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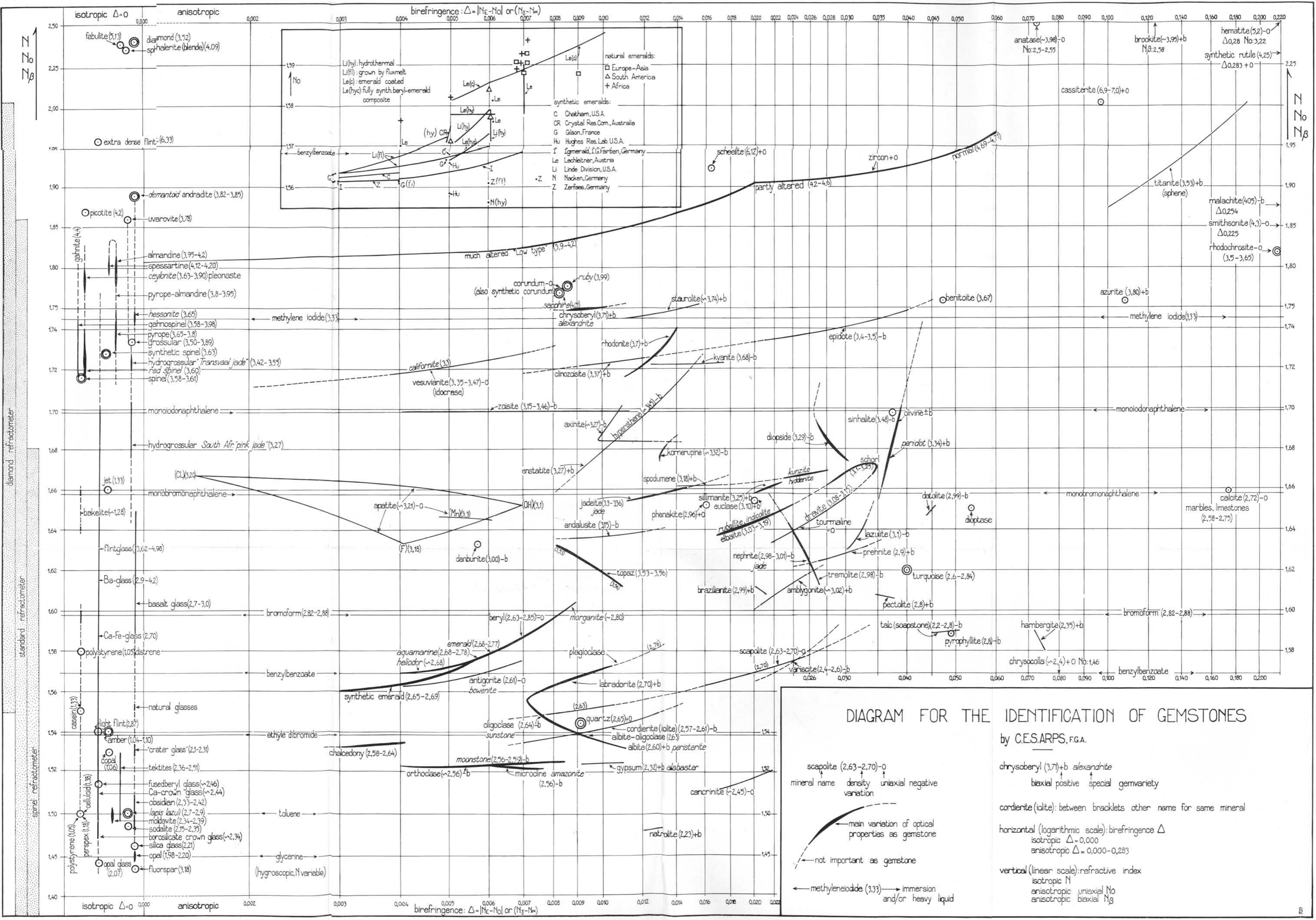
THE JOURNAL OF GEMMOLOGY

and

PROCEEDINGS OF THE
GEMMOLOGICAL
ASSOCIATION
OF GREAT BRITAIN



GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
SAINT DUNSTAN'S HOUSE, CAREY LANE
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diamond refractometer
 standard refractometer
 spinel refractometer

Li(hy): hydrothermal
 Li(fi): grown by fluxmelt
 Le(c): emerald coated
 Le(hyc): fully synth. beryl-emerald composite

natural emeralds:
 □ Europe-Asia
 △ South America
 + Africa

synthetic emeralds:
 C Chatham, U.S.A.
 CR Crystal Res. Com., Australia
 G Gilson, France
 HU Hughes Res. Lab. U.S.A.
 I Igmerald, I.G. Farben, Germany
 Le Lechleitner, Austria
 Li Linde Division, U.S.A.
 N Nocken, Germany
 Z Zertfass, Germany

scapolite (2,63-2,70)-o
 mineral name density uniaxial negative variation

chrysoberyl (3,71)+b alexandrite
 biaxial positive special gemvariety

cordierite (iolite): between brackets other name for same mineral

horizontal (logarithmic scale): birefringence Δ
 isotropic $\Delta = 0,000$
 anisotropic $\Delta = 0,000 - 0,283$

vertical (linear scale): refractive index
 isotropic N
 anisotropic uniaxial N_o
 anisotropic biaxial N_β

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THE SOURCES OF SUPPLY

By V. G. C. NORWOOD

THE demand for industrial diamond is continually increasing. As yet the gears of synthetic processes grind very slowly indeed. There is as yet no economic substitute for natural diamond. It is from the steaming jungles and arid plains of remote regions that vital supplies of rough diamonds flow to keep the wheels of modern industry turning.

But spare a thought for the men who mine these essential raw materials, the intrepid adventurers who, living in conditions of appalling privation, endure incredible hardships for scant reward, Brazil's colourful "Caboclas", the negro "Port-knockers" of British Guiana (now Guyana), and the Venezuelan "Tejana", all giants in their own particular field of production, and all making their modest contribution to the world's needs.

Much has been written about diamond prospecting. Yet surprisingly little is known about the resolute characters who forage in outlandish places, rugged individuals of every colour and creed, motivated by a common urge, sustained largely by sheer optimism, the eternal promise of "tomorrow". They accept the challenge of Nature, toil in daily pursuit of elusive mineral wealth, driven by an insatiable craving, often working in torrential rain, blistered by the torrid tropical sun, tormented by insects and ravaged by foul diseases—pawns in a game where the stakes



Pork-knockers at work. The old method.

are high but the balance between riches and death is always slender, and governed largely by pure chance.

It is more than mere lust for wealth that starts the diamond prospector on his endless, lonely quest. Adventure is in his blood, the "Call of the Wild" stronger than his will to resist. Prospecting becomes an obsession, irksome at times, and damned hard work. But never boring. The prospector breathes God's pure, fresh air in places where few white men ever venture. He knows the majestic splendour of sweeping hills and awesome crags that instil appreciation of Nature's wonders into his untutored mind, a realization of how insignificant is Mankind, and experiences at the other end of the scale the foetid reek of fever swamps, the sinister threat of gloomy jungle, the squalor of impoverished river settlements and backwater camps.

A man's life, a challenge accepted, the privation, discomfort loneliness and innumerable dangers all discounted against the weight of favourable potential. Few thrills can compare with that of taking a boat through foaming rapids along some mighty jungle river. To tackle such a journey requires nerve above average. Here, in the wilderness, man-power remains supreme, a stout

heart the major driving force, unconquerable spirit and physical strength the true measure of success. There is no turning back. Once committed the course is onward, with muscles knotting, backs straining, hearts pounding, every corded sinew responding with an even greater surge of latent power to meet and overcome Nature's relentless pitfalls.

