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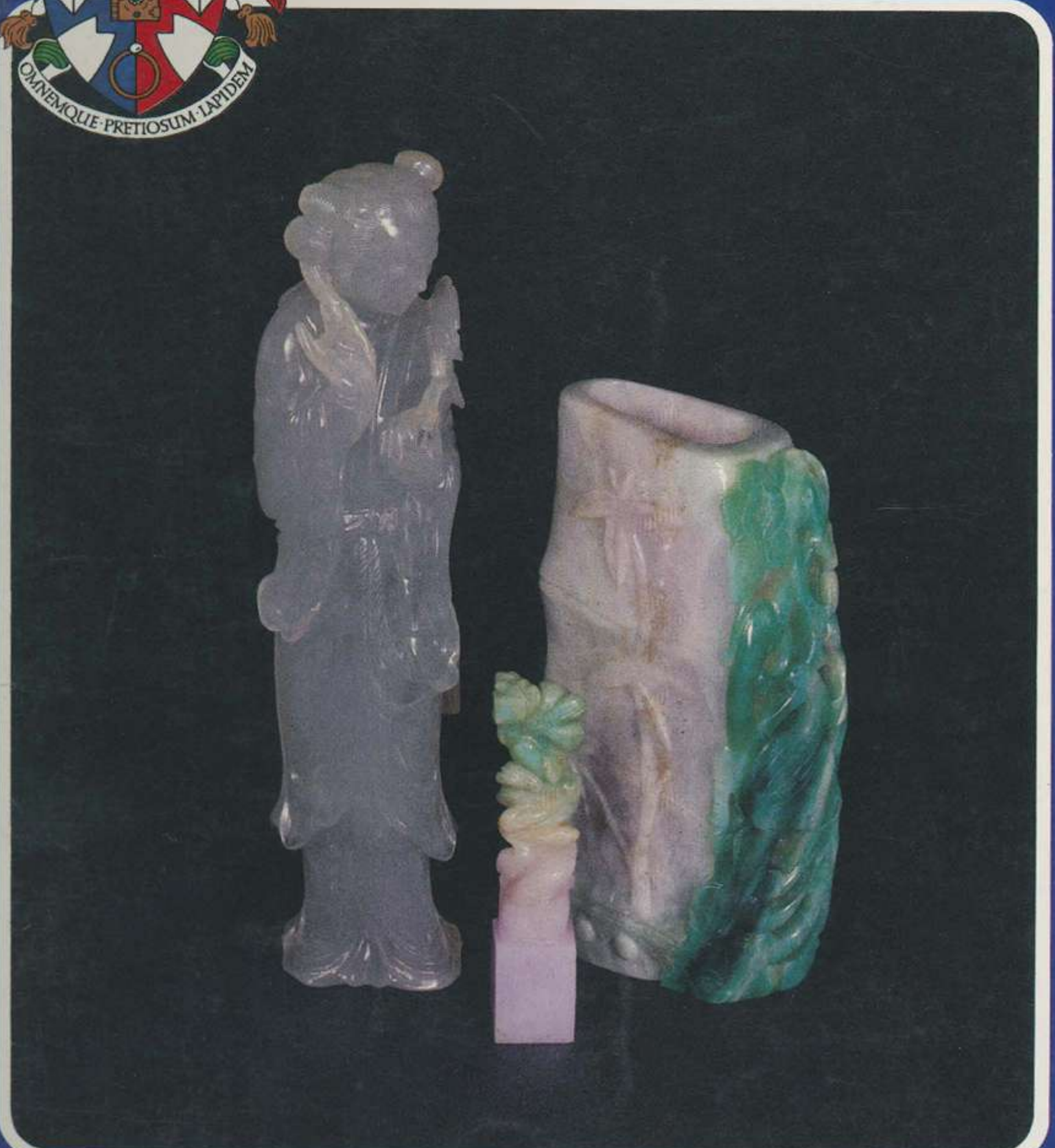

GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

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Cover Picture

An unusually translucent jadeite figurine and other jadeite carvings showing colour variation (see 'Some colour variation in jadeite', p.376).
Photograph by E.A. Jobbins.

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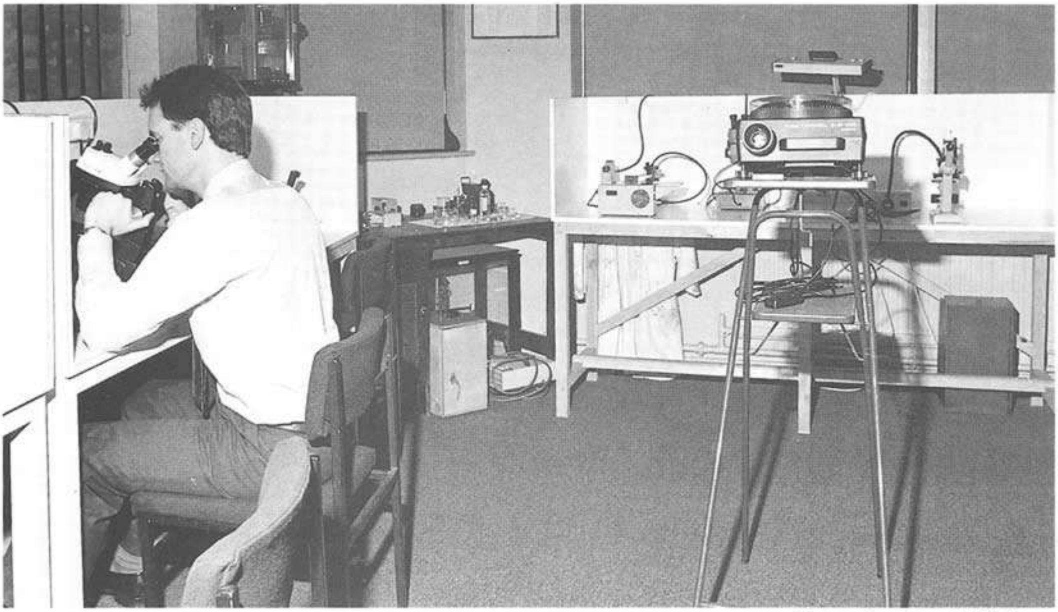
A major new initiative in gemmological education



Photograph courtesy of K. Blakemore

The Gemmological Association has collaborated with the Gem Testing Laboratory of Great Britain to launch a programme of one-day courses.

The courses have been designed for the Association by Ken Scarratt and will be held at the Gem Testing Laboratory in London.

The aim is to give practical instruction and experience to students studying gemmology, particularly those preparing to take the FGA examination by home study, and updates specialized courses for all gemmologists.

Various courses are being offered, the dates of which are:

1 and 29 May	**Practical gemstone identification – General**
3 July	**Practical identification – Pearls**
17 July	**Practical identification – Jade, amber and their simulants**
31 July	**Practical identification – Synthetic ruby and sapphire**
28 August	**Practical identification – Synthetic emerald and amethyst**
2 October	**Introduction to diamond grading (of particular interest to students preparing to take the Gem Diamond examination.)**

Each course is limited to 12 participants and is offered at the especially low charge of £55 plus VAT (including lunch). The courses are open to all students and members of the Association who would like to take a short refresher course. Further information from Paula Jennings on 01-726 4374.

To book for the courses please use the coupon given on page 397 and enclose the necessary remittance.

Damage to cut diamonds

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Swiss Foundation for the Research of Gemstones (SSEF)*, Zurich, Switzerland

Abstract

Diamonds are generally considered as extremely resistant gems. Thermal or mechanical damage is, nevertheless, possible during various stages of working (cutting, setting, soldering) or wearing the stones. Thus many cut diamonds reach the jeweller's counter with minor to distinct damage. Only a relatively small proportion of the observed injuries result from wearing. Minor blemishes can be removed with minimal weight loss by a specially trained cutter.

Chemical resistance

A diamond's high resistance to chemical attack derives from the strong covalent bonding between the carbon atoms in the diamond lattice. At low temperature and pressure conditions, it effects a strong inertia against all standard acids, caustics and solvents. However, at high temperatures, and in the presence of certain melts or gases, the diamonds do not comport themselves with such invulnerability any longer.

In our laboratory, several experiments were carried out on cut diamonds (Bosshart, in preparation) to shed light on their thermal behaviour. Exposed to air, the stones were heated in an electric laboratory furnace without any coating. Already during an annealing cycle of 30 minutes at 650°C, or after two hours at 600°C, a whitish turbidity appeared on the faceted surfaces. No transformation to (black) graphite or amorphous carbon was observed. Obviously alteration of the diamonds' outermost layers of carbon atoms by the oxygen in the air takes place as low as 600°C. During this oxidation process, the diamonds transform directly into gaseous carbon dioxide (CO_2). Whitish, shallow but rough burn marks are left behind. Considerably deeper burn pits are produced at higher temperatures and longer annealing.

In comparison with our static annealing experiments in the electric laboratory furnace, the turbulent supply of oxygen under the soldering torch of the goldsmith certainly leads to more serious burn marks at 600°C, if the mounted diamond has not, or not entirely, been coated by a borate (boric acid, Liquobor, borax, etc.). The function of the borate melt is to coat the diamond in order to prevent oxygen from reaching the surface of the stone. However, if the diamond has not been degreased, openings may form in the borate coating. Then corrosion of the diamond can start (Figure 10).

A borate melt is able to corrode corundums but not diamonds. The latter can be attacked only by the hot melts of metals like platinum, iron, tungsten, or by some strongly oxidizing compounds (De Beers Industrial Diamond Division: Properties of Diamond, special publication). Yet under all normal chemical conditions, diamonds do not react.

Mechanical Resistance

The hardness of a diamond, or more precisely its extremely high resistance to abrasion, is the prominent physical property which makes a diamond to be for ever. It is seldom that blemishes can be recognized by eye, even after decades of wearing the stone as a solitaire. A diamond occupies the uppermost level of the Mohs' scale of scratch hardness. This means that it is not scratched by any other mineral except by its own kind. The hardness depends on the direction of scratching on the crystal (hardness anisotropy). There are harder and slightly softer directions. This fact is taken into account during cutting because diamond surfaces can be worked successfully only in the softer directions.

The longevity of a diamond is limited by its tendency to split along very definite atomic layers when struck precisely parallel to them. This quality of developing flat separation planes is termed cleavage. Diamond possesses a perfect cleavage parallel to the eight octahedral crystal faces and less pronounced ones parallel to some other faces.

Another limitation is its sensitivity to knocks in any other direction, on facet edges and corners especially; bruises and percussion cracks are liable

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*Schweizerische Stiftung für Edelstein-Forschung (SSEF).

to form. Their size depends on the force of impact. Inversely, static pressure on surfaces does not harm a diamond at all.

Large inclusions represent yet another hazard for diamonds. However, it is a fairly rare accident when a piqué diamond with extended cleavages, or incorporating foreign mineral inclusions surrounded by tension haloes, breaks into pieces under mechanical or thermal stress.

Damage during cutting and polishing

Industrial cutting of diamonds cannot always be carried out with sufficient care, probably for reasons of time. Many a diamond cutter is entirely aware neither of the brittleness of all diamonds and of the internal strain inherent in many diamonds, nor of the corresponding vulnerability of the goods he is cutting. Consequently, many diamonds leave the cutting works with minor blemishes. The most frequent of these negative characteristics are small cleavages, pressure and percussion cracks, as well as burn marks.

An excessively strong pressure during the bruting process creates groups of tiny fissures parallel to the cleavage direction (Figure 1). They traverse the girdle and often appear at four different positions around the circumference, separated from each other by 90° (in the normal case of a 4-point brilliant). Finely bruted girdles show these tiny cleavages in a much less conspicuous manner than coarsely bruted girdles. In earlier days, these fissures were harmlessly designated bearding and wrongly considered external characteristics. Usually they can be removed; in these instances, the removal is easier and more complete by faceting of the girdle rather than by polishing it. Thus internal blemishes are eliminated and this results in an improvement of the clarity.

A further injury of the first hour, which is encountered quite frequently, consists of pressure cracks. They probably stem from the use of the dop, the tool which holds the diamond tight during cutting (Figures 2 and 4). The blemishes occur as small cracks, roughly on the same level of the pavilion, running across facet edges. They are caused by a too strongly tightened dop or by knocking vibrations (Figure 5). We also sometimes observe more or less circular fissures, mainly on pavilion facets, the origin of which we cannot yet explain. Possibly, however, there is a connection with the dop as well (Figure 3).

When a diamond is turned in the dop, scratches in the form of concentric arcs may occur on the table (Figure 6). The finger-like piece of metal pressing the pavilion of the brilliant into the dop causes these scratches when it is contaminated with diamond paste (Figure 4).

If diamonds are heated too much during the cutting operation, rough burn marks are incurred, especially on lower girdle facets, star facets and on the table. A build up of heat in the metal of the dop is responsible for this. As mentioned earlier, the superficial corrosion of the diamond already starts at 600°C with the formation of roundish to annular burn marks.

The view that fissures across facet edges are generated on diamonds as they are pressed against each other in a stone paper may be correct in certain cases. Stones in lots of considerable weight are particularly endangered. As a rule, however, the cause of the damage lies in the too strongly tightened dop. In order to form pressure cracks on diamonds in a stone paper, a greater force is required than that applied to such wrappings in general.

On the other hand, large diamonds merit individual packing because blemishes, like scratches and abraded facet edges can happen relatively easily.

The unpopular large culet of old-cut diamonds today has an equally extreme analogue in the pointed culet of the modern brilliant-cut (a pointed pavilion without any facet). The danger to this type of culet can be deduced from the fact that, during grading, we encounter less than ten undamaged pavilion pyramids for every one hundred diamonds originally with pointed culets. Usually the exact time of damage cannot be determined.

Damage during setting

Prominent parts of a cut diamond, i.e. not only the pointed culet but also the girdle, are especially sensitive to injuries. A girdle of medium thickness shows little tendency to cleave under the normal forces of impact during setting. However, the thinner the girdle, the easier it can chip under the influence of knocks, pressure or scratching. Thereby cleavage is stimulated if the direction of the destructive stress acts roughly parallel to it. Actually, irregularly formed fracture surfaces are encountered more frequently. Off to the sides, they readily change into short cleavage fissures.

Greater damage is occasionally caused by slipped punches, or by the stone-setter's electric hammer, and has a characteristic appearance. Mostly they are cataract fractures extending into the pavilion and are situated close to a prong (claw). In the central part of the depression, they have a conchoidal form and continue in cleavage steps towards the edge of the fracture (Figure 7).

Fig. 1. Fine cleavage fissures running across the slightly polished girdle of a brilliant-cut diamond. Darkfield illumination. 11x.

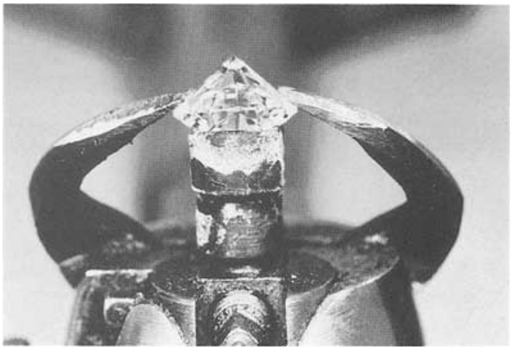

Fig. 2. Diamond fixed in a cutter's dop. Burn marks may appear at both points of contact on the pavilion.

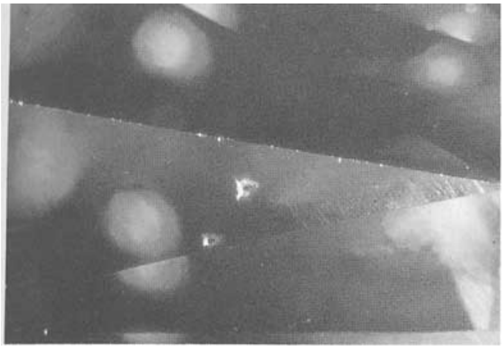

Fig. 3. Roundish cracks caused by percussion or pressure on a lower girdle facet. Darkfield illumination. 28x.

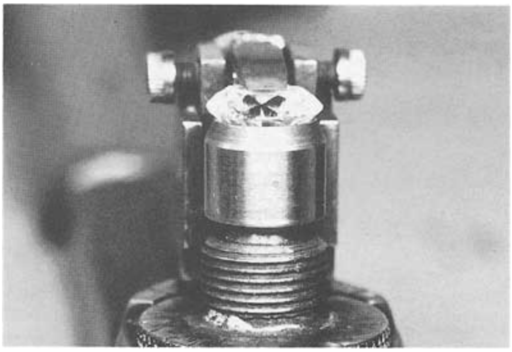

Fig. 4. Brilliant-cut diamond of 2 ct tightly mounted in the dop. Heat accumulation in the finger-like piece of metal sometimes leads to burn marks on the table.

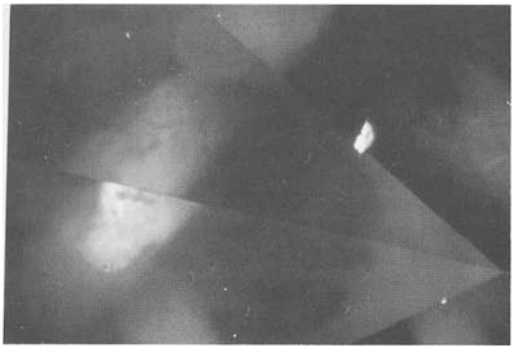

Fig. 5. Pressure crack across a pavilion facet edge of a brilliant-cut diamond. Darkfield illumination. 34x.

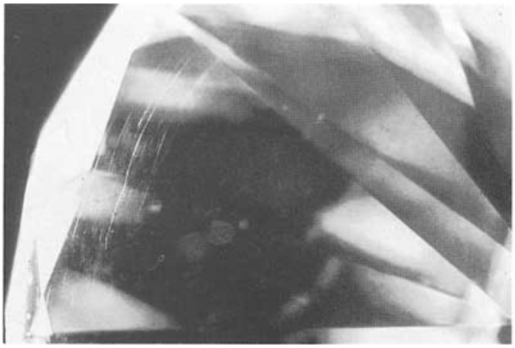

Fig. 6. Arc-shaped scratches on the table of a brilliant-cut diamond viewed from the pavilion side. Darkfield illumination. 17x.

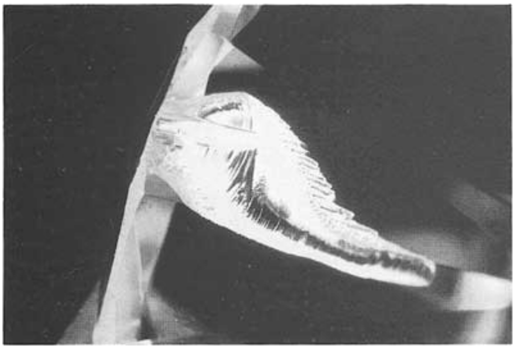

Fig. 7. Complex cataract breakage in the pavilion of a brilliant-cut diamond, generated by shock impact from the crown side on to the girdle zone. Darkfield illumination. 17x.

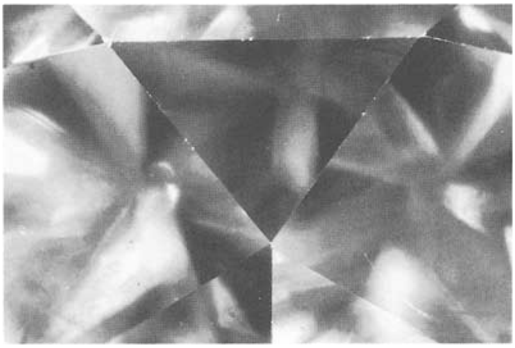

Fig. 8. Wear marks in the form of small shallow bruises on the edges and corners of a star facet and a fine scratch on an adjacent main facet. Darkfield illumination. 22x.

Damage during wear

Several types of blemishes are observed on mounted diamonds. The most widespread damage originates from knocking the set diamond against other objects. They consist of small, but loupe-visible, bruises and percussion cracks. They appear on edges and corners around the table and the crown facets. These wear marks demonstrate clearly that diamonds are slightly sensitive to the influence of shocks (Figures 8 and 9).

Larger breakages in the girdle region also occur, particularly on big diamonds with a very thin girdle (e.g. on old-cut diamonds). These cases, however, are less frequent than generally assumed in the jewellery trade. Stone settings with widely separated prongs favour the formation of such fractures. While ordinary percussion cracks effect a reduction of the clarity grade of loupe-clean stones only, larger fractures may easily lower a VS and even an SI clarity grade.

Further damage develops when a solitaire ring is worn next to a diamond-studded eternity ring. Since the ring on the neighbouring finger may rotate, it usually scratches the solitaire diamond at two opposite places according to how the ring has been placed on the finger. Rough, whitish abrasion marks result from this. They are also occasionally of fissure-like character.

Bruises and percussion cracks on the pavilion side of set diamonds are probably not the result of wearing jewellery. The pavilion is protected by the mounting and the finger. These blemishes are not recent and usually have been produced in the diamond factory, as mentioned earlier. Scratches may occur whenever diamonds touch, not only on stones in a lot but also in the mounted state, for example in the jewellery box.

Damage in repairing and transforming diamond jewellery

According to the introductory statements, superficial burn marks are produced under the goldsmith's torch if the mounted diamond has not been sufficiently degreased. The borate coating then cannot offer complete protection and burn marks are the consequences (Figure 10).

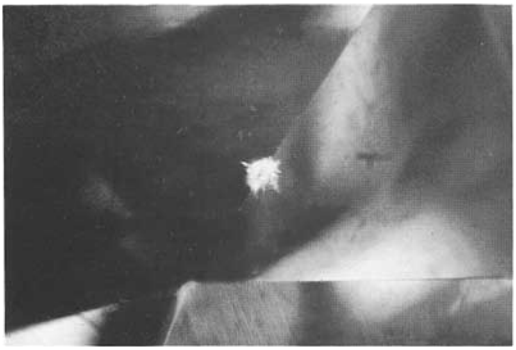

Fig. 9. Bruise on a table edge accompanied by fairly deep percussion cracks, radiating out to both sides of the facet edge. Darkfield illumination. 34x.

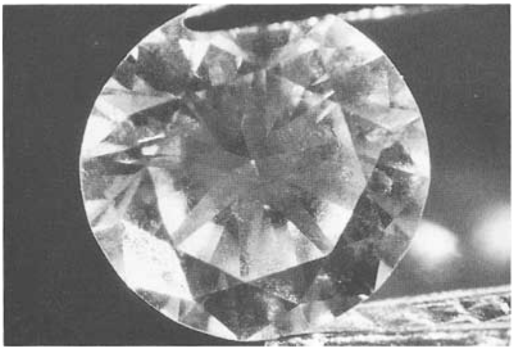

Fig. 10. Brilliant-cut diamond with whitish surface due to extensive burning. Brilliance grossly reduced. Darkfield illumination. 13x.

Repair of damaged diamonds

Most of the blemishes listed here can be removed with minor weight loss by a carefully executed repolishing operation. Damages of considerable depth demand a more complete recutting of the stone and cost more than just a few points of weight. Buying loupe-clean diamonds with weights like 1.00 ct is not recommended, for the simple reason that even a slight touch up of such a stone will decrease its weight below the critical limit.

