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PHOTOMACROGRAPHY OF GEMSTONES AND JEWELLERY IN 35 mm COLOUR

By E. LEVETT, F.G.A.

FOR the very large number of present-day users of colour film, photography is still just a pleasant way of taking shots of the family at home, on holiday or on social occasions, to be projected later for the pleasure of the few, but without much interest for the discriminating viewer unless some real pictorial quality or impact is present. Yet with the aid of photomacrography a series of close-ups of subjects can be recorded, which will interest the layman and also allow a library of reference to be built up which at any time can give information that would otherwise need many written words plus a sketch. This has already been of great importance to the medical, biological and some natural history sciences, to name but a few, and many a viewer has been thrilled by being able to examine in large detail the wonderful antennae of a moth or the pattern of a seed head, and all in colour.

A lot of most excellent photographic work on the internal structure of gemstones has been carried out by a number of microscopists, but to achieve a really high standard in this field fairly expensive equipment is required and, for the average user, a lot of film, whereas the recording of jewellery and gemstones by photomacrography can be achieved with the minimum of equipment and time and result in quite a high percentage of good results, provided that certain facts are appreciated.

Firstly, photomacrography occupies a position between general photography and photomicrography and is usually considered to be in the image scale limits of 1:10 and 25:1. For most jewellery items an image scale of 1:8 to 1:2 will be found to be sufficient, in fact it has to be, as the depth of field (D. of F.) is the limiting factor, as table A indicates.

Secondly, photomacrographic slides are of little use unless there is excellent definition, because slides to be seen at their best must be projected and screen sizes 50 times that of the original are quite usual and any faults in focusing, exposure or fuzziness due to movement can be seen, with a disheartening effect on the photographer.

Focusing faults and fuzziness can be overcome by the simple yet correct equipment, but exposure is largely a matter of experience, coupled with certain tables of figures as guides.

The basic equipment required is:—

(1) A single lens reflex camera (S.L.R.) with U.V. filter and cable shutter release.
(2) A rigid support for camera (tripod).
(3) A 50 mm extension tube that enables sections of a $\frac{1}{4}$ and a $\frac{1}{2}$ to be used.
(4) A plus 2 dioptre (D) and plus 3D supplementary lenses that will fit together to give a plus 5D power.
(5) An extinction meter.
(6) Magnifying eyepiece.
(7) Electronic flash (E.F.) or other means of artificial illumination.

Anticipating criticism, it is appreciated that the non-reflex cameras, such as Leica or Contax, are well able to take shots at the image scales quoted above, but the initial cost is more and the gadgetry is greater and a minimum of equipment is to be desired. Twin reflex cameras can also be used, but again the cost is greater and specially matched pairs of close-up lenses must be used to avoid parallax errors.

The S.L.R. is supreme as to cost, worries about parallax do not exist, there is greater versatility (e.g. a simple attachment and photomicrography is available) and one can observe before releasing the shutter what is the actual D. of F. with different aperture numbers.

With regard to the tripod, one that extends well above a

table height is required, complete with ball and socket head, as it will be found that generally it is very much easier to place items to be photographed on a flat rigid surface, and anyone who has tried to arrange a necklet for vertical taking will appreciate this. Of course bellow extensions can be used instead of tubes, but the latter are cheaper and practically indestructible.

If money were no object, a few lens manufacturers have produced special " macro " lenses that focus down to 4" without tube or supplementary lenses, but these are in the range of £50 to £75 each, and as this article is based on equipment which in total should be bought for this figure (the S.L.R. will have to be secondhand) a lens at that price is not being considered. (U.K. prices quoted).

If a S.L.R. is being purchased, there is no need to buy one with the standard lens having an aperture larger than f 2·8, as all photomacrographic work will be done by using apertures of f 5·6 or smaller, and f 2·8 will cover all general photographic needs with ease. The saving in cost of the f 2·8 over the larger apertures will pay for all or part of the ancillary equipment.

Item No. 7 lists E.F. etc. One should try to take as many shots as possible using daylight, but as it simplifies technique if film of one make and kind is always used, then E.F. is the best artificial illumination, as it can be used with daylight film with no extra filters.

Having the equipment, its use is towards (*a*) top quality definition and (*b*) correct exposure, and this is where the first table becomes necessary and is based on a circle of confusion of 1/500th".

TABLE A

DEPTH OF FIELD IN INCHES

Image Scale of Reproduction	*Lens Aperture in f*		
	11	16	22
1:10	4·75	6·75	9·40
1:8	3·10	4·50	6·40
1:6	1·80	2.60	3·25
1:4	0·85	1·20	1·70
1:2	0·25	0·36	0·50
1:1	0·08	0·12	0·16

This table applies to all focal length lenses at the same image scale and f number.

Most jewellery items and gemstones measure in depth between $\frac{1}{4}''$ and $1\frac{1}{2}''$ (to give approximate figures) so that by measuring the depth of the item to be photographed and looking at the table above, it will be seen what image scale will give the amount of D. of F. needed. It is not suggested that f 11, 16 or 22 can alone be used, as obviously if the scale image is as small as 1:6 or 1:8, then there will be sufficient D. of F. using f 5·6 or f 8 and this is where the S.L.R. is such a help, as this can be seen at the time. Having decided on the image scale, the next table B will give what is needed in extension tubes and/or supplementary lenses to give this scale, and the table is based on using a 50 mm f 2·8 Tessar. Other cameras having a standard lens of 52, 55 or 58 mm focal length can use this table as the variation will be very small.

TABLE B

Image Scale	*Supplementary Lens in Dioptre power*	*Extension Tube*	*Lens Focused at*	*Distance of Front Lens from subject to nearest* $\frac{1}{2}''$
1:8	Plus 2	Nil	∞	21″
1:6	Plus 3	Nil	∞	13″
1:4	Plus 2	Nil	0·5 metre	$8\frac{1}{2}''$
$1:2\frac{1}{2}$	Plus 5	Nil	0·5 metre	5″
$1:2\frac{1}{2}$	Nil	12·5 mm.	0·5 metre	5″
1:2	Nil	25 mm.	∞	5″
$1:1\frac{1}{2}$	Plus 3	12·5 mm.	0·5 metre	$3\frac{1}{2}''$
1:1	Nil	50 mm.	∞	3″
$1\frac{1}{2}:1$	Plus 5	50 mm.	0·5 metre	$1\frac{1}{2}''$

The last set of figures giving an image scale of $1\frac{1}{2}$:1 which, of course, is larger than actual size is the maximum that can be achieved with this combination. However, by reference to table A, it will be seen that the D. of F. has now become too small.

There are 30 combinations in which the three sections of tubes and the two supplementary lenses can be used, but the nine given above cover the image scale in whole or half numbers.

The final step is to decide the correct exposure. Using daylight of a calculated value with the film speed allows the shutter speed and f number to be chosen. When using E.F. the guide

number (given by the makers) for the film used divided by the distance of the flash head from the subject indicates an f number suitable, but at distances of 18″ or less it is largely a question of personal experience and a certain amount of wasted film until correct results are obtained. One maker suggests that between 18″ and 6″ two stops be added.

As E.F. lasts for only 1/1000th sec. approximately it is necessary to use a shutter speed on a focal plane shutter when it is fully opened and this is generally between 1/25th and 1/50th sec. according to make of camera, and in many cases the speed dial is marked. In compur or between-lens shutter cameras the speed of the shutter is usually at about 1/200th sec. The one criticism of the use of a focal plane shutter, when E.F. is used as a fill in, is the danger of a ghost image with the shutter speed being so slow, but, as jewellery and gem stones are static subjects, there is no real worry here.

The camera world is constantly changing, and even as this article is being written a camera with a focal plane shutter is being made available which enables E.F. to be used at a shutter speed of 1/125th sec. The f number selection can be a source of incorrectly exposed (*i.e.* underexposed) shots when extension tubes are used, because the lens-to-film distance is increased and the f numbers marked on the lens and known as the actual (A.) are not the new *effective* (E) numbers, and the following table C shows both, again based on a 50 mm focal length lens.

TABLE C

Length of Extension Tube	A f	E f	A f	E f	A f	E f	*X Factor*
12·5 mm.	11	**14**	16	**20**	22	**28**	$1\frac{1}{4}$
25 mm.	11	**17**	16	**24**	22	**33**	$1\frac{1}{2}$
50 mm.	11	**22**	16	**32**	22	**44**	2

These new f values must be used when calculating the shutter speed in daylight or the nearness of the flash head to the subject when using E.F.

When using supplementary lenses, as there is no increase in the camera lens-to-film distance, the f numbers are not altered. Going back to table B it will be seen that either a plus 5 D or an extension tube of 12·5 mm. give the same image scale of 1:$2\frac{1}{2}$. By using the supplementary lenses, no alteration in f values occurs and it is

easier and quicker to slip on the two close-up lenses than to remove the camera lens, fit on the tubes and refix lens. So wherever possible the use of supplementary lenses is to be recommended.

The use of the extinction meter rather than the photo-electric type is preferred, as with the short distances from lens to subject, which are generally between 3″ and 10″, a very accurate light value needs to be known.

With regard to the make of the colour film used, this is very much a personal choice. All makes seem to give good results provided that the particular colour bias of any given make of film is taken into consideration, and corrections can be made using coloured backgrounds to reduce or emphasize this bias; but once again the continued use of one make is to be recommended.

Correct colour balance allows little latitude in exposure, and if it is a special piece that is being photographed then it is wise to take an extra shot half a stop or time equivalent above and below what is calculated to be correct.

With regard to the background, this again is a matter of personal choice. Various materials can be used (wood, textiles, textured or coloured Formica-type boarding are examples), but, if E.F. is used, a non-reflecting surface is essential; otherwise highlights may distract from the subject in the slide.

