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BRAZILIANITE

by

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

THE discovery of a new mineral and at the same time a new gemstone is something of an event, and, as is now quite well known, that was the distinction attaching to well-formed greenish yellow crystals found late in 1944 at a locality variously described as near Arrasuahy, near Corrego Frio, or near Divino in the Conselheira Pena district of Minas Gerais, Brazil.

The mineral was first described by F. H. Pough and E. P. Henderson in 1945 and named brazilianite by them in honour of the country in which it was found.

When first discovered, the crystals were mistaken for chrysoberyl, to which they have some resemblance in colour, but not otherwise.

A further source was discovered in July, 1947, by C. Frondel and Mrs. M. L. Lindberg at the Palermo mine, North Groton, in Grafton County, New Hampshire, in the U.S.A.

So far as is known, the most exact description of the original Brazilian source has been provided by Sr. M. Pimental de Godoy, who says that " The deposit is an altered pegmatite dike about one metre in width between walls of biotite schist.

" The brazilianite appears to be associated with mica, feldspar and quartz. The locality is the south slope of a hill which divides the Rio Doce and the Rio Sao Matheus, near the head of a small tributary of the Divino river, which runs in turn into the Laranjeiras and then joins the Rio Doce.

" The deposit belongs to the mica group of the Conselheira Pena district in the eastern part of the State of Minas Gerais."

In addition to those minerals mentioned above, two further phosphate minerals new to science are associated with brazilianite, since named scorzalite and souzalite, and also albite, muscovite, apatite, zircon and tapiolite, the pegmatite having a central and border zone.

The second occurrence has been described in great detail by Clifford Frondel and Mrs. Marie Louise Lindberg.

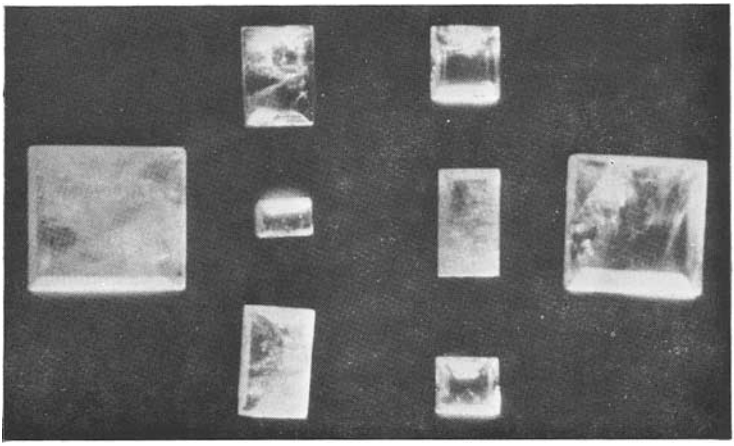
The Palermo Mine at which the discovery was made has been worked for mica since 1863. It is at present being worked for beryl and feldspar and will again be worked for mica at a later stage.

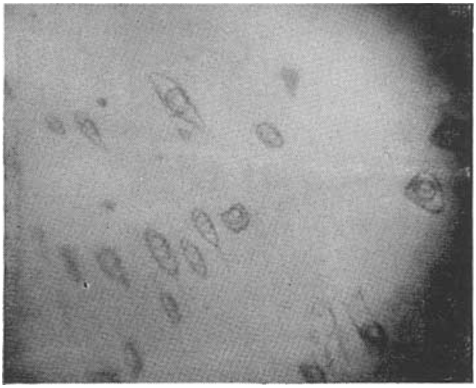
The number one Palermo pegmatite is a lens-shaped dike well zoned internally into approximately three main zones. The outer zone contains quartz, biotite, feldspar and black tourmaline. The intermediate zone, in addition to the above, contains perthite, beryl, lazulite, other phosphates and small amounts of sulphide minerals (it is this zone which is being worked). The central zone is essentially a quartz core, but contains other minerals, particularly at the edge, notably triphylite, perthite and some beryl.

The brazilianite crystals were found in cavities at the contact of the intermediate and central zones and appears to have been formed by hydrothermal action on the triphylite with the formation of other associated minerals as apatite, ludlamite, whitlockite, siderite and triploidite.

MATERIAL.

A large crystal of 973 grams is in the Canfield collection of minerals at the U.S. National Museum in Washington. Crystals of 868 and 852 grams are to be found in the American Museum of Natural History in New York, and other crystals in the Divisao do Geologia e Mineralogia at Rio de Janeiro, and in the mineral gallery at the Natural History Museum, South Kensington, London.

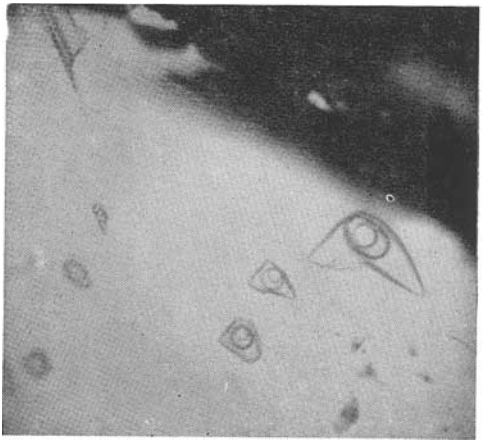




Above: Gemstones cut from 89 carat brazilianite crystal.

PHOTO-
MICROGRAPHS
OF
BRAZILIANITE

Above: Liquid and gas filled inclusions in brazilianite. × 80



Right: Cavities in brazilianite filled with non-miscible liquids and gas bubbles. × 100. (Kodak verichrome film, 8 secs. exposure, $\frac{2}{3}''$ objective, X10 ocular.)

An emerald-cut stone of 23 carats is in the collection of the Divisao do Geologia e Mineralogia in Rio de Janeiro and an oval brilliant of 19 carats is in the American Museum of Natural History in New York.

Mr. B. W. Anderson has two crystals and the writer obtained early in 1950 a crystal of 63 carats, partly clear and partly translucent by reason of flaws and liquid inclusions, the locality being given as " Corrego Frio, N. of Sao Tome, Minas Gerais, Brazil." (Sr. M. P. do Godoy quotes: " Corrego Frio, Municipio de Conselheira Pena, Minas Gerais.")

Later in the same year a further crystal of 89 carats was obtained, part of which was of superb gem quality ; the locality of this crystal was given as near Conselheira Pena, Rio Doce, Minas Gerais, Brazil.

After making full-scale drawings, photographing in natural colour and taking various measurements, this crystal has since been cut in Birmingham by a lapidary of Shipton & Co., Ltd., under the personal supervision of Miss P. E. Cutts, F.G.A., into the following stones:—

(1) A baguette of 2.988 carats. S.G. 2.997. R.I. 1.600, 1.620.
Containing one flaw and numerous liquid fingerprint inclusions.

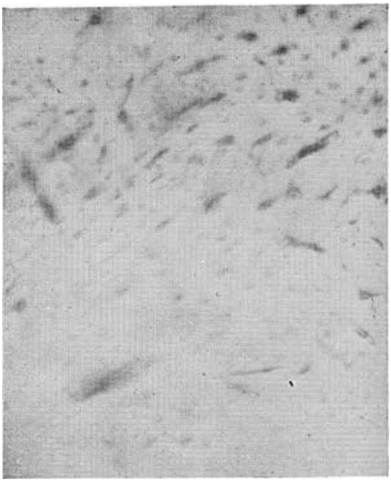
(2) A square cut stone of 1.507 carats. S.G. 2.998. R.I. 1.600, 1.620.
An almost clean stone, very brilliant and attractive, containing a few liquid fingerprint inclusions, cut from the cleanest part of the crystal. This would have been a much larger stone, but unfortunately a piece flew off which was recut into a smaller stone.

(3) A large square cut stone of 11.13 carats. S.G. 2.997. R.I. 1.601, 1.621.
Transparent to cloudy due to enormous numbers of liquid filled inclusions.

(4) A small square cut stone of 1.02 carats.
Clear, transparent with a slight flaw in one corner with a few liquid filled inclusions and some minute incipient cleavages.

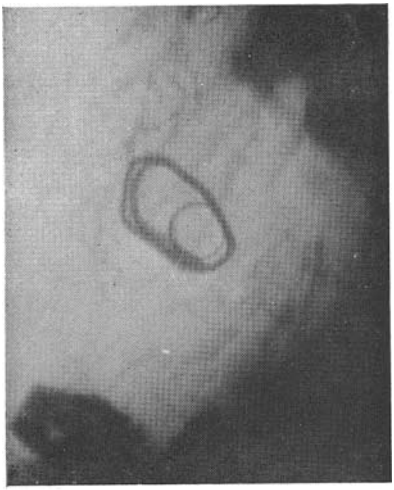
(5) A baguette of 2.215 carats.
Mainly clear and transparent, slightly paler, but numerous incipient cleavages and filimentous canals, typical liquid filled

PHOTOMICROGRAPHS
OF
BRAZILIANITE



Liquid filled inclusions in brazilianite. × 20.
(1½″ objective X6 ocular.)

Liquid and gas filled inclusions in brazilianite. × 100.
(⅔″ objective X10 ocular.)



Large liquid and gas filled inclusions in brazilianite.
× 80.

Cavities in brazilianite filled with liquid gas and bubbles.
× 80

inclusions and a few larger cavities partly filled with liquid and a movable gas bubble.

(6) A small oblong fancy step cut stone of .415 carats.
Clear, transparent, paler than the average, no typical inclusions, flawed at base.

(7) An inferior oblong flat of 1.57 carats.
Clear, transparent and with many most typical liquid filled inclusions.

(8) A large square cut stone of 8.22 carats.
Mainly clear, transparent, with liquid filled inclusions, but unfortunately spoilt by a portion of the base of the stone cleaving away.

CUTTING.

The lapidary reports that cutting brazilianite is very similar to cutting zircon. Having had no previous experience of cutting this stone, it was necessary to experiment to see which surface would take the best polish. This was found to be along the cleavage plane. Using this plane as the table facet, cutting was considerably easier and gave better results.

The cutter found that cleavage was more pronounced in the clear gem portions of the crystal than in the inferior or feathery part.

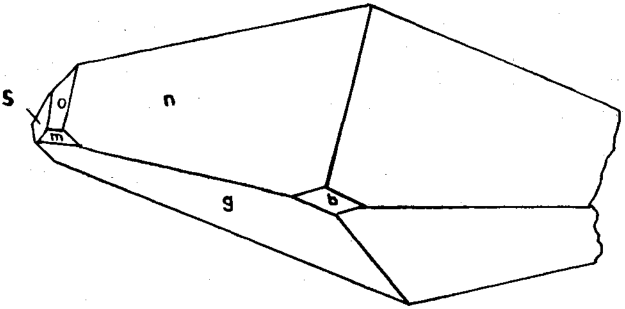
The friction of the cutting powder produced cleavage more readily than the polishing powder, which is, of course, smoother. Further, the heat of the cement used to mount the stones upon the lapidary's stick tends to produce cleavage.

