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and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

GEMMOLOGICAL ASSOCIATION
OF GREAT BRITAIN
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GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

(Originally founded in 1908 as the Education Committee of the National Association of Goldsmiths; reconstituted in 1931 as the Gemmological Association)

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THE LATE ROBERT M. SHIPLEY AN APPRECIATION

By B. W. ANDERSON

Robert M. Shipley, the undisputed founder of organized gemmology in America, died last April at the great age of 91, and it is only fitting that some account of the life story of this remarkable man should be given in this *Journal.* The details in what follows have been largely culled from an extensive article by Mitchell Gilbert in the *Jewelers' Circular-Keystone* which appeared two years ago.

Shipley was born in south-west Missouri on February 21st, 1887, the son of a railroad man, and had a very varied upbringing—being educated first by the family's negro maid (who was a college graduate) and then (to 'harden him up') at a military academy in Wisconsin, where he showed athletic talent as a long-distance runner and as an oarsman. His subsequent education at college was interrupted early by his father's death, and he returned to the family home (then at Wichita, Kansas) in search of work. By this time Robert Shipley was a strikingly handsome youth, six feet six inches in height and something of a ladies' man. After working as a switchboard operator, type-setter, and at other jobs, he married (in 1912) a local girl, Jeanette Vail, whose wealthy father

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owned a well-established jewellery store. Two years later the store manager left, and Shipley was persuaded, rather reluctantly, to join the business, which entailed an extensive silver-cleaning routine which he detested. When, after some years, he inherited full responsibility for the store his main interest was in extending it to incorporate new departments for fine china, giftware, and even an art gallery. By the early twenties he had gained a sufficient local reputation to be elected as President of the Kansas Retail Jewelers' Association, and subsequently became a member of a National Retail Jewelers' Research Group, through which he struck up friendships with nationally important jewellers—friendships which some years hence were to be his salvation when struggling to 'sell' gemmology. He also became involved in one or two really big deals in supplying stones to wealthy customers, which in two cases at least made him humiliatingly aware of his ignorance in judging the quality of emeralds and diamonds.

There then followed a black period in Shipley's life, involving nervous prostration and a sense of failure both in his marriage and his business, which he sold, passing the assets to his wife. After a period in a 'health farm' he made some money by writing movie scenarios for Hollywood. This enabled him to travel to Paris, where he learned all he could about ceramics and the arts generally by visiting museums and factories and taking courses at the Louvre. Then two things happened which vitally affected his future: he met Beatrice Bell, who eventually became his second wife—'the luckiest thing that ever happened to me in my life' as he often said in later years, and he decided to enrol in the correspondence course in gemmology then being offered by the N.A.G. in London. His money was running out, but Beatrice was able to introduce him to museum jobs as lecturer on porcelain, and in this way he discovered that he had an ability and liking for teaching.

With more money saved, Robert Shipley next went to London to take the necessary practical classes leading to his sitting and passing the Diploma* examination. This was in May 1929, and in the following December Shipley returned to the States, armed with what was only the second refractometer to reach America, intent on earning his living and on regaining touch with his beloved Bea.

*When the Gemmological Association was formally inaugurated in 1931, holders of diplomas awarded by the N.A.G. became automatically eligible for fellowship.—Ed.

In terms of job-seeking his timing could hardly have been more unlucky, as at that very time when he was on the boat home the first frightening stages of the great Wall Street crash were shaking the foundations of the business world. Shipley sought out Beatrice Bell in California and for a while they lived together on the proceeds of a small art gallery. The first tiny indicator of the shape of things to come was the result of an invitation by an old jeweller friend, Armand Jessup, to give a series of lectures on gemmology to members of the California Jewelers Association under the aegis of the University of Southern California. This he did, as many as eighty turning up for his first lecture. But some of those attending had to motor hundreds of miles to get to and from the lectures, and by one jeweller on the Mexican border he was pressed to type out his lectures and send them by mail.

Here was the germ of an important idea: to sell his typed courses to 'ethically minded' jewellers throughout the States, leading to a form of degree gained by examination, and through this to membership of an enlightened and informed Guild of jewellers. The educational side of this enormous one-man ambition Shipley styled the 'Gemological Institute of America', having as 'laboratory' Bea's kitchen, while the Guild-type group of educated jewellers was termed, when the time came, the 'American Gem Society'. Very broadly speaking, the American Gem Society corresponds to the N.A.G. in Great Britain, while the G.I.A. corresponds to our Gemmological Association. But whereas the N.A.G. is greatly senior to the G.A., in the case of Shipley's brain-children it was the educational side of his ambitious project that had a three years' start.

What is difficult to realize is the enormous effort that this one man put into selling his ideas, at the age of forty plus, with practically no capital, and at that early stage without even the moral support of his wife Beatrice, who thought his chances of success were nil. Shipley pawned his last piece of jewellery, bought an old A model Ford for 52 dollars, rented a typewriter, and 'set out across the country to sell a course that was still being written'. As can be imagined, he met with a great deal of opposition from old-fashioned jewellers who did very well despite frequent mistakes and misrepresentations and resented the idea of their junior employees knowing more about precious stones than they did. But here the mysterious 'spirit of the age' was fighting on Shipley's side—an awareness of the *necessity* for gemmological knowledge in the jewellery trades of the world, threatened by the advent and rapid spread of cultured pearls and the Verneuil synthetics. London's Laboratory had been inaugurated in 1925 and was now going strong: by 1931 similar laboratories were being established in Paris and in Idar; the *Gemmologist,* first of the specialized journals, made its appearance in 1931, and our own Gemmological Association was established. In addition to the knowledge gained from his N.A.G. course, Shipley was avidly seeking information by means of long questionnaires sent to prominent gemmologists in London and in Germany.

By the time the first course was completed, Robert Shipley Jr, already an inventive young scientist, joined his father and was able to give valuable help in the design and production of instruments specifically designed for the needs of the gemmologist, who had previously been expected to 'make do' with microscopes etc. intended for the pure mineralogist. The Shipley instruments made possible 'table-top' laboratories with which the qualified jewellers could impress their clients. The binocular microscope employing dark field illumination was one of the Shipley ideas that undoubtedly aided the study of diamond imperfections and the tell-tale signs of synthesis in the coloured corundums. Shipley Junior also helped his father write the advanced courses on coloured stones which superseded the first completed series.

During all those early formative years of the G.I.A. and the A.G.S. the administration of the organizations was in the capable hands of Shipley's wife Beatrice, assisted by Dorothy Jasper Smith, who gave dedicated service for over thirty years. Invaluable help was also forthcoming from friends amongst the big jewellers who appreciated the ideals behind the Shipley drive to educate the trade in terms of gemmology. The organization also gained some much needed academic muscle from one or two trained mineralogists who had become attracted to the scientific study of gem materials. In some cases these 'outside' attachments were short-lived—an episode, merely, in a career devoted mainly to mineralogy in its wider sense. In others, the attachment was more lasting, as in the case of Dr Edward Wigglesworth, Curator of Gems and Minerals at Boston Museum, whom Shipley persuaded to become President of the G.I.A. shortly before the war, while he himself assumed the title of Executive Director.

In 1938 the Institute moved to an apartment building in Los Angeles which was capable of expansion if needed. The coming of the war interrupted Shipley's forward-looking plans and caused him some anxiety as to the future of his Institute. Robert Junior, who was an officer in the Air Force Reserve, was called up in 1941, and Richard T. Liddicoat Jr (now President of the G.I.A.) was appointed Director of Education. This important assignment was on the advice of Dean Edward H. Kraus and Professor Chester B. Slawson of the University of Michigan, who were well known as authors of the standard textbook *Gems and Gem Materials.* Other valuable long-term appointments about that time included Robert Shipley's nephew, Alfred L. Woodill, who later became Executive Director of the A.G.S., and Virginia Hinton, on the educational side.

After the war there came an unexpectedly vast increase in student enrolment as the result of the G.I. Bill, and from then on the prosperity of both the G.I.A. and the A.G.S. was assured. George Switzer and Mark Bandy each served for a while on the G.I.A. staff and greatly enhanced its reputation on the scientific side, while of more permanent importance were Lester Benson and Robert Crowningshield—the former influential in instrument design, and the latter to become probably the world's finest and most experienced laboratory gemmologist as Director of the New York Gem Trade Laboratory.

In 1952, at the age of 65, and after 21 years of hard and continued work in directing the G.I.A., Robert M. Shipley retired, and he and his much-loved wife were able to enjoy well-earned leisure in their lovely home in South Laguna Beach, California, till Bea's death in 1973. Robert himself lived on, in full possession of his faculties, and on the eve of his 90th birthday he was able to visit the impressive new headquarters of the G.I.A. in Santa Monica and delight the assembled staff and students with racy accounts of his early struggles.

If, in the above appreciation of his work for gemmology and honourable dealing in the jewellery trade, the emphasis has been placed more on the formative years of struggle than on the later prosperity of the two organizations which Shipley founded, it is because it is the enormous tenacity and capacity for unrelenting hard work in pursuit of his ideals which chiefly excite our admiration in remembering this remarkable man.

THE TOURMALINES OF THE PALA VALLEY, SAN DIEGO COUNTY, CALIFORNIA, U.S.A.

By M. J. O'DONOGHUE, M.A., F.G.S., F.G.A.

In December 1975 I was able to visit this area through the courtesy of the Worshipful Company of Goldsmiths of London, who had provided funds for me to travel over the United States surveying methods of crystal growth and the production of new man-made crystalline materials with possible gemmological application. At the American Museum of Natural History in New York City I met (quite unexpectedly) Mr Bill Larson, of Pala Properties International, one of the owners of several mines in the Pala District. He very kindly invited me to see something of the working of the mines when I arrived at San Diego and when I arrived there a few days later I was able, with John Sinkankas, to spend a whole day inspecting two of the more important Pala mines and a good deal of their typical production of tourmaline.

Pala is in north-west San Diego County, about 45 miles north of San Diego and 80 miles south-east of Los Angeles. It forms part of the Peninsular Range province, mountain masses extending from the Los Angeles area to Baja California in northern Mexico; many pegmatites are found in this range, which has a characteristic igneous rock basis. Pala itself is a mission village on the San Luis Rey river and is surrounded by hills rising to 1500 feet; close by are even higher hills including Queen Mountain, Hiriart Mountain and Chief Mountain, all over 1500 feet. Pegmatites in the Pala district occupy an area of about 13 square miles; on Queen Mountain they are well known as a source of lithium, tourmaline and quartz. On Chief Mountain the Pala Chief mine is one of the world's largest producers of gem quality spodumene, together with beryl and some tourmaline. There are also pegmatite dikes on Hiriart Mountain, where they can be seen as projections on the slopes; gem quality spodumene and beryl with some quartz and green tourmaline occur here.

Generally speaking the pegmatites are confined to areas underlain by gabbroic rocks; they are quite well exposed, even though much of the area is covered by a dense brush. Since they resist

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erosion better than much of the country rock, they can be recognized as knobs and ribs on hillsides and this leads to their relatively easy discovery in what is rather a harsh area.

Graphic granite is the commonest rock type in the pegmatites of the Pala area. This consists of large crystals of microcline in which rodlike grains of quartz lie parallel to one another; it is easily recognized since the material is fairly resistant to erosion. Some very coarse-grained pegmatites with little graphic granite content are also found and include some of those which give commercially viable minerals. They are largely of quartz or perthite or both and many contain spodumene. Local usage gives the name 'pocket zone' or 'gem seam' to a gem-bearing portion of a pegmatite dike. This type of pegmatite occurs most commonly in the central parts of the dikes and contains for the most part fine- to coarse-grained minerals, including quartz, albite, tourmaline, lepidolite, orthoclase and microcline. Many pockets are filled with a muddy clay which is typical of this area; quartz crystals, often quite well-formed, are frequent in this type of pegmatite. Gem quality crystals of tourmaline, beryl and spodumene are often attached to quartz minerals, although the finest quality material is free within the muddy clay.

Although the principal minerals of the pegmatites of this region are quartz and potassium feldspars, tourmaline is present in quite a number of the dikes—the occurrence growing less frequent as one proceeds eastwards. In the easternmost areas the colour is largely green or yellow-green. Most colours of tourmaline are found in the area, black (schorl) being by far the commonest. This appears blue to deep violet under the microscope although in hand specimen it appears black. This type of tourmaline occurs most frequently in the upper part of the pegmatite and the crystals grow more numerous as the horizon of the pocket zone is neared. If a very concentrated area of schorl crystals is observed, it may be a sign of the presence of a pocket immediately below (which may also contain schorl crystals). Colour varieties include rubellite (often of a raspberry or 'shocking pink' colour), blue (indicolite), green and colourless. It is common for two or more colours to be present in a single crystal, although the arrangement of the colours may be random or regular.

Some crystals show a deep blue to black core with a rim of green, red, blue or pink; others with a similarly coloured core may show a number of variously coloured rims. Those with a core coloured pink and with rims successively colourless and green are well known by the name of 'water-melon' tourmaline, and this name has been extended to cover similarly coloured material from other tourmaline-producing areas of the world. Some very fine pink crystals have a very thin black or dark blue rim. Quite another group of crystals show colours in varying layers perpendicular to their long axes; some may show up to five colours in the length of the crystal but the majority are pink at one end and green at the other; some pass from black to colourless. In the case of many schorl crystals the end of the crystal nearest the pegmatite wall is black but the other end (that nearest the inner portion of the pocket) may be pink or green.

The crystals are prismatic and may occur as isolated individuals or as columnar groups or as parallel groups. They are most commonly clear and lustrous, though many contain very minute inclusions which lend a milkiness to their overall appearance. Some large fractures are healed with quartz and some crystals are altered with a decrease in transparency, loss of toughness and colour. This alteration is most noticeable in crystals from the Stewart mine. From this mine comes the lepidolite-tourmaline rock in which pink tourmaline crystals form rosettes in fine-grained lepidolite. Green tourmaline usually occurs with quartz and cleavelandite and may occur as inclusions in books of muscovite. Blue and colourless tourmalines occur in pocket-bearing parts of the pegmatites and are associated with concentrations of lepidolite.

Economically the tourmaline mines of this area have had a chequered career. Although in the early part of the century much red tourmaline was sent to China (where it is especially prized), this trade collapsed with the fall of the dynasty in 1912; the presence of the material is said to have been known as far back as 1876. In 1968 Ed Swoboda, a Los Angeles jeweller, re-opened the mines on Tourmaline Queen Mountain and formed at the same time the company Pala Properties International. This company acquired both the Stewart and the Tourmaline Queen mines and the road leading up to them was repaired. This is a very steep and difficult road, the worst part (as I can witness) being the section leading down from the Queen to the Stewart mine. In December 1968 work began to press forward to reach a section of the pegmatite in the Stewart mine ignored by the original miners, who were seeking lepidolite as a source of lithium, rather than gem tourmalines. By October 1969 pockets of gem quality tourmaline had been found, all filled with the ubiquitous pinkish clay. Most of the crystals were broken along basal planes and about 95% were pink. This pink is not quite so purple as in crystals from the Tourmaline Queen mine; with the dichroscope the colours observed are yellowish-pink and fine deep pink. Sinkankas (1976)[1] states on information received from the company that 295 kg of tourmaline were mined of which 2.25 kg were of faceting grade. In 1973, in a new work area, some green crystals were found in the Stewart mine and some of these have zones of other colours. A good account of work in this mine is that by Szenics (1970).[2] Although Sinkankas (1976) states that work had halted at that point to await completion of work at the Tourmaline Queen mine, this has now occurred and the Stewart mine is being further explored.

Pala Properties began to re-open the Queen mine in 1971, when the crystals found in the pockets were seen to be in better condition than their counterparts in the Stewart mine. Many matrix specimens were discovered and some of these have been the finest ever found in the United States. Sides of the crystals are usually striated and terminated by (0001). A purple tinge to the pink distinguishes them from Stewart crystals. As with the Stewart mine, 95% of the crystals are pink; up to the end of 1974, 363 kg of tourmaline recovered included 4.5 kg of facet-grade material and 213 kg of matrix specimens. Morganite crystals attached to tourmaline were a feature of this deposit. The work of Jahns and Wright (1951),[3] on which some of this account is based, suggested further areas for prospecting.

On the occasion of my visit in 1975 little was taking place at the Stewart mine, but at the Tourmaline Queen mine the manager, John McLean, with the assistance of two Mexican miners, was working on a suspected pocket at the time John Sinkankas and I arrived with Bill Larson. We examined the area inside the mine where the edge of a quartz core met the lower half of the pegmatite, as this type of formation is where pockets occur. As we were inside the mine nothing much happened, and we went outside to have some beer and sit in the bright sun. We had not been there long before an excited cry from inside the mine sent us scurrying back to find that a pocket had been located and opened. Bill Larson took charge at once, John Sinkankas gave advice and I held the lamp.

The pocket was filled with the expected clay, but the cause of the excitement was the end of a large crystal protruding from one of the pocket walls—it was clear that the crystal was a large one or part of a large one, and it was necessary for Bill Larson to use a screwdriver to prise it loose from the pocket. This took about 20 minutes, but on recovery it was found to be of very fine quality, partly dark blue, partly pink and some green. This was a specially fortunate day, since there had been no crystals found of this quality for the previous few months. I am unable to say what happened to it eventually, but it would certainly have been of facet grade. Interestingly and typically it was found to have fractured at some time in its history, but the other sections were not found at the time of my visit, although they may subsequently have been discovered. Later on at the Fallbrook shop 'The Collector', one of the retail outlets of Pala Properties International, I was able to see a large number of specimens from the Pala area, some cut (of which I have an example).

The future of Pala tourmaline seems to be quite bright, as work is proceeding at the Stewart mine; it may be possible to open the Pala Chief mine which was at one time famous for its crystals of kunzite; at the time of the original working some large coloured tourmaline crystals were found there. From time to time the Indians of the Pala reservation make representations (by shotgun) concerning their possible ownership of the mining area but this, together with the occasional raid on the workings (before there was a regular armed guard) does not appear to be too serious. The demand for first-class faceting material has never been greater, and if supplies can be maintained things look good in Pala.

Much useful material has been written about the area; the best geological account is that by Jahns and Wright in Special Report 7A of the Department of Natural Resources of the State of California.[3] This is issued with maps, and tourmalines are shown in colour. Accounts of early mines and miners can be found in Rynerson *Exploring and Mining for Gems and Gold in the West*.[4] Sinkankas's *Gemstones of North America*,[1] volume 2, contains personal communications from Pala Properties International to the author and is invaluable on this and other points.

For those wishing to obtain materials from the area the address of Pala Properties International is: 912, South Live Oak Park Road, Fallbrook, California 92028, U.S.A. (Telephone 714-728-9121.)

REFERENCES

(1) Sinkankas, John. *Gemstones of North America.* New York, 1976.
(2) Szenics, T. The special magic of pink tourmaline. *Lapidary J.*, **24**, 1042-5, 1048-50, 1970.
(3) Jahns, R. H. and Wright, L. A. *Gem and lithium bearing pegmatites of the Pala District, San Diego County, California.* California Division of Mines, Special Report 7-A, 1951.
(4) Rynerson, F. *Exploring and mining for gems and gold in the West.* Healdsburg, California, 1967.

[*Manuscript received 15th October, 1977.*]

IMITATION OPAL—SLOCUM STONE

By A. E. FARN, F.G.A.

The Gem Testing Laboratory, London Chamber of Commerce and Industry

How one regards innovation seems always a question of age. Since change is ever with us, it is necessary to accept that what is a stable concept now may be almost a forgotten myth tomorrow. After the first commercially successful synthetic emeralds appeared upon the market not long after the war we felt (in the Lab) fairly happy that we could easily detect those new and somewhat wonderful stones. In retrospect, life then was pleasant. Quite frankly we thought that at least star-stones were beyond the bounds of feasibility. Since then, of course, we have had not merely the hydrothermal and flux-fusion products, syntheses of corundums and beryls, but synthetic opal as well.