This then is the world of the diamond seeker. To him, all of life is a gamble. He stakes his stamina and experience against heavy odds. Either the jungle ultimately breaks down his mind, or he endures and becomes inured to the eerie borderline between blaring sound and awesome silence. The years slip by almost unnoticed. "Diamond Fever" has him in its relentless grip, and for this "disease" the sweet smell of success is the only cure.

Diamond recovery methods employed in Guyana and Brazil



A typical "pork-knocker" of the "old school" with the tools of his arduous trade.



*Industrial diamond workings
(Sierra Leone).*

differ vastly from processes followed in Africa. Guyana diamonds, for example, although of extreme hardness, generally have a kind of brown “skin” which resists grease-bed techniques, consequently work is done by hand, a wasteful method employing crude sluice-box washing. The wet gravel concentrate is finally “jigged” (a twirling action) in a cumbersome sieve to centralize any diamond content by centrifugal force. (See “A Handful of Diamonds and Drums Along the Amazon”—T. V. Boardman and Robert Hale Ltd.).

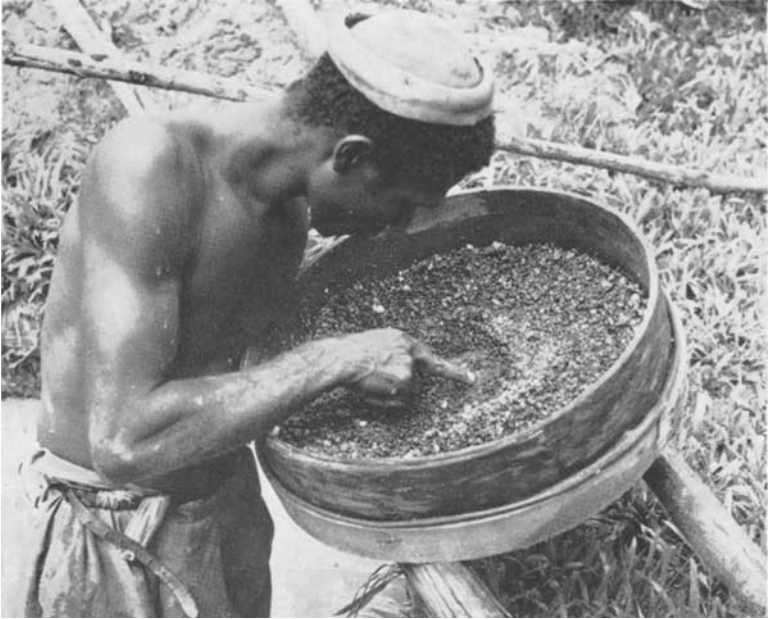
The subject of diamond origin and crystallization is absorbing, and still not conclusively proved. Whatever the nature of rock associated with diamond recovery, whether sandstone, gravel, conglomerate, or metamorphic schist, rarely is diamond found embedded in the actual parent rock wherein it was formed. In instances where diamonds have supposedly been found under such conditions the matrix has proved to be only a deposit formed around the diamond by prolonged contact with eroding soft rocks. Despite extreme hardness diamonds often reveal traces of frictional wear indicative of tremendous distances over which they have been transported in association with abrasives.

In regions where “pipes” of “blue ground” (peridotite or kimberlite) occur the extent of similar gas-blown vents indicates the forcing of matrix from the earth’s molten core by internal steam pressure, additional signs and evidence of subterranean upheaval being the uncovering of former underground rivers during excavations, coupled with the alien nature of surrounding rocks to the “blue ground” itself. Peridotite is igneous and devoid of free silicon, while being extremely rich in olivine (peridot). It has a high iron content, the yellow aspect of surface peridotite being due to oxidization. There is seldom any indication of mineral wealth in the surrounding terrain. In South Africa, red, sandy soil covers vast areas containing fabulous diamond deposits. In Guyana and Brazil, rain forests and the vegetation growth of centuries obscures craggy formations from which diamonds are continually being washed into rivers and creeks.

If we accept as fact the contention that the earth’s core consists of metallic iron in a molten state, and seismological calcu-



The suction-dredge—the modern method of diamond prospecting in Guyana.



Inspecting gravel concentrate for diamonds.

lations proving increases in temperature relative to depth, we must assume that the inner area of the earth's crust must be plastic, and subjected to tremendous compression imposed by superincumbent, solid upper layers, and by internal stresses. Consequently, water seeping through fissures and forming steam when contacting the molten core would create terrifying forces that, upon encountering comparatively weak points, ultimately blasted gaping vents through which to vomit seething, carbonaceous matter.

The affinity of iron with carbon suggests that in the absence of oxygen, and perhaps assisted by some catalytic mineral as yet not positively identified by science, any free carbon content of plastic peridotite would crystallize as appalling heat and expanding pressures dispersed at the bases of these ruptures. Peculiarities pertaining to diamonds recovered from particular "pipes" make it possible to identify the source through a process of comparison involving various known areas of prehistoric subterranean eruption.

It is not uncommon for diamonds actually to explode soon after being unearthed, due to imprisoned gas bubbles or carbonic acid activated by the sudden release from sustained pressure.

But the average diamond prospector is not concerned with theories or scientific principles. He knows diamond by sight and by touch, and learns through trial and error. The veteran prospector reduces the whole complicated process to a simple formula which, wasteful though it is, includes a reasonable amount of proven method and thus reduces the element of pure speculation.

Prospecting is a hard life, and there is little glamour or romance associated with actual diamond recovery, only hard work and dogged perseverance. Thus the diamond seeker must of necessity be of a breed endowed with endurance above average, and sharing a philosophy peculiar to his kind.

ORIGIN OF THE NAME AGATE

By E. SAROFIM, Ph.D.

THE naming of stones after the area or locality in which they were discovered, has its root in a long-standing tradition. Brazilianite, Amazonite, Uthlite, Labradorite, etc., and lately Tanzanite⁽¹⁾, are a few examples which perpetuate this trend in our modern time.

Agate, this old yet noble stone, is no exception: it is a classical example of this secular trend. To establish the locality which gave its name to this stone, the etymology of the word Agate must first be ascertained. Some authors advanced that it is derived from the Latin "Achatēs", a river in Sicily⁽²⁾, while others see its origin in the Greek word "Agatos"⁽³⁾. The appearance of the word in English dates only from 1570 A.D.⁽⁴⁾ and it appeared about the same time in other European literature.

The comparatively recent appearance of the word in modern languages and in Latin and Greek, while its Semitic transliteration "Aqiq" in Arabic or "Ahit" in Hebrew was used long before, makes it difficult to share the view of a Latin or Indo-European origin.

Egyptologists who found proofs that some 3,000 years before Christ ancient Egyptians used the banded variety of Chalcedony—today described as Agate for an infinity of purposes—are uncertain about the name which was then given to this stone. But the difficulty does not arise for the Semites who about the same time used Agate not only for ornamental purposes but for other usages such as tablets for recording religious verses or important events. It is therefore not improbable that the ten commandments might have been recorded on this stone⁽⁵⁾.

The fact that this stone was known to the Semites long before the Romans and Greeks and was called, probably as far back as the dawn of civilization, “Aqiq” or “Ahit”, leads us to believe that the origin of the word Agate is Semitic.

Our contention does not rest only on historical findings and on the trilitic formation of the words Agate and Achates, but on the fact that the literal Arabic definition of the word “Aqiq”, the parting of the hair of a new-born baby⁽⁶⁾, might well be the only plausible explanation why the use of the word Agate is restricted to banded Chalcedony. Moreover, old Arabic dictionaries state that “Aqiq” is the name of a valley near Medina⁽⁷⁾ (presently Saudi Arabia). In view of the favourable desert surroundings it is more than likely that Agate occurred in this valley which we believe gave its name to that stone, long before the Sicilians named their river.

