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PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

GEMMOLOGICAL ASSOCIATION
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MINERAL MINING IN QUEENSLAND

By VICTOR G. C. NORWOOD

THE warning, crudely daubed in white paint on a sun-warped board sign, read, "BEWARE of snakes, red-back spiders, and lunatics . . ."

The latter reference was probably added as a touch of humour. But, as I can confirm from personal experience, nobody but a lunatic would voluntarily accept, for long, the punishing conditions pertaining to sapphire prospecting around Anakie, one-time bonanza of the pioneer diggers.

I left Melbourne during one of the longest drought periods on record, with the intention of investigating geological reports of sapphire, opal, and agate discoveries in areas previously considered to be worked out. My transportation was a motor caravan equipped with bed, water-tank, cooking facilities, etc., and I planned a tour of some 8,000 miles. I undertook the journey alone.

It has long been suspected that extensive sapphire and opal fields remain to be discovered in arid regions of Australia's vast Outback. Recently, there has been keen interest in the commercial possibilities of agate, and a small factory for cutting and polishing agate, and for the manufacture of agate jewellery and components used for electrical insulators, etc., has been opened in Cairns, North Queensland.

I had been guaranteed 5s. per pound for agate delivered to the factory, and had acquired mineral rights over a large tract of barren wasteland not far from Cairns. I also had markets for all the opal and sapphires I could supply.

Travelling up country from Victoria, I considered it practical to make Anakie and The Willows my first halt. The demand for sapphires in industry is constantly increasing, and Queensland has produced some of the world's finest gemstones. The largest star-sapphire in existence came from the great ridge known as "Klondyke", two miles from Anakie. Cut from a rough crystal weighing 1,165 carats, it now weighs 733 carats and is known as the Star of Queensland, is larger than a hen's egg, and is 170 carats bigger than the previous record holder, the beautiful blue-grey gem named Star of India.

Among other fabulous sapphires found in this part of Queensland are the Abraham Lincoln (2,302 carats), the George Washington (1,997 carats), the Dwight D. Eisenhower (2,097 carats), and the Thomas Jefferson (1,743 carats), all so named because likenesses of these American Presidents have been sculped with diamond drills upon the finished gems.

Just a month prior to my visit, The Willows gemfield yielded a star-sapphire in excess of 100 carats. Reduced to 67 carats in the cutting, it is now in the possession of veteran prospector and gem-cutter Peter Laws, through whose capable hands most of the sapphires found at Anakie and The Willows in modern times find their way.

Dry-wash mining is a heart-breaking and back-breaking occupation bearing no similarity to gold and diamond recovery by the use of flume and sluice-box, or suction dredge. The nature of terrain in which sapphires occur defeats enterprise. The process involves no machinery or labour-saving devices whatever.

The site for operations is selected after inspecting likely places recognized from experience, usually a ridge or the dry bed of a former creek, for "indications" most commonly associated with sapphire, i.e., carborundum, quartz, jasper, tourmaline, and conglomerate sandstone.

Large rocks and dead wood must be removed, then the overburden spaded away and a pit dug deep enough to expose the gravel "wash". Strong poles are cut and lashed together to form a tripod from which an oblong sieve bottomed with very strong

Sapphire mining (Queensland). Shaking the sieve (no water).

steel mesh is suspended, preferably with thick wire, about three feet above the ground.

Gravel is shovelled into the sieve, which is then violently shaken and agitated until sand, dirt, and grit have been removed. Large stones are picked out by hand, hard clay masses broken up. Finally the residue is examined for sapphires and other closely allied minerals such as zircon, garnet, and amethyst.

It is wearying, monotonous work. Most Queensland sapphires are not blue but green or yellow. It takes a keen eye to distinguish a sapphire from the dry gravel concentrate. There is no water available for sluicing in the Australian Outback where rain sometimes does not fall in twenty years. Temperatures range up to 150 degrees. There is no vegetation, no shade, only skeleton husks of termite-riddled gum-trees peeling in decay, gnarled roots, and rocks.

Thirst and loneliness are the sapphire miner's constant companions, together with lizards, venomous snakes and poisonous red-back spiders, huge ants, and voracious flies. Outsize mosquitoes plague the intruder into these desolate regions. Gravel-strewn ridges, choked with fallen branches, harbour lethal brown snakes, tiger snakes, death adders, and taipans. Scorpions lurk beneath sloughing bark. Dry, curling leaves are infested with enormous ticks whose bite causes intense irritation and sickness.

The hardwood trees, however aged and rotten they may be on the inside, will turn the edge of an axe. Their incredibly tough roots writhe down among great boulders. No machinery suitable for sapphire recovery has yet been introduced to the Queensland gemfields. Methods remain unchanged from what they were 60 years ago when Anakie was the foremost producer of sapphires in the world.

I share the opinion of many prominent geologists that vast new sapphire fields exist in desert regions of Australia. But few white men can work in such intense heat, and the total absence of water often turns these arid areas into death traps. The sapphire miner must carry with him sufficient food and water to last for the duration of his stay. Even when rain does fall it drains off the granite-hard ridges almost immediately, and within an hour of the downpour the terrain is as dry as ever.

Nowadays, Anakie and The Willows, situated some 200 miles west of Rockhampton, attract tourists and drifters more than professional prospectors. Few remain longer than a day or two. There are, however, numerous long-established mines still producing saphires of gem quality, all under private ownership.

But plenty of free land is available for the free-lance. And despite crude recovery methods, sapphires continue to reward time and effort. I myself found more than 60 fine stones at Anakie within two weeks, four of them blue stones in excess of five carats. My locations also yielded a vast quantity of green and yellow sapphires, but most of these had flaws and were useless as gems, though admirably suited to industry.

It might well be worth the expense of using bulldozers to clear rocks and overburden from the old Anakie gemfields to uncover the gravel en-masse, and I am presently concerned with the formation of a company for this purpose. The introduction of mechanical shakers would simplify the work of gravel processing, but I see no alternative to dry-wash recovery.

★ ★ ★

From Anakie I drove west towards Winton, Opalton, and Horse Creek on the fringe of the desert country, all at one time rich sources of gem opal.

Opal mining, or "gouging", requires patience and considerable knowledge of the subject which can only be gained from practical experience. The most beautiful of all gems, opal is also the trickiest. Even men who have spent most of their lives in close association with opal never cease to marvel at its rich variety of form and pattern, and the constant element of surprise in its occurrence. Whether revealing pure lustre, red blaze, iridescent red and green fire, harlequin patterns, or a surface of opaque mystery, opals possess a fascination lacking in most higher priced gems.

Opal occurs not only in familiar forms like harlequin, fire, boulder, Tintenbar, pipe, light, and "potch" or "snide" (opal with no commercial value), but also in fossils and sea-shells. "Black" opal is the rarest and consequently the most valuable.

Boulder opal, formed by intense heat in opposition to water and hydrous silica cracking huge rocks which in time became filled in and solid again, occurs in thin veins in brown and grey ironstone boulders peculiar to parts of Queensland. Because of its more siliceous form, resulting in opalization without appreciable changes of temperature, Tintenbar opal from areas of New South Wales has an unusual depth of colour, and although it has a glassy, apparently oily appearance, the kaleidoscopic play of colours beneath the surface is truly magnificent.

Light opal contains pale hues, green, yellow, and blue predominating. Harlequin contains outstanding multi-colouring with emphasis on red, green, blue, purple, and orange. "Black" opal is usually translucent black on one side but coloured on the other and through its structure, whereas true fire opal reveals a blaze of beautiful colouring like the inner "fire" of a diamond. Potch is white or blue opal lacking the fire of gem-quality opal, but often possesses interesting markings and pattern formation.

The most extensive finds of valuable opal have come from White Cliffs and Lightning Ridge, both in New South Wales, the latter the world's only source of black opal. But Queensland, too, has produced vast quantities of gem opal, and a lot of ground, mostly desert, has yet to be thoroughly prospected. In 1965, I found gem opal in arid terrain west of Tennant's Creek and

Wauchope where there has been no opal mining activity for many years.

A strange factor about opal taken from a seam vertical to the surface is that the colour is always horizontal and on a flat level regardless of in what position the opal lies. When following a seam of potch it may suddenly reveal precious opal colour, and just as abruptly revert to potch. As the whole seam was opalized at the same time at equal temperatures under the same conditions involving identical ingredients of analysis, the change from potch to valuable opal and back to potch remains an enigma.