There is such a thing as reciprocity failure which occurs when very high or low speeds upset the normal balance between time and light intensity, but this need not be considered when using E.F. and only for exposures longer than one second, when half a stop should be added to exposures up to three seconds and one stop between three and five seconds, or time equivalent if D. of F. is important.

Finally to summarize the procedure:—

(1) Check D. of F. required and from table A decide image scale.

(2) For this scale obtain from table B the close-up lens and/or tube required.

(3) Focus the subject through the magnifying viewer using the largest aperture. If one is using a camera with a pre-set iris, remember to return to selected f before exposing. Cameras fitted with automatic or semi-automatic iris ensure this when supplementary lenses are added, but not in some cameras when extension tubes are used.

(4) Ascertain exposure required, remembering E f where

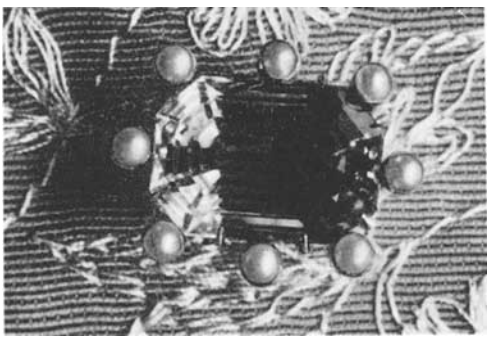
applicable. Set aperture and speed and press cable release.

It is as well to keep a detailed record of each shot, so that obvious mistakes can be avoided in the future, but, when the failures occur even with the most careful operator, a really first-class slide is more than sufficient compensation.

Notes to illustrations using 50 mm focal length lens.

(*A*) Brazilian topaz brooch. Daylight. Kodachrome 2. 25 mm tube and plus 5 D. E f 16. One second.

(*B*) Giuliano pendant. E.F. 15″ from subject. Kodachrome 2. Plus 5 D. f 16. Shutter set at 1/25th sec.



AZURITE

By L. C. TRUMPER, B.Sc., F.G.A.

IN the gemmological literature, azurite is almost invariably described as an azure blue massive mineral and, in the course of collecting gemstones, several such specimens have come into my possession, together with a small specimen of more or less radiating opaque crystals probably from Chessy, near Orleans in France, which is usually quoted as the typical locality and which gave the mineral its alternative name of Chessylite.

However in June 1961, I was agreeably surprised when Mr. K. Parkinson, on his return from one of his visits to Idar Oberstein, kindly sent to me a step-cut stone of 2·508 carats, which was not only flawless but to my surprise was also completely transparent, though of an exceedingly deep and intense azure-blue colour. The lustre was vitreous to adamantine, and there was no fluorescence under ultra-violet light. The specific gravity, carefully measured by using Toluol, was 3·80.

I next measured the refractive indices, or rather in this case index, for azurite is one of those few interesting examples where the lowest of the indices can be read on the refractometer and not the highest, for this latter is above the upper limit of the instrument. Azurite is biaxial and positive in sign. The lower reading of 1·73 was readily obtainable, but on rotating the polaroid filter, the shadow continued right up to the upper limit. The higher reading is quoted as 1·838, giving a double refraction of 0·108.

I made some efforts to try and get the upper reading on my total reflectometer, but it is difficult to do this where there are two indices of refraction and a reading somewhere in the middle is obtained.

Azurite is said to be pleochroic with two shades of blue, but I was unable to obtain any evidence of this. The hardness is given as 3·5 to 4 with a prismatic and basal cleavage, according to Sir James Walton[1]. Azurite is monoclinic.

The chemical composition is that of a hydrated copper carbonate, with the formula $2CuCO_3.Cu(OH)_2$, and it is very similar to the green mineral malachite with which it is usually found. Indeed, massive material and crystals are frequently intermingled or with malachite one end and azurite at the other.

Whilst showing a greenish colour under the Chelsea filter,

examination with the spectroscope disclosed a cut-off throughout, except for a window of deep blue between about 4,400 and 4,600Å.

Well-formed crystals have also been found at Tsumeb, S.W. Africa, where they assume many different forms, some of which are said to be of quite considerable dimensions and even up to six inches in size.

Azurite is found also in a number of other localities, including Siberia, and Clifton and Bisbee, Arizona, U.S.A.

A small specimen in my collection exhibits some quite well-formed crystals, which also appear to be quite transparent, in among a matrix of massive material, all completely blue without any sign of malachite.

Some years ago a friend gave me a specimen of azurite of quite considerable dimensions which had been on his rockery for years! This specimen consisted of innumerable small more or less roundish crystals but of the familiar and unmistakable azure blue colour.

REFERENCE

1. Walton, James. *Pocket Chart of Ornamental Stones.* London, 1954. 42-43.

COMPOSITE STONES
A survey of their types and their properties

By R. WEBSTER, F.G.A.

A COMPOSITE, or assembled, stone is no new device. Such objects have been known from the days of the Roman Empire, for they were mentioned by Pliny in his *Historia Naturalis*[1], and the Roman lapidaries constructed their *Jaspis Terebinthizusa* by cementing together three different coloured stones with Venice turpentine. Many different types of doublets were mentioned by Camillus Leonardus, of Pesara, about 1502[2]. King[3] mentions Italian glass intaglios of the 18th and 19th centuries, which could not be distinguished from the real except by a file, and to baffle this mode of detection the dealers used the ingenious contrivance of backing the paste with a slice of real stone of the same colour. When set in a ring with the junction concealed, a test with a file (presumably the test would be made on the underside rather than risk damaging the incised carving on the front) would enable the gem to be passed as real. King also refers to the fact that the same method is used for forging all the precious coloured stones, the ruby, the emerald and the sapphire; a paste of proper colour being backed by a suitably faceted rock crystal. Weinstein[4] states that the modern type of doublet, but he does not state what type, was invented by Cartier, a Frenchman, in the year 1845.

Composite stones are generally described as *doublets* when the stones consist of two main pieces; and *triplets* when three pieces are used. Internationally there are some slight differences in the nomenclature, for in North America the modern soudé-type stones are known as triplets, while in Europe these stones are called doublets.

What are the reasons for the manufacture of these composite stones? The fundamental reason in many cases is to obtain a larger stone from given natural material; or to produce a stone of much better colour and appearance. Other considerations are the provision of a harder wearing and more lustrous surface to a glass imitation, which is probably the reason underlying the making of the garnet-topped doublets, although it has been suggested that the use of garnet here is to overcome the testing by a file.

Further, doublets may be made for the purpose of supplying a rigid support for gem material which can often be found only as thin and easily damaged slices. This is the most logical reason for the production of opal doublets.

True Doublets

Literature always mentions the *true doublet*, or *genuine doublet*, which consists of two parts, constructed by cementing together two suitably fashioned pieces, one for the crown of the stone and another for the pavilion, both pieces being cut from similarly coloured material of the same species. Thus true doublets can be made of two pieces of diamond, or of ruby, sapphire, emerald or other species of stone. Except in the case of opal on opal doublets, true doublets are very rarely met with.

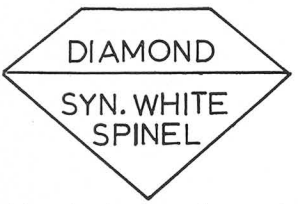
Semi-Genuine Doublets

When a piece of genuine material of the stone simulated forms the crown of the composite stone and this is cemented to a pavilion cut from a less valued stone, or even glass, the stone is known as a *semi-genuine doublet.* The most important stone of this type is the *diamond doublet*, a composite stone where the crown consists of a piece of real diamond and the pavilion of any suitable colourless stone, such as rock crystal, white topaz, synthetic white sapphire or spinel, or even glass.

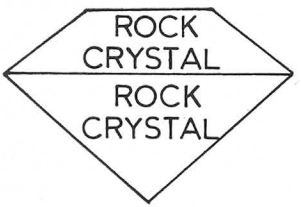
When unset such diamond doublets may easily be detected, not only by the join at the girdle which may be seen when the stone is inspected with a hand lens, but convincingly when the stone is immersed in methylene iodide or monobromonapthalene, when the difference in relief of the diamond top and the inferior material of the base is readily seen (Note: it may not be advisable to immerse doublets in which the join is made with cement or balsam, as the organic oils used for immersion may have a deleterious effect on the cement and cause pseudo-flaws or even allow the two parts to separate).

Most often the jeweller encounters diamond doublets as set stones, and usually they are set with a rubbed over setting(gipsy setting) which effectually covers the junction of the two pieces. Despite this apparent limitation diamond doublets may be readily detected, for, as reported by Tisdall[5] and also by the writer[6], if the jewel be so held that the table facet of the stone is slightly tilted

Schematic diagram of a true doublet.

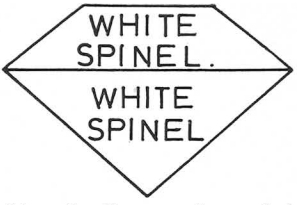


Schematic drawing of a semi-genuine doublet (in this case a diamond doublet).



Schematic diagram of a soudé (quartz type) stone where the two pieces are made of rock crystal and the coloured layer along the girdle is gelatine (early type) or sintered glass (modern quartz type).

An unusual type of doublet. The stone is white or very pale pink topaz and the tip of the pavilion is made of natural blue sapphire. The effect was not very good, and the expected total blue coloration of the stone by total internal reflection did not occur.



Schematic diagram of a spinel (soudé type) doublet.

Schematic diagram of a hollow doublet.

Schematic diagram of a garnet-topped doublet.

Schematic diagram of a false doublet.

