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ASSOCIATION
OF GREAT BRITAIN



GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
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A 70th ANNIVERSARY TRIBUTE TO BASIL WILLIAM ANDERSON

THIS issue of the Journal is a tribute, by various gemmological friends and colleagues, to Basil William Anderson, who was 70 years of age on the 3rd July, 1971. Director of the Diamond, Pearl and Precious Stone Laboratory of the London Chamber of Commerce since 1925, Anderson is an outstanding internationally respected gemmologist, who, as research worker, author and lecturer, has made numerous major contributions to the study of gemmology. Apart from his work at the laboratory, where much of his enthusiasm has been passed on to his colleagues, Anderson, an eminently precise man, brought a fresh approach to gemmological teaching in Great Britain when he took charge of the classes at Chelsea Polytechnic in 1933. He perfected many new methods of gem testing, including the use of the hand-spectroscope. A dedicated gemmologist, he has been a friend and experienced and trusted counsellor



to many people in many parts of the world and has given a dignity to a subject which he has served with great distinction.

G.F.A.

NEW ANALYTICAL RESULTS OF THE INCLUSIONS IN SIAM RUBIES

By E. GÜBELIN, Ph.D., C.G., F.G.A.

IT was a thoughtful arrangement of Mr. B. W. Anderson to publish the 8th Edition of his highly instructive and invaluable book "Gem Testing" in the same year as he is celebrating his 70th Anniversary, in whose honour the present issue of the Journal has been printed.

In the 30 years of its existence the book has experienced an enormous enrichment as regards its text and the increasing number and quality of illustrations. All fresh knowledge and every progressive step in practical gemmology have been considered in each new edition and many new illustrations have replaced the out-dated ones.

As I have always been keenly dedicated to the inclusions in gemstones, I was always particularly attracted by the beautiful and tell-tale photomicrographs of inclusions in Mr. Anderson's book. Consequently when I received my copy of the 8th Edition I first examined the illustrations of inclusions to discover whether some new examples had been inserted and I was particularly pleased to notice that Fig. 74 on page 202 in the 7th Edition portraying those highly diagnostic features of inclusions in Siam rubies appeared again in illustration 11.7 on page 211 in the 8th Edition, accompanied by a new reference in the text reading "The most typical inclusions in Siam rubies are round and opaque, always surrounded by a roughly circular "feather" (see Fig. 11.7); when these are small, careful examination is needed to differentiate them from the bubbles seen in synthetic stones". Indeed, these characteristic inclusions, consisting of a mineral surrounded by a halo of liquid droplets, are so unique of Siam rubies that every ruby containing this kind of inclusion may rightly be acknowledged as a ruby from Thailand.

During the course of the last 30 years I have examined many thousands of Siam rubies and have repeatedly encountered these local peculiarities. In a ratio of 5 to 8 out of 10 Siam rubies are earmarked with this typical feature. At an early stage my interest in their nature and appearance was aroused. It was easily possible to notice different aspects under a microscope but proved impossible

to determine their nature by orthodox gemmological tests. The flatness of the liquid halos is very conspicuous and was referred to by other authors. In fact they differ by this characteristic from the undulated ordinary healing fissures. Careful examination displays that the liquid pools with their accompanying mineral grains are usually lying flat with a twin—or parting—plane. When a great number of these characteristic inclusions are present in a Siam ruby they are often lined up in a row, vertical or inclined against twin—or parting—planes, thus being separated from each other by the individual lamellae. In transmitted light of the ordinary light microscope the mineral grains appear black and opaque. In dark field illumination it is possible to differentiate three different appearances. Some of the grains are black with a strong metallic lustre, others show a yellow or brownish to brown-red colour with a frosted surface, while the third kind is transparent and rather looks like negative crystals. While some of the brown and brown-red frosted mineral grains seem to have a crystal form of the rhombododecahedron, most of the others seem to prefer a pseudo-hexagonal shape with a large basal pinakoid, medium size rhombohedra combined with very short prism faces, thus displaying the stumpy habit of rubies. Identification of the nature of these mineral grains was delayed until the advent of the electron microprobe. The first attempts with a few specimens containing unusually small mineral grains were not particularly encouraging in that no definite results could be obtained, although the chemical elements analysed suggested the presence of almandine garnet and pyrrhotine. Therefore, I decided to collect Siam rubies in Thailand where I could select samples with particularly large and well developed mineral inclusions. When I visited Bangkok last November in the course of a business trip, I concentrated my attention on Siam rubies of lower quality but possessing their well known internal features. Meanwhile, I have subjected these Siam rubies to an electron microprobe analysis which yielded interesting results, of which I wish to report hereafter. In order to prepare gemstones for a microprobe examination of their inclusions, the stones have to be cut down, commencing from the nearest facet, so that the mineral inclusion becomes exposed. As a result of cutting down the facet until the inclusion became flush to the surface it was apparent that a great number of the transparent and colourless inclusions were actually negative crystals. Whether

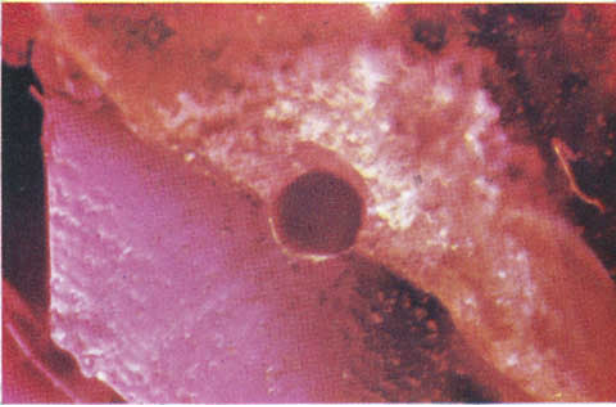


FIG. 1. Hexagonal apatite crystal with stumpy habit at the edge of a large liquid feather. 50 ×

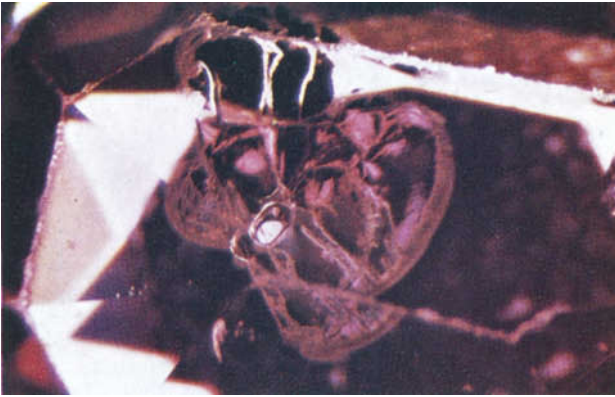


FIG. 2. Xenomorphous, brownish grain of almandine garnet circumflooded by a large film of reticulated fluid. 20 ×.

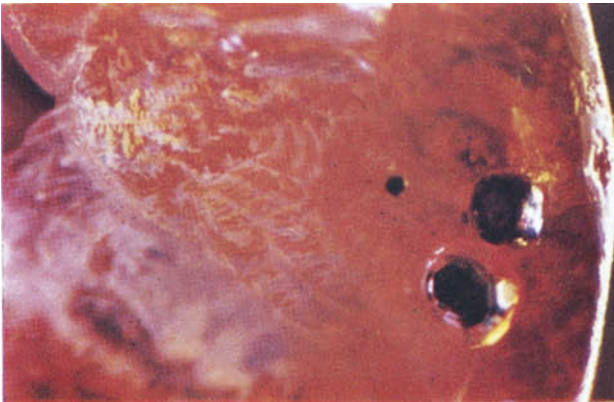


FIG. 4. Black, hexagonal crystals of pyrrhotine with high metallic lustre, and surrounded by large fluid pools with dendritic pattern. 32 ×.

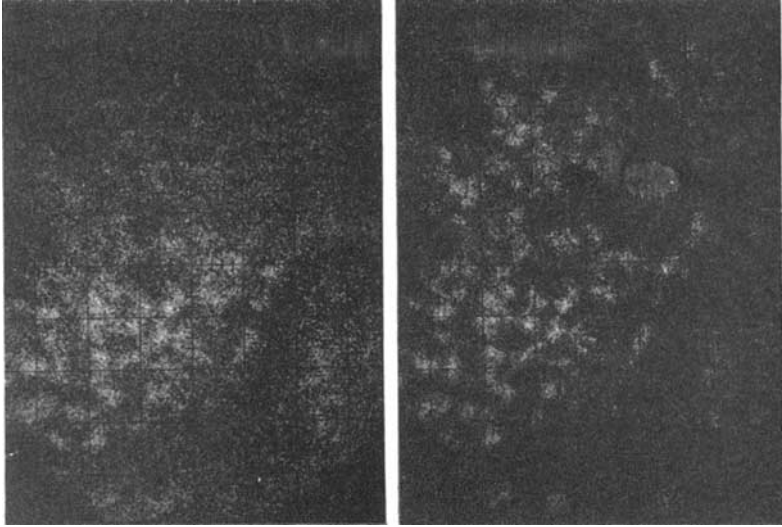


FIG. 8a. Microscanogram of the apatite of Fig. 1 showing the distribution of calcium ($K\alpha$).
500 \times .

FIG. 8b. Microscanogram showing the distribution of phosphorus ($K\alpha$). 500 \times .

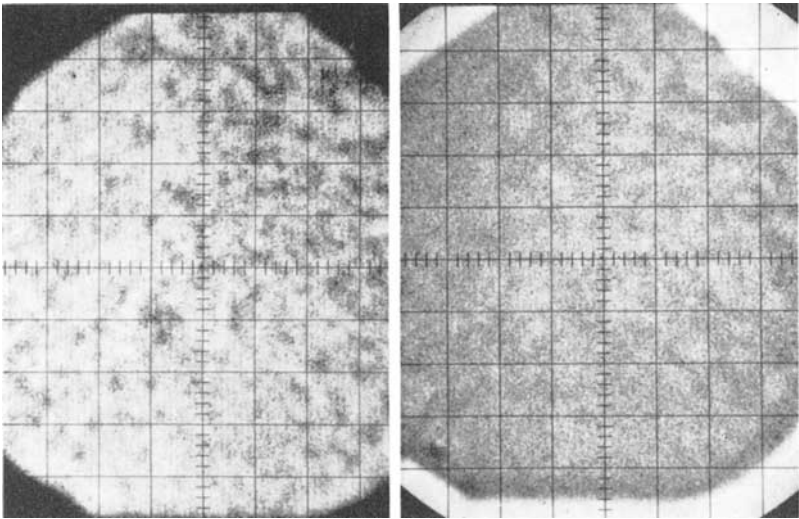


FIG. 9a. Microscanogram of the almandine of Fig. 2 revealing the distribution of the iron ($K\alpha$).
500 \times .

FIG. 9b. Microscanogram of the almandine of Fig. 2 indicating the distribution of aluminium ($K\alpha$).
500 \times .

they had been filled with a gas or liquid could not be determined because whatever filling might have been present was lost in the process of cutting. Some of them were lined with some yellowish, dirty looking substance. Yellow and brown inclusions revealed a lower degree of surface reflection than the ruby, while their colours remained unchanged. The black mineral grains often showed a rough surface and in many cases they would partly break out. Whenever their surface took a good polish it showed a high metallic lustre. It was also apparent that the black grains were much softer than the host gem.

Under the electron microprobe the yellowish to yellow guest crystals which at times displayed hexagonal shapes reacted to the calcium and phosphorus test; therefore these crystal inclusions were found to be apatite, with a composition of $[\text{Ca}_5\text{F}(\text{PO}_4)_3]$. (Compare Figs. 1 and 8a and 8b).

The brown to reddish-brown mineral inclusions which are very often rounded, but sometimes have a rhombododecahedral shape, proved to be composed of iron, aluminium and silica, thus marking the inclusion to be almandine $[\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3]$. (Compare Figs. 2 as well as 9a, 9b and 9c). Both apatite and almandine might have been pre-existent minerals when they were embraced by the development of the ruby.

FIG. 9c. Microscanogram of the almandine of Fig. 2 portraying the distribution of the silicium ($\text{K}\alpha$). 500 \times .

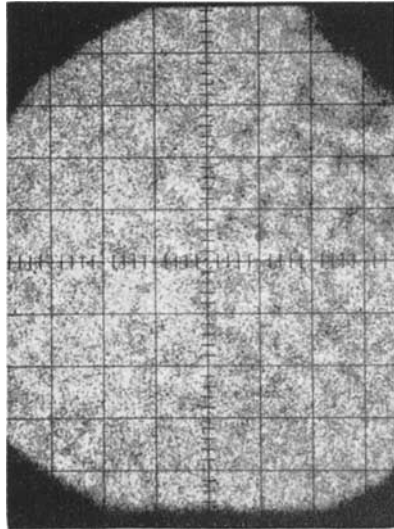
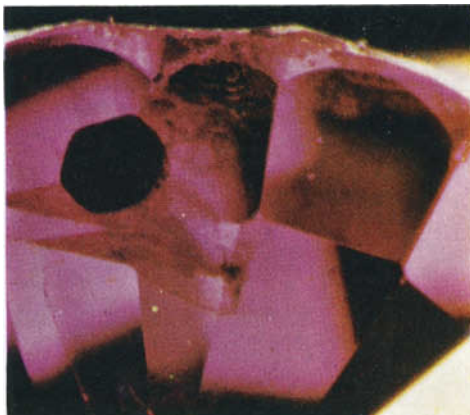


FIG. 3. Black pyrrhotine grain of hexagonal shape surrounded by multiple fluid feather. 20 ×.



The black inclusions proved to consist mainly of iron and sulphur which indicated pyrrhotine—the formula of which is FeS but may vary from Fe_5S_6 to $\text{Fe}_{16}\text{S}_{17}$ (refer to Figs. 3, 4, 10b and 10d).

Pyrrhotine occurs in large quantities associated with basic igneous rocks from which it has been segregated by some form of magmatic differentiation. It is commonly associated with chalcopyrite, pentlandite, pyrite and magnetite. The traces of nickel usually found in combination with pyrrhotine is most probably due to dissolved grains of pentlandite $[(\text{Ni}, \text{Fe})_9\text{S}_8]$, which is a rather common combination. One analysis yielded particularly interesting results; it was found that a pyrrhotine grain also intermixed with a small amount of nickel was completely encased by an envelope of chalcopyrite $[\text{CuFeS}_2]$, which was corroborated by the presence of iron, copper and sulphur (see Figs. 5 and 10a, 10c and 10d). Chalcopyrite is a very common copper ore which occurs in metalliferous lodes and in vugs in gneiss and crystalline schists as well as in contact metamorphic rocks. It is closely associated with pyrrhotine and then forms the mixture of chalcopyrrhotine, $[\text{CuFeS}_2 - \text{FeS}]$ assuming the name of cubanite.

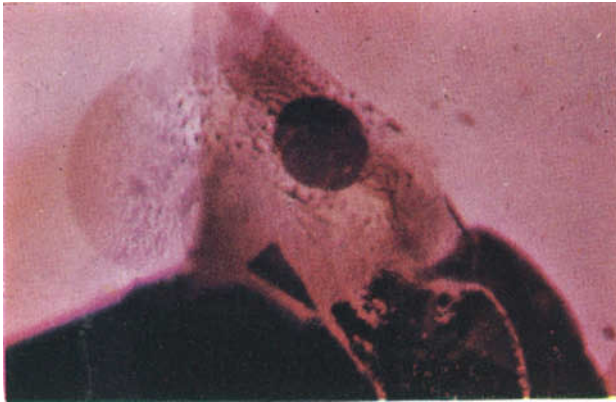


FIG. 5. Black rounded grain of pyrrhotite inter-mixed with minute grains of pentlandite and surrounded by a corona of chalcopyrite. 20 \times .



FIG. 6. Clear, transparent, rounded grains of plagioclase, which might easily be mistaken for gas bubbles when observed in an otherwise pure Siam ruby. 16 \times .



FIG. 7. Transparent, slightly greenish crystal of diopside, surrounded by multiple tension cracks. 16 \times .

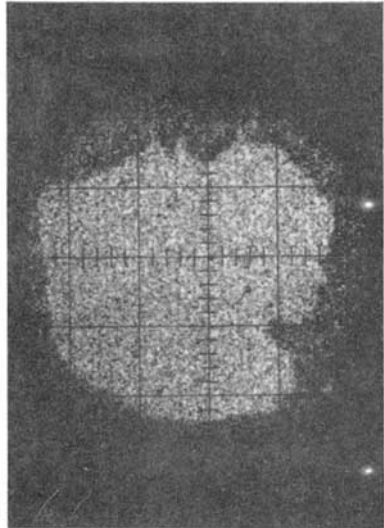
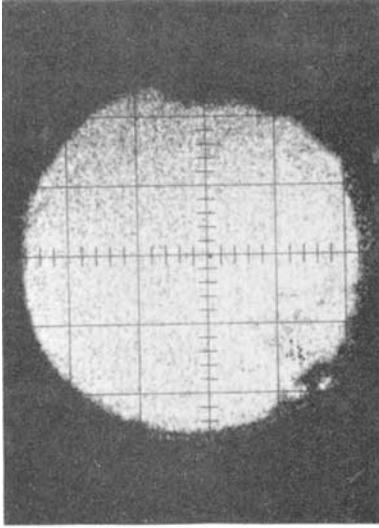


FIG. 10a. Microscanogram of the sulphide ores of Fig. 5 disclosing the distribution of the iron ($K\alpha$). 250 \times .

FIG. 10b. Microscanogram of the sulphide ores of Fig. 5 manifesting the nickel content of the pentlandite grains interspersed through the pyrrhotine ($K\alpha$). 250 \times .

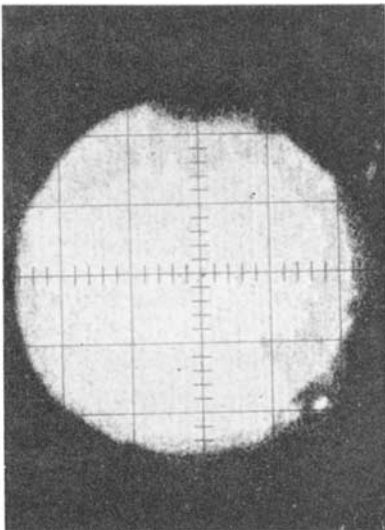
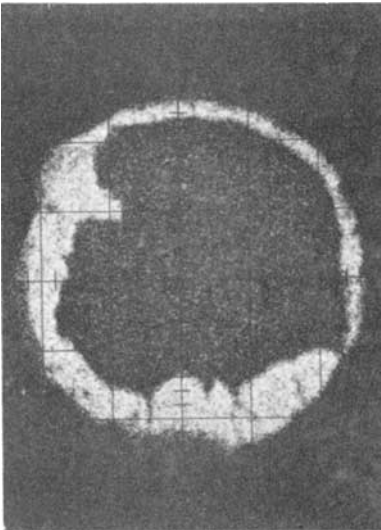


FIG. 10c. Microscanogram of the chalcopyrite corona of Fig. 5 betraying the distribution of the copper ($K\alpha$). 250 \times .

FIG. 10d. Microscanogram of the sulphide ores of Fig. 5 depicting the sulphur content ($K\alpha$). 250 \times .

These iron, nickel and copper sulphides enclosed in Siam rubies and forming the highly characteristic feature of their internal paragenesis are certainly of syngenetic origin with the host gem. Apart from these mineral inclusions which are always in contact with more or less circular fluid splashes, two other types of minerals have been found and analysed. They do not seem to have any relationship to the fluid pools of the other guest minerals, but they are distinctive because they are colourless and transparent. The smaller ones of these, which quite often appear as round grains and as such might easily be mistaken for spherical gas bubbles, produced readings on the electron microprobe which indicated the presence of calcium, sodium, aluminium and silica with traces of potassium, magnesium and iron. Consequently these small transparent inclusions were judged to be plagioclase, whereas a larger, slightly greenish and rather well shaped crystal was identified as diopside [$\text{CaMg}(\text{Si}_2\text{O}_6)$] by revealing calcium, magnesium and silica with traces only of iron and sodium when examined with the microprobe. From this enclosed dioxide crystal, which was found in one case only, a score of tension cracks projected out into the body of the ruby.

