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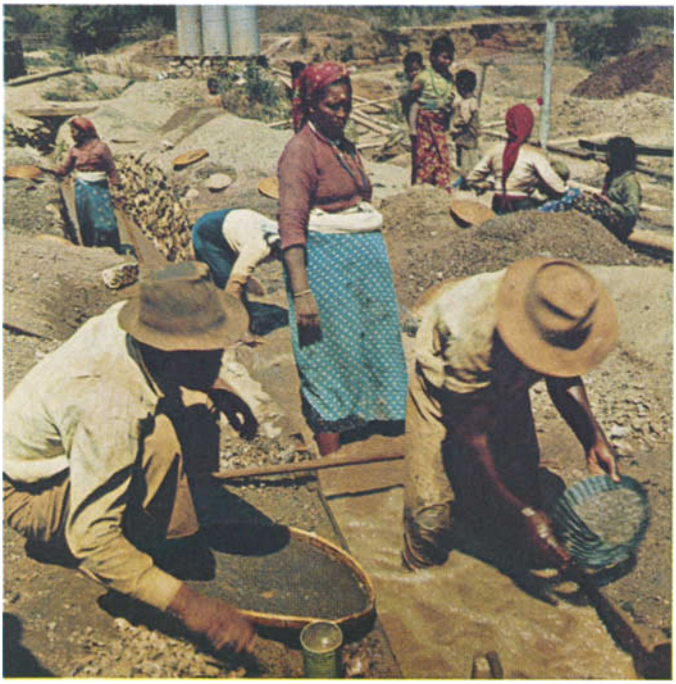

Washing and separating rubies at a ruby mine in Mogok, Burma

Photo: E. Gübelin

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THE RUBY MINES IN MOGOK IN BURMA

By E. GÜBELIN, Ph.D., F.G.A., C.G.

THE ruby mines in Burma have been known for centuries and the large mining district of Mogok above a lovely lake has always proved to be of great interest because of the wonderful rubies found there. Mogok itself is full of mysteries and whoever goes there for the first time is delighted with its beautiful streets and the soft music of the bells from the temples and pagodas. The author visited this valley for the first time three years ago, after his second stay in Ceylon, and was in no way disappointed.

The western mountainous Shan-plateau rises towards the east over the middle Irrawaddy valley; there are mountains in the north and the lake to the south. The valley of rubies is narrow and long and towards its lower end lies Mogok. It is about 700 km north of Rangoon and 150 km north-east of Mandalay, the last residential town of the Burmese kings. Only 145 km east of this town is the frontier of Burma with China. The township lies about 1500 metres above sea level and is surrounded by mountains sometimes reaching a height of 2500 metres, all covered with thick jungle. The climate is agreeable, although there is a great difference of temperature between the very hot hours around noon and the cold nights. It rains often and the rainfall during the summer months of the monsoon can reach more than 250 mm. It is very rare that the temperature during the winter drops to freezing point.

At the time of writing the visa given to foreigners does not exceed 24 hours, which makes it impossible to leave Rangoon, but before this additional difficulty arose, there were several ways of going to Mogok. Mandalay can be reached by a slow train taking two days for the trip or by a four to six hour flight by the Union of Burma Airways. From Mandalay there are again several ways of reaching Mogok. One can fly on to Momeik and if one has any friends in Mogok ask them to fetch one by Jeep. One then travels along a good mountainous road. But as it was well known that many robberies occurred at the time of the visit, the author thought it safer to use the official coach. The coach uses many dusty roads, full of ox-carts, along the Irrawaddy towards Thabeikyin. Then it crosses the Irrawaddy valley on a very bumpy road and then slowly rises on a narrow but good road through beautiful mountain country towards Mogok, where it arrives twelve hours later. Four days after the author's safe arrival three private jeeps travelling down the valley were ambushed and robbed.

There are neither hotels nor boarding houses in Mogok, and if one wants to stay in the bungalow for government officials, one has to supply one's own bed linen and either cook one's meals, or eat in one of the small Chinese stalls. The author was very lucky and was invited to stay in the house of his Burmese interpreter and agent and was thus able to take part in the daily life of the family. They were all very kind and hospitable and tried to make the visit as agreeable as possible. There are only a few streets in Mogok, the most important being macadamed and at their sides are beautiful houses. Most of these are made of wood, some using teak. In the last few years a few villas were erected from stone. Around the town and in the surrounding villages the houses are made of interwoven bamboo sticks, built on piles. These airy rooms usually form the workshop and the gems are polished here. Unfortunately only the older houses are covered with straw, tiles or brick, the newer houses being covered with corrugated metal sheets, which are not attractive. Many small shops and stalls along the two main roads form the "business quarter", where one can buy most consumer goods from a tea cup to a "loupe" or a washing basket made of bamboo strips to household articles made of plastic. Of the greatest interest is the "Bazaar", where there is a market every five days and the inhabitants of the surrounding districts and mountains gather in their colourful costumes to sell vegetables, herbs, baked articles, tobacco and all sorts of home-made goods and who seldom return home without looking at, or even buying a few rubies. One must also mention the water-works and sewage arrangements, which work very well, and a very old-fashioned electricity plant which sells its electricity (220V) during the day to the mines and only after 6 p.m. to the townspeople, so that one can only then use the electric light. It is then used so much that the voltage falls from 220 to 110, so that one can hardly read. The foreign visitor is well advised to take a torch along together with a sufficient supply of batteries. There is no official waste disposal, so it is not surprising that there are often cases of malaria, dysentery and typhoid. The visitor must be careful in every respect. Apart from various nature-cures and quacks, there are also a few good doctors in Mogok, but hospitals, old peoples' homes and orphanages are not necessary since all these services are given by the family. There is always much life in the streets. Most goods are still transported on a shoulder-yoke or by ox-cart. There are many bicycles, and few cars and vans. The richer mine owners have land-rovers, and there are various jeeps which are used as taxis to which transport people to the surrounding villages.

