out of touch with laboratory facilities.

Delving into the literature of Dakin, Jameson, and Kunz and Stevenson, I was impressed by their erudition. I began to realise how poor was my geography, how lacking my knowledge of history and how weak was my schoolboy French. I was amazed at the ingenuity of French workers, in particular in tackling the problem of detecting cultured pearls. I learned afresh of Chilowski and Perrin, Simon and Renee Bloch, and read very slowly the recorded observations of J. Galibourg and F. Ryziger (1927). Their work embraced density, structure, transparency to light rays, penetration by X-rays and how light travelled concentrically in pearls and along layers in mother-of-pearl. Knowledge of the subject matter and gemmology helped in the translation. Old hat it may be but the endoscope as used by the French and English laboratories was 100% accurate in testing drilled (necklace) pearls. Undrilled pearls succumbed to the penetration of X-rays thanks to the work of Röntgen, Von Laue, Dauvillier, Shaxby and Doelter.

When I needed to find out about historical/famous pearls and, in particular, the sources of pearls, I turned to *The Book of the Pearl* by Kunz and Stevenson. This was a veritable mine of information – if one can have a mine for pearls. When I came to the pearls of the Americas, viz. Panama, Venezuela, Mexico, Virginia and the Mississippi

Valley, I was stopped in my tracks. Here was reported the account of Captain John Smith who set out in 1605/6 to colonize Virginia, the same man as in my boyhood book. I felt 'This is where I came in'.

Captain John Smith was a remarkable man. Born in Willoughby, Lincolnshire, in 1579, he was an apprentice in King's Lynn (Norfolk). He then went abroad as a mercenary and served four years with the French army. Later he fought with the Austrians against the Turks in Transylvania. Taken prisoner, he was sent to Constantinople as a present to the wife of a local Turkish pasha. She feared for his safety and sent him to Varna on the Black Sea, where he was a slave. He killed his master and escaped to Western Europe and returned to England in 1604. Here he joined a London company expedition to colonize Virginia. Three ships plus a hundred or so migrants set sail from Blackwall late in December 1606 under licence from James I. They landed in Virginia in May 1607. Here they founded the settlement of Jamestown on the James river; both were so named in honour of King James I of England. In his notes Captain Smith mentions the importance that the tribes of the tidal water region placed upon pearls for adornment. Some thirty tribes of Algonquin Indians were ruled by a powerful chief named Powhatan. He was not happy with the presence of the white settlers and at one time took Smith prisoner with intent to kill him. Smith's life was saved by the intervention of Pocahontas, the daughter of Powhatan. She was about twelve years of age. A few years later among the additions to the settlement was John Rolfe, a graduate seeking his fortune in Virginia; his ship had been wrecked on the Bermudas. Rolfe came from Heacham, a village on the north Norfolk coast; he experimented with tobacco planting.

Following various affrays with the Indians, Pocahontas was held hostage, but was well treated. She received religious instruction and was eventually baptised Rebecka. She married John Rolfe in 1614 and their son was born the following year. A year later in 1616 they sailed for England, first visiting Heacham to see his mother before being presented at the court of King James and his consort Queen Anne. Pocahontas found England's climate chilly, with London wet and smoky, and was in poor health. John Rolfe was appointed Secretary and Recorder General of the Virginia colony. In March 1617 they set out for the return to Virginia but were held up at Gravesend. Here Pocahontas died; she was twenty-two years of age. She was buried in St. George's church, Gravesend. Rolfe eventually returned to Virginia where he died in a massacre in 1622; his son who had remained in England went to Virginia when he was twenty-five. He had one daughter, Jane.

My wife comes from a north Norfolk village not far from Heacham. Typing the details of Virginia (sources of pearls) for the book she remembered a school friend from Heacham who had pointed out a house at Heacham where it was said an Indian princess had lived long ago. She had married into the Rolfe family who were an old and important family in Heacham.

Last month we had a holiday in north Norfolk, re-visiting old haunts. We decided to visit Heacham because of my interest in Pocahontas, pearls and Captain John Smith. In Heacham parish church were many engraved tablets and memorial stones to members of the Rolfe family who had nobly served their king and country over hundreds of years. In the poor light of the interior I could see a bas-relief sculpted bust of Pocahontas which had been presented to the church by American visitors who claimed to be descendants of Rolfe's granddaughter Jane. We also obtained a short account of Pocahontas written by Jane Neville Rolfe. She was the last member of the family in Heacham and died in 1989 aged seventy-nine. A private burial plot enclosing many tombs and memorials of the Rolfe family is surrounded by a close clipped yew hedge, bringing strongly to mind that excerpt from Thomas Gray:-

*"Beneath that elm, that yew tree's shade
Where heaves the turf in many a mouldering heap
Each in his narrow cell forever laid
The rude forefathers of the hamlet sleep."*

Returning albeit briefly to my working life, it seems strange now to think of the hundreds of times en route for the Laboratory from Cannon Street Station I passed by the Wren church (1680) of St Mary-le-Bow, Cheapside. Usually it served to remind me that my mother's family were true Cockneys, having been born not a stone's throw from Hatton Garden, within the sound of Bow Bells. My grand-father worked in Mitre Court at the end of Hatton Garden. In Wren's churchyard stands a statue to Captain John Smith. It bears the following inscription: "Citizen and Cordwainer (1580-1631). First among the leaders of the settlement at Jamestown, Virginia, from which began the expansion of the English speaking peoples".

A few hundred yards westward towards the Laboratory stands St Sepulchre's Church at the junction of Holborn Viaduct (London's first flyover, 1866) and Newgate Street; here Smith was buried.

It seems a little ironic when I recall that my main memory of St Sepulchre's stems from a drinking fountain set in the corner of a wall. It was carved, I believe, from reddish serpentine from the Lizard, Cornwall.

Development has removed or obscured many facets of Old London. Development is one of those

words bracketed to or which has a connotation with mergers and 'the end of an era'.

On Wednesday, 3 May 1989, at 11.00 hours, Long Wave, the BBC broadcast an excellent programme on Radio 4. It was entitled 'The Peace of Pocahontas'.

[Manuscript received 15 October 1990.]

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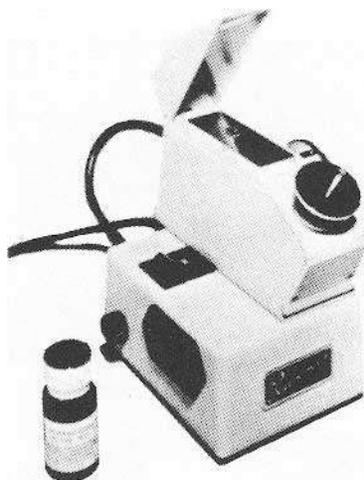
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Gem thaumasite from the Black Rock Mine, South Africa

Ulrich Henn, Markus Redmann and Hermann Bank

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Introduction

Thaumasite is a complex mineral with the chemical formula $\text{Ca}_3\text{Si}(\text{CO}_3)(\text{SO}_4)(\text{OH})_6 \cdot 12\text{H}_2\text{O}$. The hexagonal mineral shows distinct cleavage parallel to the vertical prism and conchoidal fracture; the hardness is $3\frac{1}{2}$.

Thaumasite is a typical neogenic mineral and soluble in acids. White compact aggregates of tiny acicular or needle-like crystals are usual. The known occurrences can be divided into three types:

1. associated with sulfidic ores (e.g. Sweden, Tennessee/USA),
2. in cavities of basic effusive rocks as well as in

basic metamorphic rocks (e.g. Hungary, Austria, New Jersey/USA),

3. in limestone contact zones associated with amphibole, pyroxene, chlorite, garnet, idocrase and sporadic babingtonite (e.g. Czechoslovakia, USSR, Utah/USA, California/USA).

Some occurrences represent transition types, e.g. Myto near Tachov in SW Bohemia. That locality is grouped with the genetic type 3, but numerous indications (e.g. the presence of zeolite) show close relations to type 2 (Kourimsky, 1977).

Euhedral thaumasite crystals of remarkable size have been discovered in South Africa. The locality is the Black Rock Mine in the Kalahari Manganese Field (Figure 1). That region is well known for occurrences of gem sugilite (Dunn *et al.*, 1980; Henn, 1986; Shigley *et al.*, 1987) and transparent rhodochrosite (Bank and Becker, 1977).

The thaumasite-bearing manganese ore-body contains dark brown to black manganese ores, especially hausmannite, psilomelane, pyrolusite, bixbyite and braunite. Additionally, manganese-bearing garnets have been discovered.

Results of examinations

The Black Rock thaumasite crystals investigated are up to 1.5 cm in size and show distinct hexagonal prismatic habit with well developed prism $(10\bar{1}0)$ and basal (0001) faces.

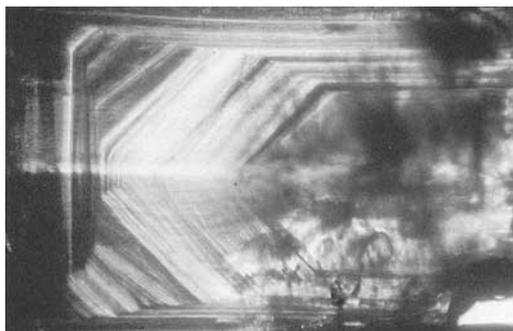


Fig. 2. Distinct growth-zoning in a Black Rock thaumasite. x10.

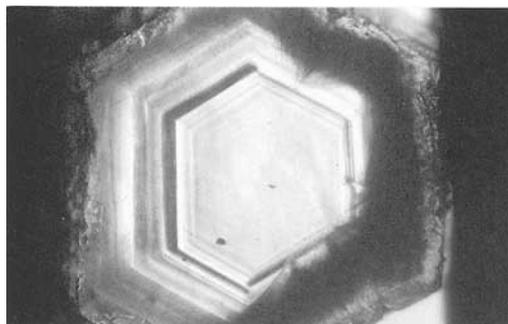


Fig. 3. Distinct growth-zoning perpendicular to the *c*-axis of the thaumasite. x10.



Fig. 4. Liquid films. Dark field illumination. x30.

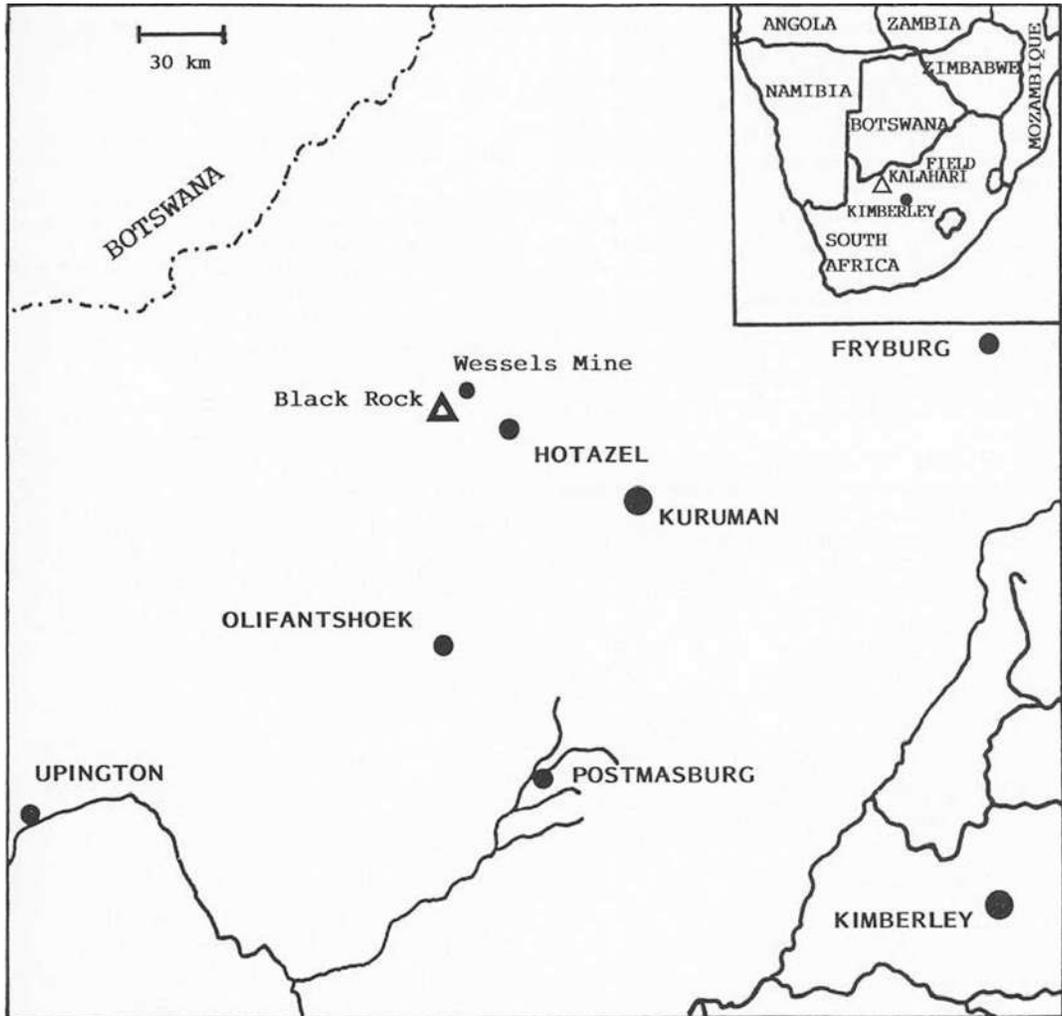


Fig. 1. Geographical map of the Kuruman region in the Kalahari Manganese Field with the Black Rock Mine and the Wessels Mine near Hotazel (after Shigley *et al.*, 1987).

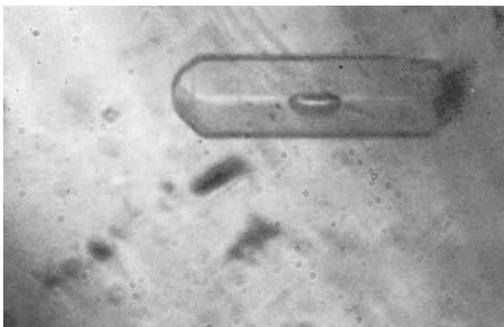


Fig. 5. Prismatic negative crystal filled with a liquid and a gas bubble. x50.



Fig. 6. Bunch-like crystal inclusions. x25.

Refractive indices, birefringence and density have been determined as $n_o=1.505-1.510$, $n_e=1.467-1.480$, $\Delta n=-0.030$ to 0.038 and $D=1.88-1.90 \text{ g/cm}^3$. These data correspond to those of thaumasites from various localities, published by Kourimsky (1977): $n_o=1.500-1.519$, $n_e=1.464-1.476$, $\Delta n=-0.031$ to 0.043 , $D=1.87-1.90 \text{ g/cm}^3$.

Thaumasite crystallizes in the hexagonal-pyramidal crystal class; the lattice constants have been determined as $a_o=11.077(6) \text{ \AA}$ and $c_o=11.412(6) \text{ \AA}$ by Guinier techniques.

The microscopical features of the Black Rock thaumasite are:

1. distinct growth-zoning parallel (Figure 2) and perpendicular (Figure 3) to the c -axis of the thaumasite host,
2. fine liquid films (Figure 4),
3. negative crystals, partially filled with liquid and a gas bubble (Figure 5),
4. bunch-like inclusions (Figure 6).

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[Manuscript received 16 October 1990.]

Gemmological teaching in Catalonia

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The writer was asked by the Director of the Escola de Gemmologia, University of Barcelona, Spain, if he would like to deliver several lectures on current gemmological topics. The invitation was of course eagerly accepted.

The first of four lectures was in the nature of a demonstration of apparatus designed and made by the writer. These instruments had sprung from a desire to demonstrate the actual physical principles involved in gemstone testing. He has long felt that there has been an inadequate practical treatment of these basic principles in most international gemmology teaching centres. He believes that before an instructor places any conventional gemstone testing

instrument in the hands of a student for the first time, there should be offered a clear explanation of the fundamental mechanics and optics upon which the instrument operates. This is most easily done by using simplified, large-scale bench-type apparatus. The students, rather than the instructor, must be encouraged to manipulate the devices themselves. This generates an understanding and confidence, particularly in students whose exposure to even elementary scientific matters has been lacking. These exercises also convey something of the beautiful complexity of design and the remarkable performances and accuracy of the tools which they routinely use. Beginners usually perceive them

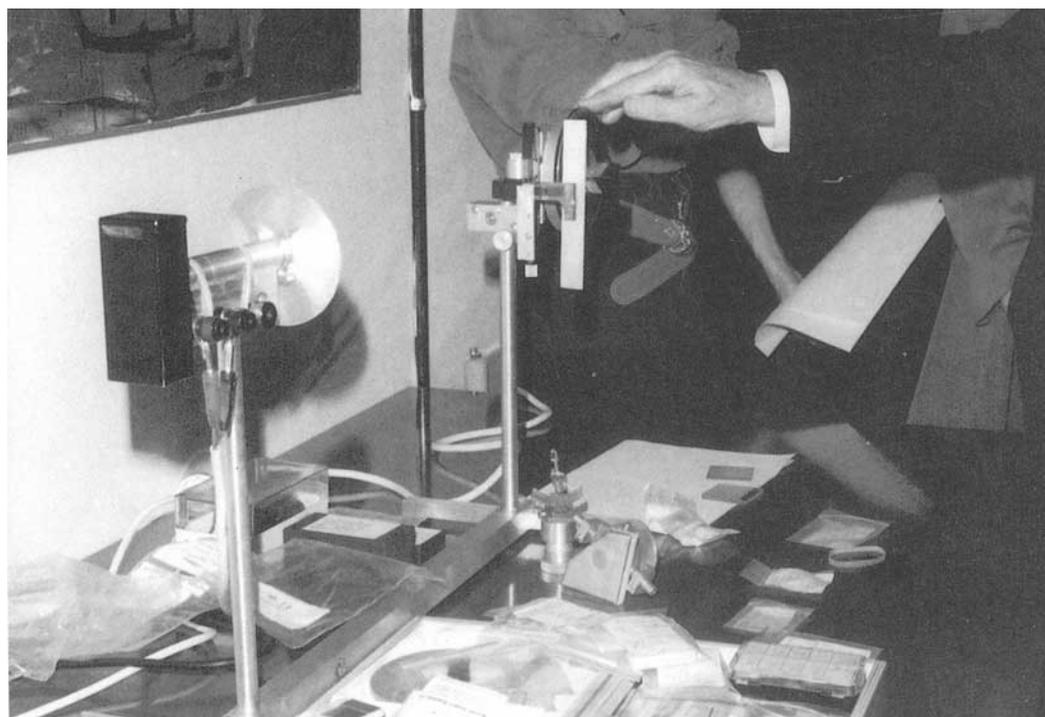


Fig. 1. The 'goniometer unit' being demonstrated.

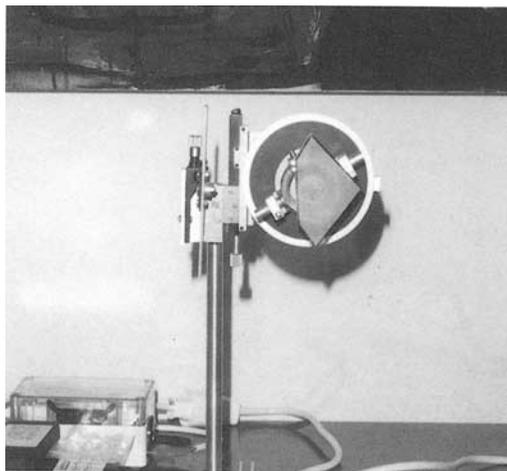


Fig. 2. A perspex profile of a 'brilliant' mounted on gimbals on the 'goniometer' circle.

simply as short lengths of capped tubing or oddly-shaped boxes with bits of glass embedded in them.

Without doubt, the most informative unit demonstrated was a device which the writer calls a 'single-circle goniometer.'

It consists of an arrangement of which one part produces a thin, parallel ribbon of intense white light. This narrow beam, or ray, can be directed in turn on to a glass prism or diffraction grating or on to various other refracting objects. One of these is a large polished Perspex plate shaped in the form of a brilliant-cut gemstone profile. The unit is thus able to display the simulated optical ray paths of the single ray of white light as it impinges on and enters and leaves the profile when it is turned through 360°.

It can also measure the angles between the facets of a variety of polished profiles or the reflecting faces of euhedral crystals, with an accuracy of $\pm 0.5^\circ$.

With the help of ancillary attachments, it allows the angular changes of refracted or reflected rays from various pre-aligned crystals and polished prisms of plastic, glass and cubic zirconia to be observed and measured. Such measurements can then yield values of refractive index, birefringence and dispersion using the minimum-deviation method. At the same time, it can demonstrate Snell's Law, the external and internal Brewster angles and Fresnel reflection intensities at angles of incidence from 1° to 89° . The production of colours, by the use of a set of gelatine filters and by selected spectral absorption, using neodymium-doped YAG and glass filters, helps to de-mystify both phenomena. Here, both diffraction gratings and prisms are used independently. Finally, long-wave ultraviolet fluorescence and phosphorescence can be

observed by excitation in the invisible ultraviolet end of the spectrum. Figure 1 shows the goniometer unit being demonstrated, while Figure 2 shows a Perspex profile mounted on gimbals on the goniometer circle.

In addition to this unit, several other visual teaching aids were exhibited. One illustrated the formation of on-axis and off-axis conoscopic figures. Another employed a horizontal axis immersion microscope to project images of the internal microstructures of gemstones directly on to a large screen. It enabled any particular image to be isolated from the general optical 'noise', by making controlled movements of the gemstone while immersed in the optical matching liquid.

A particular effort was made to illustrate the increasing interest in the quantitative measurement of the body colour of gemstones. A simple apparatus allowed the student to produce any surface colour at will through the use of both additive and subtractive colour filters. The quantitative aspect was represented by a spinning disc tristimulus colorimeter. This permitted the student to measure the colour of transparent coloured faceted stones and cabochon-cut jade, lapis lazuli, fire opal and turquoise in terms of the three CIE Tristimulus coordinates for both 'A' and 'C' CIE Illuminants. A partial view of the colorimeter is shown in Figure 3.

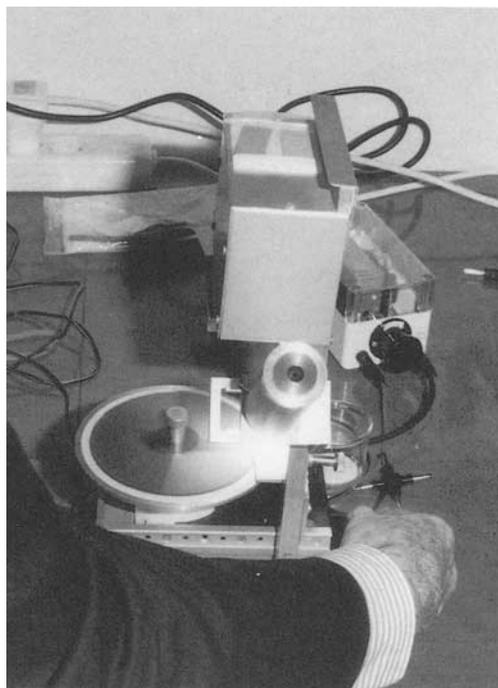


Fig. 3. A simple spinning disc tristimulus colorimeter.

The second session was an illustrated lecture on *Synthetic diamonds and gemmological methods to detect them*. A polished laser-cut section of a Sumitomo canary-yellow synthetic diamond was exhibited for microscopic examination, together with a 0.19 carat brilliant-cut stone of the same material.

The third lecture dealt with *The four optical attributes of a diamond*. Each of these (lustre, brilliance, fire and sparkliness) was treated in terms of their physical optics. Other matters which are derivative of these attributes were discussed. These are odd-number symmetry cuts, the Brewster angle refractometer, effects of adhering scattering matter, and the possible benefits and disadvantages of depositing thin films of aluminium on the pavilion facets. Various pieces of apparatus made to illustrate the optical pathways were shown.