Despite these identifying verdicts of the inclusions it is still rather difficult to present a plausible explanation concerning their mode of formation. Some mineralogists believe that the foreign mineral grains are either of pre-existent or of syngenetic primary heterogeneous origin and that their capture within the body of the host gem caused the latter to develop cracks. These started healing immediately afterwards—a process by which the flat hexagonal or otherwise polygonal platelets were created and which are considered to be healing islets formed around nucleation points. Other scientists suggest that the mineral grains crystallized from drops of alien fluid which happened to be “washed on” by convection currents and to be absorbed by the growth face during the intervals of interrupted growth. The flat film of liquid drops would then consist of the exhausted residual solution, left behind after the mineral grain had “sucked out” the constituent ingredients. Such reactions may readily be observed under the microscope in the course of microchemical spot-tests.

Personally, I do not favour the “healing theory” because I am convinced that the negative crystals and their filling substances,

as well as the fluid inclusions surrounding them are of syngenetic primary origin.

A growing crystal envelopes itself with a coat supersaturated with dissolved substances. The solubility of a crystal growing in its mother melt may increase on account of a chemical change of the mother liquor or also of alien solutions caused by impurities of some sort, so that a considerable supersaturation occurs in the middle or along the borders of the growth faces. The growth speed, which will be delayed by the physical and chemical absorption of the foreign substance on the crystal face, remains normal along the edges of the faces, yet becomes blocked in its centre. This engenders a central vacancy whose size depends upon value and degree of the minimum of the supersaturation. Immediately after a sharp drop of the temperature the vacancy develops a large basal plane, which is the beginning of a negative crystal. The size of the cavity diminishes as the general concentration of the solution decreases, when the crystal is growing in constant temperature in an enclosed *locus nascendi*. This process results in the formation of negative crystals, whose shape need not necessarily be ideal, as well as in the coating of growth faces by liquid feathers, which are characterized by net-like ramifications and resemble the well-known secondary liquid feathers. However, they distinguish themselves from secondary fluid inclusions in that they are flat and level with growth faces.

Other impurities are capable of lowering the solubility of the crystal substance, so that the maximum of the supersaturation becomes situated in the centre of the growing crystal face, and eventually a precipitation takes place in the immediate neighbourhood of the crystal face. The precipitated substances may become enclosed by the growing crystal later on. If the specific absorption on the growing face predominates over the diffusion, then the absorbed layer is marked by groups of growing islets along preferred directions, which are embraced by a reticulation of liquid channels overlaying the growth plane. This, in my opinion, seems to be the explanation of the formation of the fluid sprinkles and their accompanying negative crystals which are filled with gas, liquid or solid substances. The magmatic, hydromagmatic, pneumatolytic and hydrothermal processes of mineral formation

possess numerous faculties of supersaturations and undercoolings, so that we are bound to consider disturbed gradients of equilibrium. The evolution of primary cavities and fluid inclusions in minerals corresponds directly with a disturbed physical-chemical equilibrium.

Wherever the ruby is mined in Thailand, be it at Bang-Kha-Cha, Klong Van, Bo Vien or Bang Thum, it is discovered in deposits of coarsely grained alluvial gravel banks, which have developed from weathered basalts. These are generally fine-grained, dark-coloured igneous rocks primarily composed of calcic plagioclase and pyroxene, with or without olivine.

Apatite and magnetite are almost always present as accessories. Although Siam rubies are now found in widely scattered alluvial placers, the consistency of the inclusions described above yields evidence that the rubies were all formed under the same geological conditions either in one place or in closely adjacent deposits, which so distinctly earmarked their precious product. The presence of apatite, diopside and olivine (the latter was found in one single case only) among the guest minerals might suggest the same process of formation as in Burma. However, the complete lack of calcite, spinel and exsolved rutile (in the form of "silk") seems to indicate an entirely different combination of chemical elements in the mother melt. The composition of the present alluvial deposits and the sulphide inclusions of the Siam rubies hint at the possibility that the rubies are derivatives of interactions in contact zones between crystalline schists or granitic pegmatites and basaltic country rocks, which eons ago formed the higher mountain regions between the broad valleys of the Menam and Mekong rivers, a part of the world which not only today but also hundreds of millions of years ago experienced gigantic upheavals.

A FEW OBSERVATIONS RELATED TO SYNTHETIC EMERALD

By F. DUYK

WHEN synthetic emerald is observed under the microscope, one usually proceeds to the examination of its internal characters. The analysis of the shapes and pattern of the internal structure is then made the chief object of the examination.

I discovered that it was just as interesting to make a careful study of the surface of *uncut* crystals. In this case cutting has not taken away peculiarities of construction which are therefore clearly seen and their careful examination is very interesting.

The examination of a very beautiful crystal of synthetic emerald manufactured by Gilson has, in the first instance, under preliminary gemmological tests, given the following results, which are normal:

R.I.: 1.559–1.565 D.R.: 0.006 S.G.: 2.66

Absorption spectrum lines at 6750, 6400 and 5650Å

Fluorescence: red under long U.V.

Chelsea filter: bright red.

The classic internal examination under the microscope shows in addition to outlined formations and small liquid channels, which

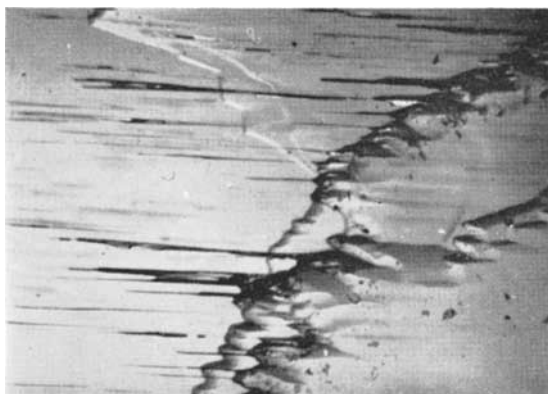


FIG. 1.

have become classic, hollow channels containing not only chromiferous liquid but also crystallites and gas bubbles (Fig. 1). It can be observed that in these channels matter is present in its three physical states: liquid, solid and gaseous. This clearly constitutes the presence in synthetic emerald of *three-phase inclusions*.

This first discovery encouraged me to recommence a study to which in the past I had already devoted some time, namely that of the morphology of the surface of rough crystals.

A first observation clearly showed that the hollow channels were the result of morphological decreases. It happens that when the growth of the crystal thins down, little by little, probably owing to a decrease in the quantity of crystallizable elements, figures or patterns become detectable similar to what formerly used to be termed "Hauy's Vicinal Faces". Active elements immobilizing themselves during the process of crystallization are responsible for the formation of the surfaces. Is it not natural then that elements taking no active part in that process such as water and gas, elements of a fluid nature, find no outlet for escaping and form those channels where one meets crystallites, water and bubbles? (Figs. 2 and 3).

These crystallites present in the hollow channels may have been formed out of non-assimilated silica, as their examination under crossed nicols shows a clear birefringence and some of them also display a fluorescence readily detectable under U.V.

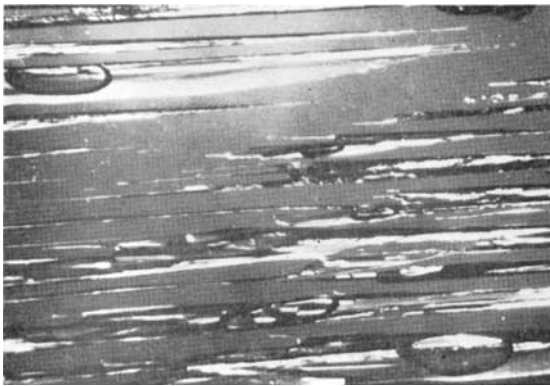


FIG. 2.

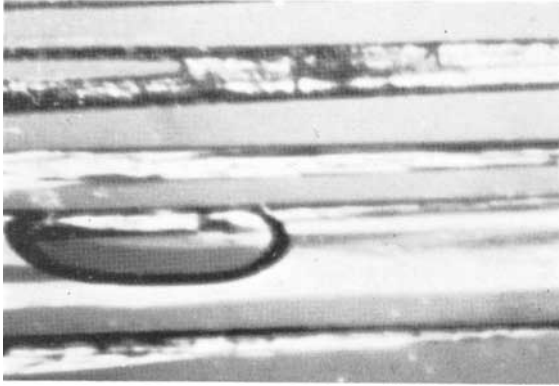


FIG. 3.

Finally, the last photograph shows growths at angles of 90° on the face P, which are quite normal but interesting to observe on account of their regularity.

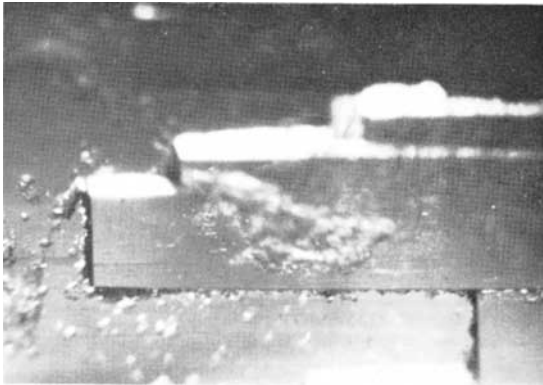


FIG. 4.

SOME RARE MATERIALS

By W. F. EPPLER

Chiastolite is an opaque and massive variety of andalusite which contains a black micaceous schist in the form of a cross or a square or both. Fig. 1 is a thin section of such a "cross-stone", as it was sometimes named. It shows a dark and fine-grained borderline consisting of mica. This line is accompanied on each side by elongated fibres of andalusite, which are followed by grains of the same material of random orientation. They form the whitish-grey part of the stone. The arms of the black cross broaden towards the outer part of the stone and here the mica is much coarser, as shown in Fig. 2. The mica is a muscovite which is darkened by minute platelets of hematite, and biotite, altered in pennine, which is a chlorite. Besides this, an acid plagioclase is present.

To a certain extent, this structure is reminiscent of the trapiche emerald, with the difference that here are only four parts around the centre. As early as 1926, F. Bernauer⁽¹⁾ described the "triplet emeralds", as they were then named, and mentioned that their single parts are nothing else than "pyramids of growth" and he adds (in translation): ". . . just as with chiastolite". This explanation, given 45 years ago, is not easy to understand with respect to this particular kind of crystallization.

Amblygonite, a well known ore of lithium, was first mentioned as a gemstone by A. Schroeder in 1953⁽²⁾. J. E. Schunk and N. Deane⁽³⁾ describe the inclusions in amblygonite as "a white mossy texture plus some of a bright green colour", while E. Gübelin⁽⁴⁾ found the inclusions to be parallel or banded clouds which consist of many fine cracks and very small brown and black coloured particles. These descriptions in mind, it was a great surprise to observe in a well coloured amblygonite threadlike inclusions as they are exhibited in Fig. 3. They all run in the same direction, but they are not parallel to each other and one or the other of them is forked. It may be possible that they consist of goethite ($\alpha\text{-FeOOH}$), as similar fibres in topaz have been found to be this kind of iron-hydroxide. Besides these inclusions, a few "clouds" are also present in the stone.

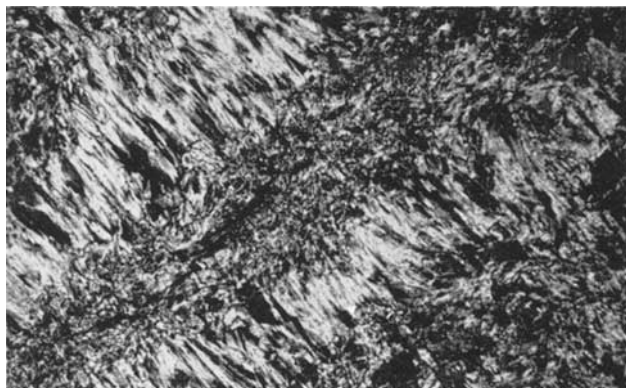


FIG. 1. Chialstolite from U.S.A. Fibres of andalusite; crossed polaroids, thin section. 65 \times .

FIG. 2. Chialstolite from U.S.A. Coarse grained mica crystals, forming the black parts of the stone; thin section. 65 \times .

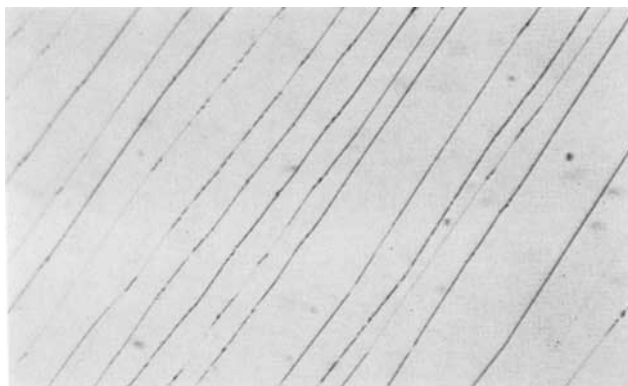


FIG. 3. Amblyonite with threadlike inclusions. 65 \times .

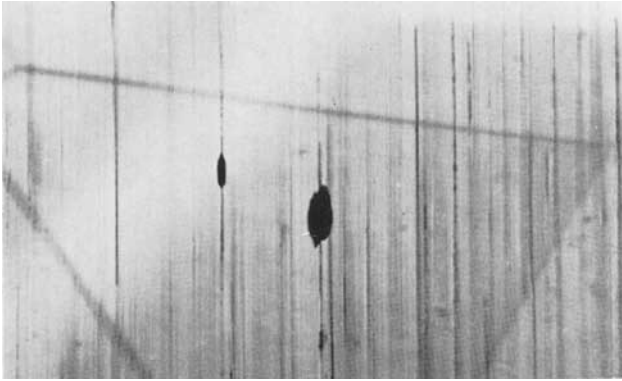


FIG. 4. Dark brown enstatite with fine needles. 65 \times .

FIG. 5. Blue-quartz with tiny fibres of crocidolite. 65 \times .

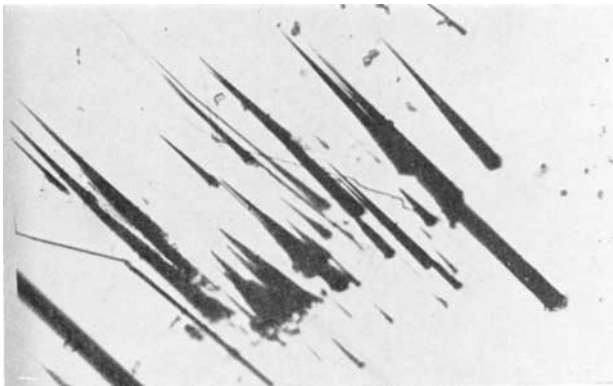
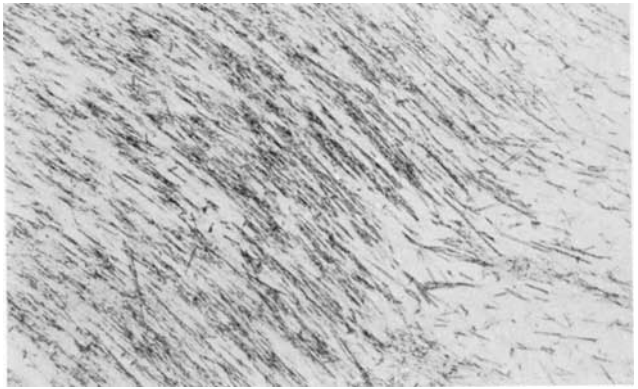


FIG. 6. Bright green grossular with cuneiform tubes of growth. 65 \times .

Enstatite of a brown colour, reddish-brown to greenish-brown and of transparent nature was recorded for the first time in 1953 by R. K. Mitchell⁽⁵⁾. In 1967, a star-enstatite was described⁽⁶⁾ with inclusions of very fine and tiny crystal needles which most probably are rutile. The crystal needles represented in Fig. 4 are embedded in a clear and transparent enstatite of a dark brown, smoky-quartz-like colour with a strong pleochroism. The nature of the needles is not yet known, but they run parallel to each other and are therefore strictly orientated. The stone of 3.5 carats was perfectly fashioned in a trap cut and surprised by its relatively high lustre.

The second edition of M. Bauer's "Edelsteinkunde", 1909, p. 600, gives the description of "sapphire-quartz" which runs as follows (in translation): ". . . it is a crystallized quartz, containing a great number of needles or fibres of a blue substance, most probably belonging to the mineral crocidolite. It occurs in veins in the gypsum of the Gypsumhill at Mooseck near Golling in the district of Salzburg". Just by chance, the author obtained a sample of this "historical" occurrence in Austria. In a thin section prepared of it, a multitude of the fine and tiny crystals of blue crocidolite (Fig. 5) can be seen.

The term "sapphire-quartz" is confusing and not correct, while the other names "lazurquartz" and "siderite" are no more in use, fortunately. So, "blue-quartz" seems to be the best, as it names, what it is, a blue-coloured quartz. By the way, it is not a crystallized rock crystal, but a massive quartz consisting of irregular grains of random orientation, a formation which characterizes the "quartzites". The stone is mentioned here, because not long ago a blue-quartz from another locality appeared on the market. This material has great and beautiful bright blue spots, which own their colour also to needles or fibres of blue crocidolite.

Transparent *green grossular* was first recorded by B. W. Anderson⁽⁷⁾ in 1966. The stones have interesting inclusions, "a large and well-developed crystal", possibly of actinolite, and in others liquid "feathers rather in the spessartite manner". They had been sent from Pakistan. Later on, a transparent yellowish-green and an emerald green grossular, both from Tanzania, have been described in the literature^(8,9), but without a hint on any kind of inclusions.

Nearly a year ago, the author received two transparent grossulars, originated from Tanzania, the values of which agreed

with those given in the mentioned publications. The colour is a lovely green, a bright green which is very near to the emerald-green. One of the stones has an enclosure of a rounded zircon, while the other contains numerous and cuneiformed tubes of growth, a group of which is exhibited in Fig. 6. They run parallel to each other and indicate the direction of growth.

Silica Glass was found by L. J. Spencer in the Libyan desert in 1932. It occurs in great lumps of a poor greenish-yellowish colour and consists of 97.6% silica. It is not very attractive, and it is only mentioned with regard to the irregularly formed gas inclusions (Fig. 7). They indicate the natural origin of the material, which formerly was doubted sometimes. In artificial glass, the gas bubbles form balls or elongated tubes which are mostly pointed on both ends.

A small but well formed Phoenician vase consists of a colourless and, of course, artificial glass. It is estimated to have been made in 300BC or still earlier. Its surface is opaque and has a fine lustre which resembles the same optical effect of pearls or of mother-of-pearl. It is obvious that this is the result of a weathering. The disintegrated surface consists of small scales which can be easily taken off. When examining one of them with the microscope, it was found that such a scale has several layers, each of which is very thin. The Fig. 8 exhibits two of them which easily can be recognized. Each of the "films" is cracked in irregular pieces, by which many little fissures have been produced. The thin films and the fissures are responsible for an effect of interference which is the reason of the iridescence. In fact, we have in this case a perfect analogy to the lustre of pearls and of mother-of-pearl. An explanation is not difficult.

It is certain, that the vase of glass was embedded in the earth for a very long time, perhaps much longer than 1,000 years. During this time, the easily soluble parts of the glass (the alkali- and the earth alkali-components) could be removed by the humidity of the soil. The remainder was permanently enriched with silica which, in the course of time, started to crystallize. With this process, a reduction of the volume was combined and it produced the layers and the cracks. In polarized light, most of the particles remain dark, which is in conformity with the amorphous state of glass. Other particles are rounded with a convex surface. They

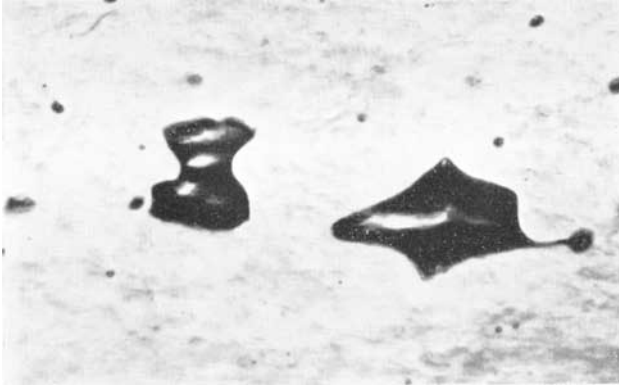


FIG. 7. Silica Glass with irregularly formed gas inclusions. 65 \times .

