

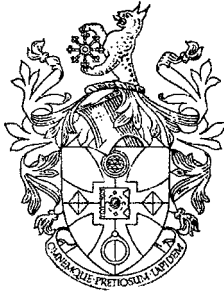
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and

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OF GREAT BRITAIN



GEMMOLOGICAL ASSOCIATION
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COLOURED DIAMONDS — NATURAL OR ARTIFICIALLY TREATED?

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SUMMARY

These days the intervention of techniques in the synthesizing and modification of the properties of precious stones is a source of worry for the gem jeweller. An actual case is described here, with the examination of 20 so-called fancy-coloured diamonds. This term covers shades other than those of the usual commercial scale for gem diamonds, which includes colourless stones to those of a yellowish tint. To begin with, the aim was to find out whether the colours of the diamonds under test were of natural origin or due to radiation treatment. The investigations were carried out under the working conditions of a well-equipped gemmological laboratory. The determining characteristics of the stones examined are set out in table form. These results enable definite conclusions to be reached in certain cases whilst in other cases giving only clues but no proof, since the positive signs of treatment are not always evident or at least not perceptible within the limits of the equipment used.

GENERAL

The distinction between natural and artificially induced coloration of diamonds is a topic causing more and more concern. An alteration of the original shade can be effected by simple means, relatively easy to detect; these effects are not permanent and are set out here as a reminder.

1. COLOURED FILM

A translucent coating or an ink is applied to the underside of the diamond. The dying stuff chosen is generally of a shade complementary to that of the diamond and thus the general colour impression is improved when the shades are mixed by the eye. These coatings are eliminated by solvents such as alcohol or acetone and are easily removed if the stone is set in an open setting.

2. FOILED BACK

A process already known for a long time and still being applied nowadays, is the use of a thin reflecting, coloured metallic leaf, or foil, covering the inside of the closed stone setting. The foil acts as a mirror and gives the impression of a better and deeper colour (in coloured stones) by optical blending. It also improves the liveliness of shallow stones or of badly cut stones. The metallic leaf is generally of aluminium. The process is revealed often by dull stains due to superficial oxidation of the metal or to infiltrated dust and liquids. Here, the pocket lens is a good means of identification.

3. FLUOR COATING

A more modern procedure is the application around the circumference on the pavilion side of the diamond of a fluoride composition similar to that used in optics for the anti-reflection coating of the lens surfaces. Here, too, the illusion of seeing better colour is due to the mixing of complementary colours by the eye. For example, a yellowish diamond having a bluish coating will appear less yellow. Detection is made by observation of the lustre, because the thin film will not show the typical adamantine lustre. Some iridescence is occasionally visible, and the edge of the coating is shown up under microscopic magnification of about $\times 60$. A treatment in hot acid removes this type of coating.

A much more complex problem is posed by the discoloration of diamonds under the action of ionizing or high energy radiation and by its identification. Since the systematic experiences of Crookes at the beginning of this century (1904) on the modifications obtained by exposing diamonds to alpha particles of radium, analogous processes of discoloration have more than purely scientific research interest and the derived methods have left the laboratory and taken their place in commerce.

The radium treatment is no longer applied because of the costs involved and because the radioactivity imparted to the stones will be retained for years, possibly being dangerous when the diamond is worn close to the skin. Detection is simple, as such stones will fog a piece of film when left in contact with the film from a few hours up to a few days.

The means of irradiation are today the cyclotron, the nuclear reactor, and the Van de Graaf generator. Based on the work of Crookes, Cork, Custers, Dugdale, Ehrmann and others, the experiences of specialists in commercial discoloration have simplified and rationalized the methods. Consequently, the irradiation, or "bombardment", of diamonds has become a relatively simple operation, costing about \$60.00 per carat.

EFFECTS OF IRRADIATION PROCESS

Irradiation effected in a cyclotron or in a nuclear reactor, modifies the original colour, turning it progressively green to an opaque dark green, depending on the size of the stone and duration of treatment. On consecutive heating and under progressive temperature in the range $+400^{\circ}$ — $1,000^{\circ}\text{C}$ ⁽⁴⁾, the dark green colour reverts to shades of brown, yellow-brown or yellow. Irradiation in a Van de Graaf accelerator results in shades of a pale blue to blue-green.

SELECTING DIAMONDS FOR TREATING

There is no point whatsoever in irradiating gem diamonds of good original colour as this would probably only result in a less prized colour. For this reason, the stones chosen for irradiation are "off-colour" stones which, it is hoped, can be improved in shade or converted to a definite fancy hue, and markedly "piqué" stones, where a new, saturated fancy body colour will help conceal the flaws. Small, old-cut stones and those of mediocre quality are often treated such as they are, because the price of recutting to ideal proportions would be too high in relationship to their colour and purity grade; in such instances, the lack of symmetry of the facets, together with wearing marks, nicks and cracks seen with a lens on such stones, evoke the possibility of treatment when they are observed together with a naturally less frequent shade.

SPECIFICATION OF ARTIFICIALLY INDUCED COLOUR

The identification of a treated diamond is not always easy. To avoid mistakes when buying and especially with regard to his responsibility towards his clients, the retailing jeweller will find it to his advantage to keep up to date with this subject. From different sides, efforts are being made to eliminate the use of abusive designations for gemstones and to encourage a more ethical approach in this sphere, particularly with regards to artificial products or artificially treated gemstones. On these lines, "bombarded" stones offered for sale should be clearly defined as such and many national organizations are trying to establish this idea.

Artificially coloured diamonds must be designated as such. Such designations, established by associations for the protection of the buying public, are welcomed by members of the trade who promote and follow an ethical professional policy and are very much aware of their responsibility, thus maintaining the confidence of their customers.

However, the application of rules is not always simple. In effect, when in an economic section a regulation of quality defined by a nomenclature and normed standards is put forward for certain products, the corollary of it is the establishment of an official or private body freely open to all interested circles, thus enabling them to classify or identify their goods. In the jewellery trade, there are control laboratories in some countries, some run on a private basis, others supported by the state or a university. Some of the best known are the laboratories for the identification of gems and pearls in London, Milan, Paris, Idar-Oberstein, Los Angeles and New York. The question of finance raises problems of the establishment of similar laboratories in regions or countries where the small number of interested parties would be unable to support such an institution. Switzerland does not, as yet, have such a body either official or partly supported by the trade. On a private basis, the Gübelin laboratory is striving to help find a solution to such problems and routine identification is undertaken. Often the experiences or discoveries made are so interesting as to be well worth conveying to the trade, as a contribution to the improvement of the general level of knowledge and understanding.

OBJECT OF THIS STUDY AND DESCRIPTION OF THE INSTRUMENTS UTILIZED

The present study has been made on a series of 20 diamonds, varying greatly in colour, in order to determine whether the origin of their coloration is natural or artificial. To overcome the difficulties of colour printing, the stones are shown on Figure 1 in shades of grey, as registered on black and white panchromatic film, without filter; their actual colours, their characteristics as well as the result of the different tests conducted, are given in table form. With reference to the weight of the stones, the reader's attention is drawn to the small size of some of these gems. Thanks to the spectroscopical techniques utilized, even the small stones could be examined at ease with good results. The spectroscope is a diagnostically important instrument, quite resourceful in investigating possibilities, but requiring much practice to master its use. The analysing direction within the specimen under test, its optimal illumination and the correct setting-up of the instrument are often the cause of difficulties, even for people with some experience, as the author has often seen. Of course, nothing would replace a personal demonstration to improve the individual technique but it is hoped that the advice in the following description might help those interested to obtain complete success.

SPECTROSCOPIC EXAMINATION

As a paradox one could say that white light is a light full of colours, as it consists of all the different and visible wavelengths resulting in a general balanced impression to the eye. The spectroscope is an instrument which spreads and analyses that visible white light in the form of a coloured ribbon of light going from the red, yellow, green, blue through violet, thus bringing to the eye the components of the spectrum or rather what appear to be differentiated steps, for, in reality, the different colours fuse into one another without definite border. The stone under examination is set within the light beam of the instrument and acts as a filter, absorbing some of the radiations and letting through others. This phenomenon manifests itself by narrow or wider black absorption bands, where no light passes, across the bright spectrum and is called the absorption spectrum. The distribution of these lines is often typical for a gemstone variety although by no means all gem materials show definite absorption bands. There are two ways of proceeding to illuminate

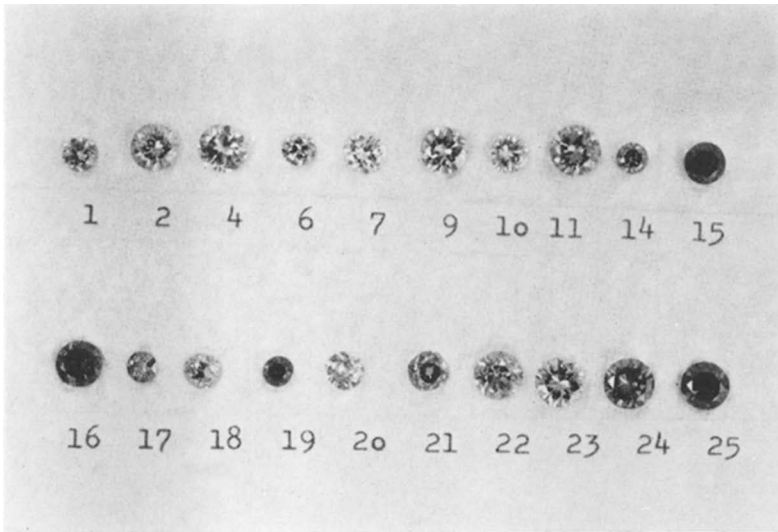


FIG. 1. *The diamonds depicted in shades of grey, as registered on panchromatic Adox KB 14 film. Compare with the actual colours cited in the general table.*

the specimen:

- (1) in transmitted light, right through the specimen;
- (2) in reflected light.

This second procedure eliminates the disturbing reflections on the facets of a cut stone, which deviates much of the light outside the slit of the spectroscope; in this way, the loss of light is reduced. The method is particularly applicable to cut diamonds, because of their high refractive index. In profile, a cut diamond can be compared to a totally reflecting prism and the light behaves in it in a similar way; with the diamond resting on its table, the beam of a microscopy low-voltage lamp is directed along the normal to the pavilion facets of the diamond, is totally reflected at the inner surface of the table side and escapes through the opposite pavilion facets to reach the collecting lens of the spectroscope, or the slit directly in the simpler instruments. The facets reflections being thus quite well suppressed, and the light efficiently utilized, a brightly illuminated spectrum is obtained even with a small specimen.

Two types of spectroscope have been used:

- (1) a modified Krüss model, to which a lighting of the wavelength

scale as well as a powerful microscopy low voltage Zeiss lamp have been added. The narrow beam has the advantage of avoiding dazzling glare, which is particularly important when looking for faint lines, where it is necessary for the eye to make use of its maximum resolving power.

It is not necessary for complete darkness in the room when working with this arrangement. The Krüss spectroscope is efficient, although its fixed angular position limits its use to examination in reflected light. The setting up is shown in Figure 2.

- (2) the latest Gubelin, which has been improved with regard to the former model: the optical system is of Zeiss origin. The precise wavelength scale is illuminated at will by a rheostat; a second rheostat controls the intensity of the main lamp, lodged in the foot of the instrument. The details are well visible in Figure 3, where the instrument is normally set for the transmitted light procedure. For reflected light, the lamp in the foot of the instrument is turned off, and the light beam of an additional lamp is directed on to the specimen, itself maintained in the

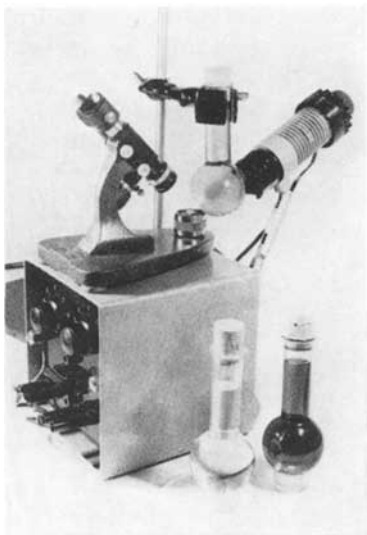


FIG. 2. *Modified Kruss spectroscope, as described in the text. The mode of illumination is clearly visible, as well as the 50 cc flasks filled with filtering solutions, used as additional light condensers.*



FIG. 3. *Latest Gubelin model, with incorporated Zeiss spectroscope, to be used in transmitted or in reflected light. The additional lamp used in the second procedure is not illustrated.*

removable stone-holder. All these refinements are handy and allow for precision work to be carried out.

Faintly coloured diamonds strongly transmit the yellow-green and the eye, being dazzled by the glare of the brightest part of the spectrum, does not easily see the faint lines in the blue and violet. To alleviate this inconvenience, it is of advantage to use filtering solutions to more or less cancel out the red and yellow end of the spectrum, as described by B. W. Anderson (Gem Testing, 1964 edition). However, instead of the large containers recommended in that book, the author has found it advantageous to use much smaller spherical laboratory Pyrex glass flasks of only 50 cc. capacity. They are very effective, thanks to the small diameter of the microscopy light beam. These spherical flasks have an effective 45 millimeter thickness of filtering solution in their diameter, which acts as a condensing lens and helps to avoid simultaneous undue heating of the specimen. Copper sulphate and liquids of different filtering capacity are used, according to necessity. The setting of the flasks on a laboratory stand provides for an easy exchange of the filters and prevents the eye from being dazzled, thus enabling a quicker eye accommodation.

SPECTRAL CHARACTERISTICS OF THE 20 DIAMONDS UNDER TEST

In the table are noted the absorption bands observed. Some of the specimens (2, 4, 9, 11) show clearly the "Cape" spectrum, its features being a series of bands based on a strong line at 4155Å, of variable width, and of accompanying bands at 4230Å, 4350Å, 4520Å, 4650Å, 4780Å, superimposed upon lines typically due to irradiation and consecutive heat treatment, at 4980Å, 5040Å, 5940Å.

Number 6 showed a weak, orangy fluorescence under copper sulphate solution, with a distinct line at 5750Å, formerly mentioned in similar fluorescing diamonds by G. R. Crowningshield and E. Gübelin. Under the same filter, number 7 had an equally weak fluorescence in the orange-yellow, without sharp limits. In the number 10, there are clues of a naturally coloured diamond, because in the 5040Å and 4980Å pair of lines, the former is predominant, the stone having a greenish fluorescence. Similarly, the number 14 speaks for a natural origin of the colour, although it was inert under UV radiation. The number 18 of yellow shade has a strong yellowish response to the ultraviolet light and shows the features of the "brown" series, with a quite distinct 4155Å line; accompanying

ones at 5370Å, 5040Å, 4980Å, have already been observed in one brown diamond by Crowningshield, as well as in the green fluorescing ones, by Miss Mani, a worker of the school of Raman, in Bangalore. But here, the stone has a yellow response and emits feebly in the red-orange at about 6200Å-6000Å under the copper sulphate light. The two bluish stones 20 and 21 both have a distinct to strong 4155Å line. Let us here recall the hypothesis of Nayar (1941) cited by Anderson on "the proportional ratio of the 4155Å line to the strength of the fluorescence"; after Anderson, the experience has not confirmed this view, as he reports having tested numerous diamonds with a 4155Å line to be inert under ultraviolet radiation. In accordance with these last facts, the 4155Å line is of equivalent strength in the two diamonds, but only one of them fluoresced blue-green (No. 20), the other one (No. 21) being inert.

A test for electrical conduction, performed on the apparatus devised by Gübelin (Fig. 4) proved the two stones to be non-conductor, thus not being of the type IIb to which naturally blue diamonds belong. Furthermore, microscopic examination showed 21 to have curious green to black spots, with round outline, located at the angle of the table, and near the girdle (Figs. 5 and 6).

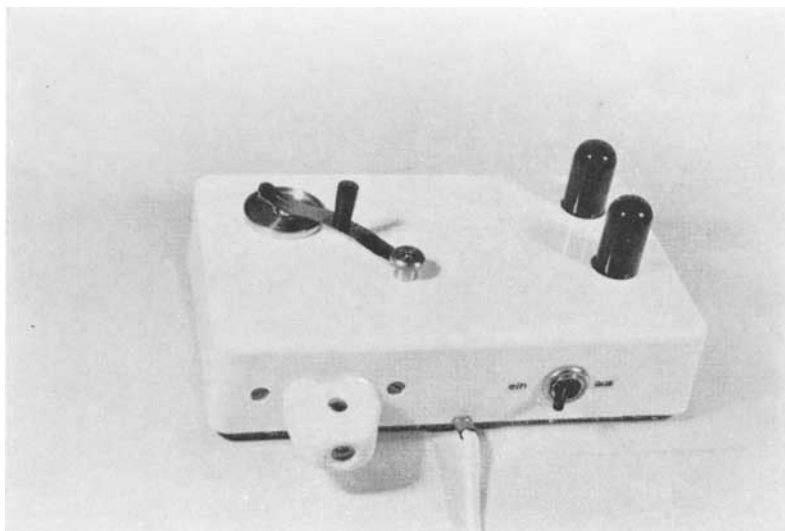


FIG. 4. Gübelin electro-conducting device, working on 220 volts. The two neon lamps light up when the tested diamond transmits electric current. The stone rests table down on the round metallic cap visible on the left side of the instrument. A flexible metallic strip ensures proper contact on the culet side.