Schematic diagram of a triplet.

away from the observer there will be seen a dark border to the opposite facet edge of the table. This is due to reflection of the facet edge on the cement layer. Further, there may be seen prismatic colours of films due to air which has penetrated along the junction layer where the cement joining the two pieces has deteriorated.

Except in the case of some opal doublets, and the diamond doublets, semi-genuine doublets are rarely if ever met with, but it would be rash indeed to say that stones with ruby, sapphire or emerald crowns cemented to base material pavilions have never been constructed. Garnet-topped doublets might be said to come under this category but in view of their being so much more commonplace they will be treated separately.

False Doublets

The so-called *false doublets* are composite stones where the crown consists of rock crystal or other colourless stone which is cemented to a pavilion of suitably coloured glass. The writer[7] reported some years ago on three specimens of such doublets, one of a sapphire-blue colour, another a purple and the third a yellow colour.

In all cases the refractive indices of the crown were 1·544-1·553, *i.e.* that of quartz, and the glass base gave for each stone an isotropic reading of 1·51.

The blue stone had a density of 2·61, exhibited the absorption spectrum of cobalt coloration, and, when immersed in water and looked at through the side, the crown of the stone was clearly shown to be colourless and the pavilion to be blue. Microscopical examination showed that there was no bubble layer at the junction of the two parts, but a few large bubbles were seen in the coloured glass base. When the stone was irradiated with long-wave ultra-violet light the characteristic fluorescence of the cement layer was seen as a bright line around the girdle of the stone.

The purple stone had a density of 2·56 and showed a faint cobalt absorption spectrum with a fainter band in the blue. Bubbles and swirl marks were seen in the glass base and the cement layer similarly showed up under ultra-violet rays. The danger of such a stone as this is that should a measurement of refractive index alone be taken the stone could be mistaken for an amethyst, which it closely resembles.

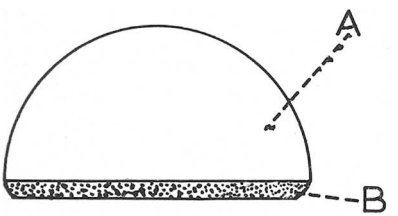
The yellow stone had an appearance very much like that of the yellow synthetic spinel, which exhibits such a strong yellow-green fluorescence under ultra-violet light; and indeed this doublet also showed a strong and similarly coloured glow from the glass base. Examination with a spectroscope showed that the glow exhibited a discrete spectrum (banded or fluted spectrum) and indicated a uranium coloration for the glass. This green glow was sufficiently intense to mask the glow from the cement layer. As in the case of the other two stones the glass base showed swirl marks and gas bubbles and no layer of bubbles was seen in the plane of joining. Examined between " crossed polars " this stone, as well as the other two, was found to show extinction at 90°. The density of this yellow stone was found to be 2·55.

Hollow Doublets

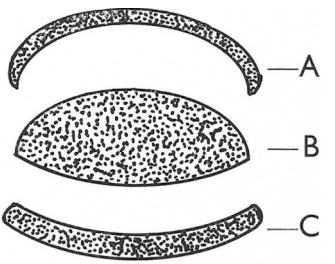
Bauer[8] mentions *hollow doublets*, a type of composite stone which the writer has not so far encountered. They are said to consist of an upper portion of colourless rock crystal or glass, which is hollowed out below, the walls of this hollowed out portion being highly polished. The cavity is filled with coloured liquid and the whole closed in with a base plate, or a pavilion, of the same material as the crown. Such composite stones are said to be readily " spotted " for the cavity of coloured liquid is visible when the stone is looked at from the side.

Imitation Doublets

This term is usually applied to doublets which consist of two pieces of colourless glass cemented together with a coloured cement.



Schematic diagram of a star-rose-quartz doublet. A: cabochon of natural star-rose-quartz; B: mirror and backing.



Schematic diagram of an "exploded" jadeite triplet showing the component parts.

Two such imitation doublets in the possession of the writer are made of two pieces of glass having an index of refraction of approximately 1·52 and densities of 2·478 and 2·488 respectively. It was interesting to note that the red colouring layer between the glass crown and pavilion had an absorption spectrum reminiscent of that of almandine garnet, for there were two strong bands in the yellow and green part of the spectrum and a weaker one in the blue part. These were centred at approximately 5720, 5330 and 5020Å.

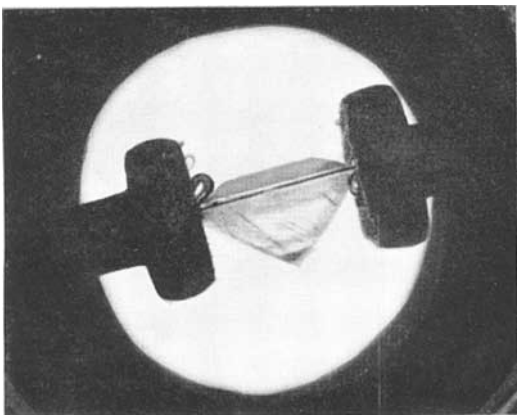
Triplets

True triplets are constructed of three pieces, the crown being some real stone, such as quartz, and the tip of the pavilion of similar material, the central portion being, usually, coloured glass. The idea behind this type appears to be that not only will the crown resist a file but the lower part of the pavilion also. Such triplets are not common.

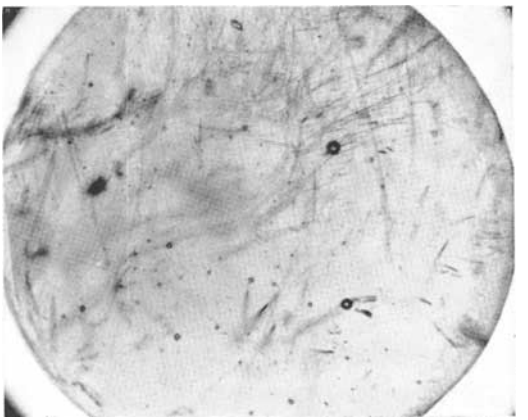
Garnet-Topped Doublets

Such composite stones are one of the more commonly met types of doublets. They are made by fusing a thin slice of almandine garnet to a blob of coloured glass. There are many colours, such as those imitating the ruby, sapphire, emerald, amethyst, topaz, peridot, and even colourless stones have been produced. It is the colour of the glass which controls the colour of the finished stone, the thin layer of garnet having little or no influence on the resulting colour.

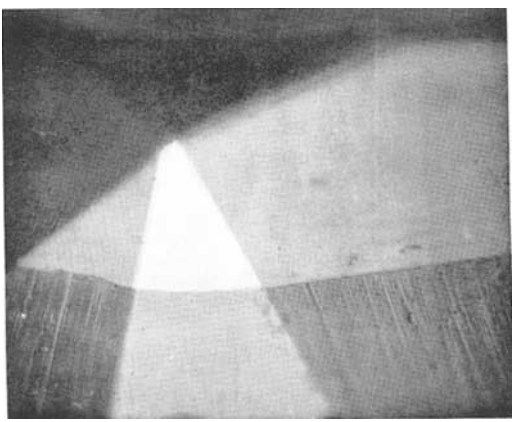
An intriguing problem was to find out when these garnet-topped doublets first appeared. It was thought that it would have probably been during the second half of the 19th century, or even a little earlier. It was significant, however, that no specific mention was made of this type of doublet in the long series of Herbert Smith's *Gemstones* until the 1940 rewritten edition[9]. However, Michel[10] in his book dated 1926 does give a very full account of garnet-topped doublets. In a personal note Dick Larkham, Senr., who has had considerable experience of the gem trade, says that to the best of his memory these doublets came out about 1923. There is a much earlier reference to the " fusing " of two parts of a doublet together, for Schrauf[11] states:—" The half-genuine doublets consist of a very thin upper layer cut from a true precious stone and cemented or *fused* to a base of glass " (my italics). Whether this



A soudé stone immersed in liquid showing the colourless crown and pavilion and the dark line of colour across the girdle.



Photomicrograph of a garnet-topped doublet showing the layer of bubbles in one plane and needle inclusions in the garnet top.



Photomicrograph showing the difference in lustre and the plane of joining in a garnet-topped doublet.

applied to the garnet-topped doublet as we know it to-day is a matter of conjecture. Garnet is the only stone which will easily fuse to glass, so the report might well be that of an earlier production which later faded out, and the production in the early nineteen twenties was a resuscitation of the method. Why such objects should be made at a time when the synthetic gems were well in production is puzzling.

These garnet-topped doublets are cut from the blob of glass to which is fused the slice of garnet. Rarely is any care taken to get the plane of joining of the garnet and glass in the plane of the girdle in the finished stone. Hence, the slice of garnet may show the join, perhaps, halfway up the side facets of the crown, and may not even be at a regular distance from the girdle all round. Examination with a hand lens will show this join and, what is just as important, will show the difference in lustre of the garnet top and the glass base. If the stone be loose and laid table facet down on a sheet of white paper a red ring will be seen round the stone. This is fairly obvious in the case of all colours of garnet-topped doublets except those of red colour where the effect is masked by the red glass.

Due to the fusing of the glass a layer of bubbles in one plane may be seen at the plane of junction of the garnet and glass when the stone is examined by a low-power microscope. Further, natural inclusions, such as crystals or a reticulation of needles may be seen in the garnet top, and if the examination be carried out by using an immersion oil the difference in relief of the garnet top and the glass will be strikingly revealed.

The almandine garnet used for the top of these doublets has a refractive index between 1·77 and 1·80, and the glass has usually an index of between 1·62 and 1·69, but occasionally a glass with an index as low as 1·51 has been found in these doublets. The density of these doublets can have no significance and a table of this constant for these stones would be of little value.