The products of Verneuil, Chatham and Gilson—ruby, sapphire, emerald, alexandrite, opal—are what I call true synthetics. They are artefacts but nevertheless are a synthesis of something which occurs in nature. Such products as strontium titanate, YIG, YAG, GG, and GGG—to name a few spin-off products of space research—do not seem to me to warrant the use

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of the adjective synthetic. They are just simply artefacts—man-made stones. However, I am not now proceeding to exercise that particular hobby-horse of mine but rather to arrive at what is clearly a satisfactory conclusion—that in the Slocum stone we have an *imitation,* not a synthetic—an imitation opal in fact.

Apart from the fantastic achievement of producing a harder-than-opal, workable substance of considerable attraction, John Slocum began by producing a true synthetic opal of outstanding beauty!

I am late in coming round to describing Slocum stone—it was well written up in the *Lapidary Journal* of September, 1976.* John Slocum decided to have a go at producing synthetic opal, since this remained a barrier which had not yet been surmounted and seemed to offer him a challenge. It took him many years of patient work and a small gravel-pit filled with his rejects and waste material before he achieved a beautiful synthetic opal. Unfortunately it inherited the faults of true (natural) opal—cracks, porosity, etc. Having achieved his goal, he was dissatisfied.

So he then decided to produce a gem of opal quality which was more durable, and he has succeeded. He has produced a very pretty and attractive material which has a play of colour closely resembling opal (see Figure 1). Looked at with the unaided eye (as most jewellery is when worn) it looks like opal of very attractive quality, whether it be black opal, water opal or white harlequin opal. The range of colours is wide. I have had a few to look at, and while I think I can claim to be a reasonably critical person and not unused to handling a 10× lens, I do not want to go on record as someone damning a very fine achievement and (as I should imagine from reading recent brochures) a commercially successful venture. Opals, of course, have all the faults: nature seldom bestows favours plenteously (this results in rarity). One thing which always strikes me about synthetics, artefacts and imitations, is their endless reproduction. I still take off my gemmological hat to John Slocum for his achievement in first perfecting a true synthetic opal and *then* proceeding to seek perfection in an imitation opal.

I must say that to me, using a 10× lens, they present no problem—perhaps none was intended. Their structures are very interesting (Figures 2, 3 and 4). I measured the densities of some of

*Schowalter (M.). *Slocum stone—a new man-made material.* Lapidary J., 1976, 30, 1370-4.—Ed.

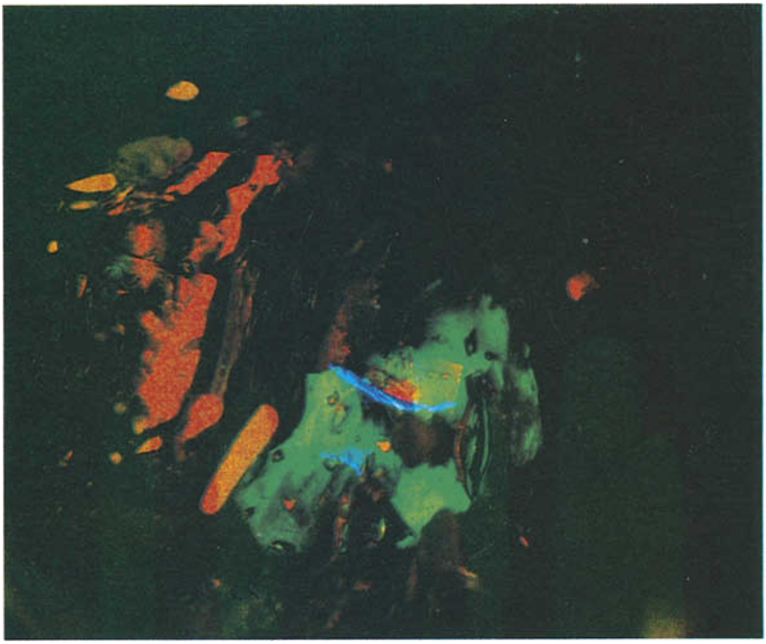

Fig. 1. Slocum stone.

the specimens. First I took a bulk SG of six stones which gave me a density of 2.49 and then I took the three largest and most strongly coloured and also the smallest which was water opal in colour. These stones, being a fair cross-section of depth of colour and size, also varied slightly in their respective RIs, as set out below:

Weight in grams	SG	RI
33	2.505	1.53
13	2.500	1.52/3
12	2.500	1.52/3
5.70	2.450	1.51

The refractive indices, taken by the distant vision method, were fairly sharp, due to a good polished surface. Under both long and short wave ultraviolet light the stones varied with no apparent clue or pattern between long or short or parallels between stones under each wavelength. With a 10× lens looking through and at the stones one could easily see bubbles and at times signs of layered

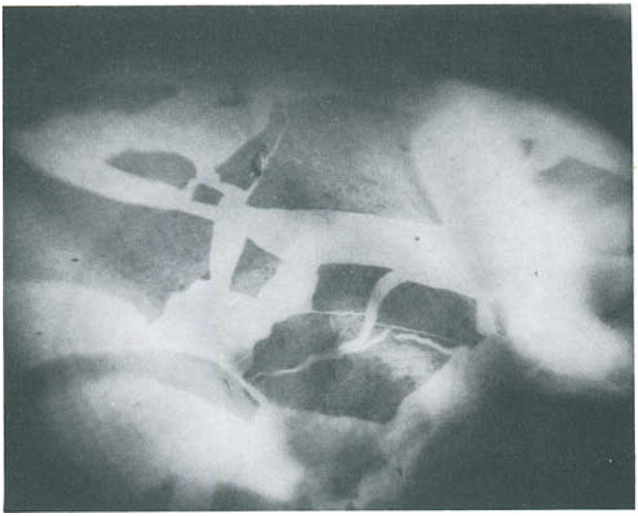

Fig. 2. Structures in Slocum stone.

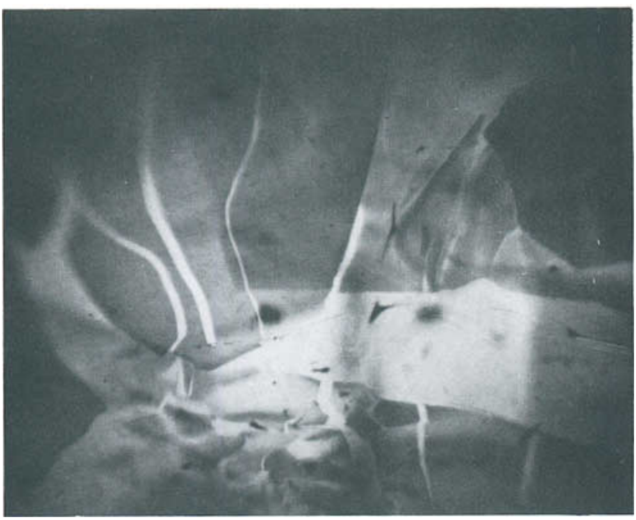

Fig. 3. Structures in Slocum stone.

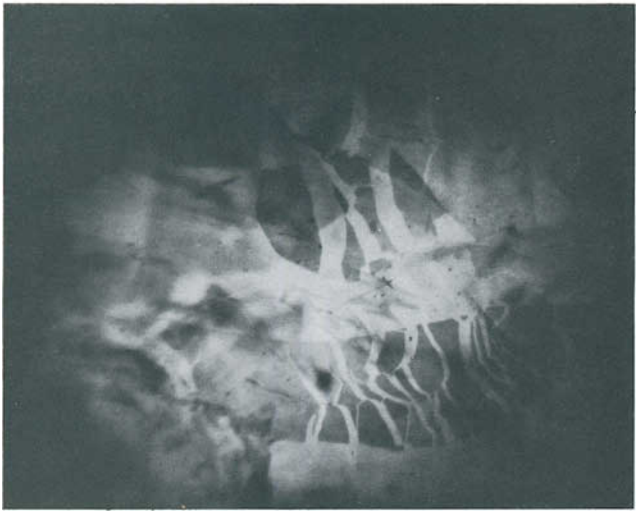

Fig. 4. Structures in Slocum stone.

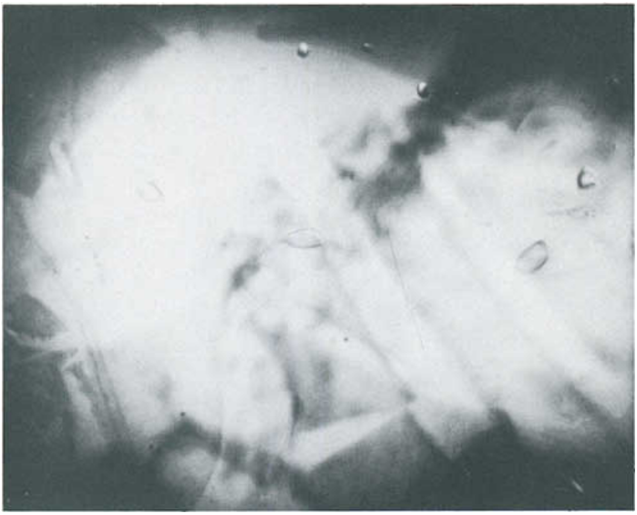

Fig. 5. Structures and bubbles in Slocum stone.

Fig. 6. Structures and bubbles in Slocum stone.

structure (Figures 5 and 6). The black opal types looked more realistic on their unpolished backs.

Slocum stone is obviously very successful. A small brochure recently published describes it as 'opal-essence: a step beyond opal'. The advantages of Slocum stone imitation opal are that it is tougher than real opal, is not porous and has no included water content to shrink or expand. It is said to be easy to cut, polish and slice. By all standards it is an intriguing, attractive, successful accomplishment.

The beautiful colour photograph was taken by B. W. Anderson and the photographs of internal structures (which are difficult to depict in black and white) were taken by K. V. Scarratt, to both of whom, and also to Harry Wheeler for the loan of the specimens, my thanks are due.

[*Manuscript received 18th February, 1978.*]

VISUAL OPTICS

By ALAN HODGKINSON, F.G.A.

This is a technique for visually observing the optical phenomena of faceted gems, set or unset. By mentally noting and combining the various phenomena which form on the retina and assessing their relative measurement, one has a method of eliminating many gem possibilities, if not always of identifying the gem in question. The technique should be seen as a supplement to instrumental gemmology, of more benefit to the gemmologist at the counter than the one in a gem laboratory.

The best introduction to Visual Optics is in a dark room with a sole light source. With practice, one can cope well in any situation, provided there is a unique light source to provide the virtual images seen. A clear bulb with 'C' shaped filament is a most useful starting point, but the normal line filament will suffice and most torch bulbs reproduce this effect and offer a practical portable light, in pocket form.

Figure 1 shows my assistant, Mrs L. Ferguson, F.G.A., demonstrating the technique, which involves closing the non-seeing eye, and virtually closing the seeing eye (the more closed the better) and placing the table facet of the gem to be observed so that it touches the eyelashes, the view being directed toward the bulb source which may be 10 or 20 feet away or more.

Proof that the eye is suitably controlled is gained by the appearance of a number of spectral reproductions of the filament image. It is advisable to start with a lower refractive gem, as the virtual images are easier to locate; the number of images being relative to the number of main pavilion facets.

The spectral images, their relative position and their optical nature, provide us with an approximate measure of all the optical phenomena. With practice this becomes a useful and competent method of gem identification, when instruments are not immediately accessible, although in no way does it pretend to compete with the instrumental approach.

Figure 2. Refraction and Double Refraction. The top diagram is a simple illustration of the various light paths taken by a light ray, as it slows through gems with varying degrees of refraction.

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Fig. 1. Mrs. L. Ferguson, F.G.A., demonstrating the technique.

Fig. 2. Refraction diagram.

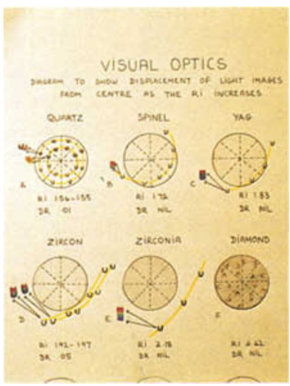

Fig. 3. Refractive phenomena—from through-the-eye position.

Fig. 4. Dichroism.

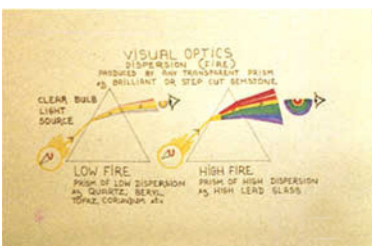

Fig. 5. Dispersion diagram.

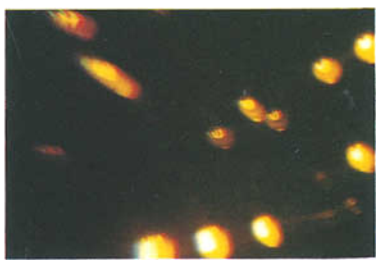

Fig. 6. Golden quartz.

The lower diagram illustrates how the eye sees these refractive variations using the 'visual optics' technique, though no attempt has been made to show the light mechanics within the eye itself. The lower the RI of the gem, the closer the image pattern occurs in relation to the culet position. The higher the refractive medium, the nearer the image occurs to the girdle and beyond, which is better shown by Figure 3.

Figure 3 shows the same refractive phenomena, but from a through-the-eye position. Low refractive gems such as quartz, bring the inner ring of light images well into the centre. Please note—the images will appear closer to the central area, the shallower the stone is cut, whilst deeper cut gems will have the opposite effect. The relative cut and proportion of each gem should be observed before employing the technique, in order to make due allowance for its virtual image positions, each of which is the product of an individual main back facet. As the different gemstones rise in their refractive power, the innermost images are located further and further from the centre.

Double refraction, being present in the quartz specimen, shows itself by the virtual images becoming doubled. The extent of the doubling will depend on the angle of viewing, whilst those corresponding with the optic axial directions, will appear only single, making it necessary to rotate the ring, bracelet, or other, in order to perceive the doubled images, and to give the gem a chance to show its maximum birefringence.

It is not possible to observe the image phenomena in a cabochon stone, and poorly polished facets also lead to difficulty because of blurring of the images—a common complaint against quartz and ruby today.

In gems of low birefringence, the slight separation of the 'C' shaped filament images may occur in any direction, though consistent in the one gem, and a series of 'M's, 'W's, '3's may be seen or, more difficult to detect, the 'C's wrapped round each other, when a 'C' filament is used.

With blurring or small separation of the images, it is useful to introduce a polarizing device between the stone and the light source, rotating the filter through 45°, which will enable the double nature of the images to be established distinctly. Occasionally one encounters rogue images superimposed on other images by reflection. There will be no regular pattern of such twinnings, and it is

Fig. 7. Glass.

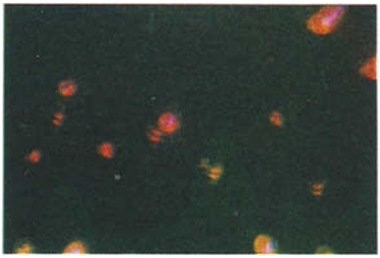

Fig. 8. Ruby.

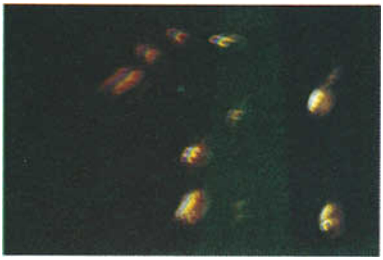

Fig. 9. Tourmaline.

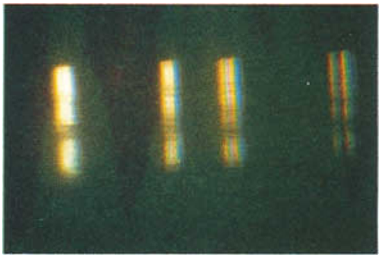

Fig. 10. Tourmaline.

Fig. 11. Peridot.

Fig. 12. Zircon.

Fig. 13. Cubic Zirconia.

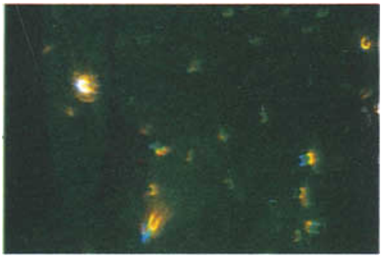

Fig. 14. Diamond.

therefore always a useful proof to find two or three consistent pairings to establish double refraction.

With low refractive gems, it is normal to see two or more patterns of lights, the images from the outer facets having a strengthening effect on the property of double refraction and dispersion, the light having travelled a further distance. In consequence, the twin images move further apart from each other. A good example is shown in the peridot (Figure 11).

In assessing a gem's refraction, double refraction and dispersion, one uses the primary images which are nearest the centre of the stone. Gems with higher RIs push the image pattern further from the centre, and by 1.73 (spinel) or 1.83 (YAG), the pattern is pushed so far from direct view, that only part of the perimeter of the inner image pattern is seen. To see the total perimeter, the stone must be rotated.

By a refractive index of 1.9 or more, e.g., zircon, then, provided the back facets are cut acceptably deep to make the stone lively in appearance, it will be found difficult to locate an image or two from the inner perimeter. The image can be found, either by slightly tilting the stone back or forth toward the light source, or by slightly raising or lowering the eye.

Another graduated effect is that the higher the refraction of the gem, the darker the stone interior becomes, until with high RIs, such as those for zircon and zirconia, etc., there is a blackout effect, which gives added accent to the spectral images when located.

Figure 4. Dichroism. Once the virtual images have been located (a task more difficult, the smaller the stone and the higher the RI), a polarizing device may be inserted between the stone and the light source, which will, if birefringent images are observed, produce dichroism in the stone, if this is one of the gem's optical products. Simply rotate the polarizer through 45° and on to 90°. In strongly dichroic stones the individual virtual images of each twin will often show this without recourse to a polarizer. The dichroism is sometimes helpful with the smallest of stones—in an eternity ring, for example—for the pleochroic effect establishes anisotropism where it may be difficult to locate any separation of the images which would establish doubling.

Figure 5. Dispersion. The diagram shows the contrasting images of the 'C' filament, when observed through transparent

quartz family members, aquamarine, topaz, etc., with their feeble dispersive images. In contrast, the normal glass gems, with their high lead content, produce striking spectra with each colour spread relatively wide. Being low in refraction, all the varieties mentioned will show the images formed up in the plan pattern of the gem, viz., a circle of images in a round cut gem.

If there is an outer pattern (or patterns) of the light images, due to the extra row (or rows) of main pavilion facets, the longer distance travelled by the light through the gem from those facets nearer the girdle causes the dispersive effect to increase, so that in a larger round amethyst, for example, the outer ring of images will achieve a spectral effect far greater than the dispersive product of quartz. It is necessary, therfore, to use the innermost row of images as an indicator of the power of dispersion. The same exaggerated effect is observed in the double refraction *(v. sup.).*

The following photographs (Figures 6 to 14) were taken by removing the lens unit from an Olympus O.M.1., S.L.R., camera and substituting the gemstones one by one, blacking out all the extraneous light by embedding the stone in a flat circle of 'Blu-Tack', which was then plastered across the lens orifice. The images could be observed through the eyepiece and photographed when best displaying the inherent properties. The only optical factor which cannot be measured on the photograph, is the refractive power, because of the angling of the gem involved in producing the best effect for the camera. In actual practice, one gauges the refraction by establishing a straight line from eye to light source, with the table facet at right angles to this line. Point one's unused arm down, or up, to the first row of images (or the first image found in a highly refractive gem); the angle between one's pointing arm and the line of eye to light is the measure of refraction, remembering to allow for the cut being shallow or deep.

Figure 6 shows various virtual images seen in a golden quartz. Some of these primary images have overexposed, although the doubling is just evident in one corner.

In the centre are two doubled image pairs, faithfully reproducing the 'C' filament. These are what I call secondary images, which come from the smaller girdle facets and then reflect off the main pavilion facet, hence the loss of light intensity and correct exposure on the film.

Figure 7. In contrast to Figure 6, this 16mm glass produces

exaggerated spectral images, enabling the spectrum to be analysed for all its colour components. The images form close into the central area, indicating low refraction, and this combination of factors indicates a glass identity.

Figure 8. Ruby. Again, the secondary images come to the rescue by displaying birefringence. Note how there is no green in the spectral image—the green, of course, being absorbed, as witness the absorption spectrum. The blue and violet have also not appeared, as the exposure time was not long enough for them to register, though in practice these short wave colours are seen.

