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CHROMIUM AS COLOURING AGENT IN PRECIOUS STONES

by K. F. CHUDOBA

COLOUR is the most obvious of the physical properties of precious stones. In many cases it is of significant importance not only for their recognition and determination, but also for value.

The pleasure given by a coloured stone is frequently connected with the problem of the cause of its colour. Mostly it is difficult to find a well-founded answer because the merely visual appearance of a peculiar colour may depend on a variety of different factors.

Naturally progress in science will have its effect on the understanding of the causes of colour in general and of chromium as colouring agent of precious stones in particular. The latter problem will be discussed shortly in this paper.

Of general importance is the fact that most precious stones are colourless when they are chemically pure. Their coloured varieties contain small quantities or even only traces of additional elements which are of no importance whatever for the chemical composition of the precious stone. The significance of these " impurities " was at first completely unknown. When, however, always the same trace elements turned up in certain colour varieties, it became highly probable that these colours owed their existence to the " added impurities." This supposition was proved to be correct, especially when different coloured stones were synthesized. In these syntheses, the typical colour could be obtained by adding those trace elements which were found in the corresponding natural crystals.

The clearest case of a connexion between a colour and a trace element exists for the element chromium, which was discovered in the year 1797 by L. N. Vauquelin in the mineral crocoite—$PbCrO_4$. It became likely that chromium was a colouring agent, when M. H. Klaproth in the year 1802 determined analytically 0·30% Cr_2O_3 in Muzo emerald. In due course the number of precious stones presumably coloured by chromium grew considerably. Contributory causes of the discoveries were improvements in chemical analysis and especially the development of different spectroscopical methods, which show the presence of even very small elements of a trace elements.

Surprising is the fact that precious stones coloured by chromium may be either red or green as shown in the following table.

TABLE I

PRECIOUS STONES COLOURED BY CHROMIUM

Precious stone	*Chemical composition*	*Cr_2O_3 content*
A. RED GROUP		
Ruby { natural synthetic }	$(Al\ cr)_2O_3$	mostly trace up to 2%
Red Spinel { natural synthetic }	$Mg(Al\ cr)_2O_4$	mostly trace up to 2%
Pyrope	$Mg_3(Al\ cr)_2Si_3O_{12}$	0·25–3·00%
Pink Topaz	$(Al\ cr)_2SiO_4(OH\ F)_2$	trace
B. GREEN GROUP		
Emerald { natural synthetic }	$Be_3(Al\ cr)_2Si_6O_{18}$	traces to 0·30% up to 1%
Spinel, synthetic	$Mg(Al\ cr)_2O_4$ + gamma Al_2O_3	up to 1%
Alexandrite	$Be(Al\ cr)_2O_4$	trace to 0·34%
Hiddenite	$Li(Al\ cr)\ Si_2O_3$	trace to 0·2%
Demantoid	$Ca_3(Fe\ Al\ cr)_2Si_3O_{12}$	up to 1·36%
Euclase	$Be(Al\ cr)SiO_4OH$	trace
Chrome diopside	$(Mg\ cr)CaSi_2O_6$	up to 2·12%
Chrome enstatite	$(Mg\ cr)SiO_3$	up to 0·95%
Chrome vesuvianite	$Ca_{10}(Mg\ Fe\ Fe)_2(Al\ cr)_4Si_9O_4(OH)_4$	trace
Jadeite	$Na(Al\ cr)Si_2O_6$	trace to $\sim$0·01%

Some of the precious stones mentioned in Table 1 contain not only traces of chromium, but appreciable quantities. The table corresponds roughly with a survey by E. J. Gubelin[1] based on extensive investigations by B. W. Anderson and C. J. Payne.[2] In some instances the correct name of the precious stone depends on the identifiable presence of chromium. A green beryl which does not contain a trace of chromium is not considered to be an emerald. An example is the green gem beryl of Vinnietharra, Western Australia. Alexandrite, too, deserves its name only if the colouring agent is chromium. The same is true in the case of hiddenite and pyrope.

The most conclusive proof that chromium as a colouring agent produces red as well as green gem varieties is the fact that both synthetic ruby and synthetic emerald owe their typical colour to a corresponding addition of chromium. The content of the colouring element, however, is considerably higher in the synthetics than in natural ruby or emerald, as can be seen in Table 1.

Further proof for the colouring effect of chromium is the relation between chromium content and colour intensity. With increasing chromium content the colour of some precious stones becomes appreciably deeper.

Stones not listed in Table I may occasionally also contain chromium, such as the deep olive-green peridot (Hawaii, 0·14% Cr_2O_3) ; the brownish-green sphene of some occurrences in Finland and California (0·01 to 0·64%) ; the dark to black-green tourmaline from the chromium iron deposits of the Urals (occasionally several per cent Cr_2O_3) ; the delicate green nephrite, especially fine qualities (traces of Cr_2O_3). These stones, however, are of a green or greenish colour also if no chromium content can be determined. This shows, as has been recognized for a long time, that not only chromium but other elements as well can cause green tints. Bivalent iron is considered the main colouring agent in green beryls, tourmalines and peridots, whereas combined addition of bivalent and trivalent iron (Fe^{11} and Fe^{111}) is supposed to produce the colour in aquamarine and green apatite. Nickel is the colouring agent in green chrysoprase.

In this connexion the question arises : What importance should be attributed to the chromium if other colouring agents are present as well? Spectroscopically several trace elements are usually found in one precious stone. Previous investigations are not always convincing. Georg O. Wild and R. Klemm[3] found that chromium and vanadium together are probably responsible for the yellow green colour of hiddenite. Esther W. Claffy[4] doubts whether the addition of vanadium has an influence on the colour of chromium-tinted hiddenite. Controversies of this kind are quite frequent because a definite proof, through synthesis for example, is lacking. Even synthesis does not remove all doubts because to the eye the same colour can be produced in a synthetic stone by adding different metal oxides to the colourless crystal material. Thus the usual aquamarine-coloured spinel owes its colour to an addition of chromium and cobalt oxides. A second, rarer variety of visually the same colour is made by the addition of cobalt and titanium oxides.[5]

Of interest also is the question whether diamond is coloured by chromium, which has been found several times as trace element in this precious stone by Frank G. Chesley.[6] From this paper Table II has been extracted :

TABLE II

Diamond occurrence	*Cr content*	*Colour*
Angola	little	colourless
	trace	white
Congo	very little	pale yellowish
Brazil	trace	very pale yellowish

A relation between colour and chromium content cannot be deduced from these sparse indications. For diamond, only iron and titanium are likely to have a recognizable effect on the colour. In any case, the presence of a certain element, such as chromium, is in itself no cogent reason to consider it to be the cause of the colour in precious stones.

So far it has become obvious that the colouring effect of chromium in precious stones is of " bichromatic " nature, i.e. chromium causes either a green or a red colour in allochromatic stones (as opposed to idiochromatic stones, which owe their colour to the substance of the stone itself, for instance malachite). Emerald-green and ruby-red are the outstanding colour tints. An exception seems to be the chromium-containing disthene (kyanite), which according to several statements is blue.

The presence of chromium as colouring agent in several precious stones leads logically to two essential questions : (1) How is the chromium disposed in the lattice of the host crystal ?

(2) Why does chromium cause either a red or a green colour—what is the cause of the bichromatic effect of chromium on the colourless substance of precious stones ?

In answering the first question, it seems of importance to point out that microscopic and ultra-microscopic investigations show that chromium-coloured stones appear to be completely homogeneous, i.e. quite uniform. Neither pigments nor other colloidally distributed colouring matter can be observed. Chromium must have been received sub-microscopically by the precious stone, in a way that led to a homogeneous solid solution.

This solid solution must be of a special kind because precious stones are crystals with a regular inner architecture. The building blocks fall with their effective centres forming a regular pattern in the three dimensions called a lattice, which can be expressed by shape and size of a single unit cell (see Fig. 1).[7]

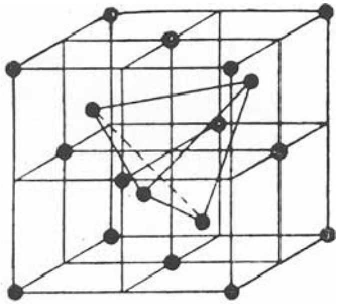

Fig. 1. Unit cell of diamond

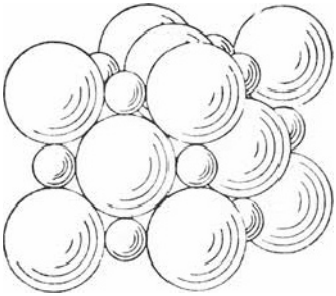

Fig. 2. Arrangement of ionic spheres in sodium chloride crystal (big spheres, chlorine ; small spheres, sodium)

In a lattice it is essential that the individual building blocks—being point charges—comprise an " electric field," which as a first assumption is considered to be spherical. These spherical fields are of different dimensions for different atoms and ions and can be expressed by the so-called atomic and ionic radii (Fig. 2). In this connexion the fact is of fundamental importance that a chemical building block of a lattice can be replaced by others, if they correspond closely in shape and size. Just as clay bricks in a wall can be replaced by glass bricks of the same size and shape, is it possible to replace chemical building blocks in precious stones by very similar ones, provided there is an inner regular array of the building blocks, i.e. provided the stone is in its crystalline state?

A replacement of an element by one of similar shape (isomorphous replacement) is possible if in the first instance the ionic radii are practically of the same size. In this connexion the simplified assumption of ionic spheres building up a chemical composition is of some importance.

A search for an element in chromium-coloured precious stones which in accordance with its ionic radius can be replaced by chromium ions reveals that only aluminium ions fulfil this condition. (In the case of ruby, aluminium only is available.) Chromium and aluminium ionic radii have only approximately the same size, namely $Al^{3+} = 0{\cdot}57Å$, $Cr^{3+} = 0{\cdot}64Å$. Not all precious stones, however, in which chromium has been detected, contain aluminium which could be replaced by colour-giving chromium. In Table 1 chrome diopside and chrome enstatite are mentioned, which do not contain aluminium. Sphene, too, which may contain chromium, is free of aluminium. Which element in the crystal lattice of these precious stones can be replaced by chromium? The element magnesium must not be overlooked. Its ionic radius has been determined to be 0·65Å and thus corresponds nearly exactly with that of chromium. It is true that magnesium has a positive bivalency (chromium is trivalent), but this is not a determining factor. The univalent sodium, too, with an ionic radius of 0·97Å is very often isomorphously replaced in various minerals by the bivalent calcium with an ionic radius of 0·99Å. An analogy is therefore given, even if on a different valency level, for chromium and magnesium. The latter element is an essential component of both chrome diopside and chrome enstatite. In sphene, titanium plays an important role. An isomorphous replacement of the tetrad titanium with an ionic radius of 0·68Å by the chromium ion (radius 0·64Å) is not only possible but practically certain. These examples show that the colouring agent chromium cannot replace Al only in a solid solution, but also the elements Mg and Ti. If not only precious stones were dealt with, but minerals in general, other elements would have to be mentioned which are replaced isomorphously by chromium.

A few explanations are given to answer the second question : Why does chromium as colouring agent cause either a red or a green colour ?

A red colour caused by chromium seems peculiar, because chromium oxide (Cr_2O_3) is green, just as most precious stones or minerals which are coloured by it. Why colourless matter should turn red through addition of a little deep-green chromium oxide is still an unsolved problem. Some explanations and interpretations do, however, exist.

It seems proved and often confirmed that the *quantity* of the colouring chromium may be decisive for the red or green colour of the precious stone. Thus it is known that the chromium in ruby powder causes occasionally a green zone near the lower part of the boule around the supporting clay rod of the furnace. On top of the green zone a pale pink sinter cone rises from which grows the deep red ruby. The green parts have an exceptionally high chromium content. According to E. Thilo[8] mixed crystals of Al_2O_3 and Cr_2O_3 are red up to a chromium content of 8%. With increasing chromium content they become at first reddish-grey, then red-green and finally from 30 atoms per cent of chromium onwards pure green.

