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and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
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ANOTHER BRIEF LOOK AT THE SANCY DIAMOND

By HERBERT TILLANDER, F.G.A., C.G.

Scandinavian Diamond Institute

Historical diamonds are not often available for examination. Most unfortunately the Sancy diamond was at the Institute of Geological Sciences for a very short time only. However, during an exhibition arranged by the Tillander jewellers both the Sancy diamonds, 'Le Grand et Le Beau Sancy',(A) were available for inspection at night in a bank safe. Some additional information may therefore be added to E. A. Jobbins's article in this *Journal* of January 1977.(B)

The stone was then still in its setting and the assessed colour-grade can therefore not be considered as exact and reliable. It compared with the GIA-Master J in our collection and was thought to lie between I and J with a slight brownish, not a yellowish tinge. The colour of the golden setting possibly influenced the judgement. The numerous abraded facet edges were found to disturb the splendour of the fine brilliancy and fire, and it was felt that this should eventually be corrected by a slight repolishing operation in order to restore the original beauty of the diamond. Table and culet

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(A) Sometimes called 'the Great Sancy' and 'the Little Sancy'.

(B) XV, 5, 240-242.—Ed.

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FIGS. 1 and 2. Two photographs of the Sancy diamond in its setting.

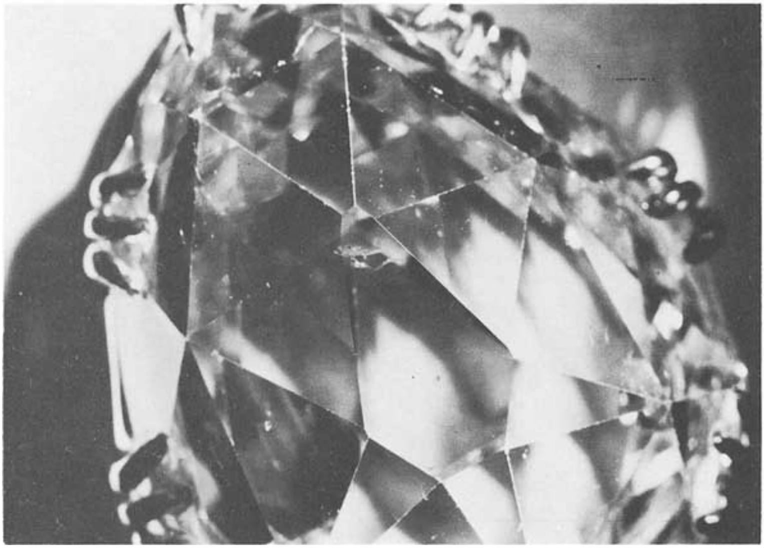

FIG. 3. Photograph of the Sancy diamond showing inclusion and abraded facet edges.

are not absolutely parallel and the inclusion is rather visible (see Figures 1, 2 and 3). The fluorescence appeared to be a clear yellow.

Germain Bapst(1) described this gem in 1889 approximately as follows: 'Its shape is a flattened pear, almost round, a pendeloque, but the pronounced convexity does not permit the design to be called "Fer de lance" or "Larme." It is faceted both above and below the girdle with a tiny table above. The light-rays entering from above through the various facets are reflected from the bottom facets and irradiate through the top facets exhibiting a fine dispersion (fire).' Bapst further cites Babinet, who believes this shape—often called the Sancy-cut—to be exceptionally economic (weight-saving).

It is surprising how exactly the Sancy diamond has been described and sketched—earliest probably by Thomas Cletscher (1598-1668). The weight, now known to be 55.232 ct (with three decimals) has been given in various old carats, thus 53 ct at 208.4 milligrams, 53¾ ct at 205.5 mg and 54 ct at 204.55 mg. De Sancy himself offered his stone in a letter dated 16th October, 1599, with a weight indication of 60 ct, obviously including the weight of the setting, since in 1604 it was sold to James I with a weight of 214¾ grains = $53^{11}/_{16}$ ct (at 205.75 milligrams). This detail may explain

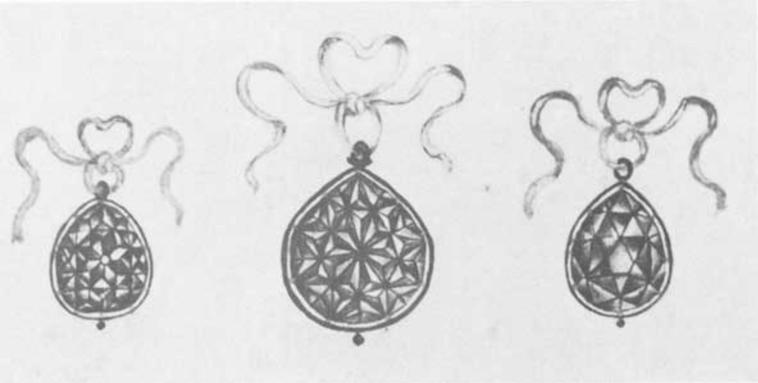

FIG. 4. The Beau Sancy, Florentine and Grand Sancy (from Cletscher, p.2r).

as it was customary in those days, the presumption that the similar stone (weighing 60 ct), once in the possession of the Maharajah of Patiala, was the Grand Sancy. It has been confirmed by the Maharajah's son.

In this connexion I cannot resist the temptation to quote some interesting historical facts regarding this famous diamond.

It has been definitely proved that it never was the property of Charles the Bold, and it seems certain that the stone came from India in its present shape. However, nothing else is known about its travels to Paris, where it was first documented in the hands of Nicolas de Harlay, Sieur de Sancy (1546-1629). He may have brought it from Constantinople, but he was never ambassador there. However, his son was. Further, it was never lost in connexion with the great robbery in 1792, but pawned by the French authorities to the Marquis of Iranda in Madrid and finally sold in Paris legally to a member of the Demidoff family, owners of large industries and silvermines in Russia. Nicholas Demidoff was a resident of Tuscany, where his son Anatol became accredited as chargé d'affaires to the Duke and later received the title of Prince of San Donato. Nicholas died in 1829, a year after he had purchased the Sancy. Anatol did not however, as is generally believed, receive the diamond. His brother Paul did, who in 1836 married a Finnish lady, Aurora Stjernvall, maid of honour at the Russian court. She received the Sancy—as is customary in the Nordic countries—as a 'morning gift' presented to the bride on the morning after the wedding ceremonies. Paul Demidoff died in

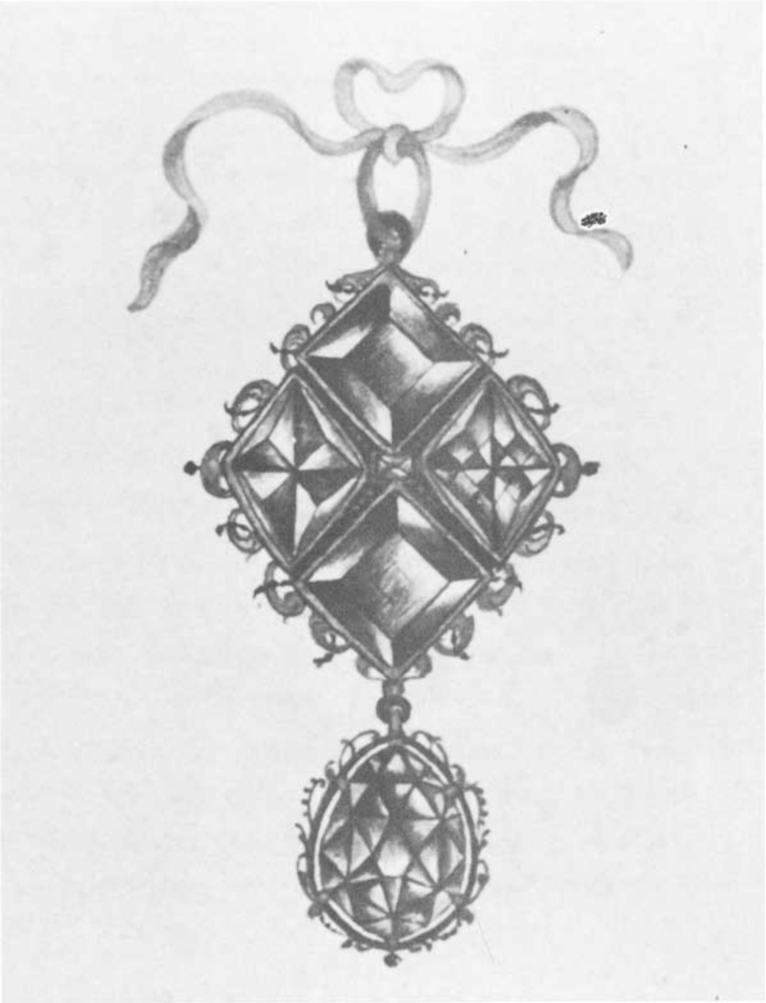

FIG. 5. Very similar to the 'Myrror of Greate Brytayne', with the Sancy pendant (from Cletscher, p.3r).

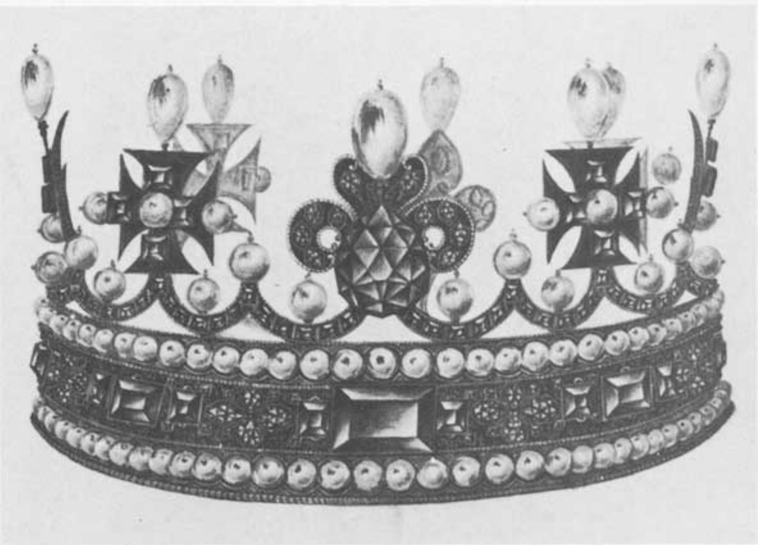

FIG. 6. Head ornament with the Sancy and (?) the Mirror of Portugal (from Cletscher, p.34).

1840 and in 1846 Aurora married Andrew Karamsin, captain of the guards, and she was again a widow in 1854, when she finally settled in Helsinki.

In 1865 the Sancy was disposed of through a jeweller in London (Garrards or Oulman) and found its way back to India to Sir Jamsetjee Jeejeebhoy. Since 1906 it was in the possession of the Astor family. The 4th Viscount Astor was the last inheritor. The Sancy is now reported to be on display in the Louvre Museum, possibly on permanent loan![C]

HISTORICAL ORNAMENTS WITH THE SANCY DIAMOND

Before the sale to James I with the assistance of De Sancy's cousin De Montglat, then French ambassador in London, the setting was very simple. The King had it reset into 'a greate and ryche jewell of golde, called the "Myrror of Greate Brytayne," conteyninge one verie fayre table dyamonde, one verie fayre table rubye, twoe other lardge dyamondes, cut lozengewyse, the one of

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[C] Subsequently reported to have been sold to France. The French weekly, *L'Express*, no. 1386, (1978), confirmed that the Banque de France and Musées de France had bought the jewel and it would take its place with the Regent and others in the Gallerie d'Apollon in the Louvre Museum.

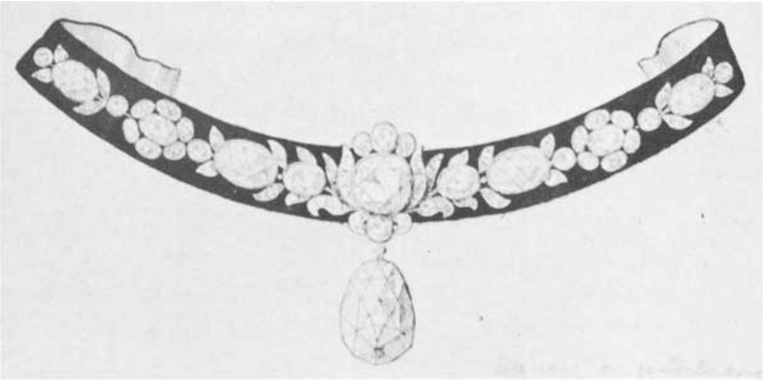

FIG. 7. Queen Marie Leczinska's necklet with the Sancy pendant (from Bapst, p.417).

them called the "Stone of the letter H of Scotlande" [the Great Harry], garnyshed wyth smalle dyamondes, twoe rounde perles, fixed, and *one fayre dyamonde, cutt in fawcetts, bought of Sauncey.'* (Calendar of State Papers—Domestic—James I—Of the Treasury of the Exchequer, p. 305, No. 51.)

Charles I, who inherited the jewels of his father, disposed of this ornament during the first year of his reign, but retained the Sancy. Thomas Cletscher, crown jeweller and Mayor in the Hague, must have been involved in the purchase, since in his famous Sketchbook(D) this diamond is illustrated in three different settings—on page 2 with a simple frame together with the Beau Sancy and the Austrian Yellow sometimes called 'the Florentine', on page 3 in an ornament very similar to the above mentioned 'myrror', and finally on page 34 in a rich head-ornament together with a huge table-cut diamond, probably the Mirror of Portugal (see Figures 4, 5 and 6).

The piece of jewellery on page 3 is accompanied with the following text—translated from the Dutch: 'This jewel was made for King James, who wore it on his hat. The two thick-stones weigh each 36 ct, one of the faceted stones (roses) has a flat base and weighs 12 ct, the other one probably 20 ct, the pendant weighs 54 ct. The jewel is exquisite and was acquired at a cost of some 70 000 pounds sterling.' In this connexion it remains to find out if the original ruby had been exchanged for a diamond, which of the

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(D) Produced between 1625 and 1647 and now in the Museum Boymans van Beuningen in Rotterdam: Cletscher was jeweller by appointment to Frederick Henry, Prince of Orange (1584-1647) and his wife Amalia von Solms.

faceted stones was the 'Great Harry' and where the two pearls and small diamonds had been fixed. A further question is posed by the appearance of a very similar pendant—a gift to Charles I's and Henrietta Maria's daughter on her marriage with Prince William II of Orange. This jewel may be seen in a picture painted in 1641 by Sir Antony van Dyck of the Princess Royal (Mary, daughter of Charles I) and Prince William of Orange on that occasion. The original painting is in the Amsterdam Rijksmuseum and a detail showing the jewel is illustrated in a book by M. H. Gans.(2) The ornament is described as being composed of four faceted diamonds joined together in such a way that they appeared as one single huge diamond.

When again a French Crown jewel—bequeathed in the will of Mazarin—it was in the crown 'du sacre' of Louis XV (pictured in Bapst's book(1) on p.411 and in Twining's(3) in Plate 84) and in the collar of his Queen, Marie Leczinska (see Figure 7). Strangely enough we have not been able to recognize the Sancy in other ornaments in portraits of the many owners during this diamond's next to 400 years history. A challenge to art students!

REFERENCES

1. Bapst, Germain. *Histoire des Joyaux de la Couronne de France.* Paris, 1889.
2. Gans, M. H. *Juwelen en Mensen.* Amsterdam, 1961.
3. Twining, Lord. *History of the Crown Jewels of Europe.* London, 1960.

[*Manuscript received 11th November, 1977.*]

NOTES FROM THE LABORATORY

By A. E. FARN, F.G.A.

The Gem Testing Laboratory, London Chamber of Commerce and Industry

AN UNUSUAL CHRYSOBERYL

I am guilty of having quite a few failings, among them proneness to flogging well known phrases to suit my own particular point of view. Most used and truthful in description of intent is that which I now employ most sincerely in apology for delay to a very keen gemmologist in Australia, Mr R. Chapman, F.G.A. 'The road to Hell is paved with good intentions'.

I received a long time ago two specimens, one rough and one cut, of a green material. They were described as green, but to me they had a brown tinge as well. The rough had been found *'in situ'* by Mr Chapman. He states it was found in a pegmatite with beryl in the Harts Range area of Central Australia, some 150 miles north-east of Alice Springs. Mr Chapman did his own testing upon the cut specimen and obtained the following refractive indices: 1.761-1.771, 1.772-1.779; DR = 0.018 biaxial negative. He also gave a density of 3.7, a hardness in excess of 8, and a broad absorption band in the blue/violet.

Having had two different results given him by two distinct authorities in Australia, he felt considerable interest to find out what his stone really was. Actually his own figures seem to me to be sufficient and he is to be congratulated as a true gemmologist in finding, cutting and polishing his own material and assessing its nature. We at the Laboratory were sent the material, both rough and cut, and promptly did a test upon it and found refractive indices, density and absorption spectrum falling fairly well in line with Mr Chapman. We took a powder scraping and used our diffraction camera. Ken Scarratt did this work and obtained a good chrysoberyl result.

