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NOTES on DISCOLORATION of PEARLS

by H. LEE and R. WEBSTER.

DURING the latter part of 1949 three cultured pearl necklets in which some of the pearls had assumed a dark colour were examined. These three necklets, which came from different sources (firms), were all of poor quality and were somewhat baroque. The blackening seemed to be concentrated and to show most conspicuously at the " pips " in the baroque pearls. The effect tended to agree with the surmise that it is the organic constituent of the pearl which is involved in the change.

The reason for the change in colour in these pearls seemed obscure, but, as nothing could be done with the pearls themselves (for they were not our property) little in the way of experiment could be carried out. X-radiographs were taken but these gave no help except that heavy pigmenting elements did not appear to be present. There was much theorizing and a small quantity of mother-of-pearl was demineralized by acid and the conchiolin recovered with a view to conducting experiments. At this stage, as there had been no further enquiries, the " urge " ceased and no experiments were carried out, the notes recorded being filed.

Last year the question again arose when a similarly discoloured necklet was passed to one of us. Preliminary examination by X-radiography again gave no indication of any unusual character, and, on request, permission was granted for some of the discoloured pearls to be removed for experiment. Our original notes were withdrawn from the file and our previous theories re-examined and those more tenable considered in greater detail. Where possible experimentation was carried out.

The investigation, of which this is a record, had two aims in mind: to endeavour to ascertain the reason for the blackening, and to see what could be done in the way of bleaching such discoloured pearls.

Various lines of enquiry were considered, one of the earliest being the likelihood of some chemical action on the conchiolin of the pearl caused, perhaps, by cosmetics, scents, or by caustic alkalies in soaps and modern detergents. Except in one case, which will be discussed later, it was difficult to see how such substances could cause this change of colour. However, two tests were made on these lines ; two white cultured pearls were placed in separate tubes and covered respectively by Eau de Cologne and a strong solution of " Tide." They were left in these tubes for one month and then removed and dried. Examination showed no obvious change, nor had they changed when they were re-examined six months later.

Another supposition was that some form of radiation had caused a photochemical action in the conchiolin, possibly due to strong sunlight. Our earlier notes recorded that the summer of 1949 was very sunny. On enquiry we were informed that the necklet received last year had started to discolour after being in a shop window facing south, and, although not in direct sunlight, did have sunlight reflected on to it from the pavement. It is well-known that shop-window casements do become exceedingly hot and could be expected to dry out the moisture content of pearls—some 4 to 5 per cent in natural pearl. Alexander[1] has pointed out that in the case of genuine pearls desiccation of the water content does occur normally over a period of time, and this writer states that if the loss is continually maintained over some years damage to the pearls could result. It is not stated what external effect would be likely to be produced—whether discoloration or only cracking—on the drying out of the pearls.

Bolman[2] also suggests that decay of pearls is due to desiccation of the conchiolin, and he further mentions that the cracks may be made less obvious by filling with warm oil rubbed in after the pearls have been cleaned, a method of repair termed *decraqueler.*

That sunlight alone was the cause of the blackening did not seem to be a likely one, for, if such was the case, then it would be expected that quite a number of complaints would be forthcoming, about both genuine and cultured necklets. However, an elementary experiment was carried out. Two cultured pearls were placed in corked specimen tubes and exposed in a sunny position. Unfortunately one of the tubes blew off the window ledge where it had been placed and was lost. The other showed no effect from the sunlight irradiation through the glass of the tube.

The question of the heating effect was tested by placing cultured pearls in long test tubes which were then placed in oil and water baths. In the first experiment the bath contained liquid paraffin which gives a heat of over 200°C. The initial test was unsatisfactory for the test tube containing the pearl was rested on the bottom of the beaker containing the oil, and, probably through local overheating, the pearl inconveniently exploded leaving powder and flakes of pearl at the bottom of the test tube. A second try was carried out, with the difference that the test tube was held off the bottom of the beaker by the aid of a retort stand. The pearl was seen to discolour to a light brown shade at about 200°C. A similar experiment using boiling water as the bath produced no effect on a cultured pearl after ninety minutes heating.

A further experiment consisted of heating a cultured pearl immersed in olive oil to about 200°C. At this temperature the pearl was found to have turned to a chocolate brown. This emphasizes the danger of heating in oil to repair cracked pearls. It is not the first time that a pearl merchant has suffered monetary loss through the overheating of pearls in oil.

These experiments have shown that the heat in a shop-window casement is unlikely to be the single cause of the discoloration of pearls, and, further, the colour assumed by the heated pearls is brown and not black.

It cannot be recalled that a natural pearl necklet has darkened in a similar manner to that shown by the cultured pearl necklets in question. Another aspect is, therefore, the trace of a manganese compound which, according to Alexander[3], is present in the freshwater mother-of-pearl normally used as a nucleus. Manganese may under different conditions act as a reducing agent, or as an oxidizing agent, and this may have some bearing on the change of colour in the conchiolin of the pearl. The writers have not been able to devise a suitable experiment to test this theory.

The theory that the discoloured pearls were pearls which had been previously treated in some way, either to enhance the growth of the nacreous layer or to bleach the pearls, seemed a possibility. In this connection it was thought, maybe, that, during the war and until 1951, when the embargo on the import of cultured pearls was lifted, a quantity of dark pearls had been bleached by some means and then marketed ; later an unknown reaction took place had caused the pearls to revert to their original dark colour. In view of the sparsity of material available for experiment nothing was done to test this. Indeed, without some idea of how the treatment was carried out no particular line of testing could be decided upon. However, examination of the literature did disclose some interesting possibilities and these will now be discussed.

It is well known that sulphur compounds will react with certain metals to produce dark-coloured sulphides, and this appeared to be a profitable line of enquiry. Pearl consists of a mineral part—calcium carbonate in the form of crystallites of aragonite ; and an organic part—a scleroprotein of keratin type known as conchiolin. The formula for conchiolin as given by Herbert Smith[4] is $C_{30}H_{48}N_2O_{11}$, and by Hackh's Chemical Dictionary[5] as $C_{30}H_{48}O_{11}N_9$. It is suggested that this difference in the formulae may be due to a typographical error. In the first formula the nitrogen content is about 5 per cent and in the second about 24 per cent, a difference not likely to be an experimental error in analysis. Thus, except for calcium, no metals or sulphur are normally present, therefore, if a sulphide theory is to stand, the action must be ascribed to one or more trace element. Sulphur is often a constituent of protein, in some cases, as in hair, it can reach as much as 8 per cent, and it needs only a trace of sulphur to produce highly coloured metallic sulphides. Experiment showed that hydrogen sulphide (H_2S) is given off by dried conchiolin when it is decomposed by heat, but not until decomposition takes place. Alternatively the sulphur could arrive from an outside source, and in this connection depilatories which contain sulphur could conceivably be an activator.

With regard to the metal, the most common sulphide of a black colour is that of lead ; but the sulphides of silver, nickel, mercury, ferrous iron, cobalt, and copper are black. To test the validity of the sulphide theory one of the original darkened pearls, after being bleached (*vide infra*), was placed in contact with a pad of filter paper kept moistened with a 5 per cent solution of sodium sulphide. After a day or so a darkening to a silver-grey colour occurred. Another of these darkened pearls was ground with a flat so as to expose the core and the ground surface examined microscopically. The darkening was seen to be just a skin effect on the nacreous outer layer. On immersing this pearl in the sodium sulphide solution the pearl quickly darkened and in a few days assumed a gunmetal colour. Other cultured pearls, a core from a cultured pearl, and some nacreous skin from a broken cultured pearl did not show any discoloration after similar treatment. From these experiments it seems most probable that the cause of the blackening is due to a metallic sulphide and that it can only occur in certain types of cultured pearls.

What metallic trace elements can be found in pearl ? Cahn, in his report,[6] mentions that Dr. T. Kosaki, of the Kyoto University Physics Department, believes that the colour in pearls depends upon some metal porphyrin in their composition. Kosaki states that pink pearls contain lead porphyrin. (The pink colour mentioned is so minute and subtle as to be distinguished only by experienced persons. The pink pearl mentioned, therefore, does not imply the non-nacreous conch pearl from the *Strombus gigas*, but the nacreous pearl from the *Pinctada martensii*). A spectrum plate, however, failed to show any trace of lead in the darkened pearl, hence the presence of another metal must be assumed. The spectrum plate was a comparison one using :—(1) copper arc alone ; (2) the pearl plus the copper ; (3) the copper arc with lead acetate giving the lead lines for comparison. It was not possible to isolate any other distinctive lines of elements owing to the comparatively low dispersion of the spectograph used. We are, therefore, unable to come to complete finality.

The immediate question from a trade point of view was whether the colour of such darkened pearls could be in anyway corrected. Reference to the literature describes many methods for bleaching pearls, some of which appear to be fraught with danger. Kunz and Stevenson[7] state : " Yellowish pearls are sometimes bleached by means of strong bleaching substances, such as chlorine or other powerful reagents, which although they may whiten the pearl, cause it to become very friable, as the animal substance becomes more brittle." Bolman[8] refers to the bleaching of pearls by immersion in phosphoric acid followed by cleaning in hydrogen peroxide.

In the Cahn report[9] mention is made that in artificial staining the cultured pearls are first bleached in a solution of hydrogen peroxide for several hours. In the same report (page 34) reference is made to the colour of black pearls as being apparently due to the presence of organic matter between the pearl layers, but that the identity of the material is not yet known, but there is some evidence to indicate that the dark colours may be related to the black secretion of the cells of the mantle edge. It is further stated that these dark pearls can be converted artificially into pink pearls by injecting hydrogen peroxide under pressure into the pigmented layer. This may have some bearing on the subject discussed.

In order to test the bleaching properties of hydrogen peroxide one of the darkened pearls from the necklet was immersed in a 10-volume solution of hydrogen peroxide for a fortnight. On removal from the solution the pearl was found to have been bleached to a good white colour. This pearl was then placed in a packet with another darkened pearl for comparison. Eight months later the pearl was found to be still a good white colour and showed no sign of reversion to a darker hue.

Further experiments were carried out on these lines using the conchiolin from the demineralized mother-of-pearl prepared in 1949. A small quantity of the dried material was separated into three portions and each placed in a specimen tube. One was left plain as a control ; one was covered with distilled water, and the third covered with 10-volume hydrogen peroxide solution. In each case the tubes were corked. These were inspected after one month and the liquids decanted off. The conchiolin which had been placed in water was found to be slightly lighter in shade (a nut-brown colour) than the control specimen. The material taken from the hydrogen peroxide solution had bleached to a pale yellow colour. Inspection of the dried samples eight months later showed that the sample from the water immersion had darkened to the same colour as the control sample, while that which had been in the peroxide was still a light yellow colour.

The theory of bleaching is somewhat involved and the writers can do little better than to refer to the work of Redgrove and Bari-Woollss[10] on the bleaching of hair, which is also a keratin type protein. These authors explain that the cause of colour of substances seem to depend upon the presence in their molecules of certain (usually unstable) groupings of atoms. Any chemical change undergone by such a substance is liable to upset the grouping and thus to destroy the colour. Thus oxidizing, or reducing, agents may cause a chemical alteration which will turn a dark-coloured compound into one which is light in colour. In the case of hydrogen peroxide (H_2O_2) the reaction is an oxidizing one. The extra oxygen atom in this compound is loosely coupled and will readily part from its fellows leaving the stable compound H_2O which is water. Further the free oxygen atom is in the highly active "nascent" condition when it will readily react with other compounds, and particularly those containing carbon, i.e. organic compounds, bringing them to an oxidized condition or to a higher state of oxidation, and often to a compound having a lighter colour. This is the probable action in the bleaching of conchiolin by hydrogen peroxide.

