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Simple Photomicrography as applied to Gemstone Inclusions

By *Norman H. Day, F.G.A.*

LIKE many who gained their first knowledge of gemmology from reading Mr. B. W. Anderson's " Gem Testing," I have always enjoyed using a microscope to study the wonderful and beautiful inclusions that occur within gemstones and have long cherished the idea of taking photographs of these for myself.

After becoming a Fellow of the Association, I turned to the subject of photomicrography and took a course in the Elementary Theory and Practice of Photography at the local technical school.

In looking for books on the subject, I found that there are a great many on photomicrography, but none that approach the subject from the point of view of the gemmologist.

Gemstones are quite different in shape and size from the very thin petrological slides of rock formations or the mounted sections of organic substances, made for use with the critical lighting and high magnification of the modern microscope.

The most useful books I have read are:—

1. " The Ilford Manual of Photography," by James Mitchell. Chapter XXIII deals with photomicrography and the other chapters give useful information on all photographic problems.
2. " Amateur Photomicrography," by Alan Jackson. Gives a clear idea of the problems and describes simple apparatus that can be easily constructed.
3. " Practical Photomicrography," by Barnard and Welch. An advanced and very thorough book on the subject. Because it is some years since the last edition was published, certain of the lighting and photographic equipment described has been superseded by later and more efficient types.

Turning to the equipment required, any microscope that is suitable for the study of gemstones can be used, though the type with a revolving stage and centering-screws has many advantages over the instrument with a fixed stage.

The laboratory making a large number of photomicrographs of high magnification uses a special camera which has long extension bellows, which is held vertically above the microscope by a rigid stand ; the shutter is worked by a cable release and at the top it has a ground glass focusing screen and a dark slide plate holder. Some cameras will take roll film and have the focusing screen at the side, which works on the reflex principle. For this type of work there are special eye-pieces for the microscope called projection-oculars ; these often have an extra observing eyepiece at right angles to the optic axis.

Very good results can be obtained with a plate camera with lens removed, preferably with double or treble extension bellows. It should be held over the microscope with a very rigid stand.

Certain miniature cameras can be used, the lenses being replaced by a special observing eyepiece which fits to the ocular of the microscope.

Satisfactory photomicrographs can be obtained with an ordinary roll film box camera using a supplementary lens, and this method was described by Mr. John Vincent, F.G.A., in the " Journal of Gemmology," Vol. I, No. 3, July, 1947.

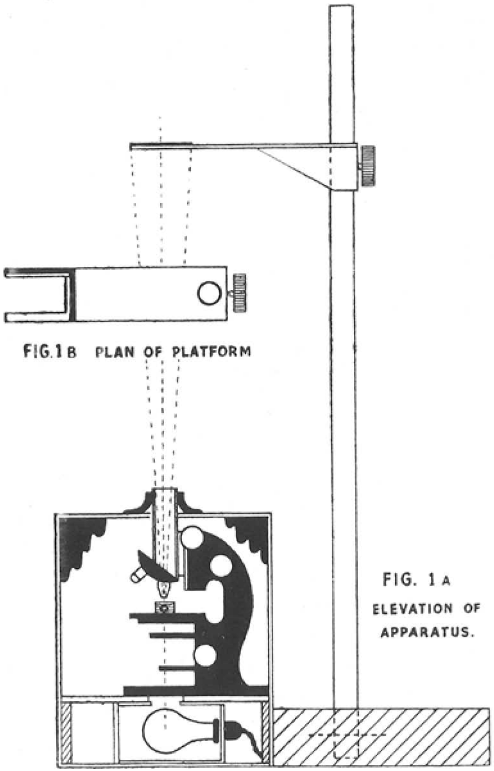


FIG. 1B PLAN OF PLATFORM

FIG. 1 A ELEVATION OF APPARATUS.

Nº	GEMSTONE				EXPOSURE	PLATE		LIGHTING			"CAMERA LENGTH" OC POSITION TO PLATE			MAGNIFICATION	DEVELOPMENT			RESULTS
	SPECIES	COLOUR	DEPTH	RI OF		TYPE	SPEED	LAMP	CONDENSER OR D.G ILLUMINATED	FILTER	OB	OC			TYPE	TIME	TEMP	
1	SPINEL	BLUE	5%	M1	16	ORTHO	O800	100	—	—	32	—	490	27	RYTOL	7	65°	GOOD
2	"	"	"	"	40	"	"	"	DG	—	32	—	"	"	"	"	"	GOOD {REQUIRES MORE DEPTH OF FOCUS
3	RUBY	DARK	4	M1	20	PAN	P1200	"	—	—	50	—	520	14	"	4½	65°	SLIGHTLY OVEREXPOSED

FIG. II RECORD SHEET.

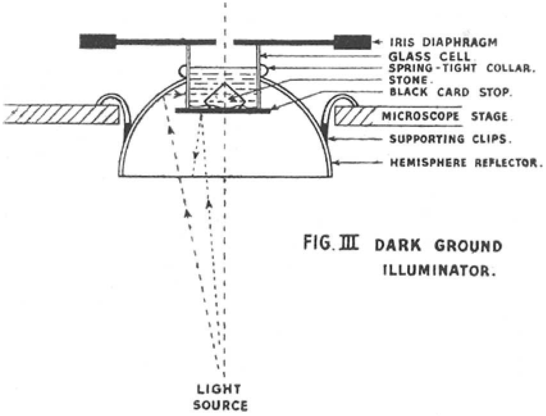


FIG. III DARK GROUND ILLUMINATOR.

By working in a dark room it is possible to take photomicrographs without using a camera. The lighting unit and the microscope are housed in a light-tight box with only the eyepiece protruding from the top ; a rigid stand holds a platform horizontally at " camera length " above the eyepiece. This platform carries the focusing screen, which is replaced with the photographic plate, which after exposure is immediately developed.

It is this last method that I have used to gain experience.

When using the microscope to examine inclusions the focus is often altered to observe a feature and to get a proper idea of its shape, but in the case of a photomicrograph only one plane can be in focus ; therefore it is necessary to use an objective that will give sufficient depth of focus in order that the true shape of the whole inclusion or plane of inclusions may be seen in one picture.

In general, it is true to say the longer the focal length of the objective the greater the depth of focus. Objectives 16 m/m, 25 m/m, 32 m/m or 50 m/m give sufficient working distance, therefore one should be chosen which gives the required depth of focus necessary for the problem in question.

For work of low magnification it is not necessary to use an eyepiece ; extra magnification can be obtained by using extra camera length. The extra magnification requires an increase in the power of the lighting source, otherwise the exposure will be unduly long.

The Setting-Up of the Apparatus

A light-tight box (see Fig. 1a) can be made from a cardboard carton strengthened with wooden battens, and the front opening covered with strong light-proof black-out curtains, draped to include all light but loose enough for the microscope to be adjusted for focus through the curtains.

The microscope is placed on a rigid wooden three-legged stand giving a clear space underneath for an asbestos box in which is mounted a 100-watt opal bulb. The asbestos box and the wooden stand have holes cut in them and are arranged so that the bulb is in alignment with the microscope.

In the top of the carton, cut a round hole large enough for the body tube ~~of~~ the microscope to pass through. A light-tight union is made from a collar of black-out material fixed to the carton with paper clips and to the body tube with a strong elastic band.

The eyepiece and draw-tube of the microscope are removed and in place of the draw-tube is placed a tube of black paper or, better still, a paper tube lined with black velvet ; this prevents unwanted reflections.

On the bench at the side of the light-tight box is placed a stand with vertical pillar, such as the stand of a vertical photographic enlarger. One can be easily made from 3½ feet of one-inch water-pipe held vertically in a 12 ins. by 12 ins. by 3 ins. block of concrete, and clamped to the vertical pillar is an adjustable bracket which carries a horizontal platform on which rests the ground glass focusing screen and, later, the photographic plate. A screw knob allows it to be fixed at the height required.

Should it be decided to use 3½ ins. by 2½ ins. plates, the platform should be made from a piece of 3-ply wood, 12 ins. by 3 ins. (see Fig. 1b). A space 3⅝ ins. by 2¼ ins. is cut from one end, and two strips, one 3 ins. and one 3½ ins., of wood or thick cardboard ¼ in. wide are glued as indicated ; these act as stops. In having only two stops it is quite easy to feel the correct position for the plate in the dark.

Give the whole platform a coat of matt black paint ; the type called poster paint is very good.

The ground glass focusing screen is the same size as the plate to be used, and for this type of work one with a medium grain is quite satisfactory ; a very fine grain requires much stronger lighting.

To avoid knocking or shaking the apparatus at the beginning of the exposure, the switch for the light inside the box is screwed on to the bench some distance from the rest of the apparatus.

THE METHOD OF USING THE APPARATUS

On the microscope stage lay an Iris diaphragm and open to about 5 m/m diameter. On this place a plain glass slide, and on this slide stand a glass cell containing the stone to be photographed.

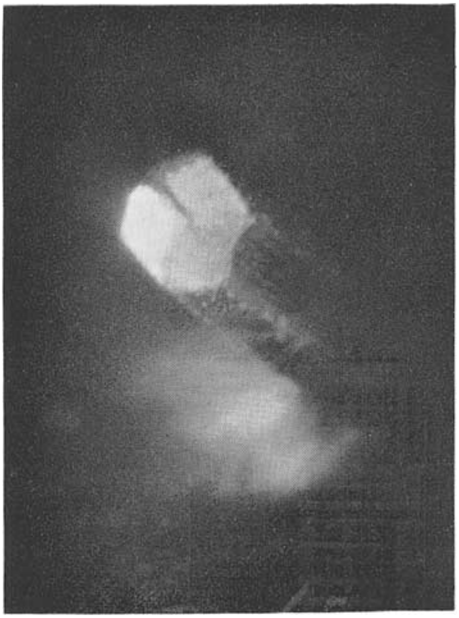
Cover the stone with a highly refractive liquid, its refractive index being near that of the stone, using, say, a 32 m/m objective racked down until it nearly touches the liquid. Place the focusing screen ground side downwards on the platform, switch out all room lights except a photographic safelight, if one is being used, drop the curtains in front of the box, switch on the light under

PHOTOMICROGRAPHS OF CRYSTAL INCLUSION WITHIN A DARK BLUE SPINEL

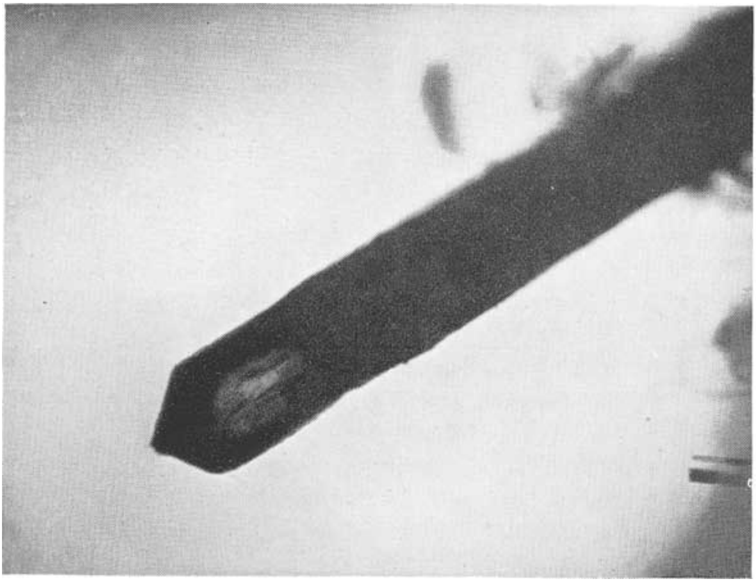
Dark Blue Spinel
RI 1.715

Oval Brilliant Cut 1.00ct.