Since two other authorities had said (1) chrysoberyl and (2) corundum, and bearing in mind that a poor surface can play havoc with RI readings, and that corundum has an absorption complex around the area of absorption in chrysoberyl, we decided to ask the co-operation of our consultant, B. W. Anderson. We sent him our

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data and our densities of 3.72 and 3.74 and we received the following report from him.

Report on Cut and Uncut Specimens of an Unusual Green Material

A step-cut transparent green stone weighing 1.52 ct, and a thin slab of supposedly the same material, weighing 3.65 ct, were carefully examined, to provide data to compare with those already established in the Gem Testing Laboratory of the London Chamber of Commerce and Industry, and Mr R. Chapman, F.G.A., of Ayr, Queensland, who originally discovered the mineral in the Hart's Range area of Central Australia.

The rough piece was found to scratch a cleavage plane of white topaz and the basal plane of a beryl crystal. The hardness can be assessed as 8½ on Mohs's scale, a figure only equalled by chrysoberyl and excelled by corundum and diamond amongst natural minerals.

The density of the cut stone was found to be 3.73 (average of two determinations) and 3.78 for the rough stone.

The refractive indices of the cut stone, as determined on a Rayner 'Dialdex' refractometer, were found to be 1.765, 1.772 and 1.777. The birefringence being 0.012, biaxial negative.

The chief feature of the absorption spectrum was an intense broad band in the violet, centred near 4470Å, with a weaker narrow band near 5080Å in the blue-green.

This absorption spectrum, together with the extreme hardness of the mineral, seem to prove that the specimens consist of a variety of chrysoberyl, or possibly a sub-species of chrysoberyl not so far recorded in literature. Normal refractive indices for gem chrysoberyl are 1.747, 1.748 and 1.756, the birefringence being 0.009 and optically strongly positive. The density is near 3.72.

In the samples here reported the density is distinctly higher than normal; but the most surprising features are the higher refractive indices, higher birefringence, and negative optical sign.

One possible explanation of these differences would seem to be the presence of ferric iron in larger quantity than usual. Both the colour and absorption spectrum are thought to be due to traces of this element in normal green and brown chrysoberyl.

B. W. Anderson. 1st May 1977
(Consultant to the Laboratory)

In his letter to me anent the chrysoberyl, B. W. Anderson gave details of how he was able to use sunlight as his light source via a wavelength-measuring Beck spectroscope. We think Mr Chapman is to be congratulated and envied for this gemmological exercise.

I have at last achieved my intention to write on these chrysoberyls and append here a table of the findings.

	R. Chapman	B. W. Anderson	Laboratory
S.G.	3.70	3.73	3.72
Hardness	Exceeds 8	8½	8½
RI	1.761-1.771 1.772-1.779	1.765-1.772- 1.777	1.765-1.772 1.772-1.778
DR	0.018	0.012	0.013
			Powder diffraction finding: Chrysoberyl

* * *

I have mentioned before a predilection for useful phrases and since they seem to spring readily to mind I think I can comfortably continue their use—particularly following our recent chrysoberyls! I too possess a high-reading brown/golden chrysoberyl, which in post-diploma days at Chelsea Polytechnic used to catch most people out—they all placed it as brown sapphire. 'It never rains but it pours.' In the Laboratory we tested for a customer an alexandrite in a ring. The stone, which later we asked to be unset, weighed 20.12 ct, which is an important size for an equally important stone. Here we were again at the chrysoberyl stakes. In daylight this particular stone was a greenish brown, carrying a nuance of red or that peculiar colour where a gemmologist looks twice or three times before he can really make up his mind. When chromium proliferates, I often find in a mixed lighting such as ours we get warning signals—or is it because we look *into* stones rather than *at* the jewellery? However, we double checked using a spectroscope and received quite a surprise: chromium—yes, signalled in the red end of the spectrum—and three bands at 4500Å, 4600Å and 4700Å typical of sapphire!

We took the refractive indices and found them to be 1.766-1.774 uniaxial negative. In artificial light the stone was a sort of brownish red, looking like a smoky quartz, but reddish. It looked, for all the world, like an alexandrite—a large poor one, but very interesting. So here we had a natural sapphire looking very much more like an alexandrite chrysoberyl: previously we had a chrysoberyl looking to some like a sapphire.

The alexandrite-like sapphire was very clean indeed, except for one long lath-like inclusion which offered no clue to identity. We took the density of the stone and found it to be 4.005.

* * *

Advances in techniques are always welcome and applauded. Mechanization, automation, stereo-zoom, transistors, printed circuits, electronic calculators—all play a part in smoothing the stony path of today's gemmologists. We used to *stand* to use a monocular microscope to test calibré stones by the hundreds and thousands. We used to do our densities by old fashioned use of multiplication, subtraction and division. We have progressed. We now have a calculator. We have a stereo-zoom lens microscope plus four stereo binocular microscopes (non-zoom—old fashioned?). Each has its strong points and some weaker ones—none are perfect—not even the simplest and most manoeuvrable of them all, the 10× lens.

I was fortunate in being taught by an enthusiast who was also an expert. Among many enjoyable evenings at Chelsea and Northern Polytechnics in B. W. Anderson's Post-Diploma class I practised and propagated the use of the 10× lens. We used to have an evening session devoted to identification by 10× lens and heft. No other instruments were allowed. Simple basic tests included finding DR by seeing the doubling of the back facets or doubling of the edge of inclusions. (I bought one or two rock crystal spheres quite cheaply by examining a sheet of paper through the sphere and noting doubling effect on the edge of the page.) The use of the 10× lens cannot be over-stressed as a sound basic beginning to further investigation. Although during my army service I was frequently told that a soldier's best friend is his rifle—I found it hard to appreciate. I do earnestly advise the 10× lens as a gemmologist's best friend.

In the laboratory, of course, we do have other equipment, our latest being a powder diffraction camera which is being appreciated by our younger staff members. We have our old faithful and unique one-off x-ray generating set, purpose-built for radiography and diffraction pattern photography of pearls, with its viewing chamber for observation of luminescence effects. When presented with undrilled pearls we automatically use our x-ray set. We take a radiograph (shadowgraph) or Laue diffraction pattern, depending upon the item—whether it is mounted, whether metal will interfere,

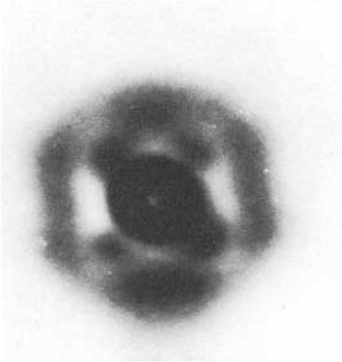

Fig. 1 X-ray 4-spot lauegram of lacquered m.o.p. bead (imitation cultured pearl?)

whether it can be unset or isolated by lead-foil, etc. From one of our customers who sends us quite a lot of pearls to test we recently received a very insignificant small round undrilled pearl weighing 1.19 ct = 4.76 grains. It was a poor-looking whitish pearl, which a quick first look by 10× lens did nothing to improve! Rather it afforded the mental observation, 'poor quality, rubbishy-looking pearl - shocking skin to it.' I took a radiograph on a dentist-size film. The result was negative (no pun intended). For want of a better phrase, it showed nothing—no skin, no core, no structures—nothing. I used the viewing chamber and it fluoresced and phosphoresced strongly as *all* cultured pearls do. Being called away I handed over to my younger colleague and asked for a diffraction lauegram to be taken in my absence. On my return I asked the result and was shown an excellent negative with a strong four spot pattern (Figure 1) characteristic of cultured pearl. This is accepted as proof positive when dealing with suspect cultured pearls.

There being no substitue for experience and remembering many an admonishment to let no anomaly slip by however small, I took another look at our pearl or cultured pearl with the 10× lens. I hadn't liked it in the first place and now less so—normally in pearl testing one looks for shape, subcutaneous markings and general 'look' of the pearl to guide one. We seldom study the actual skin structure to see if in fact it is of the ultra fine overlapping platelets of nacreous pearl. It is always there in pearl and in cultured pearl. This particular pearl was lacking any such structure (although ostensibly a pearl colour). It was in fact a plastic coating over a mother of pearl bead. The bead showed zonal structure as is seen in thin-skin cultured pearls—it fluoresced and phosphoresced as do all cultured pearls and the x-ray diffraction picture gave a four-spot pattern typical of cultured pearl.

The 10× lens gave a strong lead, which was not immediately followed, but it did prevent us from reporting a cultured pearl, on the basis of an x-ray examination, when in fact it was technically an *imitation* cultured pearl. The reliability and manoeuvrability of the 10× lens were thus graphically proved when one considers the extensive equipment employed in arriving at a slightly awry conclusion. When one moves in certain circles—i.e. dealing with pearls which basically will be natural, cultured, non-nucleated cultured, or imitation (usually glass)—one tends to expect certain precise results. In this particular case preconceived expectations allied to expensive x-ray equipment plus films and cassettes added to knowledge of patterns given by certain structures led us slightly astray. More attention to basics—more and constant use of a 10× lens—can be rewarding and time (and face) saving.

* * *

Talking of pearls, 10× lenses, experience, etc., reminds me of yet another case of x-rays not being so revealing as one would hope. Recently we received from a customer several items of jewellery, all set with pearls as centres to cluster rings and brooches, etc. We often try to obtain results from such items without unsetting the pearls, hoping that in some cases the major portion of the mounted pearl will yield sufficient information from a side-shot radiograph. One case in particular was a very steep *bouton* pearl mounted in a diamond border cluster ring. It looked as if a good picture could be obtained without unsetting. The result was as expected—definitely the structure of natural pearl (several concentric layers showing quite well). The remainder of the jewellery responded to x-ray tests.

Looking again at the ring, I was struck by the size of the pearl diameter set in the cluster surround compared with the small amount of pearl I could see underneath through the pierced basket setting. Some little warning bell rang to tell me that the shape or curvature of the base did not marry with the curve of the steeper upper portion. Using an alcohol lamp, I unset it to find I had two portions of pearl—the upper portion, a sawn pearl with flat base sitting nicely in the surround of diamonds and gold setting, and the lower portion, a smaller, shallower piece of a pearl plugging up the rear so that a natural rounded pearl base could be seen when examined by lens. The x-ray beam proved correctly that the top portion was natural pearl, but it could not penetrate the metal setting to show a flat base, and insufficient of the lower portion protruded to afford any further clues.

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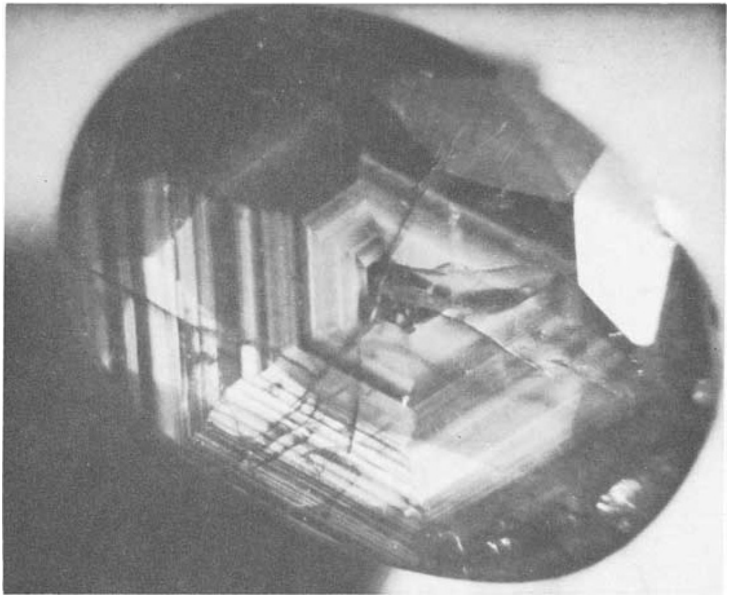

Fig. 2 Zoning in ruby.

ZONING IN RUBY

The zoning in the ruby photographed here by K. V. Scarratt (Figure 2) was so immediately impressive that the original owners, Levy Gem Co. of Hatton Garden, presented it to the Laboratory as of gemmological interest. We were impressed by its obvious self-determination and thought it might interest other gemmologists. From time to time we are presented with samples of new gems and/or synthetics, artefacts, etc. Most are recorded in 'Notes from the Laboratory'. It is refreshing to find this kind of spontaneous enjoyment of basic gemmology. Even a 10× lens was hardly necessary to decide whether natural or not.

[*Manuscripts received 18th February and 4th March, 1978*]

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GEM PERIDOT AND ENSTATITE WITH SPINEL INCLUSIONS FROM CHIHUAHUA, MEXICO

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INTRODUCTION

An occurrence of light green and light brown peridot and enstatite in Mexico prompted an examination of the material and the associated minerals to ascertain their compositions and to compare these Mexican gems with the material from the San Carlos Indian Reservation described by Dunn (1974). The peridot and enstatite occur at the Chavira peridot-olivine mines, near Kamargo, Chihuahua, Mexico. The specimens described herein were obtained from Mr Randy Shepard through the courtesy of Mr John Sinkankas, the noted American gemmologist and author.

DESCRIPTION

The peridot occurs as granular aggregates associated with enstatite of a light brown colour, bright-green chromian diopside, and chromian spinel. The massive material is attractive but serves little purpose other than as a source for the gem rough. For a description of the origin of similar deposits, the reader is referred to the work of Ross *et al.* (1954). The peridot occurs in both light green and light greenish brown colours, and stones up to 2 carats can easily be cut from the material. The refractive indices for the light green peridot, measured on two stones in sodium light, are: $\alpha = 1.651$, $\beta = 1.669$, $\gamma = 1.684$, and $\alpha = 1.652$, $\beta = 1.668$, $\gamma = 1.685$. The refractive indices of the brown peridot are $\alpha = 1.655$, $\beta = 1.673$, $\gamma = 1.690$, all ±0.003. The material is sufficiently abundant at the locality to support a local mining operation, and will very likely influence the jewellery of northern Mexico.

CHEMISTRY

The samples were analysed using an ARL-SEMQ electron microprobe, utilizing an operating voltage of 15 kV and a beam current of 0.15 μA. Standards used were forsterite for olivine, enstatite for enstatite, diopside for diopside, and spinel for spinel.

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In addition, chromite was used for chromium, manganite for manganese, and hornblende for aluminium in all samples. The data were corrected for absorption, backscatter, background and fluorescence using a computer program. The analyses of the gem peridot, gem enstatite, and associated minerals are given in Table 1.

TABLE 1
Microprobe analyses of gem peridot, gem enstatite, and spinel inclusions.

	PERIDOT NMNH 137044			*ENSTATITE NMNH 137045*		*SPINEL NMNH 137046*	
	green	*green*	*brown*				
SiO_2	41.78	41.32	40.35	53.63	53.44	0.00	0.00
TiO_2	0.02	0.01	0.00	0.05	0.04	0.12	0.11
Al_2O_3	0.00	0.00	0.00	4.92	3.94	47.38	46.34
Cr_2O_3	0.00	0.00	0.07	0.90	0.54	20.79	21.60
FeO*	8.58	8.62	11.04	6.07	6.02	11.78	12.38
MnO	0.15	0.14	0.17	0.16	0.12	0.20	0.23
MgO	49.77	49.80	48.26	33.41	33.51	18.84	18.67
CaO	0.08	0.06	0.10	0.97	0.97	0.00	0.00
TOTAL	100.38	99.95	99.99	100.11	98.58	98.81	99.33

*total iron calculated as FeO
Accuracy of data—±2% relative.

Peridot

The green peridot contains about 8.6% FeO, and is similar in composition to the San Carlos peridot. This similarity in composition further supports the observation of Webster (1970) that the iron content of good, green peridot varies little.

The brown peridot, however, has a higher iron content (11.04% FeO) and a correspondingly lower magnesium content. The other elements present do not vary significantly with colour, and it is likely that the brown colour of this peridot is related to the greater amount of iron. This Mexican peridot has between 89 and 91% of the forsterite end-member.

Enstatite

The gem enstatite is markedly less abundant than the peridot at this locality. Several samples were analysed. The analyses indicate that this Mexican enstatite is very close to the enstatite/bronzite composition borderline (Dunn, 1975), but is clearly enstatite. The composition of these enstatites is very similar to that of the San Carlos material; differing in that this material has a higher aluminium content, which is larger than commonly found in mafic rocks.

Spinel Inclusions

Spinel is found in the peridot as dark brown, almost black, anhedral inclusions. The composition of these spinel inclusions, given in Table 1, indicates that they are chromian spinels with an average Al:Cr ratio of 3:1. These Mexican spinel inclusions differ from those of the peridot from San Carlos in that they contain less chromium and more aluminium. The San Carlos spinel inclusions contained 22.62 to 34.79% Cr_2O_3.

SUMMARY

In summation, the gem peridot and gem enstatite from the Chavira peridot-olivine mines in Chihuahua, Mexico, are very similar to those from the San Carlos Indian Reservation in Arizona, U.S.A. The deposit will very likely produce an abundance of material which may be encountered by the practising gemmologist.