An interesting feature of the cutting of brazilianite is the peculiar smell generated in the process. Careful interrogation with the lapidary resulted in this smell being agreed as akin to that of fireworks or gunpowder.

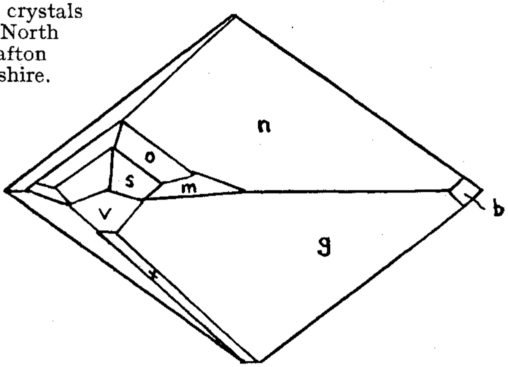
CRYSTALLOGRAPHIC SYSTEM.

From what has already been said it will be apparent that brazilianite is not only noteworthy as a new mineral, but also for the perfection and size of its crystals, which belong to the Monoclinic system.

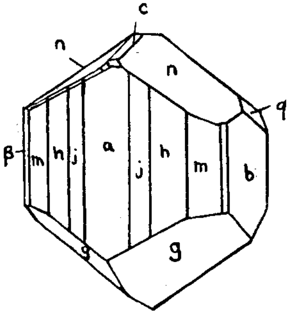
The Brazilian crystals are found in two different habits: the smaller number, of which the 868 gram crystal previously mentioned is an example, are prismatic, the prisms being slightly



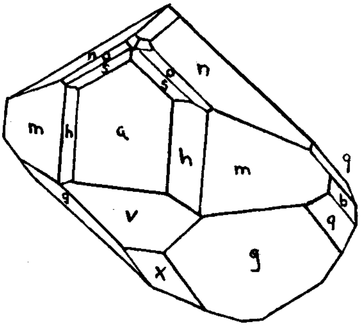
Characteristic habit of crystals from Palermo mine, North Groton, U.S.A. Grafton County, New Hampshire.



Coventional projection.



Less common slightly prismatic habit of brazilianite



Characteristic habit of brazilianite

From Conselheira Pena, Minas Gerais.

elongated and striated and the crystals somewhat rounded in outline.

More frequently the prism zone is much narrower with the principal development in the 100 zone.

The crystals from the Palermo mine, on the other hand, show an entirely different habit, this being almost the only difference between the minerals from the two sources.

The prism zone is almost entirely suppressed, whilst the *n* (011)) and *g* ($\bar{1}$11) forms are strongly developed, thus giving the crystals an elongated four-sided appearance ; the crystals are attached to the matrix by one end of the 100 axis, as is frequently the case with the Brazilian crystals also.

The prism forms, which are characteristically striated parallel to the *c* axis, are not as noticeable as the clinodome *n*, and the negative bipyramid *g* ; *v* is a common form. The negative orthodomes X and W are rare but present in about half of the cases as a slender truncation between the faces of *g*. The prisms *m* and the pinacoids *a* and *b* are always observed. Other forms observed are *c*, *i*, *h*, *j*, *z*, *p*, *o*, *s* and *q*.

CLEAVAGE AND HARDNESS.

Brazilianite has a perfect cleavage parallel to the side pinacoid *b*, and incipient cleavages may frequently be observed parallel to this face throughout the crystal. Cleavage is more pronounced in the clear, gem part than in the inferior or feathery part of the crystal.

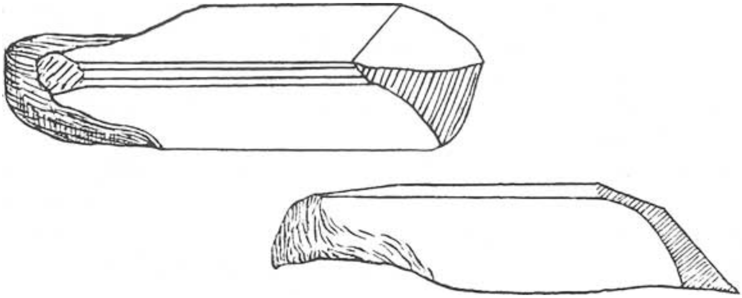
This cleavage is not too easily set going and does not unduly interfere with or prevent the satisfactory cutting of gemstones, provided due care is taken.

In spite of the well-marked cleavage referred to above, breakage more easily occurs as a conchoidal fracture. The mineral is brittle.

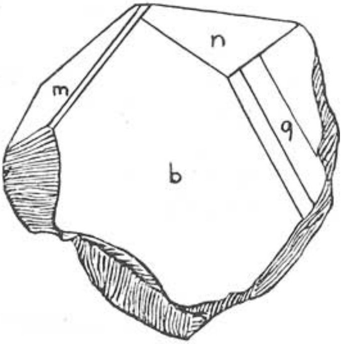
Unfortunately, brazilianite is not a hard mineral, though quite suitable for brooches, earrings and pendants, the hardness on Mohs's scale being 5½.

COLOUR, TRANSPARENCY AND LUSTRE.

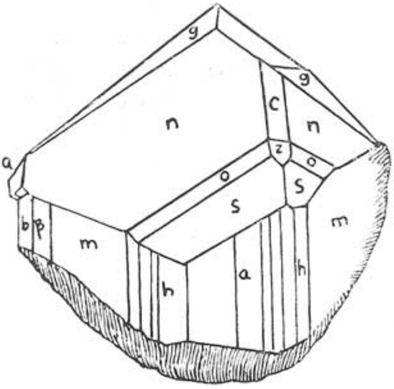
The colour is somewhere between Chartreuse yellow (B.C.C. 75) and Chartreuse green (B.C.C. 171) ; in the writer's opinion closer to the latter and matched very closely by the Wilson colour



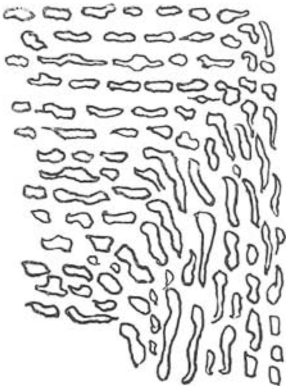
Part crystal of gem quality of 89 carats from Conselheira Pena, Minas Gerais, since cut into a number of stones.



Part crystal of 63 carats from Corrego Frio, N. of Sao Tome.



Well formed crystal from Brazil.



Typical liquid filled inclusions.

chart tint 663/2 of Chartreuse green. This tint is equivalent to British Colour Council Chartreuse green No. 171 and to Ridgeway Green-Yellow 27b, there being no equivalent in the Repertoire or Ostwald systems, nor any recognized equivalent Horticultural tint.

Measured on the Tintometer, the readings average: Blue .4 units, yellow 4.0 units ; equivalent to .4 units of green and 3.6 units of yellow, for the rough ; and on a cut stone, blue .5 units and yellow 3.5 units ; equivalent to .5 units of green and 3 units of yellow. The colour varies slightly in the same crystal and the Palermo material is slightly lighter in tint than the Brazilian and slightly less green.

Brazilianite occurs in transparent crystals well suited to the cutting of gemstones, though it is frequently semi-transparent to translucent either wholly or in part due to flaws and also to very frequent liquid filled inclusions.

The lustre of brazilianite is vitreous. On cutting, the stone takes a very high polish and has quite a slippery feel.

There is no change of colour under the Chelsea colour filter, and the reaction to ultra violet light is negative.

There is very slight dichroism observable as a change of shade only.

OPTICAL PROPERTIES.

The original readings of F. Pough and E. P. Henderson have since been shown to be too low by about .003. Recent readings have been as follows:—

Frondel and Lindberg ...	Brazilian	1.602	1.621
	Palermo	1.602	1.623
Anderson	Brazilian	1.602	1.623
Trumper	Brazilian	1.599	1.619
	Brazilian	1.602	1.622
(Cut stones)	Brazilian	1.600	1.620

Brazilianite is biaxial and positive in sign and the indices would appear to be (*a*) 1.602, (*b*) 1.609, (*c*) 1.622 and the double refraction .020 in extent. The dispersion is low, around .014. In a private communication, Mr. B. W. Anderson states that careful comparison with topaz and tourmaline as viewed through red and blue glasses on the spinel refractometer show brazilianite to have a distinctly lower dispersion than tourmaline (.017) and very similar to that of topaz (.014).

SPECIFIC GRAVITY.

The original determinations of F. Pough and E. P. Henderson again seem to have been on the low side, for recent determinations including on the original material are as follows:—

Frondel and Lindberg		Brazilian	2.980
		Palermo	2.985
Anderson	(73.88 cts.)	Brazilian	2.992
	(54.81 cts.)	Brazilian	2.993
Trumper	(89.27 cts.)	Brazilian	2.993
	(63.6 cts.)	Brazilian	2.990
11.13 cts. and 2.998 cts.		Cut stones	2.997

There is no difference between the Brazilian and Palermo mine sources and the Specific Gravity may be taken as 2.992 ±.005.

ELECTRICAL PROPERTIES.

After rubbing strongly, brazilianite attracts small bits of cotton, and similar material, but only weakly.

CHEMICAL COMPOSITION.

Determinations by E. P. Henderson and M. L. Lindberg, the latter on both the original and Palermo mine occurrences, show that the mineral is a hydrous sodium aluminium phosphate, conforming very closely to the formula Na_2O, $3Al_2O_3$, $2P_2O_5$, $4H_2O$. Only a very minute trace of impurities was found, including a trace of Cl and Mn, but no fluorine, arsenic or vanadium.

Brazilianite is distinct from any known mineral and is in a group of its own. Its nearest approach is to Turquoise, CuO, $3Al_2O_3$, $2P_2O_5$, $4H_2O$, which is of interest to gemmologists, and to a phosphate mineral, Fremontite, which it was at first thought to be.

SPECTROSCOPIC EXAMINATION.

Examination with the direct vision type of spectroscope fails to disclose any absorption bands.

INCLUSIONS.

In the course of their detailed examination F. Pough and E. P. Henderson reported on the numerous flaws to be found as well as many flawless areas, but the only other inclusions they noted were some slender crystals of green tourmaline and muscovite.

