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CHROMIUM AS A CRITERION FOR EMERALD

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

NO-ONE can deny that the finest reds and the finest greens in the whole field of gemstones are due to the presence of small quantities of chromium in an intrinsically colourless host mineral. Ruby and emerald serve as the best and most typical examples of each case, and it is significant that these are by far the most valued varieties of corundum and of beryl.

That emerald owes its colour primarily to traces of chromic oxide was recognized at least one hundred years ago by scientists. In his standard work "Manual of Mineralogy" by J. D. Dana (1862) for instance, the author stated: "The *emerald* includes the rich green variety; it owes its colour to oxide of chrome. *Beryl* especially the paler varieties which are coloured by oxide of iron . . . *Emerald* contains less than one per cent of oxide of chromium".

Later and lesser authors have voiced a less positive opinion; and while the evidence had to rest upon the *supposed* effect of a *supposed* small amount of chromium estimated by the laborious methods of quantitative chemical analysis, there was some justification for doubt and for alternative suggestions as to the cause of colour in emerald beryl. But during the last half-century or so when the evidence of analysis has been reinforced by the synthesis of emerald, and where absorption spectroscopy can be used to give quick and positive evidence, not only that the element chromium is present, but also that it is affecting the colour of the beryl crystal in a particular and characteristic way—the evidence has become so strong as to be unassailable.

And the reverse proposition should also hold. Since all emeralds owe their fine colour to chromium, no beryl lacking chromium should be called an emerald. This view was voiced over thirty years ago by the noted German gemmologist and dealer, G. O. Wild, who had pioneered in making a thorough study of the cause of colour in gemstones.(1) He wrote (1934), "The criterion for emerald is solely a content of chromium and possibly vanadium, to which the colour is due", and, later in the same article, "Any beryl whose colour is not chiefly due to chromium must in future be refuted as a true emerald". It must in fairness be added that Wild in an article "What is an Emerald?" written thirteen years later, finds it more difficult to hold to this unequivocal position. He was troubled by a difficulty in categorizing as emeralds or as green beryls stones from a Brazilian locality, Ferros, in Minas Gerais. These stones showed a chromium and vanadium content, but in some specimens were certainly not emerald from the commercial standpoint. The question is raised again to-day by the appearance of other Brazilian beryls, on this occasion from the Salininha locality in Bahia. These have been promoted as "emeralds", and even accepted as such in some quarters in the U.S.A., despite the fact that they contain no perceptible chromium. True, a quantitative spectrochemical analysis of the Salininha green beryl (kindly sent to me by Mr. Hugh Leiper, Editor of the *Lapidary Journal*) showed the presence of 0·0003% chromium in addition to 0·15% vanadium, 0·7% iron. Now this amount of chromium is equivalent to 3 parts in a million, and is quite insufficient to affect the colour of the mineral in any way. Reputable analyses of emeralds from the well-known localities have indicated the presence of from about 0·1 to 0·5% of chromic oxide, according to the depth of colour: thus it would require something like 100 times as much of the oxide as occurs in the Salininha crystals to produce a deep enough emerald green to be acceptable as a precious stone.

For the cause of colour in the Salininha beryls one must in fact look to iron and to vanadium. Iron is a well known "competitor" with chromium in the production of reds and greens in minerals, and is probably always present to some extent both in natural ruby and in natural emerald, modifying the brilliance of their colour and diminishing the strength of their fluorescence. So ubiquitous is iron in nature that it is only in synthetics that one can find entire freedom from the element. The colour of aquamarine and other green beryls is primarily due to iron, which causes a strong absorption of the red end of the spectrum when white light is passed through it, and absorption bands in the deep blue and violet. In contrast, pure chromium-coloured beryl (emerald) transmits freely in the deep red. Moreover it has quite a pronounced red fluorescence when stimulated by blue, violet, or long-wave ultra-violet light, whereas the iron-coloured beryls have no fluorescence whatever. It is, of course, the red transmission and emission that causes pure emeralds (in particular synthetic emeralds) to appear bright red through the Chelsea filter when they are strongly illuminated by a tungsten lamp; it also explains the diminution or disappearance of the red effect in emeralds from localities where iron plays its modifying role in the mineral.

Vanadium is the "mystery" element in the emerald story. It is present in greater or lesser degree in emeralds from almost all the known localities, and being one of the same group of "transition" elements as iron, chromium, copper, cobalt, etc., would be expected to exert some influence on the colour of any mineral in which it was present in appreciable amount, but we have very little information as to just what this effect may be, and what features in the way of absorption lines or bands one could take to be proof of its presence. The only natural gemstone we know about in which vanadium "shows its colours" is a variety of tourmaline from Tanganyika, which was investigated and described by Mr. Robert Webster some years ago. This type of tourmaline contained some 1·5% of vanadium, was green in colour, and showed vague absorption bands in the red and appeared red through the Chelsea filter—features which might lead one to suppose that chromium was present. There is also, of course, the well-known variety of synthetic corundum in which the vanadium present gives rise to a curious plum-coloured tint in daylight, changing to an emphatic purple under tungsten light, which is so widely sold as "synthetic alexandrite". Here there are no lines at all in the red end of its absorption spectrum (unless chromium has been added), but instead, a very useful and beautifully fine line in the blue, at 4750Å.

According to Flanigen, Breck, *et alii,*(2) in an article describing the Linde synthetic emerald, the effect of vanadium in beryl is to sadden the colour and lessen the fluorescence. While admitting freely that vanadium frequently plays some modifying role in most natural emeralds, its effect on colour is so obscure that its presence cannot be considered as an essential: still less can it be allowed to act as a sort of *locum tenens* in the absence of chromium which can enable a green beryl to conform to the emerald standard. Incidentally, a recent analysis(3) of Chivor emerald gave chromium 0·14%, iron 0·12% and vanadium only 0·05%.

To the layman, all this insistence that chromium must be present in effective quantity to justify the use of the term "emerald" for any given green beryl may seem absurd and academic. But the facts are that all the emeralds honoured for their beauty and rarity from the earliest times until the present day have had this one thing in common to distinguish them from less precious beryls which we can definitely fasten upon as a criterion, and that all the scientists who have succeeded in growing emerald crystals have used chromium compounds as their colourant. The term emerald carries with it such prestige that it must not be lightly applied. In past times the only arbiter was the unaided eye with its clear recognition of what constituted "emerald green". The same expert judgement of true emerald colour can still, of course, be relied upon in almost every case to-day. But where a laboratory decision has to be made, something more than expert colour judgement is required. Colour analysis, either by means of a colorimeter or by using a spectrophotometer to prepare an absorption curve, could undoubtedly provide useful information, but such methods require elaborate apparatus and are highly time-consuming. And to be of any value in reaching a decision, international agreement on the limits of "emerald green" in terms of colorimetry, etc., would have to be reached. A simple observation with a hand spectroscope is, on the other hand, a quick and practical test, and the strength of the chromium narrow-line doublet at 6830 and 6800Å in the deep red, and its companion line at 6370Å can give a very fair indication of the amount of chromium present. In very chrome-rich specimens such as Chatham's synthetic emeralds, a narrow line in the blue at 4775Å can also be detected. This spectrum can also be seen by reflected light if the stone is correctly angled in the beam, and may serve to determine whether a beryl in a backed setting having an apparent emerald colour owes this entirely or only partly to painting or foiling: whether, in fact, it can be called an emerald or not.

