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and

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GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
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PROPERTIES AND CLASSIFICATION OF INDIVIDUAL GARNETS

By. B. W. ANDERSON, B.Sc., F.G.A.

THOUGH we are accustomed to think of the garnets as providing perfect examples of an isomorphous group of minerals, it has been shown that not all of the six recognized garnet molecules are completely intermiscible. They fall, in fact, into two sub-groups to which Winchell has given the "portmanteau" names Pyralspite (pyrope, almandine, spessartite) and Ugrandite (uvarovite, grossular, andradite). Within each group, continuous replacement of one molecule by another is possible, but *between* the groups replacement is seldom found to exceed some 20 per cent. A reason for this may perhaps lie in the cell dimensions, since pyrope and almandine, for instance, have a value of near 11·5Å for the length of the unit cube, and spessartite only a little larger (11·6), whereas with grossular and andradite the cell is distinctly larger (11·9 and 12·0Å, respectively).

PYRALSPITE

In the " pyralspite " group the following are the values calculated (originally by W. E. Ford in 1915, and since modified by Fleischer) for the pure molecules.

Garnet	*Composition*	*Density*	*Ref. index*
Pyrope	$Mg_3Al_2Si_3O_{12}$	3·51	1·705
Almandine	$Fe_3Al_2Si_3O_{12}$	4·32	1·83
Spessartite	$Mn_3Al_2Si_3O_{12}$	4·18	1·80

In the pyrope-almandine series, to which almost all the red garnets belong, the above figures do not correspond with any stones found in nature, and quoting these figures in books as though they were testing constants has often given rise to confusion. It is important from the practical point of view to know the limits of refractive index and density actually found. The beginner, for instance, may find himself unsure from the constants he has determined for an isotropic red stone whether he is dealing with a " low " pyrope or a " high " spinel. The writer at one time went into this question in some detail, and found that, though there were a few rare cases where chrome-rich spinels might have a higher refractive index (up to 1·734) than the lowest figure for pyrope (1·730), there still existed a gap between the densities even in these extreme cases : the spinel having the exceptional index of 1·734 had, for instance, a density of 3·611, while the pyrope with the record low figure of 1·730 for its refractive index was found to have a density of 3·650. Were these the only tests, of course, confusion might occasionally arise, but differences in the absorption spectra of the two species, the fact that pyrope is inert under ultra-violet light while spinel is fluorescent, and the distinctive inclusions of each, should enable the gemmologist to be on quite safe ground, and the resort to analysis, which has been advocated, quite unnecessary.

Figures may here be quoted for some of the " low " pyropes encountered by the writer. Two rose-red specimens from an unspecified Australian source had a density 3·670 and refractive index 1·733; another stone, from an unknown source, had density 3·669 and an index of 1·732, while a specimen from Arizona had a density just below 3·65 and refractive index 1·732. These figures are exceptional, not normal. The majority of pyropes used in jewellery, from Bohemia, Kimberley or Arizona, have densities near 3·70 and refractive indices from 1·742 to 1·750. The *dispersion* of pyrope was found to be appreciably lower than the figures given in standard texts : it was in fact little higher than for spinel, being 0·021 to 0·022 for the B-G range.

It may be said, then, that pyropes in nature never contain less than 20 per cent almandine, in addition to a few per cent of grossular and of uvarovite—the latter representing the chromium to which the fine red colour of pyrope is mainly due.

Turning to gem almandines, the highest figures so far measured have been density 4·245 and refractive index 1·814, corresponding to a composition of approximately 88 per cent almandine and 12 per cent pyrope if other molecules are ignored. Other high almandines measured include one with density 4·190 and refractive index 1·811, and another with density 4·161 and refractive index 1·809. More common figures are d = 4·06 and R.I. 1·795, d = 4·004 and R.I. 1·785.

In between the undoubted pyropes and undoubted almandines are many garnets from Ceylon and elsewhere having approximately equal amounts of each, with smaller percentages of other garnet molecules. Constants for two such garnets may be given merely as examples : one had a density of 3·93 and refractive index 1·772, the other had d = 3·83 and R.I. 1·758. For such stones the name *pyrandine* was suggested by the writer some years ago, to avoid the cumbersome description " almandine-pyrope." One must admit that in the trade the term " garnet " alone is sufficient for any stones belonging to this series, but gemmologists prefer to be more specific.

One intermediate type which finds mention in most books on gems has been given the name rhodolite on account of its rose-red colour. Specimens from the well-known source, Corundum Hill, near Franklin, N. Carolina, had a bulk density (that is, the average of several small specimens) of 3·860 : one refractive index was 1·7585 and another 1·7570 for sodium light, and each had a B-G dispersion of 0·0227. The first specimens of rhodolite described were from Mason's Branch, Macon county, N. Carolina (Hidden and Pratt, 1898) and had a density of 3·838. Analysis showed the presence of 57 per cent pyrope and 35 per cent almandine, with traces of andradite and grossular.

Rhodolite is not really a suitable name for all pyrandine garnets, partly because it is tied to a certain shade of red and partly because the name itself is too easily confused with the manganese silicate mineral rhodonite.

Less familiar amongst the gemstone garnets are those belonging to the almandine-spessartite series, but such mixed manganese garnets are by no means rare, and in such cases the question of correct nomenclature assumes considerable importance. Spessartite at its best is a very beautiful stone, and highly valued by collectors. Its characteristic tint is a subtle shade of orange to which the epithet " aurora-red " has been given. This is often modified or even obscured by the presence of almandine, and it then becomes a difficult question to know at what point the more favourable " selling name " of spessartite must be abandoned.

A recent example of this was a garnet from Brazil occurring in large irregular dodecahedral crystals showing a curious layered growth-structure already observed in other undoubted spessartite crystals both from Brazil and Norway. The colour, though very deep, had perceptibly a spessartite tinge by transmitted light: the absorption spectrum, though difficult to observe because of the strong general absorption, showed spessartite bands as well as those of almandine : and the inclusions (scattered liquid films) were more like those associated with spessartite than with any almandine. The density (4·245) and refractive index (1·815) were, however, virtually those of a high almandine (see above). The case seemed sufficiently intriguing to warrant the expense of a complete professional analysis. This was carried out by Messrs. Johnson, Matthey & Co., and established the presence of 44 per cent spessartite and 53 per cent almandine, with 1·5 per cent grossular but no magnesium (pyrope). The full analysis, on 5·65 grams of material, dried at 100°C., was as follows :—

Silica (SiO_2)	35·02
Alumina (Al_2O_3)	21·22
Ferrous oxide (FeO)	23·12
Manganous Oxide (MnO) ...	18·92
Lime (CaO)	0·57
Magnesia (MgO)	nil
Oxygen and loss	1·15
	100·00

It is obvious from the above analysis that there is no single name that can be given to such a garnet. For similar manganese-rich garnets described in the literature the term " mangan-almandine " has often been used. For gemmologists, the name " spessandine " might usefully be coined for such half-way specimens, by analogy with " pyrandine " in the almandine-pyrope series. Manganese-pyropes do not seem to occur.

The constants of almandine and spessartite are too close to serve as a reliable guide in assessing the relative amounts of each that are present in a given case. *Knowing the result* of an analysis it is easy to justify the constants with reference to the theoretical figures—but working the other way round is by no means so certain. Since chemical analysis is seldom possible in dealing with gem material, one has to rely on colour, absorption bands, and inclusions in addition to the density and refractive index in an attempt to place the garnet in its correct category. The absorption spectrum of almandine (due to FeO) is of course very well known. Of the three most prominent bands, centred in the yellow (5760Å), green (5270) and blue-green (5050), the latter is the most persistent and can be seen as a fairly narrow line when quite small amounts of almandine are present. The spessartite bands (due to MnO) are confined to the blue and violet and, as with all manganese spectra, increase in strength towards the ultra-violet. A vague band at 4880Å is followed by a rather stronger band at 4620, while a powerful band at 4320 often completes the picture, since (as in all orange stones) there is strong general absorption of the violet. In pale yellow spessartites two other strong narrow bands may be seen at 4240 and 4120Å, while photographs have revealed two further powerful bands in the near ultra-violet. It is worth noting that almandine has a weak band at 4620Å, identical in position with one of the spessartite bands. If the much more powerful 5050 almandine band is missing or faint, however, a band at 4620, when seen, can only be due to spessartite.