Examined in oblique light, however, brazilianite is found to contain numerous liquid filled fingerprint type of inclusions which do not appear to be in any particular zone, but buckled up as if composed of thin veil-like material freely suspended in a liquid of similar density.

Careful examination of these liquid filled inclusions under high magnification reveals that they are of a most interesting type. The cavities are partially filled with what appears to be a double bubble one inside the other. Both inner and outer bubbles are round except where in some cases the outer bubble of liquid is too large to assume this shape, when it conforms to some exxtent with the outline of the cavity.

What appears to be an inner bubble of liquid is, in fact, a bubble of gas and is spherical or oval in every case so far observed. There is little apparent difference between the refractive indices of the two concentric bubbles.

As far as can be ascertained, every single cavity, even long cracks or narrow filaments which are occasionally observed, contain these double bubbles of liquid and gas, which are colourless. Literally hundreds of them can be seen if the magnification is sufficiently high.

So far, in only a very few cases have larger cavities been found and these also contained the same contents, and here, on rocking the stone, the inner bubble of gas can be seen to float to the highest point in the liquid bubble surrounding it. Indeed, in the microphotographs the inner bubbles may be seen all at the same end.

The liquid bubble has not been seen to move and invariably occupies the middle of the cavity.

The presence of the gas bubble is peculiar since the liquid bubble in no case completely fills the cavity, though the surrounding space between may be filled by a non-miscible liquid.

Careful examination of these inclusions, using the Becke line test under a moderately high power in parallel light, showed definitely, as was to be expected, that the body of the mineral was of higher R.I. than the inside of the cavity.

Further, the inner and presumed gas bubble has a lower R.I. than the liquid in which it occurs, again as was to be expected. It does, however, appear that the remainder of the cavity has a higher R.I. than the liquid and may thus be occupied in fact by a non-miscible liquid of higher R.I. than the liquid bubble occupying the middle of the cavities.

As each of these liquid filled formations is not wholly in any one plane, it is difficult to bring this characteristic out in microphotographs. In addition to flaws which are similarly buckled about at random, incipient cracks can frequently be seen parallel to the side pinacoid *b*, owing to the perfect cleavage of the mineral parallel to this face.

Slight variation in the depth of colour has already been noted.

BIBLIOGRAPHY

Pough, F. H., and Henderson, E. P. " American Mineralogist," 1945, Vol. 30, pp. 572-582.

Abstract in " The Gemmologist," 1946, Vol. XV, p. 34.

Frondel, C., and Lindberg, M. L. " American Mineralogist," 1948, Vol. 33, pp. 135-141.

Anderson, B. W. " The Gemmologist," Vol. XIX, 1950, pp. 89-90.

Pough, F. H., and Henderson, E. P. " A new phosphate mineral." " Am. Mineral.," 30, 572 (1945).

Filho, E. T. " Constantes Cristalogrâphicas e Formas da Brasilianita: Mineraçao e Metalurgia," 8, 373 (1945).

Godoy, M. P. Ocorrencias de Brasilianite do Corrego Frio, Municipio de Conselheira Pena, Minas Gerais: Mineraçao e Metalurgia," 8, 385 (1945).

Filho, E. T. " Duas Orientaçoes para a Brasilianita Mineraçao e Metalurgia," 11, 61 (1946).

Hurlbut, C. S., Jr., and Weichel, E. " Additional data on brazilianite." " Am. Mineral.," 31, 507 (1946).

Franco, R. R., and Loewenstein, W. " Pesquizas Roentgenographicas sobre a Brasilianita: Univ. Sao Paula Fac. Fil., Cienc. e Let " (1946).

LETTER TO THE EDITOR

Dear Sir,

The article " Notes on an Ultra-Violet Ray Cabinet," by Bevis-Smith (" Journal of Gemmology," Vol. II, No. 8) was most interesting. It is to be hoped that more practical hints of this nature will be published during the coming year.

I would suggest the use of a " Transpex " lens in place of the rather expensive 2″ quartz affair. This would bring the cabinet within the reach of all.

The " Transpex " lens is produced by a London firm and is made by casting acrylic optical resin in accurately worked glass moulds. This process permits of aspherical surfaces—a type of correction seldom met with in glass lenses, owing to the prohibitive cost of manufacture.

For general use, an added advantage is that " Transpex " can readily be drilled and sawn, thus greatly facilitating the mounting of the lens.

D. S. M. FIELD.

Canada.

EMERALDS from the AJMER District, India

A. E. ALEXANDER, Ph.D., Tiffany & Co., New York

The writer recently examined several Indian emeralds which for colour rivalled those of Muzo origin.

The emeralds came from a section of India referred to as Ajmer. The gems under study weighed approximately one-half carat each, and were for the most part quite clear. Three-phase inclusions were identified and one remarkable group was photographed. (See Fig.)

The indices of refraction were high for emerald, being 1.581 and 1.591. In this respect the mineral resembled emeralds of Russian and South African origin. The density was found to be 2.75-2.76. Negative fluorescence was noted when the emeralds were subjected to ultra-violet and X-ray irradiation. Dichroism was found to be strong: emerald-green and blue-green. Chromium lines were identified with the Gübelin absorption spectroscope. Readings of 7050Å and 6550Å differ to those measurements obtained by Anderson and Webster for chromium lines in the emeralds they have examined.

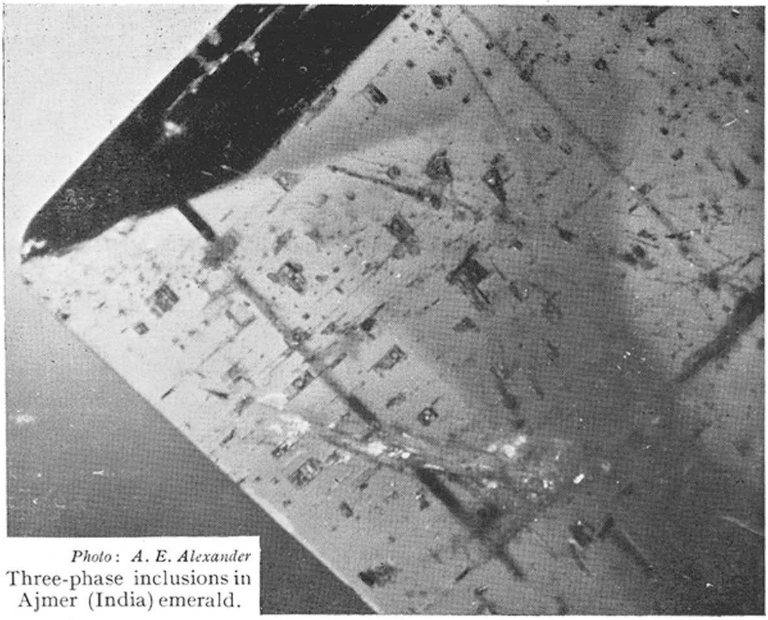


Photo: A. E. Alexander
Three-phase inclusions in Ajmer (India) emerald.

The James Bay Diamond Syndicate

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

IN the " Journal of Gemmology," July, 1949, the writer reported on the known finds of diamond crystals in glacial drift which, according to international geological authorities, originated in the wilderness of Canada, somewhere north of the Great Lakes.

Further information regarding the possible existence of deposits of diamonds in that area has kindly been furnished by Mr. J. C. Honsberger, a well-known consulting mining engineer and geologist, who has had extensive mining experience in the hinterlands of Canada.

In February and March, 1950, Mr. Honsberger, in association with Mr. Norman Vincent, of Toronto, formed the James Bay Diamond Syndicate, with holdings consisting of a solid block of twenty-eight mining claims totalling two thousand acres, located in the Vassan-LaCorne-Pressiac area of north-western Quebec Province, approximately fifteen miles by road north-west of the celebrated mining town of Val d'Or, and five miles south of the LaCorne Molybdenite Mine. The property consists, for the most part, of level farm land with a few rock outcroppings, and is readily accessible to transportation, power and water.

Mr. Honsberger is of the opinion that a diamond of good commercial size has been located in a serpentinized peridotite on the southern half of the property, and extensive development work is now under way. In a letter dated 31st July, 1950, he informed the writer that " in a matter of several weeks, the Quebec Department of Mines will do a milling test on 100 tons of the believed diamond-bearing rock from Vassan Township at their testing plant at Val d'Or."

The suggestion of a diamond deposit in the Vassan area developed when news reached Mr. Honsberger that two well diggers had encountered unusual difficulty in sinking a vertical hole on the farm of Alvida Duval on 27th March, 1948. Details of the incident are contained in their sworn statement, given below:—

CANADA. Province of Quebec.

We, Peter E. Allard, of the town of Val d'Or, in the District of Abitibi, Province of Quebec, diamond driller, and Osias Allard,

of the Town of Val d'Or, in the District of Abitibi, Province of Quebec, diamond driller, do severally make oath and say
To Wit:

1. That we have been diamond drill runners in the Provinces of Quebec and Ontario for the past twenty years, during which time the years 1930 to 1944, inclusive, were spent in the employ of N. Morisette Diamond Drilling Company, of Haileybury, Ontario, and/or its predecessor.

2. In 1944 we established our own diamond drilling firm, known as Allard Bros., Reg'd.

3. During the past three years we have been drilling water wells at intermittent periods for the Department of Colonization of Quebec.

4. On March 27th, 1948, we were drilling a water well on the Duval farm, which is located on the south half of lot 14, Ranve VII, Vassan Township, County of Abitibi East, Quebec, within a few hundred feet north of the highway between Val d'Or and Amos. We had no employees on this job and operated the drill ourselves.

The Hole was a vertical hole which required sixteen feet of casing. After collaring the hole drilling was commenced with EX bits and we drilled steadily through a soft rock to a depth of sixty feet. At this point the advance of the rods stopped and the machine began to rise with its foundation. We immediately shut off the power and placed two barrels of water on the machine foundation. The machine was then started several times but the bit refused to advance whatsoever. Never in our twenty years of drilling experience had we encountered such a condition in drilling. The rods were then pulled and the bit was examined. The diamonds on the face of the bit were polished smooth and the bit was useless for further drilling. We then put on a new bit and tried to drill again. The rods refused to advance any distance that could be measured, and when the rods were pulled the second bit was found to be polished off as smoothly as the first, after a few minutes of use. We then went to Val d'Or and sharpened our chopping bit and on March 28th we went back to the drill, put on the chopping bit, and chopped down about two inches. Before commencing to chop we tied a sludge bag on to the T of the casing and thereby collected all the choppings. This sludge was placed in a small brown bottle and taken to our office in Val d'Or.