REFERENCES

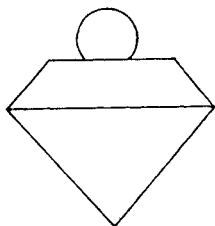
1. Name given by Tiffany of New York to Blue Zoisite. See the Wall Street Journal (New York) of 14th October, 1968.
2. See “Edelsteine und Perlen” by Professor Dr. K. Schlossmacher—printed in Stuttgart in 1965, p. 261.
3. a. 4. See the word Agate in the Shorter Oxford Dictionary on Historical Principles—printed in 1944 by Clarendon Press, Oxford.
5. cf. Exodus Chapter 24 Verse 10: It is mentioned that it might have been Sapphire. See also the Midrache Tankhouma Commentaries on Exodus Chapter 34 Verse 1.
6. a. 7. See the Arabic word “Aqiq” in Moukhtar Al-Sahah—2nd edition printed in Cairo by Boulaq Government Press in 1937, p. 446.

THE "WATER-DROP TEST" IN GEMMOLOGY

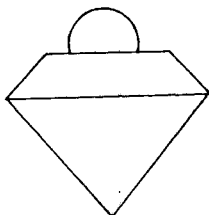
By ALBERT TAN HIEN TJWAN

THE method used is very simple, and depends upon the behaviour of a small drop of water placed upon the top surface of a gemstone. Results are indicated by the manner in which the droplet stands or stays on, falls off, or is dispersed. It is to be emphasized that only stones of inorganic origin, having the hardness property of $7\frac{1}{4}$ (beryl), $7\frac{1}{2}$ (zircon and some garnets—with the exception of demantoid garnet), 8 (topaz and spinel), $8\frac{1}{2}$ (chrysoberyl), 9 (corundum) and 10 (diamond) will provide reliable guide tests. On quartz (H. 7) peridot and demantoid garnet (H. $6\frac{1}{2}$) and other stones softer than quartz varieties the test will provide an indication that the stone is comparatively soft. The method is more or less dependent upon the hardness property of minerals, which is characteristic in the individual species, though surface tension and the nature of the polished surface is also a consideration. On the other hand, when this method is applied to gems of organic origin, such as pearl, coral and amber, etc., it is not dependent upon the hardness, but is probably dependent upon their compositions.

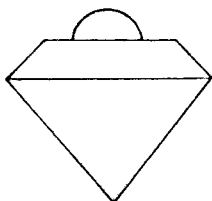
An hardness test is to be avoided not because this test has been considered unnecessary, but merely due to the fact that the act of scratching is likely to damage a stone to some extent. The scratching method is only used to test rough materials when no other test is possible. As far as identification of a gemstone is concerned, the gemmologist has other more scientific means available. But the gemmologist is not a walking laboratory. On some occasions he might come across a natural stone of doubtful species somewhere when such instrumentation as the refractometer is not available to test a stone. Perhaps the simplest apparatus a gemmologist can be expected to carry with him is the 10x lens or one or two pieces of Mohs's scale hardness points consisting of Nos. 8, 9 or 10. Supposing that during one of his trips somewhere, someone offered the gemmologist a fine specimen of a faceted golden yellow stone at the price of a true topaz. Based on its inclusions the 10x lens could only tell him that the stone is real, but possibly not its species. The inclusions of the stone are not those of a natural corundum, since they do not represent the typical angular shape of crystals, straight



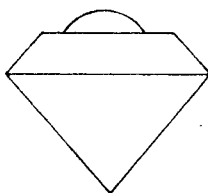
On diamond



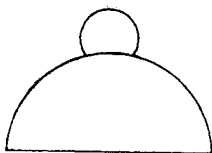
On corundum and synthetic corundum



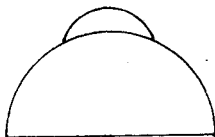
*On topaz, spinel, and some garnet,
and synthetic spinel*



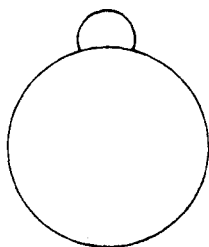
*On zircon and morganite
and some garnet*



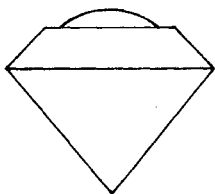
On Chrysoberyl cat's-eye



On tourmaline cat's-eye



On pearl and coral



On emerald, tourmaline and aquamarine

Behaviour of small drops of water on surface of gems.

lines, rutile needles and the liquid feathers, etc., some of which are usually present in a natural corundum. Hence the stone offered is not a yellow sapphire. It could be a topaz or a citrine. The $10\times$ lens could not detect which because it is extremely difficult to detect topaz and citrine with a hand-lens. What about the hardness test? If the stone yields easily to the No. 8 of the hardness point, then it is positively not a topaz. But the mere mention of the hardness test is frowned upon by the owner of the stone and besides, it is not for a good gemmologist to scratch a well faceted and well polished stone.

In such circumstances the "water-drop test" method is useful. The test shows that a small drop of water stands on the top surface of a topaz but falls down instantly flat and dispersed on the top surface of a citrine and other stones softer than the quartz varieties.

To carry out the test:

- (a) The gem to be tested must be kept dry, free from fingerprints, oily substances and cracks, as these will disturb the test. Absolute cleanliness is essential and is not easily achieved.
- (b) The test on the gem should be exactly on the middle of its surface.
- (c) Proceed with the test by placing a small drop of pure water on the test centre. The water may be applied by using a dropper or a thin rod of glass or metal. Too large a drop of water will just slide over the surface of the stone, while too small a drop will provide an uncertain result of the test. Larger stones provide a wider test area, so a larger drop of water may be applied, and consequently on smaller stones a smaller drop of water should be applied to the test centre of the gem.

The results of the "water-drop test" method depend solely upon the behaviour of the small drop of water which stands on the centre of the surface of the gem being tested.

- (i) On diamond, corundum, chrysoberyl, topaz and spinel (H. 10, 9, $8\frac{1}{2}$, 8) the small drop of water stands firmly, almost spherical in form on the hardest stone, and somewhat hemisphere-like on the softer stones. This hemisphere-like form of the small

drop of water varies slightly from one to another, dependent upon the characteristic hardness of each stone under test. In other words, the small drop of water stands firmest on a diamond, is less firm on a corundum, and is still less firm on a chrysoberyl and so on (see diagram).

It is difficult to note the difference in form of the small drop of water on a diamond and on a corundum of small size, but on stones of larger sizes (5 carats upwards) the slight difference may be observed.

- (ii) On stones having hardness of $7\frac{1}{2}$ to $7\frac{1}{4}$, like zircon and some garnets (except the demantoid garnet), tourmaline and beryl, the small drop of water stands less firm and nearly flat. That is, on zircon and some garnets the small drop of water stands less firmly, but on tourmaline and emerald the small drop of water becomes almost flattened.
- (iii) On stones having hardness of 7 and less (quartz, demantoid garnet, peridot, nephrite, haematite and opal, etc.), the small drop of water is dispersed, and thus provides an indication that they belong to the category of soft stones.

THE "WATER-DROP TEST" THEORY

The property of hardness in minerals is dependent upon the cohesion, or the bonding power which arranged the atomic structure in a regular, closely packed lattice-like pattern. Topaz is harder than citrine, because the atomic structure of the former is more closely packed than the latter. A harder stone will hold a small drop of water more firmly on its surface, but a soft stone has a weak bonding power and consequently gives rise to a less closely packed (lattice-like) atomic structure. A soft stone like citrine (from the point of view of the "water-drop test" method), will not hold a small drop of water on its surface.

The "water-drop test" method is similar to placing an amount of water on a filtering cloth, the construction of which can be likened as the atomic structure in a stone. The water will stay much longer on a filtering cloth of denser construction. On the other hand, the water will soon filter out on a filtering cloth of rarer and sparser construction, similarly as a drop of water is quickly dispersed on the surface of a soft stone.