If these typical chromium lines can definitely be seen in a beryl specimen, it is suggested that this should be accepted as emerald. Where the lines are only just discernible, the colour, so far as the chromium content goes, will be so pale as to be practically commercially worthless: but the trade and the public between them will reject such stones in any case, just as it will also reject emeralds with a strong chromium colour which are too flawed and full of inclusions to be used except as beads.

Even when this simple criterion is universally accepted there are bound to be border-line cases where judgement is to some extent subjective, just as in the case of an alexandrite in which a trace of chromium is essential if it is to be elevated above the ranks of ordinary chrysoberyl. But at least if it be agreed that, gemmologically speaking, a beryl must contain appreciable chromium ("appreciable" that is, by means of a hand spectroscope), and that no green beryl lacking chromium shall be classed as emerald, this will serve as a useful and fundamental basis for decisions in difficult cases.

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COLOUR IN OPAL

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

ONE wonders why it has taken so long for someone to get around to investigating the structure of opal with an electron-microscope. This has now been done by a group of scientists on the Commonwealth Scientific and Industrial Research Organization in Australia. On their findings a new and convincing explanation of the play-of-colour in opal has been formulated.

An account of their work has appeared in a paper by one of them in *Nature*(1), and in the *Australian Gemmologist*(2). A slightly edited version of the latter paper also appeared in the American Journal *Gems and Gemology*(3). (*Journ. Gemm. Abstrs.* 1965, IX, 11, 12 and 1966, 10, 1).

In an earlier paper(4) the same workers had shown that, while some common opals give X-ray diffraction patterns indicating a structure approaching that of α cristoballite, precious opals and their associated "potch" show little or no signs of this structure and may be regarded as essentially amorphous. On this evidence they consider that the two groups of opal are structurally different and have probably originated differently. This also seems to suggest that the theory that play-of-colour was due to interference at thin films of α cristoballite can no longer be upheld.

In the electron-microscope investigation it was only possible to examine surface structures and those, in a sense, "by proxy". This is commonly the case, since the immense magnifying power of this type of microscope has very little penetrating ability. In most cases it is necessary either to "shadow" the object under investigation by volatilizing a metallic film onto it, or to use a similar process to obtain an absolute replica of the surface contours which can be chemically floated off and examined.

In this case exact replicas of broken, and in some cases etched, surfaces of a large number of specimens were taken with a thin film of carbon, which was then removed with hydrofluoric acid. This was examined in the microscope at magnifications of 20,000 or more times.

Under this enormous magnification one fact was at once apparent. Every specimen of the group containing precious opal was composed of minute spheres of amorphous silica. These were

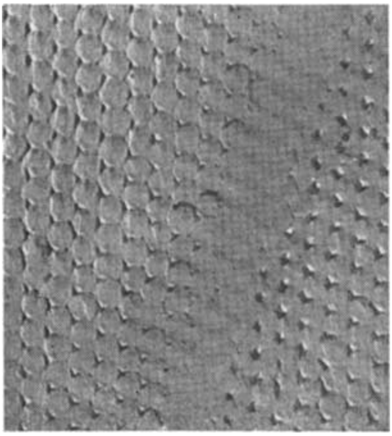

Illustration shows the spherical structure of precious opal magnified 20,000 times. The diagonal band in which no spaces or voids are seen marks an area in which pressure has compacted the material and would probably indicate the end of one colour patch and the beginning of another.

in close packed arrangements giving rise to more or less regular lattices of spheres and voids (the spaces where the spheres were not in contact). When the spheres were all of one size and their diameter was approximately the same as the wavelengths of visible light, the resultant sphere/void lattice was regular and gave rise to diffraction (Bragg diffraction at a lattice of voids) and hence to the play-of-colour of precious opal. When the spheres vary in size the lattice is insufficiently regular to produce diffraction and the milkiness of potch opal results.

The investigators went on to show that the longest wavelength obtained at a given lattice of equal spheres was approximately double the diameter of those spheres. Thus spheres with diameter of 2500 to 3500Å were observed to give deep red-flash with wavelength of 7000Å. Such specimens when turned through a decreasing viewing angle would give colour flash varying from red through the spectrum to green or blue. The actual extent of this "degrading" of wavelength depends to some extent on the curve of the cut surface, since a flat surface would stop the shortening wavelengths at green owing to total reflection. Smaller spheres, on the other hand, might give an optimum wavelength for blue light which could then only degrade to violet as the stone was turned relative to the light source and the viewer. This explains why a red-flash opal can also show yellow, green or blue flashes, while a blue-flash opal cannot show red. In every opal there must be a spectral point dependant on the sphere size beyond which cutting, polishing and stone turning cannot improve the colour of the flash.

The investigators also point out that translucent opal is best seen against a black or dark background. This is because a light background will not absorb transmitted light, but returns it. By so doing it dilutes the play-of-colour and reduces the effect very considerably. This visually observable fact can apply equally to other theories of colour-play origin. It is suggested that the above discoveries may contribute to the possibility of producing a synthetic opal.

Backed as it is by the irrefutable evidence of the electron-microscope, this new theory must be given considerable credence. It would seem that it supersedes all those theories involving interference at thin films. But the fact remains that much of the colour in opal is observably in clearly defined, sharp edged areas which have no apparent depth and are decidedly layer or film-like. Also, in some instances such films appear to be birefringent when viewed between crossed nicols, suggesting either crystallization or, more probably, strain.

If we are to reconcile the new theory with these and other observable facts it is necessary to consider most specimens of precious opal to consist of highly involved mosaics of differently oriented areas of equal spheres forming flakes, layers and grains of regular lattices randomly mixed with other areas in which the lattices are less perfect. "Twinning", faulting and other dislocations of these structures must be common, repeated and of great complexity to give rise to the heterogeneous play-of-colour with which we are familiar.