Under ultra-violet radiations the glass of these doublets may, in some cases, show a whitish or greenish glow as against the inert garnet part. It may be found that the glass gives a better response when the short-wave ultra-violet lamp (2537Å) is used.

Soudé-Type Stones

(*a*) *Early type of soudé emeralds*

These stones consisted of two pieces of rock crystal forming the

crown and pavilion of the stone, and these two pieces were cemented together by a green coloured gelatine. They were made to imitate the emerald and were thus called *soudé emeralds*. A rare variation of this stone is where two pieces of pale beryl are used instead of rock crystal. The disadvantage of such early soudés is that the green colour tended to deteriorate and turn a yellow colour, thus producing a " citrine ".

Quartz, or beryl, soudé emeralds are easily identified, for, if they be immersed in a cup of water and viewed sideways the top and base will be seen to be colourless with the dark line of colour in the plane of the girdle. The refractive indices of 1·544 and 1·553 of the rock crystal will, of course, indicate the nature of the stone unless the green colour has turned to yellow, when the stone might be mistaken for citrine. If beryl be the material used for the two pieces, then the indices of refraction will be of little help, nor will the density help in this case, for the gelatine layer makes very little difference to the specific weight. With the quartz type the density would be significant, the value obtained being slightly below that of quartz. Usually the value is near 2·62. Under ultra-violet light the cement will glow at the girdle and this will give an indication that the stone is a doublet, for neither quartz nor beryl will glow under the rays. One danger with these green-coloured early soudés is that they show red through the Chelsea colour filter, due to the dyestuff used in the gelatine.

Certain quartz soudés have been made with coloured gelatine layers in colours other than green. The writer has examined[12] two such stones. The first of these, an oblong cushion-shaped stone weighing 7·45 carats, was unusual in that its appearance in daylight was a slaty-green and in this resembled the fancy-coloured synthetic sapphire made to imitate alexandrite. Indeed, this slaty-green colour turned to purple like the " alexandrite-type " fancy-coloured synthetic corundum. The absorption spectrum of this stone showed the cobalt lines very strongly and also a very intense band in the blue-violet part of the spectrum and a weaker band in the blue. The density was found to be 2·62. When irradiated with long-wave ultra-violet light this stone appeared to glow with a purplish haze due to fluorescence of the cement layer. Under the Chelsea colour filter this stone showed a purple colour with daylight and an orange residual colour with tungsten electric light.

The other stone was an oval mixed-cut sapphire-blue stone weighing 4·27 carats. Again there was some change of colour to a purple colour when the stone was viewed under tungsten electric light. The density was 2·62 and the absorption spectrum showed the three bands of cobalt coloration. There were no bands in the blue part of the spectrum. Under the colour-filter the stone showed an orange residual colour.

No bubble layer was seen in either of these two stones, although in one or two cases bubbles in the gelatine layer have been observed in some soudé emeralds. Both these fancy-coloured soudé stones, when examined between " crossed polars " with the table facet at right angles to the light path, showed no extinction on rotation of the stone between the " polars ", the field showing a more or less continuous brightness. However, when the stone was turned sideways and similarly viewed, so that the crown and pavilion were in the field at the same time, it was seen that on rotation each part extinguished separately but the extinction of each part was four times during a complete rotation. This proved that the two pieces of rock crystal did not have the same orientation.

(*b*) *Modern quartz-type soudé stones*

These composite stones, which it is believed came on the market about the same time, or a little earlier, as the garnet-topped doublets (say about 1922), are similar in construction to the early type of soudé emerald. This newer type of soudé stone has the rock-crystal crown and pavilion in two separate pieces but differs from the earlier type in that the coloured layer, the unstable gelatine, is replaced by a layer of coloured and sintered glass; or at least this is thought to be the case. The colour is probably due to a metallic oxide and not an organic dyestuff, as is probably the case in the early gelatine types, and is therefore stable. The stones give the refractive index for quartz, but the specific gravity is found to be much higher than for quartz. Anderson [13] gives the density of these composite stones as about 2·8 and ascribes this high density as being due to the heavy lead glass of the coloured layer. An alternative suggestion is that the extra specific weight could be due to an organo-metallic colouring compound; in the case of the soudé emerald the colour is undoubtedly due to a copper compound, but what compound of this metal is not known. That the colouring agent is the cause of the high density is now considered to be less likely. Density

determinations on modern quartz soudé emeralds are given in the table below:—

Weight	*Density*
4·38 carats	2·77
—	2·79
—	2·81
1·18 carats	2·82
8·26 carats	2·83
1·15 carats	2·84
1·98 carats	2·89
2·25 carats	2·90
3·54 carats	2·96

The density must depend upon the thickness of the sintered glass layer, and it is owing to this layer that American gemmologists prefer to describe the soudé stones as " triplets ". It is understood that other colours than green have been produced, but so far the writer has not had the opportunity to examine other colours in these quartz soudé stones. Unlike the earlier type of quartz soudées, this type with a sintered glass layer does not fluoresce under ultra-violet light, and, further, the emerald-colours show green and not red through the Chelsea filter.

(c) Synthetic spinel doublets

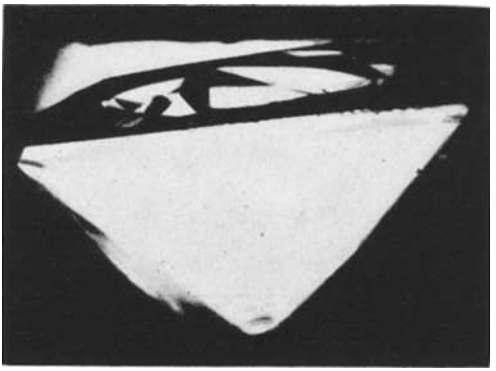
In 1951 Jos Roland, of Sannois, France, produced a type of soudé stone in which the crown and pavilion were made of colourless synthetic spinel instead of quartz. These *soudé sur spinelles* as they are called, were examined and reported upon by the writer when they first came on to the English market[14]. This type of composite stone is now made in all colours, the colouring layer being most probably a sintered glass, as in the case of the modern quartz type. Again the density of these spinel soudées is higher than for the bulk material, *i.e.* synthetic spinel which has a density of 3·63, but as was to be expected the rise was not so great as in the quartz type. As the different colours were found to give similar rise in density it seems that it is the lead glass which gives the added density rather than the colouring. Below is appended a table of the densities found in the case of various colours.

Colour	*Weight*	*Density*
Black	3·81 carats	3·63
Emerald green	26·39 carats	3·66
Peridot green	5·60 carats	3·66
Emerald green	—	3·66
Peridot green	8·98 carats	3·67
Amethyst colour	6·36 carats	3·67
Topaz colour	5·15 carats	3·68
Emerald green	4·15 carats	3·68
Emerald green	—	3·68
Aquamarine colour	14·54 carats	3·68
Peridot green	2·39 carats	3·69
Dark topaz colour	8·97 carats	3·69
Blue zircon colour	7·59 carats	3·69
Sapphire blue	5·53 carats	3.70
Emerald green	3·76 carats	3·70
Emerald green	4·19 carats	3·70

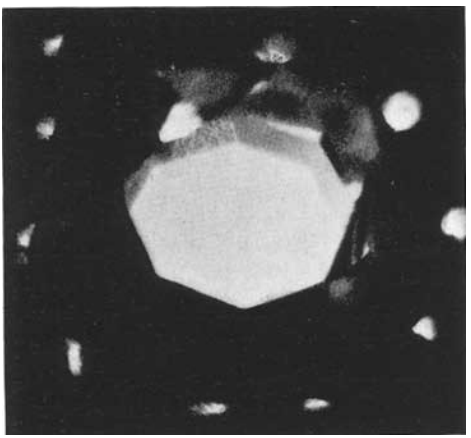
The refractive index in all cases was found to be 1·73, and like all synthetic colourless spinel there is no fluorescence under long-wave ultra-violet light, but under the short-wave lamp the strong bluish-white glow is seen and the cement layer shows up as a non-fluorescing line against the fluorescing synthetic spinel. This effect was first noticed and described by Liddicoat[15]. No characteristic absorption spectra were seen whatever the colour of the stone.

Under the Chelsea colour-filter, the emerald and peridot-green coloured stones showed a green residual colour. The blue zircon and aquamarine colours also showed greenish through the filter and *not* orange as in the case of the similarly coloured synthetic spinels. The amethyst-colour and the sapphire blue stones did show an orange colour when examined through the filter, but there was no characteristic effect with the topaz colours of these spinel doublets.

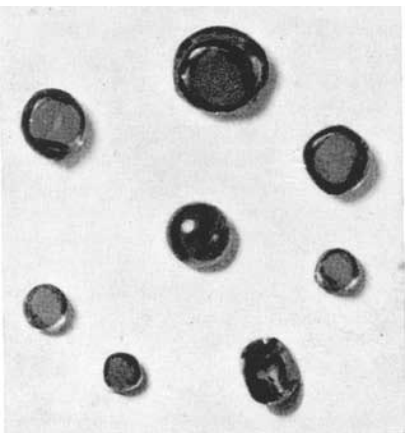
It has already been mentioned that when a quartz soudé is immersed in water and looked at sideways the stone appears colourless except for the dark line of colour across the girdle. With the spinel doublets, owing to their higher index of refraction, it is better to immerse the stones in methylene iodide or monobromonaphthalene in order to see the effect clearly; with water it is less easy.



A diamond doublet immersed in a highly refractive liquid showing the high relief of the diamond top and the low relief of the material of the pavilion.



Reflection of the table facet edge on the cement layer in a diamond doublet.