Although the whole district is only a few square miles and Mogok itself only a small town, there must be about 20,000 people living in the district. The inhabitants are very mixed: apart from Burmese, there are Ghurkas, Hindus, Chinese and the romantic looking people from the Schan tribe. On each side of the street, in market places, in front of the tea-houses and bazaars, there are small groups of squatting women showing each other small brass bowls with rubies. One soon has the impression that the whole population from the earliest youth to the oldest age is involved in the prospecting, production and sale of rubies, whether as a mine worker, mine owner, gem merchant, polisher, host or tradesman. The people are very friendly, helpful and open: the few that speak a foreign language like to talk to visitors.

The famous ruby mines are secondary deposits, that is, they have been brought down into the valley from decomposed primary deposits. Such alluvial deposits are found in most of the smaller and larger valleys of the district, and everywhere there is prospecting for rubies. Mogok lies in the lower part of a larger valley on what used to be the most profitable deposits. When the population

Fig. 1. *Women ruby dealers showing each other their goods.*

Fig. 2. *Large water reservoirs in a mine field in the valley of Mogok.*

Fig. 3. *Shallow mine with a small bamboo bridge showing a lever arrangement.*

realized this, they moved their township to the lower part of the hills so that they could mine the rubies in the valley. When there were no more rubies, the craters which were formed by the mining operations filled with water, forming the lovely Mogok lake, which to-day beautifies the valley. In the neighbouring valleys the yellow clay is full of holes, and looks like a volcanic field of craters.

Prospecting and mining licences are only given to Burmese. The owner who wants to open a small mine registers his intention with the district officer, who examines the claim. Depending on the size of the mine, the owner pays several hundred Kyats (1 kyat = 1s. 6d.) for the licence. The licence for a so-called machine-mine is about 1000 kyats. The licence cannot buy the land, which is only rented from the state for mining purposes. When mining operations are finished it is not necessary to fill in the craters and holes, contrary to practice in Ceylon. This is a defect in the law and leaves the valleys full of holes and unsuitable for agricultural purposes. For each employee the mine owner pays a monthly licence fee of 10 kyats and as a receipt obtains a small oval disc, which each miner must wear to facilitate inspection. Most mining is still done by hand with the help of water—without the local water supplies the mining could not have developed as it has.

Most of the stones are found in open-cast mines. The small narrow holes are widened with sticks and spades. The earth is put into woven bamboo baskets and lifted to the surface where it is emptied onto a heap. When the ruby-containing-the "byons"-layer is reached, a "byon" heap is started, whence the earth is transported to the washing hole. Within a few weeks the small hole has become a mine of about 100 metres in diameter, perhaps reaching a depth of 20-30 metres, when the water level is reached. From a neighbouring water tank water is hosed over the "byon" layers. The softened earth is pumped, either electrically or with a petrol engine, to a washing plant built from wood or stone and measuring perhaps four square metres and consisting of a basin which is about ½-1 metre deep and from which there is a step-like arrangement of "locks". Usually the earth is mined during the afternoon and then worked and washed the following morning, so that the gem-containing "byon" earth can settle during the night. In the morning clear water is pumped into the basin, washing away the top layer of waste earth, whilst the heavier gems settle in a series of boxes. During this time the washers stir up the deposit, so

Fig. 4. *Washing and separating the rubies.*

Fig. 5. *The lower part of the valley is combed with many trenches in which the "byon" containing the rubies is carried and deposited in the lowest part of the mine.*

Fig. 6. *View of the upper part of the so-called "machine-mine" in which a pump raises the softened "byon" or the washing water to the working level.*

FIG. 7. *Preliminary washing.*

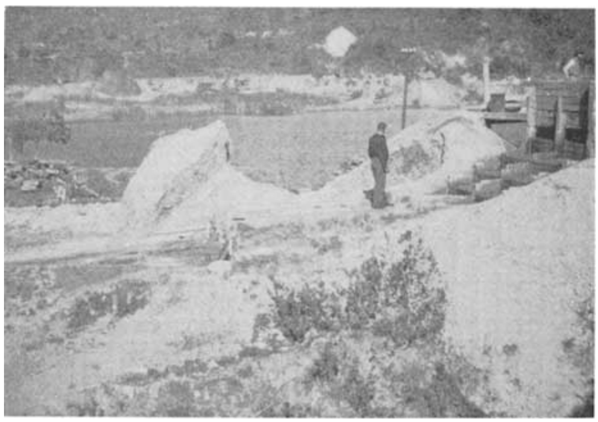

FIG. 8. *Step-like arrangements of "locks" in the washing process.*

FIG. 9. *Another view of the washing.*

FIG. 10. *Rubies being washed in the lowest "lock".*

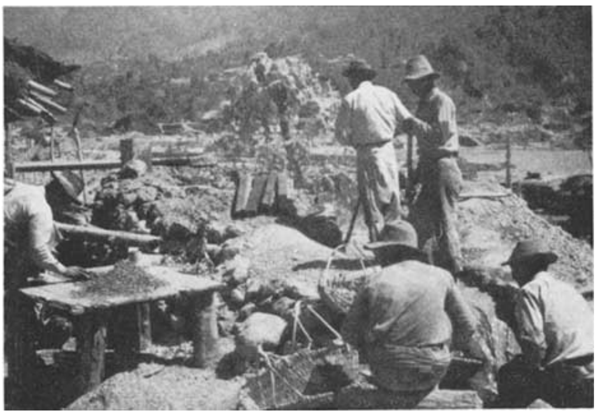

FIG. 11. *A smaller working arrangement. The two men on top are roughly sorting the stones, the two lower men are washing the rubies and at the table sits the sorter.*

FIG. 12. *A sorting table surrounded by children who all help.*

FIG. 13. *Deep mines in the dry earth of Kathe lying very near to each other.*

FIG. 14. *The product of a deep narrow mine being winched up.*

FIG. 15. *Waste earth being built into a "slack" heap, ruby containing "byon" is carried to smaller heaps.*

that it may be rinsed with water and carried away to a lower "lock". Starting at the top the washers scoop some of the deposit up with their hands and shake it in a rough wire-mesh sieve to get rid of the large stones, the finer and medium deposit is then put into a shallow basket, from which the so-called "therbat" is put on the sorting table. The sorter, who in the case of small mines is the same man as the owner, combs through the "therbat" with a wooden comb and picks out the rubies. Just as the washing of the deposit below the last "lock" is free to everybody, so friends and relatives look through the waste from the sorting table either without remuneration or against a small fee. In this way all the innumerable small rubies which are used for adorning pieces of jewellery are won.