The tremendous magnification of the electron-microscope limits observation to very small areas of exposed surfaces only, but even in these it has been shown that such faults and changes of orientation do occur commonly in opal. In view of this there seems no reason why the theory should not be considered acceptable within the restrictions of our present understanding of the nature of light itself.

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THE ORIGIN OF NEGATIVE CRYSTALS IN GEM STONES

By W. F. EPPLER

AN interesting explanation of the origin of negative crystals as inclusions in gem stones is given by E. Roedder in his article "Ancient Fluids in Crystals"(1). Principally, the author regards the negative crystals as the final phase of a healing process of a fracture, during which the fracture was still in contact with the mother-liquor. He demonstrates the steps of the healing and the formation of negative crystals in a block diagram, which is reproduced in Fig. 1.

His observation could be confirmed by heating a synthetic ruby having a fracture at temperatures below the melting point of corundum for a considerable time. Before heating, the synthetic ruby was boiled in water to expel the air from the fracture and to replace the air as far as possible by water. As shown in Fig. 2, a certain amount of air still remained in the fissure indicating that the walls of the fracture are not perfectly even.

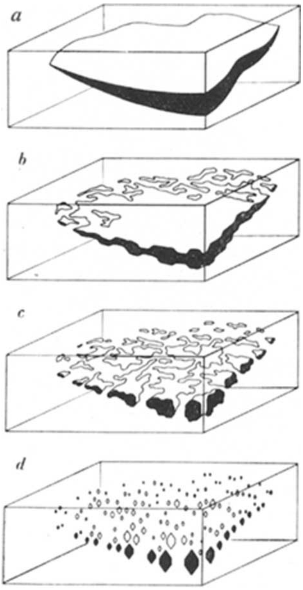

FIG. 1. *Secondary negative crystals formed in the fracture of a crystal:*
(a) *Crystal with fracture embedded in a liquid;*
(b) *Solution and redisposition of material from the liquid on the fracture surfaces results in dendritic growth;*
(c) *which meet and close off small volumes of liquid;*
(d) *these gradually lose surface area and become rounded masses or hollow negative crystals (after R. Roedder).*

FIG. 2. *A synthetic ruby with a fracture, which is partially filled with water. The dark parts of the fissure, including the "channels", are films or hoses of air, while the bright or transparent rest of the fracture is filled with water.* 65 ×

The result of the first period of heating (7 days at 1950°C) was surprising as the structure and the arrangement of the "inclusions" are heavily altered (Fig. 3). Besides the strongly developed channels of air, there are still thin films of water with a very weak relief.

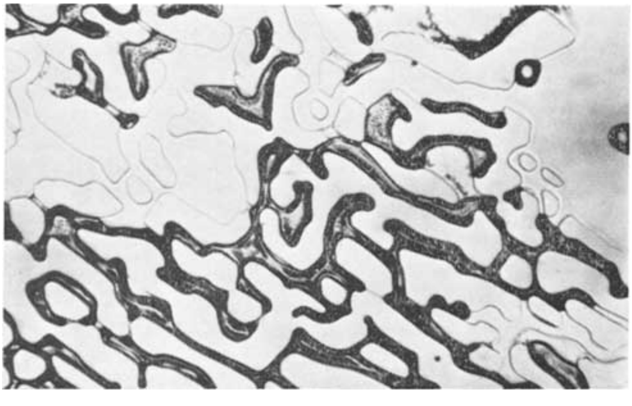

FIG. 3. *Same crack after heating the synthetic ruby during 7 days at 1950°C. The dark network of channels is filled with air, while the bright and transparent and irregularly-formed patches are films of water.* 65 ×

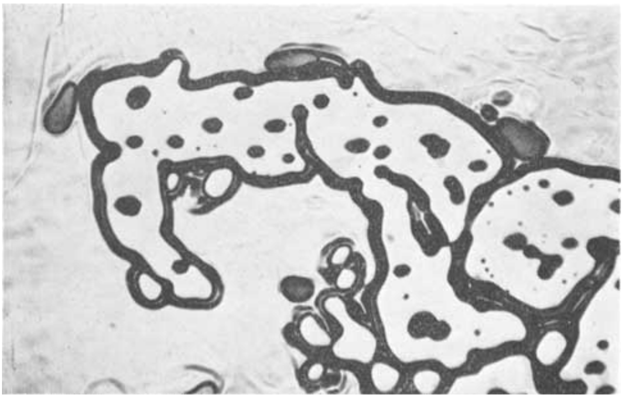

FIG. 4. *Same crack after heating the synthetic ruby during two months at 1800°C.* *65* ×

It is hard to understand that a certain amount of water did resist the heat-treatment at such an extremely high temperature. In some way, the dendritic network in Fig. 3 can be compared with the intercommunicating hoses in certain natural sapphires.

In continuing the heat-treatment for a very long time (two months at 1800°C), the pattern of the inclusions altered drastically. The hoses diminished in number and a concentration of the channels took place in such a way that they parted into smaller sections. This change was caused by a progressive healing process of the

FIG. 5. *Part of Fig. 4.* *Newly formed and parallel orientated negative crystals.* *120* ×

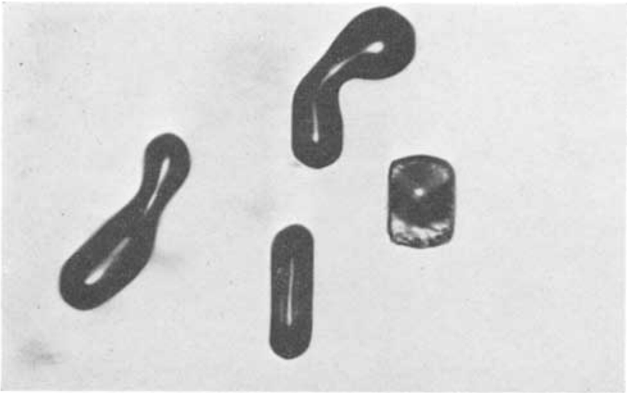

FIG. 6. *Same crack of the synthetic ruby after prolonged heating, with incipient negative crystals and with a kind of two-phase inclusion (right).* *450 ×*

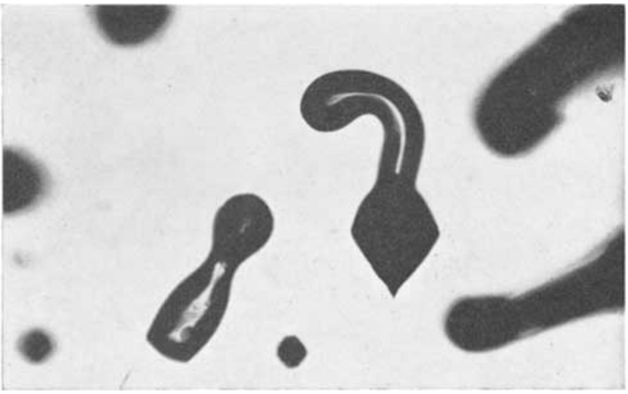

FIG. 7. *Another negative crystal starting from a curved air-filled hose. Same crack as in Fig. 4.* *450 ×*

fracture. At the same time, the hollow and air-filled sections of the former hoses started to crystallize, i.e. their walls became crystal faces and their longest extension follows now a preferred crystallographic direction of the host crystal, the c-axis. In Fig. 4, a general view is given while in Fig. 5 the newly formed negative crystals are shown at a greater magnification. At a still greater enlargement, the crystallizing of the "air bubbles" can be observed and also the tendency to be regulated into a distinct direction according to the lattice of the surrounding synthetic ruby (Fig. 6 and 7).