The colour of opal is unpredictable. A bar of good colour opal may extend right through both top and bottom strata of milky potch. Whatever the angle or position of the rock the true opal bar continues perfectly level.

Many remarkable opal oddities occur, including opalized bone, tusks, wood, and unique formations of gypsum crystals (pseudo-morphs) covered with spikes. Some of these fossils are of great value not only as relics but as gem opals, perhaps the most valuable specimen being the skeleton of a prehistoric sea creature about five feet long.

The reaction created by heat and water passing through the structure of ordinary marine shells over long periods caused them to become opalized where other shells merely crumbled. Fragile opalized corals have been preserved, things of great beauty. Instances of opalized fish and insects are fairly common. E. F. Murphy, a pioneer opal "gouger" and later one of the foremost buyers of precious opal in Australia, once purchased a perfectly preserved replica of a dog shark. Usually, however, the "fish" is merely an impression in clay which became filled with siliceous matter after the actual fish decomposed, as flesh, of course, will not opalize.

"Noodling" (seeking opal on ground previously mined) is a term originating from finds of egg-shaped opals that had formed inside lemon-sized rounds of brown sandstone which later eroded away leaving the opalized core. In Central Queensland, near the Southern Cross Mine, these "yowah nuts" as they are called were found intact and in great quantity. Cracking them open invariably results in the opaline core being split also.

The richest opal is usually found on white desert sandstone slopes, in layered ground with seams interposed between each stratum and covered on higher levels by sun-baked ground of concrete hardness. In such places, below the sandstone, which may be more than 20 feet thick, lies a gritty layer of "opal dirt" a few feet thick, underneath which is greasy clay seldom containing opal. The first sandstone stratum is usually harder and more siliceous, and it is below this that opal occurs, always forming upwards, never down. Seam opal is found in flat layers of varying thickness, generally in pieces which can be fitted together to form a whole, rather like a giant jig-saw puzzle, having been broken when, as a cooling liquid, the opal contracted.

Opal consists of 90 per cent hydrous silica and up to 10 per cent water. In a flat seam colour is usually true, and in a vertical seam crosses the stone at a regularly maintained level.

Opalized fossils are found in the "opal dirt" stratum.

Finds of coral and sea shells and the remains of marine creatures establish the fact that an inland sea extending from the Gulf of Carpenteria to Spencer Gulf once divided Australia. Over the passage of millions of years this sea was choked with debris—boulders, timber, clay, and silt deposited by flood waters from the mountains to east and west, and eventually became filled in. Ultimately, a crust formed over this immense cretaceous clay and sand region, known in this day and age as desert sandstone.

The silica content of opal comes from volcanic rock below this former sea bed which, in association with water, generated tremendous heat and formed a boiling silica-water solution that eventually poured from cracks and vertical fissures created by cataclysmic changes, and spread beneath the crust. The remainder found other vents and formed layers of opal at other levels as it cooled, sometimes reaching openings on or near the surface with resulting patches of overflow opal. Whatever objects the flow encountered were opalized.

Opal sometimes occurs with condensed steam imprisoned within its structure. A piece may have brilliant iridescent colour at one end and be blue-grey or white potch at the other, or coloured in the centre and potch at both extremities. Pattern structures, too, vary considerably, from harlequin squares and dots of "pinfire" to curly and twisted patterns, or rolls.

Some opals are basically blue and green: others flame with red, or a riotous blaze of rainbow hues. Still other examples are wholly transparent.

Among genuine black opal, opalized marine fossils, called "nobbies", are most in demand. These include sponges and corals. The rarest "nobbies" are conical with a teat base, and serrated from curling rim to pointed extremity. They are mostly found near surface sandstone, pointed end down. Others are flattened as if subjected at some time to extreme pressure, and are quite round. Having originally been of a delicate nature, black opal coral nobbies are creations of exquisite loveliness exhibiting patterns different from any other kind of opal.

Seam opal is mined by the skilful use of a pick, great care being essential as opal is brittle and easily fractured. To expose boulder opal it is necessary to crack open the rocks with a sledge-hammer—a herculean task in tropical heat often exceeding 140 degrees. Boulder opal, formed by the infiltration of silica-water solution into cracks created by flow's fierce heat, is not opalized right through like matrix, but can be cut and polished to make beautiful cameo pieces.

So-called opal "pipes" found in Queensland, resembling tree roots, are actually steam bores which later filled with liquid opal. Another peculiarity concerning pipe opal is that the consistency of colour throughout the length of the bore's content is either wholly true, or completely faulted.

Wherever opal is present underground there are surface indications such as surface opal or opalized wood. The majority of Queensland opal has been recovered from pressure-blasted vents through which silica impregnated steam escaped, and the crust, easily recognized by heaps of sandstone around the opening, often reveals opal. If this surface opal is of good colour, that below ground is usually of fine quality also. But if only potch is found above ground then excavation is generally a waste of time and energy.

As with sapphire mining, no satisfactory method of expedited recovery has yet been devised. Opal "gouging" involves pick and shovel work only, but the rewards are often well worth the labour.

At Tintenbar, an opal field near Brisbane on the Queensland coast, opal was found in association with basalt, a unique occurrence resulting from volcanic upheaval and a subsequent flow of molten lava over sandstone. A lot of Tintenbar opal contains air bubbles and tends to crack during cutting.

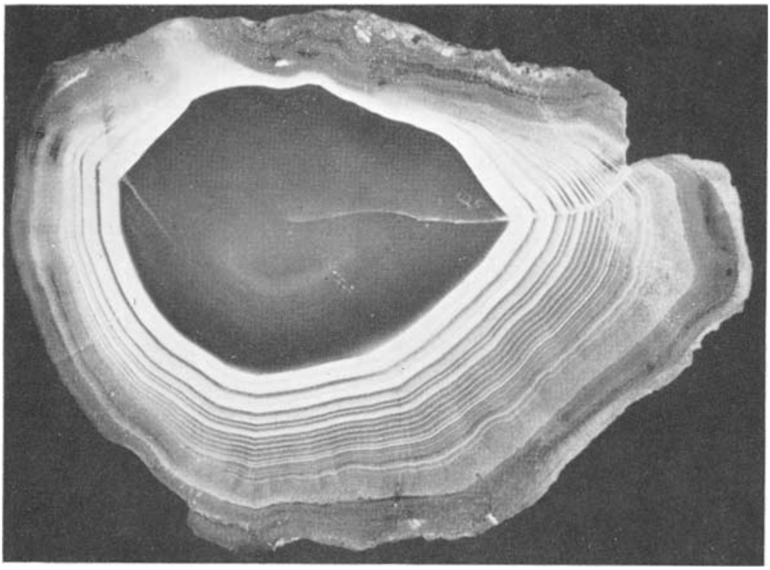
Near Horse Creek, south of Opalton, I found no surface opal, and had to bench down for 20 feet through granite-hard sandstone littered with quartz pebbles and enormous boulders before I encountered the continuation of an old seam. Much of the opal I obtained was worthless potch, but during the course of a week's hard work I accumulated some nice pieces of light and harlequin opal, and red and green blaze opal of a quality that eventually realized two thousand pounds in Sydney. There was a lot of opalized wood in the area, and numerous fossils of curio interest.

I left Horse Creek convinced that by mounting a properly equipped mining project it would still be possible to recover precious opal profitably over a long period. The difficulty in this day and age would be to get reliable men with field experience to work in such appalling heat, and the undertaking would, at best, be a gamble.