FIG. 5. *Dark spots due to irradiation, at the angle of table and star facet, on diamond number 21. The depth of penetration is 0.03 mm and was better visible in reality. Magn. $\times 25$.*

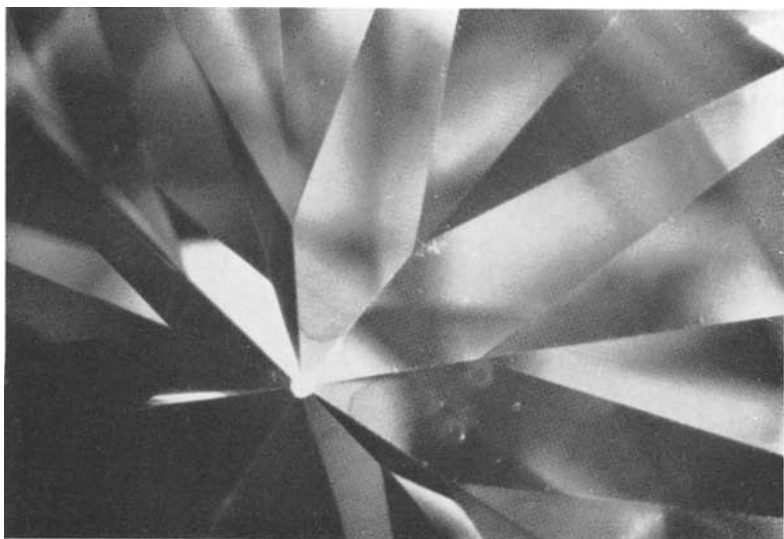


FIG. 6. *Dark green spots with round outline, along the girdle, and due to irradiation. Diamond number 21. Magn. $\times 25$.*

These spots have been found to be 0.03 mm deep, when measured with a micrometric eyepiece used on a newest X10-X70 Bausch and Lomb stereozoom microscope, mounted on a G.I.A. black-field illuminator.

As the stone is an old brilliant-cut, there is no reason to presume that it has been cut in such a way since World War II, that is to say, subsequent to the beginning of the commercialization of diamond-irradiation. The shape of the spots is reminiscent of the ones found in formerly radium-treated stones: for that reason a test was performed for possible radioactivity and turned out to be negative: after five days of contact, a radiographic sheet of film displayed no trace of fogging. Another possible cause of the spots might have been that the diamond, still in its rough condition, had been in contact or lying in the vicinity of a natural radioactive source, as according to Dugdale's⁽⁴⁾ observations in green diamonds, the colour of which is not artificially induced. In the occurrences cited by Dugdale, the green shade, accompanied by darker spots, was confined to the surface of the rough diamonds, whereas they were colourless inside the crystals. Such external markings would, of course, have disappeared during the process of cutting. Due to their location on the stones concerned, there are reasons to think that the spots have taken place after the cutting, therefore, that they are due to an irradiation treatment.

In the stone 25 the vague lines seen toward 7000Å, 6700Å, 4820Å, 4780Å (some of them cited by Dugdale) together with a green colour, suggest that the stone has been heat-treated at less than 400°C after irradiation, to lighten the green colour.

In stone 25 the 5040Å line is quite marked (about 25Å wide) whereas the 4980Å one is still just visible. This observation is in contradiction to the rule given by Liddicoat (*Handbook of Gem Identification*, 1966, p. 231): "Large treated stones may show no 5920Å line, but the presence of the 4980Å and 5040Å lines, with the former stronger, should be considered as proof of treatment". As a set-off, the features observed in number 25 correspond to the description of Miss Mani and B. W. Anderson for green stones with a green fluorescence. The same remark applies to the number 10. Against this, the number 18 corresponds to the indication of Liddicoat, but it is yellow and not green. The two lines of the pair are of equivalent strength in the numbers 2, 4, 7, 9, 11, 19, 22, 24.

As indicated in the foregoing, today it is possible to carry out a good amount of work in spectroscopy applied to gemmology, thanks to the research conducted by numerous workers, like Anderson⁽¹⁾, Crowningshield⁽³⁾, Dugdale⁽⁴⁾ and others, whose findings are a firm base for a project like the present study.

MICROSCOPIC EXAMINATION

Under black-field examination in the stereomicroscope evidence of a colour modified by irradiation treatment was present in number 11, under the form of curved, darker thin lines around the culet. ("Cloverleaf" or "umbrella" pattern) Fig. 7. This feature is well known in gemmology as being typical; in the present case, however, the pattern partly had a doubled outline consisting of two thin, more or less parallel, lines. Does this mean that the stone had been submitted twice to the irradiation, the first one having failed to result in the desired shade? The question is open.

Among other features observed under the microscope, the green spots of number 21 have already been described. As to the

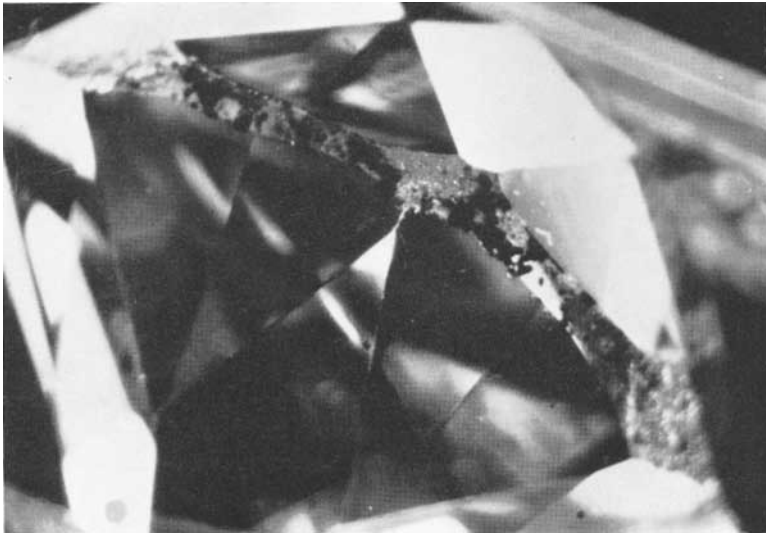


FIG. 7. *Positive signs of irradiation: curved line, partly double, around the culet of the stone, known as "cloverleaf" or "umbrella" pattern. Magn. $\times 50$.*

general quality of the cut, the diamonds were generally somewhat irregular; some were in the old full-cut style with numerous breaks and small cleavages at the girdle, due to rapid bruting. The number 19 had strong, coloured uneven alternate zones of brown colour, as marked as the growth zoning met with often in corundums.

In the numbers 1, 7, 15, 20, under $\times 70$ magnification, thin particles of carbonized matter have been observed in the numerous small cracks open to the surface of the stones. The fact suggests the possibility of a heat treatment taking place after cutting, as practised with the stones, whose colour has been modified by irradiation.

X-RAY FLUORESCENCE AND PHOSPHORESCENCE

Reference is made to the results appearing in the table. The X-ray unit used is a Siemens unit, with a molybdenum anode, working under a maximum of 60 KV/17mA. The diamonds were placed in the parallel beam usually used for pearl diffraction radiography. The response was judged by the eye, the tenuity of the reactions involved necessitating a good eye adaptation. Consequently, the test is carried out in darkness.

ULTRAVIOLET RADIATION FLUORESCENCE

Under the action of an invisible radiation of a wavelength lying beyond the violet, some substances react by emitting a radiance of a visible, longer wavelength called fluorescence. When the radiance subsists some time after the primary radiation has been shut off, the phenomenon is called phosphorescence. The relative intensity and the colour of these reactions are often typical, and are an important diagnostic element in the identification of gemstones.

Many of the ultra-violet lamps on the market use as an ultra-violet source two of the principal emission lines of mercury vapour called:

Short wave, UV radiation 2537Å

Long wave, UV radiation 3650Å.

The lamp used for this examination is an "Uvanalys" model of German make. The discharge tubes are enclosed in a fairly wide rectangular metal case, lined black inside, and made tight to external light. Opening on the sides permit the introduction of the specimen; windows allow for checking of the reactions. In this way, with the eyes close to the windows, even weak fluorescence is visible

without having to darken the room, being an advantage in the course of rapid investigation.

After the comprehensive experiences of Anderson and Payne, diamonds should be classified into three main groups, according to the colour of their ultraviolet fluorescence—:

Blue fluorescence Diamonds of the “Cape” series with absorption lines at 4780Å, 4650Å, 4520Å, 4350Å, 4230Å, and a fundamental line at 4155Å. Emission lines may be visible at 4650Å, 4520Å, 4390Å, 4285Å.

Green fluorescence Diamonds of the brown series with absorption lines at 5370Å, 5120Å, 5040Å, 4980Å, which may appear as emission lines, to the exception of 4980Å.

Yellow fluorescence Comprising the true “Canary” diamonds, without visible absorption lines at room temperature.

The classification is most helpful in interpreting the practical results gained in examination.

Spectroscopy conducted with the help of elaborate techniques (7) has made possible the discovery of two main systems of lines based on 4155Å, and on 5040Å, in the majority of the type I diamonds showing blue or green fluorescence and in type II diamonds with yellow fluorescence. These two lines seem to be the key positions around which a series of additional lines may appear in a mirror-like position, whether in absorption or in emission.

In the present instance, it has been possible to consider an irradiation treatment as the cause of the colour, when the features of the stones observed, that is, fluorescence, absorption lines, and body colour, did not agree with the generally known data typical of naturally coloured diamonds (see table).

TRANSPARENCY TO ULTRAVIOLET RADIATION

A most important diagnostic element in the identification of gemstones is the threshold of transparency to ultraviolet radiation. Usually, synthetics have a lower transparency limit as opposed to natural stones. With diamonds, the experience has shown that the feature of the majority of the type I diamonds are opaque below 3000Å and fluoresce under 3650Å UV radiation, whereas the transparency limit of type II diamonds is situated toward 2250Å and may show a weak fluorescence (7). Another important characteristic of the naturally blue diamonds is their good electric conductivity,

due possibly to the presence of aluminium in the crystalline lattice. For that reason, they have been classified in a separate category, according to Dr. J. Custers. Actually, in the light of today's knowledge, a blue non-conductor diamond can be considered as owing its coloration to irradiation. On the principle, the two blue diamonds numbers 20 and 21 have been checked as to their conductivity, using a Gübelin electro-conducting device, working on 220 volts. Both stones did not lead the current, in accordance with their other characteristics, thus proving to be "bombarded" stones.

Ultraviolet transparency to 2537Å can be checked in different ways, of which two simple methods are as follows:

(1) METHOD OF DIRECT PHOTOGRAPHY

In darkness, the stones are placed table down on a sheet of photographic paper immersed in a water-filled shallow dish, with just enough liquid to cover them. Samples of a known degree of transparency, such as an opaque material (natural beryl) and a transparent one (quartz) are placed beside the unknown stones. After a short exposure (about two seconds) to the shortwave lamp—resting at some distance above the basin—the developed photographic paper will be seen to have remained white under the opaque specimen and to have turned more or less grey, according to the degree of transparency of the others under test, or even black under the fully transparent stones.

(2) METHOD BY USE OF SCHEELITE

This mineral has the property of strongly fluorescing under shortwave radiation. As soon as a substance opaque to that radiation is placed between the scheelite and the lamp it will intercept the ultraviolet beam, and the fluorescence will cease. Therefore, it is possible to use an unknown substance as a filter and, from the reaction of the piece of scheelite, deduce if its transparency threshold lies above or below 2537Å. A simple way of proceeding is to enclose a scheelite sample in a small box impervious to light (an old cylindrical tin can used to store 10 meters of 35 mm film will suffice), the lid of which is pierced and accommodates different diaphragms, according to the shape and size of the stone being tested. The stone must lie well over the rim of the diaphragm to avoid the admittance of any stray light from the lamp placed above. The reaction of

the scheelite is observed through a lateral opening in the box. This test is to be made in darkness and precaution in the interpretation of the reactions observed is vital: prior to testing unknown stones, it is necessary to become acquainted with the strength of the reaction of known samples, as the fluorescence involved might be very tenuous. Furthermore, if the diaphragm chosen does not correctly accommodate the shape of the sample, diffused light may entirely distort the value of the test. Last but not least, some synthetics may fail to exhibit a normal transparency.

The 20 diamonds tested by this method all showed opaque and it can therefore be deduced that they all belong to type I ; in other words, that there are no naturally blue ones amongst them.

CONCLUSION

The series of tests conducted on the 20 diamonds has led to the following results:

in 11 stones positive signs of artificially induced colour were observed

in 3 stones clues to artificially induced colour were observed

in 6 stones no signs of artificially induced colour were observed.

Within the limits of the investigation methods used and based on present knowledge, their colour can be considered as being of natural origin.

The present study confirms the mysterious nature of the diamond and the oddness of some of its characters. Thanks to the efforts of numerous workers in the study of spectral features, statistics have made it possible to correlate groups of absorption lines with the fluorescence and the body colour. Some of these elements may appear today as anomalies: however, they certainly belong to the logical and coherent laws ruling natural phenomena. It is hoped that development of the science allows the puzzle to be completed, thus bringing to light the fundamental principles presiding over the appearance changes of these glittering marvels called diamonds. On the practical level of the jeweller, these mysteries result in difficulty in ascertaining the origin of the colour. Nevertheless, numerous experiments and comparisons make it possible for some points of the uncertainty to be slowly enlightened. It is hoped that the included statistical table might be helpful to the gemmologist having to cope with such problems or, more generally, taking interest in new experiments.

OBSERVATIONS ON COLOURED DIAMONDS

Stone No.	Weight ct	Colour	X-ray fluorescence	X-ray phosphoresc.	UV fluoresc. 3650Å	UV transparency to 2537Å	Spectroscope	Microscope	Identity
1	0.33	bright yellow "Jonquil"	inert	inert	inert	opaque	4930Å faint, elusive ~4510 vague 4300 cut-off	Remains of carbonized material at the surface	Clues of natural colour
2	0.90	straw-yellow	weak bluish-green	inert	medium green	opaque	5940Å elusive 5040 distinct 4980 distinct 4850 faint 4780 faint 4650 faint 4155 strong ~4015 distinct		Induced colour, treated stone with "Cape" spectrum
4	1.02	straw-yellow medium intensity	inert	inert	weak yellowish	opaque	5940Å very faint 5040 distinct 4980 distinct 4850 faint 4780 faint 4650 } broad 4510 } 4155 stark 4015 distinct		Induced colour
6	0.27	pale brownish-yellow	inert	inert	strong orangy	opaque	emission lines 6400 through copper sulphate solution 5750 distinct 4980 elusive 4300 cut-off		Clues of natural colour

OBSERVATIONS ON COLOURED DIAMONDS

Stone No.	Weight ct	Colour	X-ray fluorescence	X-ray phosphoresc.	UV fluoresc. 3650Å	UV transparency to 2537Å	Spectroscope	Microscope	Identity
7	0.65	pale yellow	weak	very faint	medium yellow-green	opaque	6400Å-6000Å some 5940 faint 5040 faint, sharp 4980 faint, sharp ~4870 faint 4780 faint 4155 strong ~4200 cut-off	Bearded girdle with cracks filled with brownish carbonized material Magn. 70 ×	Induced colour
9	0.85	medium yellow	weak bluish	inert	strong yellowish-green	opaque	5940Å very faint 5040 faint 4980 faint 4780 distinct 4620 } broad, 4500 } faint 4155 strong, broad		Treated, induced colour
10	0.42	pale yellow-green	weak bluish	inert	very strong greenish	opaque	5040Å distinct stronger 4980 distinct		Induced colour
11	0.87	golden-yellow	faint	inert	distinct yellowish	opaque	5940Å distinct * 5040 distinct * 4980 distinct 4850 faint 4780 distinct 4640 } broad faint 4500 } 4155 strong, sharp	"Cloverleaf" pattern around culet	Induced colour

