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and

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SPECTROSCOPIC INVESTIGATION OF A CANARY YELLOW DIAMOND

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INTRODUCTION

In 1943, Anderson,(1) in the course of a proposed classification of diamonds according to their fluorescent and absorption characteristics, described a certain class of yellow diamonds to which later the term 'canary' was conveniently attached, this being a well-known trade name for fine yellow fancy diamonds. The yellow colour is clearly associated with absorption at the blue end of the visible spectrum, but when examined at room temperature with a hand spectroscope these diamonds show no sharp absorption lines. This is in marked contrast to 'Cape yellow' diamonds which have prominent absorption peaks at 478 and 415 nm.(1) Again, when canary yellow diamonds are illuminated with long wave ultraviolet (365 nm) from a mercury 'black lamp' they emit a yellow or orange luminescence whereas the

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luminescence from Cape yellow diamonds, if present, is blue. No sharp lines are apparent when the luminescence band from a canary yellow diamond at room temperature is examined with a hand spectroscope.(1)

In a later paper (1962) Anderson(2) describes finding an emission line at 575 nm in some diamonds emitting an orange luminescence. Emission lines are often poorly defined when the crystal is excited at room temperature, and the present author has assumed for many years that references in the literature to *featureless* emission bands simply reflected the fact that the diamonds had not been examined at liquid nitrogen temperature. In 1965 Dyer *et al.*(3) had described a new type of diamond which they classified as Type Ib. These diamonds absorb strongly in the blue part of the visible spectrum, giving them an attractive yellow colour, and also have a characteristic absorption band in the infrared spectral region between 7 and 10 μm (1400 to 1000 cm^{-1}). Naturally-occurring luminescence in the 575 and 637 nm systems can sometimes be observed in Type Ib diamonds, and it seemed to the present author that such a diamond would be classified as a canary yellow by gemmologists.

NITROGEN IN DIAMOND

It will probably be useful to summarize here the rôle that nitrogen plays in determining the optical properties of diamond.(4) Natural Type Ib diamonds contain typically 100 parts per million (ppm) of isolated substitutional nitrogen; that is to say the nitrogen is located in the crystal lattice at positions normally occupied by carbon atoms, and no nitrogen atom is close, on an atomic scale, to any other nitrogen atom. Diamonds of this type are very rare in nature—usually the concentration of nitrogen is higher (up to 3000 ppm) and the nitrogen atoms have aggregated to form well defined defects. Diamonds containing aggregated nitrogen are classified as Type Ia, and the two dominant defects appear to be the A-aggregate and the B-aggregate. The A-aggregate is a pair of nearest-neighbour substitutional nitrogen atoms, and the B-aggregate probably consists of 4, 6 or 8 nitrogen atoms in an as yet unknown configuration.

As already noted, Type Ib diamonds have a characteristic infrared absorption with a peak at 1130 cm^{-1} (8.85 μm) and absorb strongly in the blue part of the visible spectrum. Type IaA diamonds (i.e those with nitrogen in predominantly the A-form) have a different infrared absorption, with a principal peak at 1280 cm^{-1} (7.8 μm), and absorb strongly in the ultraviolet at wavelengths less than 330 nm. The infrared absorption band for Type IaB diamonds is different again, with the principal peak located at 1175 cm^{-1} (8.5 μm). Neither the A-aggregate nor the B-aggregate of nitrogen gives rise directly to any absorption in the visible region and most colourless gem quality diamonds contain substantial concentrations of aggregated nitrogen. However, many diamonds also contain so-called N3 centres. The N3 centre is believed to be a triangle of three nearest-neighbour nitrogen atoms bonded to a common carbon atom, and gives rise to the Cape series of absorption bands. When these bands are strong the diamond has a characteristic straw-yellow colour. There is no correlation between the concentration of N3 centres and the concentration of either the A-aggregates or B-aggregates of nitrogen, but there is a tendency for the Cape absorption bands to be strong in diamonds with a large B-aggregate concentration.

Platelets—extended defects which give rise to anomalous x-ray scattering, and which are sufficiently large to be observed in the electron microscope—were once thought to be the major receptacle of nitrogen in diamond. More recent work suggests that less than 10% of the total nitrogen is incorporated in the platelets; indeed the platelets may not involve nitrogen at all. An infrared absorption peak at 1370 cm^{-1} (7.3 μm) appears to be related to the concentration of platelets, but once again there is no corresponding absorption in the visible region.

Although diamonds which are predominantly Type Ib, Type IaA or Type IaB may be found, most natural diamonds are a mixture of types. Diamonds which have no detectable absorption in the 7-10 μm region contain very little nitrogen and are, of course, classified as Type IIa.

YELLOW FLUORESCENT DIAMONDS

Recently we have begun an investigation of the optical properties of natural brown and yellow diamonds. During the course of this survey a number of diamonds have been examined which exhibit bright yellow luminescence when excited at 365 nm. No sharp lines are visible in the room temperature spectrum, and when the diamonds are cooled to liquid nitrogen temperature it is clear that the emission band is not one that has been studied in detail before. These diamonds were not a good yellow colour, and could not be described as canaries, but it was felt desirable that spectra should be obtained from a canary yellow diamond for comparison purposes.

The canary yellow diamond that has been studied is a 0.38 ct step-cut stone kindly loaned by Basil Anderson. The culet on this diamond is not polished to a sharp point, but has a small flat on it, and for the optical absorption measurements the light beam was passed through the culet and out of the table, the thickness of diamond being very close to 3 mm.

EXPERIMENTAL

The spectra shown in this paper have been recorded with the diamonds at either room temperature or liquid nitrogen temperature (77 K) using scanning monochromators. For the absorption spectra the vertical axis is absorption coefficient and this has been calculated point by point using the approximate formula $\alpha = d^{-1} \log_e I_o/I_t$, where I_o and I_t are the intensities of the incident and transmitted light, α is the absorption coefficient and d is the crystal thickness in cm. In practice about 2000-4000 points are used per spectrum, and the absorption coefficient is evaluated and the spectrum plotted using an on-line computer.

Luminescence spectra were excited using a high pressure mercury lamp with an interference filter to select one of the strong lines at 365.0, 404.7, 435.8 or 546.1 nm. The vertical axis on the spectra presented is in arbitrary units—that is, the spectra have not been corrected for the variation in the response of the spectrometer with wavelength.

RESULTS AND DISCUSSION

Figure 1 shows the absorption spectrum of the canary yellow diamond in the visible region with the sample at 77 K. For wavelengths shorter than 560 nm the absorption increases smoothly and continuously. This is entirely characteristic of a Type Ib diamond. Although this spectrum confirms the author's previous ideas about the origin of the colour of canaries, it was disappointing in that it showed none of the minor features observed in the series of yellow luminescent diamonds which we are currently studying. (A typical example will be shown in Figure 3).

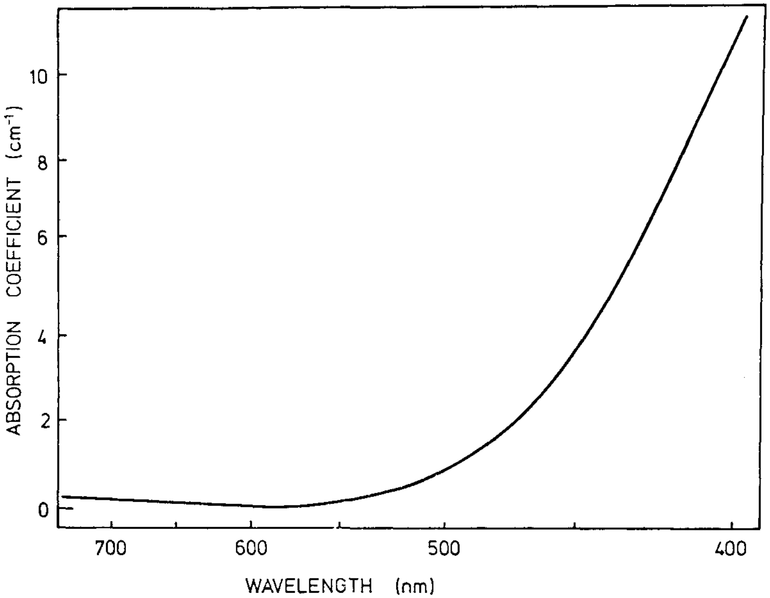

FIG. 1 Absorption spectrum of a canary yellow diamond, in the visible region, recorded with the sample at 77 K.

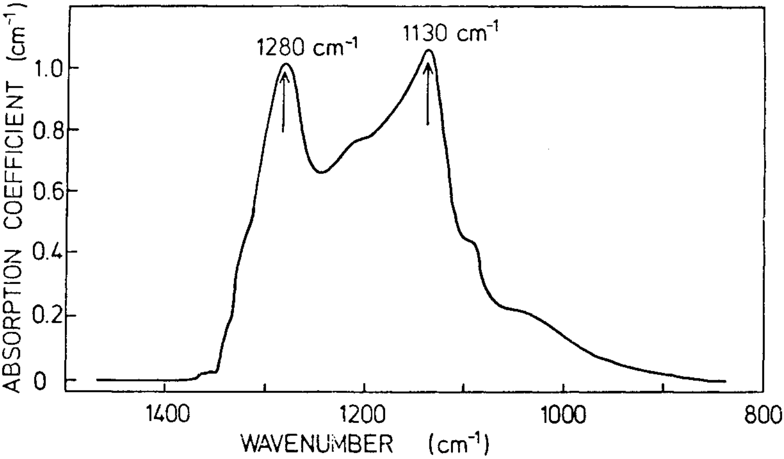

FIG. 2 Absorption spectrum of a canary yellow diamond, in the infrared one-phonon region, recorded with the sample at room temperature. The 1280 and 1130 cm^{-1} peaks are labelled.

Figure 2 shows the absorption spectrum of the canary yellow diamond in the infrared region with the sample at room temperature. The geometry of the sample made these measurements very difficult and a subjective correction has had to be applied to the raw data. The shape of the spectrum may not be exactly correct, therefore, but there is no doubt about the existence of absorption peaks at 1280 and 1130 cm^{-1}. As noted in the introduction, the 1130 cm^{-1} peak is only seen in Type Ib diamonds whereas the 1280 cm^{-1} peak is characteristic of Type IaA diamonds in which the nitrogen is present as A-aggregates. The infrared measurements show, therefore, that the specimen is a mixture of Type IaA and Type Ib material. Many diamonds which have the typical Type Ib absorption in the visible region (as in Figure 1) are found to be a mixture of Types Ib and IaA from the infrared spectra.

Figure 3 shows the absorption spectrum of one of the yellow-luminescing diamonds that we are investigating at present. It will be noted that although there is gradually increasing absorption for wavelengths shorter than 560 nm, as observed in a Type Ib diamond, there is also a broad band centred at around 490 nm and a number of minor peaks at shorter wavelengths. Clearly there is no similarity between that diamond and the canary yellow diamond which is the subject of this report. However, using a hand spectroscope, Kenneth Scarratt of the Gem Testing Laboratory has observed (personal communication) an absorption line at 425 nm in six different natural diamonds. Four of these were yellow stones which exhibited yellow fluorescence under long wave ultraviolet illumination and would properly be described as canaries. It is possible therefore, that some diamonds classified as canaries may also have the 490 nm absorption band and associated structure present.

LUMINESCENCE MEASUREMENTS

During the course of our measurements on diamonds which have an absorption band like that shown in Figure 3 we have observed that bright yellow luminescence is produced by illumination with long wave ultraviolet (365 nm), but if the crystal is irradiated with light of wavelength near the peak of the 490 nm absorption band then the diamond exhibits a red luminescence.(5) As with many optical centres in diamond the luminescence band is

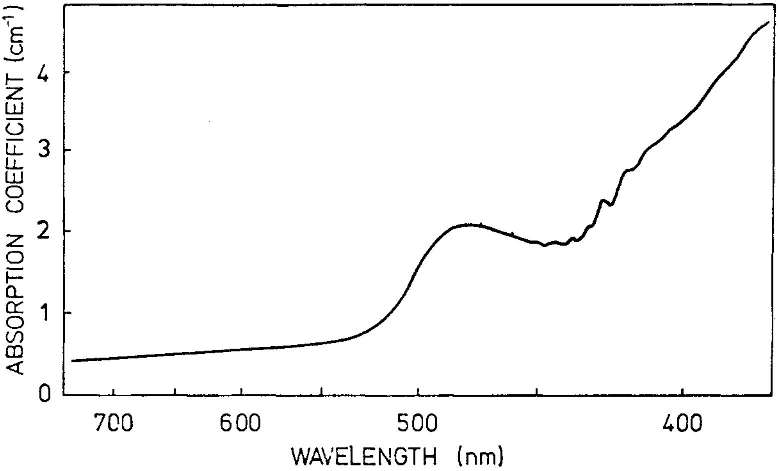

FIG. 3 Absorption spectrum of a yellow-luminescing diamond, in the visible region, recorded with the sample at 77 K.

an approximate mirror-image of the absorption band. With this in mind the luminescence from Anderson's canary yellow diamond has been examined using four different excitation wavelengths. The results with the diamond at room temperature are shown in Figure 4.

With the conventional long wave ultraviolet excitation (curve (a)) the luminescence lies predominantly in the orange region of the spectrum with its maximum near 605 nm; when excited with blue light (curve (c)) the peak of the emission band shifts to about 545 nm in the yellow-green region. Excitation at 404.7 nm (curve (b)) produces an almost equal mixture of these two components, whereas excitation with the green 546.1 nm line (curve (d)) gives rise to a third emission band in the red. Some of the structure on this band is due to luminescence in the 637 nm system, (the zero-phonon line is arrowed).

The picture, then, is an extremely confused one. At least three different components of unknown origin are present in the room temperature luminescence spectrum and these are all quite different to the yellow and red emission bands that we have recorded in diamonds containing the 490 nm absorption band. (Details of the work on these diamonds is to be published separately).(5) The situation becomes even more confusing when the luminescence from the canary yellow specimen is studied with the diamond at 77 K. One example, using 365 nm excitation, is shown in Figure 5.

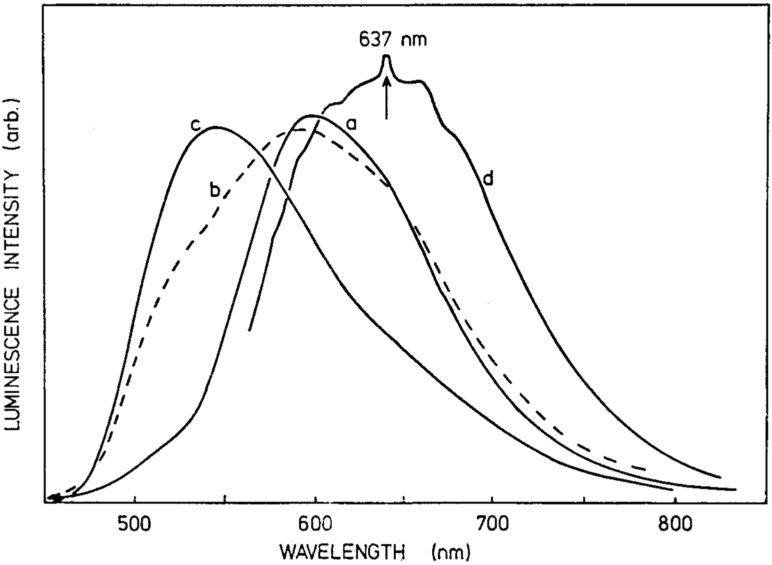

FIG. 4 Luminescence spectra of a canary yellow diamond, recorded with the sample at room temperature. The following mercury lines were used to excite the luminescence: (a) 365.0 nm, (b) 404.7 nm, (c) 435.8 nm and (d) 546.1 nm. The position of the 637 nm zero-phonon line on curve (d) is indicated by an arrow—the peak of the line is well off-scale.

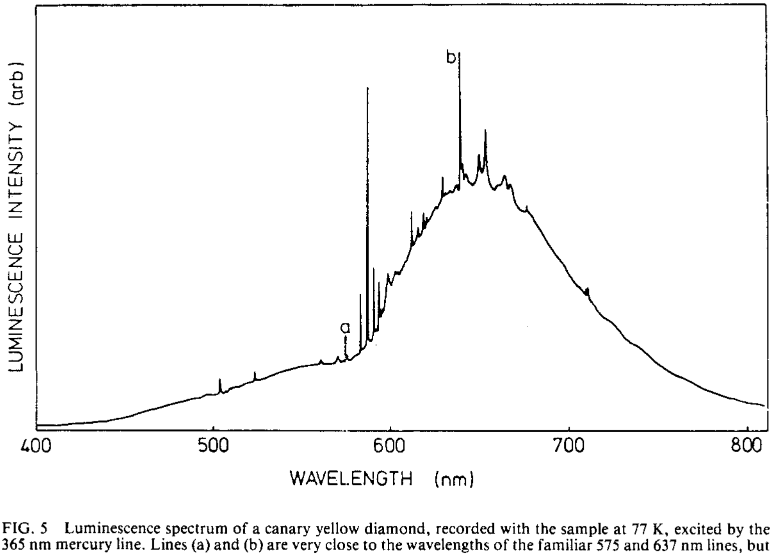

FIG. 5 Luminescence spectrum of a canary yellow diamond, recorded with the sample at 77 K, excited by the 365 nm mercury line. Lines (a) and (b) are very close to the wavelengths of the familiar 575 and 637 nm lines, but are unrelated to them. The wavelengths of all the sharp lines are listed in Table 1.

Anderson had previously noted that the 575 and 637 nm zero-phonon lines are observed in the luminescence spectra of some diamonds.⁽²⁾ The lines marked (a) and (b) in Figure 5 are at 574.1 and 638.4 nm—deceptively close to the familiar lines at 575.0 and 637.2 nm, but apparently unrelated to them. The very weak line just to the long wavelength side of (a) is in fact the 575.0 nm line, and this is far more prominent in the luminescence spectrum excited by blue light. If green light is used to illuminate the diamond the well-known 637.2 nm line is much stronger than the 638.4 nm line shown in Figure 5, and is, in fact, responsible for the structure in the room-temperature spectrum in Figure 4 curve (d). There are many other sharp lines in Figure 5 which, to the author's knowledge, have not been reported previously, and wavelengths of these 'new lines' are listed in Table 1. It should be mentioned that a qualitative glimpse of sharp line structure in the fluorescence spectrum of a canary yellow specimen was obtained by Anderson⁽⁶⁾ in the early sixties. In that investigation the diamond was cooled to about −70 °C by resting it on a block of solid carbon dioxide.

TABLE 1

Sharp lines observed in the luminescence spectrum from a canary yellow diamond excited at 77 K with long wave ultraviolet (365 nm)

S = strong, M = medium, W = weak.

Wavelengths in nm

574.1 (M);	575.2 (W);	582.6 (M);	586.5 (S)
590.2 (M);	591.4 (W);	592.7 (M);	594.5 (W)
611.1 (M);	614.5 (W);	617.5 (W);	619.4 (W)
628.1 (M);	638.4 (S);	639.3 (W);	675.7 (W)
709.4 (W);	710.4 (W).		

SUMMARY

Infrared absorption measurements have shown that the canary yellow diamond studied in this investigation is a mixture of Type Ib and Type IaA material. The absorption in the blue part of the

visible spectrum which gives the stone its yellow colour is entirely characteristic of Type Ib diamond and there is no evidence for the presence of any other absorption systems. The broad luminescence bands observed at room temperature appear to contain at least three different components, and cooling the diamond to 77 K reveals a complex series of sharp lines. The luminescence bands observed in this diamond are not the same as those seen in specimens containing the 490 nm absorption band.

No general conclusion can be reached from studies on one diamond, but it seems probable that all stones classified as canaries are Type Ib or a mixture of Type Ib and Type Ia material. It is also likely that, with so many combinations to choose from, the overall luminescence spectrum will show a marked sample-dependence. There is clearly still a great deal to learn about yellow and red luminescence in diamond, and work is in progress in the author's laboratory aimed at obtaining a better understanding of these emission bands.

ACKNOWLEDGEMENTS

The author is grateful to Basil Anderson for the loan of the canary yellow diamond used in this investigation, made available through Alec Farn of the London Chamber of Commerce Gem Testing Laboratory.I am also grateful to Mr Farn and Kenneth Scarratt of that laboratory, and to Mr Anderson, for their comments on the final manuscript. The absorption spectrum of Figure 3 was obtained by Khalid Mohammed.

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[*Manuscript received 3rd April, 1980.*]

NOTES FROM THE LABORATORY

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

The Gem Testing Laboratory of the London Chamber of Commerce and Industry

'Full many a gem of purest ray serene the dark unfathomed caves of ocean bear'. Could it be that Thomas Gray, when writing his *Elegy written in a Country Churchyard,* penned these words knowing that pearls would be the forerunner of our interest in gems as such?

Had it not been for the need for investigation into the internal world and structure of pearls and cultured pearls in the early twenties of this century, *gemstone* investigation would not have reached the position it occupies today. Gemmology, the study of gems, is usually considered by gemmologists as the study of gem *stones.* Gemmology is a science, a learning; much gemmological knowledge is used in gem testing, which is a trade activity affording a service usually from a laboratory such as ours.

Gem testing—particularly that version or variety undertaken in our laboratory—embraces many aspects of gemmological knowledge plus trade experience. To arrive at an accurate conclusion to the test or examination of a gem as a trade requirement we employ the quickest and most economical non-destructive methods to identify specimens sent for test positively.

Routine testing follows standard practice to a certain extent. We are tradespeople and have a certain degree of experience plus rule of thumb knowledge garnered over the years. My own conviction of recognition and consequent routine to follow is based upon the precept that 'the first impact of a gemstone is its colour.' By the impact of colour the course to be followed in testing is decided. I hope that all gemmologists worthy of the name will automatically use their 10× lens for first examination and decide mentally what the stone is or could be. An obvious Verneuil will need microscope and spectroscope. An aquamarine will need the (Anderson-Payne) spinel refractometer.