To sum up : the cause of the darkening of the pearls is so completely involved with the structure of the organic compound that it is difficult to make clear cut decisions. So little work has been done on the chemical nature of conchiolin, and indeed, no structural formula for this material appears to be available. Such a formula would be essential for a full understanding of the chemical changes which could occur in organic substances. The following suggestions could reasonably be applied as tentative solutions to the problem ; but they must remain as suggestions until more work is carried out on conchiolin. It is hoped that at some future date one of us may be able to deal with the problem of the structure of conchiolin. The tentative suggestions are as follows :—

1. REARRANGEMENT OF THE LINKAGES BETWEEN THE VARIOUS GROUPS MAKING UP THE COMPLEX MOLECULE OF CONCHIOLIN.
   Most likely they would not be reversible and generally speaking oxidizing agents would favour double bonds and deeper coloration.
2. TRACE METALS IN NUCLEUS.
   Would probably produce only slight but very distinct colour difference in original pearl, as in the case of the grey and pink pearls mentioned. May be rendered active later by irradiation, fumes, etc.
3. TRACE METALS AS IMPURITIES.
   - (*a*) *Purely adventitious. May occur in certain areas of water but not in others. May occur as pathogenic or post-mortem condition. Probably in heavy basic molecule.*

(*b*) *By adsorption as such or as trace metals entering as solution into the tissues by osmosis from sea (fresh) water and becoming fixed, say as sulphides or sulphates. Here again light coloration would occur and this would be reversible. S. darker ⇌ O lighter.*

As far as can be told in this short space of time the bleaching was found to be fairly stable.

Acknowledgement is made to S. T. Solomon who donated the pearls which were the subject of the experiments, and to B. W. Anderson for assistance and advice.

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A NEW IMITATION of LAPIS LAZULI

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

THE stained jasper popularly called " Swiss lapis " has for many years held the field as the only plausible imitation of the ultramarine-coloured rock known as lapis lazuli. Gemmologists will be interested to learn of an entirely new form of " ersatz " material which has recently been manufactured in Germany, a few sample specimens of which have reached this country from Idar-Oberstein.

In appearance this closely resembles fine quality lapis, though its colour contains more red, just as " Swiss lapis " contains more green, than the genuine material. It is indeed a typical cobalt blue—a fact which is indicated by the brilliant red appearance under the Chelsea filter and confirmed by examination with a hand spectroscope of the light reflected from a specimen.

When examined under a lens in a good light the imitation reveals a granular structure in which the grains are roughly circular in outline, thus differing from the patchiness seen in much true lapis. The small brassy specks of iron pyrites so typical of the natural gemstone were not to be seen in the imitation ; but the importance of this must not be too much stressed, since it is rumoured that the ingenious manufacturers of the new substance are experimenting with the incorporation of brassy grains to add to its verisimilitude—moreover there are specimens of fine lapis which reveal no pyrites.

The new material is exceedingly hard (approximately 8 on Mohs's scale), and this and the refractive index of 1.725 gives a strong hint that it is some form of artificial spinel. The density is lower than would be expected on this supposition, being 3.518 to 3.524 for the three specimens tested, but this can be accounted for if the material is a sintered product and not a single crystal. This is strongly suggested by its granular appearance and confirmed by the completely random scatter of Laue spots when an X-ray beam is passed through it on to a photographic film. Dr. G. F. Claringbull has kindly taken a powder photograph of the substance and has found its lattice constant to be 8.065 (±.005) which is near that for natural spinel (8.09).

As stated above, the sintered spinel shows a cobalt spectrum, but the distribution and relative strength of the bands are not quite the same as with blue spinel made by the Verneuil process. In particular, the band centred near 5800A, which in Verneuil synthetics is the prominent middle member of the predominant three bands of the spectrum, is here very weak, while a band at 4800A, which is hardly noticeable in the Verneuil stones is quite strong and clear. The full (reflection) spectrum is as follows :

6500A	broad and strong
5800	weak and vague
5320	very broad and moderately strong
4800	narrower ; moderately strong
4520	weak.

By condensing light from a 500 watt lamp it is possible to transmit a little light through a few millimetres of the new material, the residual rays having a reddish purple colour. This presented a remarkable sight through the spectroscope, showing a brilliant narrow transmission band in the red, centred at about 7050A, and a broader transmission region in the blue-violet ; almost all the remainder of the spectrum was absorbed. In a paper by Tromnau(1) on synthetic spinels coloured by cobalt, absorption curves are shown of these which reveal a similar state of affairs ; there is little absorption at the violet end up to about 5000A, then a steep climb in absorption to a maximum near 5850, declining steeply again until near 7000A there is a high degree of transmission.

To sum up : the new imitation lapis is an artificial sintered spinel material coloured by cobalt, having a refractive index near 1.725, density 3.52, and hardness 8. These compare with 1.50, 2.8, and 6 for true lapis. It resembles Afghanistan lapis lazuli rather closely, though rather more purple in tint. Careful examination reveals a distinctive granular structure. Its discrimination is quite simple, since its properties are entirely different from those of true lapis. Readings on the refractometer are not clear-cut, but quite good enough to prevent confusion with any other substance. The quickest test is provided by observing its brilliant red appearance under the Chelsea filter, or by examining its absorption spectrum by reflected light. Genuine lapis lazuli has no distinctive absorption bands and no marked colour-change under the filter.

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SOME INCLUSIONS in APATITES

by E. RUTLAND, Ph.D., F.G.A.

IT would be presumptuous to attempt to list in one article all the inclusions in apatite. There are too many places and varieties in which this entirely fascinating species is found. Only some of the typical or specially striking forms encountered are described and illustrated. Since words are an inadequate medium when dealing with inclusions some photomicrographs are reproduced, with apologies for their technique. Perhaps we may hope that this and other lesser gem species will receive their due attention in Dr. E. Gübelin's next book.

These notes owe their origin to a comment by Mr. B. W. Anderson on the curious bubble-like cavities he observed in some blue apatite. This stone, of which good specimens come from the ruby mines at Mogok, Burma, is already famous for its dichroism and its rare earth spectrum and figures 1–5 are based on it. The " bubbles " are of various kinds but all appear to be negative crystals and most of them contain liquids or liquids and gas.

The most common inclusions, typical of blue apatite, are clouds of small round bubble-like cavities, about 0.05–0.10 mm in diameter. Similar rounded negative crystals occur in layers or small groups in other minerals, but the dense clouds in Mogok apatite are not often found elsewhere. They are shown in Fig. 1 and it will be seen that sometimes two " bubbles " seem to have merged. Another curious excrescence which is often met with is illustrated in Fig. 2—a long thin channel extending straight from a rounded cavity. Such fine channels also occur on their own and, when they are dense and oriented, they give rise to a somewhat coarse type of cat's-eye. A photomicrograph of the latter is given in Fig. 5. It will be seen that the channels do not in all cases run parallel. It would be interesting to know if any star apatites have been encountered. It should, of course, be quite possible, though they would necessarily be of poor colour. But it may be that the channels run so predominantly parallel to the *c* axis that no stars are formed.

An even more extraordinary and quite specific type of cavity is that shown in Fig. 3. It is considerably larger, as a rule, than the " cloud " type and, unlike it, it only occurs singly or in small

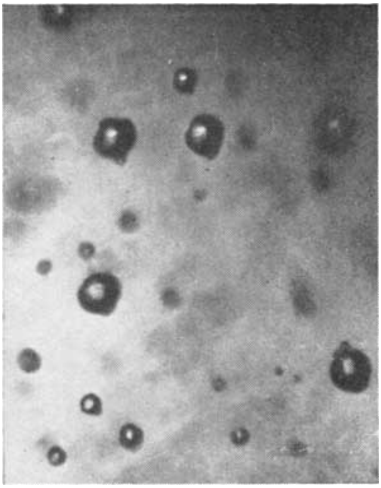


FIG. 1. *Blue Apatite. Cloud of small " bubbles."*

FIG. 2. *Blue Apatite. Small " bubbles " with one long cavity.*

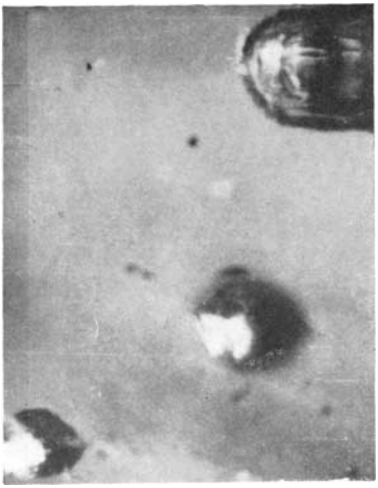


FIG. 3. *Two-phase inclusion in blue Apatite. Large cavities.*

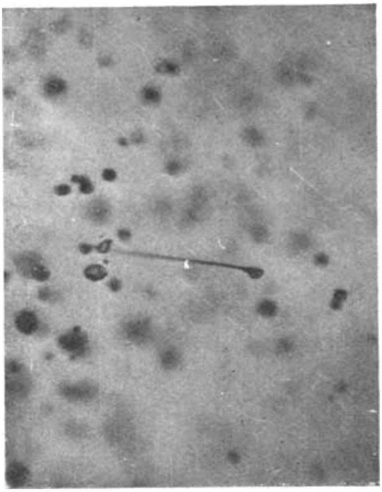
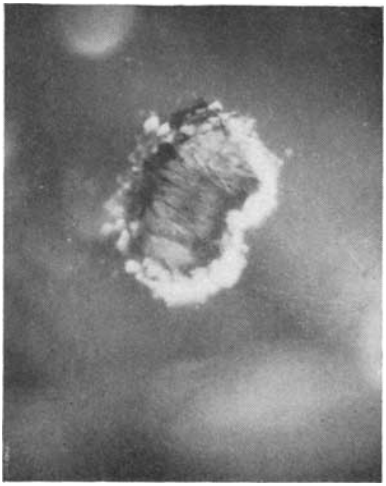


FIG. 4. *Blue Apatite. Dark blue inclusion.*

FIG. 5. *Fine channels in blue Apatite cat's-eye.*

FIG. 8. *Purple Apatite cavity.*



groups, though it may be interspersed with a " cloud." The most unusual shape of these large cavities (up to $\frac{1}{2}$ mm) is due to the corrugation of their walls with numerous crystal faces, some of which protrude into the solid stone, so that the cavity is surrounded by little pointers and pinnacles. Though they appear rounded, all these cavities have a crystalline form and some have been found as well-formed hexagonal prisms. One rounded cavity had a whole satellite system of minor hexagons attached to it by fine channels. Nearly all have two-phase contents, the gas bubbles sometimes being very large.

A rare but striking inclusion is coloured a rich blue (Fig. 4). It is a cavity intermediate in size between the two types described and also often shows crystal faces. The cause of the blue colour has not yet been determined. Specimens have been sent to Dr. Gübelin and to the Chamber of Commerce Laboratory and their findings are expected with much interest.* The blue inclusions are not dichroic. They are of a deeper blue even than the extraordinary ray but the colour sometimes does not extend over the entire inclusion. In some such cases the demarcation between the coloured and uncoloured parts is so sharp as to suggest a blue liquid and a gas bubble but in one case the inside of a cavity could be examined through the uncoloured part and it gave the appearance of being empty, with the colour coating the walls only.