The skills of a specialized diamond cutter are needed for a successful repolishing operation. He does not treat diamonds like the hardest material in the world but works gently and cautiously as if handling raw eggs. If this approach would take hold and prevail in all diamond workshops, a much larger portion of loupe-clean diamonds would reach the market.

In the damaged state, diamonds are mainly graded between VVS 1 and SI 2 if they do not contain any internal characteristics other than new cracks. SSEF clarity grading always assesses the possibility of improving the stone and a corresponding recommendation for repolishing, plus a precise sketch for the specialized cutter are provided. Thus, the repolishing operation finally raises such stones up to the clarity level which they could have had from the beginning or which they once possessed.

If, apart from the clarity, the cut can be ameliorated in the same operation, the recommendation for repolishing includes a comment for the cutter with respect to symmetry, polish, girdle or culet.

Conclusion

It can be stated that a precise microscopic examination of damage on cut diamonds in certain cases enables the recognition of the causes. The SSEF Laboratory has been in a position to carry out this type of analysis for many years. Insurance companies and other interested parties have regularly made use of this service.

Acknowledgements

We wish to extend our gratitude for technical comments and suggestions to the following professionals in Zurich: Messrs B. Christen, A. Guichon, F. Loosli, D. Roux, and P. Widmer. Figures 2 and 4 were kindly placed at our disposal by Mr Guichon.

[*Manuscript received 30 December 1986, revised 26 January 1987.*]

Confusing colourless stones

David Kent, FGA

London

Before retirement I was employed by a London firm of jewellers as an appraiser and buyer of second-hand jewellery. One day in 1976 a client offered for sale a gentleman's flush-set 18 ct gold gypsy ring, set with three brilliant-cut colourless stones. The ring carried the London hallmark for 1975. Additionally there was a valuation, also dated 1975, from a Hatton Garden firm for a three stone flush-set diamond gypsy ring, stating that it should be insured for £980. The client intimated that he would be prepared to sell the ring for about half that amount.

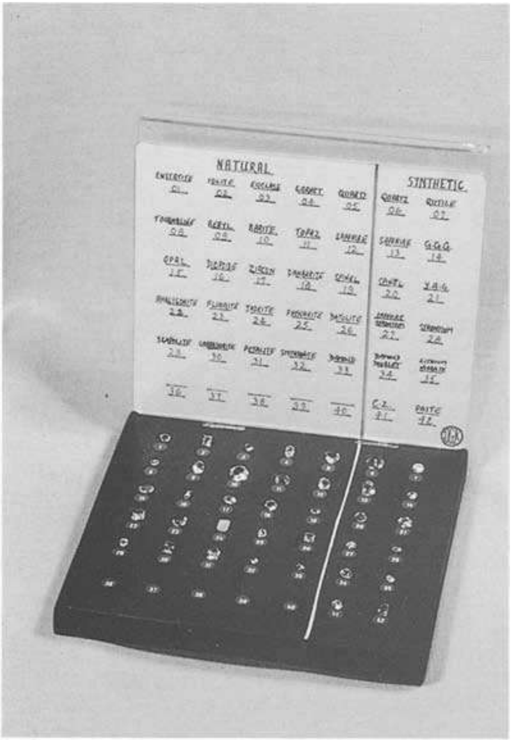

Fig. 1. Box constructed by the author to display and house his collection of colourless stones.

I was impressed by the apparent good quality of the stones, which I roughly estimated as weighing 0.50 ct for the centre and 0.25 ct for each of the two side stones. Using my lens and Moe gauge, I inspected the ring in our very good, north-facing, 'buying' daylight. I suddenly realized that the stones showed too much dispersion, and being taken aback, refused to offer, and handed the ring back to the client.

Being already familiar with simulants such as YAG and GGG, I was puzzled and immediately sent a message around the branches warning the staff that a new simulant appeared to be to hand. Two or three weeks later I learned that a number of jewellers had been defrauded of considerable sums by the use of a new diamond simulant – cubic zirconia!

Having quite a good private collection of gemstones, I resolved to display as many colourless stones as possible in one case for comparison purposes. Since this time I have been able to add to the original display, some stones being kindly presented by good friends.

The collection is housed in a purpose-made display box constructed by the author (Figure 1). A piece of hardwood (an old breadboard!) was cut to size (204 × 184 × 17 mm) and smoothed with abrasive paper. The positions of the holes to locate the stones were carefully measured out and then marked with a centre punch and a hammer. The small holes so formed were then enlarged using twist drills of suitable size to form shallow cups. A chisel was used to make rectangular holes. After smoothing the wood was stained using black leather dye, or it could be sprayed with grey primer followed by matt black, both paints being available in aerosol form from paint shops or car accessory stores. The self-adhesive numbers are available from any good stationer. A hinged lid of clear Perspex was provided to keep the stones in position.

A few years ago A.D. Morgan, FGA, made for me an efficient infrared reflectometer, and it may interest fellow gemmologists to see how closely the

Table 1. Infrared reflectometer readings on colourless gemstones in the David Kent collection. Diamond calibrated at 70.

Meter reading	Mean RI	Species	Weight (ct)	SG
17	1.434	Fluorite	2.91	3.18
17	1.438	Opal	1.96	2.00
19	1.505	Paste	1.15	2.44
20	1.506	Petalite	2.06	2.39
22	1.549	Quartz	2.67	2.65
22	1.549	Synthetic quartz	4.67	2.65
23	1.540	Iolite	1.19	2.58
23	1.555	Beryllonite	0.84	2.82
23	1.560	Scapolite	0.39	2.60
23	1.561	Labradorite	1.25	2.68
23	1.583	Beryl	1.48	2.74
25	1.615	Topaz	3.95	3.56
25	1.622	Amblygonite	2.58	3.03
25	1.629	Tourmaline	0.60	3.00 (approx)
25	1.640	Baryte	8.01	4.49
25	1.647	Datolite	0.96	2.90
26	1.633	Danburite	1.58	2.98
27	1.655	Jadeite	1.77	3.34
27	1.660	Enstatite	1.03	3.22
27	1.662	Euclase	0.43	3.10
28	1.660	Phenakite	0.85	2.98
29	1.65 vague	Smithsonite	044	4.19 (approx)
29	1.678	Diopside	0.51	3.22
30	1.712	Spinel	0.96	3.61
30	1.725	Synthetic spinel	1.68	3.65
31	1.736	Grossular	1.27	3.60
32	1.782	Benitoite	0.44	3.65
33	1.764	Sapphire	2.73	4.00
33	1.764	Synthetic sapphire	3.93	4.00
38	1.830	YAG	2.90	4.57
39	1.764	Synthetic sapphire/ strontium titanate doublet	1.12	4.66
42	1.95	Zircon	2.52	4.66
42	2.03	GGG	1.67	7.10
56	2.17	Cubic zirconia	1.51	5.80
62	2.25	Lithium niobate	0.64	4.70
64	2.41	Strontium titanate	1.21	5.14
70	2.42	Diamond	0.48	3.52
76	2.42	Diamond/synthetic sapphire doublet	1.68	3.82
80	2.62	Synthetic rutile	1.55	4.20

meter readings follow the refractive indices, shown in the Table 1. The RI values above 1.81 are approximate, having been determined by the real and apparent depth method. The specific gravities were determined by the hydrostatic method using water.

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Investigation of a sapphire cat's-eye from Burma

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Abstract

A sapphire cat's-eye from Burma is described and the cause of chatoyancy was investigated. The sample does not show needle- to rod-like inclusions, which are in general responsible for chatoyancy of gemstones. The Burmese sapphire is not a single crystal but consists of two sectors which are slightly inclined against each other: the inclination angle equals 11°. In both sectors, growth planes parallel to the hexagonal dipyramid (22$\bar{4}$1) as well as glide planes parallel to the basal pinacoid (0001) are observed. Chatoyancy is caused by total internal reflection at irregular patch-like fissures on basal glide planes.

Introduction

Rubies and sapphires from certain occurrences, e.g. Burma and Sri Lanka, frequently show asterism when the crystals are cut in the cabochon form. The most common six-rayed stars are caused by needle- to rod-like inclusions of rutile or other iron-titanium oxides. The needle axes of these inclusions are lying in the basal plane (0001) in three different orientations parallel to traces of the prism faces of the host crystal. If only one set of parallel orientated needle-like inclusions is present in corundum, a cat's-eye is produced. This condition, however, is extremely rare if existing at all in natural corundum. On the other hand, corundum cabochons revealing less than six rays on the curved surface exhibit needle-like inclusions in three orientations but are not cut in the appropriate direction, i.e. with the base of the cabochon at right angles to the *c*-axis of the crystal.

The present paper describes a small blue sapphire cat's-eye from Burma. A preliminary microscopic investigation disclosed that a light effect resembling chatoyancy is not due to needle-like inclusions parallel to one direction in this extraordinary sample. Therefore, a detailed study of the stone was undertaken in order to clarify the cause of the optical properties of the sapphire.

Microscopic investigations

The blue sapphire from Burma was cut as an oval cabochon of 4.0 × 5.5 mm in size and weighed 0.53 ct. The sample disclosed a chatoyancy-like effect on the curved surface: the direction of the reflected ray is orientated parallel to the long 5.5 mm axis of the oval stone. Microscopic investigation in methylene iodide disclosed that the sapphire consists of two parts which are separated by an irregular step-like surface looking like a landscape with a dense distribution of hillocks (Figure 1). In each part of the sample, one set of straight parallel planes is observable, the two sets of planes are slightly inclined against each other forming an angle of ≈ 169° (Figure 2). The orientations of the two sets of planes are determined to be parallel to the basal planes of the two parts of the sapphire crystal. Consequently, the sample is not a corundum single crystal but consists of two sectors, the *c*-axes of which are slightly inclined to each other: the inclination angle equals 11°. Under crossed polarizers, interference striations and interference colours are observable at the irregular boundary between both parts of the corundum crystal (Figure 3). This optical effect is due to the different crystallographical orientations of these sectors. In each part of the corundum crystal, a second type of sets of straight parallel planes is observed forming angles of 100° with the first type of straight parallel planes described above (Figure 4). By rotation of the corundum crystal about various axes, especially about the short 4.0 mm axis of the oval stone, only the first type of structural plane reveals irregular spots or patches, which display total internal reflection when the angles of the incident ray with the normal are greater than 35° (Figure 5). Transparency is observed at smaller inclinations of the face normal versus the microscope axis, i.e. when the angle of the incident ray with the primary ray of light is smaller than 35°. This critical angle of ≈ 35° corresponds with the critical angle of corundum in contact with air or vacuum, which equals 34.4° (cf. Schmetzer, 1986).

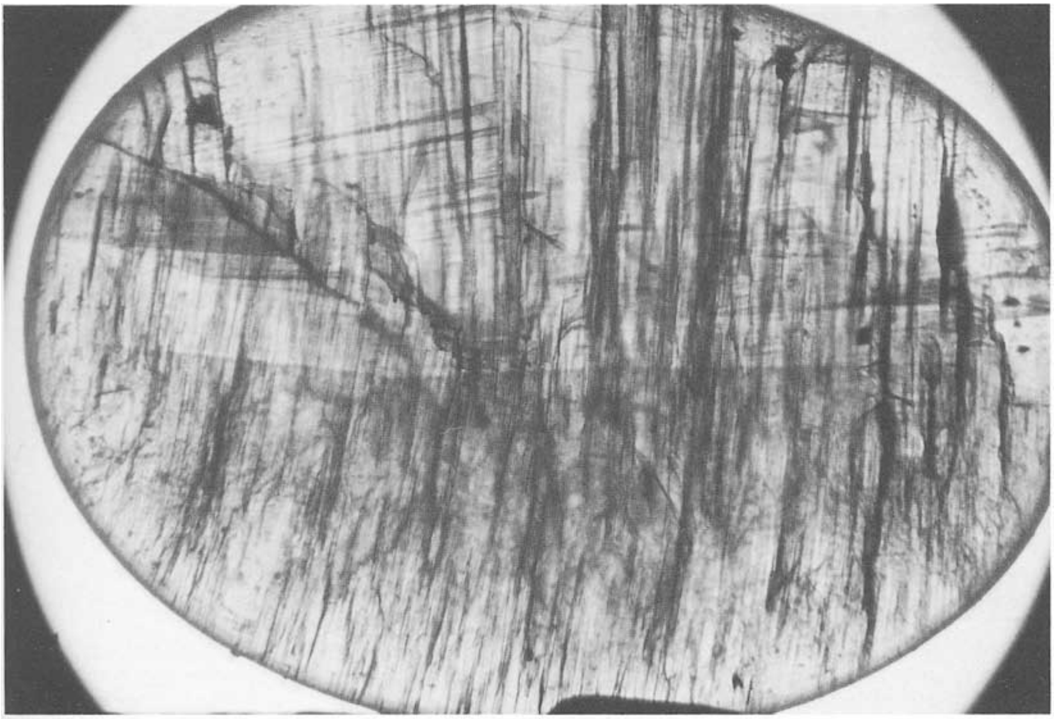

Fig. 1. General survey of sapphire cat's-eye from Burma; the sample consists of two parts which are separated by an irregular surface, each part reveals glide planes parallel to the basal pinacoid (0001). In the upper part two sets of growth planes parallel to the hexagonal dipyramids $(22\bar{4}1)$ are present. 36x.

Discussion

In general, untwinned natural ruby and sapphire crystals are single crystals without different crystallographical orientations of different parts of the crystals. Natural corundum of the particular type, which is described in the present paper, is extremely rare. In the experience of the authors, only one non-single crystal of corundum has been observed in the past. This sample from Sri Lanka, however, was only available for a limited time and thus was not studied in detail.

On the other hand, in synthetic corundum crystals which were produced by the Verneuil technique, slight inclinations of different growth sectors against each other are common. The irregularly curved surfaces between these sectors,

Fig. 2. Sapphire cat's-eye from Burma; the two parts of the stone, which are separated by an irregular surface, reveal glide planes parallel to (0001). The glide planes are inclined against each other forming angles of ≈ 169°. 50x.

Fig. 3. Sapphire cat's-eye from Burma; interference striations and interference colours are observable at the irregular boundary between the two parts of the crystal. Crossed polarizers. 20x.

Fig. 4. Sapphire cat's-eye from Burma; two sets of growth planes parallel to the hexagonal dipyramids $(22\bar{4}1)$ intersect with glide planes parallel to the basal pinacoid (0001). 40x.

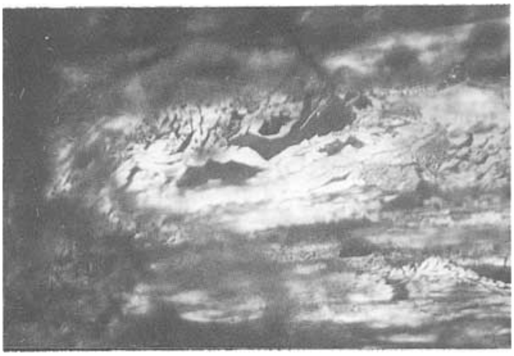

Fig. 5. Sapphire cat's-eye from Burma; irregular spot- and patch-like fissures on basal glide planes showing total internal reflection at distinct angles. 70x.

which are called small-angle grain boundaries, display interference striations and interference colours under crossed polarizers (cf. Schmetzer, 1986). A second characteristic property of Verneuil-grown corundum is the presence of intersecting glide planes parallel to the second-order hexagonal prism $(11\bar{2}0)$. These prismatic glide planes are formed at extremely high temperatures [above 2000°C] (Scheuplein and Gibbs, 1960; Stephens and Alford, 1964).

In natural or synthetic corundum, glide planes parallel to basal faces are produced by external stress at temperatures above 900°C (Kronberg, 1957; Scheuplein and Gibbs, 1960) or even at room temperature (Johnsen, 1917; Veit, 1922). Both types of basal and prismatic glide planes are shown in Figure 6. A third type of structural separation plane parallel to the rhombohedral face $(10\bar{1}1)$ is limited to natural corundum with intercalated lamellae of boehmite along these so-called parting planes (White, 1979; cf. also the paper of Judd, 1895).

The microscopic observations of two types of intersecting structural planes in the non-single crystal sapphire from Burma, which is described in this paper, suggest that at least one set of these planes are not growth structures. Growth structures in natural corundum are commonly observable parallel to the basal pinacoid (0001) as well as parallel to the second-order hexagonal prism $(11\bar{2}0)$, parallel to the rhombohedron $(10\bar{1}1)$, and parallel to different hexagonal dipyramids $(hh\overline{2h}l)$. Growth planes, however, do not display irregular patches with total reflection at distinct angles. These facts support an interpretation of both types of structural planes in the cat's-eye sapphire from

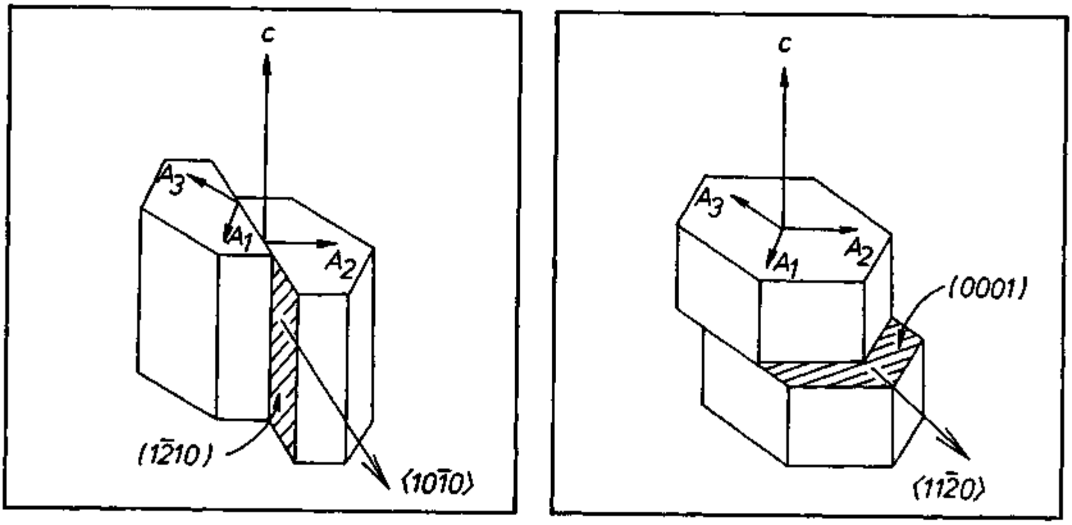

Fig. 6. Schematic drawing of basal and prismatic glide planes and glide directions in corundum (after Scheuplein and Gibbs, 1960).

Burma as growth planes parallel to the hexagonal dipyramid *z* $(22\bar{4}1)$ and glide planes parallel to the basal pinacoid *c* (0001). The different crystallographical orientation in both parts of the crystal is caused by an inclination of structural planes, which is presumably generated during the glide process. Details of the mechanism of formation of the irregular boundary between both parts of the crystal, however, are unknown at present. A possible explanation of the formation of this structural feature is a combination of basal and prismatic gliding, which was artificially produced in synthetic Verneuil-grown corundum by Scheuplein and Gibbs (1962).

The presence of irregular patch-like fissures with total reflection at distinct angles is responsible for the optical effect of the cabochon-cut stone, which is similar to a cat's-eye in other well known gemstones such as chrysoberyl and tourmaline. These irregular fissures are presumably formed on the basal glide planes during the slip process.

Acknowledgements

The authors are grateful to Mr M.P. Steinbach, Idar-Oberstein, who supplied the sapphire cat's-eye from Burma for investigation. Financial support was given by grants of the Wirtschaftsministerium des Landes Rheinland-Pfalz, FRG.

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On the colour of gemstones and Nelson's 'body colour'

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Dr Nelson's article on the measurement of colour in gemstones (Nelson, 1986) covers many of the complexities involved in this perplexing problem and gives his views of a solution for '. . . taking the first steps towards establishing international standards for the quantitative description of gemstone body colour'. In his article a number of important aspects of colour measurements are discussed. I do not agree with all the statements he makes and feel that some significant matters have been omitted, but I wish to comment here only on one specific aspect of his approach.

It appears to me that Nelson has fallen into a trap to which we scientists unfortunately are rather prone. Let us call it the *irrelevant model trap* and clarify this as follows. Frequently, in scientific and technological research, one proposes a 'model', an idealized approach to what one is trying to achieve. Such a model is usually an interpretation of what one feels are the most important aspects of the problem and includes the relationship of these aspects to characteristics that can be measured. The next step involves a study on how to perform these measurements and from these measurements to deduce the nature of the important aspects.

At this point the model is complete. The task is, however, not yet finished, for it remains to be demonstrated that the model does indeed correspond to the reality it was intended to represent. This last step has not been performed by Nelson and it is easy to show that there are fatal flaws in attempting to move from his model back to reality. These flaws involve one concept discussed by Nelson at length and one other which is never specifically discussed, although it is at the centre of his approach.

Nelson clearly recognizes that 'Colour is *what we see*' (his emphasis). It is curious therefore that he does not explain why the colour that is measured in his model is the 'body colour'. And here is the problem: when we look at a faceted gemstone, we see much more than just a body colour.

Before going any further, we need to know exactly what Nelson means by 'body colour', a term which he does not define. Part of his Figure 9, shown here as Figure 1, appears to give the answer. If a beam of white light enters the table facet near its centre at a small angle and is returned along the same path by frustrated reflection from a diffusing white rubber* in contact with the back of the stone, then the colour carried by this beam emerging from the table is Nelson's 'body colour'. Presumably this term is intended to distinguish the colour seen near the centre of the table facet from that perceived near the edges or rim of the stone. There are three separate problems with this approach, any one of which is fatal to the validity of this model.

First, '*what we see*' when looking at a gemstone does include the edge or rim region; if this is different in hue or in intensity from the central region of the gem, as it usually is, it will clearly influence the overall colour perception our brain receives from our eyes and thus can hardly be ignored. Two stones could easily have the same 'body colour' with significantly different edge colours and therefore give quite different overall colour impressions.

Second, the 'body colour' approach as used by Nelson excludes the effects of dispersion and of pleochroism (Nassau, 1983). These are, however, a part of '*what we see*'. As one example, the pleochroism is present as dichroism in the case of ruby; a piece of ruby rough shows its best colour when the cut is oriented so that the purple-red of the ordinary ray is dominant rather than the orange-red of the extraordinary ray. This aspect also makes any such measurement technique not particularly useful for rough, as suggested by Nelson, since a range of colours could be obtained depending on the orientation of the windows on the rough with respect to the optic axes.

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*Even if the white rubber were to act as an integrating sphere does (possibly implied by Nelson's use of the word *multiple* in 'frustrated multiple internal reflection' but apparently negated by subsequent statements), the remarks following would still apply, although with minor modifications.