ACKNOWLEDGEMENT

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THE 'DIAMOND EYE' AND THE 'LUSTERMETER': A REVIEW*

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Since the Second World War many diamond simulants have been synthesized and marketed; they have also misled many unsuspecting buyers. The latest and most effective yet produced, cubic zirconium oxide (zirconia), has deceived, among others, a leading diamond cutter and a very experienced London jeweller who bought a three-stone zirconia ring as diamond. Detection of zirconia has become a matter of some urgency for jewellers and gemmologists alike. The material is produced in Switzerland (djevalite), U.S.A. (diamonesque), U.S.S.R. (phianite) and elsewhere.

Modern reflectivity meters using infrared emitting diodes and suitable sensors might well be the answer if they are reliable. Earlier examples have been described in this journal and elsewhere (references 1 to 6), and it seems to be unnecessary to repeat detailed descriptions of the (internal) circuitry. Some of these earlier instruments show named species on the scale whilst others are calibrated on a numerical scale. Both types have their adherents. In the opinion of colleagues and of the author the identities of gemstones with refractive indices below 1.81 can, in general, be determined more effectively using refractometers and other techniques. Diamonds and most of the effective simulants have higher refractive indices and, coupled with these, normally have higher reflectivities, so that only the higher part of the scale of the reflectivity meter is normally necessary for the identification of doubtful stones. Loose diamond simulants can often be identified by careful appraisal of their physical properties. Mounted stones are more difficult and here reflectivity meters are very useful.

The 'Diamond Eye' is a small reflectivity meter measuring approximately 11 cm long, 6 cm wide and 4 cm deep recently introduced by Dr Hanneman, of California. The instrument is calibrated in Hanneman luster values (L_H) (an arbitrary scale) from

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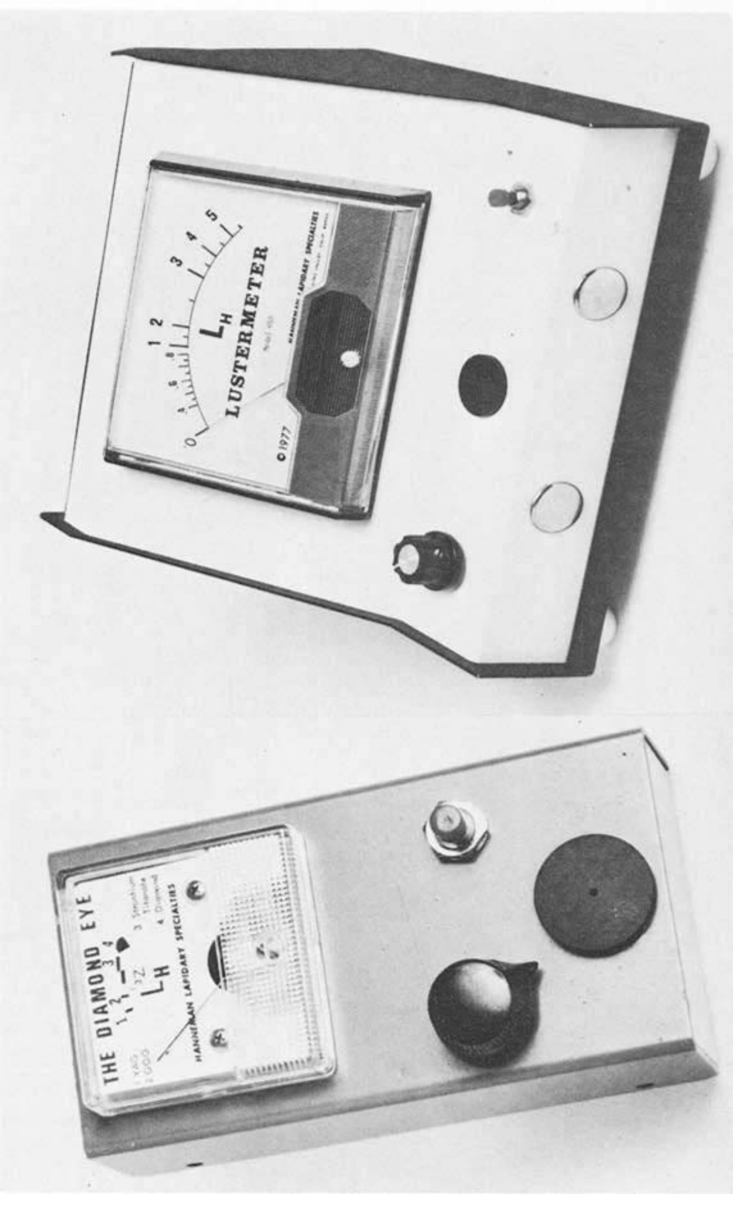

The 'Diamond Eye' and 'Lustermeter' reflectivity meters.
Controls: left—calibration knob, centre—sample platform, right—on/off switch.

1 to 4 and Table I shows the refractive indices, luster values (L_H), hardness, dispersions and specific gravities for diamond and some simulants. The value for cubic zirconia is shown as ^3Z on the meter scale.

TABLE I

	Luster value (L_H)	H	RI	SG	Dispersion
YAG	1	8—8½	1.83	4.65	0.028
GGG	2	6½—7	2.03	7.05	0.038
Strontium titanate	3	5	2.41	5.15	0.190
Diamond	4	10	2.42	3.52	0.044
Cubic zirconia	2.7	7½—8½	2.16	near 6	*c.* 0.060
Synthetic Rutile	4.5—5.5	6—6½	2.8	4.26	0.28

In the use of all reflectivity meters there are several cardinal points which it is essential to observe for meaningful results to be obtained. (1) The instrument must be carefully zeroed using one of the standard stones—diamonds are probably preferable and more generally available. (2) The stones under test must be well polished and clean—scratched or greasy stones will *not* give true readings. (3) Several readings must be taken on each stone with very slight movement between each so as to avoid the occasional high reading caused by internal reflections from within the stone. (4) The stone must be covered by the light-excluding cap provided so as to avoid extraneous light entering the stone from outside. The 'Diamond Eye' under test was demonstrated to gemmology students and was tested by several co-workers using the standard gems (marked 1 to 4 on the scale) and in all cases gave positive and reproducible readings. It was later tested in the laboratory under more controlled conditions and this testing is described below.

The instrument was first zeroed on mark 4 using a 0.25 carat diamond brilliant (4 mm diameter). A series of six yttrium aluminium garnets (YAG) ranging from 1 to 1.5 carats (6.0-6.6 mm) indicated the standard 1 on the scale varying by only the thickness of the pointer on each side of the graduation mark. A brilliant cut (7.9 mm) gadolinium gallium garnet (GGG) gave a reading only very slightly above the standard 2, but a polished 90°, 45°, 45° prism gave correct readings on the smaller polished faces, but a low reading (*c.* 1.5) on the hypotenuse face. A brilliant cut (10.1 mm) strontium titanate gave the standard reading of 3. A series of brilliant cut synthetic rutiles (recognizable at sight with their gaudy fire!) gave readings well off the scale. Lithium niobates, both brilliant (4.9 mm) and step cut (7.1 × 5.3 mm) gave consistent readings near 3. Six brilliant cut cubic zirconias ranging from 0.47 to 1.08 carats (4.15 to 5.6 mm) all gave readings within the ^{3}Z mark on the scale.

A series of twenty cut diamonds was then checked. These stones varied in weight from 0.13 to 0.90 carats, in cut from modern brilliants to old mine cuts and roses, and from colourless through greenish-blue, yellow, orange to brown, grey and black. Two stones gave high readings, and the smallest stone with an even smaller table facet read to mark 3 only; the majority gave standard readings (4). Diamond octahedra with naturally smooth faces gave standard readings. A thin diamond plate (0.56 ct) measuring approximately 8×6 mm and 1 mm thick gave an anomalous reading with the pointer going off the scale. It was not possible to get normal readings from this plate, and it seems likely that reflections from the upper and lower surfaces reinforced each other to give high values. The testing described above took 61 minutes and the meter was tested with the standard 0.25 carat diamond for correct zeroing at approximately 5 minute intervals through the period. It registered correctly throughout, and no drift was observed. The temperature remained constant at 20°C throughout.

Of the stones tested it appeared that brilliant cut stones gave more consistent readings than other cuts and that readings from unusual prisms and plates could be erratic. However, since the average jeweller is unlikely to be testing these unusual shapes this would not seem to be a great disadvantage.

Prior to testing the 'Diamond Eye' the author had examined the earlier and larger 'Lustermeter' reflectivity meter (approximately 18 cm wide, 16 cm deep and 11 cm high) which works on the same principle. This instrument gives values below the L_H1 which is the starting point on the smaller instrument, and is designed to be used for all gemstones—not just those of high refractive index and reflectivity.

Twenty diamonds (brilliant, baguette and marquise cut) were tested on this instrument with reasonably consistent results. Apart from one stone the readings obtained were mostly in the 3.8 to 4.2 range although a few were in the 3.5 to 4.5 range—the instrument was standardized at 4 on a 0.82 carat diamond. One brilliant cut stone (0.27 carat), apparently well polished, gave many readings in the 2.7 to 3.7 range, but eventually some were obtained in the 4.1 to 4.2 range.

A series of other stones including GGG, YAG, strontium titanate, synthetic rutile, lithium niobate, zircon, synthetic scheelite and synthetic spinel was also tested on the 'Lustermeter'. The values obtained were occasionally up to 0.5 on either side of the values quoted by Hanneman (*Lapidary Journal,* June 1977) but were usually much nearer. However, they were very clearly *not* the values to be expected from diamond and the important function of identifying simulants was fulfilled. During the testing of the 'Lustermeter' it proved necessary to re-standardize the instrument twice within the first 40 minutes period but in subsequent 15 to 50 minute sessions this was not necessary.

In summary both instruments fulfilled their essential function from the jewellers' and gemmologists' point of view—they enabled the user to distinguish rapidly between diamonds and simulants. The 'Diamond Eye' with the restricted scale gave more constant results and more closely matched the quoted L_H values. It is a much smaller instrument, is readily portable, and would appear to be perfectly adequate for the main need of the jeweller—the detection of diamond simulants.

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CUBIC STABILIZED ZIRCONIAS

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ABSTRACT

This article contains a short survey on the stability of zirconias and their growth as stable cubic single crystals, followed by physical and crystallographic data on transparent rough and brilliant-cut material. The chemical composition of yttria-stabilized zirconias is verified by means of rarely used formulas. The results of Vickers and Mohs hardness tests on $(Zr,Y)O_{2-x}$ are compared to the wearing characteristics of other synthetic crystals and diamond, cited in literature. Data of gemmological import are summarized in Table 1 and in Section 5 (Conclusion) which also gives instructions on the positive identification of this efficient new diamond imitation mounted in jewellery.

For the past two decades, the standards for imitating genuine diamonds have been set: their production was successfully achieved by several laboratories. This does not mean that all the other recently grown crystals are essentially less effective 'duplicates'. In general, it can be said that substances with chemical properties similar to those of the diamond (BN, B_4C, SiC, etc.) and many oxides could be very good diamond imitations (e.g. those of the pyrochlore $M^{II}_2M^{V}_2O_7$ and perovskite type $M^{II}M^{IV}O_3$ as well as oxides with garnet structure $M^{III}_3M^{III}_5O_{12}$).

1. PROPERTIES OF ZIRCONIA PHASES

In gemmology, cubic stabilized zirconias are new (chemically zirconium dioxides, in ceramics abbreviated as CSZ). Polycrystalline ZrO_2 phases already were known before 1940, single crystals for about ten years. Zirconias have very high melting points and particular ceramic, electrooptical and metallurgical properties (very small expansion coefficients and thermal conductivity). On the other hand, their technical use is limited because of the instability of the non-monoclinic phases. In the chemically pure cubic form, the substance ZrO_2 is stable only at high temperatures. Without the addition of other oxides, it changes into the tetragonal modification below approx. 2300°C and into the monoclinic polymorph below approx. 1100°C, accompanied by considerable decrease in volume. The pure, synthetic material, therefore, exists at room temperature in the same phase as the mineral Baddeleyite, which is

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merely stable monoclinic ZrO_2. A possible explanation for the existence of cubic zirconia in certain metamict zircons, along with variable proportions of cryptocrystalline SiO_2 and monoclinic ZrO_2 (baddeleyite), is the presence of small amounts of impurities (ref. 1, 2).

Improvements in the structural stability are obtained by additions of about 15 mol.% metallic oxide (p, MO_y), usually in the form of CaO, MgO, Y_2O_3, or Yb_2O_3. These stabilized $(Zr,M)O_{2-x}$ mixed-crystals remain cubic and single-phased. They display a face-centred crystal structure with 4 formula units in the elementary cell, closely related to the fluorite structure, but with oxygen vacancies in the lattice. The oxygen deficiency, $x = p(2-y)$, e.g. amounts to 0.15 O for the divalent metals and decreases to 0.075 O for the trivalent metals. The vacancies are responsible for the efficient electrical conductivity at higher temperatures. The metal ions Mn^{2+}, Sc^{3+}, La^{3+}, Ce^{3+}, Sm^{3+}; Ti^{4+}, Nb^{5+} and Ta^{5+} offer further possibilities of partial Zr^{4+} substitution on the lattice sites of ZrO_2. It is important that the radius of the metal ion be similar to that of Zr^{4+} and that the divalent or trivalent cation be less electronegative than Zr^{4+}, thus possessing a more ionic bonding. Foreign radicals such as OH^- or SO_4^{2-} ions also are conducive to the stabilization of the lattice. Adding two metallic oxides of different valences to the cubic high-temperature modification of zirconia, instead of only one, has the same effect. Thus, through the admixture of titanium-, niobium-, or tantalum-oxide, ternary mixed-crystals develop from binary compounds. They are also stable from room temperature to more than 2000°C because these metals uniformly fix the eight-, seven- and six-fold oxygen-coordination of Zr^{4+} to a coordination number of 8. Some of the aforementioned cubic zirconias, e.g. $(Zr,Mg)O_{2-x}$, become metastable at annealing temperatures as a result of the significant oxygen deficiency which apparently initiates a slow movement of oxygen ions from a disordered, random distribution inside the anion lattice to the ordered lattice sites. Monoclinic ZrO_2 exsolves. At lower temperatures, the non-stoichiometric, that is the non-integer, composition of the mixed-crystals causes a physical hardening, probably the result of oxygen immobilization (ref. 3, 4, 5, 6).

2. THE GROWTH OF STABILIZED ZrO_2 CRYSTALS

Zirconia crystal growth by the known techniques is not successful. Thus, taking advantage of the difference in electrical conductivity of ZrO_2 (insulator at room temperature and conductor at high temperatures) by applying the high frequency of an induction coil, the powder can be melted in an open cylindrical crucible. Addition of lower-melting zirconium metal grains and stabilizer powder initiates the process. Simultaneously, a thin layer of the zirconia powder is kept below the melting point at its contact with the wall of the cold crucible, so named because of the palisade of thin water-cooled vertical copper tubes. Upon slowly lowering the temperature, skull or geode shapes crystallize which consist of closely packed, columnar single-crystals measuring 25 × 15 × 10 mm or more. This process, therefore, is called the skull melting method and has just been presented in detail by Nassau (ref. 7). In his article, he states that the properties of the synthetic material now reaching the market vary with chemical composition and are yet to be investigated.

3. THE PHYSICAL PROPERTIES OF STABILIZED ZrO_2

Durafourg & Co., cutters in Lausanne (Switzerland), kindly placed at our disposal rough and brilliant-cut material of yttria-doped zirconia for examination purposes. As expected, it displays small but definite differences from the already characterized zirconia, stabilized with CaO (ref. 8, 9).