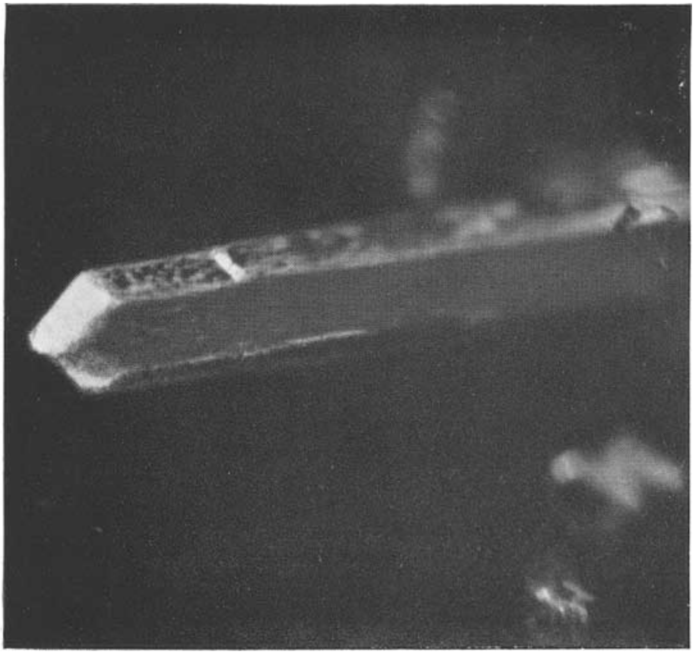
Photographs on this page are x 55 32 m/m Objective



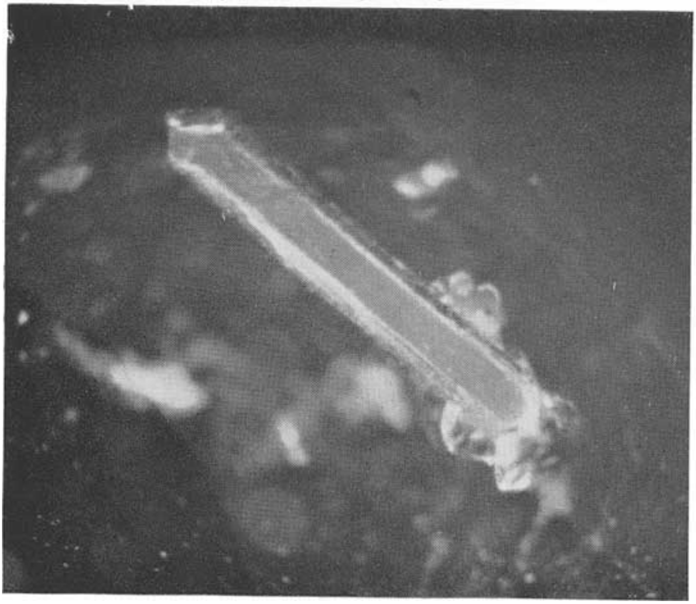
(Using dark ground illumination)



(Using direct lighting)



× 55 32 m/m objective (Using dark ground illumination)



× 35 50 m/m objective (Using dark ground illumination) the microscope, and raise the objective ; watch the focusing screen until that part of the stone required is in focus.

Now raise or lower the platform until the whole or that part of the picture it is proposed to photograph covers the whole of the screen. Adjust the diaphragm on the microscope stage so that it passes sufficient light to illuminate the picture. Should the diaphragm be open too much, the excess light will tend to spoil the definition of the picture.

It is often an improvement to place a second diaphragm on the top of the cell, which will control undesirable reflections from the cell itself.

If Iris diaphragms are not available, very good substitutes can be made from 2-in. discs of thin copper or brass, with a round hole cut in the centre and painted matt black. A useful set would have holes 4 m/m to 10 m/m diameter.

Use a watchmaker's eyeglass and, observing the focusing screen, adjust the focus until the picture is really sharp. A low-powered magnifying glass mounted on three legs and stood on the focusing screen can be very handy for this final adjustment.

See that no light is showing outside the box except that shining on to the screen ; switch out the light.

It is as well to have the light shining in the box only when adjustments are being made, because the 100-watt lamp gives out sufficient heat to boil the immersion liquid if left on too long, and should methylene iodide be used this will turn brown quite quickly.

With all lights, except the safelight, out, take a photographic plate from the packet of plates ; see or feel that the remainder are properly wrapped and returned to the packet. Replace the focusing screen with the photographic plate the emulsion side downwards.

The emulsion side can be identified by touching the corner of the plate against your moistened lip ; the emulsion side will stick slightly, the " backed " side will not.

Now switch on the light within the box, time the exposure, using a dark room clock placed near the safelight, or in total darkness count the seconds.

Switch out the light, remove the exposed plate and develop immediately in chemicals already prepared.

THE CHOICE OF PHOTOGRAPHIC MATERIAL

Photographic plates can be obtained in a great many sizes. I have found 3½ ins. by 2½ ins. useful for most work.

There are three main groups of photographic emulsion: *Ordinary*, which is colour sensitive only to violet and blue. *Orthochromatic*, sensitive to violet, blue, green and yellow, and *Panchromatic*, sensitive to all colours, but not in the same ratio as our eyes, which record yellow-green as the strongest colour. All photographic plates are most sensitive to blue light.

Some plates, usually panchromatic, are said to be " fast," that is, very sensitive to light, but for photomicrographs of gemstone inclusions it is better to use medium or slow material which has a smaller grain size.

Safelights for ordinary and orthochromatic material are much easier to see and work by than those for panchromatic material. When using panchromatic material it is often better to work in complete darkness.

It is important for this type of work to use " backed " plates. These have the back of the plate covered with a coloured film which absorbs light passed through the emulsion and prevents internal reflections within the glass plate which would produce undesirable effects. The " backing " of the plate dissolves during the developing process.

I have had good results with Kodak Ultra Speed Orthochromatic Plates O 800 and Kodak Super Panchro-Press Plates P 1200. Both are quite fast, but are types that are easily obtained.

EXPOSURE

Exposure depends upon a great number of factors:—

(*a*) The *type of plate* and its speed.

(*b*) The *quality of the light and its quantity*, governed by the type of lamp, its wattage, and the shape of the filament, as well as the light transmitting qualities of the substage-condenser, diaphragms and filters if they are used.

(*c*) *Magnification* depends on the power of the objective and the " camera length " or the power of the objective with the eyepiece and the " camera length."

(*d*) The ***stone being photographed***, its colour, the depth of colour, transparency and the refractive index of the immersion liquid.

Using the apparatus for the first time, it is possible to get a good idea of the correct exposure by using a stone with an all-over pattern of inclusions, such as Hessonite Garnet. Make an envelope of black opaque paper which covers three-quarters of the unexposed plate and expose this for 16 seconds. Turn out the light, move the envelope to cover only half the plate, expose 8 seconds, proceed by covering only a quarter of the plate, expose 4 seconds, remove envelope and expose 4 seconds. Then develop the plate which has been given a step exposure of 4:8:16: and 32 seconds. One step should cover the exact exposure, but if all the steps are over-exposed (the plate practically all over black) place a sheet of ground glass or flash opal glass over the opening of the asbestos box and try another step expose.

Should the first attempt have been under-exposed (showing only a weak outline of the picture), try two steps 64 seconds and 128 seconds ; but should the factors of the " set up " be such that an exposure of over 100 seconds was necessary, the picture would be very difficult to focus sharply on the screen because the picture would be very dim.

Because most gemstones make a mono-coloured picture, I have found that exposure can have a very large latitude and there is very little difference in the results of exposures of 20 seconds and 30 seconds.

The results of every exposure, with full details of all the factors, should be kept on a record sheet (see Fig. 2).

Once the record shows the results from exposures, using the same lighting, magnification and type of plate, with the main colour groups of gemstones, it is possible to estimate fairly well a correct exposure from a given gemstone and a given set of factors.

THE DEVELOPMENT OF THE PLATE

There are numerous formulæ for making photographic plate developers and there are many first-class ready-made developers on the market, but for the gemmologist who only occasionally requires one, ready to hand and in a fresh condition, Messrs. Burroughs Wellcome & Co.'s " Tabloid " photographic developers, marketed by Johnsons, of Hendon, Ltd., are very satisfactory.

The type of " Tabloid " called Rytol is most suitable for general work. Using 3½ ins. by 2½ ins. plates and one pair of tablets with 4 ozs. of water in a 4¼ ins. x 3¼ ins. dish will give sufficient depth of developer, which should be kept at an even temperature and at 65° F. if possible.

With development temperature and time are the important factors.

In a second 4¼ ins. x 3¼ ins. dish mix " Acid-Hypo Fixing Salts " that will give 4 ozs. of liquid, or mix plain Hypo (Sodium Thiosulphate Crystals) 2 ozs., with 5 ozs. of hot water, adding when cool ⅛ oz. potassium metabisulphite or ⅛ oz. sodium bisulphite.

Between these two dishes have a dish or basin of plain water. Take the exposed plate the emulsion side upwards, slide under the developer and gently rock the dish. Remove when the time given on the instruction leaflet for that type of plate is reached, rinse in the water and slide emulsion side upwards into the hypo fixing and rock the dish for three minutes. Take out and switch on the main light, look at the result, return to the hypo and cover the dish with a cardboard box lid. Then leave another seven minutes, take out and wash in running water for one hour. Because the emulsion is now soft, hold the plate in a form of rack to prevent scratching while washing, especially if several plates are being washed together.

Take out and shake off superfluous water and allow to dry in a place free from dust, but with a free circulation of dry air.

Prints can now be made from the negative in several ways, though often it is as well to let a professional photographer make the prints, for he has a wide range of graded papers. Photomicrographs are best printed with a glazed finish. A good negative can be enlarged, which brings out the detail, and is one way of increasing magnification without loss in the depth of focus.

Variations in the Lighting

When making photomicrographs of inclusions within stones with strong double refraction, the double refraction phenomenon may be undesirable and may be eliminated by placing a polaroid filter in the filter holder under the microscope stage and turning the filter until the picture on the focusing screen shows no double refraction.

The very interesting twin-planes seen in corundums when observed between crossed nicols can be easily photographed. First place a polaroid filter under the microscope stage and a second polaroid filter on the top of the body tube, adjusting the two filters until they are in a crossed position. Then bring the stone in the cell into the optic axis and turn until the maximum effect is observed.

DARK-GROUND ILLUMINATION

With the transmitted lighting many interesting photomicrographs can be made, but with transmitted light certain inclusions will only photograph as silhouette, and to show their true shape dark-ground illumination or a type of side lighting must be arranged.

For this I have made a unit (see Fig. 3). From a round disc of 6 S.M.G. sheet silver, 3 ins. diameter, is raised a hemisphere. This can be accomplished by using a doming block and doming punches, and frequent annealing of the silver. A silversmith friend will usually oblige if the tools are not to hand. The exact size of the hemisphere will be governed by the size of the hole in the microscope stage. Now obtain a small glass cell about $\frac{1}{2}$ in. diameter and $\frac{1}{2}$ in. high: the lower part of a cachou tube or medical phial can be cut off at the required height with a carborundum slip and the top edge ground smooth and level.

In the top of the hemisphere is cut a hole $\frac{1}{2}$ in. in diameter or the size that will allow the cell to pass through. Make a metal collar that holds spring tight round the cell to prevent it dropping right through.