Seven uncut garnet-topped doublets and one cut stone. The centre specimen is upside down to show the ball of glass, the others all show the slice of garnet fused to the ball of glass.

Opal Doublets

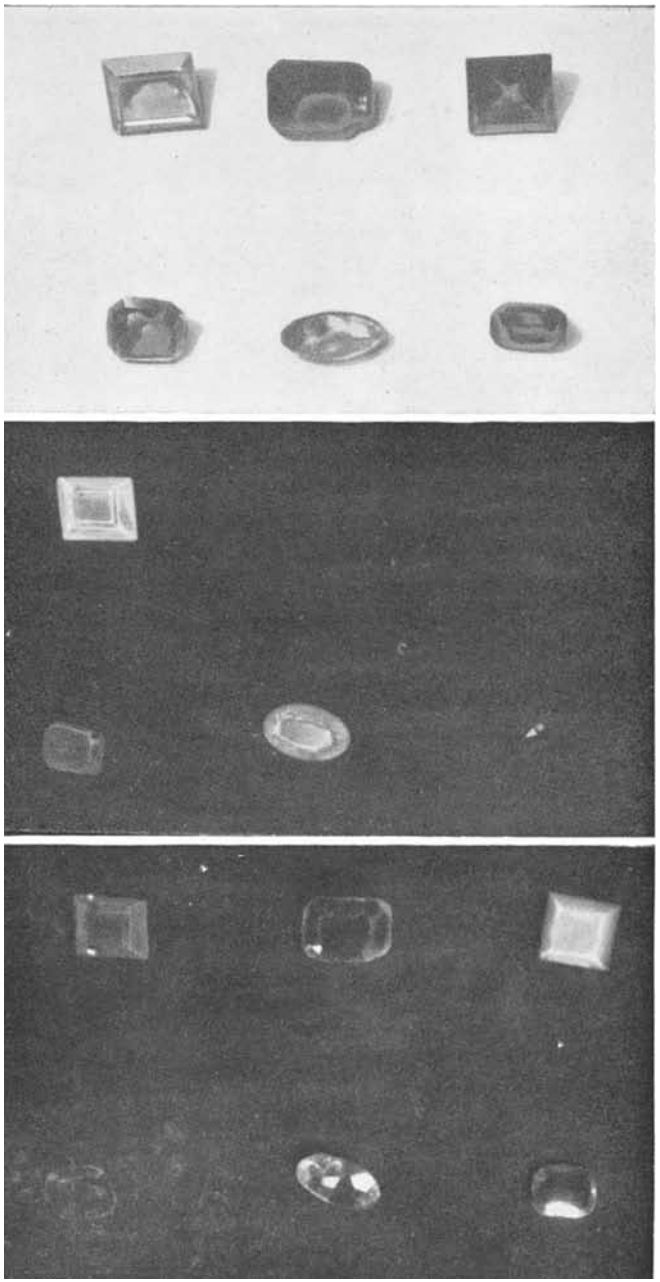
Opal which shows a fine play of colour is often found in too thin a vein to cut any solid gemstone from it. Such pieces are then backed with either common opal (potch opal, which shows little or no play of colour), by black onyx, or by a black glass called " opalite ", which is obtained from Belgium. Such a device supports the thin piece of colourful opal and allows the stone to be set into jewellery. Opal doublets on black onyx or black glass are fairly easy to detect, but opal on opal doublets are much more difficult, and when in a setting it may be impossible to be sure. The reason for this is that many natural opals are cut with the natural backing of the original seam wall and when this is fairly straight the stone can resemble to a great extent a doublet and careful examination with a lens is needed in order to distinguish between the two.

A new departure is the *opal triplet*, called by the trade-name " Triplex opal ". This is a simple opal doublet, usually with a common opal backing, to which is cemented over the top part of the opal a suitably fashioned cabochon of rock crystal. The idea is to present a better wearing face to the opal and to give the opal a better brilliancy, as to some extent the quartz cover acts as a lens. The effect produced by this cover generally makes the stone appear somewhat unreal.

An imitation opal, which could be termed a false doublet, consists of a cabochon of rock crystal or glass to the back of which is cemented a slice of iridescent mother-of-pearl, either from the pearl oyster or from the colourful paua shell (Haliotis), or abalone, as it is called in the United States of America.

Jadeite Triplets

In recent years a triplet of jade has been made and marketed which has the colour of Imperial jade. Such stones have been adequately described by Martin Ehrmann[16]. These stones are made up of three pieces, the components being a hollow cabochon of very fine translucent white jadeite about one half a millimetre all round, a cabochon of smaller size cut to fit into the hollow cabochon, and a flat oval piece to enclose in the back. The central piece, the oval cabochon, is coloured with a jelly-like dye of Imperial green colour. This dyed centre-piece is inserted into



the hollow one and the bottom piece cemented on and repolished to make a perfect fit. These triplets make attractive stones but when unset the join of the baseplate and the hollow cabochon top is clearly visible. It is when the stones are mounted with this edge concealed that they are so deceptive. They can be detected, however, by the characteristic dyestuff absorption spectrum of a broadish band in the red part of the spectrum.

Star-Rose-Quartz Doublets

An ingenious composite stone made to imitate the star-sapphire is constructed by preparing a cabochon cut from a correctly oriented piece of pale star-rose-quartz, to the back of which is cemented a blue-coloured mirror, and this may be further backed with a baseplate of some other stone. In some cases the " mirror " is sputtered on. Although rose-quartz does sometimes show asterism by reflected light (epiasterism), the best effect is found by transmitted light (diasterism), and this is the reason for the mirror at the back. The light incident on the stone travels through it and is returned by the mirror enhancing the star-effect. Unlike the star-corundums and other natural star-stones, it is generally found that when the star in star-rose-quartz doublets is viewed under an electric light, an image of the electric lamp is seen at the crossing of the rays of the star. The nearer the lamp is brought to the stone the larger the image becomes. The colour of these star-doublets is not quite like that of natural star-sapphire. Some of this difference in appearance may be due to the transparency of the rose-quartz being greater than that of natural star-sapphires, and, of course, the lustre is not so pronounced with quartz as with star-corundum.

Top Picture. *Taken in ordinary light.*
Top row: *Old type quartz soudé emerald.*
New type quartz soudé emerald.
Synthetic spinel soudé type emerald.
Bottom row: *Glass top with quartz base and gelatine layer.*
Quartz top and coloured glass base.
Garnet-topped doublet.

Centre Picture. *Same stones under long-wave ultra-violet light. Here the stones with a gelatine layer show a glow from this layer.*

Bottom Picture. *Same stones under short-wave ultra-violet light. Here the stone which is most conspicuous by its fluorescence is the synthetic spinel doublet. The rest of the stones appear to show up owing to the fact that the short-wave filter does not cut out the visible light from the lamp burner as the Wood's glass used with the long-wave lamp.*

Cameo and Intaglio Doublets

Cameo doublets, where the raised portion is separate and is only cemented on to the base, are only occasionally met, except perhaps in some cameos made of porcelain. Intaglio doublets have been made, and these date back to Roman times, if not before. Such objects are occasionally encountered. These are usually two pieces of glass, the upper piece either engraved, or more commonly moulded, for the intaglio and joined to the glass base with a reddish brown cement, so that the stone imitates a cornelian. The pigment is not very stable and the layer soon shows crazing due to deterioration. A more stable result is obtained by using a backing of true cornelian.

Moss Agate Doublets

These doublets are produced by placing some chemical, such as manganese dioxide, with gelatine on a glass plate and allowing the " tree " to form on the gel, after which the plate is gently heated so as to drive off the excess water. Another clean glass plate is then cemented on to the top and the whole is then ground and polished to a suitable cabochon form. When the stones are unset the join between the glass plates readily reveals the fake, and even when set the greater transparency to true moss agate would indicate that something was wrong.

Turquoise Doublet

Unimportant, but mentioned for the sake of completeness, is the turquoise doublet constructed by cementing a base of blue stained chalcedony to a low cabochon of turquoise-coloured opacified glass.

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Gemmological Abstracts

GENTILE (A. L.), CRIPE (D. M.) and ANDRES (F. H.). *The flame fusion synthesis of emerald.* Amer. Mineral., Vol. 48, pp. 940-944. July-August 1963.

The metal oxides (BeO 16·0g, Al_2O_3 18·0, SiO_2 67·0, Cr_2O_3 0·5) were mixed for 8 hours, ground, sintered at 1050°C. for 5 days, and treated by the Verneuil (flame fusion) technique. Two emerald boules were grown, both with an outer coat of mullite. The emerald is blue-green in colour, colourless in thin section but showing blue-green to light green pleochroism in thicker sections; it contains gas bubble inclusions. Refractive indices (ω1·561-1·562, ε1·566-1·567) are compared with those for other synthetic emeralds. The Chatham process is reported to require a run of 6 months duration.

R.A.H.

MARTIN (H. J.). *Some observations on Southern Rhodesian emeralds and chrysoberyls.* Chamber of Mines Journ., Salisbury, Vol. 4, 34-38, 3 figs., 5 pls. No. 10, 1962.

R.A.H.

SHAH (C. J.) and LANG (A. R.). *An unusual distribution of precipitates in a diamond.* Min. Mag., Vol. 33, pp. 594-599. September, 1963.

The central region of a type I stone was found by optical and X-ray topographic examination to be densely populated by small inclusions. X-ray studies showed these to be precipitates formed after the growth of the stone: they were of two sizes, 1 μ or less and around 5 μ. Nothing can yet be said about the chemical nature of the precipitates.

R.A.H.

KANIS (J.). *Notes on Southern Rhodesian aquamarine and other gemstones.* Chamber of Mines Journ., Salisbury, Vol. 4, 39-41, 2 pls. No. 10, 1962.