The final lecture concerned *The measurement of the body colour of gemstones, including diamond*. An account was given of the CIE Tristimulus System, which is the internationally adopted standard procedure for colour measurement. This system is able to express any colour quantitatively in terms of only three properties: 'hue', 'saturation' and 'luminance'. A brief description was given of the apparatus and techniques developed by the writer for obtaining these CIE colour coordinate numbers for any faceted gemstone or piece of gemstone 'rough'.

In Barcelona the Catalan language is widely spoken. That Catalan is indeed a curious and different tongue can be seen from the table below. The terms were solicited from an audience at question time following the lecture on diamonds. After much good-natured argument, the translations from English of the four optical attributes of a diamond were finally approved. The lack of initial agreement certainly showed up the real difficulties in defining and translating even these few gemmological terms.

ENGLISH	CASTILLIAN	CATALAN
Attribute	Propiedad	Propietat
Lustre	Brillo	Lluisor
Brilliance	Resplendor	Resplendor
Fire	Fuego	Foc
Sparkliness	Centelleo	Llambreig

These lectures and demonstrations were held in the lecture hall of the School of Gemmology during the 7th to the 9th March, 1989. The School occupies a large separate enclave within the Geology Faculty of the University.

Other gemmology teaching centres had already been established in some of the other autonomies,

but it was not until 1971 that Barcelona's own centre was established. This is surprising because Catalonia has by far the highest gross domestic product of all Spain's seventeen autonomies. Its creation was largely due to the professional and political skills of its two founding fathers, Professor Manuel Font-Altaba and Dr José Bosch Figuerola. The syllabus of the courses offered was based upon that of the Gemmological Association of Great Britain. Indeed both gemmologists acted as external examiners for the GA Diploma until their retirement in 1987. Their successors are Professor Joaquim Nogués Carulla and Dr Marius Vendrell Saz, Director and Secretary respectively, with Professor Angel López Soler serving as part-time professor. The School has an annual enrolment of about 120 Preliminary, 70 Diploma and 25 Diamond Course students. The examinations for the School's own 'Titulo de Gemologo' as well as that of the Diploma of the GA of G.B. are conducted both in the Catalan and Castilian Spanish languages. A view of the well-equipped class-room is shown in Figure 4. The courses are held in the daytime only.

One of the most remarkable features of the student enrolment is that by far most of the students are gemstone aficionados, collectors, hobby-lapidarists and amateur jewellery makers. Few are actually involved in the jewellery retailing or manufacturing trade. In one sense, this was not too surprising.

Barcelona's long prosperity shows in its wide, impressive, super-clean streets and squares which seethe with people until all hours of the night. It shows in its elegant shops, its new cars and its stylish fashions. However, astonishingly few women of any age were seen to wear jewellery, whether gem-set or not. Jewellers shops are scarcely to be found, apart from shops selling watches and silverware. No one who was questioned about this curious state of affairs had a ready, single explanation. All agreed that it did not exist in Madrid. A few thought that Barcelona's drug-related street crime, which peaked two years ago, was responsible, but most were dismissive of this view.

Seemingly in conflict with this observation is the high popular regard for gemmology itself. This was evident by the fact that the writer's lectures were announced daily in the 'Conferencias' columns of Barcelona's principal morning newspaper 'La Vanguardia'. Whatever its effect, each session was well attended in spite of the talks being given in English and delivered with a heavy Scottish brogue.

By virtue of its being an integral part of the University, the School enjoys very considerable benefits. Its students have instant access to all the scientific and technical libraries on the campus. All lectures are free. If post-graduate students are

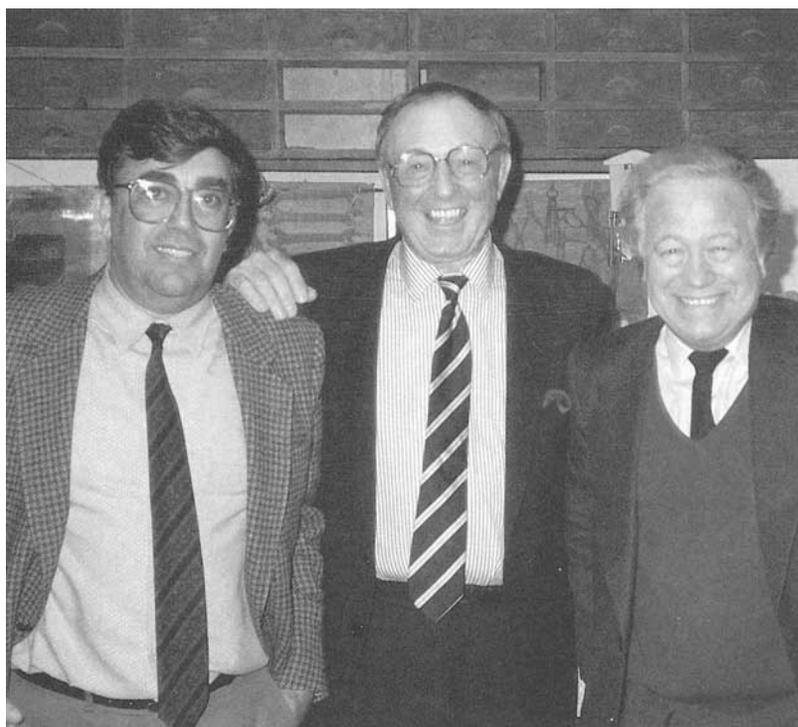


Fig. 4. A general view of the well-equipped classroom in the School of Gemmology, Barcelona.



Fig. 5. Part of the laboratory at Dr Celades Colom's home used by the Club de Talle de Gemas de Barcelona.

Fig. 6. Professor López, Dr J.B. Nelson and Dr Celades in the laboratory.



research-minded they have the opportunity to make use of expert advice and all the conventional and advanced laboratory instrumentation scattered throughout the complex.

With regard to the research aspects, the staff of the School, since its inception, have produced many original research papers on gemmology, particularly in their speciality of diamonds. These have been published only in the national journal 'Gemologia' so that they have not become universally known. This has brought home to them that a European journal of gemmology is now a much-needed vehicle for disseminating general information, research work and news. From their enquiries, many other European Societies, whose journals, magazines, news-letters and bulletins enjoy only small circulations, would also welcome such a move. They hope that the spur of the 1992 events in the EEC will catalyse the creation of a single uniquely European journal of gemmology which will bring the various national publications under one banner.

As well as the School of Gemmology, there exists another important gemmological activity. This is a non-profit lapidary club. It was started in 1982 by a small group of self-taught amateurs under the stimulus of an industrial chemist, Dr Roberto Celades Colom. Named the 'Club de Talle de Gemas de Barcelona' it is the first enterprise of its kind in Spain. Its purpose is to popularise the lapidarist's art and to encourage hobbyists and amateurs to

design and make their own jewellery and to display the faceted and 'cabbed' stones cut by them. The Club members supply their own starting materials and pay a small annual subscription; otherwise there are no fees. The sessions are held throughout the year outside the normal working hours, sometimes in week-day evenings. There is a regular Saturday and Sunday daytime session covering a total period of about twelve hours. This is especially useful for those members not living in Barcelona. It has been found that most members are able to facet two gemstones and four cabochons during a weekend's session.

The Club forms a balanced complement to the formal day-time studies at the School of Gemmology. The faceting instruction is provided by three volunteer teachers, two of whom have had commercial experience of diamond polishing. Another instructor is responsible for the design, construction and maintenance of the Club's apparatus. All four possess the FGA and the School's 'Titulo do Gemologo'. There is a wide spectrum of members, from retired people to quite young persons. Most are collectors, gemmology students from the School, jewellery professionals and those generally interested in the lapidary art as a captivating hobby. Since its inception, some 550 members have come to the Club. Many who now have their own machines, still come to enlarge their skills and exhibit their stones.



Fig. 7. Dr Celades at one of the busy lapidary classes in his laboratory.



Fig. 8. Mrs Doris Nelson congratulating an 11 year old student who has just given the final polish to a well-made emerald-cut quartz.

The plans for the future are to maintain these activities, and extend them to deal with more sophisticated cutting techniques and to promote the formation of similar lapidary teaching centres in Spain.

Dr Celades invited the writer and Professor López Soler together with their wives to attend a week-day evening session in action. The Club premises cover the entire first and second floors of Dr Celades spacious residence in central Barcelona. He and his wife occupy the third top floor, where he has his private laboratory (see Figures 5 and 6). In Figure 7 he is seen in one of the several laboratories talking to Professor López Soler and his wife. A view of one of the faceting benches is shown in Figure 8. The writer's wife is just congratulating an eleven year old member who at that moment had given the final polish to a well-made emerald-cut quartz.

This Barcelona visit was a most enjoyable experience for the writer and his wife. The hospitality of our gemmological hosts was massive and the enthu-

siasm of the students was unmistakable. The City itself is a delight. There are more museums and galleries than in many European Capitals. It has a magnificent Cathedral in the old town. The uncompleted Church of the Sacred Heart, started by Gaudi in the nineteen-twenties in the new city, is truly breath-taking. The food is superb and the municipal retail food markets are something we can only dream about in London. Barcelona's geographical position in the Mediterranean is an enviable one. It is situated in a region of great natural beauty. Its success as host to the 1992 Olympic Games is virtually guaranteed. One can only hope to return soon.

Acknowledgements

The writer is indebted to Señor Carlos Baguena-Canals for the photographs shown in Figures 1, 2 and 3 and to Professor Nogués Carulla for that of Figure 4.

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The microscopic determination of structural properties for the characterization of optical uniaxial natural and synthetic gemstones

Part 1: General considerations and description of the methods

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Abstract

The most significant crystal faces of the three optical uniaxial gem minerals corundum, beryl and quartz, as well as the angles formed by these crystal faces with the *c*-axis or the angles formed by two crystal faces are given. Methods for the determination of these structural features for faceted gemstones in the immersion microscope are described. Means used for the determinative procedure are 1) a two-axial sample holder with a 360° dial attached to the vertical axis of the sample holder and 2) a rotary measuring ocular with cross hairs attached to the eyepiece and a 360° dial attached to the ocular tube. An easy and generally performable way for a determination of all structural properties of a faceted gemstone by an efficient combination of both methods is described.

1. Introduction

Because of the value and demand of the gem varieties of corundum (ruby, sapphire) as well as beryl (emerald, aquamarine) and quartz (amethyst, citrine), an increasing number and quantity of synthetic stones of these gem varieties is produced. With improving techniques it is easy to grow synthetic gems with properties similar to those of their natural counterparts or even stones without any significant inclusions of diagnostic value.

For this reason, the determination of structural properties of gems, such as straight growth planes parallel to external crystal faces or twin planes, is becoming increasingly important as an additional and easily performable method for the distinction of natural and synthetic gemstones. In addition to the increasing application of spectroscopic data, these new supplementary and non-destructive techniques of microscopic examination enable the determination of structural properties of faceted gemstones and, thus, reveal data of diagnostic value,

which are similar to those characteristics obtainable by X-ray topography. However, the application of an immersion microscope is easily performable in every gem testing laboratory and avoids the high cost of an X-ray topography facility.

The aim of the present publication is to introduce a new method for the determination of structural properties like straight parallel growth planes or twin boundaries in natural and synthetic gems. In addition, a second method which was already described by one of the authors (Schmetzer, 1985, 1986) is completed with supplementary details for practical use.

For both methods it is necessary to use the horizontal microscope in order to facilitate the application of an immersion cell and immersion liquids. For the older already described method a sample holder with one vertical and one or two horizontal rotation axes is applied to determine crystal faces by measuring the angle between the optic axis, i.e. the *c*-axis of optically uniaxial crystals, and families of straight parallel growth planes, or to determine twin planes by measuring the angle between the optic axis and the twin plane. Part of this first method as well as a detailed description of one distinct type of the applied sample holders were published by Schmetzer (1985, 1986).

The new method to determine structural properties of faceted natural and synthetic gemstones is based on the use of an eyepiece with cross hairs and a 360° dial attached to the eyepiece tube. With this equipment it is possible to measure angles between two different families of straight parallel growth planes independently from the orientation of the optic axis of the crystal.

Table 1: Selected crystal faces and angles of corundum, $\alpha\text{-Al}_2\text{O}_3$, trigonal, crystal class $D_{3d} \cong \bar{3}2/m$

Name	Designation	hkl*	angle between <i>c</i> -axis and crystal face (rotation angle δ)	
basal pinacoid	<i>c</i>	(0001)	90°	
second-order hexagonal prism	<i>a</i>	(11 $\bar{2}$ 0)	0°	
positive rhombohedron	<i>r</i>	(10 $\bar{1}$ 1)	32.4°	
negative rhombohedron	<i>d</i>	(01 $\bar{1}$ 2)	51.8°	
negative rhombohedron	γ	(01 $\bar{1}$ 5)	72.5°	
second-order hexagonal dipyramids	<i>n</i>	(22 $\bar{4}$ 3)	28.8°	
	<i>w</i>	(11 $\bar{2}$ 1)	20.1°	
	<i>v</i>	(44 $\bar{8}$ 3)	15.4°	
	<i>z</i>	(22 $\bar{4}$ 1)	10.4°	
	<i>v</i>	(44 $\bar{8}$ 1)	5.2°	
	ω	(1414 $\bar{2}$ 83)	4.5°	

* based on the morphological cell with $a:c = 1:1.365$ (cf. Klein & Hurlbut, 1985)

Angles made by two crystal faces

$a \wedge a'$	120°	$c \wedge a$	90°		
$z \wedge z'$	121.1°	$c \wedge r$	122.4°		
$w \wedge w'$	124.0°	$c \wedge d$	141.8°		
$n \wedge n'$	128.0°	$c \wedge \gamma$	162.5°		
$r \wedge r'$	86.1°	$c \wedge n$	118.8°	$a \wedge n$	151.2°
$r \wedge n$	154.0°	$c \wedge w$	110.1°	$a \wedge w$	159.9°
$d \wedge n$	148.0°	$c \wedge z$	100.4°	$a \wedge z$	169.6°
$r \wedge d$	133.0°				

Table 2: Selected crystal faces and angles of beryl, $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$, hexagonal, crystal class $D_{6h} \cong \frac{2}{m} \frac{2}{m} \frac{2}{m}$

Name	Designation	hkl*	angle between <i>c</i> -axis and crystal face (rotation angle δ)	
basal pinacoid	<i>c</i>	(0001)	90°	
first-order hexagonal prism	<i>m</i>	(10 $\bar{1}$ 0)	90°	
second-order hexagonal prism	<i>a</i>	(11 $\bar{2}$ 0)	0°	
first-order hexagonal dipyramid	<i>u</i>	(10 $\bar{1}$ 1)	41.0°	
first-order hexagonal dipyramid	<i>p</i>	(10 $\bar{1}$ 2)	60.1°	
second-order hexagonal dipyramid	<i>s</i>	(11 $\bar{2}$ 2)	45.1°	

* based on the structural cell with $a:c = 1:0.996$ (cf. Klein & Hurlbut, 1985)

Angles made by two crystal faces

$m \wedge m'$	120°	$c \wedge m$	90°		
$a \wedge a'$	120°	$c \wedge a$	90°		
$m \wedge a$	150°	$c \wedge u$	131.0°	$m \wedge u$	139.0°
		$c \wedge p$	150.1°	$m \wedge p$	119.1°
		$c \wedge s$	135.1°	$a \wedge s$	134.9°

Table 3: Selected crystal faces and angles of quartz, SiO₂, trigonal, crystal class D₃ $\bar{6}$ 2

Name	Designation	hkl*	angle between c-axis and crystal face (rotation angle δ)
basal pinacoid	<i>c</i>	(0001)	90°
first-order hexagonal prism	<i>m</i>	(10 $\bar{1}$ 0)	0°
positive rhombohedron (major rhombohedron)	<i>r</i>	(10 $\bar{1}$ 1)	38.2°
negative rhombohedron (minor rhombohedron)	<i>z</i>	(01 $\bar{1}$ 1)	38.2°

* based on the structural cell with $a:c = 1:1.102$ (cf. Klein & Hurlbut, 1985)

Angles made by two crystal faces

$m \wedge m'$	120°	$c \wedge m$	90°		
$r \wedge r'$	94.2°	$c \wedge r$	128.2°	$m \wedge r$	141.8°
$r \wedge z$	133.7° (adjacent)	$c \wedge z$	128.2°	$m \wedge z$	141.8°
$r \wedge z'$	76.4° (opposite)				

In a second and third part of this publication, the authors discuss some fields of application in detail, e.g. the determination of crystal faces and twinning in natural and synthetic emerald (part 2) as well as in sapphire, ruby, amethyst and citrine (part 3). These structural properties are strongly dependent on growth conditions applied for the production of synthetic gem materials as well as dependent on the condition of formation of natural gem minerals. The examples are designed to prove the applicability of the two methods described by the authors for a characterization of natural and synthetic gemstones, and the application of some of these data to problems of the determination of samples of unknown nature.

II. Significant angles of optical uniaxial minerals

In order to understand the introduced methods for the measurement of significant angles useful for the determination of growth structures and twinning in the three important gem minerals corundum, beryl and quartz, which are used as examples for optically uniaxial crystals, it is necessary to give some basic explanations about crystal faces and significant angles used in this publication.

All crystals of the above mentioned three mineral species show hexagonal or trigonal symmetry, their morphology mainly consists of prism, rhombohedral and pyramidal faces. In addition to these crystal faces, the minerals corundum and beryl normally reveal the basal pinacoid as a characteristic morphological feature. The basic habit of these three minerals consists of a low number of significant, recurring crystal forms. The angles formed by one crystal face and the c-axis as well as the angles

formed by two distinct crystal faces are fixed and well known for the three minerals [Tables 1, 2 and 3].

Under microscopic observation, the angles formed by two crystal faces are directly visible and, thus, are used in this publication. In general, these angles are designated ϕ' , whereas the usual crystallographic literature works with interfacial angles ϕ with $\phi' = 180^\circ - \phi$ [Figure 1]. However, in microscopic investigation a direct observation of the traces of crystal faces is possible and therefore the angle ϕ' , which is formed directly by two crystal faces is used within this series of publications.

In Figure 2 a cross-section through a hexagonal or trigonal crystal is shown. The morphology of the crystal is formed by the basal pinacoid (*c*), a first- or second-order hexagonal prism (*m* or *a*) and any given hexagonal dipyrmaid or rhombohedron (*f* or

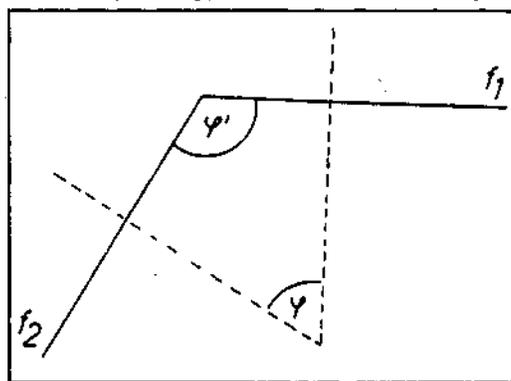


Fig. 1. Straight growth planes that form an angle; f_1 , and f_2 traces of growth planes, ϕ interfacial angle, ϕ' angle made by the two faces.

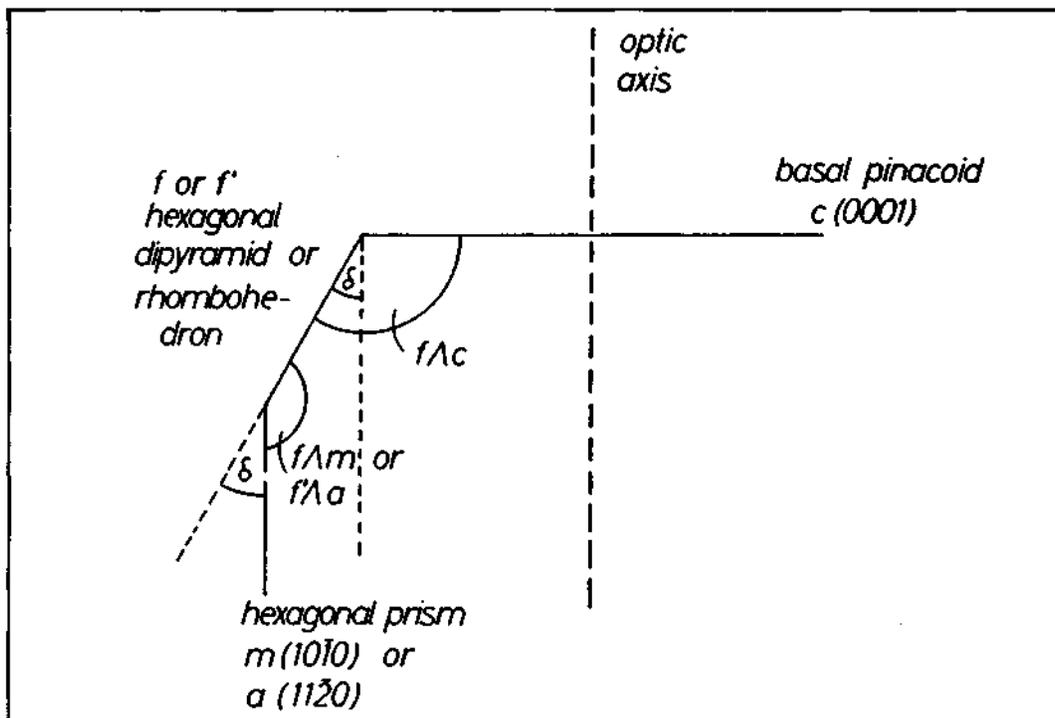


Fig. 2. Cross-section through a hexagonal or trigonal crystal showing the determination of internal structural features by use of the rotation angle δ , which is formed by the optic axis of the uniaxial crystal and any rhombohedral or dipyramidal growth plane (f or f'); further characteristic angles are formed by the basal pinacoid (c) or a hexagonal prism face (m or a) with any rhombohedral or dipyramidal growth plane (f or f'). View perpendicular to the c -axis.

f'). The angle formed by one of the crystal faces with the optic axis is designated δ . This angle indicates how much the crystal has to be tilted away from the optic axis in order to be able to observe the trace of the crystal face clearly in the microscope. By measuring this rotation angle δ , it is easy to determine the corresponding crystal face by using Tables 1, 2 or 3, respectively.

The different rhombohedral or dipyramidal crystal faces (f or f') form characteristic angles with the basal plane (c) or with prism faces (m or a), which also can be easily observed in the microscope. In dependence of δ [cf. Figure 2] there are four important formulae indicating the relation between the angle formed by any given crystal face (f or f') and prism faces (m or a) or between the angle formed by any given crystal face (f or f') and the basal pinacoid (c):

$$\begin{aligned} f \wedge m &= 180^\circ - \delta \\ f' \wedge a &= 180^\circ - \delta \\ f \wedge c &= 90^\circ + \delta \\ f' \wedge c &= 90^\circ + \delta \end{aligned}$$

Besides the above mentioned angles there exist some other important angles formed by rhom-

bohedral or dipyramidal faces, e.g. the angles between two rhombohedral faces r and r' ($10\bar{1}1$) in corundum.

In Tables 1, 2 and 3 the most significant crystal faces are listed which occur in natural and synthetic corundum, beryl and quartz. In addition, the angles formed by the corresponding crystal faces with the c -axis (δ -angles) and the most important angles formed by two crystal faces are given. In Figures 3, 4 and 5 some idealized line drawings of the relevant minerals with all important crystal faces of diagnostic value are pictured revealing the relative orientation of these faces in the crystals.