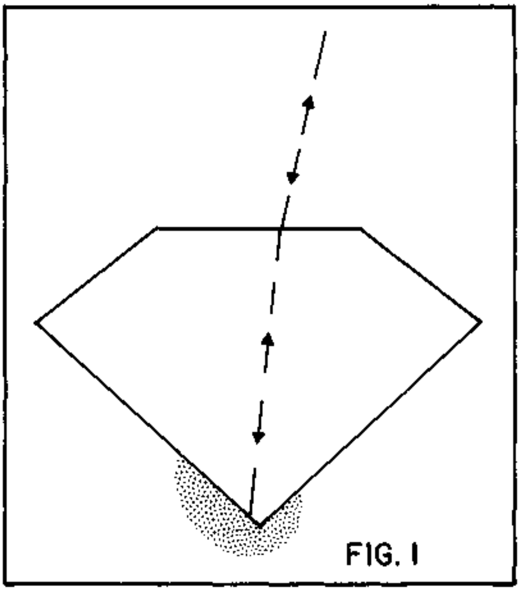

Fig. 1. The path through a gem in Nelson's 'body colour' technique.

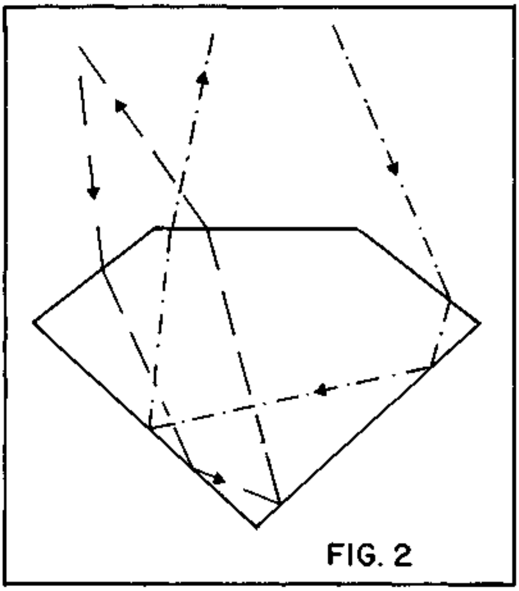

Fig. 2. Typical viewing paths in a gem, illustrated for a diamond; both paths can be traversed in either direction.

The third vitiating aspect is the question of the optical path within the gemstone. This might not matter if just a single optical path were involved, but it is not. The exact returning path of Figure 1 as used by Nelson is not present under normal viewing conditions because (a) the head of the viewer blocks that light which could produce a precise returning path and (b) frustrated reflection is not present. There is a wide range of actual paths contributing to the perceived colour, only two of which are shown schematically in Figure 2. This involves not only paths approximately perpendicular to the table, but also paths at least partially near parallel to the table, thus sampling different parts of the pleochroism. Note that paths emerging from the table may have entered the gemstone near the edge and vice versa. Also note that pleochroism does produce significant colour variation, even though the light is not polarized.

Except in rare and unusual circumstances, the result of these three effects will be that the 'body colour' determined by following Nelson's procedure will not be the same as the overall colour impression produced by the gemstone under ordinary viewing conditions. Yes, it would indeed be convenient if colour measurement could be taken over by what Nelson calls a 'dispassionate machine', but this would be useful only if it gave an answer relevant to the question being asked: '*what colour do we see?*'

These are the reasons why I believe it to be obvious that it will always be necessary to use the eye to compare the overall colour impression produced by a gemstone viewed *as a whole* with some other kind of reference material, be it a light-produced image, a set of master stones, or an opaque or transparent pigmented chart of some type. There are, admittedly, problems in each of these approaches, and a very specialized training will be required so that centre colour, edge colour, pleochroism, refractive index, dispersion, and all other optical effects present can be incorporated into a single visually-perceived colour *on which different observers can agree*. The colour measurement problem has been satisfactorily solved in many other systems, as mentioned by Nelson; he should, however, not permit himself to be taken in by the deceptively simple gemstone which poses problems far more complex than do any of these other systems.

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The two-colour beryl from Orissa, India

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Introduction

Numerous gemstones show different colours in the same crystal, sometimes differing from end to end, at other times in concentric layers as witness to the varying chemical-physical processes involved in their formation. 'Water melon' tourmaline is a well-known example of a gemstone showing different chromatic zones, colours ranging from red to pink and green in many different shades.

The corundum group sometimes produces specimens of different colours of yellow, blue and pink, occasionally mixed by the reflection of the facets in the faceted stones. Recently two-coloured quartzes have made their appearance in the trade, their colour being correlated with different oxidation states of iron. As in quartz, iron and its oxidation state is responsible for the colour of beryl, a mineral incapable of possessing any colour in its pure state.

The occurrence of beryl in the Pulbani district of Orissa State was limited to a few localities in the Eastern Ghats region, and the particular samples were mined in the Gopalbur and Lukapara area. The region is characterized by a complex of metamorphic rocks such as charnockite-khondalite-leptynite associated with rocks rich in hydrous minerals. The charnockite shows intrusive relationship towards the khondalite and has itself undergone post-magmatic changes such as albitization and myrmekitization (Crookshank, 1938). The charnockites have also formed hybrid gneisses with khondalites and sometimes with other ancient gneisses. In this region crystalline limestones, cordierite gneisses, sapphirine bearing rocks, and nepheline-syenite are also found.

The beryl-bearing and mica pegmatite bodies of variable size are probably localized along the fracture planes of the metamorphic rocks. Green shales and medium to coarse-grained yellowish sandstones, having pebbles and conglomerates of Gondwana group of rocks, also occur in the basin with faulted boundaries on east and west (Krishnan, 1982).

Orissian deposits furnish gem beryls which occur in colourless and yellow, and occasionally the crystals show lighter hued yellow colour zones, parallel to the basal plane.

Experimental

The origin of colour in beryl has recently been revised by Goldman *et al.* (1978), supporting the conclusion that iron is responsible for different colours in beryls when located primarily in the aluminium site, though the colour is derived mainly from the amount of ions located in the channels formed by the silicon ions. Less often specimens of natural origin showing sectored variation in colour and properties like the two samples from the Orissa State are reported.

The two beryls examined occurred in pegmatite bodies in the Pulbani mining area and are associated with cordierite, corundum, garnets, quartz and chrysoberyl (cat's-eye and alexandrite). The investigated specimens (Figure 1) weighing respectively 4.13 and 3.97 ct, were cut with an octagonal outline with long parallel facets (step cut) clearly showed the two-colour separation line running across the middle of table (Figure 2).

With the intent of a preliminary checking of the greatest variation between the yellow and colourless areas of each sample, the refractive indices were evaluated using oriented laminae cut parallel to the optical axis of the crystals. Preliminary optical observations led to recognition of elongated fibrous inclusions, strictly following the direction of the *c*-axis, referable to growth-tubes which are spread through the entire volume of the beryl, and are filled by birefringent material.

Cavities of different sizes with prismatic habit orientated with elongation direction parallel to *c*-axis of the beryl matrix are also present. It seemed appropriate to conduct the present study to determine the mineralogical characteristics of these two-colour beryls to define their formational conditions.

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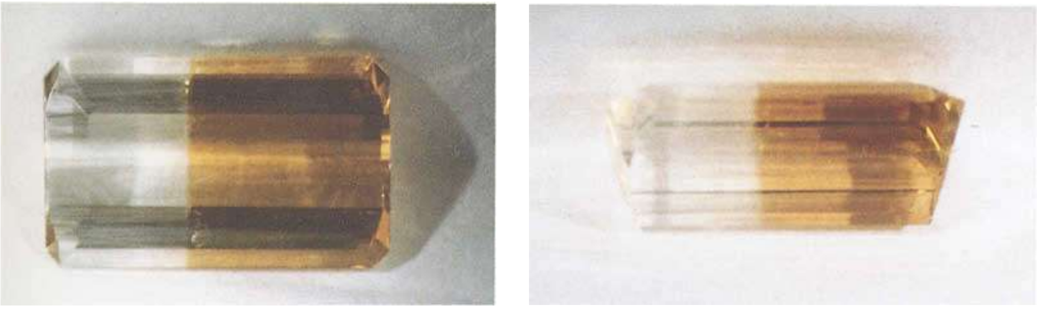

Figs. 1 (a) and (b). Two-coloured beryls from Orissa.

Table 1 summarizes the gemmological properties of one of the two samples probably cut from the same crystal. The density measured by the hydrostatic method gave a value of 2.699±0.002 g/cm^3 while the RI reading taken with a hemisphere refractometer using monochromatic sodium light, turned out to show different values corresponding to the different regions of the specimen. The shadow edge gave indices for extraordinary ray n_ϵ at 1.574 and for the ordinary ray n_ω at 1.580 on the yellow portion, n_ϵ 1.570 and n_ω 1.575 on the colourless portion.

An additional reading taken across the interface of the colours gave the values of 1.570, 1.573 and 1.580. Microscopic examination of the specimens immersed in benzyl benzoate revealed a barrier of acicular growth-tubes all oriented parallel to the main growth axis. They seem to originate from the same plane parallel to the (0001) pinacoid protruding from a layer of blocking guest microlites. Further electron microprobe analysis (EPMA) investigation confirmed the presence of acicular parallel growth tubes, some of them breaking the surface of the specimen, having the same composition as the host crystal. A section of a tube-like inclusion breaking the surface of the beryl is shown in Figure 3.

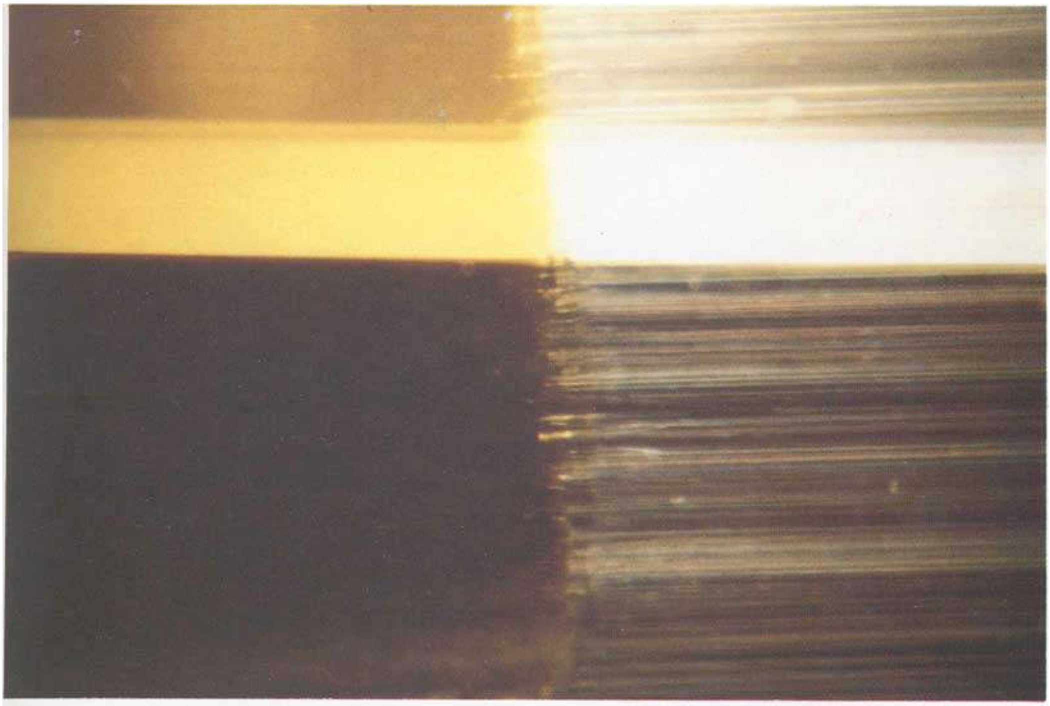

Fig. 2. Photomicrograph of some acicular inclusions reaching the middle of table and forming the border-line between yellow and colourless areas. 45x.

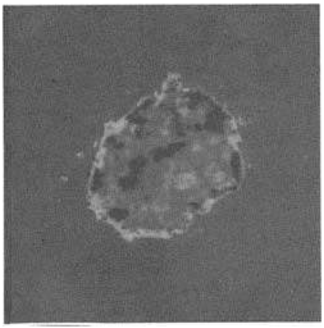

Fig. 3. Section of an acicular inclusion protruding through the (0001) plane. SEM photograph, 1000x.

EPMA quantitative analysis performed on both colourless and yellow sectors has shown different chemical compositions. The yellow area reveals a higher concentration of iron, 0.67 wt.%, against 0.13 wt.% in the colourless area, while a higher percentage of aluminium is reported in the colourless, 19.90 wt.%, against 19.32 wt.% in the yellow area (Table 2). Figure 4 shows a quantitative elemental distribution of Al_2O_3 and FeO through the two different coloured areas.

Table 1. Gemmological properties of two-coloured beryl from Orissa

Crystal system		Hexagonal
Hardness		7½ (Mohs)
Toughness		Strong but brittle
Cleavage		Poor
Fracture		Conchoidal
Density		2.699±0.002 g/cm^3
Transparency		Good
Optical character		Uniaxal negative
Pleochroism		Absent
Long-wave ultraviolet (365 nm)		Inert
Short-wave ultraviolet (253.7 nm)		Inert
Visible spectrum		540 nm (Fe)
Optical observation		Elongated fibrous inclusions, minute unidentified inclusions, some K-feldspar
Birefringence		Colourless area 0.005 Yellow area 0.006
RI	Colourless area	n_ϵ 1.570±0.002 n_ω 1.575±0.003
	Yellow area	n_ϵ 1.574±0.004 n_ω 1.580±0.002

Table 2. Chemical analyses of two-coloured beryl from Orissa

	Colourless	Yellow
SiO_2	64.16	64.53
TiO_2	tr.	tr.
Al_2O_3	19.90	19.32
Cr_2O_3	—	—
FeO†	0.13	0.67
BeO*	12.96	12.94
MnO	—	—
MgO	0.10	0.11
CaO	0.12	0.09
Na_2O	0.13	0.12
K_2O	0.16	0.12
Li_2O	nd	nd
Cs_2O	nd	nd
Numbers of ions on the basis of 36 (O)		
Si	11.571	11.594
Ti	—	—
Al	4.225	4.102
Cr	—	—
Fe	0.022	0.097
Be	5.612	5.581
Mn	—	—
Mg	0.022	0.032
Ca	0.022	0.022
Na	0.022	0.022
K	0.022	0.011
Li	—	—
Cs	—	—
Σ	9.947	9.867

Σ = sum of metal ions other than Si

†total iron as FeO
*dosed with pyrophosphate

Conclusion

The pair of unusual gemstones reported in this paper have been cut in order to place the interface, where the colours turn from colourless to yellow, exactly in the middle of the table facet producing a pleasant chromatic effect. Such interface proved to be formed by a barrier of included crystals pre-existing at the start of growth of the beryl crystal, some of them identified as K-feldspar. Such barrier of guest microlites produced a blocking effect in the growing beryl causing crystallization of growth tubes within the embedding crystal.

Acknowledgements

The constructive suggestions of Prof. G. Graziani, Dept of Earth Sciences, University of Rome, are gratefully acknowledged.

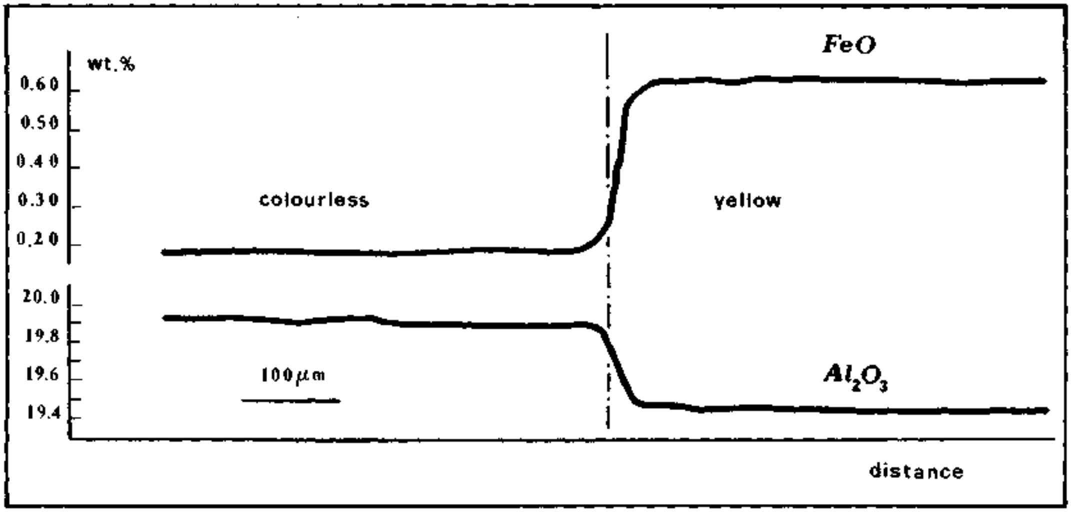

Fig. 4. Diagram showing the increased concentration of FeO in the yellow portion of the bi-coloured beryl compared with the colourless part, and the greater concentration of Al_2O_3 in the colourless compared with the yellow part.

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Notes from the Laboratory – 10

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Saussurite, a rock composed essentially of albite and zoisite and which can closely resemble jadeite and nephrite, is usually described only in brief terms in the sections of textbooks which deal with the jades rather than under its own heading, say in the sections dealing with 'unusual minerals' (e.g., Webster, 1983; G.F. Herbert Smith, 1972). Saussurite's representation in these works tends firstly to indicate that it will only be met with rarely, and secondly that the position it holds in the gemmological world is one of a substitute for the jades and that it is not regarded as a material to be considered in its own right. However, a description of saussurite in 1974 (Jobbins and Rutland, 1974) which includes colour photographs, adequately fulfils the need for more detailed information of this material.

Fig. 1. A string of one hundred saussurite beads showing the variations in colour.

Jobbins and Rutland examined six carvings in an attractive green material over a period of two years at the Institute of Geological Sciences, London. Some of these had been sold in Hong Kong or China as jade or 'new jade', but a detailed examination proved that they were composed of either dominant or very significant proportions of saussurite. Their report on the properties of these six items and two standard specimens from the collections, as well as on the properties revealed by many analyses of saussurite since it was described by H.B. de Saussure in 1780, emphasises the possible variations in the composition of this material, SG, RI, hardness, absorption spectrum and general appearance. Using X-ray diffraction their examination revealed compositions which included the presence of zoisite, Ca-rich plagioclase, clino-enstatite, diopside and chlorite, whilst their normal gemmological examination revealed SGs ranging from 2.85–3.22, RIs ranging from 1.55–1.56 for the white areas to 1.68–1.70 for the darker areas (although the latter

Fig. 2. A saussurite carving of a seated lady, mostly white in colour but with several areas of green varying in shade from light to very dark.

Fig. 3. The back of the carving in Figure 2.

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Fig. 4. A saussurite carving of two birds in a tree showing the variations in colour, cf. Figures 1, 2 and 3.

results were not felt to be reliable), a hardness of between 5 and 7, and absorption spectra varying from being 'not distinctive', to 'Cr lines in red' with 'absorption of blue/violet', to a 'line in deep violet'.

It is clear then that saussurite, unlike the majority of materials handled by gemmologists, does not have convenient constants by which it may be identified; indeed it is its variable properties coupled with its mottled green and white appearance that first give hints towards its identity. However, these are only hints and as stated by Jobbins and Rutland thirteen years ago in remarking about the specialized equipment needed to identify their specimens, 'The material will create problems in the future for many gemmologists and dealers'. A mottled green and white rock which had some properties similar to those of saussurite was examined by Robert E. Kane in 1985 (Fryer *et al.*, 1985). In this case X-ray diffraction revealed the major constituents to be a white plagioclase feldspar and a green muscovite mica and the material was therefore only reported upon as being a rock consisting of two or more minerals.

After not having examined any examples for some time, we were recently asked to examine three mottled green and white items which, following X-ray powder diffraction analyses, were identified as saussurite. The first, which was submitted by a different client to the other two, was a string of one hundred round drilled beads with a total weight of 422.74 ct (Figure 1). The second was a carving of a seated lady (Figures 2 and 3) with a weight of 445 gm and dimensions of 12 cm height, 14 cm width, and 5 cm depth. The third was a carving depicting two birds in a tree (Figures 4 and 5) which weighed 380 gm and had dimensions of 15 cm height, 17 cm width and 10 cm depth.

Fig 5. A close view of the saussurite carving in Figure 4.

The general appearance and colour distribution of the three items examined recently, are adequately displayed in Figures 1 to 5. Whilst zoisite was proved to be present by X-ray diffraction, several distant vision RI readings failed to produce a value greater than 1.60. The approximate RIs for the three items varied between 1.57 and 1.60. The absorption spectrum as seen with the hand spectroscope varied greatly, not only between the items but also between areas on each item. The absorption spectrum of the beads in Figure 1 revealed only a vague band in the blue and this was also true of some areas of the carving in Figures 4 and 5, but in other areas of this same carving the spectrum typical of chromium could be observed in the red. In the absorption spectrum of some of the areas in the carving in Figures 2 and 3 a strong band could be seen centred at 442.1 nm.

* * *

During 1986 we were fortunate to be shown a rather large rough diamond, which appeared to be a light brownish colour. The crystal which weighed 73.50 ct can be seen in Figure 6. Upon examination it was found that the surface was spotted with brown radiation marks, and the degree of influence these had on the actual colour of the crystal was not fully understood until after the crystal had been cut. The first finished stone to be cut from the crystal was a 4.75 ct pear shape (Figure 7) and when this was graded for colour and clarity it was found to be a 'Fancy Light Pink', and 'Internally Flawless'. None of the brown radiation marks were left on the cut stone and the 'light pink' was in fact the true body colour of the diamond and not the light brownish colour of the uncut crystal.

In following our routine testing procedures for coloured diamonds we noted that the fluorescence and absorption characteristics of this stone were similar to those of two pink diamonds described by Anderson twenty seven years ago (Anderson, 1960). They were similar also to those of ten natural pink stones examined in the Laboratory over the past ten years, but these were by no means characteristic of pink diamonds in general. This new stone fluoresced a very strong orange under short-wave ultraviolet light and a medium strength orange under long-wave ultraviolet. The first of the two stones described by Anderson in 1960 weighed 34.64 ct and he stated the fluorescence to be 'a strong orange-yellow or "apricot" '; the second stone was smaller at only 2.83 ct but had similar fluorescence characteristics. When Anderson examined the fluorescence of his stones with a hand spectroscope interesting and similar emission spectra were revealed for both. He described the spectrum as a series of bright lines extending towards the red end, and in diminishing strength from the end member of the series. He recorded the wavelength of this main line as 5750Å. Our observations were similar for the 4.75 ct stone. The spectrum which we obtained by bathing the stone in white light filtered through copper sulphate solution may be described as a clear and sharp bright line at 575 nm and a bright 'patch' between 590 and 650 nm.

Anderson stated that it was possible that the larger of his stones came from the old Golconda mines of India and that experiments had revealed the stone to have the ultraviolet transparency characteristics of a type II diamond. It is said that this new crystal was also found in India, and, as with Anderson's stone, ultraviolet transparency tests revealed type II diamond characteristics.