Fix clips that will suspend the hemisphere in the stage. Cut a circle of black cardboard $\frac{5}{8}$ in. in diameter and cement to the base of the cell. Durofix heat-proof cement is quite satisfactory for this. Now cut a disc of lead foil or pewter that fits inside the cell and bend it to hold the stone in the position required. The stone is covered with a highly refractive liquid.

Below the stage is an opal 100-watt bulb. The amount of light transmitted through the sides of the cell is governed by the depth that the metal collar allows the cell to pass into the hemisphere. The best results are obtained by illuminating only that plane within the stone that is being photographed.

It is an improvement to place a diaphragm on the top of the cell to prevent extraneous light reaching the objective.

CONCLUSIONS

When Dr. E. Gübelin's unique photomicrographs of gem inclusions, many of which were taken in colour, are studied, it is soon realised that he controls his lighting perfectly, so that even with the high magnification he obtains each type of inclusion is given the correct lighting and shows maximum detail.

Using the simple apparatus that I have described, it is apparent that a great improvement would be made by using a Pointolite or a type of lamp with a small but powerful light source in conjunction with a sub-stage condenser and so obtain critical lighting.

Having improved the lighting, there are many other ideas for the improvement of the apparatus described in the books I have mentioned. These must be tried to assess their value when applied to the photomicrography of gemstones:—

1. The fitting of tube-like diaphragms behind the objectives to increase the depth of focus.(3)
2. The use of filters to increase the optical performance of the microscope.(1 and 3)
3. The use of the " Parallax " method of focusing on a clear glass screen with black cross lines.(2 and 3)
4. The use of photo-electric exposure meters to measure exposure times.
5. The whole field of colour photography.(2)

I hope that this description of a successful method of making photomicrographs will encourage others to approach this interesting subject which plays such an important part in the study of gemstone inclusions, and maybe other workers will publish details of their experiences with other methods and apparatus.*

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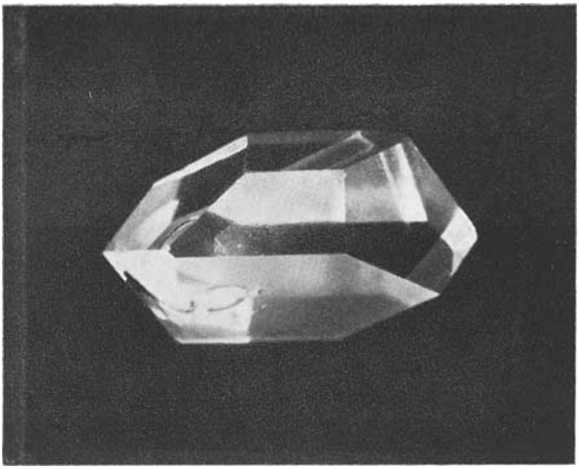
(1) " The Ilford Manual of Photography." By James Mitchell. Henry Greenwood & Co., Ltd., London, 1950.

(2) " Amateur Photomicrography with Simple Apparatus." By Alan Jackson. The Focal Press, 6th edition, 1948.

(3) " Practical Photomicrography." By J. E. Barnard and F. V. Welch. Longmans, Green & Co., 3rd edition, 1937.

* A further article on the subject of photomicrography will be published in a subsequent issue of the Journal.

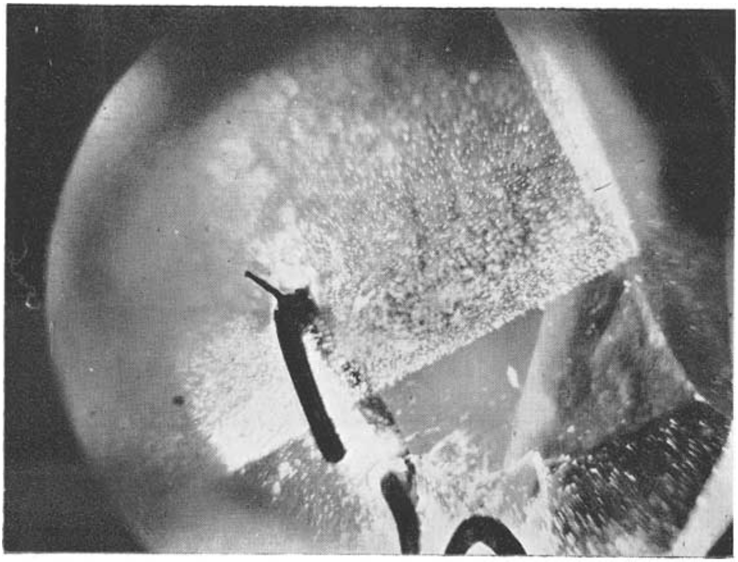
From the Laboratory . . .



Photographs of a synthetic quartz crystal made in the Bell Telephone Laboratories and described in Vol. 3, No. 1.

(*Above*) Natural size, showing development of the positive rhombohedron at the entire expense of the negative (R. K. Mitchell).

(*Below*) Magnified about 10×, showing wire hook embedded in the "seed" plate.



Gold in Britain

By Nigel W. Kennedy, F.R.S.A., F.G.A.

I.—Introduction

GOLD has been so absent from circulation in Britain for thirty-six years that two generations are unable to visualise a time when gold coinage, from the half-sovereign upwards, was in common use by all classes of the community.

For countless generations gold has been almost venerated as a precious metal, sometimes reputed to possess occult powers, and partly owing to its comparative rarity and to the fact that it is not easily destroyed or harmed by fire or normal chemical action, it has been accepted the world over as a moderately portable medium of exchange in comparison with many other forms of wealth. This attribute of preciousness is so closely associated with gold that one instinctively compares personal and other qualities with those of the Noble Metal, as in the phrases " As precious," or " as costly," or " as pure " or " as good as gold," and until comparatively recent times gold was regarded as the King of Metals, and even now many people believe gold to be the most costly metal.

Latterly, however, Platinum, Palladium, Iridium and Rhodium have commenced to replace gold in many ways.

Copper is actually rarer than gold in nature, for not only is it less widely distributed through the earth's crust, but there is actually less of it ; but while Copper is often found in more or less isolated patches of considerable size and richness, gold is widely distributed, usually in a finely divided state, and the high cost of extraction adds to its price.

Gold occurs native or almost pure in some places, or in the form of ores in combination and association with other minerals in veins and lodes traversing rock formations. Associated metals may include Platinum, Palladium, Osmiridium, as well as Silver, Tin, Lead, Copper, Iron, Bismuth, Antimony, Zinc, with Arsenic, Sulphur, Tellurium and Selenium. Many of the minerals we prize as gemstones are included in those associated with gold ores as *rarer accessory minerals*, such as Blende and Cassiterite.

During the course of time chemical processes cause gold to be released from its ores, when it may be transported by streams and deposited as scales, threads and nuggets in their beds. Mountain torrents in spate transport it, but since gold is 19 times heavier than water it is soon dropped and retained in hollows and cracks. Shepherds in olden times discovered that the woolly fibres of the sheep's coat, lying in a stream, might collect spangles of gold, and fleeces were left deliberately for the removal of gold dust from streams, thus giving rise to the legend of the Golden Fleece. Some dried-up beds of streams are incredibly rich sources of gold, e.g. the placer deposits of Kalgoorlie and Coolgardie in Australia.

Most countries have possessed such deposits, but they have usually been quickly worked out, although the original source of the gold is sometimes traced by prospectors.

Gold is usually obtained by mining its ores, and Witwatersrand at Kimberley is a famous mine, another being Mount Morgan, in Australia, where the hill was said to be practically composed of rich auriferous copper ore.

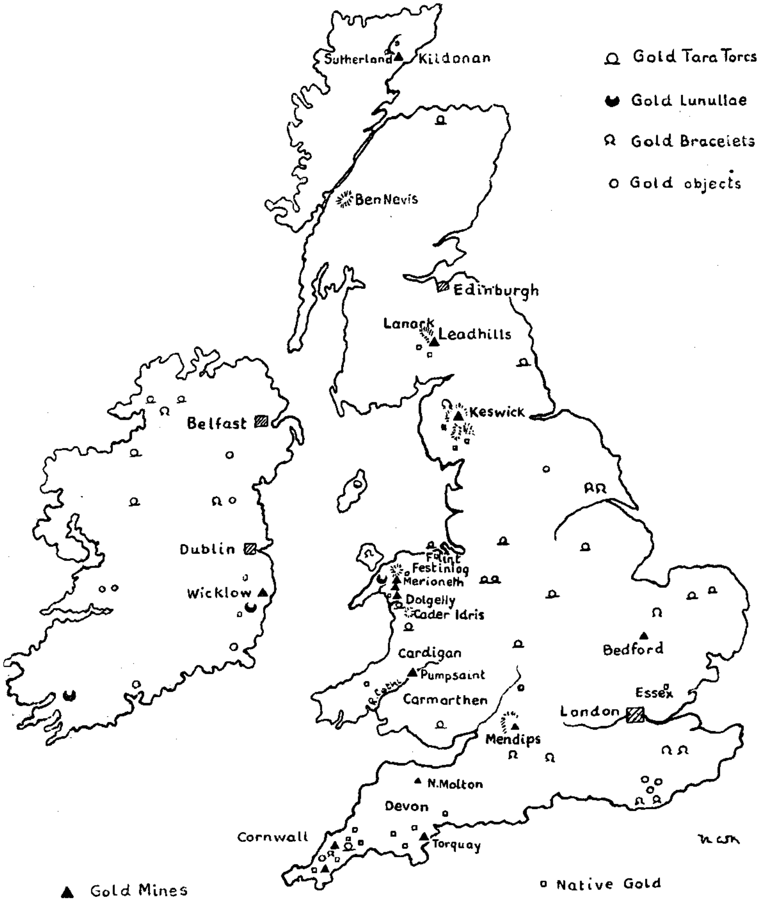
Sometimes gold-winning is relatively simple, but its production is usually laborious and costly, and may involve danger to health or life. It is probably true that more gold has been invested in gold mines than has come out of them, but this has largely been due to rank dishonesty and human greed, the desire to obtain an unduly high return for a small outlay.

Another source of gold is sea water, and many years ago the Russian scientist Dmtri Ivanovitch Mendelejeff estimated that each cubic mile of sea water contained £60,000 worth of gold, and since the earth supports 300 million cubic miles of water there is sufficient gold to interest any Chancellor of the Exchequer—only it would cost more to extract it. River sands are often rich in gold, and in 1846 the French savant M. Dubré suggested that the bed of the Rhine should be worked for the precious meal, estimated at 36,000 tons.

II.—A BRIEF HISTORICAL SKETCH OF THE OCCURRENCE OF GOLD IN BRITAIN

Britain is an auriferous area and has produced quantities of the precious metal from pre-Roman times up to the present day.

There is no reason whatever to suppose that our gold resources have been anything like worked out, but there is a good deal to support the theory that vast amounts of gold ore in very rich veins



SKETCH MAP OF THE BRITISH ISLES

The approximate positions of the Gold Mines formerly operating, and localities in which native Gold is stated to have been discovered. The approximate location of various gold objects which have been found at times is also indicated by the appropriate symbol.

still await the miner's pick in Wales and Ireland, and possibly Cornwall and Scotland.

In August, 1947, when the Press was full of news about the approaching wedding of H.R.H. Princess Elizabeth, some prominence was given to the hope that sufficient native Welsh gold would be forthcoming for her wedding ring. It was stated that the proprietor of a Welsh mine (which was the only gold mine then operating in Britain) hoped to have enough gold, and that Welsh gold had been used for wedding rings for her royal mother, Queen Elizabeth, and her august grandmother, Queen Mary.