* these 2 lines of equivalent strength

OBSERVATIONS ON COLOURED DIAMONDS

Stone No.	Weight ct	Colour	X-ray fluorescence	X-ray phosphoresc.	UV fluoresc. 3650Å	UV transparency to 2537Å	Spectroscopic	Microscope	Identity
14	0.24	deep golden-brown yellow	inert	inert	inert	opaque	5040Å very faint 4550 cut-off		Natural colour because of 5040 line and no green fluorescence
15	0.55	deep orangy-brown	weak	very faint short	inert	opaque	5940Å marked to strong 5040 ~4500 cut-off	Carbonized material inside cracks	Induced colour
16	0.80	deep orange	inert	inert	inert	opaque	5940Å distinct to marked faint * 5680 * 5040 distinct * 4980 distinct ~5000 cut-off 6200-5900 stone passes some orange under copper sulphate solution		Induced colour
17	0.21	medium brown (tea-colour)	inert	inert	faint yellowish	opaque	* 5040Å faint * 4980 faint 4200 cut-off	Many cracks and breaks	Clues of natural colour

* these 2 lines of equivalent strength

OBSERVATIONS ON COLOURED DIAMONDS

Stone No.	Weight ct	Colour	X-ray fluorescence	X-ray phosphoresc.	UV fluoresc. 3650Å	UV transparency to 2537Å	Spectroscope	Microscope	Identity
18	0.42	medium yellow (greenish hue)	distinct bluish	inert	strong yellow	opaque	<p>~5370Å distinct sharp</p> <p>5040 distinct stronger than</p> <p>4980 distinct woolly</p> <p>4850 vague</p> <p>4600 vague broad</p> <p>4155 faint sharp</p> <p>6200-6000 stone passes some orange under copper sulphate solution</p>		Clues of natural colour
19	0.24	medium brown	weak	inert	faint yellowish	opaque	<p>5040Å diffuse weak</p> <p>4980 diffuse weak</p> <p>4780 diffuse weak</p> <p>4650 diffuse weak</p> <p>4200 cut-off</p> <p>stone passes some orange under copper sulphate solution</p>	marked parallel colour zoning	Clues of natural colour

OBSERVATIONS ON COLOURED DIAMONDS

Stone No.	Weight ct	Colour	X-ray fluorescence	X-ray phosphoresc.	UV fluoresc. 3650Å	UV transparency to 2537Å	Spectroscope	Microscope	Identity
20	0.38	very pale blue	distinct bluish	inert	distinct bluish-green	opaque	4980Å very weak diffuse 4620 } weak diffuse 4600 } 4500 } vague 4155 } distinct to strong	Many cracks with carbonized material	Induced colour Stone does not transmit electric current
21	0.75	steel-blue	weak	inert	inert	opaque	4780Å faint 4155 strong 4000 cut-off	old cut dark green, round spots 0.03 mm deep: on the table angle around the girdle.	Induced colour Stone does not transmit electric current Not radium treated: negative test after 5 days exposure on X-ray film sheet
22	1.04	pale water-green	marked bluish	inert	marked yellowish-green	opaque	* 5040Å faint * 4980 faint 4155 strong— Cape line		Clues of induced colour
23	0.86	pale green	distinct bluish-green	inert	distinct bluish	opaque	4780Å distinct broad 4650 weak 4510 weak 4155 strong broad		Clues of induced colour Colour does not coincide with Cape lines

* these 2 lines of equivalent strength

OBSERVATIONS ON COLOURED DIAMONDS

Stone No.	Weight ct	Colour	X-ray fluorescence	X-ray phosphoresc.	UV fluoresc. 3650Å	UV transparency to 2537Å	Spectroscope	Microscope	Identity
24	1.00	pale water-green	faint	inert	inert	opaque	* 5040Å faint * 4980 faint 4780 distinct 4650 faint 4520 faint 4155 strong broad		Clues of induced colour Colour does not coincide with Cape lines
25	0.87	medium to dark moss-green	weak	inert	faint yellowish stronger on culet side, darker rim around girdle; weak yellowish phosphorescence	opaque distinct yellowish phosphorescence	near 7000Å lines partly faint (cited by Dugdale) 6700 faint 6200 weak large 5040 very strong ~4980 thin sharp 4820 distinct 4780 distinct 4650 weak 4200 cut-off		Induced colour Line 5040 is very much stronger than 4970, in contradiction to the rule given by Liddicoat for treated stones

* these 2 lines of equivalent strength

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Photographs by the author.

SYNGENETIC MINERAL INCLUSIONS IN DIAMOND AS IDENTIFIED BY X-RAY ANALYSIS

Summary of a Paper by J. HARRIS of University College, London, in the "Industrial Diamond Review"

THE inclusion of foreign minerals in diamond crystals is of peculiar interest in view of the mystery surrounding the conditions under which diamond was formed in nature.

Even in the 19th century several workers had described some of the more striking of these inclusions and made more or less plausible guesses as to their identity, and in several of the books on diamond published in the present century resumés of diamond inclusion investigations are given in varying degrees of detail, for instance, in Spencer's translation of Bauer in 1904, in Crookes (1909), Catelle (1911), Escard (1914), and Wagner (1914).

One of the more informed workers was Sutton, who actually worked in the diamond fields for many years and published his observations in his book "Diamonds, a Descriptive Treatise", in 1920. Most of these investigators used the microscope as their main means of identification, relying chiefly on the form and colour of the enclosed minerals, due consideration being given to the types of mineral most likely to be found accompanying diamond in the basic rocks in which, presumably, it had its birth.

By the early 1930's, calcite, iron pyrite, diopside, magnetite, pyrope, olivine and graphite had probably been correctly identified in diamond by various workers. In 1948 and in 1952 Gübelin published extensive observations on diamond inclusions, accompanied by numerous photomicrographs, and the work was carried on by Eppler, who found it possible after crushing suitable industrial rough, to isolate some of the included particles, enabling closer microscopic investigation to be carried out, including determinations of refractive index. By such methods Eppler claimed apatite and ilmenite as diamond inclusions for the first time.

There are, however, limitations to these purely optical methods, and even an accurate refractive index value may not prove conclusive. The figure 1.6585 found by Eppler as average for his apatite particles, for instance, corresponds almost exactly with the average value of 1.652 for forsterite olivine.



PLATE I. *Isometric garnet inclusion* ($\times 64$).

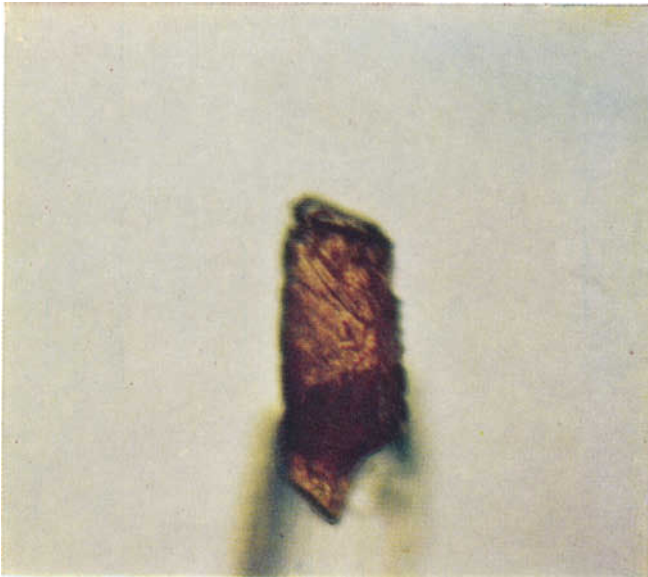


PLATE II. *Etched elongated rutile crystal extracted from a diamond* ($\times 80$).

As incidental to a general investigation of diamond a fresh approach to these problems of identification was made in the first place by Mitchell and Giardini (1953) in the U.S.A., who applied the powerful techniques of x-ray diffraction to establish the species of a number of elongated crystals of olivine which were noted in diamond "flats". These crystals were lying parallel to the (111) planes and elongated along the (101) direction of the diamond. Both x-ray rotation photographs and x-ray patterns from a single crystal, superimposed on the diamond patterns, were obtained, and the diagnosis was beyond doubt.

Since that time Russian workers have undertaken a systematic investigation of inclusions in diamond by x-ray methods, and have definitely identified chrome spinel, diamond, diopside, enstatite, graphite, iron hydroxide, olivine, pyrope garnet, and serpentine. In 1961, Milledge of University College was able to establish coesite (a high pressure polymorph of silica) as a rare inclusion in diamond. In 1966 Sharp found by x-ray powder photography that large dark regions in South African diamonds were sulphide ore minerals such as pyrrhotite, pentlandite and pyrite. The latter, however, was not considered to be a syngenetic inclusion.

During the present course of x-ray diffraction studies at University College, which is still in progress, 22 mineral species have been positively identified in diamonds from Southern Africa, Sierra Leone and Ghana. Six of these had not previously been identified by x-ray techniques, and a further three are completely new as diamond inclusions. The inclusions discussed and illustrated in this part of the paper are confined to the so-called syngenetic mineral inclusions; that is, those which are formed contemporaneously with the diamond. The other types of inclusion, not dealt with here, are known as epigenetic mineral inclusions, which are those which have formed subsequently to the formation of the diamond.

A syngenetic mineral must of necessity be one which is associated with the rocks such as peridotites, eclogites, etc., which made up the original environment when the diamonds were being formed. The mineral must also be known to have a stable phase at temperatures and pressures envisaged for the crystallization of diamond.

The illustrations show examples of well-developed syngenetic inclusions in diamond, the magnification of each being noted in

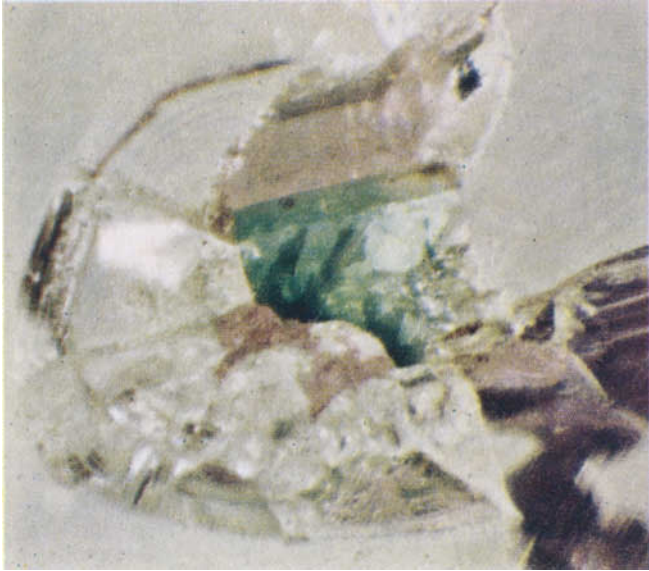


PLATE III. *Diopside inclusion* ($\times 14$).



PLATE IV. *Isometric well-faceted magnetite inclusions* ($\times 64$).

brackets. The photograph in Plate VI depicts one of three diamonds in which a dense white cloud of particles was observed; these being less than three microns in diameter. The shape of the cloud is here rectangular, but may be more rounded in other cases. Only a single line was seen in an x-ray powder photograph, but this at least indicated that the material is crystalline. So far this type of inclusion has been found only in Type I diamonds.

Single crystal syngenetic mineral inclusions vary from less than 0.05 to a maximum of 0.4 mm, and one of the main guides to their nature is their colour. Inclusions of *diamond* itself are usually difficult to see because of the similarity of their refractive index with that of the host mineral, unless the included crystal is "coated" by some other substance. Most included diamonds have an octahedral habit and show no strain birefringence, neither is there any internal fracturing or strain surrounding such inclusions.

Of the two specimens found to contain *coesite* inclusions, one showed a well-formed crystal, the other had multiple inclusions which together gave the coesite x-ray pattern. *Olivine* is the commonest inclusion in diamond, and is usually seen as colourless or faintly green crystals; sometimes well-formed, sometimes irregular in outline. *Enstatite* is a rarer inclusion, and usually a transparent faint green. It is virtually impossible to distinguish between olivine and enstatite inclusions except by x-ray analysis.

Garnet inclusions range from transparent deep red purples to light orange; some having a colour similar to topaz and zircon for which they have probably been mistaken by some workers. Garnet inclusions are commonly well-formed and isotropic. Three *rutile* inclusions found during this study were reddish to medium brown in colour: one of these was transparent and showed straight extinction. Opaque rutile is likely to be confused with goethite. *Diopside* inclusions are either a dull opaque green or transparent emerald green: the colour here forming a useful characteristic.

Magnetite inclusions are black and opaque, either lath-shaped or in long, irregular masses. So far, no octahedral crystals of magnetite have been observed. In very small diamonds (less than $\frac{1}{2}$ mm in size) the whole diamond may become attracted by a magnetic field when these inclusions are present. Irregularly shaped magnetite inclusions may easily be mistaken for graphite,

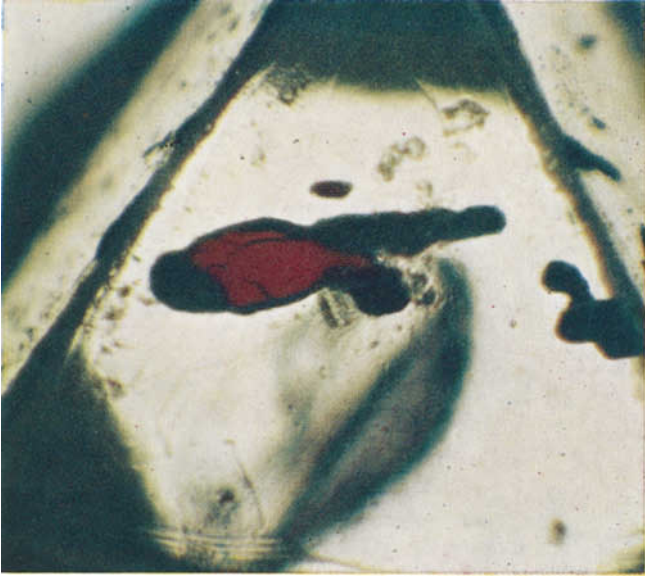


PLATE V. *Globular shaped chrome-spinel inclusion (×14).*

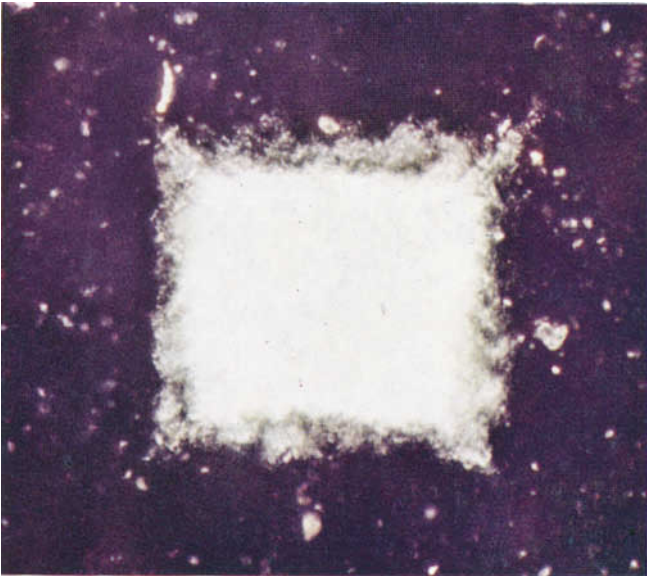


PLATE VI. *Dense white cloud-like inclusion of unknown composition.*

and discrete crystals for chrome spinel. *Ilmenite*, though common in exposed holes on the diamond surface, is extremely rare as an actual inclusion. Chrome spinel can perhaps be characterized by the deep cherry-red colour of these opaque crystals, though these may appear black in larger pieces, and then be confused with magnetite or graphite. Chrome spinel occurs commonly in dumb-bell shaped or rod-like specimens. These were found in diamond from Sierra Leone and Ghana, but doubtfully from South Africa.

Most diamond crystals exhibit internal strain when examined between crossed polars at points which can usually be seen to centre on to an inclusion; and sometimes the strain may be great enough to cause a fracture.

B.W.A

The Association is indebted to the "Industrial Diamond Review" for the coloured illustrations.

INSIGHT

By A. E. FARN

IT has been mooted among people in the jewellery trade that there are two kinds of gemmologist. The one, shall we say, the front-line troops who absorb the assaults of the gem-querying customer. The other, the support troops, who furnish the ammunition to them in the guise of theoretical and practical explanations.

It is said that the late Harry Truman, when President of the United States of America, had on his desk a notice which indicated "the buck stops here". Likewise, we in the laboratory of the London Chamber of Commerce feel the same way about jewellery tests. Provided the item is jewellery in the broad sense—we should be able to furnish the answer. We are not magic, we are almost human, we have certain skills which predominate and between the useful combination of experience, skill, training, aptitude, comparison stones, notes, books and stored-up knowledge, we come to a decision on most items.

Even to a modest expert or the shyest gemmologist there sometimes comes a moment of sheer amazement when, showing proudly a very rare or unusual piece to one's friends, acquaintance or family, they turn round and say is it rhodochrosite or is it an aximite? Just as guileless as that. In my early and possibly more enthusiastic days I bought a necklace of rhodonite beads—I had passed my diploma about six months previously and felt very proud of myself on spotting these beads on a street market stall. I showed them proudly to my wife who said, "Are they rhodonite?" She had helped me with my swotting, so maybe it was feminine insight!