This result is of importance. It means that a ruby-red boule can be expected only up to an addition of 8 atoms per cent of chromium to Al_2O_3.

The mixed crystals of spinel, too, have according to Thilo and collaborators[9] a red colour if small quantities of chromium are added and a green colour if greater amounts are present. In this case ($Mg\,Al_2O_4 + Cr_2O_3$) the dividing line red/green lies at about 15 atoms per cent of chromium. It must be mentioned, however, that special observations were made on synthetic spinel produced by the Verneuil process. It is important that red spinels are obtained only when chromium oxide as a colouring agent is added to an equimolecular mixture of MgO and Al_2O_3 (Ratio 1 : 1). Investigations of F. Rinne[10] show, however, that all synthetic spinels are mixed crystals of $Mg\,Al_2O_4$ of the cubic, unstable, gamma modification with a surplus of Al_2O_3 in relation to MgO (Ratio 5 : 1). It must be noticed that with these synthetic mixed crystals an addition of Cr_2O_3 produces never red but always green boules. Only above 1075°C., when the gamma modification

Al_2O_3 is transformed into the trigonal alpha Al_2O_3 modification, does the colour change from green to red.

A colour change through heating is also observed in ruby which becomes green between 300 and 600°C. On cooling it reverts to its original red colour. By a reverse process, at lower temperatures, green mixed crystals adopt a colour similar to ruby. With rising temperature they revert to the original green tint.

How can these observations be explained ? A conclusion reached by Thilo is worth noting. Up to an addition of 8 atoms per cent Cr in the (Al_2O_3—Cr_2O_3) mixed crystals, the chromium is screened off by the oxygen and aluminium ions of the corundum lattice in such a way that the chromium ions cannot contact each other. They remain genuine trivalent ions, and these cause the red colour in ruby. Above 8 atoms per cent chromium, there occur not only a " lattice expansion " but according to Thilo also contacts of chromium with chromium within the lattice, causing in parts a metallic bond (?). This would then result in a green colour. These explanations help also in the understanding of the red-green and green-red colour-changes through heating or cooling. Normally the chromium ions in rubies are in fixed positions and separated from each other. With rising temperatures the chromium ions become mobile. Thus, at least in parts, ions with metallic bonds are formed. These cause the green colour. On the other hand, green corundums are supposed to possess at room temperature freely moving metallic chromium ions, which become immobile and fixed at lower temperatures. Thus corundums originally green can become ruby-red. With rising temperature the original state is reached and the colour reverts to green.

The theories discussed seem clear and plausible, but reservations must be put forward. The normal colour of the Cr^{3+}ion is not red, as stated by Thilo, but green. The red colour may be caused by the character of the crystal field, the relative strength of which depends on the atomic distance (i.e. on lattice expansion and contraction). This opinion is based on theoretical and experimental investigations of W. Feitknecht.[11] He showed that a colour-change from red to blue was due to a transformation from a co-ordination number of 6 to a co-ordination number of 4 Co (II) which caused a contraction of the atomic distance Co – O in the lattice, a deformation of the ions, etc. Similar colour-changes were demonstrated by O. Schmitz-Du Mont[12] when the crystal field was weakened through an expansion of the spinel lattice (i.e. the atomic distance Co – O). In this case Al was successfully replaced by Ga. It seems reasonable therefore to attribute the peculiar colour-change of several chromium-containing precious stones during heating or cooling to a weakening or strengthening of the crystal field through lattice expansion or contraction.

The available experimental results are sparse, but they make the conclusions indicated at least probable.

The lattice expansion from pure corundum ($a_{hex} = 4{\cdot}76$Å) to green corundum with 30 atoms per cent chromium content ($a_{hex} = 4{\cdot}78$Å) can be measured, although the difference of 0·02Å is quite small.

In the case of the synthetic spinels, which according to Thilo showed a red/green dividing line at 15 atoms per cent chromium, no statements about changes in the lattice were made in the paper. For synthetic " boules," however, it is of importance that a change in the lattice is caused by a surplus of Al^{3+} replacing Mg^{2+}. Thus Rinne determined for $Mg0{\cdot}Al_2O_3$ a lattice distance of a_w 8·02Å. The same distance for $Mg0{\cdot}3Al_2O_3$ was 7·96Å. This lattice contraction seems to lead to changes in the relative strength of the crystal field and thus is connected with the red/green colour-change.

The lattice changes for the colour varieties (of garnet), namely pyrope, demantoid and uvarovite (Table III) can be shown more clearly. The chemical analogy (with the above phenomena) is striking, especially in the cases of pyrope and demantoid.

TABLE III

Colour variety	*Chemical composition*	*Cr_2O_3 content*	*Colour*	*a_w*
Pyrope	$Mg_3(Al\ Fe\ cr)_2Si_3O_{12}$	0·25–3%	red	11·51Å
Demantoid	$Ca_3(Fe\ Al\ cr)_2Si_3O_{12}$	up to 1·3%	green	?
Uvarovite	$Ca_3(cr\ Al)_2Si_3O_{12}$	6·5–27·5%	emerald-green	11·95Å

In these two colour varieties the chromium content is about the same, and the Fe_2O_3 contents too agree remarkably well according to chemical analyses. The only difference seems to point to the R^{II} element, being magnesium in the case of pyrope, and calcium in the cases of demantoid and uvarovite. The big lattice expansion of 0·44Å (from 11·51 to 11·95Å, Table III) is surely caused by the difference in size of the ionic radii of Mg^{2+} (0·65 – 0·78Å) and Ca^{2+} (0·99 or 1·06Å) and not through the replacement of Al^{3+} by Cr^{3+}. Thus an indirect change of the atomic distance is caused and with it a difference in the relative strength of the crystal field for the Al^{3+} or Cr^{3+} ions respectively. These differences seem to be connected with the colours in the various garnets.

SYNOPSIS

All chromatic precious stones with chromium as colouring agent (Table I) are predominantly green, otherwise red. It is not certain yet what role can be attributed to chromium if other colouring elements are present as well in precious stones. This applies to diamond as well (Table II). Speculations on the cause of the red or green colour in chromium-coloured precious stones are based in the first instance on observations relating to ruby and red spinel. Both precious stones change from red to green with increasing chromium content and also with increased temperature. Synthetic spinels (boules), however, are red only when the ratio MgO : Al_2O_3 is equimolecular. A surplus of Al_2O_3 causes a green colour.

According to Thilo this phenomenon is due to an exchange effect between the Cr^3 ions, because the Cr^3 ion is in undisturbed (crystal) state only if the colour appears to be red.

Based on the papers of Feinknecht and Schmitz-Du Mont, the conclusion is reached that the bichromatic (red/green) effect of chromium as a colouring agent is connected probably in the first instance with the relative strength of the crystal field. Speculations in this direction deal especially with the colour varieties of garnet—pyrope and demantoid (and uvarovite).

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ARKANSAS DIAMONDS

By HUGH LEIPER, F.G.A.

EARLY in March, 1956, an accomplished amateur gem-cutter, Mrs. A. L. Parker, of Dallas, Texas, U.S.A., set out by car in the company of Dwight Halstead and his wife for a rock hunting expedition into East Texas. Along the way, Mr. Halstead, whose profession is the manufacture of commercial diamond tools, talked about the diamonds he had previously found at the peridotite dike near Murfreesboro, Arkansas—nineteen in all at that time. As the trip progressed toward their original " petrified-wood " destination, they were also getting closer to the diamond area. However, the fascination of finding a genuine diamond is something that gets in the blood, and when the party reached a crossroad point in the East Texas pines, where a right turn would take them on to the " petrified-wood " area, or a turn to the left and many more miles of driving would take them to Arkansas—the lure of the diamond won. Mrs. Parker had never been to the location before, so looked forward to the new experience.

Early the next morning, the party reached the so-called " Crater of Diamonds," as the 72 acres of diamond-bearing earth have been named by the operators, The Diamond Preserve of the United States, Inc. For a fee of $1·50 they were permitted to enter the sketchily-fenced area. According to the rules, they could dig with anything they could carry by hand, and were entitled to keep any gem of 5 carats or less which they might find. If a stone larger than 5 carats should be found, a royalty of one-fourth of its appraised value would be payable to the owners of the property. The " finds " had been averaging about twenty to thirty a month, all of small sizes—fractional carat to 1·87 cts. As a tourist attraction, even with the lure of finding a diamond, the " Crater " wasn't exactly making anyone wealthy. Hundreds came, and went away —with nothing.

Walking into the sun, so that the slanting rays might be reflected into their eyes from any scintillating pebble ahead of them, the three members of the party went their own way over the partly-ploughed and often-picked-over pasture. Some time went by without anything being found, and finally Mrs. Parker turned back toward where a thermos-bottle of coffee had been left at the foot of a tree. Hardly had she started, when a glint of light from some white-coated object approximately 25 feet away caught her eye. Without undue excitement she advanced and picked the object up. Then it dawned on her that she was holding in her hand a large flat oddly-shaped piece which had all the ear-marks of a diamond. She had seen the smaller crystals Mr. Halstead had found on previous trips. She also had enough experience with gems from her own hobby-work with them to appreciate what a diamond should look like in the rough. But this piece she held in her hand was over one and one-half inches long and approximately seven-sixteenth inch wide, by about one-fourth inch deep.

She returned to her companions with her prize, and then the excitement began, for they assured her it was indeed a diamond. When cleaned of the superficial coating and weighed, it tipped the scale at 15·31 carats, but what was even more important, it was pronounced a water-white diamond of finest clarity and quality—probably the finest ever found on the North American continent.

After the stone had been exhibited in Little Rock, state capital of Arkansas, and named " The Star of Arkansas " by Governor Faubus, it was taken to Dallas, Texas, where it was shown in the uncut state in the window of a leading jeweller of the city. It was then forwarded to New York, where it was entrusted to Mr. Harold Branch, president of the firm of Schenck & Van Haelen, for cutting. This firm had made a speciality of Arkansas diamonds, having to its credit the cutting of the " Uncle Sam," an original 40·23 carat stone found at the Murfreesboro mine in 1924, which yielded a pinkish stone of 14·24 carats, emerald-cut. They had also cut the 20·25 ct stone, an octahedron, found in 1921, which was cleaved and made into two fine gems.

It was determined that the gem was a single crystal entity, though of very unusual shape ; that it had some very unusual markings on its surface and that it was of unusual hardness. It was not fluorescent. Dr. Ralph J. Holmes, of Columbia University, is preparing a report on the stone's structure and markings. The electron micrographs (Figs. 3 and 4) show the unique " squid-like " markings revealed by magnification at 6,700 and 10,200 diameters.

It was decided to fashion the gem into a marquise-shape. Attempts at bruting it into this outline soon showed difficulties, for " nats " or super-hard spots caused the carbonado or tool-diamond that was used to bring about the reduction to shape to erode at a ratio of 8 carats to one of weight lost by the gemstone. For days it seemed that little or no progress was being made, but eventually it yielded to the cutter's persistence and was shaped to form. From that point on, the diamond " cut itself " with little further trouble. Divisions of twelve rather than eight facets were used, and due to the unusual shallowness of the stone as found, additional small facets in the culet area were found necessary.

The finished gem preserved the original dimensions of the crystal remarkably, and is 1½ inch by 7/16 inch in size, and has the spread and appearance of a 15-carat gem. The finished weight is 8·27 carats. The gem is so brilliant that it is very hard to make out the outline of the table, and there is no dead spot, as might be expected in so shallow a stone. The " Star of Arkansas " is truly a thing of beauty. The owner does not intend to have it mounted but prefers that it remain as an exhibition piece, and it is expected that it will be sent to various places in the United States for showing in jeweller's windows as an example of a quality all-American diamond. No attempt of any kind will be made to commercialize the owner's good fortune in finding such a gem, variously valued at from $25,000 upward.