Figure 9. Tourmaline. This hemimorphic mineral makes an interesting subject for 'visual optic' study. The birefringence is usually found instantly, and, if not so, try looking through the back of the setting; while in smaller tourmalines, an across-the-girdle direction may be productive. The dichroism also readily shows itself, but particularly in the green to brown tourmaline's colour range. One of the images will be distinctly more intense than the other, due to the strong differential absorption involved, the faint image being the projection of the ordinary ray, and a unique feature of tourmaline.

The tourmaline in the photograph displays the phenomenon of four images in the centre—two strongly absorbed and two slightly absorbed, making up an image quartet. The effect was observed in several greenish brown stones, and would seem to illustrate the phenomenon written up by Keith Mitchell, F.G.A., in his report on a tourmaline's four shadow readings on the refractometer, which appeared in this *Journal.* *

Figure 10. Tourmaline. Sometimes the facet edges on larger step-cut stones light up, and are observed as doubled facet lines. This photograph shows the central facet line has allowed more light through, with consequent overexposed blurring. The succeeding three facet lines move further away from the centre and one observes that both the birefringence and dispersion increase at each facet stage, a factor described earlier.

Figure 11. Peridot is a useful stone to begin with, as its low refraction allows easy capture of the image field, the general image pattern showing the facet formation of the stone. Birefringence is at once visible, and the outer twinned images give an instant pointer to higher double refraction, approximately twice that of

*J. Gemm., 1967, **X**, 6, 194, and 1976, **XV**, 1, 17.—Ed.

tourmaline, whilst the 0.020 dispersion is unable to raise any sign of spectral behaviour other than in the outermost images.

Figure 12. Although at first it is difficult to locate the images in a well proportioned zircon due to the high refraction, once located, the powerful spectral twin images, emphatically separated, give the whole guide to a zircon's identity—high refraction, high double refraction and high dispersion.

The technique instantly distinguishes blue zircon from aquamarine, blue topaz and synthetic spinel of that colour. In brown stones, tourmaline and sinhalite are readily distinguished from zircon, whilst in white gems, even in small stone-set eternity rings, one can pick up the unique nature of zircon from the other diamond simulants, merely by looking up at the strip lights in a normal shop, though it is stressed the single clear bulb filament in a room is much safer to work with.

Lastly, white zircon and lithium niobate, with their strong optical properties can be separated by no more than lifting the stone to the eye, that is, provided one has practised 'visual optics', and, equally, is aware of the relative constants of the two stones.

Figure 13. Cubic Zirconia. Suffice it to say that in the 'Two-day Practical Gem Identification Course' which I ran in May 1978 for *Retail Jeweller* magazine, the whole group were able to distinguish between diamond and cubic zirconia. What gives the test more credibility, is that the two stones were emerald-cut, of the same size, and were handed to the group in a dark room.

With both stones, the first reaction is of blackness, but as the zirconia is tilted, or the eyes are lifted, the extravagant primary spectra are located, each colour spreading out into a long continuous spectrum. Many tiny secondary images are seen, but these are blurred compared with diamond.

Figure 14. Diamond. In the normal range of proportions of cut for diamond, the high refraction excludes the light from the eye by its total internal reflection, the result being a blackout effect, indicative of the high optical power. One does, however, see a swarm of tiny secondary images, proof of their secondary origin being their haphazard display—the 'C's pointing in all directions, unlike the formal pattern of primary images which are directly related to the symmetry of the main back facets and are the sole criteria for an estimate of refraction. The sharp focus of the secondaries is unique to diamond.

With the more shallow cut diamonds, one is able to angle the stone sufficiently to draw in one or two primary images, but their spectral display can in no way compare with that of zirconia.

Dispersion being a cone effect, the larger stone will always produce a larger spectral image and one must make due allowance for size.

'Visual Optics' has been a feature of the 'Two-day Practical Gem Identification Courses' for the last eight years, but only now have I attempted to put the concept on paper. It was, therefore, sobering to be sent a copy of *Gems and Gemology,* dated 1951, in which Robert Crowningshield* covered the ground from a different angle—literally. His article concluded—'It is hoped that the information given will prompt others to investigate this method of observing gemstones, and that perhaps other uses for the method will be reported.' I trust this is in accord with those hopes.

Gemmology is now developing a certain awesome aspect, as it reaches the level of computer identification. Much identification, however, must still be attempted at shop-counter level, falling back to the instrument section when necessary. Perhaps Visual Optics will give some help in these initial areas of investigation and may help save some time and effort by its immediacy of approach, apart from astonishing some of your gemmological colleagues.

Practice makes for improved technique in all things, but time, of course, is a commodity we all have trouble in affording, so, with tongue in cheek, may I suggest you place the light source on top of the television set, and, with one eye on the programme, the other eye can learn to decipher the identity of a gem via the visual assessment of its various optical properties, which, in combination, make each gem a unique optical phenomenom.

[*Manuscript received 26th August, 1978.*]

*Gems Gemol., 1951, VII, 4, 120-4.—Ed.

EAST AFRICAN TOURMALINES AND THEIR NOMENCLATURE

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In the past years, increasingly larger quantities of green tourmalines have come on the gem market from various localities in East Africa which meanwhile have reached a certain importance. The intensely green-coloured tourmalines are generally called chromium tourmalines. Green-coloured tourmalines from East Africa have been described as vanadium tourmalines from the Gerevi Hills, Tanzania, by Bassett (1953), McKie (1955) and Webster (1961). Chromium tourmalines of unknown locality in East Africa have been mentioned by Bank and Berdesinski (1967), and vanadium (chromium) tourmalines from the Umba Valley, Tanzania, by Zwaan (1974).

Though the lots which generally come on the market often contain stones from different mines, we have been able to separate stones from six localities by crystallographic, analytic and spectroscopic investigations. These samples are dravites and uvites of five different localities in Kenya and Tanzania, coloured by vanadium. Only one locality has furnished samples which show a higher chromium than vanadium content, but they are generally not of gemstone quality. Besides the green ones there are yellow and brown colour shades available which are caused by additional contents of iron.

Dravite and uvite are Mg-Al-tourmalines with the generalized formulae

$NaMg_3Al_6[(OH)_4|(BO_3)_3|Si_6O_{18}]$ for dravite

and $CaMg_3(Al_5Mg)[(OH)_4|(BO_3)_3|Si_6O_{18}]$ for uvite.

The significant difference is a coupled substitution of (Ca,Mg) and (Na,Al) in the structure of tourmaline. The distinguishing feature between chromium and vanadium bearing tourmalines is a sharp absorption line of Cr^{3+} at 684nm (14 600 cm^{-1}), which is not present in the case of vanadium tourmalines. This absorption line can be found by spectroscopic investigations.

In summary, green tourmalines from East Africa, which are

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often called chromium tourmalines, are mainly not coloured by chromium but by vanadium and therefore should be named vanadium tourmalines (dravites and uvites). By a simple spectroscopic test, they can be distinguished.

REFERENCES

Bank, H., Berdesinski, W. (1967): Chromhaltiger Turmalin. *Z. Dt. Ges. f. Edelsteinkunde*, **61**, 30-32.

Bassett, H. (1953): A vanadiferous variety of tourmaline from Tanganyika. *Rec. Geol. Surv. Tanganyika*, **3**, 93-96.

McKie, D. (1955): Notes on some minerals from Tanganyika. *Rec. Geol. Surv. Tanganyika*, **5**, 81-94.

Webster, R. (1961): Tanganyika tourmaline. *Gemmologist*, **XXX**, 41-45.

Zwaan, P. C. (1974): Garnet, corundum and other gem minerals from Umba, Tanzania. *Scripta Geol.*, **20**, 1-41.

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A NOTE ON COLOUR

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In his recent article, K. W. Findlay[1] discussed some aspects of colour. He suggested that the eye would perceive different colour sensations, depending on the medium of transmission (air, water, etc.). His postulate was that, since the refractive index of the medium is different, so would be the velocity of the light and hence the wavelength would change, resulting in a changed colour.

In a subsequent note Dr R. M. Yu[2] pointed out appropriately that the intermediate medium does not matter since the light is perceived within the eye where conditions are always the same. Both authors claim that the frequency of light has more meaning than the wavelength, since the latter changes with the propagating medium while the former does not.

In my article on the International System of Units[3] I discussed the meaning and conversion of the various units used to specify the colour spectrum. In the interests of brevity I did not

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there mention a fact, well known in the field of optics, which neither of the cited authors mentioned. When wavelengths, frequencies, etc. are measured by instruments, the value read and quoted is *that which would have been obtained if the measurement had been performed in vacuum.*

This convention is always followed and has several important consequences. All measurements on a given beam of light, in whatever medium, performed by any technique and on any instrument, will always give the same answer. Results will be independent of laboratory variables such as temperature and humidity. Different experimenters in the different laboratories can compare their results with the assurance that they are using the same standards. And, finally, both wavelengths and frequencies are equally meaningful, since the conversion between[3] them is the velocity of light in vacuum which is a constant.

It might be mentioned that my comprehensive survey on the twelve causes of colour in gems and minerals[4] has also recently appeared in an abbreviated but more technical version.[5]

REFERENCES

(1) K. W. Findlay, *J. Gemm.*, **15**, (6), 316-20 (1977).
(2) R. M. Yu, *J. Gemm.*, **16**, (2), 121-3 (1978).
(3) K. Nassau, *J. Gemm.*, **15**, (5), 243-7 (1977).
(4) K. Nassau, *Gems Gemol.*, **14**, 354-61; **15**, 2-11; **15**, 34-43 (1975).
(5) K. Nassau, *Amer. Mineral.*, **63**, 230-8 (1978).

[*Manuscript received 9th August, 1978.*]

THE DIFFERENCE BETWEEN MAXIXE BERYL AND MAXIXE-TYPE BERYL: AN ELECTRON PARAMAGNETIC RESONANCE INVESTIGATION

By L. O. ANDERSSON, Tekn.Dr (Stockholm),

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A deep blue beryl was discovered in 1917 in the Maxixe mine in Minas Gerais, Brazil[1]. Unfortunately, the colour was not stable in daylight. A similar beryl appeared on the gemstone market in 1972/1973 and also lost its colour after being exposed to light for an extended period of time. This beryl was thoroughly investigated by Drs Nassau and Wood[2,3] and called Maxixe-type beryl. They found a slight difference in the optical spectrum of this stone and the original Maxixe beryl. The present investigation shows that the colour arises from different impurity ions which have lost one electron, probably by irradiation, to form CO_3^- colour centres in the Maxixe-type beryl and NO_3 colour centres in the Maxixe beryl.

*Electron Paramagnetic Resonance (EPR)**. This type of spectroscopy uses microwaves, which are orders of magnitude weaker than light waves and therefore truly non-destructive to the sample. The sample, normally of dimensions between 1 mm and 1 cm, is put into a microwave cavity which is placed in a strong magnetic field. The microwave frequency is determined by the spectrometer design and resonances are observed by sweeping the magnetic field. The observed transitions correspond to energy differences much smaller than in optical spectra and are related to the energy states of unpaired electrons.

Electrons are normally paired in ions and in chemical bonds. When an electron is removed, e.g. by irradiation, the remaining entity (often a colour centre) contains an unpaired electron and can be detected by EPR. Transition-metal ions often have unpaired electrons in their inner shells and can therefore be detected by EPR in unirradiated materials. An example of this is the determination of Cr^{3+} as the impurity in synthetic yellow sapphire[4] while the natural impurity giving the colour is Fe^{3+}. Diamonds and other gem

*also called Electron Spin Resonance (ESR)

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stones have also been investigated by EPR. The interpretation of the EPR spectra not only yields the nature of the colour centre, but often also its position and orientation in the crystal lattice. Since the electrons are used as probes, effects on the atomic and molecular level are observed.

Measurements. I am very grateful to Prof. E. Gübelin, Lucerne, for lending me the Maxixe beryl[5] and to Mr J. B. Schaffroth, Zürich, for lending me the Maxixe-type 'indigo beryl' (later also called 'Halbanita aquamarine') for this study. The beryl crystals were investigated with a Varian E-109 EPR spectrometer.

The EPR spectra of the two crystals are shown in Figure 1. These spectra were obtained with the magnetic field perpendicular to the *c* axis of the crystals. The magnetic field, measured in gauss, increases from the left to the right. Since the microwave frequency of different spectrometers may be different, the frequency is divided by the resonance field (and multiplied by a constant) to give a characteristic value for the resonance, the g-value, which is independent of the spectrometer used.

The g-values for the strong EPR signals are 2.021 in Maxixe

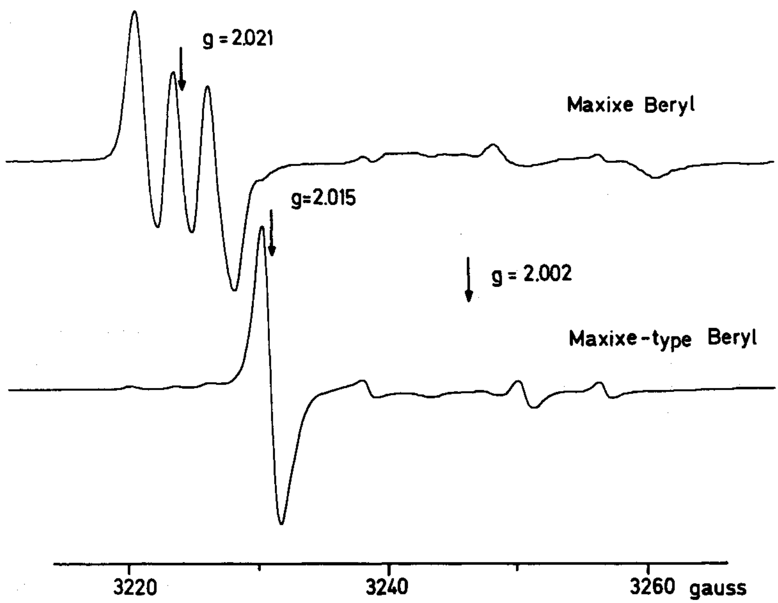

Fig. 1. EPR spectra of Maxixe and Maxixe-type beryl at a frequency of 9.1 GHz with the magnetic field perpendicular to the *c*-axis direction. These spectra were obtained at —180°C, where the lines are narrower than at room temperature. The small lines in the spectra arise from CH_4 and other radiation damage centres.

beryl and 2.015 in Maxixe-type beryl when the magnetic field is perpendicular to the *c* axis. When the field is parallel to the *c* axis the g-values are 2.004 and 2.005 respectively. The difference of the g-values from the g-value (2.002) of the free electron gives an indication of the species with which the unpaired electron is associated. Similar g-values to those observed here have been found for NO_3 (g = 2.023 and 2.003) in irradiated KNO_3 [6] and for CO_3^- (g = 2.016 and 2.005) in irradiated calcite[7]. (These irradiated crystals are also blue.)

The EPR spectra of the 'Halbanita' stone[8] and of Maxixe-type beryl obtained from morganite by x-irradiation[9] have already been interpreted. In both cases the blue colour was found to arise from a CO_3^- ion oriented with its plane normal to the *c*-axis direction and situated at the largest section of the empty channel in beryl.

In the top trace of Figure 1 the EPR signal is split into three lines. This is characteristic of a nucleus with spin = 1 like ^{14}N, while nuclei which have spin = 0 like ^{16}O and ^{12}C do not split the EPR line. The orientation dependence and the comparison with the results (g-values and size of splitting) for NO_3 in irradiated KNO_3 lead to the conclusion that the colour centre in Maxixe beryl is NO_3, positioned in the same way as CO_3^- in Maxixe-type beryl.

Discussion. It has been established by EPR that the colour centres in Maxixe beryl and Maxixe-type beryl are NO_3 and CO_3^- respectively. These centres may be created when NO_3^- and CO_3^{2-} impurity ions lose one electron or when a hydrogen atom is removed from HNO_3 and HCO_3^-. Such processes occur when crystals are exposed to x-rays or gamma rays. In certain cases electrons can also be removed by ultraviolet irradiation.

It has been demonstrated[2, 3, 9] that a deep blue colour can be produced by irradiation of certain pale beryl stones with neutrons, x-rays and gamma rays. In a report[10] on the 'Halbanita' beryl, it is stated that this Maxixe-type beryl has not been exposed to any of these energetic types of irradiation. It was admitted that a non-defined method was used to create the deep blue colour in about 10 days. Since the energy of ultraviolet radiation sometimes is sufficient to create colour centres, a test was made with a thermally bleached 'Halbanita' stone. After a few minutes of ultraviolet irradiation in the 230 to 330 nm range, one could already observe the CO_3^- signal in the EPR spectrum. After two hours of irradiation, a weak blue colour could be observed and the EPR signal was much stronger. This shows that it is possible to produce Maxixe-type beryl by ultraviolet irradiation. Since the EPR method is much more sensitive than the eye, it could be used to select those stones (after an initial short period of irradiation) which may become coloured by prolonged irradiation.

Cosmic rays or irradiation from radioactive nuclei in the surrounding minerals may have built up the NO_3 concentration in the Maxixe beryl.

Not all beryls can be coloured deep blue (or green) by gamma irradiation[3]. The present results show the necessity that the beryl contain CO_3^{2-} or NO_3^- impurities. This is, however, not sufficient. In order for the colour to remain, the lost electrons have to be strongly trapped. Otherwise they will return to the original ion, as they do under the influence of heat or light, causing the colour to bleach. The extent to which a stone can be coloured depends on the concentration of the necessary impurities (and electron traps). This explains the large variations observed[3]. (A small concentration of NO_3 is also present in the Maxixe-type beryl studied, as can be seen by the very weak NO_3 lines in the spectrum of this crystal in Figure 1.) The stability of the colour under the influence of heat and light may also vary considerably. This depends on the nature and the stability of the electron traps in the different stones.

Since the trapped electrons are unpaired, they can also be investigated by EPR. It has been found that most electrons in the Maxixe-type beryl are trapped together with protons to form hydrogen atoms[11]. This was also found to be the case in the Maxixe beryl. Many electrons in the Maxixe-type beryl are also trapped by centres which are preliminarily interpreted to be CO_2 impurities forming CO_2^- associated with different alkali metal ions. EPR signals of NO_2 are observed in the Maxixe beryl.

Heat treatment experiments show that the CO_2^- type signals are the least stable and disappear with a rate corresponding to the fast decay of the colour in Nassau's experiment[3]. The hydrogen signal disappears with a rate corresponding to the slow decay. The electrons released by the heat are caught by the CO_3^- ion and cause its EPR signal to disappear at the same rate as the colour[8, 9].

I wish to thank Mr J. B. Schaffroth for initiating the investigation of the 'indigo beryl'. I also thank Professor E. Gübelin and Mr J. B. Schaffroth for valuable comments on the manuscript.

REFERENCES

1. Schlossmacher, K., Klang, H. (1935). Der Maxixeberyll. I. *Zentralbl. Mineral. Geol. Paläont.*, **1935A**, 37-44.
2. Nassau, K., Wood, D. L. (1973). The Nature of the New Maxixe-Type Beryl. *Lapidary J.*, **27**, 1032-58.
3. Nassau, K., Prescott, B. E., Wood, D. L. (1976). The Deep Blue Maxixe-Type Color Center in Beryl. *Am. Mineral.*, **61**, 100-7.
4. Barrington, E. N. (1975). Electromagnetic Resonance in Yellow Sapphires. *Aust. Gemmol.*, **16**, 159-60, and Scala, C. M., Hutton, D. R. (1975). A Definitive Test for Golden Sapphires, *Aust Gemmol.*, **16**, 160-1.
5. A piece of the stone described by Schiffmann, C. A. (1977), Gemmologische Studie an einem Original-Maxixe-Beryll. *Gold und Silber*, July 1977, 37-39.
6. Livingston, R., Zeldes, H. (1964). Paramagnetic Resonance Study of NO_3 in Irradiated KNO_3. *J. Chem. Phys.*, **41**, 4011-12.
7. Serway, R. A. , Marshall, S. A. (1967). Electron Spin Resonance Absorption Spectra of CO_3^- and CO_3^{3-} Molecule-Ions in Irradiated Single-Crystal Calcite. *J. Chem. Phys.*, **46**, 1949-52.
8. Andersson, L. O. (1976). An EPR Investigation of the Blue Colour Centre in Maxixe-Type Beryl, presented at the Electron Spin Resonance Symposium, University of Nijmegen, the Netherlands, August 1976.
9. Edgar, A., Vance, E. R. (1977). Electron Paramagnetic Resonance, Optical Absorption and Magnetic Circular Dichroism Studies of the CO_3^- Molecular-Ion in Irradiated Natural Beryl. *Phys. Chem. Minerals*, **1**, 165-78.
10. Bastos, F. M. (1975). Maxixe-Type Beryl. *Lapidary J.*, **28**, 1530-42.
11. Andersson L.O. (1974). EPR of Hydrogen Atoms in Beryl Crystals. *Proc. 18th Congress Ampere*, (ed. P. S. Allen *et al.*) p. 129.