For sheer feminine insight though I think one of the young lady workers in the office of the N.A.G. wants some beating (metaphorically). In the course of routine business we do all kinds of tests on all kinds of jewellery for the N.A.G. and the G.A. We are never very surprised at what we receive or what we are asked to do. Among quite an interesting assortment of stone elephants, jade figures, and similar items, was a box which contained a vanity case to test. We presumed by the outward appearance of the article that it was tortoiseshell or plastic imitation. Since it was very badly damaged we felt it must be a question of insurance replacement. So

we set to work to prove the material. The lid gave a very good distant vision reading of 1.54 and an examination by microscope of the darker portions of the mottling did not reveal the multitudinous discs described in Webster's compendium. The markings of brown/black and yellow in the mottling were also too sharp in their delineation. The conclusive test came about because the item was badly damaged. Working upon the theory that a little more wouldn't do any harm, we heated to red heat a very special hat pin we keep for such delicate tasks, placed it against an inconspicuous portion of a fracture surface and sniffed. Who hasn't smelt burnt milk on a saucepan? Well here was a golden opportunity to refresh ones olfactory senses. When casein—a plastic product with a density of 1.33 and refractive index 1.55—is burned it gives a smell like burned milk—which, since casein is a milk product, is not surprising. Hence the vanity case was casein—a plastic. What really intrigued me though were the instructions on the wrapper of the box containing the vanity case, which were: "Please test case in box". Did the young lady really separate out casein to make it "case in box" or was it feminine insight again?

Gemmological Abstracts

POUGH (F. H.). *The Jacobina amethyst mine in Brazil*. Lapidary Journ., 1969, 22, 10, p. 1306.

Most of the crystals found at Jacobina are a good rich violet colour. Hard-rock digging techniques are used, as the mine lies in solid rock. It is privately owned.

S.P.

EULITZ (W. R.). *The optics of brilliant-cut diamonds*. Gems and Gemology, 1968, XII, 9, pp. 263-271, 5 illus.

This article, as the title infers, deals with the proportions of diamond, and is a continuation, if that word can be used, of the work of Roesch, Eppler, Kluppelberg and Grodzinski. The treatment is mainly mathematical.

R.W.

GUNN (C. B.). *A descriptive catalog of the Drift diamonds of the Great Lakes region, North America*. Gems and Gemology, 1968, XII, 10 & 11, pp. 297-303 and 333-334, 1 map.

A list of the known diamonds found in the Great Lakes region, a "potted history" being given with each stone recorded. This list of stones was originally part of a research on the vexed question of the original source of North American diamonds.

R.W.

McKAGUE (H. L.). *The serpentine mineral group*. Gems and Gemology, 1968, XII, 11, pp. 326-332 and 356, 6 illus.

A concise article on the serpentines. The text mainly treats with the mineralogical and petrographical aspects rather than those more useful to the gemmologist. The term "Yu-Yen Stone", ascribed to Faust and Fahey, is not a term current in gemmological literature.

R.W.

ANDERSON (B. W.). *The first two taaffeites: an historical note.* Gems and Gemology, 1968, XII, 9, pp. 259-262.

Gives an account, from personal knowledge, of the finding of the first taaffeite by the late Count Taaffe during 1945. The characters of the mineral are given.

R.W.

LIDDICOAT (R. T.). *Developments and highlights at the Gem Trade Laboratory in Los Angeles.* Gems and Gemology, 1968, XII, 9, 10 & 11, pp. 281-288; 311-320; 344-352, 64 illus.

In these reports notes are given on the effect of dust on tourmaline, an emerald with a subsidiary crystal protruding from the unpolished girdle, and an unusual hematite intaglio, which had the surface sand-blasted to give it a roughened effect. Unusual opal doublets and a doublet consisting of a synthetic sapphire cabochon top cemented to a synthetic spinel base are mentioned. By x-ray powder photograph and chemical analysis a pink mineral was identified as benitoite but no information is given as to whether the stone was transparent and suitable for use as a gemstone. Other items were interesting inclusions seen in a chalcedony and extraordinary features in a diamond. There is a discussion on green-coloured yttrium aluminium garnets grown synthetically. The result of x-ray and isotope irradiation of kunzite andmorganite is mentioned. Trapiche emeralds are again referred to, and so is another pendeloque-shaped diamond with a double culet. Among other unusual pieces examined were a possible fake amber containing a spider, a carved statuette in banded serpentine, a cut cuprite and an andesine-labradorite cat's-eye. A new source of peridot from North Carolina and emerald from Zambia are reported.

R.W.

CROWNSHIELD (R.). *Developments and highlights at the Gem Trade Laboratory in New York.* Gems and Gemology, 1968, XII, 9, 10 & 11, pp. 277-280; 304-310; 335-343, 52 illus.

This laboratory has examined several blue zoisite crystals, one of which weighed more than 1100 carats. The problem of the identification of dyed lapis-lazuli may be got over, it is suggested, by using a swab moistened with finger-nail polish remover which

colours if dye be present. The waxing of lapis-lazuli is also mentioned. An interesting item was a specimen of "Yunnan jadeite" which showed red through the colour filter although it was not dyed. There is a good report on a radium-treated diamond which recorded a radioactivity of 40 milliroentgens per hour. Recorded also were a synthetic blue spinel, which did not show red through the filter, unusual diamond inclusions, a doublet of blue synthetic spinel cemented onto a base of natural star-sapphire, a plastic-coated beryl and an imitation turquoise which revealed itself by turning yellow a spot of hydrochloric acid placed upon it. Intaglios of glass cemented to a base of chalcedony, trapiche emeralds and many varieties of composite stones are recorded. The inclusions seen in transparent green grossular, quartz and tanzanite are mentioned. The testing of a snuff bottle which was probably made of horn is discussed, as well as an unusual synthetic emerald which had a density of 2.73 and indices of refraction of 1.565-1.570. It had odd inclusions which fluoresced yellow and others of the typical veil-like synthetic type. Diamonds with rubbed facet edges, a large "portrait" diamond and a double culet effect seen in a pendeloque-shaped diamond are noted. The question of synthetic and natural brown scheelite is discussed and the absorption spectra of various synthetic scheelites are illustrated. Doublets formed of a crown of synthetic white spinel and a base of strontium titanate, are said to be fused together, but examination seems to show that a modern hard cement may have been used.

R.W.

KAGAYA (B). *Application of goniometry to gemmology*. Journ. Mining Coll., Akita Univ., Ser. A, Vol. V, No. 3, 1-21, 13 figs., 1968.

A method has been developed for the characterization and identification of individual cut diamonds by two-circle goniometry. The angular coordinates of the facets of cut stones are measured to 0.01'. The author has measured 62 diamonds of over 1 carat and considers that goniometric measurement for cut stones is as useful as the fingerprint method for individual people. Assuming the limit of the longitude and latitude of each of the 32 facets $\pm 3^\circ$ and an allowable error of the value of each facet $\pm 3'$ (including personal and instrumental errors), the probability of the occurrence of equal goniometrical data is calculated to be 9.58×10^{41} .

R.A.H.

SMITH (J. V.) & RIBBE (P. H.). *Atomic movements in plagioclase feldspars: kinetic interpretation*. Contrib.Min.Petr., Vol. 21, No. 2, pp. 157-202, 1969.

An advanced structural interpretation of the plagioclases is presented in which the delicate iridescence of peristerite and the labradorescence of plagioclases of intermediate composition are explained in terms of the diffraction of light from alternate lamellae of slightly different structural type. Labradorescence is found in intermediate plagioclases relatively rich in potassium and the lamellae represent segregation of alternate bands richer in sodium and potassium than their neighbours. R.A.H.

BARTOSHINSKIY (Z. V.). *Some features of diamonds from placers in the northeast Siberian platform*. Geol. and Geophys., Acad. Nauk SSSR (Siberian Branch), 1967, No. 3, 60-67 (in Russian; English summary p. 146).

The crystal habit, colour, transparency, photoluminescence, and degree of fragmentation of diamonds from placer deposits of the northeast Siberian platform have been statistically tabulated, and are compared with one another and with diamonds of the Yakutian fields to the south. Rounded crystals and crystals with hackly striations predominate in the northeast Siberian fields, and there is less variation in crystal morphology than in Yakutia. Coloured diamonds are more common in the northeast Siberian fields, with brown and yellow tints predominant. Non-luminescent diamonds predominate, but crystals with blue luminescence are relatively abundant. The degree of crystal fragmentation varies widely among the diamond fields studied, and is attributed to brecciation during emplacement of the source pipes. R.A.H.

BOOK REVIEWS

SUTHERLAND (C. V.). *Gold: Its beauty, power and allure*. Thames & Hudon, London, 1969 (third and revised edition). £2 10s.

Dr. Sutherland's revised and enlarged edition of his classic work is compulsive reading for all who are fascinated by the use of gold down the ages, whether for jewellery, coinage or industry. The effect of gold in the monetary world of today is dealt with in an expanded last chapter, which speculates on its future in a world of credit currency. S.P.

HURLBUT (CORNELIUS S.). *Minerals and man*. Thames & Hudson, London, 1969. £5 5s.

During the past five years various books on minerals and gemstones have been produced, most of which can best be described as "picture books". Professor Hurlbut's "Minerals and man" can, perhaps, be classed as a "picture book", but a "picture book" with a difference, for the text is detailed and entertainingly written and the colour plates are superb.

The book contains 19 chapters commencing with "Minerals and how to know them", a chapter which gives an excellent description of the elements of crystallography and the physical properties of minerals. This is followed by chapters on "Early use of minerals", "The earth and its rocks", "Minor minerals of the rocks", and "Nature's treasure house", a chapter which deals with the pegmatite rocks.

There are chapters in which the minerals and their formations are well described. Minerals which fluoresce in ultra-violet light are given a chapter on their own.

Chapters which concern the gemmologist most are "Minerals of the precious stones", "Quartz", and "Coloured stones and ornamental minerals". Then follows "Minerals for atomic energy", a chapter of modern interest; and the penultimate chapter, "The mines and minerals of Cornwall", is so well covered by this American writer that it can only be supposed that the author spent some time in the Duchy and enjoyed his stay and was intrigued by its history. The final chapter, "An incombustible fabric and a stone that burns", deals with the asbestos minerals and sulphur. The volume is completed by an appendix consisting of a table of the properties of some common minerals, which is more comprehensive than one might expect, but which does not give any optical properties. There is a very full index.

The reviewer finds the text adequate and written with that personal touch which makes so much difference to the ease of reading and, with the beautiful pictures, a real understanding of minerals. There are, however, a few minor points which merit discussion. They mainly devolve upon the fact that a mineralogist, as a rule, does not completely understand the modern conception of gemmological nomenclature, and for the benefit of future editions they may be referred to here.

The terms "hyacinth" and "jacinth", which in earlier times have been used indiscriminately for both zircon and hessonite garnet, are not now current; nor is "chrysolite" now a permitted name, for it has been used for many different species of gemstones in the past. The term "pigeon's-blood" as a colour for ruby, and the prefix "oriental" for colours of corundum common to stones of other species are outmoded terms and should not be perpetuated.

The most common alexandrite simulant is not synthetic spinel but synthetic corundum, which *is* coloured by vanadium, whereas the much less common synthetic spinel appears to owe its changing colour to traces of cobalt and chromium. That amethyst turns colourless at 450°C and yellow at 550°C is not strictly true as experiments by G. O. Wild have shown. It is doubtful whether Blue John can strictly be termed fibrous, and is there a black pyrope garnet? Mention could have been made of the important source of sphene in Baja California, and Macon Co., the source of rhodolite garnet, is in North Carolina, not in Georgia.

Some of the values of density given in the appendix table call for amendment, the most important being the value for lazurite (lapis-lazuli). The value of 2.4-2.45, as given, is probably correct for pure grains, but the ornamental lapis-lazuli is a rock and, as pointed out by B. W. Anderson, the density for the ornamental lapis-lazuli is about 2.8. The density of olivine given both in the table on page 41 and in the appendix table as 3.27-4.37 should be 3.27-3.37. 3.51 for the density of pyrope garnet is too low—it should be, to be more realistic, 3.65. Corundum has a better mean at 3.99, and better values for zircon would be 4.00 to 4.68, in order to cover the metamict low type. The values for beryl need revising for much emerald has a density of 2.69 to 2.71. A better range for beryl would be 2.7 to 2.9, which would cover the higher density of the caesium-rich beryls. Further, 2.2 is too low a value for serpentine, for most of the ornamental serpentines have a density near 2.6.

Despite these minor criticisms "Minerals and man" makes a very fine volume and is a book that can be recommended for popular reading as it gives such interesting insights into minerals and their uses.

R.W.

TOLANSKY (S.). *The strategic diamond*. Oliver & Boyd, Edinburgh, 1968, 119 pp. 7s. 6d.

This is a paper-back in the "Contemporary Science" series of the publishers. Professor Tolansky has written in the style of his established *History and use of diamond* and his book gives a popular account of diamond and its technological uses. A chapter on diamond grits, a favourite subject of the author, is of interest to industry. A useful addition to the literature on diamond, presenting known information in a fascinating way.

S.P.

THEISEN (V.). *Diamanten-Fibel*. Diamond Handbook 1968. Printed in Germany. DM 28.50.

A very well produced book on the determination of the quality of cut diamonds with 300 illustrations, many of them excellent microphotographs. There are tables of weights for the various cuts and formulae are given to determine the weight loss when re-cutting old or damaged brilliant-cut stones.

The chapters dealing with cut and purity are well set out and should prove to be useful to students as well as jewellers, especially the photographs showing the differences between, say, VVS and VS or between first and second piqué, although one could perhaps argue about one or two small points. Of special value is the confrontation of photographs with excellent drawings showing clearly the inclusions or defects under discussion. The illustrations naturally are originally photomicrographs or macrographs. Inspection under the Gemolite, for instance, at $10\times$ magnification is more critical than under a $10\times$ loupe, which is the recognized method in the trade. Any other method which tends to enlarge the importance of the smallest natural inclusion should be discouraged.

The chapter dealing with the colour grading suffers from the fact that the book is produced in black and white only, although of course, reasonable colour prints would be expensive and most difficult to reproduce. The way to determine the colour is perhaps not quite adequately described; one really should look at the stone from all angles and certainly along the girdle plane. The chapter on colour is difficult to use because references to different shades of grey and black do not convey very much.

For a jeweller with an understanding of German the book would be an excellent addition to his library.

W.S.

MUNSURI (A. SANTOS). *La Esmeralda*. Instituto Gemologico Español, Madrid. Limited edition 4,000 numbered copies. 63s.

A monograph on emerald, in Spanish, produced on good quality paper, but rather inadequately bound between limp covers. 72 colour plates which are, for the most part, excellent.

The author has devoted the first five chapters to classical references, superstitions and famous historical emeralds. A second part deals with the many sources of the gem in some imaginative detail and includes some places which are not known to produce gem quality material and others where different minerals, such as tourmaline and hiddenite, have been mistaken for emerald. Although the book professes to deal with such other minerals, the reviewer feels that their inclusion among sources of emerald is misleading.

The third section of the book deals with technical (gemmological) details. A coloured schematic representation of the chemical composition contributes little and could be mistaken for an atomic lattice. The few illustrations of absorption spectra are not always accurate. Tables of constants are a little erratic in that there is no attempt to give refractive indices in the same order every time. Chemical formulae are quoted in reverse to the usual order, e.g. $(\text{SiO}_2)_6 \text{Al}_2\text{O}_3 \text{BeO}$. Olivine (peridot) is listed as a uniaxial mineral.

Most of the illustrations are good and colour reproduction is acceptable. One obvious green aventurine quartz is labelled fuchsite mica and another, purporting to be hiddenite in pegmatite, looks much more like tourmaline in quartz. The illustrations of inclusions, all the work of the author, are particularly good and, for the most part easily interpreted.

This book is the first of a series planned on the major gems. As such its contribution could be limited by the language barrier, although Spanish is third among the major commercial languages of the world.

The single page of bibliography contains 10 or more spelling and other errors, including one in which the book has apparently written the authors. Other mis-spellings and misprints appear in the text. These occur easily where foreign names are set by type-setters unfamiliar with them, and careful proof reading is needed to eliminate such errors.

R.K.M.

YOUNG (S.). *The Queen's jewellery*. Michael Joseph, London, 1969. 35s. 120 illus (12 in colour).

A collection of photographs, with descriptions, of some of the favourite items from Her Majesty's personal jewellery. Diamonds form a considerable part, and sapphires and pearls are also favoured. In many instances the photographs show the Queen better than some of the jewellery.

S.P.