After the chopping operation a third new bit was installed and the hole was driven to a vertical depth of 121 feet with no difficulty whatsoever. At this point the hole was abandoned as no water was encountered. A second hole was started within a few feet of the first hole. This was also a vertical hole and was driven to a depth of sixty feet without any difficulty. The hole was then abandoned as no water flow was encountered. In the drilling of these two holes no attempt was made to lay the core in boxes as we were not

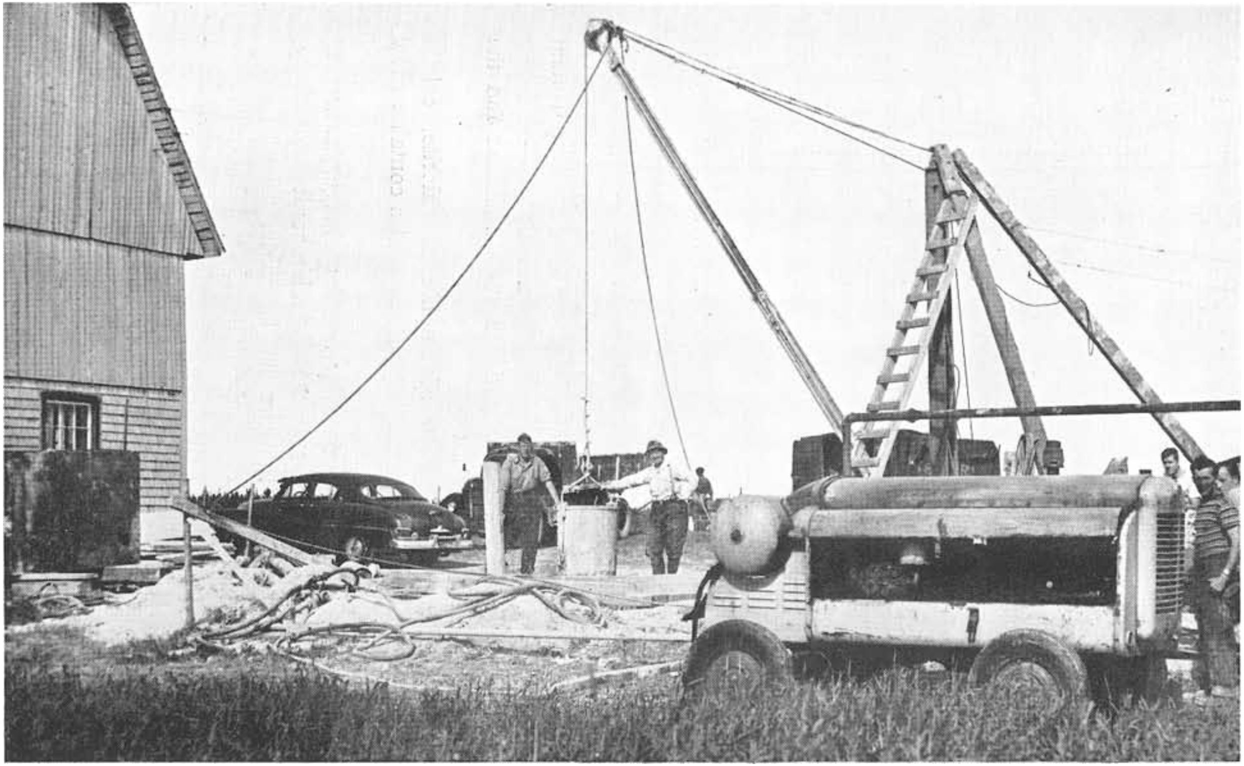


Photo: Courtesy of J. C. Honsberger, Esq.

Shaft sinking on the Duval farm, at the property of the James Bay Diamond Syndicate, Vassan Township, P.Q., August 2nd, 1950.

required by law to save the core. The core was dumped haphazardly beside the shack upon removal from the core barrel.

5. In February, 1949, Osias Allard called on J. C. Honsberger, mining engineer and geologist, at his office at Room 208, Lalonde Building, Val d'Or, P.Q., and related the aforegoing facts. These facts were later confirmed by Peter E. Allard. At Mr. Honsberger's request Osias Allard presented him with the sludge bottle and also, at Mr. Honsberger's request, they returned to the drill site and picked up, from the ground, what fragments of diamond drill core remained, amounting in all to about five feet of core, which was given to Mr. Honsberger.

Notarial Seal

Sworn before me at the village
of St. Cyrille, in the District of
Arthabaska, this 22nd day of
March, 1950.
(signed) "L. S. Joyal."

(signed)
"Osias Allard"
....

Notarial Seal

Sworn before me at the Town
of Val d'Or, District of Abitibi,
this 28th day of March, 1950.
(signed) "Armand Gilbert.'

(signed)
"Pete E. Allard"
....

On 26th March, 1949, Mr. Honsberger submitted the bottle containing the choppings to Mr. B. T. Denis, Chief of the Mineral Deposits Branch of the Quebec Department of Mines. On 22nd April, Mr. Maurice Archimbault, Director of the Department of Mines Laboratories, Quebec City, replied as follows:—

"The sample submitted by you has been examined and the following results were obtained:—

"The sample is composed of amphibole, chlorite, calcite associated with a little mica and iron pyrites. It also contains a few grains of diamond."

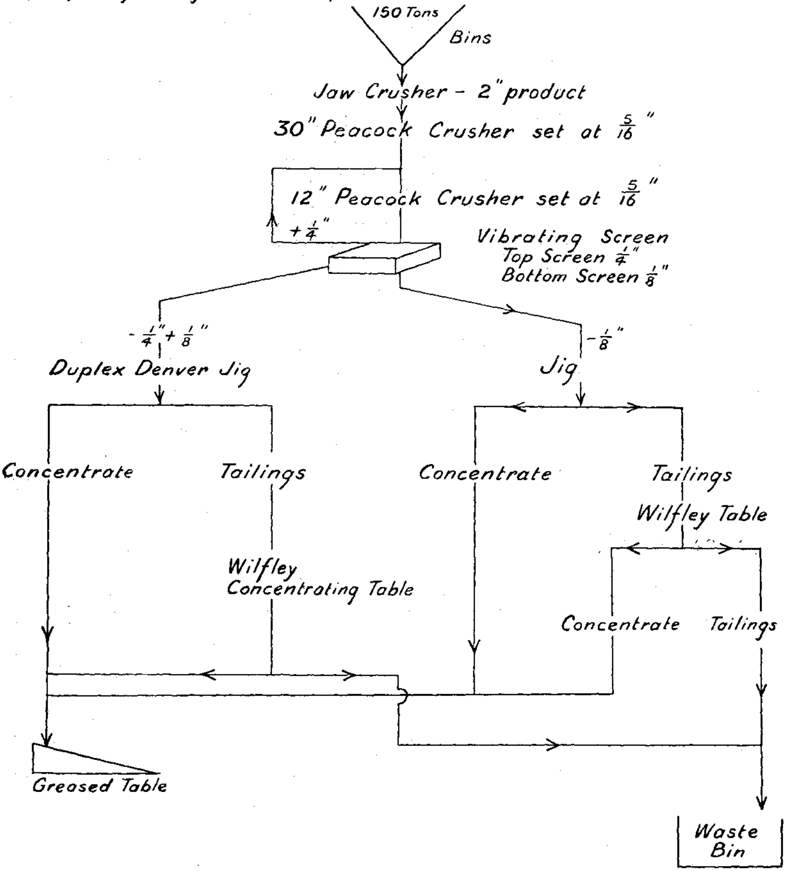
The pieces of ore, recognized by Mr. Honsberger as serpentinized peridotite, were submitted to Mr. Archimbault on 6th May, 1949, with the request that the Department of Mines determine the origin of the rock and if microscopic diamond crystals occurred in it. The findings of the Department were detailed in a memorandum, dated 28th May, 1949. The rock was indeed a serpentinized peridotite, but no diamonds were found in the samples of core submitted.

When it is considered that the production in South Africa averages approximately one carat of diamond per eight tons of processed rock, this report is not at all surprising. Indeed, it is said

Flow Sheet

James Bay Diamond Syndicate

Diamond test by the Quebec Department of Mines at Val D'Or, P.Q. on peridotite rock from the Vasson Twp. property, August and September, 1950.



that some of the South African natives have worked a lifetime in the mines without ever having once observed a diamond *in situ*.

For this reason, it was decided that the examination of a large bulk sample of the peridotite from the Quebec property would be the only practical way to determine a possible diamond content.

Mr. Honsberger comments on the topography and geology of the area as follows:—

" During the past few years, the area has been mapped in detail by the Geological Survey of Canada, aided by the fact that hundreds of miles of good colonization road extends east and west and north and south through many parts of the area. The area lies parallel to, and fifteen to thirty miles north of the Cadillac-Malartic-Bourlamaque areas.

"A large mass of granodiorite, 28 miles long east-west, with a maximum width, north-south, of 12 miles, has been intruded, the basal rocks consisting of altered volcanics and sediments. A number of north-easterly trending diabase dykes cut all other formations. A number of peridotite and serpentinized peridotite intrusives have also been noted associated with the granodiorite and other intrusive rocks and widely interspersed in the volcanics.

" A wide range of metallic and non-metallic minerals have been found in the area, and during the war two mines—the Indian Molybdenite Corporation and the LaCorne Molybdenum project—produced molybdenite. The latter mine is about five miles north of the James Bay Diamond Syndicate's Vassan Township property. The LaCorne area is potentially capable of being a large producer of lithium ore (spodumene). Beryl, columbite, tantalite, etc., have also been found.

" . . . The extreme north-east corner of the . . . (Syndicate's group of claims) . . . is underlain by sedimentary rocks of the Kewagama group, consisting of greywacke, minor amphibolite, tuff and breccia. The remainder of the group is underlain by volcanic rocks, mostly andesite, intruded by several small granitic intrusives, a number of diorite dykes with numerous small outcrops of peridotite. The large LaCorne granodiorite batholith lies about 1,500 feet north-east of the north-east corner of the group. The percentage of rock outcroppings on the entire group is under two per cent., but it is believed that the overburden in many places is light."

In addition to the 2,000-acre property purchased by the Syndicate, considerable ground in the vicinity has been staked by private interests, including several " Big Names " in Canadian mining. It is estimated that a total of some 14,000 acres have been located.