Anyone reading this would naturally infer than the finding of native gold in Britain was rare, but in 1938 it was reported that in one month 225 ounces of gold, worth £1,500, had been extracted at the reopened pre-Roman mine of Ogofau, at Pumpsaint. The official Report of 1939 to the Secretary of Mines states that in 1938 2,428 ounces of gold were mined in Wales, valued at £20,000. Since then a sort of Iron Curtain has descended on production, which is under the ægis of the Ministry of Supply.

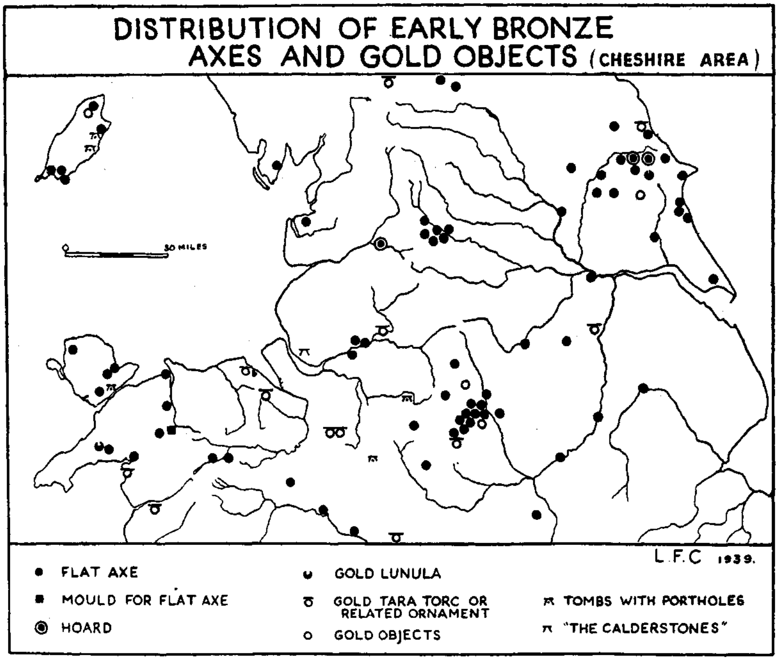
At one time we find British gold mines referred to in all good faith as a possible new El Dorado which would put Klondyke or Coolgardie in the shade, and at another the suggestion that there ever has been gold of any value in Britain is received with howls of derision.

In order to get some sort of picture as to where we have arrived in the story of the production of gold in Britain, we shall have to delve a long way back into the depths of history. The story commences in the distant past, over 2,000 years prior to the birth of Christ. It is not too easy to locate the parts of the historical mosaic and to fit them into a picture, but by searching through the local Reference Libraries, the Geological Survey Library, and by visits to the British Museum, Science Museums, Geological Survey Museum and Victoria and Albert Museum, I have at least managed to discover many fragments.

We have abundant evidence that metal workers had reached a high degree of skill in pre-Roman Britain. It is stated that gold was mined in Essex by both Boadicea and Cymbeline, whose name appears on at least 40 gold coins of different design, and also that gold coins were in circulation in Britain circum B.C. 200, and much earlier than that in Ireland.

In Saxon times King Athelstan conquered Wales and it is stated that he imposed an annual tribute upon the Welsh princes amounting to 300 lbs. silver and 200 lbs. gold (weight). This alone gives one something to think about, for since in such early days trade was carried on mainly by barter, and money was dear, the value of any gold coin must have been very great, and the heavy tribute referred to represents a tremendous figure in modern currency ; but it must have come out of native gold, either found in river beds or from ancient mines, in Britain or Ireland.

Ireland was a very rich alluvial gold area and the early Bronze Age inhabitants acquired considerable skill in the fabrication of laminated and drawn objects, such as Gold Lunulæ and Tara Torcs, for which the ductile and malleable properties of gold are very suitable. It is probable that the Druids smelted gold and guarded the secret, but whoever was responsible for the production of the excellent Irish gold ornaments dating back to before 1,300 B.C., as will be seen from some of the maps I have located, Irish gold objects



Reproduced from " Prehistoric Cheshire " (1940) by permission of the Cheshire Rural Community.

were obviously known and traded all over Britain and the West of Europe.

The impression left by these durable relics of a bygone age is of a people of high cultural attainment, with the ability to make the best use of materials at hand, and in this we have much to learn from lost peoples.

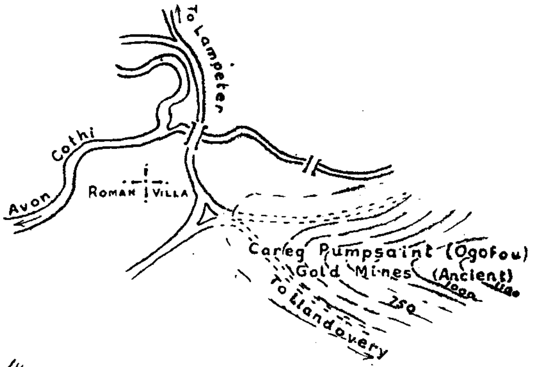
Anyone interested in early gold ornaments of Britain should visit the King Edward VII Gallery, British Museum, where two cases will be found containing some 160 objects having a total weight of at least 10 lbs. (160 ounces). They include Ear-rings, Rings, Bracelets, Ring-money, Lunulæ and Tara Torcs, and some of these weigh 18 to 27 ounces. It is certain that many more of these objects have been found than are recorded, and that many may have been melted down, and it is obvious that they were relatively common articles of commerce.

We know that the Phœnicians carried on trade with Cornwall for the tin required to make bronze, and that the source of the metal was kept secret. Herodotus refers to Britain as " Cassiterides," which I understand originally meant " The wooded place," but was the Greek name for Tin, and is still retained in the name Cassiterite for a valuable tin ore which in gem quality is occasionally cut and polished. Some writers believe that gold was the real attraction which drew the hardy rovers beyond the Pillars of Hercules to discover the source of gold in the west.

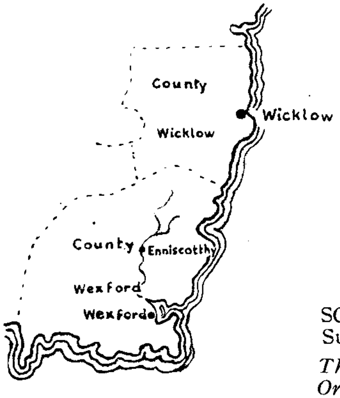
They left another name behind, for the Scilly Isles bear an ancient name which sometimes provides a puzzle, being named after Scylla, the six-headed monster which sat over a dangerous rock in the Straits of Messina, opposite the whirlpool of Charybdis, giving rise to the saying " Between Scylla and Charybdis " in reference to a choice of two evils. It is likely that a similar tidal race also existed near the Scillies.

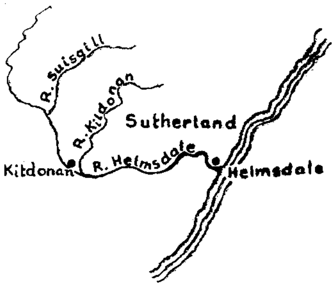
The Romans knew that Britain was an auriferous country, for we are told that Agricola, addressing his legions in the Grampians in the Scottish campaign and urging them on to fight the stubborn Scots, reminded them that " Britain produces gold, silver and other metals, the booty of victory." Calvert, writing in 1853, states that there are proofs that the Romans worked many gold mines in Britain: Poltimore Mines in Devonshire ; Ogoufou Mine, Pumpsaint, Carmarthenshire (reopened successfully in 1938); Gold Scoop

Mid-**WALES.**
Pumpsaint
Gold Mines,
Carmarthenshire
(right).



IRELAND
County Wicklow
Gold Mining
Areas (*below*).





SCOTLAND—Kildonan Gold Mine area, Sutherland (*above*).

Three sketch maps copied from the one-inch Ordnance Survey map, with the sanction of the Controller of H.M. Stationery Office.

Mines, Cumberland ; and the Lanarkshire Leadhills, which were encircled by Roman camps as though under military protection. In the Merionethshire Gold Belt there is a Roman camp near Moel Siabod in the north-east, and another close to the Clogau Gold Mine north of Dolgelly, while a significant feature of the Pumpsaint map is the inclusion of a Roman villa near the site of the old mine.

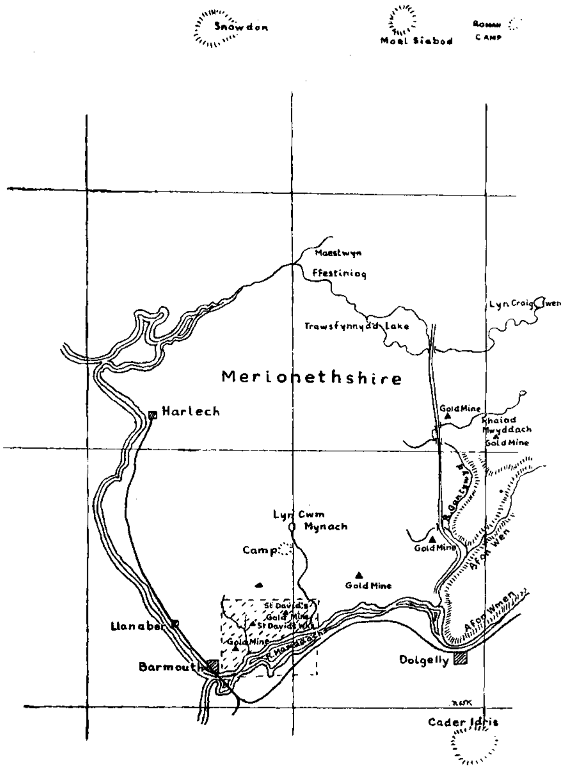
After the departure of the Roman legions in the IVth century, little or nothing is known of the history of our islands for another four hundred years, until we learn of the coming of the Saxon Kings, and under Alfred culture and learning were encouraged and history commenced to be recorded. Cultural progress would be mainly centred in Winchester, Lincoln, York and other ancient Saxon cities, but the impression one has is that most of the country was covered by dense forests, and that the people had relapsed after the departure of the Romans into ignorance and darkness, in which cities like Chester fell into ruins and were covered by many feet of soil. Under the Saxons, however, the smelting of iron and manufacture of glass made much headway, as seen by the many beautiful objects left by them, and it is certain that they were able to smelt gold and silver, so that it is equally certain that some gold mines were operating, for there is absolutely no reason to suppose that gold was at that time imported into this country. Trade did not justify it, and probably barter and exchange was sufficient in most cases.

Now one thing is certain, and that is that the Saxons were persecuted by raiders from Scandinavia—Norway, Jutland and Denmark—who ravaged the coast and pillaged the coastal towns and villages, until in the time of Ethelred II (The " Unready ") they were bought off by a levy known as the " Danegeld " and still exacted in Norman times long after the Danish raids had ceased. I have always maintained that this levy was paid in British gold, hence its name, which is different from any other imposition since—customs, tax, duties, rates, tithes, tributes, fines, etc.—but the word " gold " is never so used, and in my opinion its use was deliberate and that the Danes demanded payment in gold because they knew that Britain had rich gold resources.

This view is strengthened by the Welsh tribute imposed by Athelstan, but real corroboration is met in a reference(1) which states that in 866 A.D. Turgesiw, King of Norway, conquered Ireland and imposed a heavy tribute requiring every head of a family in the whole of Ireland to pay one ounce of gold annually or to suffer mutilation.