COMMON GEMS OF SAN DIEGO COUNTY, CALIFORNIA

By PAUL WILLARD JOHNSON

With photographs by the author

SAN DIEGO COUNTY is richly endowed with gem minerals. In the 4,258 square miles of the county more than 140 different minerals have reportedly been found. Here, the title "gem basket of the United States" is justly deserved, for no other U.S. county has the profusion, variety and quality of gems so represented within its boundaries. From the ocean on the west through the mountains in the middle to the desert on the east—San Diego County is unique in physiography.

The common gem minerals described herein, occur in pockets, or vugs, in granitic pegmatite dikes or bodies. No placer deposits of gemstones have ever been found in San Diego County. The gem mines are located in a central mountain belt trending from northwest to southeast across the county (Fig. 1). It is peculiar that the pegmatite districts closely coincide with the northwest to southeast

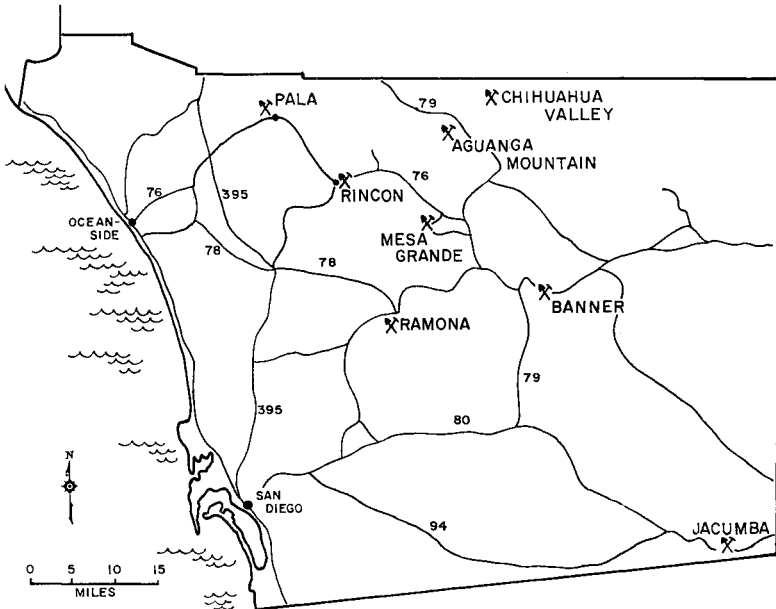


FIG. 1. Map of San Diego County, California showing the location of the main pegmatite gem mining districts.

trending fault zones. Most of the gem districts occupy areas of dense chaparral (low vegetation), composed mainly of greasewood (or chamise).

There are eight main pegmatite districts: Aguanga Mountain, Banner, Chihuahua Valley, Jacumba, Mesa Grande, Pala, Ramona and Rincon. These districts are indicated on the map. The two principal mining districts are Pala and Mesa Grande.

Lepidolite seems to be a valuable indicator mineral; without it there is very little chance of finding coloured gemstones. Lepidolite in the Pala district has been dated by John Earl using the rubidium-strontium method and found to be 106, plus or minus six million years old.

Matrix specimens in the past were usually discarded and ended up on the dump. They are currently very much in vogue and specimens of this type from San Diego County grace mineral collections throughout the world.

The most complete permanent collection of San Diego County gems and minerals, mainly a study collection, can be viewed at the San Diego Museum of Natural History in Balboa Park, San Diego, California. A small collection of specimens from the county can also be seen at the San Diego County Department of Agriculture at 5555 Overland Avenue, San Diego, California. During the summer the San Diego County Fair held at Del Mar, California, usually has an excellent collection of San Diego County minerals and gems.

HISTORICAL SKETCH

Local Indians had been collecting surface tourmaline from the Pala and Mesa Grande districts before white men arrived. In many Indian graves have been found green and pink tourmalines. The first discovery by white men of gems in San Diego County was in 1890, when Charles Russell Orcutt found pink tourmaline at what later became the Stewart mine at Pala (Figs. 2 and 3). This stimulated a local search for other gem deposits.

In 1892, 18 tons of lepidolite from the Stewart mine at Pala were shipped to New York for specimens of pink tourmaline sunbursts on lepidolite. The famous Himalaya mine, in the Mesa Grande district, was first opened in 1898. The Himalaya mine was first worked by C. R. Orcutt, and later by Gail Lewis and Fred J. Rynerson. The Mesa Grande district was most actively mined from 1902 to 1912.



FIG. 2. *Main entrance on the south side at the Stewart mine, Pala district, San Diego County, California. It was here that gemstones were first discovered in San Diego County. Because of the lilac-colour of the lepidolite (lithia mica) found here it was at first thought to be cinnabar, an ore of mercury. The large white area in the centre right is the mine dump.*



FIG. 3. *Open cut on north side at Stewart mine, Pala district, San Diego County, California. It is here that the compact lepidolite is shot through with pink tourmaline.*

Kunzite was first found at the Katerina mine on Hiriart Mountain, Pala district, in May 1902 by M. M. Sickler and his son Frederick M. Sickler. The mineral sicklerite was named for the son. In May 1903 the famous Pala Chief mine was opened on Chief Mountain in the Pala district.

The Rincon district was first prospected by John Mack in 1903 and was worked primarily from 1903 to 1910. The Ramona district was first discovered in 1903.

The fall of the Chinese dynasty, headed by the dowager Empress Tzu Hsi, in 1912 caused the market for pink tourmaline to dwindle to insignificance. Thus, the Himalaya mine was forced to close down. When the news arrived, the miners left in such a hurry they didn't even bother to remove their tools. Years later when the mine was reopened they found all the miners' equipment, just as it had been left, and open pockets of tourmaline.

Frank A. Salmons was an early developer in the Pala district. The mineral Salmons te was named in his honour.

Morganite, the pink cesium variety of beryl, was first found in the Pala district.

In 1947, George Ashley, known as a fine faceter of kunzite, bought all the mines on Hiriart Mountain in the Pala district. Presently, Norman E. Dawson of San Marcos, controls the Fargo, White Queen and Vanderburg mines on Hiriart Mountain.

Since 1914, gem mining in San Diego County has been on a small scale. Most of the gem mining at present is being done only by individuals or small groups.

PRODUCTION

From 1900 to 1914 about 90 per cent of the gem output of San Diego County was recorded. Over 90 per cent of the gem production has come from five mines: Himalaya and San Diego in the Mesa Grande district and the Pala Chief, Tourmaline Queen and Katerina in the Pala district. Over \$320,000 (£133,000) worth of gem minerals have been taken from the Pala district alone in the last 50 years. From 1898 to 1952 the Mesa Grande district produced over 244,850 pounds of tourmaline worth approximately \$779,700 (£325,000). The estimated market value of cut stones of the Mesa Grande district tourmaline from 1901 to 1912 is 2.7 million dollars (£1.1 million). The Himalaya has produced more tourmaline

(about 100 tons) than all the other mines in San Diego County combined. The total value of gem minerals (in the rough state) in the county has been at least 2.3 million dollars (£958,000).

PEGMATITES

The granitic pegmatite dikes or bodies originate in the north in Riverside County (where they were first found by Henry Hamilton in 1872 on Thomas Mountain)—pass through San Diego County and terminate on the Gulf of California about 350 miles south of the United States border in Baja California, Mexico. The pegmatites are underlain mainly by plutonic igneous rocks of the Southern California Batholith. This batholith is composed mostly of gabbro, tonalite, diorite, granodiorite and granite.

The common gem minerals discussed in this article are all pocket minerals and are found exclusively in the “pocket pegmatite” part of the dike, which usually varies in thickness from a few inches to about four feet. Pegmatite is a plutonic rock that is irregular in texture and usually very coarse grained. It is composed mainly of quartz and feldspar of the perthite variety, with minor amounts of mica and gem minerals.

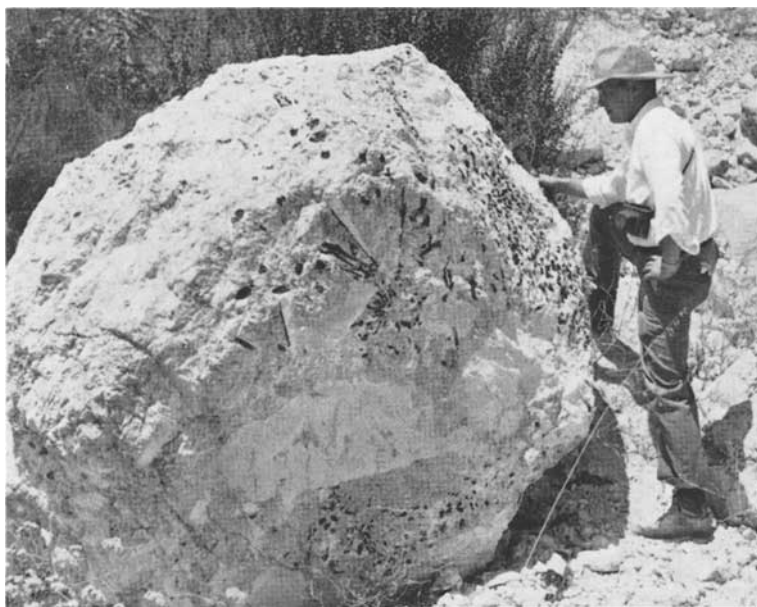


FIG. 4. Close-up of a large block of pegmatite at the north side open cut of the Stewart mine, Pala district, San Diego County, California. The black spots are black tourmaline.

Four zones of a complex pegmatite dike are frequently recognized: (1) border zones, or outermost zones, (2) wall zones, (3) intermediate zones, and (4) cores or innermost zones. Graphic granite is usually present in the border and wall zones. It is composed of a cuneiformlike pattern of quartz and feldspar. The intermediate zones, or line rock, are frequently a garnet-rich aplite. Zones of massive (bull) quartz can usually be found between the gem-bearing pegmatites and the surrounding country rock. "Pocket pegmatite" is customarily found in the cores of the dikes, and is composed mainly of quartz, albite and orthoclase with minor amounts of microcline, muscovite, lepidolite and black tourmaline. It is within the "pocket pegmatite" that the vugs and pockets of gemstones are found. A single pocket in the Mesa Grande district reportedly produced 1,500 pounds of tourmaline. The pockets are usually filled with a red clay composed mainly of the mineral montmorillonite. Most of the gems are encrusted with this pocket clay and must be cleaned to show their beauty. Sometimes in the mining operations pockets are encountered, in which the gem minerals are so friable they will crumble to pieces when touched.

Pegmatite dikes vary in thickness from less than an inch to 100 feet, and in length to about one-half mile. The productive Himalaya dike averages only four feet in thickness.

BERYL

Crystal description: Hexagonal system, hexagonal division; dihexagonal-dipyramidal class. In San Diego County it crystallizes in beautiful hexagonal prisms, some of which are vertically striated. Also equant to tabular. Faces of the second-order pyramid are commonly well-developed.

Physical properties: Colour; white, blue, yellow, green, and pink. Lustre: vitreous. Hardness: 7.5-8. Specific gravity: 2.63-2.80. Fracture: conchoidal to uneven. Cleavage: imperfect and indistinct. Uniaxial and optically negative. Transparent to sub-translucent. Tenacity: brittle. Not acted upon by acids, with the exception of hydrofluoric. Refractive index: $\omega = 1.568-1.602$ and $\epsilon = 1.564-1.595$.

Composition: $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$.

Beryllium aluminum silicate. Sodium, lithium and cesium may replace part of the beryllium, thus reducing the beryllium oxide content.



FIG. 5. Pegmatite dike at the Mack mine, Rincon district, San Diego County, California. The white area in the centre is the dike which is dipping 43 degrees southwest. This mine is noted for prisms of light-green beryl.

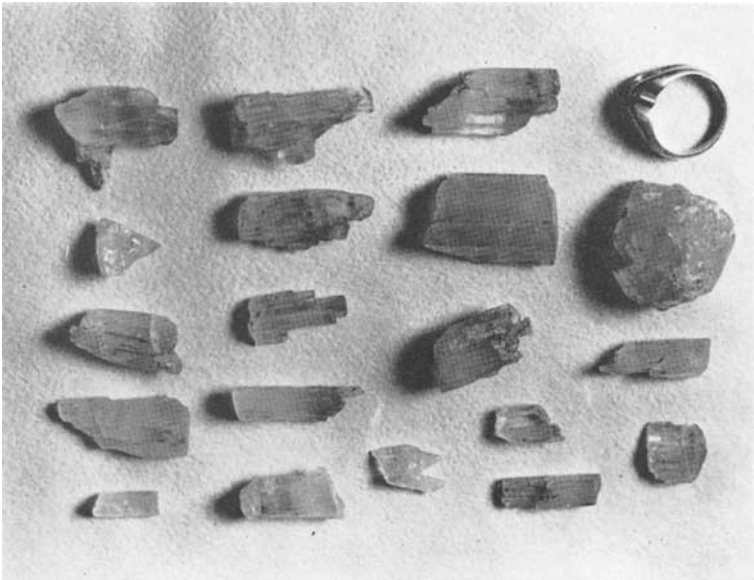


FIG. 6. Rough crystals of beryl mainly from the Emeralite Number Two mine on Aguanga Mountain, San Diego County, California. The specimen just below the ring (shown for scale) is morganite. All specimens shown are from the author's cabinet.

Varieties occurring in San Diego County:

Aquamarine—Bluish-green, blue, light green, yellow-green.

Golden beryl—Yellow. Goshenite—Colourless. Morganite

—Pink, pale rose to peach colour.

Occurrence: In San Diego County beryl has been found in the following districts: Aguanga Mountain, Jacumba, Mesa Grande, Pala, Ramona and Rincon.

Interesting facts: Beryl from San Diego County is associated with quartz, albite, lepidolite, potash feldspar, muscovite and tourmaline. Gem beryl in San Diego County occurs to about six inches in maximum dimensions, with an average of 2.5 inches or less. Non-gem beryls in the county get quite large. The author found one that weighs over 85 pounds. Some of the San Diego County beryls are tapered, probably due to the effects of corrosion.

Morganite beryl was named by Dr. George F. Kunz in honour of the banker John Pierpont Morgan. Morganite is rarer than emerald, although not as popular. Morganite seems to be more common than aquamarine in the county. Morganite and aquamarine usually occur as greatly compressed hexagonal prisms. Some of the prisms have side growths with flat terminations at different levels along the c-axis. Usually the county beryl has a flat basal termination, which sometimes has pyramidal faces developed. Some of the flat basal terminations have a negative cavity due to corrosion paralleling the c-axis. The Mack mine (Fig. 5) in the Rincon district, has produced some flawless light-green prisms of beryl. One beryl from Pala had an aquamarine centre with a morganite edge. The beryls of San Diego County are usually faceted with the emerald-cut and these are usually cut deep to bring out the colour.

Beryl from San Diego County sometimes has inclusions of muscovite, lepidolite, quartz and tourmaline. It commonly has two-phase inclusions with a gas bubble. Two movable bubble inclusions were found out of 26 specimens examined. One movable bubble, after being heated with the microscope light, disappeared. There are also veil-like liquid inclusions.

SPESSARTITE

Crystal description: Isometric system; hexoctahedral class. Commonly in crystals, usually dodecahedrons up to $\frac{3}{4}$ inch in diameter. The larger crystals from San Diego County are usually

simple dodecahedrons. Some are heavily etched and others, usually the smaller ones, are commonly trapezohedral with minor dodecahedral faces. The smaller the crystals of this garnet the more perfect they seem to become.

Physical properties: Colour: orange to dark red or brown. San Diego County spessartite varies according to the GSA rock colour chart from a moderate reddish-orange 10R 6/6 to a moderate reddish-brown 10R 4/6. Lustre: vitreous to resinous. Hardness: 6.5-7.5. Specific gravity: 4.19. Fracture: subconchoidal to uneven. Cleavage: none. Transparent to subtranslucent. Refractive index: 1.79-1.82.

Composition: $Mn_3Al_2(SiO_4)_3$.

Manganese aluminum silicate. Ferrous iron usually replaces some of the manganese and ferric iron some of the aluminum.

Occurrence: In San Diego County spessartite is found primarily in the Ramona district; with very minor amounts in the Pala and Mesa Grande districts. In the Ramona district it is found mainly at the Little Three mine, and sometimes at the A.B.C. and Hercules mines.

Interesting facts: Spessartite from San Diego County is associated with albite, quartz, perthite and black tourmaline. For a long time these garnets in San Diego County were thought to



FIG. 7. *Rough spessartite crystals from the Little Three mine, Ramona district, San Diego County, California.*

be essonite (hessonite), which is another name for grossularite. Finally, gemmological tests backed up by x-rays led to the corrected designation of spessartite.

Spessartite when fused with sodium carbonate gives a bluish-green bead (test for manganese). This rare garnet exhibits very pronounced step-like growth on the crystal faces and most crystals have been etched.