As always the Laboratory's main interest with coloured diamonds is in the area of colour origin – is the diamond coloured naturally or artificially? It is particularly interesting to be able to observe any coloured diamond both before and after cutting and even more so when the original rough shows clear signs of having been *naturally* in the presence of radioactivity as some stage in its history.

When a type Ib diamond is irradiated and annealed, depending upon the strength of the original yellow body colour and how heavy an irradiation is used, either a pink or a mauve artificially coloured diamond will be produced. Such treated pink diamonds are easily identified because the irradiation and annealing changes the typical Ib absorption spectra and induces a strong sharp line at 637 nm and further lines at 595, 575 and 503 nm, the last three of which sit on a broad absorption band centred near 560 nm. The 637 line is reported to be associated with isolated substitutional nitrogen (Collins, 1982).

On many occasions over the last ten years, both with the hand spectroscope and the spectrophotometer, we have recorded the 637 nm line in many naturally coloured yellow and brown type Ib diamonds when they have been held at low temperatures. Even at 120K, though, the 637 line in such stones is generally very weak (Scarratt, 1984, p110). Until now, only on one occasion have we observed a naturally occurring 637 line in other than a yellow or brown stone and in that case it was a 'green' stone, in which the colour was due to included material. However, when the 4.75 ct light pink stone was examined at low temperatures on the spectrophotometer, despite it appearing to have type II diamond characteristics in its ultraviolet transparency and in general terms also in its visible spectrum, this naturally coloured pink diamond recorded peaks, if only very weakly, at 637, 575, and 503 nm (Figure 8).

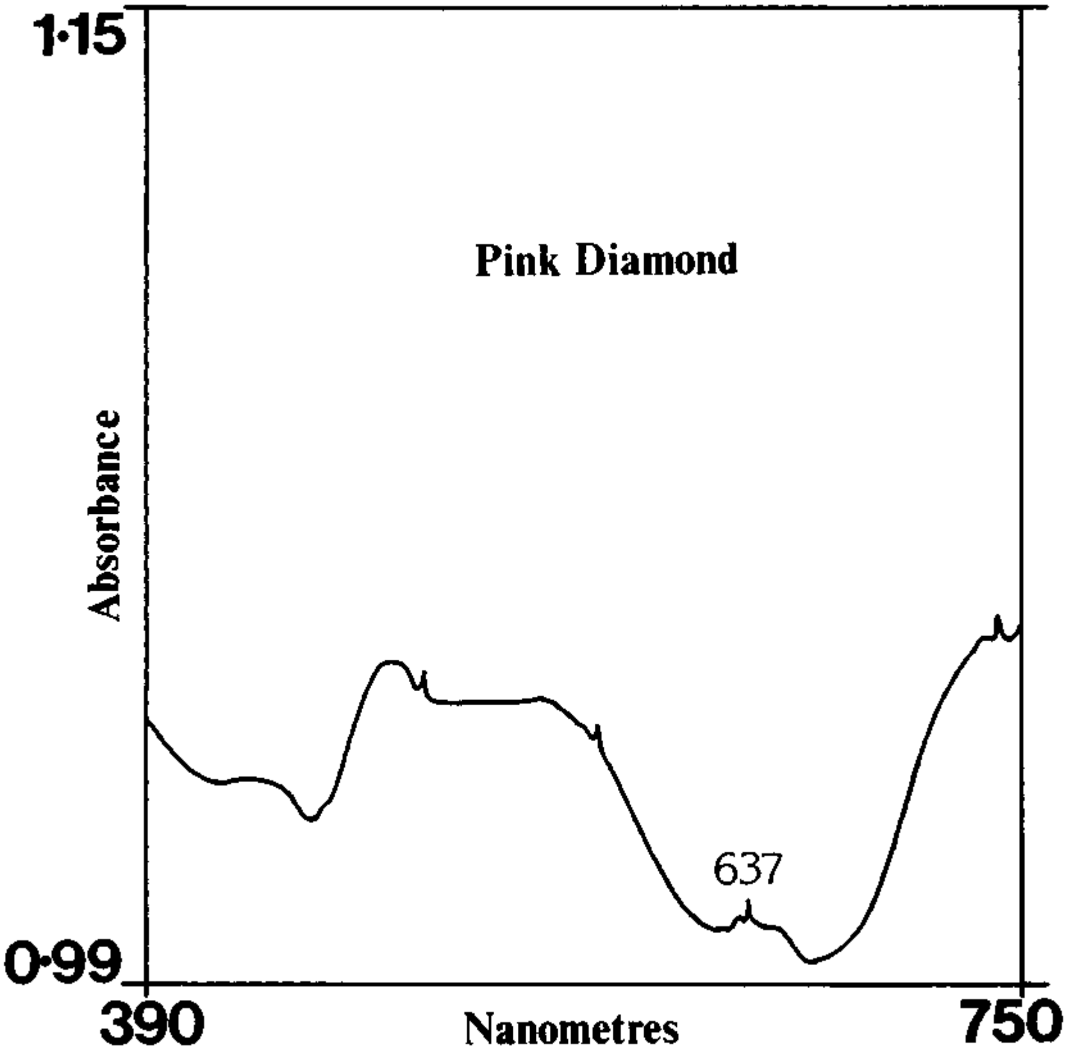

Fig. 8. The absorption curve of the 'Fancy Light Pink' pear-shaped diamond in Figure 7. The curve was obtained using a Pye Unicam PU8800/03 UV/visible spectrophotometer (Basil Anderson model) with a speed of 0.5 nm/s and a bandwidth of 0.5 nm at approximately 120K. The path length was approximately 9 mm.

Fig. 6. A 73.53 ct rough 'light pink' diamond with brown natural radiation marks on the surface. *Photograph by Mr M. Gould of M. Vainer Ltd.*

Fig. 7. A plastic model of the diamond in Figure 6 from which the three unfinished stones and the 4.75 ct pear-shaped diamond in front were cut.

Fig. 9. Brown natural radiation marks on the 'skin' of one of the partly polished diamonds in Figure 7.

To our knowledge this is the first time that a line at 637 nm has been observed in a naturally coloured pink diamond: in all other cases of pink diamonds where a line has been recorded at this wavelength the coloration has been due to man-induced irradiation and annealing.

For the record we asked if we could examine the remaining pieces of the crystal before they became finished stones, these can be seen in Figure 7 with a plastic model of the crystal in the background. Brownish radiation marks could still be seen on the uncut surfaces of the three unfinished stones (Figure 9): all behaved in the same way as the 4.75 ct stone when bathed in ultraviolet light, and similar emission spectra were also produced.

* * *

An interesting and quite effective ruby imitation was given to the Laboratory collection recently. It was a composite stone in which both the crown and pavilion were made from near colourless beryl (Figure 10) and these were joined at the girdle with a rich red adhesive. The refractive indices were 1.580–1.586 for the crown and 1.584–1.590 for the pavilion. Internally the crown was comparatively free from inclusions, whereas included in the pavilion were innumerable two-phase inclusions (Figure 11).

Acknowledgements

Thanks are due to Mr S.J. Kennedy for the production of the absorption curve of the 4.75 ct pink diamond and to Mr I. Shenker for the production of the X-ray powder diffraction details of the saussurite. Figure 6 was taken by Mr M. Gould of M. Vainer Ltd. We are also indebted to the firms of M. Vainer Ltd for allowing us to examine the large pink diamond and to E.A. Thomson Ltd for the gift of the beryl composite stone.

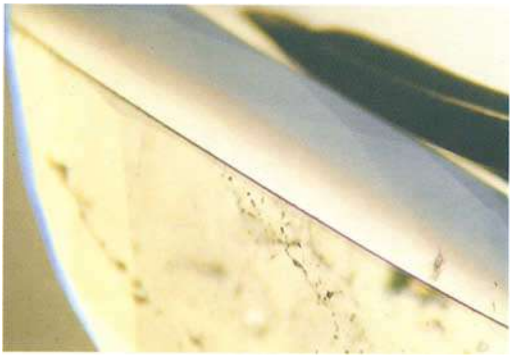

Fig. 10. A 'red' beryl-on-beryl composite stone seen here immersed in benzyl benzoate. The rich red junction can be seen following the girdle.

Fig. 11. The crown of the composite stone in Figure 10 is relatively free of inclusions whereas the pavilion, as seen here, contains innumerable two-phase inclusions. The edge of the junction can be seen as a curved red line at the top of the figure, and the pinkish coloration below this is in the plane of the junction. The stone is photographed immersed in benzyl benzoate.

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Colour and irradiation-induced defects in topaz treated with high-energy electrons

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Abstract

In topaz irradiated with electrons in the 10 to 20 megaelectronvolt range different colour centres are present in variable concentrations. Due to their strong polarization dependency the colour centres are designated as X- and Y-centres, the colour of which is blue and bluish-violet respectively.

The electron irradiated samples reveal cracks and parting planes parallel to the basal pinacoid *c* (001). In addition, a shell-like structure is observed consisting of a blue rim, a colourless intermediate zone, which is characterized by a high concentration of irradiation-induced defects, and a colourless core. This shell-like structure is explained by a temperature gradient from the surface to the centre of the topaz crystals. This temperature gradient is formed during the irradiation process of the samples which are cooled all-around with running water.

Colour, spectroscopic properties and colour causes of natural blue topaz are compared with features of topaz crystals which were artificially irradiated with gamma rays, electrons and neutrons.

Introduction

Colourless topaz has been irradiation-treated commercially for about ten years in different procedures in order to produce a more or less intense blue coloration. Under exposure to gamma rays, e.g. on irradiation to gamma rays produced by Co-60 within a gamma cell, in general only a blue coloration of low intensity is acquired. The treatment of topaz with high-energy electrons by the use of linear accelerators or with neutrons in nuclear reactors causes a more intense blue colour. By the use of gamma rays or electrons, the irradiation-treated topaz turns a more intense brown or greenish-brown colour. The desired blue coloration is produced by subsequent heating at about 200°C for a few hours in order to bleach the brown unstable colour centres in topaz.

Neutron-irradiated stones in general reveal an intense blue coloration without heat treatment. However, heating of neutron-irradiated stones is applied to remove an inky or steely hue, i.e. in order to produce lighter shades of blue (cf. also Nassau and Prescott, 1975; Nassau, 1985).

The absorption spectra of natural and artificially irradiated blue topaz crystals in the visible area were studied by different authors (Nassau and Prescott, 1975; Petrov, 1977). According to these papers, the coloration of all different types of natural and artificially induced blue topaz is caused by a broad absorption band at about 15 200 – 16 100 $\mathrm{cm}^{-1} \hat{=}$ 658 – 620 nm (cf. also Nassau, 1984, 1985).

By the use of low-energy gamma radiation, e.g. with the gamma radiation of Co–60 having energies of 1.33 and 1.17 MeV, neither radioactivity nor radiation defects are induced. The disadvantage of neutron irradiation in nuclear reactors is the generation of radioactive nuclides by neutron activation, partly with long half-lifes (in topaz mainly Sc–46 and Ta–182 are produced, subordinate amounts of Co–60 and Cs–134 are also observed after irradiation). These radioactive nuclides cause an irradiation-induced radioactivity, which is not acceptable to the trade. Therefore, according to the individual conditions of treatment as well as to the trace element contents of an individual crystal, a cooling off period between one and four years is necessary for the decay of radioactivity. After this time, the induced radioactivity has almost completely disappeared, the remaining activity being in the range of the natural background. By treatment with electrons of energies between 10 and 20 megaelectronvolts, which are commonly used for the irradiation of topaz, certain types of radiation defects are occasionally produced. This irradiation-induced cracking and damage may diminish the quality of the treated crystal or make the topaz completely useless for jewellery purposes.

The aim of the present paper is a detailed description of the coloration and different types of electron-induced defects in irradiated topaz. In addition, the study presents the first description of different types of blue colour centres in topaz, which were discovered during this research project.

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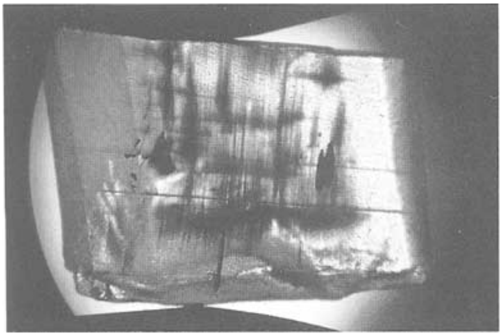

Fig. 1. Topaz from Nigeria irradiated with high-energy electrons; the sample reveals parting parallel to the basal pinacoid (above): in addition, parallel cracks are developed. At a distance of about 3 mm from the surface, an intermediate zone with a high defect concentration is formed. View perpendicular to the *c*-axis. 12x.

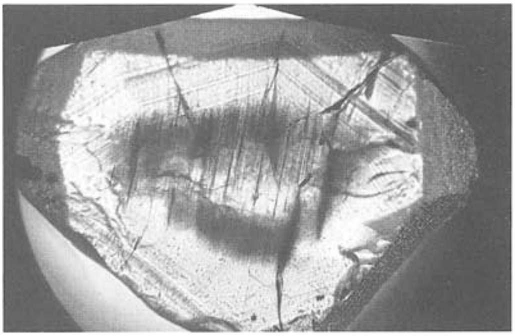

Fig. 2. Topaz from Nigeria irradiated with high-energy electrons (identical stone to that in Figure 1); all-around shell-like structure consisting of a light blue rim (about 3 mm broad), a colourless intermediate zone, which is characterized by a high concentration of defects, and a colourless core; growth planes parallel to the prism faces *m* (110) and *l* (120) are developed. View parallel to the *c*-axis. 14x.

Experimental details

For the present study, two parcels of hardly damaged topaz crystals were available. According to the information given by the supplier, both parcels of stones were recently treated by different linear accelerators in the USA. All samples were pre-shaped topazes, which had been mined in various (?) localities in Nigeria. For comparisons sake, different parcels of topaz from various localities which were treated by the author by the use of gamma rays and high-energy electrons and converted to blue after subsequent heating, neutron-irradiated samples from different occurrences as well as naturally blue coloured topaz from Brazil, Nigeria and Zimbabwe, were spectroscopically investigated.

Results

The topaz crystals from Nigeria irradiated with high-energy electrons exhibit a blue coloration of variable intensity. By examination with the naked eye, most of the stones reveal plane parallel cracks, and part of the samples were broken parallel to one or even two of these planes (Figure 1). The orientation of these parting planes is parallel to the known cleavage of topaz, i.e. parallel to the basal pinacoid *c* (001).

All topaz crystals of both parcels exhibit a shell-like zoning, which was found to be independent from the crystallographical orientation of the individual sample (Figures 2, 3). This shell-like structure was observable in all samples however, the best investigations were possible in cracked samples with one or two parting planes parallel to *c* (001). The rim of the stones reveals a uniform blue coloration beginning directly at the surface of the pre-shaped stones. The depth of this zone is also very uniform and measures about 3 mm. This uniform and all-round light blue coloration in the rim of the samples is superimposed by an irregular and spot-like bluish-violet colour, which is generally developed only in one side or in one area of the rim (Figures 3, 4). The irregular and patch-like distribution of the bluish-violet coloration is comparable with the irregular zoning of the brown colour of Nigerian topaz samples, which were irradiated in the gamma cell with Co–60 or in a linear accelerator with high-energy electrons before the stones are heat treated. In both types of samples, i.e. in heat treated and non-heat treated irradiated stones, the irregular and patchy bluish-violet or brown coloration of topaz in most cases does not follow crystal faces and varies even among crystallographical zones. In some samples growth planes parallel to the prism faces *m* (110) and *l* (120) were observable in immersion liquids. However, only in a few cases was the colour zoning found to follow this clearly developed growth zoning (Figures 2, 4). The pleochroism of the intensely coloured zones or patches is different from the pleochroism of the light blue uniformly coloured zones (Table 1). The pleochroism of these light blue zones is identical with the normal pleochroism of natural blue topaz as well as identical with that of topaz which was irradiated in a gamma cell and heated subsequently (Table 1, cf. also Petrov, 1977). In topaz from different localities which was irradiated in nuclear reactors with neutrons, the pleochroic colours are somewhat different (Table 1). Colour zoning was never observed in samples which had been treated in this manner.

The absorption spectra of natural (untreated) blue topaz as well as the spectra of topaz irradiated by neutrons, electrons or gamma rays, reveal

Table 1. Pleochroism and absorption maxima in blue topaz

	natural untreated blue topaz, Brazil, Nigeria, Zimbabwe		blue topaz irradiated in the gamma cell, subsequently heat-treated	blue topaz irradiated in linear accelerators, subsequently heat-treated		blue topaz irradiated in nuclear reactors	
colour zoning	distinct colour zoning rarely observable		no colour zoning observed	light blue, all-around developed zone	darker blue, irregularly developed zone	no colour zoning observed	
pleochroism							
X‖a	distinctly blue		distinctly blue	distinctly blue**	distinctly blue**	very intense blue to bluish-black****	
Y‖b	colourless, grey		colourless, grey	colourless, grey	intense bluish-violet	colourless, grey	
Z‖c	colourless, yellowish		colourless, yellowish	colourless, yellowish	colourless, yellowish	light bluish	
absorption maxima [in cm^{-1} and nm]							
X‖a	15200–16000 ≙ 658–625***	23800 ≙ 420	16000 ≙ 625	16000 ≙ 625**	16000 ≙ 625**	15200–16000 ≙ 658–625****	23800 ≙ 420
Y‖b	—*	—*	—*	—*	16600 ≙ 602	16600 ≙ 602	—*
Z‖c	—*	—*	—*	—*	—*	15200 ≙ 658	23800 ≙ 420
intensity ratios	X ≫ (Z,Y)	X ≫ (Z,Y)	X ≫ (Z,Y)	X ≫ (Z,Y)	X ≈ Y ≫ Z	X ≫ Z ≫ Y	X ≫ Z ≫ Y

* the presence of an absorption maximum was not confirmable for samples up to 2 cm in thickness.

** colour or intensities of the absorption bands are identical in both zones.

*** absorption maximum variable in different stones from different localities.

**** colour and absorption maximum variable according to various exposure times to neutrons and gamma rays in the reactor.

different absorption bands with maxima in the area between 15 000 and 17 000 cm^{-1} ($\approx 667-590$ nm), the intensities of all absorption bands being distinctly dependent on the polarization of the electric vector E (parallel to the three indicatrix axes X, Y, and Z). These spectroscopic investigations confirm that the absorption scheme of natural blue topaz is almost identical with that of topaz treated with gamma rays as well as with the absorption scheme of the uniformly coloured and all-round light blue area of electron-irradiated topaz. In neutron-irradiated stones, this absorption scheme is strongly intensified. In these dark blue samples, absorption bands in the Y- and Z-spectra are observed, which cannot be measured with certainty in the light blue coloured samples mentioned above. Furthermore, additional absorption maxima in the violet area of the visible region are observed in neutron-irradiated topaz (Table 1). These maxima were also present in the spectra of the darkest blue samples of natural blue topaz crystals from different localities, which were available for the present study.

In the irregular and spot-like bluish-violet areas of electron-irradiated topaz, which are, in general, developed only in one side or region of a pre-shaped sample, a distinct absorption band in the Y-spectrum is observed. This band of high intensity is not observable in natural or gamma-irradiated stones, and is found in neutron-irradiated samples only with low intensity. The intensity of the absorption band in the X-spectra of electron-irradiated topaz is identical in different areas of these crystals, i.e. in light blue and intense bluish-violet regions. These results of spectroscopic measurements confirm the visible observations, which show a homogeneous colour distribution and intensity in electron-irradiated topaz for polarized light with an electric vector E parallel to X. Strong colour zoning, however, is observable for polarized light with an electric vector E parallel to Y.

Inwards from the blue rim of the topaz crystals, which were recently irradiated by linear accelerators in the USA, a colourless zone of about 1 mm in depth is observed. This colourless zone is characterized by a high concentration of structural defects (Figures 1–5). Following this second intermediate shell (fissure zone) a colourless core is observed, which is almost free of structural defects (Figure 2). Independently from the three concentrically

Fig. 3. Topaz crystals from Nigeria irradiated with high-energy electrons; the samples reveal parting planes parallel to the basal pinacoid (001). An all-around shell-like structure consists of a light blue rim, a colourless intermediate zone, which is characterized by a high concentration of defects, and a colourless core. The uniform light blue colour of the rim is superimposed by an irregular and spot-like bluish-violet coloration. Size of the left sample approx. 17.5 × 13 mm. *(Photo by O. Medenbach, Bochum.)*

Fig. 4. Topaz from Nigeria irradiated with high-energy electrons; irregular bluish-violet coloration developed at one side of the rim of the sample, intermediate zone with high defect concentration; growth planes are parallel to the prism faces *m* (110). View parallel to the *c*-axis: polarized light with E parallel to Y. 20x.

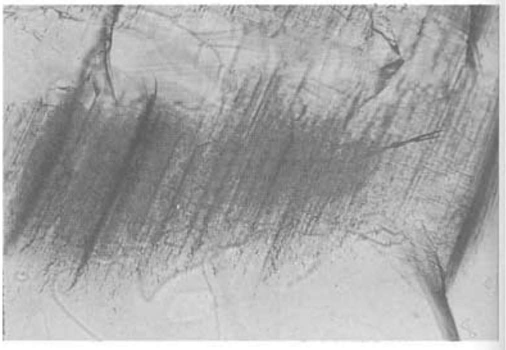

Fig 5. Topaz from Nigeria irradiated with high-energy electrons; intermediate zone with high concentration of needle-like defect structures, the orientation of the needle axes is parallel to the *a*-axis of the crystal. View parallel to the *c*-axis. 30x.

Fig. 6. Topaz from Nigeria irradiated with high-energy electrons; intersecting needle-like defect structures orientated with the needle axes parallel to the *a*- and *c*-axes of the crystal; isolated patches of cracks parallel to the basal pinacoid *c* (001). 55x.

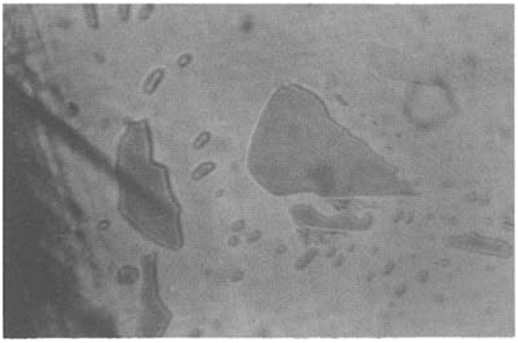

Fig. 7. Topaz from Nigeria irradiated with high-energy electrons; isolated patches of cracks parallel to the basal pinacoid *c* (001). 80x.