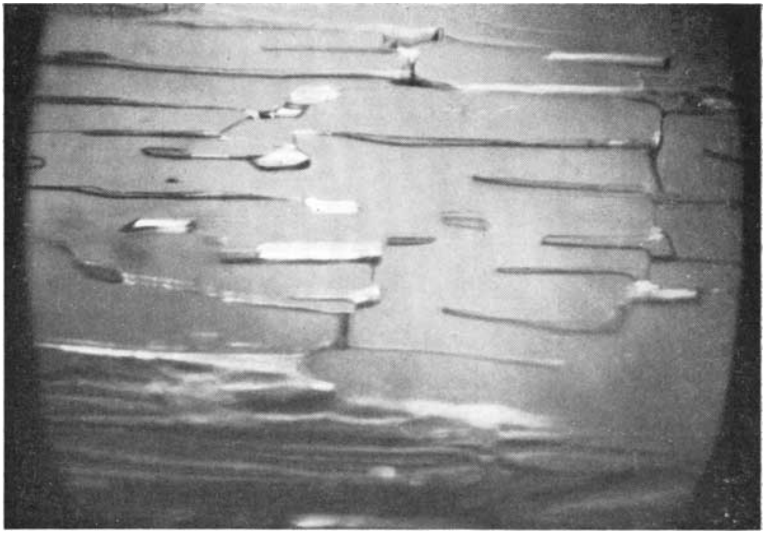


FIG. 6. *Yellow Apatite. Large channels.*

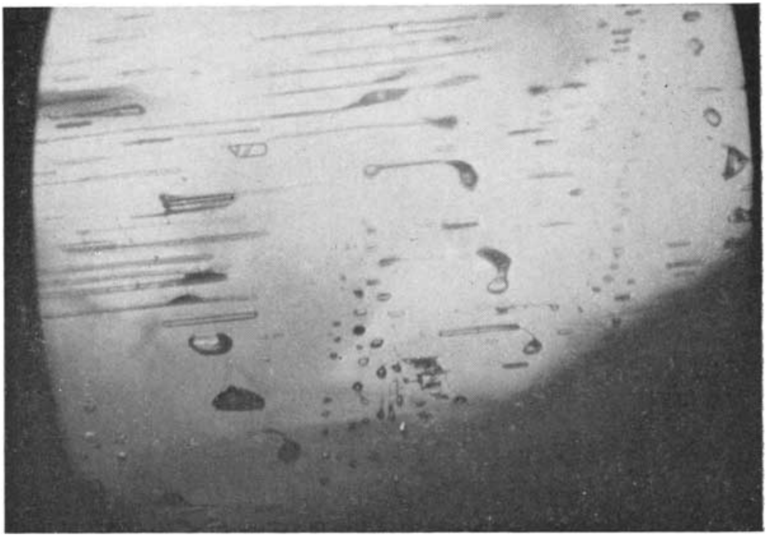


FIG. 7. *White Apatite. Beryl-like two-phase inclusions.*

Yellow apatite from Durango in Mexico, with the powerful didymium absorption spectrum, is perhaps the commonest variety. There is an abundance of beautifully clean material and it may be that only the cleanest pieces are cut, since inclusions of any diagnostic value are uncommon. The only characteristic inclusions met with are illustrated in Figs. 6 and 7. The area reproduced in Fig. 6 measured about 2 mm square, so the branching and parallel channels shown are quite large. They are also very reminiscent of the " fingerprint " channels found in several other minerals. The other inclusions are strongly similar to those found in certain beryls—flattened angular cavities and two-phase contents.

Single stones of two other varieties have been examined with negative results. A white apatite from Japan was perfectly clean apart from a few tiny phenocrysts. A green apatite from Canada was also clean and contained only a fracture feather, such as might be seen in almost any stone. There was no sign of " healing." The third variety, however, produced the most bizarre inclusion of all and it is shown in Fig. 8. It comes from a purple stone from Maine, and, as there were three similar structures in the same stone, it may be found in others from that locality. The largest of the inclusions was over 0.7 mm in diameter and all three had an apparently helical structure. There is some kinship to the large cavities in the Burma stones and these inclusions also appear to be negative crystals, without any liquid, however. The search for inclusions is full of fascination and surprises.

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*In a subsequent private communication Dr. Gubelin stated : " Those blue inclusions are very puzzling. In the polarizing microscope they definitely look like solid inclusions, while under the stereoscope with dark field illumination, they rather give the impression of cavities coloured with a blue sublimation of their walls. One particularly interesting inclusion may be described as a cubic crystal within a stumped hexagonal negative crystal. In its interior there appeared to be a blue patch in the shape of a cube. This may speak for the inclusion being a rock salt crystal with a blue cubic patch caused by excess of sodium—a well-known feature of rock salt. At this state of my observations my examination had to end."

Dr. Gübelin then goes on to say that he is having a thin section prepared to determine whether the inclusions are cavities or solids, and if the latter, whether or not they are salt crystals. He says that salt crystals could quite possibly occur in the internal paragenesis of apatite.

FURTHER NOTES on the CAUSE of COLOURS in PRECIOUS OPAL

by G. F. LEECHMAN, F.G.A.

A VERY valuable contribution to this subject has recently been made by that eminent scientist Sir C. V. Raman, head of the Raman Research Institute, Bangalore, India. Dr. Raman has been working on the colour of gem stones for a number of years and it is to be regretted that his name does not figure more frequently in the relative literature. The value of his work is well illustrated in his presidential address to the Indian Academy of Sciences at its 19th annual meeting held at Ahmedabad, India, on 27th December, 1953. In his address Dr. Raman advanced as a reasonable hypothesis that iridescent opal consists of alternate layers of two crystalline modifications of silica of slightly different refractive indices, namely low tridymite and high cristobalite. This conclusion, he said, is established by comparative study of diffraction haloes and spectra, microscopical examination in reflected light and X-ray diffraction of hyalite and of gem opal. His investigations (in which A. Jayaraman collaborated) clearly show the existence of the film-pack structure referred to in the writer's previous contribution (Journ. Gemmology, Jan., 1954). The excellent photos reproduced in the report (Memoirs of the Raman Institute, Bangalore, No. 42) bring out both the series of similar parallel films and also the equidistant spacing of the lattice structure. Spectrographs reproduced in the report establish the fact that the colours are not produced by " interference " (as the term is commonly used) but by prismatic reflection and refraction of the incident light, while X-ray photos taken with cameras of very high resolving powers showed at first glance a similarity between opal, hyalite, vitreous silica, silica glass from Libya and silica-gel, though careful scrutiny showed significant differences.

In this connection it may be not out of place to enquire the exact meaning of the term hyalite, as used by Dr. Raman. He accepts hyalite as cryptocrystalline and sometimes iridescent, while agate and chalcedony, he says, are shown by X-ray studies to consist of crystallites of quartz. According to some writers, agate consists of alternate bands of opal and quartz, which may be separated by crushing the specimen and dissolving out the opal in an alkaline solution, such as sodium hydroxide, when the residue will be found to contain crystals of quartz. Chalcedony has been considered as a form of fibrous silica related to the chatoyant quartz and to silica threads, or quartzine, as described by Sosman. Hyalite, as commonly understood, is a clear glassy silica, amorphous, similar to common opal but much more transparent. Should it show definite iridescence, it becomes water opal. If hyalite and common opal are cryptocrystalline, as Dr. Raman submits, is one justified in describing them as amorphous ?

Perhaps the answer to this question may be found with the help of colloids, a word which will be found, surely, more frequently in gemmology and mineralogy as the ubiquity of the colloidal state of matter is more fully realized. Many minerals which are to be found in crystalline form also occur in a colloidal state, and it may be that most forms which are described as mamillary, reniform, botryoidal, nodular, radiating or pisolithic are deposits from colloidal solutions or sols, where the groups of molecules (giant molecules or polymerized molecules) form particles too irregular to build up a true crystal structure; thus on solidification they settle out as a shapeless mass with, at first, but little coherence, that is, as a jelly or gel. This subsequently hardens into a mass which usually has curved surfaces, such as haematite, malachite, pitchblende, flint, much pyrites and some zeolites. In the case of opal it has been considered that the primary molecules of silicon tetraoxide (SiO_4)—produced in the sol perhaps by the action of a dilute acid incursion into a solution of a silicate—rapidly polymerize into silica threads or chains, having no regular orientation, but which on solidification produce what has been termed (by American investigators working on commercial silica gel) a " brush heap structure " —the sort of arrangement which twigs would take up when brushed into a heap. This constitutes, if opaque, common opal, and, if transparent or semi-transparent, hyalite. Under ideal conditions incipient crystal lattices in the form of parallel lamellae or film-packs are able to develop and thus produce iridescent opal.

The presence of two modifications does not appear to be necessary to the hypothesis, but Dr. Raman has shown the probability of their existence, and, indeed, previous research workers

(Dwyer and Mellor, Levin and Ott, inter alios) have formed the opinion that cristobalite is commonly present in opal, although tridymite does not appear to have been found. However, the President's inference, in an earlier paper, that the X-ray pattern of hyalite is a superposition of the patterns of high- and low-cristobalite is now admitted to be untenable to the conclusion that tridymite must be accepted, according to his evidence.

In a memorandum recently received, Dr. S. C. Robinson of the Geological Survey of Canada, a specialist in X-ray crystallography, says: "In studies of pitchblende deposits I have been impressed by the occurrence, in the same vein, of cryptocrystalline, colloform pitchblende and of euhedral discrete crystals of pitchblende. If the cryptocrystalline variety is attributed to coagulation from a sol, followed by ageing with increase in size of individual crystallites (this material yields sharp X-ray patterns, indicating that crystallites are greater than 1000A in diameter), then it must be assumed that the euhedral crystals (which are up to 0.2 mm on the cube edge) have grown from true solutions, which may well have been the liquid phase of the sol." This is an opinion with which the present writer warmly agrees.

A similar sequence has been observed experimentally, i.e. first a primary gelation, followed after syneresis and the consequent expulsion of some of the liquid phase—which lies as a clear liquor above the gel—by a slow crystallization. Not all the monosilicic acid polymerizes to form polysilicic acid, later becoming silica, but some remains in the interstices of the gel, is subsequently expelled by contraction and, since it contains simple molecules, regular crystallization can occur.

Geologically, siliceous solutions fill the joints, cracks and bedding planes of the wide-spread sandstone country. After the first precipitation of silica in the cavity a clear liquid rises above it and it is in this that colours may later develop. It has occurred to the present writer that the aspect of the terrain of the Libyan Desert is reminiscent of the Australian opal country and that possibly the silica glass brought from that area by Dr. L. J. Spencer may have been formed by a somewhat similar process.

It may be emphasized that this address provides conclusive evidence of regular internal structure, and that the photographs reproduced are very illuminating. It is perhaps a pity that the degree of magnification is not given or the measurements referred to quoted fully.

The paper is extremely valuable to the student of opal and of crystallization colour theory in general, a branch of gemmology which is calling for research. The writer personally wishes he had known earlier of the work being done in Bangalore—some of the more abtruse problems would then have proved less difficult.

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RANDOM NOTES

by J. R. H. CHISHOLM, M.A., F.G.A.

READING articles in the *Journal of Gemmology*—or other papers on subjects of similar interest—is conducive of two quite distinct kinds of mental reaction. Primarily the process is one of assimilation of fresh mental pabulum, consisting maybe of facts observed and recorded for the first time, facts newly interpreted or novelly presented, recently evolved techniques or methods of procedure—the discovery of taaffeite, perhaps, or the " distant vision " technique. But there is also a secondary effect following the primary assimilation : the new matter is turned over and over in the mind, stimulated thereby to question, to argue, to check, to compare, to carry the matter perhaps a stage further. The paragraphs which follow are the products of this metaphorical chewing of the mental cud.

* * *

I found Mr. Leechman's[1] exposition of the cause of colour in opal full of interest. Spencer[2] has written :

> " the . . . colours shown by precious opal must clearly be due to . . . interference of light in thin films. Many explanations of the nature of these films have been offered, but their true nature still remains unknown. Here is an interesting problem for some keen admirer of opals."

This is one of the problems which Mr. Leechman has tackled. I take his " incipient lattice structure " to mean the same as " incipient crystallization " and his theory of opal structure to amount to this, that, owing to the opal " sol " having " gelled " while on the point of (and partially in the act of) crystallization, it has " set " in a state partly amorphous and partly consisting of giant polymerized chain and ring molecules of silica—if I may so call it, a thing of threads and patches—and thus in the case of " precious " opal it contains numerous parallel plates of regularly spaced atoms dispersed among the randomly arranged majority of atoms composing the generally amorphous structure of the surrounding gel. If I understand him aright, I imagine he would envisage these crystal plates, being in the nature of or composed of giant polymerized silica molecules, as of considerable size (relative to the atom) in two dimensions but with a thickness of no very great number of atoms. But, while supplying this explanation of the lamellar structure, Mr. Leechman firmly denies the attribution of the colours to interference. He points out the monochromatic nature of the colour flashes and finds the cause of the brilliancy and of the monochromatic nature of these flashes in the spacing of the plates at such distances that the reflected rays do not interfere but on the contrary reinforce one another.