FIG. 8. The weathered surface of an artificial glass of Phoenician age. 65 \times .

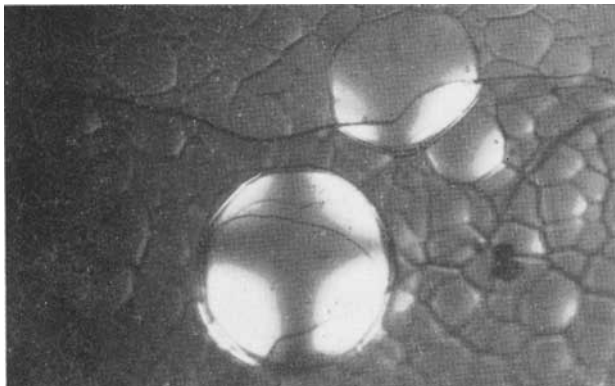
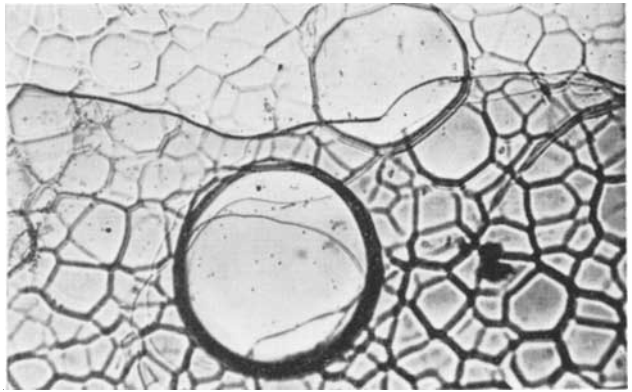


FIG. 9. Same as Fig. 8, but crossed polarizers. 65 \times .

exhibit a dark cross—like the interference figure of a uniaxial crystal (Fig. 9). When applying the mica plate of the red of the first order, the four sectors of the interference figure appear in a distribution of colours in a manner which is characteristic for a crystal with a negative optical character. It can be concluded, that the silica is crystallized, but not as quartz, which is positive in character and has an interference figure with a “hole” in its centre. It is rather an optical negative form of silica as it is represented by crystalalite.

This nice old phial is by far not a gem material, but in every collection it would be estimated without any doubt as a most valuable item.

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NEW CLASSIFICATION OF GEMSTONE COLOURS

By K. F. CHUDOBA

IN the past the colour or absence of colour of gems was always of the utmost importance in their determination. Even today great importance is attached to this obvious property because very often an expert can recognize a gem by its colour or absence of colour. However, such methods of determination are questionable. For this reason one has tried for centuries—apart from determining other physical and chemical properties—to find the natural causes of colouring and to classify these scientifically so as to aid determination.

The most important starting observations and the then following scientific advances which have been found in this connexion are

summarized in tabular form. Metallic colours are divided from the non-metallic ones and in the latter one finds manifold gem colours as well as absence of colour.

In the case of colourless gems examination of colour-causes soon showed that they can easily appear coloured by inclusions of tiny foreign bodies (pigments)⁽¹⁰⁾, as for instance green aventurine (quartz with green mica inclusions) and blue quartz (by refraction of the light caused by very fine rutile needles). These instances of the basis of colour caused J. W. Baumer⁽²⁾, in 1763/64, to remark that “the usual colours of gems are most probably caused by the admixture of metallic parts”. With hindsight one can say that this hypothesis has to some extent been proved.

In those admixtures, whose existence was guessed but could not be seen optically, examinations and determinations were not always successful and the chemical methods which had been developed in the meantime could not always determine the minimal quantities of the colour carrier—the trace elements. Only the systematic use of the spectroscope, which had been developed for gemstone examination, opened the way for a quick and reliable determination.

Most important for this method was the knowledge that certain gem types showed certain characteristic absorption spectra, i.e. that the absorption lines or bands are always to be found in the same place. Similar spectra show the relationship of certain gem types and it follows that they have similar colour pigmentation.

The spectroscopic examination and determination of gems forms the nucleus of many publications of B. W. Anderson, whose work is so well known today. In past decades he has published many works in this field, especially *Gem Testing*, now in its 8th edition⁽¹⁾. Anderson proved many times that in colourless gems with an undisturbed lattice a colourless ion can be partially replaced by a colouring trace element (isomorphous replacement by a chemical element). In this way a colourless—achromatic—stone is coloured by the addition of a colouring foreign element; this results in allochromatic gems⁽¹²⁾.

The colouring matters (chromophores) are of the greatest importance for synthetic gems, as the synthesis is achieved by their addition to colourless material. This results in the repeatable production of stones with a natural colour effect.

In order to classify gem colours it was of utmost importance to list apart from the allochromatic gems those stones which are never colourless and show a characteristic colour caused by their chemical composition in an undisturbed lattice. These colours are caused by a pure chemical substance and they are idiochromatic⁽¹²⁾. Gems of this type include malachite (green), lapis-lazuli and azurite (blue).

It seems to be important to classify the idiochromatic gem colours together with the achromatic ones and not together with the allochromatic ones, which is often done. The latter are colourless stones coloured by foreign elements (see table).

It also seems to be of importance for the classification of causes of colouration to underline the "structure-sensitive" property, that is to consider the lattice structure and its peculiar properties in this respect.

The most obvious example of this seems to be the dimorphous carbon (C), which has a cubic lattice as diamond and a hexagonal one as graphite, the first modification being mainly colourless, the second steel-grey.

According to C. W. Correns⁽⁵⁾ this structure-sensitivity relates to typical lattices of certain gemstones which can show structural irregularities, while Tertsch⁽¹¹⁾ considers that the lattice is in a labile equilibrium; this explanation is based on electro-magnetic light theories and shows how the lattice can be destroyed by treatment with x-, cathode-, radium-, electron- and neutron- and other rays. The disturbed part of the lattice then forms the colour centre, so that minimal disturbances of the lattice can cause colourations, de-colourations and colour alterations, which have to be classified as allochromatic colours in a gem classification (K. Przibram⁽⁹⁾).

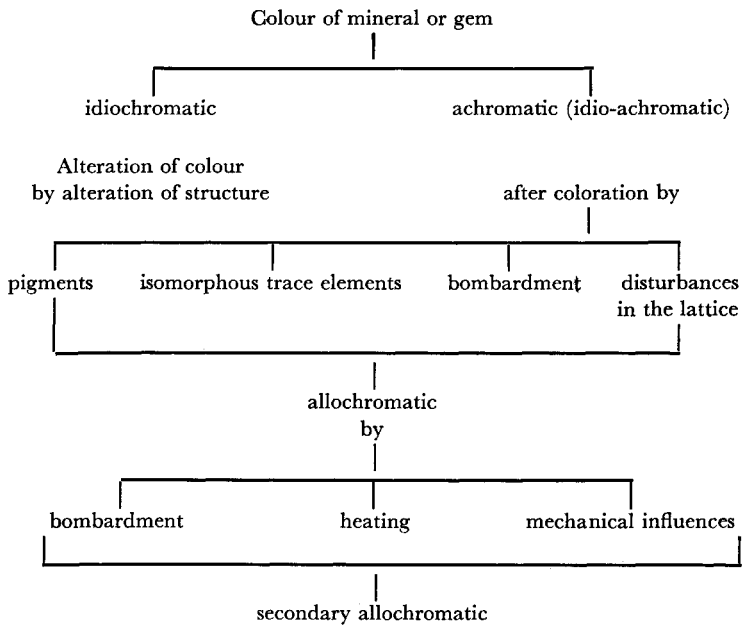
Occasionally the disturbance in the lattice causing a new allochromatic colour can also be based on an interlateral addition of another element, while usually the trace elements substitute ions of the normal lattice.

When classifying the gem colours one therefore has to consider the relationship between a lattice disturbance and the bombardment colour (see Table, page 265). Examples of this are the two gems zircon⁽³⁾ and ekanite^(6,7); in these cases the disturbed arrangement of the lattice is re-formed (retrocrystallization) at the same time as the original colour is restored.

Results of bombardment have been published many times. Diamond is coloured green or blue⁽³⁾ by intensive electron bombardment. The cause of the blue colouration has been found to be the C-atoms, which are shot out of their position by the electrons, and the resulting empty place in the lattice (absence of the central tetrahedral C-atom)—at the same time other C-atoms are pushed into an intermediate position.

In the case of some gems the colour is not only caused by trace elements, but by additional bombardment, for instance in the case of amethyst and smoky quartz^(3, 4).

From the accompanying sketch it can be seen that the determination of the colour of the stone must be based on the condition of the lattice and it is important to establish whether the colour is caused by a "pure undisturbed lattice" or a "disturbed" lattice⁽¹⁰⁾. The structure-sensitive properties are only rarely taken into consideration when classifying the colour of gems; even if notice is taken of this important property their relationships are only mentioned without showing their genetic ties. The following table shows the classification of gem colours according to today's knowledge.



Idiochromatic gems alter their colour only together with their structure, i.e. pigments, trace elements or bombardments do not change the colour, as would be the case for allochromatic colours.

It should also be added further that a colour change can be created in primary allochromatic gems by bombardment, heat, etc.; in these cases the colour is changed or improved—this could be classified as secondary allochromatic colour. An example of this type is amethyst whose primary allochromatic colour violet is changed by heat into a secondary allochromatic colour, i.e. yellow.

To summarize the scientific colour determination of gem colours, one must underline that the basis is given by the colouring trace elements. With the help of these one can re-create the colour of natural gems. It is unfortunate, however, that, for instance in the case of the synthesis of corundums and spinels, various pigments can be added, thus imitating the colour of other gems; because of these “fancy” colours the trade now deals with “alexandrite-coloured synthetic corundums” or “aquamarine-coloured synthetic spinels”. This type of synthesis (not included in the table) shows a will to imitate, as the pigments colour the basic gems into gems of a different colour.

Thus colour forms less and less the basis for the determination of a gem mainly because allochromatic colours show their characteristics in various crystal structure problems. In the present classification these were included in certain limits and a purely qualitative sense.

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NEW OCCURRENCES OF GEM MINERALS IN AUSTRALIA

By R. O. CHALMERS, A.S.T.C., F.G.A.A.

with the permission of the Trustees of The Australian Museum, Sydney

NEPHRITE

Greenish grey nephrite, of no significance as an ornamental stone, was recorded as occurring between the ore bodies and the wall rock in gold mines at Lucknow, 6 miles south east of Orange in the Central Highlands of New South Wales. In part the country rock is serpentinite.

Nephrite in association with serpentinite was discovered in the early 1960's by Colin Moore. It is in fairly rugged country in Portion 13, Parish Ogunbil, County Parry, New South Wales, 25 miles east south east of Tamworth in the general area of Dungowan. It lies within the southern New England region of northern New South Wales. The first specimens were received by the Museum late in 1964.

In November 1970, the author accompanied Colin Moore to the site, but unfortunately no nephrite was seen *in situ*. It had been recovered from weathered serpentinite in the form of flattish slabs showing signs of shearing. Several stock piles of nephrite had been left when quarrying ceased but none of this remained on the occasion of my visit. The largest of this type of specimen in the Museum collection, presented by Mrs B. G. Amey, measures 16" by 12" and has a maximum thickness of 5". It weighs approximately 20lb.

Colin Moore has supplied me with the following information. The total quantity produced was 39 short tons, 32 in boulder form, the remainder in reef form. Approximately 22 tons were sent to Hong Kong. The largest single mass was 4½ tons. It is stated that much of this total consignment was of high quality and that various carved ornaments were made such as buddhas, animals, book-ends etc.

I have seen neither the raw material sent to Hong Kong nor the carved ornaments.

The colour ranges from dark green to dark bluish green. It is fine grained and takes quite a good polish.

Both macroscopic and microscopic comparisons were made with the best quality New Zealand nephrite type greenstone (pounamu) that occurs as waterworn boulders in the Teremakau and Arahura Rivers near Hokitika in the Westland Province of the South Island. The Dungowan material is translucent only in very thin slices. A slice 2.5 mm thick was an attractive deep green but not nearly so translucent as a slice from a New Zealand specimen 3.6 mm thick.

Turner (1936) in describing thin sections of the best quality New Zealand nephrite mentions the characteristic felted or interwoven structure of the tufted aggregates of minute tremolite fibres. The thin section examined (D: 41306) showed this structure. The more this structure is developed the tougher and harder nephrite is. Turner mentions gradations between the true nephrites and the semi-nephrites in which the tremolite is much more coarsely grained. The finer grained portions of semi-nephrites show the felted interwoven structure to some degree but there is also an abundance of sheaf like aggregates of relatively coarse-grained stout acicular prismatic crystals of tremolite, arranged in parallel form.

A thin section of the Dungowan nephrite (D: 41850) shows a marked degree of schistosity. Coarser aggregates of long tremolite fibres show mainly parallel structure with little interweaving. The rest of the section is extremely fine-grained and the minute slender fibres of tremolite show interlocking.

A third Australian nephrite occurrence was discovered in 1967. It is on the property of Mr. H. A. Schiller, Section 116, Hundred of Minbrie, County Jervois, Eyre Peninsula, South Australia. It is half a mile south of Mount Geharthy Trig Station and 13 miles north of Cowell.

I have not had the opportunity of visiting the locality and the following description has been kindly provided by Mr. J. E. Johnson of Adelaide, by permission of Geosurveys of Australia Ltd. Mr. Johnson also presented the only specimen in the Museum collection.

“The rocks of the region are of Lower Proterozoic (Pre-Cambrian) age. They consist of a tightly folded series of metasediments among which dolomite beds figure prominently. Near Cowell the dolomites are partly serpentinized, being streaked and spotted with antigorite (a lamellar variety of serpentine). It

forms a handsome 'verde antico' marble which is extensively quarried.

Adjacent to cross-cutting quartz reefs, the serpentized dolomite has been altered to masses of coarse-grained actinolite separated from the unaltered serpentized dolomite by soft, weathered dark green serpentized material. Throughout this is scattered the nephrite which is fine-grained and in the form of nodular masses or fractured lenses'.

In the same general area, veins of chrysotile asbestos occur in the dolomite. In places this has been silicified by opaline solutions to form attractive yellow silicophite, which has been described and illustrated in colour by Chalmers (1967).

The one specimen of Cowell nephrite (D:41885) in the collection is very fine-grained and dark olive green. J. E. Johnson states that it is mostly black or greenish black but sometimes is a fine olive green. In thin section it resembles the extremely fine grained portion of the Dungowan nephrite comprising mainly a dense mass of minute, slender, interlocking fibres of tremolite.

Simple comparisons of hardness and toughness were made between the Australian nephrites from Dungowan and Cowell and those from the Westland Province of New Zealand. Undoubtedly the New Zealand specimens are harder and tougher. The toughest New Zealand specimen (D:31316) was from the Kumaru Diggings. The specimen (D:41306) described above in thin section, broke more easily but this may have been due to it being somewhat schistose. Turner mentions that it is almost impossible to chip the best quality nephrites with a hammer.

Despite these differences it is considered that the physical properties and microstructure of the Australian specimens warrants them being called nephrite, rather than semi-nephrite.

The registered numbers of the Museum specimens examined are quoted above.

LABRADORITE

Transparent gem quality labradorite from Australia has been mentioned previously (Oughton and Hearn 1970). The R.I. measured on a cut stone is stated to be 1.556-1.564.

A fine cut stone weighing 6.78 ct and a rough piece weighing 15.93 ct were kindly lent for examination by Diamond Traders Pty Ltd of Sydney. The R.I. reading on the table face is 1.55-1.56

and the S.G. done by hydrostatic weighing in toluene is 2.695. The S.G. of the rough specimen is 2.679. Both specimens were transparent and flawless and pale yellow in colour. The cut stone showed quite a surprising degree of brilliance.

Hearnese (1970) has stated that the source of specimens in his possession had not been disclosed except that it "was somewhere in Southern Queensland", but Diamond Traders were unable to state the exact locality of the specimens they lent me.

Numerous crystal fragments have been found in decomposed basalt soil at Hogarth Range, near Mallanganee, 26 miles west of Casino in northern New South Wales. Some few specimens I have seen are the same attractive yellow colour as the specimens from Diamond Traders. The largest fragment measured 2.5×1.5 mm. The majority I have seen are colourless to very pale straw and would range from this size down to fragments measuring about 1×0.5 mm but of course smaller ones have also been found.

The Hogarth Range occurrence was first reported to me a few years ago but I have not had the opportunity of visiting the locality.

It is not possible to estimate the total amount recovered because local residents and numerous members of lapidary clubs have all been to the locality. The total weight of good quality fragments collected, very approximately, might be in the order of several pounds.

Small fragments of the Hogarth Range material examined in liquids had an R.I. of approximately 1.55. An S.G. determination of clean, carefully selected fragments done by the pycnometer method gave a result of 2.68.

The R.I. and S.G. results obtained establish the material as labradorite, the intermediate member in the albite-anorthite chemical series of plagioclase feldspars. The values of constants obtained fall within the range of those quoted by Deer, Howie and Zussman (1963).

Dr. A. R. Ramsden of the C.S.I.R.O. Division of Mineral Chemistry has confirmed the identity of this mineral as labradorite by X-Ray diffraction.

There are extensive flows of alkali basalt of Tertiary age throughout the Eastern Australian Highlands. Labradorite is the typical feldspar both as phenocrysts in porphyritic types, as well as in the groundmass. Hand specimens of fresh porphyritic basalt from Hogarth Range are in the Museum collection. Phenocrysts

up to 1.5 mm long of transparent glassy labradorite are a feature of these rocks and undoubtedly the detrital crystal fragments of labradorite in the soil are derived from the weathering of these basalts.

In thin section the groundmass is extremely dense and characterized mainly by an abundance of minute lath-like crystals of labradorite. The phenocrysts show multiple twinning characteristic of the plagioclase feldspars.

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SOME NOTES ON GROWTH-DISTURBANCES FOUND IN COLOMBIAN EMERALDS

By JEAN-PAUL POIROT

IN the absence of disturbing elements and in a continuously constant environment a crystal grows in a regular and homogeneous manner; in nature these conditions do not occur and crystalline growth is usually uneven and, what is more, disturbed, because the various crystals get in each other's way during their formation.

Several centres of simultaneous crystallization can thus sometimes be found in the emerald. Figure 1 shows such a gem observed in the basal plane. The presence of a central core and the centrifugal growth of each seed which from this angle is seen as an hexagonal figure are easy to see. Fine inclusions are thrown out to the periphery of these elements; in the biggest they outline some crystallization ghosts (fossilized stages of growth); one of them even leaves a radial trail of colour starting nearly at the centre. When two cores come together they mutually repulse each other and the limit of influence of their respective areas of activity is represented by an agitated zone where the colour variations are numerous; this zone may be observed to bisect the angle formed by the adjoining faces of the two neighbouring individuals which in these conditions repulse each other with equal force.

A foreign crystal coming into contact with a growing emerald



FIG. 1. Colombian emerald 25 \times . Coloured growth disturbances.



FIG. 2. Colombian emerald 40 \times . Calcite crystals repulsed by growth. The direction of crystallization is from bottom to top.

tends to be repulsed by it; thus Figure 2 shows a calcite repulsed before being trapped in the crystal during growth. Behind this calcite a coloured trail is easily seen; in front of and behind this disturbing element crystalline lacunae may be observed, little canals which greater magnification shows to be filled with brine, salt and carbonic anhydride. These are due to a shortage of material resulting from interference produced by the foreign element, either because it rested on the growing face which repulsed it or because having been trapped by the emerald it provoked a local alteration in the surrounding environment. The canals associated with crystalline inclusions can be more or less long; Figure 2 illustrates this with a small calcite which has induced rather a long elongated crystalline lacuna. The two possible positions for these little canals, in front of and behind the inclusion, clearly indicate the direction of crystallization; in the absence of other elements the direction of crystallization still remains indefinite.

A foreign crystal can also be caught in a strongly disturbed zone undergoing rapid growth. Figure 3 shows a calcite repulsed and pushed about by a growing emerald: the different fossilized positions, the different movements of this inclusion are easily dis-



FIG. 3. Colombian emerald 40 \times . Calcite crystal causing intense coloured growth disturbance.

cernible; there the little canals associated with the trapped crystal are not parallel, and this indicates and confirms the “maelstrom” which reigned in that area at the time of crystallization.