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ECONOMIC GEOLOGY OF THE ANAKIE SAPPHIRE MINING DISTRICT, QUEENSLAND

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ABSTRACT

The Anakie district in east-central Queensland is the largest of the two major Australian sapphire-bearing gem gravel mining areas. The fields were established in the late 19th century for marketing distinctive royal blue hued stones to the Imperial Russian court. Since the decline in competitiveness of south-east Asian gem gravels over the last fifteen years, the Anakie sapphires have dominated the commercial gem markets. Sapphires and zircons are the major gemstones associated with the shallow Tertiary gravels of the district. Source of the sapphires has not been conclusively demonstrated. The largest commercial field is the Rubyvale-Sapphire trend, which is famed for its blue hues. The Willows field is noted for the golden yellow sapphires, as well as large green specimens, but production of blue stones is limited and of poor colour. The Tomahawk Creek field produces the finest green coloured sapphires. Commercial mining utilizes a bulldozer trenching system. Only a few commercial claims are hand-operated vertical shafts, an approach generally associated with the casual prospector. Up to 60 feet of overburden may be excavated. Commercial recovery of the sapphires involves trummel screening, sluice washing and gravity separating with a riffled pulsating jigger.

INTRODUCTION

Australia has two major commercial sapphire mining districts: the Anakie area of east-central Queensland and the New England area of north-central New South Wales. The production from these mining districts has substantially replaced the classic Asian sources on the world gem markets.

The ruby and sapphire mines near Mandalay, Myitkyina and Mogok in Burma have been in operation for centuries, probably predating the historical records. Thailand also ranks as a classic producer of fine gem quality sapphires from a coarse gravel belt that extends into Cambodia. The widespread sapphire bearing gravels of Ceylon and India are similarly famed, though their production has considerably paler hues. The primitive mining methods within relatively small claims, exhaustion of the gravels from centuries of excavation and political upheavals over the last several decades have resulted in a steadily declining production. This decline, however, has assured the economic survival of the two

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major Australian sapphire mining districts. Nevertheless, Australian sapphires, while in abundant supply, are somewhat less desirable than their Asian counterparts. They have a tendency towards a less brilliant inky blue hue rather than the more favoured, lighter 'cornflower' shades.

This is the first of two papers on the economic geology of the Australian mining district of central Queensland, and the Glen-Innes (New England) district of New South Wales with comments on the commercial marketing system and notable sapphire gems.

THE AUSTRALIAN SAPPHIRE DISTRICTS

There are two major sapphire mining districts: the Anakie district of central Queensland and the New England district of north-central New South Wales. Non-commercial sapphire occurrences are reported elsewhere over widespread areas of Australia.

The discovery of the Anakie fields is attributed to a Mr Richardson, employed as a railroad right-of-way surveyor. In 1875 he collected some red zircons on Retreat Creek, 13 miles west-south-west of Anakie. Thinking they were rubies, he shipped the zircons and their gravel concentrate for gemmological testing. He failed to notice the small sapphires with the red zircons, but upon identification, Mr Richardson became one of the partners in a company to work the field for the sapphires. This original discovery site was commercially worked in 1891 by the Withersfield Sapphire Company. The company's operations soon expanded from central Queensland to beyond Armidale in New South Wales, exploring almost every creek and river gravel bed for the gemstones. By the end of the century the commercially viable zone had been extended across 28 square miles.

Sapphires have been recovered from a number of localities in the state of Victoria. They are associated with heavy mineral concentrates recovered during gold mining. Tasmania has produced small specimens associated with its tin gravels. Gem quality sapphires are rare in Western Australia, but extensive corundum and emery deposits are recognized.

The occurrence of ruby in Australia is very rare. A number of reports are on record from the early years of this century, but the validity of their identification is questionable. It is likely that most of the specimens are actually spinel or garnet. Occasional small crystal fragments of pale pink corundum occur in the Queensland gem gravels near Sapphire, Tumberumba and Burmah. Isolated recoveries of reported ruby in Queensland have been at the Jordan Creek goldfield in the Little Beatrice River, the Henrietta Creek area, the Rocky Tate River of the Chillagoe district, Campbell Creek of the Palmer goldfield and in the Anakie sapphire district. Ruby discoveries in New South Wales and elsewhere in Australia are virtually unknown.

ANAKIE SAPPHIRE DISTRICT: PRODUCTION HISTORY

The Anakie area in central Queensland is the major producing Australian sapphire district. It was here that the sapphire bearing district had been shown by the end of the century to extend eastward for 12 miles, westward for 14 miles and northward for 16 miles. The small village of Sapphire (Figure 1) was the only business centre in the early years of the twentieth century, but by 1907 the influx of miners from the nearby worked out Black Bridge placer gold field settled and worked the gem gravels in Policeman Creek, 4 miles from Sapphire, and founded the township of Rubyvale. Today, the main workings cluster around Rubyvale, Sapphire, The Willows and Tomahawk Creek (Figure 1). These fields constitute the 'Anakie' district, although no sapphires are found in and around the town of Anakie itself. Rubyvale is but 12 miles north of Anakie. Anakie is approximately 200 miles west of Rockhampton.

The Anakie field was proclaimed on 3rd September, 1902, as a recognized mineral field subject to the state mining laws. The area was defined to cover 18000 acres or approximately 28 square miles. This has now been expanded to over 80 square miles within a potential area of over 400 square miles.

Initial nineteenth century production was minimal because of the lack of incentives related to low prices. Many of the smaller mines and prospects ceased production by the close of the nineteenth century, only to be revived with the establishment of regular markets for the gemstones by late in the first decade of this century. Virtually all of the Australian sapphire production in the 15 years prior to World War I was controlled by German gem merchants. Many of the early immigrant prospectors were German. The

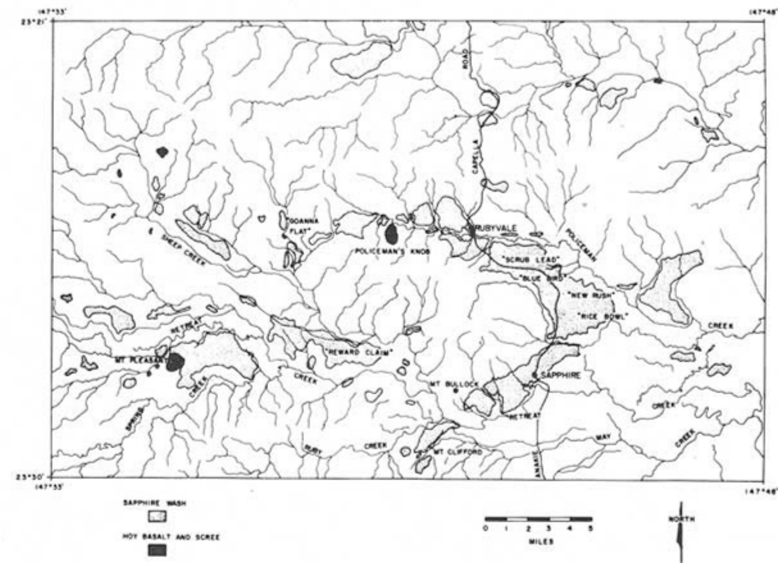

Fig. 1. Distribution of the gemmiferous gravels, the sapphire wash, in the central Anakie mining district, east-central Queensland. The most productive fields of the district are excavations of buried alluvium trends between the towns of Rubyvale and Sapphire.

sapphires were exported to Germany to be sorted, graded and cut, and finally sold to the lucrative Imperial Russian Court market. The very deep royal blue hues favoured by the Anakie fields held a fascination for the Russian nobility unmatched elsewhere in the world. Although the Australian (the Anakie and Glen-Innes fields) sapphires are predominantly deep blues, yellows and greens, only the blue hues were commercially viable as gemstones prior to World War I. The unsellable yellows and greens, as well as the discarded grades of blue, were marketed to the watch-bearing industry.

World War I eliminated the German control of the marketing but also brought about the collapse of the Imperial demand. After the end of the hostilities, however, the Anakie fields experienced a new boom that continued until the Great Depression, when western European and the new North American markets filled the vacuum left by the Russian Revolution.

Popularity and production of the Anakie sapphires was at an all time low in the decade following the Great Depression and World War II. The entire production from the Anakie district during 1957, for example, was only a hundred dollars worth of stones. The Anakie stones are a blue-black shade that is so dark as to be 'dull' when compared to the rival southern Asian sapphires. Yet the near exhaustion of the Asian gem gravels since the mid-1960s has seen a revival of the Australian production, not only for the blue hues but also for the 'fancy' colours.

Geology of the Anakie Sapphire Deposits

The Anakie fields are extensive, sapphire-bearing alluvial sands and gravels overlying a bedrock of granite, slate, clay and sandstone sequences.

The oldest geological unit in the area is the Anakie Metamorphics, a succession of quartz-mica schists, banded phyllites, quartzites and slates. Interbedded basic volcanics occur in the northern part of the field, south of Mount Ball, and limestones outcrop between Mount Clifford and Rubyvale. The Anakie Metamorphics are generally accepted as pre-Devonian, and potassium-argon dating by Webb and McDougall (1968) indicates an Ordovician age. The Anakie Metamorphic complex is intruded by the Retreat Granite (Devonian), which in the mining district consists of sheared granites, adamellites, granodiorites and diorites, and underlies the sapphire-bearing gravels, especially on Bedford's Hill and the Scrub Lead area.

A major source for quartzitic clasts of the sapphire bearing gravels is the 'Kettle Beds', an informal sequence of orthoconglomerates and gritty sandstone recognized by Robertson (1974). The unit is well exposed in the bend of Policeman Creek north of the New Rush area. The thickness of the sequence is unknown, but is estimated to exceed 150 feet (Robertson, 1974). The beds are overlain by the Hoy Basalt to the north of the New Rush area, and over widespread areas they are unconformably deposited on the Retreat Granite. Although the Hoy Basalt is postulated to be the primary source of the Anakie district sapphires, *in situ* discovery has never been confirmed. It is predominantly a porphyritic olivine basalt that emanates as a series of volcanic vents intruding the Retreat Granite.

Policeman's Knob and Mount Pleasant are the only volcanic neck structures known within the mining district (Figure 1). Corundum has been identified in the basalt on Policeman's Knob

(Robertson, 1974). It is widely advocated that the predominant portion of the sapphires and corundum associated with the mining district is derived from eroded volcanic necks somewhere, yet unknown, in the Drummond Ranges over a hundred miles to the west. Many local miners note a general tendency for the size of their recovered sapphire crystals to increase towards the west and a few small isolated sapphire discoveries have been made on the slopes of the ranges. Infrequently, cobble-sized pieces of basalt containing embedded fragments of corundum are recovered from the district's mines, but probably represent a secondary envelopment.

The sapphire-bearing alluvial deposits are termed 'wash' by the local miners, in particular reference to the stream-washed nature of the component boulders ('billy'). The wash varies in thickness from the surface to 60 or more feet in depth locally, but over most areas it is perhaps only two to four feet thick and usually under a foot or more of topsoil. Wash near the surface tends to be mainly of quartzite pebbles, while the deeper and richer deposits are generally larger boulders amid clays. In several localities, notably the New Rush area, a second wash has been found below the wash that was thought, incorrectly, to rest on basement.

The predominant colours of sapphires throughout the Anakie district are blue and green. Blue sapphire, the commercially viable commodity, is confined to a very limited area embracing the valley of Retreat Creek, but only north of the Creek itself. The fields north of Retreat Creek, especially Freehold, Reward and Sapphire, have a high proportion of blue gems, as well as considerable green-hued stones. The blue stones predominate in the Scrub Lead area. Blue stones are also found in Boot and Kettle Creek, although Carbine Creek, the next digging area to the north, only has sapphires lacking this desirable hue. Fields immediately to the south of Retreat Creek are void of blue sapphires; the green shades predominate. The fields are Zircon Gully, Washpool, Big Poverty and Subera. They have very marginal or no commercial interest.

THE MAJOR FIELDS

The gem gravels that comprise the Anakie district are distributed into three major fields. The main field is an area between and surrounding the towns of Sapphire and Rubyvale, 6 and 10 miles respectively north of Anakie (Figure 1). The Willows field is approximately 25 miles south-west, by road, of Anakie. Another major area is the Tomahawk Creek field, about 24 miles from Rubyvale in the direction of the Zig Zag Range.

The sapphire wash of the Anakie district rests unconformably on the bedrock units discussed. The gem-bearing gravels are widespread: north as far as the Clermont gold fields, east to Capalla and Taroborah, south towards Springsure and west to Alpha. They are concentrated north and south of the Anakie Range in what is called the Anakie district fields, centring around the townships of Rubyvale, Willows and surrounding creeks.

THE RUBYVALE SAPPHIRE FIELDS

There are five main runs of gem gravel in the greater Rubyvale and Sapphire area. These are the catchment areas of Central, Tomahawk, Boot and Kettle, Policeman and Retreat Creeks (Figure 1). Most of the early commercial production and subsequent production was confined to the wash associated with the gravel deposits of Policeman and Retreat Creeks, and especially the area within a few miles of Sapphire and Rubyvale townships.

The sapphire-bearing gravels of the Sapphire township extend from near Mount Bullock to the Rice Bowl. They are within six feet of the surface along the Sapphire-Rubyvale Road near Sapphire and to the east of the Rice Bowl area. This area, known as the Sapphire field (or Retreat Creek field) is responsible for the bulk of modern commercial production.

The Cainozoic gravels in the Sapphire area appear to lie mainly on the Anakie Metamorphics. There are three types of sapphire-bearing washes known (Robertson, 1974). The most widespread type consists of ferruginous quartzite 'billy' emplaced within a reddish clayey matrix. A more restricted second type consists of three feet of reddish gravel soil above six feet of a gravel consisting of clasts of quartzite 'billy', basalt and metamorphics within a red feldspathic sand matrix. This wash variety is the shallowest and has the nearest proximity to the Sapphire township. A third wash variety is along the southern margin of the field to the west of Sapphire, and is similar to that found in the Freehold area on Retreat Creek to the west of Sapphire. This lithology consists of up to 25 feet of 'billy' and metamorphic boulders as a densely packed framework with a matrix of clayey feldspathic sand.

The Retreat Creek area is considered among the greatest producers of the district and was one of the first areas to achieve significant commercial attention. The main concentrates of wash, termed a 'lead', centres around the town of Sapphire, hence 'the Town Lead'. It is shallow, and its variable thickness averages only three feet. It has been extensively worked, but short-term prospecting has frequently yielded substantial results from virgin patches amid the older abandoned workings. The deep wash that occurs about a mile west of the old township has workings averaging 20 foot depths. Substantial quantities of blue, yellow and green sapphire are still being recovered from isolated unworked patches in this area as well. Prior to World War I, during the major mining boom period, the main production zone on Retreat Creek was the Town Lead at Sapphire passing eastwards into Fighting Ridge and westwards into the Deep and Bessie Leads. Nevertheless, important zones of wash were worked on the southern side of the Retreat, areas called Grave Hill, Croker and Black Soil. Above the confluence of Sheep Station Creek were Elwood's Grave (5 miles south-west of Rubyvale), the Reward Claim and the Freehold, which are sites of the initial sapphire discoveries in the district. On the northern side of Sheep Station Creek were the deposits worked at Iguana Flat and the Granite Waterholes.

The Reward and Freehold claims reached their commercial peak at the turn of the century. They were considered the largest and most valuable deposits associated with the Retreat Creek gravels.

The Reward Claim is about seven miles from Rubyvale on a road trending south-west. It is situated but a couple of hundred yards from the road about a mile after crossing Sheep Station Creek. This site was worked by the Withersfield Sapphire Company from 1891 on the site of the first discovery of the district's sapphires in 1875. The main sapphire wash is on top of the ridge, extending down both sides and trends along some of the smaller spurs. It rests on a bedrock of weathered granite. The wash has abundant 'billy boulders' that are considered by the miners to be a favourable indicator for sapphires. The original claim workings, now abandoned, cover two hundred acres of extensively excavated ground. However, it is widely recognized that considerable portions of this claim remain unmined, since the gravels under the original dumps have never been worked. A mile further down the road is the old Freehold claim of about 100 acres. The geology of the deposit is similar to the Reward.

The Rubyvale field is the extensively worked ground approximately one to four miles north of the Sapphire field (Figure 1). Modern commercial sapphire production in the immediate vicinity of Rubyvale is from a series of gravel deposits to the east of the town along both sides of the Rubyvale-Sapphire road. The mining areas are named: Scrub Lead, Blue Bird, New Rush and the Rice Bowl. Sapphires are recovered from deposits to the north-west and west of Rubyvale on Bedford's Hill, Norman's Hill and Shotgun Hill, and Policeman's Knob and Policeman's Creek.

The wash to the east of the Policeman's Knob is composed of 'billy' boulders and basalt with minor metamorphics in a clay and black soil matrix, but to the west large 'billy' boulders predominate in the clayey matrix. These wash deposits are unconformably deposited on the Anakie Metamorphics. The wash at Shotgun Hill is similar, and is also underlain by the Anakie Metamorphics. A lithologically similar wash on Norman's Hill and Bedford's Hill overlies the Retreat Granite. Sapphires were extensively mined from these deposits around the turn of the century, especially from 60 foot deep shafts on Bedford's Hill.

The wash in the immediate vicinity of Rubyvale is generally shallow between 10 and 25 feet. Along the Keilambete road to the south of the township, the depth to the wash locally exceeds 50 feet. The wash is a clay matrix generally with 'billy' boulders, angular metamorphic clasts and quartz pebbles derived from the Kettle Beds.

The composition of the wash changes significantly to the east of Rubyvale. The gravel is an assemblage of pebbles, cobbles and boulders of quartz, basalt and metamorphics within a feldspathic sand matrix. The wash is upwards of 10 feet thick and is comparatively shallow. This commercial field includes the Scrub Lead and the New Rush area, and has yielded some of the finest quality blue sapphires in the state. The wash throughout this area is underlain by the Retreat Granite, where commercial concentrations of sapphires in the wash have been trapped within the irregular surfaces of the igneous subcrop. Depth to the bedrock surface varies widely between 3 and 60 feet, but generally is within 40 feet of the surface. The basal 3 feet of wash usually has the greatest gemstone concentration.

The most important commercial sapphire-mining pursuits for the last decade have been associated with the Scrub Lead (Figure 1).

Extensive workings can be observed from the road about a mile before reaching Rubyvale on the road from Sapphire. These mines form a mile long and a quarter-mile wide belt of several dozen open-cut mines on the south-western banks of Policeman's Creek. The Scrub Lead mines monopolize the commercial production of the district because of the relatively high recovery percentage of the most desirable deep blue-hued sapphires from workings as much as 50 feet deep. The grade of stone is immediately recognizable as the 'Scrub blues', the shades of blue that are a little lighter than the Retreat Valley average. Almost the total production is a shade of blue—yellows and green being relatively rare. An infrequent sapphire specimen recovered may reach an ounce or more.

THE WILLOWS FIELD

The second most important field in the Anakie district is the Willows field. This area is approximately 20 miles north-west of Anakie via the Capricorn Highway, then 7 miles south-east of the highway on a posted access road into the Willows township.