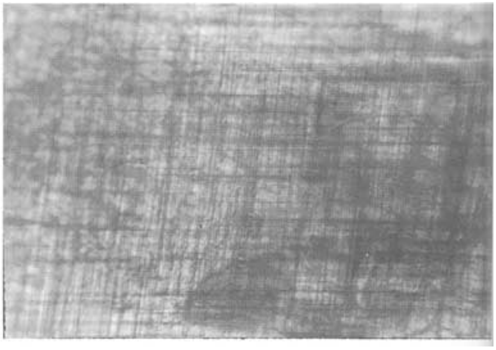

Fig. 8. Topaz from Nigeria irradiated with high-energy electrons; intersecting needle-like defect structures orientated with the needle axes parallel to the *a*- and *c*-axes of the crystal. 65x.

arranged shells or zones, the samples often revealed sets of parting planes parallel to the cleavage of topaz (Figure 1), which is parallel to the basal pinacoid *c* (001). In some areas, these cracks are not developed in the form of continuous planes, but in the form of isolated patches (Figures 6, 7), i.e. they enclose only parts of a continuous plane parallel to the basal pinacoid *c* (001).

The fine structure of the second intermediate shell of electron-irradiated topaz, which is characterized by a high defect concentration, is formed by two systems of linear fissures, which are arranged parallel to two crystallographic directions in topaz. The orientations of the needle-like defect structures were determined to be parallel to the crystallographic *a*- and *c*-axes of the samples (Figures 3, 6, 8). In some areas, the two dominant systems of needle-like defect structures intersecting at right angles (Figures 6, 8) are connected by a third subordinate system of irregular fissures.

Discussion

In some recently published papers dealing comprehensively with colour and colour causes of natural (untreated) and irradiated brown and blue topaz (Nassau, 1984, 1985), only one blue colour centre is mentioned for all types of blue topaz. The experimental results described in this paper as well as further investigations (Schmetzer, 1987), however, confirm the development of several different blue colour centres, or more precisely, the development of at least two blue X-centres and one bluish-violet Y-centre in topaz. The relative concentration of these colour centres is mainly dependent on the type of irradiation used for the coloration of the stone (cf. Figure 9). The blue X-centres with a polarization of $X \gg (Z, Y)$ are predominant in natural blue topaz, in gamma-and neutron-irradiated topaz, and in the uniform all-round light blue area of electron-irradiated topaz. The concentrations of the X-centres in neutron-irradiated samples strongly exceed the concentrations of the X-centres in all other types of blue topaz. Only in the dark bluish-violet patchy areas of electron-irradiated topaz, is the intensity of the absorption band of the Y-centre with a polarization of $Y \gg (X, Z)$ comparable with the intensity of the absorption band of the X-centres (Figure 9). The presence of both X- and Y-colour centres in this type of irradiated topaz, however, is absolutely necessary to bring the intensity of the blue coloration to a commercially usable level. In neutron-irradiated topaz, the presence of small concentrations of the bluish-violet Y-centre was confirmed by spectroscopic investigations (cf. Table 1, Figure 9).

Due to the similar position of their absorption maxima, the distinction of X- and Y-centres in irradiated blue topaz has to be conducted with polarized absorption spectroscopy. In the paper of Nassau and Prescott (1975), an absorption maximum at 620 nm in stones irradiated with Co–60 was measured; no information about the polarized spectra of these samples was published. Presumably, these stones mainly contained small concentrations of X-centres. The only polarized spectra of natural blue coloured topaz crystals were published by Petrov (1977). This paper contains adequate data on the X-centres. A connection between the concentration of part of the X-centres in dark blue, naturally coloured as well as in neutron irradiated topaz and the intensity of the new absorption band in the bluish-violet area is conceivable (Table 1). This connection, however, needs further experimental confirmation.

Presumably, the irregularly distributed and patchy bluish-violet coloration in electron-irradiated and subsequently heat-treated topaz from Nigeria, i.e. the irregular concentration of Y-centres after treatment, is caused by an irregular distribution of

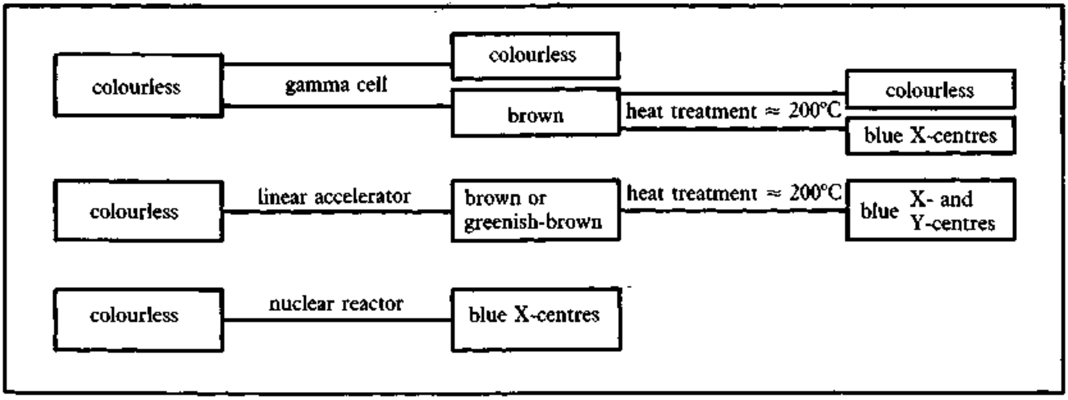

Fig. 9. The development of blue and bluish-violet X- and Y-centres in topaz by irradiation processes and subsequent heat treatment.

one or several trace elements in different areas of those crystals. Unfortunately, the colour causes of the X-centres and the newly described Y-centre in topaz as well as the different mechanisms of stabilization of colour centres, i.e. the reaction mechanisms by irradiation and heat treatment (Figure 9), are almost unknown. A first attempt to clarify some of these problems was made by Petrov (1983). Thus, the most probable connection between the irregular colour distribution and one or several trace elements has still to be confirmed analytically. Most probably, the irregular distribution of the brown coloration in gamma- or electron-irradiated, non-heat treated samples from Nigeria is also due to variable trace element concentrations in those crystals, and a connection with the irregular concentration of bluish-violet Y-centres after heat treatment of electron-irradiated samples is also conceivable.

Due to the more regular distribution of X-centres in gamma- and electron-irradiated and subsequently heat treated as well as in neutron irradiated non-heat treated topaz (Figure 9), the concentration of X-centres is less dependent on various trace element concentrations in the individual topaz crystal. Most probably, the precursor elements or precursor centres for the generation of blue X-centres in topaz are found in uniform distributions within the crystals or are not present at all (referring to topaz crystals which are uniformly coloured in X polarization by irradiation with gamma rays or high-energy electrons and to topaz crystals which are colourless in X polarization after irradiation and heat treatment; (Figure 9). By neutron irradiation, an extremely high concentration and uniform distribution of X-centres is developed, and the concentration exceeds that in gamma ray and electron-irradiated samples (among several thousands of neutron-irradiated topaz crystals, no sample was observed which remained colourless).

In order to explain the radiation induced defects in topaz two mechanisms have to be discussed. For the development of a commercially usable blue coloration in topaz an electron beam with particles in the 10 to 20 mega-electronvolt range is applied. These high-energy electrons interact in a different manner with the atoms of the topaz structure. One of these interactions is the build-up of electrical charge in topaz, causing the formation of parting planes parallel to the basal pinacoid *c* (001), which is the ordinary cleavage plane of this mineral. This process is caused by the limited penetration of electrons in topaz, which is approximately calculated for electrons with an energy of 15 MeV to ≈ 2.27 cm for the maximum range of penetration and to ≈ 0.69 cm for the half-thickness. In addition, the high-energy electrons, which are slowed down by interaction with the atoms of the topaz structure, cause the generation of heat. Therefore, the topaz crystals have to be cooled continuously with running water during the irradiation process. These facts can help to explain the all-around shell-like structure of the crystals with radiation induced defect structures. Due to the contact of the surface of the irradiated topaz crystals with running water an all-around temperature gradient from the rim to the core of the topaz is generated. Presumably, shell-like zones having different temperatures and thus zones with different thermal expansion are formed. The anisotropic heat conduction of orthorhombic topaz as well as the anisotropic thermal expansion, which is also zoned from the surface to the centre, probably causes stress in the topaz structure. As a result, the characteristic systems of defect structures described above are formed.

The absence of blue or bluish-violet colour centres in the intermediate zone and in the core of the topaz crystals is also explainable by increased temperatures in these areas. In general, the blue coloration of natural untreated as well as that of irradiated topaz is removed at temperatures between 200 and 500°C. The exact temperature is dependent on the unknown conditions of colour causes and stabilization mechanisms in an individual sample. Therefore, the temperatures in the intermediate fissure zone and in the core of the crystals are assumed to exceed 200°C during the irradiation process. Obviously, the all-around cooling by running water was inadequate to protect the whole samples. Under the experimental conditions of the irradiation process, which are unknown in detail, the cooling was only sufficient in a rim zone of 3 mm in depth for the generation and stabilization of the blue and bluish-violet X- and Y-colour centres.

Acknowledgements

Both parcels of electron-irradiated topaz from the USA were kindly submitted by Dr H. Krupp of Heidelberg, FRG. Financial support was given by grants of the Wirtschaftsministerium des Landes Rheinland-Pfalz, FRG.

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Sapphirine (not sapphire) in a ruby from Bo Rai, Thailand

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Abstract

This note describes inclusions of the magnesium aluminium silicate, sapphirine, discovered in a Thai ruby. The inclusions were identified by X-ray powder diffraction. This is the first report of sapphirine as an inclusion in any gem material.

A small broken rough ruby crystal containing three dark greenish-blue crystalline-appearing inclusions was given to the authors for examination. The host ruby was a purplish-red tabular etched crystal that weighed 0.91 carats. It was collected by Dr Peter C. Keller while studying the Bo Rai ruby mines in the Trat Province of Thailand (Keller, 1982).

Fig. 1. Dark greenish-blue sapphirine inclusion exposed at the surface of a broken Thai ruby. Dark-field illumination. 30x.

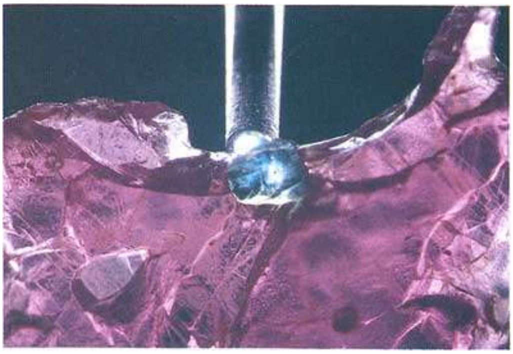

Fig. 2. A pinpoint illuminator highlights the sapphirine inclusion for optical examination. 10x.

The ruby had been broken across its centre, exposing the largest of the three inclusions to the surface for easy X-ray powder diffraction analysis (Figure 1). Since inclusions of this appearance had never before been reported in ruby, it was decided that identification would be attempted.

Testing

After gemmological verification that the host crystal was ruby, the inclusions themselves were examined optically to see what could be learned before X-ray analysis was performed.

As shown in Figure 1, the inclusions were anhedral rounded grains. This suggested a protogenetic origin in relation to their host. An 80-watt pinpoint fibre-optic illuminator was needed to get enough light through the exposed inclusion (Figure 2) to examine for pleochroism. The inclusion proved to be birefringent and the green and deep blue pleochroic colours that were observed suggested that the inclusions might be sapphire.

The inclusion was then scraped using a fine-point diamond-tipped scraper until a minute amount of powder was obtained to make a spindle for X-ray powder diffraction.

The spindle was mounted and centred in a Debye-Scherrer powder camera and exposed to X-rays generated at 46 kV and 26 mA from a nickel-filtered copper target tube for a time of 4.5 hours.

The resulting pattern was compared with our sapphire (corundum) standard pattern. It was immediately obvious that the inclusion was not sapphire. The unknown's pattern was then measured

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for d spacing using a Nies overlay scale corrected for film shrinkage, while the line intensities were visually estimated.

Using our Mineral Powder Diffraction File Search Manual (JCPDS, 1980), we found an exact pattern match with the monoclinic mineral sapphirine (ASTM File Number 21-549), chemical formula $(Mg, Al)_8 (Al, Si)_6 O_{20}$ (Fleischer, 1980).

This came as a complete surprise because although sapphirine had been reported as a cut stone (Fryer, 1985), it had not been reported as an inclusion. So in this respect it is a first observation.

Conclusion

Because of their colour, pleochroism and close proximity to ruby, these inclusions were at first thought to be sapphire. Where sapphire vs. sapphirine is concerned, this is a common mistake. Sapphirine gets its name from sapphire because small grains of the two minerals look very much alike. Even though they are completely different minerals chemically and physically, they are still easily confused. So, on the basis of looks, it is logical, if given the choice, to pick the much commoner sapphire over the rarer of the two, sapphirine.

Acknowledgements

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Diaspore, a rare faceted gem

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Abstract

In recent years, a number of gemmological laboratories have reported the appearance of gem quality diaspore*.

The writer has had the opportunity to examine some rough crystals, and six faceted stones cut from them, the measurements, weights and properties of which are described below.

Appearance

The rough diaspores examined by the writer were found in two different forms:

1) Long, flattened, prismatic crystals, occasionally twinned (Figure 1), characterized by deep vertical striations on (001) (similar to those seen in spodumene), most often showing fractured terminations, or more rarely terminated at one end by faces (110) and (111), and at the other end a flat or fractured base (Figure 2).
2) Tabular crystals with mica-like cleavage, consisting of a number of thin plates superimposed on each other. Although the cleavage (010) is perfect, it is much less facile than that of micas which it resembles.

The large emerald-cut diaspore was cut from a similar tabular crystal to the one described above, which measured approximately 77.40 × 75.50 × 43.30 mm, for a total depth of 26.80 mm, and a weight of 210 g (Figure 3).

As can be seen from Figure 3, the stone was rather heavily flawed by a number of oriented elongated canal-like inclusions running in parallel bands, and the faceted stone cut from this rough crystal attained a weight of only 7.632 g (38.16 ct).

According to the lapidary who cut the six stones from six different crystals, no particular difficulties were noticed in relation to the perfect (010) cleavage, or for fashioning and polishing the different gems which take a very good polish with a vitreous lustre.

A remarkable characteristic of these faceted diaspores is their colour change (Figure 4), comparable with that observed in alexandrite. Their colour is brownish-green in daylight, Colormaster notations BD-11/100/45 for the majority, but one stone of a deeper green colour gave ED-15/100/21. In tungsten light, the majority showed a moderate change of colour which could best be described as pinkish-brown, with Colormaster notations BD-22/100/34. The deeper green stone showed a very distinct colour change to pinkish-red, Colormaster notations ED-33/100/21.

Hardness

The hardness on Mohs' scale, taken on rough crystals with hardness points and plates, revealed that face (010) is not scratched by 6½, but slightly scratched by 7. Against polished plates, the same face was found to scratch easily GGG (gadolinium

Shape, measurements and weight

Stone No.	Shape	Approximate Measurements	Weight
1	Emerald-cut	23.76 × 16.01 × 11.13 mm	38.16 ct
2	Oval cabochon	14.65 × 10.34 × 8.22 mm	12.55 ct
3	Rectangular step-cut	12.86 × 11.23 × 7.43 mm	8.89 ct
4	Emerald-cut	11.62 × 7.68 × 5.34 mm	4.32 ct
5	Brilliant-cut	7.06 × 5.75 mm	1.87 ct
6	Round cabochon	5.92 × 4.11 mm	1.18 ct

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*Diaspore is hydrogen aluminium oxide, $HAlO_2$, which crystallizes in the orthorhombic system.

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Fig. 1. Diaspore crystal showing twinning. Approximate measurements of crystal: height 68.40 mm, width 32.20 × 27.00 mm, weight 92.34 g.

Fig. 2. Gem-quality, flattened, prismatic crystal of diaspore deeply striated parallel to its length, with one end terminated by a flattened pyramid and the other end by a fractured base. Approximate measurements of the crystal: 64.92 × 34.48 × 17.06 mm, weight 64.14 g.

Fig. 3 (a) The rough crystal of diaspore weighing 210 g from which the 38.16 ct emerald-cut stone was faceted.

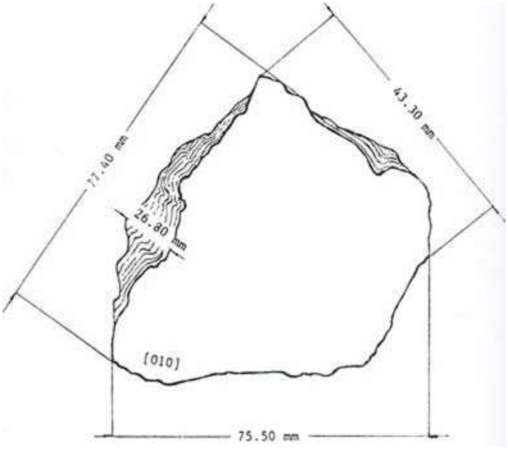


Fig. 3 (b). Sketch of the rough crystal, showing its measurements and cleavage direction.

Figs. 4 (a) and (b). The six cut diaspores studied, as they appeared under (a) fluorescent light, and (b) tungsten light.

gallium garnet), but could hardly scratch quartz. At 90° to this plane, the same hardness was found, giving a hardness of 6½–7 for this mineral.

Chemical testing

Under the action of hydrochloric and sulphuric acids, the surfaces of the stones were not etched, and their colour was unaltered.

Density

The densities were obtained by hydrostatic weighing of the stones in distilled water using a Mettler PL 300c balance (accuracy ± 0.001 carat), and gave the following results corrected to 4°C for the six different stones:

Stone Nos.	Density
1, 5 and 6	3.382 g/cm^3
2	3.402 g/cm^3
3	3.404 g/cm^3
4	3.415 g/cm^3

Refractive Indices

The refractive index determinations were carried out using a Rayner Dialdex refractometer and monochromatic sodium light. Only the table facets were tested and it was only possible to get a value for the intermediate β index on stone No. 4. In this case the upper and lower shadow edges obtained on the refractometer reached the same 1.723 value as the stone was rotated indicating that this was the value for β. In the other cases the upper and lower shadow edges did not reach a common value.

The author has observed that many faceted biaxial stones have their table facets cut parallel to critical directions, such as the table cut parallel to an optic axis or to optic axial planes or cut parallel to an acute or obtuse bisectrix. These orientations do not facilitate the determination of the β value using the table facet alone.

In many cases it is not possible to obtain readings from other facets, e.g. when the stone is set or where the style of faceting does not allow the stone to sit properly on the refractometer. For such stones cut according to critical directions, it is always a good idea to obtain an interference figure whilst the stone is being observed under the polariscope with the aid of a conoscope.

The indices obtained from the six stones are: $\alpha = 1.702$, $\beta = 1.723$, $\gamma = 1.750$, giving a birefringence of 0.048, with optic sign (+). Stone 6, the round double cabochon, gave only one reading: 1.70 (spot reading).

Pleochroism

The pleochroism of the stones, observed through the pavilion with a Rayner calcite dichroscope, was distinct; medium pinkish-brown, light greenish-brown and light brown.

Absorption spectra

The absorption spectra seen through a Gem Beck Spectroscope Unit, showed lines in the blue portion of the visible spectrum, not dissimilar to those seen in Australian sapphires.

Stone No.	Absorption spectra
1	Very strong band, 438–465 nm
2	Strong broad lines, 445, 450, 458, 465 nm
3	Strong broad band, 440–468 nm
4	Strong broad band, 440–465 nm
5	Strong broad band, 445–468 nm
6	Strong broad band, 445–460 nm

Ultraviolet fluorescence

The stones, examined with a Multispec combined LW/SW unit, revealed only a moderate green glow under the radiation of 253 nm.

Colour filter

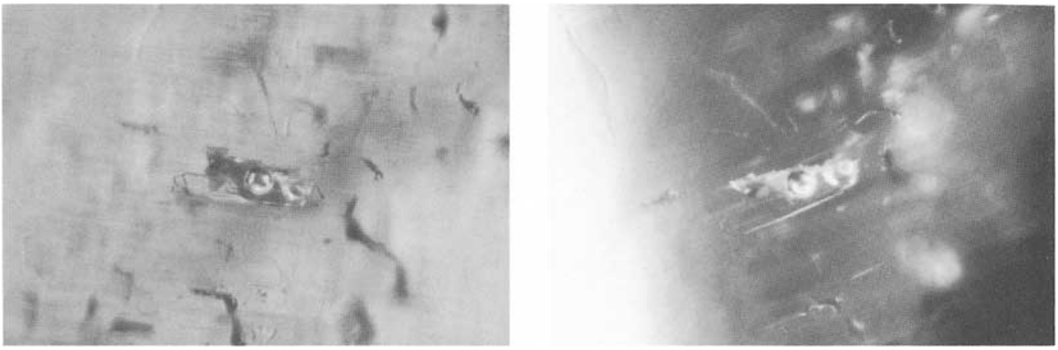
The stones remained green when viewed through a Chelsea colour filter.

Microscopic examination

The inclusions were examined under a Bausch & Lomb Mark V Gemolite binocular microscope using dark field illumination or overhead lighting, depending on whether internal or external features were to be examined.

Five types of inclusions have been observed in the six diaspores examined:

1) Disc-shaped fingerprint-like inclusions consisting of a multitude of very small, oriented, squarish, two-phase inclusions.
2) Isolated small, squarish, two-phase inclusions, reminiscent of those seen by the writer in emeralds from Mozambique.
3) Long oriented canals filled with two-phase inclusions (Figure 5).
4) A mobile bubble was seen in a negative crystal. At room temperature the bubble, which was spherical, rested in one corner of the negative crystal (Figure 6). After a few seconds, the heat from the 30W, 115–125V light bulb used for examination of the stone, made the bubble move slowly from one corner to the other (Figure 7). A few seconds after the light was turned off the



Figs. 5 (a) and (b). Long, two-phase inclusions, one of the most characteristic features, seen under high magnification (125x), (a) in transmitted light, and (b) with dark-field illumination.

Fig. 6. A negative crystal with a gas bubble resting at one end.

Fig. 7. After a few seconds, the heat from the 30W light bulb of the microscope makes the bubble shown in Figure 6 move slowly to the other end of the negative crystal. 125x.

bubble returned to its original position. The phenomenon can be reproduced under the same conditions as many times as one wishes.

5) Internal fractures, cleavages and tension cracks.

Conclusion

As can be seen from this article, gem diaspore would have all the characteristics to qualify as a highly valuable and desirable stone. Unfortunately, only very few crystals of sufficient transparency, clarity and colour have so far been reported. Some occasionally show terminations or are twinned, and these should not be cut; others are so small that they would probably only produce faceted stones under one carat. If this is the true situation, the stones analysed in this article should be considered in view of their size and beauty as exceptional.

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Some colour variation in jadeite

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Jadeite is a material which is often encountered during the normal course of commerce by the trade gemmologist. Variations of the same colour in one object are not uncommon, but two distinct colours in adjoining zones are not so often seen. This latter type of variation is most often encountered in material where the outer skin of a rough boulder has been subjected to weathering. These colour variations are commonly from greens to browns and brownish-orange. In the cover illustration two interesting examples of colour variation are seen.

Fig. 1. Upper part of a jadeite figurine (Kuan Yin) showing unusual translucency and mirror-like polish, achieved by the use of diamond. *Photograph by E.A. Jobbins.*

The brush pot is in the shape of a bamboo stem with a margin of good emerald green colour; the bulk of the pot consists of whitish to pale lavender jadeite with a little green interspersed. The dimensions are 10 × 3 × 2 cm. The pot was probably carved during the early nineteenth century, and the surface polish was achieved without the use of diamond powder.