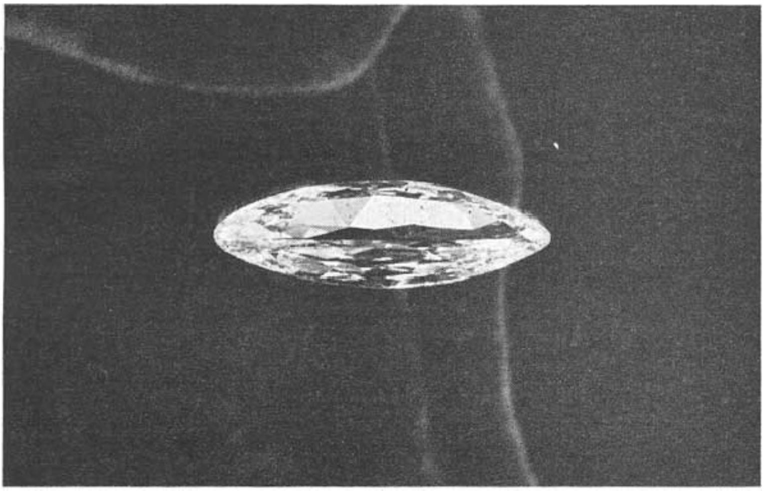

Fig. 1. The finished gem, " Star of Arkansas," 8·27 carat marquise-cut diamond, measuring 1½ inches × 7/16 inches.

(Photo, Courtesy Clint Grant, Dallas, Texas)

From the time just about fifty years before Mrs. Parker made her find at Murfreesboro, when John Wesley Huddleston, an Arkansas farmer, turned over the first crystal with his plough in the gravelly foothills of the Ouachita Mountain area of South-western Arkansas, the field has seen a kaleidoscopic turn-over of owners ; court proceedings over who owned what ; feuding and even the simultaneous burning of three separate recovery plants on various parts of the property ; mismanagement and what has been labelled outright looting from within and without. Approximately 10,000 diamonds have been registered with the state authorities for tax purposes in these fifty years since its discovery in 1906, but it is probable that five times that many diamonds have actually come out of the ground there.

The first finder, Huddleston, sent his shining pebble to Chas. S. Stifft Co. in Little Rock, for identification and was not disappointed. A local banker joined Mr. Stifft in forming the Arkansas Diamond Co. and they bought out Huddleston's 160 acres for $36,000, but the new company lacked capital properly to pursue mining and drifted along for some years. Then the banker, Sam W. Reyburn, was able to attract additional capital. The company was then reincorporated as The Arkansas Diamond Corporation of Virginia. More modern recovery equipment was procured for washing and separating the gem gravel, and a plant was built. However, operations were not a success financially, as although a considerable number of diamonds were recovered pilferage was high. The area was not tightly fenced, and it is no secret that local residents of the area could and did make a tidy income from marketing their own chance finds. The engineer in charge had no previous diamond experience, but the owners attempted to remedy their poor start by sending him to South Africa to try to learn more about the art of recovering diamonds—and keeping them. However, shortly after his return, the big plant was shut down, never to run again. It was later burned to the ground at night under suspicious circumstances.

Meanwhile, two other segments of the diamond-bearing kimberlite were under the ownership of M. M. Mauney, who leased a portion of this land to Austin Millar and his son Howard.

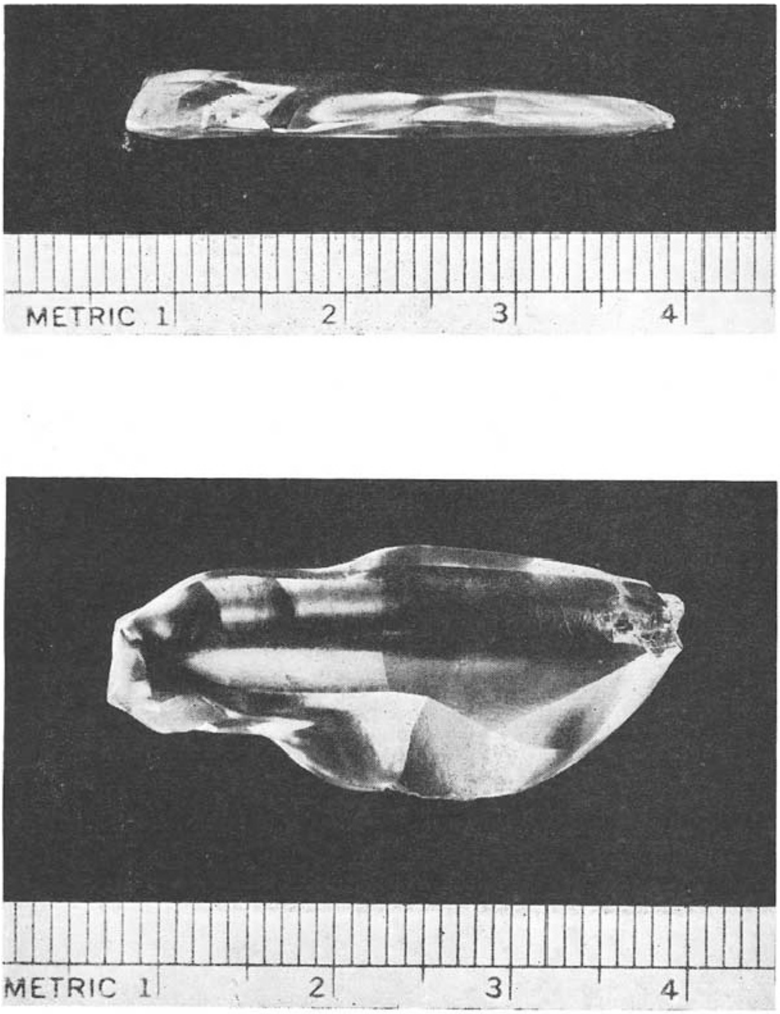

Fig. 2 and 3. Frontal and edgewise view. " The Star of Arkansas," 15·31 carat diamond crystal found at the " Crater of Diamonds," Murfreesboro, Ark., by Mrs. A. L. Parker of Dallas, Texas. Photographs by Dr. Ralph J. Holmes, Columbia University, New York.

The Millars knew how to extract diamonds successfully, but they did not get on well with the Mauneys, and disagreement ensued, with court battle after battle. Then the Millars bought a portion of the property themselves, and attempted to run this ore through the mill they had erected on the leased Mauney ground. More litigation and even shooting resulted. Attorneys were the only persons who profited.

Finally, the Arkansas Diamond Corporation of Virginia sold out to a promoter, Ray Blick, for $175,000 in 1941, but it later developed that most of this money had been put up by a Logansport, Indiana, manufacturer, the late Charles Wilkinson, whose widow, Mrs. Ethel Wilkinson, now owns the larger portion of the property.

During World War II, the increased demand for industrial diamonds and the threat of interruption in production in portions of Africa, caused the Bureau of Mines of the United States Government to institute a small pilot plant study of the Murfreesboro area under a competent geologist. Begun in 1943 and completed in 1944, this sampling effort was completed in report form in 1947, but was not published until 1948, as Bulletin 808, Bureau of Mines. The results were extremely discouraging as the average findings of 0·03 carats per cubic yard did not seem to warrant commercial operations. There have been many interpretations and much criticism of the report, some believing that the samplings were not taken from true diamond-bearing kimberlite areas, or some in ground that had already been worked over. Others contend that nothing except superficial sampling has ever been undertaken, with the deepest shaft having penetrated only 136 feet. Suffice it to say that there is still room for considerable difference of opinion as to the possible future of the Murfreesboro area as a diamond producer of consequence.

Glenn L. Martin, an aircraft manufacturer who had become interested in diamonds, formed a corporation which leased the Williamson property, and purchased the remainder of the Mauney slice for $250,000. A recovery plant was set up and operations with surface earth-moving equipment were started in 1948, under the supervision of a former building contractor and liquor-store proprietor with no diamond-recovery experience. The work continued for about a year, but on tallying up the results of the expenditure of some $700,000, Mr. Martin was faced with a total find of 246·15 carats which were registered with the State of Arkansas.

Local residents, who had seen almost everything, realized that they had now seen the outstanding experience with the mine.

The facts are that even now, with tourists only scratching at the worked and re-worked surface, the annual recovery is almost as much as that yielded by the massive Martin machinery.

THE ARKANSAS DIAMOND AREA

The Arkansas diamond area, known as the Prairie Creek Area of Pike County, Arkansas, lies just below the confluence of Prairie Creek with the Little Missouri River. The property consists of 929 acres, more or less, lying North of the Little Missouri River and east of Prairie Creek. It covers parts of Sections 20, 21, 28 and 29, Township 8 south, range 25 west. The deposit itself has the shape of a rough equilateral triangle with well-rounded corners. The diameter is approximately 1,800 feet and the depth unknown. It covers slightly more than 72 acres. Before the area was mined, the surface was fairly level from east to west, but rose approximately 50 feet in a distance of 1,500 feet from

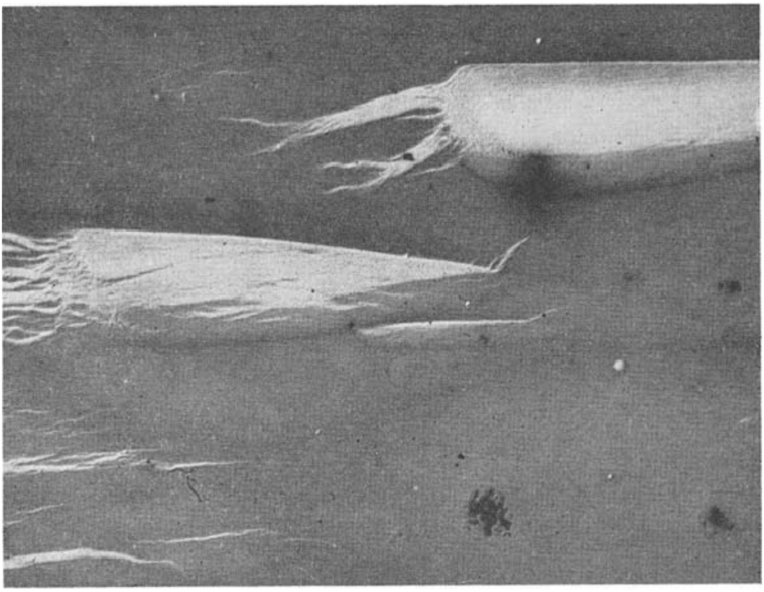

Fig. 4. Electron Micrograph by Dr. Ralph J. Holmes, Columbia University, New York, magnification 6,700 diameters, showing unusual " squid-like " markings on the surface of " The Star of Arkansas," 15·31 carat diamond found at the " Crater of Diamonds," Murfreesboro, Ark.

south to north. Present irregular contours and gullies are the result of former mining operations.

It is probable that the peridotite was intruded from a great depth, penetrating deep-seated sedimentary beds, including the Carboniferous and a portion of the Lower Cretaceous. After the intrusion of the peridotite, it seems apparent that explosions took place which ejected portions of the intruded mass and carried with them some deep-seated shale and sandstone. This ejected material probably formed a crater with sloping sides and also eventually re-cemented into a peridotite breccia. This brecciated area occurs in a roughly eliptical area covering about 28 acres on the east and south sides of the pipe. The old mine pit, covering about 15 acres, lies within this area. Several small dikes, from two inches to a foot wide, run in many directions. These contain barite, quartz and an asbestos-like material. Some garnets are found, as well as iron minerals, magnetite, perovskite, siderite and unaltered olivine. It is in this peridotite breccia that most of the diamonds are found. The tuffs and fine grained breccias are composed essentially of chlorite with phlogopite and serpentine. The colour is light blue. No diamonds have been reported found in them. There is one reported instance of a diamond having been found in the unaltered hypabyssal peridotite.

OTHER OCCURRENCES OF DIAMOND IN NORTH AMERICA

All other finds of diamonds in North America, other than those at the Arkansas mine, are the result of chance, are always in alluvial formations or as a by-product of placer-mining.