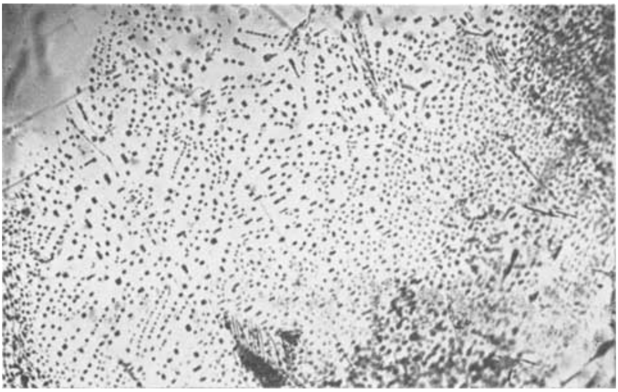

Fig. 8. *Blue spinel from Ceylon. General view of a healed crack which now is marked by a multitude of rectangular black inclusions. 40 ×*

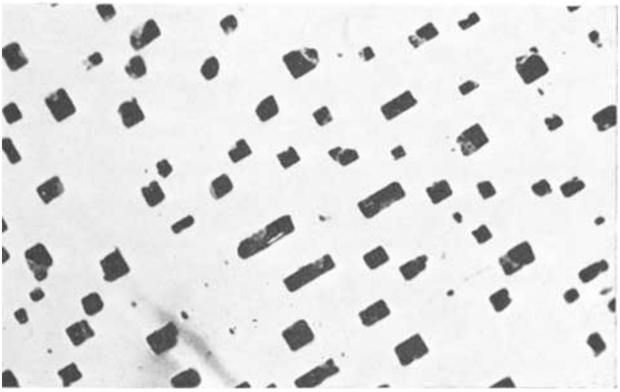

Fig. 9. *Same as Fig. 8 at a magnification of 240 ×*

With natural stones, a good example for this kind of negative crystals is given by the spinels. As is shown in Fig. 8, a former crack, which now is healed, contains a very great number of dark and rectangular inclusions which sometimes have been mistaken for tiny octahedrons of magnetite—another member of the spinel family. At higher magnification (Fig. 9), the dark inclusions are seen to be negative crystals which are filled partly with a black and opaque material, partly with transparent and doubly refractive crystals. They seem to be the deposits of material which is unsuitable for the healing process of a crack within the spinel.

In summarizing, the described negative crystals are originated by the healing of a crack. On that account, they are of secondary origin with respect to the host crystal.

On the other side, there are known other negative crystals which are originated as the result of a defect of a growing plane or as a disturbance in the growth of the host crystal. They are also characterized by crystal faces which in many cases are not so well developed as those of the secondarily formed counterparts. Obviously, they are grown simultaneously with the corresponding plane of the host crystal in small steps which is indicated now by a fine striation as shown in Fig. 10, or by irregular forms as it is demonstrated by

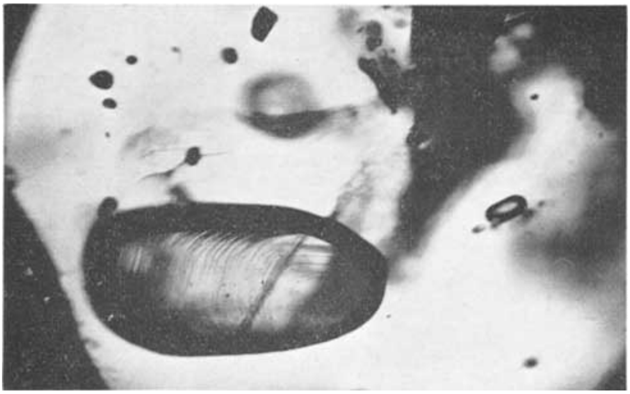

FIG. 10. *Ruby from Burma with negative crystal. 110 ×*

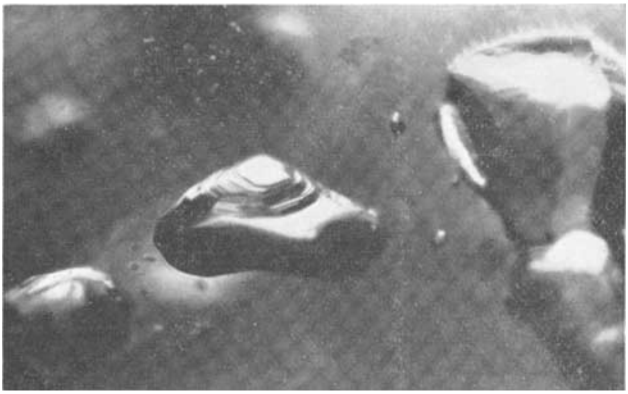

FIG. 11. *Ruby from Burma with negative crystals. 190 ×*

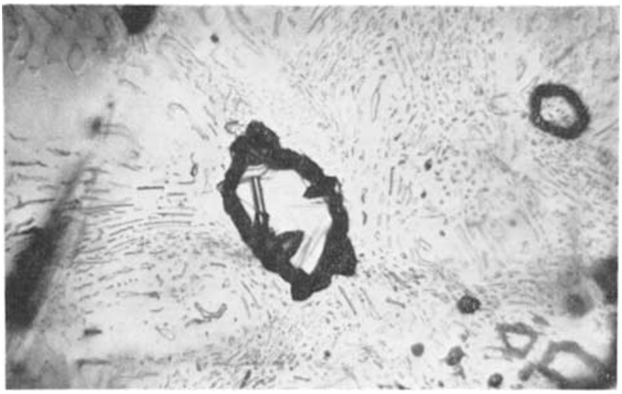

FIG. 12. *Brownish beryl from Madagascar with negative crystal.* 70 ×

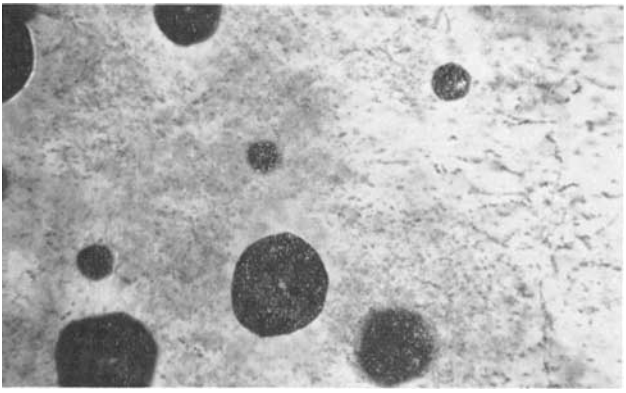

FIG. 13. *Peridot from Hawaii with rounded gas bubbles = negative crystals.* 65 ×