The “water-drop test” method when applied to gems of organic origin is not dependent upon the hardness property of the gems concerned, despite the fact that a small drop of water stands on the surface of a pearl (H. $3\frac{1}{2}$ to 4.0), coral (H. 3.75) and amber (H. $2\frac{1}{4}$) all of which are relatively soft, but on the manner in which a small drop of water is dispersed.

Coloured glass is sometimes used to imitate the coral and amber, while haematite is fashioned spherically to simulate the valuable black pearl. The “water-drop test” method easily distinguishes the organic gems from paste and haematite.

A probable cause of a small drop of water standing on gems of organic origin is some oily element in the composition of the gems. The pearl is a product of the shell-fish known as mollusc in science. Coral is a calcareous skeleton of tiny animal polyps, while amber is a fossil resin of vegetable origin. We have fish oil, and also vegetable oil. It is therefore logical that some varying amount of oily element may exist in the composition of organic gems or materials. Water is heavier than oil, and consequently it sinks in oil and oil floats on water. This act of separation or rejection is also seen when a small drop of water is placed on the surface of a substance coated with a thin film of oil, on which it stands.

In practice, sometimes a repetition of the test upon a gem is necessary, i.e. when the first test provides an uncertain result.

This can happen in the event of the following:

1. The test is carried out too hastily.
2. The small drop of water applied on the gem during the test is not of suitable proportion.
3. The surface of the gem tested is not clean or dry enough, has cracks or a thin film of oil.

It must be borne in mind that in the case of testing a stone, or a repetition of test, the gem must first be carefully wiped with a clean dry cloth or handkerchief, unstained with any oily element, and the stone must be in a dry condition.

Listed below is a comparison table of the “water-drop test” method of the chief varieties of gemstones and their possible counterparts. The manner in which the small drop of water stands or disperses is indicated above the stones listed.

<i>Firmly</i>	<i>Less firmly</i>	<i>Almost flat</i>	<i>Totally flat and dispersed</i>
Diamond	Topaz, zircon, synthetic spinel	—	Quartz, syn. rutile, strontium titanate.
Corundum (ruby and sapphire), syn. corundum	Spinel, topaz, zircon, morganite, almandine, pyrope, hessonite, synthetic spinel.	Tourmaline, aquamarine.	Quartz (amethyst, citrine and star-rose-quartz) paste.
Chrysoberyl cat's-eye.	—	Tourmaline cat's-eye.	Quartz cat's-eye, tiger's-eye (crocidolite), moonstone.
Green sapphire.	Soude emerald with syn. spinel as crown.	Emerald.	Soudé emerald with quartz as crown, demantoid garnet, peridot, sphene.
—	—	Jadeite, nephrite Some turquoise (less porous), plastic materials.	Some turquoise (porous).
True pearl, cultured pearl, glass bead coated with "essence d'orient".	—	—	Haematite (used to simulate black pearl).
Red coral.	—	—	Paste.
—	Amber.	—	Paste.

The above list is not a table of determination.

Modern gemmology demands conclusive tests, hence the "water-drop test" method should be used together with some other test in identifying a stone.

THE LIMITATIONS OF THE "WATER-DROP TEST"

It does not distinguish:

1. The characteristic hardness of a stone, only giving an indication that one stone is harder than the other.
2. Between natural stones and their synthetic counterparts.
3. Between (a) a true pearl and cultured pearl and (b) true pearl or cultured pearl from glass bead coated with fish scales known as "Essence d'Orient".
4. Between true turquoise and (a) plastic-bonded imitation of turquoise or (b) plastic-bonded real turquoise.

A STUDY OF SOME GOLD MINE DIAMONDS

By F. A. RAAL

Diamond Research Laboratory, Johannesburg, South Africa.

ABSTRACT

A non-destructive study has been made of some diamonds recovered during gold mining operations. The stones appear to be ordinary Type I diamonds which had suffered charged particle irradiation and some annealing of the radiation damage at a temperature not exceeding 500°C at some stage of their existence. Two absorption features have not been observed in diamond previously and it is thought that they might be a consequence of the time scale of the annealing process which differs vastly from anything we can practically achieve.

INTRODUCTION

Recently a small diamond was recovered in cleaning out a tube mill on one of the Witwatersrand gold mines. This rekindled interest in some other diamonds—38 in all—which are museum pieces and which have been found in gold mines from time to time. In some of the older gold recovery processes the crushed ore was sent over corduroy which retained the gold particles in its folds and allowed the lighter materials to be washed over. Being relatively heavy the diamonds were found with the gold. A non-destructive study of these unique diamonds, which have kindly been made available to us, has now been made.

APPEARANCE AND MORPHOLOGY

The 38 stones, the largest of which weighs 1.53 carats and the smallest 0.08 carats are shown in Figure 1. As can be seen they are all of reasonable crystallographic habit and a few well-shaped octahedrons and dodecahedrons are in evidence. The diamonds are all coloured various shades of yellowish-green or green, ranging from a barely perceptible green tinge in one instance to a dark-green, almost black, colour in another. The colouration appears to be only skin-deep as is the case, in our experience, with most

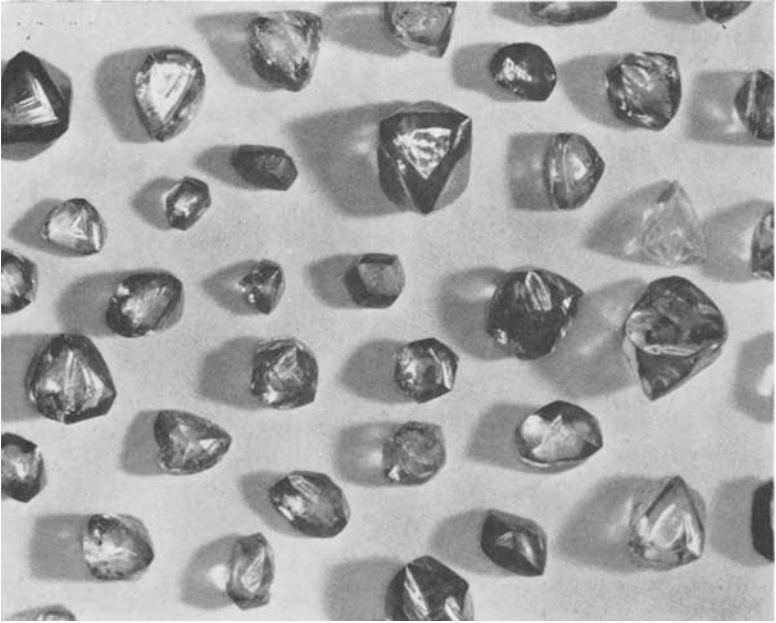


FIG. 1.

green diamonds found. The skin-deep colouration is consistent with the diamonds having been irradiated with high energy alpha- or beta-particles (Dugdale, 1953). These emanated, in all probability from uranium (or one of its degradation products) since this element is quite abundantly present in the gold mines where the diamonds were found.

TYPE DESIGNATION

Robertson *et al* (1934) were the first to draw a distinction between Type I and Type II diamonds and noticed that diamonds of the latter category have nondescript shapes as opposed to those of the Type I variety with good crystallographic features. Kaiser and Bond (1959) showed that all Type I diamonds contain varying amounts of nitrogen in substitutional position in the diamond lattice and that they are characterized by a strong absorption band at 7.8μ in their infra-red spectra. Elliot (1960) proposed that this nitrogen in Type I diamonds is segregated into a layer configuration and Evans and Phaal (1962) observed platelets in (100) planes in

these diamonds which could only be explained as being due to segregated substitutional nitrogen atoms: a qualitative study of the infra-red absorption spectra of the 38 diamonds revealed the presence of the 7.8μ band in all instances. It is concluded, therefore, that as is the case with about 98% of all diamonds from more conventional sources the gold mine stones are all of the Type I variety, i.e. they contain appreciable amounts of substitutional nitrogen in platelet configuration.