Both almandine and spessartite are quite strongly magnetic, as can be demonstrated when a specimen of either is in equipoise on an aperiodic balance and approached by a pocket magnet, when the loss in weight gives a roughly quantitative value for the strength of the magnetic effect. Using the empirical formula Loss $\times$ 100/$\sqrt{}$ weight, the values for gem almandines were found to range from 290-410, and for spessartites 250-360. In the literature almandine is said to fuse to a black magnetic globule and spessartite to a black non-magnetic globule. Experiment did not confirm this, though admittedly the almandine glass globule was the more magnetic—sufficiently so to be actually lifted by a small " Eclipse " magnet, whereas the spessartite bead (fused from a piece of orange-yellow rough showing no almandine bands) gave a magnetic value 260 on the above formula, and was sufficiently attracted to move when placed on a polished surface and closely approached by the magnet. While on this subject, magnetic values for the other garnets may be quoted : they are, pyrope 40-75 ; hessonite 40 ; demantoid 120-220, using a small horseshoe " Ellipse " magnet.

The constants of some of the gem quality spessartites we have measured may be given to provide some idea of their usual range. A dark orange specimen from Norway, kindly given to the writer by Mr. Hans Myhre, had density 4·157, refractive index 1·793. This contained appreciable almandine. A purer orange specimen from Arassuahy in Brazil had density 4·160 and refractive index 1·8003. A beautiful orange-yellow crystal from the Gold Coast gave a density 4·196—no refractive index being obtainable. Another "aurora red" specimen from Brazil, showing the 5050 almandine band, had density 4·185 and refractive index 1·800.

Ugrandite

The theoretical properties of the three remaining garnets, grouped together by Winchell as " Ugrandite," have been calculated as follows :—

	Composition	*Density*	*Ref. index*
Uvarovite	$Ca_3Cr_2Si_3O_{12}$	3·78	1·86
Grossular	$Ca_3Al_2Si_3O_{12}$	3·53	1·735
Andradite	$Ca_3Fe_2Si_3O_{12}$	3·83	1·895

In this group, problems of the kind discussed above do not arise. Uvarovite can be discounted as a gem species, despite its lovely chromium-green colour, since specimens really suitable for cutting have not yet been found, while grossular and andradite of gem quality have remarkably consistent properties and appearance, which differ greatly from each other. Hessonite, the form of grossular most used in jewellery, has a density ranging from 3·60 to 3·65, and refractive index near 1·743. Its properties are close to those of pyrope, but its characteristic orange-brown hue and granular and treacly internal structures prevent any confusion. The massive green, or sometimes pink, form of grossular, which is used as an effective substitute for jade, has lower properties than the above (d 3·48, R.I. 1·72) and shows a marked orange fluorescence under X-rays.

The magnificent green garnet, demantoid, is an almost pure andradite, coloured by chromium in addition to its intrinsic yellow colour due to ferric iron. Its density never varies far from 3·85, nor its refractive index far from 1·89—approaching closely the theoretical figures for pure andradite. Its high dispersion of 0·057 for the B-G range is twice as great as that of other garnets, and considerably higher than for diamond. Though its refractive index is beyond the range of the normal refractometer, its well-known " horsetail " inclusions of asbestos fibres (seen, curiously enough, in stones from the Belgian Congo as well as in the familiar specimens from the Ural Mountains), its fire, and its intense absorption band at 4430Å, all render it easy to identify.

Nowadays it is hardly necessary to caution gemmologists against the terms " hyacinth " or " jacinth " for hessonite or against " olivine " for demantoid. Even when these names are correctly applied to flame coloured zircon and to peridot, respectively, they are best avoided, as they engender confusion.

Apart from the attempt to provide a brief survey of the properties of the individual garnets which we meet with in jewellery, the chief purpose of this paper has been to draw attention to the difficult problem the gemmologist may sometimes be faced with in attempting to give a correct and at the same time acceptable trade name to certain garnets, not only of the commonly-occurring pyrope-almandine series, but also of the rarer almandine-spessartite series, in which latter case it must be realized that the value of the stone may be considerably influenced by the name chosen.

Gemmological Abstracts

Champion (F. C.). *Diamonds.* Science Progress, Vol. 45, No. 179, pp. 447-461. July, 1957.

A general review of the physical properties of diamonds is given with theoretical interpretations of their optical absorption, photoconductivity and luminescence in terms of their structural defects. Radiation damage can change the atomic structure of diamonds and introduce defects at will into the specimens and a detailed study of the results of such experiments is presented.

R.A.H.

Davidson (C. F.). *The diamond fields of Yakutia.* Mining Mag., Vol. 97, No. 6, pp. 329-338. December, 1957.

A review of the recent descriptions, in Russian, of the newly discovered diamond fields in the basin of the River Vilyui and nearby areas in the north-west of the Yakutia A.S.S.R. in central Siberia. Both placer deposits and kimberlite pipes have been found : one of the latter is the " Mir " intrusion near the town of Suntar, and here the kimberlite is overlain by residual clays and gravels carrying 2 carats of diamonds per cubic metre. The largest diamond so far reported is a stone of 32·5 carats from the Mir pipe, but the most characteristic feature both of the pipes and alluvial deposits is the predominance of extremely small diamonds. Most of the diamonds are colourless, the rare coloured examples having lemon-yellow to deep orange-yellow tints : these yellow stones have an octahedral habit and are commonly covered by triangular etch figures. In ultra-violet light most stones fluoresce in bluish and greenish tones, the quality of this fluorescence varying with the crystal habit. Inclusions of graphite and other minerals are noted.

R.A.H.

CHAMPION (F. C.). *Some physical properties of diamonds.* Advances in Physics (Suppl. to Phil. Mag.), Vol. 5, pp. 383-411, 5 figs. October, 1956.

Following an outline of the theory of the properties of pure diamond and a consideration of the physical behaviour of actual diamonds the applications of the defect theory are considered. The seven possible defects are dislocations and mosaicity, single vacant sites, aggregates of vacant sites, single interstitial carbon atoms, aggregates of interstitial carbon atoms, substitutional foreign atoms, and interstitial foreign atoms. The problems of diamond growth, their infra-red absorption spectrum, and the behaviour of some diamonds as conductors are discussed.

R.A.H.

DYER (H. B.) and MATTHEWS (I. G.). *The fluorescence of diamond.* Proc. Roy. Soc., Ser. A, Vol. 243, No. 1234, pp. 320-335. January, 1958.

The 3650Å group of Hg lines has been found to excite fluorescence in all the type I and type IIa diamonds examined, but type IIb specimens gave no emission with this wavelength. The fluorescence spectra usually contain one or more " systems " of lines, each system consisting of a main principal line accompanied by a banded ancillary structure : these are compared with features found in absorption spectra. The effect of irradiation and of subsequent heat treatment on the fluorescence spectrum is described. The nature of the centres responsible for the fluorescence is discussed.

R.A.H.

COULSON (C. A.) and KEARSLEY (M. J.). *Colour centres in irradiated diamonds.* I. Proc. Roy. Soc., Ser. A, Vol. 241, pp. 433-454. September, 1957.

A theoretical calculation of the energy levels, and hence absorption spectrum, of an isolated vacancy in an otherwise perfect diamond lattice has been made, and the concept of a defect molecule is introduced. The results suggest that the observed band at 2·0 eV causing irradiated diamonds to appear blue is due to spin and orbitally allowed electronic transitions in the neighbourhood of isolated neutral vacancies.

R.A.H.

KOHN (J. A.). *Twinning in diamond-type structures : high-order twinning in silicon.* Amer. Min., Vol. 41, pp. 778-784. 1956.

Relative orientations of four components in part of a silicon crystal pulled from a melt have been determined from a Laue photograph. They form a non-parallel twin complex (111), and the high order twin joins represent substantial structural discontinuities. These results are of significance for twinning in diamond.

J.Z.

SLAWSON (C. B.) and DENNING (R. M.). *Stress and double refraction in diamond.* Amer. Min., Vol. 40, pp. 1135-1139. 1955.

Compressional stress was applied across a pair of octahedral faces of a normally isotropic diamond while the specimen was viewed between crossed polaroids in sodium light. The strain birefringence produced was shown by the interference patterns (curves of equal path difference), which were similar to those produced by glass under similar conditions. Considerable birefringence can be produced by small stresses so that in naturally occurring slightly birefringent diamonds, strains (if uniformly distributed) are relatively small and probably unimportant by comparison with those suffered in subsequent industrial use.