Development of the Syndicate's holdings commenced late in July. At the present writing, a test shaft 9½ feet x 6 feet is being sunk to a depth of 65 feet. The contract for the sinking of the shaft was awarded to Patrick W. Harrison & Company, of Noranda. This company will remove approximately 100 tons of rock from the shaft and truck it to the Val d'Or plant of the Quebec Department of Mines, where it will be thoroughly examined for diamonds. The machinery and equipment for the test was assembled by Mr. E. H. Bronson, a consulting metallurgist of Toronto, in co-operation with the Quebec Department of Mines. As a matter of fact, the flow sheet has been worked out by Mr. Grainger Grant, B.Sc., metallurgist for the Quebec Department of Mines, at their test plant in the Val d'Or area.

Should the test mentioned above disclose the presence of diamonds, a company will be formed for the purpose of testing and assessing the economic importance of the property.

FROM THE LABORATORY

An X-ray photograph of a shell of the pearly nautilus mounted in gold as a pendant.

The pearly nautilus (Nautilus pompilius), a mollusc of the order Tetrabranchia, of the class Cephalopoda, a relative of the cuttle fish, is found in the Indo-Pacific.

Although in some ways resembling a snail, it belongs to a different order, and has the shell divided into sections by " septa," which clearly show in the photograph.

The animal occupies the last compartment and the septa between the compartments are traversed by a shelly tube, the siphuncle, which in life contains a prolongation of the tissues of the mantle. This tube is also discernible on close inspection of the photograph.

Chinese creature of good augury, Ch'i-lin, probably 19th century. The figure is unusual in being carved from quartzite.

Classification of Colours in Gemmology

by Professor K. Schlossmacher

THE colour of precious stones is one of the most interesting problems yet also one that has attracted only little attention in gemmology. Colour lends the chief beauty effect to most gems and is most important in gemmology. It is rich in theoretical and experimental difficulties, which explains to some extent why it has attracted so little attention.

The science of gem colour can be divided into four branches which belong to different fields of physics and chemistry. The primary conditions of the colour effect are the colouring substance and the crystal accommodating it, the so-called " host." Investigating the nature and constitution of the colouring substance two directions of research result, in which chemistry and mineralogy participate equally. Chemistry and its branch, spectroscopy, must determine the chemical nature of the substance. Mineralogy, together with crystallography, must investigate the arrangement in space and the accommodation in the " host " ; occasionally other mineralogical properties are of interest. After determining the colouring matter another field of science is entered, namely, that of atomic physics. The colour is caused through changes in the inner structure of the atoms of the colouring substance, being transformations of energy when light passes through. Research here enters one of the most difficult subjects of atomic physics and one can understand easily why up to now gemmology has not entered this field, especially as there are many other questions of gem coloration to be solved as well. The research problems mentioned so far relate to the pigment or colouring substance. There is also quite a different complex of questions concerning changes in the light itself which occur by its contact with the colouring substance. Here optics must be considered and, as most gems are crystals, crystal optics. The most important problem here is the absorption of the light intensity which is suffered by each individual colour when passing through a coloured stone (which may also appear to be colourless to the eye). Measuring this absorption is the concern of photometry and the result is an exact colour analysis. In this case the object of research is the colour phenomenon. To these two fields, the substantial and phenomenological research, there is added an appendix (belonging to both) and relating to the changing of colour in gems by physical or chemical treatment. These problems, which are of great importance to the gem industry, can be solved only by simultaneous substantial and phenomenological research. This is the reason why they are particularly difficult. Many experiments have been made because of the economic importance, but basic research has hardly been attempted.

Every descriptive exact science has as one of its objects a system of classification. The colouring substance of gems can be classified according to various points of view. Genetically, the obvious classification is according to the colour-spending chemical elements, which determine the absorption in the interior of the atom and the external optical effect. This system, however, does not carry us very far, as there are only a few elements which could be considered. Most important of these is iron, which probably takes up the largest percentage of all colouring substances, not only in gemmology but also in mineralogy. This is not surprising, as in our earth crust iron is the most common of all metals, the oxygen combinations of which are coloured. After iron in a certain distance follow chromium, copper, nickel, manganese, perhaps titanium and a few other doubtful metals. Such a classification according to colouring matter would not mean very much as our present knowledge of the subject is not sufficiently advanced. The colouring substance, which usually is only present in minute quantities, has in many cases not yet been determined, so that such a system would have many gaps.

Much more satisfactory at present is a system using the relation of the colouring substance to the host. It differentiates between idiochromatic and allochromatic colours and the latter are classified according to the type of accommodation. Idiochromatic are those gems whose colouring substance is an inevitable constituent of their chemical composition. Malachite is idiochromatic, as it cannot exist without the colouring copper in its chemical formula. Allochromatic colours are found in corundums, beryls and other gems, wherever whole series of colours are found in the same gem type. In this case there is a further classification according to the relation of colouring matter and host crystal. A simple case is that of replacement in the crystal structure. An example is the ruby (Al_2O_3), in whose crystal lattice some of the aluminium atoms are replaced by chromium. The presence of chromium has been proved chemically. But with our present resources we cannot yet say how these atoms are distributed in the lattice and whether they follow distinct rules. The next group of colouring substances comprises inclusions, which exceed atomic and molecular size, where the colouring substance is found in the form of individual crystals. These small crystals need not consist of the colouring metal only but may be a compound in which non-colouring elements participate. An example is the chrysoprase, whose basic substance is chalcedony and whose colouring substances are nickel-silicate grains. Only the nickel is the colouring substance, not the other components such as silicon, magnesium, oxygen and hydrogen. In this group of accommodation one can hope occasionally to see the colouring substance by microscopic or other suitable methods. In the case of sapphire, for instance, it is said that the pigment can be seen under the ultra-microscope (optical microscope with side illumination). This class of crystalline colouring substances can be further sub-divided according to the orientation of the crystallite in relation to the host crystal. In the case of oriented accommodation the crystallite lies with one of its main axes parallel to any one main axis of the host crystal. An example is the star ruby, where three sets of rutile needles, which cause the star, are arranged parallel to the hexagonal axes of the ruby, i.e. at 60° to each other.* Generally speaking, one can say that wherever chatoyancy is present there are parallel inclusions which are orientated in relation to the crystal structure of the host. There is, however, a group of non-orientated accommodations, a macroscopic example being the rock crystal with the rutile needles included in random directions. This classification is partly deduced from observation of gems, but to a greater extent it is derived from general knowledge of mineralogy and theoretical considerations. It is to be hoped that modern development of science, with the help of the newest microscopic

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* The star effect is not strictly a colour effect.—Ed.

methods, will bring in the next few years valuable knowledge and with it an extended classification of colouring substances in gems.

A classification of the phenomenological part of the science relating to gem colours would be most important for the gem industry and trade. A beginning has been made in the colour measuring and classification of the diamond with new instruments, such as the Colorimeter, Diamolite and Coloriscope. But essential for the classification of gem colours is the exact definition of colour, which cannot be given subjectively by the mere impression of the eye, but needs physically exact measuring. In this field, however, only the first beginnings can be noted. Fault lies with optical photometry where the measuring instruments depend too much on the human eye, which is not sufficiently sensitive to light and colour. The ideal solution of light-electrical colour measuring has caused great technical difficulties. Investigations with a new light-electrical apparatus, built during the last decades in the Mineralogical Institute of the University of Koenigsberg, have shown the interest of this research work for gemmology. In a theoretical investigation the author has suggested a classification of one-colour, two-colour, and multi-colour systems, and in the case of the two latter has calculated and experimentally proved the compound effect of the two, respecting three colouring substances. But only when the absorption curves of a great number of gems have been measured can a classification system for gem colours be compiled and new points of view found for it.

GEMMOLOGICAL ABSTRACTS *continued from page 30*

FOSHAG (W. F.). ***Exploring the World of Gems.*** The National Geographic Magazine, Vol. XCVIII, No. 6, pp. 779-810.

A well-written, popular article on gemstones, excellently illustrated with 24 Ectachrome and Kodachrome colour plates and 12 in monochrome. The fact that the author is Head Curator of Geology of the U.S. National Museum, and is on the Editorial Board of the Gemological Institute of America, ensures the soundness of the statements made. Trade errors in nomenclature are decried, and synthetic stones, while mentioned, are not elaborated. Curiously, the fine blue sapphires from Burma and Siam are not mentioned, the only blue sapphires referred to being those from Montana. A useful article enhanced by beautiful illustrations.

R. W.

Gemmological Abstracts

"*Kleiner Wegweiser zum Bestimmen von Edelsteinen*" Small Guide for the Identification of Precious Stones). By G. O. Wild, K. H. Biegel. 32 pp., illustrated. Frankh'sche Verlagshandlung, Stuttgart, 1950.

The publication is most probably useful to the German worker who has to identify precious stones practically without any instruments. It is doubtful, however, whether anybody can make good use of it unless he is an experienced gemmologist. The authors mention in the introduction that a good 8 × aplanatic lens and a pair of scales are powerful means of detecting gem properties, and that with the addition of a dichroscope and two small polarizing filters most problems of identification can be solved. This is certainly correct. The beginner, however, will be much better served with a refractometer, an instrument which is not mentioned, although it should be within reach of the jeweller for whom the booklet is written. Determining the refractive index with the help of immersion liquids as recommended requires no apparatus, but more skill. The authors may have had the particular circumstances in mind which made it difficult to procure instruments in Germany, and with due regard to this position the booklet has probably filled a gap. To the initiated gemmologist in this country, if he can read the German text, it is interesting to note how the " fun " of discarding one or the other instrument in gem determination can become a serious necessity.

The determination of the following constants are dealt with: (1) Density (hydrostatic and heavy liquid methods). Only water is mentioned as immersion liquid in hydrostatic weighing, although much trouble due to surface tension could be avoided by using one of the liquids which are suggested for the determination of the refractive index (for instance, toluol). (2) Hardness. Mohs's scale and abrasion resistance referring to quartz = 100 are given. The discreet use of a steel file is not discouraged. (3) Refractive index (immersion method). Ten immersion liquids are listed. (4) Double refraction. (5) Dichroism. A few pages are devoted to synthetic stones and good photomicrographs illustrate the text. The booklet concludes with a page on glass imitations and an index. The mainstay of the publication is three tables of constants and properties classifying the conventional gem materials into those of " distinct dichroism," those of " lacking or imperceptible dichroism " and into " colourless stones." According to this arrangement the authors seem to recommend the use of the dichroscope as first test, followed by the determination of double or single refraction. W. S.

CHUDOBA (K. F.). ***Farbumwandlungen bei Schmuck- und Edelsteinen.*** (Colour changes of precious stones and gems.) Gold und Silber, 1950, *3*, 19 (No. .10).