About 10 kilometres west of Mogok, in the small townships of Kathe and Kyatpyin, the valley is very dry and water not abundant and thus a new method of mining has developed. Parallel to each other long narrow trenches are dug, which are often connected under the surface by horizontal channels. These workings are usually co-owned by three to five men. At the opening of the shaft one or two winches are erected which help to bring to the surface the baskets which have been filled by a miner with the gem-containing earth or "byon". The last man carries the basket either to the "slack" heap or the "byon" heap, which grows during the dry months from October to the end of April, and then is washed and worked during the summer monsoon season. Characteristic of the whole district is that there are no specially rich localities, but the precious stones can be found anywhere or everywhere, in a brook, in a rice field or in a mine. Ruby is the most looked for stone, but not the most common gem; there is one ruby found to every five spinels. There are fields which yield mainly rubies, others spinels, or moonstones or sapphires, and it has been known that certain mines produce certain colours, but in one basket of "byon" all types of unusual gems can be found. For the gem collector and gemmologist the mines of Mogok are a real paradise, for apart from rubies, spinels, sapphires, moonstones and peridots, which are found in quantities, one also finds almandine garnets, amethysts, beryls, chrysoberyls, spessartites, topazes, tourmalines, zircons and citrines and mentioning some rare gems the following have been found as well: amblygonite, blue apatite, danburite, diopside, disthene, enstatite, violet fluorite, fibrolite,

Fig. 16. *At the side of the mine field Kanesima women deal in small rubies.*

Fig. 17. *Small rubies on thin sticks are worked into cabochons.*

Fig. 18. *Larger cabochons are worked on grinding wheels covered with carborundum.*

iolite, kornerupine, scapolite, titanite and others. The inhabitants of the districts know very little of these various gem types, and it is not surprising that one is often offered these stones under a wrong name. For instance, pink scapolite is known as pink moonstone and every yellow to brown stone as topaz. But if one knows anything about these stones, and in addition even possesses a refractometer, one can enrich a collection with many beautiful and rare specimens. There is trade with rough rubies everywhere, along the mines, along the streets, in the bazaars, in the market places, in the back yards, and, of course, in the houses of the mine owners and gem dealers. Because there are always people looking on, a sign language using the fingers has been developed, with which one can express all numerals. Offers and acceptances are communicated under a cloth or in the wide sleeves of the engyis worn by the natives, so that none of the onlookers and strangers are any the wiser.

A large part of the gems found in Mogok and surrounding district are cut locally. Taking into account the very primitive grinding wheels the quality of the produced goods is fairly good, and quite usable according to Western standards. Depending on the resulting style the cutter chooses his tools and his method. Small stones, which are made into small cabochons, are usually worked by children and young girls. The rough stones are fixed onto a bamboo stick; five to ten of these sticks are held in each hand, then held onto a horizontally rotating grinding wheel. It is most instructive and enjoyable to watch how the hands lead the sticks on the wheel and how a few minutes later a number of cabochons are produced.

Large cabochons and star-stones are produced by men who use special grinding boards with a carborundum covering; these boards have grooves of various widths in them which are also covered with various grades of carborundum. The rough stones are again fixed on bamboo sticks, which are pushed forwards and backwards in these grooves using finer and finer carborundum until the finished cabochons show a smooth highly polished surface.

The smaller facets are made by young boys, girls and women. The stones are fixed in a simple dop and the first facets are ground roughly on a carborundum board. After they have received their first rough shape they are fixed again onto sticks which can be held

FIG. 19. *The stone is rough-ground while being held in a primitive dop and rubbed on a carborundum-covered surface.*

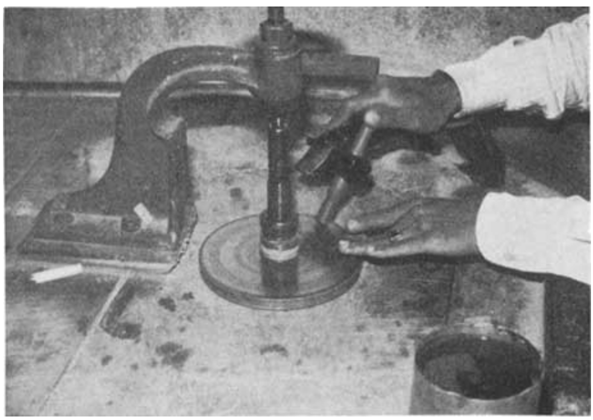

FIG. 20. *The polisher uses a very simple dop and sets the rough ground stone onto the grinding wheel.*

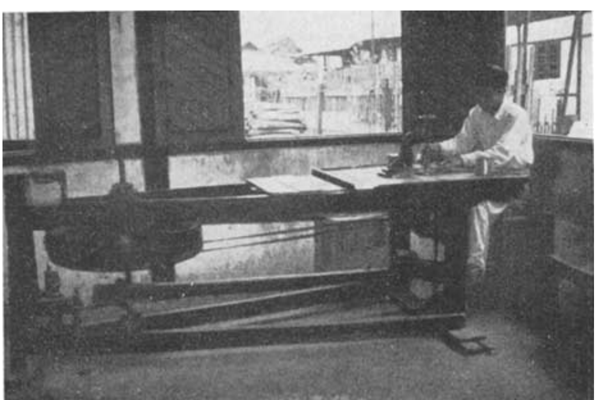

FIG. 21. *Typical grinding wheel in Mogok. The wheel is rotated quickly by a treadle arrangement.*

in a simple dop. The facets are then cut and polished on horizontally rotating grinding wheels, and from time to time checked by eye to ensure that they are even.