The successive stages of crystalline growth are often marked by crystallization lacunae which shape and outline the fossil faces as shown by Figure 4. Sometimes, at the next stage, the resumption starts badly in a hole on account of the absence of material, and this produces an irregular cavity. If the general direction of growth, indicated by colour trails or by little canals, remains the same, there can still be various irregularities locally, and a tangential growth of the crystal occasionally gives a broken appearance to some lacunae which is, without this hypothesis, difficult to explain.

Such phenomena may be observed in all gems which show some character (Colombian emeralds, Burma rubies, etc.). The vicissitudes suffered during their crystallization by especially attractive precious stones thus seem to be one of their essential characteristics, connected with their beauty: the turbulent story of their birth gives an intense life to the light which passes through them and the amateur who contemplates them is through them in communion with creation.



FIG. 4. Colombian emerald 40 \times . Three-phase crystalline lacunae of different appearances and origins. The direction of crystallization is from bottom to top.

THREADS:

Their types and some of their characters

By ROBERT WEBSTER, F.G.A.

FOR some time it has been the writer's intention to consider some aspects of the nature of the threads used to string pearls and beads into necklets, for the subject, which one might readily admit is not gemmology proper, does have some importance in answering questions sometimes posed to a laboratory.

The reason which has prompted further investigation into this sphere devolves from some remarks made by the late Dr. V. B. Meen, of Canada, after the writer had read a paper on "damage to gemstones" at the XIIIth International Gemmological conference held at Brussels in 1970. During this talk the blackening of some cultured pearls by the action of cosmetic creams was mentioned⁽¹⁾.

Dr. Meen asked if any attention had been paid to the type of thread which had been used in stringing the pearls in the case mentioned, as some types of threads were more prone to attract grease than others. It was possible to show that in the records of this case there was a note to the effect that the string did not appear to be normal, but that this aspect was not pursued.

There may be other problems, too, where some information on the nature of the string used in threading beads may well be needed. This article is an attempt to give a short survey and to provide a basis for any future investigation. It will be readily seen that any full-scale investigation on the types and characters of threads would be a long-term project, but one which might well be worthwhile.

According to Walls⁽²⁾ threads, the more scientific name being *fibres*, can be classified into four groups as follows:

1. *Animal hairs* such as wool, mohair (Angora goat), camel, none of which have any place in the present study.
2. *Vegetable fibres*, which are divided into two groups.
 - (a) *Seed hairs*, such as cotton and kapok, cotton being the only one which needs consideration here.
 - (b) *Bast and structural fibres*; these are exemplified by flax (linen), jute, hemp and sisal. Only flax is of interest.
3. *Fibres produced by the solidification of a liquid extruded through a fine*

orifice; these are again subdivided into sub-groups:-

(a) *Natural*, of which silk is the only important member.

(b) *Artificial (man-made)*; there are two well defined groups:-

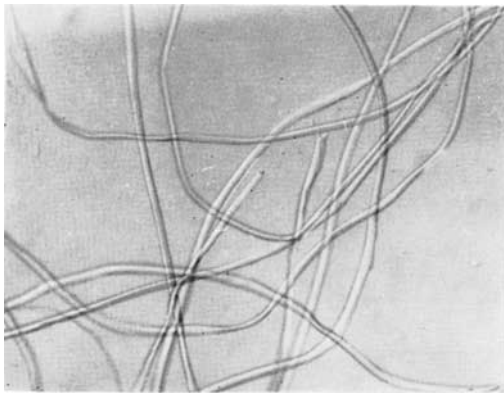
(i) Those made from animal or vegetable raw materials, such as regenerated cellulose (Rayon); cellulose esters, usually acetate (Tricel, Arnel, Trilon); alginates (from seaweed); regenerated proteins (casein) and others.

(ii) Purely synthetic fibres: such as polyolefines (polyethylene, etc.); polyamides (Nylon, Brilon); polyesters (e.g. Terylene—Dacron in the United States of America—a polyethylene terephthalate); acrylonitrile polymers (Orlon, Acrilan, Courtelle, etc.); vinyl chloride and vinylidene chloride polymers (Vinyon, Saran, and others).

4. *Miscellaneous fibres*; such fibres are natural mineral fibres (asbestos) and fibres of glass, metal, etc., which have no place in this study.

Of these numerous fibres, most of which are used in the textile industry, the only ones which need to be discussed are silk, cotton, linen, and some of the artificial fibres, particularly Nylon.

Silk. The most important fibre used for pearl stringing, silk is produced by the caterpillar of the moth *Bombyx mori*, which, when fully grown, spins a cocoon with a secretion produced by the caterpillar from a pair of tubular spinning glands. Each of these glands produces a single fibre, which is at first in a fluid condition.



Pure silk 45 ×

These two fibres are then, by muscular action, and possibly aided by another secretion, formed into a single thread. This is silk, an albumoid, and the fibres normally receive certain cleaning treatments before being spun and woven into fabrics.

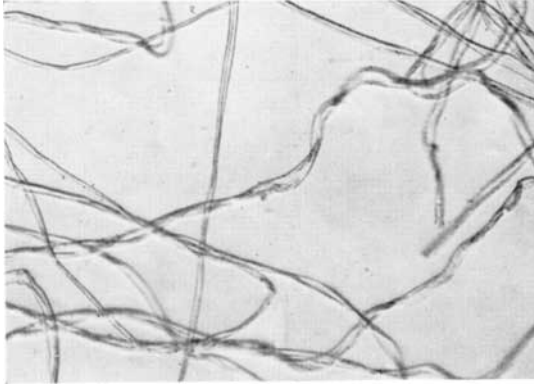
When a flame is applied to the end of a silk thread it burns, but does not readily flame, and the thread forms a shrivelled blob. The flame does not tend to travel along the thread and is quickly extinguished. Under the microscope the threads are seen to be more or less structureless cylindrical rods which at places may flatten or bulge out. The fluorescence varies considerably due, as mentioned by Radley and Grant⁽³⁾, to the "fact that *dressing agents*, oils and dyestuffs, often completely alter the colour of the fluorescence", and these writers also state that "small traces of fluorescent dyestuffs added as 'brightening agents' may produce complicating effects in ultra-violet light". Fluorescence can have scant discriminative value in the detection of the fibres themselves.

Cotton. Threads of cotton are not normally used for pearl stringing but some mention is included in this survey for there is reason to believe that they have been used for such a purpose, and, further, they are certainly used for stringing necklets of amber, coral, jet and some ornamental stones, such as malachite and rhodonite. "Star sylko" or Clark's "anchor" stranded embroidery "silks" are often used for stringing such necklets.

The most important of the vegetable fibres, cotton, consists of white or yellowish-coloured fibres which are obtained from the seeds of various species of the genus *Gossypium* of the order *Malvaceae*. Well-bleached cotton is said to be nearly pure cellulose.

When a flame is applied to cotton threads they readily burn with the flame travelling along the thread leaving very little ash. On extinction of the flame the glowing embers emit a smell of burnt wood. When fibres of raw cotton are examined under the microscope the general appearance resembles that of a wrinkled, twisted irregular ribbon which may be likened to an exhausted rubber tubing. After treatment, such as "mercerising", which imparts a lustre to the cotton so that it resembles to some extent silk, the typical appearance of the threads may not be so apparent under magnification.

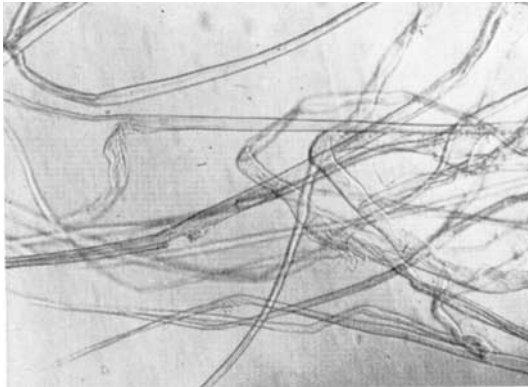
Linen. The name is derived from the flax plant *Linum usitatissimum*, which is pulled just after flowering. The linen fibre,



Cotton threads 45 ×

being the first layer under the epidermis of the stalk is separated from the rest of the stalk by retting in stagnant or running water. Following this the mucilaginous substances contained in the flax are removed by suitable treatments.

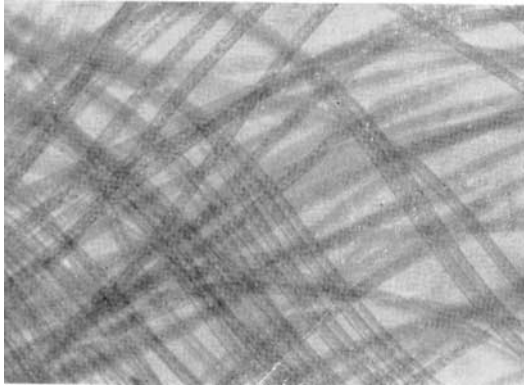
Like cotton, linen burns fairly readily with, on extinction, a smell of smouldering wood. Examined under the microscope the central canal is not so marked as in cotton and the fibre has notches at irregular intervals, and, further, may show diagonal striations. Linen lacks the convolutions shown by cotton fibres.



Linen threads 45 ×

Artificial fibres. The beginning of the artificial fibre industry began with the work of Count Hilaire de Chardonnet of France

during the 1880's, although as early as 1665 the idea of making "artificial silk" was mooted by Robert Hooke. Chardonnet's "silk" was a nitrated cellulose, a type of celluloid, and was far too inflammable and, indeed, the sale of this "silk" was eventually banned in France.



Nylon threads 45 ×

The next advance in the production of artificial silks was due to the work of C. F. Cross and E. J. Bevan, who produced the "rayons". These fibres were and are produced by regenerating cellulose. Plant cellulose, such as cotton linters, wood-pulp, are chemically dissolved and then "regenerated" and extruded through a diaphragm pierced with very fine orifices called a *spinnerette*. Such regenerated cellulose fibres are Viscose rayon, cuprammonium rayon, and acetate rayon, but these fibres have little importance in this discussion.

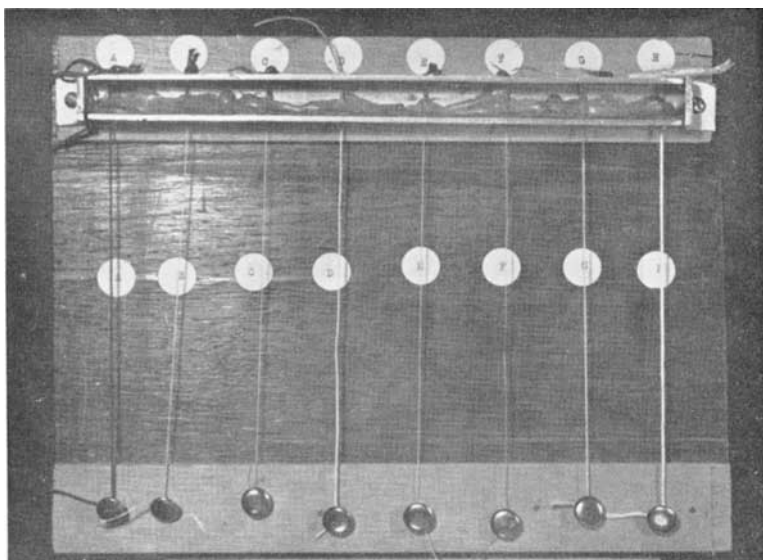
The most important of the man-made fibres for this study is the super-polyamide called "nylon", the production of which was the outcome of researches carried out by the American plastics chemist Carothers, aided by some of his colleagues. Made from hydrocarbons obtained from coal, and from ammonia, nylon, of which there are at least three types, is said to be twice as strong as silk and to be more elastic. It is probably due to this latter effect that nylon is not favoured for pearl stringing as it does not knot well and is inclined to stretch. There are two kinds of nylon cord which may be purchased for pearl and bead stringing. The first is made up of twisted fibres and resembles the true pearl silk, while

the other, more used for beads than pearls, consists of a single strand, like a flexible rod. There is a variation of this latter type which is wound round with a spiral of fine metal wire and is presumably used for heavy beads. If the single strand nylon cord is used for pearls or lightweight beads the necklet tends to bow and does not hang at all well.

Nylon melts before burning, producing a sticky blob which follows the flame travelling along the string. This blob of molten material, if dropped on to the skin, burns like hot fat. The flame of burning nylon is, however, readily extinguished. Nylons, like most of the other man-made fibres, are usually assumed to be structureless internally, but microscopical examination has shown that there appear to be masses of fine bubbles oriented parallel to the length of the fibre. This phenomenon seems to be more prominent in the case of nylon and this may be accounted for as nylon is extruded from a molten mass and not from a liquid which is expelled through the spinnerettes into a coagulating bath which solidifies the fibres.

In order to ascertain the probability of differential absorption of grease by various fibres a series of experiments were undertaken. A frame was constructed consisting of a length of channel aluminium, bored with eight small holes through both sides, which was screwed down to a suitable baseboard. The metal channel, intended to carry the grease, was closed at each end by aluminium angle plates. A series of different threads were then threaded through the holes in the channel and anchored so that they were fixed at the outer face of the channel. The threads then passed across the channel and across the baseboard for a distance of some 12 centimetres, where the ends were anchored to a fixed wooden strip by the aid of drawing pins. Suitable lettered labels were stuck down on the baseboard in order to identify the strands.

It was considered that a suitable grease would be a cosmetic cream and Pond's cold cream was used. To ascertain if the grease travelled along the string a small quantity of the chemical rhodamine was mixed with the cold cream, the notion being that it would not only give colour to the cream but would show up under ultra-violet light, for rhodamine is highly fluorescent and glows with an orange or reddish-brown light. During the experiment the frame was kept in a glass-topped box.



The frame used in grease experiments.

The strings used in the first experiment were as follows:

- (a) Silk (dyed brown).
- (b) Pearl silk.
- (c) "Sylko" mercerized cotton.
- (d) Linen thread.
- (e) Terylene thread.
- (f) Nylon (single thread).
- (g) Spun nylon pearl "silk" (Nylcord).
- (h) Clark's "anchor" stranded embroidery cotton.

The result observed after the grease had been placed in the channel was striking in that within an hour the grease had travelled down some of the threads, admittedly not very far but with significant differences. Strangely the seepage seemed to stop at these points and there was little further increase even after a week. The distances the grease, which coloured the strings, had travelled along the strings were then measured, giving the following results:

- (a) Dyed silk: no apparent effect.
- (b) Pearl silk: very weak seepage of about 1.5 mm.
- (c) "Sylko" mercerized cotton: 5mm.

- (d) Linen: 2 mm.
- (e) Terylene: 4 mm.
- (f) Nylon single cord: no effect.
- (g) Twisted nylon (Nylcord): 11 mm.
- (h) Embroidery cotton: 3 mm.

The frame was then unstrung and the grease removed and kept, and the frame itself thoroughly cleaned and restrung with different threads as under:

- (a) A fine tacking cotton.
- (b) Brown linen thread.
- (c) Terylene, same type of thread as in (e) in first run.
- (d) Pearl stringing silk. A different source from (b) above.
- (e) Pure silk (yellow dyed Regal).
- (f) Polyethylene thread (blue dyed).
- (g) Terylene (Coat's white).
- (h) Embroidery "silk" (cotton) as in (h) above.

The cold cream plus rhodamine, which was removed from the channel after the first run, was then mixed with as much again of the cold cream but no more rhodamine added. Thus the concentration of rhodamine was only half that of the previous mixture.

After some hours the frame and threads were examined, but the results appeared to be disappointing, mainly because the lower concentration of rhodamine did not strikingly colour the threads, and the fluorescence effects were masked by the strong whitish glow emitted by the threads themselves. However, some trace of differential seepage was apparent.

There was always the question of how much body heat would affect the mobility of grease in the case of a necklet worn for some time around the neck. To test this the frame was removed from the glass-topped box and placed on a warm print dryer. This print dryer gave off much more heat than the heat given off by a human body, and, hence, the results obtained would be expected to be much more rapid, as, indeed, they seemed to be as the following shows:

- (a) Cotton thread: diffuse staining decreasing in intensity up to 5 to 6 cms.
- (b) Linen: a little staining up to 2 to 3 mm.
- (c) Terylene: slight tinting for practically the full length of the string.

- (d) Pearl silk: very slight staining for 3 to 4 cms.
- (e) Yellow dyed pure silk: very slight staining.
- (f) Polyethylene: colour of the dyed thread precluded much in the way of observation or by fluorescence.
- (g) Terylene: weak staining for a considerable distance, and in fact seemed to behave rather like (c).
- (h) Cotton embroidery "silk": staining for about 15 mm.

Note: the very slight staining of the Terylenes (c) and (g) could only be identified by comparison with thread taken from the original reels.

In conclusion, it may be said that the experiments have shown that there is some justification for the suggestion that there is differential absorption and percolation of grease along fibres of different natures. However, much more information is required and far more experimentation needs to be carried out on a greater number of kinds of fibres for a really full study of the subject. It seems apparent that twisted fibres tend to carry grease more readily than single strand material, as exemplified by the nylon samples tested. This was rather to be expected and most probably due to the greater possibility of capillary attraction between the threads.

Most of the threads carried grease for upwards of two millimetres, and as the nacreous shell of a cultured pearl is seldom more than a millimetre thick, it is clear that the grease would reach the discontinuation layer between the "skin" and the bead of the cultured pearl and tend to travel along it, as indeed, was found to have happened in the case mentioned at the beginning of this article.

What is further to be considered is that the experiments were carried out with static threads on a frame. There is movement of the beads on a necklet when it is worn and this would assist the grease to seep along the string. What does seem to be proved by the experiments is that silk is the best material to use in stringing natural and cultured pearls and to use other types of threads may well lead to trouble for the jeweller.

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PEARL IDENTIFICATION:

Some laboratory experiments

By C. A. SCHIFFMANN, F.G.A., G.G.

THIS article deals with some identification problems, restricted to genuine and cultured pearls. Pearl imitations are not included, as their recognition is usually easy.

Enquiries for genuine pearls have become so scarce that the average jeweller stocks usually only cultured pearls. Hence he may think that their recognition is of little importance since, when buying to renew his stock of cultured pearls, there is no chance of mistake.

Matters are less simple when pearls have to be estimated for insurance or probate purpose, or when bought second-hand. For these reasons the laboratory work brings with it many surprises and has in a way the prickling charm of the unforeseeable: one never knows what new problems tomorrow will bring. For instance, the author remembers having once heard Mr. B. W. Anderson mention that the London Laboratory was entrusted years ago with the identification of a huge parcel of 250,000 pearls, which of course required efficiency and rapidity in testing.

The optical methods (lens examination, observation in transparency and fluorescence, endoscope test) are the first to be used in pearl testing because they are expeditious, with perhaps the exception of the endoscope. However, when typical textures cannot be found, or when the pearls are not drilled, one has to resort to other more time-consuming methods, like determining exactly the specific gravity, above all submitting them to x-rays test by direct radiography where a whole necklace or just single pearls can be tested at one time, and the diffraction method by which only one loose pearl can be tested at one time.

The x-ray methods are both more time-consuming and more expensive, and they should be used logically. Perhaps one day a laboratory will be asked to identify a pearl whose value is not worth the cost of an x-ray identification, and the next day a pearl of high value will be brought for identification when all possible gemmological methods may have to be used.

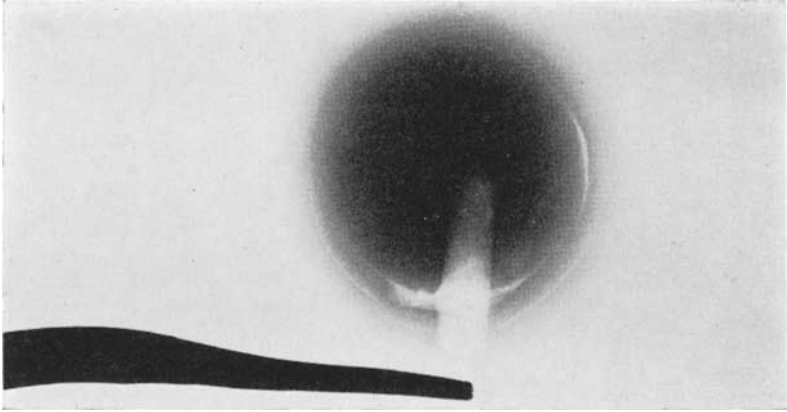


FIG. 1. Direct radiography of $13\frac{1}{2}$ mm cultured South Sea pearl, with 2 concentric conchyolin layers.