The Willows field was discovered in 1918. It has been since the scene of only intermittent mining for the commercial market. Heavy mining machinery is generally restricted to the major areas of the Rubyvale-Sapphire fields to the north and is not permitted (with a few exceptions) in the Willows area. The field is presently reserved for the casual prospector and 'tourist' digger without the use of mechanized recovery methods. The field has supported earlier in the century, however, a number of professional miners with hand-dug shafts.

The Willows field does not produce the commercially valuable blue-hued gemstones, and what blue stones are found are generally too dark to be marketable. Nevertheless, the area is widely recognized as a productive field for greens, fine yellows and parti-colours. The green-colour hues do not approach perfection. Regardless of this the generally large and flawless gem material, particularly in desirable golden yellows, provides incentive for continued prospecting.

The Willows field provides the best opportunity for success for the casual digger with but few days or weeks excavating a pit by hand (Figure 2). The average casual prospector with only a pick and shovel can excavate and process about two cubic yards of wash a day. The yield may be minimal, but a reasonable expectation is the recovery of a dozen or two small sapphires, ranging from a half to as much as 3 to 5 carats. Some collectors have dug for a week with only a third to a half ounce yield, but 20 feet away, an excavation pit may strike a small run and recover an ounce within hours.

Frequent finds of 10, 20 to 30 carat stones in green to yellow hues are notable for this field. The area is particularly famed for its golden yellow gems of a hue recognized as without rival elsewhere in the world. Such stones tend to be flawless, brilliant, evenly coloured and sizeable as well. Blue sapphires are rare at the Willows and, when found, are mostly small and with a decidedly inferior greenish shade.

There are several digging areas within the two-mile diameter Willows field. Access to the area generally initiates from the general store and caravan park within the central portion of the field, adjacent to the dam and water supply tanks. From the general store the road winds less than a mile north circumventing the dam and eastward past the Yukon claim to a large clearing several miles across. Between the Yukon claim and the clearing are several hundred yards of partially excavated ground that is popular with the casual visitor because the wash is shallow and in the shade of surrounding trees and brush (Figure 2). It is but one of a half dozen workings in the area. The sapphire bearing wash continues, as far as is known, hundreds of yards, perhaps thousands, into the cleared area. Only a few scattered wild-cat holes have been dug there, however, because of the increased overburden thickness, and also because of the lack of shade.

There are six commercial claims on the Willows field. These are permitted to utilize heavy machinery. These are still outstanding old leases, but new restrictions prohibit any more from being issued. Only the Yukon claim has any serious, though intermittent, attempt at production. Commercial success has not been encouraging because of the lack of marketable blue stones.

The Willows field is attractive to hand excavation techniques because of the thin overburden. Brown, boulder-strewn topsoil generally is 1 to 6 feet thick, generally closer to 2 feet. It overlies about a foot thickness of sapphire-bearing wash. The wash is sometimes absent or only a few inches thick, but has been observed as much as three feet thick. It is stained white by decomposed granite. Under the wash is a yellowish to brownish grey clay that persists downward to bedrock. Thickness of the underclay varies widely,

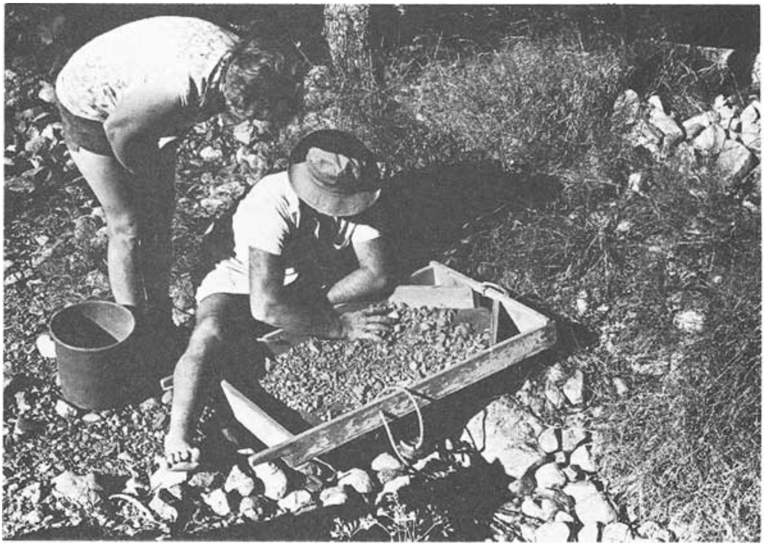

Fig. 2. Prospecting for green sapphires on the Willows field. Limited water favours the use of dry screening procedures and hand sorting at the numerous prospect pits on the field.

between 3 and 20 feet. Some prospectors excavate deeply into the underclay for a second gravel horizon, 6 to 20 feet below. This lower wash is not always present and often barren of sapphires. Most prospectors follow the wash horizons along their east-west trends, always careful to examine thoroughly the eastward (downstream) sides of any large boulders uncovered and to process a few inches of the clayey sand under the gravel for any sapphires that may have worked downward into softer sediments.

The bedrock is generally weathered basalt, but sometimes is an overlying sandstone bed as in the caravan park area and at Steptoe Hill two miles to the north.

Quality yellow and green sapphires have been found on the sandstone ridges north of Willows, particularly the Glenalva rise about 5 miles north of Willows. The Glenalva field has a potential sapphire bearing zone approximately three miles long and a mile wide. It has a few active prospects with a limited production.

THE TOMAHAWK CREEK FIELD

The Tomahawk Creek field is an important field in the Anakie district but is largely undeveloped. The field, like the Willows, does not have commercially viable quantities of blue coloured gems. Its green stones, like the yellows from the Willows, are reported to be the finest shade possible and are known throughout the world as 'Tomahawk greens'. Many feel that Tomahawk Creek, some 24 miles by road north-west of Rubyvale, offers the most encouraging opportunity for the newcomer to the sapphire fields. The topsoil is only inches thich and in many places the wash is exposed at the surface. The sapphire-bearing wash along Tomahawk Creek extends to Hut Creek, a distance of approximately 2 miles. Some of the best stones that have been found are associated with the Hut Creek and Costie Creek gravels. This field is relatively remote, and accessibility is difficult. Supplies must be brought in with difficulty from Sapphire or Rubyvale across a number of sharp, narrow creek crossings.

Black spinel (pleonaste, var. ceylonite) and zircon are abundant in the Tomahawk Creek gravels. Occasionally, some attractive zircons are cut from rough of this area.

The Tomahawk Creek field is accessible with difficulty and the potential is poorly known but considered significant. Undoubtedly it remains the major, but as yet unproven, sapphire reserve for future decades.

MINING METHODOLOGY

During 1975 field studies in the Rubyvale area, most of the commercial production was from a cluster of claims a half-mile south-east of town. Virtually all of the mines are bulldozed trenching operations (Figure 3). Only a few are hand-operated underground shafts associated with the casual prospector (Figure 2).

A typical Scrub Lead commercial sapphire mine is generally a two or three man partnership. The claim operators regularly contract-hire a bulldozer and operator to trench their claim area and stockpile the wash. It is considered economical to contract-hire when needed, generally every two weeks, since bulldozers are a relatively expensive investment and not in daily use. Several bulldozer owner-operators make a reasonable income from neighbouring claims by excavating and stockpiling their wash. Each mine operator, however, has his own mechanical backhoe or front-end loader to move portions of the stockpile to the processing plant.

Fig. 3. Excavation and processing the gravel from the Scrub Lead field south-east of Rubyvale. The sapphire-bearing gravel is excavated from the pits and dumped into a sieve, sluice and pulsating jig sequence to gravity-separate the heavy gemstones.

The Scrub Lead bedrock ranges from 6 to 50 or 60 feet below the surface. The open-cut miners process this entire section from surface downward. The independent, hand-dug shaft operator, on the other hand, preferentially mines only the several feet of rich concentrate overlying the bedrock.

The stockpiles are covered with extensive sheets of plastic to insure that the gravel wash remains dry until processing. The methodology is to dry or wet screen the wash to remove the silt and sand fraction, as well as the cobbles and boulders (Figure 4). The retention size for most plants is usually between an eighth-inch and seven-eighths inch to an inch. Since the mines are generally operated as a two man partnership, one miner operates the back-how or front-end loader to move the stockpile to the screening machinery and the screened concentrate to the wash plant, while the partner processes the gravel in the wash plant. The screening operation may be either a flat bed or a rotary mechanism. A couple of cubic yards of gravel are typically dumped into a 12 foot long, 5 foot diameter, pair of rotating drums, called a 'trummel', with a system of the desired screen mesh. Some claims use a flat-bed screen shaker mechanism for separating out the large gravel and

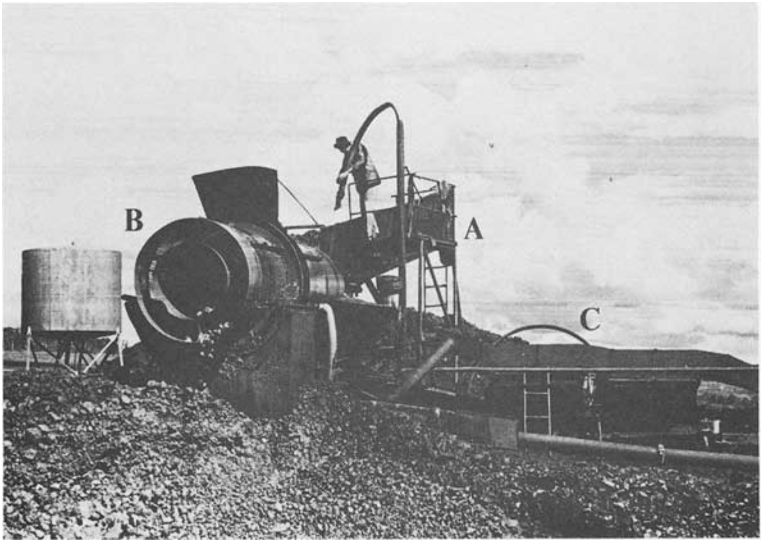

Fig. 4. Wash plant procedure to separate the sapphire-corundum-zircon concentrate.
A. The gemmiferous gravel is dumped into a wide box, and hosed into a trummel (B).
B. The trummel screens the gravel and rejects the sand and very fine gravel as well as the cobbles and boulders. The retention size is generally between a quarter and an inch or two.
C. The slurry is then conveyed into a gravity separator. The sluice and pulsating jig mechanism traps the sapphires, zircons, corundums and other heavy minerals behind riffles.

cobble clasts. Many of the mills do not have a fines separation step, but send the gem gravel directly into the washing plant. It is only essential to eliminate the large rocks and boulders in excess of an inch or two diameter. Some plants utilize a conveyor belt to direct the gem gravel from the dry screen 'trummel' into the washing plant, but most other mines use a front-end loader to move the gravel (see Figures 3 and 4).

Washing plants in the commercial mines are essentially similar in design and only vary in size. They consist of three essential components: an open tank, a sluice and a pulsating jigger. A front-end loader at a typical Scrub Lead plant dumps a couple of cubic yards of gem-bearing gravel into a flat-bottomed steel trough, 20 feet long and nearly as wide, that is tilted forward into a 20 foot long sluice. This guides the gravel slurry into the pulsating jig (Figure 4). The jig circulates the gravel up and down in a water stream to concentrate the heavier minerals, including sapphires, towards the bottom, trapped behind riffles. A jig usually has five circulation cells but recovers most of the larger gems in the first cell and only the very small ones in the fourth or fifth.

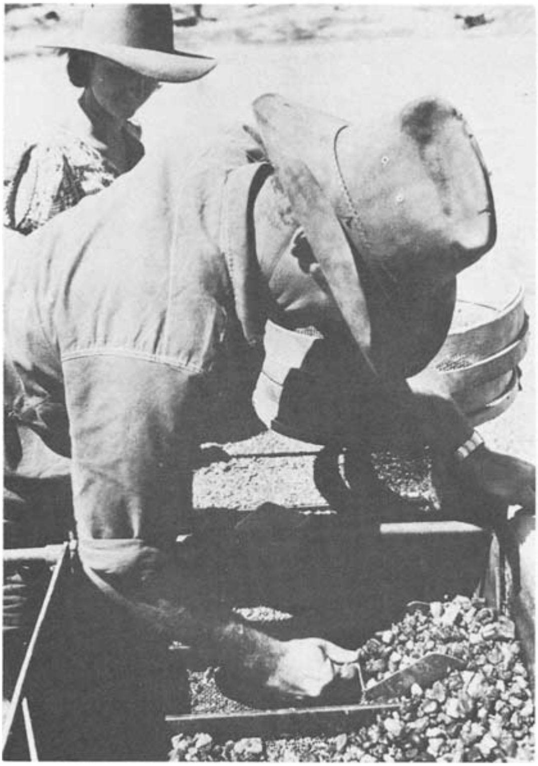

Fig. 5. The pulsating jigs on the Scrub Lead field are cleaned twice daily to recover the trapped sapphire-corundum-zircon concentrate.

The pulsator is cleaned twice a day for the concentrate by scraping the accumulated gravel with a hand trowel into buckets (Figure 5). This concentrate is hand-screened and further concentrated in a water trough and then picked through for saleable gems (Figure 6). The quantity of daily recovered sapphires varies widely throughout the Anakie district. A small two or three man claim will recover an average of an ounce or two of sapphire a day. Most of the gem sapphires are the 'Scrub Blues', a desirable light-hued royal blue, generally free of silky inclusions, as well as a smaller percentage of green and yellow sapphires. Quantities of corundum, black spinel, and considerable gem quality zircon are associated with the sapphires. The zircon portion recovered varies widely on the fields, from one ounce of zircon to four ounces of

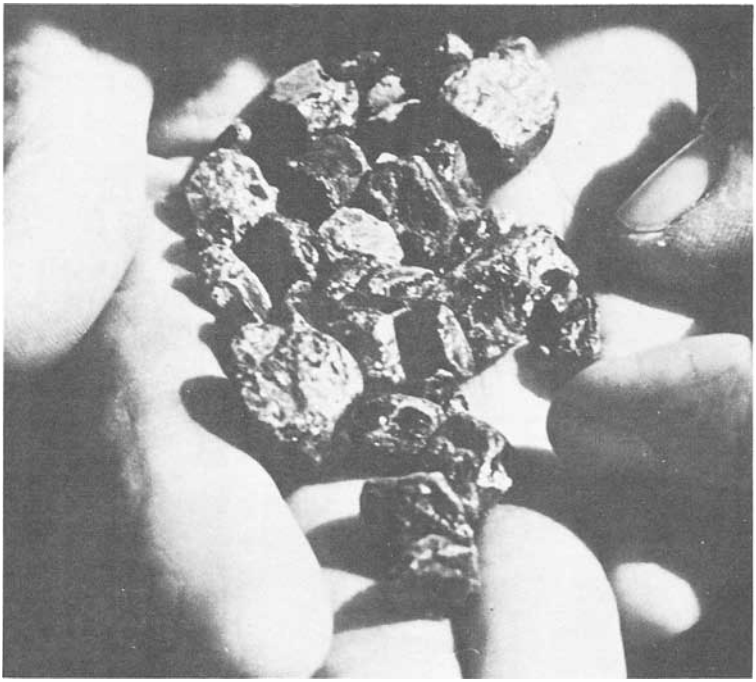

Fig. 6. An ounce of mine-run blue sapphires from the Scrub Lead. Note the angular shapes and poorly preserved crystal and cleavage faces.

sapphire recovered to as much as equal proportions. The zircon is generally flawless, water clear to light buff brown. Large pieces, 5 to 20 carats weight, are relatively common. The zircon, however, lacks a viable commercial market. Diamonds are only rarely recovered, but not unknown.

Notable Sapphire Gems Recovered from the Anakie District

Notable sapphire specimens have been associated only with the Anakie fields, virtually none with the New South Wales deposits. Sizeable gems, those in excess of 20 carats to as much as several ounces, usually have the non-blue colours, especially yellow and green hues. Many of these have been recovered from the Willows field. Two of the earliest known sizeable Anakie stones were found by W. Dyer: a gem of 20 grams rough in 1920 and a 1925 discovery of an orange-yellow stone that was cut to 31 carats. A notable orange-yellow sapphire of 13 grams was found by E. Russell in 1924 on the Freehold claim, and a fine quality 14 gram golden-yellow stone was recovered in 1949 from the Policeman's Creek alluvium. *Anderson's Yellow* was a 21 gram golden-yellow sapphire found in 1949 on the Willows field by J. Anderson. The stone was first cut to a finished weight of 70 carats with an 'off cross-table' style making it the largest gem of its kind in existence. However, the cutting failed to display the gem's proper brilliance and it was subsequently recut into several stones, the largest being a double oval brilliant weighing 35.75 carats.

The *Golden Willow,* renamed the *Golden Queen,* was found in 1951 on the Willows Field by H. Clifton-Parr. It weighed 322 carats in the rough, or approximately 2 ounces. It was sold to J. McSweeney, of Toowoomba, for cutting into a 91.35 carat finished stone.

Mr Stonebridge, of Rubyvale, has recovered from his claim a particoloured sapphire of 18.4 grams. This crystal fragment, approximately two inches long and an inch thick, is a dichroic deep bottle green and a lighter greenish yellow. The gem remains in the rough but would be suitable for two sizeable finished stones, one green and one yellow. A sizeable particoloured stone weighing 78 carats, approximately a half ounce, was found by P. Robertson and P. Tanzik from a claim near Sapphire. It was nicknamed the 'Bootmaker's Foot'.

The Willows field has produced a number of sizeable, unnamed yellow-green gems between 50 and 100 carats during the last decade. An 84 carat yellow stone was recovered in 1966; a 73 carat green stone was recovered in 1975. Dozens of equally sizeable gems have also been found, many of them simply picked from the surface. Other Anakie fields also have had large stones uncovered in recent years. The Scrub Lead produced a 4 ounce yellow sapphire in 1973 and the small Divide field, upstream from the Scrub, yielded in 1975 a 4 ounce blue-yellow particolour and a 10 ounce, partly gemmy, blue sapphire.

The black star sapphires are a class of gems usually associated with the Anakie district. There have been a number of famous specimens discovered over the years. The best known of these is the *Queensland,* an enormous 1156 carat mass that was thought at first to be a 12 troy ounce piece of nearly worthless corundum. A young boy named Roy Spencer, later in life a noted gem dealer, was visiting the Reward Claim near Rubyvale in 1934. He picked up the specimen and kept it at home as a door stop for many years. Black star corundum was not readily distinguished at this time from ordinary massive corundum and was considered essentially worthless. A visiting Sydney buyer to the Anakie fields later offered a few pounds for it but was refused. The specimen was later sold to the Kazanijian Brothers Lapidary firm in Los Angeles. The rough mass was cut into a 733 carat black star sapphire, more than 200 carats heavier than the famed *Star of India.*

The most renowned group of Australian star sapphires is undoubtedly the carved 'Heads of Presidents' series undertaken by N. Maness and H. Derian under the supervision of the Kazanijian lapidary firm. The four rough pieces of blue to black star sapphire utilized in the carving project averaged about 2.5 inches long, 2 inches wide and as deep. Three of these giant stones came from the Scrub Lead, and the fourth from the Iguana Flat field. The head of Abraham Lincoln is a blue star stone weighing 2302 carats rough and 1318 carats finished weight. The head of Dwight Eisenhower is a black star stone, weighing 2097 carats rough and 1444 carats finished. The head of Thomas Jefferson is a blue star-stone weighing 1743 carats rough and 1381 carats finished. The head of George Washington is a blue star stone weighing 1997 carats rough and 1056 carats finished. The most recent sizeable asteriated sapphire was found in 1973, which weighed in excess of 11 ounces.

The Willows field will undoubtedly remain the most prolific producer of unusually large stones for the near future, especially for those of yellow and yellow-green hues. With the future development of the Tomahawk Creek area, it would not be suprising to find a number of very large deep green gems on the world markets.