A broad belt of Northern border states, which were covered with glacial debris of the Ice Age, has produced an occasional find from creek gravels or while digging wells. These have been noted principally from Wisconsin, where several sizeable stones, notably two of approximately 19 and 13 carats, were brought up from wells ; others from Illinois, Michigan and Indiana.

In 1928, the " Punch Jones " diamond was found at Peterstown, W. Virginia, by a farm boy seeking water at a spring. This weighed 34·46 carats. Earlier in 1855, a negro workman digging an excavation in a street at Manchester, Virginia, came up with an octahedron of 23·75 carats which, however, was not of fine quality. Still another chance find was that of Mrs. Pellie Howard of Searcy, Ark. While chopping cotton in a field with her father as a young girl, she picked up a shiny pebble and kept it for twenty-one years before realizing that she might have something valuable. Finally, in 1946, it was sent to Tiffany & Co., in New York and was declared to be a 27·21 carat diamond. This area is 150 miles from the Murfreesboro diamond pipe.

Early placer-mining operations in North Carolina turned up numerous small diamonds in the area of Burke, Rutherford, Lincoln and Mecklenburg Counties in the South-western portion of the state, and one instance in Franklin County, farther to the east. The first stone found was in 1843, and this was the first instance of a diamond being found in North America, so far as is known. A yellowish-white crystal found at Dysartville, McDowell Co., N.C., in 1886 weighed 4 1/3 carats, and is now a part of the Morgan Collection in the American Museum of Natural History, New York.

The gold-rush to California and other Western States in 1849, took with it placer-miners from the North Carolina and Georgia goldfields, who had likewise gotten to know what diamonds looked like in their sluice boxes. Hence, it was to be expected that a number of gem diamonds were found in California and Oregon gold operations during this period, but more certain that sizeable numbers were crushed in stamp mills breaking up the conglomerate ores—indeed, fragments of diamond embedded in the stamps have been noted.

The U.S. National Museum (Smithsonian), Washington, D.C., houses the Col. Washington A. Roebling collection of native American diamonds, which is regarded as the finest in the country. Not previously mentioned, it includes a solitary white octahedron from Huntsville, Texas.

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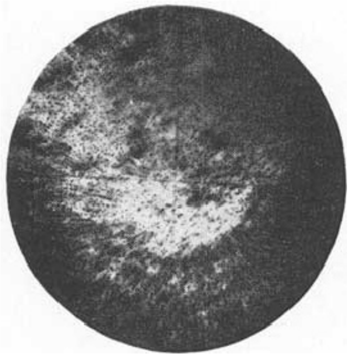
STRUCTURE & INCLUSIONS OF SYNTHETIC STAR-STONES

By A. J. BREEBAART, F.G.A., G.G.

THE microscopic study of the synthetic star-corundums, which are at present on the market, reveals some interesting features. The star-stones from the Linde Air Company, which appeared first, are first considered. It is known that the rough material is produced by the Verneuil process thus resulting in an ordinary boule, but to the chemical compounds is added a certain amount of titanium oxide. When the boule is taken from the furnace, it has to undergo a kind of annealing in order to make the added titanium oxide crystallize as oriented needles, because it is the presence of these needles which gives rise to the asterism.

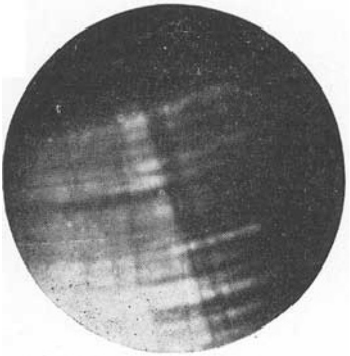
It is quite reasonable that, these stones being products of boule-production, we shall meet the same kind of inclusions as in the ordinary synthetic rubies and sapphires. There are some distinct differences however. In the first place, naturally, there is the presence of the very fine oriented rutile needles ; these needles are short and thickly packed, whereas sometimes coarser crystals of (probably) rutile are seen. Air bubbles are almost always present in the form of clouds of tiny pin-points, but their general appearance is different from that in ordinary corundum. The bubbles are spherical and very small, and they are not so thickly packed as is generally the case in ordinary corundum. Lastly there is the presence of curved striae, which especially in the case of star-ruby is quite interesting. In ordinary synthetic ruby the striations are usually very fine and invisible to the naked eye, while in the star rubies these growth lines are easily visible, because they are comparatively widely separated.

The monopoly of synthetic star-stones, however, is no longer in the hands of the U.S.A. only, because star-stones of German manufacture are reaching the market in growing quantities. Although their method of production is not known to the writer, there must be some definite differences, compared with the American procedure, because the internal features of these stones are quite different. Naturally the oriented rutile needles are present too, but they are longer and coarser than in the American stones.



German Star Sapphire. 48 ×.
Air bubbles radiating from centre of stone.

Synth. American Star Ruby. 48 ×.
(dark field)
Curved striae with oriented straight bands meeting at an angle.



American Star Ruby. 48 ×.
(dark field)
Widely spread curved striae. Straight line running across probably twinning plane.

American Star Ruby. 48 ×.
Very fine rutile needles and tiny air bubbles. Lines visible probably internal fractures.

Air bubbles are present and their distribution in the stone is quite peculiar. In the German star-sapphires they are present as tiny pin-points throughout the whole stone, and it seems that they are in some way oriented, because they seem to be radiating out of the centre of the stone towards the girdle. In the star-rubies air bubbles are seen in a great many forms, from tiny pin-points to tadpole-shaped forms, whilst their orientation is circular. In both rubies and sapphires widely separated, probably rutile, needles can be seen near the girdle of the stones, meeting at an angle corresponding with the angle between the crystal faces of the hexagonal system.

The position of these different inclusions is in layers, because when looking through a stone with the microscope, one, for instance, first has rutile needles in focus and on focusing down the air bubbles become visible.

There is a circular space in the stones, surrounded by air bubbles. This space is completely transparent and continues until about half way through the stone, where the rutile needles occur. Typical of the German stones is also the absence of curved striae. On the contrary growthlines will be seen, which are perfectly round and oriented as concentric bands. These bands are always visible and a round dark spot surrounded by concentric bands is an indication that the stone is of German origin.

COLOUR CHANGES IN IRRADIATED GEMSTONES

By E. BURBAGE, F.G.A., and THOROLD G. JONES, F.G.A.

WHEN, less than twelve years ago, the news of Hiroshima stunned the world, few could have guessed that the power hidden within the atom would soon be harnessed to the most various and unlikely tasks, from the re-creation of the primitive tulip for the plant geneticist, to the non-destructive analysis of the feldspars. Naturally, such projects as the preparation of tracer-isotopes for use in medicine have understandably received first priority treatment but it has recently become possible to find room and time for other researches of scientific and technical interest. One venture of interest to mineralogists, and in particular to gemmologists, has been the irradiation of coloured stones, and although very considerably more work is needed before anything like a survey of the field can be presented, it may be of interest to record a few notes by way of a preliminary report on work in progress.

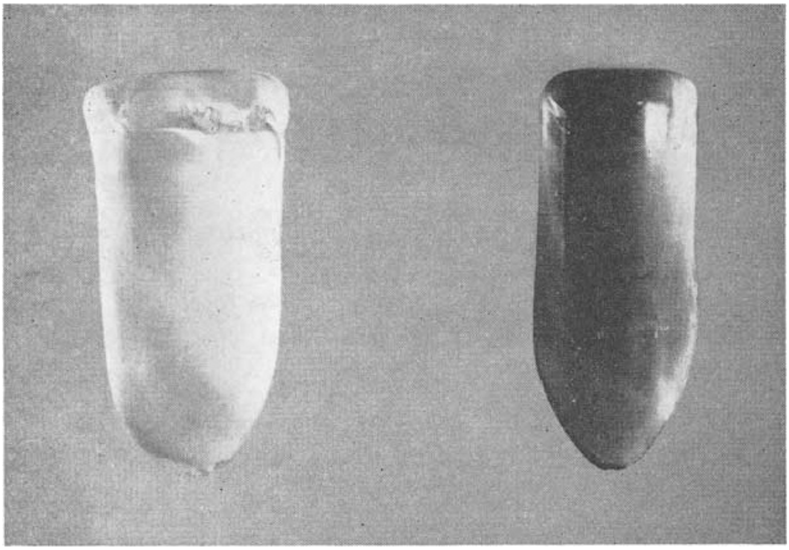
The group of stones to be described have been shown, first at Harwell during Open Week last summer, and to the public for a period of about two months during the winter at the Educational Museum at Haslemere. At the instance of the Harwell Metallurgy Division, a range of pairs of stones was assembled, one member of each pair being irradiated by neutron bombardment for periods of three or of six days, and they were displayed for study and exhibition purposes with their untreated counterparts for comparison.

The following results were noted :—

SYNTHETIC CORUNDUM

Here, the most striking change was induced in a colourless boule which became brown in colour. There was strong dichroism, which was accentuated when the light transmitted through the boule was coloured by a cyan photographic filter. Viewed in a Stokes " crossed filters " apparatus, the irradiated boule fluoresced strongly, even though the apparatus, employing " narrow-cut " cyan and red filters, normally yields less brilliant results than the conventional copper-sulphate-solution set-up. It has been noted by B. W. Anderson[1] that some colourless boules fluoresce to some extent in such an apparatus, due to the presence of chromium impurities in the alumina, and it seems probable that the greatly enhanced fluorescence in the irradiated boule results from this cause. It is only fair to record that G.E.C., the synthesizers of the boule in question, claim an exceptional purity for the alumina in such colourless material but, as has been noted by Anderson, de Boisbaudron, as far back as 1886, showed that the presence of 1 part of chromic oxide in 10,000 of calcined alumina was sufficient to cause luminescence, and impurities on such a minute scale are perhaps within the tolerance limits in commercial chemical engineering.

A synthetic ruby boule became darker with some corresponding increase in dichroism, Here, the fluorescence in the Stokes apparatus was less than in its untreated counterpart. A pink synthetic sapphire originally strongly dichroic in yellow and pink, became brown, resembling a golden zircon in colour with little change in dichroism, but its Stokes apparatus fluorescence was diminished. Two blue



Boules of White Sapphire before and after irradiation.

synthetic sapphires, both treated for six days, produced quite dissimilar results ; one became dark brown, with no appreciable dichroism, but the other stone, initially darker, became greenish-blue with very strong " directional " dichroism visible without instruments. A colour-changing so-called " alexandrite " type synthetic became a garnet-red, dichroic in yellow and red, and lost its colour-temperature sensitivity.

NATURAL CORUNDUM

Colour changes in natural corundums were less pronounced than in synthetics, a ruby showing no appreciable change, and a sapphire slight darkening.

SYNTHETIC SPINEL

A blue synthetic spinel, of colour simulating that of blue zircon, lost colour to become pale greyish-brown, with a more subdued red colour under the Chelsea filter, and a pale-blue synthetic spinel developed a more " steely " blue.

QUARTZ

A cairngorm showed slight, and an amethyst considerable, darkening. Rose quartz also darkened.

TOPAZ

A pink topaz reverted to an " unfired " sherry-brown colour, and a pale yellow topaz acquired a rather darker and greenish hue, and the dichroism was correspondingly accentuated (pink and very pale green).

ZIRCON

Both blue and golden stones had the shorter period of irradiation (three days), and were very greatly changed in colour, no doubt by reason of their rare-earth impurities. All assumed a very deep reddish-brown, almost black, appearance, and even on immersion in monobromonaphthalene they were almost opaque to transmitted light excepting at the girdle, where it was possible to check that they were still anisotropic, but non-dichroic. In the immersion cell, it was noted that, in one stone, the coloration followed a linear banded pattern similar to that common in cairngorm.

GARNETS

The garnets were not greatly changed ; rhodolite seemed unchanged, the colour deepened a little in almandine, and the emerald-green of demantoid was debased to a " peridot " green.