The colour of most gems is not dependent on the chemical constitution but on some additional pigment, as easily seen in case of corundum where different pigments with same constitution produce red rubies or blue sapphires. Such gems are termed allochromatic. The allochromatic colouration of a stone is easily influenced by higher temperatures or treatment with X-rays or other rays. Best known is the heating of amethyst-coloured quartz at 500-600 deg. C. to a yellow-red colour. When red-brown or reddish zircons are heated in a reducing atmosphere to 850-900 deg. C. they become colourless or blue, the latter hue not being present in natural crystals. Zircons can be treated with radio-active uranium or thorium, which destroys their lattice—they become green. When these " autoisotropic " zircons are heated to 1,450 deg. C. they resume their original lattice and become brown or yellow. Colourless diamonds when treated with cyclotrons obtain a green hue. If gems were treated systematically with various rays many other colour changes would result. E. S.

GÜHLER (U.). ***Studies of precious stones in Siam.*** Siam Science Bulletin, Bangkok, 1947, Vol. 4, No. 1, pp. 1-39.

Details of the Bo Ploi sapphire mines are given, together with references to gem gravels of Krat and Chantaboon. The main feature is the detail given of qualities and prices of rubies and sapphires. A. G.

GÜBELIN (E. J.). ***Ein neues Verfahren zur Erhöhung der optischen Wirkung von Edelsteinen.*** (A new method of increasing the optical effect of gems.) Uhren, Schmuck und Edles Gerät, 1950, 267-268 (9).

For some years the optical industry has made use of a method consisting in covering (" blooming ") optical glasses with a transparent film. This thin film has a certain thickness so that there are interference phenomena of the reflected rays in the air-film and film-glass border. Thus surface reflection is reduced and more light enters the glass. Similar experiments have now been made with 53 gems. It is shown that not only oblique light rays are strongly reflected and thus lost for the brilliance effect, but that also other light rays sacrifice a good part of their energy to the surface reflection. By the use of this thin anti-reflection film a great amount of the light which would otherwise be lost can be let into the stone, thus reducing reflected light. In order to reduce the loss of light to a minimum, the covering film must have a refractive index which lies between that of air and that of the stone ; it is best if that R.I. equals the root of the R.I. of the stone. A few examples are given. The thickness of the film must be a quarter of the wavelength of the used light, which, of course, is only easy in the case of monochromatic light. But with daylight the rule need not be followed too closely. There are four metal fluorides whose R.I.s make them usable for a number of gems: BaF_2, CaF_2, MgF_2 and Na_3AlF_6 (cryolite) ; TiO_2 can also be used. To protect the film, silica is used (hardness a little under 6). The two last substances are insoluble in water. There are three methods available for bringing the film on to the stone, two chemical and one physical. The chemical methods which dissolve part of the surface of the stone cannot be used for gem purposes. In the physical method the fluoride is powdered and evaporated in high vacuum on to the stone. It has been shown that in the case of diamonds the anti-reflection film can increase the entering light by 5 per cent., which improves the brilliance markedly. (Cont.) E. S.

The Diamond Industry in 1949. (25th annual review.) Jewelers' Circular-Keystone, New York, 1950.

This well-known review has been continued by W. F. Foshag and George Switzer. Details of mining, exports and imports for various countries are again given.

CHUDOBA (K. F.). ***Das Problem der Diamantsynthese.*** (The problem of diamond synthesis.) Gold und Silber, 1950, *3*, 8-9 (No. 8/9).

A query as to the use of " synthetic industrial diamonds " in Russia. Short historical review, mentioning H. Moisson (1900), M. K. Hoffman (1931), P. L. Günther (1942), and the repetition of Hannay's (1880) experiment by C. A. Parson (1919). There are two schools of thought: one according to Ostwald's law tries synthesis by quick cooling of carbon in gaseous, liquid or soluble form to obtain the unstable diamond modification—the results have been negative. The other way is to change graphite into diamond under high pressure, as diamond has a higher specific gravity than graphite. P. W. Bridgman used this method, but even pressures of 45,000 kg/sq. cm. were unsuccessful. It seems most unlikely that Russia has solved the problem ; it can be assumed that they have found new diamond deposits or are using very hard carbides. The possible use of atomic energy in relation to diamond synthesis must not be forgotten.

E. S.

GÜBELIN (E.). ***Perlen.*** (Pearls.) Gold und Silber, 1950, *3*, 11-13. No. 10.

Pearls are perfect when found. Chief properties are lustre and opalescence. They are found in three colours: white, including rosé ; black, including grey ; dark green, navy, as long as they have a metallic lustre, and coloured, which includes golden, copper, green, blue, even red. Colour is influenced by geographical position of occurrence. The production of cultured pearls by inserting a small mother-of-pearl bead into the living oyster is described, as is also the differentiating between real and cultured pearls. Six rules are given with regard to treatment of pearls: do not wear them in the bath, take them off when you are hot, remove the dust frequently by rubbing over them, have the necklace restrung every six months, do not let them come into contact with diamonds, do not throw them carelessly on the dressing table. It must also be mentioned that they need air and light and should not be kept for years in a safe.

E. S.

(continued on page 26)

SYNTHETIC QUARTZ CRYSTALS EXAMINED

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

THERE is to-day a large and growing demand for crystals of quartz for use in the telephone and other industries. Advantage is taken of the marked piezo-electric properties of the mineral in controlling the frequency of signals to a high degree of accuracy, the quartz being cut for this purpose into thin plates of definite crystal orientation and thickness.

It so happens that, of the quartz found in nature, only a small percentage of crystals have the necessary purity and freedom from twinning which are essential for these technical uses. Thus, despite the abundance of the mineral in almost every country of the world, attempts are being made by scientists to grow pure quartz crystals artificially, using small, untwinned natural " seed " crystals or plates to ensure that the completed crystals shall be of the quality needed. Success has been reported in this endeavour from many laboratories, but it is in America, notably in the laboratories of the Bell Telephone Company, that the largest crystals are now being manufactured.

Thanks to the kindness of Mr. D. S. M. Field, three specimens of artificial quartz crystals grown in the Bell laboratories have been made available to the Gemmological Association for study. Though these have, of course, no importance as gemstones, a brief description of these crystals may be of interest here.

First, something may be said as to the method of preparation. A diagram illustrating the conditions under which such crystals are grown was published in an excellent article on synthetic crystals in the August number of " Fortune," an expensively produced American periodical not easily obtainable in this country. According to this diagram, the quartz plates acting as " seeds " are suspended in an alkaline solution rich in silica, enclosed in a high-pressure columnar reaction chamber under a pressure of 15,000 pounds per square inch. The lower part of this vessel, containing quartz chips as " nutrient," is maintained at a temperature of 750° F., while the upper part of the column, where the seeds are suspended, is at a lower temperature, about 715° F.). In the same article a photograph is reproduced of the largest quartz crystal so far made by Bell—a transparent specimen weighing five ounces.

The most interesting and perfect of the specimens submitted by Mr. Field is a beautiful crystal about 1 inch long by $\frac{5}{8}$ inch broad, weighing 15.16 carats. The habit is remarkably simple ; the only faces developed being six faces of the positive rhombohedron $(10\bar{1}1)$ and six faces of the hexagonal prism $(10\bar{1}0)$. No trace of the negative rhombohedron can be seen, and there are none of the customary horizontal striations on the prism faces. This simple habit is figured in Dana's " System," but is very seldom encountered in nature.

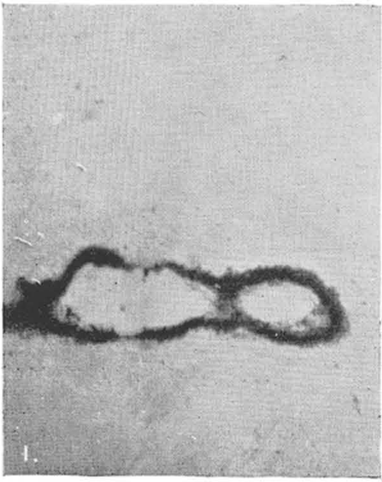
The faces show a faint iridescent tarnish, and attractive growth markings of slightly raised discs (dimples in reverse, so to speak) can be seen on the rhombohedral faces. The plate which formed the original " seed " can be seen as a " ghost " within the crystal, parallel to one face of the rhombohedron, and the metal hook by which this was suspended is partly embedded in the crystal.

One of the rhombohedral faces was sufficiently smooth to give good shadow-edges on the Abbe-Pulfrich refractometer, and, as would be expected, these were found to coincide exactly with those shown with a polished surface of natural colourless quartz.

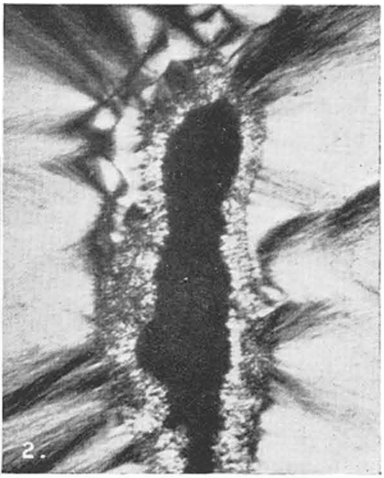
Of the other two specimens, one was a doubly-terminated crystal weighing 117.95 cts., the other being a much smaller (.30 ct.) tapering prismatic crystal with only one rhombohedral termination. The larger crystal was relatively imperfect but more normal in habit than the one described above. Both positive and negative rhombohedra were present, and also trapezohedral faces, showing the crystal to be a left-handed specimen. Externally this crystal had a dull, slightly etched surface, and internally there were cavities in bizarre shapes, containing liquid and bubbles of gas.

In conclusion, one may express the hope that eventually the success achieved in growing artificial crystals of quartz will be sufficiently great to put a halt to the wastage and destruction of fine specimens of the natural mineral which has been going on for many years.

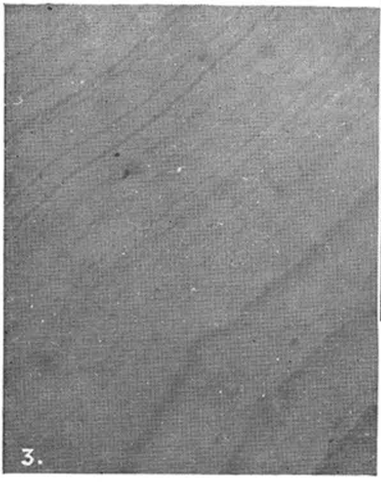
CHALCEDONY
photographed in ordinary and
polarized light.



