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GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
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A FEW MORE "REWARDS"

By B. W. ANDERSON, B.Sc., F.G.A.

EACH year, in the process of toiling through exam papers, the tedium is a little lightened for the examiners by student "howlers" which for one reason or another tickle their fancy. Some years ago I collected a small anthology of those which seemed worthy of a wider audience, which was published in the *Journal* for July, 1970. This was so well received that the exercise appeared worth while, and I now venture to offer a smaller selection gathered since that time.

To begin with, here are some examples of stones which, from the student's account, behaved in a curious manner. There was a chatoyant stone, for instance, which had "an eye that opened and closed, but poorly", and another stone which "showed no turning on and off when used by the polariscope"; yet another which "floated to the bottom of the 3·05 liquid", and an obviously polite stone which "sicks with some restraint in 3·33 liquid".

Then there were those which had an odd appearance. These included a corundum crystal which was "an oblong hexagonal cube" in shape, another crystal which was "slightly terminated at one end", a stone which suffered from "grobular inclusions", and a hessonite garnet, presumably wet to the touch, since it had "trickly inclusions". One specimen showed "a strong flourescence suggesting an overdose of some ingredient", while another was less fortunate, having "no flourlicence".

Ordinary spelling mistakes are, as Mr Callaghan knows, more a rule than an exception, but one had to admire the young lady candidate who managed to separate the "q" from the "u" in stating that a zircon crystal had a "sqaurish shape". Another described the same crystal as a "tetrangol praymarid". A beryl crystal was said to have "longatudinal strea", while a white topaz crystal was a "dome-toped pinaquoid", reminding one of Prospero's famous utterance "our revels now are ended . . ." in "The Tempest". Rather than quote the passage, I will allow the interested reader the pleasure of looking it up. One other stone is worth mention because it had a refractive index "larger than the refractometer".

Some of the crazy mis-identifications in the practical exam betrayed the complete ignorance of the students of quite common gem materials which happen to be outside the very limited range of goods which they handle in the course of business. Examples were the identifications of aventurine glass as "turquoise", of an andalusite as "amber", a quartz crystal as "plastic", while a blue jade was thought to be an "apapalite".

This may seem a rather meagre gleaning of "rewards" compared with the harvest of six years ago, but it must be realized that the former collection took some twenty years to accumulate.

[*Manuscript received 30th November, 1976.*]

A STUDY OF RECENT CHATHAM SYNTHETIC RUBY AND SYNTHETIC BLUE SAPPHIRE CRYSTALS WITH A VIEW TO THE IDENTIFICATION OF POSSIBLE FACETED MATERIAL

By KENNETH SCARRATT, F.G.A.,
The Gem Testing Laboratory, London Chamber of Commerce and Industry

ONCE again we in the Laboratory find ourselves fortunate in having such good friends in the trade. Merchants often bring interesting specimens in for our observations. Often we may only have minutes or maybe an hour to examine and note their main characteristics but sometimes, as in this case, specimens are left with us for a more detailed examination without a time limit. This is particularly useful at the present time because research work is having to take second place, due to the pressure of normal day to day testing.

Our first brief encounter with the new synthetic blue sapphire crystals was when a well-known gemmologist paid a flying visit to the Laboratory. On this occasion not a great deal of information was gained about the crystals but at least we were now aware of their presence on the market and for this we are grateful. A few enquiries around the trade brought the offer of a loan of a group of the sapphire crystals and a group of the latest Chatham synthetic ruby crystals for an indefinite period. Within a few days of receiving these first two, a further three groups of sapphire crystals and three groups of ruby crystals were forthcoming from Mr H. Wheeler of the Gemmological Association. Now with a reasonable number of specimens we began to observe and note their properties.

The individual crystals in the case both of the sapphires and of the rubies are tabular/platey in habit and randomly orientated in the groups. The first two groups obtained measured approximately: length 17 mm, width 15 mm, height 10 mm, with average individual crystal measurements of depth 2 mm, width 8 mm for the sapphires, and length 18 mm, width 14 mm, height 12 mm, with average individual crystal measurements of depth 2 mm, width 10 mm for the rubies. The later six groups (three ruby and three sapphire) were smaller but in the case of the rubies had a greater number of individual crystals. The average measurements of these groups were as follows: rubies—length 15 mm, width 9 mm, height 4 mm; average crystal size, depth 0·5 mm, width 4 mm: sapphires—length 12 mm, width 11 mm, height 7 mm; average crystal size, depth 2 mm, width 7 mm.

The colour in the case of the first sapphire group was located mainly in the tips of the crystals and covered about one-third of their mass, the remainder being colourless. In the three other smaller sapphire groups the colour was a little better, covering up to three-quarters of the individual crystals. The blue in all cases varied from medium-dark to very pale. For the rubies the colour was a good strong carmine red when seen in depth and a very pale pinkish-red otherwise. The colour in general was not patchy although there was in some cases the odd blue area.

Under a low power microscopic examination (10× to 30×) of the surfaces of both the sapphire and the ruby groups there could be seen on the base of the groups frosted areas (Fig. 1) and in a layer which showed no crystal form, where crystals met, a plane of gas bubbles (Figs 2 and 3). In two of the smaller ruby groups there were large areas on their bases which may best be described as looking like a residual covering of clear liquid—almost like water which has not been completely shaken off. These surface observations would be of little or no use in the identification of a faceted specimen. However the included material in both varieties should,

Fig. 1 A frosted area seen on the base of a group of Chatham blue synthetic sapphire crystals.

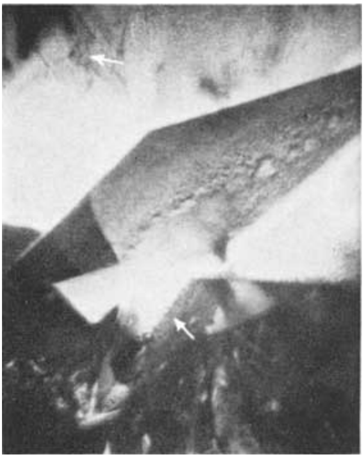

Fig. 2. Gas bubbles at the junction of two Chatham synthetic sapphire crystals and fine-line angular zoning.

FIG. 3. A plane of bubbles at the junction of two Chatham synthetic ruby crystals.

FIG. 4. Two-phase inclusions, veil-like feathers and a few small angular platelets in the Chatham synthetic sapphire.

FIG. 5. A U-shaped inclusion, angular platelets, and a few needle-like inclusions in a Chatham synthetic sapphire.

FIG. 6. Angular platelets in the Chatham synthetic sapphire.

at the very least, point the examiner in the right direction. Figs 4 to 8 show some of the inclusions seen in the sapphire and Figs 9 and 10 show some of the inclusions seen in the ruby.

The dark angular platelets (possibly metallic) are common to both the ruby and the sapphire and in both cases are present in

Fig. 7. Angular platelets in the Chatham synthetic sapphire.

Fig. 8. Angular zoning and platelets in the Chatham synthetic sapphire.

Fig. 9. Angular platelets and two-phase inclusions in a Chatham synthetic ruby.

Fig. 10. Angular platelets in a Chatham synthetic ruby.

great numbers (Figs 6, 7, 8, 9 and 10). Many of the feathers observed, but by no means all, were twisted or veil-like; an example is included in Fig. 4. The U-shaped inclusion in Fig. 5 was only seen in one sapphire crystal. Two-phase inclusions were seen in both varieties (Figs 4 and 9). Angular colour zoning, hitherto unknown in synthetic blue sapphires, could be seen easily in both varieties even with the naked eye. Fine line angular zoning could be seen with the aid of the 10× lens or microscope (Figs 2 and 8).

The absorption spectrum of the ruby variety is normal as described by B. W. Anderson*. However the spectrum for the sapphire is a little surprising in that unlike the Verneuil synthetic there is an easily seen absorption band at 4500Å (450 nm) when the deeper blue areas are analysed with a hand spectroscope. The other two bands of the sapphire complex at 4600Å (460 nm) and 4710Å (471 nm) are also present but are very weak and in all probability will only be seen by observers well versed in the use of the hand spectroscope.

It was not possible to take the refractive indices of the ruby crystals. A large reasonably flat surface on a sapphire crystal gave readings normal for corundum, 1·760–1·768, D.R. 0·008 on the dialdex refractometer, but the optical character and sign could not be obtained from this face.

The fluorescence colours under long-wave ultraviolet light—3650Å (365 nm), short-wave ultraviolet light—2537Å (253·7 nm), crossed filters red/blue and x-ray excitation for both varieties are listed in Table 1. The following is an expansion of that table.

In one instance part of the colourless area of a sapphire crystal turned a pale greenish-brown after exposure to short-wave ultraviolet light. We could not repeat this discoloration on the colourless areas of other crystals when we tried under controlled conditions.

In the case of the first ruby group, after observing its long-wave and short-wave ultraviolet fluorescence in the dark-room we turned on the light only to find that it had changed its depth of colour from a carmine red to a deep purple-red. With Mr Wheeler's permission, one of the other ruby groups was broken into several pieces so that we could try to discover, without risking the other two groups, which wavelength caused the discoloration. We subjected the pieces individually to long and short exposures of long-wave and short-wave ultraviolet light, and in a few cases a combination of both wavelengths. At no time did any of the pieces discolour. We then decided to risk subjecting the remaining two ruby groups to both long-wave and short-wave ultraviolet light and once again

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*"Gem Testing", Eighth Edition, p. 147.

TABLE 1

THE FLUORESCENCE OF CHATHAM SYNTHETIC BLUE SAPPHIRES AND SYNTHETIC RUBIES

Wave-length	*Chatham Synthetic Blue Sapphire*	*Chatham Synthetic Ruby*
Long-wave ultraviolet light 3650Å (365 nm)	Overall yellow with dark blue and greenish patches.	Strong red. One or two small areas were inert.
Short-wave ultraviolet light 2537Å (253·7 nm)	Overall blue. Parts of the surface frosted areas and where some of the crystals meet fluoresce yellow.	A strong pinkish-red. Pale bluish in crevices on the bases of the groups.
Crossed filters Red/blue	Red.	A strong flame red.
X-rays	Yellow with a hint of green, some dark blue patches. Colourless and some pale blue areas photocolour to a deep green or yellow.	Very strong red with a strong persistent phosphorescence.

neither group discoloured. Returning to the discoloured group, we found we could not return the crystals to their original colour.

The x-ray fluorescence, as can be seen in the table, proved to be very interesting. The ruby had a very strong fluorescence and strong persistent phosphorescence. The length of exposure varied from 10 seconds to 10 minutes after which the length of phosphorescence varied from 2 to 20 minutes. A small area photocoloured to an orange-red after a 4 minute exposure. This was only just perceptible.

The sapphire after fluorescing on this wavelength had no perceptible phosphorescence. However, it was found that the colourless and some of the pale blue areas of the crystals photocoloured to varying depths of green or yellow, depending on the length of exposure (the longer the exposure, the deeper the colour). These induced colours are not permanent. A deep green irradiated crystal after close exposure to the heat and light of a 40 watt bulb for 5 minutes lightened to a medium green. After 25 minutes the colour changed to a light green and after a further 8½ hours the green had almost disappeared. A yellow irradiated crystal also faded after being similarly treated. Throughout the exposure to x-rays and the 40 watt bulb the deeper blue areas of the crystal remained unchanged.

CONCLUSIONS

Up to the time of writing we have not seen any faceted stones produced from these crystals. When they do appear on the market we feel that identification in the majority of cases should not be too difficult. For the rubies, the inclusions should be enough to arouse suspicion, for although similar angular platelets have been observed in some natural rubies, never have they been in such profusion. This, coupled with their pronounced x-ray phosphorescence, which is as strong as (or in many cases stronger than) that seen in the Verneuil type synthetic, should be enough for their identification. It should be mentioned that to this date no natural ruby, with the exception of some East African stones, has phosphoresced after excitation with x-rays. In the case of the East African stones, their inclusions are quite distinctive, i.e. long needles resembling "grasshopper legs", arranged in many cases in a scaffold formation, and to date their x-ray phosphorescence has never been as strong and persistent as this new Chatham ruby. There will be the occasional clean synthetic or natural East African stone which will be difficult, but we think not impossible, to identify. The most useful identifying feature to look for in the synthetic sapphires must be their distinctive patchy yellow fluorescence under long-wave ultraviolet light. No natural blue sapphire fluoresces in this way. Great care must be taken if exposure to x-rays is necessary.

It is with pleasure that the author acknowledges the ready help given by his colleagues and friends in the Gem Testing Laboratory and at the Institute of Geological Sciences. We are indebted to Mr M. O'Donoghue for giving us our first look at the crystal groups and to Mr J. A. Fleming and Mr H. Wheeler for the loan of specimens.

[*Manuscript received 18th March, 1977.*]

AFRICAN GROSSULAR GARNETS; BLUE TOPAZ; COBALT SPINEL; and GRANDIDIERITE

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

African Grossular Garnets

Although they have been on the market in this country for the past two or three years the important and attractively coloured grossular garnets from Tanzania and Kenya have been featured in this *Journal* so far, apart from brief references by Axon (1974) and Petch (1976) and a few abstracts, only in a short note accompanied by a list of R.I.s and fluorescent reactions in a paper by A. E. Farn in the issue for January 1976.* For many of the Trade the green varieties are appearing in jewellery under the names "Tsavorite" or "chrome-grossular" with little indication of their gemmological significance.

The stones found vary from colourless to a fine clean yellow or orange-brown hessonite, lacking the sugary inclusions usually associated with this best known grossular garnet, and from a pale lime green to the rich dark green usually associated with chrome- or vanadian-tourmaline. Some of the garnets approach the colour of emerald and this fact appears to be influencing the prices.

The great majority of the green stones are small in size, averaging under one carat. This is probably due to the fragmentary nature of the rough and, at least in part, to the very deep colour. Large cut stones would tend to be too dark. A very fine four carat stone I handled recently could be regarded as exceptional. This is now in the collection of the Geological Museum.

There appear to be three sources; two in the Tsavo National Park, near Mount Kilimanjaro (hence "Tsavorite", a somewhat misleading name since it does nothing to identify the stone as garnet), which produce green stones, and another at Lalatema in Tanzania which provides green as well as the colourless, yellow and brown varieties. The testing constants are those expected for grossular garnet, R.I. 1·740, S.G. 3·68, with slight variation around these values for individual specimens. Hardness is about 7¼. Perhaps the most obvious immediate testing feature is the pink to red residual colour seen through the Chelsea emerald filter. Although this has

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*J. Gemm., 1976, XV, 1, 8-10.—Ed.

been assumed to be due to chromium which is present in small amounts (hence the names "chrome-grossular" and "chrome-garnet"), vanadium is known to be present in an appreciably larger percentage and the intense greens are almost certainly due to this element. A parallel can be drawn with the fine green "chrome-tourmaline" marketed a few years back, which gives a very similar residual colour through the Chelsea filter. This stone was also found to owe its colour to vanadium. The darker greens of these two minerals are very similar and a refractometer test, or at least one for birefringence, is probably advisable to distinguish between them. Strictly speaking both should be called "vanadian-" stones rather than "chrome-".

BLUE TOPAZ

Another gem which is now quite widely known, particularly in better class jewellery using large stones, is a deep blue topaz which has been available for the past several years.

I first heard of this material from a Rhodesian source quite a while before it was marketed here, but since then it has been reported as coming from South Africa and from Brazil. No exact locations are given. The colour is almost that of a fine medium blue sapphire, far finer than the best aquamarine generally available today. Yet the price stays comparatively low.

I believe the reason for this lies in the fact that this is a treated gem. Dr Kurt Nassau, of Bell Laboratories, New Jersey, is reported to have produced this colour by irradiation. (I have a cinnamon brown topaz crystal which has been produced from white by similar means and it is known that *this* colour is subject to fading on prolonged exposure to strong light. So far the deep blue stones have not shown a similar tendency. A German laboratory claims to have found a method of detecting the treated blues, but a promised further report is still awaited.)

Testing constants of these stones are apparently those to be expected from fluo-topaz. In one specimen tested they were R.I. 1·615–1·623 and S.G. 3·56, showing a slight move towards the values for hydroxyl-topaz. The low birefringence, 0·008, ties in with this.

One valuable test between these fine blue topazes and fine aquamarines lies once more in the careful use of the Chelsea filter.

Most aquamarines give a distinctive greenish residual colour which is almost entirely absent in the case of the topaz.