J.Z.

DA SILVA (R. R.). *Oleos Vegetais Como Líquidos de Imersão.* Vegetable oils used as immersion liquids. Gemologia, No. 12, pp. 21-24.

A list of 25 " easily obtainable " vegetable oils covering the R.I. range from 1·447 to 1·660 for use in immersion refractive index work. Apparently the liquids more normally used are difficult to obtain in Brazil, hence the suggestion that babassu oil, tomato seed oil, oiticaca oil among many others, are more easily obtained. Of the oils listed, 19 cover the range from 1·447 to 1·484, while the range from 1·500 to 1·600 includes only six of the oils. The advantages of these comparatively non-volatile liquids over such substances as chloroform, carbon tetrachloride and other rapidly evaporating liquids are emphasized.

R.K.M.

GUIMARÃES (A. P.). *O Carbonado.* Gemologia, No. 11, pp. 9–16, 1958.

An account of the cryptocrystalline type of industrial diamond found in Brazil and known as carbonado. A general account of the material, its relationship to boart and to gem diamond and particular reference to the uses to which this valuable material is put.

R.K.M.

CAMPOS (J. E. de S.). *Asterismo.* Gemologia, No. 11, pp. 17-23, 1958.

A summary of the writings of various workers on the subject of asterism in corundum and other stones. The writer discusses epiasterism and diasterism and refers to various text-books and to the detailed paper by Alice Sumner Tait (Journ. of Gemmology, Vol. 5, No. 2, 1955) which attributes the cause of asterism in corundum to oriented acicular crystals of rutile.

The writer concludes by posing further questions which he contends are not yet answered. Among them the cause of asterism in stones showing zoned growth but no rutile needles ; in stones in which the rutile needles are not regularly oriented ; and the cause of asterism produced by artificial corrosion and diasterism in minerals having no oriented inclusions. He also asks whether it is reflection or diffraction at the rutile needles which produces the effect.

4 illus. R.K.M.

MARTIN (J. G. M.). *Historical Himalaya mine resumes production.* Gems and Gemology, Vol. IX, No. 6, pp. 163-173. Summer, 1958.

A million and a half dollars worth of gem tourmaline, apart from other gem minerals, was produced by the gem mines of southern California between 1902 and 1912. The Himalaya mine was the most productive, mainly tourmaline and beryl, and much of the production was exported to China for carving. The mine, owing to the cessation of export to China and lack of outlet for its produce, was virtually abandoned in 1914, and subsequently was only culled by rockhounds. In 1952 the mine was sold and this amateur gem collecting ceased. The mining property is situated on Gem Hill at an altitude of 3,800 feet and about 4½ miles north-west of Mesa

Grande store between San Luis Rey River and the Mesa Grande Creek. Ralph R. Potter who purchased the mine in 1952 commenced reconstruction of the buildings and roads, and commenced exploratory mining. This early endeavour had many misfortunes. However, in 1957 a new tunnel was driven towards the old mining area and many small pockets of tourmaline were found. This tourmaline was of various colours, principally green, red and yellow. The associated minerals are pink beryl, albite, cleavelandite, lepidolite, apatite, muscovite, allanite (radioactive), microcline and stibiotantalite. A report of a visit to this mine by the author and G. Robert Crowningshield is mentioned. Notes on the marketing of the mine's produce and further notes on the early history of the mines are given.

9 illus. R.W.

SEMANADA (M. K. J.). *Gem mining in Ceylon.* Australian Gemmologist, Vol. 1, No. 2, pp. 11–13. August, 1958. (*Abstracted from an article in The Eastern Jeweller and Watchmaker*).

Gems are among Ceylon's oldest exports. The gems found in Ceylon are listed. In the days of the Sinhalese kings the right of digging was a royal prerogative, but this was abolished by the British and changed to a licensing system. Three methods of mining, surface-placer, pit-gemming and river-gemming, are discussed and information on the cutting and marketing of the gems given.

2 illus. R.W.

MCCONAHAY (W. C.). *Clarity.* Gems and Gemology, Vol. IX, No. 6, pp. 174-179 and 190. Summer, 1958.

The article outlines a suggestion that the usual method of grading diamonds tends to negative thinking and the author proposes another approach which avoids the issue and can yet be ethical. The author does not claim that he has solved the problem but rather to have posed a question.

WEBSTER (R.). *The Tradehall Museum at Idar-Oberstein.* Gemmologist, Vol. XXVII, No. 329, pp. 224–225. Dec., 1958.

Describes the gemstone and ornamental stone exhibits in the Gewerbehall at Idar-Oberstein. The exhibits are changed at times but when visited by the author had a general arrangement according to continents. P.B.

SCHLOSSMACHER (K.). *Fabulite—a new gem substitute.* Australian Gemmologist, Vol. 1, No. 2, pp. 8–9. August, 1958. (*Translated from the German by J. T. Altmann.*)

Fabulite—strontium titanate—is made by the American National Lead Company and in composition is near that of the natural mineral *perovskite*. The synthetic strontium titanate is made on the Verneuil-type furnace, and, like rutile, leaves the furnace black in colour and needs some hours' treatment by heating in oxygen before becoming colourless. Fabulite is cubic and the material has a refractive index of 2·40 to 2·42 and a dispersion of 0·20 to 0·22. The density is 5·13 and the hardness 6½. Some comparisons with diamond and synthetic rutile are made.

R.W.

ANON. *Australia's first pearl culture venture.* Australian Gemmologist, Vol. 1, No. 3, pp. 15–19. September, 1958.

Following a survey by a Japanese technician a site was chosen in Brecknock Harbour, North-West Australia, and operations commenced for the cultivation of spherical and half pearls in the shellfish *Pinctada maxima*. A small bay in Brecknock Harbour, recently named Kuri Bay, is the location of this first Australian culture farm. This place is approximately 200 nautical miles north-east of Broome which is the supply town for the settlement. The first harvest was expected in 1958. The half (blister) pearls are cultured by cementing a stone nucleus of half spherical shape to the shell itself underneath the mantle. This is covered with nacre by the natural processes of the oyster. The nacre covered blister is harvested by cutting out with a hollow drill. The unfinished half pearls are freighted to Japan for removal of the stone nucleus and the polishing of the inside surface of the shell of nacre which is refilled with a hemispherical piece of mother-of-pearl which is set in with a special white gum under temperature. The rear part of the pearl is completed by a backing of mother-of-pearl, which is usually finished oversize so that the jeweller can grind down to suit his needs. A description of the nature of the farm locality is given but no information is imparted concerning whole-cultured pearls. (*Samples of the first harvest of whole-cultured pearls from this locality were on show at the 1958 Jewellery Exhibition at the Royal Albert Hall, London.*—EDITOR.)

2 illus. R.W.

LEEPER (R.). *The development of the diamond industry.* Gemmologist, Vol. XXVII, No. 329, pp. 234–238. December, 1958. (*Reprinted from OPTIMA.*)

A general survey of the diamond industry from the South African diamond discoveries to the present day. The expansion of the diamond cutting industry is discussed. It was in India that diamond cutting originated and it was the Indian lapidary who adopted the basic principle that a diamond should be used to cut a diamond. Later the cutting of diamonds became centred mainly in Amsterdam and Antwerp. During the 1939-1945 war the diamond cutters of the Low Countries went to England and the United States and during the war New York became the diamond cutting centre of the world. In recent years Amsterdam as a centre has declined and the industry has developed to some importance in Israel. An estimate of the number of diamond workers in each different country for 1955 is given. There is a note on the sales organization and on the synthesis of diamond. The Russian diamond fields are mentioned.

R.W.

ANON. *Diamond find in Basutoland.* Gemmologist, Vol. XXVII, No. 326, p. 174. September, 1958.

A further report on the diamond locality in the Makhotlong area of Basutoland which lies some 9,000 feet up in a valley surrounded by mountains. The first finds were small industrial stones, but some small gem diamonds have been recovered. The mining concessions are that 60 per cent shall go to the Treasury of the Paramount chief.

R.W.