Spessartite in San Diego County commonly has two-phase inclusions with a gas bubble. It also has liquid inclusions that are very irregular in outline. It has wispy veil-like inclusions. What looked like a quartz crystal inclusion was found in one crystal. This spessartite rarely has angular three-phase inclusions which contain a liquid, gas bubble and crystal of some unknown mineral.

A garnet found in the pegmatite dikes just west of Tule Mountain, in the Jacumba area, was found by x-ray examination to be half spessartite and half almandite. This garnet, quite a bit redder than the orange-coloured spessartite, occurs on white feldspar and makes very attractive specimens, besides cutting into very colourful gems.

SPODUMENE

Crystal description: Monoclinic system; prismatic class. In San Diego County the crystals are prismatic, often flattened (lath-shaped) and vertical planes striated and furrowed. Spodumene nearly always shows lamellar twinning on the front pinacoid, with the twin plane parallel to their flat sides. Crystals as long as nine feet and 14 inches wide have been found in San Diego County.

Physical properties: Opaque varieties: buff, white, lavender and greenish; transparent varieties: lilac, colourless, light blue, yellow and green. Lustre: vitreous, on cleavage surfaces somewhat pearly. Hardness: 6.5-7. Specific gravity: 3.13-3.20. Biaxial and optically positive. Fracture: uneven to subconchoidal. Tenacity: brittle. Transparent to translucent. Coloured varieties are strongly pleochroic. Cleavage: perfect prismatic at 87 and 93 degrees. A tough splintery fracture distinguishes it from feldspar. A parting or false cleavage due to twinning is shown by most specimens; it is more readily obtained than the prismatic cleavage and yields many platy masses which may be either thick or thin. Refractive index α 1.65-1.66; β 1.66-1.67; γ 1.675-1.68.

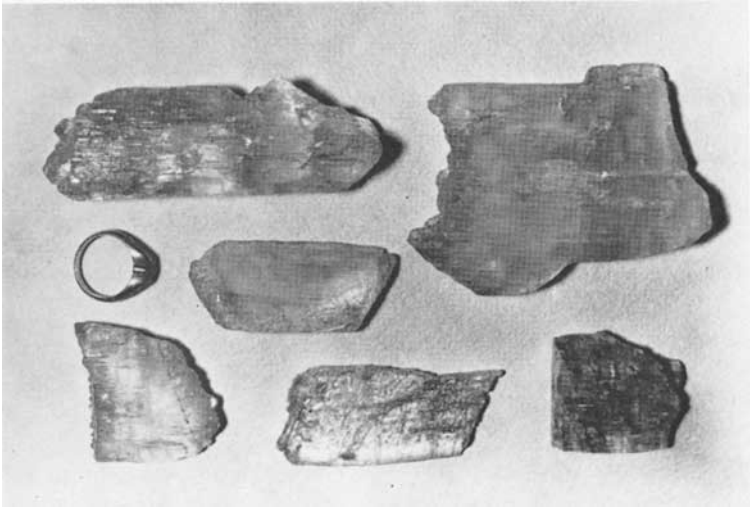


FIG. 8. *Medium-sized crystals of spodumene from the Pala district, San Diego County, California. The three specimens on the right are kuzúite and the three on the left are the triphane variety. The crystal in the lower left-hand corner is twinned.*



FIG. 9. *Small crystal fragments of spodumene from San Diego County, California. The specimen in the upper left exhibits the typical etched termination on a crystal fragment. Notice the striations.*

Composition: $\text{LiAlSi}_2\text{O}_6$.

Lithium aluminum silicate. Generally contains a little sodium which replaces the lithium.

Varieties occurring in San Diego County:

Blue Spodumene —Light blue

Green Spodumene—Light green

Kunzite —Pale to rose-pink, violet, lilac

Triphane —Colourless to yellow.

Occurrence: In San Diego County spodumene occurs at Aguanga Mountain, Mesa Grande, Pala and Rincon. Most of the gem spodumene has come from the Pala Chief, Katerina and Vanderburg mines in the Pala district. The Pala Chief mine, on Chief Mountain, has been the foremost producer of gem quality spodumene in the United States.

Interesting facts: Spodumene in San Diego County is associated with quartz, lepidolite, albite and muscovite. All transparent spodumenes are etched fragments of once larger crystals. These crystal fragments are deeply striated in a direction parallel to their elongation. The original lustre of the faces has been removed and the surface is sometimes altered to appear dull and or earthy. Many specimens occur as crystal fragments within altered spodumene. Most of the gem quality fragments have been less than 15 inches long. They also have triangular etch pits (Fig. 10). The deepest colours are seen when the stones are viewed parallel to the long axis of the crystal; the table of cut stones should also be oriented in this manner. Spodumene is usually cut deep so that maximum colour is obtained. The pre-form should be sawed into shape and then finished on a fine lap, as it has a tendency to break near the edges during cutting.

The colour of some stones fades on prolonged exposure to sunlight. Spodumene has had its colour changed to light green by exposure to a strong source of x-rays. This material will revert to its original colour when exposed to sunlight. Gem spodumene is thermoluminescent and fluorescent. Spodumene is strongly phosphorescent when exposed to x-rays, ultra-violet, radioactive emanations and high tension electric currents. Some spodumene is colour zoned with a lilac centre and a colourless to green edge. Hiddenite from a gemmological standpoint is usually reserved for the dark

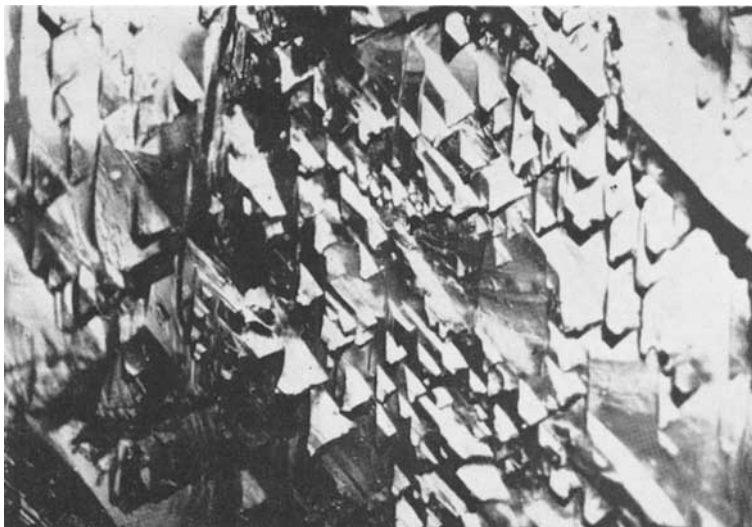


FIG. 10. *Microphotograph of triangular etch pits on the surface of spodumene, variety kunzite from the Pala district, San Diego County, California.*

emerald green variety of spodumene and derives its colour from a small amount of chromium. The light green San Diego County material owes its green colour to iron and therefore the variety name hiddenite is not applicable. It also has a light green colour which adds weight against using the variety name hiddenite.

Kunzite, the rare lilac spodumene, is found principally three places in the world: Brazil; Vanakarata, Madagascar, and San Diego County. Kunzite was named for the late Dr. George Frederick Kunz (1856-1932) gemmologist and former vice-president of Tiffany and Company in New York City. The colour of kunzite is due to manganese.

Blue spodumene, a light blue variety, was re-discovered by George Ashley, of Pala, in 1952. The name spodumene means "ashes" in Greek, in allusion to the fact that this mineral becomes ashy before the blowpipe.

San Diego County kunzite sometimes contains inclusions of what looks like pocket clay. There are also two-phase inclusions in spodumene with a gas bubble; and long, thin, rod-shaped (needle-like) inclusions. There are also funnel-shaped inclusions.

TOPAZ

Crystal description: Orthorhombic system; rhombic-dipyramidal class. In San Diego County, topaz crystals are commonly of short prismatic habit. Very rarely twinned crystals have been found. Crystals of three different terminations occur in San Diego County: one with a broad flat 001 or c-face developed; one which is an inverted V-shape with the 021 or y-face well developed; and a domed-shape with the 111 or o-face and the 112 or p-face developed (see Fig. 921, Dana's *Textbook of Mineralogy*, fourth edition, page 613). Usually, the crystals have only one termination with the base fractured on the perfect basal cleavage. However, where growth conditions were favourable, a few are doubly terminated. Topaz crystals are sometimes slightly striated parallel to the length of the prism.

Physical properties: Colour: white, colourless, greyish and light hues of blue, yellow, brown, green, violet, pinkish brown, pinkish and reddish. Lustre: vitreous. Hardness: 8. Specific gravity: 3.4-3.6. Fracture: subconchoidal to uneven. Cleavage: highly

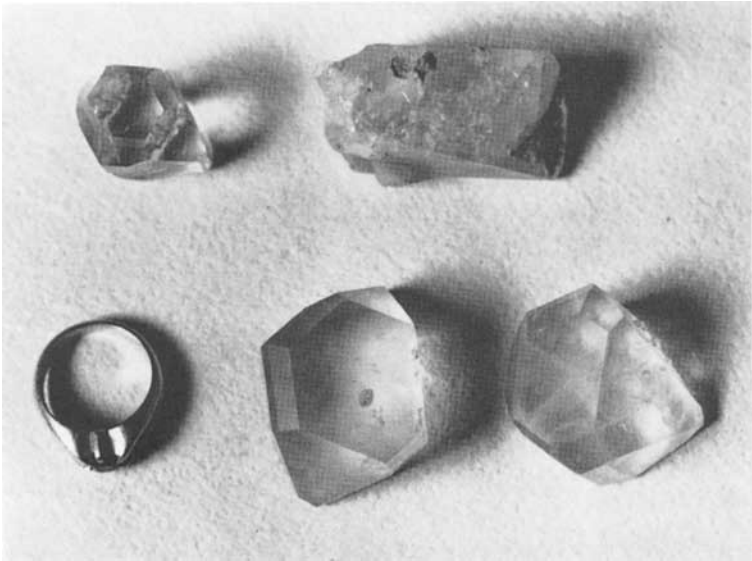


FIG. 11. *Medium-sized crystals of topaz from the Little Three mine, Ramona district, San Diego County, California. The crystal in the upper right is doubly terminated.*

perfect basal. Tenacity: brittle. Transparent to subtranslucent. Biaxial and optically positive. Refractive index: α 1.607-1.629, β 1.610-1.631, γ 1.617-1.638. Pleochroic. It is pyroelectric and piezoelectric. Infusible and dissolves slowly in sulphuric acid.

Composition: $\text{Al}_2(\text{F}, \text{OH})_2\text{SiO}_4$.

Aluminum fluosilicate.

Varieties occurring in San Diego County: The ordinary variety occurs in San Diego County and is usually colourless or white; and less commonly it is a light blue or greenish-blue.

Occurrence: Topaz occurs in San Diego County at the Little Three and A.B.C. mines in the Ramona area; and from the Emeraldite Number Two mine on Aguanga Mountain. It has also been found at the Himalaya mine at Mesa Grande and in very minor amounts in the Pala district.

Interesting facts: Topaz from San Diego County is associated with quartz, albite, lepidolite and green tourmaline. The San



FIG. 12. *Small crystals of topaz from the Little Three mine, Ramona district, San Diego County, California.*

Diego County topaz crystals are very similar to those found in the Ural Mountains of Russia. Blue topaz has been found in sizes up to $2\frac{7}{8} \times 3\frac{1}{4}$ inches at the Emeraldite Number Two mine on Aguanga Mountain, 13 miles northwest of Warner's Hot Springs. This mine was owned and operated by the late John W. Ware of San Diego. Some San Diego County crystals have frosted surfaces due to etching. San Diego County topaz has inclusions of albite. It also has two-phase inclusions with a gas bubble, and three-phase inclusions, some of which have two nonmiscible liquids, gas bubble and crystal of an unknown mineral. There are also liquid veil-like inclusions.

TOURMALINE

Crystal description: Hexagonal system, rhombohedral division; ditrigonal-pyramidal class. San Diego County crystals are usually prismatic in habit; with divergent radiating groups; also acicular. Tourmaline sometimes shows parallel side growths and columnar composites. Crystals usually display three curved sides in cross-section. They occur in size from microscopic specimens to over a foot long. The most common termination is the flat basal type. Tourmaline with a flat basal termination is called a negative termination; a slightly curved end is called a positive termination. Doubly terminated crystals usually have a flat termination at both ends or a flat end and a trigonal pyramid or modification of it. Rarely, both ends will be terminated by the trigonal pyramid, and occasionally the trigonal pyramid is itself slightly truncated by three faces.

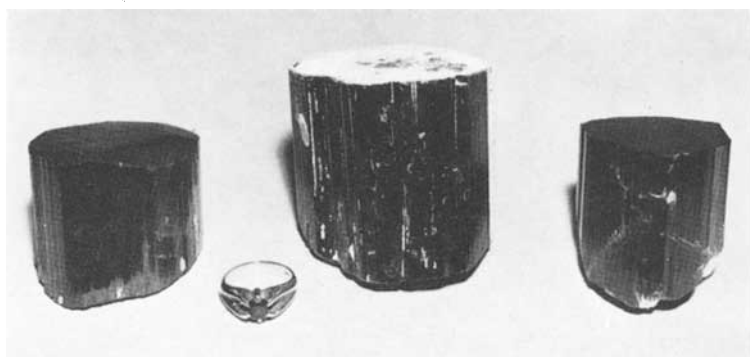


FIG. 13. Large crystals of green tourmaline from the Little Three mine, Ramona district, San Diego County, California. The crystal on the left has the "positive" termination and the other two the "negative" termination. The centre crystal is encrusted with white cookeite.

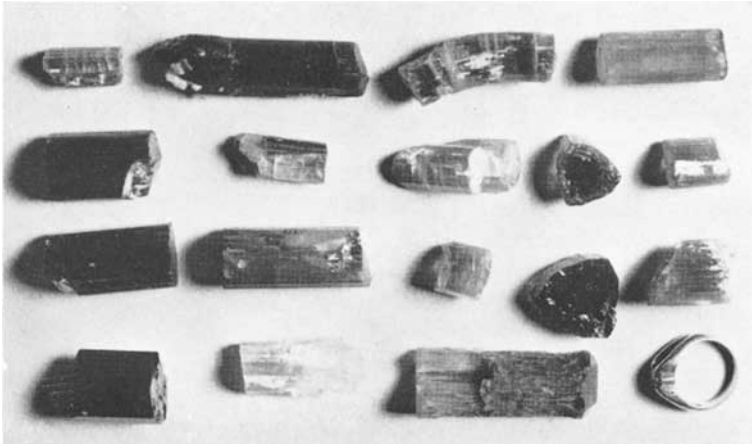


FIG. 14. *Medium-sized crystals of tourmaline, mainly from the Himalaya mine, Mesa Grande district, San Diego County, California. Notice the curved crystal in the top row and the crystal in the bottom row (next to the ring) that has been almost completely etched.*

Rarely tourmaline crystals are found that are curved or bent. Tourmaline crystals are usually vertically striated.

Physical properties: Colour: red, pink, yellow, violet, green, white, brown, black, blue and colourless. Lustre: vitreous to resinous. Hardness: 7-7.5. Specific gravity: 2.98-3.25. Fracture: conchoidal to uneven. Transparent to opaque. Cleavage: poor prismatic and rhombohedral. Tenacity: brittle. Dichroism is developed to a high degree in the darker varieties. Strongly pyroelectric and piezoelectric. A crystal is easily charged with electricity, either by friction, or by heating and shows positive at one end and negative at the other. Uniaxial and optically negative. Refractive index: ϵ_1 1.613-1.658, ω 1.632-1.698. Sometimes fluorescent in short-wave ultraviolet light.

Composition: Lithium sodium aluminum hydroxyl-boro-silicate. A complex silicate sometimes also containing: potassium, iron, magnesium, chromium, calcium and fluorine.

Varieties occurring in San Diego County:

Achroite —Colourless

Bi-coloured —Red, green, blue, black, yellow, pink, white

Bi-coloured cat's-eye—Pink and white

Cat's-eye	Green, pink, white
Green tourmaline	—Green
Indicolite	—Blue
Rubellite	Pink or red
Schorl	—Black
Tri-coloured	—Green, white, pink; blue, yellow, red
Violet tourmaline	—Violet
Watermelon	—Red or pink and green (colour zoned)
Yellow tourmaline	—Yellow.

Occurrence: Tourmalines from San Diego County are found in all the pegmatite districts: Aguanga Mountain, Banner, Chihuahua Valley, Jacumba, Mesa Grande, Pala, Ramona and Rincon.