When it comes to pearls, set or unset or strung as necklaces, they usually find their way to me. Apart from precise requests from customers in the case of pearl testing one knows which method is to be followed. A necklace of pearls of fine graduation, matching in

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colour, possibly a little 'gleaming', will be examined at the drill holes by 10× lens to check for demarcation lines and varicose protuberances. This will dictate usually a radiograph or direct x-ray photograph, in which we should expect to find a typical picture of a cultured pearl necklace. The shapes of some pearls are extremely useful in indicating possible results, i.e. a bouton shape on a bar brooch or ring is much more likely to be a natural pearl than a fine spherical shape. It would be uneconomical to utilize a fine spherical pearl in a bar brooch.

When we have to resort to diffraction-pattern x-ray we obtain a lauegram, so called after Max von Laue, a German physicist awarded the Nobel Prize in 1914. Most gemmologists know the theory of diffraction pattern by x-ray beams. The radial and concentric structure of natural pearl provides six-spot hexagonal patterns from the thin overlapping platelets of aragonite bonded with conchiolin which form the basic structure of the pearls. The layered bonded structure of the mother of pearl bead nucleus in a cultured pearl provides a four-spot pattern in one particular direction. Thus the value of the Laue method for non-drilled or part-drilled pearls. Although we take lauegrams and radiographs of pearls as *routine* we still feel quite a fascination when watching the results emerge in the developing dish. Whilst the x-ray beam does the penetration and the developer and fixer play their parts, it is the interpretation of the film and its content (or lack thereof) which counts. Usually cultured pearl necklace radiographs are easy, because of the regimentation of regularity of nuclei.

The interpretation of a fine quality natural pearl necklace is much less obvious and less rewarding. This is because fine structures regularly developed with no interruption causing conchiolin flow on a coarse growth show little or no positive signs. In fact it is sometimes this *lack* of structure (like the fine quality of the drill holes meeting at the centre) which indicates—but does not prove—a natural pearl.

Pearls like diamonds look alike until you come to examine them. Routine testing therefore is never dull, though it can be tedious when testing individual pearls of less than one grain size (4 grains = 1 carat). The 10× lens is in constant use probing into drill holes and still more in examining radiograph pictures held in front of a 60-watt bench lamp. In the dark-room, as the broad outlines emerge during developing, one gets a general idea or feeling, but it is not until a little later after washing, fixing and washing again, that full close-up details can be examined.

Recently we tested a drop-shape pearl mounted as a stick-pin. Its shape indicated that it should prove to be a natural pearl; I took a radiograph of it expecting to see one or two overlapping arc structures, a pip nucleus possibly and outer lines following roughly the perimeter of the shape. In the dark-room only the basic outline could be seen. I left the negative to fix and carried on with other items. One good point about x-ray work is that exposure-time or fixing and washing does not impose restrictions, to the exclusion of other testing. Later, sitting with a 60-watt bench lamp and a 10× lens, I began the inspection of a small batch of negatives which were part of the pearl input that morning. They were run-of-the-mill stuff seen on any gem-testing day (except the drop-shape pearl pin). This had a most unusual structure, one that I had never seen before and equally difficult to describe or to reproduce in the *Journal.* The drop shape had one or two line structures following the outer perimeter. Circular in pattern in the centre was a series of regularly irregular dots or small patches, which looked like pewter hammering or the patterns seen on a missel thrush (see Figure 1). The pattern intrigued me. I showed it to Alan Jobbins, of the Institute of Geological Sciences. He thought it could be a variety of foraminifera. His colleagues thought the structure could be a form of foraminifera termed *Gypsina,* sometimes *Stereo-gypsina,* which

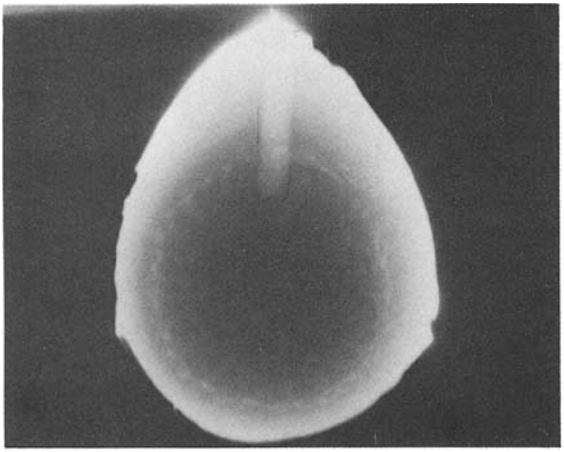

FIG. 1. 'Foraminifera *Stereo-gypsina*'. (Positive print)

has a calcareous skeleton with a complex internal structure. The small intruder is found in warm shallow tropical waters.

To add a little mystery to what should have been a routine pearl testing job, the pearl fluoresced mildly under x-ray excitation. Natural sea-water pearls do not fluoresce; fresh-water pearls do fluoresce, but our pearl did not have sufficient fluorescence to really fit into a fresh-water bracket. It did occur to me that oyster beds could possibly be found in wide estuaries of tidal rivers thus producing some fluorescence from trace manganese? Unusually for us we did a density of our pearl and found it to be 2.684-2.689. We found it gained fractionally and believe in some manner it was slightly absorbent or porous. Unfortunately the pearl had to be returned to the customer (they can be very possessive!). It is intriguing to consider that someone somewhere is wearing a *Stereo-gypsina* stick-pin or maybe it is now a pearl pendant, and they will never know what this 'gem of purest ray serene' has hidden in its unfathomed depths!

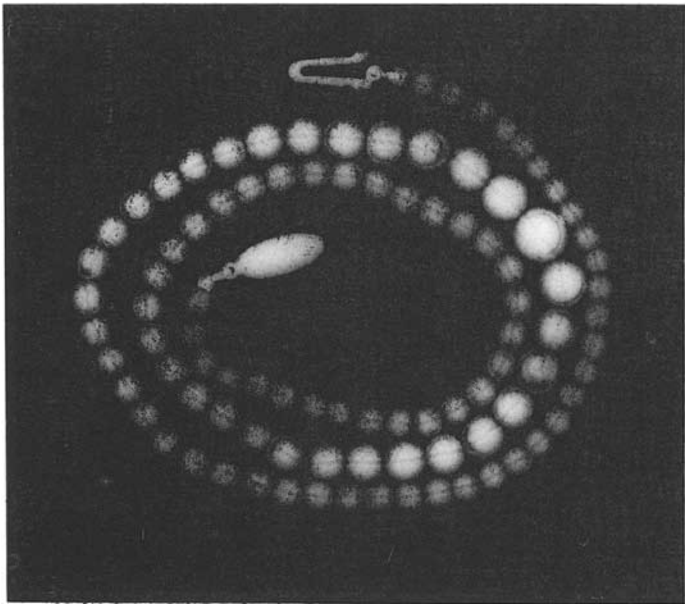

FIG. 2. An easy to spot cultured pearl necklace.

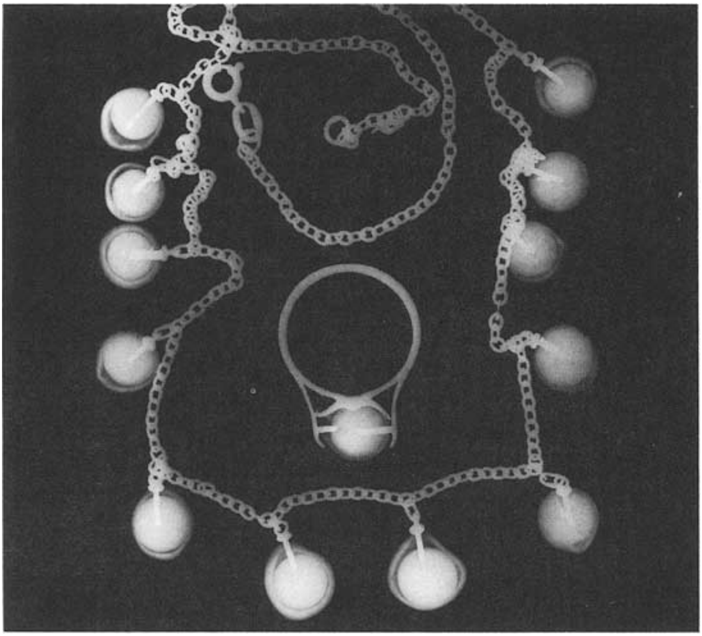

FIG. 3. Cultured (baroque shape) pearls on necklace and ring.

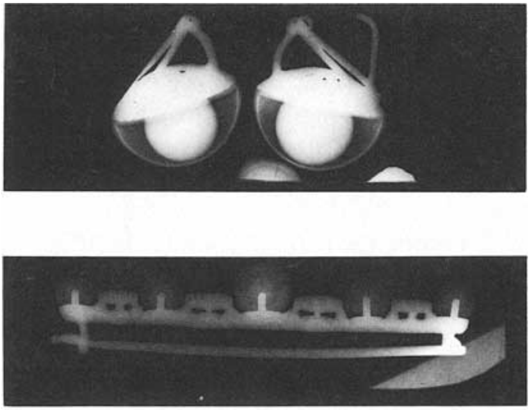

FIG. 4. Above: a pair of cultured blister-pearl ear-rings. Below: five natural pearls and four diamonds (transparent to x-rays) on a bar brooch.

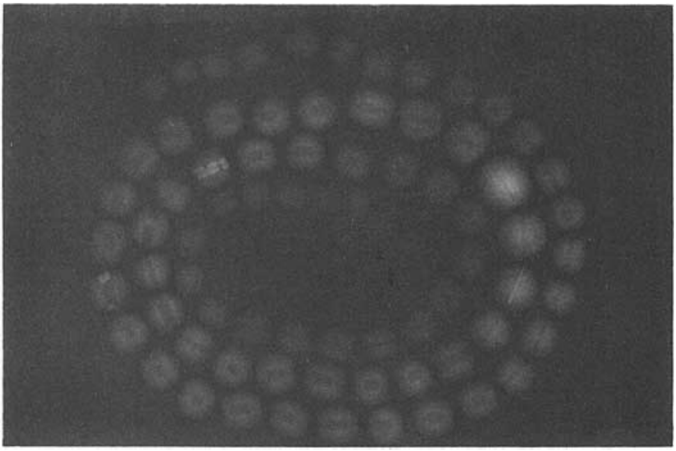

FIG. 5. Worn drill-holes in pearls plugged with m.o.p. and small glass beads.

Inclusions portrayed by x-ray method, i.e. radiographs, can be very interesting. The negatives illustrated (Figures 2-6) with their captions give some examples of the variety in this aspect of gemmology.

If readers feel we have had quite a few pearl articles in the *Journal* recently it *may* be due to bunching in the editorial pipeline.* It is due in part to the resurrected interest in pearls by the trade. It is equally due to the fact that pearls and pearl testing are a major feature in our daily routine and provide our bread and butter.

Continuing along the path of pearl testing brings to mind an allied subject—shell cameos. Most of us know a shell cameo when we see one and equally we all know it is basically our old friend calcium carbonate. Shell cameos are usually white/brown or white/pink as a basis. It was not until I had to answer a customer enquiring for the G.A. that I really looked at and into the structure of a shell cameo. The customer was asking intelligent questions on

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*It isn't!—Ed.

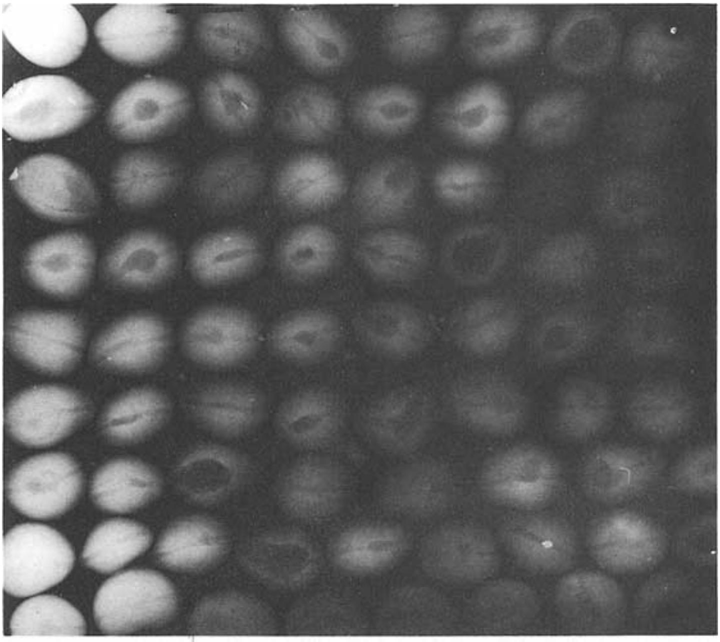

FIG. 6. Non-nucleated cultured pearls (non-phosphorescent—sea-water oyster).

shell cameo *doublets.* I have seen possibly as wide a range of doublets as any gemmologist, from glass on glass (two widely different RI readings) through all the G.T.D.s, soudé 'emeralds', spinel doublets, diamond on synthetic sapphire doublets, sapphire on synthetic ruby doublets, all the versions of opal doublets, beryl on beryl doublets and some I have forgotten, but never shell cameo doublets. The enquirer had noted the different directional structures in some shell cameos, but he couldn't find demarcation lines, bubble layers, etc. Neither could I. Neither had I seriously studied the structure of shell cameos, until this query arrived. When I did so, I was intrigued to find that there were what appeared to be definitely different directional structures in the colour layers carried in some of the cameos I had borrowed. Not that they were doublets, for it would indeed be a skill to superimpose one concave structure upon another!

[*Manuscript received 20th February, 1980.*]

ANDERSON ON HEAVY LIQUIDS

By R. KEITH MITCHELL, F.G.A.

This paper is based on a series of articles, published in the *Retail Jeweller* in 1979 under various titles,* which is important in that it gives a detailed picture of the very precise work that was done with heavy liquids over a very long period of research in the London Chamber of Commerce Laboratory. At the author's suggestion I have attempted to summarize these in order to put the most important of the collected facts on permanent record in this *Journal.*

Mr Anderson, trained as a chemist, with strong mineralogical leanings, was largely responsible for the rationalization of the use of heavy liquids in gemmology. As Director of the Laboratory in 1925 he was primarily concerned with pearl testing, since this was at the height of the cultured pearl 'invasion' which was devastating the trade in oriental pearls.

Using bromoform in various dilutions with monobromonaphthalene to cover the range 2.70 to 2.76, it was found that cultured pearls (SG 2.72-2.78) were almost always perceptibly denser than were oriental pearls (SG 2.68-2.74, av. 2.71) from the Persian Gulf—the main source in those days. This was due to the high density of the Mississippi mussel shell used for the large nucleus in the cultivated pearl. A specially made and very sensitive hydrometer, reading from 2.50 to 3.00, was used to check the densities of the liquids accurately.

Many years later (1946) Robert Webster, having recently joined the Laboratory, carried out a similar series of tests on the normally very obvious imitation pearls which, by an extraordinary coincidence, was later to provide valuable evidence leading to the conviction for murder of the psychopath Neville Heath. Mr Anderson records that a C.I.D. man was susceptible to the fumes from the liquids used and sought fresh air at an open window.

The depression following the Wall Street financial crash in 1929 had repercussions within the laboratory, which had now

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*See Abstract on p.259 below.—Ed.

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acquired the services of C. J. Payne, and the exceedingly busy pearl testing, which had kept them fully occupied for several years, slowed considerably. By degrees the work was extended to cover the testing of corundums, since synthetic rubies and sapphires were being used to a disconcerting extent in otherwise fine jewellery.

There was now time for study and research, which resulted in improvements in refractometry (the 1.81 contact liquid, spinel, blende and diamond refractometers), and the recognition that absorption spectra were to provide a powerful third leg to the microscope/refractometer combination of instruments so far relied upon.

The author admits that in those early days they were still essentially 'innocents', assuming without question that all textbook constants were substantially reliable.

The rude awakening came in 1934, when a fine lapis lazuli necklace failed to fit within the 2.38 to 2.45 density range quoted in all standard textbooks then current. Further tests on other lapis—some 500 pieces in all—using pure bromoform, or in various dilutions, showed that 95% fell between 2.75 and 2.90. Never before had Anderson found recorded data so far out, and he researched earlier literature for the reason. After much reading he found that before Breithaupt's *Handbuch der Mineralogie* was published in 1847 the values quoted were generally within the higher range. But Breithaupt had worked on quite pure 'lazurstein' (lazurite) to obtain a figure of 2.406 and thus arrived at a range of 2.38 to 2.42, ignoring the calcite, pyrite and amphibole, all denser minerals, which are also present in the rock we know as lapis lazuli. Other authoritative textbooks copied Breithaupt's figures without query.

This fundamental textbook 'error' started a prolonged investigation of all gem densities which eventually resulted in a general narrowing of the range of values for the comparatively pure gem varieties, from the broader ranges applicable to the less pure specimens of the mineralogical field. The results were published in 1939 and incorporated, with much other work from this author and his colleague, in the greatly revised 1940 edition of Herbert Smith's *Gemstones.*

A third article outlines the history of the search for convenient heavy liquids since Sonstadt's Solution in 1874. Most of the results were impractical, obnoxious, expensive, usually quite poisonous, and fell into disuse for these reasons.

Methylene iodide, CH_2I_2, provides the exception and is, to this day, the most valuable of the available gemmological liquids, both for its high SG (3.33) and for its RI (1.742). Its pungent smell is acceptable to most and a delight to the dedicated gemmologist!

This liquid was used in a considerable research which culminated in the finding of the first recognized kornerupine from what was then known as Ceylon. Since then many more specimens of this still rare mineral have been found in Ceylon and other localities. Cat's-eye kornerupine was found and marketed in quantity in 1975, again in Sri Lanka (Ceylon).

Clerici's discovery, in 1907,* of the aqueous solution of thallium malonate and formate, which gave a density, at room temperature, of 4.15, had apparently gone unnoticed by the gemmological world. Anderson chanced upon it and, realizing the tremendous value of a liquid as dense as this, introduced it in teaching and eventually in examinations. It still had the disadvantages of the earlier organic acqueous solutions, being expensive, corrosive, highly poisonous and, disastrously, non-miscible with the other, oily, heavy liquids. The latter factor made its use in examinations difficult and it was eventually dropped as a teaching liquid. Its usefulness in laboratory work remained and it was used, among other work, in the eventual investigation of the dense zinc-rich spinel now known as gahnospinel.

It was with this liquid that the straight-line graph relationship between the RI and SG of progressive solutions had been established. This was to be shown to apply equally to mixtures and dilutions of the oily liquids.

In all cases heavy liquid determinations of mineral densities are very accurate, provided that dilutions are carried out to the point of exact suspension. The method is slower than hydrostatic weighing, and can be expensive, but it suffers from none of the inherent inexactitudes which beset the latter, especially when dealing with small specimens. Larger specimens are more difficult only because they require more of the expensive liquids. They are less affected by the snags of hydrostatic weighing and can usually be tested best in this way.

Mr Anderson also recalls the very useful work which was done

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*'Preparazione di liquidi per la separazione dei minerali', *Rend. Acad. Lincei, Roma,* **XVI**, 187-95, 1907.—Ed.

on accurate RI determinations at this period, using a Beck table spectrometer and, earlier, an Abbe-Pulfrich refractometer.

The next paper deals with the use of indicators to ensure that the accuracy of the various liquids is maintained. Glass indicators of exact known density were eventually perfected by Rayner. But it was in the course of earlier work on gem mineral densities that it was realized that certain gems with simple chemical compositions were quite remarkably constant in their specific gravities. Quartz, calcite, fluorspar, diamond and corundum were some of the more obvious ones, but their exact densities needed to be obtained primarily by hydrostatic weighing. In the course of this the condition of the balance and indeed the accuracy of the weights themselves were checked with scientific thoroughness.

The question of obtaining a liquid of low surface tension was also a problem and ultimately ethylene dibromide was considered most suitable. Unfortunately this is now suspect as a possible carcinogen.* An improvement in the use of water (high surface-tension) was to boil it, removing dissolved air, and add liquid detergent in small amount. This lowered the surface tension substantially.

For greater accuracy the temperature of the water was taken and the result of the hydrostatic calculation multiplied by the known density of water at that temperature. With other liquids, such as toluene or ethylene dibromide, the fluctuation of density with temperature is far greater and such corrections are always essential.

This paper emphasizes the need to check research against relevant literature and ends with an introduction to the joys of the old Patent Office Library (now part of the British Library and less easy to use since part of the section relating to 'earth sciences' is now in Bayswater).

A further paper records early investigation of densities by a French team which had perfect cubes of quartz made and checked against the cadmium emission line at 6438.4696Å, giving accuracy to one part in half a million. Their result, when reduced to four places of decimals, was 2.6507, a figure varying only slightly in the fourth place from those obtained by Anderson and Payne by far simpler methods. It is noted that amethyst (2.647) is fractionally lower in density than rock-crystal.

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*See J.Gemm., 1979, XVI (6), 429.—Ed.

The advent of Chatham's first commercially viable synthetic emeralds caused considerable concern in the gem trade. But it was found that a bromoform liquid diluted to suspend quartz almost exactly matched the synthetic emeralds, while all natural emeralds were denser and sank in this liquid. There was a great advantage in using this method to discriminate between unmounted parcels of synthetic and natural stones since it worked equally well with stones down to the smallest size. The same accuracy could never be obtained by hydrostatic weighing.

A mention is made of a series of experiments by R. W. Yeo, published in the first issue of the *Gemmologist* in 1931, a paper which the present writer remembers well. Yeo used various dilutions and also a diffusion column to establish differences in SG of beryls and tourmalines of various colours. Anderson points out that in the case of beryl the fluctuations in density are due to the presence of alkali metals which have little effect on the colour.

Calcite (2.71), another of the very constant indicator minerals, is only slightly higher than quartz (2.651), but the two together provide a most delicate pair of indicators to regulate bromoform diluted to identify synthetic emeralds.