The large faceted stones are produced by a similar method, but only older and experienced cutters are allowed to make them. The advice of these cutters is welcomed by owners and dealers alike. The grinding wheels are rotated with the feet by a sort of treadle arrangement, as the old-fashioned electricity plant is not powerful enough to work all the wheels. Special large crystals are sometimes sawn before being cut and polished. In the whole of the district there is only one specialist who does this; he uses a machine which looks similar to an old sewing machine. It has a horizontal spindle on which a diamond sawing wheel is rotated by a foot pedal. Although the tools of their trade are primitive, most cutters are masters of their craft and know how to obtain the best results from an irregularly coloured stone, or how to place inclusions or cracks in the stone into a position where it is extremely difficult to see them. Often stones with cracks are put into pea-nut oil so that the cracks become invisible. It is also amazing how the Mogok cutters produce stones with such even facets and regularity of geometrical planes. All these points show that their technical knowledge is greater than that of the Ceylonese cutters.

The buying of gems in Mogok is a time-consuming but very interesting business, which needs absolute concentration and denial of western habits. It takes a long time for one to meet the people who sell the goods one wishes to buy. Once one has found them it needs a lot of patience until the stones are shown. Of the thousands of stones which are shown, only a few are of really good gem quality. Doubtless the families keep the very best stones to themselves and events in Burma have shown the wisdom of this. But now and then a very fine gem is offered for sale. When the author was in Mogok, only after days of bargaining did the most important dealers show him a really good ruby or sapphire. The author was thus very impressed by the rarity and value of the finest gems. Most dealers show many lots of smaller and medium as well as a few larger rubies, but these lots are only shown one at a time, and much time and patience is needed to look through them all and wait for the appearance of better stones. The deal is never finalized without the wife giving her consent. The women of Mogok not only wear the jewels, they are also important in the mining, production and trade. In fact, the female gem merchants in Mogok are much tougher than the men and understand the fine qualities especially well.

The unit of weight is not the carat, but the Burmese rattie (1 rt = 0·90 cts). The price of fine rubies has risen very sharply during the last 15 years. This has been caused not only by the increase in rarity, but also by the purchases of Indian merchants who pay too high a price for the rubies, as they earn some money on the transaction of the rupie-kyat exchange. The inflationary and political uncertainties in Burma also play a part. The Burmese Government is nationalizing all industries and has now also forbidden private businesses such as gem mining and dealing. The gem production is guarded by the army and all gems have to be sold to the Petrol and Mineral Development Corporation. The PMDC has now tried to sell the gems on the western markets, but was unsuccessful because of the low quality offered. During the first half of last December 180 gem dealers from 25 countries were invited to an officially organized sale, but most of these visitors were disappointed because of the poor quality offered to them. Many did not purchase anything as the poor qualities cannot be resold on the western markets. It seems a pity that most important gem-producing countries have made free trading so difficult. For these countries the loss is usually only a few per cent, while the loss in the free world is quite noticeable. These circumstances do not help to make the gems any cheaper, and every jeweller who has a few fine specimens is proud of them and knows how to treasure them.

The illustrations, from photos by the author, are reproduced by courtesy of the Deutsche Guldschmiede Zeitung, Stuttgart.

A NEW HYDROTHERMAL SYNTHETIC EMERALD

By FREDERICK H. POUGH, Ph.D.

EARLY in August, at the trade show in New York, the Linde Division of Union Carbide, makers of the synthetic Linde star-sapphires, announced a wholly synthetic, hydrothermally grown, emerald now being grown in Linde's Indianapolis plant, by Dr. F. R. Charvat and E. M. Comperchio. After distributing the Lechleitner stones for a few years, Linde has abandoned the unsatisfactory coated-aquamarines in favour of a uniformly coloured stone, throughout synthetic, developed in their own laboratories by Miss E. M. Flanigen, Dr. D. W. Breck and N. R. Mumbach. Since, despite attempts at obfuscation, it is common knowledge that until now commercialized synthetic emeralds have been grown by the simpler flux-melt method, we expect to find some differences between Linde's stones and the others. However, with such brief experience with the relatively few first stones, a description of the distinctive characteristics can only note some of the present similarities and differences. We cannot be sure that evolutionary changes in Linde's procedure will not alter either or both of the major clues which can be used to recognize the present Linde stones.

The brilliant red fluorescence that is typical of synthetic emeralds has not been dimmed in the new stones: on the contrary, it seems to be intensified in the newest product. Since few natural emeralds fluoresce red, even though many show red in the emerald filter, the response to ultra-violet light is still the best indication. From a distance, and to the naked eye, many of the new stones seem nearly flawless, but they do have inclusions which may prove to be as typical as the wisps we know in the Chatham *et al.* stones. The refractive indices of the Linde stones are in the same range as those of the natural stones. Hence, the simple clue to a Linde stone, at present, is an intense fluorescence, which is coupled with normal emerald refraction. Both the Gilson and the Chatham synthetic stones combine unnaturally low refractive index readings with strong (Chatham) or variable (Gilson) fluorescent responses.

A major, and perhaps more invariable, difference lies in the nature of the growth irregularities. For a number of years, the

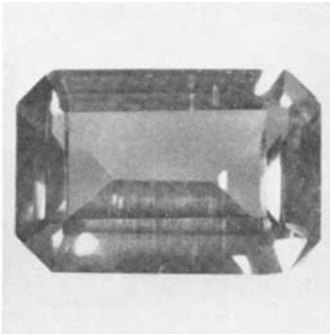

FIG. 1. *Linde synthetic emerald approximately two carat.* ×4.

"wisps" of tiny bubbles threading their way through the Chatham stones have been the dependable indication of their synthetic origin. Even the early Gilson crystals showed them, as did the Igmeralds of Hitler's day. In the Gilson crystals, which are seeded on a basal-cut and grown into very flat plates, the c-face of the crystal presents a mosaic of clear "wells", walled by veils of the tiny bubbles in a pattern that very slightly reflects the hexagonal symmetry of the structure.