A RARE SPINEL

My third stone is one which first came to my notice a good many years ago. An old friend in Ceylon sent me a bright Reckitt's blue stone with the question "What do you make of this?" The colour was similar to that of deep blue synthetic spinel, although the small native-cut stone seemed strange for this material. But one glance through the Chelsea filter showed a magnificent residual red such as one would expect from the cobalt-rich synthetic. So I wrote back saying that it was an obvious synthetic spinel. Back came the reply "What about the inclusions?"

This time I stopped jumping to conclusions and really examined the stone. It did have natural crystal inclusions and its R.I. was 1·717. Synthetic blue spinels normally have a very stable R.I. of 1·727. So, here was a natural spinel in a most unusually beautiful shade of blue. Since the normal blue colour in spinel is due to iron which suppresses fluorescence in the red, the suggestion was that in this stone the colour must be due to cobalt. The absorption spectrum showed two quite marked bands centred at 6500Å and 5400Å respectively, with a broad but vague absorption between them. The deep red was quite strongly transmitted, which accounted for the emerald filter red. The over-all spectrum was that of a faint iron absorption combined with a rather more marked cobalt one. Subsequently the original stone was analysed by the electron probe technique by Mr Brian Young, of the Institute of Geological Sciences, who found about 0·25% of cobalt together with a larger percentage of iron.

Now this gives more than one anomaly. B. W. Anderson has said that cobalt in natural minerals gives pink colours. In synthetic spinel this impurity gives a blue colour and, since this synthetic is not an exact copy of the natural stone (it contains more aluminium oxide) it was thought that the difference in colour was due to the resultant difference in atomic structure. (There is a possible analogy with colours caused by chromium. When chrome atoms are tightly packed in the lattice, as in ruby, red spinel and pyrope garnet, the colour is red; when they are in less tightly packed situations, in emerald or demantoid garnet, the colour is green. Alexandrite provides an intermediate case).

However, in the natural spinel under discussion we have cobalt apparently giving a blue colour, albeit assisted by a generous helping of iron. The resultant shade of blue is not the inky one normally expected from iron coloration and the red is not suppressed by the iron. Since the R.I. is normal for natural spinel and substantially lower than that for the synthetic material, I feel that it can be assumed that, impurities aside, the composition and hence the structure, are those of normal $MgAl_2O_4$ spinel and that cobalt in this situation overcomes the usual quenching effect of iron on the colour.

Since this first stone I have seen only two others of this fine blue colour in some twenty years. The largest of these was about 2½ carats. The two smaller stones, both under one carat in weight, are still in my own collection. I think I can safely say that they are a rare type of blue spinel.

GRANDIDIERITE

My last stone is in no way commercial, being an example of a rare mineral faceted for the sake of providing yet another "gem" for the collector of the "rare, the rarer and the down-right impossible."

Grandidierite is a slatey-blue mineral originating from southern Malagasy (Madagascar). It is, in the stones examined, only semi-transparent, due to fissures and inclusions, and the small parcel I have consists of five faceted stones and a number of cabochons. Superficially the latter are a little jade-like in appearance, if one accepts what would be very rare colour in jadeite.

Dana Ford, 1932 edition, gives the chemical composition as "a basic silicate of aluminium, ferric and ferrous irons, magnesium *etc.*". It has orthorhombic symmetry but good crystals are rare.

The R.I. of the specimens tested were α1·583, γ1·622, with β close to γ, making the sign optically negative. S.G. was 2·85. Pleochroism is marked, giving light and dark shades of the body colour. Birefringence is 0·039. These constants are low compared with those quoted in Dana but probably correspond with values obtained in more recent work on the mineral. One stone tested gave three R.I.s at one reading, suggesting a twinned structure which was presenting more than one crystal in differing optical aspect on the one surface tested.

A fragment of the original rough was finally confirmed as grandidierite by Mr E. A. Jobbins, of the Institute of Geological Sciences, who very kindly had powder x-ray diffraction tests carried out for me.

[*Manuscript received 3rd February, 1977.*]

NOTES FROM THE LABORATORY

By A. E. FARN, F.G.A.,
The Gem Testing Laboratory, London Chamber of Commerce and Industry

WE are fortunate in the Laboratory in that our members are both forward-thinking and trade-protection-minded. Whilst we occasionally pen notes upon new synthetics, new stones, new trickery, we can only do so if we are supplied with the stones to test. Whilst our function is to test gemstones and pearls for members of our trade section of the London Chamber of Commerce, we are often sent stones by members who *tell us* what the stone is or that it is from a new source or a new example of an established stone, etc. We are grateful for the opportunities and specimens provided and shown to us, which result in added protection and education for the trade in general. Thus does the trade provide the work and material for the benefit of its members and our science of gemmology.

We are now termed the "Gem Testing Laboratory of the London Chamber of Commerce and Industry". I feel that our older and longer title perhaps more adequately described our function and our role. Our old title was "The Laboratory of the Diamond, Pearl and Precious Stone Trade Section of the London Chamber of Commerce". In it we have "The Laboratory" (which is what we are), "The diamond, pearl and precious stone trade section" (which sums up gemmology), "London" (which is where we are), and finally "Chamber of Commerce" (and where would any of us be without commerce?).

* * *

Among the many items forming a routine week's work we have recently had pink opals; these look like pale pink coral without any signs of structure and are subtranslucent at the edges, with no play of colour, looking like glass imitations—in fact extremely unimpressive-looking stones. We found that they had a S.G. of 2·083 and R.I. of 1·45. Their fluorescence colour was a violet blue under long- and short-wave ultraviolet light with a green phosphorescence under long-wave ultraviolet.

* * *

A member showed us aznac stone from Peru: it is basically a deep green opaque cabochon-quality stone with small patches of blue and overall brown veins. The suppliers of the stones state that they are from the old mineral beds which supplied the Incas with their jewellery and are a mixture of chrysocolla, malachite, turquoise and azurite. They have a pleasing appearance, looking like a good green verdite: the densities of two tested were 3·29 and 3·24 respectively, and both reacted to dilute hydrochloric acid. They should make attractive suites of jewellery in silver or gold.

* * *

Another green stone was a diamond in a handsome diamond marquise cluster ring. It was quite a fair size and a tourmaline-green in colour. As any good gemmologist knows green diamonds of decent size and strong colour almost *have* to be irradiated. This one was no exception. It had the umbrella shaded culet, hallmark of a cyclotroned diamond—proof positive.

* * *

Not long ago on testing an alexandrite I should have written a certificate saying—"found to be an alexandrite chrysoberyl". Last week we wrote one—"found to be a *natural* alexandrite chrysoberyl". The synthetic alexandrites produced in America by Creative Gems force one nowadays to add *natural* to alexandrite if the case warrants. To decide whether it is a *synthetic* alexandrite is not so simple. Ideally text-books show only the strong, good and clear examples of synthesis, whether it be of emerald, ruby, sapphire, alexandrite, etc., flux fusion or hydrothermal. The synthetic alexandrite we borrowed from the Gemmological Association was used in comparison tests on a pale green alexandrite sent in for test. The owner—a capable merchant and competent gemmologist—having obtained a few sent one in for test. He was surprised at the

FIG. 1. Structures in natural alexandrite. (*Photo. K. Scarratt*)

FIG. 2. Structures in synthetic alexandrite. (*Photo. K. Scarratt*)

fairly close parallels between characteristics of natural and synthetic alexandrites. Examples of these structures suitably captioned were photographed by K. Scarratt (see Figs. 1 and 2).

Natural alexandrites have a better daylight green colour. Synthetic alexandrites show both colours in daylight but *not* markedly so. Under ultraviolet light, both appear dull red under long-wave, but the natural is a mustardy green under short-wave, whereas the synthetic is a very dull red. X-ray fluorescence shows the natural to be a pale milky-white, whereas the synthetic has a red fluorescence with no phosphorescence. The flux inclusions, depending upon the angle from which they are viewed, have a very worrying natural appearance. I am told that very clean synthetic alexandrites are causing concern and that comparison of transparency to ultraviolet light has to be an added weapon in our hands.

* * *

Recently at Liverpool a discussion on the umbrella-term "jade", which covers both nephrite-jade and jadeite-jade, elicited a statement that an apricot fluorescence under x-ray excitation would help to identify green grossular garnet (one of the jade-like minerals). Almost immediately (the following day in fact) we had to check an oriental carving, which could have been jade (or not), and discovered that *some* nephrites fluoresced in a like manner to green grossular garnet. This really brings home the fact that fluorescence can never be accepted as a basic test, but only to afford about 1% added value to a series of tests which on their own are sufficient and adequate to determine a stone without a shadow or penumbra of doubt.

Since most gemmologists are fortunate (?) enough not to possess x-ray generating equipment with a viewing chamber, this danger of relying on x-ray fluorescence will not often arise. Nevertheless the fluorescence effect even under both long- and short-wave ultraviolet light should be regarded with considerable caution and accepted only as an extra and not a fundamental characteristic. Fluorescence followed by phosphorescence is a much stronger combination as a diagnostic than fluorescence alone. A blue fluorescencing diamond with a yellow after-glow is unique (but I would still apply a boule test).

* * *

Included here is a picture of the surface structure seen on pink (conch) pearls (Fig. 3). With a 10× lens this structure is easily seen—it might be lost under a high magnification. This is one of

FIG. 3. Pink (conch) pearl "flame structure". *(Photo. K. Scarratt)*

the tests where it is not really possible to do much else except to look at it and decide that the structure, termed "flame structure", is sufficient. (Of course one could prove it to be a carbonate by adding a spot of acid, but this does not come within our non-destructive tests.) Pink pearl can be distinguished merely by structure from pale pink coral. Pink pearl, of course, has a density range of 2·83–2·86, whereas coral is about 2·70.

* * *

The 10× lens in the hands of an experienced gemmologist is a very powerful and flexible weapon. Indeed it is the most flexible and convenient of all instruments, being a pocket microscope. Double refraction even in a rubbed-facet specimen can often be detected. If it is used over white mat paper as a reflector, faint curved structures can be seen using any table lamp of 60–100 watts: these faint structures will tend to be magnified out of sight by a microscope. Garnet-topped doublets' demarcation, soft facet edges in pastes, demarcations in cultured pearl drill-holes—all can be exposed with judicious use of a lens. Its constant use makes one a better practical gemmologist in the same way that I feel one is a better motorist if one is brought up using a manual gear-change rather than starting with an automatic gear-box: after all, many an old model can be revived with a push start—which is more than can be done with a posh automatic! Double refraction and the amount of double refraction can be very useful guides when using a lens only. We had in recently a half-hoop ring, set with three blue stones, deeper than aquamarines in colour but not a sapphire blue. Examination with a lens showed easily observed D.R., much more than in quartz, and slightly rubbed facet edges. The slightly fuzzy, "out of focus", look of the stone was characteristic of zircon. Whilst it is true that as a laboratory gemmologist I also took their absorption spectra for record purposes, I would have confidently stuck to my decision without the spectroscope's help.

* * *

Simple or plain gemmology using basic instruments, such as microscope, spectroscope, dichroscope, 10× lens, Chelsea filter, refractometer, density liquids, immersion liquids and known samples of gemstones, plus the all important factor of a good grounding in gemmology and trade experience, will fit most people for gem-testing in trade terms. Whilst it has been mooted that with the advent of man-made gems based very often on spin-offs from space research programmes sophisticated equipment such as electron probes, photospectrometers, etc., in the hands of physicists will be necessary in the final event to prove a man-made stone, I find it rather science-fiction stuff. We do need and do appreciate the help of physicists at times with something quite new and usually not of jewellery potential. This jewellery-potential point surely is a key factor in our kind of gemmology. Almost 100% of our customers are tradespeople needing quick positive results. We used to be rather keen to provide a while-you-wait service for genuine cases, but in the end we had to take a stand against such speed, which could be dangerous in generating a decision to beat the clock. We know that when it comes to real sophistication we have to wait our turn and it can be weeks, not days. Normal gemmology is still the perquisite of the trade gemmologist using basic principles, instruments and know-how: an ounce of practice is worth a deal of theory—even practice with a 10× lens!

* * *

Some items which arrive at the Laboratory for testing are so interesting and gemmologically rewarding that we feel we should pay the customer for being so forthcoming in sending such intriguing specimens! However, our sense of duty overcomes our gemmophile inclinations and we carry on testing for financial reward!

One such item recently was a piece of green subtranslucent rough, with a very hackly surface offering no chance of a distant vision refractive index measurement nor any easy view of the interior (inclusions in green material could be quite a help). It seemed obvious that a specific gravity determination would be a logical next step, after an obvious check with the Chelsea filter and an absorption spectrum examination. The specimen was green through the filter and showed a rare earth spectrum. Next came the density at 3·15, which pointed to fluorspar and/or apatite. Viewed between crossed polaroids a feeble sign of D.R. (or was it strain?) did not help much. Fluor is singly refracting and apatite is notorious for having a very small D.R. Apatite has a rare earth spectrum, as does fluorspar. The density was closer to apatite, so we decided to have an optical flat put upon it to decide the issue.

One should be able to see signs of D.R. when carefully scrutinizing

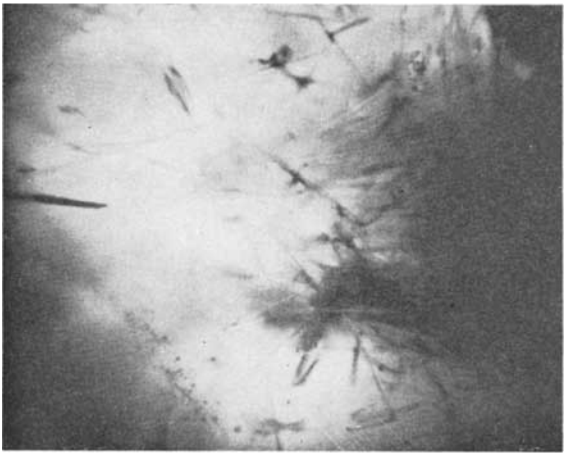

FIG. 4. Actinolite/tremolite-like needles in green apatite rough. (*Photo. K. Scarratt*)

inclusions, flaws, feathers, etc.—along an edge or back facet (if faceted) one should see doubling. So the specimen was immersed in benzyl-benzoate, and an interesting pattern of criss-crossing slender actinolite/tremolite-like needles or crystals, somewhat like Sandawana emerald inclusions, were seen (see Fig. 4). These to me were not reminiscent of fluorspar, and, frankly, I had not looked into many green apatites—usually refractive indices being obtainable and spectra would be sufficient identification. It still seemed probable that it would have to be taken to a lapidary.

We decided, however, in the interests of gemmology and practice for our staff, to obtain an x-ray powder diffraction pattern on our still new camera. Toby Rappitt and Ken Scarratt prepared the samples and took the diffraction picture. We obtained a good diffraction pattern and compared it line by line with a known recorded sample picture of apatite. (The original comparison film was of green apatite taken by Chuck Fryer of the G.I.A. Los Angeles (now Santa Monica) laboratory.) The two patterns were identical.

So the specimen was indubitably apatite. It afforded us a little gemmological ploy, a little photography, a lot of interest and considerable satisfaction in obtaining a positive result. (We never did get that optical flat put on.)

* * *

Recently we were asked (not to test) for our opinions on an opal which had faded, literally to near colourless with only a dismal remainder of the play of colour present. Most of these cases of faded stones, whether they be opals, quartz, emerald or whatever, we see only *after* the so-called fading—never, of course, before. This stone was so bad it was impossible to tell whether it had been a white opal or a water opal or a fire opal with some play of colour.

My first reaction, of course, was to look at it with a lens. I was really pleased on my first quick routine look to see a pattern described as lizard-skin, shagreen, etc., this pattern having been very well shown by photographs and drawings of K. Scarratt in his articles on synthetic opals, written in two parts, one by himself, and the other in co-operation with E. A. Jobbins and Pat Statham of the Institute of Geological Sciences (J. Gemm., 1976, XV, 2, 62-75). The typical structures portrayed were those I saw in this terribly faded synthetic (heated?) opal.

Upon mentioning this fact of (not a faded opal but) a faded *synthetic* opal to our customer, he was delighted to be able to report our findings to the owner of the ring. Obviously one doesn't worry so much over a faded synthetic opal as a faded natural—least of all if one supplied a natural!