Next in the ascending scale of constant density minerals is fluorite (3.182) with its anomalously low RI (1.434), due to the influence of fluorine.

Finally, with a note that jadeite (3.33) almost exactly matches methylene iodide (3.34) in density, we come to diamond (3.515), which, with Clerici solution diluted to an exact match, provides a useful top liquid. Another at 3.99 with synthetic corundum could also be useful. But both these latter require the use of the rather messy and unpleasant Clerici solution.

The last of these absorbingly interesting papers summarizes the uses of heavy liquids in testing, underlining again their extreme accuracy when used with proper care. The reader is advised on methods of use, some of which help to eliminate the long and tedious business of retrieving stones individually from a liquid.

As a parting shot the author describes the delight he found in testing pressed amber in the cheapest, cleanest and most simple of all 'heavy' liquids—a solution of salt in water. Such treated amber (1.06) is fractionally less dense than natural amber of similar clarity, and this fact can be proved beyond doubt by this method while hydrostatic weighing could hardly be sufficiently accurate even with large specimens.

While hoping that I have adequately given the gist of this series of papers, I acknowledge that I may have been unable to convey the quite fascinating dedication of Mr Anderson's own version. His total knowledge of his subject is enhanced by the ability to write brilliantly and with great clarity of his personal experiences over so many years.

[*Manuscript received 28th March, revised June, 1980.*]

ADDITIONAL AND CORROBORATIVE DATA ON VIOLET GEM SCAPOLITE PROBABLY FROM EASTERN AFRICA

By BRIAN JACKSON, F.G.A.

Department of Geology, The Royal Scottish Museum, Edinburgh

INTRODUCTION

The composition of gem scapolite has been the subject of papers in this and other journals but of particular interest has been the discovery of violet gem scapolite (from Kenya?) with unusually low refractive indices and density. These low values are indicative of a high sodium content, the scapolite therefore tending towards the sodium end member marialite. Pure marialite is only known in synthesized material but this new violet scapolite represents the highest sodium content so far recorded in natural scapolite giving a marialite component of 89.2% (Zwaan 1979).

PROPERTIES

Four small cut stones of approximately 0.5 ct each were purchased from the Gemmological Association of Great Britain.

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One of these was broken, and part was used for electron probe microanalysis, the remainder being used for conventional bulk analysis of Na_2O and SiO_2, by rock methods, scaled down to suit the sample size. Table 1 shows the average of five probe analyses with corroborative Atomic Absorption Spectroscopy and absorptiometric analysis for Na_2O and SiO_2 respectively.

TABLE 1

				Number of ions on the basis of 24(0)
		ox%	*el%*	
SiO_2		61.6	28.8	8.213
Al_2O_3		19.64	20.4	3.086
FeO		0.1	0.08	0.111
CaO		1.56	1.1	0.223
SrO		0.56	0.48	0.043
MgO		0.00	0.00	0.00
Na_2O		12.9	9.57	3.334
K_2O		0.79	0.66	0.028
Cl		4.36	4.36	0.985
SO_3		0.00	0.00	0.00
		101.51		
	O = Cl	0.98		
	Total	100.53		

The marialite content of this sample on the basis of

$$\frac{Na}{Na + Ca}$$

as calculated by Zwaan is 93.7%. In this sample, because of the significant minor element substitution for these major constituents the above calculation can be more accurately represented as

$$\frac{(Na + K)}{(Na + K) + (Ca + Fe + Sr)}$$

which gives a marialite content of 89.9%.

The refractive indices were measured on a Rayner Dialdex refractometer and the results obtained (Table 2) corroborated the analytical results when plotted on the approximately linear graph relating chemical composition and mean RI and birefringence

(Deer *et al.* 1963) giving results of 95.3% Ma and 85.5% Ma respectively (uncertainty value ±6.5%).

TABLE 2

Specimen number	ε	ω	*DR*
RSM GY 1979.7.1	1.536	1.541	0.005
RSM GY 1979.7.2	1.536	1.540	0.004
—	1.530	1.540	0.01

The stones all exhibited strong dichroism, varying from a violet colour parallel to the *c* axis to almost colourless perpendicular to the *c* axis. The majority of stones are therefore cut with the table facet more or less at right angles to the *c* axis. This orientation can easily be checked if the stone contains long fine straight tube-like inclusions, as these align themselves parallel to the *c* axis. All stones examined showed these inclusions which sometimes broadened out into what looked more like incipient cleavages (Figure 1).

Establishing the direction of the *c* axis, which for tetragonal minerals is the same as the optic axis, meant that a uniaxial optic

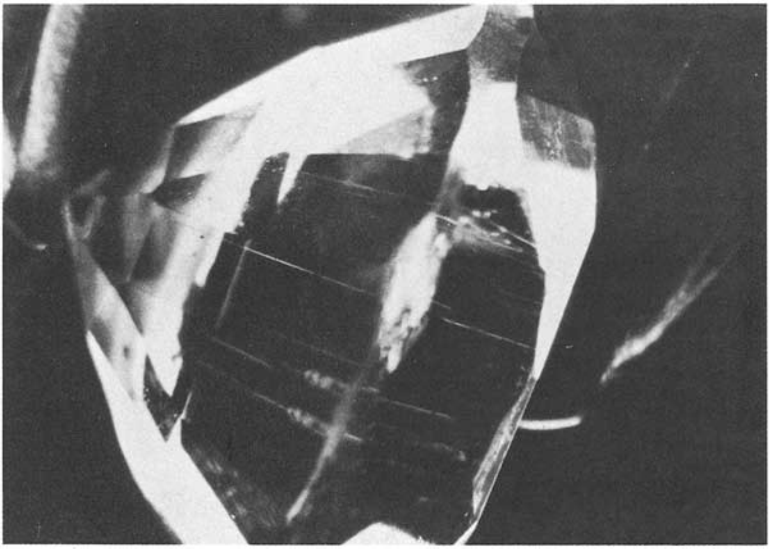

FIG. 1. Inclusions at right angles to the table facet.

axis figure could be obtained using crossed polars and a conoscopic lens. This was very useful in determining the optic sign (−ve) using a quartz wedge or accessory plate. In this orientation stones when rotated through 360° between crossed polars remain dark as the optic axis is a direction of single refraction.

The specific gravity was determined using three stones as a bulk sample. This was to reduce the % error incurred when determining the SG of small stones using the hydrostatic method. Toluene was the liquid used so as to reduce the % error further. The resultant SG of 2.65 also conformed to the trend of reducing SG with increasing sodium content, although this is a less reliable guide to composition because of the complex ionic substitution.

CONCLUSION

Although these stones could be confused with amethyst on the basis of their closely aligned colour and properties, the fact that the orientation of the *c* (optic) axis in the stone can be easily determined makes it a simple matter to determine the optic sign and thus distinguish scapolite (−ve) from amethyst (+ve). However it should be borne in mind, that extrapolation of the relationship of composition against ε and ω (Winchell 1924) indicates that at approximately 90% Ma the scapolite would be isotropic and that pure marialite would be optically positive. The trend is certainly in that direction but this optical sign inversion would not compound the similarity with amethyst for the refractive indices of approximately ε 1.533 and ω 1.528 for pure marialite are much lower than those of quartz.

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[*Manuscript received 14th December, 1979.*]

COMPUTER-AIDED GEM IDENTIFICATION

By PETER READ, C.Eng., M.I.E.E., M.I.E.R.E., F.G.A.

At the end of a talk I gave to the Gemmological Association in 1978 (on the subject of new gemmological instruments and techniques,[1] I referred to the possibility of using a low-cost home computer as a diagnostic aid for gem testing. Although the general use of such an aid may not yet be justified, my own experience in computer programming tempted me to prove the viability of the idea. This article describes and evaluates two 'Gem Data' computer programs which I developed to explore the usefulness of the technique.

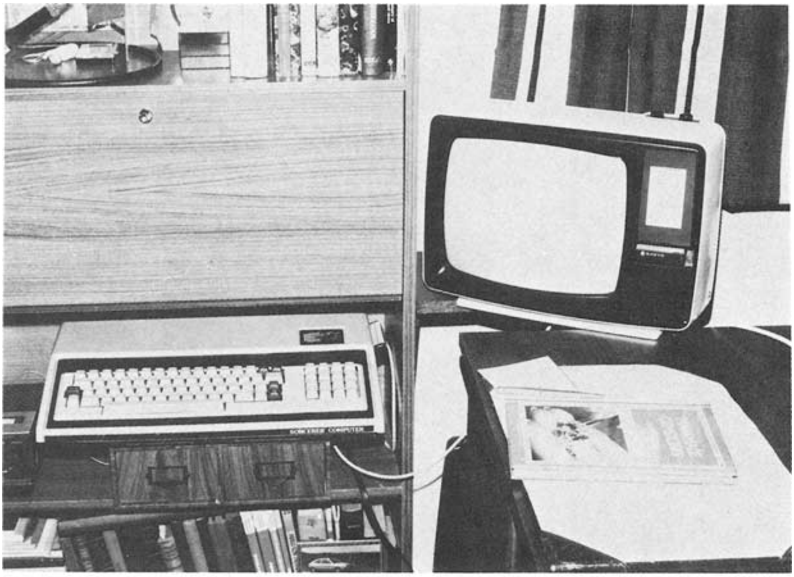

FIG. 1. The author's installation. On the left of the computer is a small domestic tape recorder which is used to feed in the GEM DATA programs.

Computers have already been employed in gemmological research work for handling and assessing test data from

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[1] Read, P. G. New Gemmological Instruments and Techniques, *J. Gemm.*, 1979, **XVI** (6), 386-407.

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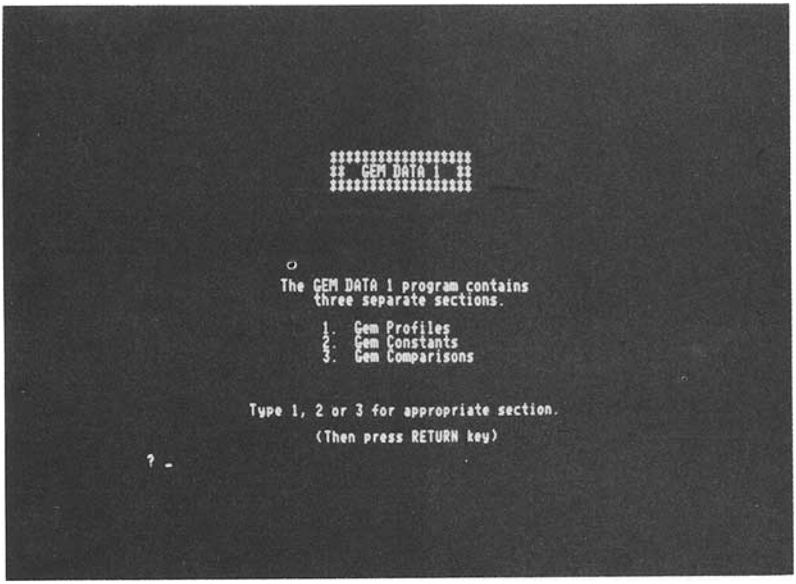


```
                 *******************
                 **  GEM DATA 1  **
                 *******************

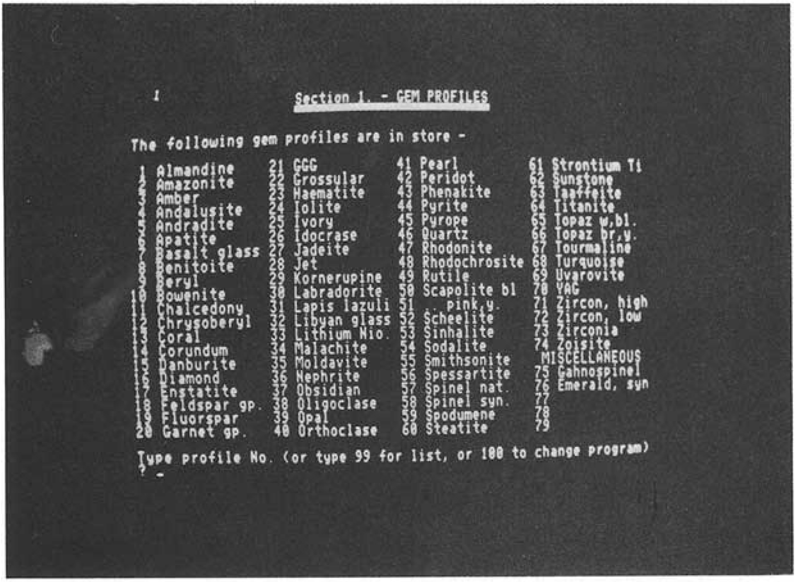

          The GEM DATA 1 program contains
              three separate sections.

                  1.  Gem Profiles
                  2.  Gem Constants
                  3.  Gem Comparisons


      Type 1, 2 or 3 for appropriate section.
            (Then press RETURN key)

 ? -
```

FIG. 2. Title 'page' of the GEM DATA 1 program which contains gem profiles and tables of constants.



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 1                Section 1. - GEM PROFILES

The following gem profiles are in store -
 1 Almandine     21 GGG           41 Pearl          61 Strontium Ti
 2 Amazonite     22 Grossular     42 Peridot        62 Sunstone
 3 Amber         23 Haematite     43 Phenakite      63 Taaffeite
 4 Andalusite    24 Iolite        44 Pyrite         64 Titanite
 5 Andradite     25 Ivory         45 Pyrope         65 Topaz w,bl.
 6 Apatite       26 Idocrase      46 Quartz         66 Topaz br,y.
 7 Basalt glass  27 Jadeite       47 Rhodonite      67 Tourmaline
 8 Benitoite     28 Jet           48 Rhodochrosite  68 Turquoise
 9 Beryl         29 Kornerupine   49 Rutile         69 Uvarovite
10 Bowenite      30 Labradorite   50 Scapolite bl   70 YAG
11 Chalcedony    31 Lapis lazuli  51 .. pink,y.     71 Zircon, high
12 Chrysoberyl   32 Libyan glass  52 Scheelite      72 Zircon, low
13 Coral         33 Lithium Nio.  53 Sinhalite      73 Zirconia
14 Corundum      34 Malachite     54 Sodalite       74 Zoisite
15 Danburite     35 Moldavite     55 Smithsonite     MISCELLANEOUS
16 Diamond       36 Nephrite      56 Spessartite    75 Gahnospinel
17 Enstatite     37 Obsidian      57 Spinel nat.    76 Emerald, syn
18 Feldspar gp.  38 Oligoclase    58 Spinel syn.    77
19 Fluorspar     39 Opal          59 Spodumene      78
20 Garnet gp.    40 Orthoclase    60 Steatite       79
Type profile No. (or type 99 for list, or 100 to change program)
? -
```

FIG. 3. The index listing the gem profiles held in memory.

instruments such as the electron microprobe.[2,3] However, it was not until the development of the microprocessor that relatively inexpensive and compact computers became available for more general use. This has made the bulk storage of gemstone data economically possible and has provided a practical means of retrieving these data in the most convenient formats for gem identification purposes.

The two programs I have written are intended for use in a small desk top computer,[4] the data input and output being displayed on a video monitor consisting, for reasons of economy, of a modified black-and-white television receiver (Figure 1). The first program is basically a data bank of gem constants and characteristics, while the second one is an interactive version which prints out identifications from keyed-in test figures.

The data bank program, which I call GEM DATA 1, contains three separate sections (Figure 2). The first of these consists of 'Gem Profiles' and contains a numbered index of over seventy gem species or materials (this number being limited only by the size of the existing built-in computer memory). In a manner similar to that used in the 'Viewdata' service, the index can be used to select and display pages of information on individual gemstones by simply keying in the appropriate reference number (Figure 3).

The page of information displayed for each gem species or material commences with a single-line specification giving the refractive index, double refraction, dispersion, specific gravity and hardness. The display then lists the chemical formula, crystal system, optical character and optic sign for the selected gem. This is followed by information on the gem's lustre and cleavage, and by details of its various colour varieties. Finally, where relevant, the gem's pleochroism is listed (Figures 4, 5, 6). Information on absorption spectra, luminescence, habit, occurrence and sources has been omitted so that the program can be contained within the capacity of the existing computer memory. However, these can easily be added as the system is expanded.

The second section of the GEM DATA 1 program contains eight pages of gem constants arranged in tabular form (RI, DR, Disp.,

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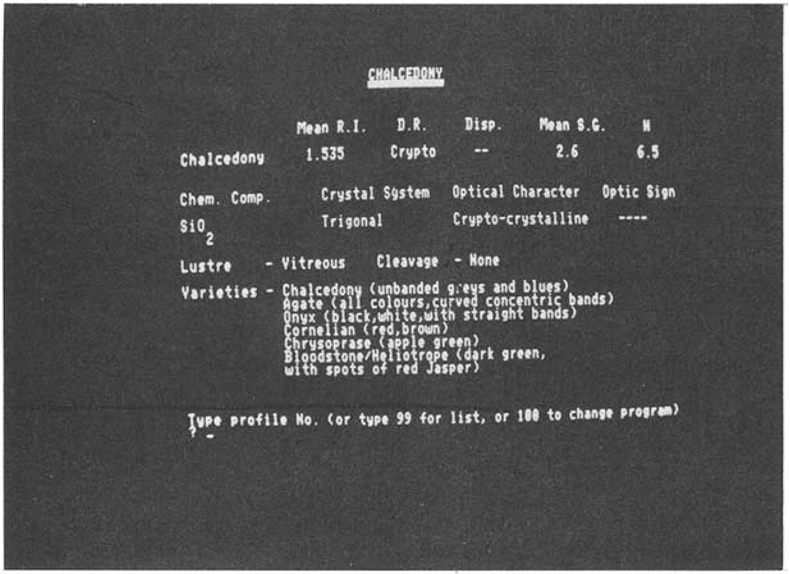
[2] Dunn, P. J. The use of the Electron Microprobe in Gemmology, *J. Gemm.*, 1977, XV (5), 248-58.

[3] Rucklidge, J. and Gasparrini, E. L. Specifications of a Computer Program for Processing Electron Microprobe Analytical Data, 1969, EMPADR VII, Dept. Geology, Toronto University, 1-37.

[4] Exidy 'Sorcerer', with 32k of RAM and 8k of ROM plug-in language (Standard Basic).



```
                         CHALCEDONY

              Mean R.I.    D.R.     Disp.     Mean S.G.     H
Chalcedony     1.535      Crypto     --          2.6       6.5

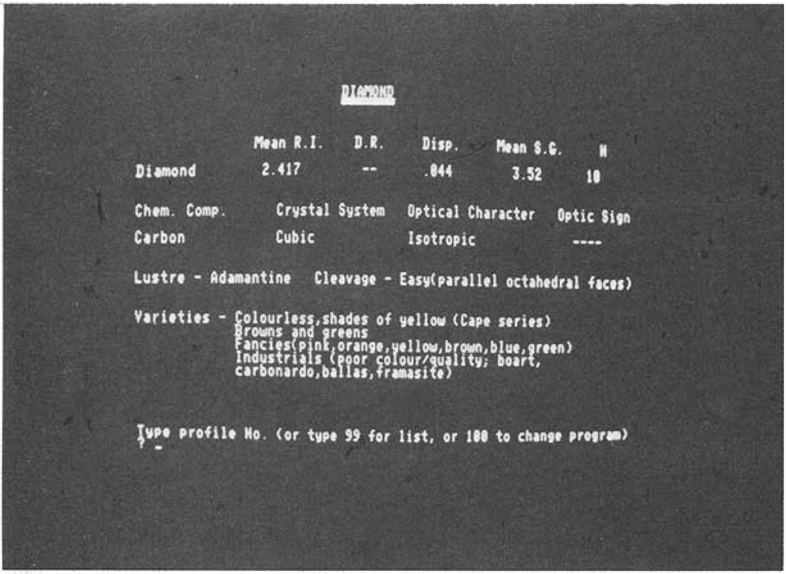
Chem. Comp.       Crystal System   Optical Character   Optic Sign
SiO               Trigonal         Crypto-crystalline    ----
   2

Lustre     - Vitreous    Cleavage  - None

Varieties - Chalcedony (unbanded greys and blues)
            Agate (all colours,curved concentric bands)
            Onyx (black,white,with straight bands)
            Cornelian (red,brown)
            Chrysoprase (apple green)
            Bloodstone/Heliotrope (dark green,
            with spots of red Jasper)

Type profile No. (or type 99 for list, or 100 to change program)
? -
```

FIG. 4. The gem profile for chalcedony.