III. Means for the determination of crystal faces and characteristic angles

III.1 Sample holder with two rotation axes and its use

In order to investigate and determine diagnostic structural properties in a faceted gemstone in different directions of view, it is often necessary to examine a given faceted sample in different orientations, i.e. to remove the sample from the holder and to place the object under investigation after its rotation back into the holder again. According to the geometrical properties of the cut gemstone, distinct directions of view in connection with the

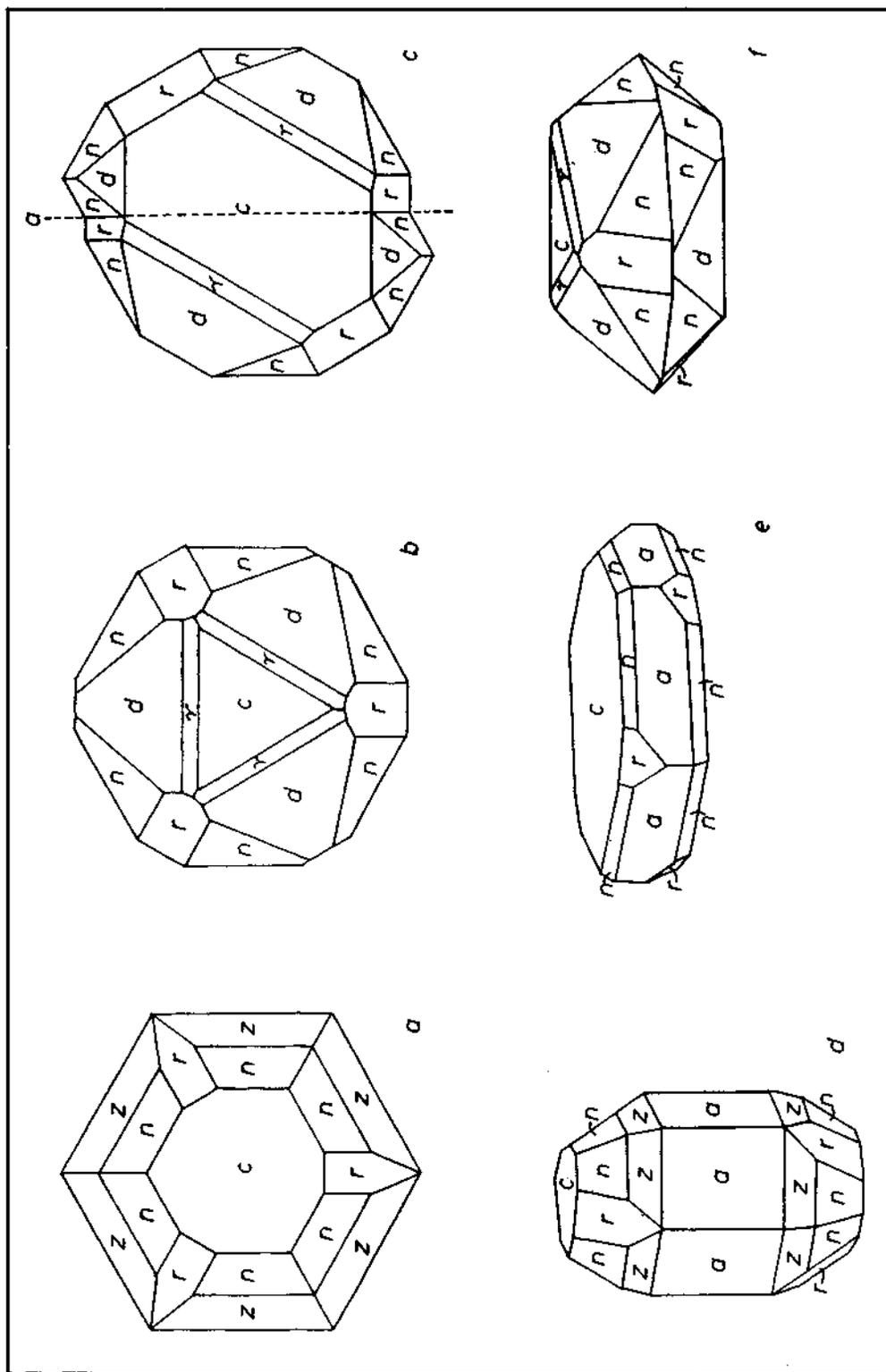


Fig. 3. The characteristic habit of natural and flux-grown synthetic corundum; a) c-axis projection of a natural crystal, b) c-axis projection of a flux-grown synthetic crystal, c) c-axis projection of a flux-grown synthetic crystal, contact twin across (1010) with a (1120) as composition plane, d) clinographic projection of a natural crystal, e) clinographic projection of a natural crystal, f) clinographic projection of a flux-grown crystal.

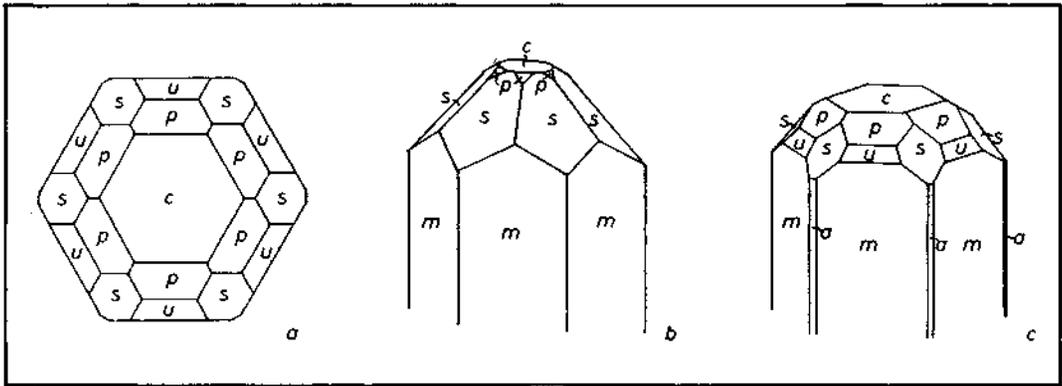


Fig. 4. The characteristic habit of natural beryl; a) *c*-axis projection, b), c) clinographic projections.

ordinary 360° rotation about the vertical axis of the conventional sample holder are easily accomplished. In other words, a cut gemstone is easily placed in distinct orientations into the conventional sample holder with one single vertical rotation axis, e.g. the gem is held by the crocodile clips between the table and culet or at the girdle. However, additional and different orientations of a cut gemstone are more difficult to obtain.

Because of this fact, it is very time consuming or sometimes even impossible to adjust the optic axis of a normally faceted gemstone parallel to the microscope axis. The recognition of structural properties, e.g. the exact determination of growth planes using the rotation angle δ , and the verification of the applicability of growth features for the distinction between natural and synthetic gemstones is practically impossible or at least very time consuming with the conventionally used gem holders.

For this reason, one of the authors (Schmetzer, 1985, 1986) improved the conventional sample holder with the generally available 360° vertical rotation axis by adding a second horizontal rotation axis. By use of this new axis a rotation of the sample about the horizontal axis through an angle up to about $\pm 40^\circ$ is practicable. By attaching a dial with a 360° subdivision to the conventional vertical axis and adding a small indicator with set screw to the 360° dial, the angle between two structural properties of a gemstone, e.g. the angle between the optic axis of an optically uniaxial mineral and a distinct growth or twin plane can be measured easily [cf. Figure 2].

The measurement of structural elements is carried out as follows: by using crossed polarizers in the gem microscope, interference figures consisting of coloured interference rings are observed in distinct orientations of the crystal. Tilting the crystal towards a position in which the angle between the optic axis of the sample and the

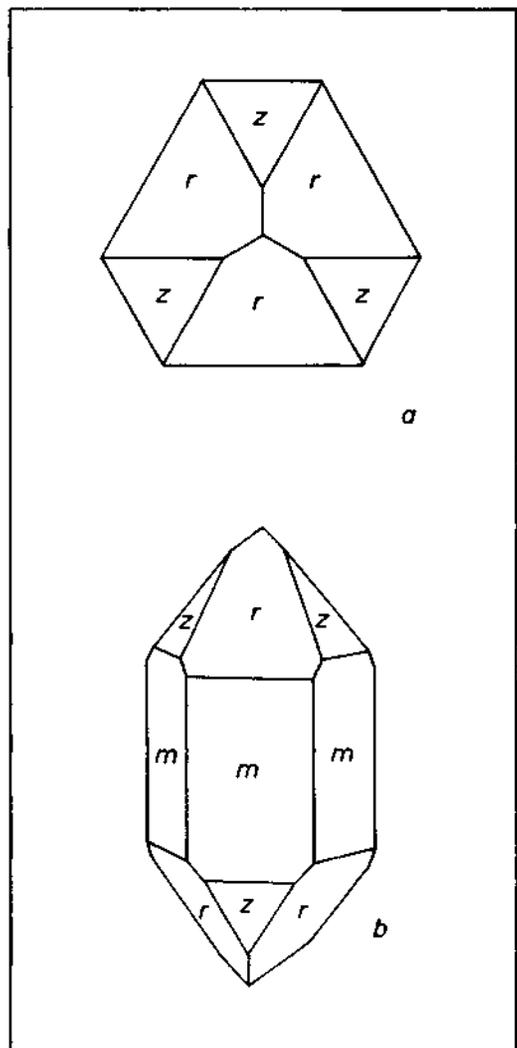
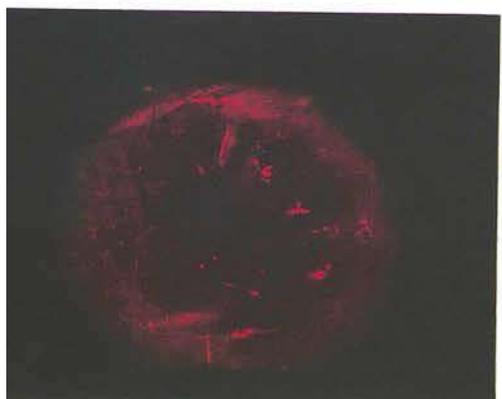
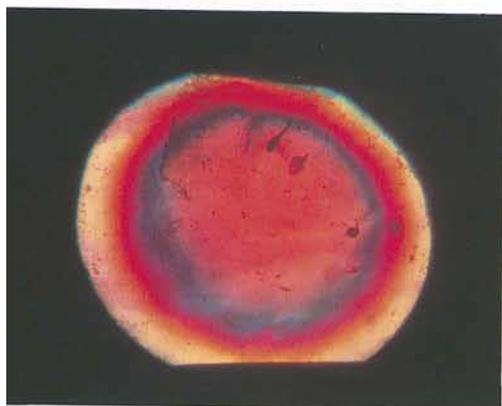
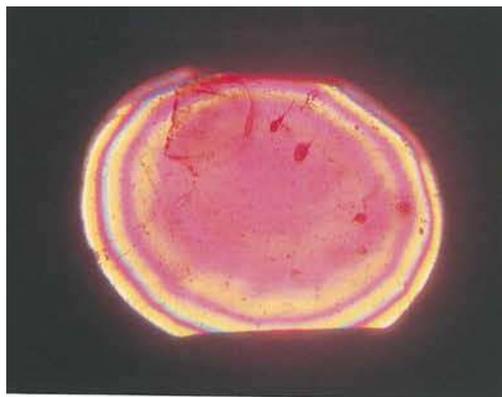


Fig. 5. The characteristic habit of natural quartz; a) *c*-axis projection, b) clinographic projection.



Figs. 6, 7, 8. This series describes the variation of interference figures of a natural ruby from Burma during a slight rotation of the stone; Fig. 6: the angle between the optic axis and the microscope axis is about 35° ; Fig. 7: tilting the corundum crystal slowly towards a position, in which the angle between the optic axis and the microscope axis is diminished moves the interference rings towards the centre; Fig. 8: the optic axis is exactly parallel to the microscope axis. Crossed polarizers, $60\times$.

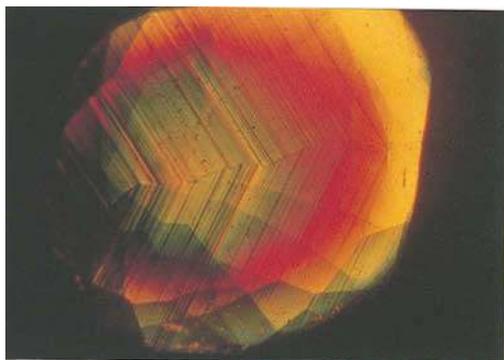
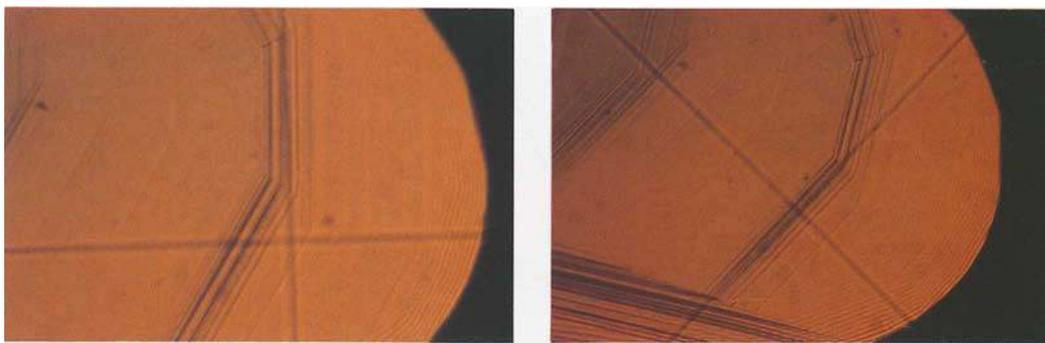


Fig. 9. Angled growth structure in natural sapphire from Pailin, Cambodia; planes parallel to the hexagonal dipyrramids z and z' ($2\bar{2}41$) form an angle of 121.1° . View 10.4° inclined to the c -axis, crossed polarizers, $20\times$.

microscope axis is diminished, the interference rings move towards the centre of the stone [Figures 6, 7]. After having placed the optic axis in the best available position [Figure 8], the indicator attached to the dial of the vertical axis is fixed to 0° . Afterwards, the sample is rotated about the vertical axis towards a position, in which sharp parallel growth planes or a single twin plane become visible in the gem microscope [Figure 9]. By use of a rotation angle δ , which is now directly readable on the dial, the growth or twin plane under investigation is exactly determined [cf. Tables 1, 2 and 3]. The experimental limit of error in the measurement of δ with the method described equals $\pm 1^\circ$. Consequently, all crystal faces quoted in Tables 1, 2 and 3 are unequivocally determined with the exception of ν ($44\bar{8}1$) and ω ($14\ 14\ 2\bar{8}\ 3$) in corundum with δ -values of 5.2 and 4.5° , respectively.

For a more detailed description of this sample holder with two rotation axes and its use for the distinction of natural and synthetic ruby as well as natural and synthetic amethyst consult the paper of Schmetzer (1986) in this journal.

A further improvement of the sample holder described above is the use of three independent rotation axes and three attached dials. This type of sample holder [Figure 12] allows the conventional 360° rotation about the vertical axis, and additional rotations about two horizontal axes, which are orientated parallel and perpendicular to the microscope axis, through angles up to about $\pm 40^\circ$ in both directions. This three-axial sample holder can be used like that one with two rotation axes, but it is also possible to use all three axes with attached dials for the determination of crystal faces by means of the stereographic projection. However, this procedure needs more experience and is quite complicated. Therefore, this method will not be discussed in further detail within this publication. The three-



Figs. 10, 11. This series describes the determination of an angle ϕ' formed by two families of straight parallel growth planes in a natural emerald from Nigeria; Fig. 10: one wire of the cross hairs attached to the objective lens is tilted towards a position exactly parallel to the first group of parallel growth planes [in this case growth planes parallel to the basal pinacoid $c(0001)$], the dial attached to the objective tube is adjusted with its 0° -position coincident with the indicator fixed to the ocular; Fig. 11: the objective with fixed indicator is tilted into a position, in which the wire of the cross hairs is exactly parallel to the second group of parallel growth planes [in this case growth planes parallel to the hexagonal dipyramid $p(10\bar{1}2)$], the angle formed by the two sets of growth planes [in this case 150.1°] is now directly readable on the 360° dial. – View perpendicular to the c -axis, the c -axis runs almost horizontally, crossed polarizers, $20\times$.

axial type of sample holder is especially applicable for optical biaxial gem minerals, e.g. for the distinction of natural and synthetic alexandrite.

III.2 Measuring ocular and its use

In situations when the optic axis is not easily orientated parallel to the microscope axis or for a direct determination of two families of straight parallel growth planes, it is often useful to work with a measuring ocular in addition to one of the above described sample holders.

The measuring ocular consists of the normal rotary eyepiece of the gem microscope with cross hairs attached to the ocular lens. Attached to the eyepiece tube there is a fixable 360° dial, and connected to the ocular there is a fixed indicator. With these supplementary facilities attached to the conventionally available eyepiece, it is possible to measure easily the angle ϕ formed by two structural features, e.g. between two families of straight parallel growth planes, which reflect the morphology of a rough crystal [Figures 9, 10 and 11].

Using the above mentioned facilities, first the trace of two families of straight parallel growth planes have to be observable in the microscope. By rotating the eyepiece with the cross hairs, the ocular is placed in a position with one wire of the cross hairs parallel to the first family of growth planes [Figure 10]. Subsequently, the dial attached to the objective tube is rotated and adjusted with its 0° -position coincident with the indicator, which is fixed to the ocular. The ocular is now turned into a position, in which the direction of the second family of parallel growth planes coincides with the wire of the eyepiece [Figure 11]. The angle between the two sets of growth planes is now directly readable at the position of the indicator fixed to the objective at the

360° dial attached to the ocular tube. In general, both crystal faces under investigation are determinable by the use of Tables 1, 2 or 3, respectively.

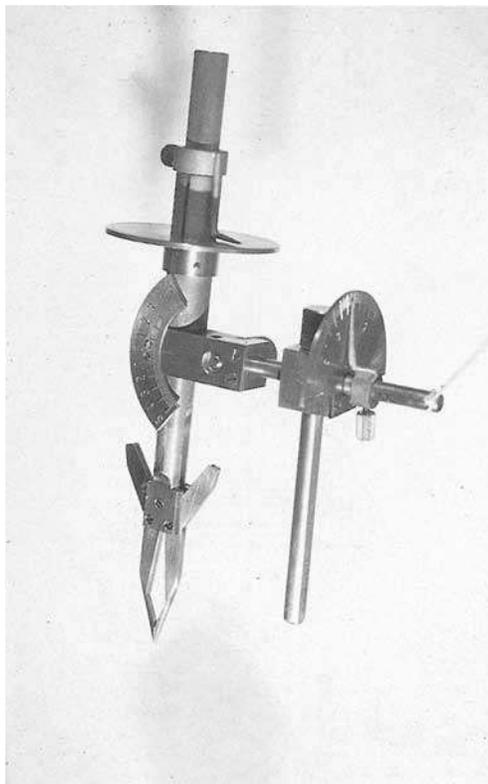


Fig. 12. Improved three-axial sample holder with one 360° vertical and two $\pm 40^\circ$ horizontal rotation axes, each of them having an attached dial.

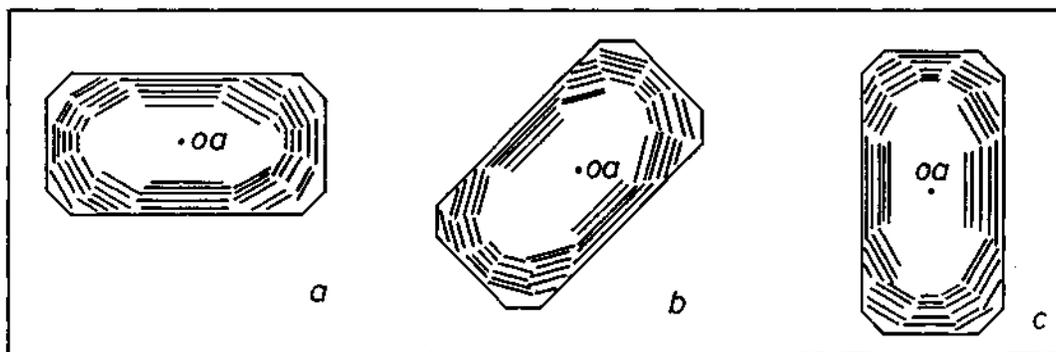


Fig. 13. Cross-sections of a faceted optically uniaxial gemstone (natural emerald) in different orientations with the optic axis parallel to the microscope axis (cross-sections (a), (b) and (c) are related by a rotation of 45° about the optic axis); rotating the crystal about the 360° vertical rotation axis, in each of the different orientations (a), (b) and (c) the traces of various sets of parallel growth planes become visible in the microscope and are determined by use of the rotation angle δ .

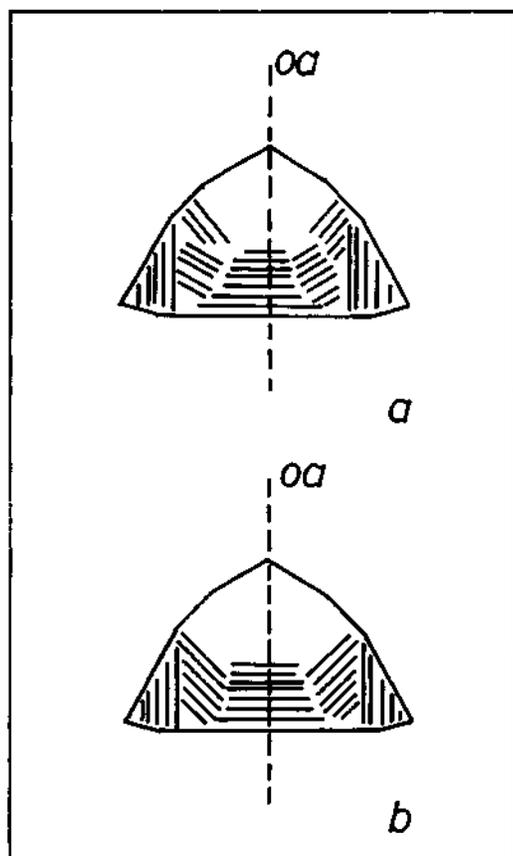


Fig. 14. Cross-sections of a faceted optical uniaxial gemstone (natural emerald) in different orientations with the optic axis parallel to the 360° vertical rotation axis (cross-sections (a) and (b) are related by a rotation of 30° about the optic axis); by a rotation through 30° about the 360° vertical rotation axis (i.e. in this particular orientation about the optic axis), various sets of growth planes become visible; by a rotation through 60° , identical sets of growth planes are repeated.

III.3 Suggested combination of both methods

For a combination of both methods described in sections III.1 and III.2, a first general step would be the determination of the position of the optic axis of the faceted gemstone under investigation as explained in section III.1. For subsequent procedures, it is helpful to retain the orientation of the optic axis relative to the girdle or relative to dominant facets, e.g. the table facet of the cut gemstone, and also relative to distinct types of inclusions if present. Now part of the internal crystal faces can be determined according to section III.1 by rotation of the gemstone about the vertical axis and measuring the rotation angle δ between appearing straight parallel growth planes and the optic axis.

To obtain a maximum number of crystal faces by this method, the stone itself should be placed in different orientations into the sample holder, which are related by a rotation of 45° about the optic axis as shown in Figure 13, keeping the optic axis parallel to the microscope axis in all different orientations. This procedure is necessary because in one simple orientation, only part of all growth planes of the gemstone become visible through a 360° rotation of the sample about the vertical axis of the sample holder.