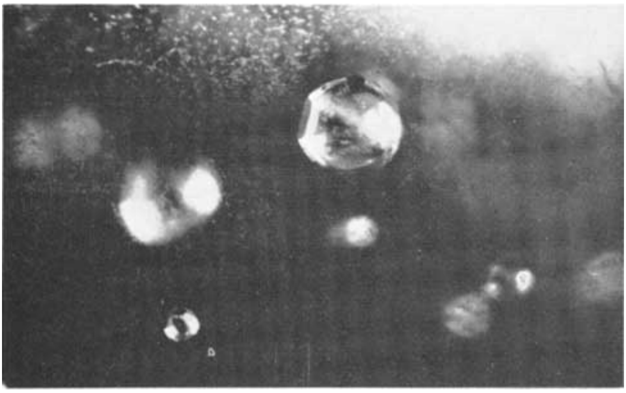

FIG. 14. *Same peridot in reflected light.* 65 ×

Fig. 11 and Fig. 12. This kind of negative crystals has to be regarded as primary inclusions which, as a rule, occur single and in greater sizes.

SUMMARY:

Secondary negative crystals as inclusions in gem stones are small or tiny and they occur crowded or in great numbers. In most cases, they follow a more or less curved plane which represents a former crack.

Primary negative crystals occur singly and have different sizes. Most of them exhibit greater dimensions than the secondarily formed crystals. Additionally, a peculiarity must be mentioned, the peridot from Hawaii. This particular gem stone is known to contain rounded gas bubbles as shown in Fig. 13. In reflected light, however, the bubbles exhibit crystal faces which indicate that the puzzling inclusions are negative crystals (Fig. 14). The origin of the bubbles is considered to be primary, i.e. they are originated during the growth of the peridot crystal. It is interesting to speculate whether a subsequent rise of temperature during growth caused a partial evaporation of the peridot material and if by such a process the bubbles, or the negative crystals respectively, have been formed in different sizes. On the other side, the origin of the negative crystals in peridot can be regarded as analogous to the genesis of gas bubbles in synthetic spinel, which sometimes display crystal faces and are negative crystals likewise. For these, E. Gübelin gives two instructive photomicrographs in his book on inclusions(2).

Finally, it must be mentioned that in the material which was available for the investigation, no glassy drops of similar appearance could be observed.

The author is indebted to Mr. B. W. Anderson, London, for his generous gift of two chromium peridot pebbles from Hawaii beaches.

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PATHS STREWN WITH GARNETS

By W. CAMBELL SMITH

DURING the years of the last war a school for evacuee children was opened in Abbots Langley, Hertfordshire, and boys from this school, playing round a pond near their sports field found round the edge of the pond a number of small garnets. This came to the notice of Mr. W. G. Rose, a member of the Geologists' Association, living in Abbots Langley. After the War he went to see the site for himself to verify the story. Sure enough he soon found garnets round the pond and, after searching for some time, he collected about a dozen. They were mostly small, not more than a few millimetres in diameter, reddish brown in colour, and they showed little sign of abrasion. They proved to be almandine, with a refractive index well over 1·74.

On further visits made by Mr. Rose after heavy rain he found more garnets, particularly on bare ground round an oak tree near the pond. Also a bucketful of mud and sand from the bottom of the pond, near the edge, yielded great numbers of garnets—but no other "heavy" minerals.

What was the explanation of this rich deposit of garnets round the pond. The clue was eventually supplied by a very old inhabitant of Abbots Langley with whom Mr. Rose had become acquainted. This man had been a gardener's boy at the "big house" not very far from the pond where the garnets were found. He remembered some bags of special sand or fine gravel arriving at the house. He thought they were intended for the garden paths but, while the bags stood in an open shed, the pigs got at them and burst one of the bags so that the sand ran out and then it was not long before the children of the house were playing with it and carrying some of it off on their own ploys.

The full story was soon supplied by the "lady of the big house", to whom I was able to write through some mutual friends. She and her family had long since left Abbots Langley but she remembered clearly about the garnets, how they arrived, and what became of them.

While the family was living at Abbots Langley a Mexican gentleman came to stay. He was given to making graceful compliments and on this occasion he was so impressed by the charm of his hostess that he vowed that her path should be strewn not merely with flowers but with precious stones, and to make good his promise, as nearly as he could, he sent three sacks of garnets to be put down on the walks of her garden.

The rest of the story was substantially as told by the old gardener. The children used up the garnets from the broken sack, putting some round a pond across the fields from the house and using others for decorating match-boxes for Christmas presents and to make garnet paths in their own little gardens. Eventually the two remaining sacks-full were strewn on the garden paths as the gallant guest had hoped they would be.

We have told this story, Mr. Rose and I, as one day someone else may find more garnets at Abbots Langley and will wonder how they come to be there in a district where the underlying rocks contain none.*

Many years after the finding of these garnets I came across another instance of "paths strewn with garnets", but this time used as top dressing for a main road.

After having attended meetings of the Pakistan Association for the Advancement of Science at Peshawar as one of the delegates of our British Association I was taken by Professor Mirza Anwar Beg on a brief trip to the lovely Swat Valley on the north-west frontier of West Pakistan.

After passing Abua on the main road from Amandara to Saidu Sharif, near the village of Gurdar we chanced to meet some road men who were applying a top dressing of coarse sand to the newly surfaced road. I was amazed to notice that this was garnet sand. When asked, the road men were able at once to tell my companion that the sand was obtained from the bed of a nearby river, a tributary of the Swat River. We took a road up the valley of this river, the Kandak Kwar, and soon found, down by the stream bed, conical heaps of sand some fifteen feet high. These consisted of the garnet sand which was being used as top dressing on the State roads. The sand is gathered from the dry gravel bed of the river and garnets form a very high proportion of it. It seems that the garnets are derived from garnetiferous schists which were formerly exposed round the headwaters of the river. Like the Abbots Langley garnets these, too, are almandine.