Linde's experience has shown that crystals that grow from a flux-melt tend to develop as stout prisms with large flat bases. The rate of growth is a probable factor, for Chatham has found that with a somewhat slower growth, his crystals, though smaller, are better in quality and develop some pyramidal faces. Although Gilson's crystals are seeded, Chatham's appear not to be, but to be volunteer growths, for he has clusters and crusts of crystals in which there is no visible seed. The wisps tend to align themselves somewhat vertically in the crystals. Since the more desired larger stones can usually be had by cutting more parallel to the c-axis, Chatham stones are usually cut with their tables in the wrong direction for a natural emerald, and a certain amount of dichroism can be observed through the table. The early Gilson crystals seen were so flat that they had to be properly cut, with the table parallel to the base, but this had the unfortunate result of emphasizing the vertically aligned clear wells and bounding streaks of flaws. A very much better recent sample from M. Gilson shows that this has been partially eliminated in recent production: perhaps he is now growing his crystals deeper.

Linde has found that, in contrast to flux-melt experience

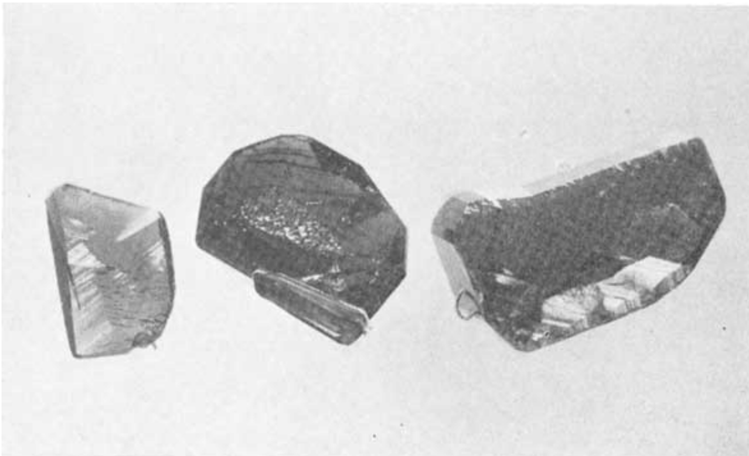

FIG. 2. *Completed hydrothermally-grown Linde synthetic emerald crystals following four growth cycles.* × 2 (*Photo Linde Co.*).

based on Hautefeuille and Perrey's pioneer work, hydrothermally grown crystals enlarge most rapidly on a pyramid face. Hence, Linde's seeds are cut at an angle to the c-axis and, as with synthetic quartz that is also grown on an oblique slice, it is almost impossible to orient a remotely hexagonal-looking crystal out of the final lump. Once it is oriented, however, it becomes possible for a crystallographer to identify a number of the common beryl forms on its surface.

The base is very easy to recognize once it has been pointed out. It makes a thin edge, but one that is marked by sharp hexagonal growth accessories. They take the form of low six-sided pyramids. The descending prism faces, now identifiable, are smoothly striated. The dominant face, however, remains the pyramid parallel to which the two sides of the slender seed plate have been sliced. This face promptly develops a very irregular pitted surface, with small pits more or less uniformly scattered over the entire surface. Visible at every growth stage, they seem to persist through the entire life of the crystal. As the crystals grow larger, the other faces (lagging directions) gradually close in, and in time the fast-growing pyramid form would disappear entirely. The reader will readily understand that the faces on a crystal are often those of the slowest growth direction, as fast growing faces eliminate themselves. One wonders

FIG. 3. *Seed plate showing rough surface following one growth cycle.* ×3 (*Photo Linde Co.*).

if Chatham might not achieve faster growth if he did seed his crystals; perhaps the slow rate he claims is partly due to the shape his crystals assume. Linde finds they can grow their crystals in a much shorter time.

Although growth is rapid, in the sealed, small, high pressure "bomb" with which Linde works, it does not continue very long before the solutions are exhausted. As a result, Linde grows its emeralds on and on, over and over again, 3 or 4 times, returning each rack of seeds to the cylinder to add additional layers and build up the thickness to a point where the original seed can be wholly eliminated in the cutting, leaving them with a stone that is all synthetic. Building sufficient thickness on the seed, without, at the same time, developing, parallel to the c-axis, one of the cracks that were troublesome to Lechleitner, and which, once started, are likely to extend out through all the growth layers, is still one of Linde's problems.

Even though a Linde stone may look nearly flawless to the naked eye, it does have inclusions that are distinctive. Even in apparently clean stones one can commonly find tiny phenakite crystal inclusions. From each there extends an elongated bubble, partially filled with liquid to make a two-phase inclusion. (Since the phenakite crystal is tightly encased and outside of the bubble, it cannot properly be regarded as a three-phase inclusion like those noted in Colombian emeralds.) Even when the phenakite is

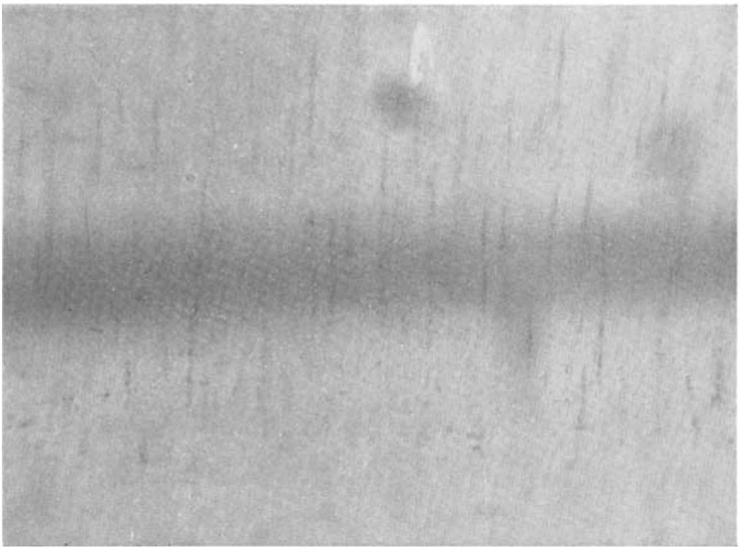

FIG. 4. *"Brush-stroke" threads which characterize the current Linde synthetic emeralds. (Photo F. H. Pough).*