MISCELLANEOUS

Brown tourmaline became greenish-brown, and kunzite a sherry-brown, dichroic in pink and brown. Peridot became a brownish-green, golden beryl assumed a deeper colour, and orthoclase turned sherry-brown with some dichroism in two hues of brown. Colourless periclase produced the most aesthetically satisfactory colour-change by turning a " blue chalcedony " blue.

REFERENCE

1. **Anderson.** " Crossed Filters for the Study of Fluorescence," Gemmologist XXII, 39-45, 1953.

FURTHER COLOUR FILTER TESTS

YELLOW AND ORANGE GEMSTONES

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

THE separation of gemstones by colour filters has already been discussed at length and red, blue and green gemstones dealt with in this respect in the Journ. of Gemmology, Vol. III, p. 149 ; Vol. IV, pp. 27, 139, 360. Yellow gemstones would not appear to offer very much scope for separation by means of combinations of colour filters, being the purest in colour of any. Orange-coloured gems alone seemed likely to hold out much prospect of giving useful results. It was felt, however, that the series would not be complete without an attempt at least being made to search for possible filters.

The following gemstones were selected :

1. *Scarlet-orange to orange-yellow*

Gemstone	*Colour*
Fire Opal from Mexico	Indian orange, colour 713 Wilson colour chart. SO 14, 12° Villalobos.
Spessartite	Mars orange, o13 Wilson colour chart. SO 15, 12° Villalobos.
Spessartite	Burnt orange, o14 Wilson colour chart. SSO 8, 9° Villalobos.
Hessonite	SO 12, 12° Villalobos. Burnt orange. Wilson, BCC 58, Rust.
Fire Opal	O 17, 11° Villalobos.
Topaz	O 18, 8° Villalobos.
Zircon	OOY 17, 12° Villalobos. Yellow ochre o7/1 Wilson.
Zircon	OOY 16, 8° Villalobos.
Zinc Blende	OOY 15, 12° Villalobos. Tangerine o9 Wilson.
Topaz	OOY 19, 9° Villalobos.
Topaz	OOY 18, 6° Villalobos.
Golden Beryl (Heliodor)	OY 17, 12° Villalobos ; Old Gold BCC 115.
Citrine	OOY 15, 11° Villalobos.
Idocrase	OOY 14, 11° Villalobos.

2. *Yellow orange to yellow.* (*YYO–Y*)

Fluor	YYO 18, 12° Villalobos. Empire yellow 603/1. Wilson. BCC 114, Gold.
Heliodor	OY 19, 12° Villalobos.
Sapphire	OY 19, 12° Villalobos
Sphene	YYO 15, 9° Villalobos.
Tourmaline	Y 17, 11° Villalobos. Canary yellow 2/2 Wilson.
Chrysoberyl	YYO 18, 8° Villalobos.
Sapphire	Y 19, 5° Villalobos.
Zircon	Y 19, 9° Villalobos.
Tourmaline	Y 17, 10° Canary yellow Villalobos. 2/2 Wilson.
Smithsonite	Y 18, 12° Villalobos. Primrose 601/1 Wilson.

Scapolite	Y 18, 3° Villalobos.
Beryl	Y 19, 9° Villalobos.
Y. orthoclase from Madagascar	Y 18, 4° Villalobos.

3. *Greenish yellow.* (*YY*2)

Yellow Spodumene ...	YYL 19, 3° Villalobos.
Brazilianite	YYL 19, 9° Villalobos. Chartreuse green, Wilson 663/3.
Chrysoberyl	YYL 17, 11° Villalobos. Chartreuse green, Wilson 663/1.
Apatite	YYL 18, 3° Villalobos.

The Villalobos colour atlas comprises 7,279 colours : three simple hues—green, ultramarine and scarlet; six transitive double hues—emerald, cobalt, violet, ruby, orange and lime green ; then twelve sets of intercalary hues of the first rank and a further twelve of the second rank.

Thus between green and ultramarine there are the following hues : green, green green emerald, green emerald, emerald emerald green, emerald, emerald emerald turquoise, emerald turquoise, turquoise turquoise emerald, turquoise, turquoise turquoise cobalt, turquoise cobalt, cobalt cobalt turquoise, cobalt, cobalt cobalt ultramarine, cobalt ultramarine, ultramarine ultramarine cobalt, ultramarine.

Each of the thirty-eight simple, main double, transitive or intercalary hues are then shown expressed in twenty gradations of light to dark (or lightness value) and each gradation is shown in each of twelve degrees of chromaticity. Thus each plate of 191 colours ranges from white through 19 neutrals to black, from palest through 19 light values to darkest, from palest to white and from darkest to black, and so on. A scarlet-orange colour of medium chromaticity and lightness would be designated—SO 11, 6°.

EXAMINATION WITH THE CHELSEA FILTER

It had already been established that of all yellow or orange stones examined, yellow beryl alone shows apple-green. This was confirmed, no other yellow gemstone showing green at all. Golden-yellow beryl or heliodor appeared colourless to yellow.

Yellow Idocrase (Xanthite) showed blackish, deep golden-yellow beryl and yellow zinc blende showed very pale cobalt blue, but these under the 502/302 filter showed deep red, and the yellow beryl blue. As before the 68/22 filter emphasized the apple-green colour. The remainder exhibited no colour-change worth recording, though the zircons showed pink and the hessonite, spessartite, fire opal deep red. With the 502/302 filter yellow beryl showed blue, idocrase deep blue green, remainder red or reddish.

Examination with Colour Discs

Careful examination with the colour discs already established for the examination of red, blue and green gemstones showed no notable colour-changes apart from those observed with the Chelsea filter and filters closely allied to it.

Examination with the Ilford series of colour filters

Examination with 110 Micro 4—minus blue, showed that spessartite, fire opal, hessonite garnet and a deep orange zircon remained distinctly orange. Smithsonite, fluor, pale yellow beryl, brazilianite, yellow apatite, orthoclase, chrysoberyl and a pale yellow ziron showed practically colourless. The remainder showed varying traces of yellow or brown.

210 Orange, showed spessartite, hessonite and fire opal orange, the yellow-brown idocrase slightly greenish-yellow and the remaining stones practically colourless. 111 Orange yellow and 108 Micro 9, pale yellow, gave results very similar to 110 Micro 4—minus blue. With 302 minus red, all showed green from light to very dark in shade. With 406 Astra, the deep orange fire opal alone showed distinctly orange.

Examination with the Wratten series of colour filters

With the filter NP 549-very deep green, the spessartite, fire opal, idocrase and hessonite only showed deep red. With 23E E Red, spessartite, fire opal and hessonite alone showed orange, the rest colourless.

Conclusions

In dealing with a bright and pure colour, it was not anticipated that much success would be achieved in a search for filters that would produce distinct colour changes. Research into the problem indeed shows that on sight alone it is impossible to identify with certainty any yellow gemstone except perhaps yellow sphene and the deeper orange-coloured fire opals.

The Filter NP 549 is useful in confirming the separation of spessartite, fire opal and hessonite, and the Chelsea filter in detecting yellow beryl. Beyond that it is not possible to go at present.

Gemmological Abstracts

DE SOUZA (J. E.). *Notas sobre Espodumenios Brasileiros.* (Notes on Brazilian spodumene.) Gemologia, No. 4, 1956, pp. 12–22 (11 figs. and 4 photomicrographs).

A profusely illustrated account of spodumene in all its varieties. The author appears to have worked at length on the morphological aspects of several crystals and provides drawings and photographs of the fine natural etching of the crystal faces. The symmetry of the etch figures reflects that of the face on which they occur. Brazilian occurrences are given in some detail and at least one locality is claimed for hiddenite. This is evidently the pale green spodumene and should not be confused with the emerald-green tone hiddenite from N. Carolina—one of the rarest of gems. Apparently the Brazilian " hiddenite " can be deepened to a blue-green colour by exposure to X-rays. R.K.M.

WEBSTER (R.). *A Esmeralda* (The emerald). Gemologia, No. 5, 1956, pp. 8–32 and No. 6, 1956, pp. 3–14.

A translation of the paper which appeared in the Journ. Gemmology, Vol. 5, No. 4, 1955. R.K.M.

CAMPOS (J. E. de S.). *Sobre un cristal de Berilo do estado de Espirito Santo.* (Aquamarine from the Espirito district.) Gemologia, No. 5, 1956, pp. 1–7.

A description of a blue-green aquamarine crystal from the Espirito Santo district of Brazil. No indication of size is given but it is this crystal which is the source of many line drawings both on the cover of the publication and in the text of the article. The author claims that some of its inclusions are very similar to those attributed by Roulet (Zeit. d. Deutsch. Gesell. f. Edelsteinkunde 1955) to Indian emeralds, while others are like those seen by Webster (Journ. Gemmology, Vol. 5, No. 4, 1955) in Siberian emeralds. Minerals included in the crystal are phlogopite, rutile, pyrites and, in three-phase cavities, calcite. Some three-phase inclusions show two non-miscible liquids as well as the gaseous and solid phases. R.K.M.
2 figs.

Zwaan (P. C.). *Some unusual gemstones in the collection of the Rijksmuseum van Geologie en Mineralogie of Leiden.* Leidse Geol. Med., vol. 20, 1955, pp. 225–237. 6 illus.

The unusual gems described include spessartite, kornerupine, diopside, bronzite, apatite, andalusite and scapolite. The data obtained during identification are compared with results of various authors. Reference is also made to the immersion contact photograph method described by Anderson (Journ. Gemmology, Vol. 3, No. 6, 1952, pp. 219–225). The illustrations are all photomicrographs of inclusions, except one of immersion contact photography. S.P.

Chudoba (K. F.). *Zur Kenntniss des Mondsteins.* (Knowledge of moonstone.) Deut. Golds. Zeitg. Vol. 54 (1956), No. 9, pp. 419–420.

A general article about the nature of moonstones, with reference to the causes of opalescence. Sir C. V. Raman thought this property to be due to a diffusion of light on tiny crystallites. There are no outstanding substitutes for moonstone, white chalcedony and heated amethyst being the nearest in appearance. Moonstones are found in Burma, Tanganyika, Madagascar and Brazil, but the most important source is still Ceylon. The importance of these occurrences steadily dwindles. The stones are usually cut en cabochon in Ceylon and re-cut and polished in Idar-Oberstein.

E.S.

Schmidt (Ph.). *Amethyst, de Adelige in der quarzfamilie.* (Amethyst, the aristocrat of the quartz family.) Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, No. 17, 1956, pp. 5–8.

A review of the qualities of amethyst known to us, and as they were known to the Egyptians, Greeks and Romans. The name probably came from the greek *amethustos*—wine-coloured, although it was thought for a long time to come from *a methuo*—not to be drunk, and was therefore worn as a charm against drunkenness.

E.S.

Leuven (E. P.). *Garnet of many varieties.* Mineralogist (Oregon), Vol. 25, No. 1, 1957, pp. 16–20.

A list of the varieties of garnet; out-moded names have been included and it is unfortunate that their obsolescence has not been indicated. S.P.

GRODZINSKI (P.). *On the history of the rose cut.* Gemmologist, Vol. XXV, No. 302, pp. 167–8, Sept., 1956.

The author has endeavoured to trace the inventor of the rose-cut, and, from documents in the Nuremburg archives, has discovered the invention to be due to Heinrich Hahn in 1591. Other information on the history of the rose-cut in the 17th and 18th centuries is included.

1 illus. R.W.

COUSEN (T. W.). *Mexican fire opal.* Gemmologist, Vol. XXV, No. 303, pp. 182–186, Oct., 1956. (Reprinted from Gems & Minerals.)

The centre of the opal mining of Mexico is at Queretaro, the mines being situated in a radius of some thirty miles around. The percentage of high grade opal found is small. The methods used by the miners for selling the recovered opal are entertainingly told. The material is precious enough to be sold by the carat and gram. The various types of opal are described and the Mexican names for these are given. Opal tends to crack on drying out, but this can sometimes be corrected by periodic soaking of the gem in water. Some of the methods used for cutting are described. The local lapidaries also cut amethyst from Guerrero.