SMITH (A.). *Freshwater pearling in Scotland.* Gemmologist, Vol. XXVII, Nos. 325 and 326, pp. 139–143 and 162–168. August/September, 1958.

British pearls were known to the Romans and in the 10th century pearls from Central Europe, France, Ireland and Scotland were highly prized, and in the 14th century France forbade the mounting of Scotch pearls in conjunction with oriental pearls except in ecclesiastical jewellery. A number of references to the use of Scotch pearls from the 16th century onwards. The natural formation of pearls is discussed. Scotch pearls are found in the mussel (*Unio margaritifera*). There is no true pearl industry in

Scotland, although at times some commercialization has been attempted. The fishing is by vagrant and casual enthusiasts. The appearance of the pearl mussel is shown by illustrations and the habits of the animal are discussed. Fishing for the molluscs is carried out by wading into the water and searching the river bed through a glass-bottomed bucket. It is not a shell-shaped object that has to be looked for, but a narrow dark streak with a fleshy grey strip along the middle about the width of a pencil, for it is only the thin syphon end of the mussel which is seen, for the animal is mostly submerged in the pebbly gravel and mud. Sudden heat and high temperature, and obnoxious gases from decaying vegetation, is fatal to them, but they seem to be immune to cold. Scotch pearl mussels are not attached to rocks by threads as in sea mussels, but live a free existence. The mussels are fished by pressing a forked stick over the shell and jerking it sharply to detach it from its hold. Misshapen specimens are most likely to contain pearls, and many of the larger pearls come from small or short-shelled animals. A clear quiet-loving water is best for mussel growth. The streams of Aberdeenshire and Perthshire were formerly the most productive of pearls. Over-fishing and pollution is the cause of the present scarcity. It is common practice to roll the pearls in olive oil or glycerine to import added lustre to them before sale. American fresh-water pearls have been sold as Scotch pearls, but do not have the lustre, but Irish fresh-water pearls are similar in lustre to those from Scotland. Some comments on the doctoring and cleaning of pearls are given and a note of the exceptional specimens found in Scottish waters is made.
4 illus. R.W.

WEBSTER (R.). *Synthetic gemstones.* Gemmologist, Vol. XXVII, pp. 124–129, 146–152, 170–173, 187–190. 1958.

A survey of the synthesis of gemstones including the history of the experiments which lead to the production of synthetic diamond and borazon by the G.E. Company of America. Experiments by Verneuil produced ruby and sapphire and, accidentally, spinel. A table of colours of synthetic corundum and spinel shows a great range. Various differences in internal structure, as a means of identification, are mentioned. The absorption spectra of synthetic corundums and the differential transparency to ultra-violet light of natural and synthetic stones are fully considered. Recently a ruby-red synthetic spinel and a schillerized spinel imitating moonstone have been produced. Synthetic sintered spinel coloured by cobalt imitates lapis-lazuli. Data on synthetic spinels are given. Centres of production are named and the series concludes with consideration of synthetic spinel, but no note is mentioned of synthetic strontium titanate.

13 illus. P.B.

HOPKINS (I.). *Gemmologist in Paris.* Gemmologist, Vol. XXVII, No. 328, pp. 211–213, November, 1958.

Discusses a visit to the Paris Mineral Gallery of the Jardin des Plantes and the Mineral Gallery of the Natural History Museum. Many of the beautiful specimens and objects of art seen in these galleries are mentioned.

2 illus. R.W.

POUGH (F. H.). *Hydrothermal ruby crystals.* Gemmologist, Vol. XXVII, No. 327, pp. 179–184. October, 1958.

The article gives a report on the growing by hydrothermal means of crystals of synthetic ruby by workers at the Bell Telephone Laboratories. The method of growth is similar to that used in the synthetical production of quartz crystals by using an autoclave. In the case of the ruby synthesis modifications were made in the autoclave in order to compensate for the higher temperatures and increased pressures (in excess of 30,000 pounds per square inch), and the more corrosive solutions used. The factors needed to give good results are mentioned. The nutrient is a hydrated alumina compound. The seed plates are round discs of Verneuil synthetic ruby cut so that their flat surfaces lie at right angles to the " c " axis, or with the " c " axis at such an angle that the growing crystal would have a rhombohedral face vertical as the crystal grows in the bomb. Pure nutrient produces in an iron autoclave greenish-coloured corundum crystals from iron contamination. The use of a silver lining to the autoclave allows colourless crystals to grow and by the addition of 1/10th of a gramme of sodium chromate to a litre of circulating solution ruby is formed. It is said that these crystals are grown for academic reasons and not for commercial exploitation.

3 illus. R.W.

BOOK REVIEW

ANDERSON (B. W.). *Gem testing* (6th edn.). Heywood & Co., London, 1958. 42s.

In the seven years since the last edition of Mr. Basil Anderson's *Gem Testing*, gemmology, like so many sciences to-day, seems to have moved faster than usual. There have been developments of new synthetic materials, there have been advances in methods of detection, there has even been the identification of a new gem mineral, sinhalite, previously thought to be brown peridot. *Gem Testing* has always, since the first edition of 1942, proved to be of especial help in practical day to day gemmology. The book is arranged to be of greatest use to the student and the jeweller who is setting out to identify a gemstone; it is a book to augment knowledge and to remind one of salient points about gemstones. The new edition retains the old order with some enlargement and rearrangement of certain chapters—notably descriptions of the immersion contact photography techniques developed by the author, and a new section on fluorescence as an aid to identification. The chapter on the use of the spectroscope has been entirely renovated, and comes equipped with a series of black and white half-tone illustrations of absorption spectra of gemstones that are far easier to comprehend than the table of absorption bands in the previous edition. The new issue has lost the coloured frontispiece of absorption spectra, but the coloured plate showing jade-like minerals that replaces it is not over-helpful and certainly not clearly captioned. The publishers have been at some pains to increase the number of text illustrations, but it is a pity that the thinner paper used has tended to diminish their impact, especially those of inclusions which play so important a part in the determination of the new synthetics. Four large photomicrographs of typical inclusions in synthetic emeralds are, however, a useful guide, and a new section deals with synthetic strontium titanate—now being marketed under the name of Fabulite. Both this and, incidentally, sinhalite, are omitted from the index which ends this admirable and most practical aid to memory for the jeweller-gemmologist.

J.B.

JADE STORY—AMERICAN

By ELSIE RUFF, F.G.A.

THE discovery of America has always been associated with Christopher Columbus, yet the name of Amerigo Vespucci (1451-1512), a Florentine merchant-adventurer, has been perpetuated by a whole continent. Both men, acquaintances if not friends, must have known that the Vikings sailed up the St. Lawrence river nearly five hundred years earlier. Columbus, we are informed, was greatly interested in Marco Polo's *Travels*, a copy of which he is said to have owned, and was also influenced by legends and stories of the sea and an ancient document that had come into his hands. Since he was searching for a passage to the East—the East of Marco Polo—it is accepted that he died believing he had touched the Orient. We are therefore left with such terms as *Indian* in reference to native peoples of the American continent, confusing enough to every young school-child. A further proof of this geographical error is the name given to the islands off the east coast of the continent, the West Indies. It seems ironical, after all the suffering, time and effort involved, that it was left for man to create this passage in the form of the Panama Canal. Sir Walter Raleigh played an early part in America, as we all know, and had a hand in potatoes, tobacco, gallantry, scribbling with diamonds on panes of glass, and, to the point of this story, jade.

There is not the slightest evidence that jade played any part in the motive that led to the New World's discovery—as we believe it did in the discovery of New Zealand by the Maoris—nor even that it was suspected, except perhaps as one of the many wonderful products of the Orient. In actuality, the Spaniards, who followed closely on the heels of Columbus (a Genoese), were primarily interested in gold, as was Sir Walter Raleigh. Perhaps it is not too much to say that just as the adventurers of to-day are fired with the conquest of Outer Space, the fifteenth century explorers—a century of explorers if ever there was one—were fired with the discovery of unknown lands that would at least prove the world a globe. Yet jade met these explorers of America at every turn ; not the raw jade that the Maoris knew in New Zealand, but wrought jade, often of great beauty. The jade or *chalchihuitl** of America (there are various spellings in old records, depending on the European rendering of the pronounced word and, perhaps, to some extent at least, on the accent of the particular area) was, too, forced upon their observation, since it was the most prized native possession. In any gesture of hospitality or good will this native substance was the medium, rather to the astonishment of the Spanish who expected to be rewarded with gold—and, at a later period, emeralds. Yet the Spaniards called this jade *jasper*, the term used by Marco Polo some two centuries earlier, for *jade* as a word was not then in use. Jasper, too, though always in the background, as the study of European jade has proved, did not at that time hold pride of place in European jewels. Sometimes this *chalchihuitl* was of so fine a colour that it was labelled *emerald* and various qualifying adjectives came into use such as *baja esmeralda*, meaning an inferior kind of emerald. In many of the inventories produced by the Spaniards these green (or greenish) stones were merely labelled *green-stones*, suggesting that the quality of this *jasper* was so much finer than commonly seen in Europe (where jasper was a generic term, anyway) that there was some doubt of the stone's identity—a doubt that yet at times forbade the use of the term *emerald*.