The reason for the fading was never followed up, but I should imagine heat could be a factor, if a ring were sized without removing

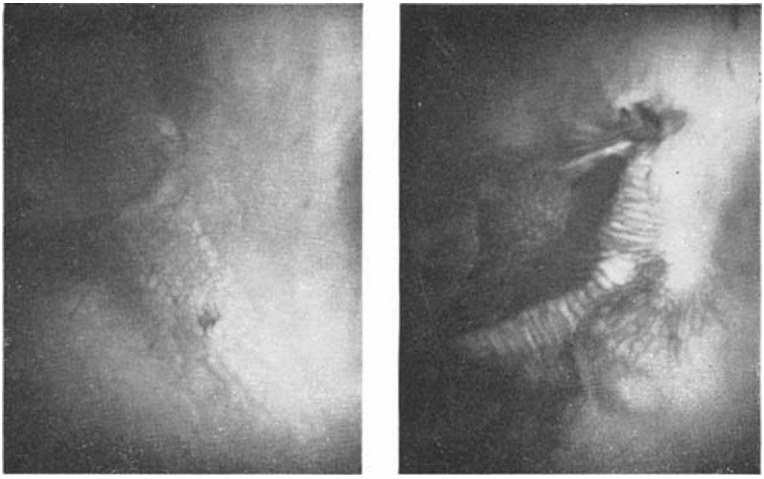

FIG. 5 (a) and (b). Structures seen in faded synthetic opal. (*Photo. K. Scarratt*) the opal. It was also quite pleasing to think that one could spot a faded synthetic opal with a 10× lens. We were so pleased we had a look through a conventional microscope and took photographs (Fig. 5) of the structures seen just for the fun of it, if not for the record!

* * *

Once upon a time all synthetic rubies had curved structure-lines and clouds of included gas bubbles. They were usually a garish red colour and due to cheap cutting had chatter-marks almost as hallmarks. If one had *any* difficulty in proving them, they could be vetted by exposing them to x-ray excitation, which would produce a strong fluorescence followed by a prolonged phosphorescence. If for any reason this should not be practicable owing to the proximity of other natural or synthetic rubies in the mount, then a transparency test with short-wave ultraviolet light would eliminate the sheep from the goats. Failing all this, there was the knowledge of rubies and their *look* which had been built up over years of testing many thousands of rubies in which about 8–10% synthetics were found.

That, of course, was once upon a time. Nowadays we have the flux-fusion and hydrothermal rubies to contend with. A little learning is a dangerous thing and perhaps a lot of learning further clouds the horizons with possibilities which might never enter the heads—or curricula—of happier gemmologists. It is indeed humbling to be faced with a ruby which one feels one should deal with in a matter of minutes (thinking the paper work will take longer!) and then be halted by indecision.

Among some items of jewellery not long ago we had a cushion-shaped red stone in a three-stone ring to test. In its mount it was not very forthcoming. What little we could see were crystals (?), a feather, and, at an acute angle, a very restricted view of what looked like looped structures. We asked to have the stone unset and never saw the customer again! Some weeks later we saw the same ring—from another source. It was very easy to recognize and just as awkward! This time, when we asked to have the stone unset, it was promptly done. It *should* have been easy after unsetting but it only served to add to our feeling that it was not natural. The crystal-like inclusions were of a two-phase type not necessarily usual in rubies from Burma, Siam or East Africa. The feather on the girdle looked just such a feather as can be seen in both natural and synthetic specimens. The loop-like structures emanated from a series of crystal-like inclusions and looked peculiar, but not necessarily typical of a synthetic—nor for that matter of a natural stone. They could have been acceptable if other stronger features had predominated but they were the few inclusions seen in a fairly clean ruby which had the body colour of a Burma or *fine* East African ruby.

The ruby fluoresced moderately under x-ray excitation with a following phosphorescence of such a weak nature that one wondered whether it was there or an effect upon the retina following fluorescence? This poor phosphorescent effect was corroborated by the younger and keen eyes of Ken Scarratt who had first had the stone to test in the ring. We then used filtered methylene iodide to obtain a close optical match for the stone and viewed it immersed, using low-, medium- and high-power objectives. We all studied the inclusions which were somewhat of an angular (two-phase?) crystalline appearance. On the girdle was what I would have been happy in earlier days to accept as natural—a feather of an oval-shape, looking quite natural. Under high power Ken Scarratt felt the looped links were of a dash-dot nature as seen in some Kashan synthetics. Having earlier on in 1975* encountered a very peculiar ruby and enlisted the opinion of Dr Edward Gübelin's laboratory, I felt a second opinion would be very helpful from the same source. We sent the stone unset with transparency photographs and drawings indicating our interests. We received corroboration once again from both Mr C. E. Schiffmann and Dr Gübelin that the stone was to be considered of synthetic origin. Together with informative, friendly and interested letters from both Mr Schiffmann and Dr Gübelin I received details of a paper written by Professor Dr W. F. Eppler on "Synthetic ruby produced by the hydrothermal method and grown from a melt",† which contained photographs of inclusions particularly of the two-phase type which were identical in shape with those noted in our problem stone. After the stone had been returned to us and our opinions strengthened and morale boosted, we decided to photograph it for record purposes. This proved to be most difficult. The photographs by Ken Scarratt show the feather on the girdle, the two-phase crystals and the looped

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*See J. Gemm., 1976, XV, 2, 104; 3, 109.—Ed.

†Z. Dt. Gemmol. Ges., 1971, 20, 1, 1-5: abstracted in J. Gemm., 1971, XII, 8, 357.—Ed.

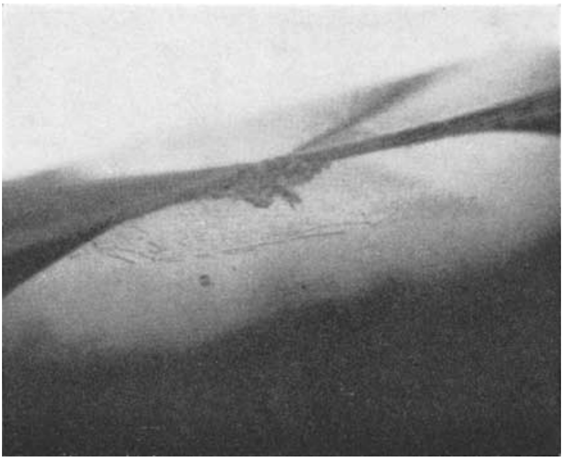

FIG. 6. Liquid feather on girdle of synthetic ruby. (*Photo. K. Scarratt*)

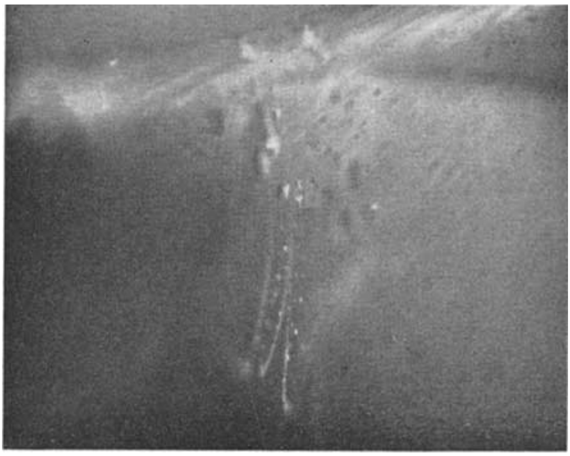

FIG. 7. Looped structures and two-phase crystalline inclusions in synthetic ruby. (*Photo. K. Scarratt*)

dash-dot links (Figs. 6, 7, and 8). Further we decided to take a short-wave ultraviolet light transparency photograph, using various synthetics of somewhat similar size plus one natural ruby as a

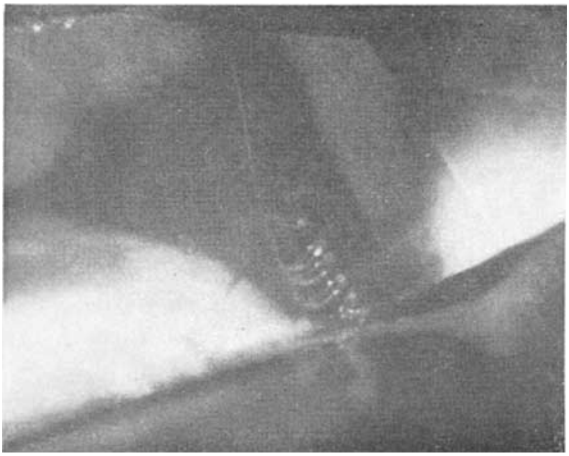

Fig. 8. Same looped structures and inclusions in synthetic ruby as in Fig. 7 viewed from position at right angles. (*Photo. K. Scarratt*)

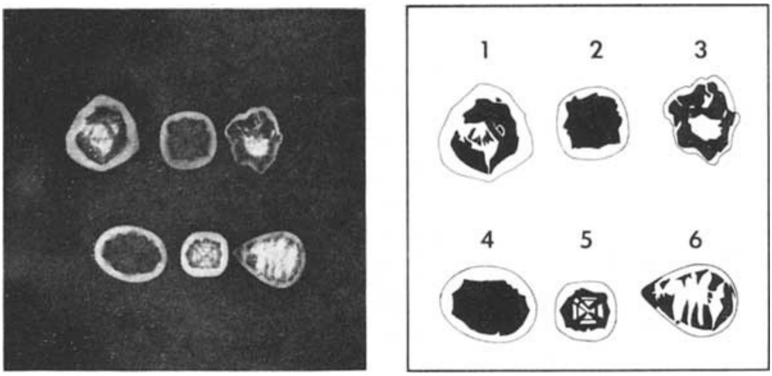

Fig. 9. Ultraviolet transparency photograph of 5 synthetic and one natural rubies. (*Photo. K. Scarratt*)

control (Fig. 9). The stones are as follows:

(1) Siam seed with hydrothermal overgrowth, 3·48 ct.
(2) Verneuil flame fusion synthetic ruby, 2·12 ct.
(3) Hydrothermal synthetic ruby (early Chatham), 1·68 ct.
(4) Kashan flux-fusion synthetic ruby, 3·09 ct.
(5) The problem (synthetic) ruby, 1·37 ct.
(6) Natural ruby from E. Africa, 1·91 ct.

How well the transparency photograph conveys the similarity of opacity of the natural and the problem stone I do not know: what I do know is that the stone in question looks natural to an experienced eye, and in a setting it could fool many people. We with quite a bit of experience didn't like it, and it took quite a time for a consensus of opinion to be reached. I should like to say "thank you" to both Dr E. Gübelin and Mr Chas. A. Schiffmann for their help and gemmological enthusiasm.

Only a few days later we had a further three Kashan-type flux-fusion rubies in to test. One matched our own Kashan for short-wave ultraviolet light transparency, two nearly matched our natural stone and previous problem stone. Two fluoresced and phosphoresced quite strongly, and one did not phosphoresce but did have "hallmark" Kashan flux inclusions. So it seems that the amount of chromium and iron are variable, causing variations of luminescence and also affecting the transparency to short-wave ultraviolet light. Inclusions, transparency and luminescence, plus a background of knowledge, with known stones as comparisons, seem necessary in testing rubies which were so easy once upon a time.

* * *

"The umbrella term jade"—which I mentioned a few pages back—was the title of a lecture given some years ago at Northern Polytechnic to the Post-diploma Class run by B. W. Anderson, assisted by A. E. Farn. This was one of many very enjoyable lectures given to that class. I have always had a very keen interest in the varieties of green materials which have at times arrived at the Laboratory to be examined—purporting to be jade. I always feel the challenge when something jade-like comes through our portals and like to have a stab at it before routine tests set in. We have been fortunate lately in receiving quite a few specimens of vases, dishes, figures, etc., in (mostly) nephrite-jade of varying colours.

One such item very recently was a very pleasing (to me) variegated green subtranslucent to transparent bowl. It was not quite eggshell in thickness or fragility but certainly very thin for a wide-mouthed bowl weighing 219g and measuring 14 cm in diameter (approx.). The variety of greens in patches, linked by transparent almost colourless patches, with some black inclusions of irregular shape made me feel instinctively it was a mixture—

more of a rock than nephrite. I did not do the test myself but kept an interested eye on the bowl as it was handled. The density was found to be 2·62 and refractive index 1·56 (in several places), *plus* a good strong band at 4650Å and a weaker one at 4970Å.

I was asked what I thought it could be, and because of the absorption band I felt flummoxed. It did not "tie in" with the colour in this thin material. The only material I could place without reference to books was a noble serpentine which has such a band, but I had not seen it with this variety of colours. A little checking with Webster confirmed the absorption bands, density and refractive index. Just a little additional detail was gathered by a discreet touch of dilute hydrochloric acid: this caused an effervescence. So then our bowl was proved to be ophicalcite, sometimes termed Connemara marble—a variety of serpentine. Because it was such a fine quality both in material and workmanship, the fragility of it gave the colours a nuance not normally seen in the more solid examples of the serpentine family. It had attained a finish and appearance not recognizable as serpentine. It did not come under the "umbrella of jade", but personally I should be very happy to provide it with shelter.

* * *

An interesting item came into the Laboratory recently in the form of an Egyptian deity's head carved in lapis lazuli. The piece looked old: or was it perhaps the association of ideas of a link with the past producing the appearance of a patina to the mind's eye?

By using the "jeweller's third eye" (to use Mlle Dina Level's expression which I have mentioned before*) pyrites and calcite inclusions were noted. The calcite was less profuse than seen in some Chile lapis, the pyrites looking softer and a hint more golden than usual. Perhaps the blue colour looked a little tired—certainly the piece looked old—a little worn—soft looking as if it had been handled a lot. Its original lines were somewhat dulled, rather in the manner of some Chinese jades which have been reverently handled and have developed a smoothness unobtainable by mechanical abrasion. The "third eye" (or 10× lens) probed meticulously around, the mind meanwhile pacing it with thoughts—"the pyrites looks more like gold and very soft, the calcite does not 'sit' naturally in the host material, and a funny look to the apparent distribution—

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*J. Gemm. 1977, XV, 5, 236.—Ed.

looks like attempted random distribution which has the mark of man".

Then the lens picked up little round blow-holes rather like woodworm exits—but surely not in lapis lazuli. Now the 10× lens fairly zoomed around all the little nooks, depressions and reliefs. Sure enough the blow-holes were found rather like blow-holes in castings. We took a density and found it to be 2·168. We checked the calcite for a carbonate reaction—positive. It was in fact an artefact, very very cleverly made—to my mind the best I have seen—not garish, not overdone, not too blue, with pyrites and calcite looking fairly normal in a *worn* piece. It was intended to deceive—in a difficult mount or setting it could well have done so if only a cursory examination had been made. I considered it to be a case of "Ten out of ten for the 10× lens"!

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EMERALDS AND EMERALDS

By ALLAN M. TAYLOR, Ph.D., F.G.A.,
Chemistry Department, Victoria University, Wellington, New Zealand

I HAVE read with interest the recent short article in the Journal by Mr Farn(1) concerning the correct usage of the term emerald. There is no doubt that a problem exists and it is to be hoped that a suitable solution agreeable to all can be evolved. In an earlier article where I described the properties of synthetic vanadium emerald(2), I suggested that a definition of emerald that was non-committal with regard to the chromophore present might be appropriate, i.e. "that emerald is a bright green variety of beryl". Indeed, emerald has been just that for several thousands of years. With the appearance on the gem-testing scene of the pocket spectroscope, during the latter part of last century, it became possible for gemmologists to positively identify with ease the presence of chromium in emerald, even at concentration levels below 0·1 wt% in many cases. Since then, the continual detection of chromium as a chromophore in emeralds has led to the gradual conclusion that all emeralds contain chromium, and eventually, that emeralds must have detectable chromium otherwise they should not be called emeralds. This latter view has been developed and expounded by Anderson(3), who has pioneered the use of the pocket spectroscope as an essential tool in gem testing.

During the last decade, the essentiality of chromium in emeralds, and hence the definition of emerald, has come under question due to the discovery and marketing of natural emerald-coloured beryls(3) lacking in chromium, and new data being available on synthetic vanadium-doped beryls or vanadium emeralds(2). Continuing developments in the chemical analysis of emeralds and of other gemstones (e.g. garnet(4, 5, 6), axinite(7), tourmaline(8), zoisite(9)) have shown that the presence of vanadium as a chromophore in gemstones, including some emeralds, can no longer be ignored. This demonstrates that things are not always as simple as they might at first appear. Just as Mr Farn informs us that the Chelsea filter is no longer of great diagnostic power in distinguishing emeralds from green paste and other imitations, it is now apparent that sole reliance on the pocket spectroscope for proving the existence of emerald may in some cases produce an equivocal result.