6 illus. P.B.

CUSTERS (J. F. H.). *Colours in diamonds.* Gemmologist, Vol. XXV, No. 303, pp. 188–190, Oct., 1956. (Extracted from Optima of June, 1956.)

Colour depends firstly upon three factors ; the source of light, the object that reflects or transmits the light, and the eye and brain, in conjunction, which interpret the colour characteristics, that is the hue, the saturation and the intensity. Each of these effects is described. The difficulty met with in the colour grading of diamonds by colorimeter or by absorption spectrophotometry is discussed. The advantage and limitations of the eye grading of diamonds in a folded white paper are mentioned. Some notes on the theories of the cause of colour in diamonds are given. Type I diamonds are said to contain more impurities than the Type II. Diamonds coloured artificially by atomic bombardment owe their colour to radiation damage.

R.W.

SWITZER (G.). *The Diamond industry*, 1955. Jewelers' Circular-Keystone, Philadelphia.

The 31st report on the diamond industry. In 1955 production was again the highest on record, although accurate figures were not available for all countries. 21,540,000 metric carats (including 17,500,000 m.c. of industrial stones) were produced compared with 20,440,000 m.c. for 1954. Sales of gem and industrial stones also set a new record at approximately £77,000,000.

S.P.

FAIRBANKS (E. F.). *A study of the polished surface.* Mineralogist (Oregon), Vol. 24, No. 9, pp. 327–332.

An interesting article on research carried out on polishing agents and surfaces. Arising from Beilby's contention that during polishing a melted or softened solid is spread over a surface to form the Beilby layer, experiments were made using abrasives with higher melting points than that of the mineral being polished. Zinc oxide with hardness 4 will polish quartz. The melting point of zinc oxide at above 1,800°C is higher than that of quartz. Zirconium carbide with melting point of 3,532°C was used by Kaplan to polish diamond (m.p. about 3,500°C). Surface temperature at points of contact during polishing may be high enough to cause melting of a metal or mineral. The point is made that the criterion to apply to efficient polishing should be speed whereby a true specular surface is developed. On this basis diamond dust for diamond polishing is unsatisfactory ; tin oxide less efficient than zinc oxide for quartz ; and cerium oxide unsatisfactory for many types of glass. S.P.

RUTLAND (E. H.). *An unusual brown beryl.* Gemmologist, Vol. XXV, No. 304, pp. 191–2, Nov., 1956.

A report on an asteriated brown beryl from Gov. Valdares, Minas Gerais. The inclusions consist of oriented rutile needles, which produce the weak star, and coarser agglomerates and flat partly resolved black inclusions parallel to the basal plane. The inclusions produce the brown hue and where the stone is relatively clean the colour is that of a pale green aquamarine. The stones show a strong schiller which tends to mask the asterism. This schiller is said to be due to the layered structure of the stone, the layers being parallel to the basal plane, and these layers act as

reflectors, as the image of a light source is clearly mirrored at the centre of the star, rather like the rose-quartz star doublet. The stone resembles bronzite but has an index of refraction near 1·59 and a density of 2·712. No characteristic spectrum was observed and there was no luminescence.
4 illus. P.B.

Anon. *Diamonds and pearls.* Kodak View, No. 3, 1956, pp. 19–22.

A general survey of the photographic techniques used in the London Chamber of Commerce Laboratory in Hatton Garden. The X-ray photographic techniques employed in pearl testing are described both in the text and by illustrations. The types of films used for such testing are mentioned. The use of fluorescence photography as a method of identity certification in the case of multi-stone diamond jewellery is shown pictorially and described in the text, as is the taking of photomicrographs for such purposes, and for illustrating purposes, and by the use of colour film, for transparencies for projection purposes. The ultra-violet transparency method for the detection of synthetic emeralds is referred to as well as the autoradiographic method used for the detection of radium-treated diamonds. An interesting and informative article enhanced by many illustrations, two of which are in colour and show a number of minerals in ordinary white light and when fluorescing under ultra-violet light. The typographical inclusion of the word " synthetic " before diamonds when the radium-treated stones are mentioned mars an otherwise excellent article.
13 illus., 2 in colour. P.B.

Webster (R.). " *Fingerprinting diamonds.*" National Jeweler, Vol. 51, No. 11, pp. 72–73 and 156, November, 1956. New York.

The differential fluorescence of diamonds is suggested as being a means of identifying jewellery set with many diamonds. Fluorescence photographs showing the differential intensity of the glows may be used as a permanent record. The employment of colour photography is considered to be too time-consuming and expensive for commercial purposes. The method advocated is to take a straight photograph of the piece of jewellery and then a second picture of the fluorescent glows induced by ultra-violet light. Long-wave ultra-violet is used, as the short-wave lamp passes too much visible light and does not give such a clear fluorescent picture. The fluorescence picture is taken with the room lights turned off, and an ultra-violet absorbing filter is needed over the camera lens for this picture, as the photographic emulsion is responsive to ultra-violet light.

7 illus. P.B.

GÜBELIN (E.). *Inclusions in synthetic spinels.* Gemmologist, Vol. XXV, Nos. 302/3, pp. 153–157 ; 173–176, Sept./Oct., 1956.

A survey of the " bubbles " and " inclusions " seen in synthetic spinels of recent manufacture. Most synthetic spinels are comparatively clean, and some may show very small bubbles of pinpoint size, which are sparse and rarely in clouds. The red synthetic spinel is an exception in that it usually shows many bubbles which lie in broad parallel bands similarly to the effect seen in some synthetic rubies (note: red synthetic spinel is not marketed). The cavities found in synthetic spinels of other colours are described and the reasons for their formation explained. These are bubbles which have elongated into hose-like or worm-like forms, which may run parallel, criss-cross, or anastomose, and may appear like natural " feathers." Low pressure of the blowpipe gases may cause speeding up of the growth of the boule and produce gaps in the lattice, giving rise to types of negative crystals parallel to the length of the boule. These may take fantastic rounded forms, termed " profilated bubbles." Shred-like formations are occasionally found and are said to be empty or gas-filled cavities formed through the rapid growth. Curved banding is rare in synthetic spinel but this has been occasionally seen. Typical cracks following definite crystallographic planes and other cracks and whorls are said to be due to strain, the strain exemplified by the anomalous double-refraction seen between crossed nicols. One manifestation of these cracks assumes a hexagonal outline and can be somewhat confusing. Two-phase inclusions have been observed in some synthetic spinels. The original theory that they contain water in the liquid and gaseous condition has been questioned from recent investigations. The newer theory is that the two phases of matter are a solid one (a glass) and a gas, which is probably air. Crystals of alumina brought into formation by a process of ex-solution form a disturbing kind of inclusion.

19 illus. R.W.

ANDERSON (B. W.) : PAYNE (C. J.). *The spectroscope and its applications to gemmology.* Gemmologist, Vol. XXV, Nos. 302/3/4/5, pp. 158–162 ; 177–179 ; 193–198 ; 211–216, Sept./Oct./Nov./Dec., 1956. Vol. XXIV, No. 306, pp. 13-14, Jan., 1957.

Parts 37 to 40 of this serialization on the absorption spectra of gemstones deal, firstly, with those of synthetic gemstones. The spectroscope will give no help in the separation of ruby and pink sapphire from the natural stones of these colours. The 4500Å line seen in the natural blue sapphire is absent in synthetic blue corundum. It is mentioned that a vague band may be seen about 4550Å in synthetic blue sapphire, which, although near that of the band in natural sapphire, is a vague blur of considerable width quite unlike the sharp nature of the band in natural blue sapphire. Such a vague band may also be visible in the yellow synthetic sapphire, and the newer brown types show an absorption from this 4550Å line onwards. Synthetic green sapphires do not show a characteristic spectrum but the " alexandrite " type shows a line at 4750Å due to vanadium. The blue shades of synthetic spinel (" aquamarine," " zircon " blues and deep blue) show, with varying intensity, the three-band spectrum of cobalt centred at 6350, 5800 and 5400Å. These bands may be also observed by reflected light in the synthetic sintered blue spinel made to imitate lapis lazuli. Many synthetic blue spinels show a bright line spectrum at 6870Å which, except for position, resembles the fluorescent line of ruby, and not the " organ pipe " fluorescence lines seen in the natural red spinel. The yellowish-green spinels which owe their hue to manganese show a strong band at 4230Å and a broader and weaker band at 4480Å. These manganese bands may in some cases be in association with the cobalt bands. Synthetic emerald shows, except perhaps for intensity, the same spectrum as natural emerald. Synthetic rutile shows a strong band at 4230Å and no bands have been observed in the new strontium titanate. The part on the absorption spectra of glasses mentions the blue, pink, orange, red and " canary " yellow and green glasses. In most blue glass the colour is due to cobalt, the spectrum being similar to that of the synthetic blue spinels, except that the outer bands are at a greater distance from the centre band, which is the narrowest (in the synthetic spinel it is the band in the green which is the narrowest). Vague blurred chromium lines may be found in some green pastes. Pink glasses are sometimes coloured with didymium and then show the typical groups of lines in the yellow, such as are seen in yellow apatite. Most red pastes are coloured by selenium in conjunction with cadmium sulphide and the spectrum exhibits a broad band in the green. Orange glasses show a cut-off near 5900Å and beyond ; to some extent this spectrum resembles that of fire opal, but the refractive index of these orange-coloured pastes is higher than that of fire opal. The uranium-coloured " canary " yellow or green glasses show no useful bands, although some vague bands may be seen with difficulty in the blue and violet. The fluorescence spectra of certain gems and minerals are remarked upon with particular reference to the chromium-coloured minerals. The rare earth fluorescence spectra are discussed, zircon being the most important gemstone in this group. The important subject of the luminescent spectra of diamond is also discussed within the limits of the scope of the article. Luminescence of diamonds is described under three groups, blue-fluorescent, yellow-fluorescent and green-fluorescent stones, and the spectral characteristics of these three groups are discussed. Blue-fluorescent diamonds show yellow phosphorescence with a strength proportional to the intensity of the blue fluorescence. Part 40 gives a summary of the absorption spectra discussed in the series, the relative reliability and practical importance of each spectrum being marked by the system of " stars." The classification of this summary is based on colour grouping. The series has an index.

2 illus. R.W.

MEHTA (M. G.). *Last remaining descendant of ancient Indian diamond artisans.* Gemmologist, Vol. XXV, No. 304, pp. 205–208, Nov., 1956.

The cleaving of diamonds was not known before the 16th century in Europe but the art was known in India many centuries before that time. The large plate-shaped diamonds found in old Indian jewellery supply the proof of the age-old cleaving of diamonds in India. The Indian names for these types of flat stones of old India are given, and the story is told of a living Indian cleaver, a descendant of those of ancient India. The methods used by this worker are described.

6 illus. P.B.

ANON. *Agate colouring by heat treatment.* Gemmologist. Vol. XXV, No. 304, pp. 208–209, Nov., 1956.

Agate will not always stain easily ; it may take the colour only in patches or even only on the surface. Brazilian agate is the more easily coloured material. It is suggested that agate should be cut into sections with the microcrystallites in parallel orientation with the layers. Inorganic mineral salts, which have smaller-sized molecules, would penetrate the agate better than the organic colouring agents (sugar, honey and aniline dyes) with their larger-sized molecules. Oil and petroleum used in the sawing process may prevent subsequent absorption of the dyes unless completely removed. G. O. Wild suggests that a preliminary heating between 200 and 300 degrees C. alters the structure of the agate and makes for easier colouring. P.B.

HANSON (L.) *Sillimanite.* Lapidary Journal, Vol. 10, No. 4, 1956, pp. 294–298 ; Reprinted Gemmologist, Vol. XXVI, No. 307, pp. 23–25, February, 1957.