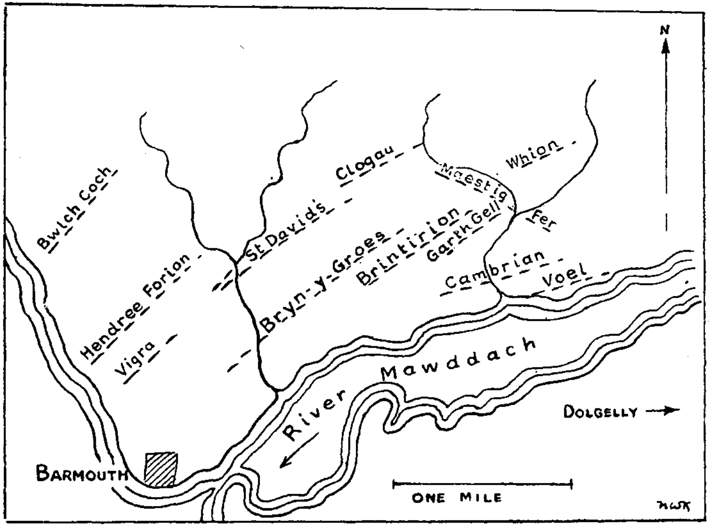
Although it is stated that coinage existed in Britain long before the Roman invasion, and that the Romans insisted on the use of their coinage, money was so dear in Saxon times that it is unlikely that much was in circulation, and although some of the coins have the same names now, in purchasing value one cannot compare them. Even 500 years ago a penny would purchase 40 or more eggs, and although a shilling may have been equivalent to 12 or 13 pence, they do not have much in common with the modern penny.

It is not necessary to plod century by century through mediæval times to trace the story of Gold in Britain, and indeed it might be difficult to obtain enough data ; but one can take outstanding events through the years, and so we learn that in the



Left : Sketch map copied from one-inch Ordnance Survey Map, New Series, showing location of Gold Mines as indicated on Maps Nos. 51, 52 and 44. (*Reproduced from the Ordnance Survey Map, with the sanction of the Controller of H.M. Stationery Office.*

Below : Enlargement of shaded area of above, showing position of rich Gold Ore Lodes. Thirteen lodes are indicated on this map, some of which have proved enormously rich in Gold Ore. *Copied from a drawing by A. R. ANDREW in his paper on "The Dolgelly Gold Belt", Geological Magazine vol. VII, (1910) p. 208. Reproduced by permission of the Geological Magazine.*



colourful times of King Henry VIII the gold mines at Keswick were worked, and that during his reign £300,000 in gold was forthcoming, although it is not definitely stated that it all came from Cumberland.

Several writers refer to Sir James Myddleton, who flourished in the reign of James I and died in 1631. He was the founder of the New River Company and paid the Crown £400 per annum rental for gold mines at Skibery Coed, Cardiganshire (which I have failed to locate), and that he cleared a profit of £2,000 per month which was devoted to the bringing of water from the New River from Ware to London. This is not strictly accurate, as I have since discovered that the mines were worked for silver as well as gold, and it is impossible to state now what proportion of each was refined.

About this time public interest was centred on speculation overseas, in gold and other Colonial produce often more valuable, and hence attention was drawn from local mining enterprise and possibilities, and so far as I can see this apathy has been popular ever since. This may account for the fact that I have not seen much mention of British production of gold from that time until the middle of the last century, when an Australian prospector named Calvert visited Britain about 1840 with the intention of investigating the possibilities of gold mining in Britain, which he felt should be a rich auriferous area. In 1853 he wrote a most interesting book(1) explaining his views and aims and the result of his investigations all over the country. He states that in his time the amount of gold found all over Britain was much greater than was supposed, for most people he spoke to told him that gold had been found on their estates at one time or another, and he came to the conclusion that owing to the excessive greed of the Government, discovery of gold in Britain was kept secret, although by law it is supposed to be reported. He particularly mentions County Wicklow, in Ireland, where nuggets of 22 ozs., 18 ozs., 9 ozs. and 4 ozs. had been found, and where worked articles weighing 17 and 27 ounces had been discovered.

III.—PRODUCTION OF GOLD IN BRITAIN

Calvert seems to have been among the earliest writers to give details of production, and is followed by many others, but, unfortunately, even the official returns issued by Government

Departments do not agree in detail with each other, which seems inexcusable. It may be that the references are not quite to the same places nor to exactly the same periods, but it is puzzling.

Vanderbilt (2) in 1888 states that Clogau Gold Mine produced 1,260 tons ore in 1862, from which 8,186 ounces gold were refined, which is a remarkable return, as will be seen later. Andrew, (7) in 1908, gives the figures as 804 tons ore, producing 5,299 ounces gold. Both figures may be correct, as one may include another lode near Clogau. Readwin(2) states that in 1887 the production of ore from five mines was 12,137 tons, yielding 14,667 ounces of gold valued at £57,000 sterling. Vanderbilt also states that Mr. Pritchard Morgan commenced crushing ore at Gwynfyndd Mine in 1888 in workings which had been abandoned and extracted 4,108 ounces gold in four months.

Coming now to the year 1908, MacLaren (4) states that gold production in the United Kingdom to that date had been:—

PRODUCTION OF GOLD IN BRITAIN

(These figures are quoted by several writers.)

ENGLAND		
North Molton, Somerset	£581	Period not stated
WALES	£417,183	" Since 1844 "
SCOTLAND		
Leadhills	£100,000	Period not stated
Sutherland	£3,000	1868/9
IRELAND	£28,855	Period not stated
Total	£549,619	Sterling

Present value at current price of gold not less than £1,400,000.

TONNAGE OF GOLD ORE MINED IN BRITAIN

The tonnage during some periods is unknown and for others is incomplete.

	EXTRACT FROM ANNUAL REPORT TO THE SECRETARY OF MINES		Gold Production in Merionethshire only (Andrew Geol. Mag. 1910) Incomplete 1860—1907	
Period	Gold Ore Auriferous Quartz	Corrected Figures		
1860—1872	Not stated	— ,,	15,167 Tons	
1873—1882	" Cannot be stated "	— ,,	22 ,,	(plus)
1883—1892	3,570 Tons	35,667 Tons	35,667 ,,	
1893—1902	10,252 ,,	10,252 ,,		
1903—1912	11,988 ,,	11,988 ,,	78,566 ,,	(plus)
1913—1922	648 ,,	6,476 ,,	98,777 ,,	To 1907
1923—1932	230 ,,	230 ,,	—	
1933—1938	? ,,	? ,,	—	
	26,688 Tons	64,613 Tons	228,199 Tons	

All Totals incomplete.

PRODUCTION OF SILVER IN BRITAIN

From 1920 to 1938 was nearly one million ounces worth £110,000.

YIELD OF GOLD
DOLGELLY GOLD BELT
Between 1860 and 1907

GREATEST TONNAGE of Gold Ore mined in one year:—
1902—29,303 Tons ore.

SMALLEST TONNAGE:—
1887—1 Ton.

LARGEST PRODUCTION of Gold during one year:—
1904—19,653 ounces Gold valued at £73,925 Sterling.

GREATEST YIELDS OF GOLD per Ton of Ore:—
(1) 1887—1 Ton Ore mined yielding 58 ounces.
(2) 1920—1 Ton Ore mined yielding 34½ ounces.
(3) 1879—22 Tons Ore mined yielding 20 ozs./Ton.

SMALLEST YIELDS per Ton Ore:—
During 1883 and 1885 904 Tons Ore were mined yielding 69 ounces Gold, or 0.08 (or 1/12th) ounce/Ton.

NOTE.—Since the figures available are incomplete for some years above data refers only to available figures.

Average Yield of Gold apears to have been approximately ½ ounce per ton of ore.

On reference to the same Report (8) for 1921 I found detailed figures for gold ore mined between 1913 and 1921 totalling 6,476 tons, which is ten times the figure quoted in the same Report a year later. Little gold mining was in progress between 1932 and 1938, but the yield from an unstated tonnage of ore was 2,906 ounces, valued at £20,230, mostly mined in 1938, according to the last Report of 1939.(8).

While reading through Andrew, who was a careful writer and gives the sources of his information, I discovered another similar error. He gives detailed tonnages of ore mined in Merionethshire, with yield in gold in ounces and value, for every year between 1860 and 1907, and for the period between 1893-1902 the total is 35,667 tons ore, or again ten times more than is stated in the Return in 1932.

A. R. Andrew's articles on " The Dolgelly Gold Belt " are most informative, and his several tables and useful maps are very instructive. His figures show that during the 47 years covered, no ore was mined in this area during eight individual years, and that figures are lacking for nine other years, although the yield of gold is given.

Some of the figures are remarkable: thus the normal yield of gold appears to have been about ½ ounce per ton of ore ; the smallest yields were in 1883 and 1885, when 900 tons ore only gave 69 ounces or about 1/12 ounce per ton. The ratio of tons of ore to ounces of gold is, of course, unknown for the nine incomplete years. In 1862 the yield from 800 tons is given as 5,400 ounces or 6.6 ounces per ton, but this is eclipsed in 1879 when 22 tons yielded 441 ounces or 20 ounces per ton. The most spectacular figure is for 1887, when the one ton mined gave 58 ounces gold, which compares with 1920, when one ton yielded 34½ ounces. In view of such figures there appears to be every justification in stating that our Welsh goldfields can compare favourably in grade of return with Klondyke and the Yukon, or indeed any known mines.

The tables compiled by Andrew refer mainly to the production of the St. David's and Clogau Mines and there seems no reason to question the statement that during the 47-year period a total of some 120,000 ounces (or something like 3½ tons of pure gold) was produced in Merionethshire alone, with a current sterling value of some £440,000, representing possibly £1,400,000 to-day.

IV.—What Constitutes a Paying Yield in a Mine?

There must be some relationship between the tonnage of ore mined and the yield of gold refined from it, but the question, however, is not a simple one, for much depends upon the type of mine, accessibility, availability of water and power, cost of labour, cost of plant, and, of course, the current price and demand for gold, not to omit the ever-open voracious jaws of the State.

Some prospectors have stumbled upon El Dorados of unbelievable wealth, such as Coolgardie, where two men literally picked up a tent-full of gold lying on the surface in a small area, but it was an arid desert, and temperature, lack of water and transport rather spoiled the picture.

Then in Papua an immensely rich deposit was found in a remote valley beyond forest and jungle covered mountains peopled by head-hunters. Everything had to be transported to and from the spot by special aeroplanes.

The more usual source of gold is a mine where it is normally associated with many other valuable ores, and often is only present in minute quantities. Thus at Witwatersrand the yield is stated to be one ounce of gold in 200,000 ounces of ore (about five tons), or approximately one-fifth of an ounce per ton ; yet in spite of the high cost of mining, which includes raising the ore 6,000 to

8,000 feet and air-cooling at the rate of one ton of air per minute, this mine manages to pay its way.

In Britain, small quantities of gold are still known to be washed down in mountain streams, and there may be much more beneath some mountain bogs, but it is doubtful if panning any stream would pay commercially.

There is no doubt that Wales is a very rich auriferous locality and properly financed and organized prospecting and mining should produce a high yield of gold, but production has had to contend with many difficulties. First of all, Calvert states that the phenomenal discoveries of gold abroad diverted public attention from British mines, and that, in addition, there was, and always had been, a bitter antipathy on the part of the Cornish miners, who for some extraordinary reason seemed to resent any sort of competition with Cornish tin. He states that although gold and silver were known to occur with their tin ores no attempt was made to refine it, and apart from that, they either did not or could not recognise gold, unless it occurred native, and anything which was not tin, copper or lead might be dumped. It is true that many valuable finds have since been made in neglected Cornish tip-heaps from which tungsten, uranium and radium have been obtained.