I was interested to read at the end of Mr Farn's article about the trade regulations and usages as formulated by the London Chamber of Commerce & Industry's Precious Stone Trade Section viz., "According to the custom of the trade the word Emerald not preceded by a qualification is applied exclusively to natural grass-green beryl with colour due to chromium." If one accepts this statement in full, then the title of my article, "Synthetic Vanadium Emerald" is perfectly in accordance with the regulations, and not a contradiction of terms, as suggested by Mr Farn.

I have been informed by Mr Chisholm(10) that the regulation was formulated in order to distinguish between natural emeralds coloured by chromium and natural green beryls from Salininha, which were claimed to be emeralds but contained only the merest trace of chromium. Whether or not the regulation was formulated with the knowledge that vanadium as a chromophore in beryl may produce a grassy-green colour equally as attractive as that due to chromium I do not know. Colour comparisons are very subjective exercises and easily open to manipulation one way or the other. I have no doubt that there are similar high proportions of poorly coloured chromium emeralds and vanadium emeralds.

In the case of "synthetic vanadium emerald", I do not see what objection there can be to the use of this term, unless it is that in subsequent descriptive writing about them, they are loosely referred to as emeralds, just as in the same manner one may loosely describe Chatham synthetic emeralds, simply as emeralds.

The real problem, however, is not with the few synthetic stones that may be in existence, but with the natural ones that do not contain any significant chromium. These have emanated mainly from certain localities in Brazil. Some analytical data on them have been published by Wood and Nassau(11). The stones from Salininha, which they call Chrome-Free Emeralds, all contain V and Fe in the range 0·1 to 3%, Mn 0·01 to 0·3%, and have only a slight trace of chromium, $<0{\cdot}001\%$. An analysis of a chrome-free emerald from Bahia is similar. From a scientific point of view it would be bad policy to label these stones as vanadium emeralds as there is no easy way to prove that they do in fact all contain appreciable vanadium, except by individual destructive chemical analysis. The further a non-chromium emerald ventures from the point of origin (whether synthetic or natural), the more doubt and suspicion is aroused—particularly if it is a good quality stone. I am not enthusiastic about the label "Chrome-Free Emerald", as it implies a certain deficiency in a gemstone which has every right to be considered on the same plane as any chromium emerald. Such a label is an unintentional and, I believe, undeserved stigma for the element vanadium, whose name is appropriately derived from that of the Scandinavian goddess of beauty.

The problem has arisen, as mentioned previously(2), because of the distinctive nature of the chromium absorption spectrum, compared to that of vanadium. This has resulted in gemmologists raising the element chromium to such a great height of excellence, that everything else is hopefully ignored. From a chemist's point of view, the importance of such a phenomenon is considered in its proper perspective. For the gem collector, the important thing is whether a stone is an object of beauty, attractive and desirable. Gemstones are the flowers of the mineral kingdom and, like flowers, they are here for us all to enjoy. Collectors may admire a gorgeous golden topaz without being concerned over whether or not it may contain detectable trace amounts of chromium or some other chromophore.

However, to return to a more constructive line of thought, I would like to throw into the ring, so to speak, the following suggestion: that emeralds be defined as "grass-green" or "bright green" (since grass-green is rather variable from place to place) variety of beryl, and are of two types, viz.

Type I: Those that contain sufficient chromium to have an absorption spectrum detectable by a pocket spectroscope.

Type II: Those that do not contain sufficient chromium to be detectable by the spectroscope. Thus emeralds-II would probably include all presently known vanadium emeralds, or any other bright green emerald-like beryls which may contain other chromophores or combination of chromophores, e.g. Fe, V; V, Mn; Ni, V; Fe, Ni, V, Mn etc.

This type of classification would mean that the merits of a particular emerald are considered on its aesthetic value. One does not have to resort to a destructive chemical test to decide what a particular stone may be—if it is a beryl and the colour is acceptable for emerald, then emerald it is; if chromium is not detectable with the spectroscope, then it would be labelled a Type II emerald. The possible case of when V > Cr and yet Cr is still detectable would be emerald Type I. An example may be the Muzo trapiche-type emerald(12), for which an XRF analysis has shown the presence of 0·10% Cr and 0·12% V. It is stated that a noticeable vanadium absorption in addition to the chromium absorption was observed in the clear outer material.

The precedent for naming of gemstones according to their colour is well established, and one does not have to leave the beryl group to find examples. Morganite, heliodor and aquamarine varieties of beryl have their distinctive colours, and yet nobody is greatly concerned about whether or not their absorption spectra are distinctive or even detectable, or due to one, two or a multiple of chromophores existing in a variety of different crystallographic sites. I think that gemmologists should be thankful that of all the chromophores found in the beryl group of gemstones, it is chromium which has a readily detectable absorption spectrum—and not say iron! If the latter were the case, the ubiquitous iron would result in nearly all beryl gemstones being named aquamarines, if one allowed the naming of gemstones to be determined solely on the criteria of having detectable and distinctive absorption spectra.

The importance of vanadium as a chromophore, whether dominant or subordinate, in many emeralds, is now fairly well established. The initial discovery was made about 1920 by the celebrated geochemist V. M. Goldschmidt(13) who found that the emeralds from the southern end of Lake Mjösen, Norway, contained 0·9% V_2O_3 and only 0·1% Cr_2O_3. This particular emerald locality, it seems, is the one described in Webster's book(14) "Gems"; however, he does not mention that these emeralds may perhaps be more correctly called vanadium emeralds. If, in this case, vanadium is the predominant chromophore, why should vanadium be ignored? Surely not because one element has a more distinctive absorption spectrum than the other!

So it would seem that at least one natural vanadium emerald occurrence, albeit unimportant commercially, has been masquerading simply as emerald in our foremost gemstone reference book for some considerable time. We may also wonder just how many fine Muzo emeralds have vanadium as the predominant chromophore.

My thanks are due to Mr J. R. H. Chisholm, whose constructive criticism of this article I found of considerable assistance.

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TRENDS IN DIAMOND SYNTHESIS

By DENNIS ELWELL, B.Sc., Ph.D.

GROWTH OF DIAMOND AT HIGH PRESSURE

In spite of the ever-growing family of simulants, diamond retains its unique position as the outstanding gemstone in terms of hardness and optical properties. For the materials scientist, diamond presents a challenge since it is the stable form of carbon at high temperature and very high pressure. The great pioneer of high pressure physics and technology, P. W. Bridgman, is said to have attempted the graphite→diamond transformation as the first experiment whenever he had developed some new technique to obtain higher pressures than those possible in his earlier apparatus.

The first reproducible synthesis of diamond was achieved not simply by the attainment of temperature and pressure conditions in the diamond-stable region but by the addition of a "catalyst". It has now been recognized that the formation of diamond by the process first reported in 1955 by General Electric involves crystallization from a solution of carbon in a molten metal. A wide range of solvents has been found to yield diamond, and a study of the solvent action has been reported by Wentorf (1966). Fig. 1 shows the phase diagram of carbon, with the shaded region indicating the area which has been used for the growth of diamond from a metallic solution.

The possibility of diamond crystals of gem size and quality was investigated only in the last few years. Wentorf (1971) reported successful experiments in which small diamond crystallites were heated at about 1450°C in contact with a molten nickel solvent and transported in the solution to deposit on a diamond "seed" crystal at 1420°C. The maximum rate at which diamonds could be grown was found to decrease as the crystals got larger, and a diamond 5 mm in diameter took a week to grow. This necessity to decrease the growth rate as the crystal gets larger is a normal phenomenon in crystal growth from solution and the theory behind this effect is discussed by Elwell and Scheel (1975). Gemmologists may take comfort from this phenomenon of "supersaturation inhomogeneity", which has the consequence that, although synthetic diamonds of high quality and weighing over 1 carat may be produced, their cost is at present uneconomic. Only the development of new equipment to permit large volumes of solution to be

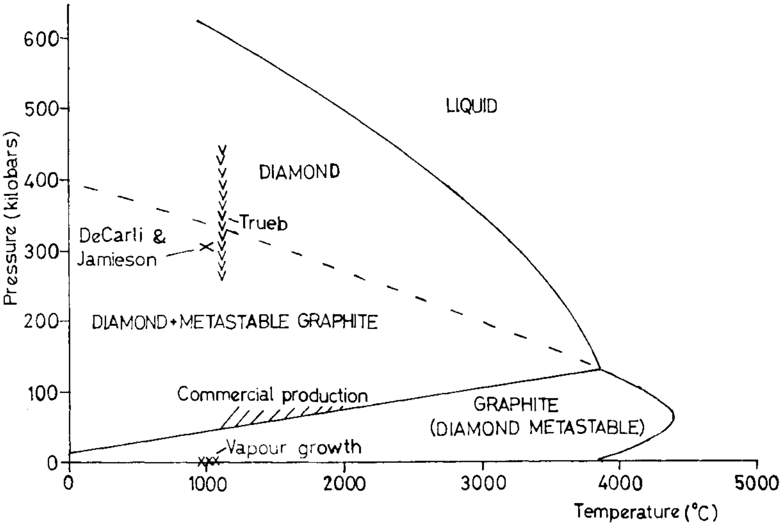

Fig. 1. Phase diagram of carbon (after Bundy *et al.*, 1973) showing approximate regions of experiments discussed.

maintained under a pressure of about 55 kbar* over long periods at relatively low cost would change this situation.

Crystallization of industrial diamond from metal solution is, of course, a major industry and roughly half of the diamond grit for cutting and polishing is produced synthetically. Production occurs in Czechoslovakia, Ireland, Japan, the Netherlands, South Africa, Sweden, and the Soviet Union as well as in the U.S.A., and it is possible that China is also a producer. At least 30 tons of graphite have been converted into diamond, and the actual figure may be several times this amount.

USE OF SHOCK WAVES

In the absence of a solvent ("catalyst") the pressure required to transform graphite into diamond greatly exceeds the minimum value expected from the phase diagram. The earliest attempts at producing diamond, by Hannay in 1880, made use of a chemical reaction to generate a high pressure and temperature. The

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*that is, 55000 × atmospheric pressure, approx. a 350-ton load on each square inch. (1 bar $= 10^5$ pascals, and 1 Pa $= 1 \mathrm{m}^{-1}$ kg s^{-2}.)

authenticity of Hannay's experiments has been questioned, and the first proved synthesis of diamond by shock compression was reported by De Carli and Jamieson (1961). They used a charge of high explosive to generate a pressure estimated at 300 kbar for about 1 microsecond. The presence of diamond in the graphite sample to which this pressure was applied was confirmed, but the particles were very small, comparable with "carbonado" in meteorites. The graphite which was transformed to diamond was in the rhombohedral form, and its transformation occurred by compression along a particular crystallographic axis (the so-called c-axis). The approximate region of the phase diagram reached in these experiments is shown in Fig. 1, and is clearly well removed from the graphite-diamond boundary. The pressures and temperatures are still not sufficient, however, to ensure 100% transformation to the diamond phase.

A more recent study by Trueb (1971) involved pressures of 250–450 kbar for 10–30 microseconds, and produced a post-shock temperature of 1100°C. The graphite used was in the form of platelets 0·5–5 μm in diameter and the diamonds produced were of similar size, up to 36 μm. However, these particles were found to be made up of aggregates of much smaller cubic diamonds, in the size ranges 10–40 Å and 100–1600 Å. ($1\ \text{Å} = 10^{-10}\text{m} = 10^{-4}\mu\text{m}$.) The suitability of these diamonds for industrial application will depend on the behaviour of these particles during use for cutting or grinding. The use of explosives could reduce the cost of industrial diamonds, but the tiny particle size would be a deterrent except perhaps for resin-bonded wheels where some wear of the diamond is acceptable. At present, however, shock-produced diamond does not appear to have been used commercially.

A related method which has produced commercial diamond involves shock-compression of metal blocks, for example of cast iron, containing small inclusions of graphite. Patents for this process were granted in 1966 to G. R. Cowan, B. W. Dunnington and A. H. Holtzman of DuPont de Nemours & Co. The pressures generated are above one million atmospheres and the metal, since it is less compressible than the graphite, serves the function of cooling the carbon inclusions very rapidly. This prevents the tendency of the diamond formed during compression to revert back to graphite after the passage of a pressure wave. The diamond formed by the DuPont process is partly of the hexagonal type (lonsdaleite), which forms under conditions of very high pressure and relatively low temperature.

Ion Beam

Alternative means of producing diamond are frequently under investigation. The general principle is that the energy required for the growth of diamond-like carbon may be obtained by some technique other than compression, and in the method of Aisenberg and Chabot (1971) this energy is obtained by accelerating a beam of carbon ions by an electric field. Positive ions of carbon were produced in an electrical discharge at low gas pressures, and accelerated to high energies so that the carbon atoms incident on the surface of a diamond seed crystal (or perhaps a metal needle to be coated with diamond for use in a record player) have high effective surface temperatures. A detailed evaluation of the results of this experiment has not yet appeared, but the layers were probably amorphous. No information is available on the maximum thickness of the diamond films.

Growth from the Vapour

Perhaps the most interesting development in diamond synthesis in recent years has been the deposition onto diamond seed crystals from the vapour phase under conditions well inside the graphite-stable region. The process of diamond deposition by the decomposition of a carbon-containing gas at low pressure was developed independently by B. V. Derjaguin and B. V. Spitsyn in the U.S.S.R. and by W. G. Eversole in the U.S.A. The early Russian study used carbon tetraiodide, CI_4, while Eversole used methane, CH_4.

Since graphite normally co-deposits with diamond in this method, conclusive proof that diamond is, in fact, deposited was not easy and there has been scepticism at the validity of the various claims. Scepticism was certainly the general mood of delegates at the 1968 International Conference on Crystal Growth (see Elwell and Robertson, 1968), but it is now widely accepted that diamond does deposit. To understand this phenomenon we must consider the relative probability of deposition onto a diamond surface of new diamond or of graphite as carbon atoms arrive from the vapour phase. The growth of diamond is possible because the arrangement of new carbon atoms on the surface replicates that in the existing crystal lattice, and it is possible for the probability of nucleation of new diamond layers to exceed that of graphite clusters. However, graphite clusters do tend to form in the vapour and these are deposited with the diamond on the crystal surface.

In order to remove this graphite, the growth process is interrupted at intervals and the material heated in hydrogen at 50–200 atmospheres pressure. Hydrogen reacts more readily with the graphite and so the diamond crystals are cleaned. Alternatively the graphite is removed by oxidation at atmospheric pressure, which is clearly more convenient.

For growth of diamond, the Russians now use typical conditions of 1020°C and a methane pressure of 0·07 torr (about 10^{-5} of an atmosphere)* and claim that the fastest growth rates are about 0·1 μm per hour, with about 1 carat deposited per hour in the whole reactor (Derjaguin and Fedoseev, 1975). The highest growth rate mentioned is of several μm per hour, under conditions of pulsed heating by a xenon discharge tube.

It has recently been reported (Derjaguin *et al.*, 1975) that the crystallographic cell dimension of the diamond layers is about 1% lower than that of the natural diamond crystals on which growth occurred, so that the film grows under compression.

The American work (now mainly at Case Western Reserve University) uses similar growth conditions (1000°C, 0·2 torr pressure of methane) to give an increase in weight typically of 6% in 20 hours, corresponding only to 0·001 μm per day linear growth rate. Much higher growth rates are found during the initial stage, possibly because of the strain which occurs because the film and crystal are of slightly different lattice dimension. Perhaps the most interesting observation from a gemmological viewpoint is the colour change from grey or off-white to light blue, which was reported to occur after several deposition and cleaning cycles (Poferl *et al.*, 1973).

This treatment may enhance the appearance of cut stones of poor colour, and it may well be that diamonds treated in this way will appear in some future series of "Notes from the Gem Testing Laboratory" or "Highlights at GIA's Lab", although it does not yet appear possible to deposit diamond layers uniformly on relatively large stones.

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*1atm = 101 325 Pa, and 1 Torr = (101 325/760) Pa.