A report on the sillimanite (fibrolite) from the Clearwater River Valley, Idaho. The material is white to blue in colour with often patches of black, brown or yellow. It is fibrous and produces a cat's-eye effect when cut cabochon. The hardness is said to be 7 to 7½, although some pieces are said to exceed 8. The black to yellow patches of colour turn to a pale salmon-pink or red when heated, but the blue colour does not alter. At Dent, Idaho, some fifty miles upstream, there is a further deposit of water-worn material and nearby is a source *in situ.* Gem quality sillimanite is found in Burma, Ceylon and Brazil.

R.W.

MEINKE (H.). *Crystals produced in a carbon arc.* Gemmologist, Vol. XXVI, No. 307, pp. 33-38, February, 1957.

The author, the central figure of the Bonn diamond synthesis affair, discusses the growing of crystals by the use of a carbon arc in a gaseous atmosphere in a special pressure chamber, the temperature being in the region of 6000°K. The " mushroom " formed is said to consist of pure and transparent graphite crystals, which, although not properly identified, are not silicon carbide. The arrangement of the furnace is described and reasons for the

non-burning of the graphite when oxygen is the gas used in the furnace are given. The gases used were oxygen, argon, nitrogen and air. Much technical data is given.
6 illus, 2 tables. R.W.

ANON. *What atomic irradiation can do to precious stones ; " Bombarded " and normal gems compared.* Illustrated London News, Vol. 230, No. 6142, Supplement page 4, 23rd February, 1957.

A coloured plate showing a number of stones from the collection of Thorold Jones which illustrates the colour before irradiation and after treatment in an atomic pile. Mention is made that colour changes normally disappear when the stones are heated to 500°C. It is not considered that the sale of coloured diamonds will be seriously affected by stones colour-changed by irradiation. The stones illustrated in the plate are synthetic corundums and spinels of various colours, natural sapphire and natural blue zircon.

R.W.

DÉRIBÉRÉ (M.). translated by CHISHOLM (J. R. H.). *Luminescence of minerals : Luminescence of diamond.* Gemmologist, Vol. XXV, No. 304, pp. 200-204, November, 1956, and Vol. XXVI, No. 306, pp. 4-6, January, 1957.

The luminescent effects seen in a number of minerals, including some which are gem minerals, are mentioned. Fluorescence, phosphorescence, radio-luminescence, cathodo-luminescence, triboluminescence and thermo-luminescence are discussed. Much is told of the luminescence of diamond. Under some radiations certain diamond crystals exhibited different strengths, and even shades of colour, of the glows on the various crystal faces ; the cube face showing the brightest luminescence. A diamond activated by contact of long duration with radium bromide, showed, when heated, a clear thermoluminescence. Under long-wave ultraviolet light the luminescence is less constant and it is suggested that this effect might, providing previous knowledge be known, provide a check on a piece of diamond jewellery should it be stolen and recovered and have subsequently to be re-identified. Some of the applications of luminescence in mining and mineralogy, and in industry, are given.

R.W.

Breebart (A. J.). *A simple, but effective, dark-field illuminator.* Gemmologist, Vol. XXVI, No. 307, pp. 21-22, February, 1957.

Instructions for the construction of a simple home-made dark-field illuminator for the microscope stage. The materials needed consist of a tin lid, a bicycle lamp reflector with lamp holder for a low-voltage lamp to be fed from a step-down transformer, a metal disc and the necessary screws, nuts and electric wire. The stone is held in spring tweezers mounted on a pivot.
1 illus. R.W.

Anon. *Modern Chinese carving in ivory and jade.* Gemmologist, Vol. XXVI, No. 306, pp. 8-13, January, 1957.

A report on the exhibit of Chinese craftsmanship which was shown by the Chinese Peoples Government at the Handicrafts exhibition held at Olympia in West London. Carved ivory and jade pieces shown were said to have been carved within the last ten years. The main centres for this craft are the towns of Shanghai and Peking (mostly jade) and Canton (principally ivory). Craftsmen in China are now said to number 100,000 and they work in communities. Their products are marketed through a Government organization. Traditional methods are used in carving and the craftsmen tend to specialization. Coral, turquoise, emerald, serpentine, rock crystal, agate, rose quartz and soapstone are also carved.
4 illus. R.W.

Crocker (R. C.). *The Yogo Sapphire mine.* Gems and Gemology, Vol. VIII, No. 11, pp. 323-330, Fall, 1956.

A comprehensive article on the Yogo sapphire mine at the foot of the Little Belt Mountains, Montana. The location of the mines and the flora and geology of the locality are given. The sapphire was first discovered at Yogo Gulch in 1894 by prospectors searching for placer gold. The history of the mining area from the early 1890s to the current year is fully told. Yogo sapphires have a metallic lustre and vary in colour from a pale steel-blue to a cornflower blue. The crystals are small in size.
5 illus. R.W.

COLEMAN (R. G.). *Jadeite from San Benito Co., California.* Gems and Gemology, Vol. VIII, No. 11, pp. 331-334, Fall, 1956.

A factual report on the jadeite found along Clear Creek in San Benito County. The mineral jadeite is compared with nephrite, and mention is made that only three other localities for jadeite have been previously known: they are Upper Burma; Kataki, Niigata Prefecture, Japan, and near Manzanal in the Motagua valley of Guatemala. Jadeite was first reported from California in 1939 but the Clear Creek boulders were not discovered until 1950. The geology and the mineralogy of the material is given. It is a very pure jadeite in white and dark green colour but does not compare favourably with the jade from Burma. The optical properties of the white material are given as α 1·654, β 1·657, γ 1·666, and the density is stated to be 3·34. The dark green material polishes better than the white material.

3 illus. and 1 table. R.W.

SPAULDING (D. L.). *The ruby mines of Mogok, Burma.* Gems and Gemology, Vol. VIII, No. 11, pp. 335-342, Fall, 1956.

The writer visited Mogok and the Stone Tract during the Fall of 1955 and this article is a very full account of the area as it is since Burma was given her freedom by the British in 1948. Present conditions of travel are told and the state of Mogok itself. The native method of mining is mentioned. The gem minerals found in the tract are listed. " Ruby rough " consisting of skillfully tumbled synthetic corundum is reported. Native cutting methods are explained and the method of bargaining for stones by holding hands under a cloth is described. Conditions in Burma are hazardous and the State holds an uncertain future, but the finest rubies are found at Mogok.

11 illus. R.W.

ANON. *Irradiated gemstones : Colour changes by irradiation.* Gemmologist. Vol. XXV, No. 305, pp. 217–220. December, 1956.

The first of these articles describes the display of various gemstones in conjunction with similar stones which had been irradiated in an atomic pile at Harwell. This display had been on show at an " open day " at Harwell and then at the Haslemere

Educational Museum. The species of the stones irradiated are given in the caption to one of the illustrations, and it is told that most of the irradiated stones assumed a darker and muddier colour. A specimen of colourless periclase did, however, turn to a much more attractive deep blue. The second article makes an attempt to explain the cause of colour and what happens on irradiation. Idiochromatism and allochromatism, parti-coloration, pleochroism and sheen are referred to. The staining of black onyx to a black colour by sugar and sulphuric acid, and the pinking of topaz by heating are mentioned. The effect of heat and radiation in altering the colour of gemstones is referred to and the reasons described by illustrations. Ion vacancies in the lattice, the missing ions of which may be present interstitially producing Frenkel defects, or on the surface giving Schottky defects, are alluded to, and colour may be caused by incident radiation ionizing other atoms and ions which become trapped in the vacant sites giving rise to absorption of light. The higher energy of neutrons and high energy electrons may in addition cause ions to become displaced in the lattice.

4 illus. R.W.

CHALMERS (R. O.). *Some aspects of New South Wales gemstones.* Journ. and Proc. of Royal Society of New South Wales, Vol. LXXXIX, pp. 90-108, Sydney, 1956. Reprinted as *Gemstones of New South Wales.* Gems and Gemology, Vol. VIII, No. 11, pp. 343-349, Fall, 1956.

This article is the report of the Clarke Memorial Lecture delivered by the author to the Royal Society of New South Wales on 16th June, 1955. It deals with diamond, opal, sapphire, ruby and spinel, beryl and emerald, topaz, zircon and garnet, quartz, turquoise, titanite (sphene) and prehnite, each section being fully dealt with both historically and scientifically. The writer concludes with some notes on the economic significance of the gemstones in the State of New South Wales. Considerable information is given on the localities of the various gem minerals mentioned, and these are supplemented by line maps. This very important paper is completed with a good list of references.
4 maps (not in Gems and Gemology reprint). R.W.

EPPLER (W. E.). *Ueber die Färbbarkeit des Achates.* (Colouring Agate.) Deutsche Goldschmiedezeitung, Vol. 54, No. 11, 1956, p. 551.

Agate consists of SiO_2, or more correctly of two types of SiO_2, namely crystallized quartz and opal, which can have a larger or smaller water content. The colouring property of agate depends on the water content of the opal, which can be as high as 10%. The greater the water content, the easier it is to colour the agate. The colouring is also influenced by the structure of the crystalline SiO_2. The closer knit the fabric, the less room there is for the water-carrying opal, and therefore the more difficult it is to colour the stone. The theory is proved by the specific gravities which are

rock crystal = 2·651
technical agate = 2·600 ± 0·002
coloured gem agate = 2·594 ± 0·002

E.S.

GRODZINSKI (P.). *Edelsteine in der alten indischen Literatur.* (Gems in old Indian literature.) Gold und Silber, Vol. 9, No. 12, 1956, pp. 21–22 (also in Gemmologist, Vol. XXV, No. 295, pp. 28–30, February, 1956).

An extract of information about diamonds as compiled by L. Finot in Paris in 1896 collected from old Indian writings. The colour of the diamond was thought to be determined by the caste to which it belonged and was dedicated to one particular god, and accordingly certain virtues belonged to the stone, i.e. riches or glories. The form of the stone is discussed and a list of stones is given which can be used to imitate diamonds.

E.S.

KLÜPPELBERG (E.). *Eine neue Darstellungsweise der Schleifrichtungen am Diamanten.* (A new method of demonstrating the grinding direction of diamonds.) Deutsche Goldschmiede-Zeitung, Vol. 54, No. 12 (Dec.), 1956, pp. 607–608 ; Vol. 55, No. 1, 1957, pp. 15–17.

The article is an extract from a book by the author on the " Grinding of the brilliant " which will be published soon. It describes a new method developed and tried out by the author at the Industrial Trade School in Idar-Oberstein. Previously drawings showed the grinding directions by indicating the natural growth lines and the direction of the grinding marks on the facets. The new method brings these indications in relation to the direction of the scaife rotation and the position of the tongue which holds the diamond. Thus the apprentice can visualize more readily the connexion between the drawing used as a visual aid at school and the actual work he is asked to perform in the shop. The direction of lap rotation is indicated by thick parallel arrows from the right. The axis of the tongue is at right angles to this direction and is indicated on the drawing by showing part of the tongue. The eight " compass directions " (in — out — against, etc.) of the tongue are shown by a circle with four black and four white octants. Within this circle a rotatable disc is placed, which shows the facets of the brilliant or eightcut together with the superimposed growth marks of the 2, 3 or 4 point. This drawing then shows to the apprentice the position of the stone as he sees it when he actually looks onto the stone " in the tongue," i.e. when the tongue is removed from the scaife for inspection.

W.S.

FREY (E.). *Edelsteine in Süd-Afrika.* (Gems in South Africa.) Deutsche Goldschmiede-Zeitung. Vol. 55, No. 1, 1957, pp. 18–120.

A general survey of gems found in South Africa. The author does not believe in the stability of diamond value as allegedly (*a*) the price is kept artificially high and (*b*) the synthetic stones are going to oust them from their leading position. South-West Africa, the former German colony, the author alleges to have been searched most thoroughly. In this part one finds beryls, tourmalines, topazes, malachites, azurites and other minerals. In Namaqualand, south of the river Oranje, one finds diamonds, rock crystals, amazonites, malachites, beryls (no emeralds) and spodumenes. A sketch of this region is included. In West Griqualand amethysts, garnets, jaspers, and tiger's-eyes are found. Transvaal is very rich, where apart from gems one finds gold, iron, chromium, platinum, asbestos, coal, tin and mica. The gems include diamond, rock-crystal, agate, haematite, emerald and tourmaline. This district (Letaba) was also the site of the recent find of the largest emerald (24,000 cts.).