```
                          DIAMOND

              Mean R.I.    D.R.     Disp.    Mean S.G.    H
Diamond        2.417        --       .044       3.52      10

Chem. Comp.       Crystal System   Optical Character   Optic Sign
Carbon            Cubic            Isotropic             ----

Lustre - Adamantine   Cleavage - Easy(parallel octahedral faces)

Varieties - Colourless,shades of yellow (Cape series)
            Browns and greens
            Fancies(pink,orange,yellow,brown,blue,green)
            Industrials (poor colour/quality; boart,
            carbonardo,ballas,framasite)

Type profile No. (or type 99 for list, or 100 to change program)
? -
```

FIG. 5. The gem profile for diamond.

SG, H.). The first four pages list the gems in alphabetical order (Figure 7), while the remaining four pages list them in ascending order of refractive index (Figure 8). The third and final section of the program enables single-line gem specifications to be selected from the gem index and displayed adjacent to each other for comparison purposes (Figure 9).

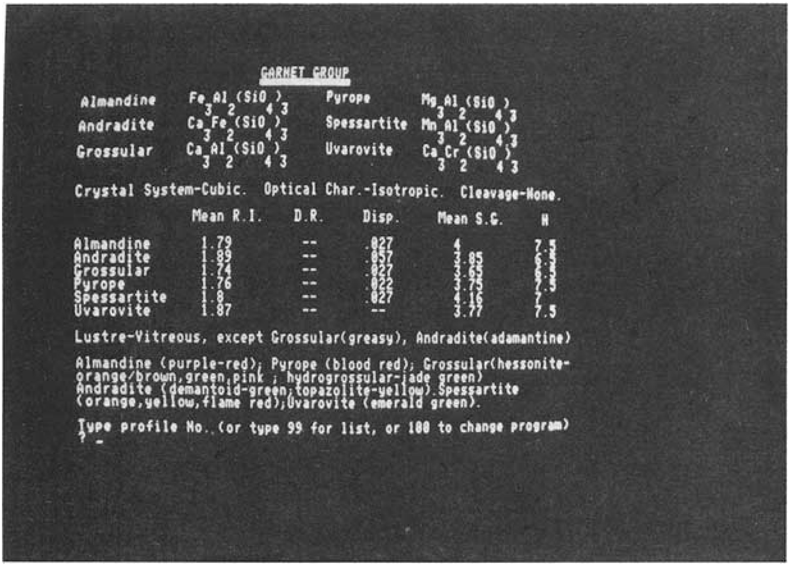
The second computer program, called GEM DATA 2, is a diagnostic one, and helps to identify a gemstone under test by matching its measured constants (fed in via the keyboard) with data contained in lists of gem constants held in the computer memory (Figure 10). When this program is in use, the computer requests, in sequence, the values of the gem's mean *refractive index, double refraction* and *specific gravity* (Figure 11).

Where it is not possible, for instance, to obtain a reading for refractive index, a '9' is keyed in (Figure 12), and this instructs the program to bypass its lists of RI constants. If it is only possible to detect that the gem is singly-refractive, doubly-refractive or cryptocrystalline (by means of a polariscope), then a '0', a '1' or a '9' is keyed in respectively when the computer requests the value of double refraction. Similarly, if no value is available for specific gravity (e.g. when the gem is mounted) then a '9' is keyed in when the computer requests this value.

Finally, to allow for variations in test measurements, and to accommodate the normal spread of values caused by impurities in the gem, a choice of two 'search tolerance' limits is available. Selection of the appropriate limit is made in response to the computer's request *'Choose Search Limit (type 1 for narrow, 2 for wide)'*. The *narrow* search (input 1) matches the keyed-in data against the stored data over the tolerance limits of ±0.005 for RI, ±0.002 for DR, and ±0.01 for SG. The *wide* search limit broadens these limits to ±0.01, ±0.004 and ±0.03 respectively. Some gem materials such as glass, 'intermediate' zircon and 'low' or metamict zircon have much wider ranges of RI and SG values than are catered for in the search limits, and these are allowed for by means of individual data 'filters' in the program.

If, during a narrow search, the computer is unable to find a match between the keyed-in data and the data in its memory, it will print out the following message:

> *'For narrow search limits, no match has been found with any gem held in memory. Try wide search limits'.*



```
                    GARNET GROUP
Almandine   Fe Al (SiO )       Pyrope       Mg Al (SiO )
              3  2    4 3                     3  2    4 3
Andradite   Ca Fe (SiO )       Spessartite  Mn Al (SiO )
              3  2    4 3                     3  2    4 3
Grossular   Ca Al (SiO )       Uvarovite    Ca Cr (SiO )
              3  2    4 3                     3  2    4 3

Crystal System-Cubic.  Optical Char.-Isotropic.  Cleavage-None.

              Mean R.I.     D.R.     Disp.     Mean S.G.     H

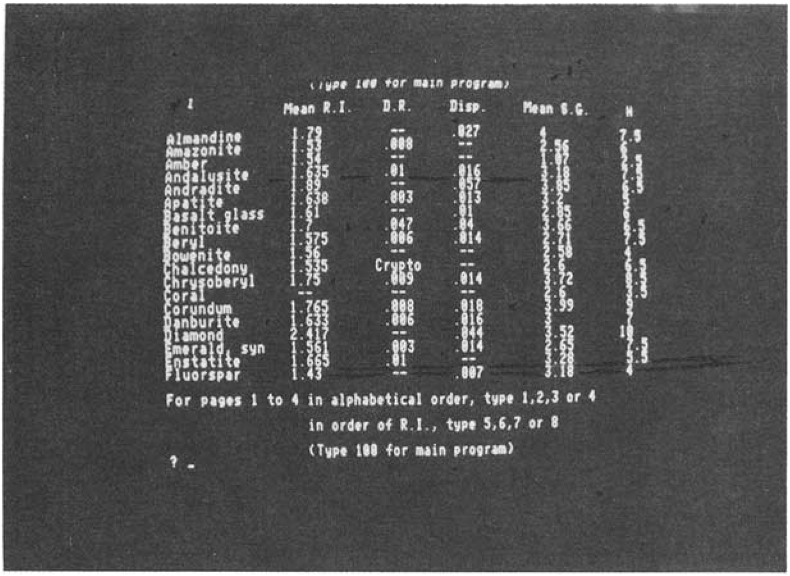
Almandine       1.79         --      .027        4          7.5
Andradite       1.89         --      .057        3.85       6.5
Grossular       1.74         --      .027        3.65       6.5
Pyrope          1.76         --      .022        3.75       7.5
Spessartite     1.8          --      .027        4.16       7
Uvarovite       1.87         --       --         3.77       7.5

Lustre-Vitreous, except Grossular(greasy), Andradite(adamantine)

Almandine (purple-red); Pyrope (blood red); Grossular(hessonite-
orange/brown,green,pink ; hydrogrossular-jade green)
Andradite (demantoid-green;topazolite-yellow).Spessartite
(orange,yellow,flame red);Uvarovite (emerald green).

Type profile No..(or type 99 for list, or 100 to change program)
? _
```

FIG. 6. The gem profile for the garnet group.



```
                  (type 100 for main program)
 1
               Mean R.I.     D.R.      Disp.      Mean S.G.     H

Almandine        1.79         --       .027         4          7.5
Amazonite        1.53        .008       --          2.56       6
Amber            1.54         --        --          1.07       2.5
Andalusite       1.635       .01       .016         3.18       7.5
Andradite        1.89         --       .057         3.85       6.5
Apatite          1.638       .003      .013         3.2        5
Basalt glass     1.61         --       .01          2.85       6
Benitoite        1.7         .047      .04          3.66       6.5
Beryl            1.575       .006      .014         2.71       7.5
Bowenite         1.56         --        --          2.58       4
Chalcedony       1.535      Crypto      --          2.6        6.5
Chrysoberyl      1.75        .009      .014         3.72       8.5
Coral             --          --        --          2.6        3.5
Corundum         1.765       .008      .018         3.99       9
Danburite        1.633       .006      .016         3          7
Diamond          2.417        --       .044         3.52      10
Emerald, syn     1.561       .003      .014         2.65       7.5
Enstatite        1.665       .01        --          3.28       5.5
Fluorspar        1.43         --       .007         3.18       4

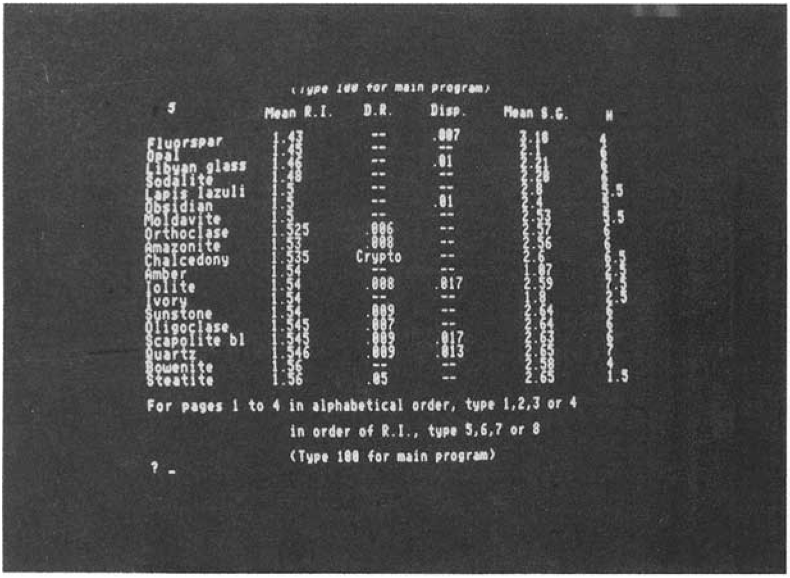
For pages 1 to 4 in alphabetical order, type 1,2,3 or 4

            in order of R.I., type 5,6,7 or 8

            (Type 100 for main program)

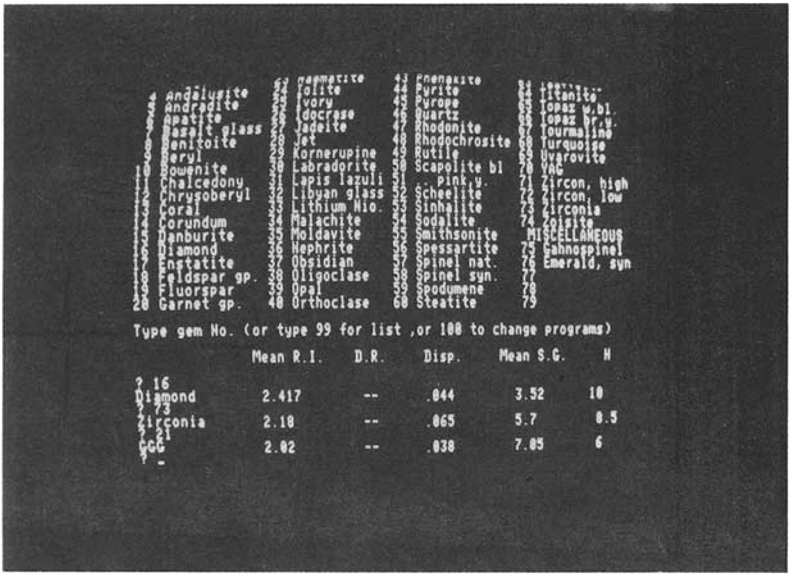
? _
```

FIG. 7. The first of four pages of tabular information in alphabetical order of the gemstones.



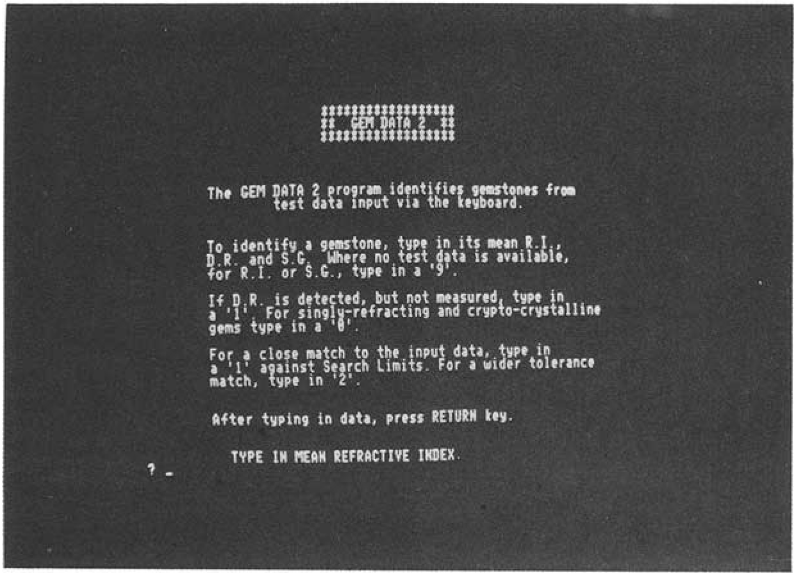
```
              (Type 100 for main program)
  5             Mean R.I.    D.R.     Disp.     Mean S.G.     H
Fluorspar        1.43         --       .007       3.18        4
Opal             1.45         --       --         2.1         6
Libyan glass     1.46         --       .01        2.21        6
Sodalite         1.48         --       --         2.28        5
Lapis lazuli     1.5          --       --         2.8         5.5
Obsidian         1.5          --       .01        2.4         5
Moldavite        1.5          --       --         2.53        5.5
Orthoclase       1.525       .006      --         2.57        6
Amazonite        1.53        .008      --         2.56        6
Chalcedony       1.535       Crypto    --         2.6         6.5
Amber            1.54         --       --         1.07        2.5
Iolite           1.54        .008     .017        2.59        7.5
Ivory            1.54         --       --         1.8         2.5
Sunstone         1.54        .009      --         2.64        6
Oligoclase       1.545       .007      --         2.64        6
Scapolite bl     1.545       .009     .017        2.63        6
Quartz           1.546       .009     .013        2.65        7
Bowenite         1.56         --       --         2.58        4
Steatite         1.56        .05       --         2.65        1.5
For pages 1 to 4 in alphabetical order, type 1,2,3 or 4
              in order of R.I., type 5,6,7 or 8
              (Type 100 for main program)
? _
```

FIG. 8. The first of four pages of tabular information in ascending order of gemstone RIs.



```
                       23 Haematite      43 Phenakite      63 [illegible]
 4 Andalusite          24 Iolite         44 Pyrite         64 Titanite
 5 Andradite           25 Ivory          45 Pyrope         65 Topaz w,bl.
 6 Apatite             26 Idocrase       46 Quartz         66 Topaz br,y.
 7 Basalt glass        27 Jadeite        47 Rhodonite      67 Tourmaline
 8 Benitoite           28 Jet            48 Rhodochrosite  68 Turquoise
 9 Beryl               29 Kornerupine    49 Rutile         69 Uvarovite
10 Bowenite            30 Labradorite    50 Scapolite bl   70 YAG
11 Chalcedony          31 Lapis lazuli   51  .. pink,y.    71 Zircon, high
12 Chrysoberyl         32 Libyan glass   52 Scheelite      72 Zircon, low
13 Coral               33 Lithium Nio.   53 Sinhalite      73 Zirconia
14 Corundum            34 Malachite      54 Sodalite       74 Zoisite
15 Danburite           35 Moldavite      55 Smithsonite     MISCELLANEOUS
16 Diamond             36 Nephrite       56 Spessartite    75 Gahnospinel
17 Enstatite           37 Obsidian       57 Spinel nat.    76 Emerald, syn
18 Feldspar gp.        38 Oligoclase     58 Spinel syn.    77
19 Fluorspar           39 Opal           59 Spodumene      78
20 Garnet gp.          40 Orthoclase     60 Steatite       79
Type gem No. (or type 99 for list ,or 100 to change programs)
                 Mean R.I.    D.R.     Disp.     Mean S.G.     H
? 16
Diamond           2.417        --       .044       3.52       10
? 73
Zirconia          2.18         --       .065       5.7         8.5
? 21
GGG               2.02         --       .038       7.05        6
? _
```

FIG. 9. Individual sets of gem constants can be selected and displayed for comparison purposes.



```
                    ##################
                    ##  GEM DATA 2  ##
                    ##################

      The GEM DATA 2 program identifies gemstones from
              test data input via the keyboard.

      To identify a gemstone, type in its mean R.I.,
      D.R. and S.G. Where no test data is available,
      for R.I. or S.G., type in a '9'.

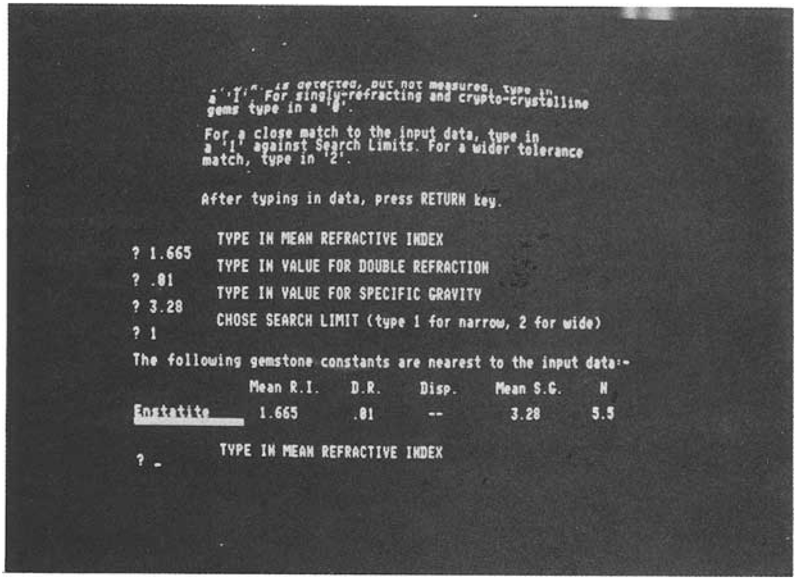
      If D.R. is detected, but not measured, type in
      a '1'. For singly-refracting and crypto-crystalline
      gems type in a '0'.

      For a close match to the input data, type in
      a '1' against Search Limits. For a wider tolerance
      match, type in '2'.

      After typing in data, press RETURN key.

        TYPE IN MEAN REFRACTIVE INDEX
   ? _
```

FIG. 10. Title 'page' of the GEM DATA 2 program which identifies gems from keyed-in test data. When the value for DR is requested, a recent modification to the program provides for an input of '9' to indicate that the gem under test is crypto-crystalline.



```
         is detected, but not measured, type in
      a '1'. For singly-refracting and crypto-crystalline
      gems type in a '0'.

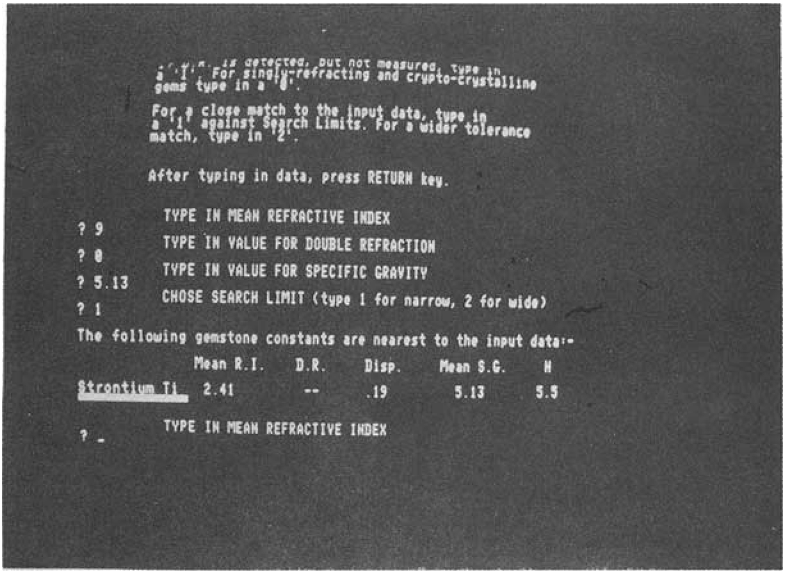
      For a close match to the input data, type in
      a '1' against Search Limits. For a wider tolerance
      match, type in '2'.

      After typing in data, press RETURN key.

        TYPE IN MEAN REFRACTIVE INDEX
? 1.665
        TYPE IN VALUE FOR DOUBLE REFRACTION
? .01
        TYPE IN VALUE FOR SPECIFIC GRAVITY
? 3.28
        CHOSE SEARCH LIMIT (type 1 for narrow, 2 for wide)
? 1
The following gemstone constants are nearest to the input data:-
              Mean R.I.    D.R.     Disp.    Mean S.G.    H
Enstatite     1.665        .01      --       3.28         5.5

        TYPE IN MEAN REFRACTIVE INDEX
? _
```

FIG. 11. Data is keyed-in against the computer requests for RI, DR and SG. A narrow search limit has been chosen, and the computer identifies the gemstone as enstatite.



```
          .R. is detected, but not measured, type in
          a '1'. For singly-refracting and crypto-crystalline
          gems type in a '0'.

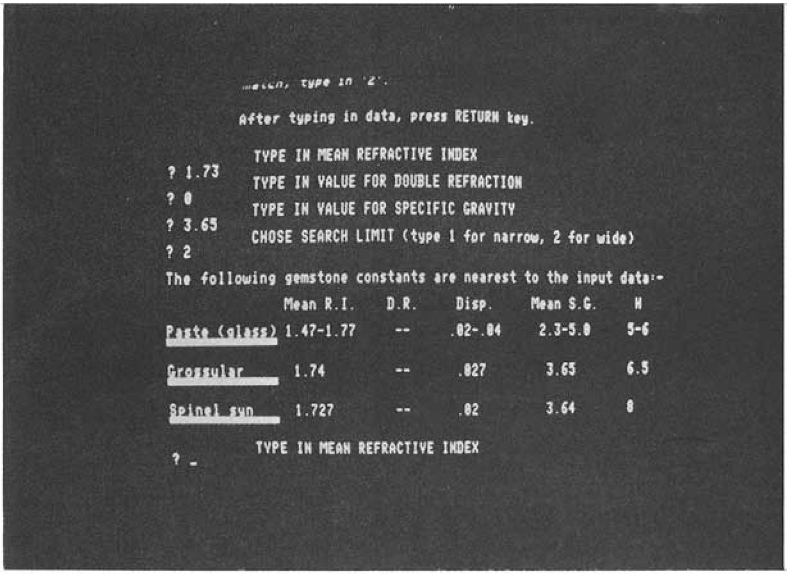
          For a close match to the input data, type in
          a '1' against Search Limits. For a wider tolerance
          match, type in '2'.

          After typing in data, press RETURN key.

             TYPE IN MEAN REFRACTIVE INDEX
? 9
             TYPE IN VALUE FOR DOUBLE REFRACTION
? 0
             TYPE IN VALUE FOR SPECIFIC GRAVITY
? 5.13
             CHOSE SEARCH LIMIT (type 1 for narrow, 2 for wide)
? 1
The following gemstone constants are nearest to the input data:-
                  Mean R.I.    D.R.    Disp.    Mean S.G.    H
Strontium Ti      2.41         --      .19      5.13         5.5

             TYPE IN MEAN REFRACTIVE INDEX
? _
```

FIG. 12. Here, the RI is not known and strontium titanate is identified from the value keyed-in for SG and the '0' value for DR.



```
          match, type in '2'.

          After typing in data, press RETURN key.