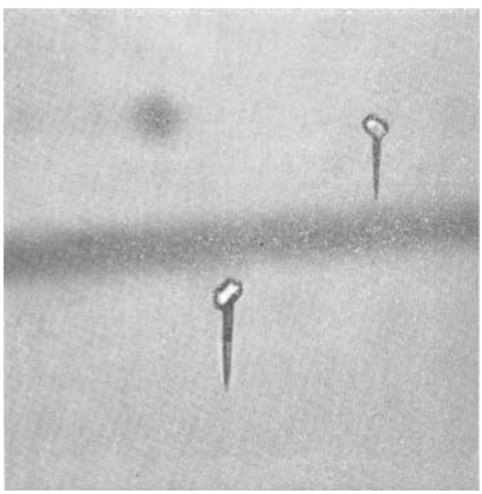

FIG. 5. *Tiny included crystal at the start of a two-phase void. Probably phenakite, its refractive index is considerably above that of the enclosing beryl. (Photo F. H. Pough).*

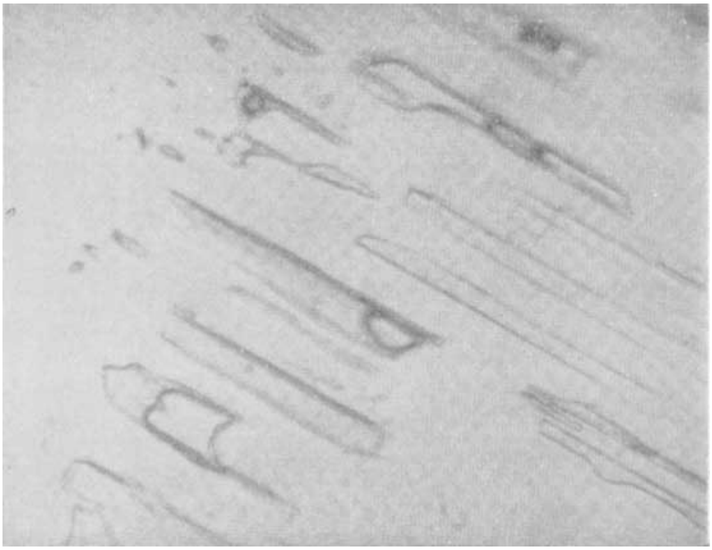

FIG. 6. *Two-phase cuneiform inclusions in Linde synthetic emerald* ×400. (*Photo Linde Co.*).

absent, there are likely to be parallel swarms of the little bubbles, which gradually taper to nothing: they have been called cuneate or cuneiform inclusions from their arrangement and shape. Lastly, the bubbles fade out into thread-like markings that continue through the stone, like a series of parallel brush-strokes.

The brush-stroke pattern seems to be characteristic of present production. It can probably result from the numerous pits on the growing surface. Since these are bounded by crystal "faces", each direction has a different affinity for the various ingredients, particularly the impurities, in the solution. One of the plane surfaces may be slightly more accessible to Cr than others, with the result that the final mass is streaked by very minor compositional differences that evidence themselves in this brush-stroke pattern. At the very middle of each growth centre there is a slightly less transparent thread, perhaps the locus of immeasurable impurities banished from the aligning molecular ranks.

The effect of these marks is not unpleasant, for they give the Linde stones a slightly softer look, making it look less glassy in spite

FIG. 7. *Rack and seeds after one growth cycle, with the bomb being used in the early development work. This may be altered in actual production later on. (Photo E. M. Flanigen, Linde Co.).*

of its clarity, much as a Kashmir sapphire owes its luminosity to microscopic inclusions. However, it is too soon to say that these will always be definitive for Linde stones, and a change in the orientation of the seed, with a consequent difference in the growth figures on the plate's surface, would be likely to modify, and perhaps even eliminate, the "brush-marks".

Returning for a moment to the fluorescence, it can possibly be said that the Linde emeralds with their ultra-purity have carried fluorescence to an extreme where it might become a handicap. When the stone whose inclusions are illustrated in Figures 4 and 6 was placed upon the microscope stage, and lit by an intense tungsten light, fluorescence was evoked which tended to wash out the green, while a red glow was kindled in the shadowed areas. A comparison with other synthetics showed that the Linde stone was the only one to respond in this way. In long-wave UV light, compared even with Chatham's, the redness of the lighter and more brilliant Linde stones is marked, nearing the appearance of a ruby in the same light. Through an emerald filter, too, the brighter hue of the Linde red is reminiscent of a ruby, so light is it. If the stone were often to be seen under such lighting conditions it could be detrimental; though, under normal conditions of wear and observation, the fluorescence will probably not be noted.

To summarize the properties of the new Linde synthetic emeralds, as reported by their developer, Miss Edith Flanigen, the density is 2·67 to 2·69, the refraction (0) 1·571 to 1·578 and (E) 1·566 to 1·572 compared with Chatham's 1·562 to 1·564 and 1·559 to 1·561, respectively. The Gilson stones are slightly higher (1·564 and 1·561 to 1·567 and 1·562). These figures are identical with some that Linde made by the lithium molybdate flux-melt method in which they put .2 to .5% Cr. The Zerfass and I. G. Farbenindustrie stones are still lower in refractive index. It has been published that the latter was crystallized from a lithium molybdate flux.

Intense fluorescence combined with the normal refractive indices is the most obvious mark of a Linde stone. As long as growing conditions remain the same, we can confirm it with the phenakite crystal inclusions and the innumerable "brush-strokes" which generally are oriented to descend from the table facet.