R.A.H.

CROWNINGSHIELD (R.). *Developments and highlights at the Gem Trade Lab. in New York.* Gems and Gemology. 1963, XI, 1, pp. 23-27 and 2, pp. 38-44.

Investigation of emeralds set into green plastic cups, the "doublet" effect in "fish-eye" diamonds, and orthoclase cat's-eyes. Pink grossular garnet is sometimes referred to by the misnomer "pink jade". An electro-conductive diamond, a yellow-fluorescing brown diamond containing dense clouds of minute inclusions and a pale green cyclotroned-diamond are referred to. A dark greenish-brown diamond showed no absorption lines but did exhibit a bright fluorescent line at about 6300Å, which was probaby related to the strong orange fluorescence under short-wave ultraviolet light. A "bull's-eye" effect in a Mysore star-ruby and the inclusions in a star-almandine are reported. An unusual surface structure was seen on a fresh-water clam pearl and sections of nautilus shell were met with in jewellery. Petrified dinosaur bone is used for the cutting of cabochons by amateur lapidaries. Other points discussed are knots and dragmarks on a diamond, banding in synthetic emerald, a quartz cat's-eye with unusual vermiform canals, a yellow cat's-eye apatite and stained lapis-lazuli.
29 illus. R.W.

DRAPER (T.). *Diamond mining in Brazil.* Gems and Gemology. 1963, XI, 1, pp. 12-16 and 2, pp. 45-49.

A continuation of an article first published during 1951 concerned with the Grão Mogol, which is an extension of the Diamantina diamond field. The story of the Maria Nunes mine which comprises part of the original bed of the Jequitinhonha river is mentioned. Much is told of the financing by U.S.A. citizens of the various Brazilian mines, many of which proved to be disastrous ventures. A table is given of the estimated production of diamonds and gold in the area.
9 illus. R.W.

WEBSTER (R.). *Gem laboratory in Paris.* Gemmologist (Horological Journal). 1963, pp. 313-314 and 341-342.

Details the working of the Paris pearl and gem testing laboratory and some comparison is made with the work done in the London laboratory.
6 illus. P.B.

LIDDICOAT (R. T.). *Developments and Highlights at the Gem Trade Lab. in Los Angeles.* Gems and Gemology. 1963, XI, 1, pp. 17-22 and 2, pp. 50-57.

Reports a diamond with clouds of cottony inclusions, a diamond-and-emerald brooch and matching earrings in which the stone in the brooch was an emerald but those in the earrings were glass containing "feathers" of bubbles, and an "emerald" which proved to be fluorite. Tests made on topaz from San Luis de Potosi, Mexico, are detailed. "Lava" cameos were found to be fine-grained marble or limestone, but a grey-coloured one was found to be glass. Mention is made of scorodite, transparent staurolite, opalescent quartz and transparent lapis-lazuli. Fabulite sold for diamond is reported. An unusual phenacite of pale greenish-blue colour had strong dichroism with "twin colours" peacock blue and violet red, and R.I. of 1·654-1·670, a density of 3·00 and an ultra-violet light fluorescence of light blue colour. A letter from G. H. Marcher decries the use of the term *triplet* for the soudé emerald and claims that it should be correctly termed a *doublet*. A 40-carat rich yellow diamond was found to have been irradiated, and a 16-carat good colour diamond was found to have been cut in an unusual manner in that the corners of the emerald-cutting consisted of three sets of facets instead of the usual one. A discussion is given on the recutting of "old mine" stones and something is told of the inclusions seen in diamond. The Pluto effect is referred to. Other stones mentioned were fine Imperial green jadeites, lazulite, a 4·5 carat benitoite, a chrome-green sphene, a transparent rhodochrosite, a violetish-pink tremolite, a brownish-red feldspar and a yellow zoisite.

17 illus. R.W.

WEBSTER (R.). *Massive grossularite.* Gems and Gemology. 1963, XI, 2, pp. 35-37 and 61.

Fifty specimens of massive grossularite from the Transvaal, South Africa, were examined. Apart from green colours, known under the misnomer "Transvaal jade", a number of other colours were found, such as red, pink, yellow, brown and white. The refractive index was found to be near 1·72, and the density varied from 3·06 to 3·66 but was mainly in the range 3·36 to 3·57. The absorption spectrum of the green material showed a band centred at 6000Å, the greenish and greenish-yellow material a band at

4635Å. The material showed little fluorescent response under ultra-violet light, but under X-rays most of the material glowed with orange light. The material takes a good polish and makes an attractive addition to the range of ornamental materials.

P.B.

RUZIC (R. H.). *Gem mines in Thailand.* Gemmologist (Horological Journal). 1963, pp. 247-248.

Describes a visit to the Thailand (Siam) gem mines. The methods used in mining and the varieties of corundum found are discussed. There are, with gold, some 38 minerals found there and these include zircon, spinel and garnet. Some tecktites are found in the country.

R.W.

MIYAUCHI (T.). *New cultured pearl technique.* Gemmologist (Horological Journal). 1963, p. 342.

Reports the effects on the use of the antibiotic aureomycin chlortetracycline in order to obtain an improved rate of pearl production.

R.W.

MALES (P.A.). *Colour of prase and chrysoprase.* Australian Gemmologist. 1963, 26, pp. 11-12.

A comparison of chrysoprase from Mount Davies, South Australia, with prase from Coolgardie, West Australia. Prase is said to be a granular mosaic of chalcedonic quartz containing coloured impurities while chrysoprase is comparatively colourless chalcedony with aggregate and fibrous structure. Chrysoprase contains nickel and prase does not.

R.W.

O'MATE. *Hungarian opal.* Australian Gemmologist. 1963, 25, pp. 8-9.

A note on the history of the Hungarian opal deposits from ancient times until the present day. The mines are now considered to be no longer a commercial proposition.

R.W.

OSTWALD (J.). *Etruscan gemstones and jewellery.* Australian Gemmologist. 1963, 26, pp. 5-6.

A short note on the history of Etruscan jewellery and the gemstones used in it.

R.W.

ZWAAN (P.). *Edelstenen en hun dubblegangers.* Natural and artificial gems. Technisch-Wetenschappelijk Tijdschrift, 1963, 32, 7.

A survey of gem-testing methods, including identification of pearls by Laue method and transparency technique. Distinguishing between different gems and the synthesis and technical application of artificial stones are considered.

S.P.

BOOK REVIEWS

QUICK (L.). *The Book of Agates.* Sir Isaac Pitman and Sons Ltd., London, 1963. (U.S.A. edition by Chilton Co., Philadelphia). 63s.

This book deals largely with the collecting places for agate in North America, and has aimed at encouraging collectors not only to go out into the field to gather stones, but to cut, polish and arrange specimens. The history of agate and definition of its types are adequately dealt with. There are three good colour plates and most of the numerous black and white illustrations are adequate. This is not a scientific text but a useful general work which can be commended.

S.P.

DOUGHTY (O.). *Early diamond days: the opening of the diamond fields of South Africa.* London (Longmans), 1963, X+237 pp., 16 pls., 1 map. Price 25s.

A fascinating description of diamond mining in the Kimberley area from 1870 until the foundation of De Beers organization in 1888, enlivened by quotations from first hand accounts.

R.A.H.

SOME RARE BLUE GEMSTONES

By J. OSTWALD, B.Sc., F.G.A.A.

Introduction

A couple of years ago the author was asked by a gemmologist friend to identify a blue emerald-cut stone which did not seem to fit any of the descriptions in his textbooks. Knowing his friend's technical skill to be above question the author suspected the presence of some new species. However, a glance down the lists in Dana's "Textbook" (and in Herbert-Smith's "Gemstones" also) proved the mineral to be the known but rare species dumortierite. Since this time the author has studied a number of other blue minerals, not mentioned in the gemmological texts, some from museums, some cut, and some, unfortunately, only from the textbooks and scientific papers. The purpose of this study was simply to enlarge the list of possibilities. While this may make identification of some perhaps common stone longer, it might stop some rare stone being overlooked because it was "not in the book". The minerals and gemstones studied included dumortierite, lawsonite, sapphirine, grandidierite, serendibite, catapleiite.

Mineralogy of the rare blue minerals:

1. *Dumortierite* $(Al, Fe)_7\ O_3(BO_3)\ (SiO_4)_3$

Orthorhombic. Usually massive, fibrous or radiating. Blue or pink. Transparent to translucent. Vitreous lustre. H = 7. S.G. 3·26–3·36. $\alpha = 1{\cdot}675$. $\beta = 1{\cdot}685$. $\gamma = 1{\cdot}692$. (The above for blue dumortierite). Birefringence moderate, 0·017. Pleochroism strong, generally in blues.

Found in metamorphic rocks and rarely in pegmatites. Mainly from Lyons, France; Madagascar; Brazil; California; and Nevada.

The author was able to examine two cut specimens, one quite small, the other 4 carats.

2. *Lawsonite* $H_4\ Ca\ Al_2\ Si_2\ O_{10}$

Orthorhombic. Euhedral crystals common, also massive. Colourless to pale blue. Transparent; vitreous lustre. H = 8. S.G. 3·08–3·09. $\alpha = 1{\cdot}665$. $\beta = 1{\cdot}669$. $\gamma = 1{\cdot}684$. Birefringence 0·019. Pleochroic, X = blue, Y colourless to pale yellow.

Occurs in amphibole schists in California; with saussurite in Italy; and in New Caledonia.

A cut specimen of about 2 carats was studied and its R.I.s were found to agree with the figures above.