             TYPE IN MEAN REFRACTIVE INDEX
? 1.73
             TYPE IN VALUE FOR DOUBLE REFRACTION
? 0
             TYPE IN VALUE FOR SPECIFIC GRAVITY
? 3.65
             CHOSE SEARCH LIMIT (type 1 for narrow, 2 for wide)
? 2
The following gemstone constants are nearest to the input data:-
                  Mean R.I.    D.R.    Disp.      Mean S.G.    H
Paste (glass) 1.47-1.77        --      .02-.04    2.3-5.0      5-6

Grossular        1.74          --      .027       3.65         6.5

Spinel syn       1.727         --      .02        3.64         8

             TYPE IN MEAN REFRACTIVE INDEX
? _
```

FIG. 13. In providing possible identifications for a gem, the computer program in its present form takes no account of colour or transparency.

If the wide search limits fail to identify the gem, this produces the message:

> *'For wide search limits, no match has been found with any gem held in memory. Check test results'.*

If, in the absence of any measured value for RI, a value for DR is fed in (other than a '0', '1' or '9') the computer responds with the message *'Invalid Data'*, as this is not a logical test situation. As the program takes no account of colour or transparency, the printout occasionally includes unlikely identifications (Figure 13).

Both the GEM DATA 1 and GEM DATA 2 programs are written in 'Standard Basic' computer language and are recorded using Manchester code at 1200 band on a tape cassette. The data bank program occupies the full 32k of computer memory, and the diagnostic program occupies 16k of memory.[5]

After using both programs for several months, I have found that the data bank version provides a very convenient and efficient method of both retrieving and comparing data on gemstones, without relying on one's own memory (or looking up information in textbooks). The diagnostic program also has its uses in reminding one of possible alternatives when attempting a difficult identification with insufficient test data. One can, for instance, ask the computer to display all doubly-refracting gems having a specific gravity close to, say, 3.18 (andalusite, apatite, spodumene). Alternatively, a printout can be obtained of all singly-refracting stones with a refractive index in the region of, say, 1.8 ('low' zircon, almandine, spessartite). By taking the computer through the RI range for isotropic materials (DR input = 0) one can also see the paste 'window' for transparent gems in the region of 1.5-1.7.

If the figures 9, 1, 9, 1 are keyed in (in response to the computer's request for RI, DR, SG and Search Limit) the computer can be made to display sequentially all the doubly-refracting gems held in memory. If 9, 0, 9, 1 is typed in, this will produce a display of all singly-refracting gems in the memory. Similarly, 9, 9, 9, 1 will produce a display of all crypto-crystalline gems. These three inputs form a useful check facility when verifying or amending the memory contents.

Although both programs are viable in principle, in their present limited form they are probably more suited as teaching aids

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[5] The size of a computer memory (or a program length) is given in terms of its 'word' capacity. An 8k memory, for example, can hold up to 8000 'words' of program information or instruction. Each computer 'word' is composed typically of 8 'bits' of binary information. The 'baud' is the rate at which data are transferred or transmitted, e.g. 1200 baud = 1200 bits per second.

for students (all of the gems in the Preliminary and Diploma syllabuses are contained in the programs). While current technology has made it possible to reduce the size of the gem data computer installation to that of a hand-held calculator, an alternative use for the full-size version could be as a counter attraction for customers in a jeweller's shop!

The efficiency of all data retrieval systems depends on the accuracy and completeness of the stored data, as well as on the organization of its retrieval techniques (i.e. the programming). When used in an interactive mode for diagnostic purposes the system also depends on the accuracy of the keyed-in test data.

From the results of this work I believe that with a larger memory (perhaps of 64k), and with faster data storage and loading peripherals, both programs can be expanded to a point where they would make a useful contribution to gem identification. If it is to remain effective, however, an essential part of such an information system would be its continual up-dating as new gem materials are discovered or created, and as old data are modified or corrected.

The increasing world-market for gem test instruments is making it economically worth while to develop and market such sophisticated instruments as the pulsed IR reflectivity meter, and the thermal-probe diamond tester (devices which are already making use of integrated circuits, the predecessors of the microcomputer). In other fields, machines and test equipments have been given a degree of intelligence by the exploitation of microcomputer technology. Perhaps the availability of low-cost bulk data storage devices may one day similarly transform our own gem test instruments.

Although the hand lens and the computer may appear to be at opposite ends of the gem testing spectrum, both artefacts have their place in gemmology. The first device has proved its worth over the years, while the second one is just on the threshold of its application.

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A PHOSPHOROSCOPE

By R. M. YU, Ph.D., F.G.A., and D. HEALEY, Ph.D., F.G.A.

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1. INTRODUCTION

The phenomenon of luminescence in gems has been widely used as a quick way of sorting gems. The usual method involves the excitation of gems by long wave (365 nm) or short wave (253.7 nm) ultraviolet light and observing the characteristic luminescent emissions in the visible region. Experience has accumulated a large store of information for distinguishing natural gems from their synthetics by their luminescent properties (Webster 1975, Anderson 1971, Liddicoat 1966). For this purpose ultraviolet lamps are readily available from various commercial suppliers. For example Gemmological Instruments Ltd (U.K.) markets a 'Multispec U.V. Light Source', while the Gem Instruments Corpn (U.S.A.) markets a 'Combination Short & Long Wave Mineral-Light'.

Another use of ultraviolet light in gem identification is to compare the absorptances of the natural and the synthetic stones. Chatham emeralds absorb light of wavelength shorter than 230 nm while natural emeralds start at 300 nm (Anderson 1971). Type II diamonds are distinguished from Type I by the fact that the former start to absorb ultraviolet light at wavelengths shorter than 230 nm while the latter absorbs below 300 nm (Copeland *et al.* 1960).

Mr N. Day* has suggested a method of comparing the ultraviolet absorptances of gemstones (Anderson 1971, p. 86). The stones are placed on a sheet of photographic paper in a dark-room and exposed to ultraviolet light for a short time. The developed photographic paper will show quite clearly the relative absorptances of the gemstones. We have devised a simple phosphoroscope which allows us to observe the ultraviolet absorptance instantly without resorting to a dark-room or tedious photographic process. It also allows us to observe the luminescent emissions of the stones at the same time. The underlying principle of our instrument is similar to the experimental apparatus described by Mr Ian Campbell (Campbell 1978); we have improved

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**Transparency of Gemstones to Short Wave Ultraviolet Light*, J.Gemm., 1953, IV(4), 183-9.—Ed.

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the design and shown also how the appearance of the gem under transmitted light may be understood in terms of the simple model of a spherical cabochon. The appearance depends essentially on the curvature of the gem and its refractive index.

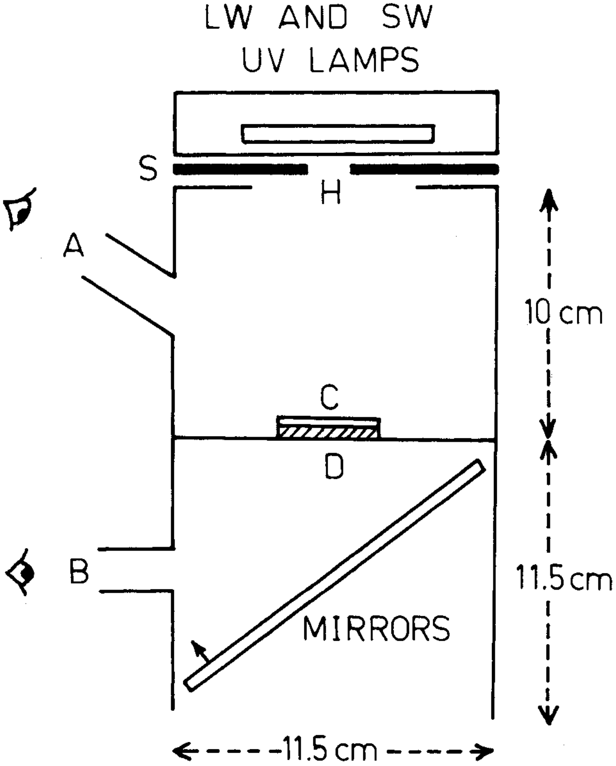

FIG. 1 Cross-sectional diagram of the phosphoroscope.

2. CONSTRUCTION OF THE PHOSPHOROSCOPE

The phosphoroscope consists of a wooden box, the cross-section of which is shown in Figure 1. The inside of the box is painted matt black. The side with a viewing port A is a hinged door, which may be opened to allow gems to be placed on a thin sheet of phosphorescent paper C supported on a glass slide D. Any ultraviolet light transmitted through the gem will reach the phosphorescent paper C. The resulting visible phosphorescent emission is transmitted by the glass slide D, reflected by the mirror and observed through the viewing port B. The ultraviolet absorptance of the gems can thus be observed visually by the naked eye or recorded on photographic film by using a camera. To observe the characteristic luminescent emission of gems, the phosphorescent paper C is covered up with a piece of black cloth and the gems placed on top of the cloth. Visible luminescent emissions from the gems are then observed through the viewing port A.*

To improve the resolution of the picture a screen S with a 1 cm diameter hole H is inserted to reduce the size of the ultraviolet light source.

3. OBSERVATIONS

Our main objective is to compare the short wave ultraviolet (SWUV) absorptances of natural gems and their synthetics. Figure 2a shows a picture that would be observed through the viewport B of the phosphoroscope when an aquamarine cabochon, an oval mixed-cut synthetic ruby and an emerald-cut synthetic corundum (imitating alexandrite) were placed with their flat faces resting on the phosphorescent paper C (see Figure 1). Normally no photography is required, but as illustrations for the present article we have recorded the picture on Kodak Tri-X Pan film with a camera. The SWUV light source was stoppered by the screen S (see Figure 1). The exposure time can be reduced from 60 seconds to 8 seconds if the screen S is dispensed with. Then the resolution of the picture deteriorates somewhat (Figure 2b). Since the resolution of the picture does not affect our study of SWUV absorptance of gems, the succeeding photographs were taken without the screen S.

---

*It may be noted that—

(i) The areas underneath the gems are stimulated only by UV transmitted by the gems. The areas of the phosphorescent paper C not covered by gems are stimulated by direct UV; this is desirable since it forms a bright background with which the UV transparency of the gems can be compared.

(ii) In the case of luminescent gems, the visible light emitted by the gem also shines on the phosphorescent paper C. We found the effect negligible even in the case of a strongly synthetic ruby.

(iii) As a result of bleaching during the manufacturing process, most white papers are phosphorescent to some degree. By trials we found a paper which was highly phosphorescent; this has worked well for over a year, and we expect it will continue to work for many years. A weakly phosphorescent paper can be made more phosphorescent by smearing with 'invisible pen' made by Besco of Hempstead, N.Y. and marketed by Edmund Scientific at 8985 Edscorp Bldg, Barrington, N.J. 08007, U.S.A. The latter also markets a 'black light spray' which should work well with paper, but we have not tested this product.

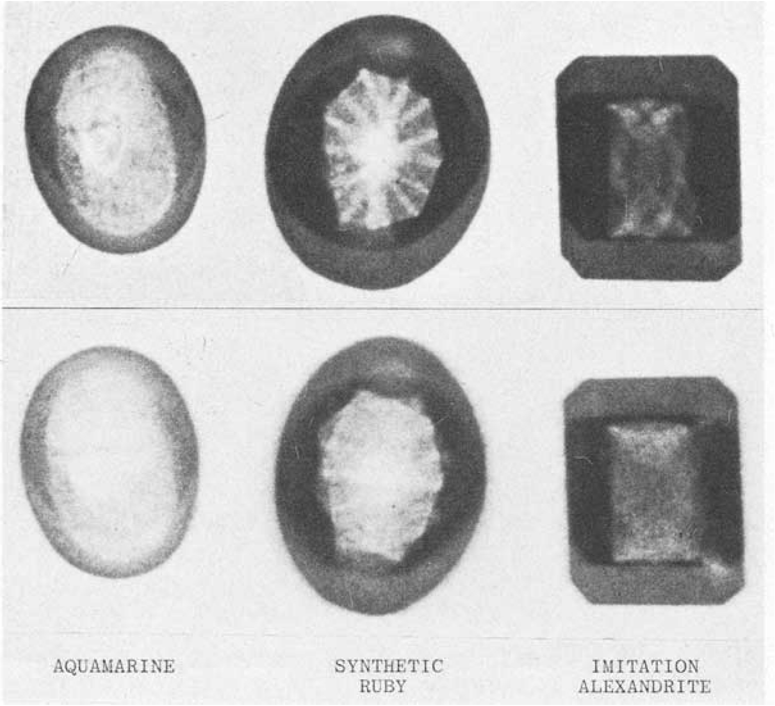

FIG. 2 SWUV absorptance photographs of aquamarine, synthetic ruby and imitation alexandrite: 2a (above) with stopper aperture: 2b (below) without stopper aperture.

In both Figures 2a and 2b a dark rim appears around the edge of the aquamarine cabochon. This dark rim is not due to the higher absorption at the edge of the gem, since aquamarine is transparent to SWUV. Rather it is due to the refractive property of the cabochon. To account for this effect quantitatively we consider a spherical cabochon ABCG of radius of curvature R and centre O as shown in Figure 3.

The cabochon is illuminated with a beam of light perpendicular to its back surface ABC. At a point G on the spherical surface of the cabochon the angle of incidence i is equal to the angle θ betwen the radius vector OG and the vertical direction OB. The incident ray FG is refracted towards the centre of the

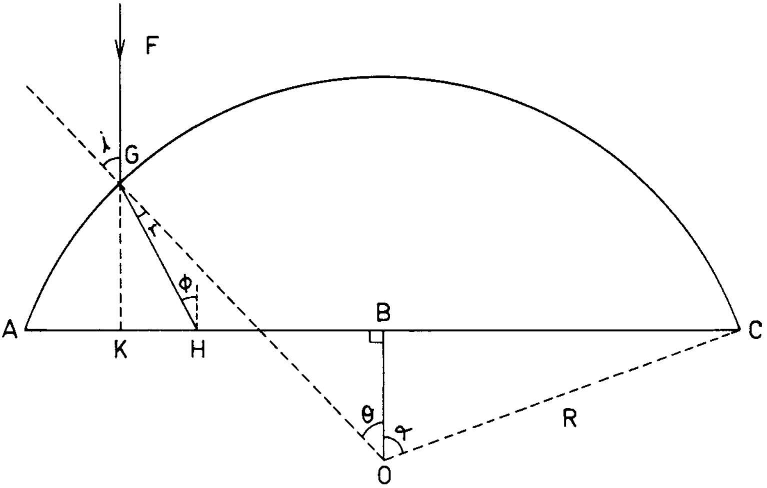

FIG. 3 Ray-tracing in a cabochon.

cabochon, meeting the back surface at H. The angle of incidence ϕ at H is given by

$$\phi = i - r = \theta - r \tag{1}$$

where r is the angle of refraction at G,
Snell's law of refraction gives

$$\frac{\sin i}{\sin r} = n \tag{2}$$

therefore

$$\begin{aligned} \phi &= \theta - \sin^{-1}\left(\frac{\sin i}{n}\right) \\ &= \theta - \sin^{-1}\left(\frac{\sin \theta}{n}\right) \end{aligned} \tag{3}$$

As the point G moves towards the edge A, the angles θ and ϕ increase. When ϕ equals the critical angle ϕ_c the light ray will be totally internally reflected at H rather than transmitted to reach the phosphorescent paper C (see Figure 1). The value of θ corresponding to ϕ_c is denoted by θ_m and calculated from the following equation:—

$$\phi_c = \theta_m - \sin^{-1}\left(\frac{\sin \theta_m}{n}\right) \tag{3a}$$

In other words light entering that part of the gem subtending an angle θ larger than θ_m will not be able to penetrate the back surface of the cabochon. Thus that part of the gem looks opaque through the phosphoroscope, irrespective of the absorptance of the gem.

For aquamarine the refractive index in the UV region is slightly higher than in the visible region. For argument's sake we ignore the birefringence of aquamarine and assume a refractive index of 1.57. The critical angle for total internal reflection is then

$$\phi_c = \sin^{-1}(\frac{1}{n}) = \sin^{-1}(\frac{1}{1.57}) = 39.6° \qquad (4)$$

Hence

$$\theta_m = 78.2°$$

A quantitative measure of the dark rim due to the refractive effect is given by the ratio of the lengths BH/BA

where $BA = R \sin\alpha$

$$\begin{aligned} \text{and } BH &= BK - KH \\ &= R \sin\theta_m - GK \tan\phi_c \\ &= R \sin\theta_m - (R \cos\theta_m - R \cos\alpha) \tan\phi_c \end{aligned} \qquad (5)$$

For a hemispherical cabochon $\alpha = 90°$

therefore $$\frac{BH}{BA} = \sin\theta_m - \cos\theta_m \tan\phi_c$$

$$= 0.81$$

The above consideration applies to a hypothetical hemispherical cabochon of aquamarine. It explains qualitatively the occurrence of the dark rim around the aquamarine cabochon shown in Figures 2a and 2b. Similar dark rims are abserved in the oval mixed-cut synthetic ruby and the emerald-cut imitation alexandrite. (Note that the smaller 'extra dark' rims are umbra, the larger darker rims are penumbra.) The calculations are much more complicated but the principle is the same. Figure 4 shows schematically that a light ray PQR entering near the culet of a round brilliant-cut gem is transmitted, while a light ray XYZ entering near the girdle is totally internally reflected. As a result the rim of the gem looks darker compared to the centre as shown in Figures 2a and 2b. By looking at the centres of the gems shown in

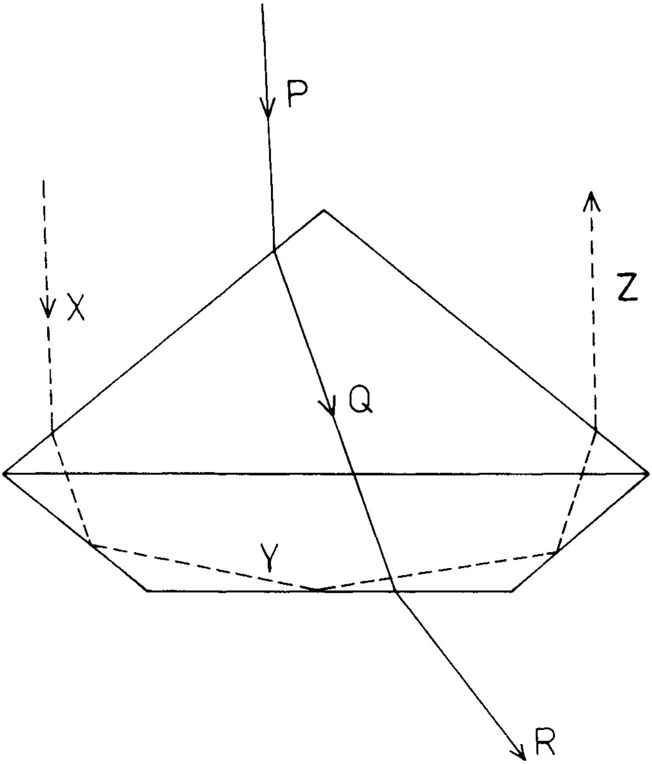

FIG. 4 Transmission and total internal reflection of light rays in a gem.

Figure 2 we can deduce that while the aquamarine cabochon and the oval synthetic ruby are transparent to SWUV, the imitation alexandrite is slightly absorbent.

4. RESULTS AND DISCUSSIONS

Figure 5 is a SWUV absorptance photograph of various types of ruby. The picture shows clearly that the synthetic, Burmese and Sri Lankan rubies are transparent to SWUV while the Thai and Tanzanian rubies are opaque. The absorption of SWUV in the Thai and Tanzanian samples may be attributed to their higher iron content. Using the crossed-filter technique the red fluorescent lines (692.8 nm, 694.2 nm) characteristic of chromium ions are not

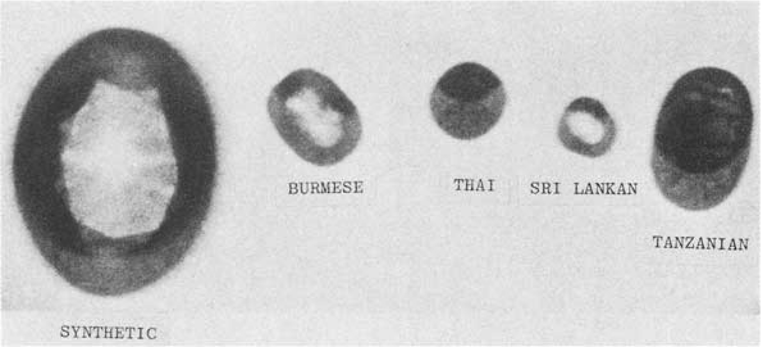

FIG. 5 SWUV absorptance photograph of rubies.

observable in these two stones. This 'quenching' of red fluorescence in ruby can be explained in terms of crystal field theory (Nassau 1978, p.221).

The SWUV absorptance photograph of various types of sapphire is shown in Figure 6. The picture shows that Sri Lankan sapphires are transparent to SWUV, while Thai and Australian sapphires are slightly absorbent. Again this indicates that the latter have higher iron content than the former. The blue colour of sapphires arises from molecular orbital transitions involving the following two valence states: (a) Fe^{2+} and Ti^{4+} (b) Fe^{3+} and Ti^{3+} (Nassau 1978, p.225). Since the optical transition involves both the titanium ion and the iron ion, an excess of iron ions does not make the gems bluer, but renders the gem more absorbent of SWUV radiation.

Figure 7 shows that the Chatham emerald is transparent to SWUV, the natural emeralds are slightly absorbent and the Gilson emeralds are highly absorbent. This phosphoroscopic indication of the iron contents of these types of emeralds agrees with conclusions

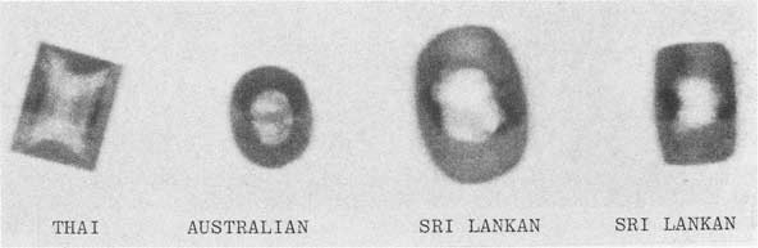

FIG. 6 SWUV absorptance photograph of sapphires.

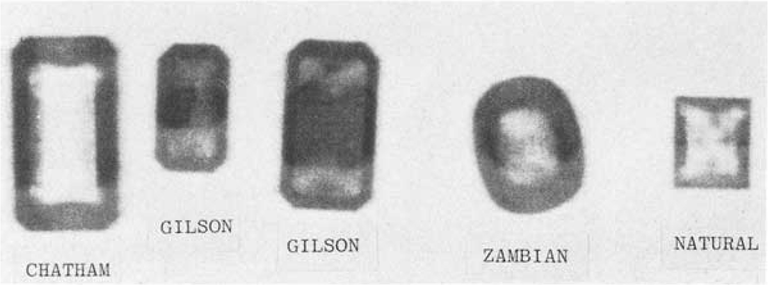

FIG. 7 SWUV absorptance photograph of emeralds.

reached by separate electron spin resonance studies of emeralds (Hutton and Barrington 1977). They found that while both Gilson and Chatham emeralds showed rich chromium electron spin resonance spectra, only Gilson synthetics showed a pronounced iron spectrum. They also found that the concentration of iron ions varied quite markedly in natural emeralds from different sources. Traces of iron were found in emeralds from Poona, Colombia and Minzie but not in samples from Rio Tinto.

In conclusion, the phosphoroscope provides us with a simple and quick way of observing the ultraviolet absorptance of gems. In appropriate cases this instrument may be used to distinguish natural gems from their synthetics. It will become increasingly useful as more and more data of ultraviolet absorptance of gems are collected.

ACKNOWLEDGEMENT

We are most grateful to Mrs Anne C. Paul, F.G.A., Mrs Rosamond Clayton, F.G.A., and Mr S. P. N. de Silva, F.G.A., for allowing us to photograph their fine collection of gems.

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[*Manuscript received 24th May, 1979.*]

GEMMOLOGICAL ABSTRACTS

ANDERSON (B. W.). *Discovering the importance of heavy liquids in gemmology.* Retail Jeweller, **17**, 402, 3: *Errors discovered as gem laboratory branched out.* id., **17**, 403, 21: *More solutions used to test gems.* id., **17**, 404, 8: *The virtues and vices of the Clerici solution.* id., **17**, 406, 36: *Indicators: the search for accuracy.* id., **17**, 408, 15: *Checking the results of new research.* id., **17**, 410, 38: *Using diamond as an indicator.* id., **17**, 413, 18: *Summing up the usefulness of the liquids.* id., **17**, 416, 16-17: January-August, 1979.

An important series of papers on the history and uses of heavy liquids in gem testing, from the pen of this country's most experienced gemmologist.* Abstracter understands that the slightly fatuous titles of the separate articles were the choice of the publishers, not of Mr Anderson. R.K.M.

ARPS (C. E. S.). *The immersion contrast polariscope: an attractive addition to a well known technique.* Z.Dt.Gemmol. Ges., **28**, 4, 184--6, 1 fig, 2 diagrams, 1979.

This is a paper read to the 17th International Gemmological Conference in Idar-Oberstein, September 1979. The instrument is cheap and useful in the laboratory. Based on the principle of immersion of gemstones in liquids to produce RI contrasts and on optical anisotrophy. E.S.

BARKER (B.). *Know your diamonds.* Gems & Gemology, **XVI**, 8, 248-53, 1979.

A bibliography of recent diamond literature. R.K.M.

BLAIR (G.). *Diamonds of the Wyoming outback.* Lapidary Journal, **34**, 2, 496-8, 4 figs, 1980.

Account of the 'salting' with diamonds, emeralds and corundum of an area in the southern Red Desert of Wyoming. M.O'D.

BROWN (G.). *The absorption spectra of beryl.* Wahroongai News, 27-32, Feb. 1980.

An extensively informed paper, apparently based almost entirely on advanced scientific research by Dr Kurt Nassau. Most of the really significant absorption factors which discriminate between natural and synthetic beryls occur at infrared wavelengths well outside the range practical in normal gemmology. Graphs make their point but are crudely drawn. R.K.M.

BROWN (G.). *Gold corals—some thoughts on their discrimination.* Gems & Gemology, **XVI**, 8, 240-4, 5 figs, 1 table, 1979.

A discussion mainly concerned with the differences between 'gold' coral, from Hawaiian waters, and 'golden' coral from the Philippines. Differences, apart from semantics, lie chiefly in the surface structures; gold coral smooth—golden, a bleached or acid-treated whip coral, rough and spiny. Cross sections also differ.

R.K.M.

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*see *Anderson on Heavy Liquids,* p.230 above.—Ed.

Brown (G.). *Painite updated.* Wahroongai News, 16, Feb. 1980.

Work by Moore and Araki published in 1976 changes the previously recognized composition of this rare gem, eliminating Si and introducing Zr as constituents, with some changes in the theoretical structure. (Mr Brown still refers to it as a 'single crystal' mineral, but the material for this work was taken from the Natural History Museum's *second* crystal, also found by Pain: and last year the abstracter had information from Mr R. T. Liddicoat to the effect that a third specimen had been found among Burmese rough which had been in the possession of the G.I.A. for many years.) R.K.M.