APATITE CRYSTALS IN A CEYLON SPINEL

By P. C. ZWAAN, Ph.D., F.G.A.

INTRODUCTION

During the winter of 1958/59 I spent three months in Ceylon where I got the opportunity of visiting the gem pits in the well known Ratnapura district of Sabaragamuwa Province. From one of the pits (Pelmadulla) I collected many pebbles of minerals, mainly corundum, garnet and quartz.

Back in Holland I sent a number of these pebbles to Idar-Oberstein, in Germany, to be cut. I got back, among others, an oval-shaped faceted stone of 3·20 carats, having a violet-blue colour and containing many inclusions of crystals with a prismatic habit (Fig. 1). The stone has a refractive index of 1·717, and is isotropic. Its specific gravity, measured with the balance and using ethylene dibromide, is 3·599. The absorption spectrum shows the pattern of natural blue spinel. The stone therefore appeared to be a spinel.

At the Gemmological Conference in Helsinki in 1962 I spoke about this stone to Prof. W. F. Eppler, who expressed the wish to examine it. So I sent the stone in question to Freyung and after a few weeks Prof. Eppler returned it together with some of his famous colour slides. In his comment on the stone he said that the inclusions were very interesting but he did not know to what sort of mineral they belonged. I suggested that, in my opinion, they were crystals of zircon (because I only inspected the stone quickly), but Prof. Eppler replied again that this was impossible because the refractive index of the crystal inclusions was much lower than that of the stone. So the case of the crystal inclusions became a problem which had to be solved.

After a week or so I wrote him to say that these crystals might be either beryl or apatite. Prof. Eppler replied that this preliminary result was very interesting but he did not believe that it was true, on the ground of the birefringence which, according to him, should be rather large. Afterwards it was found that the high interference colours were due to the thickness of the crystals.

OPTICAL INVESTIGATION

The conclusion that the crystals must be beryl or apatite I drew from the following observations:

First of all it was seen that the crystals have a six-sided habit

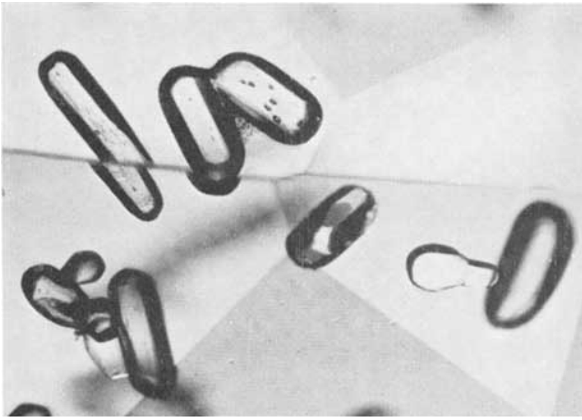

FIG. 1. *Crystal (apatite) inclusions in the spinel* (40 ×).

and that they are built up by prism faces terminated by pyramid faces at both ends of the longest direction (Figs. 2 and 3). The crystals have a parallel extinction and the optic orientation, observed by using a gypsum plate, is as follows:
$N'_x = E$ and $N'_z = O$, supposing that the crystals are uniaxial, which is almost certain.
Moreover, a distinct dichroism in tones of yellow (O) and blue (E) can be seen, in which $E > O$.

From the above-mentioned data it is obvious that the optic sign of the crystals is negative.

Measurements of the thickness of one of the crystals, having an interference colour grey of the first order, indicated approximately 0·050 millimeter, so that the double refraction must be small, in any case smaller than 0·005. These measurements have also been taken of other crystals with higher interference colours. They all led more or less to the same conclusion. Finally, it was seen that the refractive index of the inclusions was smaller than that of the spinel, but it was impossible to obtain an estimated value from crystals touching the surface of the stone.

From these data the nature of the inclusions could not be determined with certainty although apatite was indicated on the ground of the crystal form and the occurrence in the spinel.

X-RAY INVESTIGATION

Mr. C. F. Woensdregt, of the Geological Mineralogical Institute of Leiden University, made a rotation photograph of one

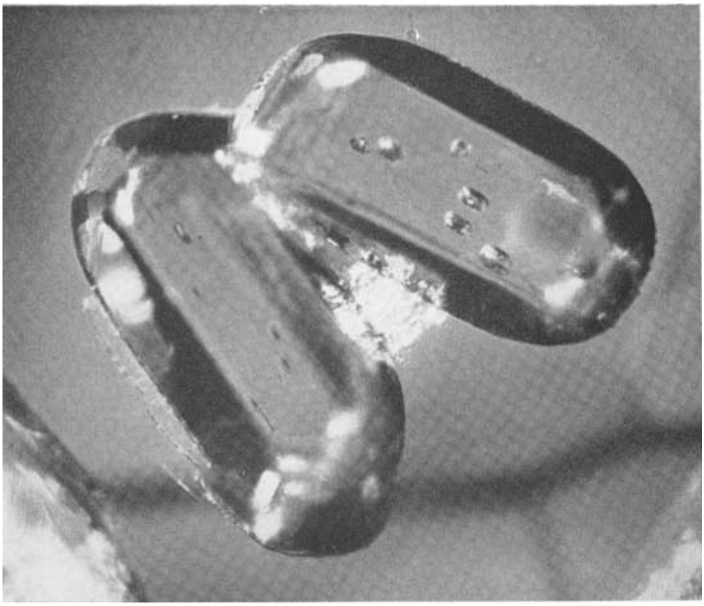

FIG. 2. *Two of the crystals from Fig. 1 in reflected light* (100 ×).