When Mr. Leechman was writing he was evidently unaware of the illuminating recent work on the same subject of Sir C. V. Raman and A. Jayaraman,[3] although he refers to their earlier work on iris quartz. The two papers first recording the new work on this problem of colour in opal are so important, that as they have not up to now been noticed in this *Journal,* I may be excused for quoting from them somewhat freely.

Undertaking the investigation " with the aim of elucidating the origin of the characteristic iridescence of precious opal," Raman and Jayaraman first conducted a series of experiments with four pieces of hyalite (or, as I should describe them, three water opals and one fire opal), using both optical and X-ray diffraction pattern methods, and concluded :

> " A study of the optical behaviour of iridescent opal indicates very clearly that the silica present in the material has a regularly stratified structure in which the alternate layers differ in refractive index, such difference being small but the same throughout the stratifications. A critical examination of the X-ray diffraction patterns of cryptocrystalline hyalites exhibiting optical phenomena identical with or analogous to those of precious opal confirms this finding and enables the two species of silica present in association with each other and giving rise to these phenomena to be identified respectively with high and low cristobalite."

Further studies were then carried out with gem opals as well as hyalite using X-ray cameras of higher resolving powers, and the resulting photographs were precisely measured. In the result they found that their identification of low cristobalite was incorrect but were

> " enabled . . . to reach the definite conclusion that the *two modifications of silica present in hyalite are respectively low-tridymite and high-cristobalite.* X-ray studies have also been made . . .

> with common opal which occurs in massive form with a waxy lustre. These have led to a similar conclusion regarding the nature of the latter material.
>
> The X-ray patterns of gem opals are diffuse, thereby making it less easy than in the case of the cryptocrystalline materials hyalite and common opal to identify the nature of the atomic groupings which appear in the alternating layers of its lamellar structure. Nevertheless, a careful examination of the patterns leaves little room for doubt that, as in the case of the iridescent hyalite, we are concerned with two modifications of silica present side by side in it, one of them having a structure resembling that of low-tridymite and the other that of high-cristobalite. Comparative studies of the optical behaviour of hyalite and of gem-opal . . . confirm this finding and establish this as the origin of the iridescence exhibited by these materials."

Although high-cristobalite usually becomes unstable and reverts to low-cristobalite under 300°C they consider it reasonable to assume that its association with low-tridymite, itself normally stable at ordinary temperatures, gives it the necessary stability.

> " Since the two materials have the same chemical composition and nearly the same density, and since their structures have the silicon-oxygen tetrahedra as a common factor, there is no . . . difficulty in making such an assumption. Since the two structures are not identical, the materials would naturally tend to segregate and form layers so disposed with respect to each other as to present the maximum possible degree of continuity in the chains of valence bonds between the silicon and oxygen atoms extending through the material. Since the structure of low-tridymite is pseudo-hexagonal while that of high-cristobalite is cubic, geometric patterns in which the two structures alternate may be expected to arise, as is indeed actually observed in opal."

Mr. Leechman's references to the monochromatic nature of the colour flashes and to visible straight-line patterns are confirmed.

> " Spectroscopic examination reveals that the internal reflections and the corresponding extinctions in the transmitted light are highly monochromatic. . . . When a gem-opal is examined through a microscope which has arrangements for illuminating the object from above the stage and viewing it by the

> internally reflected light, the lamellar structure . . . becomes immediately evident. In not a few cases, geometric patterns of a very striking character are observed."

It is, moreover, made clear that "precious" opal is not amorphous. Common opal and hyalite, like agate and chalcedony, are shown to be cryptocrystalline and gem-opal to be minutely so.

> ". . . the X-ray data point clearly to the conclusion that the structure of gem-opal is essentially the same as that of hyalite, except that the crystallites are now much smaller, thereby tending to make the material simulate a vitreous solid."

Thus all forms of opal, from common opal through hyalite to "precious" or gem-opal, have a similar structure and composition, the differences in optical behaviour being due to the diminishing size of the constituent crystallites and the increasing proximity of the laminae as the material becomes more "precious."

> "It is clear from the facts that the optical effects exhibited by transparent hyalite and by iridescent opal form a continuous sequence in which there are three stages. In the first stage, the stratifications are too widely spaced to result in internal reflections, but give rise to diffraction haloes or diffraction spectra in forward directions. In the second stage, the stratifications are too closely spaced to give diffraction effects in forward directions, but result in reflections backwards towards the source. Finally, we have a third stage when the stratifications are too closely spaced to give any effects at all, unless the wave-length of the light is sufficiently small. In the cryptocrystalline hyalites, we would naturally expect the first stage to be commonest, and the second stage less common. In the gem-opals, on the other hand, where the material is approaching the vitreous condition, the stratifications may be expected to be much finer and the third stage therefore attained, unless the wave-length of the light is chosen sufficiently small. We do indeed have opals which exhibit a bright yellow or red iridescence. But those with a green, blue or violet iridescence are commoner, indicating that the more closely-spaced stratifications are favoured."

Confirmation that this is the true cause of the monochromatic colour flashes of gem-opal is found in the theory of the reflection of light in a regularly stratified medium which

> "has been elaborately discussed . . . by G. N. Ramachandran.[4]

> As has been shown by him, the degree of monochromatism of the reflections by such a medium cannot be indefinitely increased by increasing the number of its stratifications, their spectral width having a minimum limiting value which depends only on the reflecting power of an individual stratification. If such reflecting power be large, the monochromatism would necessarily be very imperfect ; *per contra*, if high monochromatism is actually observed, it indicates that the reflecting power of an individual lamination is small. These conclusions have an important application to the case of opal. They indicate that the difference in refractive indices of the alternate layers of the stratifications in opal is quite small. Further, such variation is strictly periodic and of the same magnitude throughout an individual set of stratifications."

While the last word may not have been said on the subject (in fact Mr. Leechman has some further observations elsewhere in this issue), Sir C. V. Raman claims[5] that the problem has at last been definitely solved and, so far as I can judge, it looks as if this old question of the cause of the play of colour in opal has indeed been finally answered.

* * *

Mr. N. Kennedy's " Gemstone Mysteries "[6] proved particularly evocative and set me thinking on the unfortunate lack of precision of some of the words we use.

For the identification of " girasol " with fire opal he need not have looked further than Herbert Smith's last edition[7] or the Oxford English Dictionary, and in deference to these two authorities we may think that this represents the orthodox modern English usage. But that is not the end of the matter, for the O.E.D.'s definition of " girasol(e) " as " a variety of opal which reflects a reddish glow in a bright light ; called also fire opal " is not very apt for the typical Mexican fire opal and some of the examples it quotes are quite clearly not what we now call fire opal or even not opal at all. Thus Cotgrave[8] in 1611 described " girasole " as " a precious stone, of the kind of the opals, that yields an eye-like luster, which way soever you turne it, unless it be towards the sunne ; for then it casts forth beames like the sunne," while in 1796 the mineralogist Richard Kirwan[9] wrote, " To this family (oriental sapphire) we may also annex the stone called Girasole."

And there is worse to come. If the Danas (father and son)[10] are reliable guides, then in America girasol for a hundred years has meant an opal " bluish white, translucent, with reddish reflections in a bright light " (which might be the same as Cotgrave and the O.E.D. intended), and finally Shipley[11] says that girasol is a name that has been applied to moonstone, to fire opal, to an almost transparent opal with a bluish floating light, to an opal with blue to white body colour and a red play of colour as well, and to many other stones, quoting Bauer – Spencer.[12]

The moral seems to be that the meaning of girasol in any author's works should be regarded as doubtful unless he obligingly describes it for us or at least provides sufficient clues to enable us to make a reasonably confident guess : and indeed this cautious approach is advisable in respect of all gemstone nomenclature, especially in the older literature on the subject. With regard to Heddle's statement of the occurrence of girasol in Scottish agates, quoted by Mr. Kennedy,[6] I would suggest that he probably used the word in the same sense as his fellow-mineralogists, the Danas, and that anyone searching Scotland for anything like true Mexican fire opal is doomed to disappointment.

* * *

When Mr. Kennedy[6] wrote of the " famous dichroism " of alexandrite, simulated (not very effectively) by synthetic corundum and synthetic spinel, he was clearly not referring to its pronounced pheochroism, due to differential absorption of light in the three principal optical directions, but to its capacity to look two different colours, green and red respectively, when viewed in natural and artificial light—a capacity which I am surprised to learn is apparently shared by a certain rare variety of tourmaline known in America as " chameleonite."[11] Science appears to have no special term to describe this latter type of " two-colouredness " or dichroism, and, unless we are to court confusion by earmarking " dichromism " or " dichromatism " for this meaning, it might be better to invent a word and call it " alexandrescence " (since " alexandritescence " comes awkwardly off the tongue).

Of course, all coloured objects possess this quality of alexandrescence in some degree : it is only the absolutely colourless—black—that shows no change of colour however much changed is the wave-length or combination of wave-lengths of the light in which it is seen. The phenomenon, however, only becomes noticeable—and therefore notable—when the different colours are seen in types of light, such as sunlight and electric light, which are commonly encountered. Not all alexandrites appear red in all forms of artificial illumination : the change to red in this case depends upon the degree of richness in long and poverty in short wave-lengths of the particular illuminant used relatively to sunlight, and alexandrite owes its fame to the fact that all the light-sources hitherto common in domestic use, from the candle to the incandescent-filament electric bulb, have been comparatively deficient at the blue end of the spectrum. May it not then be that the introduction of new forms of illumination (fluorescent lighting, etc.) may extend the practical importance of alexandrescence, and other gems also may become notable for this type of colour-change ? I do not, of course, suggest that a ruby turning black in sodium-lighting is likely to make it popular—but there may be forms of lighting already with us or yet to come which will become common in places where ladies are wont to wear their finery and which will cause attractive colour-changes in gemstones hitherto unsuspected of any capability of alexandrescence.

* * *

I have some doubt whether Westropp's " blue crystal . . . found in France . . . near Expilly . . . called saphirs de France, or saphirs de Puy-en-Velai," quoted by Mr. Kennedy,[6] was indeed blue quartz, since Dieulafait[13] also refers to the " saphir de Puy " from Expilly (" sa couleur varie du bleu le plus foncé au bleu le plus pâle ; parfois elle passe au bleu rougeâtre et même au vert jaunâtre ") and states categorically that it is corundum. He does mention a blue quartz, however, called " saphir d'eau " (a name also used for iolite)—" il existe des saphirs d'eau qui sont des quartz presque purs "—whose colour " d'un blanc clair mêlé de bleu céleste constitue une nuance mixte, montrant . . . une différence complète avec la magnifique couleur bleu du saphir d'Orient." He calls it " une pierre à peu près sans valeur."