Butler (J. N.). *An attempt to assess the recent popularity of different gems.* Wahroongai News, 33-8, Feb. 1980: *Recent fluctuations in the trade popularity of some gem materials,* id., 3-11, March 1980.

Two articles which try to assess popularity of gem species by counting numbers of articles in the popular press and trade press, and numbers of advertisements. (It is doubtful whether inferences drawn are necessarily correct. Most articles and/or advertisements are written to create interest, and in the latter case there is a tendency for them to increase when supplies are plentiful and demand low.) R.K.M.

Campbell (Ian C. C.). *Personal notes on gems, minerals and related aspects, Zimbabwe Rhodesia.* Lapidary Journal, **33**, 12, 2626-35, 17 figs, 1980.

Special reference is made to emerald, aquamarine, blue topaz, citrine, garnet, alexandrite and serpentine. Authoritative details of finds and commercial potential are not available due to the political situation, but many gemstone species have exciting possibilities. Some have been over-priced in the past, again for political reasons. M.O'D.

Carr (S. G.), Olliver (J. G.), Conor (C. H. H.), Scott (D. C.). *Andamooka opal fields—the geology of the precious stones field and the results of the subsidized mining program.* Rept. Invest. Geol.Surv. South Australia, **51**, 68pp, 8 figs, 24 pls, 6 appendices, 1979.

At Andamooka, opal has formed within a bleached profile at the interface of a white, sandy clay or kopi, and an underlying, impermeable, grey-brown montmorillonitic clay or mud in the Cretaceous Marree formation. Generally, this interface or level, is marked by a pebble or conglomerate layer. Precious opal has accumulated in suitable crevices or has been trapped by permeability barriers. Basically, the level undulates gently, reflecting sedimentation on a slightly irregular surface. Small-scale faults or slides, disrupt the level only locally. No structural control of opal has been recognized, but detailed mapping of individual fields is continuing. W.A.F.

Cassedanne (J. and J.). *Les grenats de Poço dos Cavalos, Ceará-Brésil.* (Garnets of Poço dos Cavalos, Ceará, Brazil.) Revue de Gemmologie, 62, 5-8, 9 figs, 1980.

The location is in the centre of the State of Ceará; garnets are found in a pegmatitic body. The chemical composition shows that the stones are between almandine and spessartine; the colour is rose-orange. SG 4.15, RI 1.815. M.O'D.

CAVENAGO-BIGNAMI (S.). *New grey-black, greenish-black cultured pearls.* Z.Dt.Gemmol.Ges., **28**, 4, 187, 1979.

Paper read to the 17th International Cemmological Conference in Idar-Oberstein, September 1979. These greenish-black grey-black pearls can grow up to 15mm in diameter and come from Manihi, Tahiti, French Polynesia, produced by the *Pinctada maxima.* Exposure to x-ray for a Lauegram does not influence the colour of the pearls. E.S.

CROWNINGSHIELD (R.). *Developments and highlights at GIA's Lab in New York.* Gems & Gemology, **XVI**, 7, 194-202, 37 figs (36 in colour), 1979.

Yellow and orange-red sapphires unlike any seen before are causing problems. Red colour patchily on surface reminiscent of Lechleitner emerald effect seen when overgrowth is partially polished away. There is reticulation of surface layers, again a feature of Lechleitner emeralds. It is surmised that these are natural stones which have been artificially treated. (Generally the colour plates—photographed by A. Roditti—are an immense improvement over the former monochrome, but occasionally they print dark and detail is lost; one of a 20 ct green sphene ring is too dark to reveal much detail.) 'Emerald' in matrix proved to be green plastic on plastic-bonded grey rock; an unusual self-colour opal, looking like obsidian, is described.

Remaining items include a variety of diamond inclusions and the possibility of using interesting ones as merchandising factors is discussed in view of shortage of clean stones (Gübelin of Switzerland has been doing this for many years). The question of grading a diamond in which a single inclusion reflects in many facets is also discussed. A diamond tested with a diamond point, as a possible cubic zirconia, had been badly scratched—octahedral (hard) point on cubic (softer) facet. (A sapphire point is quite hard enough to reveal cubic zirconia, and will not touch diamond.) Comment is made on the rarity of true cleavage chips of diamond in jewellery. These are fairly common in antique jewellery from India. Finally, an interesting comment on the dearth of fine colour diamonds in smaller sizes, thought to be due to cut, girdle condition, etc., which have more effect on smaller stones. A chance to grade stones of 100 ct plus, down to quite small sizes, all from one crystal, showed that all were grade D (fine on GIA scale) except three which were below 1 ct each and poorer in colour. Recutting can sometimes lower the colour grade of a diamond.

Two new imitations reported by Dr Kurt Nassau: one a microcrystalline cellulose made to resemble ivory (RI 1.5, SG 1.53, H 4½, UV fluorescence medium yellow, no 'engine-turning' pattern). The other a blue glass cabochon with a structural (non-mobile) star built into it, rather like the canes used in glass paper-weights. R.K.M.

CURTIS (C. M.). *'Malaya' lady of the evening.* Lapidary Journal, **33**, 11, 2348-9, 1980.

In the context of the article 'Malaya' is an adjective, for it derives from one of the Bantu group of languages and has the meaning 'out of the family'. It has been given to an orange garnet found near the village of Mwakijembe in the Umba Valley of Tanzania. RI is given as 1.75-1.76. A variety of inclusions have been noted, and the stones are said to belong to a pyrope-spessartine series. M.O'D.

DUYK (F.). *Reflexions sur le diamant.* (Reflections on diamond.) Revue de Gemmologie, 62, 9-11, 2 figs, 1980.

Considers the work done by various writers on diamond from classical times to the present. M.O'D.

FARN (A. E.) *The first impact of a gemstone.* Z.Dt.Gemmol.Ges., **28**, 4, 188-90, 1979.

Paper read to the 17th International Gemmological Conference in Idar-Oberstein, September 1979. Aspects of the work of the London Laboratory are shortly mentioned and the differences in jade-like materials are used to illustrate the work of a gemmologist. E.S.

GRAZIANI (G.). *Crystal inclusions and their implications.* Z.Dt.Gemmol.Ges., **28**, 4, 191-3, 1979.

Paper read to the 17th International Gemmological Conference in Idar-Oberstein, September 1979. Modern methods are applied to find a solution to genetic problems of minerals. Two beryls are taken as examples. E.S.

GÜBELIN (E.). *Neue Edelsteine aus Sri Lanka.* (New gemstones from Sri Lanka.) Z.Dt.Gemmol.Ges., **28**, 4, 194-6, 1979.

Paper read to the 17th International Gemmological Conference in Idar-Oberstein, September 1979. The author discusses and describes four new gemmological minerals from Sri Lanka, giving details of physical properties in each case. The first is a sillimanite, which had previously been found in Sri Lanka in light blue and light green varieties. This sillimanite is a saturated blue, more like a sapphire or a cordierite. The second stone described was a yellow-brown epidote, the colour being caused by iron and the colour intensity being determined by content percentage. The third gem mentioned is an idocrase showing an agreeable warm brown. The stone from Sri Lanka seems to be a little more yellow than its relatives from Canada and Kenya. The last stone was first taken to be a red taaffeite; however, it is now shown to be a new gemstone which the author calls 'taprobanite' (RI 1.177-1.721 [*sic*]*, DR 0.004; SG 3.607±0.005; H 8+. Dichroism yellow red/deep red.) Chromium seems to be responsible for the colour. E.S.

HEALEY (D.). *The gem scene in Sri Lanka.* Lapidary Journal, **33**, 10, 2274-9, 1980. Already abstracted from J. Gemm. Assoc. Hong Kong at p.185 above.

HEDGES (R. E. M.). *Archaeological evidence from chemical analysis.* Science & Industry, **15**, 12-15, 6 figs, 1 table, 1980.

Chemical analysis techniques can provide information on archaeological artefacts. Some examples are given—pottery, iron, bronze, ceramics and also obsidian. Sources of obsidian (a volcanic glass) in Europe and the Middle East are not common: each lava flow tends to be unique in composition and can generally be differentiated from flows of different eruptions (even from the same volcanic source) on the basis of measurements of concentrations of such trace elements as Ti, Mn, Rb, Ba, Zr. Often the major elements are quite different and it suffices to measure the RI. Usually the analysis of a single subject is sufficient for the

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*Probably 1.717-1.721?—Ed.

identification of its source, once a sufficient body of analyses of material from known sources has been built up. J.R.H.C.

HEHAR (W. C.). *The discovery of golden amethyst.* Lapidary Journal, **34**, 2, 582-3, 1 fig, 1980.

A stone in which deep purple alternates with wedges of citrine colour was exhibited in the U.S.A. It is said to emenate from the area of Rio Grande de Sol [*sic*-? Rio Grande do Sul] in southern Brazil. M.O'D.

KANE (R. E.). *Developments and highlights in GIA's lab in Los Angeles.* Gems & Gemology, **XVI**, 7, 205-12, 29 figs in colour, 1979.

An apparently new type of synthetic ruby, which shows intersecting growth lines and others which resemble laminations due to twinning in natural stones, is described. Such lines do not extend through the stone as would be expected of twinning planes. Other rather natural-looking inclusions of flux and veil-like wisps and strings are also seen. Illustrated alongside natural stones in 16 fine photographs. The stones with lines needed careful positioning before the effect was seen, rather as is the case with Verneuil stones. (Query: what was the transparency to short UV and did they phosphoresce after x-rays?) One large cushion antique cut synthetic had poor symmetry reminiscent of native-cut natural rubies. (It is not unknown for synthetics to be native-cut.)

A 13 carat cabochon trapiche emerald had central prism surrounded by six other broad prisms with only narrow areas of opaque material between. (Illustration rather too dark to convey this.)

Other figures are concerned with unusual inclusions in diamond. Strangely, both labs report and illustrate examples of the rarely seen square (cubic face growth pit) naturals on diamond girdles. R.K.M.

KANE (R. E.). *Developments and highlights at GIA's lab in Los Angeles.* Gems & Gemology, **XVI**, 9, 277-82, 19 figs, (Spring) 1980.

Various unusual inclusions in diamond illustrated; an imitation cat's-eye made from optic fibre had exceptionally sharp eye, was transparent from side and showed hexagonal fibre structure under magnification. Random oriented rutile (?) needles reported in emerald; also particoloured, blue and yellow, UV fluorescence in a diamond. Several more unusual inclusions in diamond illustrated and an example of 'lizard-skin' polish on one, due to polishing too close to an octahedral (cleavage) plane. R.K.M.

KIZIYAROV (G. P.), TATARINOV (A. V.), PLATONOV (A. N.), BELICHENKO (V. P.), ZAV'YALOVA (L. A.). *First finds of gem-quality jadeite in West Sayan.* Soviet Geology and Geophysics, **19**, 11, 72-81, 8 figs, 1978.

Three new varieties of jadeite clinopyroxenites have been found on the Kantegir river, West Sayan, U.S.S.R. Some of the jadeite was coloured by chromium and showed a fine green with translucency. The best quality was quite close to Burmese jadeite. Absorption bands are studied and classified. M.O'D.

KOIVULA (J. I.). *Fluid inclusions.* Gems & Gemology, **XVI**, 9, 273-6, 6 figs, (Spring) 1980.

Paper explains dangers of heating stones containing minute fluid or fluid and gas inclusions. Liquids are incompressible and, once cushion of gas bubble is absorbed, tremendous pressure develops and disaster rapidly follows, either in the form of a bad fissure or in actual explosion of the stone. Point is made that heat applied in repairs, dopping, etc., can exceed that of the stone's formation; it is graphically underlined by the series of photographs of an oil-filled inclusion in quartz at various temperatures. R.K.M.

LEITHNER (H.). *Alexandrit aus dem Ural.* (Alexandrite from the Urals.) Lapis, **5**, 4, 25-8, 11 figs (3 in colour), 1980.

Locations for both alexandrite and emerald are given, with a simple sketch-map. Characteristic crystals are described and illustrated. M.O'D.

LESH (C.). *Gemlure. Opal: smolder of fortune?* Gems & Gemology, **XVI**, 9, 283-8, (Spring) 1980.

Attempts to trace the reputation of opal for ill luck to Scott's *Anne of Geierstein* and for good luck over a period of 3000 years, mentioning Aztecs, Incas, Java, ancient Greece and Rome, Napoleon, the Black Death (plague), Australian aborigines and other primitives: also queries the usual derivation of the name from Sanskrit 'upala' (precious stone), preferring a derivation from two Greek roots, said to mean 'see change'. R.K.M.

LIDDICOAT (R. T.), FRYER (C.). *Developments and highlights at GIA's lab in Santa Monica.* Gems & Gemology, **XVI**, 9, 265-72, 11 figs, (Spring) 1980.

'Sugar cube' and a 'tooth-shaped' inclusions in diamonds are described; a Japanese graded diamond had its report number, weight and grade sintered on the table facet and clearly visible at 10× magnification; a treated grey-green diamond had blue areas. A corundum with badly etched table facet had been damaged by heating with borax or by hot pickle containing borax.* A Va/Cr, green-blue to purplish-red, colour-change garnet proved to be in pyrope-spessartite series with some trace of hessonite and almandine. Problem of testing stones in very large inlaid screen solved by powder x-ray diffraction test proving stone to be serpentine, not nephrite as claimed. An almost colourless stibiotantalite was identified by electron-scan methods. A sapphire-blue taaffeite reported (3.34 ct) found among heat-treated sapphires, and colour may also be the result of heat treatment. Another corundum showed faint colour change reminiscent of alexandrite. Green cabochon was proved by electron probe to be anorthite with brown titanite and green uvarovite inclusions. R.K.M.

MCGLASHAN (I.). *The story of the Hope diamond.* Lapidary Journal, **33**, 10, 2242-9, 1980.

A brief history of the celebrated Hope blue diamond with a number of references to the literature. M.O'D.

MANSON (D. V.). *Recent activities in GIA's research department.* Gems & Gemology, **XVI**, 7, 217-19, 1979.

Reports steady progress in cataloguing some 9000 items now in the reference collection. Specific problems now being tackled include: origin of colour in diamond

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*Heat alone can seriously affect colour of corundums, and they need to be unset whenever considerable heat is to be applied to a mount.—Abstracter's Note.

and in lavender jadeite; a review of the gem garnet group; colour permanence, and composition of gem materials. The finding of the 'second' known example of Painite among gem spinels from Mogok is reported (actually the *third* known example since the British Museum, Natural History, has had two specimens for many years). Maw-sit-sit, examined by electron-scan proves to be a combination of ureyite (previously known only in meteorites) and natrolite; not chrome jadeite and albite as previously thought.

Gem garnets from Kenya and Tanzania are proving to be a new spessartite/pyrope/grossular combination hitherto unrecognized. The name Malaya garnet (from Swahili 'Malia') is unfortunately confusing. RI is between 1.74 and 1.76, colour rich golden-orange. Plastic impregnated opal and all-plastic opal imitations are also reported. R.K.M.

NASSAU (K.). *Gemstone imitations made of glass, ceramics, plastic and composites.* Lapidary Journal, **33,** 12, 2528-50, 11 figs (6 in colour), 1980.

Reviews interesting cat's-eye imitations made by two firms in the United States and by Iimori Laboratories, Japan; Slocum stone, products made from ceramics, including a lapis lazuli imitation made from spinel and turquoise imitations; composites and plastics. M.O'D.

NASSAU (K.). *The size and weight of diamond and diamond imitations.* Gems & Gemology, **XVI,** 7, 203-4, 1 graph, 1979.

Graph compares diameter of diamond brilliants of known weight with those of GGG, cubic zirconia and YAG of the same weight. R.K.M.

NASSAU (K.). *The size and weight of diamond and diamond imitations.* Lapidary Journal, **33,** 11, 2350-2, 4 figs, 1980.

Weight and diameter of diamond and some of its imitations are plotted and the warning given that some retailers give the weight of a diamond when selling a substitute. M.O'D.

NASSAU (K.). *Synthetic gemstone developments in the nineteen seventies.* Gems & Gemology, **XVI,** 8, 226-39, 9 figs, 1 table, 1979.

An important summary, largely from author's own papers elsewhere, of progress in all fields of gem synthesis over the period named, giving a better idea of the industry in the United States than is normally available. The Czochralski process is capable of producing high quality 'boules' of corundum in very large sizes; one of 10 kilograms is illustrated. Colour treatments by irradiation of natural stones are included and a forecast of possible developments in the 1980s is made. R.K.M.

NASSAU (K.). *Synthetics in the seventies.* Lapidary Journal, **34,** 1, 50-68, 15 figs (9 in colour), 1980.

Developments in man-made gemstones from 1970-80 include diamond simulants, opal, turquoise and diamond itself. The rate of production of new materials is expected to slacken in the 1980s but perfection of existing materials will be sought. M.O'D.

NASSAU (K.), NASSAU (J.). *The growth of synthetic and imitation gems.* Crystals: Growth, Properties and Applications, **2,** 1-50, 25 figs, 1980.

This is a comprehensive introduction to the growth of gem-quality crystals and includes a most useful table of 153 references. Growth methods are described with the particular crystals so that all Verneuil products, etc., are reviewed together. A useful feature not generally found in purely gemmological texts is a list of the dopants used for obtaining the colours of corundum. (Since the MS was submitted in 1978, there are no notes on the coloured varieties of cubic zirconia.) Details of the infrared absorption from two types of water in emerald are given, again the first detailed reference easily available. (An offprint of the paper would be most welcome.) M.O'D.

PABIAN (R. K.). *Gem collecting in Nebraska.* Lapidary Journal, **34**, 2, 462-76, 12 figs in colour, 1980.

Agate, jasper and labradorite are among the relatively few gem materials in the State of Nebraska. Blue agate is the official gemstone of the State. M.O'D.

PABIAN (R. K.). *Lake Superior agates; a historical review.* Lapidary Journal, **34**, 1, 110-53, 9 figs, 1980.

Agates from Lake Superior were worked by lapidaries 140 years ago. The article reviews the history of the deposits. M.O'D.

PAYNE (T.). *Shedding light on ultraviolet.* Gems & Gemology, **XVI**, 9, 258-64, 7 figs, (Spring) 1980.

An account of ultraviolet light, its sources, filters, and precautions to be taken when using it. R.K.M.

PERHAM (J.). *New adventures in Maine tourmaline.* Lapidary Journal, **33**, 10, 2114-52, 10 figs (2 in colour), 1980.

Further deposits of tourmaline have been located at the classic Mount Mica site in Maine. M.O'D.

PFAFFL (F.). *Böhmische Granate.* (Bohemian garnet.) Lapis, **5**, 4, 30, 1 fig in colour, 1980.

Location and history of this type of garnet are given. M.O'D.

POUGH (F. H.). *Gemological Update—Part I.* Lapidary Journal, **34**, 1, 154-60, 1980.

Reviews a number of developments and practices, including heating, irradiation and oiling, prevalent today. A number of new finds, extravagantly described, are now known to be less important than was first believed; stones in this category include kunzite from Afghanistan. Opal from Brazil has declined in quantity. The author finds the recent determinations of tourmaline types confusing. M.O'D.

ROSSOVSKII (L. N.), MAKAGON (V. M.), KUZ'MINA (T. M.). *Characteristics of the formation of a kunzite deposit in Afghanistan.* Soviet Geology and Geophysics, **19**, 11, 82-7, 2 figs, 1978.

The deposit is at Kulam, 80km south-east of the centre of Lagman Province, on the right-hand side of the Kulam river belt, a left tributary of the Alingar river. The deposit is in a pegmatite. Kunzite is found in zones and pockets with lepidolite, blue cleavelandite, vorobyevite (pink beryl), pollucite and quartz. Crystals of gem quality range up to 3 × 15 × 35cm and have a well-developed vertical striation. Colours include pink-violet, red-violet, greenish-lilac, lilac, blue-green, light blue, bluish-green, green, yellow-green and yellow. Combinations of colours are also found. M.O'D.

SCAMBARY (R.). *Australia adds rubies to its mineral riches.* Gems & Gemology, **XVI**, 7, 220-1, 2 figs, 1979.

Australian Information Service reports small quantities of cabochon grade and some facet grade rubies found in Harts Range, north-east of Alice Springs. R.K.M.