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*The pond has now been filled in. It was beside the drive leading to the "Ovaltine Farm" marked as "Parsonage Farm" on the 1951, O.S. 1:25,000 map. The map reference of the pond is TL095025.

AN ALBITE-TREMOLITE DECORATIVE ROCK

by R. Webster

IT is manifest that this article should commence with some explanation of what is implied by the term rock as used in the title. Briefly, rocks are usually an aggregation of a number of minerals which in themselves may be large enough to be clearly identifiable, or to be so intimately disseminated throughout the rock mass for identification to be made only with considerable analysis. In some cases, however, the rock can consist of one mineral only, and such a rock is the white marble from Carrara in Italy, which is practically a pure calcite in the form of irregularly oriented grains. Granite, on the other hand, is a rock consisting of recognisable feldspar, mica and quartz.

Although rocks have been used for architectural ornamentation from the earliest of times, they have until recent years had little place as jewellery stones, although there are exceptions. Lapis-lazuli has been known from ancient days and the Indian peoples have known the green aventurine quartz, which is a quartzite rock with green fuchsite mica disseminated through the rock, for centuries. The new rock called Maw-Sit-Sit reported by Dr. E. Gübelin in the *Journal of Gemmology* (1965, 9, 11) is stated to be a jade-albite rock, the chrome-rich jadeite being intimately dispersed in the feldspar. Another rock which attempts have been made to market as a jewel-stone consists of intimate intergrowths of massive idocrase and massive grossular garnet.

The purpose of this article is, however, to discuss another rock, which has received some prominence in the United States of America as a material for tumbled stones and polished pieces.

Samples of this material, which has a bright green and pale green mottling, have been examined. The density determinations showed the material to have a range of 2.80 to 2.95, but most were fairly constant at about 2.84. The index of refraction, as far as it could be assessed by gemmological techniques, was about 1.56, and no luminescence could be observed when the stones were viewed under either range of ultra-violet light. Under x-rays some patchy whiteish fluorescence could be seen, which had also a slight phosphorescence. There was no electro-conductivity.

An X-ray powder photograph, taken by the officers of the

Geological Survey, on powder scraped from one specimen of this material gave the information that the constituents were mainly albite feldspar and the tremolite variety of the amphiboles.

The stones examined may be the same as the material listed by certain American mineral dealers as "snowflake jade", and, further, the writer has been credibly informed that there is an intention to market this stone under the name "Wyoming jade". This poses the question of nomenclature.

The name jade may only rightly be used for the mineral consisting of a compact mass of fibrous crystals of the tremolite-actinolite series of the amphibole group—that is *nephrite*—or the more highly prized pyroxene mineral known as *jadeite*. Whatever the source of the rock reported on by the Geological Survey (and it is not known for sure where it comes from) it may well be from Wyoming in the United States of America. True nephrite jade is also found in this American State, and it would be incorrect to call a rock which consists of a mixture of two distinct minerals by the name jade. There is some justification, however, for calling the material *jade matrix*, a term which has a precedent as in the case of "turquoise matrix", "emerald matrix" and others.

A NEW INVENTION

Scientists employed by Decca Radar have recently invented and developed an electronic machine for counting small objects at great speed. This is the Decca Mastercount. This machine has been an instant success in counting such objects as varied as transistor parts, nuts, bolts and seeds.

Specific problems posed by adapting the machine to counting diamonds and precious stones, both rough, cut and polished, have now been overcome, and the Mastercount is now able to count diamonds and precious stones at a speed of 500-600 per minute, with an amazing accuracy: achieving a level of accuracy of the order of 1 in 1,000, much higher than any other method.

J. Aardewerk (Diamonds) Ltd. has the sole distribution rights for Great Britain and Belgium, in the diamond and jewellery trades.

Gemmological Abstracts

ANON. *Data on Brazilian emerald.* Gems and Minerals, 1966, 340, p. 34.

A report that the Institute of Industrial Technology of the Brazilian School of Mines has not found chromium in specimens of green emerald obtained from the Salininha deposits in Brazil. Chromium is reported to be present in specimens obtained from deposits at Caraniba, but the method of spectrographic analysis is not mentioned. The tests on the Salininha specimens correspond to direct vision spectroscopic tests made on crystal from the same area made available in the U.K.

S.P.

RAAL (F. A.). *A scientific study of the Hope diamond.* Ind. Diamond Review, 1965, 25, p. 250.

Examination of the Hope diamond showed it to be a type IIb stone, which is typical for blue diamonds. When exposed to irradiation from a high pressure mercury lamp with a quartz envelope the stone showed a strong pinkish-red phosphorescence. In type IIb diamonds the phosphorescence is usually light blue and the author is unaware of a pinkish-red colour being observed in type IIb stones before.

S.P.

ANON. *Nitrogen in diamonds governs their shape and colour.* South African Mining and Engineering Journal, 1965, Dec. 17.

Short account of the work being done at the I.D.D. Research Laboratory in Johannesburg on the influence of stray nitrogen atoms in diamond structure on colour and form.

Nitrogen atoms replace carbon atoms in random positions in the lattice. The carbon outer shell has four electrons; nitrogen has five. In low concentrations this surplus electron influences absorption of light and causes yellow colours. When nitrogen is present in greater than 1 part per million absorption changes and a greenish tinge results. Natural blues contain no nitrogen. Concentrations of greater than 1 part per 1000 result in the nitrogen coming together to form platelets of atoms and the free electron is taken up in the bond. In this state they no longer absorb visible light. An intermediate state is believed to cause brown shades.

By regulating the nitrogen content of synthetic diamond the Laboratory has been able to produce "squarer" crystals, which give improved cutting qualities and longer life to the material. These also are yellow in colour.

R.K.M.

BROOKS (J. H.). *Marlborough Creek chrysoprase deposits.* Gems and Gemology, 1965, 11, XI, pp. 323-330 and 351.

An important article on the occurrence of the chrysoprase found in Queensland, Australia. The geology of the area and the associated minerals are fully discussed. The chrysoprase is found in vein form, and the veins have an average width of 2 inches for the best quality material, and up to 8 inches for that of poorer quality. The results of mineralogical and chemical examination are recorded. The colour is stated to be due to hydrated nickel silicate; 2·38% of nickel being found in the best quality material and 0·65% in the inferior pale green chrysoprase. This is compared with the 0·5 to 1·0% of nickel oxide found by Goodchild in Silesian chrysoprase. The chrysoprase is found as veins in serpentinite over an extensive area and it is considered that more will be found as prospecting intensifies.