To an investor, the main object of a gold mine is to produce gold and pay a dividend, but I cannot help feeling that in Wales the main object of gold mining has been to relieve unemployment irrespective as to whether the undertaking paid or not.

Then MacLaren (4) draws attention to another factor which, if it still operates, would certainly make it impossible for any gold mine to pay in this country. He states that the Kildonan Gold Mines, operating in 1868/9, paid the State royalties on a declared production of £3,000 at 10 per cent., namely, £300, but that he believes the real production to have been more like £12,000, and that much was concealed by employees and others. At one time 400 men were employed, and a Government tax of £1 per head per month was levied. If one assumes that 200 men were constantly employed over a year, this tax would amount to £2,400, so that the State would receive £2,700 out of a total return of £3,000, leaving £300 to cover all charges for wages, plant and, of course, dividend! Personally, as a Scot, I fervently hope that my country-men did find £12,000 worth of gold, on which the State charges would still be far too high. Any Government making such an imposition encourages the law-breaker.

Lewis,(10) writing in 1930, evidently tried to discover what return had been made from British gold mines, and, like myself, he found it difficult to compare one set of official figures with another, and after comparing three sets of figures covering production during the same periods, he observes: —

" It is difficult to reconcile these conflicting statements ; the fact that stands out quite clearly is that, whatever the yield, it did not pay expenses involved."

My own opinion is that there appears to be abundant evidence that very large quantities of gold exists in a definite goldfield in Wales, in rich but erratically distributed lodes, and that it seems worth while, with the resources of modern science and mining equipment, to locate the precious metal in the Snowdon area, and to operate with a moderate staff, and with a much more restricted levy by the State, paid on profits not upon total yield.

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The Relation between Lustre and Stereoscopic Vision

By G. T. Clarkson, F.G.A., C.M.B.H.I.

AT the outset, it is wise for the writer to say what he understands by lustre, which word is used as a technical term in gemmology and is also a commonly used word in less specialized matters. It is not thought that the specialized use differs in any important way from the general use, and it is taken to mean the quality of " shiny-ness." It depends entirely upon the way the surface concerned reflects light falling upon it, and this in turn will depend upon (a) the nature of the substance and (b) the quality of the surface, by which is meant the geometrical regularity of the surface and the degree of smoothness or polish applied to it. The reflections of incident light that lustre is concerned with occur at or near the surface (say within the top hundredth of an inch) ; it is not concerned with internal reflections. It is highly probable that the nature of the substance is involved in the question of lustre only so far as it affects the degree of smoothness it permits the surface to accept. Obviously, blotting paper could not be given a polished surface like metal or glass.

The meaning of the term " stereoscopic vision," or, more properly, the stereoscopic effects of binocular vision, is equally clear in most people's minds, but it will have to be dealt with a little more fully. Cyclops, having but one eye, would see objects at any one time from one viewpoint only. Without moving his head, he would be completely unable to ascertain and grasp the solidarity of an object ; any " depth " dimensions, along his line of sight, would not exist. A normal person, however, gets two separate and different views of one object, one with each eye. The difference between these views depends upon the difference in perspective resulting from a change of view point. For near objects the difference is considerable, but for distant objects it is only slight. The apparent movement of objects relative to each other which results from a change of viewpoint is known as " parallax," and this term also covers the change of perspective which occurs with each change of viewpoint, since the principle of relative movement still applies when the objects are selected points on a single object.

The ordinary person receives on his two retinas two flat pictures which, if superimposed, would not fully coincide. One of the functions of the brain is to explore these two images, note the amount of parallax in various places and from this data calculate the " depth " along the line of vision. This it does with amazing rapidity and efficiency, thus giving a single solid or stereoscopic picture which reveals the complete form of the object and its placing relative to other objects within the field.

This is true stereoscopic vision, and every point made above can be proved by making drawings of a real or imagined object from two viewpoints, laterally displaced relative to each other, and by simple experiments involving the use of one eye at a time. Zeiss made hundreds of stereoscopic pairs of drawings, and there is nothing difficult about it, as the writer has satisfied himself. It is also quite possible for a normal person to use these pairs stereoscopically, to achieve depth and solidity, without using a stereoscope. Now Cyclops, with one eye—and there are lots of people about having only one useful eye each—will hotly deny, with perfect truth, that he is unable to " see solidly." This is because of nature's resourcefulness and because of nature's deep desire, strengthened by millions of years of evolutionary development, to see in depth as well as in the flat. It is of the utmost importance for a living being if he is to stay alive to be able to judge of the complete form of an object in all three dimensions and also to judge its placing in depth (or distance from the eye) relative to other objects. Robbed of the " stereoscopic pairs " of flat pictures, nature therefore falls back upon such other expedients as (a) slightly moving the head laterally and (b) taking advantage of the movements of the objects themselves, and also (c) drawing conclusions from the size the object appears—just as a distant car can easily be hidden by a visiting card pasted on the windscreen of one's own vehicle. It is very unlikely that the depth perception of one-eyed people is appreciably inferior to that of normal beings, but it is also unquestionable that one-eyed people can easily be deceived in the matter of depth dimensions if the circumstances are such as to rob them of the aids mentioned in (a), (b) and (c) above.

To return to the question of lustre. It is obvious that the higher the degree of lustre of any surface, the more perfect will be the reflections in that surface of surrounding objects and light sources. Thus the image of a small light source—say a candle flame or an electric bulb—will be clear and sharply defined in a lustrous surface. A one-eyed person, so long as both he and the object remain still, will gather his appreciation of the lustre of a surface purely from the sharpness and vividness of the reflections. Just as the perspective of an object varies with each change of viewpoint (and *only* with a change of viewpoint), so the apparent position of each reflection will change with the viewpoint. And just as the parallax brought about by the lateral separation of the two eyes, applied to the perspective, gives the effect of solidity in the viewer's eyes and brain, so the effects of parallax applied to the relative positions of the various reflections from the surface give the effect of lustre. And thus lustre is largely a stereoscopic effect. A one-eyed observer will, however, see lustre just as (or almost as) vividly as a normal person, but he will depend upon the expedients already mentioned instead of a stereoscopic pair of flat pictures embodying reflections.

If the reader desires proof, let him set up a large stone in a fixed near position with one or two light sources conveniently placed and, holding the head quite still, cover each eye alternately whilst examining the stone. He will find that just as the perspective varies for each eye, so does the position of the reflections of the lights from the stone's surface. Because the stone is assumed to be of high lustre, the reflections will be sharp and clear and the apparent changes in their shapes and positions for each eye will be abundantly clear. For further proof, it would be a simple matter to incorporate in hand-drawn stereoscopic pairs reflections whose parallax corresponds with the perspective parallax, and unquestionably the effect would be one of lustre.

We may sum up by saying that just as a one-eyed person gets a flat, two-dimensional, and very imperfect grasp of the solid form of an object, so he would also get a very imperfect idea of the lustre of its surface *except* that, by long practice and by intense desire, he would bring in " parallax of reflections " so skilfully, though probably quite unconsciously, that he would see the lustre almost or quite as well as others: just as he normally uses this method to correct and amplify his understanding of the solid form of the object.

The James Bay Diamond Syndicate

by D. S. M. FIELD, A.G.A.

A PRELIMINARY report on the newly formed James Bay Diamond Syndicate, whose holdings are located in the Vassan-LaCorne-Pressiac area of North Western Quebec Province, Canada, was published in the " Journal of Gemmology " in January, 1951 (Vol. III, No. 1).

At that time work had commenced on the sinking of a shaft for the removal of a bulk sample of rock for testing at the Val d'Or plant of the Quebec Department of Mines.

Details of the test and the findings of the Mines Department are contained in a second report recently made available to the writer by J. C. Honsberger, Esq., B.Sc., of Val d'Or, who, together with Mr. Norman Vincent, of Toronto, formed the Syndicate in March of last year.

The rock was shipped as mined from a shaft sunk to a depth of 65 feet in Range VII, Vassan Township, Abitibi District, in the Province of Quebec. The shaft followed a vertical diamond drill hole in the drilling of which the bit had encountered a substance it could not penetrate at a depth of 60 feet. Examination of some of the choppings from the hole at that depth showed the presence of a few particles of diamonds. All rock mined from a depth of 43 feet to the bottom of the shaft at 65 feet was shipped for treatment and amounted to 147.6 tons. The rock consisted of both peridotite and amphibolite, the latter being encountered in the lower part of the shaft. The peridotite was both massive and sheared and contained a good deal of fine magnetite. Pyrite occurred in well-formed crystals, a few of which with edges 1½ in. in length.

CRUSHING

After a study of the sizes of diamonds found in Arkansas, at Prairie Creek and the Arkansas Mine, and at the Premier Mine in South Africa, it was decided to crush all the rock to minus ¼ inch. The average weight of 3,000 stones found at the Arkansas Mine was 0.4 carat. Seventy per cent. of the stones found at the Premier Mine are below ¼ carat in weight. A 1.2 carat stone of fairly regular shape easily passes through a $\frac{1}{4}$ inch screen. It was realized that any large stones above $\frac{1}{4}$ inch diameter would be fractured, but as the main purpose of the test was to prove the presence or otherwise of diamonds, crushing to $\frac{1}{4}$ inch seemed to be a safe procedure. Coarser crushing would have added greatly to the cost of the test and would have been difficult to carry out with available equipment.

Primary crushing was done in a 9 ins. by 14 ins. jaw crusher ; $1\frac{3}{4}$ inch secondary crushing in a 30 ins. Peacock differential crusher set at 5/16 in. opening. The product of the 30 ins. crusher went to a 12 ins. Peacock crusher with the same opening. The smaller diameter of the cone of the 12 ins. Peacock crusher broke up slabby pieces of rock without crushing too fine. The product of the 12 ins. crusher went to a Dillon double-deck vibrating screen. The top screen had $\frac{1}{4}$ inch openings (square) ; the bottom screen had $\frac{1}{8}$ inch square openings. Plus $\frac{1}{4}$ inch material was returned to the 12 ins. crusher.

A screen analysis of the finished screen products was as follows:

Mesh	Per Cent.	Per Cent. Cumulative
$-\frac{1}{4}$ in. plus $\frac{1}{8}$ in.	49.8	49.8
$-\frac{1}{8}$ in. plus 10	10.5	60.3
-10 plus 20	11.8	72.1
-20 plus 35	7.3	79.4
-35 plus 65	4.9	84.3
-65 plus 100	1.7	86.0
Minus 100	14.0	(100)

The two finished products from the screen, namely $-\frac{1}{4}$ in. plus $\frac{1}{8}$ in. and minus $\frac{1}{8}$ in., were jigged separately.

The jig used was a 12 ins. x 18 ins. Denver Duplex, with a bottom screen of wedge wire type with 1/16 in. slotted openings. A bed of 3/16 in. steel shot, about 2 ins. in depth, lay on the jig screen. Jig stroke was 3/16 in. Feed to the jig was by pump at the rate of 1,300 pounds per hour. Naturally, any diamonds with a diameter of over 1/16 in. would be retained on the jig screen. The screen was cleaned off several times during the run, and the material collected was considered concentrate.