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THE AGATES OF THE MIDLAND VALLEY OF SCOTLAND

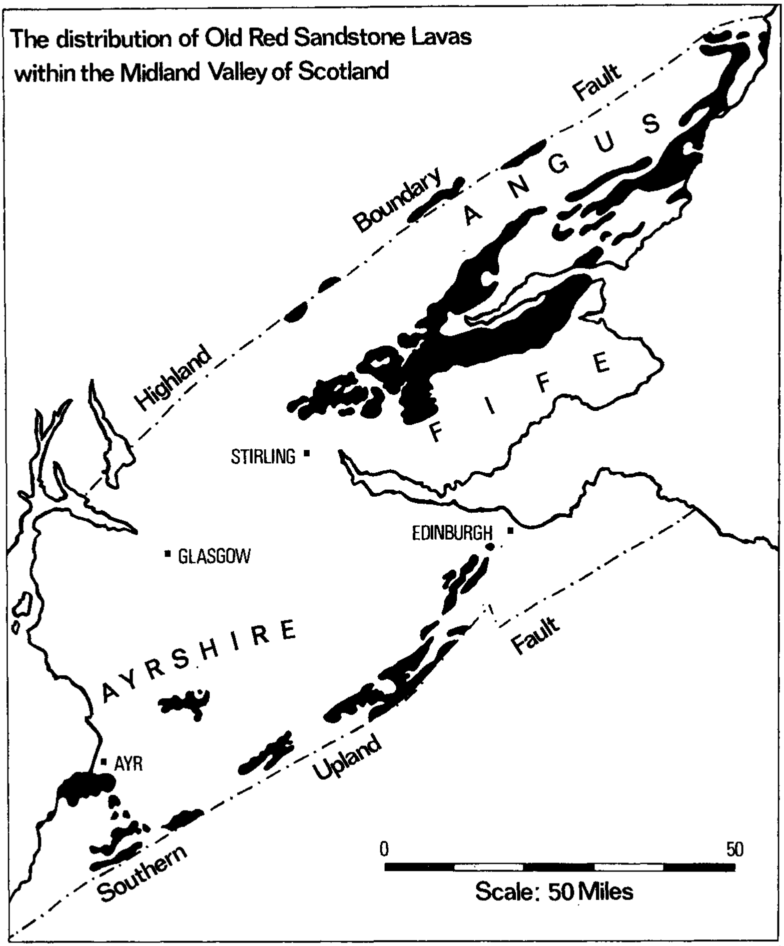
(An appraisal of the work of Dr M. Forster Heddle)

By ALISTIR TAIT, F.G.A.

THERE can be few stones of gemmological interest that receive as little attention as the agate. Perhaps its relatively common abundance has had much to do with its underrated position amongst the popular gems. However, it is my opinion that this beautiful stone merits much attention from the serious gemmologist. Popular literature on gemmology affords little space to the many individual varieties of agate or their particular genesis.

As a Scottish student of gemmology one is very aware of the natural abundance of this intriguing stone occurring in a belt of andesites and basalts of mostly Devonian age across the Midland Valley of Scotland. Since Victorian times these stones have been collected from fields, rivers and *in situ* from their parent rock as "Scotch Pebbles" and mounted in traditional jewellery.

One of the first mineralogists to concern himself seriously with the formation of the Scottish agates was Matthew Forster Heddle,



1828–97. Professor of Chemistry at Saint Andrew's University, he amassed a unique collection of Scottish minerals, said to be the most complete collection of a country's minerals ever made. In 1858 he revised and partly edited Greg and Lettsom's "Mineralogy of Great Britain and Ireland" and in 1879 was elected President of the Mineralogical Society of Great Britain. However, it is his work into the formation of agate that concerns us here. Most of his research was done on specimens collected by himself in the Midland Valley of Scotland and from these he derived his theory of their formation. His splendid collection of minerals and agates now resides in the Royal Scottish Museum, Edinburgh.

The belt of agate-bearing lava was erupted from a number of volcanic vents during the Devonian, Old Red Sandstone, age. The existence of only a few can be traced today from a number of volcanic centres which have been obscured by subsequent geological activity, and some may lie under the North Sea off the Angus coast. Briefly this area extends in patchy exposures from Kincardineshire, Angus and Fife in the north-east of the Midland Valley, south-westwards to Ayrshire on the opposite coast. Basically the agates occur in an andesite which is a fine-grained intermediate igneous rock, although the exact composition will tend to vary between different flows. These lavas due to their once semi-liquid state, are, particularly near their surface, riddled with masses of air bubbles caused by the expansion of gases formerly compressed in the magma. These are commonly known as amygdules or amygdales from the Greek "amygdalos", an almond shape which these vesicles resemble. These exist in vast numbers and vary in size from pinheads to several feet in length. One observed at Dunure, Ayrshire, measured 3 feet by 12 feet. It is within these vapour cavities that the majority of agates form and from the shape of this cavity there is much we can tell about the condition of the lava before cooling. The agate nodule will cleanly "pop" out of its cavity, like a pea out of its shell, when the rock is split.

Amygdales are found in most lava flows. In a very static flow with little forward motion they will be roughly circular in shape. In a fast moving stream, however, amygdales will assume various shapes depending on the character of the flow. In a very viscous lava where gas bubbles rose upwards only with great difficulty while the flow continued to move forward, rod-shaped forms occur often lying virtually at the horizontal with their blunted noses like tadpoles facing the direction of flow. If, on the other hand, there has been little forward motion and a great deal of fluidity then the cavity will be pear or balloon-shaped. When mobile and very fluid, then characteristic axe-shaped nodules occur which are well known to collectors of the agate. When a lava has been moving forward rapidly with considerable speed and fluidity, then Dr Heddle described the resultant shape as lanceolate. With very large cavities there is often an elevation in the centre of the floor rather similar to that in a wine bottle. Agates with a flat

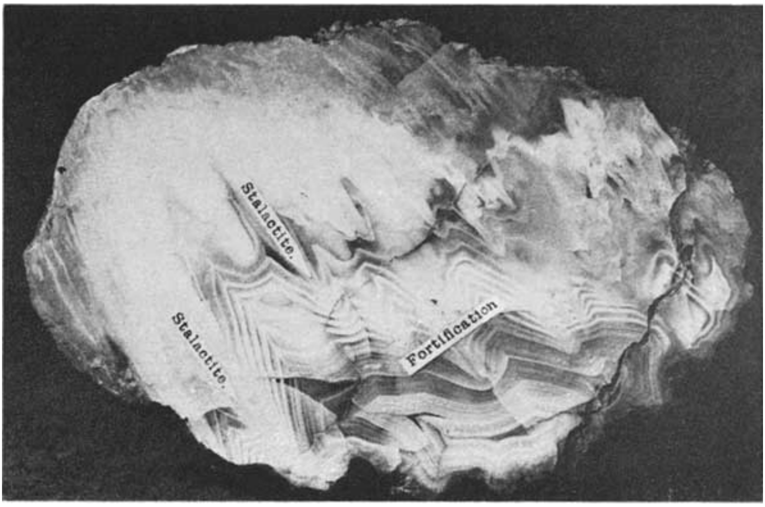


FIG. 1. Stalactitic agate (Norman's Law, Fife).

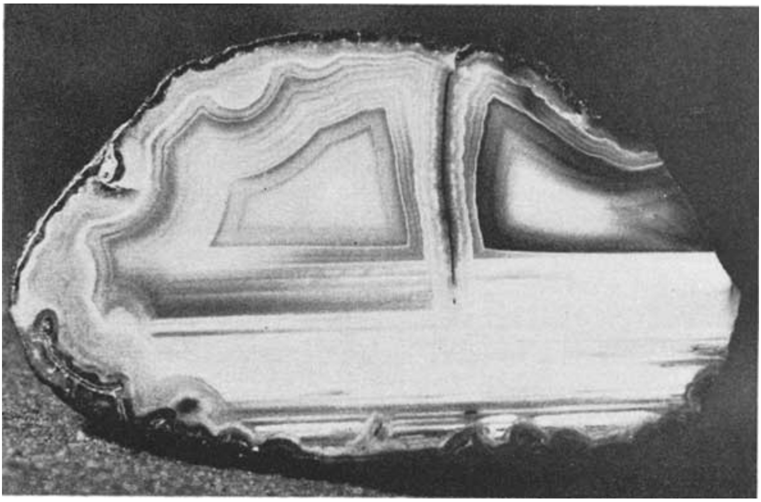


FIG. 2. Fortification agate (Usan, Montrose).

underside, Heddle observes, are almost invariably onyx-agates, although the parallel layers may not necessarily accord with the flat surface of the amygdale.

Where there is a high degree of excess silica in the lava an agate infilling will occur although often other minerals will crystallize out. In close proximity to agates vesicles may contain various other forms of silica such as crystalline amethyst, smoky quartz, rock crystal or the amorphous cacholong, opal or hornstone. In areas where the composition of the rock contains less silica other minerals may occur. The most notable group is the zeolites. Natrolite, stilbite, thomsonite and heulandite are commonly found as well as the closely related pectolite and prehnite. However, it is mostly the hydrous and anhydrous modifications of silica which concern us, along with the zeolites which occur with them.

Heddle found that in the majority of Scottish agates the first two outer layers are remarkably consistent. The first is the skin which completely coats the inside of the vesicle and usually consists of one of the following materials: celadonite which imparts a characteristic green colour to the skin and is soft, often earthy, formed by the decomposition of augite in the rock matrix: the other may be natrolite or stilbite which is red in colour. After the skin a uniform layer of colourless chalcedony is deposited which is often totally uncharacteristic of the subsequent colouring and banding in the stone. These subsequent layers of differing materials can be deposited in almost any order although usually the hydrated silicas form first.

Numerous theories have been proposed as explanation of the origin of the concentric ringed structure of agate. Perhaps the most significant contribution came from Raphael Liesegang, a German photographer who in 1896 observed that a crystal of silver nitrate placed in potassium dichromate in gelatin diffused outwards to form a concentric banding not dissimilar to that seen in agate. Whether this similarity is purely superficial or the key to the genesis of agate has been debated ever since. More recent experiments in the laboratory by Copisarow and Copisarow (1942) and Christamanos (1950) have attempted to reconstruct an environment where the effects of this rhythmic precipitation could be studied. It is my personal belief that although this form of rhythmic precipitation may have had some bearing on agate formation their structures are too complex and varied to be satisfactorily explained in this way.

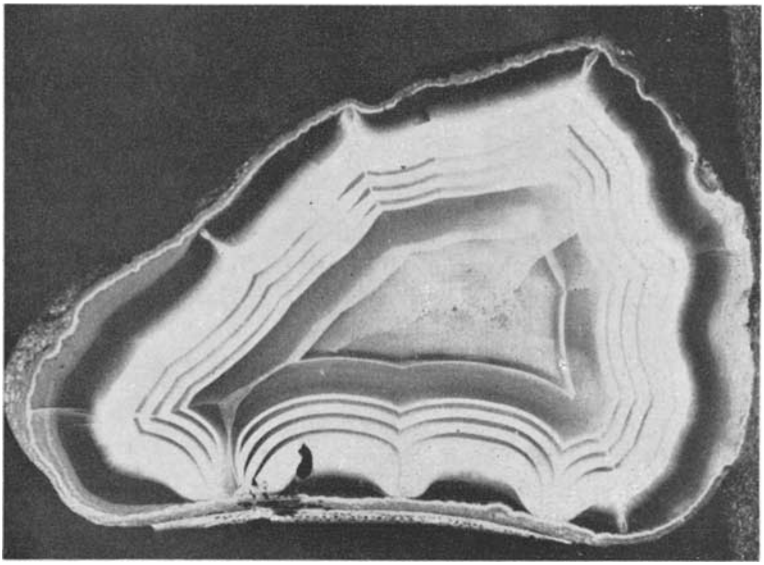


FIG. 3. Agate showing a multitude of expulsion tubes (Balmeadowside, Fife).

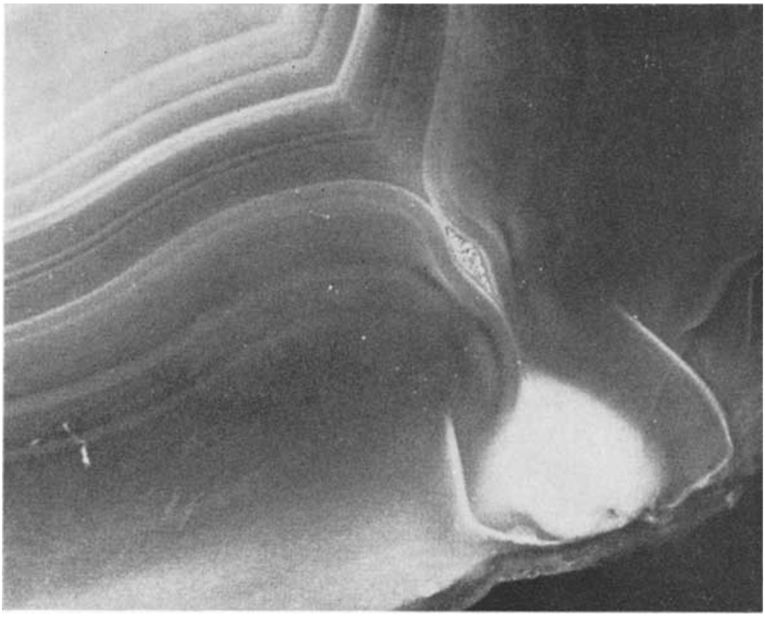


FIG. 4. Detail of dilatation in tube of escape.

Sim (1973) suggested that the banding was caused by seasonal fluctuations in the water-table generating successive depositions of silica, and Knoll (1942) attributed the rhythm to climatic variations and volcanic activity affecting the availability of siliceous material.

Fundamental to any theory of the formation of agates is an explanation of the so-called tube of escape. Such tubes exist in virtually all agates if examined in sufficient detail, and it is not uncommon to find several. One specimen showed as many as twenty. Dr Heddle supposed that chalcedonic material in solution is forced by endosmosis through the layers of chalcedony along the divergent fibres of tridymite into the semi-filled cavity. Here the solution deposits its silica and is subsequently forced out via one or many of the escape tubes by a further influx of solution. Heddle found many of these openings to the surface not round but linear in form easily mistaken for a rent. On the surface of the agate nodule these can often be traced as slight ridges traversing the agate's skin. Each layer deposited diminishes in thickness as it nears this tube of

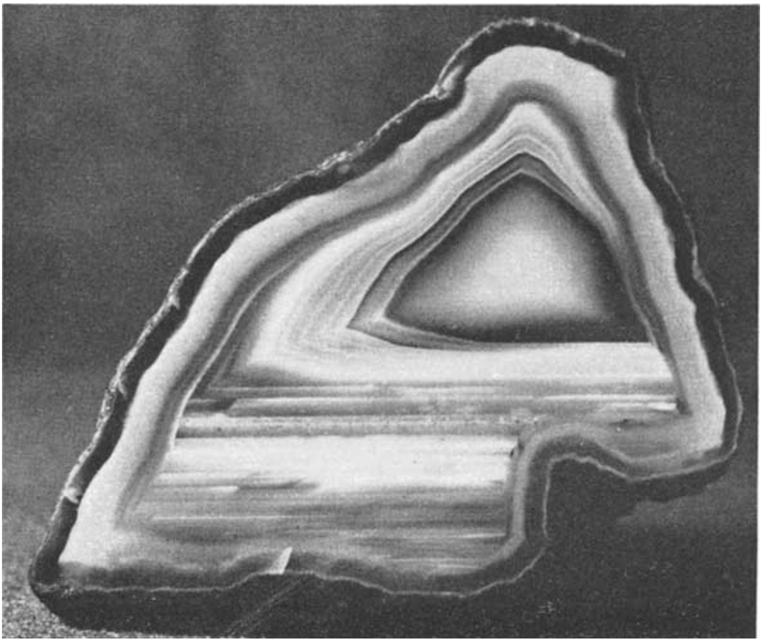


Fig. 5. Onyx-agate (Montrose).

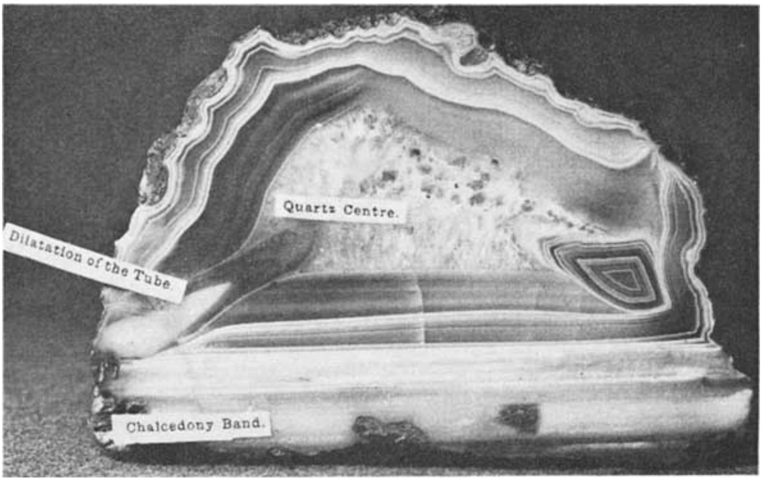


FIG. 6. Onyx-agate with quartz centre and tube of escape.