SCHAWALLER (W.). *Erstnachweis eines Skorpions in Dominikanischen Bernstein der Stuttgarter Bernsteinsammlung.* (First record of a scorpion from Dominican amber in the Stuttgart amber collection.) Stuttgarter Beiträge zur Naturkunde (Series B), 45, 1-15, 8 figs, 1979.

A new fossil of the family Buthidae, probably genus *Centruroides Marx,* has been found in a specimen of amber from the Dominican Republic in the amber collection of the Staatliches Museum für Naturkunde, Stuttgart. This is the first record of a tertiary amber scorpion from the American continent and the most southern record of a fossil from this group. M.O'D.

SCHAWALLER (W.). *Neue Pseudoskorpione aus dem Baltischen Bernstein der Stuttgarter Bernsteinsammlung.* (New pseudoscorpionidae in the Baltic amber in the Stuttgart amber collection.) Stuttgarter Beiträge zur Naturkunde (Series B), 42, 1-22, 17 figs, 1978.

Pseudoscorpionidae *Chthonius pristinus, Microcreagris* and *Cheiridium sp. (?hartmannii)* have been found in amber specimens from the Baltic in the collections of the Staatliches Museum für Naturkunde in Stuttgart. All three are new or possibly new species. M.O'D.

SCHMETZER (K.), BANK (H.). *Brauner Aktinolith aus Ostafrika—ein Glied der Mischkristallreihe Tremolit-Aktinolith-Ferroaktinolith.* (Brown actinolite from East Africa—a link in the mixed crystal series tremolite-actinolite-ferroactinolite.) Z.Dt.Gemmol.Ges., **28**, 4, 179-83, 1979.

A brown-coloured transparent actinolite from East Africa was described. It had RI n_x 1.633 n_z 1.653 and a density of 3.15. The authors discuss the position of this crystal in the actinolite solid solution series. E.S.

SCOTT (D. C.). *Turquoise occurrence near Mount John.* Min. Resrcs Rev., South Australia, **145**, 69-74, 3 figs, 1979.

An iron-rich zone of silcreted sandstone, near the base of the parachilna formation of Early Cambrian age, near Mount John, in the Flinders Ranges of South Australia, contains small patches of blue-green turquoise. Quartz grains in the turquoise cause pitting, preventing the production of high-quality polished articles. Accessory minerals occurring in the turquoise-cemented silcrete include zircon, rutile, alunite, goethite, and carbonate. W.A.F.

SEAGER (A. F.). *The origin of a tetrahedral diamond.* Mineralog. Mag., **43**, 377-87, 9 figs, 1979.

A tetrahedral crystal of about 4mm edge-length has been examined for evidence relevant to the controversy as to whether the symmetry of diamond is $4/m\bar{3}2/m$ or

$\bar{4}3m$, the rare development of tetrahedral morphology having been cited in favour of the lower symmetry. On this crystal one quadrant containing (111) differs topographically from the other three; the latter have nearly plane faces each surrounded by six curved surfaces of form $\{hkl\}$, and show coplanar banding of trigons II ($\mathrm{I}\bar{\mathrm{I}}\mathrm{I}$) with striations on the curved surfaces parallel to it. The banding and striations are interpreted as stratigraphic etching of nitrogen-rich layers II ($\mathrm{I}\bar{\mathrm{I}}\mathrm{I}$) in a Type I diamond; slip and apparently polygonization occur in the unique quadrant. The doubt cast on tetrahedral morphology (and the inferred twinning on {100} or about <100> as evidence for lower symmetry) strengthens the case for assigning diamond to class $4/m\bar{3}2/m$. R.A.H.

SENIOR (B. R.), MOND (A.), HARRISON (P. L.). *Geology of the Eromanga Basin.* Bull. Bur. Min. Resrcs, Australia, **167**, 102pp, 16 figs, 18 pls, 3 coloured geol. maps, 1978.

The Eromanga basin is a Jurassic to Cretaceous sedimentary basin. In late Cretaceous time the upper 130 m of the sequence was kaolinized and partly silicified and ferruginized by chemical weathering. Precious opal occurs in the chemically weathered sediments and several large open-cut mines are producing opal from depths of up to 10 m. I.M.H.

STONE (J.). *Coober Pedy—the opal town.* Gems & Gemology, **XVI**, 7, 213-16, 4 figs, 1979.

An Australian Information Service write-up of this desert location. R.K.M.

SUWA (K.), SUZUKI (K.), MIYAKAWA (K.), AGATA (T.). *Vanadian and vanadium grossulars from the Mozambique metamorphic rocks, Mgama Ridge, Kenya.* 4th Preliminary Report of African Studies, Nagoya University, 87-96, 4 figs, 1979.

Vanadium-bearing grossular garnet is found as 'potatoes' (porphyroblasts) in a calc-silicate gneiss at the Lualenyi mine, Mgama Ridge, southern Kenya. Properties and chemistry are given, together with maps of the area. M.O'D.

SVISERO (D. P.). *Piropos cromíferos da mina de diamantes de Romaria: composição química e origem.* (Chrome pyrope from the Romaria diamond mine: chemical composition and origin.) Boletim Mineralogico, 6, 7-14, 3 figs, 1979.

Chrome pyrope has been found associated with diamond at the Romaria mine, Minas Gerais, Brazil. Crystals of up to 1cm have been found. M.O'D.

SZOMOR (I.). *Bernsteinfarbener Opal aus Ungarn.* (Amber-coloured Hungarian opal.) Lapis, **5**, 5, 31, 2 figs in colour, 1980.

An amber-coloured opal without play of colour is found in the Eperjes-Tokajer area of Hungary, close to the Czech border. M.O'D.

WAND (U.), NITZCHE (H.-M.), WETZEL (K.). *Nitrogen isotope composition in natural diamonds—first results.* Chemie der Erde, **39**, 1, 85-7, 1980.

Nitrogen isotope composition was determined from a collection of 13 natural diamonds. The nitrogen was found to be slightly enriched in ^{15}N compared to atmospheric nitrogen. The method of experimentation proved that the argon content in the samples must have come from the stones themselves and not from atmosphere. M.O'D.

WENTORF (R. H.), DEVRIES (R. C.), BUNDY (F. P.). *Sintered superhard materials.* Science, **208,** 4446, 872-80, 11 figs, 6 tables, 1980.

Diamond or cubic boron nitride particles can be sintered into strong masses at high temperatures and pressure at which the crystalline forms are stable. Hardness and thermal conductivity approach those of large single crystals: resistance to wear and splitting is superior. Produced on commercial scale and increasingly used as cutting tools on hard or abrasive materials. J.R.H.C.

YAMAGUCHI (S.), SETAKA (N.). *Essai de synthèse du diamant.* (Experimental synthesis of diamond.) Bull. Min., **103,** 120-1, 1 fig, 1980.

Diamond was produced when a mechanical mixture of carbon monofluoride and copper in the ratio 1:9 was exploded in a closed tube by applying an external shock wave. The pressure and duration of this shock were 0.9 Mbar and 10^{-12} sec, respectively. The diamonds obtained were identified by electron diffraction; their dimensions are ~ 100Å. R.A.H.

YU (R. M.). *The Brewster angle refractometer.* Gems & Gemology, **XVI,** 8, 245-7, 3 figs, 1979.

A refractometer with no upper or lower limits to its capacity. Depends on Brewster's Law which, briefly, states that light reflecting from a polished surface (other than metal) is completely polarized parallel with that surface at an incident angle directly related to the RI of the substance. The instrument, like others based on the same principle, measures the angle approximately and exact RIs are not obtained. Suggests that solid state versions with digital displays might have greater potential. R.K.M.

YU (R. M.), HEALEY (D.). *Practical color systems for gems.* Lapidary Journal, **33,** 10, 2238-41, 1 fig, 1980.

Attempts have been made to match the colour of gemstones with established colour grading systems such as Munsell and the Gem Master Color System. Instrumental measurements were found to possess some advantages over the eye. M.O'D.

NOTE: to avoid confusion, the Spring 1980 number of Gems & Gemology is so described above, because, although in fact part 9 of volume XVI, it carries the number 8.

BOOK REVIEWS

BOSSI (Jorge). *Recursos minerales del Uruguay.* (Mineral resources of Uruguay.) Ediciones Daniel Aljanati, Montevideo, 1978. pp.348. Illus. in black-and-white and in colour. $(US)34.00.

Amethyst and some ornamental marbles are the chief materials of interest to the gemmologist, but this exhaustive book covers many other minerals of economic importance. Maps of deposits are given. M.O'D.

CZARNOWSKI (S.). *Baroque jewellery.* National Museum, Warsaw, n.d. Unpaginated. 9 figs in colour. Zl 20.

A pocket-sized guide for visitors to the galleries of the National Museum, Warsaw. M.O'D.

CZARNOWKSI (S.). *Rock crystal products.* National Museum, Warsaw, n.d. Unpaginated. 9 figs in colour. Zl 20.

A pocket-sized but well-illustrated book for visitors to the galleries of the National Museum, Warsaw. M.O'D.

FUGGER (B.). *Die Mineralien des Herzogthumes Salzburg.* (The minerals of the Duchy of Salzburg.) A. Strasser, Salzburg, 1979. pp. viii, 124. Price on application.

This book is a reprint of a work first published in 1878 and includes all the original text and a map of the area. Minerals are arranged in chemical order. The area is important to gemmologists since it includes the emerald-bearing district of the Habachthal, which is described. M.O'D.

HÄNNI (H. A.). *Mineralogisch und mineralchemische Untersuchungen an Beryll aus alpinen Zerrklüften.* (Mineralogical and mineral-chemical examination of beryl from alpine clefts.) Universität Basel, Basel, 1980. pp.107. Illus. in black-and-white. Price on application.

This close study of the occurrence of beryl in alpine clefts was presented as a Ph.D. thesis. The central alpine regions provide the chief localities for beryl. Chemical analysis of a number of crystals and examination of accessory minerals give a clear range of constants for alpine beryl. M.O'D.

HOWARTH (S.). *The Koh-I-Noor diamond.* Quartet Books, London, 1980. pp.viii, 160. Illus. in black-and-white and in colour. £15.00.

This is an account of the history of the celebrated diamond and does not attempt to discuss the stone itself. It is very readable and contains a wealth of information which would be quite difficult to assemble, and for this the author is to be congratulated. There is an ample bibliography; though it would have been useful for complete references to have been given, this would admittedly have greatly increased the price of the book. The plates are good and those in colour very good—the standard of production is high overall. Those interested in Indian History, religions and legends will find the book good value. M.O'D.

KALDIS (E.), (ed.). *Current topics in materials science.* Vol. 4. North-Holland Publishing Co., Amsterdam, 1980. pp.viii, 596. $(US)102.50.

The fourth* in this excellent series contains papers on the unusual luminescent properties of Eu^{2+}, on phase diagrams of electronic materials (this paper also contains an explanation of phase diagrams with special reference to their importance for crystal growers), on defect structures and growth mechanisms and on the preparation and properties of lanthanide oxides. References to all papers lead the reader with an interest in the properties of crystals to a variety of important sources; those whose business it is to look out for the advent of new materials should familiarize themselves with books such as this, although the price means that a library copy will inevitably be the one consulted. M.O'D.

KUZ'MIN (V. I.), DOBROVOL'SKAIA (N. V.), SOLINTSEVA (P. S.). *Turmalin.* (Tourmaline.) (In Russian.) Nedra, Moscow, 1979. pp.268, 11 figs in colour. R1.60.

This major work on the composition and properties of tourmaline includes work done up to 1976; a bibliography of over 300 entries includes both Slavonic and western works. M.O'D.

LEAMING (S. F.). *Jade in Canada.* Geol. Surv. Canada, Paper No. 78-19, pp.59, 37 figs, 1978. $4.00 (Canada), $4.80 (other countries).

Although dealing chiefly with jadeite and nephrite in Canada, this review includes information on occurrences elsewhere in the world. The physical and chemical properties of jadeite and nephrite are summarized and eight chemical analyses of Canadian nephrite are tabulated. Nephrite is considered to have originated mainly by either metamorphism of calc-silicate rock or metasomatism between serpentine and other rocks. The mineral occurs in alluvial deposits, colluvial deposits (large blocks lying downslope from bedrock occurrences) and *in situ* deposits. The chief Canadian deposits are found in British Columbia, mainly between the coast and Rocky Mountains, associated with serpentinite. Details are given of a number of deposits in British Columbia and Yukon. The largest deposit, in the Cry Lake area of B.C., has a probable reserve of 3600 tonnes. The appendix contains a glossary of technical terms. M.O'D.

LEGRAND (J.). *Diamonds, myth, magic and reality.* Crown Publishers, New York, 1980. pp.287. Illus. in colour. $50.00.

This fine book is divided into sections, each dealing with a particular diamond-producing country. Preliminary material describes and illustrates the use of diamond as shown in early manuscripts, later chapters outline the mining, testing, sale, grading and cutting of diamond. Expensive and somewhat unwieldy, but the text is sound and photographs first-class. M.O'D.

MCCABE (J.). *Opal mining at Lightning Ridge.* Kelly Books, Melbourne, 1979. pp.64. Illus. in colour. Price on application.

A simple guide to mining, this book concentrates on the practical side of obtaining opal. Illustrations in the text are helpful. M.O'D.

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*Reviewer advises that Vols 2 and 3 are not in our field: for review of Vol. 1 see J. Gemm., 1979, XVI(6), 419.—Ed.

MATTIOLI (V.). *Minerali Ossolani.* (Minerals of Ossola.) Vittorio Mattioli, Milan, 1979. pp.267. Illus. in colour. £12.00.

This is a first-rate mineralogy of the area of the Val d'Ossola in northern Italy. Minerals are arranged chemically and there is a short bibliography at the end of each section. Introductory matter deals with the geology or the area. Minerals especially noteworthy include emerald, andradite garnet and tourmaline. M.O'D.

MULLER (H.). *Jet jewellery and ornaments.* Shire Publications, Princes Risborough, 1980. pp.32. Illus. in black-and-white. 75p.

This is an admirable little book, very well illustrated and containing all the information those interested in jet are likely to want. It is pleasing to know that several craftsmen are turning to jet and that there is a demand for jet jewellery. This book, which can be read at a single sitting, covers the history and geology of jet, the Whitby jet industry, jet manufacture and imitations. The price is something of a triumph for today. M.O'D.

READ (P. G.). *Beginner's guide to gemmology.* Newnes Technical Books, London, 1980. pp.234. Illus. in black-and-white and in colour. £3.25.

It must be said at the outset that comparison with *Practical Gemmology* is inevitable. Both books aim at the same audience—the student and beginner in gemmology. Accurate comparison must take into account the great change in educational standards since the first appearance of *Practical Gemmology* in 1943. Though many will deplore the apparent decline in standards today, the over-all picture is much more satisfactory, if only in that almost anyone who wants it can obtain higher education. The style of this new book reflects the change in study patterns more than it does anything else (to save the reader time I find it very satisfactory!); *PG* was didactic, and this was understandable, since most readers at that time would have had unimpressive educational backgrounds. It was also wooden and not well arranged; on the other hand it was accurate and had useful questions at the end of the chapters. This book is well written, logically ordered, far better illustrated (the illustrations in *PG* are frequently outdated or irrelevant) and, of course, up-to-date. After an introductory section in which gemmology is defined, the reader is first introduced to colour, then to specific gravity, optical properties, synthetics and simulants, appendices and tables. There are some errors—I am told that a paperback merits only one proof-check, so that if the illustrations are altered the index may be out of step—but all this can easily be corrected in a later edition. In view of the author's background the sections dealing with instruments are especially well done as one would expect. I do find some fault with the arrangement of material toward the end of the book; inclusions in ruby and some other stones are described in the section on synthetics and in the midst of the appendices some more inclusion data are given. This should all be tided up. The bibliography could have been a little extended (journals are not included) and arrangement under the name of the author is *de rigueur* in any book of standing. 'Russia' as a locality is inadequate and inaccurate. The whole section on gemstones could be expanded; 'pyramid' could be added to the glossary of crystallographic terms; the use of 'primary' and 'secondary' in a geological context is dangerous, since confusion with the same terms used for mineralization is possible. It is hard for the present reviewer to put himself into the position of the beginner; I feel that as a textbook it covers the ground very well indeed but also that it should be used in conjunction with more elementary explanations from instructors; the impression given is that it expects some degree of subject knowledge. M.O'D.

SUPERCHI (M.), ROLANDI (V.). *A proposal for delimiting ruby (from rose and violet corundum) and emerald (from light green and dark green beryl).* Laboratorio di Analisi Gemmologiche, Sezione di Milano, Milan, n.d. Unpaginated and unpriced.

The West German colour standard (DIN 6164 Farbkarte) is used as a basis for distinguishing ruby from close relatives and emerald from other green beryls. M.O'D.

YAVERBAUM (L. H.). *Synthetic gems, production techniques.* Noyes Data Corporation, Park Ridge, N.J., U.S.A., 1980. pp.xi, 353. $39.00.

This book updates and continues a previous publication, *Synthetic gem and allied crystal manufacture,* which like this one, was based on U.S. patents. As in the previous work, the contents are divided into corundum, asteriated gems, rutile, titanates, garnet, miscellaneous crystals (including emerald, zirconia, alexandrite, amethyst, citrine, opal and several others). This takes the reader rather less than half-way through the book, the remainder of which is devoted to diamond.

Each patent is described and most give step-by-step accounts of the manufacture of the materials. It is interesting to note that one manufacturer of synthetic alexandrite states that both chromium and iron are necessary to achieve the colour change; that the orange variety of cubic zirconia owes its colour to cerium oxide; and that there are several ways of stabilizing the array of silica spheroids to obtain workable opal. Readers with an interest in man-made gems should have access to this book. A list of patents is provided together with an index of inventors.

M.O'D.

South African Directory of Jewellery and Precious Metals. Thomson Publications S.A.(Pty) Ltd, Johannesburg, 1980. pp.166. Illus. in black-and-white and in colour. Rd 27.

This 1980 edition is the first of what is hoped will be a regular publication. Mostly consisting of advertising material, the book also contains pieces on gemmology (with some horrifying misprints) and on precious metals, prices and retailing. South African dealers will find it most useful. M.O'D.

ASSOCIATION NOTICES

OBITUARY

CECIL JAMES PAYNE—GEMMOLOGIST EXTRAORDINARY

A Tribute by B. W. Anderson

Cecil James Payne was born at Ipoh in the the Malay States (Malaysia) on 5th July, 1905, where his father was an Incorporated Accountant and also Managing Director of the Times Malaysia Press. In 1914 he was sent to England with his sister Joan and lived with four aunts and an uncle in Holland Road, Kensington. He was educated at a Prep. School in Earl's Court and later at Westminster School as a weekly boarder and later dayboy. He finally became a student at King's College, London, where he obtained a B.Sc. in geology

Payne's mother and three younger sisters (Marjorie, Dorothy and Nancy) returned to England in 1920, and he lived with them in Kensington until his father retired and bought the Old Vicarage at Ospringe where the family lived for some years.

It was in October 1928 that he joined me in the Laboratory where I had been working single-handed (with a commissionaire for company) since 1925. As in my case, Payne obtained the job through the good offices of W. T. Gordon, Professor of Geology at King's College. The work at that time was concentrated entirely on pearl testing and for some months I had been working overtime in a vain attempt to cope with the great demand for the elimination of all cultured pearls not only from the bunches as they were imported from Bombay but also from the stocks already held by the big jewellers of the day. I was thus mighty glad to have a team-mate of similar scientific background to work alongside me, and was doubly lucky in that he proved to be a congenial companion. An entry in my diary for 15th October, 1928, reads: 'C. J. Payne, B.Sc., came for the first time today and proved to be a very good sort. Somewhat impetuous but very willing and cheery. He soon was able to weigh and count pearls accurately, which was of considerable help'.