To the gemmologist, the discovery of America was the discovery of American jade, and just as the European term was also a generic one, so did *chalchihuitl* appear to be. The word was defined by Molina (*Vocabulario Mexicano*) in 1571 as an inferior kind of emerald. On the other hand emerald proper was called *quetzalitztli*, that is, *quetzal*, the bird known to science as *trogon resplendens*, and *itztli*, stone. The word *chalchihuitl* undoubtedly covered turquoise, in certain areas at least, amazon-stone, and some emeralds. The very fact that much of this jade work has been claimed the equal, technically and aesthetically, of the best in China, repudiates any suggestion that these people were merely natives on a stone-age level. Yet it was a stone-age jade—that is, the jade was worked with stone-age tools, as was the jade of the Maori. (Metals were nevertheless known and used about three centuries before the advent of Europeans.)

* ch as in church, al as in alcohol, chi as in chick, h mute, ui as in wit, tl as in cuttlefish.
In some instances this word has been treated as singular, the final "l" dropped for the plural and the Spanish "es" added.
For this pronunciation I am indebted to Mr. C. A. Burland, F.R.A.I.

Although Columbus sighted the mainland of South America during his third voyage, in 1498 (according to some reports Amerigo was there in 1497), he did not set foot on the soil. What he had noted, and thought to be another island, was the peninsula of Paria, the north-eastern extremity of what is now Venezuela. But on his two earlier voyages, and on his fourth and last one, he spent much time in the various islands of the West Indies. From then on it was merely a matter of time before Europeans were flocking to the New World. In 1513, Vasco Nunez de Balboa took formal possession of the Pacific Ocean (no less) for the Spanish crown on the Peninsula of Nicoya. In 1517, Francisco Hernandez de Cordova discovered the east coast of Yucatan and " the remains of a high aboriginal civilization which had already entered upon decline. There were deserted cities falling into ruins and others, like Chichen-itza . . . which were still inhabited by remnants of their former Maya populations." Hernando Cortés was busy, between 1519 and 1521, overthrowing the Aztec empire with its base in Mexico City. His first landing, on Good Friday, 1519, was in the harbour which he named Vera Cruz, later to become the most important port of the republic. The chronicler, Bernal Diaz del Castillo,[1] wrote of this landing and of the first messengers sent by the celebrated emperor Montezuma with "four *chalchihuitls*, a species of green stone of uncommon value, which is held in higher estimation with them than the *smaragdus* " (emerald). In another place he says that each *chalchihuitl* was held in higher regard than a great cargo of gold.

To understand the high development of American jade it is necessary, at least, to glance at its background. The *Edinburgh Review* of 1867, in a series of articles on *The Archaeology of North America* by several competent writers, gives us a brief picture : " From Guatemala to Upper Canada and from the Atlantic to the Pacific ocean, the surface is strewn with stupendous ruins of pyramidal temples and tumuli, entrenched camps and fortifications, walled towns and villages, amphitheatres and pictorial grottos, embankments and bridges, towers and obelisks, wells and aqueducts, high roads and causeways, gardens and artificial meadows ; the greater part of which was designed, constructed and maintained by numerous intelligent and skilful races of men who have long since disappeared from the several scenes of their labour, bequeathing to posterity no written or even solitary traditional memorial of themselves or even of their ancestors . . . ' When I beheld the delicious scenery around me,' exclaimed that honest old soldier Bernal Diaz, ' I thought we had been transported by magic to the terrestrial paradise. . . . Some of our men who had visited both Rome and Constantinople declared that they had not seen anything comparable in those cities for convenient and regular distribution or for number of people ' . . . "

Perhaps one of the most astounding things of the New World colonization was the early appearance of the printing press. This was only possible, surely, because one culture was superimposing itself upon that of another. The first press was set up in Mexico around 1538 (official dates differ), hardly a hundred years after the printing press appeared in Europe and about twenty since the arrival of Europeans in the New World. We are privileged therefore in having vivid accounts of those early days. In an imaginary dialogue printed in Mexico during 1554 is a description of the city itself. " How the view of this great street delights the mind and refreshes the eyes ! How wide and ample it is, how straight, how level, all paved with stones, lest in winter the feet be mired. Along its centre, for ornament and use, flows water in its channel, open to the sky, that it may give the greater pleasure. All the houses on both sides are splendid and costly, such as befit the richest and most noble citizens. . . . "

Continuing this American scene at the time of the early Spaniards, which was a geographical concentration on the narrow neck of land from Mexico to Peru (known as Middle America) plus the contiguous islands, we have, nevertheless, a picture also of the Amazon country to the south by C. W. King in his book *Antique Gems*, published in 1872. King is here quoting from Wallace's *Amazon* :

" I now saw several of the men with their most peculiar and valued ornament, a cylindrical, opaque, white stone looking like marble, but which is merely quartz imperfectly crystallized.† These stones are from 4″ to 8″ long and about 1″ in diameter. They are ground round and flat at the ends, a work of great labour, and are each pierced with a hole at one end, through which a string is

† *See* Journ. Gemmology, p. 410, Oct., 1956.

Jade ornaments from Old Mexico. (Bernal Diaz tells that a jade as big as a man's thumb could be exchanged for a man's load of gold.)

Jade pendant, Mexico. (Part of Sloane Collection.) Photos by courtesy of the British Museum.

inserted to support it round the neck. It appears almost incredible that they should make this hole in so hard a substance without any iron instrument for the purpose. What they are said to use is the pointed flexible leaf shoot of the large plaintain, triturating with fine sand and a little water, and I have no doubt it is, as it is said to be, a labour of years. Yet it must take a much longer time to pierce that which the Tushatia (chief) wears as an emblem of his authority, for it is generally of the largest size and is worn transversely across his breast, for which purpose the hole is bored lengthways, from one end to the other, an operation, I was informed, that sometimes occupied two lives. The stones themselves are procured from a great distance up river, probably from near its source at the base of the Andes ; they are therefore highly valued and it is seldom that the owner can be induced to part with them. The chiefs scarcely ever." (One is reminded here of Captain Cook's almost identical words in another part of the world in reference to native jade.)

A fascinating account of the early contact that the Spaniards effected with Mexico, is contained in Bernal Diaz' report, published in 1632.[2] He writes of the fabulous Montezuma possessing everything he could desire, largely acquired by force from those who would not willingly part with their riches. Foremost among these luxuries was *chalchihuitl*, nevertheless Montezuma was ready and willing to pay tribute to the Spaniards' " Great Emperor." This tribute covered gold, silver, cloth and *chalchihuitl*. The only stipulation was that the Spaniards absented themselves from Mexico. On one occasion Montezuma ordered his governors to barter gold for some green beads of the Spaniards, in the belief that these beads were of *chalchihuitl*. It would seem that of this substance the ancient Mexicans could never get enough. Diaz writes of the skilled workmen employed by Montezuma such as lapidaries and " workers in gold and silver and all hollow work, which even the great goldsmiths in Spain were forced to admire. Then for working precious stones and *chalchihuites* which are like emeralds, there were other great artists." Later in the narrative we find Diaz on the march again and arriving at another town where they were received and given something to eat ". . . but not much, unless we paid them with some pieces of gold and *chalchihuites* which some of us carried with us, and they gave us nothing without payment."