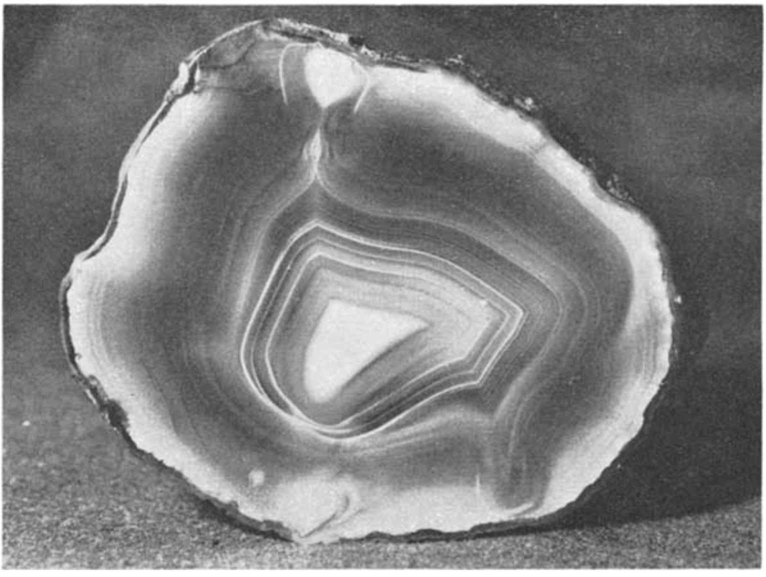


FIG. 7. Agate with tube of excape (Montrose).

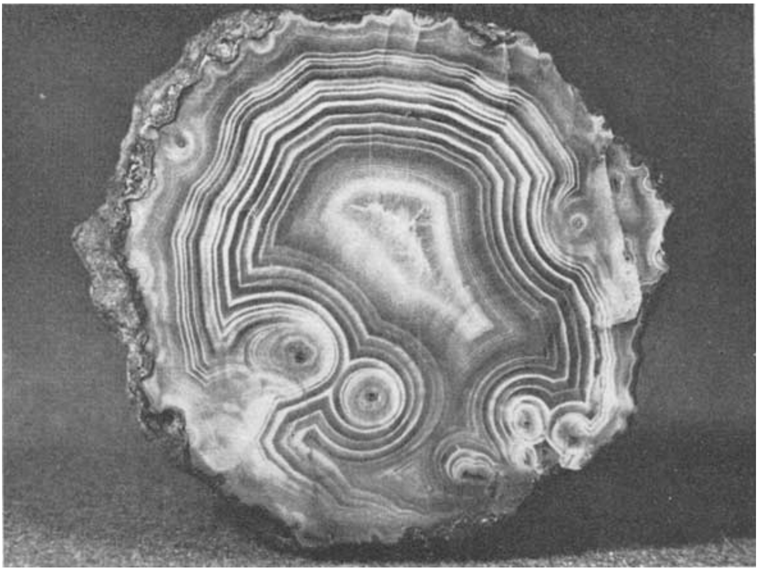


Fig. 8. Fortification agate.

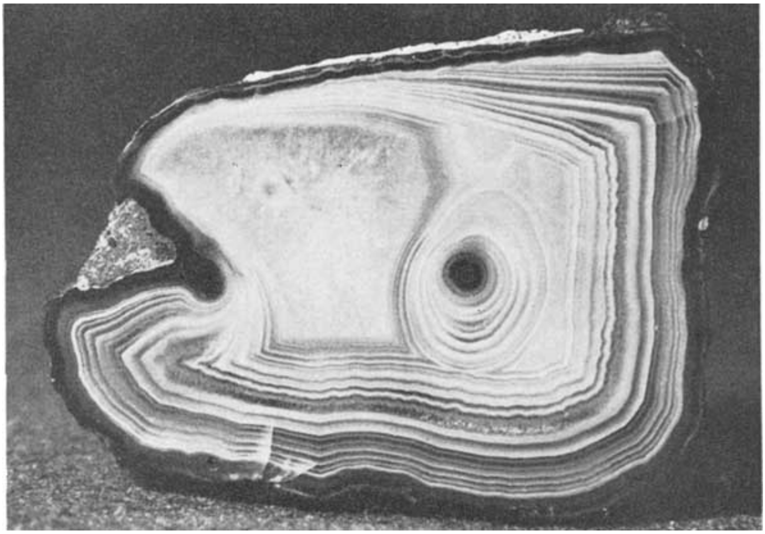


Fig. 9. Agate with quartz centre.

escape, it being the last portion of the cavity to be filled. The tube reaching the skin may be of virtually microscopic dimensions. In almost all cases there is a large dilatation at the end of the tube of escape at the point where the first clear layer of chalcedony has been deposited. It resembles a congestion such as when a moving stream of people is arrested at a narrow exit. Although doubtless significant, Dr Heddle could not explain what has caused this curious feature other than it being pressure outwards of the silica solution. This is an interesting point, as some authorities maintain that this tube is the means by which solutions entered and others that it is irrelevant to the formation of agate at all.

Onyx is common either partly or completely filling the amygdale. Heddle explained onyx as the silica gel whilst in solution being less viscous than normal and so instead of adhering equally to all the sides of the amygdale it settles by the laws of gravity in the lowest part of the cavity. In some instances, due to localized earth movements, the solidified lava has been tilted causing a disruption in the deposition of the banding, i.e. the bands are not parallel but inclined to one another. Such occurrences are, however, uncommon.

The work of Dr Heddle poses a number of intriguing questions regarding agate and its formation. Many of the features he observed are peculiar to specific localities or regions and more recent theories on agate are not satisfactory in explaining their origins.

ACKNOWLEDGEMENT

The Author wishes to acknowledge the valuable assistance of Mr R. J. Gillanders in photographing specimens, also of Dr H. Macpherson and his staff at the Royal Scottish Museum for making available specimens from the Heddle collection.

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Gemmological Abstracts

Berdesinski (W.), Schmetzer (K.) and Müller (E.). *Palygorskit aus Peru und Mexico.* (Palygorskite from Peru and Mexico.) Z.Gt.Gemmol.Ges., 1977, 26, 1, 6-8. 2 illus. Bibl.

This material is pink or grey-pink, a comparatively rare clay mineral formed by erosion of Mg-rich rocks, also found in sedimentary deposits. Physical properties vary according to chemical composition, i.e. amount of Mg and Ca present. Can be orthorhombic or monoclinic. The authors compare material from Peru and from Mexico, the first being more intensive pink, with density 2·18, R.I. 1·55, the latter being paler, with density 2·10, R.I. 1·55. The editor adds that this material is marketed in Germany under the name "pink opal" and the rough is imported as "angel-skin opal". E.S.

Brown (G.). *Two new precious corals from Hawaii.* Australian Gemmologist, 1976, 12, 12, 371-377. 6 figs.

Deals in detail with pink coral (C. secundum) and gold coral (Parazoanthus sp.), both occurring at 300 to 500 metre depths off Hawaii. The pink coral appears to be similar to other pink corals occurring in other localities. It is affected by hydrochloric acid. Gold coral, on the other hand, although apparently growing in symbiotic association with the pink, is much more like black coral in its nature and properties, i.e. the substance is similar to conchyolin and does not react with hydrochloric acid. There is some suggestion that it is a parasitic growth on bamboo coral. This seems to be the most complete paper on these corals so far published in gemmological literature and, as such, is important.
R.K.M.

Cassedanne (J. P. and J. O.). *La turquoise de Pau à Pique (Brésil).* (Turquoise from Pau à Pique, Brazil). Revue de Gemmologie, 1976, 49, 3-6.

The location of the deposit is in the north-west of the State of Bahia and the main rock is a biotitic gneiss. Much of the turquoise occurs in veins cutting quartzite and also in a cement of iron-bearing variscite. S.G. of the turquoise was approximately 2·65 (blue cryptocrystalline fragments), 2·40 (greenish-blue porous material); hardness varied between 5·5 for compact material and 4 for porous stones. Mean refractive index was approximately 1·618. Mining is now thought to have been abandoned. M.O'D.

Chalmers (B.). *Emeralds—three for* $150. Australian Gemmologist, 1976, 12, 12, 365-370. 6 figs.

An account of a visit to Bogota with some historical background to the country and the emerald sources. The $150 (Australian) of the title becomes $1.50 in the text. R.K.M.

Crowningshield (R.). *Developments & highlights in GIA's Lab in New York.* Gems & Gemology, 1976, XV, 7, 218-224. 17 figs.

Several examples of serious laser damage to diamonds are illustrated, including one with a brown burn on the table. The tilt or light-spillage test for diamond simulants is described but illustration is too small to be clearly interpreted. Aventurine quartz and realistic "paste" emeralds and yet another fake emerald crystal are also described. Random fibres in chatoyant chrysoberyl, simulated ivory "engine-turning" in a plastic copy of a netsuke, and a partially dyed monolith jade ring are described, while a dyed marble bangle proved to be easily frangible. R.K.M.

Czygan (W.). *Die schwarze Varietät.* (The black variety). Lapis, 1977, 2, 3, 20-21.

Melanite, the black variety of garnet, is found in the Kaiserstuhl area of Germany; common forms encountered are the rhombic dodecahedron and a combination of this form with the icositetrahedron. M.O'D.

Dunn (P. J.). *Gem Notes.* Gems and Gemology, 1976, XV, 7, 199-202. 3 figs.

Notes on Madagascan hambergite; inclusions in Yogo Gulch (Montana) sapphires; green fluorite from New Hampshire; opalescent sandstone from Louisiana; and inclusions in Brazilian andalusite; presumably based on specimens in the Smithsonian collections. R.K.M.

Fischer (K.). *Sphen.* (Sphene). Lapis, 1977, 2, 1, 27-29.

The characteristics and localities for sphene are reviewed with two illustrations in colour. M.O'D.

Girgis (K.), Gübelin (E.) and Weibel (M.). *Vanadiumhaltiger grüner Kornerupin vom Kwale-Distrikt, Kenya.* (Vanadium-containing green kornerupine from Kwale District, Kenya). Schweiz. Min. Petr. Mitt., 1976, 56, 65-68.

New detailed chemical data are given on the green iron-free vanadian kornerupine of gem quality in southern Kenya. The analysis presented by Schmetzer *et al.* (in their paper abstracted in J. Gemm., 1975, XIV, 6, 297) seems to be erroneous in the determination of boron and water. M.W.

Godefroy (G.), Lompré (P.) and Dumas (C.). *Pure and doped barium titanate; crystal growth and composition.* Materials Research Bulletin, 1977, 12, 2, 165-9.

Single crystals of barium titanate have been grown by the Czochralski and Remeika methods and have been doped with Fe, Cu and Co. M.O'D.

Gramaccioli (C. M.). *Grüne Samen in Asbest.* (Green offspring in asbestos). Lapis, 1977, 2, 3, 10-13.

An account, illustrated in colour, of the occurrence of the demantoid variety of andradite garnet in the Malenco-Tal, Italy. The garnets occur in a chrysotile asbestos with magnetite. M.O'D.

Grice (J. D.) and Williams (R.). *Jeffrey Mine, Asbestos.* Lapis, 1977, 2, 3, 14.

An account, illustrated in colour, of the occurrence of hessonite and a green variety of grossular garnet at the Jeffrey Mine, Asbestos, Quebec, Canada. M.O'D.

GÜBELIN (E.). *Alexandrite from Lake Manyara, Tanzania.* Gems and Gemology, 1976, XV, 7, 202-209. 7 figs, 3 in colour.

An excellent and very full account of the sparse occurrence of alexandrite in the emerald deposits of this comparatively newly opened gem area. The Manyara material contains less iron than does alexandrite from other known areas and in luminescence and transparency to long U.V. light resembles synthetic material to some extent. Colour plates are rather garish. R.K.M.

KOCH (S.). *Granatfels aus den Karpaten.* (Garnet in the Carpathians). Lapis, 1977, 2, 3, 25.

Good garnet crystals are found in the Banat area of Romania; andradite is the commonest variety encountered, but the colour inclines to dark brown or brownish-red rather than green. M.O'D.

LEAVENS (P. B.). *The hall of minerals and gems at the American Museum.* Mineralogical Record, 1977, 8, 1, 28-31.

The new display at the American Museum (of Natural History, New York City) opened in 1976 and consists of a cluster of rooms, carpeted and dimly lit except for the cases themselves. The gemstone display is fine in quality but cramped, and some of the larger minerals are not in the best condition. One notable exhibit is a made-up pegmatite pocket. M.O'D.

LIDDICOAT (R. T.). *Developments & highlights at GIA's Lab in Santa Monica.* Gems and Gemology, 1976, XV, 7, 210-215. 18 figs.

A hornbill snuff-bottle proved to be composite, not one piece. A spodumene cat's-eye (no colour given), African alexandrites, quartz inclusion in emerald, and knots (naarts) in a fancy diamond, are illustrated and described. Inclusions and striations in botryoidal opal from a North Mexican locality, a spodumene-like inclusion in synthetic emerald, and devitrification around a bubble in a paste stone, are also reported and illustrated. R.K.M.

MEIXNER (H.). *Aus der Gamsjagd entdeckt.* (Found in the Gamsjagd). Lapis, 1977, 2, 3, 6-7.

A short account of the occurrence of garnet in the Tirol with illustrations taken from an early work. The garnets are pyropes. M.O'D.

MERTENS (R.). *Beitrag zur Erkennung synthetischer Opale.* (Contribution to the recognition of synthetic opals.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 28-29. 4 illus.

Article based on one by Jobbins, Statham and Scarratt in J. Gemm., 1976, XV, 2, 66-75. The author points out that when viewed sideways layers of varying colour can be observed. Another effect is the formation of "scales" in individual colour-zones. These scales are irregular and nearer to lizard scales than fish scales. The colour-zones are clearly defined as opposed to those in natural opals. E.S.

NASSAU (K.). *How to define non-single-crystal synthetics.* Gems and Gemology, 1976, XV, 7, 194-198.

Dr Nassau proposes scientific requirements for the use of the term "synthetic" in connexion with such substances as man-made opal, lapis lazuli and turquoise. He considers that they should be congruent with the natural product at four out of five levels, i.e. chemical composition, crystal structure at x-ray diffraction level, sub-micro structure at electron microscope level, and at macro-structure (visual) level. Only micro-structure may vary to some extent, as it does in the natural stone. R.K.M.

NASSAU (K.). *Zur Bestimmung von "nicht-einkristallinen Synthesen".* (Definition of non-single-crystal synthetics.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 19-23.

This article is a translation by B. Günther from the English (*v.sup.*). E.S.

NASSAU (K.). *Das internationale System der Einheiten in Messwesen und seine Anwendung in der Gemmologie.* (The international system of units and its application in gemmology.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 24-27.

German translation of Dr Nassau's article in J.Gemm., 1977, XV, 5, 243-247. E.S.

O'DONOGHUE (M. J.). *Two interesting zinc minerals.* Australian Gemmologist, 1976, 12, 12, 364.

An account of the zinc spinel, gahnite, and of the zinc tungstate, sanmartinite, with brief reference to their synthesis. Confused by a mass of mineralogical data much of which is academic and of little consequence to the gemmologist. Reference to "cubic oxygen", vagueness about gahno-spinel and a printer manifestly out of his depth add to this confusion. Sanmartinite does not appear to have been cut as a gem. R.K.M.

OKRUSCH (M.), BUNCH (T. E.) and BANK (H.). *Paragenesis and petrogenesis of a corundum-bearing marble at Hunza (Kashmir).* Mineralium Deposita, 1976, 11, 278-297.

A calcite marble containing gem-quality ruby is exposed in the Hunza Valley, in north-western part of the Karakoram mountains, Pakistan zone of Kashmir. Electronprobe microanalyses are reported for two rubies and for claret-red, greyish red-violet, and cornflower-blue spinels (and also for garnet, biotite, phlogopite, chlorite and plagioclase). The rubies have a maximum size of 15 mm; only a few of them are of gem quality but they are reported to compare in colour and clarity with Burma rubies; they have ε1·762, ω1·770; sp.gr. 3·99. The two ruby analyses show Cr_2O_3 0·14, 0·17, total iron as FeO 0·01, 0·01%. The cornflower-blue spinel has Cr_2O_3 0·19, total iron as FeO 1·88%; the claret-red spinel has Cr_2O_3 0·41, FeO 0·39%. R.A.H.