ECONOMIC VIABILITY OF THE ANAKIE DISTRICT: A COMMENT

The Australian sapphire mining industry faces two serious economic crises. The mining claims in Queensland are restricted in size to limit the viable operations to a two or three man partnership. The Scrub Lead claims, for example, are limited to a maximum of three acres. This normally contains enough reserves for three of four years of production. The laws are designed to favour the 'independent' mine operator and to prevent the monopoly of the industry by large, well-financed syndicates employing dozens of men and innumerable pieces of mechanized equipment. This latter approach dominates the fields in New South Wales. Neither approach seems satisfactory. The small producer in Queensland is rapidly facing a land squeeze. There is considerable sapphire bearing land, more than 100 000 acres, remaining largely unworked in Queensland, but most of it is either too isolated or patchy to permit effective mechanized mining, or the land is restricted against mechanized mining in favour of hand-excavated trenches and shafts for the 'tourists' or casual prospectors, who are loath to see the areas declared commercial districts. New regulations (1976) would allow hand operators to confine their excavation to about one-quarter acres, while the machinery operators would be restricted to a four acre area, but open up grounds previously zoned against commercial development. Nevertheless, the over-mechanization in adjacent New South Wales is frequently responsible for flooding the market with an oversupply of gem material and promoting frequent recessions in the industry. Many of the large syndicates operations at best are being utilized at only partial capacity or at worst have been forced into only intermittent production.

REFERENCES

Robertson, A. (1974). Preliminary geological report on the Anakie mining field. *Geol. Surv. Queensland. Rec.*, **18**, 1-11.

Webb, A., McDougall, I. (1968), The geochemistry of the igneous rocks of eastern Queensland. *Jour. Geol. Soc. Aust.*, **15**, 313-46.

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ASSOCIATION NOTICES

GIFTS TO THE ASSOCIATION

The Council of the Association is indebted to the following for their gifts:

Mr H. Alexanian, Cairo, Egypt, for a parcel of rough pieces of peridot from the Isle of St John.

Mrs Joan Bass, Deal, Kent, for a piece of amber containing a number of interesting inclusions with attractive shapes.

Mr D.B. Hoover, F.G.A., Denver, Colorado, U.S.A., for three pieces of uncut material and one cut and polished stone weighing 1.90 ct of anorthite from Great Silkin Islands, Alaska, U.S.A.

Mr R.W.K. Mackenzie, Salisbury, Rhodesia, for one set of Rhodesian stamps (1c, 3c, 4c, 5c and 7c) featuring gemstones—morganite, amethyst, citrine, blue topaz and garnet.

Mr E.A. Thomson, London, for one GGG cut stone weighing 2.12 ct.

NEWS OF FELLOWS

On the 16th September, 1978, Mr Peter G. Read, C.Eng., F.G.A., gave a talk on 'New Gemmological Instruments and Techniques' to the Wessex Branch of the N.A.G. in Bournemouth, followed by a demonstration of a selection of reflectivity meters, and on 1st October, 1978, he gave a talk on 'Automatic Weighing and Sorting of Rough Gem Diamonds' to the Deutsche Gemmologische Gesellschaft during their Second Technical Meeting 1978 at Idar-Oberstein.

Dr Stanley Holgate, F.G.A., is again taking classes in the 1978/79 diamond course at Central Liverpool College of Further Education.

Mrs Sheila J. Lewis, F.G.A. and Mr Michael J. O'Donoghue, M.A., F.G.S., F.G.A., gave a course entitled 'Synthetics Simplified' at Harrow College of Further Education on 10th November, 1978. A wide variety of set pieces was shown and members were invited not only to identify the stones but also to value the pieces. In some cases they were asked to estimate weight and value loss in re-cutting. Materials just entering or about to enter the jewellery area (including a crystal of synthetic gem-quality diamond) were also shown, along with a set of slides depicting important features of man-made stones.

Mr M.J. O'Donoghue spoke to the Tunbridge Wells and Tonbridge Branch of the N.A.G. on the 19th October, 1978. The subject was 'Exploration for gem materials' and the talk was illustrated by specimens.

MEMBER'S MEETINGS

London

On Wednesday, 11th October, 1978, M. Pierre Gilson gave a talk at the Geological Museum Cinema Theatre, South Kensington, entitled 'Precious Stones of the future from the Laboratory'. A full report of the talk will appear in a future issue of the *Journal.*

Midlands Branch

On the 22nd September, 1978, Mr Alec Farn, F.G.A., gave a talk on carbonate gems.

On Friday, 20th October, 1978, Mrs Mary Salloway, F.G.A., gave an illustrated talk entitled 'Gemmological Travels'.

On Friday, 17th November, 1978, Mr Sid Tisdall, F.G.A., gave a talk entitled 'Tisdall on Gems'.

All three talks were given at the Royal Institute of Chartered Surveyors Headquarters, Birmingham.

North-West Branch

On Thursday, 7th September, 1978, at Church House, Hanover Street, Liverpool, 1, Mr Roy Reid gave an illustrated talk on the subject of pearls.

The third Annual General Meeting of the Branch was held at Church House, Hanover Street, Liverpool, on 12th October, 1978. The following officers were re-elected: Mr H. Eakins, F.G.A., Chairman; Mrs D.M. Brook, F.G.A., Secretary.

South Yorkshire and District Branch

A meeting was held on the 2nd November, 1978, at the Sheffield City Polytechnic, when Mr Peter G. Read, C.Eng., F.G.A., gave a talk on 'Diamonds', covering formation, mining and recovery, sorting, polishing and grading of gem diamonds.

COUNCIL MEETINGS

At a meeting of the Council held on Wednesday, 20th September, 1978, at Saint Dunstan's House, the following were elected to membership.

FELLOWSHIP

Athiniotaki, Vassiliki, Athens, Greece. 1978
Beach, Rowan M., London. 1978
Berry, Elizabeth K., Melbourne, Vict., Australia. 1978
Bogollagama, Rarindra C. B., Kurunegala, Sri Lanka. 1978
Boles, Julian D., London. 1978
Dillmann, Rolf, Berne, Switzerland. 1978
Dunn, Brian R., Crawley. 1978
Faulder, John A., Purley. 1978
Ghaswala, Sudhir R., Bombay, India. 1977
Golbey, Terence M., Harrow. 1978
Hammond, Glenys M., Barnet. 1978
Hailey, Robert J., New Malden. 1978
Haugh, Breda M., London. 1978
Hiscox, Peter C., Solihull. 1978
Houlgrave, Peter B., Rickmansworth. 1978
Jamieson (née Fish), Lorraine A., London. 1974
Jerome, Philip, Woodford Green. 1978

Jobin, Marc P. B., Henley. 1978
Keast (née Jefferson), Barbara J., Lower Kingswood. 1976
Lyall Grant, Ian H., Dartmouth. 1978
Miller, Neil, London. 1978
Turner, Michael J., Sheffield. 1978
Weissler, Chaggai, London. 1978
Wilson, Philip, Newcastle-upon-Tyne. 1978

TRANSFERS FROM ORDINARY MEMBERSHIP TO FELLOWSHIP

Barcham, Kathryn L., Hong Kong. 1978
Bennett, Russell K., Winchcombe. 1978
Bramwell, Peter, Durham. 1978
Busaracome, Suwin, Khon Kean, Thailand. 1978
Chang, He O., London. 1978
Crawford, Hugh B., Kirkcudbright. 1978
Daniels, Brian R., Dunedin, N.Z. 1978
Davis, Jonathan V., Edgware. 1978
Dominguez Mondelo, Segundo, Oviedo, Spain. 1977
Dougan, Patricia M. S., Nairobi, Kenya. 1978
Duckworth, Andrew S., Bolton. 1978
Emslie, Iain A., Bromyard. 1978
Faiz, M. H. M., Colombo, Sri Lanka. 1978
Fennessy, Sean, Paris, Tex., U.S.A. 1978
Gianforte, Carmen A., Sarasota, Fla, U.S.A. 1978
Grant, John W., Milledgeville, Ga, U.S.A. 1978
Gryg, Bessie, Hilton, W. Australia. 1978
Hashimoto, Mieko K., Yokohama, Japan. 1978
Healey, David, Hong Kong. 1978
Heatlie, James W. M., Edinburgh. 1978
Henniker-Heaton, Gay D. A., Cape Town, S. Africa. 1978
Hitchen, Alan, Aldridge. 1978
Hitchman, Michael J., Leicester. 1978
Hoover, Donald B., Lakewood, Colo., U.S.A. 1978
Hughes, Susan M., Kowloon, Hong Kong. 1978
Israel, Nigel B., London. 1978
Jayasuriya, Ranjit L., Colombo, Sri Lanka. 1978
Kinch, John C., Morden. 1978
Krakowiak, Czeslaw, Ul. Chlopska, Poland. 1978
Lakdawalla, Noshir J., Bombay, India. 1978
Lander, Charmian E. M., London. 1978
Langoulant, Peter B., Welkom, O.F.S., S. Africa. 1978
Lowe, Sylvia J., Harrow. 1978
Martin, William J., Nairobi, Kenya. 1978
Mayling, Clifford G., Slough. 1978
Megel, Gary E., Colorado Springs, Colo., U.S.A. 1978
Moyersoen, Jean-François, London. 1978
Okano, Chizuru, Tokyo, Japan. 1978
Perrett, Roy, Manchester. 1978
Pope, Lesley J., Lymington. 1978
Ros-Jones, Catherine A., South Ascot. 1978
Seal, Richard M. P., Bridlington. 1978
Shaikh, Leela, London. 1978
Shimomura, Michiko, Tokyo, Japan. 1978
Takigawa, Junko, Kyoto, Japan. 1978
Teakle, Simon J., Lewes. 1978
Thomas, Ian, Duffy, A.C.T., Australia. 1978
Visser-Bonnmann, Maria I. A., Delft, Holland. 1978
Vollom, Paul A., Eugene, Oreg., U.S.A. 1978

Watson, John L., Bulawayo, Rhodesia. 1978

Weeresinghe, N. P. O., Ratmalana, Sri Lanka. 1978

Wong, Tak C., Kowloon, Hong Kong. 1978

Yoshikawa, Kazuhiko, Wakayama Pref., Japan. 1978

Yu, Robert M., Hong Kong. 1978

ORDINARY MEMBERSHIP

Agapiou, Andreas C., Nicosia, Cyprus.
Allen, Darold C. A., Portland, Oreg., U.S.A.
Amarasinghe, A. G. B., Ratnapura, Sri Lanka.
Angelo, Luiz, Rio de Janeiro, Brazil.
Archer, Kenneth A. G., London.
Arla Pont, Antonio, Barcelona, Spain.
Ascher, Claude D., Montreal, Que., Canada.
Atlas, David S., Philadelphia, Pa, U.S.A.
Attanayake, Asoka, Pasyala, Sri Lanka.
Austin, Kenneth N., Sumter, S.C., U.S.A.
Barbosa, Jose E. C. A., Madrid, Spain.
Bargilis, Christos, Limassol, Cyprus.
Barkir Marikar, Mohamed, Harrow.
Behne, Bernhard H., Ottawa, Ont., Canada.
Berent, Stephen V., Geneva, Switzerland.
Berjaud, Philippe, Abidjan, Ivory Coast, W. Africa.
Bradstock, Anne M., Newbury.
Bramley, Charles H. V., Nottingham.
Brown, Douglas R., St Helier, Jersey.
Bryant, John R., Scottsdale, Ariz., U.S.A.
Bucolt, Christine, Milwaukee, Wis., U.S.A.
Buhl, Robert A., West Vancouver, B.C., Canada.
Burns, Karen F., Albuquerque, N. Mex., U.S.A.
Butterfield, Ernest B., Albuquerque, N. Mex., U.S.A.
Bylander, Liliane D., Sigtuna, Sweden.
Carpenter, Linda S., Durango, Colo, U.S.A.
Castanera Rodriguez, Luis, Barcelona, Spain.
Cattni, Naginchendra J., Nairobi, Kenya.
Chan, Bun Yuen, Kowloon, Hong Kong.
Chan, Chung Chee G., Hong Kong.
Chan, Therese K. S. C., Hong Kong.
Chappel, Sharon, Salisbury, Rhodesia.
Charlesworth, Anthony R., Southport.
Cheng, Kwan To R., Hong Kong.
Chilvers, Anthony C., Chigwell Row.
Chin, Chong-Meng, Singapore.
Chow, Peter S. C., Hong Kong.
Colonica, Nancy L., Santa Monica, Cal., U.S.A.
Cousins, Nigel T., Deal.
Currie, Spencer J. A., Manurewa, N.Z.
Curry, Sonia, North Battleford, Sask., Canada.
De Graaf, Lambertus, Bristol.
Dugar, Kanak M., Bombay, India.
Dupuis, Ronald J. R., Toronto, Ont., Canada.
Durham, Dennis, Hull.
Dwyer, Michael G., New Town, Tas., Australia.
Ebrahim, Bilquis H., Hong Kong.
Eckermalm, Hjordis, Tumba, Sweden.
Edwards, Peter M., Aberystwyth.
Eliezri, Israel Z., Ramat Hasharon, Israel.
Epstein, Mario, Porto Alegre, Brazil.

Fagg, Primrose M., Wallington.
Fernandez, Ixidro, Madrid, Spain.
Flusser, Peter, Culver City, Cal., U.S.A.
Foakes, Margaret A., Birmingham.
French, Yuko, Bangkok, Thailand.
Furber, John M., Sydney, N.S.W., Australia.
Gabella, Laurent P., London.
Garfinkel, Derek A., Pretoria, S. Africa.
Gerber, Rolland D., Challenge, Cal., U.S.A.
Giacone, Anna G., Norwich.
Gibson, David, Scarborough.
Gleizes, Michel, The Hague, Holland.
Goby, Jacqueline A., Nairobi, Kenya.
Gomm, Elizabeth A., London.
Gordon, Clement R. I., Brisbane, Qld, Australia.
Grant, William J. C., South Shields.
Green, Richard D., Sedgley.
Greeson, Gordon, Carmel, Cal., U.S.A.
Guinn, Mack F., Houston, Tex., U.S.A.
Haagensen, Kathryn, Medway, Mass., U.S.A.
Hadden, Myra, Carlow, Ireland.
Hanosh, Pamela A., Batavia, Ill., U.S.A.
Harada, Shigeo, London.
Hardewall, Per-E, Geneva, Switzerland.
Harding, Keith J., Holden, Mass., U.S.A.
Heath, John A., Grand Bahama, Bahamas.
Hedd, Harold S. A., Washington, D.C., U.S.A.
Heeney, Barbara A., Hong Kong.
Helne, Mary K., Rome, Italy.
Henwood, Glyn A., Basingstoke.
Ho, Antonio C. J., Cebu City, Philippines.
Holcombe, Neil S., Purley.
Hung Chuan-An, John A., Taiwan.
Jeffery, Robert G., Jakarta, Indonesia.
Jennings, Harold F., Roanoke, Va, U.S.A.
Joly, François J., Champeix, France.
Jørgensen, Svend E., Nordborg, Denmark.
Kaminski, Peter E., Dollard des Ormeaux, Que., Canada.
Katsuta, Yuu, Yokohama-shi, Japan.
Keller, Peter C., Los Angeles, Cal., U.S.A.
Kelson, Anthony P., Santa Monica, Cal., U.S.A.
Kenyon, Robert V., Gladstone, Qld, Australia.
Kim, Yong K., San Francisco, Cal., U.S.A.
Khairallah, Hafez, London.
Kirkeby, Laurits, Haderslev, Denmark.
Klages, Helen, Orlando, Fla, U.S.A.
Kuranuki, Yoshinori, Tokyo, Japan.
Larcombe, David B., Wincanton.
Lau, Theodora A., Hong Kong.
Leeds, Paul, Highland Park, Ill., U.S.A.
Le Mon, Marie, Denver, Colo, U.S.A.
Levine, Leona R. B., Norwich.
Liberatore, Paolo, Rome, Italy.
Lien, Jan P., Norrkoping, Sweden.
Lim, Boon C., Malacca, Malaysia.
Lim, Kathleen A. L., Perak, W. Malaysia.
Lindley, Michael P., Edgware.
Liu, Chie M. M., Den Bosch, Netherlands.
Lum, Koke C., Kuala Lumpur, Malaysia.
Marques da Silva, Francisco, Lisbon, Portugal.
Marques da Silva, Nair, Lisbon, Portugal.
Matsuda, Haruyoshi, Kobe, Japan.
May, James W., Greenford.
Meacham, John F., Sooke, B.C., Canada.
Moffatt, Kathleen G., Ottawa, Ont., Canada.
Moore, Paul R., Frimley.

Morse, Robert A., Enfield.
Mozaffarian, Simin, New York, U.S.A.
McCallum, Marcus A., Newbury.
McKenzie, Alastair J., Paisley.
McMordie, Ken R., N.E. Calgary, Alta, Canada.
Nicita, Domenico, Milan, Italy.
Nieto Reynoso, Luis, Barcelona, Spain.
Oakley, Norman S., Salisbury, Rhodesia.
Obayashi, June T., Hong Kong.
Olpherts-Forrester, Richard W. G., Brighton.
Osborne, John, Canterbury.
Ovitigala, Mangalika S., Kadawata, Sri Lanka.
Ow, Yue Heong, Singapore.
Packman, Joseph A., Willowdale, Toronto, Canada.
Padley, David J., Chester.
Pantos, Konstantin, Eskilstuna, Sweden.
Pattni, Aruindkumar, London.
Pattni, Shashikant, Loughborough.
Peattie, Andrew, Singapore.
Penwell, G. Norman, Dowell, Mass., U.S.A.
Perrella, Antonio, Benevento, Italy.
Peyronel, Giorgio, Milan, Italy.
Pilbrow, Ian J., Gisborne, N.Z.
Pittock, Hugh R., Colorado Springs, Colo, U.S.A.
Poff, Stephen G., Invercargill, N.Z.
Potgieter, Sandra L., Pietermaritzburg, S. Africa.
Pridan, Gad, Antwerp, Belgium.
Quinn, Kathryn, Dublin, Ireland.
Rajab, Jehan S., Kuwait.
Raniga, Dilip R., Nairobi, Kenya.
Raniga, Umesh C. G., Sigatoka, Fiji.
Rastall, Mirhane, Southwell.
Reinhardt, Annie, Geneva, Switzerland.
Renel, Ronald J., Bishopstoke.
Rhoades, Emily M., Calgary, Alta, Canada.
Ricci, Sandro, Rome, Italy.
Ridding, Michael J., Banff, Alta, Canada.
Rimmer, Peter, Harrogate.
Roos, Raimo H., Nairobi, Kenya.
Sakata, Taketoshi, Tokyo, Japan.
Sandefer, George H., Gainesville, Fla, U.S.A.
Sanders, Mark J., Wellington, N.Z.
Sanz Balague, Joaquin, Barcelona, Spain.
Schwieger, Rolf, Ratnapura, Sri Lanka.
Shamdasani, Ramchandra H., Hong Kong.
Shami, Farouk Y., Jeddah, Saudi Arabia.
Shams, Dunia M., Banbury.
Shelemay, Aviva, London.
Sherwood, Stephen L., Nottingham.
Sito, Wah, Singapore.
Smith, Brandon C., Karlsruhe-Durlach, W. Germany.
Spence, Lynette M., Hong Kong.
Stevens, Graham W., Hambledon.
Stone, Frederick J., Carshalton.
Stratford, Helen M., Forrestfield, W. Australia.
Styles, Sidney B., Kenilworth.
Subky, Thaha A. M., Colombo, Sri Lanka.
Subramaniam, Manoharan, Virginia Water.
Sweeney, Patrick J., Amsterdam, Holland.
Thomas, Michael A., Salisbury, Rhodesia.
Tinkler, Wilfred, Toronto, Ont., Canada.
Ueda, Kokichi, Osaka, Japan.
Uvenhoven, Elvira, Nairobi, Kenya.
Warren, E. William, Leesburg, Fla, U.S.A.
Weinberg, Joan, London.
Welmerink, Edith C., Aadorp, Holland.
Whibley, Alan K., Tonbridge.

Williams, Michael, Ryde.
Wood, Barbara A., Amersham.
Yee Yung Shing, Jimmy, Singapore.
Yeung, Raymond K-K., Kowloon, Hong Kong.
Young, Gerald G., Dunedin, N.Z.
Young, Helen D., Dunedin, N.Z.
Zimmermann, Ursula T., Kowloon, Hong Kong.
Zoll, Harry F., Medford, N.J., U.S.A.

At a meeting of the Council held on Wednesday, 1st November, 1978, at Saint Dunstan's House, the following were elected to membership.