Interesting facts: Tourmaline from San Diego County is associated with quartz, albite, lepidolite, beryl, perthite (feldspar), muscovite and cookeite. The colour is sometimes arranged in transverse layers along the length of the prism, producing bi-coloured or tri-coloured stones. The colour may also change from the centre outward showing very definite colour zones. Sometimes, there is a black core with a yellow edge, or a yellow core with a pink edge. The pink core with a green edge indicates the famous watermelon tourmaline. Rubellite with an indicolite edge is sometimes called a blue-skinned rubellite.

Coloured tourmalines show the best colour through the side of the prism or when viewed through its length. Faceted tourmaline is therefore usually cut with the table parallel to the length of the prism, or perpendicular to it, to take advantage of the colour. The emerald-cut and round brilliant-cut are usually used.

Rubellite, either red or pink, was a popular gem in China, where it was carved into beautiful figurines. The fall of the Chinese Dynasty in 1912, however, caused this market to dwindle to insignificance, and the resulting drop in price contributed to the virtual discontinuance of profitable mining in the Mesa Grande district. In the early days of gem mining in the county, occasionally microscopic tourmaline crystals would penetrate the miner's fingers and they would become infected.

Tourmaline is commonly encrusted with the white mineral cookeite. Tourmaline can be cleaned, especially of cookeite, by the use of hydrofluoric acid. Tourmaline is sometimes found with an altered crust revealing a hard nodular core that has a conchoidal fracture and is often flawless. Only about three per cent of the

tourmaline recovered is of gem quality. Etching on tourmaline is sometimes quite pronounced, even to the extent of eating holes in the crystals. Some of the pink tourmaline crystals from the Himalaya mine are encrusted with a very thin coating. They look like they had been sprayed with black paint. Negative cavities sometimes begin on the termination and are oriented parallel to the sides of the prism. A bi-coloured pink and white cat's-eye, with the eye in the white end, has very rarely been found in San Diego County. Rarely, tourmaline is found encrusted with muscovite casts. These casts with a core of tourmaline have been found at the Himalaya mine. Some of the green tourmaline crystals from the Himalaya mine have a black cap, which is terminated by a trigonal pyramid.

The Emeraldite Number Two mine on Aguanga Mountain, produced tourmaline that was closest in colour to the GSA rock colour chart light blue 5B 7/6 and light blue green 5BG 6/6. This tourmaline in the past has been called "emeraldite". One unusual colour zoned tourmaline from the Tourmaline King mine in the Pala district, had a pink core surrounded by four distinct green bands. Radiating sunbursts of pink tourmaline (called tourmaline suns) in a fine grained lepidolite are found at the Stewart mine in the Pala district. The famous Himalaya mine in the Mesa Grande district has probably produced more tourmaline (about 100 tons) than any other mine in the world. The only colour of tourmaline not normally found in San Diego County is brown.

Small, usually less than an inch, radiating groups of pink tourmaline associated with lepidolite, cookeite, and quartz (which was the last to form) have been found in San Diego County. Some of the small, thin, black looking tourmalines from the Ramona district are actually a beautiful brown when viewed by a strong transmitted light.

San Diego County tourmaline sometimes has inclusions of quartz, albite and the micas. It also has two-phase inclusions with a gas bubble, and is usually very irregular in shape. Very fine, long, rod-shaped inclusions and small elongated cavities that are triangular in cross-section are oriented parallel to the length of the prism. When these inclusions are numerous enough they are the cause of the chatoyancy, or cat's-eye phenomenon.

Tourmaline, that myriad coloured gem that mimics the spectral hues of the rainbow, is the most colourful of the San Diego County gems.

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Minerals reportedly found at the Little Three mine, Ramona district:

Albite, var. Cleavelandite $\text{NaAlSi}_3\text{O}_8$
 Allanite $(\text{Ca}, \text{Ce}, \text{La}, \text{Na})_2 (\text{OH}) (\text{Al}, \text{Fe}, \text{Be}, \text{Mn}, \text{Mg})_3 (\text{SiO}_4)_3$
 Andalusite Al_2SiO_5
 Apatite $\text{Ca}_5 (\text{F}, \text{Cl}, \text{OH}) (\text{PO}_4)_3$
 Axinite $\text{Ca}_2 (\text{OH}) (\text{Fe}, \text{Mn}) \text{Al}_2 (\text{BO}_3) \text{Si}_4\text{O}_{12}$
 Beryl, var. Blue $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Golden $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Goshenite $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Green $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Morganite $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Cassiterite SnO_2
 Columbite $(\text{Fe}, \text{Mn}) \text{Nb}_2\text{O}_6$
 Cookeite $\text{Li} (\text{OH})_6 \text{Al}_3\text{Si}_2\text{O}_9$
 Eosphorite $(\text{Mn}^{II}, \text{Fe}^{II}) (\text{OH})_2 \text{Al} (\text{PO}_4) \cdot \text{H}_2\text{O}$
 Epidote $\text{Ca}_2 (\text{OH}) (\text{Al}, \text{Fe})_3 \text{Si}_5\text{O}_{12}$
 Hambergite $\text{Be}_3 (\text{OH}) \text{BO}_3$
 Lepidolite $\text{KLi}_2 (\text{OH})_2 \text{AlSi}_4\text{O}_{10}$
 Microcline KAlSi_3O_8
 Montmorillonite $(\text{Al}, \text{Mg})_8 (\text{OH})_{10} (\text{Si}_4\text{O}_{10})_3 \cdot 12\text{H}_2\text{O}$
 Muscovite $\text{K} (\text{OH})_2 \text{Al}_3\text{Si}_3\text{O}_{10}$
 Opal, var. Hyalite $\text{SiO}_2 \cdot n\text{H}_2\text{O}$
 Orthoclase, var. Adularia KAlSi_3O_8
 Quartz, var. Milky SiO_2
 Quartz, var. Rutilated SiO_2 with Rutile
 Quartz, var. Smoky SiO_2
 Quartz, var. Tourmalinated SiO_2 with black tourmaline
 Rhodochrosite MnCO_3
 Spessartite $\text{Mn}_3\text{Al}_2 (\text{SiO}_4)_3$
 Stibiotantalite $\text{Sb} (\text{Ta}, \text{Nb}) \text{O}_4$
 Stilbite $\text{CaAl}_2\text{Si}_4\text{O}_{18} \cdot 7\text{H}_2\text{O}$
 Tantalite, var. Manganotantalite $(\text{Fe}, \text{Mn}) \text{Ta}_2\text{O}_6$ Mn:Fe > 3:1
 Topaz $\text{Al}_2 (\text{F}, \text{OH})_2 \text{SiO}_4$
 Tourmaline, var. Bi-colour $\text{Na} (\text{O}, \text{OH}, \text{F})_4 (\text{Al}, \text{Fe}, \text{Li}, \text{Mg}) \text{B}_3 \text{Al}_6 \text{Si}_6 \text{O}_{27}$
 Tourmaline, var. Green $\text{Na} (\text{O}, \text{OH}, \text{F})_4 (\text{Al}, \text{Fe}, \text{Li}, \text{Mg}) \text{B}_3 \text{Al}_6 \text{Si}_6 \text{O}_{27}$
 Tourmaline, var. Rubellite $\text{Na} (\text{O}, \text{OH}, \text{F})_4 (\text{Al}, \text{Fe}, \text{Li}, \text{Mg}) \text{B}_3 \text{Al}_6 \text{Si}_6 \text{O}_{27}$
 Tourmaline, var. Schorl $\text{Na} (\text{OH})_4 \text{Fe}_3 \text{B}_3 \text{Al}_6 \text{Si}_6 \text{O}_{27}$
 Zinnwaldite $\text{K}_2 (\text{F}, \text{OH})_4 (\text{Li}, \text{Fe}^{II}, \text{Al})_6 (\text{Si}, \text{Al})_8 \text{O}_{20}$

Minerals reportedly found at the Stewart mine, Pala district:

Albite, var. Cleavelandite $\text{NaAlSi}_3\text{O}_8$
 Amblygonite $(\text{Li}, \text{Na}) (\text{F}, \text{OH}) \text{Al} (\text{PO}_4)$
 Beryl, var. Golden $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Goshenite $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Morganite $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beyerite $\text{Ca} (\text{BiO})_2 (\text{CO}_3)_2$
 Bismite Bi_2O_3
 Bismuth, Native Bi
 Bismuthinite Bi_2S_3

Bismutite $(\text{BiO})_2(\text{CO}_3)$
 Bornite Cu_3FeS_4
 Chalcocite Cu_2S
 Chrysocolla $\text{CuSiO}_3 \cdot 2\text{H}_2\text{O}$
 Columbite $(\text{Fe}, \text{Mn})\text{Nb}_2\text{O}_6$
 Columbite, var. Ferrocolumbite $(\text{Fe}, \text{Mn})\text{Nb}_2\text{O}_6$ Fe:Mn > 3:1
 Cookeite $\text{Li}(\text{OH})_6\text{Al}_3\text{Si}_2\text{O}_9$
 Heterosite $(\text{Fe}^{\text{III}}, \text{Mn}^{\text{III}})(\text{PO}_4)$
 Hureaulite (Palait) $(\text{Mn}, \text{Fe}^{\text{II}})_3\text{H}_2(\text{PO}_4)_4 \cdot 4\text{H}_2\text{O}$
 Lepidolite $\text{K}(\text{OH})_2\text{Li}_2\text{AlSi}_4\text{O}_{10}$
 Lithiophilite $\text{Li}(\text{Mn}^{\text{II}}, \text{Fe}^{\text{II}})(\text{PO}_4)$
 Malachite $\text{Cu}_2(\text{OH})_2(\text{CO}_3)$
 Manganese oxides
 Microlite $(\text{Na}, \text{Ca})_2(\text{O}, \text{OH}, \text{F})\text{Ta}_2\text{O}_6$
 Muscovite $\text{K}(\text{OH})_2\text{Al}_3\text{Si}_3\text{O}_{10}$
 Muscovite, var. Damourite $\text{K}(\text{OH})_2\text{Al}_3\text{Si}_3\text{O}_{10}$
 Orthoclase, var. Sanidine KAlSi_3O_8
 Petalite $\text{LiAlSi}_4\text{O}_{10}$
 Pucherite BiVO_4
 Purpurite $(\text{Mn}^{\text{III}}, \text{Fe}^{\text{III}})(\text{PO}_4)$
 Quartz SiO_2
 Salmonsite $\text{Mn}_2^{\text{II}}\text{Fe}_2^{\text{III}}(\text{PO}_4)_8 \cdot 14\text{H}_2\text{O}$ (?)
 Sicklerite $(\text{Li}, \text{Mn}^{\text{II}}, \text{Fe}^{\text{III}})(\text{PO}_4)$
 Stewartite $\text{Mn}_2(\text{PO}_4)_2 \cdot 4\text{H}_2\text{O}$
 Strengite $\text{Fe}^{\text{III}}(\text{PO}_4) \cdot 2\text{H}_2\text{O}$
 Tantalite $(\text{Fe}, \text{Mn})\text{Ta}_2\text{O}_6$
 Tourmaline, var. Bi-colour $\text{Na}(\text{O}, \text{OH}, \text{F})_4(\text{Al}, \text{Fe}, \text{Li}, \text{Mg})\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Green $\text{Na}(\text{O}, \text{OH}, \text{F})_4(\text{Al}, \text{Fe}, \text{Li}, \text{Mg})\text{B}_3\text{Al}_3\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Rubellite $\text{Na}(\text{O}, \text{OH}, \text{F})_4(\text{Al}, \text{Fe}, \text{Li}, \text{Mg})\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Schorl $\text{Na}(\text{OH})_4\text{Fe}_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Triphylite $\text{Li}(\text{Fe}^{\text{II}}, \text{Mn}^{\text{II}})(\text{PO}_4)$
 Triplite $(\text{Mn}^{\text{II}}, \text{Fe}^{\text{II}}, \text{Mg}, \text{Ca})_2(\text{F}, \text{OH})(\text{PO}_4)$
 Vivianite $\text{Fe}_3^{\text{II}}(\text{PO}_4)_2 \cdot 8\text{H}_2\text{O}$

Minerals reportedly found in the Mesa Grande district:

Albite $\text{NaAlSi}_3\text{O}_8$
 Albite, var. Cleavelandite $\text{NaAlSi}_3\text{O}_8$
 Allanite $(\text{Ca}, \text{Ce}, \text{La}, \text{Na})_2(\text{OH})(\text{Al}, \text{Fe}, \text{Be}, \text{Mn}, \text{Mg})_3(\text{SiO}_4)_3$
 Almandine $\text{Fe}_3\text{Al}_2(\text{SiO}_4)_3$
 Amblygonite $(\text{Li}, \text{Na})(\text{F}, \text{OH})\text{Al}(\text{PO}_4)$
 Andradite $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$
 Apatite $\text{Ca}_5(\text{F}, \text{Cl}, \text{OH})(\text{PO}_4)_3$
 Arsenopyrite FeAsS
 Bavenite $\text{Ca}, \text{BeAl}_2\text{Si}_2\text{O}_7 \cdot \text{H}_2\text{O}$
 Beryl, var. Aquamarine $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Common $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Goshenite $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Beryl, var. Morganite $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$
 Biotite $\text{K}(\text{OH})_2(\text{Mg}, \text{Fe})_3\text{AlSi}_3\text{O}_{10}$
 Bismite (?) Bi_2O_3
 Bismuth, Native Bi
 Bismutite $(\text{BiO})_2(\text{CO}_3)$
 Cassiterite SnO_2
 Chrysocolla $\text{CuSiO}_3 \cdot 2\text{H}_2\text{O}$
 Columbite $(\text{Fe}, \text{Mn})\text{Nb}_2\text{O}_6$
 Columbite, var. Ferrocolumbite $(\text{Fe}, \text{Mn})\text{Nb}_2\text{O}_6$ Fe:Mn > 3:1
 Columbite, var. Manganocolumbite $(\text{Fe}, \text{Mn})\text{Nb}_2\text{O}_6$ Mn:Fe > 3:1
 Cookeite $\text{Li}(\text{OH})_6\text{Al}_3\text{Si}_2\text{O}_9$
 Epidote $\text{Ca}_2(\text{OH})(\text{Al}, \text{Fe})_3\text{Si}_5\text{O}_{13}$
 Eucryptite $\text{Li}(\text{Al}, \text{Si})_2\text{O}_4$
 Fluorite CaF_2
 Gahnite ZnAl_2O_4
 Grossularite $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$
 Halloysite $\text{Al}_2(\text{OH})_2\text{Si}_2\text{O}_7$
 Hambergite $\text{Be}_2(\text{OH})\text{BO}_3$
 Hatchettolite $(\text{Ca}, \text{Fe}, \text{U})_4(\text{O}, \text{OH}, \text{F})_7(\text{Nb}, \text{Ta}, \text{Ti})_4$
 Helvite $(\text{Mn}, \text{Fe}, \text{Zn})_2\text{Be}_2\text{Si}_4\text{O}_{21}\text{S}_2$
 Hematite Fe_2O_3
 Heulandite $\text{CaAl}_2\text{Si}_2\text{O}_8 \cdot 6\text{H}_2\text{O}$
 Hureaulite (Palait) $(\text{Mn}, \text{Fe}^{\text{II}})_3\text{H}_2(\text{PO}_4)_4 \cdot 4\text{H}_2\text{O}$
 Kaolinite $\text{Al}_2(\text{OH})_4\text{Si}_2\text{O}_7$
 Laumontite $(\text{Ca}, \text{Na})_2\text{Al}_2(\text{Al}, \text{Si})_2\text{Si}_2\text{O}_{10} \cdot 25\text{H}_2\text{O}$
 Lepidolite $\text{K}(\text{OH})_2\text{Li}_2\text{AlSi}_4\text{O}_{10}$
 Lithiophilite $\text{Li}(\text{Mn}^{\text{II}}, \text{Fe}^{\text{II}})(\text{PO}_4)$
 Magnetite Fe_3O_4
 Manganite $\text{Mn}(\text{OH})\text{O}$
 Microcline KAlSi_3O_8
 Microlite $(\text{Na}, \text{Ca})_2(\text{O}, \text{OH}, \text{F})\text{Ta}_2\text{O}_6$
 Monazite $(\text{Ce}, \text{La}, \text{Y}, \text{Th})(\text{PO}_4)$