E.S.

Chudoba (K. F.). *Neue Diamantfunde : in der ostsibirischen Sowietrepublik Jakutien.* (New diamond finds in the east Siberian Soviet republic of Jakuta.) Deutsche Goldschmiede-Zeitung, Vol. 55, No. 1, 1957, pp. 20–21.

Short survey about properties, occurrence and synthesis of diamonds. In Jakuta no systematic production of diamonds has yet begun. Up to now diamonds of 4–6, occasionally 11 cts., were found, also one of 32 cts. Nothing is known of the quality.

E.S.

Quick (L.). *Story of Benitoite.* Lapidary Journal, Vol. 10, No. 6, Feb., 1957, pp. 510–518.

A useful account of benitoite. Discovered in 1906, this rare gem occurs in the unusual form of a ditrigonal bipyramid of the hexagonal system at a mine near Santa Rita Peak, San Diego County. Much good material was destroyed early on by attempts to hammer crystals from parent rock—a natrolite dike in serpentine, associated with neptunite. Later it was found possible to dissolve the matrix with hydrochloric acid. Many crystals are flawed and unsuitable for cutting and it is rare to find a faceted stone of more than about a fifth of a carat. A stone of seven carats is in the Smithsonian Institution, Washington.

S.P.

Schiebel (W.). *Gewichtsformel fuer regelmaessig geschliffene Steine* und *Perlen, insbesondere fuer dem Diamant-Vollbrillant.* Weight formulae for pearls and cut stones especially the full cut brilliant. Zeitschr. d. deutsch. Gesellsch. f. Edelsteinkunde, No. 18, Winter 1956/57, pp. 16-22.

From the weight given in Diebener's tables for a brilliant of 10mm. diameter the author determines the factor 0.003449 with which the cube of the diameter has to be multiplied to obtain the weight in carats. Based on the ideal relationship between girdle diameter—table diameter, total height, height of crown and pavillion, for the fine cut brilliant (without girdle height) a long table has been evolved giving all these data (in reasonable small steps) for brilliants from 0·003 to 20·000 cts. In a log log diagram with the weight in carats as one co-ordinate and the girdle diameter as the other, all other dimensions of the brilliant are represented by parallel straight lines. Facts are also given to determine the weights of different pearl varieties from the diameter. W.S.

KLUEPPELBERG (E.). *Beobachtungen an Gaseinschlüssen in Glas und synthetischen Steinen.* Observing gaseous inclusions in glass and synthetic stones. Deutsche Goldschmiede-Zeitung Vol. 54, No. 10, 1956, pp. 496–498.

The appearance of gas bubbles under the microscope in transmitted and reflected light is discussed. In transmitted light the bubble appears as a dark rim with a bright centre. This bright centre is due to the light beam which is deviated less than 8 deg. (for glass with a R.I. of about 1·5). Photomicrographs show bubbles with a dark spot in the bright centre due to indian ink marks at the under side of the glass specimen. In a very small bubble the bright centre is hardly discernible. Interesting mathematical explanations by Eppler relating to the light path are given. In reflected light (incident at 70-80 deg.) the bubble appears three-dimensional. 8 photomicrographs, 2 line drawings. W.S.

PENSE (J.). *Achate unter dem Elektronenmikroskop.* Agates under the electronmicroscope. Zeitschr. d. deutsch. Gesellsch. f. Edelsteinkunde, No. 18, Winter, 1956/57, pp. 7-9.

Two electron photomicrographs show an etched agate specimen at 3200 × and 15000 × magnification. According to the author's interpretation, a network of coarser and finer fibres was seen. The fibres are supposed to be crystallized chalcedony and the spaces between the fibres presumably opal. Whether the opal plays any part in the artificial colouring of agate remains to be investigated within a research programme to be carried out by the Mineralogical and Petrological Institute of the University Mainz. W.S.

BÖLSCHE (R.). Ueber das Smaragdvorkommen im Habachtal. Occurrences of emeralds in the Habach valley. Zeitschr. d. deutsch. Gesellsch. f. Edelsteinkunde, No. 18, Winter, 1956/57, pp. 10–14. Conclusion. See Journ. Gemmology, Vol. 5, No. 8, 1956, p. 394.

By carefully removing surrounding matrix the author found small emerald crystals in helical arrangement indicating that these emeralds were formed in plutonic penetration channels. Investigation also showed a multitude of small crystals in random orientation more or less within a plane.
3 illus. W.S.

CHUDOBA (K.). *Lapislazulifarbiger synthetischer Spinell = Sinterspinell.* Lapis-lazuli-coloured synthetic spinel = sinter spinel. Zeitschr. d. deutsch. Gesellsch. f. Edelsteinkunde, No. 18, Winter, 1956/57, pp. 15-16.

Prof. Chudoba draws attention to different nomenclature by the manufacturer (Degussa) of the sintered spinel. The white " sintered " material which is also called " Degussit " is used for fine ceramic products. The lapis-lazuli-coloured " synthetic " spinel is used as gem material for adornment. The author suggests it should be correctly called lapis-lazuli-coloured sinter spinel (as opposed to synthetic spinel). W.S.

GOEBELER (H.). *Bestimmung von gelben ind farblosen synthetischen Korunden.* Determination of yellow and colourless synthetic corundums. Zeitsch. d. deutsch Gesellsch. f. Edelsteinkunde, No. 18, Winter, 1956/57, p. 23.

Summing up of known methods. Fluorescence observed under ultra-violet light (wavelength around 3650Å) was allegedly different from that reported by B. W. Anderson, namely :

natural yellow corundum : weak green,
yellow corundum (Ceylon) : orange to apricot yellow
natural colourless corundum : very weak orange to yellow,
synthetic yellow corundum : carmine red,
synthetic colourless corundum : weak ; dim green.

W.S.

GRENVILLE-WELLS (J.). *Harder than diamond ?* New Scientist, No. 15, Feb., 1957, pp. 16-18.

A short account of the G.E.C. experiment in making a compressed form of boron nitride, which has been named borazon. Under pressure boron nitride (white graphite) changed from a hexagonal to a cubic form, the crystals produced being sand grain size. Borazon withstands a temperature of 1,800°C, while diamond " burns up " in air at 800°C. Optical properties are not yet known but borazon crystals are claimed to be harder than diamond, though it has not been stated whether the new material will scratch the synthetic diamond produced by G.E.C. in 1955. Hardness probably lies somewhere between the two. Cleavage, differential hardness and toughness will be important in assessing the usefulness of borazon relative to diamond. Its high temperature resistance is already notable. S.P.

ASSOCIATION NOTICES

ANNUAL MEETING

The 27th annual general meeting of the Association was held at Goldsmiths' Hall, London, E.C.2, on Friday, 15th March, 1957. Mr. F. H. Knowles-Brown, Chairman of the Council, presided.

The audited accounts and report of the Council for the year ended 31st December, 1956, were adopted. Sir Lawrence Bragg, F.R.S., was re-elected as President and the retiring Chairman, Vice-Chairman and Treasurer were also re-elected. Miss E. Ruff and Mr. T. H. Bevis-Smith were re-elected to serve on the Council, and Mr. D. J. Ewing elected to serve in the place of Mr. R. K. Mitchell.

Messrs. Watson Collin & Company continue as auditors to the Association.

In his report the chairman mentioned the 1956 Herbert Smith Memorial Lecture, which had been given by Dr. F. Pough. He did not know whether or not that speaker had had "his tongue in his cheek" when he had said that a time might come when, owing to the shortage of gems, synthetics might be of far greater value and interest than at the present time. Mr. Knowles-Brown commented that that may seem far-fetched but that a famine of gemstones might not occur because there was a dearth of them in the earth. They had entered the Plastic Age. It had come upon us without our realizing it. Veneers had been produced upon plastics in such a way that the veneer was better than the genuine article. This was a factor that they were not realizing at the moment. They were also entering another age—the Synthetic Age. Human nature did not keep pace with scientific research ; he could remember the time when there were no cinemas, no gramophone disc records, no telephones, nor aircraft, and only a few motor cars ; he could also remember when men were happy ! All the things we had now in this modern world had appeared in the speaker's own lifetime. He could not be expected to understand it all. Progress was being made faster and even the younger men in the audience would not be able to keep pace with it. There were things which were a complete mystery to him and yet schoolboys understood and accepted them.

Diamond had now been produced by man; now it seemed that the position of the diamond as the hardest thing on earth was being disputed. Years ago, corundum had been synthesized, but the identification of the synthetic had been a comparatively easy matter. To-day's condition and those of the future would call for a far greater technological understanding and for the use of much more complex and expensive equipment. Gemmologists would have to change their approach to their study of gems. They must be more prepared to identify these synthetics.

The chairman also spoke of the keen and useful work of the Midlands section, represented at the meeting by the Association's vice-chairman, Mr. Norman Harper.

COUNCIL MEETING

A meeting of the Council of the Association was held at Saint Dunstan's House, Carey Lane, London, E.C.2, on Friday, 1st February, 1957. Mr. F. H. Knowles-Brown presided.

The following were elected to membership :—

Fellowship

Bentley, Dennis C., Epsom. D.1956
Maxwell, John A., London. D.1956

Probationary

Callaghan, David J., London
Francis, Barry P., London
Hope, Kenneth, London

Ordinary

Bettis, Violet A., Reading
Cavenago-Bignami, Prof. Speranza Milan (Italy)
Dickenson, William N., Godstone
Hadjizade, Ahron, London
Harland, Ian P., Newcastle-on-Tyne
Kent, Muriel C., Folkestone
Langton, Edward G., London
Rose, William E., Southwater
Staley, Harry F., Birmingham
Warburton, Frederick W., Toronto (Canada)
Weaver, Gerald O., London

DEPARTMENT OF MINERALOGY—BRITISH MUSEUM (NATURAL HISTORY)

Lectures in the Mineral Gallery on Saturdays at 3.0 p.m.

1957			
MAY	11th	How new minerals are found ...	Dr. G. F. Claringbull
	18th	Natural glasses	Mr. S. E. Ellis
	25th	The alteration of minerals	Mr. P. G. Embrey
JUNE	8th	Colour in minerals	Dr. M. H. Hey
	15th	Amber	Dr. A. A. Moss
	22nd	Crystal architecture	Dr. G. F. Claringbull
JULY	6th	The story of garnets	Dr. G. H. Francis
	20th	Mineral associations	Mr. P. G. Embrey
	27th	British gemstones	Miss J. M. Sweet

This programme is subject to alteration

TALKS BY MEMBERS

Blythe, G. A. : " Gemstones," Women's Fellowship, St. Aidens Church, Belfairs, Leigh, 19th February, 1957.

" Gemstones," Young Conservatives' Association, Prittlewell, 26th February, 1957.

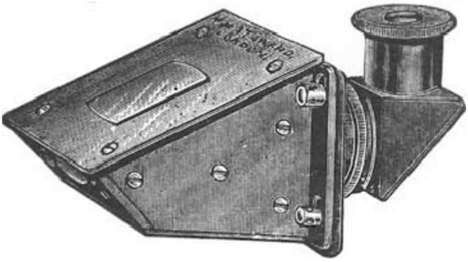
Duncan, James M. : " Gemstones," Paisley Naturalists' Society, 11th January, 1957.

Forsey, Patricia : " Gemstones," Auxiliary Missionary Group, Runnymede United Church, Toronto, 28th January, 1956.

Johnson, T. J. : " Gemstones," St. Oswald's Church Young Wives' Association, Croxley Green, 11th March, 1957.

Webb, Malcolm H. : " Gemstones," 2nd April, 1957, to Church Guild, Maidstone.

Webster, R. : " Modern synthetic stones and fakes," Tunbridge Wells, Tonbridge and District Branch, N.A.G., 8th January, 1957.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April, 1957

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