3(a) Inclusions

The fragment of a columnar crystal, almost 70 ct in weight, consists of a white crust on the base and subconchoidal lateral faces. According to the direction of the breaks, conchoidal faces result, having either a concentric cascade or a radial feather structure. These are accompanied by razor-like edges that will splinter to some extent. The inclusions are confined to the crust, which represents the contact zone of the melting oxide powders in the centre of the crucible and the cold, thermally insulating layer of powder at the innermost wall of the crucible. The polycrystalline crust is terminated by irregular pyramidal surfaces from which run tubelike and dumbbell-shaped cavities toward the centre. These internal growth characteristics continue through the 3 to 4 mm thick crust, becoming subparallel rows of isometric negative crystals. All inclusions are colourless and semitransparent. Their interfaces are lined with ZrO_2 powder which had been prevented

TABLE 1

Identification of Cubic Stabilized Zirconias

Properties	(Zr, Y) O_{2-x}		(Zr, Ca) O_{2-x} (ref. 8)
Cut	round brilliant 32/24		brilliant 32/24(?)
Weight	3.86 ct	1.38 ct	—
Proportions			
Table	58%	60%	
Crown	15½%	14%	
Girdle	6%	6%	
Pavilion	45½%	47%	
Symmetry	good	good	
Polish	medium	insufficient	
Colour	weak yellowish	very weak pink (almost colourless)	colourless; according to pigmentation also various hues and degrees of saturation
Refractive Index n_D	2.1712 (±0.0005)	2.1651 (±0.0005)	2.1775 (±0.005)
Dispersion n_F—n_C	0.0338	0.0336	(0.0376)
n_G—n_B	0.0591	0.0587	0.0653
Reflectivity $R_{meas.}$	13.0% (polish)	12.3% (polish)	—
$R_{calc.}$	13.6%	13.5%	13.7%
Fluorescence			
UV-A	none	vw, reddish	none
UV-C	vw, greenish-yellow	w, greenish-yellow	distinct, yellow
Absorption total	below 370 nm	below 340 nm	below 310 resp. 360 nm
in the VIS	no lines or bands		no lines or bands
Inclusions	parallel rows of small, semitransparent, isometric crystal-like cavities extending into hazy stripes of tiny particles	none	in the experimental stage of growth small gas bubbles and individual large ones; in the new cuttable material no inclusions remain
Spec. Gravity (4°C)	5.950 (±0.005)	5.947 (±0.005)	5.65 (5.60 to 5.71)
Cleavage	none	none	—
Vickers Hardness V (500 g test load)	1250 to 1570 kg/mm² (indentation not oriented)		1407 and 1437 kg/mm² (oriented?)
Mohs Hardness			
$M_{det.}$	approximately 8¼		8½
$M_{calc.}$	approximately 8.2 (8.0 to 8.5)		(8.2 and 8.3)
Brittleness	more brittle than synthetic corundum but less than $Y_3Al_5O_{12}$		analogous
External characteristics	roundish facet edges, percussion marks, small chips		analogous
Magnetism	indifferent (diamagnetic?)		
Conductivity	electrical insulator (room temp.)		

from melting by the insulating action of a liquid or air trapped in the crust. These cavities, therefore, are of two phases, i.e. of the sl- or sg-type (solid, liquid, gaseous, ref. 6).

At the experimental stage of crystal growth, the subparallel rows of isometric negative crystals extended beyond the crust in the form of hazy stripes. The yellowish brilliant-cut $(Zr,Y)O_{2-x}$ of 3.86 ct obviously came from the crust area of a crystal grown in that stage. The new refined material is essentially colourless and the inclusions do not extend into the clear columnar part of the crystal. The 70 ct crystal fragment only possesses a faint orange tinge and is completely transparent. But its surface consists of small, finely chiselled faces which form a weak growth striation parallel to the crust. When compared to each other, the aforementioned striations are perpendicular and leave the impression of 'frozen-in' interference patterns produced by standing mechanical waves.

The crystal fragment rather resembles the smaller brilliant-cut $(Zr,Y)O_{2-x}$ in its properties. The specific gravity, 5.966, is actually slightly higher and the fluorescence is somewhat stronger: UV-A weak, orange; UV-C medium, yellow. The scratch hardness is about 8¼. Material from the crust area manifests specific gravities as low as 5.80.

3(b) Scratch Hardness and Indentation Resistances

The investigation on the resistance to mechanical impact is more important when characterizing new synthetics than during subsequent gemmological identification, which in every normal case must be effected with non-destructive techniques. Which hardness test should be relevant is difficult to determine. The Mohs scratch-hardness values, a purely qualitative sequence of numerals, give a picture of the scratching rather than the cutting strength and general stability. A better measure for the velocity of wear of solids is the resistance to penetration, as determined by the Vickers and Knoop tests, both permitting an estimation of the barely measurable brittleness. Other tests deal with cutting or impact resistance qualities. As is to be expected from the atomic bonding, specific for each substance, these properties have a certain relationship to each other. The relationship of Mohs hardness (M) to any indentation hardness (IH) can be expressed by the following empirical, non-linear formula:

$$\log(IH) = 0.2M + 1.5\ .$$

With the Vickers test, a square impression is formed by a diamond pyramid with 136° interfacial angle, under a given test load (P) and during a penetration period of normally 30 seconds.

The average diagonal length (d) of the square is then measured and used to calculate the Vickers hardness as follows:

$$V = \frac{1.8543\ P}{d^2}\left[\mathrm{kg/mm^2}\right].$$

In general, the size of the indentation depends on the test load, the shape of the indentor (sphere, cone; rhomboidal, square or pentagonal pyramid), its crystallographic orientation relative to that of the specimen and the test temperature. Experimentation has proved the Brookes method of indenting hard solids to be the best. Its pentagonal diamond pyramid has a longer life expectancy than other indentors and diminishes the distorting influence of hardness anisotropy on the shape of the impression (ref. 10, 11).

The Vickers hardness of $(Zr,Y)O_{2-x}$, as measured under the Leitz-Microhardness instrument, lies between 1250 and 1570 kg/mm². Applied to the first formula, these values place the Mohs hardness at 8 to 8.5 which coincides with the actual scratch result of 8¼. Interestingly, tests with a 1 kg load on a universal indentation apparatus (industrial model OM 250 of Gnehm & Co. in Horgen, Switzerland) resulted in Vickers hardness figures in the same range. The average of 1400 kg/mm² is slightly lower than the specifications for $(Zr,Ca)O_{2-x}$, but this may not be a real difference since the indentations were not oriented (Table 1). Under the same conditions, resistances to penetration were found to be about 1570 kg/mm² for $Y_3Al_5O_{12}$ and 2290 kg/mm² for synthetic ruby. These orders of magnitude correspond to the data in the literature (1550 kg/mm² for YAG, and 2200 kg/mm² for sapphire). Calculated Mohs hardness values are approximately 8.5 and 9.3. So, the new zirconias are not harder than their predecessor, YAG, but less brittle, for they show less tendency to splinter at the edges of the impression produced by the diamond. The synthetic ruby is tougher and considerably harder, though maybe not quite as hard as suggested by the calculation ($M \approx 9.3$). However, for $M > 9$ the given relation with V is not quite certain.

The hardness anisotropy of stabilized zirconia samples is possibly a bit higher than indicated, yet in no way extreme. For diamond, hardness differences strongly depend on cleavage directions. Indentation resistances are known to range from 5700 to 10 400 kg/mm², with averages near 9000 to 10 000 kg/mm². These values illustrate the demands placed on a convincing diamond imitation. With a hardness near 4500 or 4750 kg/mm^2, cubic boron nitride (BN), among all known substances, comes closest to the diamond in this respect. The great hardness of both materials originates from the same type of strongly covalent, oriented bonding. It differs only in the atomic spacing which measures 1.57Å in boron nitride and 1.545Å in diamond and in the absence of any ionic bonding character of the diamond (ref. 12).

3(c) Absorption

The spectral diagram (see Figure 1) reflects the typical course of different nearly colourless synthetic materials and diamond. The relationship among the curves is not real. In each case, however, they display good transparency of the solids in the visible range (VIS) and gradual to steep decrease of transmission (increase of absorption) toward the ultraviolet region. The absence of absorption lines and bands in the VIS causes the weak body colours. The absorption edges of strontium titanate and synthetic rutile have virtually no influence on colour. The human eye is quite insensitive to the violet wavelengths and would not detect their absence. Gadolinium gallium oxide (GGG) demonstrates interesting absorption lines in the UV and emission lines in the VIS, under the stimulation of short-wave UV radiation (medium strong 595 nm and weak 614 nm, not recorded here).

4. THE STRUCTURE AND COMPOSITION OF $(Zr,Y)O_{2-x}$

The microprobe analysis showed Zr and Y as metal constituents. Semiquantitatively, proportions of ≈15.8 mol% $YO_{3/2}$ for the crystal fragment and of ≈18.3 mol% $YO_{3/2}$ for the round $(Zr,Y)O_{2-x}$-rough were detected. Ca, Mg, and Ti are not present in these samples. Because of line interferences (even from higher electron orbits), rare earth elements could be ascertained only with considerably refined mathematical corrections. It is very likely that trace elements, e.g. Nd, Ce, Er, cause the very weak pink colour of the small brilliant-cut $(Zr,Y)O_{2-x}$. Hafnium, in the form of hafnia, with its chemical affinity to zirconium, is a permanent companion of zircons ($ZrSiO_4$), suppliers of the raw materials. Separation of the two oxides, HfO_2 and ZrO_2, is both difficult and costly. It is only done for special purposes and for the extraction of hafnia which does not form independent minerals. A HfO_2 content

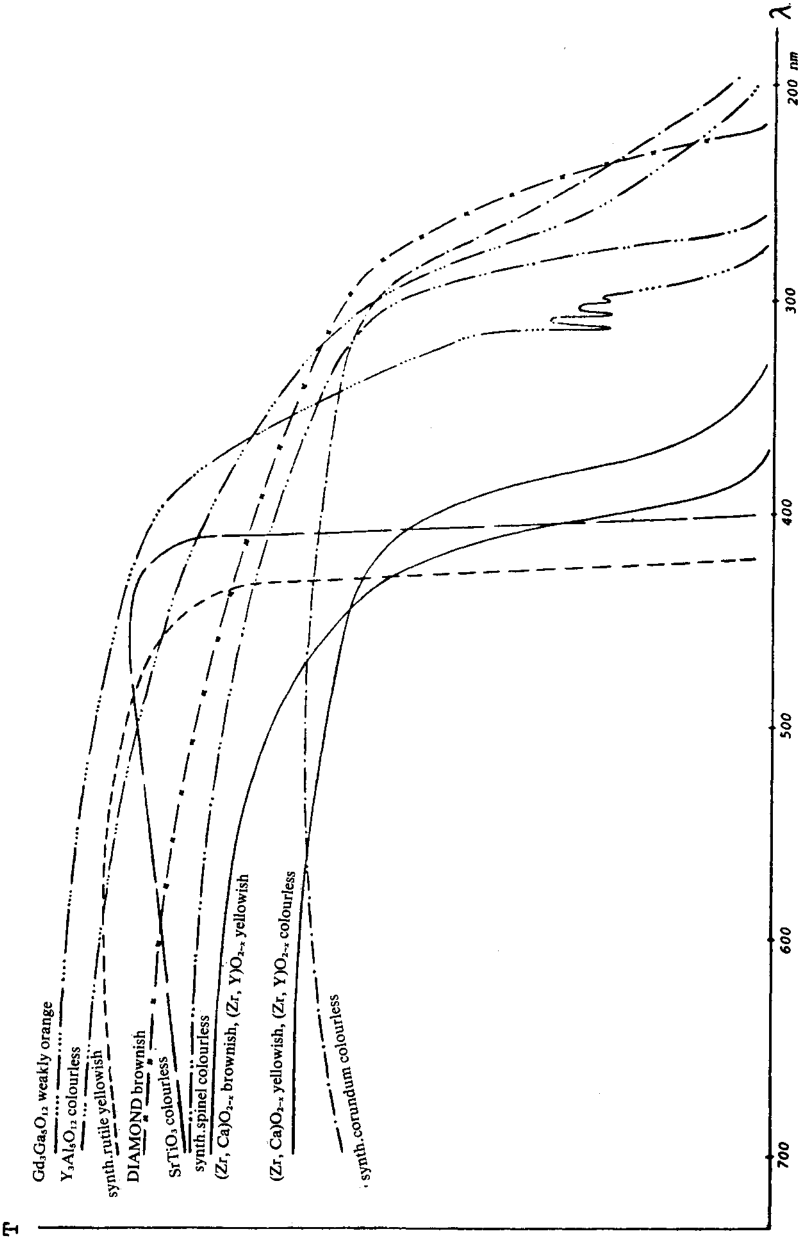

Fig. 1 Schematic presentation of the spectial transmission behaviour of diamond and its most important imitations at ambient temperatures.

in the magnitude of 0.5 to 1 mol% cannot be ruled out although in the present synthetic crystals no significant quantities were discovered.

4(a) Crystal Structure

The specification of crystallographic data is also required for the characterization of a new solid. Together with optical values, it allows verification of the chemical composition which, in the present cases, cannot be considered completely reliable. From the x-ray diffraction pattern of powdered $(Zr,Y)O_{2-x}$, a close relationship to cubic ZrO_2 of the crystal-class O_h can be deduced. This is especially so with respect to the stabilized binary phase $(Zr_{0.85}Ca_{0.15})O_{1.85}$ (ref. 13). An evacuated, self-focusing x-ray camera of the Guinier-de Wolff type was used.

The lattice constant (a_o) can also be established. From this, the specific gravity is calculated for the cubic case and in the

TABLE 2

Interplanar Spacings d_{hkl} of Stabilized Zirconias

$(Zr_{0.84}Y_{0.16})\ O_{1.92}$ $\lambda(CuK\alpha/Ni) = 1.5418$ Å silicon standard			$(Zr_{0.85}Ca_{0.15})\ O_{1.85}$ $\lambda(CuK\alpha_1/Ni) = 1.54056$ Å ASTM card 26-341		
d [Å]	hkl	$I_{estim.}$	d [Å]	hkl	I/I_1
2.97_5	111	100	2.961	111	100
2.58	200	15	2.565	200	20
1.820	220	50	1.815	220	45
1.552	311	40	1.548	311	25
1.484	222	5	1.4823	222	4
1.286	400	5	1.2837	400	4
1.180	331	10	1.1781	331	6
1.149	420	5	1.1482	420	4
cubic system space group Fm3m $a_0 = d\sqrt{h^2+k^2+l^2}$			1.0484	422	5
			0.9884	511 333	4
			0.9080	440	1
$a_0 \cong 5.145$ Å (weighted)			$a_0 = 5.135$ Å (weighted)		

CGS-system (cm,g,sec) according to the formula:

$$SG = \frac{z\,M}{N\,V} = 1.6602\,\frac{z\,M}{(a_o)^3},$$

where z represents the number of formula units in the elementary cell (= 4 molecules). V is the unit cell volume and M the molecular weight of the mixed-crystal. N represents the Avogadro number of molecules per mole (= 6.023×10^{23} mole^{-1}; ref. 14).

4(b) Verification of the Chemical Composition

The specific gravity gives a clue to the chemical composition and to impurities such as inclusions and other perturbations of the real crystal. The specific gravity (5.966±0.003) as well as the lattice constant (5.145±0.005Å) of the crystal fragment are known. So the equation can be resolved for the molecular weight. It follows that M = 122.35. This coincides with the molecular weight of 122.4 from the analysis, if a trace of hafnium oxide is taken into account. On the basis of 4 (Zr + Y), the approximate non-stoichiometric, that is the non-integer, structural formula can be given as $(Zr_{3.37}Y_{0.63})O_{7.68}$. The formula for the round rough approximately is $(Zr_{3.27}Y_{0.73})O_{7.63}$. Alternatively, these formulas can be expressed as $(Zr,Y)O_{1.92}$ and $(Zr,Y)O_{1.91}$ or, in dualistic writing, $3.37\ ZrO_2 .\ 0.63\ Y_2O_3$ and $3.27\ ZrO_2 .\ 0.73\ Y_2O_3$ (ref. 15).

Gladstone and Dale's rule offers another means of verification. The specific refractivity (or specific refractive power, K) of a material is related to its specific gravity (SG) and refractive index (n) through the following equation:

$$K = \frac{n-1}{SG}$$

The specific refractivity can be cross-checked with the partial refractive powers (k) and weight proportions (q) of the constituent oxides by the formula:

$$K = k_1q_1 + k_2q_2 \ldots\ldots k_nq_n$$

For most minerals, the two results of K differ by less than 5% (ref. 16).

The results lie within the expected limits, especially if a small amount of HfO_2 would be taken into consideration. Calculations with lattice constants from precise x-ray data lead to reliable values for the specific gravity (and molecular weight). This second, physical method is only appropriate for verifying the overall

TABLE 3

Verification of the Chemical Compositions

Specimen	$K = \frac{n-1}{SG}$	$K = k_1q_1 + k_2q_2$
$(Zr, Y)_4O_{7.68}$	0.197	0.193
$(Zr, Y)_4O_{7.63}$	0.196	0.191
$(Zr, Ca)_4O_{7.44}$	0.209	0.203
$k(ZrO_2) = 0.201$, $k(Y_2O_3) = 0.144$, $k(CaO) = 0.225$, $k(HfO_2) = 0.3$		

chemistry because of the relatively uncertain partial refractive power values. A systematic inadequacy of the formula cannot be excluded since it was developed for liquids and gases.

Nevertheless, when the weight proportions of a compound are varied or constituents substituted, the qualitative behaviour of its refractive index and specific gravity can be predicted by means of the two equations for K. Thus, $(Zr,Ca)_4O_{7.44}$ should show a similar refractive index, but a distinctly lower specific gravity than the two $(Zr,Y)_4O_{8-4x}$. Table 1 confirms this. The partial refractive power of the CaO stabilizer is higher and the molecular weight lower than that of the yttria additive, with lattice constants of the binary zirconias being almost identical (5.07 to 5.15 Å). For cubic stabilized hafnia, theoretically being cuttable material, essentially higher refractive index and specific gravity values must be expected than for each stabilized zirconia, since its lattice constant also is near 5.2 Å (ref. 9, 3).