We have, too, a description of Montezuma when first interviewed by Cortés, his mantle thickly studded with *chalchihuitls* and pearls. " Out of this same gem (i.e. *chalchihuitl*) was carved the elaborate clasp fastening the monarch's imperial robe ; for green was the colour appropriated to royalty in ancient Mexico." Diaz seems to have contented himself with four pieces of *chalchihuitl* alone out of all the treasure he apparently could have had, and found later that he had made a wise choice ; for at that stage Cortés had been forced to evacuate Mexico and those who had burdened themselves with nuggets of gold perished in their attempts to ford the beaches.

Prescott, in his *Conquest of Mexico* (Vol. III, p. 323), writes of the gifts Cortés made to his youthful bride which " excited the admiration and envy of the fairer part of the court. This was five emeralds of wonderful size and brilliancy. These jewels had been cut by the Aztecs into the shapes of flowers, fishes, and other fanciful forms, with an exquisite style of workmanship, which enhanced their original value. They were probably part of the treasure of the unfortunate Montezuma, and being easily portable may have escaped the general wreck of the *noche triste*." One has only to read Monardes (Journ. Gemmology, Vol. V, Jan., 1955, p. 10) to question whether these jewels were in fact emeralds.

One of the earliest chroniclers of this part of the world was the Franciscan monk Bernardino de Sahagun,[3] who was in Mexico as early as 1529. He it was who described *chalchihuitl* as " the Mexican or *Nahutl* name for it which appears to have been applied to any greenish, partially transparent stone, capable of receiving a handsome polish." He too submits it was a " jasper of very green colour, or a common emerald." Writing in 1530, he quotes a native father addressing his daughter upon reaching the age of discretion : " Although you are but a little damsel you are as precious as a *chalchihuitl*." This simple statement reveals much. It shows us how close in thought and symbol these ancient Mexicans were to the early Chinese, who never ceased to liken loveliness of character and preciousness generally to jade. Similarly it establishes an immediate link with the Maoris. It tells us too that despite the tribal customs which Europeans professed to be appalled by (and which were those of a nation in decline) these people did not treat their girl children cursorily. " The little damsel " was obviously precious to her father. Dr. Alberto Ruz (Lhuiller) writing in 1953[4] says, on the other hand, that " My Jade " was the sweetest term of endearment a mother could address to her son. Sahagun writes too of four Mexican gods who were patrons of the lapidaries. These gods were honoured as the inventors of the art of working stones and *chalchihuites*, which work included drilling and polishing. The same recorder gives us also some valuable information on the classification of this stone. " Among the jaspers," he says, " is a variety in colour, white, mixed with green, and for this reason called *iztac chalchihuitl* (*iztac* signifies white ; i.e. white-*chalchihuitl*) Another variety has veins of clear green or blue, with other colours interspersed with white. . . . And there is yet another kind of green stone which resembles the *chalchihuites*, and called *xoxouhquitecpatl* (from *xoxouhqui*, *cosa verde*, something green, and *tecelic*, stone ; i.e. green-stone). It is known to the lapidaries as *tecelic*, for the reason that it is very easy to work, and has spots of clear blue. The wrought and curious stones which the natives wear attached to their wrists, whether of crystal or other precious stones, they call *chopilotl*—a designation that is given to any stone curiously worked or very beautiful."

Writing of the emerald (whatever Sahagun meant by the word) he says : " The emerald which the Mexicans call *quetzalitztli* is precious, of great value, and is so called because by the word *quetzalli* they mean to say a very green plume, and by *itztli*, flint (or stone). It is smooth, without spot ; and these peculiarities belong to the good emerald ; namely it is deep green with a polished surface, without stain, transparent, and at the same time lustrous. There is another kind of stone which is called *quetzalchalchivitl*, so called because it is very green and resembles the *chalchivitl* ; the best of these are of deep green, transparent, and without spot ; those which are of inferior quality have veins and spots intermingled. The Mexicans work these stones into various shapes ; some are round and pierced, others are long, cylindrical and pierced ; others triangular, hexagonal or square. There are still others called *chalchivites*, which are green (but not transparent), mixed with white ; they are much used by the chiefs, who wear them fastened to their wrists by cords, as a sign of rank. The lower orders (*macegudles*) are not allowed to wear them. . . . There is yet another stone called *tlilaiotic*, a kind of *chalchihuitl*, in colour black and green mixed. . . . "

Sahagun describes also the ornaments of the Mexican lords used in their festivals : " . . . a head-dress called *quetzalalpitoai*, consisting of two tassels of rich plumes, set in gold, and worn suspended from the hair at the crown of the head, and hanging down on each side towards the shoulders. They also wear rings of gold around their arms and in their ears, and round their wrists a broad band of black leather, and suspended to this a large bead of *chalchihuitl* or other precious stone. They also wear a chin ornament (*barbote*) of *chalchihuitl* set in gold, fixed in the beard. Some of these *barbotes* are large crystals, with blue feathers put in them, which give them the appearance of sapphires. There are many other varieties of precious stones which they use for *barbotes*. They have their lower lips slit, and wear these ornaments in the openings, where they appear as if coming out of the flesh ; and they wear in the same way semi-lunes of gold. The noses of the great lords are also pierced, and in the openings they wear fine turquoises or other precious stones, one on each side. They wear strings of precious stones around their necks, sustaining a gold medal set with pearls, and having in its centre a smooth precious stone."

In another part of this work we get even further details of jade. The *Quetzal chalchihuitl* was precious *chalchihuitl*, white, without much transparency and a slight greenish tinge, " somewhat like jasper," *Tlilavotic chalchihuitl*, which means literally of a blackish-watery colour, had shades of green and black intermingled and was partially transparent. *Tolteca-iztli*, literally " Toltec knife " or Toltec Obsidian was a clear, translucent green and very beautiful, we are told.

" The ancient Mexicans, according to Sahagun," says a modern journal,[5] " called their most precious green jade *quetzal chalchihuitl*, on account of the resemblance in colour to the gorgeous metallic-green plumage of the *quetzal* bird ; the Chinese, by a curious coincidence, no doubt accidental, derive the name *feia-ts' ui* from a kingfisher, the peacock-green plumes of which they often use inlaid in jewellery. In fact, all the jade objects that have been discovered in Mexico and Central America are made of jadeite."

From Viscount Kingsborough's *Antiquities of Mexico*, published in 1848,[6] we have : " The following is a literal translation of the greater portion of the 21st chapter of the sixth book of Sahagun's *History of New Spain*. ' Those who lived a life of perfection in

Small jade figures found in Honduras, in the museum of the American Indian Heye Foundation (Photo by courtesy of the Museum).

this world uttered them, and those who conform to them are indeed like precious *chalchihuites* and costly sapphires in the eyes of the Lord. The *chalchihuitl* was a sort of green jasper highly prized by the ancient Mexicans. It deserves to be remarked that the jasper and the sapphire were stones on which the Jews set extreme value and they are frequently referred to in the Old Testament for a similie. . . . This similie is borrowed from a curious belief of the Mexicans tha precious stones always emitted fine vapour at sunrise."

The late F. W. Foshag, a modern authority on the jade of the Americas, left us a concise picture of early days :[7] "When the Spanish explorers of the early sixteenth century reached the coast of Mexico, they found a light-green stone in use among the inhabitants of the region, which the indigenous lapidaries fashioned into ornaments and figurines. The early chroniclers, impressed by the vivid green colour of the stone, and by the great value placed upon it by the natives, referred it to the emerald. This is not surprising since they had no previous experience with a stone of this nature, and the superior quality of the emeralds recovered as loot from the Incas of Peru, and later from the mines of Colombia, was not yet known to them. The Aztecs of Mexico, who particularly esteemed the stone and demanded it in tribute from their vassals, called it *chalchihuitl* and restricted its use to the emperor and nobles. . . . Within fifty years after the conquest of Mexico, the supply of jade for amulet use became practically exhausted, because the stones in the possession of the nobles were by then already sold (see Monardes) and the knowledge and appreciation of this gem in its original home was soon forgotten. . . Among the Aztecs *chalchihuitl* was the most precious of substances. . .. The greatest virtues were comparable to this stone. . . . Sahagun was the first to refer to " esmeralda " in Mexico, but no occurrence of emerald is known in Meso-America, and no emeralds have been found in archaeological sites north of Panama. It is suggested here that this stone is the finest quality of jade, similar to the Chinese *fei-ts'ui* jade, emerald-green in colour, flawless, and almost transparent. This opinion is supported by Monardes, who states the finer qualities of ' piedra de yjada,' that is *chalchihuitl*, resemble emerald."