OPTICAL ABSORPTION FEATURES AND DISCUSSION

Three octahedrons with relatively smooth parallel-sided faces lent themselves to optical studies of a more quantitative nature. The optical spectra obtained for these three stones showed identical absorption features although the strength of the bands varied in degree. Spectra were recorded at liquid nitrogen temperature (80°K) and a typical spectrum is reproduced in Figure 2 where the product of absorption coefficient and thickness of the diamond is plotted as a function of the photon energy of the incident radiation.

As can be seen there are prominent absorption band systems centred at 3.3, 2.6 and 1.7 eV respectively. In addition, there are

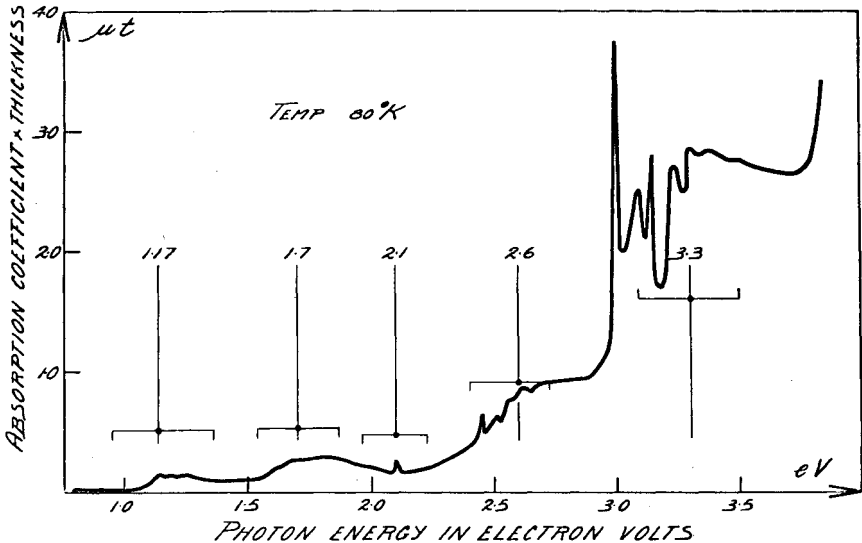


FIG. 2.

present two absorption systems with main bands at 2.1 and 1.17 eV respectively which to our knowledge have never been observed in diamond before. It is probable that these are a result of annealing of irradiation damage in the diamond over many thousands of years at a temperature which might have been well below but not exceeding 500°C as we have reason to believe.

The 1.7 eV band, designated G.R.1, is known to be associated with radiation damage in diamond (Clark *et al*, 1956). Experiments in this laboratory have shown that on heating irradiated Type I diamonds to 500°C G.R.1 can be annealed out completely with time to produce the band at 2.6 eV. At lower temperatures G.R.1 is annealed out only partially and an equilibrium with the 2.6 eV band is reached dependent on the temperature of heating.

Since both the G.R.1 and 2.6 eV bands are present in the gold mine diamonds the inference is that these diamonds were initially irradiated by a natural radio-active source and at some subsequent stage in their histories were heated to a temperature not in excess of 500°C and most likely considerably less than this value to partially anneal out the G.R.1 system.

Figure 3 depicts the absorption spectra at room temperature of one of the selected octahedrons before and after the diamond had

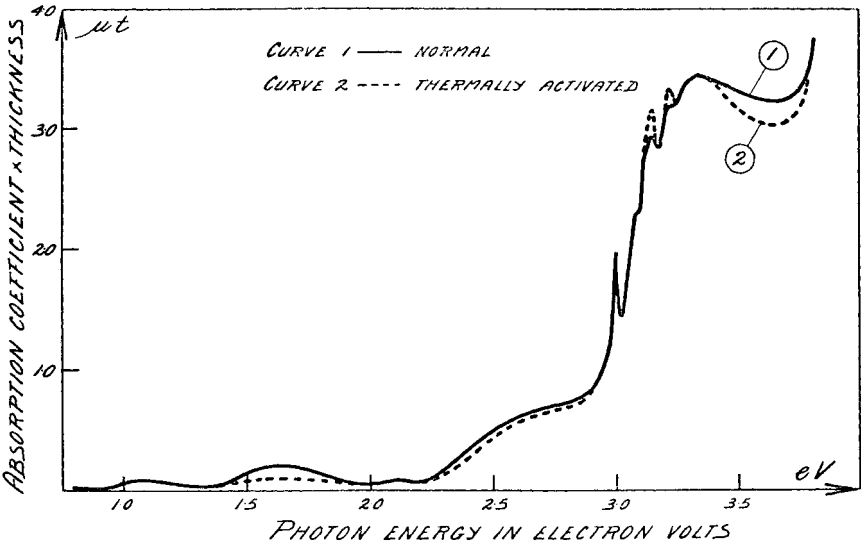


FIG. 3.

been heated in the dark at 400°C for 10 minutes. Curve 1 is that of the diamond in its normal state whereas curve 2, superimposed on curve 1, is that of the diamond in its thermally activated condition. On exposure to ultra-violet light or daylight curve 2 reverts to curve 1, i.e. the activated state reverts to the normal condition.

As can be seen there is a difference in light absorption between the normal and activated states. By heating the diamond in the dark the G.R.1 and 2.6 eV systems are reduced and the one at 3.3 eV enhanced. The G.R.1 and 2.6 eV bands being in the visible part of the spectrum one would expect a visible colour change to accompany the heating and light exposure cycles. This is indeed the case. After heating in the dark at 400°C for a few minutes the diamond appears yellow which colour rapidly changes to yellowish-green or green on exposure to light. Similar observations have been made in this laboratory on natural Type I diamonds which have been irradiated (Dyer and du Preez, 1965). Our understanding of this chameleon behaviour of diamond substantiates the claim that the gold mine diamonds were subjected to irradiation as well as annealing of the radiation damage at temperatures probably very much less than but not exceeding 500°C at some stage during their existence.

ACKNOWLEDGEMENTS

Thanks are due to the Anglo American Corporation of South Africa Limited for the loan of the diamonds and to Industrial Distributors (1946) Limited for permission to publish this paper.

The Association is indebted to the *Industrial Diamond Review* for permission to reprint Dr. F. A. Raal's article.

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Gemmological Abstracts

ROLFF (A.). *The aquamarine-bearing regions of Brazil*. Lapidary Journ., 1968, 22, 8, 1044.

A brief account of the prolific Brazilian gem area of Teofilo Otoni. S.P.

ANON. *Diamonds from Methane*. Science Horizons, 1968, 98, 6.

Diamonds can now be grown from methane, the gas which is better known as marsh gas. At present the process is extremely slow and is used only to increase the size of industrial diamond abrasive powder. But a long-range goal of the research into methane-produced diamonds, which is being carried out at Case Western Reserve University in Cleveland, Ohio, is to grow a synthetic diamond of gemstone size and quality.

In the experimental process they have developed, methane is passed over a diamond seed crystal at temperatures of about 2,000°F. The gas decomposes and gives off carbon, which deposits on the crystal. The carbon atoms arrange themselves in the same atomic pattern as the seed crystal and it grows. A potential application is the production of diamond for use as electrical conductors at high temperatures.

MORRISSEY (F. R.). *Turquoise deposits of Nevada*. Nevada Bur. Mines Rept. 17, 1968. 36 pp., 2 figs., 1 map. Published by Mackay School of Mines, Univ. of Nevada, price \$1.50.

All known deposits of turquoise in Nevada are recorded for their location, production and history of mining.

R.A.H.

MAPLES (ERNEST). *Let's call a jade, a jade*. Rocks and Minerals, 1968, 43, p. 491.

Numerous minerals are incorrectly called jade by dealers in gems and ornamental stones. In these names the term jade is usually modified by a geographical name. Ten examples are cited and correctly identified.