5. CONCLUSION

The stabilized zirconias are the latest products in the jewellery trade. For the time being, they may be considered as the most convincing of medium expensive, highly refractive diamond imitations. The gemmologist has no reason for anxiety if he remains alert and is able to effect a determination of the specific gravity and light refraction, e.g. by the apparent depth method. As many tests have demonstrated, the refractive index (n = measured depth: apparent depth) can be established, by means of a microscope and competent measurement, with an accuracy better than 1% (n for $(Zr,\bar{Y})O_{2-x}$ = 2.17±0.02 to 2.16±0.02). This technique has the advantage of being independent from the quality of the surface (polish and flatness) and of being more precise than the approximation of n based on the principle of reflection, e.g. with a Gemeter or micro-spectrophotometer (R in Table 1).

Usually, not the real but the diamond weight corresponding to the size of the mounted synthetic stone is stated, and this creates additional confusion. It therefore is not possible to determine or estimate the specific gravity of the fake diamond. For positive identification, a value in addition to the refractive index figure would be useful in this case. Here dispersion becomes important. It can be approximated by the microscopic technique mentioned above, applying interference filters. Most likely the differentiation between yttria- and calcia-stabilized zirconias would not be possible. However, this has little significance.

The variations of the gemmologically important values, recently published by Nassau (ref. 7), are: refractive index $n_D = 2.15$ to 2.18, dispersion $n_G - n_B = 0.060$ to 0.063, Mohs hardness $M = 7\frac{1}{2}$ to $8\frac{1}{2}$ and specific gravity about 6. For jewellery material they have to be slightly altered. The variation of n remains the same. The dispersion range must be extended to $\leqslant 0.059$ for $(Zr,Y)O_{2-x}$ and to $\geqslant 0.065$ for $(Zr,Ca)O_{2-x}$. Mohs hardness has not been found inferior to $M = 8$. The specific gravity enables the unequivocal separation of $(Zr,Y)O_{2-x}$ and $(Zr,Ca)O_{2-x}$. Their ranges are 5.94 to 5.97, and 5.60 to 5.71 respectively (values for CaO-stabilized zirconia by Gübelin, ref. 8). Stabilized zirconias may be coloured by pigmentation. Almost colourless specimens transmit the visible radiation freely, but absorb totally below about 340 nm. Inclusions are absent in the newest products. At room temperature, zirconias are structurally stable, physically resistant and chemically inert.

It is conceivable that zirconias will appear containing stabilizers other than yttria or calcia. The indicated variations, therefore, may again increase in future.

To verify Mohs hardness values and the chemical composition of solids, rarely used mathematical formulas have been presented. The rule of Gladstone and Dale should be pointed out. It permits a qualitative prediction of the refractive index and specific gravity of materials with identical crystal structure and variable composition. The x-ray data of Table 2 demonstrate that the interplanar spacings and lattice constants, on the other hand, are fairly insensitive to chemical variations.

Reflection patterns of the two brilliant-cut $(Zr,Y)O_{2-x}$ with mediocre polish, recorded by means of a Gemprint instrument, did not differ greatly from those of the predecessors $Y_3Al_5O_{12}$, synthetic spinel, synthetic rutile, and $SrTiO_3$. The patterns display a limited number of large multipartite black spots on the film negative. They cannot be confused with the configurations of numerous small but intense reflections produced by diamonds and zircons. However, an approximate matching would be possible by improving the polish and reducing the pavilion angle and girdle thickness of the latest diamond imitations.

ACKNOWLEDGEMENTS

The author takes this opportunity to express sincere thanks to the following persons who have contributed to the project as follows: Durafourg & Co., cutters in Lausanne, for the loan of specimens; B. Suhner in Herisau, for the determination of refractive indices and dispersion values with goniometric precision and for running transmission spectra on our synthetic stones; R. Gubser for the microprobe analysis; C. Solenthaler for the microhardness tests; and Prof. Dr G. Bayer for his valuable recension of the ceramic and crystal growth sections; the three last mentioned being members of the Swiss Federal Institute of Technology in Zurich.

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BRIEF NOTES ON SOME NEW SYNTHETICS

By M. J. O'DONOGHUE, M.A., F.G.S., F.G.A.

Two amethysts, both cut and of large size and good colour, have been examined recently. They were obtained through the good offices of Dr L. Baumgartner, of the firm of Swarovski in Austria, one stone being in the author's collection and the other belonging to the Worshipful Company of Goldsmiths. I am informed by Dr Baumgartner that the stones are manufactured in the U.S.S.R. and other reports have been made which seem to indicate that similar stones are reaching the American market.(1) Neither stone showed any noticeable inclusions under 10× magnification or under the microscope (about 40×). Though the stone is presumably manufactured by the hydrothermal process with the use of a seed, there is no sign of the usual discontinuity in the region where seed and overgrowth meet (the area in which 'heat-shimmer' or 'breadcrumbs' are frequently seen). Refractive index and specific gravity are typical for quartz; there is no trace of luminescence nor any absorption in the visible spectrum. Neither stone transmitted short-wave ultraviolet light. One feature only strikes the observer: the colour, although dark and quite pleasing, contains a degree of mauve-brown which can be seen in the stones under discussion when tilted slightly away from the light source; this is not shown with the dichroscope and, although quite easy to see, would not be noticed by the layman, although the experienced dealer or gemmologist might be put on his guard. Generally speaking, there is no way to identify synthetic quartz if cut from a region well away from the seed; fortunately there seems to be little chance of this material making a commercial success. Recent studies seem to show that some synthetic quartz is opaque, or at least far less transparent, to short-wave ultraviolet radiation. More tests on a wider range of synthetic material need to be carried out before this can be said to be useful—green synthetic material, for example, appears to behave in this respect very much the same as natural quartz*.

Two white opals made by the firm of Pierre Gilson have recently been examined. Although magnification reveals the customary hexagonal 'honeycomb' structure, the stones are translucent to a much greater degree than some of the earlier

*See J. Gemm., 1978, XVI, 3, 218-220.—Ed.

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products from this firm, and could be confused with water opal at first sight. No luminescence or phosphorescence was observed.

I have recently received from the manufacturer (Djévahirdjan) two specimens of coloured zirconia. The manufacturer states that they will not at present market coloured material but concentrate on perfecting the colourless crystals which have potential as diamond simulants. One of the coloured pieces (both are crystal sections) is violet and resembles the scapolite from East Africa as far as colour goes; the presence of a heavy didymium absorption spectrum at once reveals its true nature, or at least its artificial genesis. In the stone examined the doping had been so heavy that the two groups of fine lines had each coalesced into a band-like structure. The other piece, brownish-pink in colour, showed no absorption in the visible region and the colour may be due to Ti or Ni.

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GEMMOLOGICAL COLORIMETRY

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ABSTRACT

The necessity and advantages of a system of colorimetry for gemmological use are first propounded. Various scientific methods of specifying colours are then described. Transparent cabochons are chosen as examples for the application of these methods.

§1 INTRODUCTION

The value of a gem is dependent on factors such as its weight, perfection, cutting and colour. Among its various attributes only the weight can be easily measured and unambiguously quoted. So far there has not been any objective means of specifying a colour. A gem dealer in London cannot describe accurately the colour of a gem to his client in New York without actually sending the stone. Yet the price of a ruby or sapphire can change by several hundred per cent as a result of a slight variation in colour.

Whether the colour of a gem is natural or artificially induced, it is liable to fade or change over a period of years. Chemical and physical transformations take place slowly as a result of heat, moisture, radiation or simply aging. (Findlay 1977, O'Donoghue 1974, Hutton 1974). Lacking any objective quantitative measurement of colours it is impossible to detect slight colour changes that take place very gradually. Hence posterity several centuries from now will not be able to visualize the colour of a crown jewel as it appears today.

The above considerations indicate clearly a real need for a scientific method of measuring and defining colours in gemstones. In other words, we should develop a new branch of science called gemmological colorimetry.

As far as their colour-rendering properties are concerned, gems may be classified into the following three categories:

(1) Transparent cabochons; e.g. ruby and sapphire cabochons.

(2) Opaque, translucent or iridescent cabochons; e.g. turquoise, jade and opal cabochons.

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(3) Transparent faceted stones; e.g. diamond and emerald in round brilliant or emerald cuts.

In the second category several shades of colours are usually present on one cabochon surface, so that it is necessary to describe the distribution pattern as well as the varieties of colours. In the third category the faceted stones disperse the incident white light into all the colours of a rainbow, giving 'fire' to the stone. As a first step in the development of gemmological colorimetry we shall deal with the first category exclusively in the present discussion.

§2 SPECIFICATION OF COLOURS

§*2.1* *Hue, Saturation and Lightness*

Any colour is completely described by its hue, saturation and lightness. Hue is the attribute of visual sensation according to which the observer distinguishes light of different spectral compositions. A hue is denoted as red, yellow, green and so on, depending on the wavelength of the light. An achromatic colour is one not possessing a hue. It can be roughly described as 'white' in layman's language.

The saturation of a colour is the degree of its difference from the achromatic colour most resembling it. Saturation can be pictured as the 'strength' of a hue. For example, two drops of red ink dispersed in water would give a colour of higher saturation than one drop of red ink dispersed in the same amount of water. The lightness of a colour is the attribute of visual sensation ranging from black to white for achromatic light diffusing objects, and from black to perfectly 'colourless' for achromatic transparent objects.

The visual perception of the lightness of a colour is a subjective experience depending on the observer as well as on the incident light. The capacity of light to evoke lightness sensation is called the luminous flux. Equal amounts of radiant energy of different wavelengths do not produce visual sensations having equal lightness. A luminous efficiency curve shows as ordinates the capacities (reciprocals of the required amounts of energy) of light of various wavelengths to evoke sensations of equal lightness. The luminous efficiency curve of the standard observer for photopic vision as adopted by the International Commission on Illumination (Commission Internationale de l'Eclairage, abbreviated CIE) is shown in Figure 2.1 (CIE Proc. 1924). It is assumed to be valid for

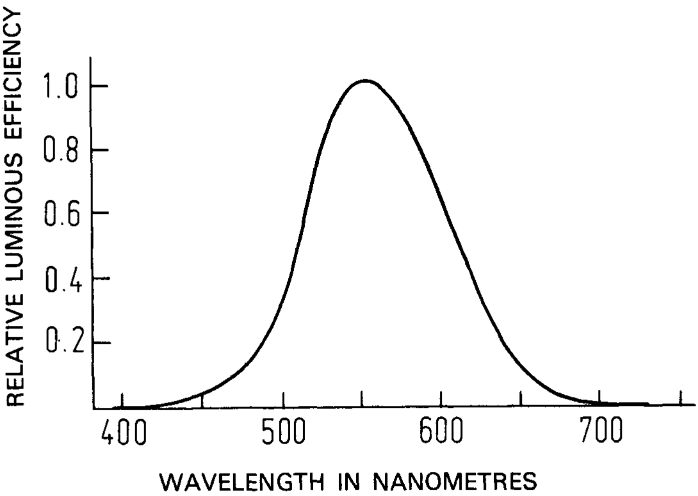

Fig. 2.1 Luminous efficiency function for photopic vision.

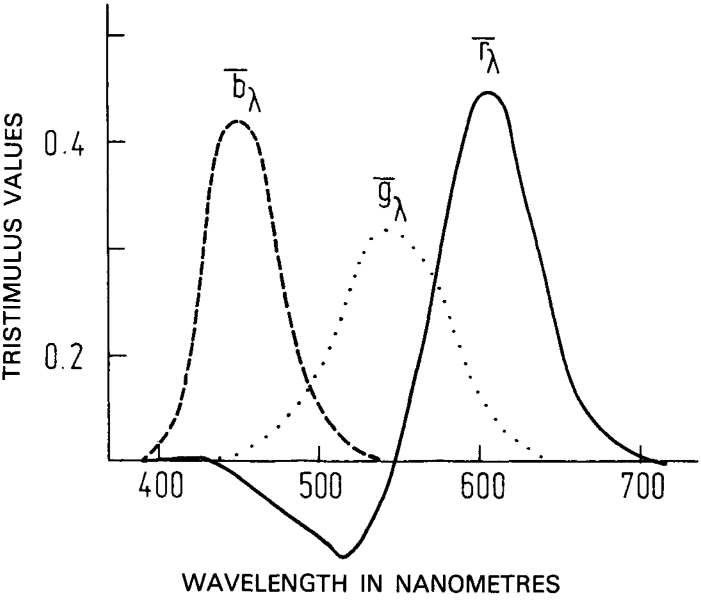

Fig. 2.2 Colour-matching functions in ***R, G, B*** system.

about 95% of the total population, i.e. for people having normal colour vision.

§2.2 *Trichromatic Colour-matching*

Any colour can be precisely specified by the method of 3-colour matching. The colour to be specified (hereafter called the sample colour) is visually compared with a mixture of three primary colours, usually red, green and blue. The amounts of the three primary colours are adjusted so that the resultant mixture appears to have identical colour with the sample. Suppose $\boldsymbol{S}_1$ is a vector representing the sample colour and $\boldsymbol{R}$, $\boldsymbol{G}$, $\boldsymbol{B}$ are vectors representing unit amounts of the three primary colours, then the vector equation

$$\boldsymbol{S}_1 = \mathrm{R}_1\boldsymbol{R} + \mathrm{G}_1\boldsymbol{G} + \mathrm{B}_1\boldsymbol{B} \qquad (2.1)$$

indicates that the sample colour $\boldsymbol{S}_1$ is matched by an additive mixture of quantities R_1, G_1, B_1 of the respective primary colours $\boldsymbol{R}$, $\boldsymbol{G}$ and $\boldsymbol{B}$. The scalar quantities R_1, G_1 and B_1 are called the tristimulus values of the sample colour $\boldsymbol{S}_1$ with respect to the chosen set of primary colours $\boldsymbol{R}$, $\boldsymbol{G}$ and $\boldsymbol{B}$.

There are some colours which cannot be matched by a direct mixture of $\boldsymbol{R}$, $\boldsymbol{G}$ and $\boldsymbol{B}$ as indicated by Eq. (2.1). Such a colour has to be mixed first with a suitable amount of one of the primary colours before it can be matched with a mixture of the remaining two primary colours. Eq. (2.2) shows the matching equation for such a colour $\boldsymbol{S}_2$:

$$\boldsymbol{S}_2 + \mathrm{r}_2\boldsymbol{R} = \mathrm{g}_2\boldsymbol{G} + \mathrm{b}_2\boldsymbol{B} \qquad (2.2a)$$

$$\boldsymbol{S}_2 = -\mathrm{r}_2\boldsymbol{R} + \mathrm{g}_2\boldsymbol{G} + \mathrm{b}_2\boldsymbol{B} \qquad (2.2b)$$

Note that Eq. (2.2b) has the same form as Eq. (2.1) if we allow negative values of tristimulus values. Thus all colours can be specified by their tristimulus values.

Suppose the three primary colours are chosen to be monochromatic light of wavelength 700 nm *(R)*, 564.1nm *(G)* and 435.8nm *(B)*. If equal amounts of light from narrow regions of the entire visible spectrum are successively employed as the sample colour, the amounts of the $\boldsymbol{R}$ primary colour necessary for the colour match is shown in the solid curve of Figure 2.2. It is known as the colour-matching function $\bar{\mathrm{r}}_\lambda$ in the primary system $\boldsymbol{R}$, $\boldsymbol{G}$, $\boldsymbol{B}$. Similarly the amounts of $\boldsymbol{G}$ & $\boldsymbol{B}$ primary colours required for colour-matching are shown as functions $\bar{\mathrm{g}}_\lambda$ and $\bar{\mathrm{b}}_\lambda$ in Figure 2.2. In

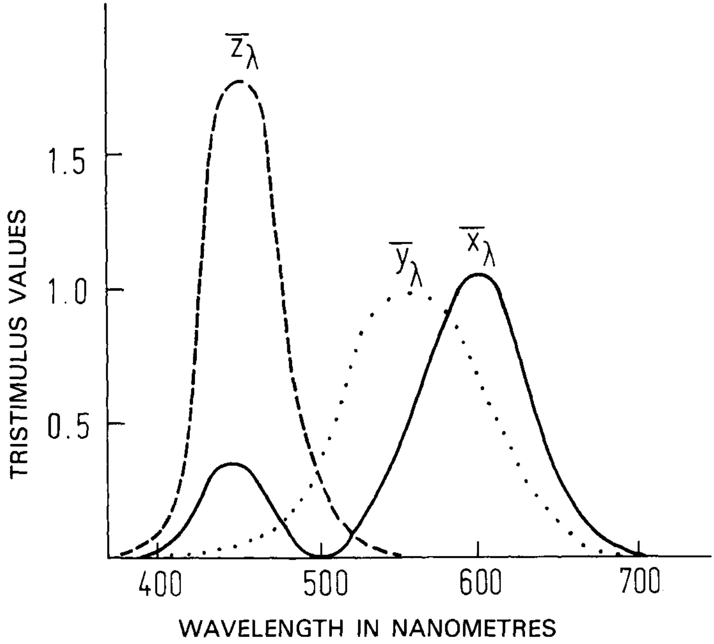

Fig. 2.3 CIE colour-matching functions $\bar{x}_\lambda$, $\bar{y}_\lambda$, $\bar{z}_\lambda$.

the ***R*, *G*, *B*** system defined above the colour-matching function $\bar{r}_\lambda$ has negative values for wavelengths around 500nm. In order to facilitate computation in colorimetric work the International Commission on Illumination adopted the ***X*, *Y*, *Z*** system in which the colour matching functions $\bar{x}_\lambda$, $\bar{y}_\lambda$, $\bar{z}_\lambda$ have no negative values, as shown in Figure 2.3 (CIE Proc. 1931).