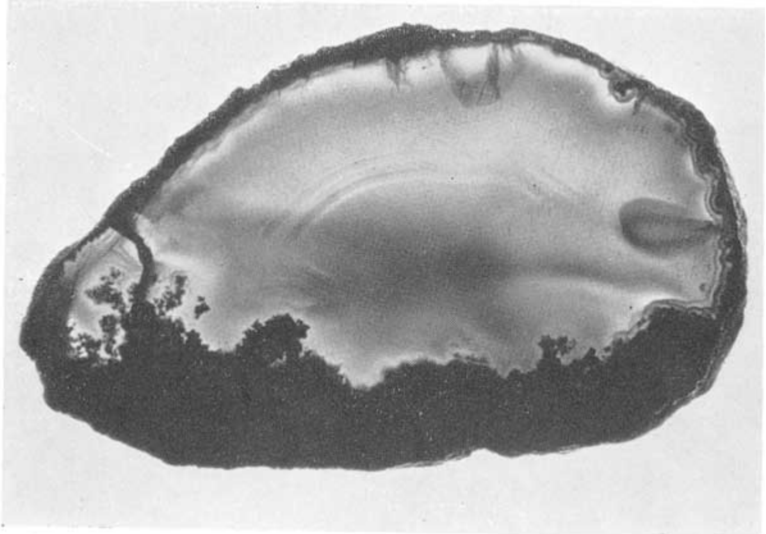
* * *

The agate, I considered, was a more rewarding proposition taking everything into account. One does not have to look far to find agate—it is there, lying around on the ground, in certain areas, countless tons of it, hitherto regarded as practically worthless.

Open deposits of agate, North Queensland, Australia.



Banded agate from North Queensland.



Unusual design in lump of agate from North Queensland.

Using Cairns, in tropical North Queensland, as a base, I acquired a soundly constructed truck, hired half a dozen rugged types who claimed to know something about agate, and eventually established a camp on the remote sector covered by my mining concession.

All I had to do was break up agate boulders into pieces of a size easily handled, selecting the more colourful grades, load the truck and drive to Cairns. The each-way journey took two days, during which time my crew got together other choice loads, improved living accommodation, and eventually devised and constructed a crushing device from balanced hardwood logs shod with iron, a crude but efficient rig that eliminated a lot of back-breaking sledge-hammer work and made the reducing of huge agate rocks to lumps one man could easily carry simplicity itself.

Over a period of six weeks I moved some 40 tons of agate. In addition to exploring new sapphire fields the proposed company will be concerned with opal recovery and supplying agate for industry. The three undertakings will be under separate management.

Meanwhile, having organized these projects, I envisage a return to Guyana where there have been some interesting developments in bauxite mining, and where I already have established diamond recovery interests.

It is just possible that the Australian ventures might provide the capital necessary for machinery to mine bauxite, including high-pressure hoses, diesel operated, for I am reluctant to turn my Guyana bauxite holdings, acquired in 1951, over to any of the major Canadian, American, or Dutch concerns at present monopolizing the industry, and would prefer to form my own company.

Certainly there is no lack of opportunity both in Guyana and Australia, Queensland in particular, for in addition to opals and sapphires I know of several locations within a short drive of Cairns where gold occurs in association with quartz, and black sand. The possibility of a gold mine operating within sight of the Great Dividing Range may well become reality during 1968.

DISPERSION IN DIAMOND

By B. W. ANDERSON

THE great attraction of diamond as a gemstone depends, of course, chiefly upon its optical properties—its high degree of clarity or transparency, its high refractive index, and its dispersion. The effect of fire in a well-cut brilliant-cut stone is so marked and so beautiful that it is understandable that diamond is commonly said to have a high dispersion. High it certainly is in comparison with other colourless stones used in jewellery, but it must be remembered that these have a much lower index of refraction. In cold fact the dispersion of diamond is exceptionally low when compared with the few transparent minerals which have indices of similar value, and indeed is surpassed by many gemstones which have considerably lower indices of refraction.

Students of gemmology will already be aware of these facts, but there is undoubtedly a tendency to think of minerals which surpass diamond in this particular as abnormal or freakish in having so high a dispersion, whereas in reality it is *diamond* which is quite abnormal in this property, as in so many others. An effective way of bringing this home is to draw a graph in which the dispersion figures for the B - G range are plotted against the refractive index for a wide range of gem materials, including diamond. This has been done by the writer and is shown in Fig. 1. Here one can see that there is in general a rough correspondence between the two figures for the majority of gems, and how completely out of line is the "plot" for diamond.

Another way of demonstrating the relatively low dispersive power of diamond in the visible range when compared with minerals of comparable index of refraction is shown in Fig. 2, where the R.I. of strontium titanate (1), zinc blende (2), and diamond (3) for a number of different wavelengths are plotted. This has provided an opportunity to reproduce data not available in text-books. For diamond, I have selected some values from the great range extending from the deep red to 2265Å in the far ultra-violet—i.e. virtually to the ultimate absorption edge of pure, nitrogen-free (type II) diamond—which were given by Fritz Peter in an important but neglected paper in the Zeitschrift für Physik, published in 1923.

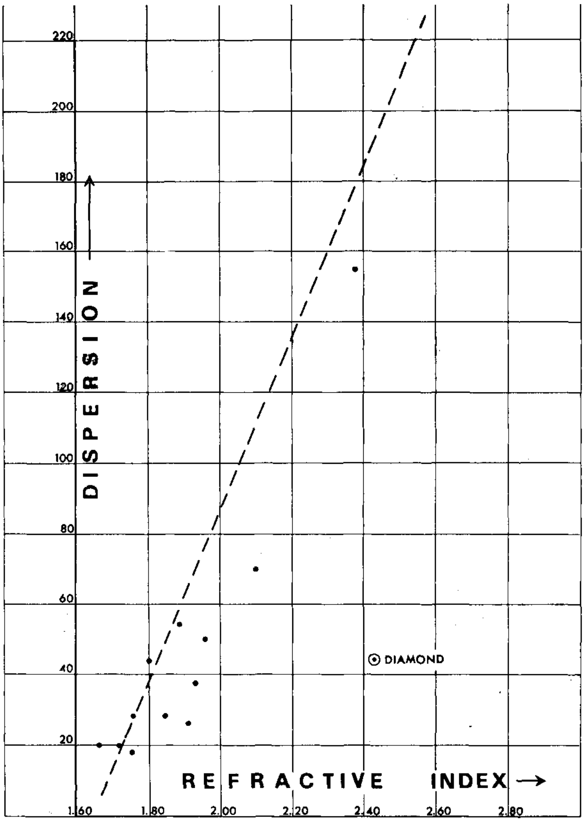


FIG.1

Fig. 1. *Refractive index for sodium light plotted against the B - G dispersion for diamond and a number of other gemstones.*

Peter was fortunate in that of the thirty diamonds he tested two were transparent in the far ultra-violet: the rare type of diamond which was distinguished as "Type II" in the well-known paper by Robertson, Fox and Martin written eleven years later. For these measurements, a prism of 26° 50′ was used, cut from one of Peter's Type II stones, the deviation being recorded on a photographic plate of rays striking a face of this prism at perpendicular incidence. It will be noticed from the graph that there is a steep rise in refractive index as the absorption limit is approached. This is a common phenomenon with solids, and serves to "explain" why the dispersion

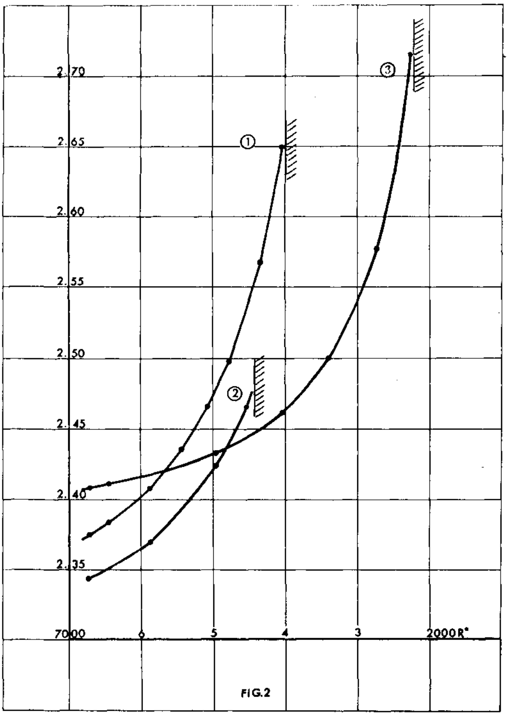


FIG. 2. *Dispersion curves for* (1) *strontium titanate,* (2) *zinc blende, and* (3) *diamond.*

of diamond in the visible region lags so far behind those such as demantoid, zinc blende, strontium titanate, and synthetic rutile where in each case there is a powerful absorption band either in the violet or in the near ultra-violet.