* * *

Mr. O. Dragsted[14] deserves our gratitude for recalling the gemmologist's debt to the seventeenth century scientists, Bartholin and Steno. There can be no objection to describing a man as a gemmologist merely because he lived and died before the word was coined, but it is not a title that should be given to all those who have made to the general body of scientific thought contributions which have subsequently been useful in the study of gemmology. I feel that " gemmologist " is a name which should be reserved for those who, whatever their other interests, have devoted particular attention to the study of gemstones and all that pertains to them. This may deprive the ranks of the gemmologists of some of the great names of science, from Archimedes onwards, but although it has only been named in comparatively recent times and its emergence as a separate branch of learning has been a gradual development, due to the ever-widening horizons of knowledge and the increased specialization consequent thereon, our branch of science nevertheless has had its devotees from times of respectable antiquity—at least from the time of Theophrastus (c.372—287 B.C.), whom we may perhaps call the father of gemmology. And who knows how many centuries, how many millennia, before Theophrastus, there were gemmologists—in the civilizations of Egypt, Mesopotamia, Crete, and even earlier in the mists of stone-age pre-history—men who have left no written record, but who in their lives strove to attain beauty and extend the bounds of knowledge through the understanding use of gems ? *Vixere fortes ante Agamemnona. . . .*

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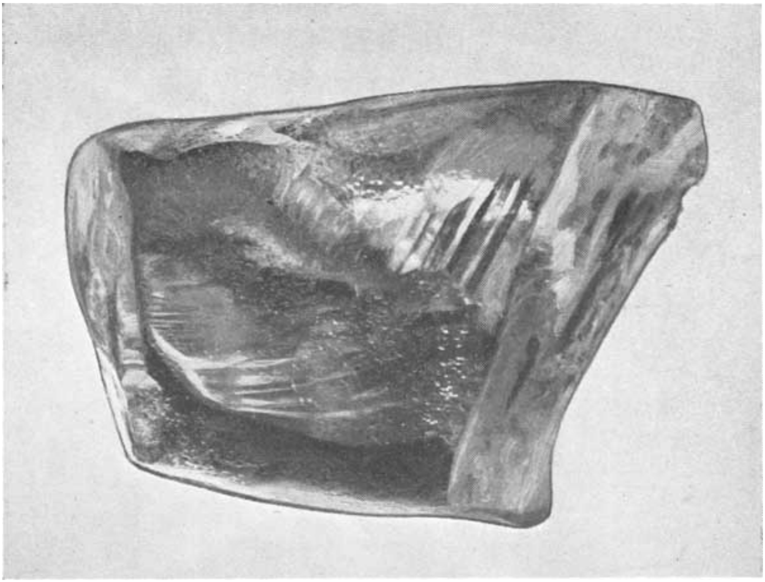
PREMIER MINE DIAMOND



(Photograph by courtesy of De Beers Consolidated Mines)

A large diamond, weighing 426½ carats, was recently found in the Premier Diamond Mine at Cullinan, South Africa. Its size may be compared with the half crown. It is reported to be bluish-white and of good quality and Dr. J. F. Custers, who has examined the stone, mentioned in his talk to members in June that it was a Type IIb stone. The new diamond is one of the largest found though the Cullinan (3106 carats), Excelsior (995.2 carats), Jubilee (650.8 carats) and (allegedly) the Koh-i-noor (800 carats) exceeded it.

QUEEN MARY'S COLLECTION

by ELSIE RUFF, F.G.A.

WHEN Queen Mary visited the Gemmological Association's Exhibitions, she came, not as a gemmologist, as a collector. Nor was she a collector of gemstones. Her beginning as a collector, we are told, goes back to early childhood. Whereas some children assemble stamps, Queen Mary, then Princess May, was in a better position and her taste ran to *objets d'art.* Along with her other treasures to be seen at the Victoria and Albert Museum is her jade. Nevertheless, snuff boxes were snuff boxes, independent of gemstones. (Many boxes so catalogued were not either created for snuff.) Among her Fabergé treasures, the same spirit prevailed. Fabergé made his material fit his design. He might use metal or he might use gemstone material. The gemstones themselves were chosen for their decorative features.

Gemmology in its widest sense must embrace gemstones and gem materials (sometimes termed ornamental stones) in whatever form. While gemmology is necessarily allied to jewellery, it still has a relationship to bric-à-brac generally. Yet within this framework, the gemmologist stands at the opposite end to Fabergé, say. He was the jeweller-craftsman-designer fitting his medium to his design. The gemmologist proper fits his design to his gemstone.

The current collection at the Victoria and Albert Museum, therefore, has much to interest the gemmologist. He might begin by sighing for the wonderful materials common so short a time ago. Rhodonite, for example, approaches jade in its adaptability. Fine pieces of lapis lazuli tell one and all that to restrict it to the odd signet is a grave omission. Pieces of lapis lazuli in the collection have been combined with mother-of-pearl and also with green jade. A case of jades, from greenish white to wonderful dark greens, once decorated Queen Mary's dining room. And a separate case of jewelled jade places this Indian period somewhere between Fabergé (as the ultimate exponent) and the gemmologist proper. There is a large jade bowl that, unfortunately, stands on a green leather-

FIG. 1. *A German box of bloodstone mounted with gold and diamonds, formerly part of the Russian crown jewels. Dated about 1770.*

topped table, to the benefit of neither. There are beautiful examples of tortoiseshell and of ivory. There is serpentine, malachite, and moss agate. There is rock-crystal, often wedded to enamel. There is a bloodstone box heavily decorated with diamonds, part of the Russian Crown Jewels, and a diamond encrusted horse. And there are the consoling rubies and emeralds and sapphires and, of course, pearls. These earlier designers had the world of gems to choose from apparently and could do so with neither apology nor explanation. The modern cigarette case has never replaced the snuff box. When snuff went out of fashion, the gap must have been enormous—more so perhaps than one might contemplate should present propaganda add up to a non-smoking generation.

To men of the Fabergé calibre, there would seem to be no class-consciousness among gemstones at all. He needed red—very well, rubies if possible, but, rather than a line of unmatching corundums, garnets will do equally well. Fabergé was the supreme toy-maker perhaps, and Queen Mary was interested in toys. Her doll's house, now at Windsor, is an outcome of this interest. The modern world has little time for jewelled toys. Maybe, something between the Fabergé baubles and the realistic designs of to-day is needed. Salvador Dali has been cited as an adventurer in this field. From the gemmologist's point of view, it seems all to the good, for he appears to stand at the cross roads of Design and Gems.

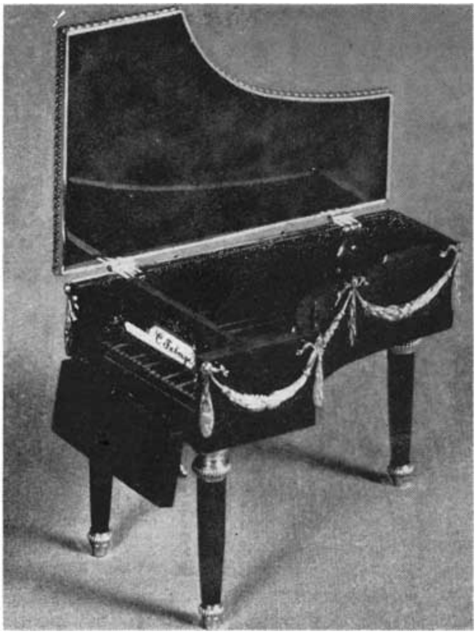


FIG. 2. *From Queen Mary's Fabergé masterpieces, a nephrite and gold miniature piano.*

No matter how one approaches this collection, it is almost impossible to view it as a collection. Rather is it an expression of a personality. And that gives it warmth. Queen Mary was no slave to any particular period, though the *Regency* undoubtedly captured her imagination early in life. Hers was a collection of things that she loved and wanted to live with. She had obviously concerned herself little with standards. The treasures at the Victoria and Albert Museum give the visitor contact, not necessarily with the collection, with the collector.

Many a gemmologist will see this exhibition. He will likely begin with the egg[1]—the first centre case as one enters the main hall—and almost certainly return to it. There he will also see a miniature grand piano in Siberian nephrite, which at least announces that the jade craftsman is still with us, as well as a rather vulgar rose quartz Buddha. Illustrated, Fabergé's Easter egg of 1914 conveys little. It depends on light and colour. As an example of the jeweller's craft it is, surely, exceptional. It might be described

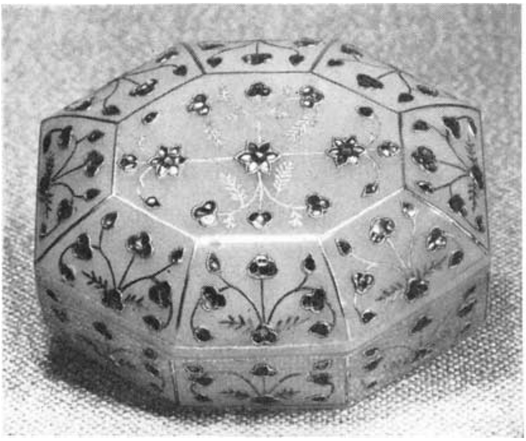


FIG. 3. *An 18th-century Indian box from Jaipur of white jade mounted with gold and rubies.*

as a jewelled cobweb styled into an egg. And this exquisiteness in platinum and gold and opaque white enamel would hardly count were it not for the minute gemstones and pearls. Whatever the individual part played by Fabergé in this creation (he employed something like 700 craftsmen) it must have afforded him intense satisfaction to sign his name to it. As it transpired, it was more than a personal signature—it was the signature of an era. Perhaps this too might be said of Queen Mary's collection.

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1. Not one of the four eggs exhibited in London at the end of 1949.

Members' Meeting

Dr. J. F. H. CUSTERS' talk on

RECENT RESEARCH on DIAMONDS including ARTIFICIAL COLORATION

NEW facts about diamonds were revealed by Dr. J. F. H. Custers, Director of Research of the Diamond Research Laboratory, Johannesburg, at a talk he gave to members of the Gemmological Association at the Medical Society of London headquarters on 3rd June.

Earlier knowledge, said Dr. Custers, has made it clear that there are two types of diamonds, commonly known as Type I and the rarer Type II. The actual differences in structure are not fully understood, but there are clear differences in properties, notably in transparency in the ultra-violet range. It has been suggested by later research that there are even more types and the matter has become a little more complicated since it was discovered at the Johannesburg laboratory that there is a further sub-division of Type II into " a's " and " b's." Type IIb is characterized by being strongly phosphorescent when suitably treated. In the laboratory a large stone of 426½ carats showed remarkable phosphorescent effects when excited by short wave ultra-violet light.

Type IIb is a very good conductor of electricity. Diamonds are, of course, normally good insulators, but a Type IIb of one-sixth inch diameter would pass a few milli-amps when 100 volts was applied to it. This current would increase to about five amperes in a few minutes. It is very surprising to find that a diamond would conduct such a current, said Dr. Custers.

He then went on to explain this by pointing out that there are two forms of conductivity. Electricity could be carried by the atoms themselves or the electrons could move. This type of diamond evidently started off by having the current carried by the electrons and as the electrons got more excited and raised the temperature amid the imperfect lattice construction of the diamond additional electrons got liberated to allow still more current to be carried. As a result the diamond became red hot and would oxidize if the current was left to run long enough.

The properties of these diamonds may open new fields for their use. For example, in a vacuum they might be used as semi-conductors at a high temperature. Such semi-conductors are becoming increasingly important nowadays. Germanium is one of them and it is used as a transistor device. It might be possible to use diamonds for such a purpose. Some of the British universities are working on these matters and Dr. Custer's own laboratory keeps in touch with them. Not only might the Type IIb diamond be used as a transistor, but " b " types are good counters of gamma rays. A Geiger instrument is usually employed for this, consisting of a gas-filled tube through which a wire runs. The electrons of the gamma rays pass through the diamond and liberate other electrons in the lattice and the movement is amplified and counted or heard.

The diamond is a crystal, said Dr. Custers, being one form of carbon. Graphite or charcoal are the common modifications. Graphite is the more stable. This is why high temperatures could transform diamond into graphite, but the transformation could not be done the other way because of the high pressures required. Even with 16,000 atmospheres of pressure it would take millions of years. High pressures have been obtained and in the United States they have attained 250,000 atmospheres but only for a fraction of a second. That, of course, is not long enough, even at an absolute temperature of 2,000 degrees.

The first part of the talk was concluded by Dr. Custers giving an explanation of how the phosphorescence could be kept " stored " for several weeks by maintaining the diamond at a temperature near absolute zero. If heated quickly then, the phosphorescence would come as a blue light so intense that one could almost see print by it.