Consider a sample colour ***S*** with tristimulus values X, Y, Z in the *X, Y, Z* system. We define its chromaticity coordinates by

$$x = \frac{X}{X+Y+Z}$$

$$y = \frac{Y}{X+Y+Z} \qquad (2.3)$$

$$z = \frac{Z}{X+Y+Z}$$

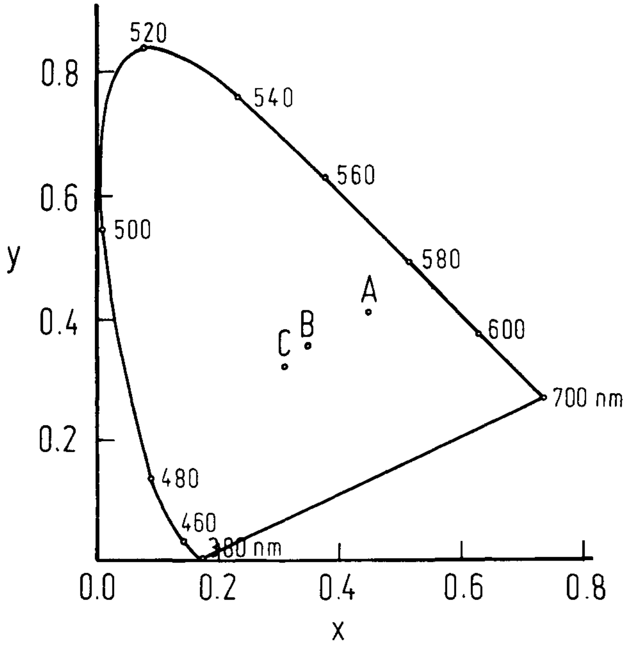

Fig. 2.4 CIE (x, y) chomaticity diagram.

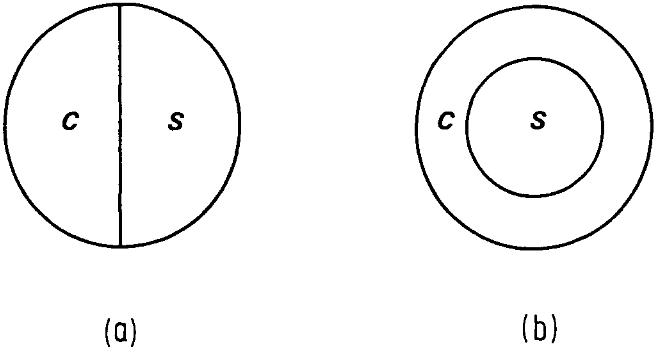

Fig. 2.5 Field of view in visual colorimeters.

Since the sum of x, y and z is always unity, the chromaticity of a colour is completely defined by any two of its three chromaticity coordinates. Two such coordinates fix the position of a point on the chromaticity diagram. The chromaticity coordinates of each spectrum colour are calculated from Eq. (2.3) and plotted on a chromaticity diagram (Figure 2.4). The locus is a smooth continuous curve. The points A, B, C on the diagram correspond to the CIE standard light sources A, B, C to be described in §3.

§2.3 *Colorimeters*

A visual colorimeter is a device by which a sample colour *S* can be matched visually with another adjustable comparison colour *C*. The field of view consists of the sample and comparison colours, as shown in Figure 2.5. The observer adjusts the comparison colour until it matches the sample colour. Various types of visual colorimeters are available (Judd & Wyezecki 1963, Committee on Colorimetry of the Optical Society of America 1963). In Stiles trichromator or Wright colorimeter the comparison colour is formed by a mixture of lights of three primary colours. The tristimulus values of the sample colour with respect to the instrumental primary colours are convertible to the CIE (X, Y, Z) tristimulus values. In this way they provide absolute quantitative specification of colours.

§3 ILLUMINATION AND COLOUR MEASUREMENT

The colour of a transparent cabochon arises from reflection of the incident light by its top and bottom surfaces. The reflected light depends not only upon the nature of the reflecting surfaces but also upon the spectral distribution of the incident light. It is well known that the colour of a gem can vary markedly with the illumination. Alexandrite appears green in daylight but red under a lamp. A yellow diamond that displays intense blue fluorescence will look bluish under strong daylight. Therefore consistent and meaningful data on the colour of gemstones can only be obtained by using standard light sources and adopting standard conditions of illumination and measurement. Natural daylight is obviously unsuitable as a standard light source since it is subject to great fluctuations in both intensity and spectral composition. The International Commission on Illumination recommends the following three standard light sources for colorimetry (CIE 1931, Davis *et al.* 1953):

(1) Source A—an incandescent tungsten lamp operated at a colour temperature of 2854 K (K stands for degree Kelvin—see Nassau 1977).

(2) Source B—the source A combined with a two-cell Davis-Gibson liquid filter B, the composition of which is given in Table 3.1 (Davis & Gibson 1931). Source B is a simulation of direct sunlight at noon. Its correlated colour temperature is about 4870 K.

(3) Source C—Source A combined with a two-cell Davis-Gibson liquid filter C. It is an approximation to the average daylight. The correlated colour temperature is about 6770 K.

Table 3.1

Composition of Davis-Gibson Liquid Filters B & C

	Filter B	Filter C
Cell 1 (1 cm)		
Copper sulphate ($CuSO_4.5H_2O$)	2.452g	3.412g
Mannite ($C_6H_8(OH)_6$)	2.452g	3.412g
Pyridine (C_5H_5N)	30 cm^3	30 cm^3
Distilled water to make	1000 cm^3	1000 cm^3
Cell 2 (1 cm)		
Cobalt ammonium sulphate ($CoSO_4(NH_4)_2SO_4.6H_2O$)	21.71g	30.58g
Copper sulphate ($CuSO_4.5H_2O$)	16.11g	22.52g
Sulphuric acid (density 1.835)	10 cm^3	10 cm^3
Distilled water to make	1000 cm^3	1000 cm^3

Figure 3.1 shows the spectral distributions of these three standard light sources. In the diamond trade the northern-sky light has been the standard light source. Since CIE source C has a spectral distribution very similar to the northern-sky light (Taylor & Kerr 1941), it is ideal as a standard light source for gemmological colorimetry. It will provide stable standard illumination day and night under all weather conditions.

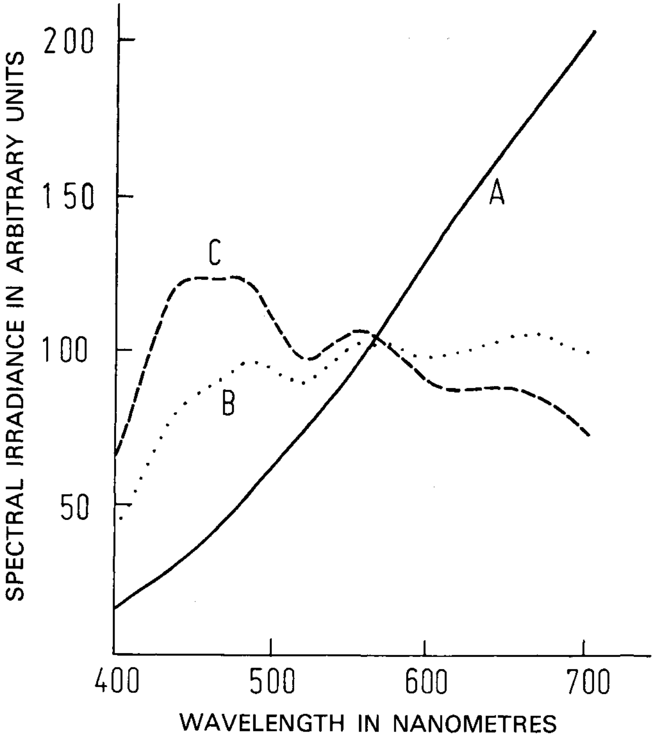

Fig. 3.1 Spectral distributions of standard light sources A, B & C.

The colour of a gem is dependent on its position relative to the light source and the observer. For measurement of the spectral reflectance of surfaces the International Commission on Illumination (CIE Proc. 1931) recommends the (45°, 0°) arrangement in which the reflecting surface is illuminated at 45° and viewed perpendicularly to the surface. This arrangement has already been widely used in jewellery shops. (Figure 3.2). We propose that for gemmological colorimetry the distance of the gem from the observer be fixed at 25 cm, the nearest distance of clear vision for normal eyes.

§4 OTHER COLOUR SYSTEMS

Material standards are often selected to represent scales of hue, saturation and lightness. A sample colour may be specified by

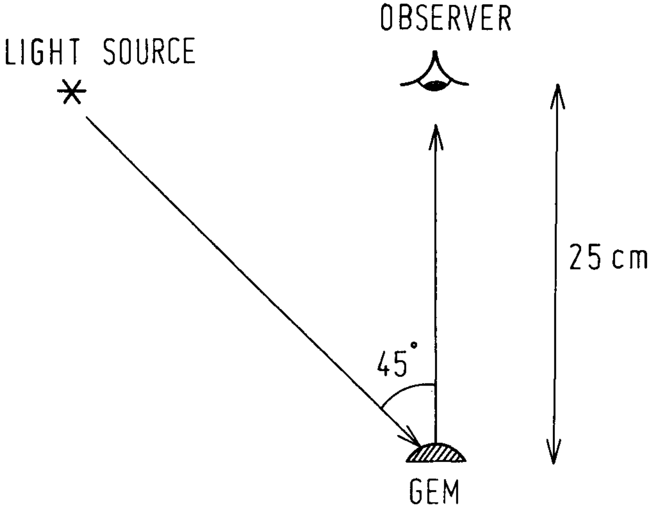

Fig. 3.2 The (45°, 0°) arrangement of illumination and observation.

identifying it with a particular member of such a material colour system. The DIN Colour System (DIN 6164) has been realized in the form of painted rectangular paper chips with a matt finish. The chips are arranged in terms of hue (DIN- Farbton), saturation (DIN- Sättigung), relative lightness (DIN- Dunkelstufe) and specified accordingly. The Munsell Colour System (Davidson *et al.* 1957) is realized in the form of 1225 different colours painted on high-gloss surfaces. The Inter-Society Color Council and the National Bureau of Standards have developed a systematic set of colour names (Kelly & Judd 1955). The ISCC-NBS publication includes equivalent ISCC-NBS designations for 7500 colour names previously published in eleven different colour systems, among which are the Munsell Colour System, the Maerz and Paul Dictionary of Color (Maerz and Paul 1951), the British Colour Council Dictionary of Colour Standards (British Colour Council 1934).

Provided the necessary precautions are taken the colour of a gem can be accurately recorded on a colour slide. If the light source and the magnification of the slide viewer are correctly chosen, an actual-size, true-colour image of the gem can be readily observed. Colour slides of a precious stone can be sent to potential buyers all over the world at the same time. This would effect considerable saving in time as well as in insurance costs. As holographic techniques improve we shall soon be able to record 3-dimensional colour pictures of gems and jewellery in colour holograms.

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GEMMOLOGICAL ABSTRACTS

ALTHAUS (E.). *Fehler in der Struktur.* (Defects in structure.) Lapis, **3**, 4, 12-15, 5 figs (3 in colour), 1978.

Discusses the cause of colour in the varieties of beryl with reference to absorption spectra and irradiation. M.O'D.

ANDERSON (M.). *Brazil—nature's mineral treasure chest.* Lapidary Journal, **31**, 11, 2303-12, 23 figs (10 in colour), 1978.

Describes and illustrates the gem-bearing areas of Brazil with particular reference to Ouro Preto in the state of Minas Gerais. Topaz from this region is depicted in colour and a map of the area is included. M.O'D.

ANDRES-GAYON (J. I.). *Una nueva síntesis.* (A new synthesis.) Boletin del Instituto Gemológico Español, **17**, 37-38, 1978.

Describes a new synthetic emerald with RI 1.547-1.552, DR 0.005. It shows a medium red through the colour filter. Very small sizes made so far; name of maker not given. M.O'D.

BAKER (W. E.). *Some exotic minerals of Western Tasmania.* Australian Gemmologist, **13**, 4, 99-103, 4 figs, 1 map, 1977.

Accounts of anglesite, cerussite, crocoite, dundasite, pyromorphite and stichtite occurring around Dundas and Zeehan in an area chiefly noted for gold and cassiterite. Not of gem significance. R.K.M.

BALL (R. A.). *Identification of synthetic opal—a review.* Australian Gemmologist, **13**, 5, 131-3, 3 figs, 1978.

A summary of the findings of several writers. R.K.M.

BALL (R. A.). *Imitation opal.* Australian Gemmologist, **13**, 5, 156-8, 5 figs, 1978.

A paper on Slocum stone which confirms the layered structure of included films but throws doubt on Darragh and Sanders' suggestion that they are alternating layers of silica and alumina. R.K.M.

BALL (R. A.). *Natural or synthetic opal.* Australian Gemmologist, **13**, 4, 104-5, 2 figs, 1977.

A short paper on structural differences revealed by electron-micrographs at 5000×. Author doubts infallibility of this test. Synthetic opal showed tendency to disintegrate when etched and under electron beam. R.K.M.

BANCROFT (P.). *Royal gem azurite.* Lapidary Journal, **32**, 1, 66-129, 15 figs (12 in colour), 1978.

Describes an azurite noted for hardness and toughness found on the Copper World mining property between Barstow and Las Vegas. M.O'D.

BANK (H.). *Gelber schleifwürdiger Skapolith mit hoher Licht- und Doppelbrechung aus Ostafrika.* (Yellow cuttable scapolite with high RI and double refraction from East Africa.) Z.Dt.Gemmol.Ges., **27,** 1, 23-25, bibl., 1978.

Various scapolites examined in the last few years are described and some additional high value R.I.s and double refractions mentioned. Further details to follow. E.S.

BANK (H.). *Skapolithe, orange-gelb avanturisierend.* (Orange-yellow aventurized scapolites.) Z.Dt.Gemmol.Ges., **27,** 1, 26, 1978.

The author describes two scapolites from Kenya showing an aventurine-like effect caused by needle-like inclusions of iron oxide. The stones were orange-yellow. E.S.

BANK (H.). *Topas als Danburit bestimmt.* (Topaz determined as danburite.) Z.Dt.Gemmol.Ges., **27,** 1, 41, 1978.

A number of gemmologists diagnosed a simple topaz as danburite. Dr Bank compares the physical and optical values of the two stones. E.S.

BASTOS (F. M.). *Occurrence of cordierite in the state of Minas Gerais, Brazil.* Lapidary Journal, **31,** 11, 2336-8, 3 figs, 1978.

Cordierite is found in the district of Virgolandia, close to the cities of Pecanha and Governador Valadares. It occurs with quartz and biotite mica. Some stones were sufficiently transparent to allow them to be faceted as gemstones. Details of the properties of cordierite are given. M.O'D.

BERKOWITZ (R.). *Report on microscopes.* Canadian Gemmologist, **2,** 2, 10-13, 1978.

Discusses the relative merits of the De Luxe Mark V Gemolite, the Custom Mark V Gemolite B, the Custom Mark V Gemolite A, the Nikon SMZ3, the Olympus model JM, the Zeiss Jena Citoval and the Carl Zeiss stereo-microscope DV4. This last was found to be the best optically, though the best all-round value was thought to be the Custom Mark V Gemolite B. The Nikon gave best performance for a low price. M.O'D.

BROWN (G.). *The Burinut.* Australian Gemmologist, **13,** 5, 134-40, 6 figs, 1978.

The buri nut, the seed of the talipot or corypha palm of SE. Asia, is being used as a source of vegetable ivory in Australia. The naturally spherical seeds are tumbled to give beads with either dark brown, mottled or off-white finish according to the degree to which the outer surface is removed. Resultant beads are porous cellulose and white ones can be bleached to a better ivory hue, or stained to other colours with aniline dyes. R.K.M.

CALAS (G.). *Le chrome et la couleur des minéraux: un exemple 'pédagogique'.* (Chromium and colour in minerals: a study for students.) Revue de Gemmologie, **54,** 6-8, 6 figs, 1978.

Shows by means of graphs the absorption spectra of chromium in synthetic green diopside, ruby from Mogok (Burma), red spinel from Mogok, synthetic emerald and Norwegian garnet; the part played by chromium in these materials is discussed. M.O'D.

Chermette (A.). *La bonne aventure ou l'histoire d'un placer.* (Good luck or the story of a placer.) Revue de Gemmologie, **54,** 2-5, 8 figs, 1978.

Describes the author's experiences as a gold prospector in the Republic of Bénin (formerly Dahomey). M.O'D.