Juan de Torquemada[8] tells us that when a great dignitary died in Mexico his corpse was richly decorated for burial with gold and plumes of feathers, and they put in his mouth a fine stone resembling an emerald, which they call *chalchihuitl*, and which they say they place as a heart. The stone, according to another chronicler, " if laid upon the tongue of the deceased, will help the soul to pass the seven ordeals before reaching *Quetzalcoatl* in Heaven."

The American *Journal of Science* for March, 1858, says : " Torquemada makes frequent mention of *chalchihuitl* and regarded it as a species of emerald. He states that the Mexicans gave the name of *chalchihuilt* to Cortés, intending thus to show their respect, ' for *chalchihuitl* is the colour of the emerald, and emeralds were held in high esteem.' Offerings of this stone were made by the Indians in the temple of the goddess Matlalcueye. . . . The Indians state that the art of cutting and polishing *chalchihuitl* was taught to them by their god Quetzalcohual."

Torquemada also wrote of the goddess of water who bore the name of Chalchihuitlicue, the woman of *chalchihuites*, and that the name of *Chalchiuhapan* was often applied to the city of Tlaxcala, from a beautiful fountain of water found near it " the colour of which was between blue and green." Quetzalcoatl, the lawgiver, high-priest and instructor of the Mexicans in the arts, was said to have taught, amongst other things, the art of working metals, and " en especial el arte de labrar piedra preciosas, que son *Chalchihuites* que son piedras verdes, que extimaban en mucho precio." According to certain traditions, this authority also claims that Quetzalcoatl himself was begotten by one of these stones, which the goddess Chimalma placed in her bosom. *Chalchihuites* were offered to the goddess Metlalcueye together with the plumes of the Quetzal.. . . .

Another chronicler, Villaguitierre,[9] in his account of the conquest of the Itzaes of Yucatan, speakes of idols in their temples " of precious jasper, green, red, and other colours." In describing the great temple of Tayassal, he mentions particularly an idol which was found in it, " a span long, of rough emerald (*esmeralda bruta*), which the infidels called ' the god of Battles,' and which the conquering general, Ursua, took as part of his share of the spoil. . . . "

Fuentes y Guyman[10] was another to contribute a history of Guatemala, never to be published. He wrote of the Indians of Quiché wearing " head-dresses of rich feathers and brilliant stones, *chalchihuites*, which were very large and of great weight, under which they danced without wearying."

A further historian, though of slightly later date, was Herrera. His *General History of America*[11] was translated and published in London during 1725. In Volume One he reports the voyage of Alonzo de Ojeda in 1498 (though 1499 seems to be the official date) and of the natives of the east coast of South America. " All their wealth consisted of feathers, of several colours, and sometimes beads made of fish bone and of white and green stone, which they wore at their ears and lips. They neither sought nor valued gold, pearls, or other precious things."

In the Tribute Roll of the ancient Mexican Empire, the *Codex Mendoza*, we find the tax levy from each district and city given in detail. Strings of *chalchihuitl* are mentioned, evidently referring to rounded pieces used as beads and obtained from the sands and streams. From one district alone were large pieces demanded, perhaps again depending on what was available.

Thomas Wilson's famous *Jade in America* paper (1900) provides interesting information about this tribute roll. He tells us of the last years of Montezuma's reign concerning these tributes. Tribute was paid in tithes and " the roll represents every imaginable object in use by the natives. The sum total estimated in, or reduced to Mexican money, was 13,158,522 dollars. I have examined the list in search of objects of jade and turquoise." Wilson goes into details of objects in these substances, examining the roll both in Spanish and that published in the native hieroglyphics " and rendered in colour." These substances he was able to separate, in that the various items were labelled *blue* or *green*. " An examination and comparison of the respective figure with their different colours all satisfactorily explain the differences between the two minerals according to the native understanding. Whatever their names, the natives must have known the difference between jade and turquoise, and while *chalchihuitl* represents jade, it did not to them represent turquoise. There are four plates in the Tribute-roll which contain this hieroglyphic, signifying in each place *chalchihuitl*, that is to say, jade. The resumé of the tribute shows 20 pieces valued . . . at 254 dollars. I consider this a demonstration that a string of beads, four long and three round, was the native hieroglyphic for *chalchihuitl*, and was jadeite, or, rather, Mexican jade."

The late G. F. Kunz, an archaeologist as well as a gemmologist, contributed a picture of the period of the Conquest as a result of his own researches, published in 1915 in his book *The Magic of Jewels and Charms*. He writes : " In the native language of Mexico and Central America, the name *chalchihuitl* most frequently denotes jadeite, but it appears sometimes as the so-called Amazon-stone from the region of the Amazon river, and even occasionally to Turquoise. Thus the talismanic value of the *chalchihuitl* seems to have depended rather upon its hue and its rarity than upon its mineralogical character ; indeed among primitive peoples stones of the same or closely similar colour, although of a different composition, often bore the same name, and were conceived to have the same virtues, whether talismanic or therapeutic." Later he writes : " Among eight green stone objects sent to the writer at one time as jadeite, four were jadeite, one was laminated serpentine, another a greenish quartz, and two a mixture of white feldspar and green hornblende. In a string of beads were four pieces of jadeite, but all the others were, as are the jadeite beads, in the form of rounded pebbles, drilled from both sides, and there were nearly a dozen different substances in this string. The fact that these jadeite beads were strung in with the others, apparently without any order except that they were graded to taper towards each end, points very strongly to the conclusion that they were found with the other pebbles in a brook and, being of the correct size, had been drilled the same as the others, although very much greater in hardness. . . . Among other green stones used by the ancient Mexicans were green jasper, green plasma, serpentine, a fine-graded green shale, and the Tecali marble, which was often of such a rich green colour that at a glance it might have been mistaken for jadeite." In another place Kunz advanced the suggestion that the term *chalchihuitl* covered turquoise in the north (New Mexico) and jade in the south (Old Mexico).

F. W. Rudler, quoted at length in the J. of G., July, 1955, page 142, in his series of European jade, asks : " And what, after all, was this extraordinary stone—so wondrously endowed and so highly prized ? This is a question which, in spite of all that has been written on the subject, has not yet, and perhaps never will, be answered with scientific accuracy. Some have described the *chalchihuitl* as a coarse emerald, others a turquoise, others as a jasper, and some finally as jade. Probably the term comprized a number of distinct minerals, having in common a green or greenish-blue colour, and including the jade-stone." This article appeared in 1879 and is interesting in view of present knowledge.

The late George C. Vaillant,[12] who contributed so much to our information on Mexico, and indeed died in the field, wrote, in 1939, the following : " Art is a common denominator in all types of human culture. . . . The tendency of our artists and designers to draw inspiration from the arts of other peoples in other climes and other times may be due in part to this communal poverty in artistic expression and in part to the specialization implicit in a highly skilled profession . . . The jades from southern Mexico rival in sheer intrinsic value of colour and design the long admired art of China. Yet there is no doubt of the independent evolution of these two arts."

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9. Quoted by E. G. Squier, April 5th, 1869.
10. Quoted by E. G. Squier, April 5th, 1869.
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ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council of the Association is grateful for a gift of books from Mrs. F. L. Tully.

MEMBERS' MEETINGS

At a meeting of members held on the 14th October in the Medical Society of London Hall, the Secretary of the Association presided in place of the Chairman, who was indisposed. The subject of the evening was "Emeralds," and in introducing it the Secretary said : "Recently, in America, sapphire has been produced hydrothermally, but the experiment was academic and unlikely to have any commercial significance. It has been suggested that gemmologists should look for a new word to describe man-made stones which have not been produced by the accepted process of synthesis. But if one consults a dictionary it is found that there is really no need to coin a new word merely to describe another process of production. The term 'synthetic' is well understood by gemmologists, jewellers and public alike and I do not think that we need confuse the matter by thinking up a new word. Whether it is rubber, oil, sapphire or emerald, the word 'synthetic' can suffice for the product of the laboratory."