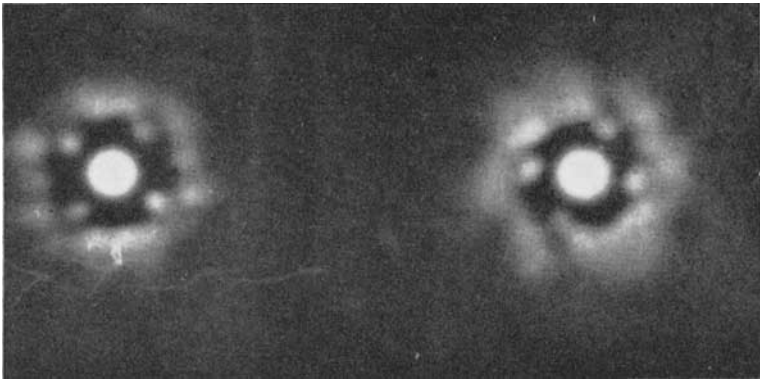


FIG. 2. Left, standard 4-fold pattern of a large cultured pearl with nucleus. Right, distorted pattern of a large cultured pearl with nucleus.

Usually, the first x-ray examination is made by direct radiography. When this first step is not conclusive for a few pearls, they are then tested with the diffraction method. It may be interesting to look at not only fine typical pearl patterns as seen in text-books, but also at diagrams obtained that are not conclusive or difficult to interpret.

Fig. 1 shows the radiogram of a cultured pearl $13\frac{1}{2}$ mm in diameter from the South Seas, with two distinct layers of conchyolin. The outline of the core did not appear as a complete circle and had

a somewhat irregular perimeter, and so for safety the pearl was submitted to a diffraction test, which result appears in Fig. 2, the two images being obtained in two directions at 90° to one another, one showing a standard rectangular pattern, whereas the second pattern is slightly distorted because of an occasional lack of alignment between the x-ray beam and the optimal position of the aragonite prisms of the mother-of-pearl layers.

The spot in the centre of the pattern is the trace of the primary beam. Theoretically, the pattern obtained should have a 4-fold symmetry for a cultured pearl with nucleus, and a 6-fold one for a genuine pearl, or for a cultured pearl with a nucleus along a

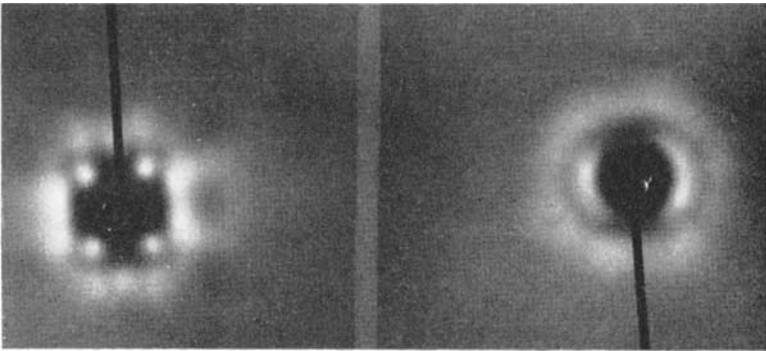


FIG. 3. Cultured pearl, in two positions at 90° to one another.

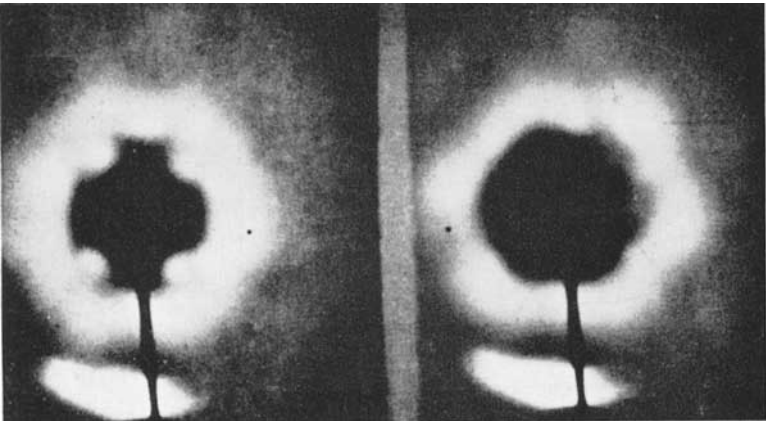


FIG. 4. Cultured pearl, in one direction along the pseudo-hexagonal axis of symmetry one 6-fold exceptional pattern is visible. In the direction at 90° the usual 4-fold symmetry pattern proves it to be a cultured one.

particular direction, or for one without. Nothing is proved if a hexagonal picture is obtained. The pearl has to be turned through 90° and another picture taken.

Fig. 3, left, shows an indefinite pattern intermediate between the optimal positions, whereas in a direction at an angle, a clear pattern has been obtained. On this figure, the action of the primary beam on the film has been prevented by interposing a primary beam catcher, whose holder's shadow is visible as a thin vertical line.

Fig. 4 proves that the advice in some text-books, preferably to test a pearl in two directions at right angles to one another is justified. It shows that an exceptional position along the pseudo-hexagonal symmetry axis of the aragonite crystals may occasionally occur by chance, as it did here. Of course, the pearl could be brought intentionally into that position, but this would require a number of runs until the mother-of-pearl layers were correctly orientated, and this would be time-consuming and also expensive. The instrument setting used for these diffraction patterns is shown on the Fig. 5. Using Polaroid film in a film holder of the same make shortens the exposure time by approximately five times.

FIG. 5. Photograph of the x-ray unit, set up for diffraction. To the left is the Polaroid cassette; between it and the target, the small white spot is the pearl, supported on a goniometer as holder, itself affixed to the axis of a small electric motor. The beam catcher is visible as a thin thread just above the pearl.

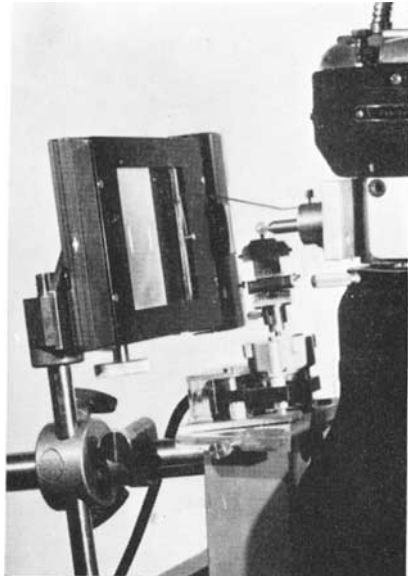




FIG. 6. Cultured pearl: left, revolving, and right, stationary.

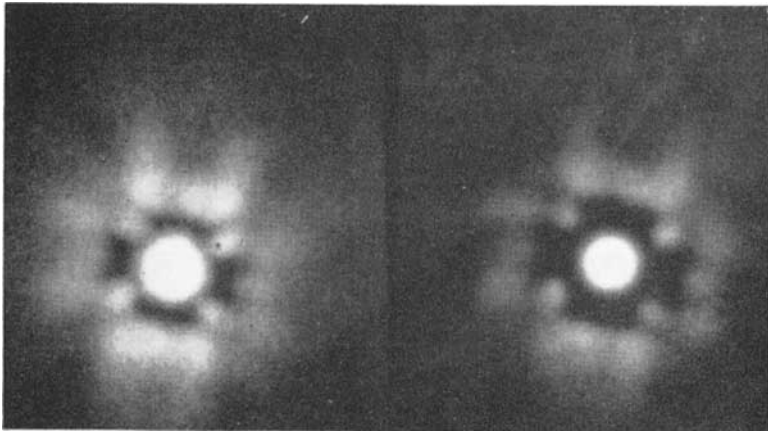


FIG. 7. Two separate runs of the same pearl in rotation.

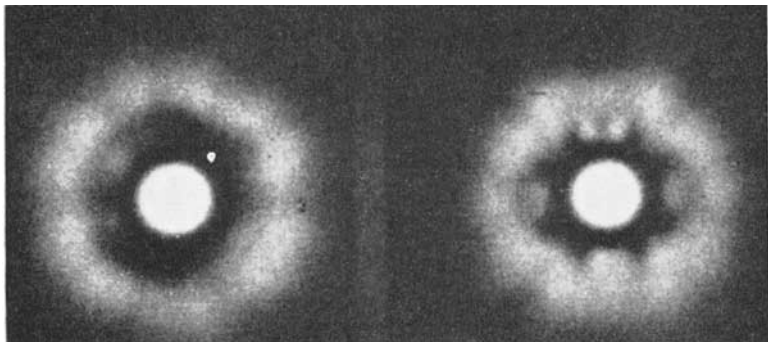


FIG. 8. Pearl in rotation: left, hazy pattern of an irregularly shaped genuine pearl: right, other type of pattern of a cultured pearl.

Here the pearl is affixed to the spindle of a small electrical motor by means of a goniometer, enabling a precise setting. The diffraction pattern may be obtained from the pearl stopped in two positions, or, by a variation of the powder diffraction method of x-ray analysis, the pearl may be rotated by an electrically driven motor, with the advantage that instead of two separate exposures, one single run is enough in the optimum cases, and this reduces the necessary time once more by 50%.

With the pearl rotated, the patterns obtained are somewhat different.

In Figs. 6, 7, 8 and 9 the central spot in the pattern is the trace of the primary beam which had not been shielded.

Fig. 6 shows us on the right the pattern of a cultured pearl in a stopped position, at left when revolving about 1 rev. per minute.

Fig. 7 shows two different exposures of the same cultured pearl in rotation giving both very obvious and regular patterns.

On the left, Fig. 8 shows a somewhat hazy but recognizable design of the 6-fold symmetry in a genuine pearl in rotation. This is due to the fact that the pearl being not quite round, the x-ray beam did not pass exactly in the middle of it. On the right of the same figure there is a somewhat different design given by a cultured pearl in rotation.

Fig. 9 shows two runs on the same button-shaped genuine

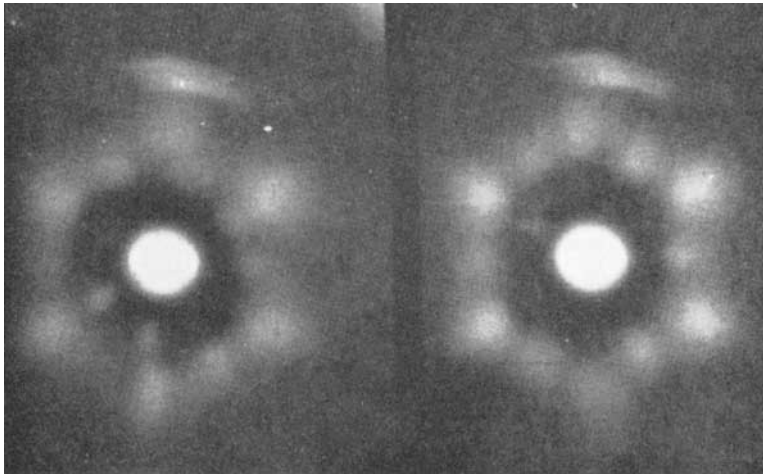


FIG. 9. Genuine pearl in rotation: two runs on the same pearl, along two different orientations

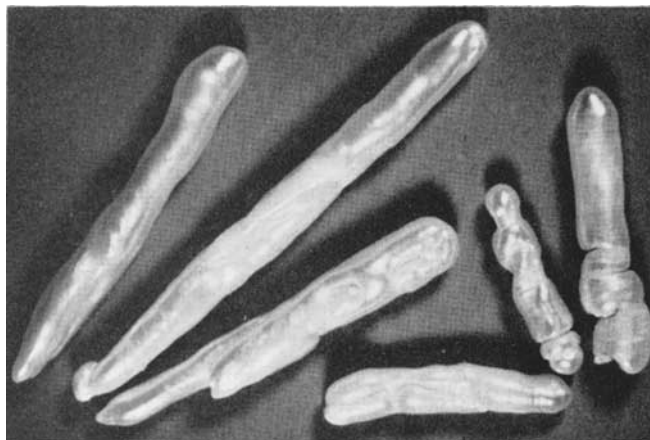


FIG. 10. Lake Biwa pearl formations without nuclei: elongated baroques, the longest one measuring 50 millimeters.

pearl in rotation, but along different directions, the pearl having been set in another orientation between the runs.

Another problem likely to give some difficulties is the identification of Lake Biwa pearls. It is known that these are produced without nuclei. Besides the ones that are rounded and have been bleached, it is interesting to look at some baroque shapes of this type of pearl. Figs. 10 and 11 are macrophotographs. In

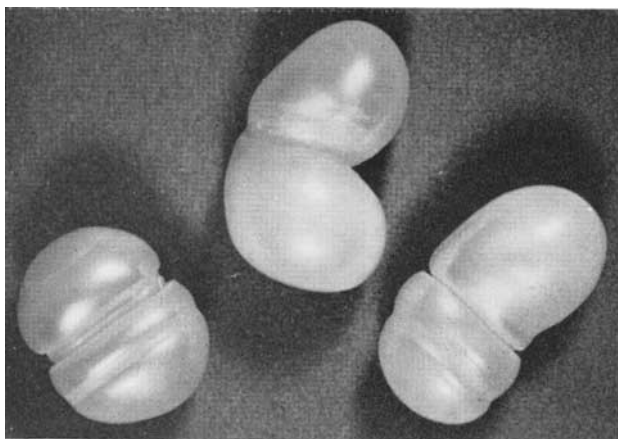


FIG. 11. Other types of baroques of the same origin, some having grown joined two by two. (Three of a parcel).

Fig. 10, the scale is given by the longest bar, which measures about 50 millimeters in length with a diameter of about 6 millimeters. The same baroques were x-rayed and the results appear in Figs. 12, 13 and 14 (on this figure there is a parcel of 9 pearls, from which only three are shown in Fig. 11). Noteworthy are the internal textures, with the irregular deposits of conchyolin.

Another type of Lake Biwa pearl, that is less known, is a type made by use of nuclei, (because of the shortage of molluscs), which may be up to about 12 millimeters in diameter. Fig. 15

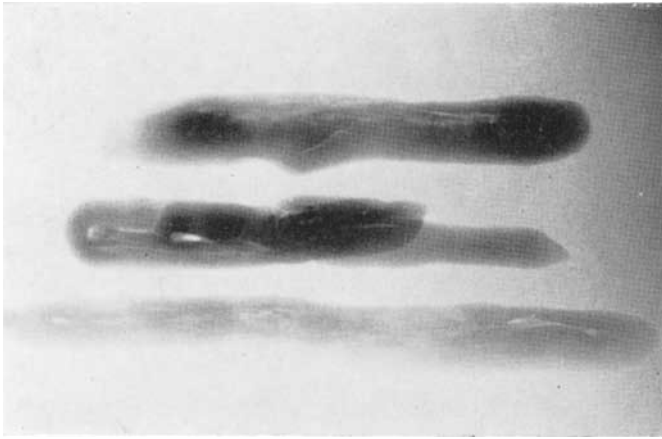


FIG. 12. Radiograph of the pearls of figure 10.

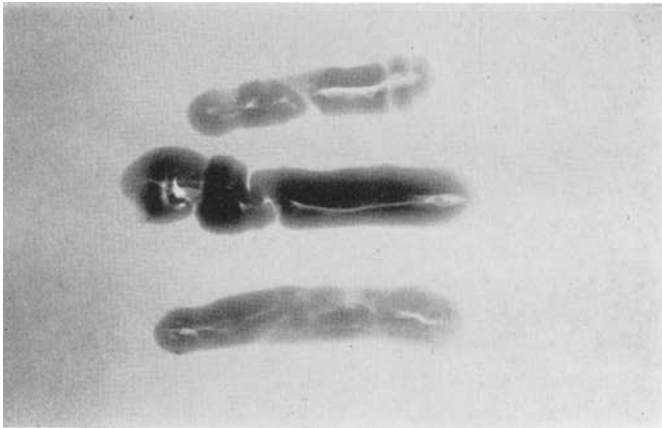


FIG. 13. Radiograph of the pearls of figure 10.

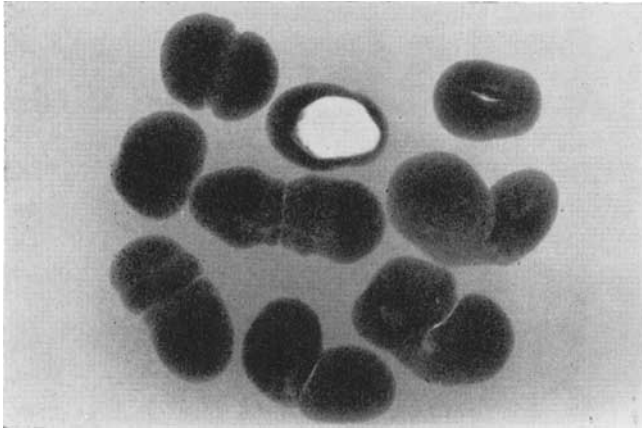


FIG. 14. Radiograph of a parcel of pearls as in figure 11.

shows three of these rather baroque pearls, and Fig. 16 the same which has been radiographed, with the easily recognizable core. It should be noted that the cores are drilled, but that the baroque external layers are not.

Nature sometimes reveals examples of its inexhaustible reservoir of beauty. Considering the Fig. 17, the baroque pearl illustrated bears a definite resemblance to a statue of the Mother of God, which is a rather modern interpretation of the Antiquity where Venus was said to have been born in an oyster!

Returning to the identification of pearls without nuclei, it is known that pearls or mother-of-pearl from fresh waters may show a fluorescence under x-rays, due to a small content of manganese. This would help distinguish between natural pearls (which may occasionally fluoresce) and products like pearls from Lake Biwa or other fresh waters, having a distinct fluorescence, where the core of salt water cultured pearls, made of river shells, can be seen to fluoresce under proper conditions.

A new approach to the detection of manganese in pearls might well be initiated by using Electron Spin Resonance, originally demonstrated by the Soviet physicist Zavoiskie in 1944. This phenomenon is concerned with the absorption of magnetic radiation by materials having unpaired electrons, when subjected to a magnetic field of a specific strength. Interaction between the unpaired electron and its environment gives the technique analytical

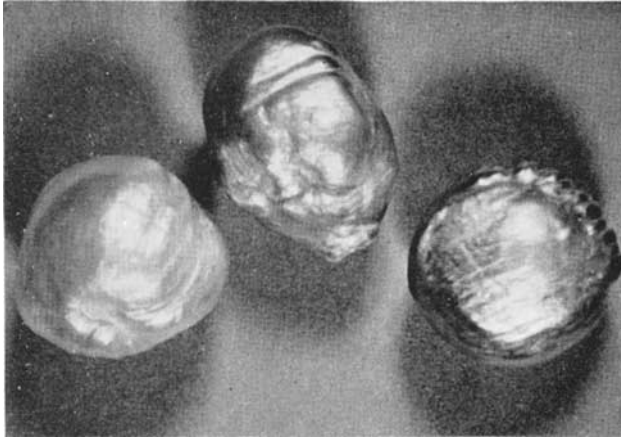


FIG. 15. Macrophotograph of three baroque Lake Biwa pearls with nuclei. Diameter is about 12 millimeters.