R.A.H.

PETERSON (HELEN). *Black star-corundum*. Rocks and Minerals, 1968, 43, pp. 492-493, 2 figs.

Black asteriated corundum crystals, averaging $\frac{3}{4}$ inch across, occur in nepheline syenite near Bancroft, Ontario. The removal of the crystals from the matrix by using hydrochloric acid is discussed. R.A.H.

ANON. *Gem stones of Western Australia*. Rocks and Minerals, 1968, 43, pp. 651-653.

Comments on major localities are given for diamond, beryl (emerald, aquamarine, heliodor, morganite), opal, topaz, corundum (ruby, sapphire), quartz (amethyst, chalcedony, agate, chrysoprase, prase, jasper), tourmaline, and others. R.A.H.

POUGH (F. H.). *The Carnaiba Emerald Mine*. Lapidary Journ., 1968, 22, 9, p. 1162.

The Carnaiba Mine, in Bahia, was found four years ago and is the biggest producer at the present time. The majority of crystals found are small and cut stones can only be a carat or so at best. S.P.

MCLAREN (A. C.). *The problems of amethyst*. Australian Gem-mologist, 1968, 10, 4, p. 7.

At Monash University, Australia, electron and nuclear spin resonance techniques are being used in an attempt to ascertain how the presence of iron, which is associated with the colour of amethyst, fits into the quartz structure. S.P.

The German Gemmological Society issued a special booklet in honour of the seventy-fifth birthday of Georg O. Wild, of Idar-Oberstein. Professor Karl Chudoba introduced the booklet with a biographical sketch of Wild and a bibliography of his published work. His position as an evening class teacher of gemmology is also mentioned. Abstracts of the principal articles which appeared in the special issue are set out below.

CHUDOBA (KARL F.). *Ueber die Bedeutung, Entstehung und Klassifikation der Mineral—insbesondere der Edelsteinfarben im geschichtlichen Rückblick.* Deutsche Gemmologische Gesellschaft, 1969, 3, 27-40.

About the importance, formation and classification of mineral colouring, especially colouring of gems seen from a historical point of view. This article includes a bibliography of 55 items and describes the classification according to colour of many minerals or gems starting with Agricola. Gems were at different times subdivided into having metallic or non-metallic colours; or being idiochromatic, allochromatic or colourless(!); he also subdivides inclusions into macroscopic, microscopic and submicroscopic, these being either ultra-microscopic or electron-microscopic.

E.S.

BAMBAUER (H. U.), LEHMANN (G.). *Farbr und Farbveränderung von Quarzen.* Colour and colour alteration in quartzes. Deutsche Gemmologische Gesellschaft, 1969, 3, 41-49. This article includes a bibliography of 16 items, 7 tables and graphs.

Quartz can be sub-divided into macro-crystalline quartz, such as rock-crystal, smokey quartz, amethyst, citrine, etc. and micro- or crypto-crystalline quartz such as agate or aventurine. This article only deals with the first group. The various trace elements in these quartzes are compared. Quartz seems to be one of the purest minerals due to the fact that Si can only be replaced by few ions, and then only to a limited extent. Details are given about rock-crystal and smokey quartz, amethyst citrine, rose and blue quartz.

E.S.

RÖSCH (S.). *Optisches über die Farbe des Amethysten.* Optics of the colour of amethyst. Deutsche Gemmologische Gesellschaft, 1969, 3, 50-54.

The colour of amethyst has usually been examined in relation to the chemical composition of the stone. The author tries to measure and compare the colour of various amethysts with the help of DIN colour plates (German standard colours).

E.S.

EPPLER (W. F.). *Pleochroitische Höfe*. Pleochroic halos. Deutsche Gemmologische Gesellschaft 1969, 3, 55-57.

The importance for gemmology of pleochroic halos or radioactive halos is the similarity to stress cracks in transparent gems. This is illustrated with 3 photographs, one showing a stress crack in a Ceylonese almandine, the other two a pleochroic halo in a zircon inclusion of a biotite at various magnifications.

E.S.

WILD (K. E.). *Produktion und Handelswege der Edelsteine aus Brasilien*.

Production and trade in gems from Brazil. Deutsche Gemmologische Gesellschaft, 1969, 3, 73-87. This is the text of a lecture given at the institute in Idar-Oberstein in 1967, with an added bibliography of 19 items.

The lecture included details of the historical development, especially of the special relationship between miners, traders and dealers with Brazil, the geographical situation of the various finds and the development of the trade between Brazil and Germany. The gems mostly traded are agates, amethysts, fired amethyst, citrine, rock-crystal, aquamarines and tourmalines. The author also mentions Brazilian emeralds and diamonds.

E.S.

BANK (H.). *Amethystverkommen in Bahia, Brasilien*. Amethyst finds in Bahia, Brazil. Deutsche Gemmologische Gesellschaft, 1969, 3, 88-96.

Description and maps of the various occurrences of amethyst in Bahia, showing geological formation and geographical details.

E.S.

HAHN (M.). *Edelsteine aus Indien und Ceylon*. Gems from India and Ceylon. Deutsche Gemmologische Gesellschaft, 1969, 3, 97-101.

Historical survey of the gem trade of India and Ceylon, starting with the Romans and later with Marco Polo and Vasco da Gama up to today's financial difficulties.

E.S.

BOOK REVIEWS

GUBELIN (E.). *Die Edelsteine der Insel Ceylon*. Lucerne, 1968, pp. 152. 70s.

This text in German, has many fine colour plates and black and white photographs. It is a concise account of the occurrence, mining, recovery, cutting and selling of the gems found in Ceylon. The various species are considered in detail and there is a useful tabulated guide. There is a comprehensive bibliography. Much of the information stems from the author's first-hand knowledge of Sinhalese gems acquired during periodic visits to the island.

S.P.

RICHTER (G. M. A.). *Engraved Gems of the Greeks and the Etruscans*. Phaidon Press, London, 1968. £18.

A study of Greek and Etruscan gems is singularly rewarding. They span the whole evolution of Greek art, beginning with the Geometric period of the late ninth and eighth centuries, proceeding to the time of heterogeneous Oriental influences and then passing stage by stage to the pure Greek forms of the archaic, the developed, and the Hellenistic periods.

This is the first comprehensive book on the subject since Furtwängler's monumental work published in 1900. Dr. Richter gives a representative selection of 695 Greek and 181 Etruscan examples, taken from all major European and American collections. In most cases an illustration of the intaglio in the original, minute size is accompanied by an enlarged illustration of the impression, which shows the design as it was intended to be seen when used as a seal.

The material is arranged chronologically, with an introductory chapter for each period, preceded by a general introduction dealing with the uses of engraved gems, the choice of designs, the materials used, the technique, and information about the artists.

Etruscan gems are treated in the same way.

The book, which will be followed by a companion volume on the engraved gems of the Romans, is intended to serve as a standard work on an important field of classical archaeology.

P.P.

THE DETERMINATION DIAGRAM: AN AID FOR RAPID IDENTIFICATION OF GEMSTONES

By C. E. S. ARPS, F.G.A.

Stichting Ned. Inst. Wetensch. Ond. Edelstenen en Paarlen (Gem. Laboratory), c/o Rijksmuseum van Geologie en Mineralogie, Leiden, The Netherlands.

INTRODUCTION

For many years, diagrams similar to the one introduced in this article have been used successfully by geology students from the Geological and Mineralogical Institute of the University of Leiden. They have proved to be a valuable help when minerals must be identified on slides of rocks and grains.

Because of the good results with such diagrams it seemed justifiable to produce a similar determination diagram for the special benefit of the gemmologist. Many minerals of interest, including several scarcely known in gemmology, have been set out in this clear, comprehensive diagram and it is therefore expected that the diagram will be of use even to the more experienced among gemmologists. But it may also be of special interest to those experts, including many jewellers, who can only afford some relatively low cost instruments, such as the refractometer, to supplement the immersion (density) liquid tests.