In the question time that followed one member asked whether the flow of current is in one direction. " This has not been established," answered Dr. Custers. A second question was whether differences in colour or purity were a mark of the different types of diamond. There are two schools of thought on this, said Dr. Custers, and they are still trying to find out. Fluorescent stones always had the same spectrum. If it was a matter of impurities, Dr. Custers said he could not understand why the diamonds should have the same spectra, but he thought it was a matter of structure and lattice defects.

Mr. B. W. Anderson, Director of the London Chamber of Commerce Diamond and Precious Stone Laboratory asked several questions, and the lecturer in reply said that Type IIb diamonds also re-acted to X-rays. There was no record of one type being transformed into the other by any kind of treatment.

Dr. Custers then spoke of the coloration and reaction of diamonds to atomic treatment. About three years ago it was found that a diamond put in an atomic pile turned green. There are three types of atomic radiation to which diamonds might be exposed—alpha particles, beta particles and gamma rays. Diamonds with the same green colour that is given by alpha particles are also found in gold mines in South Africa, though there is a difference between the two. The whole diamond is made green when exposed in a pile, whereas with those in the mines there is only a superficial skin effect.

Neutrons, being uncharged particles of similar mass to a proton (hydrogen nucleus) are able to run through the lattice atoms of the diamond and displace the atomic nuclei. At the same time the electrons are displaced, thus altering the absorption of light. Colour varies from light green to bottle green and if the diamond is kept in the pile long enough it turns black.

If the atoms of the neutron irradiated green diamonds have the chance to move again by heat treatment they do so and the diamond might turn from deep green to amber or light yellow, but the original colour is never restored. Some permanent damage has been done. That damage is called radiation damage. A green diamond is not of great interest in the diamond world, but the making of a blue diamond is quite another matter. Two years ago it was found that this could be done. To do so neutrons were not used as projectiles, but electrons. The neutrons damaged the lattice fairly severely, but the electron is lighter and did not cause so much damage. Electrons do not penetrate so far unless they are speeded up when damage could be more severe and the green colour again obtained. The coloration is only about one-fiftieth of an inch deep in a brilliant, but with the naked eye it could not easily be ascertained whether the blue-white colour was natural or not. However, all natural blue-white diamonds are Type IIb, and no exceptions have been found. These are conductors of electricity and so it is possible to apply this test. It has also been found they have a different factor of light absorption. The artificially coloured ones absorb light more weakly in the red end of the spectrum. The blue-white colour can be corrected slightly by heat treatment afterwards.

Only a few days ago, said Dr. Custers, he had heard the first results of colouring diamonds by the use of gamma rays. Radiation had been carried out for about 1,000 hours. The gamma rays are not very readily absorbed by a diamond, but they liberate the electrons that surround the carbon nuclei in the diamond, thus allowing movement. As a result the whole diamond is coloured blue instead of a surface area. One difficulty is to find gamma rays of the right energy. Radio-active cobalt is one answer to this. Gamma rays are promising, but they are rather expensive.

There are still many problems to be solved and riddles to be answered so far as the diamond crystal is concerned, Dr. Custers said in conclusion of his talk. In his laboratory they are trying to find out more and better uses for industrial diamonds. The gem side does not interest them so much, but the matter of coloration is of such importance that it cannot be ignored.

At the beginning of the meeting the Chairman, Mr. F. H. Knowles-Brown had expressed the Association's gratitude to Dr. Custers for so kindly consenting to give a talk to members during an extremely brief and busy visit to Britain. Mr. B. W. Anderson, in moving a vote of thanks to Dr. Custers, said that although there were many minerals which had many problems to solve, diamond could still be regarded as the most puzzling and fascinating of them all and he expressed the indebtedness of members to Dr. Custers for such an interesting talk.

AUSTRALIAN PEARL FISHING EXPERIMENT

A BOLD experiment to save Australia's rich pearling industry began in April when the Intergovernmental Committee for European Migration (ICEM) transported a ten-man crew of Greek sponge fishers from Athens to Darwin, Australia, the world's largest pearl-beds, sprawled under the waters off the northwest coast of Australia.

The crew, recruited from among the fishermen of Kalymnos, a barren rock island in the South Aegean Sea, includes three divers, three tenders, three crew members and an engineer.

Darwin's pearlers will keep a close watch on the Greek sponge divers, their last hope to get the industry back on its feet. Australia's pearling fleet once numbered 300 luggers and employed 2,000 Asiatics. The war brought an abrupt end to that because the Japanese had dominated the industry before the war.

Only Japanese divers were able to go to the depths required, sometimes as much as 20 fathoms. Since the war, the Government has tried to utilize white divers, but with no marked success. Even the Malays were able to descend only or 12 to 14 fathoms. Last year, Australia was forced to re-admit 35 Japanese divers to Western Australia, despite the political implications of such a move. Divers from Koepang and Thursday Island were able to win barely enough shell to keep the industry alive.

Shell has become a great dollar earner for Australia and is now priced at the unprecedented figure of £700 Australian the ton. In addition to its commercial importance, a successful pearling industry would mean the maintenance of population in the continent's exposed northwest flank.

The Australian Northwest, a territory of some 530,000 square miles, holds fewer than 7,000 white persons. Much of this land is given over to enormous cattle and sheep stations but the potential economic wealth of this undeveloped region lies underground. There are valuable deposits of tin, lead, copper and iron, as well as of rarer metals. There have been rich strikes of uranium and oil. To hold on to this rich, unsettled land, Australia knows she must populate it.

Last year, the Commonwealth Government proclaimed its jurisdiction over the waters of the continental shelf, including the pearl-beds, long a fishing ground for Japanese pearl luggers. The Government is now backing up its claim with the importation of the Greek diving crew. If the experiment is successful, other sponge fishermen from Kalymnos are expected to follow.

For the people of Kalymnos, the Australian test may be the answer to their own difficulties. The 15,000 Greeks who make the rock island their home have only one source of income—sponges. For centuries, the hardy islanders have wrested their living from the bed of the Mediterranean.

For more than two years, however, the financial advantages of sponge-fishing have dropped so disastrously that the islanders have been forced to serious consideration of mass emigration. According to Anton Mavrikakis, mayor of the island, 500 of his people stand ready to quit Kalymnos.

Last September, an unofficial Australian emissary, Mr. Eugene Gorman, visited the Greek island, after conversation with ICEM officials in Geneva, to take a first-hand look at the Greek sponge divers. He asked two questions : Can Kalymnians dive as well as the Japanese ? Do Kalymnians know anything about shell-fishing ? He found that the island divers can go down as far as 35 fathoms, and that the adaptation to shell-fishing should not be difficult for sponge-divers.

Gorman warned the islanders that life in the Australian Northwest will be lonely and harsh. The people of Kalymnos already knows what that means. Their home is a bleak, yellowish-grey mass of rock. Even in springtime, it is hard to find a green patch anywhere on its dry, barren hills or cliffs. On feast days, many of the families have little more than bread, tomatoes and a few olives.

If the plan for Kalymnos wins final approval, the Intergovernmental Committee for European Migration will prepare the islanders for emigration, give them basic English courses, and arrange their transport to Australia.

Gemmological Abstracts

CUSTERS (J. F. H.). *Artificial coloration of diamonds.* Optima, Vol. 3 No. 4, pp. 8–12, December, 1953. Reprinted Gemmologist (1st instalment), pp. 81–85, No. 274, Vol. XXIII, May, 1954.

Written in non-technical language this article reports on the change of colour that diamond may assume after bombardment by particles of atomic size. The Rutherford-Bohr conception of the atom prefaces the note on the two best known ways in which radiation can interact with atoms. These are interaction with the outer electrons and interaction with the nucleus itself. The latter type of interaction did not have any importance until the invention of the cyclotron in 1925, and later that of the nuclear reactor, or as it is better known, the atomic pile. The writer explains the " radiation damage " as a displacement of the atoms in the crystal pattern which can drastically change the thermal and electrical properties, and also the absorption of light, hence change of colour can occur. A clear explanation is given why neutrons are more efficient than other particles, such as protons and electrons, for the penetration of atomic nuclei. A note is given on what is known about the colouring agents of natural fancy diamonds, which may be due to trace elements or to structural defects in the crystal lattice. Diamonds bombarded in an atomic pile turned bottle green if the dose of radiation was light, but if heavy the induced colour was so intense that the stone became black. On heating these irradiated stones the colour turned to deep amber to light yellow shades depending on the time and temperature of the heating. The discovery by R. A. Dugdale that diamonds could be turned blue by bombardment with high speed electrons from a Van de Graaff generator is commented upon. The colour of these " blued " stones is said to be only skin deep and of a shade different from the blue of natural stones. It is suggested that the natural blue diamonds form a new structural type which the author proposes to call Type IIB. All natural blue diamonds have been found to be of the rarer Type II. The article closes with the statement that the artificially blued diamonds can be readily recognized as man-made coloration, and that the market value of a diamond will not be enhanced by artificial coloration. The light absorption of the artificially blued diamonds is said to differ from the natural blue stones, and it might be possible to devise a suitable light filter which will distinguish the natural colour from that artificially produced, the colour of which is said to be less stable than that of the natural blue. An informative and important article. 6 illus. (one in colour). R.W.

KLEEB (A. A.). *Watch jewels of the past.* Gems and Gemology. Vol. VIII, No. 1, pp. 3–15, Spring, 1954.

Tells of the first use of watch jewels and of the authors examination of the bearing jewels in a number of antique watches. Chrysoberyl and quartz were found to be quite common in these old watches ; beryl, ruby, sapphire, natural spinel, garnet and diamond (as end stones) were also found. Cornelian had been used for clock pallets and another clock had the bearings made of ivory. One watch was found to have " fake " bearings of red glass. 11 illus. R.W.

ANDERSON (B. W.) ; PAYNE (C. J.). *The spectroscope and its applications to gemmology.* Gemmologist, Vol. XXIII, Nos. 272–3–4, pp. 48–52, 72–76, 87–90, March, April, May, 1954.

Three further instalments of the most useful series in which description and methods of use of the quartz spectrograph are given, and also absorption spectra and the methods of observing them are discussed. A short but adequate survey of the quartz spectrograph is given ; the characteristics of the small, medium, and large instruments being covered. The methods employed in taking spectrograms with such apparatus and the methods of " reading " them are explained. After a short history of the early work carried out on the absorption spectra of minerals and gems there is a full description of the types of spectroscopes that can be best employed in observing the absorption spectra of gemstones. The best type of lighting to use and the various set-ups which aid satisfactory observation of the distinctive absorption bands and lines. 4 illus. R.W.

DEANE (N.). *Adventures in lapidary work.* Gemmologist, Vol. XXIII, No. 272, pp. 41-46, March, 1954.

The third instalment of this series deals with the writer's early trials and difficulties in obtaining suitable spindles to run his apparatus. The making of jamb pegs and dop sticks is discussed. The author's early attempts at faceting are told and a discussion on polishing powders follows. Remarks are made on the difficulty of getting suitable rough material in this country. 4 illus.

R.W.

WEBSTER (R.). *Gemstone luminescence.* Gemmologist, Vol. XXIII, Nos. 272–3–4, pp. 58–60, 77–78, 98–100, March, April, May, 1954.

The concluding three instalments of this series comprise the luminescent characters of spodumene to zoisite. Appendices giving tables of the more pronounced luminescences, grouped in colours, for the three wave-bands covered by the series, i.e. long-wave ultra-violet light, short-wave ultra-violet light and x-rays. The series ends with a short glossary of terms. P.B.

CROWNINGSHIELD (R.). *Simple means to distinguish yellow chrysoberyl and yellow sapphire.* Gems and Gemology, Vol. VIII, No. 1, p. 31, Spring, 1954.