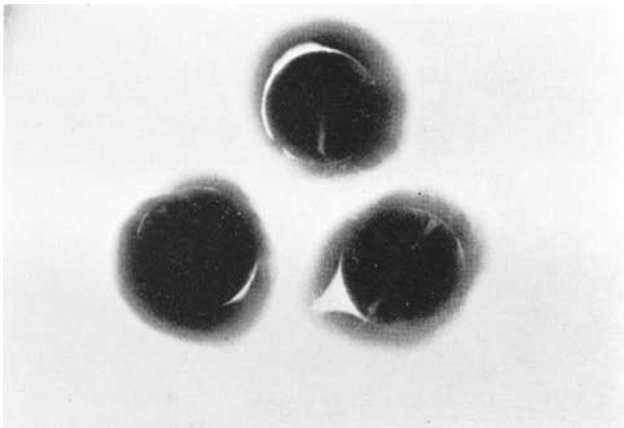
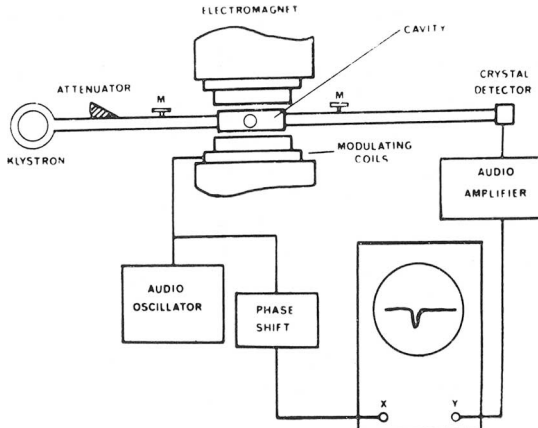


FIG. 16. Radiograph of same with drilled cores, the outside skin being undrilled.

significance. Until recently laboratory apparatus for Electron Spin Resonance consisted of large and heavy machines, but tests have been undertaken on an ESR prototype weighing only about 80 kgs.

The principle of the apparatus is shown in Fig. 18. The sample is placed in a resonator, located between the poles of an electromagnet and submitted to a magnetic field. A beam of microwaves is sent through the sample and absorption through it is

FIG. 17. Lake Biwa pearl without nucleus, resembling a statue of the Virgin. Height 18 mm.



Block diagram of simple room temperature electron resonance spectrometer.

FIG. 18. Principle of the Electron Spin Resonance method.

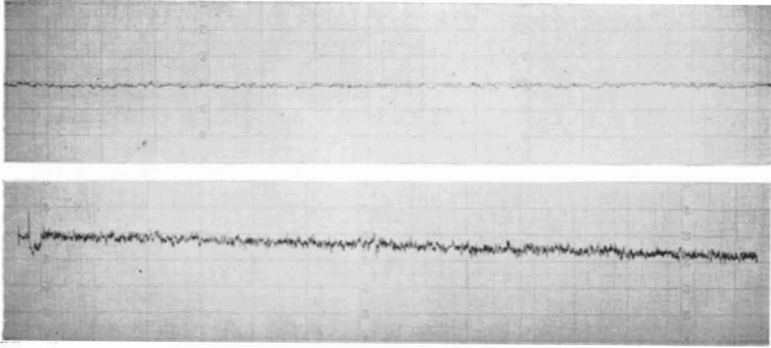


FIG. 19. Electron Spin Resonance curves of two genuine sea-water pearls.

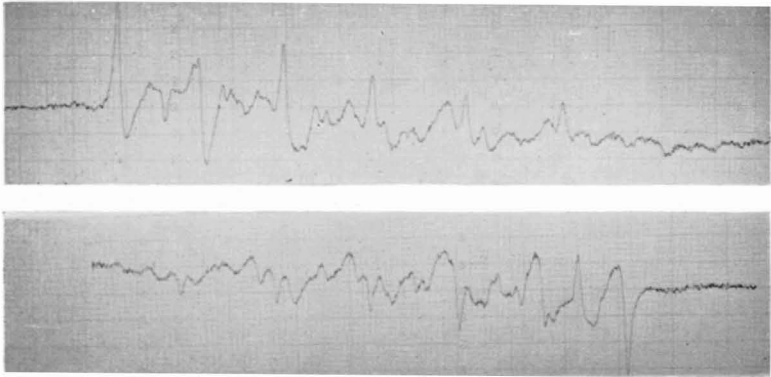


FIG. 20. Electron Spin Resonance curves of two cultured pearls (Salt-water type), with mother-of-pearl nuclei.

analysed in a crystal detector and registered by a recorder. One run necessitates only 5 minutes and the positioning of the sample is quite easy (it is affixed to a non-magnetic, non-crystalline rod and is suspended in the cavity of the resonator).

Thanks to the courtesy of Beckman Instruments, Geneva, it was possible to make a series of tests in their Laboratory on a prototype of their make. The results are provisional and the data not definitive.

The appearance of the resultant curves is strikingly different. The signals given by two different genuine pearls are rendered in Fig. 19 both lines being straight. Quite to the contrary, the signals of two cultured pearls give jagged lines according to irregular absorption presumably caused by a small content of manganese (Fig. 20).

This last method closes this short survey of a number of problems with which the laboratory worker might have to cope, and a few suggestions as to how to try to solve them, thanks to instruments used in other fields of applied science.

With the increasing complexity of man-made or man-modified products, more that ever it is rewarding for the gemmologist to keep his eyes open and his interest keen with regard to the developments of instruments to help him, even if their use may be beyond the financial possibilities of single individuals, and consequently be rather limited to laboratory work.

A GEM GARNET FROM THE ISLAND OF OTTERØY

near Modle, Western Norway

By JENS HYSINGJORD

INTRODUCTION.

Most Norwegian gemmologists made their first acquaintance with the name of B. W. Anderson in about 1949. At that time some enthusiasts had obtained the opportunity to organize gemmological courses in Norwegian, based upon those used by the Gemmological Association of Great Britain. Over the years Norwegian gemmologists have appreciated Anderson's friendliness and willingness to share with others his extensive knowledge and members of the Norges Gemmologiske Selskap will long be grateful for his pioneer work.

GEM GARNET FROM W. NORWAY.

The material described was collected by the author during a visit to Otterøy in the summer of 1963, at the request of Mr. Johs Forberg, jeweller, of Stjørdal, Norway.

The local people are well acquainted with the garnet deposit, and stones have in the past occasionally been sold for gem production.

The gem garnet occurs in garnetiferous peridotite at Uglvik, about three kilometers N.E. of Misund in Otterøy. (The locality is shown on a map published by Tore Gjelsvik (l.c.)). The percentage of garnet in the mother-rock is highly variable. In

certain zones the content was estimated as 10%, but at other places garnet may almost be absent.

The rock itself is altered and contains serpentine, olivine, pyroxene and garnet as chief constituents. Hornblende occurs subordinately, and chromite is an accessory mineral.

The pyroxene is mainly enstatite. Chrome diopside occurs in smaller amounts; it contains 1.9% of Cr₂O₃ according to an analysis of one sample.

The garnet is seen as millimetre-sized crystals in a finegrained groundmass; more rarely it is encountered as centimetre-sized aggregates.

CHEMICAL AND PHYSICAL DETERMINATIONS

According to determinations carried out by members of the staff of the Geological Survey of Norway, namely Mr. Per-Reidar Graff, lab. engineer (chemical analysis), and Mr. Magne Ødegård (spectrographic det. of V, Ni and Cu) the composition of the garnet is:

SiO ₂	42.32%		
TiO ₂	0.00%		
Al ₂ O ₃	21.09%		
Fe ₂ O ₃	0.73%		
FeO	7.11%		
MnO	0.42%		
MgO	19.20%		
CaO	5.03%		
Na ₂ O	0.06%	Ni	x/1000%
K ₂ O	0.07%	Cu	x/1000%
H ₂ O	0.15%		
P ₂ O ₅	0.00%		
Cr ₂ O ₃	3.72%		
V ₂ O ₅	~0.05%		
Total	99.95%		

This composition corresponds to a pyrope garnet. Recalculation to an ionic formula where 0 = 12 gives the following numbers:

Si	3.038	Fe*	0.427	} 2.908
(OH)	0.072	Mg	2.054	
Al'''	1.785	Mn	0.026	
Fe'''	0.039	Ca	0.387	
Cr'''	0.211	Na	0.008	
V'''	0.002	K	0.006	

Molecular percentage of end members:

Almandine	14.72%	Pyrope	70.81%
Andradite	2.04%	Spessartite	0.88%
Grossularite	0.64%	Uvarovite	10.92%

According to X-ray diagram taken with a 11.8 cm Debye-Scherrer camera, using Fe-radiation and Mn-filter, the cell size is a₀=

$11.54 \pm 0.01 \text{ \AA}$.

Index of refraction: 1.747 ± 0.001

Sp.G.: 3.715 ± 0.005

SPECIAL INVESTIGATIONS

The garnet from Otterøy has very peculiar colour properties. When the quality of illumination is altered, the colour of the mineral changes to such an extent that an alexandrite-like effect is seen. In transmitted daylight the garnet appears violet, in lamp light it is wine-red.

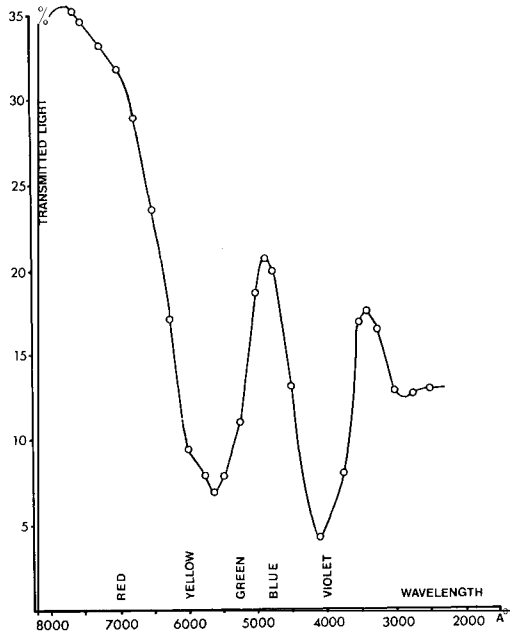
Examination of faceted stones with a hand-spectroscope revealed two broad absorption bands, one of them in the violet part of the spectrum, the other covering the interval from the lower part of red to the higher part of green.

To get a more exact picture of the nature of the transmitted light an examination with a Beckman DB spectrophotometer was undertaken (by Per-Reidar Graff). A garnet plate of 0.8 mm thickness was cut, and glued on to a glass plate with canada-balsam. For zero reference a glass plate with a layer of canada-balsam was employed.

The diagram (p. 299) shows the transmission curve of the garnet with its maxima of absorption (minima of transmission) at 5600\AA and 4000\AA . The curve explains the observed change of colour, since it shows that light penetrating the garnet mainly consists of red and blue colours. Ordinary daylight has its energy maximum within the short-wave region, lamp light in the long-wave part. When daylight is used, blue colours will accordingly be predominating in the transmitted light. With lamp-light, red will similarly preponderate.

Natural alexandrite is green in daylight and red in lamp-light, and imitations consisting of synthetic corundum coloured with V_2O_5 exhibit a somewhat similar change of colour. According to White, Roy and Crichton the alexandrite-effect with genuine alexandrite is due to a content of Cr_2O_3 and with imitation alexandrite it is due to V_2O_5 .

Many of the garnets from Otterøy are transparent with a clear, even colour; further, they are free from cracks. In these respects they are well suited for gem production. Their size is, however, modest. Garnets picked from the peridotite are usually



Gem garnet from Otterøy. Transmission of light measured with Beckman D B spectrophotometer.

3-4 mm, more rarely 4-5 mm. The average weight of 73 garnets was 119 mg, or slightly above $\frac{1}{2}$ ct.

Unfortunately it is difficult to extract whole garnets from the mother-rock. If the peridotite is crushed, the garnets usually break into pieces considerably smaller than those referred to above, the average weight of 126 "great" fragments being only 34 mg.

Even if the garnets from Otterøy are beautiful and of a rare colour, their somewhat small average size combined with the difficulty of procuring unbroken specimens render the prospects for the exploitation of the deposit somewhat doubtful.

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 White, W. B., Roy, R., and Crichton, J. M., 1967. "The Alexandrite effect": an optical study. *Amer. Min.*, V.52, pp. 867-871.

X-RAY TOPOGRAPHY OF A NATURAL EMERALD AND A SYNTHETIC EMERALD*

By HENRI-JEAN SCHUBNEL and ALBERT ZARKA

THE present article summarizes the first results we have obtained by using X-ray topographies in studying the structural defects of gem minerals and their imitation in artificial crystals of corresponding chemical formula and similar colour.

The first examples studied by Lang's method are natural and artificial emeralds, and their topographies show clearly that their crystallization took place in extremely different conditions.

We should like to recall to the attention of gemmologists the principles involved in arranging experiments by Lang's method.

I. METHOD OF X-RAY TRANSMISSION TOPOGRAPHY

A beam of X-rays issued from a quasi point source impinges on a crystal governed under Bragg incidence. A first slit restricts the beam from spreading. It can be separated into plane waves; each gives rise, inside the crystal, to two fields of waves, whose propagation directions are spread between the incident direction AB and the reflected direction AC. Such fields of waves are propagated along the distance Ap and interfere.

The angular size of the reflection profile is of the order of some seconds. So in a perfect crystal only a weak part of the incident beam is reflected; the most important part, the direct beam, merely suffers photo-electric absorption in traversing the crystal. A second slit f_2 then stops the direct beam and isolates the reflected beam which is received on a photographic plate.

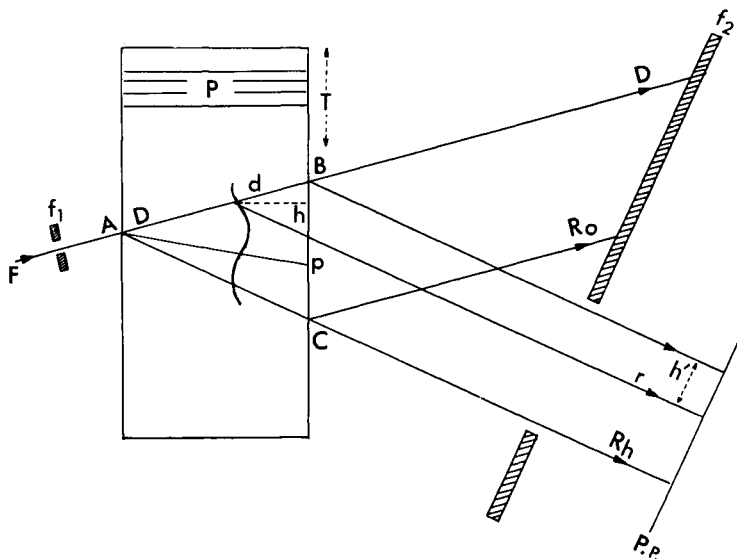
If, in a certain area of the crystal, the lattice planes are slightly misoriented, the interference phenomena suffered by the X-rays are modified or even suppressed. In the trace of the beams R_h and R_0 can be seen an image called dynamic image.

On the other hand the misoriented planes will be able to reflect part of the direct beam, if the divergence of the beam is not of less extent than the misorientation. The areas which will reflect most are those where the slope of misorientation is strongest.

Thus in the reflected beam R_h an image i is obtained: its distance h' to the edge of the beam enables the distance h from the defect to the face of the crystal to be calculated.

For this reason it is said that the trace of the reflected beam on the plate represents a *section* of the crystal. To obtain the map or topography of the disturbed areas throughout the crystal, the crystal and the photographic plate must be moved simultaneously.

The method does not allow observation of the defects themselves but of the misorientations which they cause in the crystal lattice.



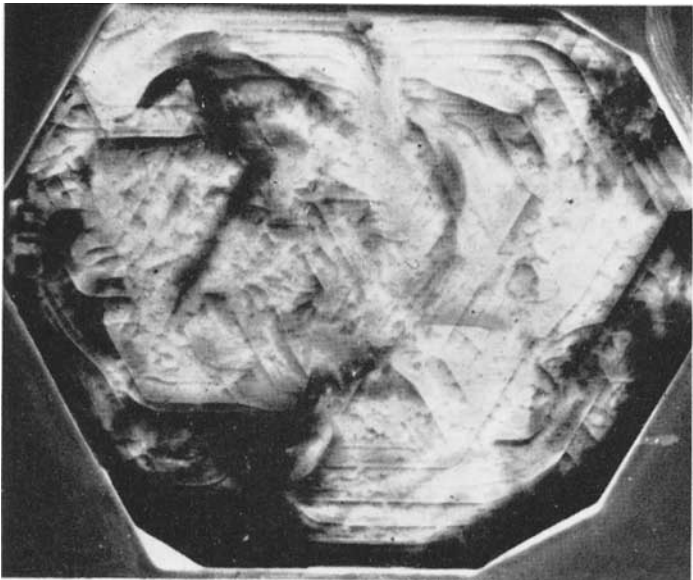
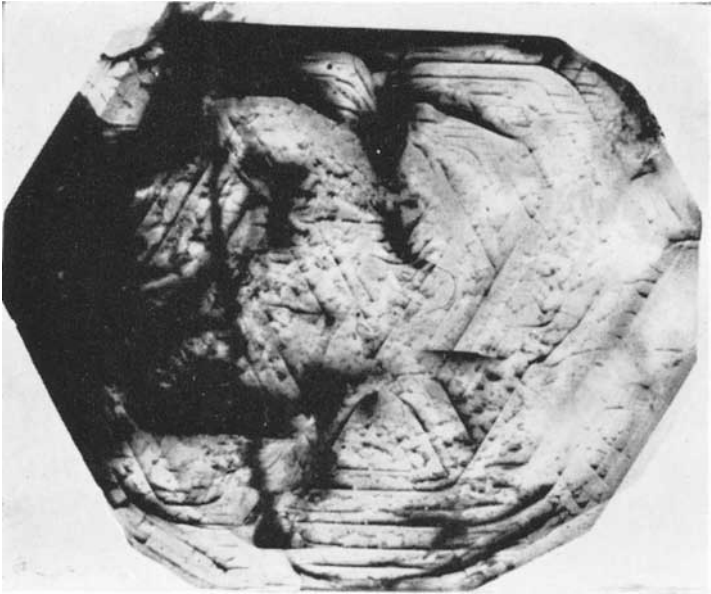
- F: Source of X-rays.
- f1: Slit restricting the beam's spread.
- P: Lattice planes of crystal.
- d: Misoriented area.
- h: Distance from defect to face of crystal.
- D: Direct beam.
- Ro: Beam emerging in the direction of transmission.
- Rh: Beam emerging in the direction of reflection.
- r: Beam reflected by defect d.
- P.P.: Photographic plate.
- h': Distance of the image i to the edge of the beam.
- f2: Rear slit stopping D and Ro.
- T: Direction of movement.

II. COMPARISON OF THE TWO TYPES OF TOPOGRAPHY

Topography of a natural emerald

The specimen studied came from Muzo. A slice of 1.5 mm thickness was cut perpendicularly to the *c* axis in the crystal.

In the topographies shown in Figures 1 and 2, zonings can be seen following the *a* directions. These zonings are related to the growth spirals. The steps are easily visible and are thought to be the result of rather strong misorientations which are produced at



Figs. 1 and 2. Topography of a natural emerald (Muzo mine).

each resumption of growth and are probably due to their decoration by impurities during each fluctuation of crystallization.

Topography of an artificial emerald

The limpid crystal studied was manufactured by the Gilson organization. A slice of 1.5 mm thickness was cut perpendicularly to the c axis.

This slice broke in the course of the cutting and we worked on the biggest fragment (Fig. 3). The presence of sub-grains can be seen, due to very strong internal tensions. There is present a veritable mosaic of juxtaposed grains, misoriented with each other, each grain being itself curved. It is very probable that the dislocation density in the grain boundaries is high.

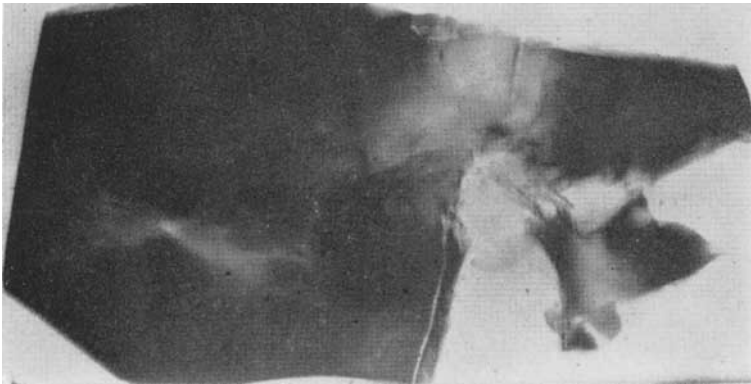


FIG. 3. Topography of a synthetic emerald (Gilson factory).