Our work mostly involved cutting the pearls from the bunches in their various sizes, counting, weighing and packeting and eventually testing each pearl on the endoscope. This was a remarkably efficient instrument but not easy to operate without considerable practice. Payne spent some weeks working through pearls I had already tested, but eventually we settled down into an efficient testing team and gained much pleasure from handling such superbly beautiful goods and in winkling out any 'Japs' that had intruded.

Our initiation into the larger world of gemmology was slow in coming, but, when it did, our progress was extremely rapid. The almost complete cessation of routine testing during the great trade depression of the early 'thirties gave us time on our hands which at first we frittered away with such things as chess-playing but soon turned to very good purpose.

The times were propitious for advance. In 1931 the Gemmological Association was founded as an entity separate from its parent N.A.G.; Arthur Tremayne's venture *The Gemmologist,* originally intended as the G.A.'s official journal, made its first monthly appearance in August of that year and acted as an ideal vehicle for reports of any advances; laboratories similar to our own were being established in Paris and in Idar, and Robert Shipley, having obtained his G.A. Diploma, was beginning his giant task of bringing the light of gemmology to the United States jewellery trade.

In our laboratory so much began to happen that it is difficult to place things in their right order, nor, in this context, does this greatly matter. The work that Payne and I carried out in that period on liquids of high refractive index designed to increase the range of the refractometer and on the refractometer itself, on establishing the spectroscope as a major gem-testing instrument, on devising the Chelsea Filter, and on improving the accuracy of the reported constants of the precious stones, etc., has been adequately described in '1925 . . . And All That',[1] and it would be out of place to reiterate it here. We strove together in complete harmony on work which was scientifically serious but also (to us) tremendous fun. We shared a taste for what to an outsider must seem extremely silly jokes. For example, James liked to label our odd assortment of instruments with peculiar Christian names. Ermyntrude (I still remember) was our Tully refractometer, Henry and Henrietta our two pearl shovels, Walter, Eustace and Stubby three of our favoured spectroscopes, and Edgar the 500 watt projection lamp we used with them.

Our most fortunate purchase during this period was a Beck table spectrometer which served us well for the observation and measurement of spectrum emission lines and for the accurate determination of the refractive index of liquids (contained in small hollow prisms) and for the RI and dispersion of gemstones where these were sufficiently well cut. I mention this instrument particularly because it provided the first instance where James became particularly adept[2] and I was well content to be his 'dog's-body'.

I imagine that there are few gemmologists living today who have had the experience of measuring the refractive indices of gems by the beautiful minimum deviation method. There are commonly several spectra visible produced by a

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1. *J. Gemm.*, XIII(7), 249-62, 1973: for further details of our research, see 'The Pleasures of Discovery', *id.*, XIV(3), 97-113, 1974, and 'Twenty-five Years', *id.*, XIV(6), 257-72, 1975

2. see his 'Dispersion in Gemstones', *Gemmologist,* IV, 263-5, (April) 1935, and 'Dispersion of Rarer Gemstones', *id.,* IX, 32-5, (October) 1939.

C. J. Payne in gunner's uniform and sporting his Chaplin moustache to which he was addicted for a short time.

succession of facets, so that the correct marrying of facet angles and the minimum deviation observed needs great skill and patience to achieve, involving deft adjustments of the specimen. In this technique C.J.P. showed exceptional aptitude and patience. Later (1937) Payne devoted one of his rare but always well-written papers in the *Gemmologist* to the table spectrometer[3] giving instances of calculations, which were used by Robert Webster in his *Gems.* Another of his special interests was revealed in an earlier paper on 'Interference Figures and Gemstones'[4], showing his excellent grasp of crystal optics. We heard little of his private life, and his marriage in 1933 to Enid Slattery came as a surprise. Enid was clearly devoted to him but, sadly, she had a weak heart which caused her early death in 1941.

Believing strongly that the F.G.A. title should be properly earned both Payne and I entered in turn for the examination in an *hors concours* capacity and thus

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3. 'The Table Spectrometer and the Measurement of Refractive Indices', *Gemmologist*, VI, 207-18, (April 1937.

4. *Gemmologist*, VI, 55-61, (October) 1936.

earned our Fellowship title in the regular manner, an example which was followed later by Dr Edward Gübelin.

When, following the capitulation of Münich, the advent of war became imminent, James Payne began his training as a gunner in an anti-aircraft battery operating in Hyde Park, while I joined the London A.F.S. When war was declared in September 1939, James was called up at once and I had to hurry back from holiday to carry out stand-by duty at various fire-posts in the Holborn neighbourhood and keep the Laboratory going. Payne was eventually sent overseas and served with the famous 8th Army for the remainder of the war, mainly in North Africa.

At the beginning of August 1945 he was back in England and almost immediately demobbed. My diary entry for 3rd September reads: 'Almost exactly six years after going forth to war James Payne resumed work in the Laboratory. Tackling all the stack of endoscope work with real determination, he soon got his hand in and whittled it down'. One had the impression that for him the war had been a boring and tiresome episode which had to be gone through before resuming his proper avocation.

In the following year a sudden vastly increased need to test imported rubies and sapphires owing to the infiltration of synthetics, demanded additional staff if we were to fulfil this work in addition to our usual pearl testing. In April 1946 Robert Webster joined the Laboratory, followed a month later by Alec Farn. From then on our team of four was able not only to deal with all the routine testing but to carry out research work in the field of testing methods which enhanced the world reputation of London's Laboratory.

The work of the Lab. eventually became somewhat departmentalized: Robert Webster tackled the x-ray testing of pearls and kept our books, Alec Farn did the bulk of our stone testing and the work of drilled pearls was almost entirely James Payne's reponsibility. My own work was flexibly directed wherever needed. Payne's skill and vast experience with pearls by now enabled him to make decisions by careful lens inspection only, with an x-ray test for anything at all doubtful. The shift from the endoscope was almost a necessity because of the dearth of good needles.

There was no fear, however, of C.J.P. being out of the swim in pure gemmology.[5] We had throughout been fortunate in becoming involved with the discovery of new gem minerals. Before the war we had found hitherto unsuspected zinc-rich gahnospinels in the gem gravels of Sri Lanka and had also been the first to find kornerupine in this same rich source. Soon after the war Count Taaffe had passed to us for investigation the first small spinel-like stone (recovered from a jeweller's junk box) which was eventually proved to be a new mineral and was appropriately named Taaffeite. I feel that Payne's greatest triumph as a gemmologist was the recognition in October 1949 of a second Taaffeite in a parcel of mixed Ceylon stones sent in for routine testing.[6] He was alone in the Lab. when the rest of us were at a Gemmological Exhibition in Goldsmiths' Hall. Our best refractometers were at the exhibition so that Payne had to rely on a uniaxial negative interference figure to confirm his discovery. And there were further new gem

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[5] 'Sinhalite, a New Mineral and Gemstone', *Gemmologist*, XXI, 177-81, (October) 1952: 'Kornerupine', *id.*, XXIII, 215-19, (December) 1954.

[6] 'A New Gemstone', *J. Gemm.*, III(2), 77-80, 1951: 'Further Notes on Taaffeite', *id.*, III(6), 234-5, 1952.

C. J. Payne at his pearl table.

minerals in which he was involved. In August 1952 Chas. Mathews & Son sent to the Laboratory a dark red crystal belonging to A. C. D. Pain, a well-known gem dealer and collector in Mogok, which he had failed to equate with any known mineral. We jointly established its properties, but it was C.J.P. who worked out its hexagonal crystallography and later joined with G. F. Claringbull and M. H. Hey who carried out the necessary x-ray and chemical analysis in the eventual paper, in which the new mineral was named Painite. Only two other crystals have so far been found. In 1950 the purchase from Imperial College of a Zeiss Abbe-Pulfrich refractometer in prime condition gave C.J.P. fresh opportunities for making accurate optical measurements on the rarer gemstones.

Gemmology was by no means the only subject that concerned C. J. Payne: curiously, he seldom bothered to read any gemmological literature. History and anthropology were perhaps his most abiding loves, and his interest in early man led him to undertake a journey to Tanganyika (accompanied by his godson Martin Willis) where L. B. Leakey had recently found the skull of 'Nutcracker Man' reputedly 600 000 years old. The books that he read increasingly obsessed his mind and each in turn became almost his sole topic of conversation. In recent years weather statistics for some reason became almost an obsession and his desk was littered with scraps of paper inscribed with figures for rainfall and recorded hours of sunshine. He did not take holidays in the usual sense but did pay frequent week-end visits to an aunt (who reached the age of 101) and cousin living near Haywards Heath, where he enjoyed working in the garden. He also frequently visited his widowed sister Nancy Hopkins and her two daughters, first in Rye and later Canterbury.

But he was at all times a lonely man by choice and temperament. Unfortunately each of his two closest friends, Maurice Arnold and Leslie Willis (with whose family he used to spend Christmas), predeceased him by many years. These were fellow intellectuals, and when either dropped into the Lab. to share our lunch time the air became thick with learned arguments on this and that. There was for him a rather pleasant short period in his home life when he befriended the small son of a widowed neighbour, and we heard a good deal about the sayings of 'little Gregory' and their visits together to the Royal Tournament and the like.

But after his retirement he had no contacts with people of similar tastes and withdrew more and more into himself with only two cats for company. The last time that the Lab. staff of his day met together was in March 1975—the occasion being a lunch at Goldsmiths' Hall held to mark the 50th anniversary of the Laboratory's inception. James Payne was dressed up for the occasion and appeared to be in good spirits, but his mind seemed more occupied with the new fancy waistcoat he was wearing than with the honour being paid to the Laboratory.

After an illness, the assistance of a social worker was needed to keep an eye on him and later of a kind home help who was very good to him. He had a slight stroke and his mind became unsettled. Eventually he was moved to a Borough Council Home, and there died quite suddenly of heart failure, on 20th April, 1980.

Although he was a very self-centred man, James Payne had a remarkably even temper and inspired affection in all who knew him well. I shall always be glad that each edition of *Gem Testing* contained the dedication: 'To C. J. Payne, with recollections of happy partnership in routine and research'.

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Mr Edwin W. Clifford, F.G.A., (D.1956), Cassington, Oxfordshire, died on 19th April, 1980.

Mr David G. Lennie, F.G.A., (D.1953), West Kilbride, Scotland, died on 25th June, 1980.

Mr Leslie Herbert Tye, F.G.A., (D.1956), Orange, N.S.W., Australia, died on 30th January, 1980.

GIFTS TO THE ASSOCIATION

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

Mr Christopher Cavey, F.G.A., Greenford, Middlesex, (Roughgems Ltd), for the following: four specimens of rhino hide (one is fashioned as a button, one as a round bead); a copy of 'Ivory' by Geoffrey Wills, published by Arco, London, 1968; a collection of specimens in a presentation box including elephant ivory, wild boar ivory, hippopotamus ivory, walrus ivory, sperm whale ivory, narwhal ivory and corozo vegetable ivory.

Mr W. A. Harris, Exeter, for 'Manual of precious stones and antique gemstones' by H. M. Westropp, published by Sampson Low, Marston, Low & Searle, London, 1874.

Mr R. Holt, F.G.A., London, for parcels of zircon, aquamarine, ruby and sapphire crystals and rough pieces ideal for students' use.

Mr E. A. Thomson, London, for a round cabochon tugtupite from Greenland, weighing 2.24 ct.

NEWS OF FELLOWS

Mr M. J. O'Donoghue, M.A., F.G.S., F.G.A., gave a talk on synthetics on 31st May, 1980, to the Wessex Branch of the N.A.G. Members examined a variety of man-made stones. Mr O'Donoghue also gave a lecture entitled 'The formation of mineral deposits' to the Amateur Geological Society on 1st July, 1980.

In July 1980, the Council of Legal Education announced the results of the Trinity Examinations of students of the Inns of Court, in which Mr Jonathan P. Brown, F.G.A., (Lincoln's Inn) was placed second in Division I of Class II (i.e. fifth overall) and was awarded the Colyer Prize in the law of landlord and tenant.

MEMBERS' MEETINGS

Midlands Branch

The Annual General Meeting of the Branch was held on 24th April, 1980, at the Society of Friends, Dr Johnson's House, Colmore Circus, Birmingham. Mrs S. E. Spence, F.G.A., was elected Chairman and Mrs J. S. Leek, F.G.A., re-elected Secretary. The A.G.M. was followed by an illustrated talk by Dr W. Bardsley, from the Crystal Growth Laboratory of the Royal Radar Establishment at Malvern, on the techniques of growing synthetic crystals. Crystals grown by the laboratory are used for optical purposes (e.g. lasers), and Dr Bardsley discussed the methods of production used.

North-West Branch

On 26th June, 1980, Dr Stanley Holgate, F.G.A., gave a talk on 'Gemmology on a Budget' at Church House, Hanover Street, Liverpool. Dr Holgate demonstrated home-made equipment for the examination of gemstones.

South Yorkshire Branch

On 29th June, 1980, a field trip was organized for members of the South Yorkshire and North-West Branches. The trip commenced at Nettlerdale, about half a mile from Ashford, where specimens of Rosewood Marble were found (the Derbyshire marbles are a black or grey decorative type of carboniferous limestone, which cuts and polishes well and provided a flourishing local industry in the nineteenth century). After lunch the party proceeded to Friden where pieces of barytes, chalcedony and silicified wood were found.

On the 26th July, 1980, a barbecue was held.

COUNCIL MEETING

At a Meeting of the Council held on Wednesday, 30th April, 1980, Mr D. G. Kent, F.G.A., was appointed as an Examiner in Gemmology. The following were elected to membership:

FELLOWSHIP

Gunn, John F., Brentwood. 1969

Verma, Rajiv, New Delhi, India. 1979

TRANSFERS FROM ORDINARY MEMBERSHIP TO FELLOWSHIP

Sanchez-Lafuente Mariol, José, Barcelona, Spain. 1977

Yamagishi, Shoji, Kanagawa-Ken, Japan. 1979

ORDINARY MEMBERSHIP

Aliprandi, Riccardo, Ostia-Roma, Italy.
Beck, Jennifer S., Rose Bay, N.S.W., Australia.
Boulle, M. J. D., London.
Brookes, Stanley W., Ottery St Mary.
Cook, Duncan J., South Ascot.
Cope, Keith N., West Palm Beach, Fla, U.S.A.
Cottam, Donald L., Jr, Germantown, Tenn., U.S.A.
Craig, Paul N., London.
Crowcroft, Peter J., Bangkok, Thailand.
Dawson, Joan M., London.
Diercks, James S., Gainesville, Fla, U.S.A.
Erickson, Carolee, Billings, Mont., U.S.A.
Fadnes, Jane B., Stavanger, Norway.
Flanagan, Thomas P., Regina, Sask., Canada.
Gimeno Camacho, Vicente, Vina Del Mar, Chile.
Hakomori, Eiko, Tokyo, Japan.
Halley, Eileen D., Palmerston North, N.Z.
Hanneman, W. William, Castro Valley, Ca, U.S.A.
Harris, Ian A., London.
Hauser, Adolf, Zurich, Switzerland.
Hermans, Johannes S., Delft, Netherlands.
Houghton, Carole S., Grantham.
Hui, Yat-Sun, Hong Kong.
Hyman, Alan M., Santa Rosa, Ca, U.S.A.
Johnson, Jeanne L., Vancouver, B.C., Canada.
Jolliff, James V., Edgewater, Md, U.S.A.
Keating, Molly I., Nairobi, Kenya.
Kim, Choo A., Singapore.
Lundholm, Carolyn, Stockholm, Sweden.
Malkin, Stuart J., Van Nuys, Ca, U.S.A.
McDowell, Robert B., Beltsville, Md, U.S.A.
Richards, David, Nottingham.
Robins, Alan P., Bishops Stortford.
Schnider, Jack, Manchester.
Spooner, Carole A., Ruwi, Oman.
Tan Hong Chang, Bernard, Singapore.
Tan Meng Chiang, Francis, Singapore.
Thompson, John E., Elizabeth North, S. Australia.
Walker, John C., Leighton Buzzard.
Williams, Brian E., Stevenage.
Woodward, Christine M., London.

ANNUAL GENERAL MEETING

The Annual General Meeting was held at Saint Dunstan's House, Carey Lane, London, EC2V 8AB, on Friday, 16th May, 1980 at 6.00 p.m.

The Chairman, Mr Douglas King, welcomed those present and then expressed thanks to members of Council, Branch Chairmen, Examiners and Instructors for their assistance during the year and in particular for the work done by the members of the Committee concerned with the review of the Preliminary and Diploma Examinations Syllabuses. He praised the quality of the *Journal,* which had such high standing in the gemmological world and extended thanks to the Editor, Mr John Chisholm, and to his Assistant, Mrs Mary Burland. The Treasurer had once again done a very good job with the result that there was a surplus at the end of the year. In closing, Mr King expressed his regret at having to give up the Chairmanship but felt that he should take heed of medical advice. He had thoroughly enjoyed his short term of office and thanked the Secretary, Harry Wheeler, for all his help and assistance. He felt sure that the younger incoming Chairman would do a first class job for the Association.

There were no questions relating to the Annual Report or Accounts, and Mr Barry Jones seconded the motion, proposed from the Chair, for the adoption of the Audited Accounts and Report of the Council for the year ended 31st December 1979, which was carried unanimously.

Sir Frank Claringbull was re-elected President: Messrs David J. Callaghan and Noel W. Deeks were elected Chairman and Vice-Chairman respectively: and Mr F. E. Lawson Clarke was re-elected Treasurer: Mrs S. Hiscox and Messrs P. Daly and M. J. O'Donoghue were re-elected, and Messrs C. Cavey, A. Hilbourne and P. Read were elected to the Council.

Mr Callaghan in taking Office as Chairman said he would do his utmost for members and for the furtherance of the Association. Mr Deeks expressed his thanks on being elected and said he would give every support to the Chairman.

Messrs Hard Dowdy, Watson Collin & Co., Chartered Accountants, signified their willingness to continue as Auditors and this concluded the business of the meeting.

REUNION OF MEMBERS AND PRESENTATION OF AWARDS

The Reunion of Members is to be held at Goldsmiths' Hall, Foster Lane, London E.C.2., on Monday, 17th November, 1980, between 6.00 and 7.00 p.m.

Following the Reunion the awards gained in this year's examinations will be presented by Sir Edward Ford, K.C.B., K.C.V.O., past Prime Warden of the Worshipful Company of Goldsmiths.

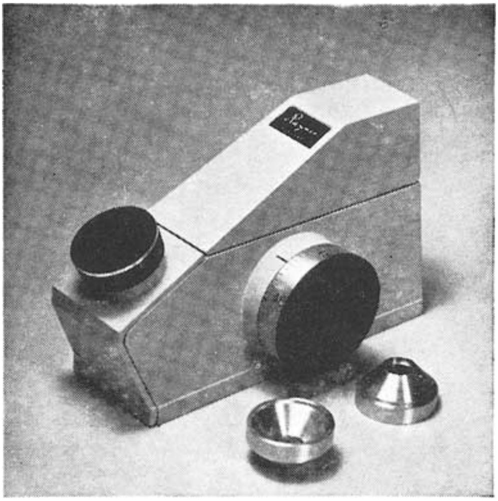
CORRIGENDA

On page 72 above (line 12), for 'carbon monoxide' read 'carbon dioxide'.

On page 160 above (line 8), for 'Beck line' read 'Becke line'.

On page 166 above (line 7), for 'of' read 'or'.

On page 181 above (line 15), for 'Hylda Bracewall' read 'Hylda Bracewell'.



Historical Note

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

Affiliated Associations are the Gemmological Association of Australia, the Canadian Gemmological Association and the Rhodesian Gem and Mineral Society.

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

Notes for Contributors

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

Articles published are paid for, and any number of prints of individual articles may be supplied to authors provided application is made on or before approval of proofs. Current rates of payment for articles and terms for supply of prints may be obtained on application to the Secretary of the Association.

Although not a mandatory requirement, it is most helpful if articles are typed (together with a carbon copy) in double spacing on one side of the paper, with good margins at sides, top and foot of each page. Articles may be of any length, but it should be borne in mind that long articles are more difficult to fit in than short ones: in practice, an article of much more than 10 000 words (unless capable of division into parts or of exceptional importance) is unlikely to be acceptable, while a short note of 400 or 500 words may achieve early publication.

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