FELLOWSHIP

Andersen, Henrik, Copenhagen, Denmark. 1978
Anverally, Fahemida Z., Colombo, Sri Lanka. 1978
Cassidy, David F.F., Alfrick. 1978
Davies, Robert I., Coventry. 1978
Diggle, Anna S., London. 1978
Galasko, Gail T.F., Johannesburg, S.Africa. 1978
Glaze, Barbara C., San Diego, Cal, U.S.A. 1978
Guiu Clua, Jose L., Tarragona, Spain. 1978
Gunawardena, Manel S., Colombo, Sri Lanka. 1978
Hkimian, Michael, London. 1978
Hindshaw, Judith L., Nairobi, Kenya. 1978
Houghton, Linda A., Burnley. 1978
Hysted, Anne E., London. 1978
Johnson, Marilyn E., Poole. 1978
Kanagawa, Kaeko, Osaka, Japan. 1978
Kangaasvuori, Matti J., Hameenlinna, Finland. 1978
Lammi, Lauri V., Hameenlinna, Finland. 1978
Mahaindra, Mohanraj S. Colombo, Sri Lanka. 1978
Mathiaparanam, Mathi V., Colombo, Sri Lanka. 1978
Meckoni, Harshad R., Bombay, India. 1978
Micilotta, Francesco C., Port Elizabeth, S.Africa. 1978
Moller Duran, Rodolfo, Barcelona, Spain. 1978
Moll, Salvador A.L., Calvia, Mallorca, Spain. 1978
Mouat, Susan G., Lower Hutt, N.Z. 1978
Murray, Gillian M. St.C., Inverclyde. 1978
Proctor, Sarah-Jane L., London. 1978
Rajaratnam, Evelyne V., Ratnapura, Sri Lanka. 1978
Richard, Gil Y., Chigny, Switzerland. 1978
Robins, Henry, Liverpool. 1978
Saez Perez, Maria A. Tarragona, Spain. 1978
Saito, Andrea L., Santa Monica, Cal., U.S.A. 1978
Shah, Nikunj V., Bombay, India. 1978
Shiek, Swun-Kou, Colombo, Sri Lanka. 1978
Sosna, Boris J., Wembley Park. 1978
Suren, Jane L.L., Edenbridge. 1978
Tashey, Thomas E., Santa Monica, Cal., U.S.A. 1978
Tattersall, Simon R., London. 1978
Taylor, Barbara J., Los Angeles, Cal., U.S.A. 1978
Taylor, John A., Ontario, Canada. 1978
Truman, Raymond H., Ilford. 1978
White, John P., Mansfield. 1978
Whiting, Peter J., Auckland, N.Z. 1978
Wood, Roger D., Bristol. 1978
Young, Helen M., Waltham Abbey. 1978

TRANSFERS FROM ORDINARY MEMBERSHIP TO FELLOWSHIP

Amarasinghe, Bodhipala G., Ratnapura, Sri Lanka. 1978
Currie, Spencer J.A., Manurewa, N.Z. 1978
Hallauer, Rainer, Nussbaumen, Switzerland. 1978
Mackenzie, Ronald W.K., Salisbury, Rhodesia. 1978

ORDINARY MEMBERSHIP

Aiiso, Miki, Tokyo, Japan.
Arrate Segura, Juan, Canary Islands, Spain.
Asakawa, Mamoru, Fukuoka Pref., Japan.
Axelsen, Timothy J. London.
Azimullah, Ahmad B., Singapore.
Bannon, Lewis A., Baton Rouge, La., U.S.A.
Bein, Steven, Los Angeles, Cal., U.S.A.
Bonisoli, Giovanna, Torino, Italy.
Booth, Neil, Alyangula Groote Eylandt, N. Territ., Australia.
Brazell, Kenneth B., Norwich.
Brereton, John F., Malahide, Co. Dublin, Ireland.
Celades Colom, Robert, Barcelona, Spain.
Chapman, Ernest J., Exeter.
Chesney, Hazel, Portglenone.
Chesney, William, Portglenone.
Chulani, Resham L.H., London.
Cornwell, Michael W., Hemel Hempstead.
Cracknell, John, Ryde.
Dougan, David A., Dublin, Ireland.
Douglas, Ian B., Wellington, N.Z.
Eastaugh, Roberta M.H., Kowloon, Hong Kong.
Errera, Michel G.L., Brussels, Belgium.
Gion, Yasuko O., Hokkaido, Japan.
Hanataka, Jitsuo, Hyogo Pref., Japan.
Hata, Kenichi, Koto-fu, Japan.
Hatane, Nobuo, Osaka, Japan.
Hayakawa, Chieko, Osaka, Japan.
Hinde, Rosemary J., Hong Kong.
Hiraoka, Satoshi, Tokushima Pref., Japan.
Horii, Toshiji, Hogo Pref., Japan.
Inatsugi, Shiko, Osaka, Japan.
Inenaga, Atsushi, Fukuoka Pref., Japan.
Ishiguro, Osamu, Tokyo, Japan.
Ito, Eiko, Kanagawa Pref., Japan.
Iwaguchi, Seichi, Osaka, Japan.
Joshi, Mangala V., Panaji-Goa, India.
Kagami, Kimiko, Tokyo, Japan.
Kagita, Mayumi, Kyoto, Japan.
Kajita, Motoyoshi, Shizuoka Pref., Japan.
Kajita, Yukio, Tokyo, Japan.
Kaneko, Isamu, Tokyo, Japan.
Kanesaka, Masatoshi, Chiba Pref., Japan.
Kanzaki, Ichiro, Tokyo, Japan.
Kermoal, Violette H., Buntingford.
Kibas, Masataka, Tokyo, Japan.
Kita, Masako, Fukuoka, Japan.
Kodama, Mariko S., Melbourne, Australia.
Kogai, Shozabruro, Tokyo, Japan.
Kuki, Tohru, Kanagawa Pref., Japan.
Kuroiwa, Satomi, Paris, France.
Lilley, Derek J., Windsor.
Mackechnie, Valerie J., St Albans.
Maeda, Setuko, Tokyo, Japan.
Matsubara, Hiroshi, Hyogo Pref., Japan.
Matsunobu, Hiroshi, Tokushima Pref., Japan.
Miki, Machiko, Osaka, Japan.
Mitchell, Ann V., Limuru, Kenya.
Miyahara, Reiko, Tokyo, Japan.

Miyake, Yasuhiro, Kyoto-Fu, Japan.
Mizoguchi, Toshizumi, Osaka, Japan.
Morishima, Katsusuke, Hokkaido, Japan.
Mukai, Yujiro, Yamanashi Pref., Japan.
Nakayama, Anako, Tokyo, Japan.
Ng, Shirley S-Y, Hong Kong.
Nojiri, Masatomi, Fukuoka Pref., Japan.
Nonaka, Masayuki, Kanagawa Pref., Japan.
Nozawa, Hidekazu, Shiga Pref., Japan.
Ochiai, Nobusuke, Tokyo, Japan.
Ohta, Kazou, Hyogo Pref., Japan.
Oono, Hideki, Hokkaido, Japan.
Ozaki, Naoko, Hokkaido, Japan.
Partridge, Raymond O., Wellington, N.Z.
Pattani, Narendra V., Leicester.
Pattani, Versha N., Leicester.
Reeks, Graham W., Johannesburg, S.Africa.
Ryan, Margaret E., Hong Kong.
Sacher, Leonhard K., Sinsheim, West Germany.
Saito, Masahiko, Hokkaido, Japan.
Sato, Atsuko, Tokyo, Japan.
Sato, Koji, Miyagi Pref., Japan.
Sato, Kuniko, Tokyo, Japan.
Sima, Takehiko, Tokyo, Japan.
Sugita, Tadashi, Chiba Pref., Japan.
Suzuki, Kimio, Hokkaido, Japan.
Tajika, Kazutaka, Tokyo, Japan.
Telford, Robert A., Southampton.
Tohyama, Akiko, Tokyo, Japan.
Toti, Patricia A., Cape Town, S.Africa.
Tsekouras, Dimitrios, Athens, Greece.
Tsuji, Takao, Tokyo, Japan.
Wacker, Penny Sue, Hong Kong.
Weber, Rudiger G., London.
White, Anthony F.J., Enfield.
Woodward, Paul R., Burnley.
Yamasita, Hisao, Yamanashi Pref., Japan.
Yeo, David S.C., Singapore.
Yoshida, Jyunitiro, Wakayama Pref., Japan.
Yoshida, Katsuji, Wakayama Pref., Japan.
Young, Laurie P., Auckland, N.Z.

GEM DIAMOND EXAMINATION 1978

Twenty-six candidates entered for the Association's 1978 Gem Diamond Examination, of whom fourteen qualified, one with distinction. The following is a list of successful candidates arranged alphabetically.

QUALIFIED WITH DISTINCTION

Castanera Rodriguez, Luis, Barcelona, Spain.

QUALIFIED

Alabaster, Stephen P., Birmingham.
Arla Pont, Antonio, Barcelona, Spain.
Baldock, Lynette, Neston.
Chadderton, Yvonne E., Oldham.
Clarke, Kathleen D., London.
Eakins, Harry, Heswall.
Emmanuel, Peter J., Croydon.
Gayton, Mildred P., Southport.
Havlik, Jan C., London.
Henocq, James E. R., S. Croydon.
Henocq, Rosemary S., S. Croydon.
Prats Ballester, Juana, Barcelona, Spain.
van der Meulen, Anne W., London.

EXAMINATIONS IN GEMMOLOGY 1978

In the 1978 Examinations in Gemmology, 711 candidates sat for the Preliminary Examination (420 passed), and 450 candidates for the Diploma Examination (155 passed, including 10 with Distinction).

In the opinion of the Examiners no candidate attained the standard required for the Tully Memorial Medal. The highest marks were gained by Mr Rowan M. Beach of Twickenham who deserves commendation for an excellent set of papers.

The Rayner Prize, in the Preliminary Examination has not been awarded.

The following are lists of successful candidates, arranged alphabetically.

DIPLOMA EXAMINATION

QUALIFIED WITH DISTINCTION

Beach, Rowan M., Twickenham.
Boles, Julian D., Cattistock.
Dillmann, Rolf, Berne, Switzerland.
Hallauer, Rainer, Nussbaumen, Switzerland.
Israel, Nigel B., London.
Littman, Esther P. M., Curaçao, Neth. Antilles.
Moyersoen, Jean-Francois, Brussels.
Taylor, Barbara Jean, Clinton, Iowa, U.S.A.
Whiting, Peter J., Auckland, N.Z.
Wong, Tak-Chiu, Kowloon, Hong Kong.

QUALIFIED

Amarasinghe, Bodhipala G., Ratnapura, Sri Lanka.
Andersen, Henrik, Copenhagen, Denmark.
Anverally, Fahemida Z., Colombo, Sri Lanka.
Armitage, Kevin P., Rotorua, N.Z.
Atapattu, Nirmala K., Mount Lavinia, Sri Lanka.
Athiniotaki, Vassiliki, M., London.
Attanayake, Walter, Ratnapura, Sri Lanka.
Barcham, Kathryn L., Peak, Hong Kong.
Bates, Adrian J., Sutton Coldfield.
Bennett, Russell K., Aylesbury, Bucks.
Berry, Elizabeth K., Melbourne, Australia.
Birch, John W. de Gray, Mexico.
Bogollagama, Ravindra C. B., Kurunegala, Sri Lanka.
Bou Castillo, Angel D., Almazora, Spain.
Bramwell, Peter, Durham.
Busaracome, Suwin, Thailand.
Cassidy, David F. F., Worcester.
Catala Marti, Joaquin, Gandia, Spain.
Celades Colom, Roberto, Barcelona, Spain.
Chang, He Ok, London.
Collado Gil, Tomas, Valencia, Spain.
Currie, Spencer J. A., Manurewa, N.Z.
Crawford, Hugh B., Kirkcudbright.
Daniels, Brian R., Dunedin, N.Z.
Davies, Robert I., Coventry
Davis, Jonathan V., London.
Diggle, Anna Sylvia, London.
Dillimuni, Dayananda, Colombo, Sri Lanka.
Domenech Plo, Juan, Valencia, Spain.
Dougan, Patricia M. S., Nairobi, Kenya.
Duckworth, Andrew S., Bolton.
Dunn, Brian R., Crawley.
Emslie, Iain A., Bromyard.
Faiz, M. H. M., Colombo, Sri Lanka.

Faulder, John A., Purley.
Fennessy, Sean F., Paris, Tex., U.S.A.
Fookes, Mark H., Brentwood.
Fuster Casas, Miguel, Badalona, Spain.
Galasko, Gail T. F., Johannesburg, S. Africa.
Gianforte, Carmen A., Florida, U.S.A.
Gil Garcia-Miguel, Jorge, Barcelona, Spain.
Girbes Faba, Adolfo, Valencia, Spain.
Glaze, Barbara C., San Diego, Cal., U.S.A.
Golbey, Terence M., Harrow.
Grant III, John W., Milledgeville, Ga, U.S.A.
Gryg, Bessie, Perth, W. Australia.
Guiu Clua, José L., Reus, Spain.
Gunatilake, Abaya Geetha, Moratuwa, Sri Lanka.
Gunawardena, Manuel S., Colombo, Sri Lanka.

Hailey, Robert J., New Malden.
Hakimian, Michael, London.
Hammond, Glenys M., Cockfosters.
Hashimoto, Mieko Kojima, Yokohama, Japan.
Haugh, Breda M., London.
Healey, David, Loughborough.
Heatlie, James W. M., Edinburgh.
Henniker-Heaton, Gay D. A., London.
Hindshaw, Judith L., Nairobi, Kenya.
Hiscox, Peter C., Knowle.
Hitchen, Alan, Aldridge.
Hitchman, Michael J., Leicester.
Hoover, Donald B., Lakewood, Colo., U.S.A.
Horkel, Dorothea, Vienna, Austria.
Houghton, Linda A., Burnley.
Houlgrave, Peter B., Rickmansworth.
Hughes, Susan M., Hong Kong.
Hysted, Anne E., New Eltham.
Jayasuriya, Ranjit L., Colombo, Sri Lanka.
Jerome, Philip S., London.
Jobin, Marc Paul B., London
Johnson, Marilyn E., Poole.
Kan, Neville Y. C., London.
Kanagawa, Kaeko, Osaka, Japan.
Kangasvuori, Matti J., Hameenlinna, Finland.
Kinch, John A. C., Morden.
Krakowiak, Czeslaw J., Gdansk Oliwa, Poland.
Lakdawalla, Noshir J., Bombay, India.
Lammi, Lauri V., Hameenlinna, Finland.
Lander, Charmian E. M., London.
Langoulant, Margaret J., Salisbury, Rhodesia.
Langoulant, Peter B., Perth.
Lowe, Sylvia J., Harrow.
Lyall Grant, Ian H., Kingswear.

Mackenzie, Ranald W. K., Salisbury, Rhodesia.
Mahaindra, Mohanraj S., Colombo, Sri Lanka.
Martin, William J., Nairobi, Kenya.
Mathiaparanam, Mathi Vathani, Colombo, Sri Lanka.
Mayling, Clifford G., Slough.
Meckoni, Harshad R., Bombay, India.
Megel, Gary E., Colorado Springs, U.S.A.
Micilotta, Francesco C., Port Elizabeth, S. Africa.
Miller, Neil, London.
Moll, Salvador A. L., Mallorca, Spain.
Moller Duran, Rodolfo, Barcelona, Spain.
Mouat, Susan G., Lower Hutt, N.Z.
Murray, Gillian M. St. C., London.
Okano, Chizuru, Tokyo, Japan.
Perrett, Roy, Swinton.
Pethiyagoda, Upali Kumarasane, Kandy, Sri Lanka.
Pope, Lesley J., Lymington.
Proctor, Sarah-Jane L., Guildford.
Rajaratnam, Evelyne V., Ratnapura, Sri Lanka.

Richard, Gil Y., Chigny, Switzerland.
Robins, Henry, Liverpool.
Ros-Jones, Catherine A., Ascot.
Rubesinghe, Savithri P. K., Mount-Lavinia, Sri Lanka.
Saez Perez, Maria A., Reus, Spain.
Saito, Andrea L., Santa Monica, Cal., U.S.A.
Seal, Richard M. P., Bridlington.
Seevaratnam, Nagalingam, Colombo, Sri Lanka.
Seoane Garcia, Maria E., Valencia, Spain.
Shah, Nikunj V., Bombay, India.
Shaikh, Leela, London.
Shiek, Swun-Kou, Colombo, Sri Lanka.
Shimomura, Michiko, Tokyo, Japan.
Sosna, Boris, Wembley Park.
Stanislaus, Saverimuttu J. L., Colombo, Sri Lanka.
Suren, Jane L. L., London.
Takigawa, Junko, Kyoto, Japan.
Tashey, Thomas E., Santa Monica, Cal., U.S.A.
Tattersall, Simon R., Radlett.
Taylor, John A., Toronto, Canada.
Teakle, Simon J., Lewes.
Thomas, Ian W., Brisbane, Australia.
Truman, Raymond H., Ilford.
Tubella Llurba, Carlos, Reus, Spain.
Turner, Michael J., Sheffield.
Ueta, Kouji, Osaka, Japan.
Van Den Berge, Diane M., Niedernhausen, W. Germany.
Vargas Perez, Manuel de, Barcelona, Spain.
(Verduyn) Walter, Laetitia, The Hague, Holland.
Virtanen, Anne M., Helsinki, Finland.
Visser-Bonnmann, Maria I. A., Delft, Holland.
Vollom, Paul A., Eugene, Oreg., U.S.A.
Watson, J. Lincoln, Bulawayo, Rhodesia.
Webster, Pamela R., Middlesbrough.
Weeresinghe, Nedra P. O., Kandy, Sri Lanka.
Weissler, Chaggai C. A., London.
White, John P., Mansfield.
Wilson, Philip, Newcastle-upon-Tyne.
Wood, Roger D., London.
Yamaguchi, Takashi, Osaka, Japan.
Yoshikawa, Kazuhiko, Gobo, Japan.
Young, Helen M., Waltham Abbey.
Yu, Robert M., Hong Kong.

PRELIMINARY EXAMINATION

QUALIFIED

Aasen, Signe Louise, Oslo, Norway.
Abasolo, Ander, Bilbao, Spain.
Abayasingha, Amaranath, Colombo, Sri Lanka.
Abels, Jan L., Schermerhorn, Holland.
Acheson, Jeffrey Duncan, Blairgowrie, S. Africa.
Adams, Audley Vivian, Cranbrook, Qld, Australia.
Akiyama, Masashi, Hokkaido, Japan.
Alva, Shyamala, Bombay, India.
Amoroso, Robert E., Boston, Mass, U.S.A.
Andersen, Henrik, Copenhagen, Denmark.
Andrews, Sheila Marjorie, Dalkeith, Australia.
Arnold, Martin John, Edgware.
Asagai, Osamu, Osaka, Japan.
Aspero Fageda, Carlos, Barcelona, Spain.
Aubertin-Watson, Kunigunde, London.
Auma, Richard Aol Henry, Nairobi, Kenya.
Austin, Kenneth Neil, Sumter, S.C., U.S.A.