In a second step, the gemstone should be rotated through 90° towards an orientation, in which the optic axis of the gemstone is placed in a direction parallel to the 360° vertical axis of the sample holder [Figure 14]. In that particular orientation, the growth structures parallel to the basal pinacoid (c) or parallel to the first- or second-order hexagonal prism faces (*m* or *a*) can be recognized easily. During a rotation of the gemstone about the 360° vertical axis of the sample holder, the basal pinacoid (c) or growth structures parallel to this face are permanently visible in the gem microscope [Figures 14, 15]. After each 30° or 60° rotation,

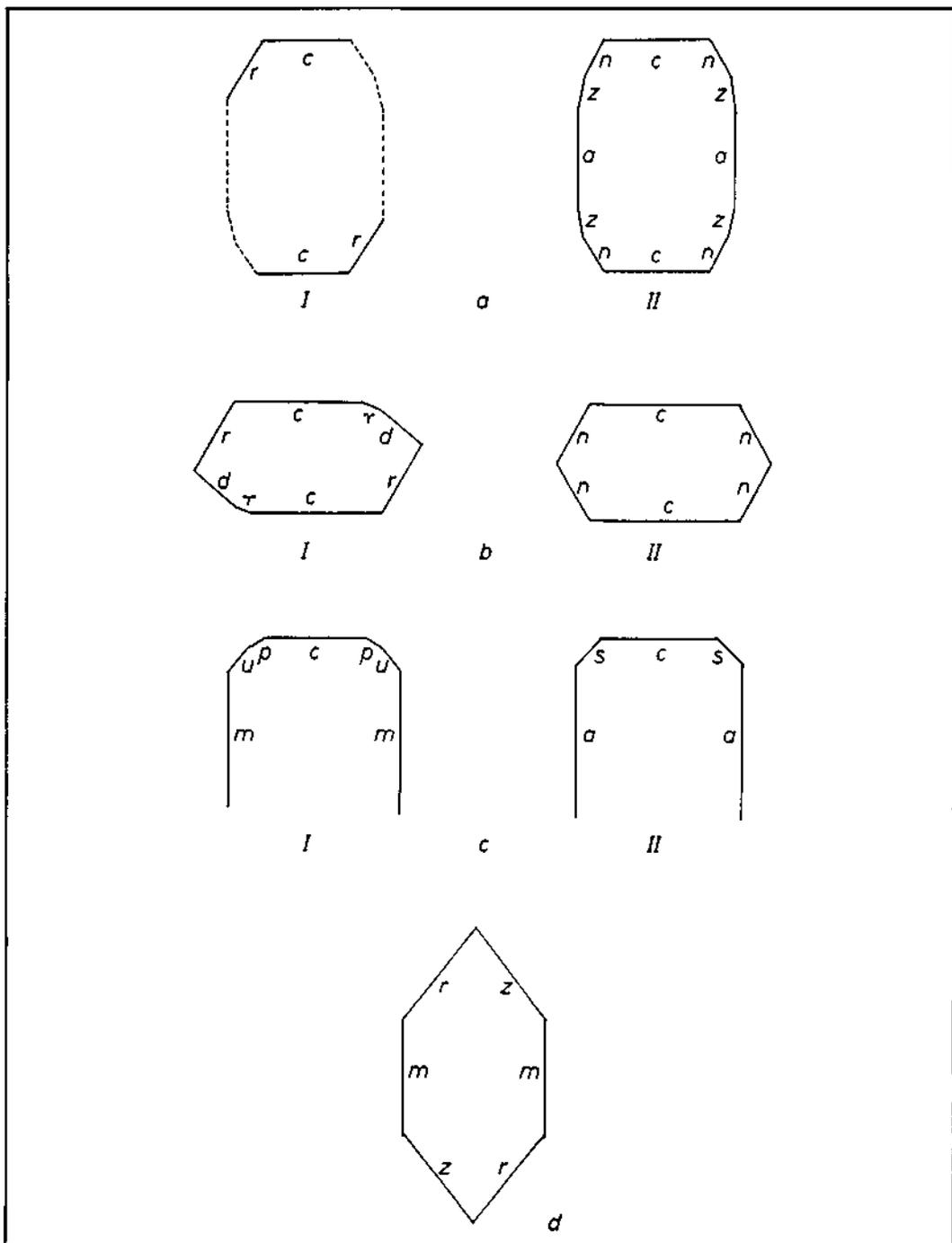


Fig. 15. Cross-sections of natural corundum (a), synthetic flux-grown corundum (b), natural beryl (c), and natural quartz (d); solid lines represent traces of crystal faces, dashed lines represent edges of the crystals; (a), (b), and (c): by a rotation through 30° about their optic axis, cross-sections (I) of the optical uniaxial crystals are converted to cross sections (II); by a rotation through 60° about the optic axis cross-sections (I) of the optically uniaxial crystals are converted to cross-sections (I') with identical faces or cross-sections (II) are converted to cross-sections (II') with identical faces, respectively; (d): by a rotation through 60° about the optic axis identical cross-sections are repeated. - View perpendicular to the c-axes, the c-axes run vertically.

subsequent first- and/or second-order prism faces become visible (if present in the sample under investigation). After measuring the angles ϕ' formed by an unknown crystal face (f or f') with the basal pinacoid (c) or with prism faces (m or a ; cf. Figure 2) using the method described in section III.2, both angles can be used for the determination of the unknown growth planes (cf. Tables 1, 2 and 3).

After the exact determination of one group of growth planes is performed in one distinct orientation of the sample, subsequently rotating the hexagonal or trigonal gemstone about its vertically placed optic axis, after each rotation through 30° , successively the next set of growth planes with different ϕ' angles should appear for corundum and beryl [Figures 14, 15]. However, the angles between the growth planes (f or f') and the basal pinacoid (c) or one of the prism faces (m or a) are repeated after each rotation through 60° for all three minerals, corundum, beryl and quartz [Figure 15]. In general, with several subsequent rotations of the crystal about the optic axis through 30° each, a complete set of growth structures becomes visible in the gem microscope and the determination of all structural properties of the mineral is performable.

IV. Conclusions

In this first part of the article a general survey of different possibilities for the determination of structural features of faceted uniaxial gemstones by use of a sample holder with two independent rotation axes is given. The basic purpose for the addition of a second horizontal rotation axis is an easy orientation of the optic axis of the gem parallel to the microscope axis. With an additional improvement of the two-axial sample holder towards a three-axial one, it is also possible to determine characteristic crystal faces and angles of optically biaxial minerals, e.g. alexandrite. For this somewhat more complicated method the use of the stereographic projection is necessary.

In a first step, it is important to locate the optic axis of the stone under investigation relative to the dominant facets of the stone. With the optic axis orientated parallel to the microscope axis, it is possible to determine the rotation angles δ of growth planes by tilting the gemstone in a direction, in which the optic axis is horizontally twisted towards an orientation perpendicular to the microscope axis. The angle δ between the optic axis and a family of straight parallel growth planes is readable at the dial fixed to the 360° vertical axis of the sample holder. Having performed the alignment of the optic axis and the determination of growth structures by rotation of the sample about the

vertical axis of the sample holder and measurement of the rotation angle δ , this procedure is at least twice repeated in different orientations of the gemstone, which are related by a rotation of 45° about the optic axis.

A second new method for the determination of crystal faces of optical uniaxial minerals used by the authors is the measurement of characteristic angles between two crystal faces by using cross hairs in a measuring ocular and a 360° dial attached to the tube of the eyepiece. In order to perform these subsequent series of measurements, the stone is removed from the sample holder and reorientated in a position, in which the optic axis is perpendicular to the microscope axis. This means the optic axis is now parallel to the vertical 360° rotation axis of the sample holder, which allows a rotation of the faceted gemstone under maintenance of the position of the optic axis. The structural features are then determinable by measuring the angles between known crystal faces that appear frequently, like the basal pinacoid (c) or one of the hexagonal prism faces (m or a), and an unknown crystal face (f or f'). With the same method a determination of twin or glide planes is possible. Furthermore, the angles between adjacent rhombohedral or pyramidal faces are able to be determined.

With some experience, the combination of both methods allows the complete determination of all existing growth structures as well as twin or glide planes of every optically uniaxial mineral.

In the second and third part of this publication, which will appear in subsequent issues of this journal, some examples for the application of the methods described for the characterization of important gem minerals of distinct occurrences as well as some common synthetic gemstones available in the trade are described in detail.

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Emeralds from Colombia (Part 1)*

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Abstract

Introduction (Part 1)

- A1. The history of the Colombian emerald mines
- A2. The geographical location of the emerald occurrences
- B1. The emerald deposits and their geological environment
- B2. Hypotheses of emerald genesis
- B3. The mine workings

Gemmological properties (Part 2)

- C1. Morphology, quality and size of the emerald crystals
- C2. Chemical composition, chromophore and trace element contents
- C3. Light absorption, colour and fluorescence
- C4. Optical values and density
- C5. Inclusions and growth characteristics

Treatments (Part 3)

- D. Oil, ultrasonic and heat treatments

Discussion

- E. Differentiation of the Colombian emeralds from natural emeralds of other origins, synthetic emeralds and emerald imitations

Acknowledgements

Bibliography

Abstract

A condensed historical and mining survey is followed by a compilation of the most notable crystals of Colombian emeralds ever found and of the details of their chemical composition. A summary of the elemental substitutions and their effects on the outlined range of gemmological data is given.

Special emphasis is placed on the cause of the famous, vividly green coloration, i.e. on the selective absorption of orange-red and violet light, dictated by minor contents of the chromophoric elements Cr and V substituting for Al^{3+} in octahedrally coordinated sites of the

*This is a paper which will be published in *The Journal* in three parts. The complete bibliography is presented with Part 1.

beryl lattice (Cr \approx V, with the Cr/V ratio found to be ranging from 4.5 to 0.5, in extreme cases from about 10 to 0.1). Iron, however, has barely been detected in the UV/VIS absorption spectra of Colombian emeralds. Though generally present in slightly larger amounts than Cr^{3+} , iron does not recognizably influence the colour (little Fe^{2+} and possibly some Fe^{3+} positioned in the axial channels of the ring-silicate structure).

A detailed presentation of the currently known internal characteristics (inclusions and growth structures) is supplemented by a discussion of identification problems with treated emeralds and the disclosure of the treatment during transactions in the wholesale and retail trade.

Allocation of the emeralds to individual Colombian mines on the basis of inclusion patterns does not appear possible in most instances. However, the differentiation of Colombian emeralds from other natural emeralds (such as those from the Panjsher Valley exhibiting very similar (s,l,g) three-phase inclusions) or from difficult, modern hydrothermal and flux synthetics is shown to be feasible by a combination of microscopy, refractometry, and absorption spectrometry (UV/VIS and NIR/MIR), assisted by chemical analysis only in the most difficult cases. Safe identification of authenticity, treatment, and origin of emeralds, however, is increasingly becoming the task of the experts in the specialized laboratory.

The mineralogical definition of emerald as a yellowish to bluish-green variety of natural beryl is shown to be valid for any Cr and V-containing variety except possibly the rare, absolutely chromium-free (V,Fe)-beryls (modification of the former definition of type II emerald): in many of the preferred Colombian emeralds, chromium is clearly dominated by vanadium (Cr/V ratio < 1). However, chromium has a higher efficiency of coloration than vanadium and a much higher one than iron ions in the various substitutional and interstitial lattice sites of beryl. Cr influences colour even at very low trace levels.

An extensive and up-dated selection of literature, covering all aspects cited, completes the synopsis.

The introduction to this review is based on the study of a fraction of the extraordinarily extensive literature on Colombian emeralds.

The main part of the paper (Part 2) contains data collected and findings achieved over many years in the SSEF Laboratory in Zurich.

Part 3 will deal with the difficulties encountered in identifying treated emeralds and with the disclosure necessary when selling them and will discuss the possibilities of differentiation between Colombian and other natural emeralds and the synthetic emeralds.

Introduction

A1. *The history of the Colombian emerald mines*

The ancient South American Indian tribes were rich in natural resources, yet their need of these goods was modest and sensible. Gold and emeralds were used commercially as well as for royal insignia. Both had a symbolic and ceremonial character. The original inhabitants of Peru, Mexico and the Caribbean were treated less kindly by fate than the Chinese, Japanese or other ancient cultures. From about 1500 onwards, the Incas, Aztecs and Mayans were overrun, enslaved and exploited by the so-called discoverers from the Old World.

The emerald pits of the Chibcha Indios near Somondoco, later called Chivor, were discovered by the Spaniards in the early sixteenth century and from then on intensely mined. The finds of the Muzo Indians took the same course once the tribes had been subjected by the Spaniards. In the seventeenth century, the decimation of the Colombian Indians through imported illnesses and drudgery was such that it led to a shortage of cheap slave labour. Chivor was forced into oblivion for the next 200 years and the deposits were overgrown by jungle vegetation. Mining in Muzo became sporadic.

However, between 1537 and 1650 the Spanish royalty had accumulated such immense riches that all purchasing wishes of the Indian Moguls, the Ottoman aristocracy and the European courts could be satisfied. Because of the scarcity of green woods and fields in their own countries, the Muslims have treasured for ages the colour green. In fact it is the holy colour of Islam. This explains the abundance of Colombian emeralds in the treasuries of Arabian sheiks. The Persian crown jewels in particular are said to abound with these gems. Hundreds of cabochons and faceted emeralds over 100 carats, some even over 300 carats, were to be found in the safes of the Banque Markazi in Teheran.

Beautiful and large, rough and cut, engraved and inscribed Colombian emeralds from that period can also be admired in the Topkapi Palace Museum in Istanbul.

Notable historic crystal groups, single crystals and Colombian emerald gems from colonial times are also exhibited in the Natural History Museum in Vienna (among others the group of crystals named 'Moctezuma', measuring 17x16 cm and consisting of single Muzo and Chivor crystals glued together). An original Chivor crystal group approximately 30 cm across, carried by the figure of a Moor, and an emerald suite are displayed in the Green Vaults of Dresden. Fine specimens are to be seen in many other museums (except in Spain where royalty was said to have preferred gold to emeralds).

Not all Colombian emeralds reached the Spanish

coast 400 years ago. A ship of the Tierra Firme fleet, the galleon Nuestra Señora de Atocha for instance, sank in 1622 near the Florida Keys, carrying valuable gold and emerald freight. In 1985, over 2300 loose and set emeralds were successfully lifted off the wreck. The largest stones recovered weighed 64 and 30 carats.

A2. *The geographical location of the emerald occurrences*

The Andes are mountain chains rich in raw materials. Together with the Himalayas, the Alps and the North American cordilleras, they belong to the youngest and highest mountain systems in the world. All these Alpine type mountain ranges were and still are being thrust upward at the front of slowly drifting Continental plates (in the case discussed, at the front of the very old Brazilian and the Guyana plates)¹.

The results of plate movements and orogenies are frequent earthquakes and volcanic eruptions, such as the big quakes in North Yemen (1982), Mexico City (1985), the San Francisco Bay (1989) or the Philippines (1990) and the eruptions of Mount St. Helens (1980) or of the Nevado del Ruiz (1985), less than 100 km north-west of Muzo.

From the south-west to the north-east, the Colombian Andes divide into three mountain ranges, the Cordillera Occidental, Central and Oriental. The connection with the North American cordilleras is established via both Central American branches, the western chain running directly through the west of Mexico, the eastern chain bending via Venezuela and the long Caribbean archipelago back to Yucatan and then northward towards the Rocky mountains.

Extending for some 150 km, the *Colombian emerald belt* stretches from the north to the east of the capital, Bogotá, across the eastern branch of the Andes. This Cordillera Oriental divides the belt into two mining districts² with Muzo and Cosquez in the north-west (Boyacá Province), and Chivor (Boyacá and Cundinamarca P.) and the mines of Gachalá in the south-east (Cundinamarca Province). Even between neighbouring mines of the Muzo district there is no very obvious geological relationship. The rugged terrain and the thick

¹The formation of the Colombian Andes is not due to simple or nappe folding. They are marine and continental block formations generated by the horizontal north-west drift of the Guyana plate (presently at a rate of about 50 mm per year) onto the subducted Pacific Nazca plate. Geological terms: orogeny = formation of mountains, subduction = down-movement (of marine plates), circum-Pacific mountain systems = Andes/Rocky Mountains/Aleutian island arch/Japan/Philippines/New Guinea/New Zealand Alps.

²The mines of the Muzo district from south to north are: El Peñon, Aposentos (near Yacopi), Coper, Maripí, Muzo (Tequendama, Santa Barbara, El Chulo), Cosquez and Peñas Blancas. Those of the Chivor district from S to N are: Vega de San Juan, Las Cruces, El Toro, El Diamante (all near Gachalá), Mundo Nuevo, Buenavista, Chivor, Achiole und Sagrada Familia (near Somondoco).

subtropical mountain vegetation have made access for geological mapping and systematic prospecting very difficult.

Apart from the mines of Muzo and Chivor – renowned worldwide for the quality and quantity of their emeralds – there is supposedly a large number of smaller, less important diggings and mines (about 200), the names and locations of which are obscure or conflicting. Localities such as Borur, Borbur and Burbar are quoted, but it is conceivable that all these names refer to one and the same occurrence. The spelling of several mines also varies in literature (Cosquez/Cosquez, Peñas Blancas/Peña Blanca, etc.). Apart from further mines in the Colombian emerald belt, Kazmi & Snee (1989) mention an isolated occurrence in the Valle Andaluía (240 km WSW of Bogotá). Reports that emeralds have been found as far south as Ecuador, however, have not been confirmed (Schwarz, 1989a).

B1. Emerald deposits and their geological environment

The Colombian emeralds occur in dark, carbonaceous shales and thin, inter-layered limestones of early Cretaceous age, that is, about 120 to 130 million years old. This rock series was formed of chalky and argillaceous, marine and continental sediments of high organic content and is therefore grey to black in colour. Since the early Tertiary period, they have been lifted, folded, faulted and mineralized (Figure 1).

Emeralds appear enriched in places where large-scale tectonic faults once cut through the sediments. The Muzo district lies directly at the Rio Itoco fault (striking NW-SE) and the Chivor district at the San Fernando fault system (striking NE-SW). The emeraldiferous lodes and veins follow the minor lateral clefs as well.

In the so-called Villeta series of Muzo and in the somewhat older Caqueza series of Chivor the veins form sills and often fill out cavities and steep fissures. The emeralds preferably concentrate in the lower fold axes of the carbonaceous shales but especially at intersections of veins and clefs. The crossings seem to have offered quieter crystallization conditions creating an easier migration of mineral forming solutions than in the actual veins.

In the *district of Muzo* the emerald-bearing lodes and veins consist mainly of calcite and show thicknesses of a few up to 300 millimetres. In contrast, veins with dolomite, albite and baryte are frequently barren of emeralds (sterile). The calcite veins of Muzo are characterized by the following succession of parageneses (chronological sequence of mineral associations):

1. Calcite and pyrite,

2. *Main crystallization*: calcite, pyrite, dolomite, quartz and emerald with the accessory minerals parisite, albite, pink apatite and colourless fluorite,

3. Calcite, pyrite, dolomite and baryte.

Parisite is a very rare, brownish $\text{Ca}(\text{Ce}, \text{La}, \text{Di})$ -carbonate named after the Colombian José Ignacio Paris (last century).

The northern part of the *district of Chivor* is less well explored than the Gachalá and Muzo areas. In Chivor the veins are known to be poor in calcite, but rich in albite and pyrite, and found between or underneath nearly horizontal limonite beds. The crystallization sequence is:

1. Pyrite and quartz,

2. Pyrite, emerald and albite with subordinate apatite and dolomite.

Limonite (mainly goethite) on the one side and micas (muscovite, sericite, fuchsite) plus clay minerals (kaolinite) on the other side are encountered as dissociation products of pyrite and albite (the white feldspar). A second beryllium mineral, a bluish euclase ($\text{BeAl}[\text{SiO}_4]\text{OH}$, monoclinic), has been detected in company with the emeralds of Gachalá as well, although not often.

Omnipresent minerals in Muzo are calcite and pyrite and in Chivor pyrite and albite.

B2. Hypotheses of emerald genesis

The genesis of the emerald deposits is controversial. The postulation put forward most frequently in literature is the *formation from hydrothermal solutions*. This conclusion has been reached by studies of the paragenesis of the gangue (vein matrix) and of the homogenization temperatures of multi-phase inclusions in the emeralds (Kozłowski, *et al.* (1988) suggesting a minimum temperature of the fluids of 470°C, prior to taking into account a correction of at least +100°C for an overburden pressure of ≤ 1 kbar).

Fluid phases under pressure are exceptionally mobile and can easily travel long vertical distances. As hydrothermal differentiation products of magmatic crystallization cycles, they are thought to represent residual solutions which delivered the light elements Si, Al, Na, (Mg) and in particular the volatile beryllium. However, other origins of the solutions such as fossil and possibly marine waters from rock pores containing sodium and chlorine may be argued as well.

Rising through the fracture systems and clefs in the argillaceous, calcareous and evaporitic sediments characteristic of these parts of the Cretaceous succession, these brines in addition could have dissolved:

1. carbonates, sulphides, sulphates, fluorides, phosphates and quartz, all observed as gangue minerals,

2. the emerald colour-causing transition elements

Cr and V plus Fe,

3. the element Be (Escovar, 1979) and

4. some rare earths (Ottaway, *et al.*, 1986).

Generally it seems less likely that chromium and beryllium have been extracted or leached out from the limestone and clay rocks (except in the Gachalá area), in contrast to vanadium which is well known to be present geochemically in sediments with organic constituents such as those in the dark shales. Correspondingly, vanadium is observed in elevated concentration in the Trapiche emeralds of the Muzo district (Hänni, 1982). In addition, hardly

This appears to have happened in the area of the mines El Diamante and Las Cruces near Gachalá. In contrast, the wall rocks in the Muzo district are said to be unaltered.

The third variant of the hydrothermal hypothesis of emerald formation involves *circulating ground waters*. Such carbon dioxide-containing waters seep into inclined rock layers and fault systems, reach a certain depth and mineralize under the influence of heat and pressure. During their re-ascent, the waters become oversaturated due to decreasing temperature and pressure so that their mineral



Fig. 1. Two specimens of carbonaceous shale with calcite veins (one with abundant pyrite) and a pale emerald crystal group, about 4cm in length. All specimens from the Colombian mining district.

any metamorphic rocks, ultrabasic or acid bedrocks have been found in the wider vicinity of either mining district which could be considered as possible sources of Cr and Be (major ophiolitic and granitic rocks are present in the western Colombian cordilleras only, associated with important platinum and gold deposits).

A variant of the hydrothermal hypothesis is the concept of metasomatism, in which process individual minerals of the wall rocks are not only leached out by the hot brines, but are replaced materially (i.e. they are carbonatized and albitized).

contents are precipitated on the side walls of the clefts.

However, the postulation of hydrothermal formation must be re-examined in view of the facts that the hypersaline brines have been at temperatures of up to 600°C and that in many places they have apparently not affected the wall rocks of the emerald veins at all. For the time being, the origins of beryllium, chromium and water (fossil rock porosity waters originally of marine provenance, from depths of $\geq 5000\text{m}$?) also remain unexplained.

According to Kazmi & Snee (1989), the suture

zones of the earth's crust contain the highest potential for emerald deposits in the world. Examples are the broad collision belt between the Indian sub-continent and the Eurasian plate in North Pakistan and Afghanistan and to a lesser extent the Ural mountains and the vicinity of the African Rift Valley (Egypt, Tanzania, Moçambique). The collision of submarine ultrabasic rocks and acid plutons, with their geochemically increased contents of chromium and beryllium respectively, would alone offer the rare and favourable conditions for the formation of emeralds in these suture zones. The Cordillera Oriental in Colombia also represents a collision zone (in front of the north-west drifting Guyana plate). In the author's judgement (cf. C5. Inclusions and growth characteristics, footnote 7), the Colombian emerald belt has yet to give up the secret of its possibly remote chromium and beryllium sources.

B3. The Mine Workings

Since the end of the last century the Colombian mines have had an eventful history. At times the mines were in private hands, sometimes they were supervised by the Government or the Banco de la República. Alongside these more or less strictly controlled forms of management, a tolerated black market fed by the unorganized *guaqueros* (treasure hunters) has for a long time been an important economic factor. These *guaqueros* search the waste washed down to the river beds below the mines. Nationalized mining also suffered heavy losses after the closure of the Muzo mines from 1973 to 1977 due to a series of murders. Today the whole district is a prohibited area, closely guarded by the army.

Since 1978 private companies were given mining leases by the State for five year periods. It is said that such short contracts (today the leases are for ten years) force the managements to use dynamite as well as bulldozers and pressurized water to move large rock masses. This is a very questionable development in operating the mines, with immense effects on the ecology of the environment.

Over the centuries, the *Muzo* mines have yielded by far the largest and most constant production of emerald in the world (1986 estimated to be an enormous 300,000 ct). Until approximately 20 years ago, these mines were worked almost exclusively by open-cast methods in small terraces, but from then on by massive removal of complete rock layers. Presently it is planned to convert to modern underground mining.

The neighbouring *Coscuez* mine has also been worked for 400 years, but this deposit has been marked by long periods of inactivity. In the past few years, however, *Coscuez* has overtaken *Chivor* as the second largest producer with an estimated yearly

output of 150,000 ct (1986). Because of the clear concentration of emeralds in large clefts, tunnelling is the preferred method of mining.

Chivor, historically the oldest mine, has had production peaks and total break-downs since the times of the Conquista. At present the output appears to be fairly low. *Chivor* was and still is essentially an open-pit benching operation, but there is some underground mining too.