As a safety precaution, jig tailings passed over a Wilfley Standard Sand concentrating table, where a fairly wide cut was made to insure that any diamonds present that might escape the jig would not pass into the Table tailings. Table tailings were stockpiled outside the mill, where they could be reclaimed for further treatment, if such were deemed necessary. Table concentrates were collected for treatment on the grease table with the jig concentrates.

The weight of the concentrates obtained was as follows:

Jig Concentrates: 8,800 pounds.

Table Concentrates: 4,200 pounds.

Approximately 5 per cent. of the concentrates was pyrites.

GREASE TABLE WORK

Before any grease table work was done, advice was obtained from the Government Metallurgical Laboratories in Johannesburg, South Africa, as to the type of grease to use and its application. This was a mixture of approximately 20 per cent. Petrosene and 80 per cent. Light Amber Petroleum Jelly. The composition was varied according to the temperature of the air and water in the mill. It was found that at plant temperatures very little Petrosene made the grease too hard.

To test the efficiency of the grease table, natural rough South African diamonds, about 1/10 carat in weight, were put in with the concentrate, or put over the table after a run of concentrate. Results were never satisfactory. The grease became contaminated even after as little as ten pounds of concentrate was put over the table, and the diamonds generally rolled over ; although there were occasions when 50 pounds were tabled and the diamonds were still held by the grease.

In South Africa, stationary as well as vibrating tables are used. Both were tried at the Val d'Or plant. The first table was built on top of a Wilfley sand table, was 2 feet wide, and had a slope of 7 degrees. Grease was applied $\frac{1}{4}$ in. thick for a length of 6 feet. The table was fed by hand, evenly and slowly. Stroke was 3/32 in. and speed 300 per minute. The grease rapidly took up a film of fine magnetite and other minerals, and the test diamonds soon rolled over. A microscopic examination of this film showed that 40 per cent. was magnetite and the remainder talc, chlorite, amphibole and fine pyrite. Tests were then run on small lots, with as much of the magnetite as possible removed by electro-magnet. Results were still unsatisfactory. A stationary grease table was built, 24 ins. wide, 6 feet long, and with a slope of 12 degrees.

This table was carefully fed by hand, with varying water temperatures and grease mixtures, with no better results being obtained.

An account of the poor results of the tests was submitted to the Diamond Research Laboratory in Johannesburg. Their recommendation was to remove as much magnetite as possible, to screen out all minus 20 material and to spray-wash the remainder to remove soft mineral particles. They stated that, in any case, it would be very difficult to remove any diamonds found in the minus 20 mesh range from the grease table. Their final recommendation was to resort to hand sorting if satisfactory results were not obtained with other methods. It was also suggested that the PH of the water should not be above 9. The PH of the water used at the Val d'Or plant was found to be 7.

Removal of the minus 20 mesh fraction and spray-washing, as recommended, did not improve the results, so hand sorting was resorted to.

HAND SORTING

Hand sorting of 6½ tons of concentrate would have been an endless procedure with the few men available at the Val d'Or plant, so steps were taken to reduce the bulk of the concentrate. About 28 per cent. reduction was obtained by screening out the minus 20 mesh material. The remainder was jigged four times. Material remaining on top of the jig screen was carefully removed after each jigging operation and considered as concentrate, together with all material passing through the jig screen into the hutch. It was confidently felt that no large free diamonds would be lost in the jig tails when the operation was repeated so often. Any diamonds less than 1/16 in. diameter would, of course, pass into the jig hutch. By this means the concentrate to be hand sorted was reduced to approximately 2,200 pounds.

For hand sorting, reading glasses with a magnification of 4 × were used, under hooded lights. Sorting was one at the rate of about three pounds of concentrate per hour. As such was a tedious operation, men were limited, generally, to only a few hours' sorting at one time, and it was for this reason that the operation covered a period of about five months. Owing to the very small amount of quartz, calcite and other minerals in the concentrate, which might have been mistaken for diamonds, sorting was not as difficult as might be imagined. Particles of quartz, calcite, garnet, ilmenite, etc., stood out very prominently, and for this reason it is difficult to imagine any diamonds over twenty mesh in size being missed. The quartz found was glassy, milky-white, light green or rose coloured.

Any particles that had the slightest resemblance to a diamond were tested by squeezing by hand between two silver coins, since it was reasoned that a diamond would not fracture under such pressure. The only minerals sorted which did not fracture, or did so with difficulty, under this test were garnets and ilmenite. About 12½ grams of garnet and 12 grams of ilmenite were picked out. The ilmenite particles were rounded and worn, and it is felt that these had remained in the jig from a previous operation and worked out of crevices during the test. The garnets were probably native to the rock. Their colour was generally brownish-red, rose or yellowish. The average weight of the garnets was about 20 milligrams.

The above report is based upon the official report of G. S. Grant, Esq., of the Quebec Department of Mines Plant at Val d'Or.

CONCLUSIONS

Although no diamonds larger than 20 mesh were found, the matter is not closed. One of the shareholders, a mining engineer from California, with many years of diamond mining experience in South Africa, is planning to make further tests during the summer months.

Incidentally, it may be of interest to record the fact that competent scientific examination of the huge (world's largest) circular crater only recently discovered in Ungava Territory, in the extreme north-west corner of Quebec Province, indicates that it resulted from the impact of a meteorite striking the earth approximately 3,000 years ago.(1) This knowledge disproves the originally propounded theory that the Ungava crater is similar in nature to the diamond pipes of South Africa, and the possible source of the alluvial diamonds carried to the United States during the Ice Age. The whereabouts of Canada's diamond treasure is still very much a mystery, and only time will solve it.

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(1) For a detailed and first-hand account of the expedition to the crater and the discoveries made there, read " The Secret of Ungava," by Ken W. MacTaggart, in " World Wide " Magazine (Tower House, Strand, London, W.C.2), June, 1951.

Gemmological Abstracts

WALKER (A. C.). ***Laboratory synthesis of quartz crystals.*** Gems and Gemology, Vol. VI, No. 12, pp. 359-361. Winter, 1950/1.

A description of the apparatus used for the synthetical growth of quartz crystals in alkaline solution with a note on the applications of piezoelectric crystals in telephony and radio communication. Two illustrations.

See also Journal of Gemmology Vol. 2. No. 6. p. 227 and Vol. 3. No. 1. p. 31.

R. W.

CROWNINGSHIELD (G. R.) and HOLMES (R. J.). ***Synthetic red spinel.*** Gems and Gemology, Vol. VI, No. 12, pp. 362-268. Winter, 1950/1.

The description of a synthetically produced spinel crystal of octahedral form, the origin of which is not known. The crystal, an unusually well-formed octahedron with 13.5 mm. edge, has been grown on a metallic disc, probably of palladium, and with a crystal encrusted loop attached. Microscopic examination showed the presence of triangular pits on the crystal faces and numerous internal imperfections and inclusions, giving the whole crystal a cloudy effect. Examination by the electron microscope showed uniformly distributed sub-microscopic triangular markings on the octahedral faces and in some areas markings in the form of rosettes having a possible six-fold symmetry. The hardness was found to be greater than natural spinel or synthetic spinel grown by the Verneuil method. The density to be greater than 3.63 and less than 3.98 (misprint for 3.68 ?). Both large crystal and the smaller incrusted crystals adhering to the metallic disc and wire loop showed marked zonal colour distribution. The material is singly refracting and shows no anomalous double refraction. The R.I. was found to be 1.75. The absorption spectrum is discussed in relation to natural red spinel and to ruby. X-ray powder diffraction patterns of the material and of natural red spinel were taken, and patterns of Verneuil synthetic pink spinel and red corundum are compared with the others. The unit-cell size for the natural red spinel was found to be 8.089 A.U., for the synthetic red spinel under discussion to be 8.084 A.U., and for the Verneuil pink spinel 7.975 A.U. A spectrogram showed that this synthetic spinel is an aluminium and magnesium compound containing appreciable chromium and is similar to a spectogram of natural red spinel. Nothing is known as to how this unique specimen was produced—hydrothermal method of growth suspectecd. Six illustrations.

R. W.

DRAPER (T.). ***The gemstones of Brazil.*** Gems and Gemology, Vol. VI, No. 12, pp. 369-375. Winter, 1950/1.

A popular and historical article on the mining of gemstones in Brazil. The discovery of the gem fields may be said to have commenced in the 16th century, when expeditions were organized to search for emeralds which had been reported to exist in the then remote regions of Brazil. Tables of the gemstones found in the different zones of the country, and of the largest diamonds found in Brazil, are given. Six illustrations.

R. W.

ANDERTON (R. W.). ***Report on the Chivor emerald mines.*** Gems and Gemology, Vol. VI, No. 12, pp. 376, 377 and 379. Winter, 1950/1.

A general article by a former Manager of the mines on the working and recovery of emeralds from the Chivor mine in Colombia.

R. W.

SCHLOSSSMACHER (Prof. K.). ***Die internationale Edelstein-Nomenklatur.*** (The international nomenclature of gems.) Gold und Silber, 1951 (5), 13-14.

In the beginning gems were named according to colour, causing much confusion, which is still encountered occasionally. In 1935 an international gem nomenclature was published in Berlin. The American Gem Society is now working on a new nomenclature. The term " semi-precious " is discredited.

Sachverstandigenkonferenz der BIBOA in Idar-Oberstein. (Congress of BIBOA experts at Idar-Oberstein.) Gold und Silber, 1951 (5), 14.

Experts of the BIBOA met at Idar-Oberstein on April 3rd-5th, 1951. Among other items, the publishing of a new international nomenclature for gems was discussed, as was also the measurement of colour and definition of purity in a diamond, experiences with new synthetics and new methods of examining gems and pearls.

E. S.

ROBB (C. J.). ***Irish pearls.*** Gemmologist, Vol. XX, No. 237, pp. 96-97. April, 1951.

A short history of the river pearl fisheries of Ireland (Eire). The early methods of fishing are discussed. Fishing practically ceased after the 18th century and now industrial pollution has destroyed many of the pearl mussel beds. Some rivers are still mussel bearing and may be revived at a future time.

R. W.

ANON. ***Westphal balance.*** Gemmologist, Vol. XX, No. 238, pp. 104-107. May, 1951.

An informative article on the operation and use of the Westphal balance. The balance itself is first described and the arrangement and method of using the weights discussed. Examples are given. The application of the balance to the determination of the density of gemstones and of liquids is explained.

R. W.

WRIGHT (L. A.). ***The gemstones of California.*** Gemmologist, Vol. XX, No. 238, pp. 117-121. May, 1951. *Reprinted from Department of Natural Resources, Department of Mines, Bulletin No. 156 "Minerals of California."*

A full Governmental report on the gemstones and ornamental minerals found in the State of California.

R. W.

SCHLOSSMACHER (Prof. K.). ***Die Farben der Edelsteine.*** (The colours of gems.) Gold und Silber, 1951 (4), 11-14.

The article discusses the properties on which the colour in gemstones depends. The phenomenon of absorption is described in detail. Lambert's law (referring to the thickness of the absorbing material) and Beer's law (referring to the colour density, i.e. relative quantity of pigment in the material) are mentioned. Generally speaking, colouring matter in gems is supplied by eight elements only, namely, Nos. 22-29 in the periodic system (titanium, vanadium, chromium, manganese, iron, cobalt, nickel and copper), which have remarkably small atomic volumes. They are all paramagnetic. The eight elements have the same number of electrons in the K, L and N orbits ; in the M orbit, however, the number of electrons increases from 10 to 17. This might be the reason that these elements can absorb light.