The interval between the B line (6870Å) and the G line (4308) is 2562 Angstroms. Using Peter's results, one can calculate that an equivalent range to this leading up to the ultimate absorption edge of diamond would give the dispersion of the mineral as 0·280, which is close to the dispersion of synthetic rutile and higher than that for strontium titanate for the B-G range. The figures for the dispersion of strontium titanate used in the graph are those recently given by Professor S. Rösch of Wetzlar in the Spring, 1967, issue of the Zeitschrift der Deutsche Gesellschaft für Edelsteinkunde. These agree closely with those obtained by C. J. Payne some years ago, but are more extensive. The values plotted for the zinc blende are those obtained by C. J. Payne before the war. As Professor S. Rösch points out, the refractive indices of diamond and of strontium titanate are identical for light of wavelength 5680Å, the value being 2·4204.

For his work Peter used mainly lines in the emission spectrum of cadmium: the highest index he recorded for diamond was 2·7151 for the cadmium line of wavelength 2265Å. He also describes similar experiments on quartz and calcite: it is interesting to note that the value for the ordinary index of quartz for wavelength 2265Å is 1·6179, and for calcite, 1·8131.

A SEVENTEENTH-CENTURY NOTE ON GEM PRICES

By M. J. O'DONOGHUE

IN 1652 Thomas Nicols, formerly of Jesus College Cambridge, produced his celebrated book "A Lapidary, or the History of Precious Stones". The copy in the Library of the British Museum has the alternative title-page "Arcula Gemmea, or a Cabinet of Jewels."

A feature of the book is the reference to the value of gems, expressed in crowns or ducats. In Nichols' time a crown was worth five shillings and a ducat about ten shillings.

It has always been difficult to be specific about prices of gemstones at any period of history and Nichols is one of the few writers who mentions them. Here are some examples.

DIAMOND

A well polished diamond without fault, of the weight of a peppercorn, is worth ten florins or crowns, according to Boethius, who also says that a diamond cut with one plain upper table and four lateral tables two of which are wont to be longer than the other two, weighing one ceratium or four grains, is worth 50 ducats or crowns. Stones cut in pyramidal forms are of less value. According to Cardanus in his book "De Subtilitatibus" (1550), a diamond at Antwerp "wanting one scruple of the weight of an ounce" is valued at 150,000 crowns.

RUBY

If it weigh two scruples* which is the greatest (for seldom any of the excellent ones are found of greater magnitude than a filbert), because of its grateful colour with which it feedeth the sight and because of those glorious beams which it seemeth to dart forth of itself, it is esteemed as of great worth as the most excellent

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* a scruple is 1/24th ounce or 20 grains

diamond. If it be found in the weight of four ceratia that is of 16 grains, it is of the same value with a diamond which weigheth so many ceratia.

BALASSIUS (RED SPINEL)

It is of much less value than the ruby. Linshortanus saith that one of the weight of one ceratium or four grains is worth ten ducats. A spinel of the old rock, of the weight of one ceratium, cut into a tablet, is worth half so much as a diamond of the same weight, if in its own glory and rosie lustre it be found and free from blemishes.

GARNETS

The Bohemian ones are worth 20 shillings a piece and if they be found bigger than ordinary the price of them is increased. The best Oriental ones of the weight of four grains are worth two crowns, and by how many times they are found to be double in weight so many times will double their value . . . as if they weigh eight grains they are worth four crowns and so proportionately . . . but with this proviso that their colour . . . be always the perfect colour of the ruby. (Almandine is classed separately; this jewel is known to very few and therefore scarce of any price).

AMETHYST

The Oriental ones, if they be hard without clouds and blemishes, though they weigh but four grains a piece, they are worth many pounds a piece, and as oft as they are double in weight, so oft is their price to be doubled. The best are worth as much as the best Oriental diamond of the same weight.

PEARL

If they be of the weight of four grains a piece, fair and round, they are worth three crowns a piece.

SAPPHIRE

One of the weight of four grains is worth many crowns. The best of these are as much worth as a diamond of the same bigness.

OPAL

Their price and esteem is not great in these days: for one of four grains weight of the first and best kind is scarce worth three crowns.

EMERALD

The Oriental ones have been esteemed worth a quarter so much as a diamond of the same weight. Linshortanus doth esteem them of greater worth than the diamond and valueth an emerald as big as a diamond of four grains well worth eighty ducats, whereas he esteemeth the diamond of that bigness not worth more than 70 ducats.

CHRYSOLITE (PROBABLY TOPAZ)

A chrysolite of the weight of eight grains is worth four crowns; one of these excellent ones of 12 grains weight is worth nine crowns and one of these glorious ones of the weight of two scruples is worth 100 crowns.

Gemmological Abstracts

LENZEN (G.). *Geschichte der Qualitätsmerkmale des Diamanten.* History of determining the quality of a diamond. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, no. 60, summer 1967, pp. 20-28. Extensive bibliography.

The article is the second in the series and deals with purity and cut. The early Indian period is discussed; the era lasted from about 400 B.C. to 600 A.D. At that time the quality and therefore the price was based on the crystal form and on the optical characteristics. It was considered most important that the octahedra had 6 perfect corners, next the 12 edges were supposed to be present and then in order of importance were the 8 faces. The optical quality was dependent on transparency and lustre.

E.S.

SCHLOSSMACHER (K.). *80 Jahre. Professor Dr. K. Schlossmacher.* Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, no. 61, autumn 1967, pp. 3-11.

This is an issue published in honour of Professor Schlossmacher's 80th birthday. In the beginning of the journal there is a biography of Professor Schlossmacher and there are two congratulatory articles by X. Saller and B. W. Anderson.

E.S.

BAIER (E.). *Gezuechtete Kristalle.* Synthetic crystals. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 12-26.

Survey of synthetic crystals which are used in industry. Various methods of production are discussed. There are 7 illustrations of the final crystals, which include calcium fluoride, quartz copper monoxide, silicon, silicon carbide, etc. The main use for the synthetic crystals are in optical lenses, prisms and filters, in lasers and masers, in x-ray monochromators, in counters, for piezoelectricity, in transistors and semi-conductors and for hard materials such as bearings and needles.

E.S.

BANK (H.) and BERDESINSKI (W.). *Chromhaltiger Turmalin.* Tourmaline containing chromium. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, no. 61, autumn 1967, pp. 30-32.

The constants of an emerald-like tourmaline are given in detail. The colour is caused by chromium. Graphs show the relationship between the lattice constants and the axes.

E.S.

BANK (H.) and OKRUSCH (M.). *Mineralogische Untersuchungen am Alexandrit der Novello Claims in Rhodesien.* Mineralogical examination of the alexandrite found in the Novello claims in Rhodesia. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 33-29. 9 illustrations with bibliography.

The geographical-geological occurrence of the alexandrites in the Novello claims in South Rhodesia is described. The crystals were examined by chemical analysis, spectrography and *x*-ray. These stones are mostly found in triplet form. Density was found to be between 3·646 and 3·768 + 0·002. The pleochroism showed red to darker green. A mean R.I. is 1·748, but many variations are given, birefringence 0·008-0·011. Crystallographic details are described as well as inclusions which are mainly phlogopite.

E.S.

BANK (H.). *Zur Diagnostik von Chrysoberyll.* Determining chrysoberyll. Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1967, 61, pp. 54-57.

The refractive indices of the alexandrites found in the Novello claims in Rhodesia are discussed as the R.I. is particularly high with a birefringence of 0·011. The author advises gemmologists always to use more than one method of determination.

E.S.

EPPLER (W. F.). *Der synthetische Smaragde von Linde.* The synthetic emerald of Linde. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 58-66.

Linde's synthetic emerald has been produced by hydrothermal methods. The crystal examined by the author is 21·2 mm × 11·5 mm × 7·2 mm and weighs 16·07 cts. The surprising fact about this crystal is that apparently it took only 12 days to grow.

The crystallographic and optical characteristics are described fully and there are 12 photographs. The colour is a very good green. There are not many inclusions, but there are a few small phenakite crystals.

E.S.

TILLANDER (H.). *Zur Fruehgeschichte des Diamantschliffs.* The early history of diamond cut. Zeitschr. d. deutsch. Gesellschaft. f. Edelsteinkunde, 1967, 61, pp. 111-114.