O'LEARY (B.). *Opals of Indonesia.* Lapidary Journal, 1977, 30, 11, 2484-2500.

The material, found on Java, is said to be volcanic in origin and both white and black varieties are found, as well as a jelly opal (i.e. fire opal). A jet-black variety is said to display a garnet-red colour. Pseudomorphs after various fossils and a variety resembling boulder opal are also found. Security considerations prevent further disclosures at the present time. M.O'D.

PENSE (J.), SCHNEIDER (W.) and SCHRADER (H. W.). *Magnesit als Türkis Imitation.* (Magnesite as turquoise imitation.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 17-18. Bibl.

Various pieces had been offered as turquoise and were examined and shown to be coloured magnesite gel, which has similar density to turquoise. (Dr Lenzen has added a note to the above, giving details. The examples were baroque pieces which had been used for necklaces. The magnesite can be dissolved at room temperature in 25% hydrochloric acid; however, care should be taken not to immerse real turquoise in such solution as the colour can change.) E.S.

SANDERS (J. V.). *Precious opal in the Warrumbungles.* Australian Min., 1976. 3, 9-11, 5 figs. (in Australian Gems & Crafts Mag., no. 16).

Precious opal and white potch opal occur in vesicular lavas in north-western N.S.W. The precious opal has the normal structure of regular equal-sized spheres of diameter 0·15-0·3μ with cusp-shaped interstitial holes, whereas the potch consists of spherical particles of variable size up to 10μ. Curved boundary surfaces between particles are due to void-filling after the irregular-sized spheres had settled together. D.R.H.

SCHMETZER (K.), BERDESINSKI (W.) and KRUPP (H.). *Grüner Opal aus Tansania.* (Green opal from Tanzania). Aufschluss, 1976, 27, 381-384. 2 figs.

Green opal from Tanzania can be structurally placed into the cristobalite-tridymite-opal group. As in chrysoprase, the colour is due to a small amount of Ni. The Ni^{2+} ions are probably situated in Mg^{2+} positions in clay minerals which are present in green opal as admixtures. The bands of the absorption spectrum of the opal, which is reproduced together with one of chrysoprase from Australia, are assigned to Ni^{2+} transitions in octahedral coordination. A.P.

SCHMETZER (K.), GÜBELIN (E.), MEDENBACH (O.) and KRUPP (H.). *Skapolith-Katzenauge und Sternskapolith aus Zentral Tansania.* (Scapolite cat's-eye and star scapolite from central Tanzania.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 3-5. 7 illus. Bibl.

The authors examined yellow scapolites from central Tanzania which were cut en cabochon and showed a cat's-eye effect; in one example a four-rayed star was observed. Under the microscope leaf-like, tabular and needle-shaped inclusions of reddish-brown and orange-red colouring were seen to have higher R.I. and are thought to be iron oxides or iron hydroxides (haematite, goethite, lepidocrocite). The inclusions are quite different from those found by Anderson and Payne in 1934 in scapolite cat's-eyes from Mogok in Burma. E.S.

SCHMETZER (K.), OTTEMANN (J.) and KRUPP (H.). *Skapolith aus Zentral-Tansania,* (Scapolite from Central Tanzania). Aufschluss, 1976, 27, 341-346. 3 figs.

Yellow scapolite of gem quality from the region between Dodoma and Singida in central Tanzania is described. The microprobe analysis reported indicates 26% meionite. The cell dimensions are a 12·06, c 7·56 Å, space group $P4_2/n$. Refractive indices and dispersion are reported in detail. On 199 crystals that have been studied 10 forms in 19 different combinations have been recorded and are fully tabulated. $\{100\}$, $\{110\}$ and $\{101\}$ are invariably present; next most common is $\{301\}$, recorded on 131 crystals. A.P.

SINGHEE (A.). *Ivory carving in India.* Gem World, 1976, 3, 11, 23-25.

The ivory carving trade in India is in a very healthy state and during 1975/76 exports reached a record level. Ivory used comes from Mysore, Tamil Nadu, Kerala and Assam in India, though this material is only suitable for small pieces. African ivory is used for the larger carvings. Cutting is carried out by hacksaw; hydrogen peroxide is used for bleaching and marble powder for polishing.

M.O'D.

STRUNZ (H.). *Djevalith-Kristallstruktur und Chemismus.* (Crystal structure and chemistry of Djevalite.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 9.

The author measured the cubic crystal with a =5·12Å, and gives further crystallographic details. He reads the density as 5·62 (5·60 and 5·71 according to Gübelin). The author also mentions electrical conductivity of the material.

In a footnote on p. 10 Dr Gübelin corrects an error in his article in Z.Dt. Gemmol.Ges., 1976, 25, 4, 204-210 (abstracted on page 328 *ante*). The right value for dispersion is G-B 0·0653, i.e. nearly 50% higher than diamond. E.S.

STRUNZ (H.) and WILK (H.). *Violetter Skapolith von Edelsteinqualität aus Ostafrika.* (Violet scapolite in gem quality from East Africa). Aufschluss, 1976, 27, 389-391. 2 figs. 1 coloured pl.

Violet scapolite of gem quality is found in a modern placer deposit near Dodoma, Tanzania. Morphology, cell dimensions, and optical properties are fully reported. The crystals are markedly pleochroic, colourless parallel to *c*, intense violet normal to *c*. A full chemical analysis shows that this scapolite is a marialite with a substantial magnesium content (MgO 1·60 wt%). The Ti and Mn content is less than 0·01%; Cr was spectrographically detected. A.P.

SUHNER (B.). *Eine einfache Methode zur Messung der Dispersion.* (A simple method of measuring dispersion.) Z.Dt.Gemmol.Ges., 1977, 26, 1, 11-16. Bibl.

The author uses two interference filters: blue 480 nm and red 654 nm together with a good light source on a Japanese Topcon refractometer. He claims that it is possible to obtain values to within 0·001. Various gems are given as examples.

E.S.

WANKLYN (B. M.). *Growth of silicate and germanate crystals from* $PbO\text{-}SiO_2$ (GeO_2) *fluxes.* Journal of Crystal Growth, 1977, 37, 1, 51-56.

Zircon has been grown from several flux systems and its possible use as a laser material has been suggested. Deep blue crystals were produced when a flux of V_2O_5 was used. Crystals doped with Tb were yellow, those doped with Cr were green. M.O'D.

WILKE (H.J.). *Outokumpu.* Lapis, 1977, 2, 3, 16-19.

An account, illustrated in colour, of the occurrence of uvarovite at Outokumpu, Finland. Pyrrhotine and chrome diopside are also found in this locality.

M.O'D.

Zeitner (J. C.). *The turquoise blues.* Lapidary Journal, 1977, 30, 11, 2460-2472.

Reviews the types of turquoise currently available with particular reference to Indian jewellery. M.O'D.

Zeitner (J. C.). *Agates around the world.* Lapidary Journal, 1977, 30, 12, 2668-82.

The nature and occurrences of agate are reviewed by country; chrysocolla is erroneously grouped with quartz. M.O'D.

Joyaux et objets d'art de Louis XIV. (Louis XIV's jewels and *objets d'art*). Revue de Gemmologie, 1976, 49, 9-16.

In the recently re-opened Collection National de Gemmologie, housed in the Museum d'Histoire Naturelle, Paris, are a number of celebrated historical objects which are described, some being illustrated in colour. M.O'D.

Man-made gem diamonds have exclusive properties. Retail Jeweller, 20th January 1977, p. 6.

A report was released by Diamond Grading Laboratories Limited on two synthetic gem diamonds made by the General Electric Company. One stone, weighing 0·28 ct, was brilliant-cut and greyish in colour. No absorption was seen as 4155Å nor at any other position. Under long-wave ultraviolet light there was a yellowish fluorescence with no phosphorescence; under short-wave irradiation the fluorescence was similar in colour but with a bluish-green phosphorescence lasting several minutes. Under x-rays a strong light blue fluorescence with a light blue phosphorescence was seen. In the other stone, rod-like inclusions could be seen with a 10 × lens and were thought to be voids, carbon not taken into the diamond structure or catalyst. The first stone was graded SI by SCANDN but colour grading was not applied. M.O'D.

Pearls. Gem World, 1976, 3, 11, 26-33.

The Indian pearl trade has suffered a decline in recent years, especially in the last two decades. Large-scale pearl farming in off-shore shallow bays has been started with a view to offsetting this situation. M.O'D.

Türkis. (Turquoise). Lapis, 1977, 2, 2, 5-18.

Accounts by various authors with illustrations in colour of the occurrence, properties and use of turquoise. M.O'D.

BOOK REVIEWS

Axon (G. V.). *The California gold rush.* Mason/Charter, New York, 1976. pp. vi, 136. Illus. in black-and-white. $6·95.

The gold rush began with the discovery of gold at Coloma, California, in 1848. This short book traces the development of the state of California and shows why its acquisition was so vital to the expanding Union; since prospecting attracted many men of initiative, the area soon prospered and even without gold would eventually have done so; contemporary illustrations show some original settlements and typical figures of the time. M.O'D.

Baltǎ (P.) and Baltǎ (E.). *Introduction to the physical chemistry of the vitreous state.* Abacus Press, Tunbridge Wells, 1976. pp. 287. £14·65.

Readers interested in the formation and properties of the various types of glasses will find some chapters in this book useful, in particular those on oxide glasses, the behaviour of ionic colouring agents in glasses and light absorption by charge transfer. The style of the book (a translation from Roumanian) is a little heavy but the matter is worth scanning. 671 references are given but there is no index. M.O'D.

Bariand (P.). *Marvellous world of minerals.* Abbey Library, London, 1976. pp. 126. Illus. in colour. U.S. $12·50.

Those familiar with the world of minerals will know Nelly Bariand's superb photographs. Here they accompany a brief text translated from the French by David Macrae. The book is printed in West Germany and the standard of reproduction is as high as one would expect. But the specimens themselves provide the magic which fills the book; among many delights are sphalerite from Tenagh, Ireland, erythrite from the classic locality of Bou Azzer, Morocco, cyanotrichite from Grandview, Arizona. Arrangement is simple and there is a short introduction. As in Roberts *et al.*, "Encyclopedia of minerals" (reviewed on p. 401), the specimens are small, sometimes of micromount size; this ensures the presentation of the finest possible crystal. The scale is given for each illustration. At the price (or at almost any price) a superb book. M.O'D.

Kouřimský (Jiří). *A colour guide to familiar minerals and rocks.* Octopus Books, London, 1975. pp. 190. Illus. in colour. £0·99.

Faults in this remarkably cheap and handy-sized book chiefly spring from mistranslations, the original language being Czech. Many of the minerals described are given outdated and unnecessary synonyms and much important detail is omitted. As one comes to expect, the nature of the cause of colour in precious opal is incorrectly given; it is odd to see the cleavage of fluorite given as "difficult". The crystal system of arsenopyrite is monoclinic, not orthorhombic (the crystals are pseudo-orthorhombic); argentite is classed as orthorhombic (pseudo-cubic) and no mention is made of its relationship to acanthite (cubic crystals of Ag_2S are paramorphs of acanthite after argentite). The quality of the coloured illustrations is not high and certainly unflattering to many of the species described. Although the price is low readers will be much better served, within the same size and range and in nearly the same price range, by Hamilton *et el.* "The Hamlyn book of minerals, rocks and fossils" (reviewed in J.Gemm., 1974, XIV, 4, 194). M.O'D.

ROBERTS (W. L.), RAPP (G. R.) and WEBER (J.). *Encyclopedia of minerals.* Van Nostrand Reinhold, New York and London, 1974. pp. xxv, 693. Illus. in colour. £41·00.

This is in every way a magnificent production and serves immediately as a most welcome standard reference work. All known minerals are listed alphabetically and in addition to the expected constants much more information is given, including the three strongest diffraction lines, lattice constants and best reference in English (this is frequently Palache *et al.*, "Dana's System of Mineralogy", 7th edition, lamentably still incomplete; the present work goes far towards alleviating this sorry state of affairs). As this review (by oversight) is written rather a long time after publication the present reviewer has had the advantage of reading other appraisals; all are favourable, and very few errors and omissions have been noted. One or two species have been listed under names now relegated to synonym status by the International Mineralogical Association (sphene, now titanite, and cobaltocalcite, now spherocobaltite; less alarming are celestite for celestine and niccolite for niccoline). There are some other errors and inconsistencies, which can no doubt be cleared-up in a second edition.

The coloured illustrations are arranged in eight groups of 16 pages; they are of very high quality. Although there are 16 of diamond and eight of these are Nomarski phase-contrast photographs, the other minerals illustrated include many rarities and some have not been shown in colour before. Most of those illustrated are micromounts, which helps to ensure that the crystals are beautifully formed, since larger ones are more frequently distorted.

Some points of description are explained in the introduction and there is a glossary. Altogether this is a book which the serious mineralogist must have; there is not likely to be anything else of this quality available for many years, if ever, and, although the price is high, it is not exaggerated. M.O'D.

TANNER (B. K.). *X-ray diffraction topography.* Pergamon Press, Oxford, 1976. pp. xiii, 174. £6·25.

This interesting and lucid work includes chapters on crystal growth from solution, from the melt and from the solid state. Each chapter includes a bibliography. M.O'D.

ZUCKER (B.). *How to invest in gems.* Quadrangle & the New York Times Book Co., New York, 1976. pp. 120. $12·50.

This book purports to show that cut gemstones can show a profit on outlay and supports this thesis with a table of prices. Remarks on colour and quality are vague and ill-informed; the whole subject is sketchily treated. This reviewer does not believe that gemstones can be regarded in this light. M.O'D.

Lapis. Die aktuelle Monatsschrift für Liebhaber & Sammler von Mineralien & Edelsteinen. (Lapis. A topical monthly magazine for lovers and collectors of minerals and gemstones). Christian Weise Verlag, Munich. Annual subscription DM 48.

A beautifully illustrated new journal covering rocks, minerals and gemstones with the emphasis on minerals. In the issue examined (Jahrg. 1 no. 2) were articles on hauyne, the mines of Panasqueira and Alpine minerals. M.O'D.

ASSOCIATION NOTICES

MEMBERS' MEETINGS

Midlands Branch

On the 12th May, 1977, at the R.I.C.S. Headquarters, Birmingham, a talk was given by Mr A. Monnickendam entitled "The CIBJO Grading System". The Annual General Meeting of the Branch was also held during the evening, and Mr D. Morgan, F.G.A. was elected Chairman and Mr C. L. Hundy, F.G.A., re-elected Secretary.

North-West Branch

A talk was given on the 20th April, 1977, at the Royal Institution, Liverpool, by Mr B. W. Anderson, B.Sc., F.G.A., on "Liquids in the Service of Gemmology".

On the 19th May, 1977, at Church House, Liverpool, Mr R. Huddlestone, of Diamond Grading Laboratories Limited, gave a talk on the subject "Diamond Fingerprinting and Diamond Colour Grading, the State of the Art Today".

The collection of jewellery at the Liverpool Museum was viewed by a group of members on the 26th May, 1977.

Scottish Branch

The West of Scotland Mineral and Lapidary Society was visited on the 15th March, 1977, when members were able to see the cutting and setting of stones.

Following the Branch A.G.M. held on 13th April, 1977, when it appeared that the expense of travelling long distances had the effect of severely reducing the numbers attending meetings, it was announced with regret that no further meetings would be arranged for the time being. Mr G. M. Turner, "Kimberley", 39 Grahamshill Street, Airdrie, Lanarkshire, ML6 7EN, has taken over all the records in the hope that in the not too distant future it will be possible to activate the branch again.

South Yorkshire and District Branch

At a meeting held on the 14th March, 1977, at the University of Sheffield, Dr D. A. Carswell gave a talk entitled "Geology of Diamonds". This covered the latest thinking on the origin of diamonds and the analysis of the various minerals found in the kimberlite pipes, as well as the various minerals found in the xenoliths which had been carried along with the pipe material. Dr Carswell illustrated his talk with slides and samples, many of which he had gathered himself.

COUNCIL MEETING

At the meeting of the Council held on Monday, 14th March, 1977, the following were elected to membership.