It is reported that a simple test for the distinction of yellow chrysoberyl from yellow sapphire by the refractometer is to employ a drop of methylene iodide as the contact liquid in place of the normal 1.81 liquid. Under such conditions if the stone be a chrysoberyl a portion of the spectral edge will be seen in the blue-violet, but if a yellow sapphire no spectral colours will be seen. The writer points out that if monochromatic light or a spectroscope be available these more orthodox tests would be better used.

R.W.

LEWIS (M. D. S.). *The history of paste.* Gemmologist, Vol. XXIII, Nos. 272 and 274, pp. 53–57, 91–94, March and May, 1954. (See Journ. Gemmology Abstracts, Vol. IV, No. 5, p. 213, Jan., 1954). The continuation of the article on the history of the making of paste stones).

These instalments discuss the use of glass imitation gemstones from the 15th century on. It is said that the prohibition in 1615 of the use of timber as fuel in English glass houses led to the change in process which gave the lustrous English flint glass. As the use of coal as a fuel necessitated the employment of covered glass pots and hence a flux to lower the melting point, lead oxide in some quantity was added to the glass metal. The story of Stras, the Paris chemist-jeweller, is told with regard to the production of the heavy lead-glass pastes which go by the name of " strass." The article concludes with some details of the use of paste in jewellery and the design of jewellery in the 18th and 19th centuries. A note is given on the foiling of stones. The prevalent idea that modern jewellery is cast in a mould while antique jewellery was always " hand-made " is refuted by the writer, who avers that much antique jewellery was cast. 3 illus. R.W.

RAMAN (C. V.) and JAYARAMAN (A.). *The structure and optical behaviour of iridescent opal.* Gems and Gemology, Vol. VIII, No. 1, pp. 21–26, Spring, 1954. (Condensed and reprinted from The Indian Academy of Sciences Proceedings, Vol. XXXVIII, Section A, No. 5, from which quotations are given on pp. 292-296 of this issue of the *Journal*).

Gem opal shows an orange-red light by transmitted light and this may be reflected from the rear surface and enhance the beauty of the gem by contrast with the blues and greens of the " play of colour." Spectroscopic examination shows that the internal reflections and the corresponding extinctions in the transmitted light are highly monochromatic. This infers regularly stratified layers in great number. The lamellar structure can be observed by microscopic examination employing overhead illumination. It is suggested that this lamellar structure consists of alternate layers of two crystalline modifications of silica of slightly different R.I. This hypothesis is supported by X-ray diffraction patterns; and the iridescence is due to alternate layers of high cristobalite and low tridymite. 4 illus. R.W.

PAYNE (C. J.). *The Rotagem.* Gemmologist, Vol. XXIII, No. 273, pp. 47–48, April, 1954.

Describes an ingenious accessory, devised by D. S. M. Field of Canada, to fix on a Rayner refractometer in place of the cover, in order to hold and rotate the stone on the dense glass without damage and with greater ease than when the stone is held in the fingers. 1 illus. **P.B.**

ROBB (C. J.). *Imitating rubies in* 1699. Gemmologist, Vol. XXIII, No. 272, p. 57, March, 1954.

A note taken from an old manuscript which gives a formula for making imitation rubies. As the description tells of taking four ounces of natural crystal to which is added various other substances and the whole heated in a glass-house furnace, will the result be glass or " reconstructed ruby " ? P.B.

SCHLOSSMACHER (K.). *Die Entstehung der Edelsteine.* The formation of precious stones. Zeitschrift d.Deutsch.Gesell.f.Edelsteinkunde, Spring, 1954, No. 7, pp. 3–7.

Our direct observations are confined to the outer boundaries of the silicate shell (lithosphere) which reaches a depth of about 750 miles. Most rock-forming minerals (feldspars, micas, augites, hornblende, olivine, etc.) and many precious stones are silicates. Under the silicate shell lies the sulphide-oxide shell (750–1800 miles), which consists of metal-sulphur and oxygen compounds, and under this the iron-nickel core.

The eruptive cycle and the eruptive rocks are most important for the study of gem deposits and a differentiation is made between rock magma, extrusive rocks and intrusive rocks. The rock magma congeals in three phases. During the (first) intramagmatic phase some minerals crystallize and form rocks (for instance granites, diorites, gabbros). Precious stones of this phase are the diamond, some garnets, peridot and labradorite. The (second) pegmatitic-pneumatolytic phase starts when the pressure of the remaining solution grows to such an extent that part of it is pressed into the surrounding rocks. Of the intrusive rocks which are formed, the pegmatites are of the greatest importance as gem deposits. Pegmatitic minerals are tourmaline, topaz, most beryls including aquamarine, chrysoberyl, euclase, phenakite, etc. When magma is pressed into fissures surrounding rocks dissolve and recrystallize. This process is called contact metamorphosis, and deposits of ruby, many sapphires, emerald and nephrite are of this kind. This pneumatolytic part of the second phase owes its name to the volatile components which are prominent. Contact minerals are not only formed around intrusive rocks, but also around solidifying rock magma. During the (third) hydrothermal phase aqueous solutions from the magma penetrate into the surrounding rocks, fill fissures and cause hydrothermal contact phenomena. Hot springs are solutions of this kind which reach the earth's surface. Many gems of the quartz group belong to this phase.

The three phases take place within the earth's crust and are called intrusive. When the magma penetrates to the earth's surface, they are called extrusive phenomena. These are of less importance for gemmology, only opal and agate being formed in this way from hot aqueous solutions.

The sedimentary cycle is of no importance for the formation of gems, except perhaps for amber and jet. However, many gems are found in secondary or tertiary deposits in sediments and sedimentary rocks.

Crystalline schists are formed from existing eruptive and sedimentary rocks through pressure, high temperature and solution. If the pressure was exerted in one direction only, a scaly habit resulted. Some rocks belonging to this group are gneiss, mica, serpentine and marble ; gem stones of this group are some garnets, nephrite and jadeite, which were formed at the same time through contact metamorphosis.

The cycle of weathering does not lead in general to the formation of new gem stones. Only turquoise, chrysoprase, malachite and azurite are products of weathering. However, weathering is of great importance for the formation of alluvial gem deposits.

E.S.

SCHLOSSMACHER (K.). *Eine neue Lapis-Imitation.* A new lapis imitation. Zeitschrift d . Deutsch . Gesell . f . Edelsteinkunde, Spring, 1954, No. 7, pp. 8–9.

Description of a new imitation lapis-lazuli. The colour is that of finest Afghanistan lapis. The hardness is over 8 Mohs's scale. The main constituent of the imitation is a colourless singly refractive mass of R.I. 1.72 and S.G. 3.6 pointing to a spinel-like composition. The second constituent is the pigment, perhaps a cobalt compound, appearing under the microscope as very small grain of nearly black colour. The greater hardness, R.I. and S.G. as well as the higher lustre and the lack of pyrites inclusions allow differentiation from genuine lapis lazuli. (A more detailed analysis of the new imitation is given on p. 281 of this issue of the Journal). E.S.

ANON. *Prasiolit—ein grün gebrannter Quartz.* Prasiolite, a green fired quartz. Zeitschrift d.Deutsch.Gesell.f.Edelsteinkunde, Spring, 1954, No. 7, p. 10.

Allegedly green quartz, completely transparent, was first discovered when amethyst rejects from Minas Gerais, near Montezuma, were accidently burned in a camp fire. To-day the material is selected and carefully fired in Rio de Janeiro and marketed in New York as " prasiolite." The crystals which are found in geodes within a particular vein, are small, at the utmost four inches long. Of interest is the elongation of the crystals in contrast to amethyst pyramids. The colour is pale, an outer zone of about ¼ to 1 inch is colourless. The crystal faces are green and covered with iron oxides. Only 4 per cent of the material are of the best colour. The stones resemble green beryls ; more rarely green tourmalines ; and especially liked is the peridot colour. The price corresponds to that of calibrated amethysts. A sufficient quantity to be of importance for the Christmas sales, 1954, is said to be available.

E.S.

REITENBACH (A.). *Aus dem Achatbergbau Idar-Obersteins.* On agate mining at Idar-Oberstein. Zeitschrift d.Deutsch.Gesell.f.Edelsteinkunde, Spring, 1954, No. 7, pp. 13–17.

Historical aspects and speculations concerning early agate mining in the Idar-Oberstein district. W.S.

VARIOUS AUTHORS. *Ädler Stenar.* Precious Stones. C. G. Hallbergs Guldmedsaktiebolag, Stockholm, 1953, pp. 51.

This is a very attractive propaganda brochure designed to stimulate interest in precious stones and jewellery. On twelve pages Dr. T. Lenk reports on the Swedish crown jewels, depicting characteristic examples in excellent reproductions. A fine colour plate shows the famous and magnificent crown made in 1561 by Cornelius ver Weiden for King Erik XIV. W. Deines reports shortly on the cutting of diamonds and precious stones and in another article gives a concise glossary of the most important gem species. This part of the brochure is most effectively illustrated by two colour plates by W. Wild. B. Tillberg devotes a few pages to precious stones in history and literature. Other articles deal with folklore, famous diamonds and modern jewellery. This booklet is extremely well laid out, very pleasing in appearance and therefore should appeal not only to the gemmologist, but also to the connoisseur and potential buyer. W.S.

GRINSTEAD (L. R.) and DAKE (H. C.). *Methods of collecting specimens.* Mineralogist (Oregon), June/August, 1954, pp. 227 - 248.

A short account dealing with various ways of collecting specimens. S.P.

HALPERN (J. M.). *Arctic jade.* Rocks and Minerals, N.Y., 1953, Vol. 28, pp. 237 - 242, 1 fig., 1 map.

A short account of jade (nephrite and jadeite) occurring in the Arctic regions of Alaska and Canada. Occurrence is mainly in boulder form and there is a good deposit in Alaska, in the river Shungnak area. The article includes information on the use of jade by the Esquimo during several centuries. S.P.

FRONDEL (CLIFFORD). *Commercial synthesis of star sapphires and star rubies.* Trans. Amer. Inst. Mining Metall. Eng., 1954 (Jan.), pp. 78 - 80, 4 figs.

Short notes on the production of star stones. By the use of the Verneuil process boules are produced with the addition of ·06 - 2% Titanium to form a solid solution in Al_2O_3 at about 2000°C. Strain is removed by annealing at about 1900°C. and a solution of TiO_2 is caused by heating in an oxidizing atmosphere at 1100 - 1500°C. The rutile needles are perpendicular to the *c*-axis of the crystal. For sapphire ferric iron (0·3%) and for ruby chromium (1·4%), are added. S.P.

BOOK REVIEWS

SCHLOSSMACHER (PROF. DR. K.). *Edelsteine und Perlen.* Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, 1954. pp. 280, illustrated.

More than thirty years have passed since Prof. Schlossmacher successfully completed the tremendous task of revising Bauer's great " Edelsteinkunde "—the first edition of which was translated into English by Dr. L. J. Spencer and is now a collector's item. Had the war not intervened it is possible that another new edition of " Bauer-Schlossmacher " would have appeared or be in preparation, but unfortunately present-day conditions and costs do not make so ambitious a work a practicable venture on the part of the publisher.

Schlossmacher's new book, *Edelsteine und Perlen*, is intended by the author to act in some measure as a small substitute for a revised version of the " Edelsteinkunde." He describes it as " ein Buch der Mitte "—a book, that is, not intended for the pure scientist on the one hand nor for those who read only illustrated papers on the other, but for the intelligent jeweller, dealer, or lapidary, and for the interested amateur of gems.

In this the author succeeds very well, the book being readable as well as informative. The opening sections on gemstones as minerals, the nature of their occurrence in the rocks, and their chemical compositions, are excellently done. After that, the book seems for a while curiously empty and lacking in " meat." This is partly because the author is afraid of giving too much detailed information of the sort one is accustomed to find in the average text-book, on crystal form, physical and optical properties, and the methods of measuring these.