The author considers it very unlikely that diamonds were cut in the thirteenth century, and believes that we have to accept the second half of the 14th century as the earliest date. The Black Prince (1351-1356) collected valuable jewellery partially set with diamonds, but mainly forms which occurred in nature and which were polished. The first illustration of a diamond is of the year 1400, on a picture of the English Henry IV. Up to the year 1530 diamonds seem to have been retained in their natural shape and only polished over, then slowly long-cut stones evolved, especially the "scissor cut". The author also doubts the legend of Peruzzi as the inventor of brilliant-cut, which only seems to have come into use about the 17th century.

E.S.

STRUNZ (H.) and WILK (H.). *Zur Morphologie der St. Anne's Topase.* St. Anne's Topazes. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 106-110.

These topazes are of a good blue colour, though hardly useable as gem material, but make good mineralogical specimens. They are found in the Miami region of South Rhodesia and are seldom larger than 7·5 cm × 8 cm. Crystallographic details are given. The colour is not heat-resistant: loss of colour commences at 200°C and at 400°C stones become colourless. On cooling the colour does not return.

E.S.

EPPLER (W. F.). *Le mica dans l'aigue-marine.* Assoc. Francaise de Gemmologie, 1967, Bull. 13.

After mentioning the most common inclusions in aquamarine, non-orientated and orientated inclusions in aquamarine are given and the method of investigation described.

G.A.

NEUHAUS (A.), RECKER (K.) and LECKEBUSCH (R.). *Beitrag zum Farb- und Luminenzproblem des Fluorit.* Colour and luminescence of fluorite. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 89-102.

Detailed article, with many graphs, giving the absorption and luminescence spectra of natural fluorite and radiated as well as unradiated synthetic fluorite. The tests are to be continued.

E.S.

LENZEN (G.). *Lupenrein; Geschichte und Geschichten.* Loupe-pure stones: history and stories. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 86-88.

Discussion about how the "purity" of a diamond is handled in various trade centres and bourses over the world.

E.S.

GÜBELIN (E.). *Mineralogisch-gemmologische Untersuchungen an Apatiten von Edelsteinqualitaet aus dem Casaccia Tal, Tessin.* Mineralogical and gemmological tests of gem quality apatites from the Casaccia valley in the Tessin. Zeitschr. d. deutsch. Gesellschaft f. Edelsteinkunde, 1967, 61, pp. 75-85.

The apatites discussed vary from light to dark violet and are of good gem quality; they are fairly large and come from the Tessin district of Southern Switzerland. There are 7 illustrations, two showing unorientated liquid inclusions, two with orientated negative crystals.

E.S.

ARTAMONOV (V. S.). Semi-precious stones in northwestern RSFSR. Materially po Geol. i Poleznym iskopaemym, Severo-Zapada RSFSR, 1962, 3, pp. 195-213 (in Russian).

The distribution of amethyst, almandine garnet, moonstone and sunstone in the Kola Peninsula and Karelia areas of northern Russia is reviewed.

R.A.H.

BASTOS (F. M.). *Diamonds in Minas Gerais.* Lapid. Journ., 1968, 21, 10, p. 1240.

A brief sketch of the history of diamond mining in Minas Gerais is followed by an account of present day conditions in an area which still has considerable potentiallity for the recovery of diamonds.

S.P.

ZWAAN (P. C.). *Een imitatieparel van ongewone samenstelling.* Edelmetaal, 1967, 1, p. 16.

Imitation pearls having a mother-of-pearl nucleus have been investigated by chemical, optical and X-ray methods. The way how to distinguish them from genuine and cultured pearls is given.

P.Z.

PETCH (H. E.). *Bancroft's star-sapphire.* Rocks and Minerals, 1967, Vol. 42, pp. 563-566.

Asteriated black corundum and sapphire occur in the Bancroft area of Ontario, Canada. The history of corundum collecting and mining in the area is reviewed, with particular reference to the Burgess mine, Carlow township, and the Craig mine, Raglan township. The gem uses of corundum in various cultures are considered.

R.A.H.

CROWNINGSHIELD (R.). *Developments and highlights at the Gem Trade Lab. in New York.* Gems and Gemology, 1967, XII, 7, 199-210.

Such various topics are oolitic opal, black-cored emerald crystals, star-enstatite, crystals in jadeite, and features of an imitation emerald are mentioned. There is a good description of the new blue zoisite. Snuff bottles made of amethyst, citrine, veined common opal and crested hornbill "ivory", a material of yellow to orange-red colour obtained from the beak of the hornbill, are interesting items discussed. In the field of synthetics, flux-fusion rubies and garnet-structured crystals, as well as an anomaly in the refractive indices of a colour-banded Gilson synthetic emerald are reported upon. A low density plastic amber imitation and dyed "angel's-skin" coral are mentioned. Four light blue Type IIb diamonds were recently seen in this laboratory.
29 illus.

R.W.

LIDDICOAT (R. T.). *Developments and highlights at the Gem Trade Lab. in Los Angeles.* Gems and Gemology, 1967, XII, 7, 212-223.

Examination of the 5·34 carat taaffeite found in a parcel of stones in the U.S.A. showed the uniaxial refractive indices to be 1·720–1·724 and the density to be 3·608. The inclusions are described and photomicrographs illustrate them. An unusual cat's-eye doublet consisting of a very transparent chrysoberyl top cemented to a more opaque back is described. Other items referred to were green andesine feldspar; inclusions in and scratches on polished facets, as well as unpolished facets on cut diamonds. An opal substitute made of tiny fragments of precious opal pressed into a resin matrix and a plastic substitute for amber are mentioned. A new source of emerald in Western Australia is reported.
23 illus.

R.W.

TAYLOR (A. M.). *Synthetic vanadium emerald.* Australian Gemmologist. 1967, 75, 10-13.

Expected to enter the gem market is a synthetically produced grass-green beryl coloured by vanadium (*Journ. Gemmology* 1967, 10, 7). The crystals are grown by a hydrothermal method and are produced in Australia. The stones have refractive indices of $\omega = 1{\cdot}571$ to 1·575 and $\varepsilon = 1{\cdot}566$ to 1·570, the double refraction being 0·005. The density varies from 2·67 to 2·69.
4 illus.

R.W.

SMITH (C. C.). *A preliminary account of Rhodesia's new gemstone—chrome chalcedony.* Chamber of Mines Journal. Rhodesia, 1967, IX, 12, 31-34.

A report on the green chalcedony coloured by chromium, which has recently been found in Rhodesia. The author, Craig C. Smith, is Keeper of Geology at the National Museum at Bulawayo and has recently prospected the area. The material was first noticed by M. J. Maclean at the end of 1955 in a small spruit off the western slopes of the Great Dyke and just north of Mtoroshanga. It has now been established that the mineral occurs along a strike of about a mile running north-south along the western edge of the dyke. The material, which is mined by pig-rooting or gophering, varies in quality from a deep green evenly distributed colour to material which is more variegated. Much of the recovery is sold to Hong Kong but other markets are being investigated. From analyses the chromium content varies from 0·15% to 0·4% and nickel 0·05% to 0·2%. The effect of the chromium and nickel on the colour, and the way the chromium is associated in the mineral are discussed. The refractive index was found to be 1·5395 and the density of 2·593 was found on the specimen determined, but values found by other workers are given. There is no luminescence. The article contains a good description of the geology of the area, and a discussion is made on the question of the correct naming of the mineral. It is suggested that the mineralogical name should be chrome chalcedony, but names, taken from the locality where it is found, have been used in trading. Such names are mtorodite, matorolite and matorodite.

5 illus. R.W.

ILER (R. K.). *Formation of precious opal.* Gems and Gemology, 1967, XII, 7, 194-198. (Reprinted from *Nature.*)

Experiments on the formation of opal structures from silica sols, producing a colourful opaline layer. The experiments are correlated with the sphere theory of J. V. Sanders and throw light on the formation of precious opal in nature, and a discussion is made on this.

1 illus. R.W.

McDONALD (N. R.). *Synthetic beryllia crystals.* Australian Gemmologist. 1967, 75, 8-9.

Colourless crystals of beryllia (BeO) have been produced by the flux fusion technique. The crystals are of hexagonal symmetry, have a hardness of about 8, and refractive indices $\omega = 1{\cdot}719$ and $\varepsilon = 1{\cdot}733$.