Cockayne (B.). *The melt growth of oxide and related single crystals.* Journal of Crystal Growth, **42,** 413-26, 2 figs, 1977.

Describes some of the new methods devised over the past three years in the growth of crystals from the melt. More importance is attached to the atmosphere in which a crystal grows, and crystals are now examined with greater resolution. M.O'D.

Cozar (J. S.). *Estudio de las proporciones de talla en el diamante.* (Study of the proportions of the cut of diamond.) Instituto Gemológico Español, **17,** 27-31, 6 coloured figs, 1978.

Examines the use of the various instruments which estimate the nearness of a particular cut stone to an ideal proportion. M.O'D.

Crowningshield (R.). *Developments & highlights at GIA's Lab in New York.* Gems & Gemology, **XV,** 12, 361-70, 25 figs, 1977.

Cubic zirconia is discussed at length as a very close imitation of diamond which presents a considerable problem to the gem trade. It is appearing in a fraudulent context in the States. A pale pink one has been seen. Brown type IIb electrically conductive diamond is reported. A grey IIb lost its conductivity when irradiated to a blue colour. Hence conductivity still indicates a natural blue diamond. A 25 carat natural green diamond of type IIa was transparent to short UV. A pair of light green-blue diamonds showed the 4155Å line of a Cape stone, but origin of the colour was not determined. A diamond with a twin-plane (grain) line in the girdle plane was at first suspected of being a doublet. An intense fancy yellow-brown diamond had a fluorescent line at 5400Å. Worm-like inclusions in a diamond are illustrated. A 204 carat multi-star blue-grey quartz resembled corundum. Quartz triplets made to resemble red/blue-green tourmaline are reported. Tahiti black cultured pearls are described as unstained and reacting as for natural black pearls to long UV. Synthetic amethyst from USSR described as generally brownish purple and not fine in colour. An emerald resembling a swirled 'Ferrer'-type paste is illustrated: also a collection of ambers from the Dominican Republic, ranging from pale yellow to almost black-brown, many with insect fossils, none with stress spangles. Quench-fractured synthetic sapphires and a Mexican opal with negative crystal inclusions are also illustrated. A visitor to Russia expected to buy demantoid garnets but was disappointed: best source today said to be in secondhand and antique jewellery. R.K.M.

Darragh (P. J.), Gaskin (A. J.), Sanders (J. V.). *Synthetic opals.* Australian Gemmologist, **13,** 4, 7pp. (insert between p.108 and p.117) 11 figs (5 in colour), 1977.

A careful account of visual, structural and other differences between synthetic and natural opals. At electron-micro level synthetics show some particulate choking of interstitial spaces as well as concentric structure in the spheres of silica gel which are absent from natural opal. At visual level under magnification synthetic opal shows identifiable columnar grain and sub-grain structure which are seen much less frequently in natural opal. Spherule size so far produced has generally given synthetics with exceptionally fine red flash predominating. Any of these visual features could be changed in future batches. Gilson synthetics appear to be more porous than natural opal, especially when sliced to make triplets. In solid opal this may become more apparent on repolishing. R.K.M.

DARRAGH (P. J.), SANDERS (J. V.). *Slocum stone.* Australian Gemmologist, **13**, 5, 146-8, 4 figs (2 in colour), 1978.

A short paper on this spectacular glass simulation of opal. Obvious visual differences are mentioned. Colour flakes are thought to be due to alternating layers of silica and alumina suspended in a featureless transparent glass. Electron micrographs show the regular structure of these flakes which is responsible for the diffraction colours. R.K.M.

DIEHL (R.). *Künstliche Produkte mit Granat-Kristallstruktur.* (Synthetic products with garnet structure.) Z.Dt.Gemmol.Ges., **27**, 1, 12-21, bibl., 1978.

The rare earth garnets YAG and GGG have been introduced as diamond imitations, but are only two of a whole series of synthesized garnets. Oxide compounds which crystallize in the garnet structure have the general chemical formula $A_3B_2C_3O_{12}$—A, B and C being symbols for the vast number of chemical elements having a garnet structure, the A element being a rare earth, the B and C aluminium, gallium or iron. Since the Al and Ga garnets are transparent, have high value hardness and high RI and can be coloured by chromium, cobalt or nickel or some rare-earth elements, they can make attractive gem materials. Some yellow and pink-red uncut gemstone material was identified as mixed crystals of yttrium and holmium aluminium garnet and yttrium and erbium aluminium garnet. Both materials are grown as new laser material for eye-secure lasers. E.S.

DUNN (P. J.), APPLEMAN (D. E.), NELEN (J.). *Liddicoatite, a new calcium end-member of the tourmaline group.* American Mineralogist, **62**, 1121-4, 1 fig, 1977.

Many large multi-coloured tourmalines from the Malagasy Republic were found to have a high Ca content. A new calcium analogue of elbaite has been named after Richard T. Liddicoat, President of the Gemological Institute of America. Ideal formula is given as $Ca(Li,Al)_3Al_6B_3Si_6O_{27}(O,OH)_3(OH,F)$. Space group is R3m, cell dimensions $a = 15.867$ (4), $c = 7.135$ (4)Å. Zoning is usually parallel to a pyramid; in elbaite it is usually parallel to $\{0001\}$ or $\{10\bar{1}0\}$, $\{11\bar{2}0\}$ or both. M.O'D.

FOORD (E. E.). *The Himalaya dike system, Mesa Grande district, San Diego County, California.* Min. Record, **8**, 6, 461-74, 22 figs (4 in colour), 1977.

Describes the pegmatite-aplite dike system of the Mesa Grande district in north-central San Diego County. The area is especially celebrated for its fine tourmaline crystals, which are found together with beryl and quartz; some gem quality apatite is found. The beryl (morganite) ranges in colour from peach-orange to strawberry-pink. M.O'D.

GALAS (C. A.). *Thomas Range, Utah, U.S.A.* Lapis, **3**, 4, 28-31, 15 figs (4 in colour) 1978.

Describes the occurrence of manganese-bearing beryl with topaz and pseudobrookite in the Thomas Mountains of Utah, U.S.A. M.O'D.

GALIA (W.). *Zufällig entdeckt.* (Chance discovery.) Lapis, **3**, 4, 34-5, 4 coloured figs, 1978.

Discusses the cause of colour in aquamarine, golden beryl and non-emerald green beryl with remarks on absorption spectra and luminescence. M.O'D.

GLAS (M.). *Beryll Fundorte.* (Occurrence of beryl.) Lapis, **3**, 4, 10-11, 3 coloured figs, 1978.

Describes the mode of occurrence of beryl with particular reference to and illustration of materials from Bavaria and Austria. M.O'D.

GÜBELIN (E.). *Charakteristische Einschlüsse in Aquamarin und Smaragd.* (Typical inclusions in aquamarine and emerald.) Lapis, **3**, 4, 18-19, 13 coloured figs, 1978.

Photographs illustrating inclusions in emerald and aquamarine. Magnification ranges from 20× to 400×. M.O'D.

GÜBELIN (E. J.). *Jadeite, der grüne Schatz aus Burma.* (Jadeite, green treasure of Burma.) Lapis, **3**, 2, 17-28, 12 figs in colour, 1978.

Describes the jadeite occurrences of Burma and illustrates mining scenes. A map is included. Methods of recovery, fashioning and selling procedures are outlined. M.O'D.

GÜBELIN (E.), SCHIFFMANN (C. A.). *Aus der Untersuchungspraxis.* (From the testing practice.) Z.Dt.Gemmol.Ges., **27**, 1, 33-40, bibl., 1978.

The authors describe various interesting stones they encountered in their laboratory work, a sapphire, various quartzes, emeralds, synthetic and genuine, with beautiful photomicrographs. E.S.

GUILLEN (P.). *Vuelven las perlas.* (Returning to pearls.) Boletin del Instituto Gemológico Español, **17**, 9-25, 6 coloured figs, 1978.

A review of the history of the use of pearl as an ornamental material. M.O'D.

GUNARATNE (H. S.). *Blue sapphires and rubies—precious commodities of investment.* Facets, **2**, 1, (1), 1 illus., n.d. (1978?).

Advises fine quality blue sapphires and rubies as investments as good as diamonds. While production of coloured stones has been increasing and demand dropped as a result of the oil crisis, there has been no fluctuation in the prices of quality blue sapphires and rubies of bigger sizes, which may be regarded as suitable for investment. J.R.H.C.

HANNEMAN (W. W.). *Gemological instruments—which should I buy?* Lapidary Journal, **32**, 1, 422-9, 11 figs, 1978.

Reviews the instruments made or supplied by the Gem Instruments Corporation (GIA), Gemmological Instruments Ltd (Gemmological Association of Great

Britain) and Hanneman Gemological Instruments (Hanneman Lapidary Specialties). Also recommends books for gemmological study. M.O'D.

HANNEMAN (W. W.). *Water as a gemological tool.* Lapidary Journal, **31**, 12, 2576-8, 1978.

Attempts to show how the shape and behaviour of a drop of water placed on a polished stone may determine its identity. M.O'D.

HARTFORD (W. H.). *Color and the chromium minerals.* Rocks & Minerals, **52**, 169-75, 5 figs, 1977.

Discusses the minerals in which chromium acts as a colouring agent and gives a special account of crocoite from Beresov, Urals, USSR. M.O'D.

HERTING (S.), STRUNZ (H.). *Jeremejewit von Cape Cross in SW-Afrika.* (Jeremejevite from Cape Cross, SW Africa.) Aufschluss, **29**, 43-53, 7 figs, 1978.

Jeremejevite is found in a pegmatite at Cape Cross, 100 km north of Swakopmund in South-West Africa. Crystals are described and illustrated and their characteristics are compared with those of the occurrence in Transbaikalia, U.S.S.R. Specific gravity is given as 3.313, RI as 1.641 (ϵ), 1.649 (ω), with a DR of 0.008. M.O'D.

HOCHLEITNER (R.). *Die Berylliumpegmatite von Tittling im Bayerischen Wald.* (The beryllium pegmatite at Tittling in the Bayerischen Wald.) Lapis, **3**, 2, 4-16, 15 figs (4 in colour), 1978.

Describes the pegmatite in which milarite, epidote, monazite, samarskite, bertrandite, albite and, more rarely, crystals of purple fluorite and other minerals are found. M.O'D.

HUTTON (D. R.), BARRINGTON (E. N.). *Electron spin resonance of emeralds.* Australian Gemmologist, **13**, 4, 107-8 and 117-8, 4 figs, 1977.

A technique which measures magnetic fields to detect minute percentages of transition metals in beryl, allowing distinction to be made between (a) natural and synthetic emerald, (b) Chatham and Gilson synthetics, (c) emerald and green beryl. No detail of procedure or apparatus given. Printer has converted Gilson to 'Gibson' throughout. R.K.M.

KELLER (P. C.), KAMPF (A. R.). *The Natural History Museum of Los Angeles County.* Min. Record, **8**, 6, 487-93, 10 figs (5 in colour), 1977.

The Natural History Museum of Los Angeles County is about to open a new display area for minerals and gemstones, some of the finest of which are illustrated. The recently-acquired Hixon collection has made the Museum's gem collection one of the most important in the U.S.A. M.O'D.

LARSON (B.). *The best of San Diego County.* Min. Record, **8**, 6, 507-15, 12 figs (6 in colour), 1977.

Describes San Diego County, California, with particular reference to the main pegmatite districts, Chihuahua Valley, Aguanga, Pala, Rincon, Mesa Grande, Ramond and Jacumba. Pala is probably the best-known of these areas, since the production of tourmaline and to a lesser extent morganite, spessartine and spodumene is important commercially. More tourmaline comes from the Himalaya mine in Mesa Grande district and fine quality spessartine from the Hercules mine, Ramona district. The Beebe Hole mine in Jacumba district has recently yielded crystals of yellow, blue and purple spodumene. M.O'D.

MATEIKA (D.), RUSCHE (Ch.). *Coupled substitution of gallium by magnesium and zirconium in single crystals of gadolinium gallium garnet.* Journal of Crystal Growth, **42**, 440-4, 6 figs, 1977.

Crystals with magnesium and zirconium substituting for gallium show less tendency to form cracks during growth. Growth is by the Czochralski process; substituting ions occupy octahedral sites. M.O'D.

MICHEL (D.), PEREZ Y JORBA (M.), COLLONGUES (R.). *Growth from skull-melting of zirconia rare-earth oxide crystals.* Journal of Crystal Growth, **43**, 546-8, 3 figs, 1978.

Describes the use of the so-called skull-melting technique to produce crystals of zirconia with different compositions. Lanthanide oxides were used in stabilization experiments. M.O'D.

MITCHELL (R. S.). *'Odell diamonds', barite crystals from Gage County, Nebraska.* Rocks and Minerals, **52**, 357-9, 3 figs, 1977.

'Odell diamonds' are transparent to translucent pink barite crystals found in a Cretaceous shale near Odell, Gage Co., Nebraska. Some colour-zoning can be seen. M.O'D.

MORTEANI (G.), GRUNDMANN (G.). *The emerald porphyroblasts in the penninic rocks of the central Tauern Window.* Neues Jahrbuch der Mineralogie (Mönatschefte), 509-16, 3 figs, 1977.

Discusses the emeralds found in the Leckbachscharte, Habachthal, Austria. They are found to be porphyroblasts which have grown in biotite-epidote-plagioclase gneisses and in metasomatically altered serpentinites. Zoning observed in the emeralds is thought to be due to a change in metamorphic conditions. The origin of the Be is assumed to be volcanic. M.O'D.

NASSAU (K.). *Wie Mahlwerke für Zuokerrohr.* (Like millstones for sugar-cane.) Lapis, **3**, 4, 20-3, 7 figs (4 in colour), 1978.

An account of the so-called trapiche emerald found in Colombia. In some examples emerald is intergrown with albite. M.O'D.

NASSAU (K.), SCHONHORN (H.). *The contact angle of water on gems.* Gems & Gemology, **XV**, 12, 354-60, 3 figs, 1977.

A paper which puts into scientific perspective the water spot test, previously thought of as an indicator of hardness. Contrary to the thinking of other writers it was found that soft imitations such as YAG, GGG, and cubic zirconia, together with corundum, zircon and other natural stones, all give higher contact angles than diamond and hence more spherical water spots. A test to be used with great care, but not to be discarded if it helps with the worrying cubic zirconia, djevalite. Irradiated diamonds and other stones do not respond normally to this test and must be specially cleaned with Linde A to remove an extraneous layer of altered oil resulting from the irradiation. R.K.M.

NICHOL (D.). *The colour of nephrite jade from Cowell.* Quarterly Notes, Geological Survey of South Australia, **53**, 9-12, 2 figs, 1975.

Nephrite from this area is not so vivid a green as that from New Zealand; this is attributed to the lower chrome content (less than 0.1% compared to 0.4%). M.O'D.

O'DONOGHUE (M.). *Aquamarin und Morganit.* (Aquamarine and morganite.) Lapis, **3**, 4, 16-17, 3 figs, 1978.

Describes the aquamarine and morganite varieties of beryl with reference to the Maxixe stones and to the general occurrence and properties of the two varieties. (Author's abstract) M.O'D.

O'DONOGHUE (M.). *Crystal structures.* Gemmological Newsletter, **7**, 13-17, 1978.

An introduction to the basic structures of crystals with an explanation of co-ordination numbers, the various types of ionic packing and description of the structures of some well-known minerals with particular reference to the silicates. (Author's abstract) M.O'D.

O'DONOGHUE (M.). *Russian minerals.* Gems, **10**, 2, 9-12, 1 fig, 1978.

A survey of the better-known minerals recorded from the U.S.S.R. with particular reference to those with gem application. Most of the finest gem species come from the Ural Mountains, though Siberia has produced a number of important minerals, especially diamonds. Chrome diopside is also found in Siberia and nephrite is well-known from the shores of Lake Baikal. (Author's abstract) M.O'D.

PETROV (I.). Farbe, Farbursache und Farbveränderungen bei Topasen. (Colour, causes of colour and colour changes in topazes.) Z.Dt.Gemmol.Ges., **27**, 1, 3-11, bibl., 1978.

More than 1500 topaz crystals from different localities were tested as to their absorption spectrum. Other tests included thermoluminescence tests and systematic radiation and heating experiments and the comparison of the absorption spectra before and after radiation and heating. Thus a connexion between the colour of the topazes, the content of trace elements and the formation of colour-centres was found. The results were shown in (A) topazes coloured by chromium (these included only the violet-coloured topazes) and (B) topazes coloured by colour-centres, which were subdivided into (1) those without chromium and with colour-centres and (2) those with chromium and colour-centres. B(1) topazes were again subdivided into (a) red-brown and yellow topazes (the red-brown colour is caused by red and yellow colour-centres, while the yellow colour is caused by yellow colour-centres alone) and (b) blue and green topazes (the blue colour is caused by blue colour-centres, the green by blue and yellow colour-centres). The second group of topazes (B(2)—with chromium and colour-centres) includes yellow, orange-coloured and violet stones. The colours produced by colour-centres can be destroyed by heating and reconstructed by radiation. The blue colour can be obtained by radiation with succeeding heating. Orange-coloured topazes (from Ouro Preto) were changed to violet by heating (the yellow colour-centres were destroyed, only the Cr stayed effective). E.S.