3. *Sapphirine* $Mg_5\ Al_{12}\ Si_2\ O_{27}$

Monoclinic. In tabular crystals, of prismatic shape. Usually massive; pale blue. Transparent. Lustre vitreous. H = 7·5. S.G. = 3·42–3·48. $\alpha = 1{\cdot}704–1{\cdot}729$. $\beta = 1{\cdot}707–1{\cdot}733$. $\gamma = 1{\cdot}708–1{\cdot}734$. Birefringence weak, 0·003–0·006. Pleochroism weak.

Occurs in mica schists in Greenland, and in Western Australia.

No cut specimen was observed and the material in the rough state does not seem very promising.

S. H. Ball, the American geologist and expert on the precious stones of antiquity, states that sapphirine occurs in Roman jewellery. The determination was by E. H. Warmington (no reference given).

4. *Grandidierite* $H_2Na_2\ (Mg, Fe)_7\ (Al, Fe, B)_{22}\ Si_7O_{56}$.

Orthorhombic. Crystals anhedral, also massive. Blue to green. Transparent; lustre vitreous. H = 7·5. S.G. 2·99. $\alpha = 1{\cdot}602$. $\beta = 1{\cdot}636$. $\gamma = 1{\cdot}639$. Birefringence strong, 0·037. Pleochroism extreme with X = dark blue, Y colourless, Z dark blue.

Occurs with quartz, feldspar and garnet in pegmatites in Madagascar. A rare mineral.

Only massive material was available for study, and even this by reflected light showed extreme pleochroism.

5. *Serendibite* $(Fe, Ca, Mg)_5\ Al_5\ B\ Si_3O_{20}$

Triclinic. In plates and masses. Blue; transparent. H = 7. S.G. = 3·42. $\alpha = 1{\cdot}701$. $\beta = 1{\cdot}703$. $\gamma = 1{\cdot}706$. Birefringence 0·005. Pleochroic from pale blue to deep blue.

Occurs in a layer with diopside, green spinel, scapolite in the moonstone quarries near Kandy, Ceylon. A rare mineral. No specimen was available for study, but as the material is derived from a noted gemstone locality it is included here.

6. *Catapleiite* $H_4\ Na_2\ Zr\ Si_3\ O_{11}$

Monoclinic. In euhedral crystals, twinned, also massive. Blue to violet in the soda catapleiite, reddish to yellow in ordinary sodium-calcium catapleiite. H = 6. S.G. 2·8. $\alpha = 1{\cdot}591$. $\beta = 1{\cdot}592$. $\gamma = 1{\cdot}627$. Birefringence moderate 0·035.

Occurs in pegmatites and alkali syenites in Langesunfjoid, Norway; and in Greenland. The massive material available for study was from the former area, and was reddish-yellow and not likely to be used as a gemstone.

DISTINCTIONS

In the following table the important physical properties of the rare and common blue minerals are listed.

Mineral	*H*	*S.G.*	*R.I.*	*D.R.*	*Pleochroism*
Sapphire	9	3·99	1·76 –1·77	0·008	Strong
Benitoite	6·5	3·67	1·75 –1·80	0·047	Strong
Kyanite	4–6	3·69	1·71 –1·73	0·016	Strong
Spinel	8	3·60	1·72	—	—
Serendibite	7	3·42	1·701–1·706	0·005	Weak
Sapphirine	7·5	3·42–3·48	1·704–1·734	Variable	Weak
Dumortierite	7	3·26–3·36	1·675–1·692	0·017	Strong
Lawsonite	8	3·08–3·09	1·665–1·684	0·019	Moderate
Tourmaline	7	3·10	1·62 –1·64	0·020	Strong
Catapleiite	6	2·8	1·591–1·627	0·035	
Cordierite	7	2·59	1·53 –1·54	0·009	Strong

With the use of a modern refractometer there should be little difficulty in determining the above minerals.

REFERENCES

Iddings, J. P. (1911). *Rock Minerals.* John Wiley & Sons.
Dana, E. S. (1903). *The System of Mineralogy.* John Wiley & Sons.

ASSOCIATION NOTICES

PRESENTATION OF AWARDS

An exceptionally large number of members and friends attended the annual presentation of awards held at Goldsmiths' Hall, London, on 28th October, 1963. Mr. F. H. Knowles-Brown, the Chairman of the Association, presided and in his welcoming remarks thanked the Worshipful Company of Goldsmiths for once again allowing the Association to use its hall. The chairman commented that 1963 marked the 50th anniversary of the first examination and that the Association had achieved much since the first small examination in 1913. He specially welcomed those present who had taken the examinations some thirty or forty years ago.

This year the number of entries for the examinations was only one less than last year's record, though there had been more failures, due largely to the enthusiasm of candidates exceeding their ability. Mr. Knowles-Brown commented that failure in an examination could be due to various factors and he hoped that those who had not been successful would be encouraged to sit again. Acquisition of knowledge was the most important thing.

The Chairman paid tribute to the examiners, who had maintained a high standard over the years, and to the instructors for all their patience throughout the year. He also thanked the staff for a monumental piece of work in arranging the examinations at centres throughout the world.

Mr. Knowles-Brown referred to the first gem diamond examinations that had been conducted by the Association. He specially thanked the Vice-Chairman of the Association, Mr. Norman Harper, who had devised the course with the enthusiastic co-operation of the Headmaster of the Jewellery and Silversmithing School in Birmingham. The Chairman also thanked the U.K. Diamond Publicity Committee, for making it possible to obtain cut and uncut diamonds for teaching purposes, and Professor S. Tolansky, F.R.S., of Royal Holloway College, London, Mr. Cyril Ginder, M.A. and the Hon. Iain Balfour, M.A., who had assisted in assessing the papers. They had set a similar high standard as that required in the diploma examination.

Mr. Knowles-Brown then welcomed Mr. Lionel Burke, of De Beers, who had kindly come along to present the awards. De Beers had always taken a kindly interest in the Association's work.

Mr. Burke, responding after the presentation had taken place, referred to the prestige and influence of the Association and said that in his constant visits to other countries he had always heard admiration expressed for the Association. It was a pioneer in gemmological work and he said that his colleagues at De Beers would wish him to congratulate the Association on having had its first examination fifty years ago. De Beers were particularly gratified that there was an examination for the Association's Gem Diamond Certificate and he added his thanks to Mr. Norman Harper. He knew that the contact which De Beers had with the jewellery trade was most valuable and the company appreciated all that the Association was doing and had done to encourage interest in gemstones.

The Vice Chairman offered the thanks of the meeting to Mr. Burke.

MIDLAND BRANCH

The "classification and grading of diamond crystals" was the subject of a talk given to the Midlands Branch of the Association on October 30, by Mr. Norman Harper, vice-chairman of the Gemmological Association and of the branch. The talk was a condensation of a lecture on the subject which forms part of Mr. Harper's Diamond Course lectures at the School of Jewellery and Silversmithing in Birmingham. It was illustrated by the diamond crystals which were provided by the U.K. Diamond Publicity Committee for the diamond course. This particular subject was chosen by Mr. Harper because he felt that while many people in the trade were clear about the grading of cut diamonds, few really understood De Beers methods for grading crystals.

COUNCIL MEETING

A meeting of the Council of the Association was held at Saint Dunstan's House, Carey Lane, London, E.C.2, on 28th October, 1963. Mr. F. H. Knowles-Brown presided.

The following were elected:

Elected to Fellowship

Wad, M. B., Edgware, Middx.
Abbott, Henry C., Liverpool, Lancs.
Allaby, Frank E., Warrington, Lancs.
Allden, Arthur G., London, S.W.14.
Berry, William, Kirkcaldy, Fifeshire
Bilby, David, London, S.W.4.
Campin, Andrew J., Mansfield, Notts.
Dahlsveen, Jon, Trondheim, Norway
Feltell, Raymond, Birmingham
Fernandez, Cyril W. A., Bombay, India
Franklin, Jerry N., Washington, U.S.A.
Fryer, Charles W., San Diego, U.S.A.
George, Stanley W., London, S.E.9.
Giblin, Michael, Bury, Lancs.
Holländer, Helmut, Pforzheim, Germany
Hopkins, Peter J., Derby.
Horrox, Conrad, Manchester, Lancs.
Irwin, Eric, Liverpool, Lancs.
Kari, Raija Helena, Lahti, Finland
Kiuas, Eljas-Jussi, Pukinmäki, Finland
Krzempek, Evelyn, Nottingham
Lahtinen, Ake J., Helsinki, Finland

Mäki, Juho K., Riihimäti, Finland
Meddings, Ann E., Burton-on-Trent, Staffs.
Nairis, Honno J., Stockholm, Sweden
Nimalasuriya, Nanda, Colombo, Ceylon
Pudner, Robert A., Liverpool, Lancs.
Pyke, John S., Higher Bebington, Cheshire
Reekie, Robert, Stratford upon Avon
Rintala, Berit, Riihimäki, Finland
Snell, Richard G. F., Bournemouth, Hants.
Spacey, Peter W., Sutton Coldfield, Warks.
Storgmeir, Inkeri, Huopalahti, Helsinki, Finland
Straiton, Timothy, Hove, Sussex
De Szejko, Anna-Liisa, Hämeenkylä, Finland
De Szejko, Wiktor I., Hämeenkylä, Finland
Tarratt, Christopher D., Leicester
Taylor, John L., Blackpool, Lancs.
Teissala, Hannu H., Helsinki, Finland
Thurlby, Paul A., Birmingham
Virtanen, Pentti E., Helsinki, Finland
West, Peter J., London, E.7.
Wight, Peter, Wallasey, Cheshire
Paananen, Erkki, Helsinki, Finland