4 illus. R.W.

P.A.M. *Phosphorescence in Australian opal.* Australian Gemmologist. 1967, 75, 18.

Details some experiments of a New South Wales gem research group on the luminescence of opal under long-wave ultra-violet light. It was noticed that while opal from Australian sources fluoresced blue and white, the material from Nevada and Arizona, U.S.A. showed a yellow-green glow. This difference is being ascribed to the uranyl ion. It was further noted that many Australian opals showed a phosphorescence of greenish-yellow colour not unlike the fluorescence of the American stones, which did not apparently show an afterglow.

R.W.

COOGAN (C. K.). *Diffraction gratings.* Australian Gemmologist. 1967, 75, 19-26.

A brief history and theory of diffraction gratings and the problems of producing them. The various types of machines which have been made for the purpose of ruling such gratings are mentioned. An excellent article on a subject which is usually neglected.
9 illus.

R.W.

WEBSTER (R.). *Forensic problems in jewellery.* Criminologist. 1968, 7, 40-51.

The work of the expert witness in Court cases involving jewellery and gemstones is discussed. Reports of a number of Court cases and remarks upon them are given. The possibility of litigation through damage to jewellery from various causes, by blows or pressure, by heat, by radiation and by cosmetics, is discussed.

P.B.

GUNARATNE (H. S.). *Rocks and Minerals of Ceylon.* Ceylon National Museums Handbook Series, 1967.

Rock types of Ceylon, their component minerals and a brief account of the gemstones of Ceylon is followed by a catalogue of the mineral collection in the Colombo National Museum. A map of Ceylon in the twelth and thirteenth centuries is given.

S.P.

METEORITES AND TEKTITES *

By M. H. HEY

IT has been common knowledge since the dawn of civilization that stones, and more rarely masses of iron, sometimes fall from the sky, to the accompaniment of light and sound phenomena that naturally tended to be confused with thunder and lightning.

The ancient accounts range from bald statements to obviously embroidered tales, but include many clear and excellent records such as this account of the fall of a meteorite:

"the town is Hatford, in Berkshire, some eight miles from Oxford, 9th April, 1628, about 5 of the clock in the afternoon . . . . . in an instant was heard first a hideous rumbling in the air, and presently after followed a strange and fearful peal of thunder . . . . . Amongst all these angry peals shot off from heaven, at the end of the report of every crack, a hizzing noise made way through the air, not unlike the flying of bullets from the mouth of great ordnance, and by judgement were thunderbolts; for one of them was seen by many people to fall at a place called Bawkin Green, being a mile and a half from Hatford; which thunderbolt was by one Mistress Greene caused to be digged out of the ground, she being an eye-witness among many others of the manner of the falling. The form of the stone is three-square . . . . . , in colour outwardly blackish, somewhat like iron; crusted over with that blackness about the thickness of a shilling; within it is soft, mixed with some kind of mineral, shining like small pieces of glass. This stone broke in the fall. The whole piece is in weight nineteen pound and a half, the greater piece that fell off weigheth five pound, which together with other small pieces being put together, make four and twenty pound and better . . . . . for certainty there was one other one taken up at Lecombe, and is now in the custody of the sherrif."

It is one of the outstanding puzzles of meteoritics why, with such plain evidence before them, the scientists of the mid-eighteenth century should have decided that the fall of stones from the sky was incredible—a mere vulgar superstition.

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* At the request of various members the full text is given of Dr. Max Hey's 1967 Herbert Smith Memorial Lecture delivered on 16th November, 1967.

The intellectual climate of the time must have had a lot to do with this disbelief—the notion that the Newtonian physics had explained the whole cosmos, in principle if not in detail, and therefore nothing could exist outside the earth's atmosphere but the sun, a few major planets, and the distant stars—a magnificent non-sequitur—; but no doubt the admixture of incredible stories with the more accurate records helped.

In France, the Académie des Sciences decided that the fall of stones from the sky was an impossibility, and that was that: who could contradict the Académie? The fall at Lucé in 1768 was a trifle inconvenient, but was happily explained as stones struck by lightning.

In Britain, eighteenth century science was much less organized, and anyway, who could doubt the evidence of a gentleman of quality who saw these things happen himself? Moreover, the English country gentleman was much less inclined to reject the evidence of his servants and tenants as mere vapourings of an ignorant peasantry. Accordingly, few in this country doubted that the thing happened, though the explanations offered were often a trifle far-fetched. Thus the fall at Pettiswood, Ireland, in 1779, was explained as a concreted mass of sand from a nearby lake, carried up along with water-vapour to the clouds and there congealed.

Gradually the evidence built up; falls at Vago and Siena, Italy, could be attributed to Vesuvius, and even the 56lb stone that fell at Wold Cottage in Yorkshire, could be explained as coming from the volcano Hecla, in Iceland. But between modern, well-attested accounts and the mass of historical evidence collected by Chladni and by King, the sceptics were wavering by the close of the century, and in 1803 the Académie des Sciences admitted that a shower of stones at L'Aigle were real, neither a figment of the imagination nor stones struck by lightning.

Short as it was, this period of scepticism—a mere 60 years or so —had one very unfortunate result: many of the meteorites then preserved in various cabinets of curiosities were thrown away as rubbish. On the other hand, the ten-year controversy stimulated interest in meteorites, and their scientific study was soon fairly launched.

Once it was established that stones, and more rarely masses of iron, fell from the skies, the next question was "whence"? Soon pretty well every possible origin had been suggested, and their rival merits were hotly debated, though the evidence to decide between them was scanty.

Agglomeration of dust particles in the atmosphere, with or without the assistance of fusion by lightning, was a favourite for many years, until the difficulty of keeping the mass suspended during the agglomeration process was realized.

Many favoured the nearest active volcano, though it might be several hundred miles away; but as the chemical evidence slowly accumulated it was found that meteorites, with a few rare exceptions, differ greatly in chemical composition from terrestrial rocks.

If not terrestrial volcanoes, then what about the moon? Astronomers had been busy mapping the moon, and surely all those obvious craters must be volcanoes? Or again, it had just been shown that the major planets are not the only members of the solar system—the gap between Mars and Jupiter had just been filled by the first few asteroids to be discovered; these were surely the fragments of a planet that broke up and, if so, might not some of the fragments continue to circle the sun in highly eccentric orbits, and ultimately collide with the earth?

Then, once the possibility of a genuinely extra-terrestrial origin was admitted, what about the comets? These bodies were so obviously losing material in those vast tails—might not the meteorites come from them? Or might they not even be visitors from outside the solar system altogether?

The possibilities are numerous, and pretty well all of them had been advanced early in the nineteenth century, but the evidence to decide between them was lacking, and could only be acquired by patient collection of observations at the time of fall and careful study of the meteorites themselves—a task that is still far from complete today.

The fall of a meteorite is usually a spectacular affair, though there have been occasions when little was seen or heard—just a dark object, seen to fall with a bump. But normally a brilliant fireball is seen to move across the sky, and shortly afterwards a number of bangs and rumblings are heard; these are often compared to thunder or to artillery fire. Minor noises such as hissings and cracklings are often heard; the fireball may throw off sparks, or may break into two or more portions, and the break may be repeated.

The trajectory of the fireball could, of course, be anything from almost horizontal to vertical: leaving aside those cases where the sky was heavily clouded, it seems likely that the rare instances where nothing was seen are examples of near-vertical falls. At the other extreme, a procession of some hundreds of fireballs was seen all the way from Saskatchewan to beyond Bermuda (9th February, 1913), and probably fell in the sea some hundreds of miles east of Bermuda.

The fireball is commonly followed by a trail, which may persist for a considerable time or may be thrown into serpentine forms or rapidly dispersed by the winds of the upper atmosphere; by night, the trail is often luminous.

All these phenomena are readily understood in terms of our current knowledge of the physics of the upper atmosphere, and have little to do with the meteorite itself. The minimum velocity of its entry into the upper atmosphere must be seven miles a second, the earth's escape velocity, and at this speed the air is simply swept up and compressed, with the evolution of much heat. The meteorite's kinetic energy is rapidly converted into heat—but only a thin skin on its forward surface is heated; this thin skin is soon melted, and as fast as it melts it is swept off to form the smoke trail. The mechanical shock may fracture the mass, particularly if it has an irregular shape; on the other hand, because the pressure is uniform over the whole front surface, some very fragile meteorites survive; a few meteorites are so friable one cannot pick them up without fragments falling off, yet they came though, though probably with a great loss of weight.