This chart is not meant to replace the many indispensable textbooks. Its importance lies in the speed with which information can be gained from the diagram, after the initial observations are obtained using the refractometer and/or some immersion (density) liquids. After reading the "possibilities" from the chart, the textbooks may be consulted if necessary.

THE CONSTRUCTION OF THE DETERMINATION DIAGRAM

The diagram consists of two fields: a small field on the left where minerals with single refraction (isotropic) are set out and a larger one for the minerals with double refraction (anisotropic).

The coordinates of the fields are the values for birefringence (Δ) along the abscissa (horizontal) and for the refractive index, whether N for isotropic minerals or N_o and N_β for the anisotropic uniaxial

and biaxial minerals respectively, in the direction of the ordinate (vertical). The birefringence is set out logarithmically and the refractive indices linearly with irregular changes in scale.

The optical properties of the minerals of interest to the gemmologists are seldom presented as single points on the diagram but most often as lines. The optical properties (and also densities) vary with the chemical composition of the minerals, and in some cases the process of metamictization causes a decline in the refractive indices, birefringence and density (zircon). All chemical variations known belong to complete or partial isomorphous replacement series (garnets, spinels, some tourmalines, some apatites, and olivines).

For most of the minerals of interest, the mean of the optical variations could be represented sufficiently on the diagram with lines and circled dots, but in some cases the mineral properties are much more scattered than the lines indicate (apatite, variscite, chrysocolla, etc.). In the case of very small variations or when too few analyses were available, the mineral positions on the chart are shown by circled dots.

The physical properties of the minerals in question were mainly obtained from Deer, Howie and Zussman (1962), Winchell (1959), Anderson (1964) and Webster (1962).

The physical variations of most of the minerals are generally greater than the variations in the known gem varieties; therefore, the optical variations are often drawn as dotted lines when these properties are of less importance to the gemmologist (e.g. nephrite is a gem variety of the tremolite-actinolite series; peridot is the gem variety of the olivine series; of the scapolite series two gem varieties are known).

According to their general importance as gem varieties, the minerals in the diagram are indicated by heavy lines and dots circled twice when the more important gems are considered and thin lines and dots circled once for the more or less unusual stones.

Density, another major physical property of the gem varieties, has been added to the mineral names. For the minerals with double refraction, symbols are included to indicate whether the minerals are uniaxial or biaxial, with a positive or negative optical sign, (respectively $+0$, -0 and $+b$, $-b$).

The presence of so many minerals on the diagram clearly emphasizes that certain coordinates which lead more or less to an

important gem variety might also indicate another mineral of minor importance with physical properties very near to the former (examples are peridot and sinhalite; quartz, iolite and scapolite with low birefringence; sillimanite and euclase).

It is evident that when larger quantities of gemstones are to be identified at the same time, the diagram will once more prove its usefulness. The immersion-contrast method is advised here (Gem-testing by B. W. Anderson), thus subdividing the minerals into smaller groups with relatively similar properties. For this reason, the refractive indices and also in a few cases the densities of several of the more important immersion liquids have been included in the chart (methylene iodide, bromoform, benzyl benzoate).

In addition to the many natural minerals, the most important synthetics, glass varieties and other imitations can be found in the diagram.

Special attention has been paid to synthetic emeralds. The optical properties of the known natural emeralds and their synthetic counterparts have been grouped together separately in more detail in the upper left corner of the diagram. It is, however, still important to stress that all natural emeralds have a mean refractive index higher than the immersion liquid benzyl benzoate (1.569), but emeralds with a mean refractive index higher than 1.569 might still include some synthetic emeralds (Lechleitner, Linde). To complete the diagram, the scale ranges of the standard Rayner refractometer (1.30-1.86), the spinel refractometer (1.30-1.68) and the diamond refractometer (1.55-2.05) are also indicated.

THE USE OF THE DIAGRAM

The refractometer readings must be carefully carried out to obtain the most reliable results from the chart. The refractometer determines many important optical details of the minerals in question (Anderson, page 40). Thus it is possible to distinguish between singly and doubly refractive minerals, and very often between anisotropic uniaxial and biaxial minerals.

When a faceted stone is placed with the table facet on the refractometer and only one shadow-edge is seen through the ocular,

the stone will probably be isotropic. Isotropy is proved only when the shadow-edge remains fixed as the stone is rotated on the refractometer. The reason for this necessary check is that anisotropic minerals can behave isotropically when light is transmitted through the stone in the direction of (one of) the optic axis(es). It rather often occurs that uniaxial minerals are cut in such a manner that the direction of the optic axis is parallel to the table facet (beryl, quartz, tourmaline); when the stone is examined through the refractometer, full birefringence will be visible in one position (Δ maximal) but after being rotated over 90° , only one edge will remain ($\Delta = 0$). This edge, the ordinary ray, either corresponds with the higher refractive index when the mineral is uniaxial negative, or with the lower reading for the uniaxial positive mineral. Uniaxial minerals cut this way produce readings which are perfectly suited to the diagram, because the maximum double refraction is equal to the birefringence of the mineral while the stable shadow-edge corresponds with N° . An arbitrarily cut uniaxial mineral placed on the refractometer will, after rotation, be recognized by the fixed shadow-edge (N°), which is always present, and another (N_e') shifting toward or from the ordinary ray. The maximum distance between the rays must be measured (Δ'). For an arbitrarily cut stone this maximum difference (Δ') will nearly always be smaller than the birefringence (Δ).

Thus $\Delta' \leq \Delta = N_e - N_o$ for uniaxial positive minerals, or

$$\Delta' \leq \Delta = N_o - N_e \text{ for uniaxial negative minerals}$$

on the other hand, certain cuts of biaxial minerals may behave similarly and uniaxiality must therefore be proved (although this is not always possible) by obtaining refractometer readings from different facets of the same stone. The fixed shadow-edge will always be present; however biaxial minerals are different in that two movable shadow-edges will then be visible. Finding the birefringence of biaxial minerals is also a matter of routine.

$\Delta' \leq \Delta = N_\gamma - N_\alpha$ counts for both biaxial positive and negative minerals. N_α , N_β and N_γ are the three principal indices and $N_\alpha < N_\beta < N_\gamma$ always. Thus finding the coordinates of biaxial minerals needed for the diagram means finding the lowest refractive index N_α' (where $N_\beta \geq N_\alpha' \geq N_\alpha$) and the highest index N_γ' (where $N_\beta \leq N_\gamma' \leq N_\gamma$) then $\Delta' = N_\gamma' - N_\alpha'$. The average between N_α' and

N_{γ}' will often more or less correspond with N_{β} . As Anderson pointed out (page 42), the optic sign of biaxial minerals can also be found, but this is in practice a rather difficult matter. Anderson states that "If the higher R.I. edge is seen to move beyond the half-way position between maximum and minimum readings it must be positive. If the lower R.I. edge moves past the half-way position, the stone is negative". It is clear that it will be easier to evaluate the optic sign of biaxial stones when the birefringence is high. But even when birefringence is high, if at the same time the optical angle of the mineral is large, about 90° , the deduction of the optic sign will be difficult.

Summarizing, it can be said:

1. The measurements suitable for application to the diagram are most exact for the singly refractive minerals (one stable N and $\Delta = 0$).
2. In the case of uniaxial minerals, the ordinary ray will always be visible, while birefringence depends on the orientation of the optical properties of the stone compared with the facets ($\Delta' = |N_e' N_o|$).
3. Measurements on biaxial stones must be carefully carried out to obtain the best results for the diagram; N_{β} more or less corresponds with the mean refractive index and the double refraction with the maximum possible difference between the highest and the lowest measurable refractive indices —
($\Delta' = N_{\gamma}' - N_{\alpha}'$).
4. To distinguish between isotropy, uniaxiality and biaxiality, one must at least rotate the stone on the table facet and it is sometimes necessary to obtain readings from other facets.
5. In the case of cabochon cut stones it is impossible to get these exact results for the optical properties.