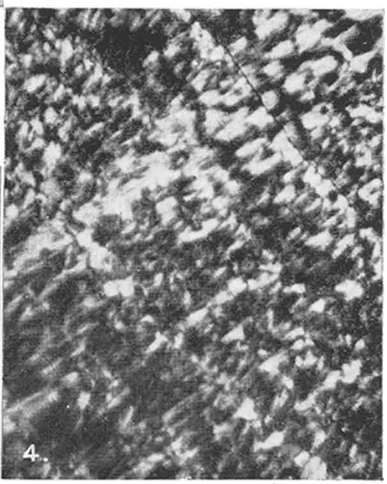
Ordinary light.



Polarized light.



Ordinary light.



Polarized light.

Photos 3 and 4
STRIPED AGATE

STATISTICS and GEMMOLOGY

A Survey and Trial Enquiry

by E. BURBAGE and T. G. JONES, FF.G.A.

AMONG the questionable advantages of maturity must be reckoned the jettisoning or transformation of many of the agreeable fables which beguiled one's youth, by which process, in the cautionary anecdotes of Strewwelpeter, a covert Freudian undercurrent presents itself, Hy. Brasil fades, and Dr. R. Lloyd Praeger, armed with a vasculum and a geological hammer, deflates St. Patrick's Purgatory. Thus, we have cherished for many years the agreeable picture (in Wells's " Food of the Gods ") of Redwood's investigation of the Diurnal Variation of the Butting Frequency of the Young Bull Calf (an enquiry, it will be remembered, which discommodated the teaching staff to some extent, but which yielded curves of a most interesting nature). Now, unfortunately, a very slight acquaintance with statistical methods has punctured the Wellsian fantasy: if a paper describing the successful achievement of this research has not yet reached the sober pages of Biometrika, it is not, we conjecture, because the research is inherently unsuitable for statistical handling—c.f. (as the textbooks say), the classical Poissoniam distribution of casualties from the kick of a horse in a Prussian army corps (1875-94), described by Quetelet and von Bortkiewicz. In fact, a grounding in Statistics teaches one to regard with a coldly sceptical eye any plexus of events which on rule-of-thumb commonsense criteria would be relegated to the limbo of " unrelated " or " random " happenings. For instance, a gemstone whose cutting is unrelated to the crystal symmetry of the original material we had previously been content to consider as having random orientation. We now regard the term " random " with some dubiety, and deplore the incurious acceptance of an almost total lack of information as to the relationship between crystal orientation and that imposed by the lapidary.

The question presents itself in two forms: (i) in those gemstones where there is cleavage, dichroism, or some other factor to influence the lapidary's choice of direction for cutting, to what extent does this external factor operate? For instance, when there is a direction of " best colour " with what frequency and precision is this reflected in the cutting? (ii) In minerals where no evident compulsion exists to bias the lapidary in any particular direction, does a statistical enquiry show that there is, in fact, an even distribution of directions of cutting?

The field of enquiry presented by these two questions is a very extensive one, but large areas of it are probably inaccessible to the statistician by reason of the impossibility of collecting the necessary data. For instance, the relationship between the fashioning of isotropic gemstones and the original crystal symmetry cannot usually be discovered. Also, however one reduces the labour involved in collecting the data required by simplifying one's methods, it still remains considerable. Ideally, this is a chore suitable for collective handling, and here one could do well to borrow from our American friends the practice, common in their societies and clubs, of launching a " project," a joint enterprise of a group of members. Our own effort is only by way of a trial sortie, open to criticism on both gemmological and statistical grounds, and we claim no especial merit for it other than the virtue of indicating a fresh field of enquiry to persons with more leisure and better facilties than we possess.

In an earlier paper in this journal* we described a method, using extinctions, to determine the orientation of an uniaxial gemstone with respect to the optic axis. Having decided to use this technique in our statistical work, we had to select a suitable gemstone from the uniaxial group, a group which, although large, contained a great number of stones which were for various reasons inacceptable for our purpose. Thus, rarities were " out," for two reasons: first, that it would have been difficult to procure sufficient specimens to give results of any significance in a statistical enquiry, and secondly, because a great number of unusual stones are cut to the specific instructions of a collector, and are consequently special cases lying beyond the scope of our enquiry. Quartz, an obvious choice, was rejected in view of the complication introduced by the rotation of the plane of polarization. Tourmaline filled the bill on

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* Burbage and Jones. " Optical Orientation in Uniaxial Gemstones." " Journal of Gemmology," Vol. II, pp. 304 to 309 (July, 1950).

the grounds of the accessibility of specimens, and it would, indeed, be interesting to consider this gemstone as furnishing a multivariate distribution on the basis of colour. Since Mr. R. W. Yeo's pioneer paper* relating specific gravity and colour in tourmalines, work on this gemstone has not been extensive, and this relative neglect provided an additional inducement to use it for our purpose. We reluctantly abandoned the idea, as the number of stones we needed to consider would have had to be far greater than when dealing with a univariate distribution. In addition, colour is a subjective business which does not readily lend itself to statistical handling.

Finally, we decided to work on aquamarines. The material for our purpose consisted of 45 faceted stones, cut in a variety of styles, including briolettes, mixed-cut, and step-cut, and ranging in size from .6 to 17 carats, of which few were of good, and none of fine colour. We need not recapitulate our earlier description of the method used for finding the angle between the normal-to-table direction and the optic axis. For a number of stones it was not easy to interpret the results from the first set of readings, and it proved necessary to remount them to get a second set ; in other stones, patchy extinction presented a difficulty. Our final results, expressed as a frequency histogram, are shown in Fig. 1.

It will be appreciated that, for a complete picture of the situation, one would need to plot a frequency surface in three dimensions, for, although our method enabled the angle made by the normal-to-table with the optic axis to be determined, its direction remains unknown, and, indeed, unknowable, at least by any elementary means. Such a surface would be contained within two boundary planes intersecting at 30°, one of which will contain the histogram corresponding to normal-to-facet directions lying in the plane containing the optic axis, and cutting a prism face at right angles, and the other will contain the histogram corresponding to those directions lying in the plane containing the optic axis and emerging at the junction of prism faces, the other points on the frequency surface being furnished by planes lying between these two extremes. As hexagonal prism faces are similar in the same crystal, and one cannot therefore establish a correspondence between any particular faces in a set of aquamarine crystals, this hypo-

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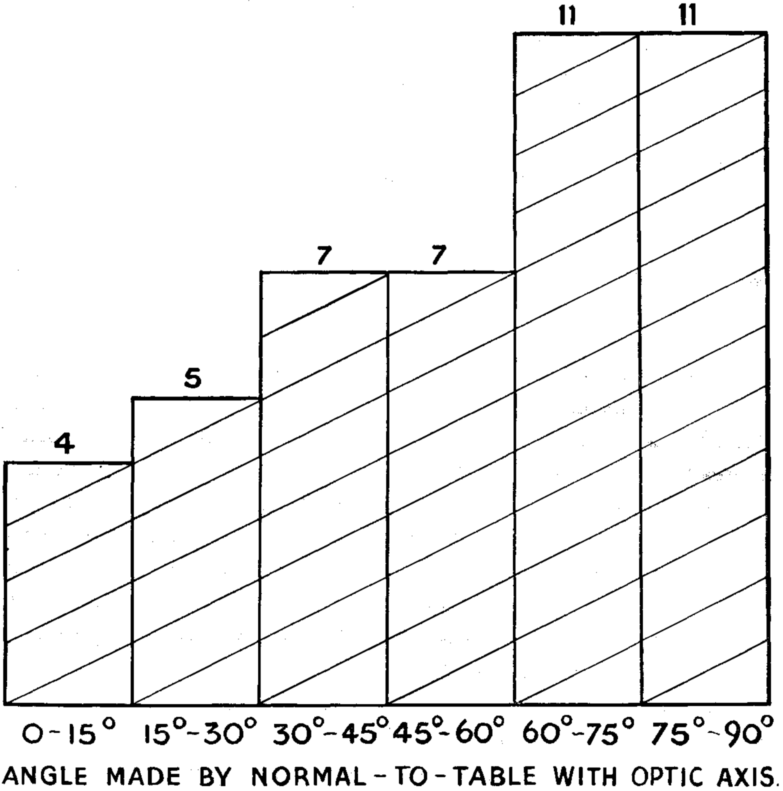
* Yeo, R. W. "Gemstones and Specific Gravity." "Gemmologist," Vol. No. 1, August, 1931, pp. 16-20.

Fig. 1 DISTRIBUTION OF CUTTING-ORIENTATIONS IN PARCEL OF 45 AQUAMARINES.



thetical frequency surface would necessarily be confined to the 30° sector described. We do not believe that the surface would be one of revolution, but failing the impracticable method of surveillance of the actual process of cutting, one cannot hope to establish this.

Our data provided us with the values of the angles made by the normal-to-table direction with the optic axis, without providing an indication of sign, which would in any event be meaningless, and in consequence our histogram departs from the usual form in peaking at the end instead of in an approximately central position. One would intuitively reject the hypothesis that here we have a group of stones in which the fashioning has been purely random with respect to the crystal symmetry, and it is not difficult to obtain a fairly decisive quantitative confirmation of this impression by means of the Chi-squared distribution. As grouped in our histogram, the frequencies are too low to use with any confidence for this purpose, and therefore we used the broad groupings of 0-30°, 30°-60°, and 60°-90°. Setting up the hypothesis of an equal distribution, we then had as " observed values " 9, 14 and 22 respectively, as against an " expected value " of 15, giving a Chi-squared total of 5.73. For the two degrees of freedom concerned, this figure is near the 5.99 of the 5 per cent. confidence level, showing that the probability of a Chi-squared as great or greater than the value calculated being given by random sampling is about one in twenty—a probability sufficiently low to rule out the hypothesis. Having thus rejected fairly decisively the hypothesis of equal distribution, one then asks what alternative hypothesis can replace it, and that of a normal distribution immediately suggests itself (using the term " normal " in the restricted statistical sense in which it describes a class of single-humped curves defined by an algebraic expression involving the exponential function). Unfortunately, the same difficulty presented by small frequencies in a six-class classification again presents itself to render impossible the fitting of a normal curve, and one would not attempt to do so for a lesser number of cells, for which in any case the additional constraints involved would limit the degrees of freedom too greatly to permit a Chi-squared test for goodness of fit.

We would note incidentally that in a characteristically brilliant feat of gemmological expertise, Mr. B. W. Anderson, from whom we had invited an opinion before starting this enquiry, had correctly predicted that our findings would be as stated. As previously noted, there were few stones of good colour among those examined ; a fortiori, with specimens of fine colour one would reasonably expect an even greater majority to be cut so that the normal-to-table directions made large angles with the optic axis.