The falling meteorite is soon accompanied by a globe of heated and ionized air, many times its own diameter, and this constitutes the visible fireball; slow recombinations of atoms and ions may give rise to a luminous trail, and electrical effects are probably responsible for the hissing and crackling noises. The bangs, at one time supposed to be the explosions of the meteorite itself, are clearly the shock-wave and its reflections.

By the time the meteorite is some 20-25 miles from the earth's surface it has usually lost most of its cosmic velocity, and the rate of heat formation drops off; the fireball quickly extinguishes, and from this point on a meteorite of ordinary size falls as a dark body, striking the earth with a velocity little greater than that of an object dropped from a high-flying aircraft. The actual point of impact may be many miles horizontally from the point of extinction, a circumstance that often misleads observers of spectacular fireballs.

The behaviour of a really large meteorite is quite different. Because the kinetic energy increases as the cube of the average diameter, but the average cross-section only as its square, the buffeting effect of the earth's atmosphere decreases with the size of the incoming body. A small object, up to about pea size, will be wholly melted and dispersed as fine dust; such are the common "shooting stars". A still smaller object—a mere dust particle—will be so quickly checked in the outer atmosphere that it is not melted, remains dark, and slowly drifts down to the earth's surface; unfortunately, it is very difficult if not impossible to distinguish such particles from terrestrial dusts. On the other hand, a really large object will retain much of its cosmic velocity, and will still be travelling at several miles a second when it hits the ground. A meteorite about 20 to 25 feet in diameter would weigh roughly 1,000 tons, and at the moderate cosmic velocity of 12 miles a second its kinetic energy, all of which must be released on impact, would be about equal to the energy of the first atomic bomb.

Thus a really big meteorite will literally explode on impact, and will produce a crater, with fragments of meteorite material scattered around it. Fortunately, such events are very rare; the fall of 12th February, 1947 in the Sikhote-Alin mountains of far eastern Siberia produced several craters, the largest about 90 feet across (the event of 30th June, 1908, on the Stony Tunguska river in central Siberia is now believed to have been caused by the head of a small comet, and not by a meteorite proper). But much bigger craters have been formed in the past: one near Flagstaff, Arizona, 3/4 mile across, was originally about 700 feet deep; it has been partially filled by drifting sand, to a depth of some 100 feet. Even bigger craters have been shown to exist in the ancient rocks of northern Canada.

By far the commonest sort of meteorites are the stones; apart from their black fusion crust the casual observer will see little to distinguish them from terrestrial rocks. Most meteorites contain small particles of metal, but these readily escape notice on a freshly-broken surface; they are, however, a sure diagnostic feature, for they consist of a nickel-iron alloy that is peculiar to meteorites; nickel-iron alloys do indeed occur in a few terrestrial rocks, but they are very rare and contain far more nickel than any meteoritic alloy. Again, microscopic study shows that most meteorites are largely composed of small spherules of olivine and pyroxene, in a texture quite unknown in any terrestrial rock. Indeed, an observer with adequate experience of meteorites rarely has any difficulty in recognizing one, though a few rare types do closely approach certain terrestrial rocks in composition and texture.

Chemically the stony meteorites vary very little in bulk composition, apart from about 5% of rare types. The common kinds all consist mainly of pyroxene, olivine, and nickel-iron alloy, with subordinate feldspar and iron sulphide, and accordingly their chemical analysis as compared to terrestrial rocks shows high magnesium, iron, and nickel, low silicon, aluminium, calcium, manganese, titanium, and sodium, and very low potassium. Almost all the known elements have been detected in meteorites.

The exceptional 5% of stony meteorites are very varied; some are almost pure enstatite, some resemble certain basalts in composition, and a few contain considerable amounts of free sulphur, sulphates, hydrous silicates such as serpentine, and complex carbon compounds.

About 6% of all meteorites seen to fall are solid metal, consisting of a nickel-iron alloy. The great majority contain 8 to 11% nickel, and on a polished and etched surface these show a very characteristic pattern; this pattern has not been reproduced in artificial nickel-iron alloys, because it is not possible to anneal them long enough—calculations show that the pattern probably took some millions of years to develop. A few irons contain as little as 5% nickel, and a few up to 30% or more, and these lack the Widmanstätten pattern.

Though irons are only a small fraction of the meteorites seen to fall, they are more readily recognized as something unusual, and remain recognizable for longer when exposed to the weather; once its black fusion crust has gone, a stony meteorite looks just like any other stone to the casual observer. This is the reason why rather more than half of those meteorites that are found, not seen to fall, are irons.

About 3½% of all known meteorites, and 1½% of those seen to fall, are "stony-irons", with roughly equal amounts of nickel-iron alloy and silicates; they are a very varied group and space does not permit of their further consideration here.

Meteorites contain traces of several radioactive elements, some primordial constituents, others produced by cosmic ray impact during the meteorites' sojourn in space. From a study of the nature and amounts of these radioactive nuclides and their breakdown products, it has been possible to deduce a good deal about the history of the meteorites. They all appear to have been originally formed about 4,500 million years ago, at about the same time as the earth and the other planets, but were originally part of one or more larger bodies. These larger bodies were subsequently broken up by collisions, or at least chipped, and the meteorites now reaching the earth are fragments deriving from collisions that occurred up to 500 million years ago or more; there are as yet not enough data for a consistent pattern to have emerged, but it seems likely that one collision some 25 million years ago may have produced a considerable fraction of the stony meteorites the earth is now encountering.

While the new evidence enables us to exclude many of the early nineteenth century theories of the origin of meteorites, we still cannot be definite about their source; some workers believe that they come from the moon, others that their parent was Mars, while probably most would agree that they originate from collisions among the asteroids. There is a fair body of evidence suggesting that they came from a parent body of the order of 100 to 300 miles in diameter: too small a body could never have melted internally (by radioactive heating), too large a one could not have cooled off quickly enough. But the details of the formation and history of the meteorites are still under dispute, and with a considerable bulk of new evidence becoming available annually this year's theories will almost certainly be out of date in a very short time.

TEKTITES

No account of the meteorites would be complete without some mention of those problematical objects, the tektites.

Should they be included with the meteorites? The question has been in the air now for many years; to some extent it is merely one of definition: if a meteorite is a solid body falling on the earth from outside the atmosphere, australites and moldavites, and probably all tektites, must be classed as meteorites; but if meteorites are defined by their composition or by their presumed origin in the asteroidal belt, tektites are not meteorites.

This, however, is to anticipate the evidence. The first tektites to come to scientific notice, in the late 18th century, were the moldavites, from the basin of the Moldau river in southern Bohemia; small fragments of olive-green glass, they have been held to be volcanic, or fragments from a vanished glass factory, but their composition is too siliceous for either explanation. The mid-nineteenth century saw the discovery of the australites, dark brown to black and often of remarkable and characteristic shape. Other discoveries of glassy bodies of high silica content in localities where igneous origin appeared impossible followed, and in 1900 Suess proposed the non-committal name tektites as an inclusive term for all such glasses. They are now recognized from Czechoslovakia, Indochina, Malaysia, Indonesia, the Philippines, Australia, the Ivory Coast, Texas, and Georgia. There are also glasses of unexplained origin from Tasmania, Mauritania, and Libya that are not usually considered to be tektites.

Chemically, the tektites are highly siliceous glasses (SiO_2 70 to 80%, Al_2O_3 11 to $14\frac{1}{2}$%) with little iron, with potash (2 to 3%) in excess of soda ($\frac{1}{2}$ to 2%) and with mere traces of water. Such a composition is very different from the cosmic average (which the meteorites as a whole closely approach), but resembles that of some terrestrial sediments and some acid volcanic rocks, indicating an origin from material that has undergone considerable chemical differentiation. Their trace-element content too is different from the cosmic ratios or those in the meteorites, and generally similar to the average for the earth's crustal rocks.