The mines near *Gachalá* were discovered in 1953 and flourished during the fifties and sixties. Since then the emeralds from these mines are hardly ever encountered on the gem market.

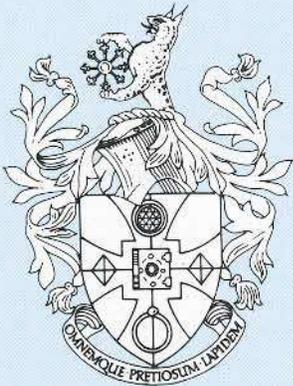
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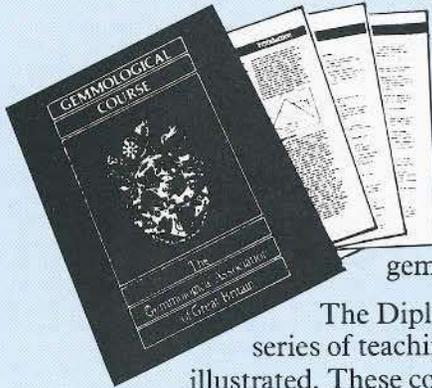
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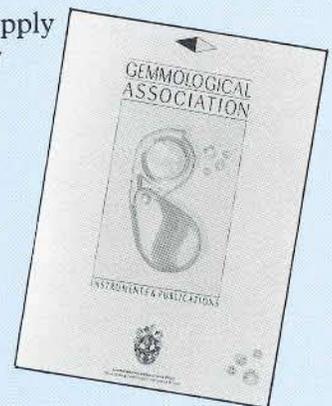
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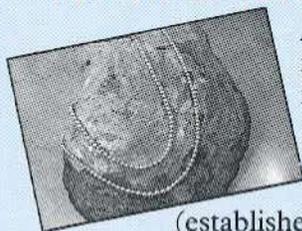
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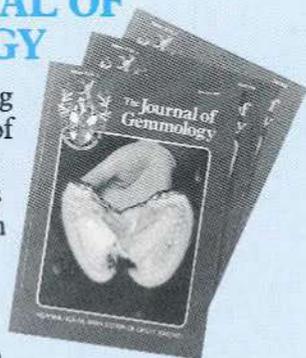
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Sodium polytungstate as a gemmological tool

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Currently, the use of heavy liquids is probably the most noxious activity of gemmologists. Aside from health factors, these liquids are foul smelling and are light sensitive. They decompose into acidic and/or corrosive products and they are not reclaimable. There ought to be a better approach – and there is. It utilizes a substance known as sodium polytungstate (Ref. 1,2,3,4).

Pure sodium polytungstate ($3\text{Na}_2\text{WO}_4 \cdot 9\text{WO}_4 \cdot \text{H}_2\text{O}$) is a white crystalline powder. It is not volatile and has no odour. Sodium polytungstate is both heat and light stable. It is easily dissolved in water, easily rinsed from a gem, and can be easily reclaimed. It is non-reactive, and its solutions are neutral.

Sodium polytungstate is available in small quantities as a solution of 2.8 g/cm³ density for \$12 per ounce from Hanneman Gemological Instruments, P.O. Box 2453, Castro Valley, CA 94546. Densities as high as 3.1 g/cm³ are easily prepared. A dropper is supplied to facilitate dilutions.

Safety

As is true with all substances, the dose makes the poison. Consequently, not even water or oxygen can be guaranteed to be completely safe. Currently there is no evidence at all that sodium polytungstate causes health problems for its users (Ref. 2,4). It produces no fumes and is not absorbed by the skin. Nevertheless, one obviously should not eat it, and one should keep it away from children. In any case, in all aspects it is a vast improvement over the organic bromine compounds currently being used.

Use of sodium polytungstate solutions

Gemmologists accustomed to using the traditional heavy liquids should have few problems adjusting to the use of sodium polytungstate solutions. They are simply a high concentration of an inorganic salt dissolved in water. Consequently, if left open to the atmosphere, the water will evaporate, leaving the white salt. However, the solution can be easily reconstituted by replacing the water.

Whenever a gem is removed from this heavy

liquid solution, both the stone and the stone tongs should be dipped into a container of rinse water. Any 'lost' sodium polytungstate can be reclaimed later by simply allowing the rinse water to evaporate.

Retrofitting heavy liquid sets

The simplest type of retrofit for practising gemmologists (especially those with several sets of bottles containing dried up and/or decomposed heavy liquid solutions) is to clean out the old bottles and, using the same reference stones, replace the liquids with appropriate solutions of sodium polytungstate. This service is also provided by Hanneman Gemological Instruments.

Determination of density using sodium polytungstate solutions

The determination of any density below the value of 3.10 g/cm³ on any gemmological specimen can be easily accomplished using sodium polytungstate solutions. The procedure starts with a saturated solution of sodium polytungstate or one in which the test specimen floats. Then, by the careful addition of water by means of a dropper, the density of the solution is reduced to the point at which the specimen just remains suspended. The density of the solution now matches that of the gem. A drop of the liquid is then removed, and its refractive index (n_D) is determined on any gemmological refractometer. This value is compared with the graph shown in Figure 1 from which the density can be determined.

Alternatively the density can be calculated by using the following equation:

$$\text{Density (g/cm}^3\text{)} = 2.80 + 8.43 (n_D - 1.555)$$

Notes on the use and preparation of solutions

When making solutions of sodium polytungstate, only distilled, deionized, or softened water should be used. The presence of calcium ions will cause the formation of a fine white precipitate. If this should happen, either ignore it or allow it to settle to the

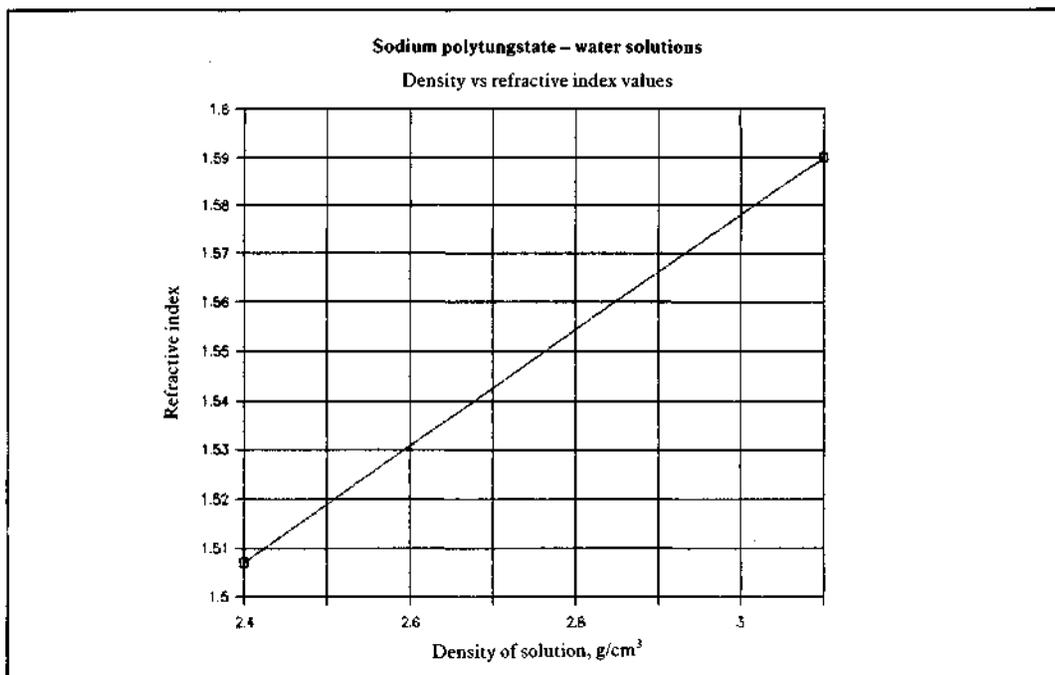


Fig. 1. Graph showing the relationship between refractive index and density of sodium polytungstate solutions.

bottom and remove it.

The solubility of the sodium polytungstate in water is enhanced by heat. Supersaturated solutions are easily prepared by the addition of solid salt to a warmed solution. On standing overnight, crystals will form as the supersaturated solution becomes merely saturated. The density of this solution is about 3.10 g/cm³. Probably the best way to maintain your sodium polytungstate stock solution is as a saturated solution with a few crystals in the bottom.

Unlike organic heavy liquids, there is only a minor change in density when a warm solution cools. Since the refractive index also changes, there is a built-in temperature compensation. As a practical matter, as long as density values are expressed to only two decimal places, the effects of temperature can be neglected.

Sodium polytungstate can be reclaimed from solutions at any time by allowing the water to evaporate. Overnight, in an open vessel, will usually be sufficient. Heat will accomplish it in a very short time. It is not necessary to go to complete dryness. Nevertheless, it is usually helpful to have a small quantity of dry salt available for adjusting densities upward. This is simpler than evaporation.

Any powdery film of salt remaining on a gem, tool, or refractometer surface can be removed by wiping with a soft damp cloth.

Densities above 3.1 g/cm³

From the preceding, it is apparent sodium poly-

tungstate solutions cannot replace pure methylene iodide (density 3.32 g/cm³). Because of its high refractive index (1.73), methylene iodide is extremely useful as an immersion liquid for the microscopic examination of the corundum gems. Consequently, methylene iodide probably always will remain a vital component of the gemmologist's arsenal. As such, it will still be available for density determinations. Fortunately, of all the heavy organic liquids, methylene iodide is probably the least noxious.

On the other hand, for those workers who wish to obviate all heavy organic liquids as well as the highly toxic Clerici Solution, the Hanneman Direct Reading Specific Gravity Balance (Ref. 5) is the most cost-effective approach.

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Spessartine garnet in Brazilian topaz

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Fig. 1. Two of the six topaz crystals examined for this report. The larger of the two measures approximately 24 millimetres in length. Note the orange-coloured inclusion clearly visible in the smaller crystal. *Photograph by Robert Weldon.*

Abstract

Spessartine garnet inclusions were identified in topaz crystals from an area north of Teófilo Otoni in Minas Gerais, Brazil. The inclusions were studied using a combination of optical microscopy and X-ray powder diffraction analysis.

Introduction

The topaz crystals examined for this report were obtained in February 1990 in Tucson, Arizona at the annual gem and mineral show. Natalino Eugenio de Oliveira, a Brazilian mineral dealer from Belo Horizonte had a collection of approximately 40 of these crystals ranging in size from about 1 to 6

centimetres in length. He stated that they had been mined from a small granitic pegmatite near the town of Padre Paraíso in Minas Gerais, Brazil, approximately 100 kilometres north of Teófilo Otoni on highway 116.

One of the authors purchased six of these crystals for examination, two of which are shown in Figure 1. The crystals were sold only as topaz, and while some of them had prominent eye-visible mineral inclusions of a slightly pinkish-brownish orange colour, no mention was made of them by Mr. Oliveira. It was, however, these inclusions that were of interest to the authors.

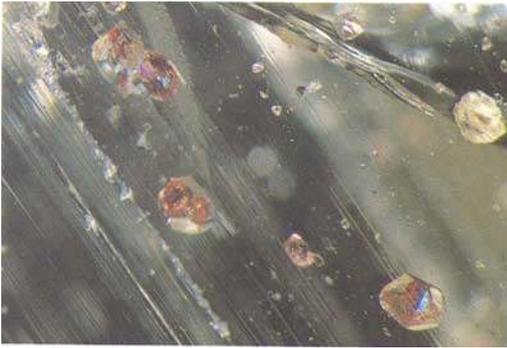


Fig. 2. Several well-defined spessartine garnets lie just beneath a prism face of their host topaz. Photomicrograph by John I. Koivula. Magnified 5 \times .

Description

The colour of the topaz crystals was a very pale brownish-yellow, possibly resulting, at least in part, from the presence of brownish-yellow limonitic stains in surface-reaching pits and fractures. A well-developed prismatic form, typical for topaz, was common to all these crystals (Figure 1). The terminations were a combination of pyramid faces and pinacoids, while the bases looked to be cleavage planes modified by very light etching.

The inclusions in all of the topaz crystals were confined to the near-surface area (Figure 2). They showed a slightly pinkish brownish orange colour as previously mentioned, with a transparent to translucent diaphaneity. Initial examination with a gemmological microscopic revealed an outward shape of the inclusions that suggested an isometric structure. While some of the inclusions exhibited distorted forms, others showed obvious dodecahedral symmetry (Figure 3). The reported pegmatitic origin of the topaz hosts together with the generally isometric appearance and colour of the inclusions, suggested that the inclusions might be spessartine garnet.

As all of the inclusions were completely enclosed by the host topaz it was decided that one of the crystals would be broken in order to expose some of the inclusions for analysis by optical microscopy and X-ray diffraction.

A rock and mineral splitter was therefore used to accomplish the task of exposing the inclusions for further study. Once the topaz was broken one of the largest inclusion fragments was removed from its host and placed on a 3 \times 1 inch glass slide for microscopic examination. The inclusions, still attached to the freshly broken topaz surface, were set aside for X-ray powder diffraction analysis.

Optical microscopy

The inclusion fragment on the glass slide was centred on the stage of a Zeiss research microscope

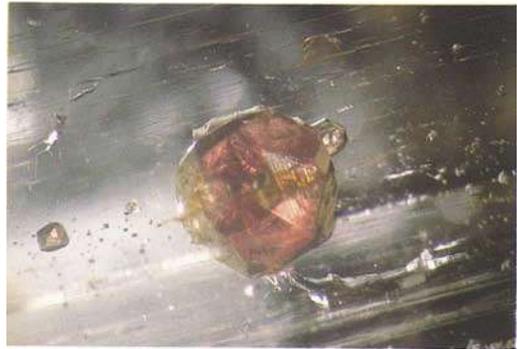


Fig. 3. The largest of the inclusions, a 1.7 millimetre spessartine garnet exhibiting distinct isometric symmetry. Photomicrograph by John I. Koivula.

and a tiny drop of refractometer contact liquid (RI 1.81) was placed on the fragment. When so immersed the fragment virtually disappeared, showing that the inclusion and the liquid were almost identical in refractive index. Examination of the inclusion with polarized light while immersed in the liquid proved it to be isotropic.

Next, brightfield illumination was employed. The microscope was critically focused on the fragment and the stage lowered, increasing its distance from the objective lens. This caused the bright Becke line to move slightly outward into the liquid, proving that the liquid (1.81) had an index of refraction higher than the inclusion. The results showed that the inclusion's refractive index was within the range previously established for spessartine garnet (Liddicoat, 1989; Anderson, 1990).

X-ray diffraction

Using a glass fibre, a spindle was prepared for X-ray powder diffraction from a minute amount of powder obtained by scraping one of the inclusions exposed at the topaz crystal's surface. The spindle was mounted in a Debye-Scherrer powder camera and exposed for 13 hours to X-rays generated from a copper target tube by a voltage of 46 kilovolts and a current of 26 milliamperes. Once exposed, the film was developed and allowed to air-dry.

Because spessartine was initially suspect, the resulting pattern was first compared to our standard file pattern for this garnet. The result was a perfect match, indicating structure very close to the (pure) spessartine end member.

Conclusion

Optical microscopy and X-ray diffraction were used to identify the euhedral to slightly distorted high-relief inclusions in these topaz crystals as spessartine garnets. The distinct shape and near-surface entrapment of the inclusions are typical of late-stage syngenetic growth.

This is not the first time that spessartine garnet has been identified as an inclusion in topaz (Gübelin and Koivula, 1986). However, this is the first time that the authors have had the opportunity to examine specimens that are so locality-specific.

Topaz and spessartine garnet are both known to occur in complex granitic pegmatites (Roberts, Campbell and Rapp, 1990). They are sometimes found as well-formed, gem-quality crystals in the core-zone of these pegmatites, in 'gem pockets' (Shigley and Kampf, 1984). Within these 'pockets' topaz is the more common of the two minerals. Because of its chemistry, topaz can crystallize late in the development of a 'pocket', as can spessartine for the same reason. The near-surface location of the spessartine inclusions in these topaz crystals indicates that a single cycle of garnet growth occurred near the end of the growth cycle of the topaz (James E. Shigley, *personal communication*).

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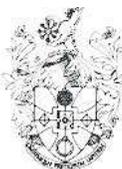
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Gemmological Abstracts

ARJALAGUER I VILARDELL, D., 1990. Abaco para determinación de los precios aproximados de los diamantes con talla brillante de River a Top Cape y para las purezas de Internally flawless a Pique en el intervalo de pesos de 0.25 a 3.00 quilates. (Abacus for determining the approximate prices for brilliant-cut diamonds from River to Top Cape and from clarity grades Internally Flawless to Pique with weight intervals from 0.25 to 3.00 ct.) *Gemologia*, 32, 85/86, 5-11, 1 loose chart.

An abacus [chart] is proposed for the determination of brilliant-cut diamond prices within certain qualities and clarity grades. M.O'D.

BANK, H., HENN, U., 1990. Künstlich gefärbte Quarze als Imitationen für Smaragd, Rubin und Saphir. (Artificially dyed quartzes as imitations for emeralds, rubies and sapphires.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 147-51, 7 figs (6 in colour), bibl.

The raw materials for these imitations are transparent to translucent quartzes, i.e. rock crystal to milky quartz. Both rough crystals and cut stones have been examined by the authors. Cracks are artificially induced, then the dye concentrates in these cracks, colouring them green, red or blue. According to CIBJO regulations these stones must be offered as artificially irreversible (or permanently) dyed agates. E.S.

BANK, H., HENN, U., 1990. Geschliffener, rosa-farbener Hodgkinsonit aus Franklin Furnace, New Jersey, USA. (Cut, pink hodgkinsonite from Franklin Furnace, New Jersey, USA.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 273-4, bibl.

The authors describe the physical data of cut, pink hodgkinsonite from Franklin Furnace in New Jersey. Hodgkinsonite is a silicate of the eucalderite-hodgkinsonite group $MnZn_2[(OH)_2SiO_4]$ and is monoclinic-prismatic. SG 3.98, RI values $n_x = 1.720$, $n_y = 1.739$, $n_z = 1.743$. DR 0.023. E.S.

BANK, H., HENN, U., PLATEN, H.V., 1990. Geschliffener, durchsichtiger, gelbbrauner Parisite aus Muzo, Kolumbien. (Polished, transparent, yellowish-brown parisite from Muzo, Colombia.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 229-32, 1 graph, 1 table, bibl.

Parisite is a well-known inclusion material of emerald. It is also found in Muzo in combination with emerald, pyrites, marcasite, dolomite, albite, calcite, quartz and gypsum. The authors examined a faceted specimen which was transparent and yellowish-brown. SG 4.33-4.34, RI 1.671-1.772, DR 0.101, hardness 4-4½. The stone showed a distinct rare earth spectrum Nd^{3+} and Pr^{3+} . E.S.

BARTOLI, F., BITTENCOURT ROSA, D., DOIRISSE, M., MEYER, R., PHILIPPY, R., SAMAMA, J.-C., 1990. Role of aluminium in the structure of Brazilian opals. *European Journal of Mineralogy*, 2, 5, 611-19, 6 figs.

Major and trace element analyses by ICP of precious opals from the State of Piauí, NE Brazil, show that the Al_2O_3 content appears to be the major control on the close-packed structure of silica spheres, surface properties and colour. The Al-poor opals (Al_2O_3 0.6=1.3 wt.%) are white-yellow to dark yellow, relatively well ordered and associated with sandstones; their physically adsorbed water is lower (2.6=3.4 wt.%) than in Al-rich opals. In contrast, the Al-rich opals (Al_2O_3 1.4=1.8 wt.%) and hydrated opals (physically adsorbed water 3.8=4.9 wt.%) present blue iridescence due to a less dense packing of silica spheres; they occur in claystones. The IR, XRD and DTA patterns all show that the substitution of Al for Si in the tetrahedral network is a function of the Al_2O_3 content. R.A.H.

BECK, R.J., 1983. A new development in understanding: the prehistoric usage of nephrite in New Zealand. *Bulletin of the Friends of Jade*, 3, 48-53, 5 figs.

After a general note on New Zealand nephrite, an account is given of experiments to duplicate the appearance of prehistoric artefacts by heating. Hardness tests are also described. M.O'D.

BENTE, K., THUM, R., WANNEMACHER, J., 1991. Colored pectolites, so-called 'Larimar' from Sierra de Baoruco, Barahona Province, southern Dominican Republic. *Neues Jahrbuch für Mineralogie, Monatshefte*, 1, 14-22, 2 figs.

Pectolites from the Sierra de Baoruco, Dominican Republic, are found in white to greenish and light

bluish to blue colours. They form part of hydrothermal alteration products within a picritic basalt of Cretaceous age. Formation temperature is thought to have been below 240°C. M.O'D.

BIANCHI POTENZA, B., DE MICHELE, V., LIBORIO, G., NANA, G.P., 1989. L'olivina della Val Malenco (Sondrio) come materiale di interesse gemmologico. (Olivine from the Val Malenco (Sondrio) as a material of gemmological interest.) *La Gemmologia*, 14, 3/4, 23-33, 15 figs (12 in colour).

Green transparent olivine from the Giuel quarry in the Val Malenco, Sondrio, Italy, has SG 3.39, RI 1.661, 1.679, 1.699. Composition is close to 85.7 mol% forsterite, 14.0 mol% fayalite and 0.3 mol% tephroite. Serpentine fibres and colourless diopside crystals are found as inclusions. M.O'D.

BITTENCOURT, ROSA D., 1990. Les opales nobles du District de Pedro II dans l'Etat de Piauí-Région Nord-Est du Brésil. (Precious opal from the Pedro II district in the state of Piauí, north-east Brazil.) *Revue de Gemmologie*, 104, 3-7, 14 figs (3 in colour).

Precious opal is reported from the Pedro II district of Piauí state, north-east Brazil. The opals have a comparatively low water content and should be stable. Quality is said to be good. M.O'D.

BLANKENSHIP, D.T., 1985. The toughness of nephrite. *Bulletin of the Friends of Jade*, 4, 56-60.

The toughness of nephrite is discussed with particular reference to modern lapidary methods. M.O'D.

BLEIKER, R., 1991. Die berühmte chilenische Lapis-Lazuli-Lagerstätte bei Ovalle, Region Coquimbo. (The famous Chilean lapis-lazuli location near Ovalle, Coquimbo region.) *Lapis*, 16, 1, 18-23, 10 figs (8 in colour).

Lapis-lazuli is found in Chile near Ovalle in the Coquimbo region on the border with Argentina. Geological details of the occurrence are given. M.O'D.

BOSSHART, G., 1990. Les émeraudes de Colombie. (Colombian emeralds.) *Revue de Gemmologie*, 105, 13-16, 1 fig. in colour.

The paper introduces the history of Colombian emerald mining and goes on to describe the geography of the mine sites. Emerald formation and properties are discussed and there are notes on exploitation. M.O'D.

BROWN, G., 1985. Detecting dyed jadeite. *Bulletin of the Friends of Jade*, 4, 28-32, 1 fig.

Standard gemmological tests for jadeite are outlined. M.O'D.

CASSEDANNE, J., 1990. Un nouvel indice de microcline gemme à Minas Gerais. (A new variety of gem microcline from Minas Gerais.) *Revue de Gemmologie*, 104, 13-14, 6 figs (2 in colour).

A hyaline variety of microcline is reported from Fazenda Bel Vista, or Corrego do Luis, Minas Gerais, Brazil. The microcline occurs in a pegmatite and has SG 2.57, H 6.5, and RI 1.518, 1.522 and 1.525 with a DR of 0.007. No absorption spectrum nor luminescence could be detected. Various inclusions are described. M.O'D.

CASSEDANNE, J., 1990. Un nouveau matériau gemme: le quartzite à lazulite (Bahia-Brésil). (A new gem material: lazulite in quartzite from Bahia, Brazil.) *Revue de Gemmologie*, 105, 117-18, 3 figs in colour.

Gem quality translucent to opaque blue lazulite is reported from a quartzite in the north-west of the state of Bahia, Brazil. The locality is between the valleys of the Rio Paramirim in the east and the São Francisco, in the west. Cabochons cut from the lazulite have SG 2.76, RI 1.603-1.635 and 1.639-1.674. Stones appear a greyish-maroon through the colour filter. Neither luminescence nor a useful absorption spectrum were observed. M.O'D.