ELECTED TO ORDINARY MEMBERSHIP

Anderson, William J., London, S.W.1.
Antonucci, Francesco, Rome, Italy
Boggs, Charles A., Valley Stream, N.Y., U.S.A.
Bowcock, Leslie, Newcastle, Staffs.
Bradburn, Gwendoline, Bondi, N.S.W., Australia
Buckingham, Anthony C., Upper Hartfield, Sussex
Cain, Winifred, London, S.W.5.
Drew, Frank H., Wanganui, New Zealand
Dugas, Joseph V., Rhode Island, U.S.A.
Fishberg, Michael S., London, N.3.
Fullerton, Kenneth J., Bridgend, Glam.
Harley-Mason, Robert J., Nairobi, Kenya
Harpin, Joyce A., Seekonk, U.S.A.
Harris, Victor, London, N.16.
Hoffman, Lanrence E., San Francisco, U.S.A.
Hooker, Grady A., Cheshunt, Herts.
Howie, Robert A., London, W.C.2.
De Krassnokutski, Leo K., Johannesburg, S. Africa
McBain, Sherman W., Valley Center, California, U.S.A.
Mangold, Thomas, Geneva, Switzerland
Marshall, Sheila, Ibadan, Nigeria
Martin, John F., Kansas, U.S.A.
Moore, Henry, Solihull, Warks.
Moyse, Claude A., Hanau (Main), Germany
Myers, Julia H., Double Bay, N.S.W., Australia
Myers, Leah M., Double Bay, N.S.W., Australia
Oesterlin, Winhelmina P., Mosman, N.S.W., Australia
Padley, Alastair C., Tunbridge Wells, Kent
Pfau, Robert G., Pala, Calif., U.S.A.
Ridgeway, Robert F., Greenville, U.S.A.
Rius, Carlos E. R., Barcelona, Spain
Rowbury, William G., San Francisco, U.S.A.
Rush, Hazel S., Cincinnati, U.S.A.
Schiffmann, Charles A., Geneva, Switzerland
Williams, Wanda F., Wanganui, New Zealand

ELECTED TO PROBATIONARY MEMBERSHIP

Anderson, Brian M., Orpington, Kent
Bergseth, Idar, Burnaby, Canada
Bloom, Harry, Johannesburg, S. Africa
Carr, Philip, Blackburn, Lancs.
Chernencoff, Wade, Coquitlam, Canada
Clough, Michael B., Bolton, Lancs.
Cook, Murray E., Vancouver, Canada
Drew, William H., Wellington, New Zealand
Fruitman, R. Lawrence, Toronto, Canada
Gatward, Anna B., Hitchin, Herts.
Goudriaan, P. A., Kampen, Holland
Hanley, Clive E. M., Rugby, Warks.
Hudson, John D., Woodford Green, Essex.
Jochems, Cornelie, The Haag, Holland
Kamil, Mohamed S. M., Weligama, Ceylon
Legg, Susan, Finchampstead, Berks.
Lewis, Elliott A., Salford, Lancs.
Riel, Christa, Heim St. Ludwig, Austria
Smith, Stephen S., Doncaster.

TRANSFERRED FROM ORDINARY AND PROBATIONARY MEMBERSHIP TO FELLOWSHIP

Axon, Gordon V., New York, U.S.A.
Blatter, Robert, Toronto, Canada
Coop, Norah M. N., London
Dambrink, Darel W. J., Apeldoorn, Holland
Fernando, Kurukula S. L. T., Colombo, Ceylon
Forbes, David R., Melbourne, Australia
Fraley, Lawrence, Wheelersburg, U.S.A.
Gaydon, Julie H., Surbiton, Surrey
Ghisalberti, Danilo Lucerne, Switzerland
Herring, John T., Radcliffe-on-Trent
Houston, David F., El Cerrito, U.S.A.
Hudson, Felix N., Dunfermline
Jensen, Bjarne A., Bergen, Norway
Kaufmann, E. Pius, Montreal, Canada
Loupekine, Igor S., Nairobi, Kenya
Mackenzie, Iain F., Warrington
Mulien, Joseph, Glasgow
Porter, Robert G., Brisbane, Australia
Primavesi, Thomas, Montreal, Canada
Quartermaine, Helen L., Kuala Lumpur, Malaya
Scholl, Werner, Zollikerberg, Switzerland
Schwartz, Raymond N., London
Smith, Benhamin H., Wilmington, U.S.A.
Städelin, Alwin, Lucerne, Switzerland
Stanley, Edward, Manchester
Thomson, Patrick N., Cape, South Africa
Watts, James W., Grimsby
Wood, Mary B. H., Sidmouth, Devon

The Council gave consideration to problems consequential upon the considerable number of entries that had been received during recent years, particularly concerning accommodation and the preliminary examination.

MEMBERS' MEETINGS

The following meetings have been arranged:—

1964

30th Jan. West of Scotland Branch. Talk on pearls by Mr. James Gillougley, F.G.A.

31st Jan. Conversazione. Goldsmiths' Hall, London, 6.30–8 p.m. Exhibits.

5th Mar. Photographic evening. Goldsmiths' Hall, London, 7 p.m. Members are invited to submit for selection not more than six 2″ × 2″ slides illustrating jewellery or any aspect of gemmology. Slides should be submitted, with full details, by 21st February.

26th Mar. West of Scotland Branch meeting. Mr. L. G. Burke, of De Beers Consolidated Mines, Ltd., on "The sorting classification and marketing of rough diamonds".

9th April Herbert Smith Memorial Lecture. Royal Institution, London, The President of the Association, Sir Lawrence Bragg, F.R.S. will reminisce about early problems with minerals.

17th April Midland Branch annual meeting.

30th April Annual meeting of West of Scotland Branch in Glasgow, followed by an illustrated talk on the " Regalia of England and Scotland ", by Mr. W. C. F. Butler, F.G.A.

TALKS BY MEMBERS

BLYTHE, G. A., "Gemstones", Southend-on-Sea Young Conservative Organization, 1st October, 1963. St. Clement's Young Wives' Group, St. Clement's Hall, Leigh-on-Sea, 19th November; Belfairs Branch, Young Conservatives, Leigh-on-Sea, 25th November, 1963.

HUDSON, F. N., "Gemstones", Inner Wheel, Dunfermline, 14th November, 1963.

OBITUARY

Mr. F. H. Neale, F.G.A., (aged 70) director of Conroy Couch Ltd., Torquay, and of the R. W. Yeo (Associated Companies) Ltd. He gained his diploma, with distinction, in 1933 and was awarded the Tully Memorial Medal, the fourth time that it had been awarded.

WEST OF SCOTLAND BRANCH

A meeting of the Branch was held at the Royal Hotel, Glasgow, on 26th September, 1963, when a film show was held.

GIFTS TO THE ASSOCIATION

From Mrs. Rhoda Blyth, F.G.A., British Columbia, a crystal of star-sapphire from Montana, U.S.A.

LETTER TO THE EDITOR

Synthetic Emeralds

DEAR SIR,

It is still an unanswered question why the values of synthetic emerald from different producers differ so markedly. For instance:

Synthetic emerald made by	$n\omega$	$n\varepsilon$	$n\varepsilon-n\omega$	*S.G.*
Chatham	1·564	1·561	0·003	approx. 2·65
Lechleitner	1·576	1·570	0·006	approx. 2·7
Zerfass, quoted by Schlossmacher[1]	1·561	1·555	0·006	2·66

Of course, the methods used are different. While Chatham and Zerfass synthesize within a melt, the synthesis of Lechleitner is the result of a hydrothermal process. But, this does not explain the differences in full, as the stones of Chatham and Zerfass still differ a certain amount, particularly with the birefringence values of 0·003 and 0·006 respectively.

With regard to this situation, it seems to be worthwhile to refer to an article of W. T. Schaller and collaborators[2]. It describes an unusual beryl from Arizona, U.S.A., unusual in respect of the extremely high values of this particular beryl. In the paper, an average chemical analysis is given which reveals the presence of a large number of extraneous ions within the beryl's lattice. And these additional ions—or chemical impurities—are the cause of the unusual properties of the beryl in question, according to the authors.

A general view is given of the variation in the properties of beryl, depending on the amount of foreign material, as follows:

Beryls	*Percentage of constituents other than* SiO_2, BeO, Al_2O_3, *excluding* H_2O	$n\omega$	$n\varepsilon$	$n\varepsilon-n\omega$	*S.G.*
Colourless synthetic ...	0	1·560	1·557	0·003	2·635
Synthetic emerald ...	3	1·567	1·563	0·004	2·67
Common	1–5	1·570 to 1·590	1·564 to 1·584	0·006 ±	2·67 to 2·76
High cesium	7–10	1·599	1·590	0·009	2·86 ±
Arizona	15	1·608	1·599	0·009	2·92

Even if the origin of the synthetic emerald in the table is not mentioned and the given values are not in full accordance with those mostly quoted for Chatham's synthetic emerald, a constant increase of the values with an increasing percentage of the "impurities" is evident.

Besides other considerations, this may give a hint of the reason for the varying values of synthetic emeralds: the lower the amount of chemical impurities, the lower also the values, and the more such impurities are present, the higher are the values. In evaluating such a conception, the synthetic emerald of Zerfass should be the "purest".

1. K. Schlossmacher: Eine neue Smaragdsynthese, Zeitschrift der Deutschen Gesellschaft für Edelsteinkunde, Heft 43, Frühjahr 1963, 27–29.
2. W. T. Schaller, R. E. Stevens and R. H. Jahns: An unusual beryl from Arizona, American Mineralogist, 47 1962, 672–699.

Yours sincerely,

W. F. EPPLER.

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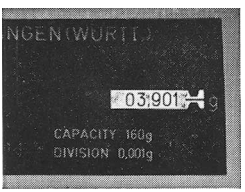

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