But when one passes on to the descriptions of individual gem species which occupy some 60 per cent of the book it begins to come to life, and one finds that a surprising amount of information has been packed in under the smooth unbroken surface of the prose. Careful reading, indeed, reveals much matter which will be useful even to the advanced gemmologist. The description of inclusions found in corundum and beryl from the different localities, for instance, is unusually good and detailed. It is a pity that only one plate containing six photomicrographs is shown to supplement these descriptions. The author is a good photographer, and it would have been worth while to include several more such black-and-white plates rather than to go to the expense of preparing the two coloured plates of rough and cut stones, which are poor in quality and unlikely even to help in selling the book (which is, one suspects, sometimes the raison-d'être of such plates) since they are tucked away at the extreme end of the volume.

The book makes no attempt to be comprehensive. Fourteen of the non-commercial gemstones are described in a brief section (there are no numbered chapters) at the close of which 45 undescribed species are listed in alphabetical order. Several of these rejected gems might, one feels, have been allowed a description in preference to some of the favoured fourteen. The reviewer, for instance, would consider diopside, kornerupine, phenakite, sinhalite and sphene more worthy of inclusion than (natural) rutile, kyanite, dioptase, epidote and chrysocolla. But such a choice must of course be coloured by local trade conditions and sources of supply.

For those who wish to know the constants of these and other stones there are tables at the end of the book giving the refractive indices, density, and hardness of practically all the materials cut as gems. Surprisingly, these tables are taken (with acknowledgement) en bloc from R. T. Liddicoat's " Handbook of Gem Identification." One would have expected that a man of Prof. Schlossmacher's experience and opportunities would have been able to provide figures derived from his own experience. Liddicoat's values, as one would hope, are for the most part very well chosen ; but 2.99 would have been a better density figure than 2.94 for brazilianite and 3.34 instead of 3.40 for peridot. Since the density of pure corundum and for pure quartz have been well established at 3.99 and 2.65 respectively, these also might have been correctly given.

The refractive indices of yellow or pink topaz, which are practically the only types used in jewellery, are 1.630 and 1.638 for the lowest and highest rays, and it would have been better to quote these in the table than the figures 1.619 and 1.627, which are the arithmetic mean between these and the lower figures found in colourless types, and are seldom found in any individual stone.

As the title of the book suggests, there is quite a long section on pearl and cultured pearl, and on the chief methods for distinguishing between them. The book concludes with rather brief accounts of synthetic and imitation stones, and a description of cutting styles and methods.

The book is pleasantly bound and clearly printed on good paper : as already stated, it contains much useful information, but this is rather difficult to find. In a work which is so poorly sign-posted in the matter of chapters and sub-headings, a fuller index would have been helpful to the reader who wishes to use it for reference and not for bedside reading.

B. W. A.

BARTLETT (NORMAN). *The Pearl Seekers.* Andrew Melrose, London. pp. 312, illus. 15, and end-paper maps.

An authentic story of the Australasian pearling industry told as the result of investigating present and past conditions. The book is full of tales of the adventures of many of the early pearl fishers, and its appeal to the gemmologist who is seeking new information about the pearl itself is somewhat limited. The author vividly describes a typical day of pearl seeking and emphasizes the hard work and anxieties connected with the industry. He also discusses the economical and labour problems that confront the Australian fishers to-day, including that of making satisfactory arrangements with the Japanese over fishing rights.

Four types of shell maintain Australia's shelling industry : *Pinctada maxima, Pinctada margaritifera, Pinctada radiata* and a non-pearl-bearing *Trochus* (*Rochia*) *Nilotious*, which is used for poorer-quality buttons. The better pearls are found in *P. maxima*, which inhabits deeper and therefore more difficult-to-fish water. Maturity of the oyster is at two years and it may live until it is ten years old. *P. margaritifera* lives in shallower waters. It is the shell of the oysters, rather than the pearls that they may produce, that is the important part of the industry.

The Australians are interested in pearl culture in the Torres Straits area, but the author states that the Japanese are producing glass beads coated with iridescent essence at a value almost equal to the export trade in cultured pearls and they claim that " only experts can distinguish these pearls from real or cultured pearls." This new trend has apparently dislodged K. Mikimoto from his hitherto unchallenged eminence in the pearl industry.

Mr. Bartlett's book is most readable and, although it is filled with drama and adventure, it is undoubtedly a gemmologist's *divertissement* and should take its place on the bookshelves along with Murphy's " They Struck Opal," Rosenthal's " Here are Diamonds," and Rainier's " Green Fire."

S.P.

TERTSCH (H.). *Die stereographische Projektion in der Kristallkunde.* Wiesbaden (Verlag für angewandte Wissenschaften) 1954. iv + 122 pp., 71 figs.

The stereographic projection is an indispensible aid in the detailed study of crystals, both for crystallographic computations and in the treatment of the physical properties. This detailed little treatise is reproduced from typewritten copy by a photolithographic process which has successfully reproduced some very complicated diagrams, though a larger scale might have been chosen with advantage. Little is said of the history of the projection ; after brief mention of earlier works the author provides a very detailed explanation of the construction and application of the S.P. under chapter headings : I.—Elements and chief properties of the S.P. (10 pp.). II.—Basic properties of the S.P. (14 pp.). III.—Graphical crystal computations by the S.P. (34 pp.). IV.—Crystal drawing by means of the S.P. (44 pp.). V.—Application of the S.P. in crystallographical research (13 pp.).

The first chapters give very full details of the constructions so widely used in crystallography. The last discusses the use of S.P. in crystal optics, recognition of the crystal system, computation of extinction angles, axial angles, and universal stage procedures (in a very brief outline with references to Berek, Reinhard, etc.).

A.F.H.

ASSOCIATION NOTICES

COUNCIL MEETING

A meeting of the Council of the Association was held at 19/25 Gutter Lane, London, E.C.2, on Wednesday, 26th May, 1954, at 4.30 p.m. Mr. F. H. Knowles-Brown presided.

The following were elected to membership :—

FELLOWSHIP : Laurence F. Dunne. Northampton (D.1929).
PROBATIONARY : Bernard R. Worth. Leicester.
ORDINARY : Dennis Bradshaw. London.
Alexander M. Ramsay. Glasgow.
Howard M. Vaughan. Ross-on-Wye.
Richard D. Buttermore. U.S.A.

The Council received details of the plan of the major trade organizations occupying offices in 19/25 Gutter Lane to move to other offices during 1955, and they accepted proposals of the National Association of Goldsmiths concerning accommodation for the Association.

A matter discussed at length by the Council was the varying and often disappointing standard of education of some of the students attending gemmological classes. In some cases it was felt that the student attended because his employer had told him to and that a reason for a promising student suddenly to become disappointing was concerned with deferment of National Service. As the classes in gemmology came under the jurisdiction of local education authorities the matter could not be dealt with by the Association.

Arrangements were made for the presentation of awards gained in the 1954 examinations to be held on 20th October.

The Council also heard of the bequest to the Association of the collection of gemstones of the late Mrs. Rose Meisl, F.G.A. It was her wish that the Association should have her collection and the Council, in recording their deep gratitude for the gift, decided to maintain the stones as the "Rose Meisl Collection" and use them for educational work.

TALKS BY MEMBERS

Penn, L. : "Pearls." Birmingham Microscopical Society, 6th January.

Blythe, G. : "Gemstones." Young Wives Group, Thorpe Bay, 11th February : Southend Inner Wheel, 5th April.

Leak, F. E. : "The science of jewellery." Knowle West Contact Club, 23rd February ; Bristol International Club, 10th March ; Westbury Park Townswomen's Club, Bristol, 13th April.

McKenzie, I. : " Identification of gems." W. of Scotland Branch of the British Horological Institute, Glasgow, 24th February.

Anderson, B. W. : " Gem testing without instruments." Bristol and West of England Jewellers' Association, 8th April.

Warren, Kathleen : " Gemstones." Orpington Young Conservatives, 26th April.

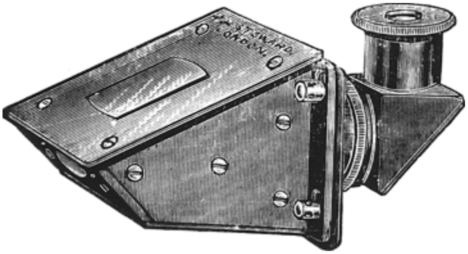
Webster, R. : " Precious Stones." Hillingdon Young Conservatives, Uxbridge, 13th May.

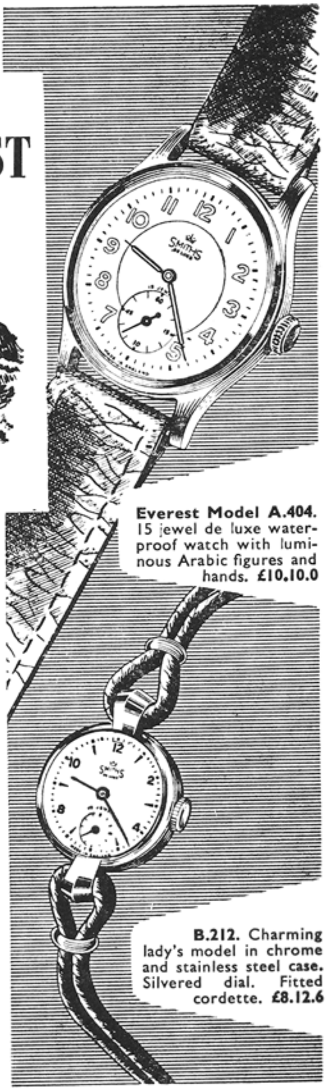
OVERSEAS VISITOR

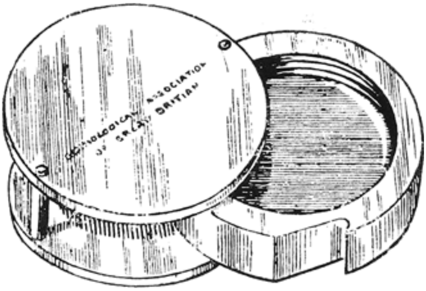
In April the Association received a visit from Barnett C. Helzberg, Chairman of the Board of Directors of the Diamond Council of America. He is also a member of the Council of the American National Retail Jewellers' Association and the Jewellery Industry Council.

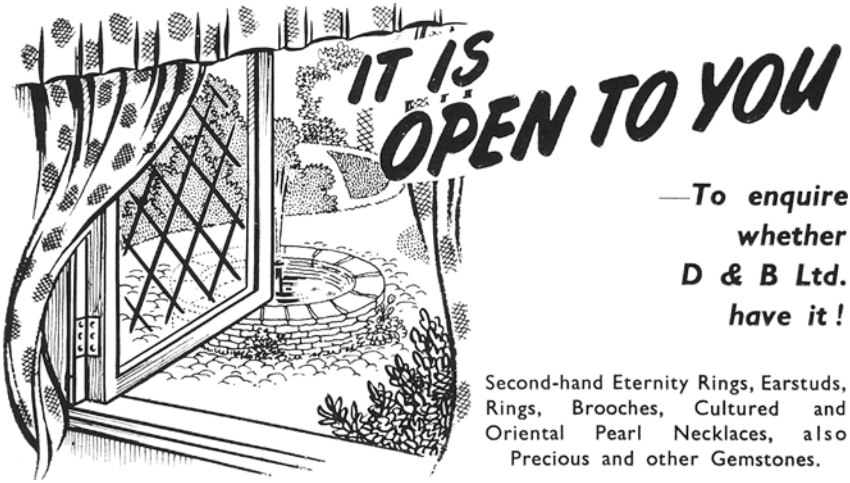
NATURAL HISTORY MUSEUM

The staff of the Mineral Department of the British Museum (Natural History) will be giving talks in the Mineral Gallery of the Museum each Saturday, at 3.15 p.m. Some of the talks already given have included " Minerals and metals of the Ancients," " Gem minerals " and " Building stones," and members of the Association who are able to visit the Museum on a Saturday afternoon will find other talks of equal interest.





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