CONCLUSION

As one of the problems was to know if this method could eventually be applied to cut gems, we then applied to the slices the polishing techniques used by lapidaries. The results have been conclusive, classic polishing giving a very satisfactory surface state which excludes cleavages and chemical attacks formerly used for other crystals (particularly carbonates).

It has been possible to prove the vast differences existing in the architectural organization of the two crystals being studied and that the natural crystal (Muzo mine, Colombia), although showing

inclusions grouped in the form of swirls, was more regular than the synthetic crystal (manufactured in the Gilson factories) which, despite its optical limpidity, has a most disturbed crystalline architecture, as is often the case with synthetic crystals (particularly synthetic spinels).

*Extracted from bulletin No. 25, 1970, of the French Gemmological Association.

YELLOW SCAPOLITE

Another gem-mineral from Umba, Tanzania

By P. C. ZWAAN

National Museum of Geology and Mineralogy, Leyden, Netherlands

INTRODUCTION

In July, 1967 I visited a gem mine in the most north-eastern part of Tanzania. The mine-area is called Umba, according to the Umba River. It is a small location in the jungle. The mine produces a number of minerals of gem quality, especially corundum, garnet and tourmaline. These minerals occur in different metamorphic rocks which, according to Solesbury (1967), are of pre-cambrian age.

Since 1967 a number of papers dealing with minerals from the Umba area have been published. The locality, therefore, is well known now to many mineralogists and gemmologists.

During my visit to the mine the manager gave me a number of different gem-minerals; among others I received two samples of yellow scapolite. Both stones are in the collection of the National Museum of Geology and Mineralogy at Leyden, Netherlands. According to a personal communication of the manager both originate from his mine and are found in secondary deposits.

Meanwhile one of the rough stones has been cut while the other is still in its original state, provided however, with one polished face to facilitate measurements of the refractive indices on an Anderson-Payne-spinel refractometer. The specific gravity of these two stones was measured by using a hydrostatic balance and ethylene dibromide. The X-ray powder photograph of the rough

specimen was made using Fe-radiation and a Debye-Scherrer camera with a diameter of 114.6 millimeters.

Recently Bank and Nuber (1970) described transparent scapolites from Mozambique and Madagascar. It is interesting to compare their results with the ones obtained from these Tanzanian stones.

DESCRIPTION OF THE SPECIMENS

1. RGM 151264 is an oval-shaped faceted stone of 7.51 carats, having a light yellow colour and containing needle-like inclusions (Figs. 1, 2 and 3). Its size is $14.9 \times 10.3 \times 7.6$ millimeters. The average density, derived from several measurements, is 2.671. The refractive indices, measured on the table, are 1.567 for the ordinary ray and 1.548 for the extraordinary ray, while on one of the back facets the figures 1.568 and 1.550 could be observed. This means that the maximal birefringence which could be measured is 0.019.

The stone has a distinct dichroism in tones of pale yellow and almost colourless. No characteristic absorption bands could be observed.

Under long-wave ultra-violet light the stone has a weak reddish orange fluorescence, while under the short-wave lamp the glow is much stronger in the same colour.

The inclusions are in fact hollow tubes with a tetragonal or orthorhombic prismatic habit. They are filled with soft whitish material and partly covered with a reddish brown powdery material. They resemble the anhydrite tubes sometimes occurring in smoky quartz from Switzerland.

Figs. 1, 2 and 3 show that these needle-like inclusions are oriented in two directions, making an angle with each other of about 60° . Fig. 2 shows a doubling effect, due to the rather strong birefringence of the stone. Moreover in this photograph two black parts are visible, which can be ascribed to a beginning of cleavage against which the transmitted light is totally reflected. In fig. 3 the powdery material covering the needles can be seen.

In regard to the orientation, accepting that the cleavage is parallel with 100, it is seen that the thinnest needles run parallel with the c-axis while the thick tubes lie in the 111 direction.

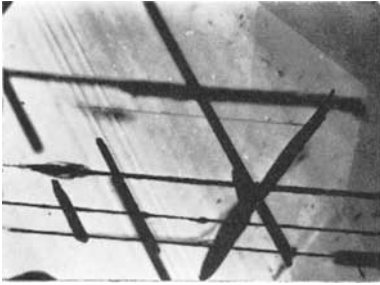


FIG. 1. Needle-like inclusions in scapolite RGM 151264 (25 ×).

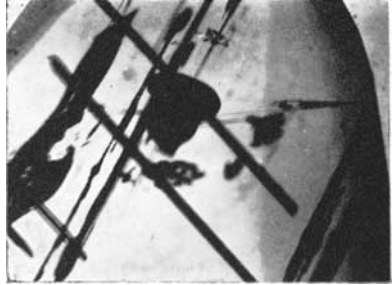


FIG. 2. Needle-like inclusions and beginnings of cleavage in scapolite RGM 151264. The doubling effect is due to the rather strong birefringence of the stone (25 ×).

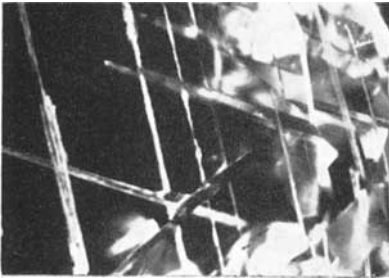


FIG. 3. Needle-like inclusions in scapolite RGM 151264 in reflected light (25 ×).



FIG. 4. Etching figures on scapolite RGM 107194 in reflected light (25 ×).



FIG. 5. Needle-like inclusions in scapolite RGM 107194 (25 ×).

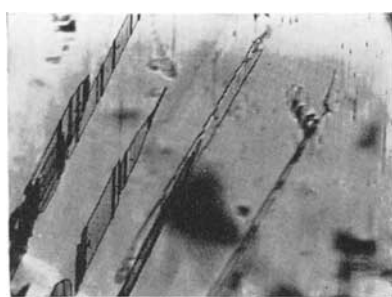


FIG. 6. The same inclusions as in fig. 5 showing the parallel striation in the needles (50 ×).

One may only make a guess at the original nature of these needles, but it is very likely that they were xenogenetic inclusions, according to the classification of Gübelin (1957), from which the contents have been lost in the course of time.

2. RGM 107194 is a rough stone with a yellow colour, weighing 7.23 carats after being provided with a polished face. Its specific gravity is 2.659; the refractive indices are 1.562 for the ordinary ray and 1.543 for the extraordinary ray, hence a maximal double refraction of 0.019 could be measured.

A very distinct dichroism in tones of straw-yellow and almost colourless may be observed, while no characteristic absorption spectrum has been detected.

Under the long-wave ultra-violet lamp it fluoresces weak yellowish orange. Under short-wave ultra-violet light it glows a rather strong yellowish orange.

Although no distinct crystal habit can be seen, there are triangular depressions observable on one of the natural faces of the stone (Fig. 4), probably caused by a natural etching process, or being an irregularity in the crystalline development of the specimen. They are very similar to the inverted triangular depressions often seen on the octahedral faces of diamond crystals.

A remarkable fact is that the needle-like inclusions (Fig. 5) all emanate from the centre of the depressions, like stalactites. In contrast with those of the cut stone these tubes are extremely thin, hence they have a bladed habit. Fig. 6 shows a structure of parallel lines in these inclusions. These lines all lie in an extinction direction of the stone and resemble the cleavage-lines in calcite.

The X-ray powder photograph (No. mm 1714), taken of this stone, gives a pattern of diffraction lines, characteristic for scapolite.

The observed X-ray data are given in the Table and compared with those of three other scapolites, namely one from Mozambique, one from Madagascar and one from an unknown locality. Those from Mozambique and Madagascar are described by Bank and Nuber (1970). The other one is a marialite from the collection of the British Museum, according to the data given by the American Society for Testing and Materials.

COMPARISON OF THE RESULTS

As might be expected in an isomorphous group of minerals

TABLE: X-ray powder diffraction data for 4 scapolites

hkl	Mozambique Bank and Nuber 1970		Madagascar Bank and Nuber 1970		Unknown locality ASTM 2-0412		Tanzania RGM 107194	
	d _{obs}	I	d _{obs}	I	d _{obs}	I/I ₁	d _{obs}	I
110								
101	6.449	8			8.49	40	8.49	4
200	6.059	8	6.09	8	6.16	40	6.44	1
211	4.400	6	4.422	3			6.09	2
220	4.270	6	4.295	5	4.24	70	4.42	1
310	3.816	100	3.839	10	3.78	90	4.24	1
301	3.557	18	3.569	13			3.78	8
112	3.470	76	3.468	100	3.44	100	3.55	1
202					3.21	20	3.44	10
321	3.064	100	3.075	24	3.03	100	3.04	9
400	3.016	46	3.032	12			3.01	3
330	2.845	12	2.859	6				
222	2.837	12			2.84	40	2.83	2
411	2.722	16	2.746	8				
420			2.713	7			2.71	2
312	2.690	66	2.699	7	2.68	90	2.68	2
421					2.52	20	2.53	1
510	2.368	2	2.379	3			2.36	1
501	2.301	8	2.311	10	2.29	70	2.29	3
422	2.199	10	2.198	6	2.19	20	2.19	1
521			2.158	3				
440			2.143	13	2.12	70	2.13	3
303	2.142	18						
530	2.072	20			2.05	20	2.06	1
600			2.021	8				
323	2.018	10						
512			2.016	6	1.99	70	2.00	2
611	1.9194	8	1.928	13			1.948	1
413	1.9136	26						
620	1.9087	16	1.9174	5				
004	1.8967	32	1.8967	12	1.90	90	1.907	7
532	1.8178	6			1.81	60	1.807	2
602	1.7775	4					1.774	1
631	1.7514	4	1.7577	3				
503	1.7468	6			1.73	40	1.741	2
710	1.7075	8	1.7143	5	1.69	40	1.698	2
640					1.66	20	1.669	1
721	1.6197	4						
404			1.6078	4	1.61	30	1.607	1
613	1.5608	8	1.5652	4	1.59	20	1.596	1
712					1.55	60	1.553	2
543	1.5116	4			1.50	40	1.508	2
811	1.4692	4						
732	1.4623	8	1.4681	3	1.45	70	1.458	2
215			1.4611	2				
703			1.4295	3				
444			1.4209	3				
305	1.4199	6			1.41	70	1.417	2
723			1.3921	3			1.400	1
325	1.3821	8	1.3849	3			1.379	2
822	1.3655	26	1.3720	14	1.37	40	1.363	4
840			1.3574	3	1.36	70		
624					1.34	20	1.342	1
752			1.3214	2	1.32	20	1.332	1
921					1.31	40	1.316	2
505			1.2868	2	1.28	40	1.286	2
950			1.1780	2			1.172	1
635	1.1602	8					1.161	1
1002			1.1553	3				
426			1.1465	1			1.149	2
725	1.1193	6					1.129	2
1042			1.0793	3			1.084	1
880							1.066	1
1060	1.0349	12					1.035	1

like the scapolites it is very unlikely that even two examples from one locality will have the same properties.

RGM 151264, the cut stone, has the highest values for refractive indices and density. They are very close to those of the Madagascar scapolite, mentioned by Bank and Nuber (1970). This Tanzanian scapolite therefore lies somewhere in between dipyre and mizzonite (after the diagram of Bank, 1970).

RGM 107194 has somewhat lower properties. Plotted in the diagram, mentioned above, these figures indicate a scapolite in the dipyre field. The X-ray data, stated in the Table, however, agree best with those from the marialite of unknown locality. Anyway this scapolite seems to have a chemical composition in which the molecular percentage of marialite is predominant.

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NOTES ON RECENT SYNTHETICS AND THE BLACKENING OF NATURAL OPALS

By RICHARD T. LIDDICOAT, Jr.

IT is a pleasure and an honour to be able to participate in a tribute to Basil W. Anderson on the occasion of his 70th birthday.

He is not only recognized throughout the world, but revered for his contributions to the science of gem-testing in too many ways to count. Perhaps the contribution that we in American laboratories appreciate the most is his pioneering work in the use of the spectroscope in gem-testing. We have been able to take advantage of his work and to appreciate the exceptional usefulness of this instrument in testing. There was a time when it was used but rarely in routine testing in our laboratories; however today the

spectroscope has become of equal importance to the refractometer. So many of the tests that we use every day were pioneered by Basil Anderson, that all of us in this field can only say "thank you" to a great man.

Every year brings new examples of the value of the spectroscope in gem-testing. In the last year or two, the development by Pierre Gilson of synthetic emeralds that have properties well within the range of the natural, i.e. approximately 1.572–1.579 in refractive index and about 2.68–2.69 in specific gravity, would have made detection difficult except for the new absorption line introduced by the addition of iron oxide to dampen the fluorescence and raise the properties of the synthetic. With a spectroscope, a line surely caused by the iron is to be seen at about 4270Å in the violet. If no inclusions are to be seen, the 4270Å line will become exceedingly important to the gemmologist seeking to detect a synthetic emerald. Fortunately, to date most of these show an abundance of the wispy or veil-like inclusions we associate with flux-melt grown products.

Certainly, the use of the spectroscope has added a very important dimension to gem-testing, which even though it has been present for quite a number of years, is still one that is enjoyed particularly by the gem-testing fraternity.

NEW TYPE OF TREATED BLACK OPALS

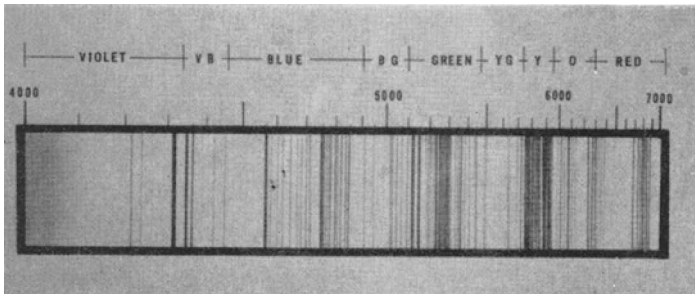
For over a year we have been receiving for testing black opals that we were sure had been treated in some fashion. When we first encountered these very dark opals, we were given a story about the method of treatment, but did not consider it factual, because of certain properties and other characteristics. We learned that the stone first is covered completely with brown wrapping paper. Placed in a crucible, the wrapped opal is heated slowly with a torch until it is hot enough for the paper to burn. We would have expected the opal to shatter, but no evidence of cracking was present. This "smoking" imparts a black colour that penetrates less than 1 mm.

The black opals are beautiful, with a great deal of fire. Every one tested revealed a very, very low refractive index—about 1.37, and an exceptionally low specific gravity—usually about 1.25 (one floated in water until it absorbed enough to sink). When subjected to the point of a needle they seem to indent rather than break out. These treated black opals do not show the evidence of treatment that we use to detect the usual sugar-and-acid treatment.

The only opals we have encountered with comparable properties are semi-translucent white opals from Jalisco, Mexico. They have a similar pattern of fire as well.

A NEW YTTRIUM ALUMINATE

One other material that we feel will be encountered in gem-testing laboratories around the world in the next few months is an yttrium aluminate that, unlike YAG, is doubly refracting. This one has a formula $Y_2O_3:Al_2O_3$ (in contrast to the $3Y_2O_3:5Al_2O_3$ of YAG), which crystallizes in the orthorhombic system. Presumably this material is colourless when pure, but the only specimens we have been able to study were heavily doped with didymium, which imparted bluish-pink to orangy-pink colours. The absorption spectra were spectacular. The drawing by Charles Fryer, below, does not exaggerate the sharpness and intensity of the many lines.



We only have rough, so we have not measured the refractive indices, but the strength of doubling suggests a birefringence in the $\cdot02\text{--}\cdot03$ range. The manufacturer indicates a refractive index of $1\cdot938$ at 6568\AA and $1\cdot955$ at 4868\AA , hardness equal to YAG (8+) and a specific gravity of $5\cdot35$.

This material may soon appear in a colourless form as yet another diamond imitation.

KAKORTOKITE—AND OTHER ORNAMENTAL EUDIALYTE ROCKS

By O. DRAGSTED

IN July 1967, the author visited the Kangerdluarssuk fjord in the Julianehåb district of Southern Greenland. The fjord is beautifully framed with snowcapped mountains, here and there with tiny grassy shelves which once served as pastures for the cattle of a lonely viking family. The aluminium speed-boats cut through the water, glittering cascades shot up like fireworks and then washed over the foredeck, and over the chart which had to be studied all the time to avoid submarine rocks. Sudden swerves when small icebergs were sighted sent showers of water over the crews.

The boats were dragged ashore on the innermost coast near the remains of an old eskimo cottage, under the shelter of a slope covered with heather and creeping bushes of willow and juniper and polar birches which together with the mosses and the yellow arctic poppies and red silenes and bluebells lent their aromatic scents to the air. The song of the snow-birds and Lapland buntings was accompanied by the sound of the waterfalls of the Salmon Brook and the hoarse cries of ravens.

Crossing the delta of the brook we reached, under the instructive guidance of John Hansen of the Greenland Geological Survey, the southern bank of the fjord over which loomed a mountain spectacularly built up of wavy bands of *kakortokite*, some of them greyish white, others nearly black, and all of them spangled with brick-red little spots of the rather rare mineral *eudialyte*. Debris on the beach formed a nice sample range of the many *kakortokite* varieties. The *eudialyte* is embedded in white grains of nepheline and some felspar. The black mineral is *arfvedsonite*⁽¹⁾.

The first report⁽²⁾ of this mountain, which forms the lower part of the interesting Ilímaussaq intrusion, was given by Karl Ludwig Giesecke (1761-1833) who during 1806-1813 undertook an intensive survey, commissioned by the King of Denmark. Giesecke presumed the red mineral was a type of garnet. His stay was extended over seven years because of the Napoleonic War. By the way, several boxes of rocks and minerals, which he sent home, were seized by the British and found their way to Scotland. In these collections

were discovered two hitherto unknown minerals, *sodalite* (Th. Thomson, 1811) and the amphibole *arfvedsonite* (H. J. Brooke, 1823). But the greater part of the collections reached the European continent, and the minerals were analysed in Copenhagen and elsewhere. The presumed garnet was studied in Göttingen by Friedrich Stromeyer (1776-1835) who found that it was a complex zirconium silicate and named it, in 1819, *eudialyte* (Greek eu = well, dialyein = dissolve, because it is readily attacked by hydrochloric acid).

Because of the zirconium contents of the eudialyte (about 10-15% ZrO_2) the Danish mineralogist K. J. V. Steenstrup (1842-1913) undertook, in 1888 and 1899, to send home loads of the



Eucolite
in rock

3 eudialyte
crystals
(fragments)

Kakortokite
rock

Kakortokite
oil lamp

naujaite heart
and
bowl

2
kakortokite
cabochons

rocks; the Cryolite Company hoped to create interest therein, but in vain. Remains of the barrel hoops were still spread around. Quarrying took place again in 1946, and now mining of the eudialyte-bearing rocks is again under consideration because of the growing importance of the zirconium metal. If so, the kakortokite mountain will probably disappear from the map, together with the neighbouring occurrences.

Eudialyte is present in the three nepheline-syenites, which N. V. Ussing (1864-1911) named kakortokite, naujaite (the next one according to age) and lujavrite (the youngest one of the three); they build up the Ilímaussaġ intrusion, so rich in rare minerals. The age of the formation has been determined by radioactive methods as 1,000,000,000 years.

Also the naujaite (Eskimo nauja = seagull) is most attractive. It is a whitish rock of nepheline and feldspar containing numerous pastel green grains of sodalite and thus has very much the appearance of a seagull's egg. Further there may be dark green aegirine (acmite) and black arfvedsonite included. With red grains of eudialyte the naujaite forms a most attractive decorative rock.

Most of the eudialyte in these rocks lacks crystal faces, but in the small Qeqertaussaġ skerry in the fjord specimens with well developed crystal faces may be collected during low water.

Some eudialyte has weathered into the yellowish-brown *eucolite*. The chemical formula of eudialyte has not been easy to determine; it is now usually written $(\text{Na,Ca,Fe})_6\text{Zr}[(\text{OH,Cl})(\text{Si}_3\text{O}_9)_2]$. Eudialyte crystallizes in the trigonal system. The hardness is $5\frac{1}{2}$ Mohs, and the gravity about 2.9. The pleochroism is distinct (under a strong light-source): rose-red and dark brownish red. The mean refractive index is 1.61 with a weak positive birefringence (0.003); eucolite has a mean R.I. of 1.62 with weak negative double refraction. The S.G. of kakortokite ranges from 2.7 to 2.8.