The carved desk seal shows colours varying from medium green, through a whitish zone to a fine lavender. This item is typical of material carved in China for export to Europe during the latter part of the nineteenth century. The base of the seal is engraved with a European armorial crest. The dimensions are 6 × 1.2 × 1.1 cm. Refractive index measurements were easily made on the flat surface of the lavender coloured base.

The third object (see cover picture and Figure 1) is a very unusual type of jadeite of a pale blue/grey/green colour, depending upon the type of illumination in which it is viewed. In daylight it is an icy bluish-grey colour and is much the same colour in tungsten light, but in fluorescent light it appears a pale celadon (pale green) colour. The material is of exceptional translucency and is virtually transparent around the fingers and on the thinner edges. Normal fibrous, granular jadeite structure is visible but only when searched for carefully and then only evident in small areas. The carving is of the Goddess Kuan Yin and is thought to be of modern workmanship. The polish is mirror-like and no 'orange-peel' effect is visible, which would indicate that it has been achieved using diamond powder. Refractive index and birefringence measurements were easily taken from the base, and it shows a remarkably strong absorption band at 437.4 nm. The dimensions are 14.5 × 3 × 2.3 cm.

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On the inclusions in emeralds from Santa Terezinha de Goiás, Brazil

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Abstract

Inclusions in emeralds from Santa Terezinha de Goiás, Brazil, are investigated by electron microprobe analysis (EPMA). The inclusions are determined as pyrite, magnesioferrite and mica (possibly biotite).

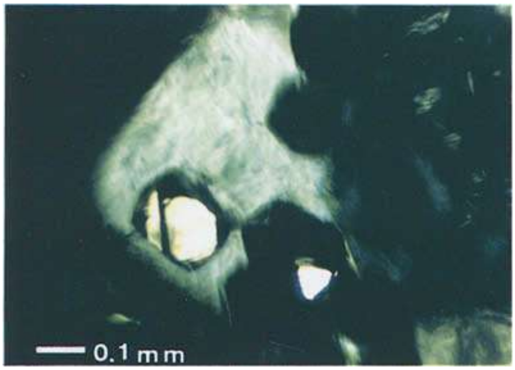

Fig. 1. Pyrite inclusion in emerald; diameter of pyrite approximately 0.2mm.

Introduction

The Santa Terezinha emerald has been reported firstly by Liddicoat (1983), and comprehensively by Cassedanne and Sauer (1984). They reported on locality, history, geology and gemmological properties including inclusions. On inclusions, they listed chromite, pyrite, biotite, calcite and two-phase inclusions. Special regard must be paid to pyrite and chromite. For pyrite, the locality is the only one except Colombia whose emeralds include pyrites. For chromite, the basis of their identification relies on the presence of chromium detected by X-ray fluorescence. There may be some doubt as to whether chromium was due to the inclusion or the host crystal, because of the rather broad analysing area of the method.

Fortunately, we obtained some cut samples in which a few inclusions appeared on facets and were able to investigate the inclusions without damage to the faceted stones.

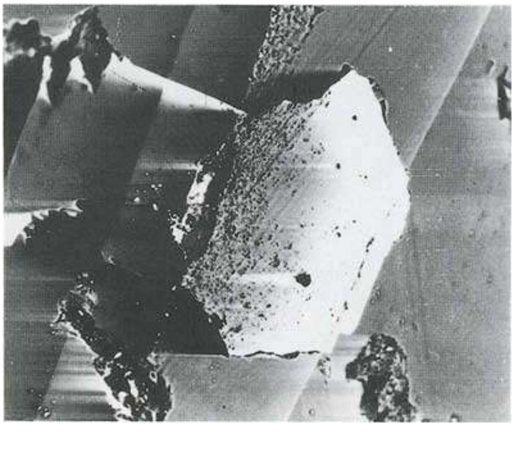

Fig. 2a. SEM photograph of the pyrite appearing on a facet.

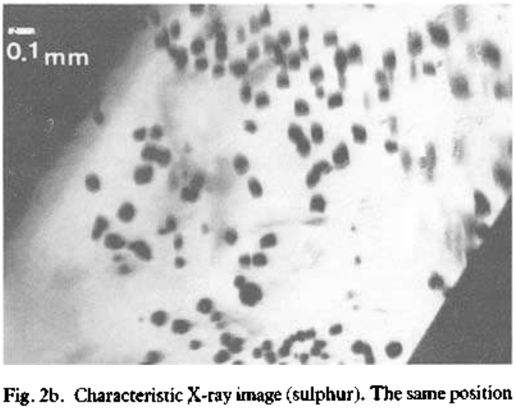

Fig. 2b. Characteristic X-ray image (sulphur). The same position as Figure 2a.

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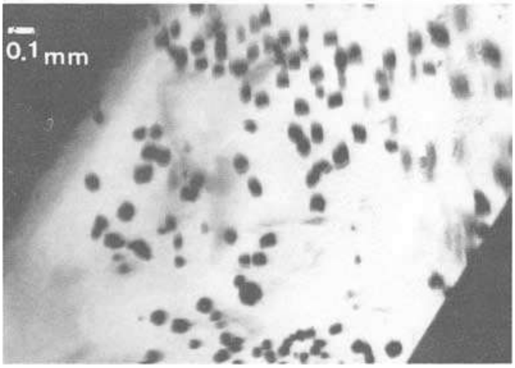

Fig. 3. 'Coal-like' inclusions in emerald. Each crystal is about $50\mu m \sim 100\mu m$.

Results

Two specimens of emerald were examined by microprobe EPMA (JEOL – 733). Experimental conditions were: acceleration voltage 25 kV; absorption current 1.0×10^{-8} amperes.

Figure 1 shows inclusions in the Santa Terezinha emerald. They occur as well-formed or slightly rounded cubes with metallic lustre. Their diameters are about 0.2mm and one (lower left) appears on a facet edge. We detected iron and sulphur, but cannot detect zinc by EPMA.

Figures 2a and 2b show a scanning electron microscope (SEM) image and a characteristic X-ray image (for sulphur) of the inclusion. Further semi-quantitative analysis of the inclusion revealed that the ratio or iron to sulphur was ½ and the inclusion can be concluded to be pyrite.

Figure 3 shows typical inclusions in Stanta Terezinha emerald which we describe as 'coal-like'. They are present as rounded crystals and distributed as clouds. Each individual crystal is $50 \sim 100\mu m$ in size. A few of them occasionally appeared on the table facet (Figure 4); one shows a rod-like shape on the facet. An SEM photograph is shown in Figure 5. Compositions were analysed at three points on the included crystal. Elements Mg, Fe. Cr and traces of Ni, Cu were detected. Chromium was also detected by EPMA which has an analysing area much smaller than X-ray fluorescence analysis. Figures 6a and 6b show the concentration of magnesium and lack of aluminium in the included crystal. These results suggest that the inclusion is magnesioferrite [$Mg(Fe,Cr)_2O_4$] or magnesiochromite [$(Mg,Fe)(Al,Cr)_2O_4$] rather than chromite [$FeCr_2O_4$]. All belong to the spinel series.

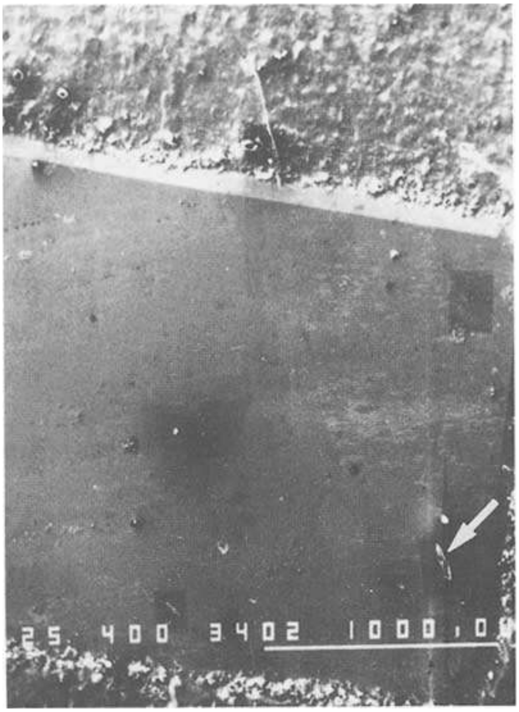

Fig. 4. One of the 'coal-like' inclusions on a facet which shows rod-like shape (arrow indicates). White bar represents $1000\mu m$.

Fig. 5. SEM photograph of the rod-like crystal. The white bar represents $10\mu m$.

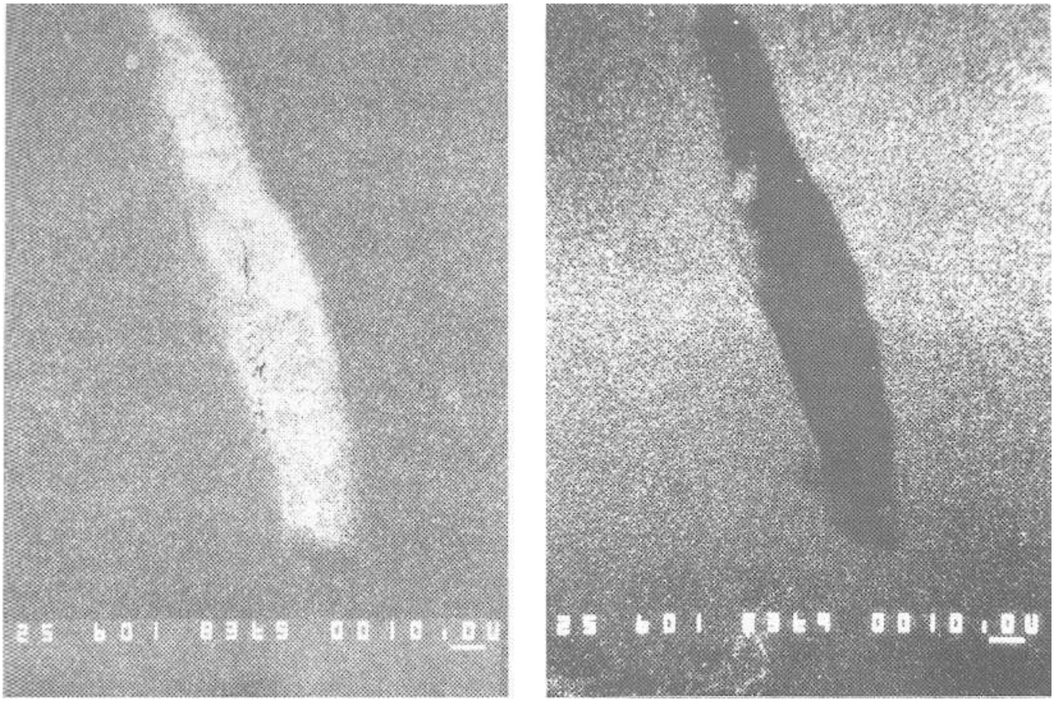

Fig. 6a. and 6b. Characteristic X-ray images (Mg and Al) of the same crystal as in Figure 5. These photographs reveal the concentration of Mg and the lack of Al in the crystal. White bar represents 10μm.

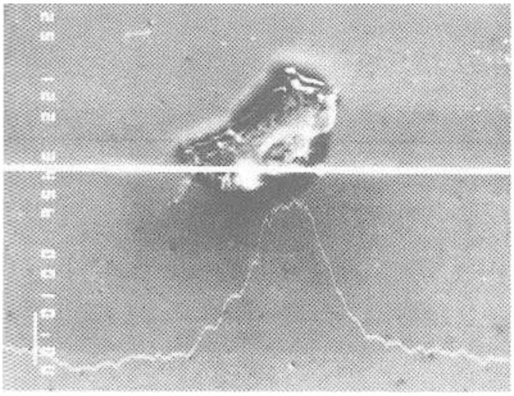

Fig. 7. SEM photograph and the line profile of K concentration on the other included crystal. This crystal may be biotite. White bar represents 10μm.

Figure 7 shows a SEM image and line profile of the potassium content of another included crystal. The crystal was determined as mica (possibly biotite) by the high concentration of potassium together with aluminium and magnesium.

Conclusion

In emeralds from Santa Terezinha, three types of inclusion minerals can be identified by EPMA. They are pyrite, mica and magnesioferrite. The existence of pyrite in these emeralds is very important, since no other locality except Colombia has provided emeralds with pyrite inclusions. Hereafter we cannot conclude that an emerald must come from Colombia simply because it contains pyrite as an inclusion.

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[*Manuscript received 5 June 1986*]

Gemmological Abstracts

BALFOUR, I. 1986. Famous diamonds of the world, XXVI. La Belle Helene. *Indiaqua*, **44** (1986/2), 125–7.

Found early in 1951 in one of the Consolidated Diamond Mine's southernmost workings along the inhospitable Namibia coast, La Belle Helene was a perfect blue-white stone weighing 160 ct. It was bought by Mr Romi Goldmuntz and cut in his New York premises to yield three gems: two pear-shaped stones of 30.38 and 29.71 ct, and a marquise of 10.50 ct, all of which were sold through Cartier's to private buyers. P.G.R.

BALFOUR, I. 1986. Famous diamonds of the world, XXVII. The Vainer Briolette. *Indiaqua*, **44** (1986/2), 129–30.

Although the origin of the 202.58 ct rough diamond that yielded the 116.60 Vainer Briolette is not known, it is believed to be a South African stone. In its rough state, the diamond was yellowish, lightly spotted, and of an almost perfect octahedral shape. It was cut in London in 1985/6 by the firm of M. Vainer Ltd. to produce a principal stone (which has the distinction of being the largest diamond briolette in the world) plus five other gems weighing a total of 14.93 ct. The Vainer Briolette was purchased by the Sultan of Brunei. P.G.R.

BALFOUR, I. 1986. Famous diamonds of the world, XXVIII. Matan. *Indiaqua*, **45** (1986/3), 123–4.

The Matan (or 'Mattam') takes its name from a town in West Borneo. The diamond was discovered there in the local diamond mines in the early 1800s, and was said to weigh 367 ct. When cut, the stone was described as being about the size of a walnut and drop-shaped. The present whereabouts of the gem is unknown, but it may have been part of the cargo of diamonds shipped out of Borneo by the Japanese during World War II. The cruiser carrying the shipment was sunk off the coast of Eastern Sumatra. P.G.R.

BALFOUR, I. 1986. Famous diamonds of the world, XXIX. Emperor Maximilian. *Indiaqua*, **45** (1986/3), 126–8.

Acquired by Archduke Maximilian (younger brother of Joseph I, Emperor of Austria) when he was visiting Brazil in 1860, the Emperor Maximilian was a cushion-cut stone weighing 41.94 ct, and was so named after the Archduke became Emperor of Brazil in 1864. The diamond survived Maximilian's execution in 1867, and after being bought by a Chicago diamond dealer in 1919, was eventually sold by him to a private collector in New York in 1946. P.G.R.

BANK, H., 1986. Gemmologische Kurzinformationen. (Short gemmological notes.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 185–9.

Four short articles, each with its own bibliography. The first note deals with an olivine from the Eifel, between Mayen and Gerolstein, from the volcanic limestones present there. These local stones are of interest only to collectors as they are too small to be cut. An olivine of brownish-olive colour was discussed that had an exceptionally high RI, n_x 1.670, n_y 1.688, n_z 1.706, SG 3.43. Dr Bank then discusses Brazilian scheelite (yellowish-white, or grey to brown and colourless), H 4.5–5, and senarmontite. The other two notes have been worked on by Dr Bank with Th. Lind and U. Henn and deal with emeralds from Sta Terezinha de Goias, Brazil, with relatively high RI, and with synthetic emeralds produced hydrothermally in the USSR, showing growth irregularities and 'nail-like' inclusions. E.S.

BRIGHTMAN, R., SANDEMAN, D., 1986. Boulder opal triplet imitating natural solid boulder opal. *Australian Gemmologist*, **16**, 4, 151–2, 4 figs in colour.

Several opals were found to be triplets made by cementing a layer of fine crystal opal, with a mixture of powdered ironstone and resin, to a genuine boulder opal base. These are convincing imitations but may show bubbles in the cement layer, which will soften under a hot needle. They originate from Hong Kong. R.K.M.

BROWN, G., 1986. An unusual keshi pearl. *Australian Gemmologist*, **16**, 4, 139–40, 2 figs.

Describes a large adventitious bouton pearl with a non-nacreous back. Thought to be tissue nucleated. R.K.M.

BROWN, G., 1986. The gemmology of the shell cameo. *Australian Gemmologist*, **16**, 4, 153–61, 19 figs in colour.

An excellent account of various shell cameos. R.K.M.

BROWN, G. 1986. Benitoite. *Wahroongai News*, **20**, 12, 4–7, 4 figs.

A good summary of the known facts of this rare gemstone. Normally blue, a 'reddish' variety is mentioned.

This may stem from a report of a pink benitoite mentioned by Anderson in the fourth edition of Webster's *Gems*. Abstracter believes that the pink stone was reported from one of the West Indian islands and that nothing more was heard of it. R.K.M.

CASSEDANNE, J. 1986. L'améthyste de Pau d'Arco (Pará-Brésil). (Amethyst from Pau d'Arco (Pará, Brazil). *Revue de Gemmologie*, 89, 12–15, 9 figs (8 in colour).

Two new locations for amethyst have been discovered in the Amazonian forest in the state of Pará, Brazil. The locations are known as Pau d'Arco and Maraba. Colour banding, goethite crystals and fibres are all prominent inclusions. SG is 2.66 and RI 1.544 and 1.553 with a DR of 0.009. An absorption band exists between 560 and 520 nm. There is no luminescence and stones will lose colour when heated to 450°C, passing through a grey-violet colour at 350°C. M.O'D

ELLIOTT, J. 1986. Contemporary intarsia: the Medvedev approach to gem inlay. *Gems & Gemology*, **XXII**, 4, 229–34, 6 figs in colour.

A revival, by a Russian artist lapidary, of skilled inlay of stone in contrasting colours. Nicolai Medvedev now works in the United States, producing remarkably fine, high quality work in thin veneers of opaque stone such as malachite, lapis lazuli, sugilite, opal and rhodochrosite, each piece selected, sawn, cut and polished to an exact fit in a highly intricate design, whether for boxes or for flat pendant pieces. A remarkable skill reminiscent of earlier times. R.K.M.

FITZGERALD, S., RHEINGOLD, A.L., LEAVENS, P.B. 1986. Crystal structure of a Cu-bearing vesuvianite. *American Mineralogist*, **71**, 1011–14.

A blue Cu-bearing vesuvianite from Franklin, New Jersey, was determined and the formula given. M.O'D.

FRYER, C.W. (Ed.), CROWNINGSHIELD, R., HURWIT, K.N., KANE, R.E. 1986. Gem Trade Lab Notes. *Gems & Gemology*, **XXII**, 4, 235–40, 19 figs in colour.

A natural amethyst showed Brazil twinning even in unpolarized light. A synthetic amethyst had a 'nailhead' hydrothermal-type inclusion. A natural andalusite with curved growth lines was seen. Faceted orange clinohumite, cut and rough (RI 1.631–1.668, biaxial positive, SG 3.18) were donated to the GIA. A diamond with a heart-shaped cloud inclusion was seen.

Synthetic spinel soudé stones with sintered glass coloured layers investigated and one found which gave an RI of 1.682 for the glass, as well as the expected 1.724 for the spinel crown. A white 'breadcrumb' inclusion was seen in a hydrothermal synthetic emerald. 'Lapis' beads were proved to be surface-dyed dolomite. Natural pearl was badly eroded by skin acid. 'Coques de perle' imitations were found to have been worked from nautilus shell. A large weakly chatoyant pink cabochon represented as analcime was identified as petalite. A necklace of dark beads was found to be quartz heavily included with pyrite crystals. All items are illustrated. R.K.M.

GAUTHIER, J.-P. 1986. Synthese et imitation de l'opale noble. (Synthesis and imitation of precious opal.) *Revue de Gemmologie*, 89, 16–23, 12 figs.

A useful review of the known facts about the synthesis of opal and the nature and manufacture of its various imitations. Electron microscopy of opal structure is described and illustrated. M.O'D.

GÜBELIN, E. 1986. Die diagnostischen Eigenschaften der neuesten Synthesen. (Diagnostic features of the latest synthetics.) *Goldschmiede Zeitung*, **81**, 11, 69–76, 47 figs in colour.

Characteristic inclusions are described and illustrated for emerald (Lennix, Biron, Russian hydrothermal and flux and Seiko), ruby (Lechleitner) and sapphire (Seiko and Lechleitner). A yellowish and an alexandrite-like Lechleitner product are also illustrated. M.O'D.

GÜBELIN, E.J., 1986. The distinguishing criteria of the garnet family with special emphasis on inclusions. *Indian Gemmologist*, **1**, 1, 5–14, 16 figs in colour.

A full account of the characteristic inclusions to be found in gem species of garnet with high-class colour illustrations. M.O'D.

GÜBELIN, E., KOIVULA, J.I., 1986. Inklusen im Bernstein. (Inclusions in amber.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 73–86, 45 figs in colour.

The article consists of a short introduction and 45 beautiful photographs of plant and animal inclusions in mainly Dominican and Baltic amber (a couple of illustrations are of copal resin from Colombia and Africa), including a photograph of a rare scorpion inclusion. E.S.

HÄNNI, H.A., 1986. Behandelte Korunde mit glasartigen Füllungen. (Treated corundums with glassy fillings.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 87–96, 8 figs (5 in colour).

During thermal treatment of corundums, chemicals are applied which may form glassy coatings or fillings of cavities and fissures. This is practised in increasing measure mainly in Thailand. The applied glasses vary in their Si, Al, Mg, Ca, Na and K content. The introduction of these glasses into cracks can improve the transparency of the stone significantly, but, if the cooling rate is low, partial recrystallization of the glass may occur, leading to an opaque filling. E.S.

HAZEN, R.M., AU, A.Y., FINGER, L.W. 1986. High-pressure crystal chemistry of beryl ($Be_3Al_2Si_6O_{18}$) and euclase ($BeAlSiO_4OH$). *American Mineralogist*, **71**, 977–84, 2 figs.

Objectives of the study were to determine pressure-volume equation-of-state parameters and compression anisotropies by measuring the pressure variation of unit cell dimensions; to calculate polyhedral bulk moduli from high-pressure structure data, to test the effects of structure on the moduli and to identify geometrical changes in the beryl and euclase structures. Findings are given in tabular form. M.O'D.

IYER, J.P., 1986. Panna diamonds in the world context. *Indian Gemmologist*, **1**, 1, 31–5, 5 figs.

Panna diamonds are generally of a high standard of quality, size and crystal perfection. Diagrams of the commoner forms are provided. M.O'D.

JHAVERI, K., 1986. Diamond grading. *Indian Gemmologist*, **1**, 1, 19–25, 10 figs.

The first part of a promised series of papers, this one deals with the path of light in a cut diamond and with styles of cutting. M.O'D.