PETROV (I.). *Farbuntersuchungen an Topas.* (Colour investigation of topaz.) Neues Jahrbuch der Mineralogie (Abhandlungen), **130**, 288-302, 3 figs, 1977.

The colour of violet topaz is ascribed to an absorption spectrum with two groups each with three absorption bands correlated with Cr^{3+} substituting for Al^{3+}. Orange topaz is coloured by the addition of yellow and violet; blue by colour-centre operation and also by an absorption band in the direction of oscillation X. Green is formed by the addition of blue and yellow. Change of colour by radiation and heating is discussed. M.O'D.

PETROV (I.), SCHMETZER (K.), BANK (H.). *Violette Topase aus Pakistan.* Neues Jahrbuch der Mineralogie (Mönatshefte), 483-4, 1977.

Violet-coloured crystals of topaz from Katland in the Mardan district of Pakistan show {110} {120} and {011} {012} and {112}. Refractive indices are 1.632, 1.633 and 1.641; pleochroism yellow, violet with red and violet with blue. X-ray examination shows the stones to be OH-rich with around 15% F. The violet colour is due to Cr^{3+}. M.O'D.

POIROT (J.-P.). *La lecture de l'indice de réfraction au réfractomètre à prisme.* (Reading refractive index with the prism refractometer.) Revue de Gemmologie, **54**, 14-16, 9 figs, 1978.

An account of the theory of refractive index illustrated with diagrams. M.O'D.

RECKER (K.). *Smaragd-Synthesen.* (Synthesis of emerald.) Lapis, **3**, 4, 24-7, 5 figs (1 in colour), 1978.

The process of manufacture is described and characteristics of the crystals given. M.O'D.

REED (T. B.), FAHEY (R. E.), MOULTON (P. F.). *Growth of Ni-doped MgF_2 crystals in self-sealing graphite crucibles.* Journal of Crystal Growth, **42**, 569-73, 4 figs, 1977.

Optical quality MgF_2 crystals doped with Ni are light green in colour. Growth by a vertical gradient freeze technique may be appropriate for other materials of a volatile nature. M.O'D.

SAUL (J. M.), JOBBINS (E. A.), STATHAM (P. M.), YOUNG (B. R.). *Un essai d'établissement d'une échelle de couleurs pour des grenats de la vallée de l'Umba, Tanzanie.* (An attempt to establish a colour range for garnet from the Umba Valley, Tanzania.) Revue de Gemmologie, **54**, 9, 2 figs, 1978.

In a graph on which refractive index is plotted against specific gravity garnets are found to be grouped by colours. Three groups have been identified, reddish-purple, red and yellowish-red. M.O'D.

SKINNER-NIXON (E.). *The alteration of colour of gemstones.* Australian Gemmologist, **13**, 3, 85-8, 1977.

A summary of methods under headings: 1, irradiation; 2, heat-treatment; 3, staining. R.K.M.

SMITH (D.). *That looks interesting let's put it under the microscope.* Australian Gemmologist, **13**, 4, 121-126, 5 figs, 1977.

Describes various types of microscope and advises on purchasing one. But power of a microscope is incorrectly stated as being the sum of the power of the objective and the eyepiece. R.K.M.

SNOW (J.). *Paste or glass.* Australian Gemmologist, **13**, 3, 71-4, 1977.

An account of artificial and natural glasses reprinted from Wahroongai News. Marred by many printer's errors. R.K.M.

SUHNER (B.). *Zur Diagnose der Zirkone.* (The diagnosis of zircons.) Z.Dt.Gemmol.Ges., **27**, 1, 27-32, 1978.

The diagnosis of zircons is more difficult than that of many stones because of its RI of 1.8 being above those measurable by ordinary refractometers. A characteristic of zircons is their radioactivity caused by uranium and thorium; it is suggested that this should be used for their identification. Only a few zircons show no radioactivity. By measuring the radioactivity, the stones could also automatically be identified as high, normal or low zircons. Ekanite is also radioactive, but has about a ten times higher radiation intensity as compared with the low zircon and can also be differentiated from zircon by its sp. gr. (3.28) and its RI (1.595). E.S.

TENNYSON (C.). *Gerüste aus Ketten und Schichten.* (Framework of chains and layers.) Lapis, **3**, 4, 6-9, 6 figs (1 in colour), 1978.

Illustrates with diagrams the atomic structure of beryl. M.O'D.

THORSSON (H.). *The Zeiss slit lamp microscope.* Canadian Gemmologist, **2**, 2, 14-16, 1978.

This instrument was designed for ophthalmological work but can be adapted for use in gem testing. M.O'D.

WISE (W. S.), GILL (R. H.). *Minerals of the benitoite gem mine.* Min. Record, **8**, 6, 442-52, 31 figs (6 in colour), 1977.

The most important minerals from this mine are benitoite, neptunite and joaquinite, but these occur in a number of interesting forms. Although most neptunite appears black, a red crystal is illustrated. M.O'D.

WRIGHT (Pearce). *Doubt thrown on tests of diamond pedigrees.* The Times newspaper, No. 60337, p.2, 26th June, 1978.

Spectroscopic analysis has been recognized by the G.I.A. as providing a test for distinguishing between natural yellow diamond and diamond whose yellow colour is due to irradiation and heating to 700-800°C. But Dr Alan Collins (King's College, London) has found that when treated yellow diamonds are heated to 1000°C the anomaly between them and the natural yellow diamonds disappears, while the colour remains unchanged: this throws doubt on the reliability of the test. J.R.H.C.

Manufacture of ornaments. Facets, 2, 1, (2-3), 4 illus., n.d. (1978?)

Among ornamental stones to be found in Sri Lanka, including spodumene, apatite, cassiterite, fluorspar, crystalline limestone, quartzites and rose quartz, particulars are given of serpentine (including Bowenite) - approximating to the formula $MG_6(OH)_6Si_4O_{11}$, RI 1.49 to 1.57, SG 2.5 to 2.6, H 2½ to 4 - which is cut into chessmen, eggs, ashtrays, boxes, clock dials and bases, as well as pendants, earrings, necklaces and cufflinks. J.R.H.C.

Stones seen... Australian Gemmologist, **13**, 5, 154, 1978.

Reports a cubic zirconia, other than djevalite, showing a sharp absorption line at 5125Å. R.K.M.

The collector's library. Min. Record, **9**, 1, 5-13, 1978.

A number of specialists have listed the books that they consider most necessary for a study of minerals and gemstones. Items are given with bibliography details, excluding prices. M.O'D.

BOOK REVIEWS

Brazeau (E. G.), Brazeau (L. S.). *Standard mineralogical catalogue, mid 1977 to mid 1978.* No publisher or place of publication given in book; available from the authors (address: Mineralogical Studies, 7805 Division Drive, Battle Creek, Michigan, 49017, U.S.A.); dealers only; unpriced.

Lists minerals in alphabetical order with prices for ½", 1", 2", 3" and 4" specimens. Introductory notes provided. M.O'D.

Hurlbut (C. S.), Klein (C.). *Manual of mineralogy, after James D. Dana.* 19th edn. Wiley, New York, 1977. pp.xi, 532. Illus. in black-and-white. £7.95.

This is the mineralogy students' friend in a new format with new material of petrology and morphology and more species described. An interesting feature is the treatment of the crystal systems; the authors begin with the triclinic (the system of lowest symmetry) and end with the isometric; in each of the systems the classes are arranged in decreasing symmetry order. The aim is to be able to describe lower symmetry classes as special cases of the higher classes. The typography is very pleasing and with a reasonably low price the book can be highly recommended. M.O'D.

Schmetzer (K.). *Vanadium III als Farbträger bei naturlichen Silikaten und Oxidenein Beitrag zur Kristallchemie des Vanadiums.* (Vanadium III as a colouring agent in natural silicates and oxides—a contribution to the crystal chemistry of vanadium.) Inaugural-Dissertation zur Erlangung der Doktorwürde der Naturwissenschaftlichen Gesamtfakultät der Ruprecht-Karl-Universität, Heidelberg, 1978. pp.277, 71 figs. Apply to the University for copies.

Dr Schmetzer illustrates the role played by vanadium in the colouring of silicates and oxides; in particular he discusses emerald, tourmaline, corundum, kornerupine, zoisite, kyanite, epidote, topaz, axinite, diopside, chrysoberyl amongst other minerals not of gemmological importance. There is a very detailed survey of the relevant literature. M.O'D.

WANKLYN (B. M. R.). *Sources of single crystals in the United Kingdom and Scandinavia.* Clarendon Laboratory, University of Oxford, 1978. pp.78. Available to scientists only on application.

This compilation takes its place with similar ones from other European countries and the U.S.A. It lists the various organizations engaged in crystal growth with the materials that they manufacture. General availability of the materials is shown. M.O'D.

WOOLLEY (A.), ed. *The illustrated encyclopedia of the mineral kingdom.* Hamlyn, London, 1978. pp.240. 150 figs in colour, many in black-and-white. £5.95.

The present reviewer had a sense of *déja vu* when seeing this book for the first time. Like his own (O'Donoghue, ed., The encyclopedia of minerals and gemstones, Orbis, 1976), this book introduces the unlearned reader to the world of minerals and describes some of the better-known species (300 in this case as against over 1,000). There are chapters on crystals, the geological environment of minerals and rocks, mineral properties and study, gemstones and economic minerals, building a collection and a guide to the literature on minerals. All are written by a team of professional workers in mineralogy and each is illustrated by appropriate photographs. Study of the earth and the planets leads to a consideration of the internal structure of the earth, the elements to be found on it and their chemistry. A good deal of attention is paid to the types of rocks and to the mineral assemblages which accompany them and this part of the book should be especially useful.

The chapter or section describing 300 mineral species is called 'The mineral kingdom'—surely an overworked phrase by now and eerily familiar to this reviewer. Minerals are arranged in crystallochemical order, so that the index is needed to locate a particular item if its nature is unknown. Each description includes chemical composition, crystal system, physical and optical properties, formation and occurrence. Many entries do not give localities, which, in a book aimed at the general reader, is surely a blunder. Dimensions of specimens are omitted so that one has no idea how large (micromount or cabinet size) a particular mineral is.

A short chapter on gemstones ends rather suddenly and is disappointingly dull but includes some interesting data (e.g. on saussurite) not always found in books of this type. A chapter on economic minerals, much like similar chapters in other books, is followed by notes on building a collection, again with nothing to make it stand out in the memory. Bibliography and index are adequate.

The standard of illustration, bearing in mind the indifferent quality of the paper, is quite acceptable but scarcely exciting by today's standards. This is the main impression left by the book; it is certainly workmanlike, free from serious error and very cheap, but it is so like other books that there is nothing to distinguish it. Style ranges from the didactic (properties and study of minerals) to the pedestrian (gemstones); it would be good to see at least some of the excitement over the beauty of minerals (as in some papers in Mineralogical Record) coming across to the reader. But perhaps such transports are beyond the reach of British workers! M.O'D.

ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

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

Mr Don Demarray, London, Ontario, Canada, for a packet of small green fluorite crystals with mauve centres from Faraday Mine, Bancroft, Ontario.

Mr R. I. Gait, Assistant Curator of Mineralogy, Royal Ontario Museum, Toronto, Canada, for two booklets entitled *A General Guide to the Gallery of Mineralogy* and *A Guide to the Teaching Section.*

Mr B. Krijger, F.G.A., The Hague, Netherlands, for a book entitled *Edelstenen in Kleur* revised and translated into Dutch from the German original.

Mr Alec Pickett, F.G.A., London, for a copy of *Investing in Diamonds* by David H. Wolf, F.G.A., South Africa.

Dr D. J. Talati, Ahmedabad, India, for two cabochons and 25 pieces of rough copper-bearing aventurine zeolite, mined in Jalampura, Gujarat, India.

Mr Grant W. Waite, Toronto, Canada, for three pieces of ruby corundum in matrix from the Fiskenaesset area, South West Greenland, one piece of thomsonite in matrix and four pieces of green agate from Lake Superior, U.S.A.

Mr Benjamin Zucker, New York, U.S.A., for a copy of his book *How to Invest in Gems: Everyone's Guide to Buying Rubies, Sapphires, Emeralds and Diamonds,* published by the New York Times Book Company in New York and by the Blandford Press in England.

MEMBER'S MEETINGS

Midlands Branch

The Annual General Meeting of the Branch was held on the 15th June, 1978, at the Royal Institute of Chartered Surveyors, Birmingham, and was followed by a talk by Mr Alan Hodgkinson, F.G.A., entitled 'Visual Optics'. Mr Hodgkinson brought along several specimens and a Diamond Eye (one of the new diamond testing instruments), and a practical demonstration was given.

North-West Branch

On the 9th July, 1978, branch members joined with the Wirral Mineral and Lapidary Society for a field trip. The venue was Dyserth and two further quarries nearby. Travertine, chert and galena were collected.

SECRETARY'S VISIT TO CANADA

During a holiday visit to Canada Mr Harry Wheeler met officials of the Canadian Gemmological Association in Toronto. He gave an evening talk at the Sheraton Centre on Wednesday, 12th July, 1978, to members of the Canadian Association. The talk mainly concerned the history of the Gemmological Association of Great Britain, its educational activities, including examinations, and the instruments handled by Gemmological Instruments Ltd. During the period he spent in Toronto he was entertained by Officers of the Canadian Association.

HARROW COLLEGE OF TECHNOLOGY AND ART

A short course of nine weekly two-hour lecture demonstrations on 'The Science of Minerals and Gems' starting on Wednesday, 17th January, 1979, is being organized by Mr F. A. Fryer, B.Sc., C.Chem., M.R.I.C., F.G.A., (senior Lecturer in Inorganic Chemistry). It is expected that the lectures will be given by Mr Fryer, Dr Paul Madget (Geology Lecturer), Mr James Harding, F.G.A. (Senior Lecturer in Silversmithing) and Mrs Sheila Lewis, F.G.A. Enquiries should be addressed to Mr Fryer at Harrow College of Technology and Art, Northwick Park, Harrow, HA1 3TP. (Telephone 01-864 4411).

COUNCIL MEETING

At a recent meeting of the Council it was agreed that with effect from 1st January, 1979, the annual subscription for Fellows and Ordinary Members shall be £6.00. The annual subscription for the *Journal* for non-members is increased to £8.00.

BACK ISSUES OF THE JOURNAL

The Association is interested in aquiring from members copies of the previous issues of the Journal listed below in order to supplement our stock.

Vol. 1, No. 1, 1947.
Vol. 1, No. 2, 1947.
Vol. 1, No. 3, 1947.
Vol. 1, No. 4, 1947.
Vol. 1, No. 5, 1948.
Vol. 1, No. 6, 1948.
Vol. 1, No. 8, 1948.
Vol. 2, No. 1, 1949.
Vol. 2, No. 2, 1949.
Vol. 2, No. 3, 1949.
Vol. 2, No. 4, 1949.
Vol. 2, No. 5, 1950.
Vol. 3, No. 1, 1951.
Vol. 3, No. 4, 1951.
Vol. 9, No. 12, 1965.
Vol. 11, No. 4, 1968.
Vol. 11, No. 5, 1969.
Vol. 12, No. 2, 1970.
Vol. 13, No. 1, 1972.
Vol. 13, No. 2, 1972.
Vol. 13, No. 5, 1973.
Vol. 13, No. 8, 1973.
Vol. 15, No. 2, 1976.
Vol. 15, No. 7, 1977.

Members are requested to write with details to the G.A. office.

EXAMINATIONS 1979

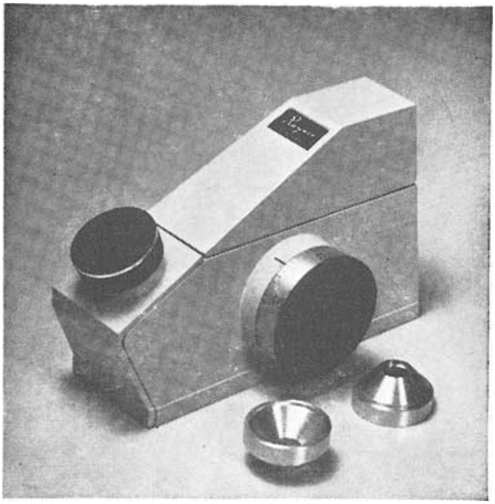
The dates for the 1979 Gemmological Examinations are as follows:
Preliminary: Theory, Tuesday, 26th June.

Diploma: Theory, Wednesday, 27th June.
Practical, Tuesday, 26th June, Thursday, 28th June, Friday, 29th June (London). Other centres as arranged.
Gem Diamond Examination: Monday, 11th June.

The *final* date for entry is the 1st March. Entry forms available from the Association.

CORRIGENDUM

On page 213 (line 6), for 'GALL (Robert A. P.)' read 'GAAL (Robert A. P.)'.



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