E. S.

SCHLOSSMACHER (Prof. K.). ***Ende der Halbedelsteine.*** (The end of semi-precious stones.) Gold und Silber, 1951 (3), 10-11.

The name " semi-precious " stones lead to many misunderstandings and difficulties. It was first used by H. F. Benedikt Brückmann in 1773 (?). In 1949, E. H. Kraus suggested to the American Gem Society that " members should not employ the term ' semi-precious ' in referring to any gemstone."

CHUDOBA (Prof. Dr. K.). ***Bestrahlung von Edelsteinen mit "schnellen" Elektronen.*** (Treatment of gems with " fast " electrons.) Gold und Silber, 1951 (3), 12-13.

The use of new, energy-rich electron, proton or deuteron rays, as obtained with the betatron and cyclotron, opens a new field of research in gemmology, the results of which, for instance, in the case of cyclotron-coloured diamonds, are not only of importance scientifically, but also practically. Diamonds, which are treated with deuterons, become strongly radio-active, which property fades after about an hour. They become green, but the colour is located in the surface only. On polishing a treated diamond loses its colour or becomes brown. Many gems such as tourmaline, zircon, rock crystal, synthetic ruby, etc., display luminescence when exposed to betatron rays.

E. S.

JACOBSOHN (W.). ***Diamond Tool Patents IV, Polishing of Gem Diamond.*** Price 12s. 6d. Industrial Diamond Information Bureau, Industrial Distributors (Sales), Ltd., London, E.C.1. October, 1950.

A patent survey has been made by Industrial Diamond Information Bureau of the patents issued during the last 60 years on improvements in diamond polishing, leading to semi-automatic and automatic machines. These have been published as a brochure of 40 pp., containing a large number of illustrations. A short abstract is given of each patent, indicating the main features. Patents in England, U.S.A., Germany, Switzerland, Belgium and France are covered. In addition to the main section on diamond polishing, patents relating to diamond bruting are dealt with in an appendix. A publication of this kind has long been needed in this field, as every inventor and designer has had to compile his own list of patents in order to evaluate correctly the new ideas which he wanted to put forward. This new publication, compiled by W. Jacobsohn, A.M.I.Mech.E., gives the inventor the chance of studying, relatively inexpensively, exactly what has been done in this field, and of evaluating new potentialities. Obviously many of the patented ideas described have not been realized, and at present only a few diamond works use automatic or semi-automatic machines of the kind considered in these patents. The expert diamond polisher has the tendency always to revert to the simplest tool, which is, as a matter of fact, more universal than all improved tools, i.e., to the solder dop with copper stalk and wooden tang. But with progressing engineering developments it should be possible to overcome this point of view and to introduce more elaborate and sensitive operating tools which will bring diamond polishing into line with other high-class engineering activities.

A. G.

ASSOCIATION NOTICES

COUNCIL MEETING

A meeting of the Council of the Association was held at 19/25 Gutter Lane, London, E.C.2, on Wednesday, May 23rd, 1951, at 4.30 p.m. Mr. F. H. Knowles-Brown presided, and welcomed Miss E. Ruff, who was attending a meeting for the first time.

The sub-committee appointed to consider the working of the Association since the date of incorporation was further charged with reporting upon all matters appertaining to the examinations in gemmology. Mr. R. K. Mitchell was appointed to the committee to serve in the place of Dr. G. F. Claringbull. It was agreed that the examiners should be co-opted to the committee for the purpose of considering the syllabus of examinations.

GEMMOLOGY IN SCHOOL

Mrs. L. H. Knight, B.Sc., who is a science teacher at a High School in the East Riding of Yorkshire, writes to tell us that in her school timetable she has fifth form, with which she chooses her own subject in which she has a special interest. She chose a short, simplified course in gemmology and has found the students most interested. Last year Mrs. McKnight took the gemmology classes at the Stow College of Engineering, Glasgow, and it is very praiseworthy that she has elected to introduce the subject of gemmology to students before they leave school. Such teaching can be valuable in interesting students in jewellery sufficiently for some of them, perhaps, to express a desire to enter the trade on leaving school. Whatever the result, this interest in the beauty and science of gems at an early age will be beneficial.

TALKS BY FELLOWS

Mr. H. C. Fishberg: Broadfields Park Residents' Association, Hendon. " Precious Stones," April 30th.

Mr. G. A. Blythe: Rochford Women's Institute. " Gems," May 9th.

AMERICAN GEM SOCIETY

Mr. Kenneth G. Mappin, C.G., F.G.A., of Mappin's, Ltd., Montreal, has been elected as President of the American Gem Society. Mr. Mappin is the first Canadian to be elected as President, and the Council of the Gemmological Association of Great Britain has sent him their good wishes for a successful term of office.

1951 GEMMOLOGICAL EXHIBITION

A Gemmological Exhibition is being arranged by the Association, to be held at Goldsmiths' Hall, Foster Lane, London, E.C.2 (by kind permission of the Wardens of the Company) on October 8th, 9th, 10th and 11th, between 2 p.m. and 8 p.m. each day. Admission will be free.

CORRECTION

In connection with the article " A New Gemstone," by C. J. Payne, which appeared in the last issue of the Journal, Messrs. Chas. Mathews (Lapidaries), Ltd., have pointed out that it was Mr. Chas. L. Arnold, a director of the Company, who cut the new gem.

OVERSEAS VISITORS

During May the Association was honoured by visits from several overseas gemmologists, including Mr. A. Stromdahl (Secretary, Sveriges Gemmologiska Forening, the Swedish Gemmological Association founded in 1946). Mr. Stromdahl welcomed the opportunity of discussing gemmological matters with various members of the Association.

Other Swedish visitors were Mr. E. Gewers and Mr. Inglebert, members of the Gemmologiska Riksforbundet (a Swedish Gemmological Union founded last year). The Association was advised that Mr. H. Tillander, F.G.A., C.G., of Finland, gave a lecture-demonstration to the Union on May 27th, when its annual meeting was held. The Association was also pleased to receive a further visit from Mr. Hans Myhre, of the Norwegian Gemmological Association.

LONDON CONGRESS OF B.I.B.O.A.

The 1951 Congress of B.I.B.O.A. (Bureau Internationale de la Bijouterie, Orfèvrerie, Argenterie et Horlogerie) was held in London from May 23rd to May 26th.

Eight commissions were appointed to consider international problems connected with the jewellery, silverware and horological trades, and probably the most interesting was the one dealing with gemstones.

The Diamonds, Pearls and Precious Stones Commission was presided over by Mr. G. Fontana (France), and the British delegates were Mr. R. Klean and Mr. A. Triefus. The Commission included Dr. G. F. Herbert Smith (representing the Gemmological Association of Great Britain), Mr. F. H. Knowles-Brown and Mr. G. F. Andrews (the National Association of Goldsmiths), and Mr. B. W. Anderson was one of the representatives from the Pearl and Precious Stone Section of the London Chamber of Commerce. Among Fellows of the Association from overseas were Mr. A. Bonebakker (Netherlands), Mr. O. Dragsted (Denmark), Ing. J. Hammes (Netherlands), Dr. E. Gübelin (Switzerland) and Mr. W. Goldschmeding (Netherlands). Mr. G. Göbel, Head of the Precious Stone Section of the Paris Chamber of Commerce, who is an Honorary Fellow of the Association, acted as Secretary of the Commission.

Dr. E. Gübelin presented a paper on the present state of research in gemmology. He particularly mentioned the method of distinguishing between natural and synthetic corundum by means of the ultra violet light absorption spectroscope. Another part in his extremely interesting paper dealt with the changes of light at various times of the day and season that affected diamond grading by the naked eye and the importance, therefore, of grading by the use of a binocular microscope. Dr. Gübelin particularly urged the setting up of an international colour grading for diamonds.

A paper by Professor K. Schlossmacher (Germany), who was unable to attend the Congress, was read by Mr. Göbel. It dealt with the recognition of various gem testing laboratories by B.I.B.O.A. and of the importance of adhering to the gemstone nomenclature that had been agreed by the countries of Western Europe.

Mr. B. W. Anderson, in an *ex tempore* talk, referred to the history of gemmological development in the United Kingdom, and emphasized the importance of the pioneer work of the National Association of Goldsmiths, Dr. Herbert Smith and others interested in gemstones.

He dealt at length with the early and latest methods used to distinguish between natural and cultured pearl and mentioned that the origin of natural pearls was not yet fully understood in many cases.

The attestation for diamonds, pearls and precious stones, regulation of the correct use of designations and the services offered by the Paris Gem Testing Laboratory were described by Mr. G. Göbel.

After the presentation of the various papers a number of resolutions were approved, the significance of which was not of importance. Mr. G. Fontana and Mr. G. Göbel were re-elected as President and Secretary of the Commission with acclamation.

Interested visitors to the Exhibition

EDINBURGH
Gemmological Exhibition

APRIL 25th, 26th and 27th, 1951

A THREE-DAY Exhibition showing the scientific methods of testing gemstones in action was recently held at the Heriot-Watt College, Edinburgh. The exhibition was open to the general public for three hours for each of three consecutive evenings and over a thousand people attended.

The purpose of the exhibition was to show, since the popular coloured varieties of gemstones occurred in many species, that it was necessary for jewellers to call in the aid of science to identify stones. It was hoped to make clear that such aids, when properly applied, identified stones accurately and without ambiguity.

A particular feature of the exhibition was that all visitors were conducted round each exhibit by members of the Association and present students. At the entrance a brief introduction to the purpose of the exhibition was given to each small group of visitors before they were subsequently handed over to the operators of the various gemmological instruments.

Apart from the display of cut and uncut gemstones and the usual gem-testing apparatus, a series of mock instruments was set up to enable the layman to appreciate better the principles of the various instruments he saw in use around him.

For the refractometer a special ray board was set up which had the advantage of showing a ray of light entering a hemisphere of dense glass. This hemisphere was movable and it was therefore an easy matter for an operator to illustrate the critical angle of total internal reflection.

Similarly, for the spectroscope a lantern directed a beam of light through a prism, causing a spectrum to be shown on a small screen. This was particularly helpful in explaining the function of the spectroscope.

Another lantern and screen was also provided with two polaroids and served as an excellent medium for demonstrating polarized light.

Finally, an ultra-violet lamp was available for those who wished to take advantage of seeing the effects of this light on the various natural and cultured pearls and other gemstones.

A party from the North of England Jewellers' Association (Newcastle), headed by Mr. J. Wadham Grant, Chairman of the National Association of Goldsmiths, attended on the first evening. The visitors were much impressed with the exhibition.

Among those who contributed to the success of the Exhibition were: Professor H. B. Nisbet, Ph.D., D.Sc., F.R.I.C., Principal of the College, for kind permission to hold the exhibition and for arranging the necessary publicity ; Professor W. H. J. Childs, Ph.D., D.Sc., F.Inst.P., Head of Physics Department, for advice and guidance and invaluable help in the general layout of the venture. Mr. J. Allen, Mr. G. Cummings, Mr. A. Inch, F.G.A., Mr. J. Kinnear, Miss J. Lumsden, Mr. A. McAlpine, Miss T. McDonald, F.G.A., Mr. E. Shearer, Mr. E. Towe, Mr. J. Walker, Mr. G. Winnert, F.G.A., and Miss E. Wood, stewards during the exhibition, and Mr. D. J. Ewing, Lecturer in Gemmology at the Heriot-Watt College. Several Edinburgh jewellers kindly loaned specimens, jewellery and show cases for what was a most valuable contribution towards making the public aware of the importance of gemmological study to the jeweller.