KIEFERT, L., SCHMETZER, K., 1986. Morphologie und Zwillingsbildung bei synthetischen blauen Sapphiren von Chatham. (Morphology and formation of twinning in Chatham synthetic blue sapphires.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4 127–38, 10 figs (2 in colour).

The article discusses morphological and crystallographic properties of Chatham blue synthetic sapphires. Most crystals show contact twinning. Internal structural properties such as straight parallel growth planes and twin boundaries applied to the differentiation between natural and synthetic corundum are discussed. E.S.

KIEFERT, L., SCHMETZER, K., 1986. Rosafarbene und violette Sapphire aus Nepal. (Pink and violet sapphires from Nepal). *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 113–25, 16 figs (6 in colour).

The exact occurrence of these sapphires from Nepal is unknown. The colour is caused by chromium (pink) and a combination of chromium, iron and titanium (violet). Associated minerals found were calcite, phlogopite, margarite and rutile. The samples show intercalated lamellae of corundum in twin position and straight parallel growth planes. Small platelets of mica seem to be the most characteristic inclusion of this new locality. The sapphires also show healed and unhealed fractures, making them somewhat unsuitable for jewellery purposes. E.S.

KOIVULA, J.I., 1986. Three-phase inclusions in 'Regency' synthetic hydrothermal emerald. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 97–9, 2 figs in colour.

The paper describes the discovery of true three-phase inclusions in Vacuum Ventures 'Regency-created' hydrothermal synthetic emeralds. The three separate phases comprising these inclusions are contained within the spike-shaped voids commonly associated with hydrothermal synthetic emeralds. The solid daughter crystals display the habit of phenakite and are birefringent. E.S.

KOIVULA, J.I., FRYER, C.W., 1986. Hollandite in quartz: a first observation. *Australian Gemmologist*, **16**, 4, 141–2, 3 figs.

A rare black sub-metallic barium-iron-manganese oxide was found as radial formations in a large faceted rock-crystal from Minas Gerais. R.K.M.

KOIVULA, J.I., FRYER, C.W., 1986. Blue-green zircon in Pakistani beryl. *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 35, 3/4, 101–3, 1 fig in colour.

Idiomorphous crystals of translucent blue-green zircons were identified for the first time as inclusions in a pale blue aquamarine crystal derived from a pegmatite in northern Pakistan, situated near the Afghanistan, Russian and Chinese borders. The crystal was 2cm long. E.S.

KOIVULA, J.I., MISIOROWSKI, E. 1986. Gem news. *Gems & Gemology*, **XXII**, 4, 246–8, 4 figs in colour.

Irradiated green amblygonite seen. Bicolour green/orange beryl from Minas Gerais heats to blue/pink. Chalcedony stained blue with copper salts develops copper dendrites when treated electrically. Chrome-green sphene from Baja, California, is being marketed as Mexican emerald. Green amazonite crystals found in Teller Co., Colorado. Pink/green West African tourmalines used in carvings for Intergem '86 exhibition in Idar-Oberstein. Kenyan rubies are exported to Thailand for heating to improve their transparency: results are said to be 'dramatic'. A green jade-like cabochon was shown to be meta-variscite. A new find of elbaite tourmaline reported from Minas Gerais. R.K.M.

MISIOROWSKI, E.B., DIRLAM, D.M. 1986. Art nouveau: jewels and jewelers. *Gems & Gemology*, **XXII**, 4, 209–28, 22 figs in colour.

A beautifully illustrated paper on a fantasy art style which was largely killed by the grim realities of the 1914–18 war. The paper deals briefly with a number of the leading designers and makers of jewellery which was often characterized by whip-lash lines and somewhat distorted naturalistic forms very skilfully executed in gems, precious metals and enamels. Today these pieces are eminently collectable. R.K.M.

MOON, A.R., PHILLIPS, M.R., 1986. Inclusions in sapphire and heat treatment. *Australian Gemmologist*, **16**, 4, 163–6, 6 figs.

A further examination of important features related to the current practice of heating sapphire rough to improve colour and/or asterism. R.K.M.

NAGIN, T., NAGIN, I., 1986. Quartz crystals of Colombia. *Lapidary Journal*, **40**, 8, 38–41, 6 figs.

A useful account of a quartz deposit at Alto de Cruces, Colombia, with descriptions of the crystals and of their mode of formation. An Arkansas company is marketing them. M.O'D.

O'DONOGHUE, M., 1986. Gems and gemmology. *Watchmaker, Jeweller and Silversmith*, November, 45–7, 1 fig.

The whole column is devoted to a detailed review of Gübelin's *Photoatlas of inclusions in gemstones* from which a number of extracts are taken, dealing in particular with diamond, emerald and ruby. (Author's abstract.) M.O'D.

O'DONOGHUE, M. 1987. Gems and gemmology. *Watchmaker, Jeweller and Silversmith*, January 1987, 47–9.

Among the topics discussed are the partially restored Green Vaults at Dresden, glass made from volcano ash, gem and mineral nomenclature and cobalt-coloured natural blue spinel. (Author's abstract) M.O'D.

PANJIKAR, J., 1986. Gem resources of India. *Indian Gemmologist*, **1**, 1, 15–17, 1 fig.

The first part of a promised series of papers on Indian gem minerals, this section outlines the geology of the beryl deposits with special reference to aquamarine. M.O'D.

PATTANI, H. 1986. The precious metal gold. *Indian Gemmologist*, **1**, 1, 27–30.

A short account of some of the uses for jewellery during the last 6000 years of gold and its various standards/alloys – also of rolled gold and gold plating. J.R.H.C

PEARSON, G., 1986. Opal pineapples from White Cliffs. *Australian Gemmologist*, **16**, 4, 143–50, 13 figs in colour.

A detailed account of a new finding of these pseudomorphs of glauberite, usually described as 'pineapples' and here referred to also as 'fruit'. Difficult hand mining conditions are described. Better specimens found in powdery white clay. Cleaning of specimens presented difficulties. Some 'pineapples' are available for sale. R.K.M.

POUGH, F.H., 1986. Gem treatment: opal. *Lapidary Journal*, **40**, 7, 16–18.

Brief summary of the various treatments applied to opal and notes on some imitations. M.O'D.

POUGH, F.H. 1987. Garnet. *Lapidary Journal*, **40**, 10, 16–18.

A brief and general discussion of the garnet gem species. M.O'D.

POUGH, F.H. 1986. Zircon. *Lapidary Journal*, **40**, 9, 15–18.

A short review of the various treatments applied to gem-quality zircon. M.O'D.

READ, P.G., 1984–1985. (1) Spotting the Fakes, *Gem Instrument Digest*, August 1984, **1**, 6, 76–7, 1 fig: (2) Gem Instrument Reports, *ibid.*, 77–84, 14 figs: (3) Disclosure of Gemstone Treatments, *id.*, November 1984, **1**, 7, 90–1, 1 fig: (4) Gem Instrument Reports, *ibid.*, 91–8, 11 figs: (5) Gem Instrument Design Trends, *id.*, February 1985, **1**, 8, 103–4, 1 fig: (6) Gem Instrument Reports, *ibid.*, 104–11, 12 figs:

(1) Diamond seems to be the only stone identifiable with some certainty without the use of expensive research equipment: the risk of mistaken identification increases as each new synthetic coloured stone is introduced. As each new effective test is discovered, manufacturers seem to go out of their way to defeat it, and we are back to using a gem's distinctive internal features to separate the genuine from the fake.

(2) Reports on Rayner LED-illuminated Dialdex refractometer; OPL Wavelength Spectroscope; Presidium DiaMeter; Eickhorst Uviscope Pocketlite;

Gemlab Digital Spectroscope; Eickhorst Gemlyzer; Diamontron thermal tester; Demetron UV curing adhesives and lamps; Diamond Mounting Gauge by Centennial Casting Co.; Master Pearl Grading Sets (Midwest Gem Lab.); three new light sources (Illuminator/Magnifier by Beech & Son Ltd; Aristo Mic-O-Lite illuminators; Omnilite high-intensity fibre-optic probe).

(3) The disclosure rules of the Federal Trade Commission (USA) and CIBJO are compared and discussed.

(4) Reports on GemPro Digital Analyser; Rayner Polariscope with Konoscope attachment; SKS Macroscopes; Eickhorst LED-Lite Refractometer Illuminator; widefield lens for Rayner S Refractometer; battery/stand unit for Eickhorst Thermolyzer; Prior ZS2500 stereo-zoom microscopes; JDN FireScope; Leveridge gauge for melée weight estimation; Mettler CE150 and AE500C electronic balances.

(5) No major innovations in last two years other than the GemPro, but some unusual features introduced and existing instruments improved to reduce cost and improve ease of handling. Queried whether Rofin 6010 unit (light source, scanning monochromator, sample holder/photodetector, with absorption spectrum shown on standard oscilloscope) is 'poor man's version' of spectrophotometer.

(6) Reports on Eickhorst Microlab; Spectroscope Unit M-1 (McCrone Research Associates); Kassoy Gemmological Microscope; two light sources (Krüss fibre-optic units KL5120, KL5130; Kassoy halogen Jeweller's Lamp); static elimination (Zerostat 3; 3M Anti-static mat; ASP40 Anti-static spray); Nelson Ray-path Unit; GRC Gem Color Analyzer; Pye Unicam PU8800 UV-Vis Spectrophotometer ('Basil Anderson Spectrophotometer'). J.R.H.C.

READ, P.G. 1986. A question of colour. *Canadian Jeweller*, November 1986, 25–7, 9 figs in colour.

The mechanism of colour production in gemstones is discussed (transition elements in allochromatic and ideochromatic gems, pleochroism, interference and diffraction effects, and colour centres). The second part of the article comprises a series of product knowledge profiles covering the characteristics and occurrence of twenty-two gem species. (Author's abstract) P.G.R.

READ, P.G. 1986. Grading coloured stones. *Canadian Jeweller*, November 1986, 11.

A review is made of the politics and techniques of instrumental colour grading for both diamonds and coloured gemstones. Instruments for diamond colour grading (Eickhorst Diamond Photometer, the Okuda Diamond Color Checker and the Kalnew GemColor 2) are briefly described as are two instruments used for grading coloured stones (GIA Colormaster and Zeiss spectrophotometer). Mention is made of the computer-based 'expert' network developed by American Gem Market System (AGMS). (Author's abstract) P.G.R.

READ, P.G. 1986. Fancy diamonds: treated or not? *British Jeweller*, September 1986, 39.

Contains a brief historical review of the alteration of a diamond's colour by irradiation and heating, together with the methods of discriminating between treated and untreated diamonds. Since the discovery that the diagnostic 595 nm absorption line in a treated diamond can be eliminated if the stone is heated to around 1000°C, identification problems have existed. Drs Collins and Wood have solved these problems by detecting two more diagnostic lines in treated diamonds at 1,936 and 2.024 nm. (Author's abstract) P.G.R.

ROHRBACH, R.P., 1986. Stars and stripes forever. *Lapidary Journal*, **40**, 7, 20–30, 8 figs in colour.

Non-rigorous account of asterism and chatoyancy in gemstones. M.O'D.

ROOT, E., 1986. Gems and minerals of the USSR. *Lapidary Journal*, **40**, 8, 42–7, 6 figs (5 in colour).

A brief account of some of the gem materials to be found in the Soviet Union, based on a tourist visit. M.O'D.

ROUX, J. 1986. The information revolution – thirty years on. *Indiaqua*, **45**, 1986/3, 97–9.

The author, formerly Information Officer of De Beers Central Selling Organization in London, contrasts the early days, when diamond knowledge and lore were jealously guarded and passed down from father to son, with the printed information explosion of the present day. P.G.R.

SCHLUSSEL, R. 1986. Nouveau traitement de rubis naturels. (New treatment for natural rubies.) *Revue de Gemmologie*, **89**, 4–8, 13 figs in colour.

This paper forms the second part of an account of methods used to improve the appearance of natural rubies. Cavity filling is the technique mainly described. M.O'D.

SCHMETZER, K., KIEFERT, L., 1986. Untersuchung eines Sapphir-Katzenauges aus Burma. (Investigation of a sapphire cat's-eye from Burma.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 105–11, 6 figs (1 in colour).

The chatoyancy was examined in a sapphire cat's-eye from Burma which did not show any needle or rod-type inclusions. The crystal was shown to be twinned, inclination angle about 11 degrees. Both 'twins' have growth planes parallel to the hexagonal dipyramid as well as glide planes parallel to the basal pinacoid. Chatoyancy is presumed to be caused by total internal reflection at irregular patch-like fissures on basal glide planes. E.S.

Shigley, J.E., Fritsch, E., Stockton, C.M., Fryer, C.W., Kane, R.E. 1986. The gemological properties of Sumitomo gem quality synthetic yellow diamonds. *Gems & Gemology*, **XXII**, 4, 192–208, 20 figs in colour.

In 1985 Sumitomo Electric Industries produced gem quality yellow synthetic diamond crystals in quantity. They now make them up to 2 carats in weight, primarily for the industrial market as heat sinks and for precision cutting tools. But some have been faceted as gems, the largest to date being a brilliant of 0.8 carat. Grown at high temperatures and pressures in a metal flux solvent around seed crystals of synthetic diamond, giving crystals which are consistent in their properties. Yellow colour is due to dispersed nitrogen which is carefully controlled in amount.

The twenty samples examined were all deep yellow, cleavage-free and with no prominent inclusions. Growth trigons were absent. All were type Ib and their spectra lacked the strong lines of the natural type 1a yellow diamond. Inert to LWUV, the crystals glow greenish-yellow under SWUV. They are non-conducting of electricity, but their thermal conduction is similar to that of natural diamond. Specific gravity (3.505) is slightly lower than that for most natural stones. Inclusions: random pinpoints of whitish material and some opaque crystals of flux. Some crystals had colourless thread-like veins near their surfaces which were not retained in the cut stones; these are not seen in natural diamonds. Parallel colour graining is a prominent feature of these synthetics, while a 'Maltese Cross' of wedge shapes is seen in some of them. Polarizing microscope showed an interference pattern of a twisted dark cross. Two crystals were slightly magnetic.

Identification: the inert reaction to LWUV and the bright yellow under SWUV provide an easy test. Sharp absorption lines in the blue will confirm natural yellows, but their absence cannot be taken to indicate a sure synthetic. Large stones of deep yellow, at this stage, are unlikely to be synthetic. Pale yellows also seem unlikely to be made. A valuable paper on a significant synthetic. R.K.M.

Shigley, J.E., Kane, R.E., Manson, D.V., 1986. A notable Mn-rich gem elbaite tourmaline and its relationship to 'tsilaisite'. *American Mineralogist*, **71**, 1214–16, 1 fig.

A tourmaline with an uncommon yellowish-green colour was found to have the most Mn-rich composition ever reported for tourmaline. The postulation is of a possible solid-solution series between elbaite and a hypothetical Mn analogue 'tsilaisite'. RI was 1.621, 1.649 with a DR of 0.028; SG was 3.13. The stone is thought to have come from Zambia. M.O'D.

Slahor, S., 1986. Mysterious moonstone. *Lapidary Journal*, **40**, 7, 37, 1 fig.

Single page note on the legend and lore of moonstone. M.O'D.

Sobott, R.J., 1986. Gemmologisches Wissen im christlich geprägten Kulturraum zur Zeit des Frühund Hochmittelalters (7.–12.Jh.n.Chr.). (Gemmological knowledge in the sacred arts between the 7th and 12th centuries AD.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 139–59, 4 figs in colour.

Much work was done by medieval goldsmiths for the church making extensive use of gemstones. Monks and bishops also wrote treatises on gems which are of great interest, but because of their lack of knowledge of the subject, do not contribute to the progress of gemmology. The author lists many such works and also quotes a number of original texts in Latin with translations; the stones discussed by these medieval authors are mainly sapphires, emeralds, amethysts and carbuncles. E.S.

Stripp, D.M. 1986. Beginner's luck. *Lapidary Journal*, **40**, 9, 24–31, 4 figs in colour.

The article describes a visit to the gem-hunting grounds at Spruce Pine, North Carolina, USA, and the emerald crystals recovered. M.O'D.

Strunz, H., Wilk, H., 1986. Die modernen Edelstein-Refraktometer. (The modern gem refractometer.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 161–77, 13 figs.

The article is sub-titled 'Basis, shape and materials of refractometers, how they are handled, their history and corrections'. European refractometers generally use Rayner reflectors, American ones a semi-cylindrical reflector. Indicatrix used since 1910 gives rise to some misunderstandings which are corrected. The author points out that the light entering the modern refractometer does not graze, but enters at an angle from below; also that the depth of the light from the reflector into the gemstone measures only a few wavelengths (589nm). E.S.

Themelis, T., 1986. Synthetic stars. *Lapidary Journal*, **40**, 7, 46–8, 6 figs in colour.

Straightforward account of the manufacture of starstones. M.O'D.

THEMELIS, T. 1986. Urano-pyrochlore in sapphire. *Lapidary Journal*, **40**, 9, 19, 2 figs in colour.

A short description, with references, of the uranium pyrochlore found as a reddish inclusion in sapphire crystals from Pailin, Khmer Republic. M.O'D.

VOGLER, K., 1986. Neue Untersuchungen an einem farblosen Chrysoberyll. (New investigation of a colourless chrysoberyl.) *Zeitschrift der Deutschen Gemmologischen Gesellschaft*, **35**, 3/4, 179–83, 2 figs.

A colourless chrysoberyl of 8.2 ct of doubtful origin, previously examined by K. Schmetzer (*Zeitschrift der Deutschen Gemmologischen Gesellschaft*, 1985, **34**, 1/2, 6–12*) has been re-examined by non-destructive, chemical analysis (EDS XRF) and the presence of gallium was clearly shown. This and other internal features showed the specimen to be of natural origin. E.S.

WINKLER, R. 1987. Berylliummineralien aus der Umgebung von Böckstein. (Beryllium minerals from the neighbourhood of Böckstein.) *Lapis*, **12**, 2, 11–14, 11 figs (8 in colour).

Among the crystals found in the area of Böckstein are aquamarine and phenakite; the location is in the eastern Austrian alps. M.O'D.

ZEITNER, J.C., 1986. Phenomenal gems – find them in the USA. *Lapidary Journal*, **40**, 7, 32–6, 3 figs in colour.

Useful account of some gem minerals found in the United States. M.O'D.

ZHOU, Y. 1986. Growth of high quality large Nd:YAG crystals by temperature gradient technique (TGT). *Journal of Crystal Growth*, 78, 31–5, 6 figs.

Though usable laser rods of YAG doped with Nd are usually grown by the Czochralski pulling technique, such crystals often show an optically inhomogeneous core region due to the convex interface attained during growth. TGT growth allows the whole crystal rather than outer regions only to be used. M.O'D.

Book Reviews

BRUTON, E. 1986. *Legendary gems or gems that made history*. NAG Press, Ipswich (and Chilton Books, Radnor, Pennsylvania). pp.xii, 239. 23 colour plates, 75 figures. £15.95.

This is essentially a narrative book, but it will also serve as a reference book on legendary gems. The author has written authoritatively on diamonds, clocks and many other subjects, and can truly list his professions as writer, publisher, horologist, gemmologist and restorer of old houses.

Chapters one and two deal in fascinating detail with the history of the Koh-i-Noor diamond from its probable source in the Kollur mines in India, through its acquisition by the Moguls and other rulers, to its unfortunate re-cutting in the nineteenth century and its incorporation in the British Royal Regalia. Chapter three relates the stories of the diamonds which have now vanished, including the Great Mogul, the Moon of the Mountains, the Mirror of Portugal, the Pigot and the Great Table (although the Persian Darya-i-Noor is now thought to be part of this stone). Chapter four includes the story of the Great Blue diamond from which the extant Hope diamond may have been cut. Chapter five explains the French connections of the Sancy, Regent (Pitt) and Hortensia diamonds and tells of the wars and other international machinations associated with them. Chapter six is a fascinating mixture of history with science and includes accounts of the Florentine, De Beers, Red Cross, Kimberley, Tiffany, Wittelsbach, Dresden Green and other coloured diamonds. Chapter seven, entitled 'The greatest gem of all time', is mainly devoted to the Cullinan diamond but inclusion of the Excelsior and Star of Sierra Leone completes the descriptions of the three largest known rough gem-quality diamonds. Chapter eight is devoted to 'rubies' and sapphires – in particular to the Black Princes and Timur rubies, which are, of course, red spinels. The legends surrounding the St Edwards and Stuart sapphires are covered in some detail and

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*Abstracted in *Journal of Gemmology*, 1985, **XIX**, 8, 731.

the modern sapphire carvings of the heads of various American presidents receive attention. Chapter nine is largely devoted to legendary emeralds, but famous aquamarines, alexandrites, amethysts and opals, are also covered. Chapter ten relates the stories of famous pearls from 2560 BC to the present day. Chapters eleven and twelve complete the narrative with 'Legends in the making' and the stories of dealers and collectors of great gems.

The foregoing summary of the chapters in this book cannot convey the extremely interesting way in which the various legends (and facts) surrounding the fabulous gems are recounted. Access to information in the book is facilitated by the gemstone species arrangement, but the provision of a good index is an even better way of finding a specific topic. The author provides a good bibliography and freely acknowledges his debt to the authors of the source books listed.

It would be surprising if no errors were to be found, and apart from minor typographical mistakes the reviewer could draw attention to the following points. On page 139 it states that spinel is 'an oxide of aluminium and manganese' and on page 161 that 'ruby and sapphire have a lower relative density' than diamond! Figure 9–7 shows a celebrated gem-quality aquamarine crystal some 25cm high and *not* the Devonshire emerald, which has been clipped from the bottom of the picture.

The book was manufactured in the USA and the spelling is American, but this should not detract from its good narrative flow and the assemblage of so much gemstone history and legend in one convenient volume. E.A.J.

HICKLING, J. 1986. *Practical jewellery repair*. NAG Press, Ipswich. pp.vi, 192. Over 200 black and white illustrations. £9.95.

Well known for their range of practical books, NAG Press Ltd, of Ipswich, have just published *Practical jewellery repair*, which is sure to become a standard textbook for the amateur restorer of jewellery, as well as the working professional and apprentice.

Starting where it all begins – in the workshop or workroom – the author shows how a wide range of repair work can be undertaken with even quite a modest set-up, that can be extended as finances and the skills of the user permit.

There is a very thorough grounding in the various processes and materials required, including working with precious metals and solders and stocking some of the less expensive gemstones. Basic skills such as soldering, casting, wire-drawing, polishing, sawing and filling, are fully explained and illustrated throughout with many clear line drawings. Based on his own wide experience, the author introduces some effective and ingenious methods and short cuts that save both time and cost or improve the work entailed.

With over 30 years' experience, in the UK, Australia and New Zealand, the author provides tried and tested advice on restoring all kinds of antique and modern jewellery, with particular emphasis on the making and repairing of rings. He also describes some of the more unusual repairs to lockets, bracelets, earrings, brooches and watch-cases, including the making of joints, safety catches, pins, respringing and polishing. The appendices also include a useful and comprehensive 'Jeweller's guide to gemstone handling' using a lathe and, increasingly important these days, workshop security. P.R.