Mr. Keith Mitchell demonstrated the crossed filter technique in distinguishing synthetic emerald. The stone is illuminated by a powerful source of light. Using an infra-red filter, synthetic emerald will emit strong fluorescence, natural emerald much less strong fluorescence. A further application of this method was examination of the stone in light transmitted through a copper sulphate solution, and viewing it through two filters. The natural emerald (except, occasionally, for a fine glow from Colombian emeralds) was blacked out completely, whereas synthetic emeralds still betrayed fluorescence. Using crossed polaroids, a spectacular effect was obtained, with synthetics showing a brilliant red, and at most the faintest of glows, but usually complete blackness, from the natural emeralds.

Mr. B. W. Anderson offered a note on the transparency of natural and synthetic emerald—an extension of earlier work on the corundums. Using a laboratory quartz spectroscope transmitting down to about 2,000 Ångström units, ordinary film and a copper arc, he had discovered that natural emeralds all showed absorption in the 3,000Å region, while synthetic emeralds were exceedingly transparent, down to about 2,300Å or 2,200Å. This was due to traces of impurities in natural emerald, notably iron. Using water for immersion, Mr. Anderson then demonstrated the method and produced on the spot a photograph proving the greater transparency of the synthetics.

The Secretary then showed members slides produced by Dr. E. Gübelin and Professor W. Eppler showing the characteristic inclusions in synthetic emerald—

notably the veil-like two-phase inclusions which were a useful diagnostic aid in determining synthetic emerald. It had been suggested that these inclusions were healed fissures due to the fast growth of the synthetic stone. Other inclusions were groups of phenakite crystals. Mr. Andrews then showed slides of typical inclusions in the emeralds recently mined in Rhodesia—most typical were dense masses of tremolite crystals.

The Council of the Association is indebted to Messrs. Charles Mathews & Son and Messrs. George Lindley & Co. Ltd., for the loan of Colombian and Sandawana emeralds respectively, to Messrs. Rayner and Mr. Theo Stern for examples of synthetic emerald and Dr. E. Gübelin and Professor W. Eppler for photomicrographs.

COUNCIL MEETING

A meeting of the Council was held at Saint Dunstans House on 11th November 1958. Mr. N. A. Harper presided in the absence of the Chairman.

The following were elected to membership :—

Fellows

Ainsworth, Michael B., Blackburn
Aldridge, Patrick E., London
Atkinson, James C., Whitley Bay
Baglee, Gordon, Whitley Bay
Black, Vete George, Spring Valley, California, U.S.A.
Bowden, Aubrey, Plymouth
Boyd, Russell T. F., Toronto, Canada
Brandsma, A. H., Maastricht, Holland
Clarke, Eric M., London
Cooke, Barrie E., Birmingham
Eakins, Harry, Liverpool
Falconer, Richard A., New Malden
Ferguson, Charles Thomas, Smethwick
Greene, Patrick, London
Gunning, Jack W., Toronto, Canada
Hermitage, Wendy B. (Miss), London
Hill, Stanley G., Birkenhead
Huddy, George, Liskeard
Mackenzie, Enid L. D. (Miss), Glasgow
Ould, Thomas A., Plymouth
Peplow, William R. H., Stourbridge
Petterson, Bjørn W., Oslo, Norway
Reeves, Roger C., Chatham
Reynolds, Helen M. (Miss), Ludlow
Ritchie, Arnold J., Toronto, Canada
Roach, John G., Birkenhead
Roots, Jack L., Rainham
Skinner, Ramon, Borough Green
Smith, David J., Hove
Steadman, Ivor Noel, Huntingdon
Stitt, John, Toronto
Stol, Dirk, Amersfoort, Holland
Taylor, Joseph N., Newcastle
Walton, Joseph H., Cirencester
Wille, Robert F., Toronto, Canada

Ordinary

Anderson, Thomas M., Epsom
Benthall, Richard P., Calcutta, India
Brousseau, Murray P., Toronto, Canada
Charles, Russell J., Camp Hill, Pa., U.S.A.
Curmi, G. T., Valetta, Malta
Engstrom, Hans W. E., London
Flower, John C., Cleveland, U.S.A.
Hickman, John T., Bristol
Hool, R. H., Rotterdam, Holland
Keiser, Paul J., Detroit, U.S.A.
Law, Leslie, London
Jones, Mayhew Pettus, Tenn., U.S.A.
Meadows, Everard C., Purley
Overdorff, Frank C., Johnstown, U.S.A.
Parsons, Elizabeth M. (Miss), Leicester
Phillips, Roy E., Sutton
Riddell, Eileen Rose (Miss), Armagh, N.I.
Sellers, Thomas L., Margarita, Canal Zone
Smith, Denis E., Derby

The following were transferred from Ordinary and Probationary Membership to Fellowship :—

Biggers, Willard B., London
Callaghan, David J., London
Coakley, Brian, Manchester
Delario, Anthony J., Paterson, N.Y., U.S.A.
De Silva, Lindamulage, J. C. F., Colombo, Ceylon
Donaldson, Robert G., London
Francis, Barry P., London
Fuhrbach, John R., Amarillo, U.S.A.
Jones, James R., Mortdale, N.S.W., Australia
Lema, Audrey Hayes de (Mrs.), Colombia, South America
Phillips, Dennis, Leeds
Rushworth, Jack, Halifax
Smith, Clifford J., Walsall
Tungate, James B., London
Warburton, Frederick W., Toronto, Canada
Weller, George T., Tunbridge Wells
White-Hide, Richard G., Wadhurst

In connexion with applications from India concerning membership and the holding of examinations it was decided that the rules should not be altered to meet special circumstances.

With new methods of producing synthetic and imitation stones there was a possibility that present instruction might not be able to be confined to the present two-year period and the Council decided to review the syllabus of examinations with a view to keeping it within reasonable limits.

MIDLANDS BRANCH

At the sixth annual meeting of the Midlands Branch of the Association, held in Birmingham on 24th October, 1958, the following were elected to office: Chairman, Mr. T. P. Solomon, for the sixth year; Vice-Chairman, Mr. A. E. Shipton; and Mr. J. R. Shaw, Secretary, who succeeds Mr. A. E. Shipton. Miss J. Rice and Messrs. A. E. Shipton, J. Hoskyns, B. Clay and J. Harper were elected to serve on the Committee.

The Branch have decided to commission a Chairman's Badge of Office. The following meetings have been arranged—Friday, 30th January, 1959, Dr. H. Proctor on " X-rays." Friday, 17th April, Mr. B. W. Anderson on " Recent developments in synthetic gemstones." Both meetings will be held at the Auctioneers' Institute, Birmingham. The Branch will hold a dinner at the Medical Institute, Five Ways, on Saturday, 7th March, 1959.

WEST OF SCOTLAND BRANCH

A dinner was held by the Branch on 4th December, 1958.

HERBERT SMITH MEMORIAL LECTURE

This year's lecture will be given by Dr. D. K. Hill, of the British Glass Industry Research Association, at the Science Museum, London, S.W.7 on Wednesday, 15th April, at 7 p.m.

The twenty-ninth Annual General Meeting of the Association will be held at Saint Dunstan's House, London, E.C.2, on Friday, 1st May, 1959, at 6.15 p.m.

TALKS BY MEMBERS

GILLOUGLEY, J.: " Facts about diamonds," Paisley Business and Professional Women's Club, 24th November, 1958.

CAIRNCROSS, A. D.: " Gemstones," Inchture W.R.I., 10th September., N.U.R. Women's Guild, 29th October, and Murthly W.R.I., 18th November; "Pearls," Institute of Bankers in Perth, 16th October, and Perth and District Jewellers, 26th November, 1958.

FORSEY (Mrs. Patricia) : Dunnville Quarter Club, Ontario ; " Gemstones," 18th September ; " History of a diamond," 30th October ; " Coloured gems and pearls," 11th December, 1958.

1959 EXAMINATIONS

The 1959 examinations of the Association will be held as follows :—

Preliminary : Wednesday, 3rd May.
London, provinces and overseas.

Diploma : Thursday, 4th May (theoretical).
Friday, 5th May (practical).
London and overseas.

U.K. provincial centres to be arranged.

Completed entry forms must be received no later than 2nd April, 1959, and entries cannot be accepted after that date.

INCOME TAX AND SUBSCRIPTIONS

Members are referred to page 394 of the October, 1958, issue of the Journal (Vol. VI, No. 8) whereon is set out procedure for claiming the whole of the amount of subscription as a deduction for income tax purposes by those who qualify for tax relief.

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CONTENTS

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