Eudialyte is a brittle mineral—anyway the Greenland material is not suited for fashioning. But when embedded in the nepheline or feldspar it forms a rock which takes a nice polish.

Endeavours are made to make kakortokite a souvenir of the city of Julianehåb (founded 1775). Small bowls (which are not

ashtrays but models of eskimo grease lamps) and other objects of art, as well as cabochons for silver ornaments, have been made. Also the naujaite is being polished on a small scale, and it is hoped that the Greenlanders will utilize these attractive materials and thus earn an extra income.

Mineralogists link another hope with eudialyte, which they intend to establish as the zirconium standard for the microprobe.

Although rare, eudialyte is found in several places around the world. It has been reported, often together with eucolite, from Pilandsberg in Transvaal, from Norra Kär in Sweden, Langesunds-fjord in Norway and from Ampasibitika in Madagascar. Famous among American collectors are the well developed eudialyte crystals found in the coarser part of the nepheline-syenite of Magnet Cove, Arkansas. They are of a pink hue. In formations which have much in common with the Greenlandic geology, eudialyte is found in the Khibina tundras in the Kola peninsula in Lapponian Russia and Sedlovatoi island in the White Sea off Archangelsk.

The Russian mineralogist A. F. Fersmann (1883-1945) relates⁽³⁾ a tale by an old Lapponian woman. Foreigners, maybe Swedes, penetrated into the land of the Saami people and drove them away, depriving them of many reindeer. So the men gathered to fight the intruders and regain their property. But the enemy slew their right flank and they slew their left flank and much Lapponian blood was shed and sprayed out over the mountains and tundras.

“You have seen it, the beautiful stone in the mountains, that it is the blood of the Lapponians, the blood of the old Saami”!

“Blood stains”—a comparison known also from the legend of the heliotrope jasper or bloodstone—is most descriptive for the appearance of the beautiful eudialyte rocks.

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A DIFFERENT POINT-CUT DIAMOND

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

IT has been said that the fine, symmetrical diamond of octahedral shape—possibly improved through cleaving, but not through polishing—was the earliest example of a gem diamond. This, and the fact that such “glassies” were never exported has been documented by G. Lenzen⁽¹⁾ in regard to ancient India.

The earliest diamonds encountered in Europe (with the exception of those used as tools) are mostly small, translucent octahedra, dodecahedra or twins. Some of these are crudely buffed by hand, many in their natural state. Such diamonds were originally worn as talismans only and their subsequent use in antique jewellery seems to have served similar purposes rather than decorative. A fine example from 1380 is preserved in the treasury of the Royal residence in Munich. It is the bridal crown, worn by Princess Blanche at her marriage to the Elector Ludwig III⁽²⁾. In this crown the coloured stones and pearls dominate to the extent that the many small rough diamond octahedra were not mentioned in the catalogues before 1970, when the author’s diamond inventory was included⁽³⁾.

Until the art of cutting was invented, Europe must thus have been a limited market for quasi gem diamonds of regular crystal shapes only. But neither specialists on antique jewellery nor gemmologists have yet been able to disclose when and where diamond cutting originated. Several indications, however, point towards the 14th century and Venice, as well as Bruges, seem to have many supporters as cutting centres of that period. Strangely enough many authors still cling to the tale of a French jeweller who in 1661 claimed that one of his ancestors had invented the method of cutting diamonds in 1476. They seem to believe that the natural crystal faces of the early gem diamonds were just polished and that the first stage of cutting was a mere grinding away of the tip of a natural octahedron. However, such a treatment would not have been possible. Neither the octahedral, nor the dodecahedral faces can be polished even by modern methods. In order to obtain smooth and shiny faces a diamond crystal must be attacked at an angle to the above mentioned crystallographic planes.

It is true that the earliest gem diamonds in the various collections all over the world at first sight appear to have crystalline proportions, but a close examination of thousands of pyramidal- and table-cuts has revealed distinctly divergent angles. The initial stage of diamond cutting seems thus to have been a transformation of more or less unsymmetrical crystals into mirroring gems. The very first diamond cutters obviously had no, or very restricted, knowledge about hard and soft faces or directions. Their success must nevertheless have been immediate since it did not take long before all kinds of fancy shapes appeared on the market. Even with regard to imagination the evolution was concluded around 1450 with some 200 different cuts registered by the author. Further progress was concerned with details of the appliances for precision and power for comfort and speed. No basically new shape has been cut since the middle of the 15th century. It is obvious that at first there was no demand for any other shapes than those similar to the natural diamond crystals. The supply of rough must then have been restricted to these types and many were probably cut into gemstones. In addition diamond had since Biblical days been used as a technological and industrial hard material and this type of rough may well have induced early cutters to experiment with irregularly shaped rough, which was available and gradually found a growing market in Europe.

For reasons of Pythagorean mysticism⁽¹⁾ the pyramidal- and table-cuts were preferred to other shapes and held their ground until the mid-17th century. It is, therefore, not surprising that the cutters very soon had to look for other than octahedral rough.



FIG. 1.

- a. The corners of the square reflection touch the sides of diamond when the proportions are equal to the natural octahedron.
- b. A small reflection with its corners well inside indicates proportions of the diamond far below the octahedral.
- c. A large reflection with its corners outside indicates proportion above the octahedral.

They fashioned, as we have seen before⁽³⁾ tablet-cuts from “flats” and we shall now see how triangularly crystallized diamonds could be transformed into point-cuts. As briefly explained in a previous article⁽⁴⁾ practically all of the historical point-cuts (pyramidal cuts) have been produced from octahedral rough by working towards the apices of the crystal (Fig. 1b). Cutting towards the girdle and therewith reducing the outline (size) and increasing the relative height of the finished gem must have been out of the question. Nevertheless point-cuts of proportions indicating such shaping can be seen in numerous pictures and a few have been preserved from recutting. One of exceptional size and beauty is the stone in an elaborate renaissance ring in the collections of the Green Vault in Dresden (Fig. 2). This ring, together with some other pieces of antique jewellery with diamonds of intricate shapes, was on loan in Helsinki in 1970 and on display at a diamond exhibition arranged by the author.



FIG. 2. Photographs of the renaissance ring in the collections of the Green Vault in Dresden.

The pyramidal diamond in this ring was thoroughly examined and found to be of a type not previously described. The visible part of the stone is equilateral in shape and the angle of inclination

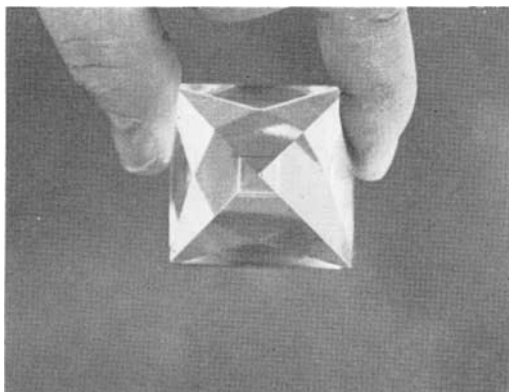


Fig. 3. The reflection picture of the depicted diamond.

of the four main facets towards the girdle plane thus 60° against $54\frac{3}{4}^\circ$ in the octahedron. Obviously also the reflections show an entirely different picture from the normal point-cuts with angles of inclination lower than $54\frac{3}{4}^\circ$. The small square in the centre suggested at first a culet in the pyramidal pavilion, hidden in the closed setting (Fig. 3).

The problem could only be solved through experimental comparisons. During the stage when point-cuts of lower than octahedral proportions were first studied a series of models in plastic (with an R.I. of 1.50) were produced. Professor S. Rösch, of Wetzlar, assisted with a graph permitting correct comparisons with diamond. Subsequently he published a paper on the reflection figures in point-cut and table-cut diamonds. The author further found that if two single pyramids were placed on top of each other no interference took place; the reflections proved to be identical with those of double pyramids made out of one single piece. This observation much simplified the experimental work. Twelve pairs of single pyramids were enough to cover the whole scale of point-cuts encountered in the various collections. They were cut with a basis of 40×40 mm and a range of height figures from 8, 12, 16, 20, etc. up to 52 mm covering a sufficiently long series of angles of inclination for diamond from 11° up to $60\frac{1}{2}^\circ$.

Obviously the highest pyramid was found to compare best with the reflections of the diamond in the ring. Surprisingly,

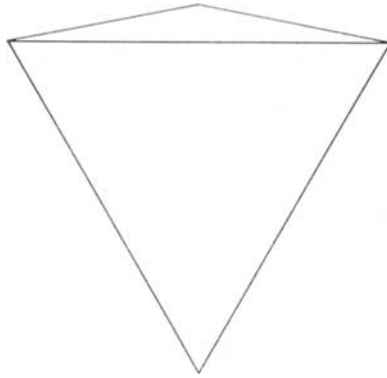


FIG. 4. A crosscut of the Dresden diamond showing the proportions of the double pyramid.

this also displayed the little square in the centre. It was further found that every diamond of higher than octahedral proportions must show a similar square reflection, the size of which is directly related to the height of the pyramid. It then remained to recognize the complete reflection picture. This was found after applying the very lowest plastic pyramid under the highest, thus indicating clearly a crown angle of about 60 or $60\frac{1}{2}^\circ$ and a pavilion angle of some 11° . These proportions are shown in Fig. 4. The story of this peculiar point-cut diamond does, however, not yet end. It was evident that the rough from which it was produced could

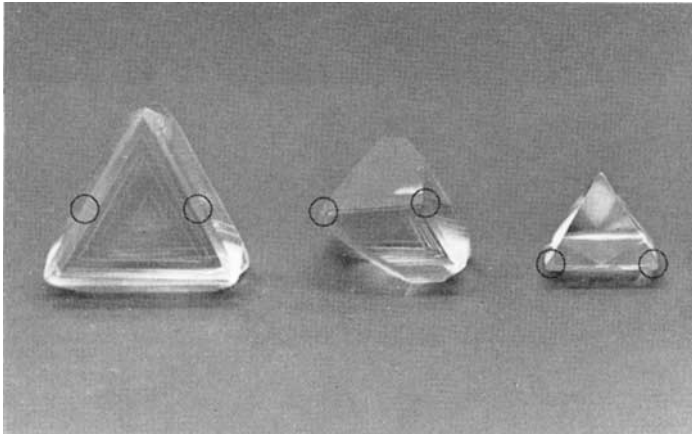


FIG. 5. The sequence of the cutting operation.

not logically have been of octahedral shape. Naturals on two adjacent corners and a tiny, hardly visible cleavage helped to solve this problem. The equilateral, triangular shape of the upper pyramid and the extremely flat lower one suggested a triangular, slightly rounded macle of the spinel-twin type. A plastic model of that shape was therefore made and it was found that this lent itself to cutting into the described point-cut. A further and rather unexpected result from this operation was that two corners remained blunt, thus corresponding with the naturals on the diamond. The direction of the tiny cleavage was an additional confirmation of a correct solution. Finally it was found that only some 40% of the original weight of the rough was lost in the cutting operation—a commercial proposition (Fig. 5).

Just as tablet-cuts have been produced from “flats”⁽³⁾ it has now been shown that point-cuts have not necessarily been derived from octahedra.

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ASSOCIATION NOTICES

OBITUARY

SIR LAWRENCE BRAGG, C.H., O.B.E., M.C., B.Sc., F.R.S.

The eminent physicist, Sir Lawrence Bragg, died at Ipswich on the 1st July aged 81.

Sir Lawrence, who honoured the Association by becoming its President in 1954 was, with his father, the late Sir William Bragg, awarded the Nobel Prize for Physics in 1915. At the time he was only 25. He was elected a Fellow of the Royal Society at the age of 31. Sir Lawrence was made a Companion of Honour in 1967 for his services to science. During his distinguished career he was Langworthy Professor of Physics, Victoria University of Manchester, Director of the National Physical Laboratory, and Cavendish Professor of Experimental Physics, Cambridge. In 1953 he became Fullerian Professor of Chemistry, Royal Institution, and in 1954 Scientific Director of the Royal Institution, posts which he held until 1966. He was knighted in 1941.

His principal work concerned x-ray and crystal structure and the discoveries of both father and son made it possible to map out the positions of atoms in molecules and crystals with great certainty. Sir Lawrence was awarded the Copley Medal for contributions to crystallography and analysis of molecules by x-ray diffraction in 1966.

ANNUAL GENERAL MEETING

In the absence of the Chairman, Mr. D. King, Vice-Chairman, presided at the 41st Annual General Meeting of the Association, which was held on the 30th April. Mr. King said that as the Annual Report had been circulated there was little about which he could comment as the year under review was one of routine rather than spectacular achievement. Nevertheless, he reported that it had been a busy year with an increased volume of corres-

pondence and enquiries. He said that in the examinations 510 candidates sat for the preliminary and 301 for the diploma, against 460 and 307 respectively for 1969. For the second year running the Tully Memorial Medal and Rayner Prize were not awarded. Mr. King reported that the Association has been particularly gratified at the interest in examinations overseas, especially in Spain and Japan, and it is encouraging that Barcelona University recognized gemmology as a faculty subject.

The Vice-Chairman went on to say that the National Association of Goldsmiths had reorganized the Sir James Walton Library to house, among other things, the two pieces of silver which this Association gave to them in 1968 to commemorate 60 years of gemmology in Britain. Both organizations added to the library from time to time.

Mr. King reported that the Association had agreed to contribute a more realistic sum to the National Association of Goldsmiths for administrative work. He thanked the many people who had contributed towards the work and the success of the Association during the year under review. The audited accounts and report of the Council for the year ended 31st December, 1970, were then adopted.

The following Officers were re-elected: President, Sir Lawrence Bragg, C.H., O.B.E., M.C., F.R.S.; Chairman, Mr. Norman Harper; Vice-Chairman, Mr. Douglas King; Treasurer, Mr. F. E. Lawson Clarke. Mr. Philip Riley continues as Deputy Chairman. Messrs. D. J. Ewing, J. M. B. McWilliam and R. Webster were re-elected to serve on the Council.

The Vice-Chairman announced that Messrs. Watson Collin & Co., chartered accountants, had signified their willingness to continue as auditors.

BRANCH MEETINGS

The Annual General Meeting of the Scottish Branch of the Association was held on the 22nd April, 1971, at the North British Hotel, George Square, Glasgow. Mr. Dennis Hill, Chairman, presided.

Mr. D. Hill and Mr. M. Turner were re-elected Chairman and Secretary respectively.

At the Annual Meeting of the Midlands Branch held at the

Auctioneers Institute, Birmingham, on the 30th April, 1971, Mrs. S.E. Hiscox was elected as Chairman. She is the first woman to become Chairman of a local branch. Mr. J. Marshall was elected as Vice-Chairman and Mr. P. J. West continues as Secretary.

The retiring Chairman, Mr. P. Spacey, outlined the activities of the past year, among which was a visit to the Crown Jewels and a talk by Mr. Robert Webster on "Modern Synthetics".

GEM DIAMOND CLASSES

Gem Diamond Classes, open only to Fellows of the Association, will commence at the Sir John Cass College, Whitechapel High Street, London, E.1. in September. If sufficient students enrol, classes may also be held at the School of Jewellery and Silver-smithing, Vittoria Street, Birmingham and the Barmulloch College of Further Education, Rye Road, Glasgow, N.1. It is suggested that Fellows interested in attending should contact the appropriate College as soon as possible.

EXHIBITION OF GEMSTONES

The Exhibition of Gemstones to be held in Glasgow (see April 1971 issue) will be officially opened on the 16th September, 1971 at 7.30 p.m. by Professor George of the Department of Geology, Glasgow University. The closing date is the 10th October, 1971. The exhibition is being arranged by the Scottish Branch of the Association.

GIFTS TO THE ASSOCIATION

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

The gift of the Gemmological Association of All Japan of an Olympus dark field stereo-zoom binocular microscope, model J.M. The costs of customs clearance and delivery charges were covered by the Metallurgical Services Laboratories Ltd., the U.K. Agents for Olympus Instruments.

A powellite cut stone, a synthetic material produced for scientific purposes, from Mr. E. C. Parrott, Vancouver, Wa., U.S.A.

Holly leaves carved in nephrite and coral, mounted on gold stems and set in a rock crystal jar, have been presented by Mrs. E. Stern, London, to the Sir James Walton Library, a favourite piece of the late Dr. W. Stern.

A series of transparencies and study specimens from Mr. R. Webster, London.

A twin quartz crystal from the Kuro-daira, Koofu City, Yamanashi Pref., Japan, presented by Mr. H. Fukabayashi, Sapporo, Japan.

Tourmaline crystals from St. Just in Cornwall, presented by Mr. Aubrey Bowden, Plymouth.

Specimens of Japanese gem minerals including jadeite, rhodonite and rhodochrosite presented by Mr. P. Tamiya of Cosmo Ltd., Tokyo, Japan.

A pocket guide to precious stones from Mr. P. Ruppenthal, Idar-Oberstein.

A specimen of green opal, Brazil, from Mr. J. Petsch, Jr., Idar-Oberstein.

A collection of study specimens, including Mexican opals, peridots and Montana sapphires, from Mr. A. C. Bonnano, F.G.A., Maryland, U.S.A.

Edelsteine—systematik under beschreibung. A gift from Dr. H. Bank, Idar-Oberstein.

MEMBERS' MEETINGS

A reception for Fellows of the Association was held at Goldsmiths' Hall, London, on Wednesday, 20th April, 1971.

COUNCIL MEETING

At a meeting of the Council held on 20th April, 1971, the death of Dr. W. Stern was recorded with great regret. Dr. Stern gained his Fellowship, with distinction, in 1947 and became a member of the Council in 1950. He contributed much to the work of the Association, particularly with the translation of abstracts for the *Journal of Gemmology*.

The following were elected to membership:

FELLOWSHIP

Ballester, Juana Prats,
Barcelona, Spain D. 1970

Godfrey, Kenneth E.,
Brighton, Sussex D. 1948

Gimeno, Jose Luis Garcia,
Zaragoza, Spain D. 1970

Girona, Maria M. Marti,
Barcelona, Spain D. 1970

Lopez, Rafael Sallan,
Zaragoza, Spain D. 1970

Ribera, Arturo Ricart,
Barcelona, Spain D. 1970

ORDINARY MEMBERSHIP

- Backshall, Henry G. R.,
Hainault, Essex
- Bearman, Jerry,
St. Louis, Missouri, U.S.A.
- Bilham-Boulton, J., Chelmsford, Essex
- Bott, Patricia A., Rugby, Warwicks.
- Coventry, Olive P., Liverpool, Lancs.
- Coventry, Stanley W. J.,
Liverpool, Lancs.
- Davis, Gerald A.,
Marion, Ohio, U.S.A.
- Eason, John R.,
Manurewa, New Zealand
- Ferguson, Louisa,
Neilston, Renfrewshire, Scotland
- Fitterman, Murray R.,
New Bern, Carolina, U.S.A.
- Frayne, Samuel F.,
Hanover, Pa., U.S.A.
- Hiok, Ng Seng, Singapore
- Holm, Franz, Stockholm, Sweden
- Kahn, Stanley B.,
Pine Bluff, Arkansas, U.S.A.
- Leat, William J., Torquay, Devon
- Levy, Ralph M.,
Greensboro, Carolina, U.S.A.
- Littman, Herbert,
Highland Park, New Jersey, U.S.A.
- Loeters, Leo, Diksmuide, Belgium
- Longhurst, William A. S.,
Bexleyheath, Kent
- Mylvaganan, Jeyakumar P.,
Colombo, Ceylon
- Nissanka, Geeta S.,
Colombo, Ceylon
- Ramshad, Seyed H., Cambridge
- Reyner, Charles S.,
Greenville, Carolina, U.S.A.
- Ruppenthal, Paul,
Idar-Oberstein, W. Germany
- Shindler, Albert,
Harrow, Middlesex
- Vogt, Arno R.,
New London, Conn., U.S.A.
- Walpitagama, Karunapala,
Gantalawa, Ceylon
- Webb, Ronald J.,
Auckland, New Zealand
- Kawahara, Makio,
Fukuoka City, Japan
- Parsons, K., Plymouth, Devon
- Renel, Ronald C. J., Eastleigh, Hants.
- Vanderkelen, Peter,
Melbourne, Australia

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