Montmorillonite $(\text{Al,Mg})_3(\text{OH})_{10}(\text{Si}_4\text{O}_{10})_2 \cdot 12\text{H}_2\text{O}$
 Muscovite $\text{K}(\text{OH})_2\text{Al}_2\text{Si}_2\text{O}_{10}$
 Oligoclase $(\text{Na,Si,Ca,Al})\text{AlSi}_2\text{O}_6$
 Opal $\text{SiO}_2 \cdot n\text{H}_2\text{O}$
 Orthoclase KAlSi_3O_8
 Pollucite $\text{CsAl}_2\text{Si}_6\text{O}_{20} \cdot \text{H}_2\text{O}$
 Psilomelane $\text{Ba}(\text{OH})_4\text{Mn}^{\text{II}}\text{Mn}^{\text{IV}}_8\text{O}_{16}$
 Pucherite BiVO_4
 Purpurite $(\text{Mn}^{\text{III}},\text{Fe}^{\text{III}})(\text{PO}_4)$
 Pyrite FeS_2
 Pyrochlore $(\text{Ca,Na,Ce})_2(\text{O,OH,F})_7(\text{Nb,Ti,Ta})$
 Quartz SiO_2
 Sicklerite $(\text{Li,Mn}^{\text{II}},\text{Fe}^{\text{III}})(\text{PO}_4)$
 Spessartite $\text{Mn}_2\text{Al}_2(\text{SiO}_4)_3$
 Spinel MgAl_2O_4
 Spinel, var. Pleonaste $(\text{Mg,Fe})\text{Al}_2\text{O}_4$
 Spodumene, var. Common $\text{LiAlSi}_2\text{O}_6$
 Spodumene, var. Green $\text{LiAlSi}_2\text{O}_6$
 Spodumene, var. Kunzite $\text{LiAlSi}_2\text{O}_6$
 Spodumene, var. Triphane $\text{LiAlSi}_2\text{O}_6$
 Stibiocolumbite SbNbO_6
 Stibiotantalite $\text{Sb}(\text{Ta,Nb})\text{O}_4$
 Stilbite $\text{CaAl}_2\text{Si}_6\text{O}_{18} \cdot 7\text{H}_2\text{O}$
 Strengite $\text{Fe}^{\text{III}}(\text{PO}_4) \cdot 2\text{H}_2\text{O}$
 Tantalite $(\text{Fe,Mn})\text{Ta}_2\text{O}_6$
 Tantalite, var. Ferrotantalite $(\text{Fe,Mn})\text{Ta}_2\text{O}_6$ Fe:Mn > 3:1
 Tantalite, var. Manganotantalite $(\text{Fe,Mn})\text{Ta}_2\text{O}_6$ Mn:Fe > 3:1
 Topaz $\text{Al}_2(\text{F,OH})_2\text{SiO}_4$
 Tourmaline, var. Achroite $\text{Ca}(\text{O,OH})_2\text{Mg}_3\text{B}_3\text{Al}_3\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Bi-colour $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Cat's Eye $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Green $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Indicolite $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Rubellite $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Schorl $\text{Na}(\text{OH})_2\text{Fe}_3\text{Al}_3\text{B}_3\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Tri-colour $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Tourmaline, var. Yellow $\text{Na}(\text{O,OH,F})_4(\text{Al,Fe,Li,Mg})_3\text{B}_3\text{Al}_6\text{Si}_6\text{O}_{27}$
 Triplite $(\text{Mn}^{\text{II}},\text{Fe}^{\text{II}},\text{Mg,Ca})_3(\text{F,OH})(\text{PO}_4)$
 Vermiculite $(\text{Mg,Fe}^{\text{II}},\text{Fe}^{\text{III}},\text{Al})_{1-2}(\text{OH})_4(\text{Si,Al})_8\text{O}_{20} \cdot 8\text{H}_2\text{O}$
 Zinnwaldite $\text{K}_2(\text{F,OH})_4(\text{Li,Fe}^{\text{II}},\text{Al})_6(\text{Si,Al})_8\text{O}_{20}$
 Zircon, var. Cyrtolite ZrSiO_4 with H_2O

Reported by Jahns and Hanley, and Schaller.

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ASSOCIATION NOTICES

A YEAR OF GEMMOLOGY IN BURMA

A year he spent teaching gemmology at Rangoon University, in Burma, resulting in all 15 students passing the preliminary examination of the Gemmological Association, and 10 of them, in addition, passing the diploma examination—two with distinction, was the subject of a most interesting talk given to members of the Association, at Goldsmiths' Hall, London, on 12th March, 1969, by Mr. E. A. Jobbins of the Institute of Geological Sciences.

Mr. Jobbins started his lecture by giving a few facts about Burma and how he came to be associated with setting up a training scheme at the University.

The army took over the government in 1962 and formed a revolutionary council. In 1963 there was extensive nationalization of all industries and means of distribution, which, with other restrictions, particularly on foreigners, resulted in many of the Chinese who ran the jade industry, Indians, Burmese and British who ran the gemstone industry, and the Japanese who were largely responsible for the pearl fisheries leaving the country.

Again, another result was the loss of the expertise of the people who left, and it became apparent to the authorities at Rangoon University, and others, that outside help in setting up a training scheme and laboratory for gemmological studies was very necessary. It was also considered that those to be trained should be graduates or students about to become graduates.

Putting action to thought, an approach was made to UNESCO for assistance, and Mr. Jobbins was asked in November 1966 if he would be interested in going to Burma. Being keen to go, and having got the blessing of the director of the Institute of Geological Sciences, Mr. Jobbins left for Burma on 19th July, 1967, where he arrived at 7.30 on the morning of 30th July, having called at Delhi and Colombo on the way out.

His first impression while approaching land was of a bright yellowish-green colour, coupled with a general mirror-like reflection which he soon realized was from flooded paddy fields. On disembarking the heat and humidity really hit him. He took up residence in a modern hotel, about five miles from the centre of Rangoon, and this was his home for the rest of his stay—most of the time in a pleasant (and very expensive) flat on the fourth floor, overlooking a lake.

The geology department in the University (now known as the Arts and Science University) where he was to work had a staff of one professor, three lecturers and about 10 demonstrators. Discussions with the professor resulted in agreement that there should be two courses, one for postgraduates and one for undergraduates and that the syllabus for both should be that for the diploma examination of the Gemmological Association, with extensions as appropriate.

The University term in Burma began on 1st November, and Mr. Jobbins was faced with two pressing tasks—to get together the necessary instruments and specimens, and to inaugurate a new laboratory. Both had to be started from scratch, there being only two very corroded and useless Rayner refractometers and no laboratory extant.

Fortunately, the previous professor of geology had been elevated in 1964 to Secretary for Education to the Government. Mr. Jobbins, with virtual direct access to him, found him very helpful throughout his stay. It was through his good offices that foreign exchange was made available for five sets of refractometers, sodium lights and spectrosopes to be ordered from the Gemmological Association, in London, on 15th August. This order was delivered in Rangoon on 8th September—a very quick turnaround, for which Mr. Jobbins publicly thanked the GA staff for their co-operation. Specimens were not so easy to obtain, and assuming that nothing would be available in Rangoon, Mr. Jobbins was able to borrow 50 rare and unused stones from Mr. Basil Anderson, 30 stones from the GA, 20 from Mr. Robert Webster (which he subsequently presented to the Burmese) and jade and jade-like specimens from the Natural History Museum. To these Mr. Jobbins added his own collection of 300 specimens, which was used for day-to-day gem testing. No other gemstone specimens were received from other sources until May 1968, so the loan specimens proved indispensable.

The room designated for the laboratory had no fittings, a wood block floor with cracks large enough to lose sizeable gemstones and very poor electrical fittings. The laboratory was replanned and the work was started on obtaining the fittings and building materials of which none were available on the open market, because there was not really an open market. A high proportion of the normal electrical and other shops had closed down, only to be replaced by a few people's shops.

To obtain the necessary electrical fittings, paint, curtain materials, and other commodities, it was first necessary to go to the head of the appropriate trade corporation to obtain the necessary permits, which were then taken to the appropriate people's shops.

The actual fitting out of the laboratory took four months longer than it would have taken in England, but, apparently, quicker than it normally took in Burma.

The laboratory was completed at the end of November, and courses were started at the beginning of December 1967.

The laboratory was designed to take up to nine students, and two practical courses were instituted—the undergraduates formed a group of six and the post-graduates made up another nine. In the latter group were the principal gemmologist, planning manager and two other managers of the Gem Trade Corporation, a mineralogist from the Mineral Development Corporation, a geologist from the Applied Research Institute, and a customs and excise assessor; in effect, all the top Government officials concerned with practical aspects of gemmology.

All students spent two long morning, weekly, on practical work, which sometimes continued into the afternoons, and at least three hours of lectures. By really hard work it was hoped to cover the normal two-year G.A. Course in six months. All of the students had, previously, studied crystallography and some mineralogy, although some of the older men had forgotten most of it.

In October 1967, Mr. Jobbins went to Bangkok, and while there he called

upon the Department of Mineral Resources, and discussed Thai and Burmese mineral production with geologists there. Following this visit he received an invitation to visit the Thai Mining Convention in January 1968, in Bangkok, and he was lucky enough to obtain the necessary approval for the trip.

From the gemmological point of view, said Mr. Jobbins, the most interesting part of the trip was a visit to the gem-mining area of Chantaburi, some 200 miles east of Bangkok towards the Cambodian border. He was accompanied by a Thai geologist. A side issue on this trip was the time he spent one evening bargaining for specimens with a Chinese-Thai who, at one stage, produced a Rayner refractometer which someone had offered him in exchange for specimens.

By then, January 1968, the laboratory was working well and Mr. Jobbins obtained Oertling semi-automatic balances, which were in use by 24th February, and an Olympus stereo-zoom gemmological microscope Model JM, which he said he could thoroughly recommend and which compared very favourably with the American Gemolite microscope.

The G.A. examinations took place from 11th to 13th June, but the examination specimens were taken to the examination centre by an assistant commissioner from the customs and opened in his presence. He stayed during the examination and the specimens were sealed up again, in his presence, at the end of the practical examination. The incident had its funny side, said Mr. Jobbins, but it was of considerable practical use because it avoided any subsequent customs trouble.

The examination results were available at the end of August and all 15 students had got through the preliminary examination and 10 of them had also got through the diploma—two (undergraduates) with distinction. The results, said Mr. Jobbins, were very pleasing both to him and the Burmese, and made the front pages in both English language papers and in most of the Burmese, too.

During the time he was in Burma the 4th Gem Emporium was held. Although, in theory, the Emporium is the sole exporting source of Burmese gems, jade and pearls, in fact Burmese gemstones are freely available in Bangkok to where they are known to be extensively smuggled in return for consumer goods.

Broadly, the actual gem-workings are still in private hands and the recovered gems are supposed to be sold to government buyers who make fortnightly visits. Jade recovery, usually in fair-sized boulder, is largely in the hands of the Mineral Development Corporation, who use some modern equipment. The cultured pearl industry is run by the Peoples' Pearl and Fishing Board.

As time was running out, Mr. Jobbins managed to fit in a week's tour to Mandalay and, to his surprise, was invited to visit the new jade factory of the Gem Trade Corporation. The most important fact there was that slabbing of boulders and cutting of cabochons had been mechanized. American machinery was installed and work was to close tolerances, and there was a careful inspection system. Most of the workers were young men and a few of them were being trained in jade carving by a master carver of the old school.

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GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to Miss Verena Theisen, of Dusseldorf, for a copy of her book *Diamanten Fibel* (Handbuch der Diamant-Graduierung) and to Mr. R. Webster for a collection of Canadian gem minerals.

ANNUAL GENERAL MEETING

Mr. Norman Harper, chairman of the Gemmological Association, presided over the 39th annual general meeting of the Association, held at Winston Churchill House, Ethel Street, Birmingham, on 16th April, 1969. Welcoming those who were there, he said the annual general meeting gave members and fellows of the Association a chance to see what the officers had done through the year.

Making his report, Mr. Harper said that last year the Association celebrated the diamond Jubilee of gemmology in Great Britain and on that occasion had presented to the National Association of Goldsmiths of Great Britain and Ireland with two pieces of antique silver. The presentation was made, he said, because they were the people that founded the Gemmological Association.

He went on to say that the annual examinations were attracting more candidates as the years went by, and it was becoming quite a business to organize them. Those people present and the Association generally owed a great debt of gratitude to the permanent staff for handling the work so efficiently. Last year there were a large number of students from Spain and this year there were going to be even more of them. The work involved was not apparent when one read the list of names of people who had passed, but papers were returned from Burma, Japan, Spain, Finland and other countries, and marking of the papers was a formidable task. Mr. Harper then proposed adoption of the report and audited accounts for the year ended 31st December, 1968.

Seconding the proposition, Mr. D. N. King said anyone who read the report would do so with a great deal of pride and pleasure, because it set out the affairs of the Association in a concise manner. It hid, also, a great deal of the work that went into the Association. The Association had, he said, just celebrated 60 years of gemmology and for more than half of that time the affairs of the Association had been in the hands of Mr. Gordon Andrews, himself a fellow, and of him he would say, he knew of no man who ran such an able association, who demanded so little of its members and made so much work for himself. He conducted the Association's affairs quietly, efficiently, and ably and it would be an extremely sad day when he felt the time had come to lay down his office. He hoped it would not be for many years yet. Mr. King continued by saying that he also included the many people who worked with Mr. Andrews and hoped that he would convey to them the meeting's thanks and good wishes.

Turning to the balance sheet, Mr. King said it was years since he read such a pleasant sheet which showed such an excellent surplus. He knew the money

was well invested and used as and when the opportunity arose. The Association's expenses were increasing all the time and it was fortunate that it had been possible to accumulate funds for what one might call "a rainy day".

The election of officers followed and the retiring president, Sir Lawrence Bragg, C.H., F.R.S.; chairman, Mr. Norman Harper; vice-chairman, Mr. Philip Riley; and treasurer, Mr. F. E. Lawson Clarke were re-elected, there being no other nominations.

In the election of members of the Council, Mr. T. Bevis-Smith was re-elected; Mr. M. Asprey, who had served on the Council as a co-opted member for several years, and Mr. D. G. Kent, who had taken an active interest in the Association's affairs over many years, were nominated and elected. Messrs. Watson Collin & Co., chartered accountants, signified their willingness to continue as auditors.

After the Annual Meeting Dr. M. J. A. Smith, of the School of Physics, University of Warwick, spoke to members about a physicist's view of diamond.

MIDLANDS BRANCH

The Annual Meeting of the Midlands Branch of the Association was held on Friday, 16th May, 1969, at the Auctioneers Institute, Birmingham. The following Officers were elected:

Chairman: Mr. Peter Spacey. Vice-Chairman: Mrs. S. Hiscox. Deputy Chairman: Mr. D. N. King. Secretary: Mr. D. M. Jones.

The retiring Chairman, Mr. D. N. King, thanked the Committee and Branch members for the support they had given to him during his three years of office. He also thanked the national Chairman, Mr. Norman Harper, for his guidance and support. Mr. King reported that the Branch had had a particularly successful year with many interesting meetings and two social occasions being arranged.

Before the election of Officers was held, Mr. King presented a beautiful bouquet of flowers to Mrs. Hiscox in appreciation of her six years as Secretary of the Branch.

Messrs. J. Marshall, A. Alabaster, D. Price and J. Salloway were elected as Committee members. Minor alterations to the Branch regulations were approved.

After the meeting members were shown two films: "Looking for Gold and Silver" and "Hallmark".

GEMMOLOGY INSTRUCTOR

2nd year theory instructor in gemmology required for evening work at Sir John Cass College, London. Details of qualifications to Dr. E. Rutland c/o the Association.

MEETINGS

9th October, 1969. Herbert Smith Memorial Lecture. Mrs. Nancy Armstrong on "Jewellery". Goldsmiths' Hall, London.

19th November, 1969. Presentation of awards by Professor S. Tolanksy, F.R.S., at Goldsmiths' Hall, London.

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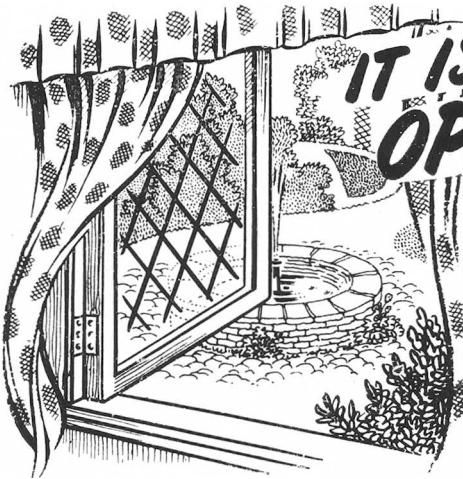
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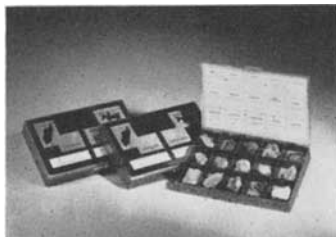
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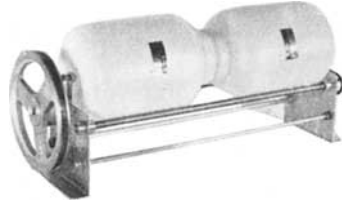
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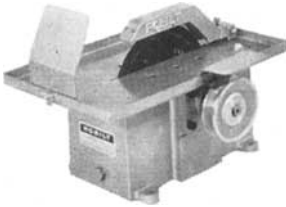
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