CASSEDANNE, J.P., ALVES, J., 1990. Crystallized rose quartz from Alto da Pitorra, Minas Gerais, Brazil. *Mineralogical Record*, 21, 5, 409-12, 7 figs (6 in colour).

Fine crystallized rose quartz is reported from Lavra [mine] da Pitorra, on the northern slope of the Serra da Piorra range, 8km east north east of Galilea, Minas Gerais, Brazil. The quartz occurs in radiating clusters, in groups of parallel to subparallel prisms and as isolated crystals. M.O'D.

CHENG, TE-K'UN, 1985. Chinese jade exhibition, Chengtu 1945. *Bulletin of the Friends of Jade*, 4, 61-6.

An introduction to Chinese jade in general precedes details of a jade exhibition held in Chengtu in 1945. Chinese characters for the basic jade artefact shapes are given. M.O'D.

CHIHARA, K., 1989. (JADEITE IN GUATEMALA.) *Journal of the Gemmological Society of Japan*, 14, 1/4, 26-35, 10 figs. (In Japanese.)

Geology, petrology, mineralogy and usage of Guatemalan jadeite are discussed. M.O'D.

COENRAADS, R.R., 1990. Key areas for alluvial diamond and sapphire exploration in the New England gem fields, New South Wales, Australia. *Economic Geology*, 85, 1186-207, 19 figs.

At least two distinct periods of volcanic activity

are recorded for the Tertiary Central volcanic province which includes the New England gem fields of New South Wales, Australia. These define key areas for diamond and sapphire exploration. Other gem minerals found with sapphire include zircon, rare chrysoberyl and chrome spinel in the placer deposits and in nearby basaltic soils olivine and enstatite have been found. M.O'D.

CONKLIN, L.H., 1990. The Harvard diamond crystal. *Matrix*, 1, 6, 90-2, 3 figs (1 in colour).

A yellow diamond crystal weighing 84 ct and of octahedral form was stolen from the Harvard mineral museum in 1962. The history of the crystal is given. M.O'D.

CORONA-ESQUIVEL, R., BENAVIDES-MUÑOZ, M.E., 1989. Excursión de la Sociedad Mexicana de Mineralogía a las minas de ópalo del Estado de Querétaro. (Excursion to the Querétaro opal mines by the Sociedad Mexicana de Mineralogía.) *Boletín de Mineralogía*, 4, 1, 80-5, 3 figs.

Details of the opal mines in the Mexican state of Querétaro are given with notes on the geology and mineralogy. The most important of the mines are La Carbonera and Santa María Iris, both north of the town of San Juan del Río. M.O'D.

COZAR, J.S., 1989. Determinación de rasgos de tratamiento, en topacios azules irradiados, por espectroscopia gamma de alta resolución. (Determination of signs of treatment in irradiated blue topaz by gamma-ray spectroscopy.) *Boletín del Instituto Gemológico Español*, 31, 8-18, 14 figs (8 in colour).

Gamma-ray spectroscopy is ruled to be the only method of distinguishing natural from irradiated blue topaz. M.O'D.

COZAR, J.S., SARMIENTO, L., BARBOSA, J.E., 1990. Trifilita gema. (Triphylite as a gemstone.) *Boletín del Instituto Gemológico Español*, 32, 31-6, 14 figs (7 in colour).

Orange-brown triphylite from Minas Gerais, Brazil, has SG 3.51, RI 1.689, 1.693, 1.698 with DR 0.007. M.O'D.

CURRAN, R.T., 1988. A Hamlin Mount Mica tourmaline. *Matrix*, 1, 5, 77-8, 2 figs.

A crystal from the collection of the Hamlin family has come to light in the author's collection. A cavity at Mount Mica was opened by Augustus C. Hamlin in 1868 although the first tourmaline discoveries in the area date back to the 1820s. The crystal measures 1½ inches in length and weighs approximately 60 ct. The colour is fine blue-green. M.O'D.

DE MICHELE, V., 1988. Kamienie szachetne i ozdobyne wloch. (Gem materials of Italy.) *Mineralogía Polonica*, 19, 2, 127-36, 1 fig.

Translation of a paper first appearing in *La Gemmologia*, 7, 3/4, 17-25, 1981. M.O'D.

DIEHL, R., MENG, K.H., 1990. Ein graviertes Kashmir-saphir. (An engraved Kashmir sapphire.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 193-200, 7 figs (1 in colour), bibl.

The sapphire weighed 6.175 ct and measured 12.19 x 10.04 x 5.32 mm, antique cut. 32 crown facets and 4 x 16 facets on pavilion. Thin girdle. Silk and microscopic inclusions showed it to be of Kashmir origin. The engraving represents a lion sitting on a crown. The sapphire was found to have been engraved with fine diamond points using non-rotating tools. Due to the complexity of the motif, the documents thus sealed could not be forged. It is assumed that the seal was used by an Indian ruling family, probably Sikh, but origin and age are not known, although this sapphire has been used frequently as an official seal. E.S.

FERREIRA, J.A.M., KARFUNKEL, J., SILVA, L.T., 1990. Turmaline mit ungewöhnlich intensiven Farben von Salgadinho, Paraíba, Brasilien. (Tourmalines with exceptionally intensive colours from Salgadinho, Paraíba, Brazil.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 165-7, bibl.

This new find in Paraíba in the north east of Brazil consists of four small occurrences in Salgadinho. The tourmaline crystals are up to one metre in length, but internally flawed due to tectonic movements. The cuttable stones are therefore relatively small. Colours are particularly intense and occur as emerald green to red, aquamarine-blue to violet. Multi-coloured stones are no exception. Some physical and chemical data are added. E.S.

FLINT, D.J., DUBOWSKI, E.A., OLLIVER, J.G., 1985. Latest report on Cowell jade. *Bulletin of the Friends of Jade*, 4, 82-5.

More than one hundred outcrops of nephrite have been found since 1966 in the Cowell area of the Eyre Peninsula, South Australia. Country rocks are quartzo-feldspathic gneiss and dolomitic marble. M.O'D.

FREY, R., 1983. Jade in Korea. *Bulletin of the Friends of Jade*, 3, 66-69, 4 figs.

Several colours of nephrite are found in Korea, a large deposit of white-to-cream material being particularly valuable. This occurs at the Chuncheon mine situated near the city of the same name, about

70 km north-east of Seoul.

M.O'D.

FRIESE, B., 1991. Morphologie und Entstehung der Sternsaphire aus Zaire. (Morphology and origin of star sapphires from Zaire.) *Aufschluss*, 42, 47-52, 11 figs (10 in colour).

Star sapphire with a yellowish-brown background and a dark star is reported from Zaire.

M.O'D.

FUERTES MARCUELLO, J., GARCIA GUINEA, J., 1990. Caracterización mineralógica e histórica del larimar de Barahona (República Dominicana). (Mineral characteristics and history of larimar from Barahona, Dominican Republic.) *Boletín del Instituto Gemológico Español*, 32, 6-12, 11 figs in colour.

The ornamental blue variety of pectolite, larimar, is found at Barahona in the Dominican Republic. Characteristics and mining history are given.

M.O'D.

GRICE, J.D., BOXER, G.L., 1990. Diamonds from Kimberley, Western Australia. *Mineralogical Record*, 21, 6, 550-64, 9 figs (3 in colour).

The Argyle AK1 mine is producing the largest number of diamonds in the world at the time of writing. Pink stones are conspicuous in the production and 'cognac', yellow 'champagne', apricot, green and blue stones are also found.

M.O'D.

GROAT, L.A., RAUDSEPP, M., HAWTHORNE, F.C., ERCIT, T.S., SHERRIFF, B.L., HARTMAN, J.S., 1990. The amblygonite-montebrazite series: characterization by single-crystal structure refinement, infrared spectroscopy and multinuclear MAS-NMR spectroscopy. *American Mineralogist*, 75, 992-1008, 9 figs.

The F = OH substitution in the amblygonite-montebrazite series is referred to a battery of tests.

M.O'D.

GRUBESSI, O., AURISICCHIO, C., CASTIGLIONI, A., 1989. Lo smeraldo delle miniere dei faraoni. (Emerald mines of the Pharaohs.) *La Gemmologia*, 14, 1/22, 7-21, 9 figs (5 in colour).

Emeralds found in a quartz and mica schist with phlogopite, plagioclase and calcite at Djebel Zabarah, Egypt, are thought to be similar to stones used in early Egyptian jewellery. They are akin to Habachtal stones in properties and appearance.

M.O'D.

GRUNDMANN, G., SCHÄFER, W., HOFER, H., 1991. Smaragde aus der Kesselklamm, eine interessante Neuentdeckung im Untersulzbachtal. (Emerald from the Kesselklamm, an interesting new discovery in the Untersulzbachtal.) *Lapis*,

16, 2, 37-46, 20 figs (14 in colour).

Emerald has been found on the Kesselklamm in the Austrian Untersulzbachtal. The area is south-east of Neukirchen and the emeralds, some crystals of which reach 7 mm in length, occur in a biotite schist.

M.O'D.

HÄNNI, H.A., 1990. Les gemmes du groupe des beryls. (Gemstones of the beryl group.) *Revue de Gemmologie*, 104, 8-12, 8 figs in colour.

Gemstones of the beryl group are described and some notable specimens illustrated.

M.O'D.

HÄNNI, H.A., 1990. Ein Beitrag zu den Erkennungsmerkmalen der Kaschmir-Saphire. (A contribution to the determination of Kashmir sapphires.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 107-20, 21 figs (9 in colour), bibl.

More than fifty cut Kashmir sapphires were investigated. The detected inclusions confirmed those previously described in literature. Those specifically examined were tourmaline, pargasite, zircon, plagioclase, uraninite, allanite and probably rutile. Specific healing fissures and growth characteristics and spectral peculiarities are discussed.

E.S.

HEMRICH, G.L., 1983. The jade work of India. *Bulletin of the Friends of Jade*, 3, 54-7.

The article discusses the origin of the jade pieces in the collection of the Moguls. Afghanistan is suggested as a place of origin for some of the pieces.

M.O'D.

HENN, U., 1990. Cordierit aus Süd-Norwegen. (Cordierite from south Norway.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 99-106, 5 figs (4 in colour), 1 table, bibl.

The cordierite occurrence in south Norway lies a few kilometres away from Kragero, in an aventurine-feldspar-rich pegmatite layer surrounded by Precambrian para-gneiss and amphibolitic zones. RI 1.532-1.534 to 1.537-1.540, DR 0.010-0.012. SG 2.55-2.57. The pleochroic colours are blue, bluish-violet and yellow, caused by iron. The spectrum shows two bands at 936 and 573 nm, caused by iron. There are hematite platelet inclusions causing the aventurism and/or a cat's-eye effect.

E.S.

HENN, U., BANK, H., 1990. Über die Farbe der Sodalith-Mineralen: Sodalith, Lasurit (Lapis lazuli) und Hauyn. (About the colour of the sodalite minerals: sodalite, lazurite (lapis-lazuli) and hauyne.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 159-63, 1 table, 1 graph, bibl.

The article summarizes the causes of colour in minerals of the sodalite group. Colour centres are

responsible for the colour. The blue colour is caused by SO_3^- or O^- centres, while sulphur complexes like SO_4^- or SO_3^- and S_3^- or S_2^- are responsible for the blue colour in lazurite and haüyne. S_2^- centres are the reason for the orange-red luminescence. E.S.

HENN, U., BANK, H., BANK-SCHERNER, M., 1990. Rubine aus dem Pamir-Gebirge, UdSSR. (Rubies from the Pamir mountains, USSR.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 201-5, 6 figs (1 in colour), bibl.

The cuttable rubies originate in a marble zone of the Pamir mountains in the USSR near to the Chinese border. The red, reddish, and violet-red stones have an SG 3.98, RI $N_e = 1.761-1.762$, $n_o = 1.769-1.770$, DR 0.008. Under the microscope one can see twinning lamellae, healing cracks, fluid inclusions, rutile dust and distinct growth striae. Trace elements were found to be chromium, iron and titanium. The absorption spectra showed typical Cr bands and the fluorescence is strong red. E.S.

HUNSTIGER, C., 1990. Darstellung und Vergleich primärer Rubinorkommen in metamorphen Muttergesteinen. Petrographie und Phasenpetrologie. Teil III. (Presentation and comparison of primary ruby occurrences in metamorphic rock. Petrography and phase petrography. Part III.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 121-45, 7 figs (4 in colour), 3 tables, extensive bibl.

Part III of this article deals with the formation of rubies in marble, in more detail with the occurrences in Prilep in Macedonia, where the rubies of irregular shape occur in white marble. The corundum found in Passo Campolungo/Passo Cadonighino in Switzerland is found as ruby as well as sapphire. Other ruby-carrying marbles mentioned are those in Stirigma in Greece and those in Hunza, Kashmir. The petrology of rubies in marbles and dolomites is discussed. Further occurrences described are those in Mangari in Kenya, in kyanite, tourmaline and feldspar rock, those found in Ngorongoro in Tanzania, found in anatextite, as well as finds in O'Briens Claim, Zimbabwe, Mashishimala in South Africa, three mines in Madagascar (Vatomandry, Ankaratra and Gogogogo) and finally those in Malawi. In the majority of cases the rubies seem to be a decomposition product. E.S.

KAMMERLING, R.C., KOIVULA, J.I., 1990. An update on assembled emerald specimens from Africa. *South African Gemmologist*, 4, 3, 9-15, 4 figs in colour.

Supposed emerald crystals from Zambia turned out to be colourless quartz fragments cemented with a green epoxy-like material. M.O'D.

KAMMERLING, R.C., KOIVULA, J.I., 1990. An investigation of a dyed quartzite resembling sugilite. *South African Gemmologist*, 4, 3, 20-7, 3 figs in colour.

A dyed quartzite was confused with manganooan sugilite from the Wessels Mine near Kuruman, South Africa. The colouring is seen to be concentrated in fractures. M.O'D.

KATO, M., 1989. (Nomograph for calculating facet cutting angles.) *Journal of the Gemmological Society of Japan*, 14, 1/4, 12-15, 4 figs. (In Japanese.)

Nomographs are presented for the purpose of evaluation of facet cutting angles. M.O'D.

KATO, M., 1989. (Nomographs for diamond incidence-radiation.) *Journal of the Gemmological Society of Japan*, 14, 1/4, 16-20, 4 figs. (In Japanese.)

Four nomographs are presented to illustrate the elucidation of scintillation in diamond. M.O'D.

KATO, M., 1989. (Nomographs of diamond incidence-radiation on a pavilion.) *Journal of the Gemmological Society of Japan*, 14, 1/4, 21-5, 4 figs. (In Japanese.)

Nomographs are used to illustrate the passage of light through the pavilion of diamond. M.O'D.

KATO, M., 1988. (The scintillation by the incident rays through the pavilion.) *Journal of the Gemmological Society of Japan*, 13, 1/4, 13-19, 15 figs. (In Japanese.)

The paper discusses how to counteract loss of some of the incident rays through the pavilion of gemstones. M.O'D.

KATO, M., 1988. (Incidence-radiation relations between the incident rays through the pavilion.) *Journal of the Gemmological Society of Japan*, 13, 1/4, 22-4, 5 figs. (In Japanese.)

Five examples of gemstone cutting are discussed with particular reference to the behaviour of rays passing to and through the pavilion. M.O'D.

KEVERNE, R., 1983. A worldwide view of the jade market. *Bulletin of the Friends of Jade*, 3, 14-21.

Sale-room prices for notable jade artefacts are given: the year represented an improvement on previous market performance. M.O'D.

KINNUNEN, K.A., MALISA, E.J., 1990. Gem-quality chrysoprase from Haneti-Itiso area, central Tanzania. *Bulletin of the Geological Survey of Finland*, 62, 2, 157-66.

Gem-quality, apple-green, Ni-bearing chalcedonic silica occurs as veins in silicified serpentine in

the Haneti-Itiso area. AAS gave high Ni 0.55 wt.% and low Co and Cr (120 and 1ppm, respectively); NAA revealed near chondritic REE contents. XRD showed that the chrysoprase consists mainly of α -quartz and some opal-CT. The chrysoprase has RI 1.548-1.553, mean SG 2.56. Microscopically the Tanzanian chrysoprase consists of spherules which are highly disordered, concentric, and composed of bipyramidal quartz, chalcedony, quartzine and opal-A. They can be classified into four main types according to the arrangement of concentric shells. The diameter of the spherules ranged from 40 to 77 μ m. Fluid inclusion types in the bipyramidal quartz are single phase, low-T type. The spherules, silica types and REE contents suggest that this chrysoprase was deposited by evaporation of surface waters connected with the silicification of the serpentinites. R.A.H.

KIDWELL, A.L., 1990. Famous mineral localities: Murfreesboro, Arkansas. *Mineralogical Record*, 21, 6, 545-55, 14 figs (3 in colour).

The area is the largest and best-known diamond producer in the United States and forms part of the Prairie Creek intrusive, about 3.5 km south-east of Murfreesboro, Pike County, south-west Arkansas. Diamond crystals are recovered from several different places in the area where they occur randomly. Their origin is at present unknown. M.O'D.

KOIVULA, J.I., FRYER, C.W., 1990. Forsterite in Arizona pyrope. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 207-9, 5 figs in colour, bibl.

Some Arizona pyropes were examined by X-rays and under the microscope. Forsterite was identified as the inclusion. Pyrope is also a common inclusions in peridot (which is olivine of forsteritic composition). E.S.

KOIVULA, J.I., KAMMERLING, R.C., FRYER, C.W., 1990. Gormanite in quartz. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 153-7, 3 figs in colour, bibl.

Crystal inclusions of a dark bluish-green stalk-like birefringent mineral in a rough grouping of quartz crystals are described and identified, at least in part, as gormanite (an iron aluminium phosphate) by means of X-ray diffraction and optical microscopy. The host quartz was collected from the Yukon territory in north-west Canada. E.S.

KOMATSU, H., 1989. (Origin and a counterplan of 'Uroko' (scaly spot) on the surface of pearls.) *Journal of the Gemmological Society of Japan*, 14, 1/4, 3-11, 19 figs. (In Japanese.)

Scaly spot is a local deterioration of the nacreous

layer on the surface of pearls. Incidence can be lowered by keeping specimens in low or constant humidity conditions. M.O'D.

LARSSON, T., 1990. Värmebehandlade blå safirer. (Heated blue sapphire.) *Gem Bulletin*, 2, 4-7.

Details of the heat treatment of blue sapphire are given with a short list of references. M.O'D.

LEAMING, S., 1983. On the origin of jade. *Bulletin of the Friends of Jade*, 3, 30-4.

The crystal structure and chemical composition of the jade minerals are discussed. M.O'D.

LEUNG, I.S., 1990. Silicon carbide cluster entrapped in a diamond from Fuiian, China. *American Mineralogist*, 75, 1110-19, 7 figs.

A diamond crystal from Fuiian, China, was found to contain four bluish-green 6H silicon carbide crystals overgrown by grains of the 3C polytype. The multicrystalline cluster is surrounded by a thin layer of K-Al-Si-rich glass in which an iron-rich spherule is embedded. It appears that cubic SiC is a distinct though unnamed mineral species. M.O'D.

LHOEST, J.J., GAUTHIER, G.J., KING, V.T., 1991.

The Mashamba West mine, Shaba, Zaire. *Mineralogical Record*, 22, 1, 13-20, 19 figs (13 in colour).

Among the minerals found at this copper mine are cobaltian calcite and transparent cuprite. Both are of gem quality. M.O'D.

LINTON, T., 1990. Lighting techniques for microscopic observation. *Wahroongai News*, 24, 6, 24-7, 6 line drawings.

A useful paper on illumination and use of a polarizing microscope. R.K.M.

LOWE, E.J., 1983. The jade dilemma of the 1980s. *Bulletin of the Friends of Jade*, 3, 22-9.

The general characteristics of jadeite and nephrite are discussed with notes on the main sources and a short bibliography. M.O'D.

MCCOLL, D., PETERSON, O.V., 1990. Titanite crystals from the Harts Range, Central Australia. *Mineralogical Record*, 21, 6, 571-4, 7 figs (5 in colour).

Gem quality crystals of sphene [titanite] are reported from a feldspathic vein in the Harts Range of Central Australia, 200km north-east of Alice Springs. M.O'D.

MACKENZIE, R.W.K., 1990. An additional use for the Eikhorst [sic] Thermolyzer. *South African Gemmologist*, 4, 3, 28-31.

The Eickhorst Thermolyzer is used to distinguish diamond from its simulants. It can also be used to say what these simulants are. A thermal conductivity table of gem materials is appended. M.O'D.

MEYER, A.B., 1985. The nephrite question 1888. *Bulletin of the Friends of Jade*, 4, 20-7.

Theories on the origin of jade artefacts found in America are advanced. It is believed that the pieces originated in Asia but the article challenges this theory on the grounds of as yet unlocated deposits in Mexico and near the Amazon River. M.O'D.

M.G.C., 1985. Jade auction in Burma, 1979. *Bulletin of the Friends of Jade*, 4, 67-80.

The paper consists largely of a reproduction of a catalogue of gems, jade and pearl issued by the Myanmar [Burma] Gems Corporation in 1979. M.O'D.

MIVATA, T., 1988. (An introduction to gem mines of Pakistan.) *Journal of the Gemmological Society of Japan*, 13, 1/4, 31-42, 20 figs. (In Japanese.)

The gem production of Pakistan is discussed with a map of general deposits and a smaller scale map of the Hunza ruby mines. M.O'D.

NAITO, Y., 1988. (Gem-grade chromian diopside found in the upper stream of Sano River, Yamanashi Prefecture.) *Journal of the Gemmological Society of Japan*, 13, 1/4, 25-30, 9 figs. (In Japanese.)

Large single crystals of emerald-green chrome diopside are reported from the upper stream of the Sano River in the Kamisano area of Yamanashi Prefecture, central Japan. Crystals up to 2 cm in length have been found. M.O'D.

NICHOL, B., 1983. Nephrite jade deposits near Cowell. *Bulletin of the Friends of Jade*, 3, 77-88, 5 figs.

Nephrite is found associated with an isoclinally folded dolomitic marble and calc-silicate rock horizon in the upper 'Gneiss' complex of the Cleve Metamorphics (Lower Proterozoic) near Cowell, Eyre Peninsula, South Australia. Colours are greenish-yellow and green and vary from pale tones to black with increasing iron content. Fine-grained black nephrite is the most valuable. M.O'D.

PLASZYNSKA, M., 1988. Measurement of transmission of Chelsea filter. *Mineralogia Polonica*, 19, 1, 113-15, 1 fig.

The transmission curve for the Chelsea filter is examined using a spectrophotometer. The distinctive transmission characteristic equals zero at 333-361.4nm and 607.7-684.5nm and increases distinct-

ly for $\lambda > 684.5\text{nm}$ reaching the value $\gamma \approx 70\%$ in the region of λ which responds in the deep red. There is a minor maximum at $\lambda_0 \approx 578.7\text{nm}$. M.O'D.

PLASZYNSKA, M., 1988. Niektóre współczesne metody badan kamieni szlachetnych. (New methods in gem testing.) *Mineralogia Polonica*, 19, 1, 131-6, 2 figs.

The paper describes the Ceres Diamond Probe and the Gem Diamond Pen. A useful short bibliography is appended. M.O'D.

PONAHLO, J., 1990. Kathodolumineszenz-und Absorptionsspektren gelber Saphire. (Cathodoluminescence and absorption spectra of yellow sapphires.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 225-8, 2 figs, bibl.

A microspectrophotometric method is proposed based on cathodoluminescence spectra to differentiate between yellow, yellow-brownish and orange sapphires coloured by Cr and Fe from similar sapphires with different colouring agents. E.S.

QUELLMALZ, W., 1991. Die edlen Steine Sachsens. (Gemstones of Saxony.) *Lapis*, 16, 1, 24-35, 8 figs in colour.

Gem and ornamental minerals from Saxony, Germany, are briefly described with notes on the whereabouts of notable specimens. M.O'D.