1 map; 2 tables. R.W.

LIDDICOAT (R. T.). *Developments and Highlights at the Gem Trade Laboratory in Los Angeles.* Gems and Gemology, 1965, 11, XI, pp. 339-341.

Quartzite beads dyed violet-red were found to show an absorption spectrum consisting of a strong band between 5500Å and 5900Å. Other items mentioned were a slag glass, an emerald-green tourmaline and a diamond showing colour banding.

4 illus. R.W.

CROWNINGSHIELD (R.). *Developments and Highlights at the Gem Trade Laboratory in New York.* Gems and Gemology, 1965, 11, XI, pp. 331-338 and 351.

This quarterly report on the activities of the New York laboratory mentions a large Montana sapphire crystal and a red spinel crystal which contained striking inclusions. Other items discussed are a synthetic sapphire with natural-looking inclusions, a metamict zircon, and a reddish chalcedony cameo, which owed its peculiar reddish colour to bright red oddly formed inclusions. A treated diamond with an unusual absorption spectrum is reported, and a yellow-green laminated diamond was found to be electro-conductive. Some synthetic emeralds with an unusual "melted" surface were examined and the conclusion reached was that the stones had been subjected to heating to a high temperature. Mention is made of green massive idocrase ("californite") from Pakistan and the name "jade-albite" suggested for Maw-Sit-Sit is criticized on general grounds of nomenclature.

17 illus. R.W.

MALES (P. A.). *The geological environment of Australian precious opal.* Australian Gemmologist, 1966, 55, pp. 5-7.

The precious opal of Australia, unlike the deposits in most other countries, occurs in sedimentary rocks. The article deals with the types of these rocks and details their variation in the various Australian opal fields. Some notes are given on trace elements in opal. There is a list of references.

R.W.

BOOK REVIEWS

DICKINSON (JOAN Y.). *The book of diamonds.* Crown Pubs., New York 1965 and F. Muller, London, 1966. 42s.

A popular account of the fascinating story of diamonds, of interest more to the lay reader than the serious gemmologist. As well as a short history of the diamond and famous diamonds there are some intriguing items of information. In the chapter on cutting the dubious claims about Lous de Berquem and Vincent Peruzzi are repeated. There is much of excellence in a chapter which discusses diamonds in the world of fashion and useful hints in another section about purchases. This entertaining book is profusely illustrated and ends with a short glossary. In a bibliography the author lists various sources which she used, most of them reliable but one or two not dependable.

S.P.

McCallien (W. J.). *Scottish gem stones.* Univ. Microfilms Ltd., 1965. 30s.

Originally published in 1937, the author's intention was to write a book "for those who hope to collect precious stones in Scotland, and who at the same time want to identify their finds for themselves. It also aims at telling them something of the natural history of our gem stones".

There are chapters on identifying minerals, and descriptions of various gems. One chapter is devoted to discussing where stones are to be found and why. There are 36 line drawings and maps within the text.

The 120 page octavo reprint is bound in good quality bookcloth and tilted in gilt on the spine. All illustrations in the text have been reproduced but the coloured frontispiece has been omitted from this limited edition.

K.M.

Pearl (R. H.). *An introduction to the mineral kingdom.* Blandford Press, London, 1966, pp. 254 and 35 colour photographs. 25s.

This book has been edited and adapted by Prof. J. F. Kirkaldy, London University, from a work by Prof. Pearl which has run to several editions in America. The text is in language which should appeal to the general reader and student seeking first information about minerals. Student gemmologists should find the work stimulating enough to encourage them to further studies. The chapter on gemstones is brief, but there is sufficient in this well-written book to attract the student gemmologist.

A.G.

ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council is indebted to Col. A. G. T. Gould, of West Moors, Dorset, for a gift of books, specimens and gem-testing instruments, which are a valuable acquisition to the Association's collection.

The Council is also grateful to the following who responded to the Association's request for back copies of the Journal of Gemmology:—Mrs. F. L. Tully, Mr. S. N. Weighell and Messrs. Rayner & Keeler, Ltd.

ROSSER REEVES RUBY

A 138·7 carat star-ruby, which is claimed to be the largest in the world, has recently been presented to the Smithsonian Institution. The curator of the Smithsonian, Dr. G. Switzer, has described it as "one of the most important acquisitions in a long time". It will be displayed alongside the Hope diamond and the sapphire known as the Star of Asia. The former owner of the stone, Mr. Rosser Reeves, who was responsible for its presentation, is chairman of the advertising firm of Ted Bates and Co.

OBITUARY

February 1966. Mr. J. S. Miles, F.G.A., of Acton, London, who gained his diploma in 1933.

March 1966. Mr. L. P. Waites, F.G.A., of Birmingham. (Dip. 1953).

March 1966. Mr. P. J. Hopkins, Biddulph, Staffs. (Dip. 1963).

TALKS BY MEMBERS

WELLER, R. J. H. "The production of cultured pearls"; Norwich & District Jewellers' Association, February, 1966.

PATCHING, S. W. F. "Gemstones"; Officers' Wives' Clubs, 1st and 3rd Malaysian Rangers; Australasian Institute of Mining (Malaya Section); Batang Padaung Club of Hydroelectric Power Scheme staff; Dept. of Mines Research Division, Ipoh, 1965.

CAFFELL, E. W. "Gemstones"; Cobham Branch, Anglican Young Peoples' Association, 6th March 1966.

McWilliam, J. "Pearls"; Glasgow Pawnbrokers' Association, 28th February 1966.

Anderton, B. W. "Gemmology on a shoestring", West of Scotland Branch of the Association, Glasgow, 10th March 1966.

MEMBERS' MEETINGS

About one hundred and fifty members went to Goldsmiths' Hall, London, on Tuesday, 18th January, 1966, for a film evening. Two films were shown, "Out of the blue", which dealt with diamond mining, and "Deep Level Gold", an intensely interesting film made by the Anglo-American Corporation.

DISPLAY OF INCLUSION PHOTOGRAPHS

As an additional note of interest for a Stores' Swiss Fortnight at the beginning of March, the Army and Navy Stores, London, illustrated Swiss Gemmology by means of an exhibit of large colour prints and transparencies of inclusions in gemstones. Considerable interest was aroused by these very striking photographs. which were very kindly loaned for the occasion by Dr. E. Gübelin, Lucerne. A further selection of prints illustrating mining scenes from gem areas visited by Dr. Gübelin was also shown.

PRESENTATION OF AWARDS

The presentation of the awards gained in the 1966 examinations of the Association will be held at Goldsmiths' Hall, London, on Monday, 24th October.