FELLOWSHIP

Abraham, Robert, Amsterdam, Holland. D. 1976
Alvarado Moro, Odorico, Barcelona, Spain. D. 1976
Baldock, Lynette, Neston, Wirral. D. 1976
Beck Kaiser, Margrit, Barcelona, Spain. D. 1976
Callaghan, Christopher C., Port Elizabeth, S. Africa. D. 1976
Chapellier, Dominique M. B., Lausanne, Switzerland. D. 1976
Cook, Judith A., Northwood. D. 1976
Cottrill, Susan D., Stockport. D. 1976
Elliott, Douglas H., Nairobi, Kenya. D. 1976
Engelbrecht, Johann P., Pretoria, S. Africa. D. 1976
Fabregas Guardiola, Virginia, Barcelona, Spain. D. 1976
Gaarder, Kierstin, Vöyenenga, Norway. D. 1976
Hornytzkyj, Seppo, Helsinki, Finland. D. 1976
Lewis, Ian R. M., Sheffield. D. 1976
Moline, Sala A., Barcelona, Spain. D. 1976
Mollfulleda Buesa, Antonio, Barcelona, Spain. D. 1976
Montserrat Nebot, Alfredo, Barcelona, Spain. D. 1976
Oria Albero, Maria P., Valencia, Spain. D. 1976
Pons Gomez, Joaquin, Barcelona, Spain. D. 1976
Ranasinghe, Mahesha, Yogiyana, Sri Lanka. D. 1976
Ribes Cudinach, Emilio, Barcelona, Spain. D. 1976
Richards, Patsey-Ruth, Brisbane, Qld, Australia. D. 1976
Rider, Stephen G., Chelmsford. D. 1976
San Juan Ribes, Antonio, Valencia, Spain. D. 1976
Speekenbrink, Wilhelmus A. M., Den Haag, Holland. D. 1976
Vilá Perales, Vicente, Barcelona, Spain. D. 1976
Vleeschhouwer, Willy A., Schoonhoven, Holland. D. 1976
Zaveri, Rupesh P., Bombay, India. D. 1976

ORDINARY MEMBERSHIP

Aksoy, Ayhan, Istanbul, Turkey.
Ando, Taiichiro, Wembley Park.
Aron, Mass K., Nugegoda, Sri Lanka
Bandara, Ranasinghe M. K., Colombo, Sri Lanka
Barrella, Lydia, Cape Town, S. Africa
Bayley, Adrian, Kowloon, Hong Kong
Beach, Wendy, Twickenham.
Beg, Mirza Z., Woking.
Bennett, Russell K., Aylesbury.
Bram, Carol B., North Melbourne, Va, Australia.
Burk, Ralph, Pforzheim, W. Germany.
Carr, William F. Hyannis, Mass., U.S.A.

Carter, Maurice, London
Chamberlain, Colin S., Leicester.
Choi, Yat H., Kowloon, Hong Kong.
Chong-Keun Lee, Joseph, Seoul, Korea.
Coffin, David G., Highbridge.
Cole, Arthur G., London
Cooray, Harindra T., Moratuwa, Sri Lanka.
Costet, Louis, Walnut Creek, Cal., U.S.A.
Culverwell, James C., London.
Daniels, Brian R., Dunedin, New Zealand.
Davis, Jonathan V., Stanmore.
Demouthe Smith, Jean, San Francisco, Cal., U.S.A.
Dharmawardene, Kahanawita G.E.R.W., Southall.
Dickson, Dorothy S., Harrisburg, N.C., U.S.A.
Driscoll, Richard F., Washington, D.C., U.S.A.
Eldridge, W. Randle, Kerrville, Tex., U.S.A.
Ellis, Paul A., Colchester.
Ereira, Jack, North Wembley.
Fernando, Bathiya D., Colombo, Sri Lanka.
Fielding, Evelyn, Klemzig, S. Australia.
Gadda, Fabrizio, Milan, Italy.
Gallant, Sherry L., Grand Island, N.Y., U.S.A.
Giorgetti, Pierangelo, Milan, Italy.
Golding, Ian A., London.
Harte, Partrick J., Whitstable.
Henniker-Heaton, Gay D. A., Cape Town, S. Africa.
Hein Dessing, Johan H. P., Gouda, Zuid, Holland.
Hitchen, Alan, Aldridge.
Holgeth, Jean, Grimsby.
Hood, Glynis M., Johannesburg, S. Africa.
Horata, Yoshihiro, Shibuya-Ku, Tokyo, Japan.
Hornstein, Sydney, Montreal, Que., Canada.
Hubbard, Audrey L., New Malden.
Hurst, Adam K., Solihull.
Inparajan, Athanas B., London.
James, Paulette V., Bognor Regis.
Jayanetti, Don C., Colombo, Sri Lanka.
Jayanetti, Prema, Colombo, Sri Lanka.
Kalra, Om P., London.
Katz, Raphael D., London.
Kaye, Ian D., London.
Kinch, John C., Morden.
Kuehn, Robert L., Dallas, Tex., U.S.A.
Landvik, Jan, Djursholm, Sweden.
Langoulant, Peter B., Salisbury, Rhodesia.
Lee, Dennis P., Leatherhead.
Leong, Lee-Wah, Singapore.
Lindsay, K. Sharon, Salisbury, Rhodesia.
Liu, Kin-Shun, Hong Kong.
Loh, Swee K., Singapore.
Maeda, Kiseko, Shibuya-ku, Tokyo, Japan.
Mahinda, Balasingham, Colombo, Sri Lanka.
Martin, William J., Nairobi, Kenya.
Matsuo, Harumitsu, Shibuya-ku, Tokyo, Japan.
Miragli, Giovanni, Varese, Italy.
Muruganantham, Katherval, Colombo, Sri Lanka.
Oetter, Leroy P., Phoenix, Ariz., U.S.A.
Oka, Hirobumi, Shibuya-ku, Tokyo, Japan.
Pantelli, Andrew, London.
Parry, Julie, Pewsey, Wirral.
Patney, M. L., Lusaka, Zambia.
Payne, Philip, London.
Perrett, Roy, Manchester.
Pierce, Alan L., Los Alamitos, Cal., U.S.A.

Plomp, Jan, Alkmaar, Netherlands.
Pope, Lesley J., Lymington
Pretty, Elaine, Orakei, Auckland, New Zealand.
Quick, Rodney J. A., Torquay.
Rafi, Mohamed, Colombo, Sri Lanka.
Reeves, A. Smith, San Francisco, Cal., U.S.A.
Roberts, Edward A., Kowloon, Hong Kong.
Robertson, Thomas B., Bundaberg, Qld, Australia.
Ros-Jones, Catherine A., South Ascot.
Saito, Shigeji, Shibuya-ku, Tokyo, Japan.
Sarna, Rajesh, Nairobi, Kenya.
Sasaki, Shizuo, Yokosuka-Shi, Kanagawa-ken, Japan.
Seal, Richard M. P., Bridlington.
Shepherd, Kenneth G., Barnard Castle.
Snowden, Robert F., San Marino, Cal., U.S.A.
Spencer, Bernard J. C., Marlow.
Stayte, Philip A. J., Leicester.
Takayama, Naoyuki, Shibuya-ku, Tokyo, Japan.
Tanaka, Kiyofumi, Yokohama-Shi, Kanagawa-ken, Japan.
Towler, Eric A., Kowloon, Hong Kong.
Tsukagoshi, Hideaki, Bunkyo-ku, Tokyo, Japan.
Turelli, Manuel L., São Paulo, Brazil.
Tyson, Jeffrey G., Carmarthen.
Ueda, Yoriaki, Ikeda-city, Osaka, Japan.
Veo, Luana, Vanderbijlpark, S. Africa.
Vickers, William, Beer.
Yokoyama, Kiyoshi, Shibuya-ku, Tokyo, Japan.

ACTIVITIES BY FELLOWS

The following Fellows of the Association have recently been granted the freedom of the Worshipful Company of Goldsmiths—Miss Judith Banister, Mr Eric Bruton, Mr A. E. Farn and Mr Alan Hodgkinson.

On the 6th May, 1977, Mr E. A. Jobbins, B.Sc., F.G.A., gave a talk on "Gemmological Survey" to the Wessex Branch of the N.A.G. in Bournemouth.

THE SHAPES OF PEARLS

The Japan Pearl Promotion Society has recently promulgated a set of expressions to specify the shapes of pearls, having reclassified all terms hitherto used in Japan and elsewhere in describing the shapes of pearls and selected those considered most appropriate, including those most widespread in English. In the past, confusion has been caused by the various different descriptions of some shapes of pearls and this has led the Society to take action to promote uniformity of phraseology. The new list of expressions covers virtually all shapes of the seawater species and the Society intends gradually to adopt new terms to designate such new and unusual shapes of freshwater pearls as may occur in the future. The shapes of pearls with their authorized names are set out in the accompanying Figs 1 and 2: a "Pearl Chart" showing them in colour may be obtained from the Gemmological Association of All Japan, Tokyo Bihokaikan Building, 1-24 Akashicho, Chuo-ku, Tokyo, Japan.

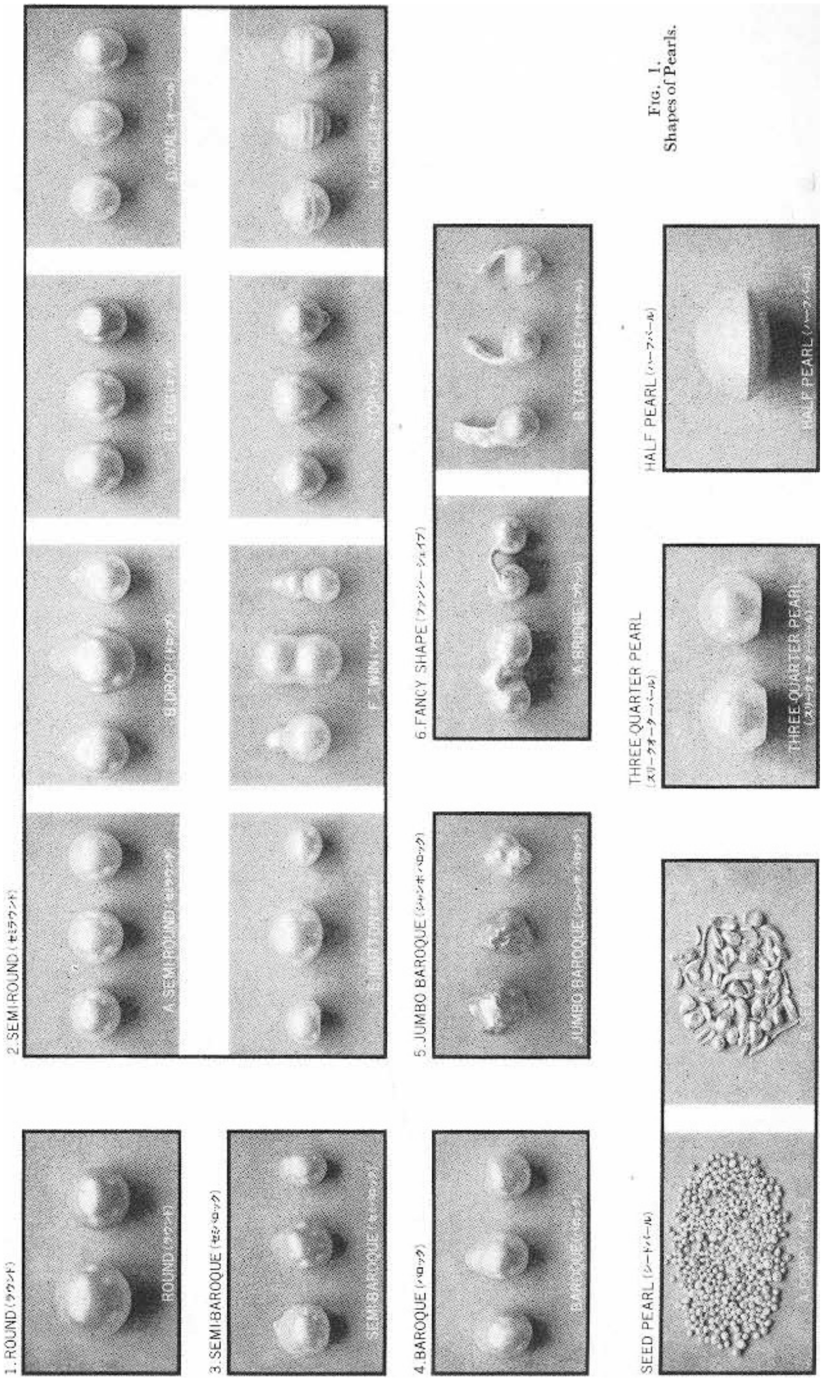

FIG. 1.
Shapes of Pearls.

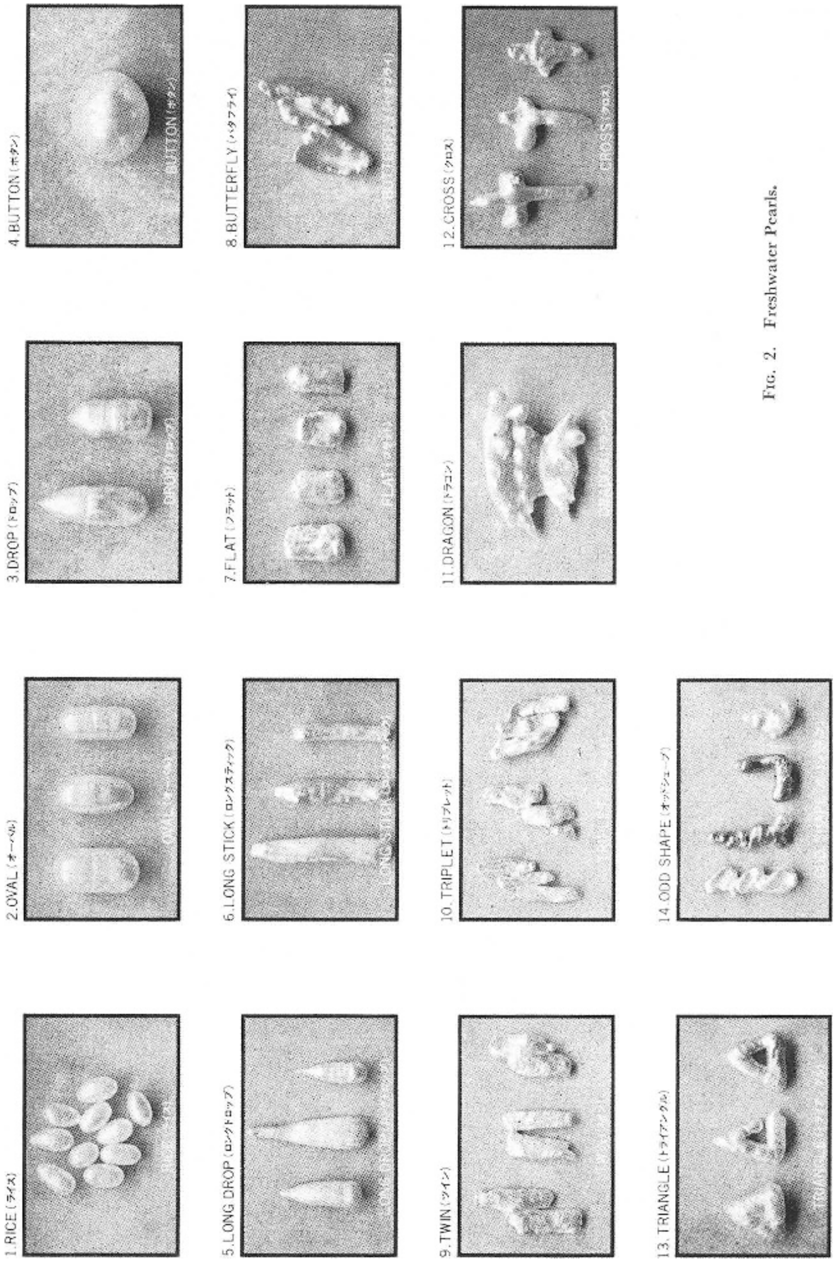

Fig. 2. Freshwater Pearls.

OBITUARY

Mr A. T. Kemp, F.G.A. (D.1936), London, died on the 2nd October, 1976.

GIFTS TO THE ASSOCIATION

Arising from a bequest by the late Mr A. T. Kemp, F.G.A., the Association has been presented with bound volumes of The Gemmologist and Journal of Gemmology, and various instruments including a microscope, refractometer, dichroscope and spectroscope.

PRESENTATION OF AWARDS

The Reunion of Members and Presentation of Awards is to be held at Goldsmiths' Hall, London, on Monday, 24th October, 1977, and NOT as originally arranged in November.

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