MITCHELL, R.H. 1986. *Kimberlites, mineralogy, geochemistry and petrology*. Plenum, New York. pp.xv, 442. $78.00.

The book is concerned primarily with the petrology of kimberlites rather than prospecting for them. Though the occurrence of minerals in kimberlite is described in chapter six, the main aim of the book is to give a survey of the advances made in kimberlite studies over the past 25 years. For this reason the discussion of diamond with respect to kimberlites is left to a short section towards the end of the book. Discussion turns upon whether diamonds are xenocrysts in kimberlite; if they are, then the role of the kimberlite is merely one of transportation. Diamond is regarded as a mineral which can occur in a variety of parageneses in the upper mantle so that several modes of origin are possible. These are briefly discussed. M.O'D.

TAYLOR, L. 1985. *Struck by lightning*. Jon the Printer Pty Ltd, Ashmore, Queensland. pp.183. Illus. in black-and-white and in colour. $5.15.

Now published by the author at Box 675 PO, Surfers Paradise, Queensland, this cheerful book consists mostly of anecdotes and poems, all with an opal mining background and theme. Among the tales are sections on the mining, selling and nature of opal. M.O'D.

Some semi-precious and ornamental stones of South Australia. Geological Survey of South Australia, Adelaide, 1980. pp.159. Illus. in colour. Price on application.

This is a useful survey with a considerable amount of detail given about the mines, their owners and their production. Opal is not included. There is a map in a pocket at the back of the book. M.O'D.

Proceedings of the Gemmological Association of Great Britain and Association Notices

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to Mr Peter Read for the gift of the computer installation used by him to develop his Gemdata programs (Read, 1980 and 1983), which is now installed in the Association's library at Saint Dunstan's House.

The Gemdata program provided for use with the computer has five sections:

(1) Gem identification, using test inputs for RI values, optic sign, SG, etc.
(2) Gem data tables, arranged in alphabetic, RI and SG orders.
(3) Gem data comparisons, enabling side-by-side comparisons of selected gems.
(4) Gem data pages, comprising an encyclopaedia of over 200 gem materials with information on their constants, characteristics and principal occurrences.
(5) Gem calculations, for the determination of SG, reflectivity, critical angle and Brewster angle.

The computer donated by Mr Peter Read, with the Gemdata programs.

The computer, with its Gemdata program, constitutes a means of rapid access to gemmological data for both exam, revision and gem identification purposes. It is available for use, on request, to both students of gemmology and to visiting gemmologists, particuarly those who wish to evaluate the use of the computer for gemmological purposes.

References

Read, P. 1980. Computer-aided gem identification. *Journal of Gemmology*, **XVII**, 4, 239–49.

Read, P. 1983. A computer program for gem identification. *Gems & Gemology*, **XIX**, 3, 157–63.

NEWS OF FELLOWS

The Association's Honorary Treasurer, Mr Nigel Israel, of Nibris Books, is moving in April. His new address will be 1 Simon Lodge, 76 Victoria Drive, Wimbledon, London SW19 6HJ. Telephone 01-789 0200.

Mr Michael O'Donoghue chaired a seminar on 'Geological and mineralogical literature' at the British Library's Science Reference and Information Service on 3 December 1986. Mr Nigel Israel presented a paper on 'The literature of gemmology' at the seminar.

MEMBERS' MEETINGS

Midlands Branch

On 20 February 1987 at Dr Johnson House, Bull Street, Birmingham, a talk was given by Mrs Carole Gibbs on the subject of tortoiseshell, including its recovery and marketing.

On 20 March 1987 at Dr Johnson House, Mr Alec E. Farn gave a talk on pearls.

North West Branch

On 16 October 1986 at Church House, Hanover Street, Liverpool 1, the Annual General Meeting was held, at which Mr S.G. Hill, FGA, was re-elected Chairman and Mrs I. Knight, FGA, elected Secretary.

On 20 November 1986 at Church House, Mr J. Dickson gave a talk entitled 'Microscopy, equipment and specimens'.

On 21 January 1987 at Church House, Mr J. Condrupt of Sotheby's gave a talk on jewellery that had been auctioned.

On 18 February 1987 Dr G. Trecise arranged a special viewing of gemmological specimens at Liverpool Museum.

On 18 March 1987 at Church House, Mr John Pyke, Sen., gave a talk on his newly catalogued collection of gemstones.

EXTRAORDINARY GENERAL MEETING

An Extraordinary General Meeting was held at the Royal Automobile Club, 89 Pall Mall, London SW1, on 28 January 1987, at which special resolutions were passed making a number of changes in the Memorandum and Articles of Association.

COUNCIL MEETING

At a meeting of Council held at the Royal Automobile Club immediately following the Extraordinary General Meeting on 28 January 1987 the business transacted included

(1) the appointment to the Council and nomination for election to the Council at the next Annual General Meeting of the following Fellows, namely Drs A.J. Allnutt, G. Harrison Jones and R.R. Harding and Messrs E.M. Bruton, A.E. Farn, E.A. Jobbins, D.G. Kent, P.G. Read and K. Scarratt.

(2) the establishment and terms of reference of an Executive Committee in accordance with the new Article 61.

(3) the appointment to serve on the Executive Committee of Sir Frank Claringbull (President), Mr David Callaghan (Chairman), Mr Noel Deeks (Vice-Chairman), Mr Nigel Israel (Honorary Treasurer), Dr G. Harrison Jones (Chairman of the Education Committee), Mr E.A. Jobbins (Chairman of the Board of Examiners), Drs A.J. Allnutt, R.R. Harding and J.B. Nelson, and Messrs E.M. Bruton, C.R. Cavey, A.E. Farn, P.G. Read, K. Scarratt and C.H. Winter.

(4) receipt of a report of the recent satisfactory business of Gemmological Instruments Limited.

(5) the election to membership of the following:

Fellowship

Abell, Alison M., London. 1986
Gentsidou, Fontini, Serres, Greece. 1986
Goodlin, Franceen D., Toronto, Ont., Canada. 1986
Lloyd, Jeremy J., Birmingham. 1986
McIntosh, Stewart F., Glasgow. 1986
Malhotra, Kapil, Bombay, India. 1986
Rowell, Unni G., Bloomington, Ind., USA. 1960
Skoropad, John D., Edmonton, Alta, Canada. 1985
Torrance, Claire H., Auckland, New Zealand. 1986
Van Dijk-Pietrzak, Jolanta A., Utrecht, Netherlands. 1986

Ordinary Membership

Andersen, Aud N., Grimstad, Norway.
Aoki, Yuka, Osaka, Japan.
Arthur, Lynne, Denny.
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McDonagh, Bernard, Wrightington.
Manning, Mark J., North Lancing.
Marumo, Kayo, Osaka City, Japan.
Matsumoto, Akira, Honjo City, Japan.
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Mumabe, Atsuhiro, Tokyo, Japan.
Nimry, Lina, London.
Nordby, Anita, Oslo, Norway.
Ogawa, Yoko, Kana Gawa Pref., Japan.
Olivares, Rosana, Gibraltar.
Owen, Margaret E., Pietermaritzburg, South Africa.
Ozier, Stephen M., Bournemouth.
Raskin, David A., Glasgow.
Reavell, David, Dunstable.
Roberts, Charles, San Antonio, Tex., USA.
Rodwell, Peter F., Malmesbury.
Routledge, Hylton M., Bromsgrove.
Sabel, Sara, London.
Sarna, Rajesh, Nairobi, Kenya.
Sato, Hitoshi, Tokyo, Japan.
Saunders, Geoffrey P., Transvaal, South Africa.
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Shread, Andrew, Beeston.
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Usui, Kenichi, Tokyo, Japan.
Wadia, Aneeta, London.
Warrington, Jeffrey T., Brighton.
Wege, Joyce, Leeds.
Weiss, Anthony S., Bushey.
Winterbottom, Martin, Watford.
Yanagi, Narue, Tohka-Machi City, Japan.
Yang, Richard K. K., Kelantan, Malaysia.

ANALYSIS AND TECHNOLOGY OF ANCIENT GEMSTONES

The European University Centre for the Cultural Heritage is organizing an international symposium on 'Analysis and technology of ancient gemstones', to be held in Ravello, Italy, from 13 to 16 November 1987. Further details from Prof. T. Hackens, European University Centre for the Cultural Heritage, Villa Rufolo, I 84010 Ravello, Italy.

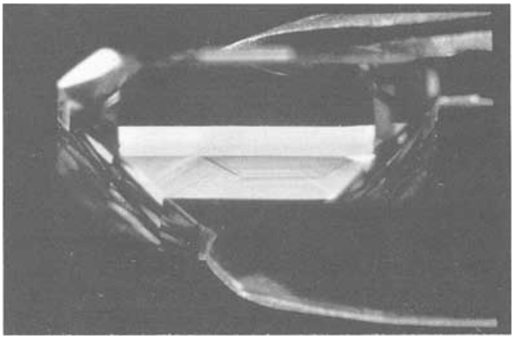
GEM TRADE RESTRICTIONS IN KENYA

As from 30 December 1986 anyone trading in minerals or gemstones in Kenya must have a licence. As a result of the enactment of the Statute Law (Miscellaneous Amendment) Act 1986, it is now illegal and an offence to be in possession of or trade in gemstones and/or other minerals without registering and having obtained a mineral dealers licence from the Commissioner of Mines and Geology.

GEM QUALITY SYNTHETIC DIAMOND IS BEING MARKETED

A synthetic diamond, identified at GIA's Gem Trade Laboratory in New York, is the first indication that new synthetic diamonds are circulating in the gem market. GIA broke the news of the new synthetics in January in the Institute's quarterly journal, *Gems & Gemology*. The article, entitled 'The gemological properties of the Sumitomo gem-quality synthetic yellow diamonds', was prepared by GIA's research department in Santa Monica, California.

The colour of the 23 point stone, submitted by a gem dealer, was a very intense yellow. Jewellers should definitely be wary of any fancy yellow diamonds they come across in the trade.



An emerald-cut synthetic Sumitomo diamond. The distinctive hourglass-shaped internal graining pattern has not been observed in any of the rough crystal sections studied.
Photomicrograph by John Koivula, from *Gems & Gemology*, Winter 1986.

GIA Board Chairman, Mr Richard T. Liddicoat, is not surprised at the appearance of the new synthetics in the diamond market. 'As I wrote in *Gems & Gemology*', Mr Liddicoat says, 'we knew they would show up. The question was when, and it turns out to be sooner rather than later. But then, our labs are always among the first to see new synthetics whenever they appear'.

The first synthetic diamonds were two stones submitted by a customer on 18 February, with a request for an origin of colour report. The smaller stone was identified as a diamond using a thermal inertia instrument, a standard test. It was then found to match the characteristics described in *Gems & Gemology*.

GEM IDENTIFICATION COURSE

Two- and three-day courses on gem identification run by Mr Alan Hodgkinson will be held at the British Horological Institute, Upton Hall, Newark, Notts., in the autumn.

Full details from the *Retail Jeweller*, 100 Avenue Road, London NW3 3TP.

LETTER TO THE EDITOR

From Bernice Backler
Barnscott Gemological & Metallogical Laboratory

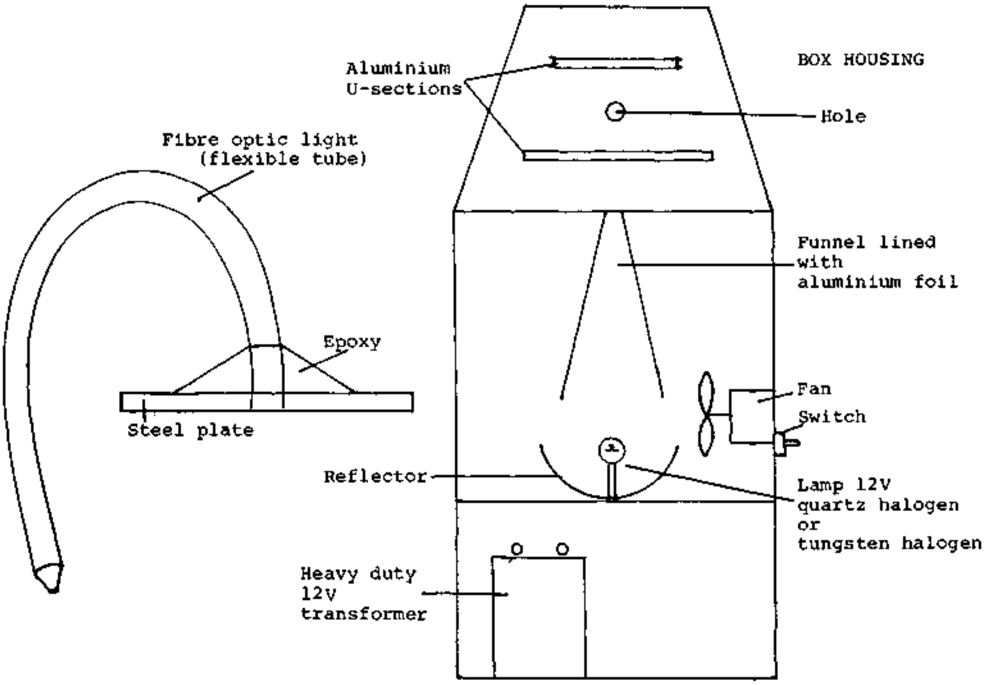
Dear Sir,

Further to your request in Vol. 20, No. 4, p.241, re low cost accessories, we have pleasure in submitting the following:

Let there be light in your darkness

The attached sketch (we may be many things but not artists) shows that a light-source can be made with a minimal amount of expenditure and effort. We do not claim that the idea is original, only that we put brain in gear and got the pumpkin pip moving after reading an article by Hugh Crawford.

The sketch is virtually self-explanatory except to say that the transformer and fan are connected into the same electric line where the switch will operate both when it is activated.



Getting the parts is fairly simple – you scrounge them – the flexible fibre optic tube can be obtained from any abominable surgeon, or hospital, who throw them out when they break. The fan is obtainable from a refrigeration engineer who also throws out and replaces with new; this is a cold counter fan. The quartz halogen headlamp and reflector comes from a motor scrapyard, the electric cable is nicked from your wife's iron* and the box can be anything handy.

Words of warning – before switching on the quartz halogen lamp wipe it off with a cloth dipped in benzine, which disposes of any oddities your sweaty paws have left on it. If you don't do this your lamp will go 'bang'.

The use of this light box is manifold – you will note that the hole in the top through which the light escapes has two pieces of aluminium U-section (with a gap of approximately ⅛ inch). Into this U-section are placed strips of black plastic with holes (to correspond to the box hole) ranging from 1mm up to what you need. Here you can check rough stones for flaws, cracks, inclusions, etc. Another word of warning – unless you want to make your doctor rich, don't look directly into the light – it is powerful – view obliquely.

For instance, you can check garnet for flaws, inclusions, etc., pearls, aquamarine, you name it. To check a diamond against a simulant, place a piece of ground glass in the U-section, position the diamond table down and if a dark star appears in the culet you have a diamond, if not, you have something else.

Cement, with epoxy, the fibre optic into a sheet of steel and you have a totally movable light source.

*This could be dangerous on at least two counts! – Ed.

With a bit of ingenuity (and anyone who is a member of the GA is ingenious) a clamp can be made so that this light source is used, for instance, on the microscope.

With felicitations from the mad professor. If you publish this I'll send you more, if you don't I'll use my alchemy to turn you into something that shivered in your recent cold spell.

Yours etc.,
Bernice Backler
19 January 1987
2c Medical Centra, 79 Compton Street,
PO Box 1692, Pinetown 3600, South Africa.

ANNUAL GENERAL MEETING

The Annual General Meeting of the Association is to be held on Tuesday 16 June 1987 at the Flett Theatre, Geological Museum, Exhibition Road, South Kensington, London SW7, at 6.30 for 7.00 pm. This will be followed by a Gemmological Forum, when a panel of experts will be answering questions on a number of subjects.

THE JOURNAL OF GEMMOLOGY COMBINED ISSUE

The Editor is pleased to announce that following the successful launch of the present volume of *The Journal of Gemmology* in its new format, plans are underway to develop the contents of the *Journal* further in a way to maximize the interest and benefit to the readership. As a result of these plans, a combined issue will appear in September/October this year. This issue will comprise numbers 7 and 8 of the current volume which means that members will *not* receive a journal in July.

CHALCOPYRITE IN PERIDOT

In the paper by J. Koivula and C.W. Fryer, (*Journal of Gemmology*, **20**, 5, 272–3), this was claimed to be the first recorded occurrence of chalcopyrite in peridot. We have been informed, however, by Dr H.J. Schubnel of Paris, that he described chalcopyrite in peridot in a paper published in 1968 (Giraud, R., Picot, P., and Schubnel H.J., 1968. Les inclusions sphéroídales des gemmes de roches ultrabasiques. *Revue de Gemmologie*, No. 14, 9–11). We apologize to Dr Schubnel for this error.

CORRIGENDA

On p. 176 above, 1st column, line 15, for '$(T_b^3 - H_c)/(1 - T_b)$' read '$H_cT_b^3/(1 - T_b)$'.

On p.176 above, 2nd column, lines 2, 3 and 8, for '$(1 - T_b)H_c/(1 - T_b^3)$' read $H_c(1 - T_b^3)/(1 - T_b)$'.

On p.287 above, the caption to the last figure in the 2nd column should read 'Fig. 7. The thin section of a natural freshwater pearl (Laboratory collection).'

On p.288 above, the caption to the first figure in the 1st column should read 'Fig. 6. A closer view of the internal structure of a freshwater pearl seen in Figure 5.'

On p.289 above, the illustrations to figures 13 and 15 have been transposed.

On p.309 above, in first column, line 27, for '1983–1985' read '1983–1984'.

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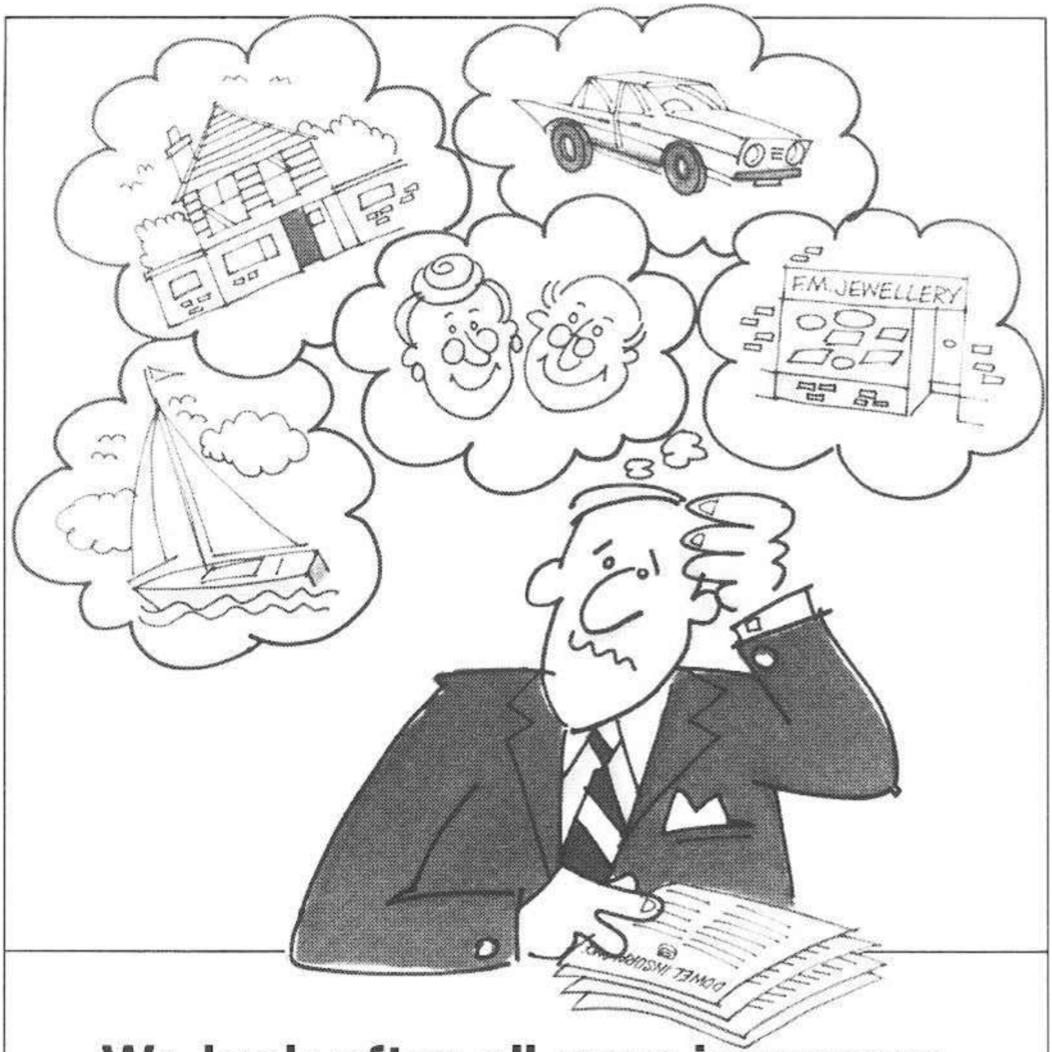
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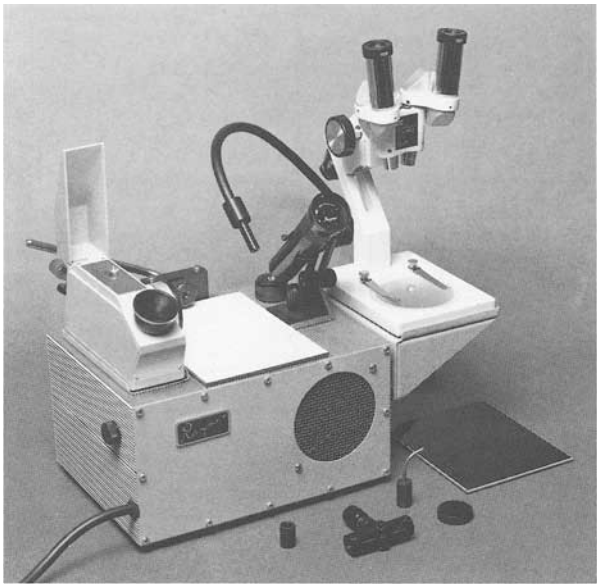

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Further details are published on page 338 in this issue. To book for the courses, please use the coupon below and enclose the necessary remittance.

To: Paula Jennings, Gemmological Association of Great Britain, Saint Dunstan's House, Carey Lane, London EC2V 8AB
Please reserve .... place(s) for the course to be held on .... (Date).
Enclosed is my remittance for £ .... The fee is £55 plus VAT (i.e. £63.25) per person, per course.
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Asian Institute of Gemmological Sciences,
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Any company or individual interested in commencing an Agency should contact Bill Pluckrose at the Gemmological Association.

GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

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

Historical Note

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

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

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

Notes for Contributors

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

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

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

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