HERBERT SMITH MEMORIAL LECTURE

The 1966 Herbert Smith Memorial Lecture will be given by Mr. R. C. Chirnside, of the General Electrical Company, on 8th November. By kind permission of the Wardens of the Goldsmiths' Company the lecture will be given in the Livery Hall at Goldsmiths' Hall.

36th ANNUAL MEETING

The 36th annual general meeting of the Association was held at Goldsmiths' Hall, Foster Lane, London, E.C.2, on Tuesday, 22nd March, 1966. Mr. Norman Harper, Chairman of the Association, presided.

After welcoming members the chairman emphasized some of the features of the annual report of the Council, which had already been circulated. He specially welcomed the considerable increase in membership, and thanked members of the Council and others who had assisted in the work of the Association. He also thanked those responsible for the successful year's work of the Midlands and West of Scotland Branches, particularly the local secretaries.

Mr. Harper recalled that four years ago a gem diamond course had been commenced at the Jewellery and Silversmithing School in Birmingham, and he was pleased to say that a similar class was planned to commence in London in the autumn. The classes would not be under the aegis of the Association, but the

G.A. would be responsible for the examination that would be held at the end of the course. It was pointed out that application to join the course should not be sent to the Association.

Dr. E. Thain seconded the motion adopting the annual report and audited accounts, and said that as someone who was not a professional he had derived much pleasure from members' meetings and getting to know so many pleasant and interesting people. The annual report and accounts were adopted.

The President, Sir Lawrence Bragg, was re-elected, together with the Chairman, Mr. Norman Harper, Mr. Philip Riley, Vice-Chairman, and Mr. F. E. Lawson Clarke, Treasurer. Messrs. E. Levett, C. T. Mason and T. H. Bevis-Smith were re-elected to serve on the Council. Messrs. Watson Collin & Co., chartered accountants, continued as auditors to the Association.

After the meeting members went to the Exhibition Room of Goldsmiths' Hall where, in addition to seeing some of the Company's collection of antique and modern silver, a small gemstone exhibition had been arranged.

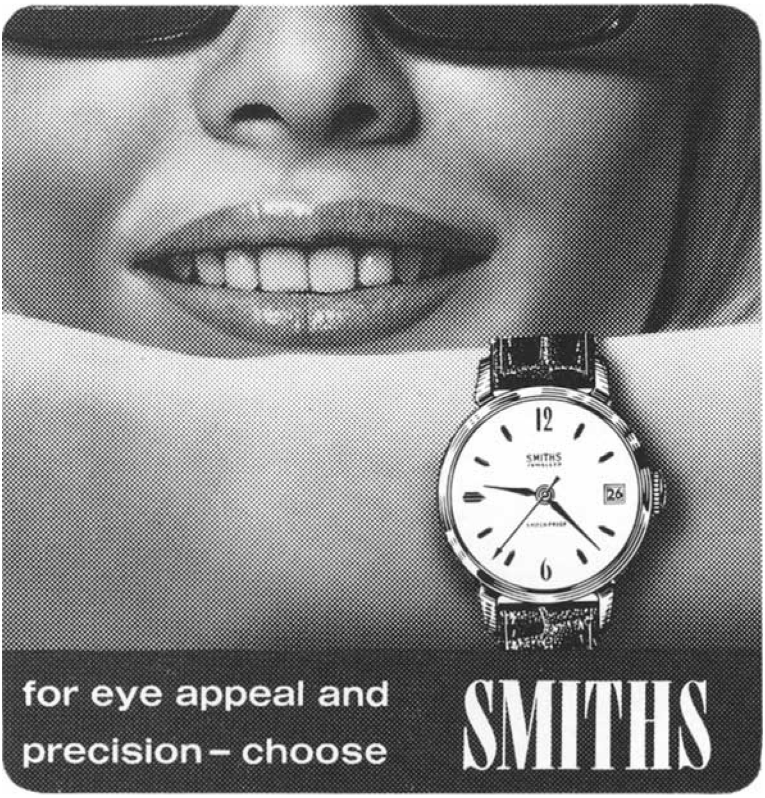
Mr. Peter Wilding exhibited a most interesting instrument, being a "new or improved optical instrument for the detection of imitation diamonds". Accompanying the instrument was a provisional Patent Specification describing the instrument dated 5th October, 1894, and a complete specification, dated 4th July 1895. (After the meeting Mr. Wilding kindly presented the instrument to the Sir James Walton Library and it will be fully described in the July issue of the Journal).

A magnificent collection of cut gemstones was shown by Mr. Max Davis. Outstanding among these was a superb morganite of 69 cts, a dark blue zircon weighing 79 cts and a 36 ct chrysoberyl, in addition to blue topaz (227 cts), golden quartz (146 cts) and a golden beryl (198 cts).

Mr. Davis also provided a collection of smaller stones, which included a chrome-green sphene, benitoite, green enclase and yellow apatite, and a collection of Zerfass, Chatham, and Gilson synthetic emeralds.

Other interesting cut stones and gem minerals were also on display.

Members were provided with refreshment in the Drawing Room.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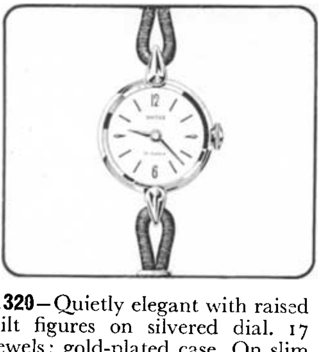
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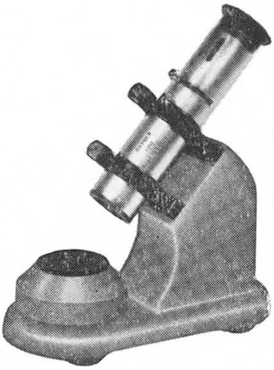

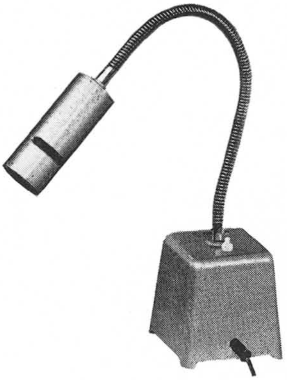

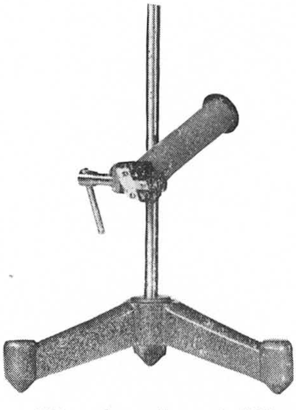

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