Avasia, Rohinton Kersasp, Bombay, India.
Aye, Htun, Birmingham.
Bada-Marzo, Daniel Vicente, Valencia, Spain.
Bae, Hyung Soon, Seoul, Korea.
Bahl, Neela, Bombay, India.
Bahl, Sujata, Bombay, India.
Bailey, Rosemary Jane, Solihull.
Balague Lopez, Leonor, Barcelona, Spain.
Barker, Maxwell, Sandton, S. Africa.
Barrett, Louise A., Bowmanville, Ont., Canada.
Barthau, David Stephen, Markham, Ont., Canada.
Bawa, Mohamed Shah Nawaz Marikar, Colombo, Sri Lanka.
Beech, Trevor Alan, Blackpool.
Beevers, Jacintha Mary, Hong Kong.
Behne, Bernhard Heinz, Ottawa, Ont. Canada.
Bell, Robert Douglas, Durban, S. Africa.
Bernus Altes, Agustin, Barcelona, Spain.
Berry, Elizabeth Kate, Melbourne, Australia.
Bertrand, Sarah, Lancing.
Betterton, Natalie Ann, Chatham.
Bird, Victor Paul, London.
Blanckenberg, Antoinette, Southampton.
Boast, William Ernest, Cheadle.
Bogues, Patrick Martin, Omagh, N. Ireland.
Bokhobza, Robert, London.
Borras Torra, Ignacio, Barcelona, Spain.
Borreda Perez, Federico, Valencia, Spain.
Bouman, Els, Utrecht, Holland.
Bower, John Cyril, Singapore.
Boyd, Warren Frederick, Toronto, Ont., Canada.
Boyes, Richard William, Haydock.
Bradoch, Robert V., Tokyo, Japan.
Bradshaw, Barbara Ann, Preston.
Braine, Margaret Joan, Nedlands, Australia.
Brennan, Ranee Lilamani, Seria, Brunei.
Bresco Pont, Florencio, Barcelona, Spain.
Bridgwater, Mark, Brierley Hill.
Britland, Trevor, Johannesburg, S. Africa.
Brohier, Kenneth Gordon, West Kirby, Wirral.
Brown, Valerie Jane, Bognor Regis.
Brownlow, Arthur Hume, Needham, Mass, U.S.A.
Bucciarelli, Robert, Downsview, Ont., Canada.
Busaracome, Suwin, Khon Kean, Thailand.
Butler, Adrian Christopher, Tamworth.
Carlsson, Björn, Täby, Sweden.
Carson, Constance, Wanstead.
Cartier, Richard Harvey, Toronto, Ont., Canada.
Castello Torres, Maria Dolores, Valencia, Spain.
Chadwick, John Harlow, Clacton on Sea.
Chamberlain, Timothy Mark, Bolton.
Champaneria, Deepti Sharad, Thana, Maharashtra, India.
Chappell, David Andrew, Goole.
Charatan, Ivan Louis, Northolt.
Chawla, Gulzari, Downsview, Ont., Canada.
Cheung, Kai Yuen, Happy Valley, Hong Kong.
Chosokabe, Yukuto, Nagoya-City, Japan.
Chuc, Ruby Carrera Lowe, Hong Kong.
Chulani, Resham Lachman Hariram, Hong Kong.
Claeÿs, Olivia Elvira Eugenie, Schoonhoven, Holland.
Clarke, Francis Brian, Upminster.
Coffin, David George, Highbridge.
Collett, Richard, Cassington.

Condom Rovira, Maria Lourdes, Barcelona, Spain.
Cooper, Nicholas Tyson, Croydon.
Cornwell, Michael William, Hemel Hempstead.
Costa Campos, Ana Maria, Barcelona, Spain.
Cracknell, John, Ryde.
Cukier, Gerard, London.
Curry, Sonia A. N. Battleford, Sask., Canada.
Curtis, Malcolm David, Gosport.
DaCosta, Michael Stuart, Toronto, Ont., Canada.
D'Arcy, John Patrick, Dunlaoire, Ireland.
De La Rue, Nigel Peter, Vale, Guernsey.
Dickson, Dorothy S., Harrisburg, N.C., U.S.A.
Diggle, Anna-Sylvia, London.
Dillimuni, Dayananda, Colombo, Sri Lanka.
Dillmann, Rolf, Berne, Switzerland.
Dimtrio, Maria, Eskkstuna, Sweden.
Dolz Adell, Maria del Carmen, Valencia, Spain.
Donald, Robert Johnston, Willowdale, Ont., Canada.
Douglas, Brian Sydney, Downsview, Ont., Canada.
Douglas, Ian Barry, Wellington, N.Z.
Douglas, John James, Cardiff, N.S.W., Australia.
Dupuis, Ronald R.J., Toronto, Ont., Canada.
Ebrahimjee, Mustanseir, Harrow.
Echarri Zapiain, Maria José, Barcelona, Spain.
Eckermalm, Hjördis Margareta Eleonora, Tumba, Sweden.
Edmunds, Roger Alan, Accrington.
Eldridge, William Randle, Kerrville, Tex., U.S.A.
Escursell Pujol, Maria del Carmen, Barcelona, Spain.
Esteve Bosch, José, Prat de Llobregat, Barcelona.
Esteve Fernandez, Jaime, Barcelona, Spain.
Evans, Huw Mercer, Townsville, Qld, Australia.
Eves, Michael Sydney Harold, Nairobi, Kenya.

Fagg, Primrose Mary, Wallington.
Fairweather, Robin John, Brisbane, Australia.
Farooqi, Muhammad Atiq Alam, Rawalpindi, Pakistan.
Felani Rodriguez, Jaime, Barcelona, Spain.
Feria Aguilera, Francisco, Barcelona, Spain.
Fernandez Montiel de Prado, Oscar, Pamplona, Navarra, Spain.
Fitzmaurice, Gabrielle Mary, Roscommon, Ireland.
Foakes, Margaret Ann, Birmingham.
Franks, John Wilson, Altrincham.
Fraquet, Helen Rosemary, Frinton on Sea.
Fulwiler, Jack Henry, Abilene, Tex., U.S.A.
Furuya, Shuji, Tokyo, Japan.

Gabella, Laurent Pierre, London.
Garrigos Fernandez, Ma Asuncion, Valencia, Spain.
Garrigos Fernandez, Ma José, Valencia, Spain.
Gaudy, Monica Elisabet, Solna, Sweden.
Geikler, Patricia Jean, Richmond, Va, U.S.A.
Gillett, Christopher, Bexhill on Sea.
Glen, Jillian, London.
Gonzalez Fernandes, Inmaculada, Barcelona, Spain.
Gonzalez-Quiros Corujo, Ma Angeles, Oviedo, Spain.
Gonzalez-Quiros Corujo, Ma Pilar, Oviedo, Spain.
Good, Amanda Grahame, London.
Goonesekera, Shantilal Sudirikku J., Colombo, Sri Lanka.
Green, Edward Maurice, London.

Griffin, Catherine Elizabeth, Silver Spring, Md, U.S.A.
Griffiths, Geoffrey Edward, Grimsby.
Groenenboom, Hans Karel, Spykenisse, Holland.
Gryska, Stephanie Margaret, Worksop.
Guiu Clua, Mariano, Lerida, Spain.

Hakamada, Tetsuo, London.
Hall, Clive Denis, Edgware.
Hall, Michael D., Derby.
Hamid, Mohammed Rizavi, Colombo, Sri Lanka.
Hamilton, Hamish Donald, Burntisland.
Harada, Shigeo, London.
Harding, Roger Robertson, London.
Harker, Judith Margaret, Bradford.
Harkins, Charles Francis, Glasgow.
Harris, Barbara, Toronto, Ont., Canada.
Harris, David Kenneth, Gloucester.
Hart, Judith Elizabeth, Denby.
Hartzman, Mark Jeffrey, New York, U.S.A.
Hayashi, Hidenori, Tokyo, Japan.
Hayes, Thomas William, Sidcup.
Healey, David, Hong Kong.
Heapy, Timothy Maurice, Macclesfield.
Hemsted, Simon Garnet, Plymouth.
Hernandez Ordonez, Arturo, Valencia, Spain.
Hidaka, Masano, Silver Spring, Md, U.S.A.
Hills, Albert Edward, Leeds.
Hirst, Rosalind, Johannesburg, S. Africa.
Hochstrasser, Beat, Zurich, Switzerland.
Holdsworth, Ian, Stafford.
Hopkins, Philip Keith, St Albans.
Hopkinson, Barbara Joyce, Nottingham.
Hordyk, Robert Ernst, Schoonhoven, Holland.
Horkel, Dorothea Elizabeth Irma, Nairobi, Kenya.
Horstead, Brian Thomas, Coventry.
Howarth, Janet, Bolton.
Huby, Michael, Nafferton.
Hudyma, Robert William, Don Mills, Ont., Canada.
Hughes, Brian Richard, Nairobi, Kenya.
Huo, Bonnie Tin-Wing Kwan, Hong Kong.
Hurrell, Joanna Louise, Erdington.
Hussain, Surajul Hilmy, Mount Lavinia, Sri Lanka.

Inamdar, Geeta, Newmarket, Ont., Canada.
Ingram, Ian Stephen, Bridgwater.
Ipekdjian, Denise Virginia, Antwerp, Belgium.
Izquierdo Grasas, Jorge, Barcelona, Spain.

Jägerstig, Björn Olof, Saltsjöbaden, Sweden.
Jalaldeen, Mohamed Roshan, Dehiwela, Sri Lanka.
Janse, Robin, Toronto, Ont., Canada.
Jayawardena, Palihawadana Arachchige J.L.P., Colombo, Sri Lanka.
Jealouse, Roy George, Crewe.
Jensen, Edna, Huddinge, Sweden.
Jhaveri, Mahendra Manmohandas, Bombay, India.
Jibiki, Emiko, Tokyo, Japan.
Jonani, Jacob Evans Ondeuo, Nairobi, Kenya.
Jones, Edith Winifred, Peppermint Grove, Australia.
Jones, Gordon, Hounslow.
Jones, Jeffrey Malcolm, London.
Jonestrand, Helene, Johanneshov, Sweden.
Jovanovic, Tomislav, Birmingham.
Joynt, James, Hereford.

Kämäri, Arvi Nestori, Alvettula, Finland.
Kawakami, Sumiyo, Osaka, Japan.
Kayman, Shelley Naomi, London.

Keating, Molly Imelda, Nairobi, Kenya.
Kemp, Roy E.H., Farnham.
Kendall-Smith, Stephen, Beaconsfield.
Kessler, Paul, London.
Keydar, Susan, London.
Kimura, Shinichi, Kyoto, Japan.
Kimura, Takashi, Tokyo, Japan.
Kita, Keiko, Osaka, Japan.
Klaver, Gerardus Johannes, Johannesburg, S. Africa.
Ko, Yiu Wai Richard, Hong Kong.
Kohara, Sachiko, Tokyo, Japan.
Kojima, Michinaka, Tokyo, Japan.
Kowalewsky, Adrian Paul, Hereford.
Kristensen, Jorgen Anton, London.
Kuehn, Robert Lary, Dallas, Tex, U.S.A.
Kurotaki, Akira, Tokyo, Japan.
Kuruppu Achchige, Don Edward, Pelmadulla, Sri Lanka.
Kyriacou, Mamas, London.

Lainé, Paul David, Vale, Guernsey.
Lakdawalla, Noshir Jamshed, Bombay, India.
Lane, Mark John, Mansfield.
Latham, William Gary, Manchester.
Laucher, Frank Andrew, London.
Lee, Dennis Philip, Leatherhead.
Leith-Smith, Jean Elizabeth, Sai Kung, Hong Kong.
Lemar, Desiree Racheal Bridgette, Hyattsville, Md, U.S.A.
Lemire, Flora Marianne, Toronto, Ont., Canada.
Li, Woon So, Wanchi, Hong Kong.
Lien, Jan Peter, Norrköping, Sweden.
Lilley, Derek John, Windsor.
Lindsay, Kathryn Sharon, Salisbury, Rhodesia.
Llado Badia, Carlos, Barcelona, Spain.
Low, Teck Khoon, Bombay, India.
Lurie, Joseph, Randburg, S. Africa.
McAteer, Alice, London.
McCubbin, Diane Frances, Sutton Coldfield.
Machlup, Peter Mark, Johannesburg, S. Africa.
Mackenzie, Ranald William Kenneth, Salisbury, Rhodesia.
MacKichan, Brian Somerled, London.
Mc Millan, Grace Margaret, St Lucia, Australia.
Madrenys Mur, José Oriol, Barcelona, Spain.
Madrid Safont, Isabel, Prat de Llobregat, Barcelona.
Mai, Van Lieu, Brussels, Belgium.
Martel Vilaplana, Ma Mercedes, Barcelona, Spain.
Martin, John Patrick, Nairobi, Kenya.
Mathu, Sidney Kamau, London.
Meckoni, Harshad Ramniklal, Bombay, India.
Megel, Gary Edward, Colorado, Springs, U.S.A.
Melhus, Per Kristian, Bekkestua, Norway.
Mimica, Stefano, Rome, Italy.
Minster, David, Pretoria, S. Africa.
Miura, Hiroyuki, Kanagawa, Japan.
Miyumo, Julius Blasio, Nairobi, Kenya.
Mizoguchi, Toshizumi, Osaka, Japan.
Moesker, Anneke Antje Geke Elisabeth, Schoonhoven, Holland.
Monner Dieguez, Jaime, Barcelona, Spain.
Montagu, Christopher Robert, Bournemouth.
Moore, Roderich Rudiger, Solihull.
Morimoto, Towa, Kyoto-City, Japan.
Mortimer, Paul, Harrow.
Moscrop, Laurence Brent, Kandy, Sri Lanka.
Moxon, Michael David, Palmerston North, N.Z.
Munas, Carmel Leonte, Morden.
Mungania, Charles Ndegwa, Nairobi, Kenya.
Munro, Lesly, Cowbridge.
Murphy, Mary Margaret, New York, U.S.A.

Murray-Jones, Pauline Ann, Hong Kong.

Narukawa, Yoshiko, Tokyo, Japan.
Nasser, Sahera, Northwood.
Nathanson, Daniel Philip, London.
Neo, Nobushiga, Osaka, Japan.
Nicholson, Edgar Irving, Port Elizabeth, S. Africa.
Nishino, Tomoji, Tokyo, Japan.
Nosé, Yoshishige, Nagano, Japan.

O'Donnell, Francis Xavier Desmond, Liverpool.
Ogombo, John Joel, Nairobi, Kenya.
O'Hare, Jane Kathleen, Liverpool.
Okamoto, Ichiro, Tokyo, Japan.
Okayasu, Kuni, London.
Ong, Kim Chin, Birmingham.
Onozawa, Katsumi, Tokyo, Japan.
Opere, Solomon Ben Ariko, Nairobi, Kenya.
Osborne, Annie Wai-Sou, Hong Kong.
Osborne, John, Canterbury.
Owen, Neil Trevor, Romford.
Oyugi, Joash Owino, Nairobi, Kenya.

Palmer, Joanna Grace, London.
Pastor Bernat, Francisco Manuel, Valencia, Spain.
Pattni, Pravin A. London.
Perera, Pathirage Wijitha, Colombo, Sri Lanka.
Perez Mir, Antonio, Barcelona, Spain.
Pert, John Arthur, Twickenham.
Pick, Francesca Jeanette, Sleaford.
Pickering, Caroline Ann, Nairobi, Kenya.
Pietruska, Julia Elizabeth Jane, London.
Pijnenburg de Jong, Henriette Maria Anna, Tilburg, Holland
Pladellorens Tarres, Magin, Barcelona, Spain.
Pluckrose, William Henry, Dartford.
Podsiadly, Maria Teresa, Birmingham.
Pouncey, Jean Margaret, Solihull.
Poyser, Edward Stephen, Nottingham.
Prades Tortajada, Manuel, Valencia, Spain.
Premaratne, Udeni Nimal, Colombo, Sri Lanka.
Preston, Stephen Paul, Birmingham.
Pretty, Elaine, Auckland, N.Z.
Proctor, Kevin Roger, London.
Pushon, Clayton Richard, Regina, Sask., Canada.

Quan, Theodore Guy, Don Mills, Ont., Canada.
Quero Gonzalez, Manuel, Valencia.

Raniga, Chandrakant Rugnathbhai, Nairobi, Kenya.
Raniga, Dinesh Rugnathbhai, Nairobi, Kenya.
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Rowe, Regina, Torquay.

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Sato, Yasuyo, London.
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Shelemay, Aviva, London.

Shelemay, Daniel, London.
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Sherwood, Stephen Laurie, Nottingham.
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Shimaoka, Mitsuaki, Osaka-City, Japan.
Shimomura, Michiko, Tokyo, Japan.
Shipley, Christopher Timothy, Southall.
Sibtsen, Johannes Christianus, Heerjansdam, Holland.
Sideras, Triantafilio Rose, Nairobi, Kenya.
Sierp, Marcus, Birmingham.
Siggers, Alexander Gerald, Gravesend.
Sigswoth, Trevor, Croydon.
Sinclair, Netta, Enfield.
Singleton Graham Stanley, Cardigan.
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Soleiman, Shlomo, London.
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Styles, Jonathan Appleby, Enniskillen, N.Ireland.
Stypulkowski, Lili Reine-Marie, Birmingham.
Sũne Dupre, Elisenda, Barcelona, Spain.
Swain, Anthony Philip, Llandudno.
Takahashi, Ikuo, Kyoto, Japan.
Takahashi, Junko, Saitama, Japan.
Tan, Carmela, Hong Kong.
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Tripp, Reginald Upton Gordon Howard, Hong Kong.
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Turner, Phillip John, Sidcup.
Twycross, Stephanie Jill, Kirby Muxloe.
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Uppard, John Edwin, Westcliff-on-sea.
Uren, Derek Christopher, London.
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Van Der Ree, Anne Christine, Schoonhoven, Holland.
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Venter, Raymond Vincent, Salisbury, Rhodesia.
Verma, Rajiv, Dehra Dun, India.
Vincente Picola, Marta, Barcelona, Spain.
Vives Colomer, José Maria, Barcelona, Spain.

Vonk, Philippe André Jean, Schoonhoven, Holland.
Wallooppillai, Arjuna, Colombo, Sri Lanka.
Walters, Susan Mary, Twickenham.
Walton, Betty Marlene, Toronto, Ont., Canada.
Watson, Joy Sylvia, Cottingham.
Watz, Jenny, Oslo, Norway.
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Wensley, Barrie John, Liverpool.
Wesley, Bernice Vera, Cheltenham.
West, Clive Graham, London.
Wezel, Renée, Maasland, Holland.
Whiting, Peter John, Auckland, N.Z.
Wightman, David Francis, Liverpool.
Wijeyesekera, Devapriya Chitral, London.
Williams, David Alan, Sleaford.
Wilson, Hiroko, Hong Kong.
Withycombe, Darroch Blair, St, John's, Newf., Canada.
Wong, Yuet Wah, Kowloon, Hong Kong.
Woodward, Angela Rosemary, Sheffield.
Woodward, Paul Robert, Burnley.
Woollings, Joan Emily, Toronto, Ont., Canada.
Woolnough, Michael George, Cheltenham.
Wright, Stephen Richard, London.
Yokowo, Naoya, Tokyo, Japan.
Yokoyama, Ken-Ichi, Tokyo, Japan.
Yost, Dara Elizabeth, San Diego, Cal., U.S.A.
Younghusband, Jacqueline Elizabeth, Durban, Natal, S. Africa.
Yu, Robert Miu, Hong Kong.
Yuzi, Mizuno, Nagoya-city, Japan.
Zanoon, Norfel Wazir, Colombo, Sri Lanka.
Zelley, Michael John, Bishop's Stortford.
Zimmer, Alvin Fredrick, Tucson, Ariz., U.S.A.

RESIDENTIAL GEMMOLOGY COURSES AT CHICHESTER

Mr Peter G. Read, C.Eng., M.I.E.E., M.I.E.R.E., F.G.A., F.I.S.T.C., is tutoring weekend residential courses in gemmology at the West Dean College, Chichester. The new gemmology course is an extension to the College's existing jewellery and lapidary courses and includes the principles and methods of use of gem testing instruments, the identification and testing of gemstones, the identification of diamond and diamond simulants, and related topics. Details of the course can be obtained from Miss Susan Overman, West Dean College, West Dean, Chichester, West Sussex, PO18 0QZ (telephone Singleton 301).

ROCK AND GEM HUNTING IN CORNWALL

'Yonder Towan Cornish Purpose Holidays' for 1979 (3rd March—3rd November) include nine one-week (Saturday to Saturday) 'Rock, Gem and Mineral Hunting' holiday courses, combining daily field collecting trips and museum visits, with evening lectures given by qualified visiting tutors. Full particulars may be obtained from Yonder Towan (Field Holiday) Centre, Newquay, Cornwall. (Telephone: Newquay (STD 063 73) 2756).

OBITUARY

It is with great regret that we announce the death of Mr Gordon F. Andrews, F.G.A., former Secretary of the Association, on 5th January, 1979. A full obituary notice will appear in the April issue of the *Journal.*

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