The tektites are usually small; at one extreme, an indochinite of 3,200 grams has been recorded, but the average in most if not all tektite fields is under 100 grams, and a complete australite weighing only 0.06 gram is on record. In shape they vary from the slabby, layered masses from the Muong Nong area of Thailand to spheroids, pear-shaped, and the remarkably developed button forms, with lens-shaped core and outer flange, of some australites. Some philippinites contain spherules of nickel-iron alloy. Many indochinites are full of bubbles, but australites and moldavites normally have few and very small bubbles; in all cases the gas pressure in the bubbles is very low.

To sum up, the chemical and petrological data all tend to suggest that the tektites from each major field originated in one event, by fusion of material similar to a siliceous sedimentary or igneous rock, at a temperature far enough above the melting point for appreciable loss of alkalis and other relatively volatile oxides to occur in a short time, followed by rapid chilling. Fusion could well have been due to impact by a giant meteorite.

Indeed, of all the numerous theories of the origin of tektites that have been advanced, only the theory of meteoritic impact remains—but there is no agreement as to the site of these impacts (one for each tektite field).

The main requirements that must be met are: the peculiar chemical composition of tektites, calling for an impact target that can only occur at the surface of the earth or a body that has undergone comparable differentiation; and the peculiar lens-and-flange structure of the australites, which is fairly conclusive evidence that these bodies fell at a high velocity through the earth's atmosphere, and started this flight as cool, rigid masses.

One school of though bases its argument mainly on the facts that possible meteorite craters can be recognized within reasonable range of nearly all tektite fields (with the significant exception of the australites, though here a hypothetical impact crater under the ice of Antarctica has been postulated) and that there is no evidence for materials of the composition of the earth's crust elsewhere in the solar system. This leads to the conclusion that the impacts were on the earth.

The other school relies mainly on a detailed study of the flow lines in australites and their deformation near the forward surface; this is held to indicate that the australites entered the earth's atmosphere with a velocity in excess of the earth's escape velocity and cannot, therefore, have had a terrestrial origin. Instead, they are believed to have originated by the impact of giant meteorites on the moon.

At present it does not appear possible to decide definitely between these rival theories, and the tektites remain, in many respects, an unsolved problem.

ASSOCIATION NOTICES

MEMBERS' MEETINGS

London: An audience of 241 attended Goldsmiths' Hall, London, on Tuesday, 30th January, 1968, to see three films—City of Gold (a re-creation, with the aid of contemporary photographs and based on old-time prospectors' recollections of the Klondyke Gold Rush of 1896); The making of a jewel—(showing scenes at Harry Winston's, the New York); Diamonds (a De Beers film telling the story of diamonds from mining to jewellery).

OBITUARY

Brown, Arthur Bayliss, of Ilford, Essex. (D. 1945).

LECTURES IN CEYLON

The Gemmological, Jewellers' & Tourist Traders' Association of Ceylon, commenced a series of gemmological lectures in January, 1968. The first series of 12 lectures is intended mainly for foreign missions in order to advertise the work of the Association internationally, but other courses for the public and the trade will follow.

GIFTS TO THE ASSOCIATION

The Council is indebted to Mr. C. F. Dudek, Oregon, U.S.A., for the gift of a faceted feldspar (var. bytownite) and to Mr. R. Webster for a collection of gem materials brought from Southern Africa.

Mr. S. Gunaratne of Ceylon has sent a booklet "Gems of Ceylon" written in Sinhalise.

MIDLANDS BRANCH

The Branch held an interesting evening on 22nd March, 1968, when members exchanged views on the merits of gems and their prices.

SCOTTISH BRANCH

On 29th February, the Curator of the Huntarian Museum, Dr. Rolfe, gave a short introductory talk about the development of the Museum and showed members some of the outstanding exhibits. Members were also able to handle specimens not normally displayed.

SITUATION REQUIRED

Solicitor's daughter (aged 20), eight "O" levels, working knowledge French and Spanish, good typist, seeks work in London, E.C.1. area. Studying gemmology. Keen to handle gems. GA/25/68.

COUNCIL MEETING

At a meeting of the Council of the Association held on 7th February, 1968, the following were elected:—

FELLOWSHIP

Foster, Angela Maureen (Miss), Liverpool. Dip. 1967.
Hubbard, Kenneth D., Leigh-on-Sea. Dip. 1946.
Kirkpatrick, Maurice Robert, Kenilworth. Dip. 1951.
Nash, Geoffrey Edwin, Walsall. Dip. 1967.

ORDINARY MEMBERSHIP

Baker, Kenneth Robert, Whitehaven.
Chambler, Kenneth, Reigate.
Chang, Yut-Ying Jimmy, Hong Kong
Chapman, Edward, North Ferriby, E. Yorks.
Copping, Dorothea (Mrs.), London
Smith, Craig Cameron, Bulawayo, Rhodesia
Eddy, Donald B., Esher
Elwell, Dennis, Cowplain, Hants.
Fairburn, Michael Jeffrey, Reading
Foster, Joseph, Bloomfield, U.S.A.
Kilpatrick, Constance (Mrs.), Aberdeen
Lewes, Cyril Herbert, London
Mirwald, Gerhard, Tokyo
Moore, I. E. (Mrs.), Solihull
Mosey, Irene (Mrs.), Lancaster
Payne, Henry Arthur Sheldon, Harpenden
Ponahlo, Gertrude (Mrs.), Vienna, Austria
Proctor, Hugh C., Don Mills, Ontario
Pyle, Ralph, London
Robertson, John Mackay, Portsmouth
Roca, Rogelio, Jnr., Barcelona
Russell, Lionel Harold, London
Sorsby, Nicholas John, Kampar, Malaysia
Spangenberg, Harry, Milwaukee, U.S.A.
Tammarine, Arthur, Vista, California
Tuckey, Harry Russell, Dartmouth, Nova Scotia
Wang, Archie, Hong Kong
Yamakawa, Masako (Mrs.), Geneva, Switzerland
Yoshimoto, Aiko (Mrs.), Hyogo Pref., Japan

PROBATIONARY MEMBERSHIP

Alabaster, Anthony Paul, Birmingham
Bartlett, Stewart Michael, Northwich
Cann, Jonathan D., Fontwell
Heykoop, Nicolaas, Rotterdam, Holland
Lee, Richard, Richmond
Saunders, Geoffrey Peter, Barkingside
Shapiro, Eric, London
Rae, Francis Carl, London
Weerasinghe, Gamani Bandula, Ceylon
Whitehead, Paul, Tamworth


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E/C	Blue	1·28 cts.	£ 7 0s. 0d.	per carat.
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Oval	Blue	4·00 cts.	£14 0s. 0d.	per carat.
Round	Blue	4·12 cts.	£14 0s. 0d.	per carat.
Oval	Blue	7·20 cts.	£14 0s. 0d.	per carat.
Oval	Blue	5·01 cts.	£15 0s. 0d.	per carat.
Oval	Brown	9·20 cts.	£22 0s. 0d.	per carat.
Cushion	Blue	9·72 cts.	£20 0s. 0d.	per carat.
Pear shape	Mauve	11·42 cts.	£20 0s. 0d.	per carat.
Cushion	Mauve	12·32 cts.	£22 10s. 0d.	per carat.
Cushion	Mauve	12·97 cts.	£30 0s. 0d.	per carat.
Round	Mauve	13·15 cts.	£30 0s. 0d.	per carat.
Oval	Mauve	17·75 cts.	£30 0s. 0d.	per carat.
Cushion	Mauve	21·36 cts.	£40 0s. 0d.	per carat.
Oval	Blue	23·92 cts.	£30 0s. 0d.	per carat.
Cushion	Mauve	48·62 cts.	Offers Invited.	
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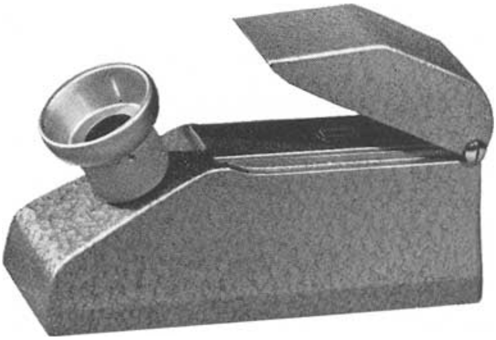


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