QUELLMALZ, W., 1990. A brief look at the Saxon Erzgebirge. *Mineralogical Record*, 21, 6, 565-70, 10 figs (6 in colour).

Among the minerals found in the Erzgebirge (ore mountains) area of Saxony, Germany, are yellow topaz from Schneckenstein, violet crystals from Greifenstein, honey-yellow baryte crystals from Poehla near Schwarzenberg and several occurrences of native silver. Gem quality quartz crystals are found at Ehrenfriedsdorf (rock crystal); amethyst is found at Wiesenbad near Annaberg and smoky quartz at Zinnwald. M.O'D.

RAMSEYER, K., MULLIS, J., 1990. Factors influencing short-lived blue cathodoluminescence of alpha-quartz. *American Mineralogist*, 75, 791-800, 19 figs (16 in colour).

Crystals of alpha quartz from the Swiss Alps and from Grand Canary showed a short-lived blue, bluish-green or yellow luminescence with some areas remaining inert. A longer-lived violet and a brown luminescence of increasing intensity are less often seen in alpha quartz. The phenomenon is ascribed to the uptake of charge balancing single charged cations associated with the substitution of

Al for silica. H can also cause short-lived cathodoluminescence. M.O'D.

REDMANN, M., 1990. Changierender Fluorit aus dem Schwarzwald. (Colour-changing fluorite from the Black Forest.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 2/3, 169-72, 1 graph, bibl.

The colour-changing fluorite was found in the Clara Mine near Wolfach in the Black Forest. The Clara Mine yields mainly barytes and fluorites but also many rare minerals. The fluorites are usually colourless or blue, violet, green, yellow or pink. The colour-changing stone was deep blue in daylight and violet in artificial light. RI 1.434, SG 3.18. The absorption spectrum contains bands with maxima at 580, 400, 335 and 225nm, caused by a F_m^{3+} colour centre. Absorption minimum in the visible range is located at 480nm. E.S.

ROBERT, D., 1990. Mesure de couleur au microscope. (Colour measurement with the microscope.) *Revue de Gemmologie*, 105, 19-20, 4 figs in colour.

A means of assessing colour values using the microscope is outlined. M.O'D.

ROBINSON, G.W., 1990. Famous mineral localities: De Kalb, New York. *Mineralogical Record*, 21, 6, 535-41, 13 figs (6 in colour).

Some of the green transparent diopside crystals from De Kalb, New York, are of gem quality. They are found in Precambrian metasedimentary rocks of the Grenville series and are retrieved from a north-trending ridge of interbedded quartzite and calcite rock. Their matrix ranges from a quartz-tremolite schist to a nearly pure white massive diopside. Crystal habits vary from simple to fairly complex, the green colour being pale on the whole. M.O'D.

ROBINSON, G.W., KING, V.T., 1990. What's new in minerals? *Mineralogical Record*, 21, 5, 481-92, 10 figs (9 in colour).

Among the minerals described are pale morganite from Pala, California; very fine bi-coloured elbaite from the Himalaya Mine at Mesa Grande, California, and morganite crystals on albite from the White Queen Mine in the same state. Gem quality fire opal is reported from Sabine Parish, near Toledo Bend Reservoir, Louisiana. Fine morganite is reported from the Bennett Mine, Buckfield, Maine. Lettuce-green gem quality spodumene is reported from Resplendor, Minas Gerais, Brazil. In the same state are very high quality rose quartz crystals at the Pitorra Mine near Galilea and fine colour zoned elbaite crystals from Barra de Salinas. Fine quality zoned elbaite is also reported

from the Jos region of Nigeria. From the area of Pereval, Lake Baikal, USSR, come pale pink octahedra of spinel in white marble. M.O'D.

ROSENZWEIG, A., 1983. On the 'rind' of nephrite jade. *Bulletin of the Friends of Jade*, 3, 70-1.

The brownish coating of many nephrite pebbles has been attributed to weathering but the author suggests that in some cases at least the effect may be a consequence of inherent colour zoning. M.O'D.

ROSENZWEIG, D., 1983. Flowers in Chinese jade carving. Part I. *Bulletin of the Friends of Jade*, 3, 37-44, 4 figs.

Flowers are a common Chinese jade decoration and are found particularly on Qing (1644-1911) pieces. Flowers are commonly grouped into sets (e.g. the four noble plants, plum, chrysanthemum, bamboo and orchid). M.O'D.

SCHÄFER, W., 1990. Belmont und Sta. Terezinha. Reise zu den brasilianischen Smaragdminen. (Belmont and Sta Terezinha. Journey to the Brazilian emerald mines.) *Lapis*, 15, 11, 13-26, 29 figs (23 in colour).

The paper describes a visit to the Belmont and Santa Terezinha emerald mines in the state of Goiás, Brazil. Crystals are found in various matrices, including quartz and biotite on the one hand and yellowish feldspar or dolomite on the other. Details of marketing are given. A table lists the constants for the Itabira [Belmont] and Santa Terezinha emeralds. M.O'D.

SCHLUESSEL, R., 1990. Les saphirs de Bo Ploi (Kanchanaburi-Thailande). (The sapphires of Bo Ploi, Kanchanaburi, Thailand.) *Revue de Gemmologie*, 105, 6-10, 20 figs (6 in colour).

Geology and gemmology of blue sapphires found at Bo Ploi, Thailand, are described together with notes on handling, cutting and marketing. The sapphires are a dark to medium blue, have refractive indices 1.761-1.769, DR 0.008 and SG 4.0. Plagioclase crystals, acicular rutile and some multi-phase inclusions showing interference colours are among the inclusions reported. M.O'D.

SCHWARZ, D., 1990. Die chemischen Eigenschaften der Smaragde. I. Brasilien. (The chemical properties of emeralds. Part I. Brazil.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 233-72, 1 map, 14 graphs, 15 tables, extensive bibl.

The author comprehensively researched the chemical properties of emeralds from different localities world-wide. This first part deals with Brazilian emeralds. About 200 samples were examined by

microprobe. The amount of variation and mean concentration of the elements chromium, iron, magnesium and sodium are tabulated. The results are also correlated in graph form. E.S.

SCHWARZ, D., 1990. Turmalin als Einschluss in Beryll. (Tourmaline as an inclusion in beryl.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 191-2, 1 fig. in colour (on front cover of issue).

The author describes the crystals of brown tourmaline found as inclusions in a colourless beryl from the Governador Valadares district, Minas Gerais, in Brazil. Tourmaline is a common inclusion material in beryl from many localities (Zambia, Urals, Habachtal, Madagascar, Socoto and Carnaiba). Beryl as an inclusion in tourmaline is rare. The author explains this to be a definite crystallization sequence, the boron-rich phase coming before the beryllium enrichment. E.S.

SCOVILL, J.A., WAGNER, L., 1991. The Fat Jack mine, Yavapai County, Arizona. *Mineralogical Record*, 22, 1, 21-8, 19 figs (9 in colour).

Fine crystals of amethyst and smoky quartz are found at the Fat Jack mine, Yavapai County, Arizona. The mine is located in a large schist inclusion in the Crazy Basin quartz monzonite. Some of the quartz takes the sceptre form. M.O'D.

SENA SOBRINHO, M. DE, 1985. Notas sobre aluviões diamantíferas do Estado de Minas Gerais, Brazil. (Notes on diamond-bearing placers in the state of Minas Gerais, Brazil.) *Iheringia. Série Geologia*, 10, 3-18, 14 figs.

A study of the diamond-bearing placers of the main producing areas of Minas Gerais, Brazil, showed that at least three geological ages for alluvial fertile deposits have been defined. M.O'D.

SOBCZAK, T., SOBCZAK, N., 1990. Die klassischen polnischen Chrysoptas-Vorkommen von Szklary in Niederschlesien. (The classic Polish chrysoptase location of Szklary in Lower Silesia.) *Lapis*, 15, 10, 29-31, 3 figs (2 in colour).

The Polish chrysoptase deposit at Szklary in Lower Silesia is described. The chemical and physical details of chrysoptase are given. M.O'D.

SOBOLEV, N.V., SHATSKY, V.S., 1990. Diamond inclusions in garnets from metamorphic rocks: a new environment for diamond formation. *Nature*, 343, 742-6, 2 figs.

Cubo-octahedral diamonds averaging 12 μm in size are found in zircon and garnet from high-pressure metamorphic garnet-pyroxene and pyroxene-carbonate-garnet rocks, biotite gneisses

and schists from the Kokchetav massif, northern Kazakhstan, USSR. Kyanite, mica, rutile, sphene, clinopyroxene and zircon occur as inclusions in garnet; the inclusions are often intergrown with diamond. It is thought that the material of the host protected the diamonds from retrogressive transformation to graphite. M.O'D.

SOLANS, J., DOMENECH, M.V., 1990. Estructura cristalina, composición química y propiedades físicas de las gemas II. La dureza. (Crystal structure, chemical composition and physical properties of gemstones. II. Hardness.) *Gemologia*, 32, 85/86. 13-20, 1 fig.

The use of hardness in gem testing is discussed.

M.O'D.

SOSSO, F., SOI, V., PILATI, T., DIELLA, V., LOBORIO, G., GRAMACCIOLI, C.M., 1989. Alessandrite sintetica: nuovi dati cristallografici ed analitici. (Synthetic alexandrite: new crystallographic and analytical data.) *La Gemmologia*, 14, 3/4, 7-21, 9 figs (5 in colour).

Synthetic alexandrite from the USSR is examined and found to be Cr-rich and Fe-poor. Negative crystals in parallel arrangement and with crystalline phases within are characteristic of the product. M.O'D.

SOUZA, R.A., WILSON, W.E., GANGEWERE, R.J., WHITE, J.S., KING, J.E., 1990. The Hillman Hall of Minerals and Gems, the Carnegie Museum of Natural History, Pittsburgh. *Mineralogical Record*, 21, 5, 32pp [outwith the main pagination of the issue], 54 figs in colour.

Fine crystals of peridot, grossular garnet, topaz, tourmaline and quartz, are among the exhibits featured in the recently re-opened display. M.O'D.

WADE, K., FUJINUKI, T., 1988. (Factors controlling amounts of minor elements in pearls.) *Journal of the Gemmological Society of Japan*, 13, 1/4, 3-12, 5 figs. (In Japanese.)

A chemical analysis compared the amounts of minor elements in pearls with those in molluscan shells. In general seawater pearls have larger amounts of alkaline earth elements, alkali metal elements and anion elements, while freshwater pearls are rich in manganese. M.O'D.

WEERTH, A., 1991. Neue Mineralfunde aus den berühmten pakistanischen Edelsteinpegmatiten. (New mineral discoveries from the famous Pakistani gem pegmatites.) *Lapis*, 16, 1, 36-7, 3 figs in colour.

Tabular crystals of a pinkish apatite, prismatic morganite and schorl crystals with colourless topaz

on albite are reported from the gem pegmatites of Stak-Nala, Shigar-Dassu and Shingus respectively. All these locations are in the northern areas of Pakistan. M.O'D.

WIGHT, W., 1988. Kamieni szlachetne i ozdobne Kanady. (Gems and ornamental stones of Canada.) *Mineralogia Polonica*, 19, 1, 119-29, 1 fig.

Translation of a paper first appearing in *Journal of the Gemmological Society of Japan*, 8, 27-39, 1983, and the *Journal of Gemmology*, 18, 6, 544-62, 1983.

M.O'D.

WILKE, H.-J., 1990. Die mineralogische Sammlung des Natural History Museum in London. (The mineral collection of the Natural History Museum in London.) *Lapis*, 15, 10, 13-24, 16 figs (12 in colour).

The history and present arrangement of the mineral collections of the Natural History Museum in London are described. Some outstanding mineral specimens are illustrated.

M.O'D.

WILSON, W.E., 1991. What's new in minerals? *Mineralogical Record*, 22, 1, 53-5, 8 figs in colour.

Fine crystals of red beryl from the Violet claims in the Wah Wah mountains of Utah feature in this short article together with stalactitic groups of rhodochrosite from the La Capillita mine, Catamarca, Argentina, and beryl from Dusso, Pakistan.

M.O'D.

WOLLAERT, E., VOCHTEN, R., VAN LANDUYT, J., 1990. Characterisation of gem opal and inferior opal qualities by means of electron microscopy. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 39, 4, 211-23, 11 figs, 1 graph, bibl.

The structural differences between gem opal and potch are investigated by means of the electron microscope. Potch does not show any play of colour because it lacks the necessary complete uniformity of a perfect stacking of perfect spheres of identical size and absence of void filling with silica. In gem opal the colour grains of the surface are the result of different orientation of the microscopic planes that constitute the surface.

E.S.

ZHILIANG, N., 1983. Preface to collected illustrated works on ancient jade. *Bulletin of the Friends of Jade*, 3, 58-62.

Seventeen Chinese language books on jade are briefly summarized with brief notes on bibliography and text.

M.O'D.

1990. Fluorit. (Fluorite.) [Single topic issue of] *Emser Hefte*, 11, 3, illus. in black-and-white and in colour.

World fluorite occurrences are described, the main emphasis being placed on German-speaking countries. Extensive lists of references are provided.

M.O'D.

Gemmologie Aktuell, 2/90. [No individual authors.]

The issue includes descriptions of: violet scapolite from Afghanistan; tourmaline and kunzite cat's-eyes from Brazil and a zoned tourmaline coloured purple and rose-colour from Paraiba, Brazil; colourless, light yellow and light green montebrasite from Brazil; alexandrite from Orissa, India, and an Indian ruby cat's-eye; yellow, yellowish-brown and brown parisite from Colombia; adularescent orthoclase from Austria; star chrysoberyl from Sri Lanka; rose-coloured spinel from the USSR and ruby from the Pamirs where the USSR borders China; facetable hodgkinsonite from Franklin, NJ, USA; ruby and sapphire from North Vietnam. A synthetic ruby made from polycrystalline material is also reported.

M.O'D.

1991. FM-IGMS-MSA symposium on azurite and other copper carbonates. *Mineralogical Record*, 22, 1, 64-9, 9 figs (8 in colour).

The papers abstracted are: Ribbe and Eriksson on azurite and malachite, chemically and structurally related minerals: North on azurite and malachite from the Morenci and Metcalf mines, Greenlee County, Arizona; Wenrich on azurite and other copper carbonates in northern Arizona solution-collapse breccia pipes.

M.O'D.

1990. Guinean diamond production: a model to be emulated? *Mazal U'Bracha*, 34, 43-50, 10 figs (8 in colour).

The article describes the progress made recently in exploiting the diamond mines of Guinea.

M.O'D.

1985. 'Khotan' jade, past and present. *Bulletin of the Friends of Jade*, 4, 40-50, 1 fig.

Some accounts of Khotan and its jade deposits are extracted from the literature.

M.O'D.

Book reviews

ANNELS, A.E., BURNHAM, B.C. (EDS), 1986. *The Dolaucothi gold mines*. 2nd edition. Division of Mining and Minerals Engineering, School of Engineering, University of Wales College of Cardiff, Cardiff. pp.62. Illus. in black-and-white. Price on application.

Gold has been mined in this area of South Wales at least as far back as Roman times and this study outlines the work done on reconstructing the mining history of the area. Mineralogy and geology are discussed and the archaeology of the site is related to other sites in the vicinity. It is hoped that some of the mine may be established as a working mine museum. M.O'D.

ANTHONY, J.W., BIDEAUX, R.A., BLADH, K.W., NICHOLS, M.C., 1990. *Handbook of mineralogy*, Vol. 1. Mineral Data Publishing, Tucson, USA. pp. vii, 588. US\$82.50 plus \$5.00 shipping.

It is now 40 years since the last volume of *Dana's system of mineralogy* was published and, apart from Michael Fleischer's *Glossary of mineral species* there has been no up-to-date monographic treatment of minerals since then. The present book devotes one page to all the known and accredited elements, sulphides and sulphosalts up to 1988 in most cases. Further volumes will follow in due course; the second will cover silica and the silicates, the third halides, hydroxides and oxides, the fourth arsenates, phosphates, uranates and vanadates and the fifth borates, carbonates and sulphates. Smaller groupings will accompany larger related ones in the appropriate volume and organics will be covered by volume 5.

Each entry gives crystal data, physical properties, optical properties, cell data, chemistry, occurrence, association, name, location of type material, where known and the best references. Where known and appropriate X-ray powder pat-

terns, polymorphism and series are also given: major locations are given in all cases though of necessity these have to be selective.

The book is very well produced and when we realize that there were over 3,000 distinct species known at the time of writing we can see that the book is long overdue. M.O'D.

BEVINS, R.E., SHARPE, T., 1982. *Welsh minerals*. National Museum of Wales, Geological Series no. 4, Cardiff. pp.9 [19]. Illus. in colour. £1.80.

This small book in landscape format illustrates thirty Welsh minerals, some with possible ornamental application. Part of the economic and informative publishing programme of the NMW, this is a well-produced book, giving chemical composition, mode of occurrence, hardness, specific gravity, size of specimen depicted and location for the thirty selected minerals. M.O'D.

CRAM, L., 1988. *Journey with colour*. Lightning Ridge, NSW. Reproduced from typewriting. Unpaged.

This unusual production consists of typewritten sheets containing papers, or the whole text, from the Lightning Ridge Flash newspaper of the famous Australian opal field. A great deal of interesting information is included. M.O'D.

DABDOUB, T., 1985. *Opal report from Honduras 'The fire still burns'*. Tropical Gem Explorations, Metairie, LA. pp. iii, 61. Illus. in black-and-white and in colour. Price on application.

A useful guide to the opal fields and mining industry of Honduras. At Erandique, the chief opal locality, the stones are found in seams or veins penetrating basalt/trachyte rock. Various backgrounds are found with play of colour and stones from this area are not subject to crazing. Other

mining areas are also described and the author includes some entertaining and informative anecdotes. M.O'D.

DIETRICH, R.V., SKINNER, B.J., 1990. *Gems, granites and gravels: knowing and using rocks and minerals*. Cambridge University Press, Cambridge. pp. viii, 173. Illus. in black-and-white and in colour. £15.00.

The book attempts to answer the question 'Why study minerals?' and concentrates upon explanations of the nature and use of mineralogy, petrology and soil science. The book begins with an overview of the mineral world and then describes the crystalline state and mineral chemistry. Later chapters cover rocks, soils, dusts and muds, ores and ore minerals, building materials and concludes with a discussion of rocks and minerals in diverse environments. Three appendices give a description of chemical symbols and the periodic table, identification of the common-rock forming minerals and the identification of rocks. Coloured pictures of good quality form a centre section. The book is presumably aimed at a wide readership and is a good attempt to bring a complicated science to the attention of those who may one day take it up.

M.O'D.

DUNHAM, K.C., 1990. *Geology of the northern Pennine orefield. Vol. 1. Tynne to Stainmore*. 2nd edition. HMSO, London. pp. x, 299. Illus. in black-and-white and in colour. £32.00.

The northern Pennine orefield is one of the world's major producers of fluorite in both commercial and specimen qualities. This new edition replaces one which had become a quarry for collectors and covers that part of the orefield which contains the most productive fluorite deposits. All mines, both working and abandoned, are described in considerable detail with plans of the most important veins. Each chapter has its own list of references and a final chapter comments on future prospects for the area. Baryte and witherite, both long sought by collectors, are also prominent in this area. The book forms an economic memoir covering the areas of 1:50,000 and one inch geological sheets 19 and 25, with parts of sheets 13, 24, 26, 31 and 32 (England and Wales). Having spent many hours at many of the working and abandoned sites above and below ground, I can strongly recommend this book which I saw in proof some years ago and greatly welcome now.

The book begins with a history of mining in the area followed by a survey of the country rock of the Lower Paleozoic foundation and sedimentary stratigraphy. Next comes a survey of the igneous intrusions followed by an overview of the general

structure. The remainder of the main text, over 200 pages, is devoted to the general and detailed description of the mineral deposits which are divided into the nine areas of the Escarpment, Alston Moor, West Allendale, East Allendale, Wear-dale, Teesdale, Haydon Bridge and the Durham Coalfield. The book is well printed and the mass of detail is easy to work through; maps are clearly lettered. M.O'D.

GILLARD, G., 1983. *Gemfields*. Boolarong Publications, Ascot, Queensland. pp. 60. Illus. in black-and-white. Price on application.

This attractive book contains sketches of mining life at the gem centres of Anakie, Rubyvale, Sapphire and other centres in central Queensland.

M.O'D.

GRICE, J.D., 1989. *Famous mineral localities of Canada*. National Museum of Natural Sciences, Ottawa. pp. 190. Illus. in colour. £16.95.

The author presents some of Canada's most interesting mineral localities chosen because he particularly likes them. This idiosyncratic approach makes for a readable book with quite good coloured pictures (though not quite up to the best standards of today). Among the localities producing minerals of ornamental interest are the Jeffrey mine, Asbestos, Quebec, celebrated for grossular garnet; Thunder Bay, Ontario, an amethyst location; Nain, Labrador (labradorite); Baffin Island (lapis-lazuli); the Cassiar Mountains, British Columbia (nephrite). Other sections describe the naming of minerals, mineral identification and mineral formation, but this varied information is made part of the general treatment of particular localities. There are useful lists of minerals by locality (those described in the text) and a good bibliography. This is a good book to give to someone beginning to study minerals, whether they plan to visit Canada or not. The style is personal and friendly and the price gives very good value for today.

M.O'D.

HALL, R.G., 1982. *Opals of the Never Never*. Castle Books, Cammeray. pp. viii, 152. Illus. in black-and-white and in colour. Price on application.

Paperback reissue of the book first published in 1981*.

M.O'D.

HAMMOND, C., 1990. *Introduction to crystallography*. Oxford University Press and the Royal Microscopical Society, Oxford. pp. viii, 101. Illus. in black-and-white. £19.95.

This short book forms Vol. 19 of the Royal Microscopical Society's *Microscopy Handbooks* and provides a question-and-answer format with useful

*Reviewed *Journal of Gemmology*, XVIII, 5, 444. - Ed.

notes on computer programs to assist learning what is described as a very simple subject. Black-and-white photographs illustrate various types of packing but as always the paucity of well-formed natural crystals prevents photographic illustration in depth (cost may also play some part in this). A useful appendix gives biographical details of celebrated crystallographers and the names and addresses of crystal-making kits are given. Otherwise the treatment of the subject follows established lines.

M.O'D.

HOLBECHE, S., 1989. *The power of gems and crystals: how they can transform your life*. Piatkus, London. (Reprinted 1990.) pp. 185. Illus. in black-and-white and in colour. Price on application.

Whatever your opinion on the power of inanimate objects to alter human health and behaviour, this is an attractively produced book whose contents will help many to get through life if no other source of inspiration or comfort is available. Some at least of the gemmological material is accurate, but this is not the first purpose of the book.

M.O'D.

MASCETTI, D., TRIOSI, A., 1990. *Earrings from antiquity to the present*. Thames and Hudson, London pp. 224. Illus. in black-and-white and in colour £30.00.

Two members of the staff of Sotheby's have collaborated in the production of a recognizable Thames & Hudson book; large, well printed and with carefully chosen illustrations of high standard of reproduction and captioning.

Worn throughout recorded history by men and women, earrings are perhaps the most popular item of jewellery and are found in all civilizations with access to any form of ornamental material. This makes the field of study so wide that a single book could not cover it adequately and for this reason male and ethnic earrings have been omitted. The authors also make the point that at the time of writing earrings have seen the greatest developments in materials and design, especially in the past few years when the number of materials used has never been greater. The book begins by surveying the historical background from antiquity to the seventeenth century. At the end of this period earrings had become complicated and the eighteenth century saw a more subdued elegance with the use of the girandole consisting of a surmount with detachable drops, the style first coming into use in the middle of the preceding century. This design followed changes in fashion and hair styles and gave jewellery makers the chance to use a variety of stones in fairly large sizes. The nineteenth century saw a renewal of experiment, with complicated designs, classical imitations and considerable

use of enamel. One or two pages from the catalogues of designers are reproduced and it is plain that earrings were now intended to be used by a much wider social group.

By the present century experiment with earrings could be seen in many countries and above all this has been the century in which earrings gave designers the opportunity to display their products. Many designers have been one-person workshops and innumerable attractive pieces are seen in daily use. This chapter outlines developments before the First World War and then decade by decade.