It would certainly be interesting to have data of this sort for the more important gemstones. and we think it likely that it would be of value in their study. In the strictly practical business of identification, ancillary information of this sort has its merits. This would be more especially true when a number of stones of one kind were in question. For instance, if one had a " normal " frequency curve of a particular gemstone, one would have the means of assessing if a particular random set is likely to have been drawn from this species. For example, if it could be established that the relationship between the cutting and the crystal orientation were significantly different in synthetic and natural rubies, and if the distributions of both were known, one could use the multiplicative properties of the relative probabilities to give a fairly conclusive answer as to whether a set of rubies, not necessarily very many in number, were natural or synthetic. Although it may be objected that the gemmologist has by now taken the measure of synthetic corundum without the need to call upon unorthodox criteria of this sort, it is possible that when dealing with other gemstones, maybe in circumstances limiting the application of standard tests, information about cutting orientations would be of value.

It is a little surprising that, while in so many sciences and branches of learning common ground has been found in which amateurs of these studies have either contributed to, or been indebted to, gemmology, Karl Pearson and his co-workers and successors might never have existed as far as the impact of their work on gemmology is concerned. If we may imagine the appointment of a statistician to the staff of a gem research laboratory, how, we may ask, could his abilities and technical training be most profitably employed? One rather prosaic and unexciting but unquestionably useful job which he could tackle would be to impose some kind of statistical order upon the published data on the physical constants of gemstones. Twenty years ago a text-book would confidently assert that a particular gemstone X had a specific gravity of 3.63 (say). Nowadays, in a text-book having any claim to a reasonably full treatment, the s.g. of our hypothetical gemstone X is likely to be dealt with as follows: " The spec. grav. varies from 3.617 to 3.638, except in the metamict types, where it may be as low as 3.605, and in the iron-rich variety from Paraguay, where it may rise to 3.67." Confronted with such a plethora of information, the student may well sigh for the dogmatic half-truths of the 1930 text-book, and in point of fact, a statement in the form quoted (which could without difficulty be matched by actual quotations from modern text-books) is not very helpful. One does not need to know anything of such matters as frequency distributions, variance and kurtosis to feel that a statical presentation would bring order to this hodge-potch of facts. Our hypothetical statistician could profitably wade through the mass of readings upon which the text-book statement was based to provide answers to the following questions: Is the distribution " rectangular " within the range quoted? If not, where and how steeply does it " peak "? How likely is it that one should come across stones having very high or very low s.g.'s? If the variation in s.g. is accompanied by a variation in r.i., what degree of correlation can be established between them, and can both be related to variations in composition?

An important contribution which the statistician could make to gemmological studies is in the assessment of the results of experiments, and in testing the significance of observations. It is difficult arbitrarily to invent situations where tests of this sort would be applicable, but they are of value in circumstances where, having various possible hypotheses to test, observations are on immediate inspection not sufficiently weighted one way or the other to enable a decision to be made. Here there are techniques available which permit an actual comparison of the relative probabilities of correctness.

ASSOCIATION NOTICES

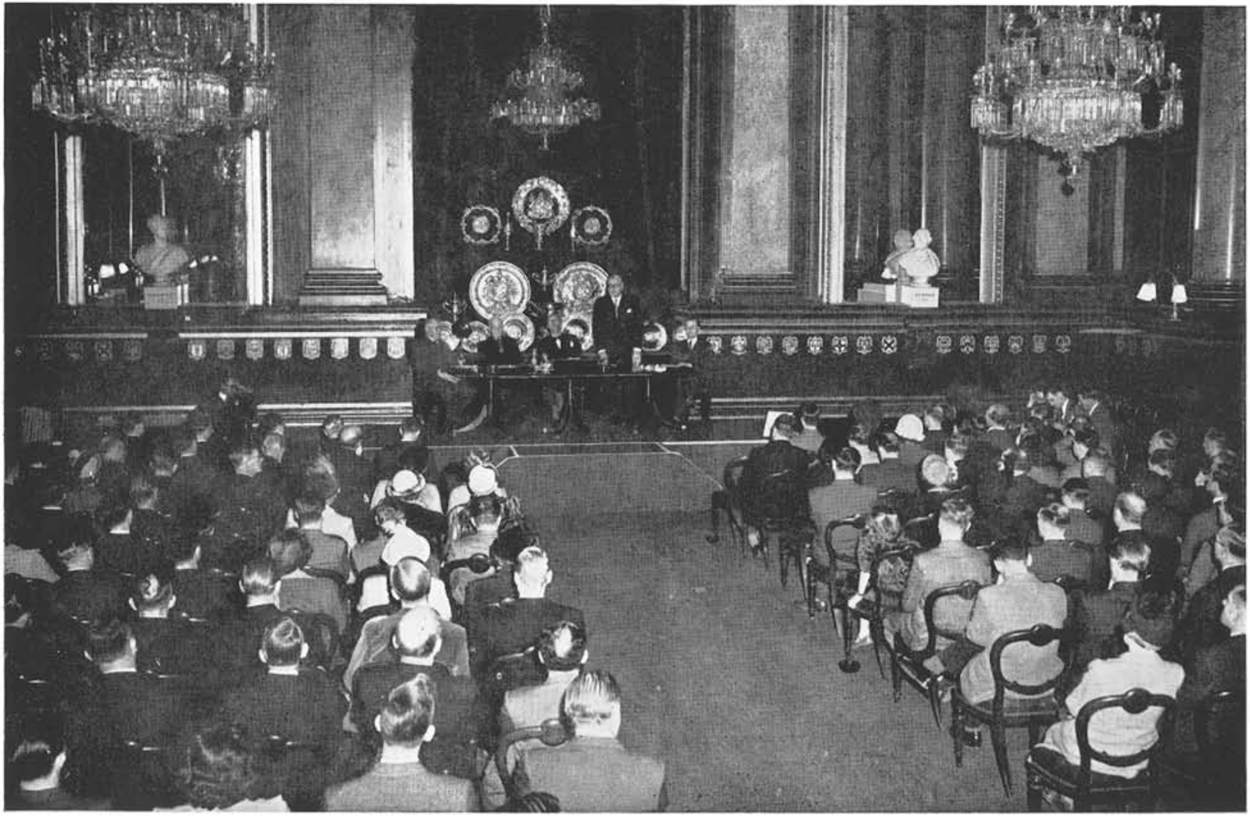
GIFTS TO ASSOCIATION

The Council of the Association is indebted to Mr. L. C. Trumper, B.Sc., F.G.A., for two cut specimens of brazilianite.

Mr. D. S. M. Field, A.G.A., has recently sent to the Association three specimens of synthetic quartz. He obtained them, through the courtesy of Dr. A. C. Walker, from the manufacturers, the Bell Telephone Company, and the Council of the Association is grateful for this addition to its collection.

MEMBERS' MEETING.

A meeting of members was held at the British Council Cinema, London, W.1, on Thursday, 16th November, 1950. Mr. J. R. Knight, B.Sc., A.I.M., deputizing for Dr. E. C. Rhodes, who was unfortunately ill, described and discussed the manufacture of jewellery in palladium and its handling and treatment when carrying out repairs. The talk was followed by a film, in colour, which showed the various stages of production of palladium and how well it was suitable for making fine pieces of jewellery.



Scene at Presentation of Awards at Goldsmiths' Hall, London, October, 1950.

COUNCIL MEETING

At a meeting of the Council held on Wednesday, 11th October, 1950, at 19-25 Gutter Lane, E.C.2, the following were elected:—

Fellows

Akehurst, H. R., Saskatoon, Canada.
Aston, C. R. C., Gt. Missenden.
Bruton, E. M., London.
Chapman, V. K., Perth.
Crosthwaite, S. A., Glasgow.
Davidge, K. C., Otford.
Doidge, R. J., Tavistock.
Dyce, S. B., Perth.
Falconer, R. S., Edinburgh.
Frake, W. J., London.
Garner, L. W., London.
Gribben, A. T., Birmingham.
Gunters, H. D., The Hague, Holland.
Hanslip, M. J., Torpoint.
Heighes, C. E., Los Angeles, U.S.A.
Hurst, J. C., Olton.
Jarvis, C. A., Ilford.
Jones, O. D., Burton-on-Trent.
van der Loo, J. A. M., Rotterdam, Holland.
Modahl, Oivind, Oslo, Norway.
O'Donoghue, T. J., London
Quartermain, J. F., Westgate-on-Sea.
Raymond, P., Kenton.
de Rosa, R., London.
Sawyer, J. B., London.
Schaap, A., Amsterdam, Holland.
Snell, J. S., Romford.
Speed, P. G., King's Lynn.
Tindall, E. H., Harrogate.
Warren, F. W., Bristol.
Whitehead, M. W., Surbiton.

Probationary

Mason, S., Harrogate.

Fellows transferred from Probationary

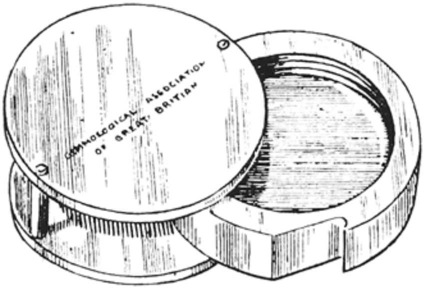
Corfield, R. H., London.
Katz, B., Johannesburg, S. Africa.
Bailey, B. O., Birmingham.
Batty, R. W., Southport.
Best, J., Stourbridge.
Boyes, K. A., Scholes.
Cassidy, R. F., Worcester.
Chisholm, J. R. H., Leverstock Green.
Cornelius, A. R., London.
Davison, P. J. F., Goodmayes.
Denton, G. W., Clacton-on-Sea.
Fishberg, H. C., Edgware.
Fishberg, J. M., London (Life Member)).
Hathaway, Miss A. H., Stratford-on-Avon.
Henn, Miss B. M., Bridgnorth.
Hollander, Miss J. C., London.
King, R. F., Welling.
Pellett, W., London.
Siu, M. C., Hong Kong.
Thomas-Ferrand, Mrs. J. M., Bury St. Edmunds.
Warnes, Miss S. G., King's Lynn.

Associates transferred from Probationary

Cunningham, F. M., Toronto, Canada.
Lowe, R. W., Broken Hill, N. Rhodesia.

OBITUARY

We regret to record the death of Professor W. T. Gordon, M.A., D.Sc., F.R.S.E., Professor Emeritus of Geology, University of London. To gemmologists he will be remembered for the delightful talks that he gave to members before the last war. An appreciation of Professor Gordon will be included in the next issue of the Journal.


GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN


Rayner
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LONDON