ACKNOWLEDGMENTS

The author is greatly indebted to Dr. P. C. Zwaan, F.G.A. and Dr. P. Hartman for many fruitful discussions on the subject of this article and for critically reading the manuscript.

Many thanks are also due to Mr. B. Lieffering who expertly drew the diagram and to Mrs. G. P. Bieger-Smith for correcting the English manuscript.

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ASSOCIATION NOTICES

MEMBERS' MEETING

Mr. Robert Webster was the speaker at a meeting of members of the Association held at Goldsmiths' Hall on Wednesday, 22nd January, 1969. He spoke about a recent trip to associations and gem-testing laboratories in Canada and the U.S.A.

His visits included the Canadian Gemmological Association, the Royal Ontario Museum, the Smithsonian Institution, and the laboratories of the Gemological Institute of America in Los Angeles and New York. Mr. Webster was also able to have discussions with Dr. Kurt Nassau, of the Bell Telephone laboratories.

In addition to describing the various gem-testing techniques which he had seen, Mr. Webster displayed various natural and synthetic gem materials which had been presented to him during his visits. These included synthetic quartz and garnet, flux-grown magnetite and peristerite feldspar, microcline feldspar, sodalite and rose-quartz.

Collections which Mr. Webster showed came from the Royal Ontario Museum, Bell laboratories, Mr. Grant Waite, of Toronto, Mr. Hugh Leiper, F.G.A., Editor of the U.S. Lapidary Journal, Mr. Maziarek of the Venezuelan Dept. of Mines, and Mr. Jerry Call, of the New York laboratory of the Gemological Institute of America.

MIDLANDS BRANCH

A well attended meeting of the Midlands Branch of the Association was held in Birmingham on the 23rd January, 1969. The speaker of the evening was Chief Inspector J. A. Birch, D.P.A., M.I.W.M.A. of the Weights and Measures Department in Birmingham. Mr. Birch discussed the 1968 Trade Descriptions Act at length and subsequently answered questions concerning descriptions that were used in the jewellery trade. Mr. Douglas King, Chairman of the Branch, presided, and Mr. W. A. Peplow of Stourbridge proposed a vote of thanks to the speaker.

SCANDINAVIAN DIAMOND NOMENCLATURE

The Gemmological Society of Finland has recently published a chapter on clarity from the Scandinavian Diamond Nomenclature. It comprises over 180 illustrations, with descriptions of the various clarity grades of diamond to be used in Denmark, Finland, Norway and Sweden. The official version of the nomenclature is in English. Copies of the clarity chapter may be obtained from the Association, price 25s. 0d. including postage.

GIFTS TO THE ASSOCIATION

Mr. Argimiro Santos Munsuri, of Madrid, has kindly donated a copy of his book "La Esmeralda" to the Library of the Association.

The Association is grateful to Mr. Walter E. Johansen of California, U.S.A., who has donated a parcel of synthetic red spinel preforms.

The Association has received various gifts for its library which include a transparent faceted grossular garnet from Central Africa, presented by International Gems of Luxembourg, and a refractometer and polariscope from the Gemmological Association of All Japan.

Mr. John R. Fuhrbach, of Amarillo, Texas, U.S.A., has kindly donated various specimens for student use.

OBITUARY

February 29th, 1969. Mr. John R. Page, F.G.A., of Knockholt, Kent. (D. 1948), aged 62.

COUNCIL MEETING

At a meeting of the Council of the Association held on Tuesday, 25th February, 1969, at Saint Dunstan's House, Carey Lane, London, E.C.2, the following were elected to membership:—

FELLOWSHIP

Arla, Felisart, Ramon, Barcelona, Spain	Derges, Leonard Frederick, Paignton, S. Devon.
Ash, Stephen Leslie, Exeter, Devon.	De Souza, Victor J., Kobe, Japan
Baguena, Ruiz, Carlos, Barcelona, Spain	De Vroomen, Leonardus Johannes Maria, London
Ball, Norman Douglas, Bideford, N. Devon.	Domenech, Bisbe, Juan, Barcelona, Spain
Barrenger, Jonathan, Weybridge, Surrey	Fieldhouse, John Ernest, Sutton Coldfield, Warwicks.
Best, Joseph, Santa Barbara, California, U.S.A.	Gastager (Jr.), Max, Bad Reichenhall, Germany
Bos, Elisabeth, Amsterdam, Holland	Gibson, Paul Walter, London
Broughton, Timothy John, Knutsford, Cheshire	Glen, Susan Elizabeth, Coventry, Warwicks.
Bruquetas, Dot, Eduardo, Barcelona, Spain	Goodson, David Lloyd, Wolverhampton, Staffs.
Buckingham, Robert George, Witney, Oxon.	Goodson, David Lloyd, Wolverhampton, Staffs.
Connard, John Martin, Southport, Lancs.	Holroyd, Philip, Frodsham, Cheshire
Dalewski, Orest, London	Htein, U Win, Durham
Davenport, Charles Edward, Coulsdon, Surrey	Hulme, Elizabeth, York.
	Jones, Stephen Richard, Newtown, N.S.W., Australia

Kaye, David, Leicester.
 Kjendlie, Karl Magnus,
 Larvik, Norway
 Lewis, David Trevor Keyes,
 Nottingham.
 Mason, Harold Ensor, London
 Mercer, Ian Frederick, London
 Millington, Grenville Arthur,
 Warley, Worcs.
 Mitchell, Frank Richard,
 Gloucester.
 Moreno, del Rio, Carlos,
 Barcelona, Spain
 Morgan, Deryck,
 Pembroke Dock, S. Wales
 Morrow, Roger Anthony,
 Lymm, Cheshire
 Pairman, Gordon Sinclair,
 Leven, Fife.
 Pardoe, Paul Roger,
 Worthing, Sussex
 Pass, John, Haslington,
 Nr. Crewe, Cheshire
 Pitt, Robert William,
 Sutton Coldfield, Warwicks.
 Pladellourens, Lluçh, Jose,
 Barcelona, Spain
 Pragnell, Jeremy Martin,
 Stratford-upon-Avon, Warwicks.

Purchon, Eric, Brandford, Yorks.
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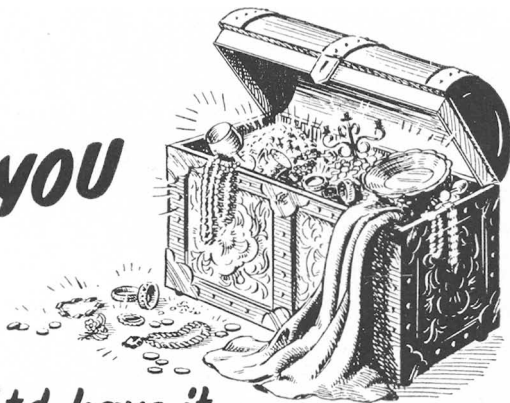
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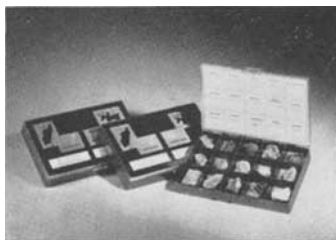
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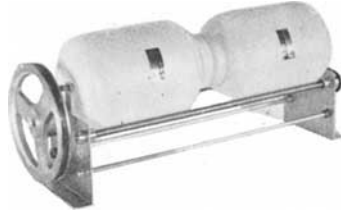
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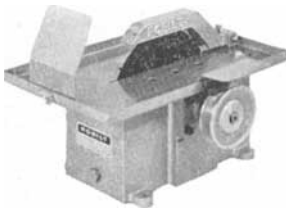
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