With the close of the historical survey the book goes on to give biographical notes on the major designers and a glossary and index. There is a short but useful bibliography; here space prevents citation of periodical articles. This is a most enjoyable book and successfully bridges the sometimes imaginary gap between a work relying only on its illustrations and a purely scholarly undertaking.

M.O'D.

MUMME, I.A., 1988. *The world of sapphires*. Mumme Publications, Port Hacking, NSW, Australia. pp. xvii, 189. Illus. in black-and-white and in colour. Price on application.

Early October 1990 was a time of corundum for this reviewer since both this book and the Richard Hughes book, *Corundum*, arrived in the same week. There is no need to compare the two – both are first-class, but the work under discussion deals only with the various types of sapphire and omits ruby. By far the largest section is devoted to the sapphire regions of the world though the book opens with a discussion of the types of sapphire and ends with the more usual details of properties and testing, synthetics and fashioning. The chapter on the world deposits gives a particularly rich amount of detail on Australian occurrences and this alone makes the book well worth buying. Many of the deposits are depicted on maps and there are some, though not many, bibliographical references.

This is an attractive book, written in a style which demands many very short paragraphs, and it is clearly aimed at students. There are a number of misprints which should have been caught but they in no way detract from the quality of the book. I should have liked to see a much larger bibliography and better quality colour pictures – some of those in the book are amateurish and do not show the detail of their subject. For several reasons the picture showing mounted sapphires would have been better omitted.

M.O'D.

NEWBURY, C., 1989. *The diamond ring: business, politics and precious stones in South Africa*.

Clarendon Press, Oxford. pp. xvi, 431. Illus. in black-and-white. £42.50.

The book studies the history and production of diamonds with their marketing from the time of the Kimberley diamond rushes and the rise of De Beers to the formation of the Central Selling Organization. In the preparation of the book many sources hitherto unpublished have been drawn upon; these include mining company archives as well as public ones. The sources, as well as a most useful bibliography, can be found at the end of the book. A considerable amount of labour history and of the effects of diamond sales on the overall economy of South Africa forms the main theme which opens with a study of ownership and governance, 1867-1889. The development from loose miners' oligarchies led to company consolidation and thence from monopoly to cartel over the years 1890-1919 with the beginning of the De Beers operations. This second part of the book takes up the years to the end of the First World War and the formation of Consolidated Diamond Mines. The third and last part of the book deals with the cartel contracts, alluvial mining, the Diamond Corporation, cutting and industrial outlets and a survey of the strategy of diamond marketing and the formation and control of the diamond stockpile. This is a most interesting survey of a complicated topic and should be required reading for anyone working on the politics and economics of mining; it also helps to straighten out some of the intricate details of the development of the De Beers organization and of the near-monopoly that it holds.

M.O'D.

O'DONOGHUE, M., 1990. *Kvartz*. (Quartz.) Mir, Moscow. pp. 135. Illus. in black-and-white and in colour. 85 kopecks. (In Russian.)

Russian edition of the author's *Quartz*, first published in 1987. (Author's note) M.O'D.

PALMER, A., 1990. *Poona WA and the seekers of its emeralds*. Lap Industries, North Lake, WA. pp. x, 97. Illus. in black-and-white. Price on application.

This is an excellent account of the finding and exploitation of the emerald deposits in the Poona area of Western Australia. The book begins with the mining and social history of the area and goes on to describe the finding of emerald. The deposits began to be worked commercially in the 1920s but work declined in the late 1930s, to be revived later. For some years exploitation and recovery appeared to have failed to reach the levels expected but in the 1970s a number of efforts to revive production were made. At the time of writing a further period of inactivity seems to have succeeded one of small production.

The area also produces gold and there are many references to gold recovery as well as to that of emerald. Useful details of the geology are given and there are text maps which help to place the area. Even more useful are the citations to newspaper articles and to obscure journals which would otherwise be impossible to trace.

M.O'D.

ROBERTSON, R.S., SCOTT, D.C., 1990. *Geology of Coober Pedy precious stones field*. Geological Survey of South Australia, Adelaide. (Geological Survey of South Australia. Report of investigations.) pp. 55. Illus. in black-and-white and in colour. Price on application.

The report summarizes work on the Coober Pedy opal fields during 1981-1986 giving details of each worked claim. Excellent colour photographs show the various kinds of rock in which opal has been found to occur and there is a general summary of the area geology to open the book. A geological map of the area comes in a pocket at the end of the report.

M.O'D.

SCHUBNEL, H.-J., 1990. *Cristeaux precieux*. (Precious crystals.) Muséum National d'Histoire Naturelle, Galerie de Minéralogie, Paris. pp. 40. Illus. in black-and-white and in colour. Price on application.

This is a beautiful catalogue, with short accounts of various aspects of the mineral collections of the Natural History Museum in Paris. Among the gem quality specimens illustrated are Brazilian beryl crystals and emerald crystals from Colombia.

M.O'D.

SCHUBNEL, H.-J., 1987. *Larousse des minéraux*. (Minerals of Larousse.) 2nd edition. Librairie Larousse, Paris. pp. 365. Illus. in colour. Price on application.

This well-produced book describes a very large number of minerals in alphabetical order. Each description includes chemical composition and crystal system, note on nomenclature and the main constants. Very brief locality notes are given and preliminary material covers the usual introduction to chemistry, crystallography and the history of mineralogy. The standard of illustrations is quite high but does not reach present-day levels of achievement. The lack of a bibliography is a serious fault and the small print may make reading difficult for some. Notes on French nomenclature variation provide a certain charm as does the use of rhombohedral as a name for the trigonal crystal system.

M.O'D.

SNOWMAN, A.K. (ED.), 1990. *The master jewelers*. Thames and Hudson, London. pp. 262. Illus. in colour. £28.00.

Fifteen major jewellers of the period from 1850 to the present are discussed with illustrations of some of their finest pieces. The jewellers are Castellani and Giuliano (taken as one), Fontenay, Hancock, Falize, Boucheron, Fabergé, Tillander, Lalique, Vever, Fouquet, Tiffany, Cartier, Van Cleef and Arpels, Verdura and Bulgari. There is a section of useful notes and a bibliography at the end of the main text. The standard of colour reproduction is very high and the book provides an attractive introduction to the period for the jewellery historian and student of the decorative arts. M.O'D.

WEIBEL, M., GRAESER, S., OBERHOLZER, W.F., STALDER, H.-A., GABRIEL, W., 1990. *Die Mineralien der Schweiz. Fünfte Auflage*. (Minerals of Switzerland. Fifth edition.) Birkhauser Verlag, Basel. pp. 222. Illus. in black-and-white and in colour. DM48.00.

The first edition, by Weibel alone, was published

by John Wiley in 1966 and was planned to form the first of a series covering all the European countries. Standards of production have improved since then and the projected series never materialized but this book is a pleasure to read and use, with high-quality illustrations, diagrams and maps. Some Swiss minerals are gemmologically interesting if not significant and in any case greater awareness of Alpine-type mineral associations is always valuable. Among minerals with ornamental or specimen importance are fluorite, quartz and sphene. M.O'D.

WYKOFF, G.L., 1982. *Beyond the glitter*. Adamas Publishers, Washington DC. pp. iv, 206. Illus. in black-and-white. \$17.95.

The book attempts to give jewellers and their customers some idea of the principles behind gemstone and jewellery purchasing, valuation and care. While very many small details are inaccurate and much of the writing rather breathless, the book succeeds fairly well in its task and does include much material which would be hard to find without a good deal of searching. M.O'D.

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

OBITUARIES

Mr Edward H. Tindall, FGA (D.1950), Poole in Wharfedale, died in January 1991.

NEWS OF FELLOWS

Michael O'Donoghue gave lectures on gemstones to Ightham Historical Society on 16 January 1991 and to the West Kent Radio Society on 18 January 1991.

Alan Hodgkinson, Alan Jobbins and Kenneth Scarratt gave lectures at the Tucson (Arizona) Gem and Mineral Fair in February 1991. Their subjects were respectively 'A taste of Scottish gemmology', 'The Cheapside Hoard' and 'The diamond connection'.

MEMBERS' MEETINGS

London

On 26 March 1991 at the Flett Theatre, Geological Museum, Exhibition Road, London SW7, films were made available by De Beers, covering many aspects of the diamond industry.

Midlands Branch

On 18 January 1991 at the Society of Friends, Dr Johnson House, Colmore Circus, Birmingham, **Dr J.C. Wright** gave a talk entitled 'Macro to micro'.

On 15 February 1991 at the Society of Friends, **Mr Nick Sturman** gave a talk entitled 'Pearls and pearl identification'.

On 15 March 1991 at the Society of Friends, **Dr Roger Harding** spoke about the work of the Geological Museum and also that of The Gemmological Association and Gem Testing Laboratory of Great Britain.

North West Branch

On 16 January 1991 at Church House, Hanover Street, Liverpool 1, **Mr Kenneth Snowman** gave a talk entitled 'Little boxes'.

On 20 February 1991 at Church House, **Mr John Pyke** gave a talk entitled 'A gem collection'.

MEETING OF THE COUNCIL OF MANAGEMENT

At a meeting of the Council of Management held on 13 March 1991 at 1 Burlington Gardens, London W1X 2HP, the business transacted included the election to membership of the following:

Fellowship

Chen, Xiugin, Hubei Province, China. 1990

Cook, Peter B., Bewdley. 1958

Fu, Lintang, Hubei Province, China. 1990

Li, Yali, Hubei Province, China. 1990

Liao, Xiangjun, Hubei Province, China. 1990

Nazareth, Christopher T., Bombay, India. 1990

Porebska-Brozyna, Dorota, E. Rutherford, NJ, USA. 1990

Puerto Albero, Magdalena, Baneres, Spain. 1990

Qi, Lijian, Hubei Province, China. 1990

Temelcoff, Catherine F., Toronto, Ont., Canada. 1990

Wang, Manjun, Hubei Province, China. 1990

Wezel, Annemarie, Den Haag, The Netherlands. 1986

Wu, Haiou, Hubei Province, China. 1990

Yan, Weixuan, Hubei Province, China. 1990

Zeeman, Walentin, Bunnik, The Netherlands. 1990

Zhang, Liangju, Hubei Province, China. 1990

Ordinary Membership

Araki, Kazuo, Hyogo Pref, Japan.

Asano, Isamu, Osaka, Japan.

Banks, Mary, Exeter.

Blackett, Barbara, Windsor.

Bowles, Michael, Pretoria, S. Africa.

Bradford, Christine L., Hassocks.

Brooks, Anna T., Watford.

Brown, Parvis S., London.

Callaghan, Stephen, Horsham.

Carmona, Charles, Los Angeles, Calif., USA.

Cassidy, Lucinda, Bristol.

Charlot, Donald R., Ruislip.

Day, Brynley J., Oldham.

De Kock, Jhr H.M., Gouda, The Netherlands.

F.G.A.

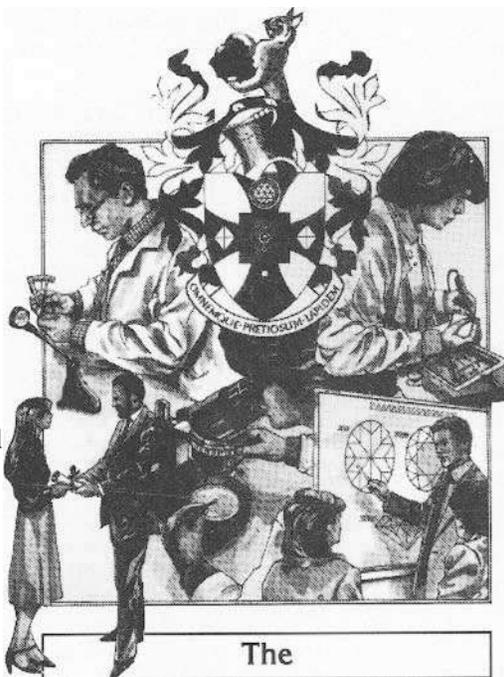
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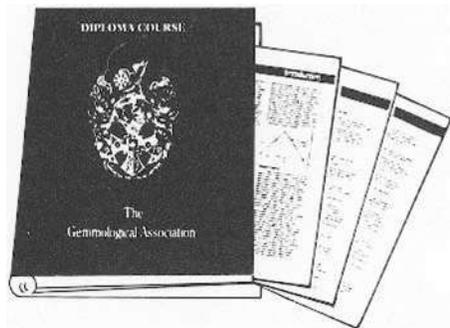
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Dobashi, Yumiko, Osaka, Japan.
 Downing, Lucy N., London.
 Eckman, James, Boardman, Ohio, USA.
 Erker, Rianna S., Chicago, Ill., USA.
 Fleitman, Beth, Milton, Mass., USA.
 Fruttauro, Patricia A., Kew.
 Fukushima, Hideaki, Tokyo, Japan.
 Gofa, Sophia, Athens, Greece.
 Hasegawa, Shoji, Saitama-ken, Japan.
 Hirakawa, Noritatsu, Osaka, Japan.
 Homer, Neil, Glasgow.
 Hosoi, Sadayuki, Osaka, Japan.
 Imakubo, Kohei, Nara Pref., Japan.
 Ishida, Hiroyoshi, Osaka, Japan.
 Ishikawa, Noriko, Tokyo, Japan.
 Ito, Yuko, Kanagawa-ken, Japan.
 Iwata, Takeshi, Hyogo-Pref., Japan.
 James, Robert C., St Maarten, Netherlands
 Antilles.
 Johns, Antony A., Freeport, Bahamas.
 Kadowaki, Kayoko, Osaka-fu, Japan.
 Kawabata, Toshikatsu, Saitama Pref., Japan.
 Kawabe, Makoto, Kyoto, Japan.
 Kawaguchi, Michie, Osaka, Japan.
 Kohara, Sanae, Osaka, Japan.
 Kvasnik, Brian, Minnesota, USA.
 Larkins, Barry, London.
 Mansfield, Julia R., London.
 Maung, Thein L.O., Singapore.
 Minami, Kazumasa, Osaka, Japan.
 Moon, You S., Osaka, Japan.
 Mori, Junko, Hyogo Pref., Japan.
 Morikawa, Shuji, Osaka, Japan.
 Nishi, Tetsuomi, Hyogo Pref., Japan.
 Oda, Hideki, Hyogo Pref., Japan.
 Okamoto, Kyoko, Osaka, Japan.
 Oldfield, Gemma M., London.
 Oyama, Keiko, Fukuoka-ken, Japan.
 Papi, Stefano, Rome, Italy.
 Preece, Susanne L., Trowbridge.
 Rennes, Michael D., London.
 Romano, Rossella, Ilford.
 Sandum, Mark A., Margate.
 Sato, Hiroshi, Tokyo, Japan.
 Shibata, Kazue, Chiba-ken, Japan.
 Shimada, Kiichiro, Saitama-ken, Japan.
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 Sugihara, Hideko, Osaka, Japan.
 Takano, Hirofumi, Tokyo, Japan.
 Tanami, Kazuhiro, Kanagawa Pref., Japan.
 Tanigaki, Takako, Osaka-fu, Japan.
 Taniuchi, Toshiko, Osaka, Japan.
 Toft, Peter C., Copenhagen, Denmark.
 Trathen, John E., Stoney Creek, Ont., Canada.
 Tsai, Shwu-jen, Hsinchu, Taiwan, ROC.

Tsai, Yeou Y., Hsinchu, Taiwan, ROC.
 Tsurita, Kazuo, Osaka, Japan.
 Vaughan, Michael, Ellesmere Port.
 Wikstrom, Michael D., Iowa, USA.
 Yamamoto, Atsuko, Hyogo Pref., Japan.
 Yamamoto, Keiko, Shiga Pref., Japan.
 Yamamoto, Midori, Fukuoka-shi, Japan.
 Yamanaka, Kazuko, Osaka-fu, Japan.
 Yonehara, Machiko, Hyogo Pref., Japan.
 Yoshikawa, Youichi, Hyogo Pref., Japan.
 Yumoto, Atuko, Osaka-fu, Japan.
 Zhang, Youxu, Hubei Province, China.

CULTURED BLACK PEARL AUCTION

The Cook Islands, a close neighbour of Tahiti and one of the smallest island nations in the world, will be holding its second Cultured Black Pearl Auction from 8 to 12 June 1991.

The Cook Islands have a large natural resource of *Pinctada margaritifera* from which the black pearl is produced. The black pearl industry was introduced in 1986 by a Tahitian company and has expanded rapidly. The pearls are grown in the atoll of Manihiki, a small atoll with a population of 600 people, located 400 miles away from its closest neighbour.

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For more information contact Cook Islands Pearl Farmers Association, PO Box 160, Rarotonga, Cook Islands, South Pacific. Telephone: 682 21743, Fax 682 21543.

Verbal testing at Laboratory

Would Fellows and Associate Members please note that as from 1 April 1991 the charge for a verbal test on articles sent to the Laboratory by post will be £11.00 per stone (including VAT) plus £4.00 postage and packing. The articles should be accompanied by a cheque for the total amount made payable to the GA & GTL of GB. The goods will be returned by Registered Post with a receipt for the amount paid.

Letter to the Editor

From R. Keith Mitchell, FGA

Dear Sir,

DI-IODOMETHANE AND ALL THAT

In my review of E.A. Jobbins' excellently revised 10th edition of B.W. Anderson's valuable text book *Gem Testing* (*The Journal of Gemmology*, 22, 4) I commented that certain name changes, particularly those of our old friends methylene iodide and mono-bromo-naphthalene 'might make organic chemists happy, but tend to leave established gemmologists puzzled', and I went on to wonder why the second of these names should exchange the 'mono-' prefix for the figure 1, while methylene iodide becomes di-iodomethane and not 2-iodomethane.

These comments were made in a somewhat 'tongue-in-cheek' frame of mind and might be attributed to a dour outlook engendered by a surfeit of years. We 'Golden Oldies' tend to dislike change for the sake of change!

However, I am not an organic chemist and I did speak out of turn on something of which I knew very little, a fact which my good friend and former student, A.D. Morgan, FIBF, FGA, of Northfield, Birmingham, who understands the subject far better, made plain in a kindly personal letter at the end of last year.

Another letter on the same lines was received by our Editor in February, from Dr Martin F. Ansell, of Blackheath, London.

Doug Morgan points out that the old name 'methylene iodide' was a poor one since 'iodide' implies that it is a salt of iodic acid, which it is not! The heavy and highly refractive liquid (the heaviest known at normal temperatures apart from the metal mercury) is based on methane, CH_4 (marsh gas!), in which two of the hydrogen atoms are replaced by two iodine atoms to give CH_2I_2 which is now more logically and correctly named di-iodomethane. The two molecules can be formulated diagrammatically as in Figure 1.

The name 1-bromonaphthalene is again more accurate and logical than monobromonaphthalene. I have always thought that the prefix 'mono-' and the figure 1 were synonymous, e.g. mono-rail, mono-syllable, meaning one rail or one syllable. But in the far greater complexities of organic chemistry they are used to convey different meanings.

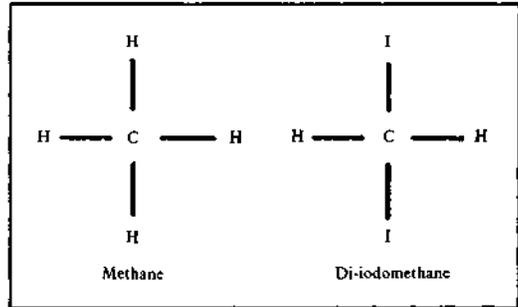


Fig. 1.

So 'di-' in di-iodomethane indicates that there are two atoms of iodine, but the 1 in 1-bromonaphthalene indicates that a bromine atom replaces a hydrogen in the two linked six-sided rings that comprise the naphthalene (C_{10}H_8) molecule at position 1. The hydrogen positions are numbered 1 to 8 in a clockwise direction, as shown in Figure 2. Mr Morgan mentions that a compound with two bromine atoms would have them at positions 1 and 3 in the double ring and would be called 1-3-dibromonaphthalene.

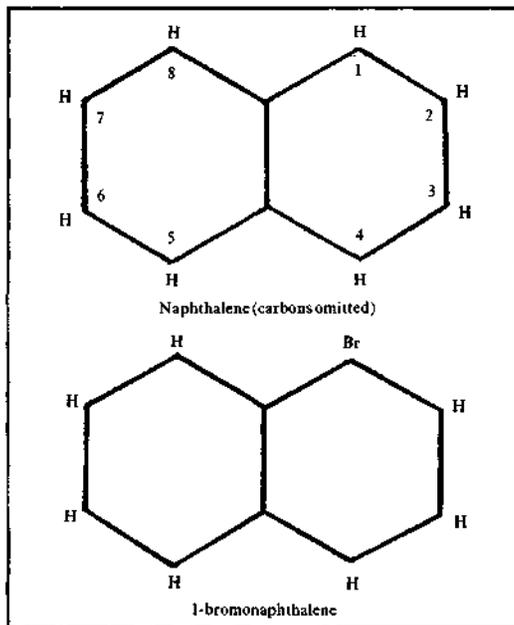


Fig. 2.

Dr Ansell points out that my contention that the name could be written '2-iodomethane' is nonsense, since it implies the presence of two carbon atoms in the methane molecule when there is only one. The di-iodomethane name makes clear that there are indeed two univalent iodine atoms which together with the two hydrogen atoms satisfy the tetravalence of the one atom of carbon.

I am indebted to both these gentlemen and I promise not to use I-chrome when I mean monochrome.

It will be noted that organic formulae need to be diagrammatic in order to be explicit, and the actual naming describes the positions and the numbers of replacing atoms, at least in the simpler compounds.

All this reflects the immense complexity of organic chemistry in comparison with inorganic chemistry, which is largely our concern in gemmology. The former is the chemistry not only of simple hydrocarbons, but of life itself. While agreeing with Dr Ansell that a knowledge of this greater science is helpful, I thank Heaven that I am merely a Gemmologist, and perhaps too old to learn new tricks!

Yours etc.,
R. Keith Mitchell

20 March 1991
Orpington, Kent.

ADVERTISING IN THE JOURNAL OF GEMMOLOGY

The Editors of the *Journal* invite advertisements from gemstone and mineral dealers, scientific instrument makers, publishers and others with interests in the gemmological, mineralogical, lapidary and jewellery fields.

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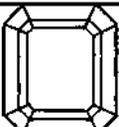
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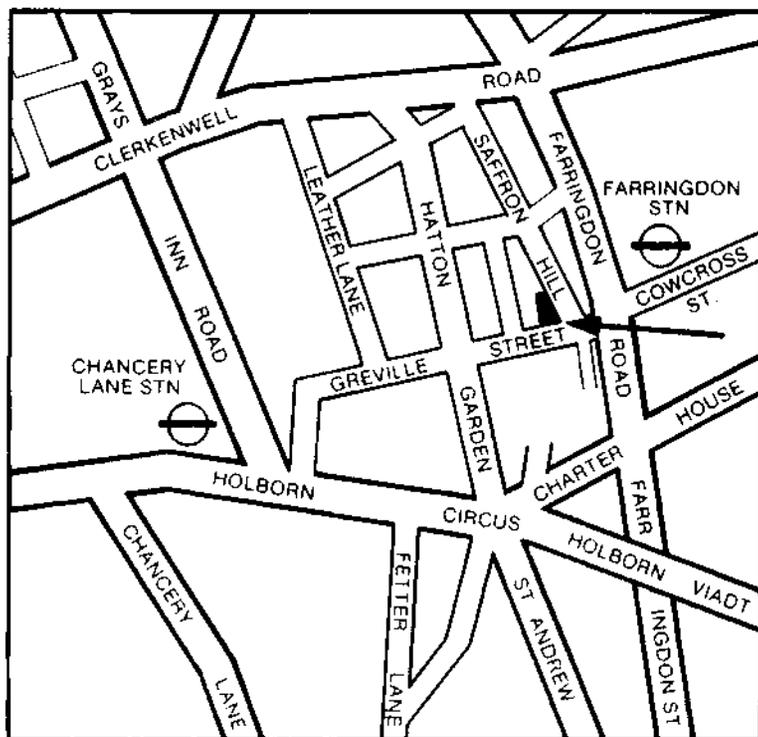
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