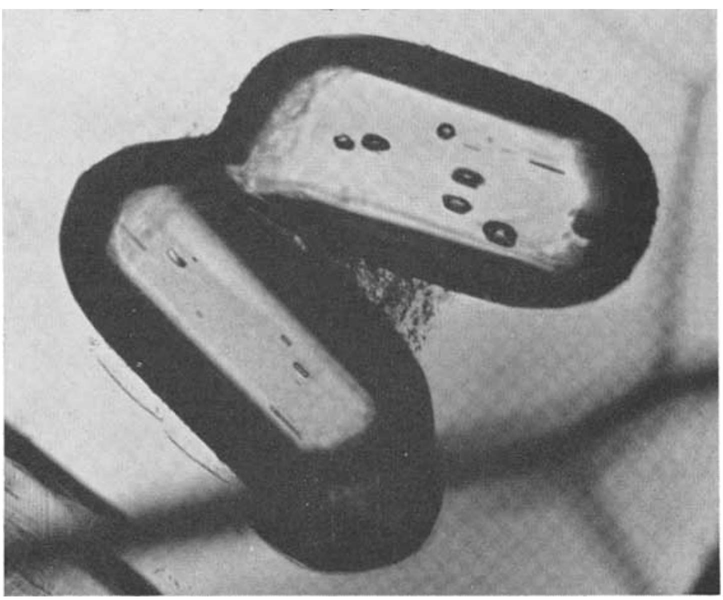

FIG. 3. *The same inclusions as in Fig. 2 in transmitted light* (100 ×).

of the crystals, using Cu-radiation with Ni-filter, oscillating it over 15 degrees round the longest direction. He compared his results with a photograph, made under the same conditions, of an apatite crystal from St. Gotthard, Switzerland, and was almost certain that the crystals in question are apatite crystals.

Finally, an X-ray powder photograph (No. m m 1017) was taken, using Fe-radiation and a camera with a diameter of 114·6 millimeters. The sample was obtained by scraping down part of a crystal touching the surface, with a steel needle. The material obtained appeared to be much weaker than the surrounding spinel. Use was made of the so-called "sphere" method, because only very small amounts of material were available. This method, introduced by S. A. Hiemstra[1] and used with great success by A. H. van der Veen[2], is as follows:

A small grain, transferred to a clean glass slide, is immersed in a tiny drop of thin rubber solution by using the point of a steel needle. The immersed grain is then covered with a second clean slide. Thus the grain can be ground without losing any material.

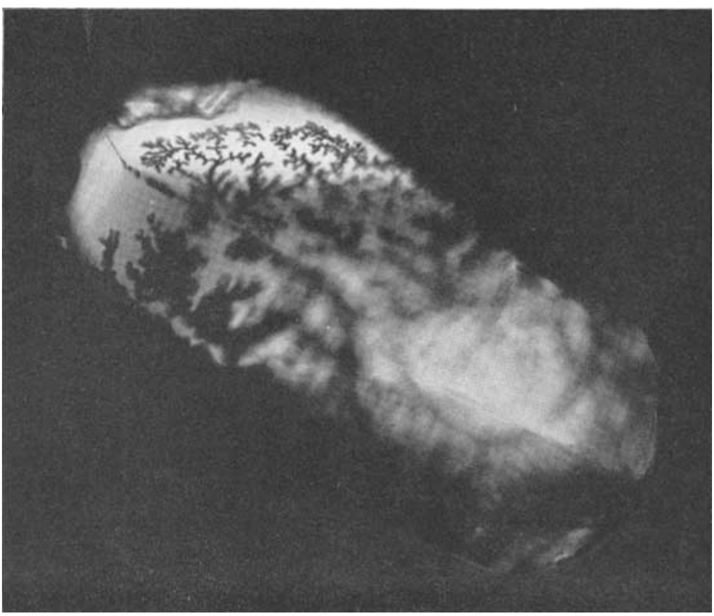

FIG. 4. *Dendritic forms on crystal faces of one of the inclusions* (190 ×).

By circular motion the solution, loaded with powder, is worked to a ball, measuring 0·2 to 0·5 millimeter in diameter. The ball is mounted with a little glue or similar solution on top of a Lindemann glass capillary. This is then placed in the camera with the mounted ball placed before the centre of the collimator hole. The exposure time is increased (for our sample until ten hours). The loss of weight of the spinel was 0·0002 grams, so that its weight in carats has not been altered.

The X-ray powder photograph obtained gave a pattern of diffraction lines, characteristic for apatite. The X-ray data for some of the strongest lines are as follows:

d (*in* Å)	*Intensity* (*estimated*)	*hkl*	(*d in* Å)	*Intensity* (*estimated*)	*hkl*
3·42	5	002	1·801	2	321
2·81	10	211	1·773	1	410
2·78	7	112	1·749	2	402
2·70	6	300	1·711	3	004
2·62	3	202	1·636	2	322
2·25	2	301	1·471	2	502
1·935	3	222	1·448	2	323
1·884	1	312	1·431	2	511
1·832	4	213			

By comparison of these data with those stated in the index to the X-ray powder data file of The American Society for Testing Materials (Nos. 3-0736, 9-432 and 12-261), it turned out that they agreed well with the corresponding data of hydroxylapatite.

My colleague, Mr. C. J. Overweel, identified the type of apatite as follows:

He made use of the data of Gottardi, *et al.* (3) on the $2^{\theta}{}_{Cu}$ values of the diffraction lines 140 (or 410) and 004.

According to Gottardi the following data are found:

hydroxylapatite $2\theta_{140} = 51{\cdot}275°$
$2\theta_{004} = 53{\cdot}178°$
chlorapatite $2\theta_{140} = 50{\cdot}08°$
$2\theta_{004} = 54{\cdot}08°$
fluorapatite $2\theta_{140} = 51{\cdot}550°$
$2\theta_{004} = 53{\cdot}175°$

Mr. Overweel measured $2\theta_{140} = 50{\cdot}96°$ and $2\theta_{004} = 53{\cdot}34°$ for a blue apatite from Matale in Central Province, Ceylon. The X-ray powder photograph (No. m p 1053) was made by using a camera with a diameter of 19 centimeters and Cu-radiation, the preparate being mixed with $12\frac{1}{2}$ weight percent NH_4Br (ammoniumbromide) for standard purposes.

He plotted the obtained data in a diagram, made by Gottardi, *et al.* and found that this apatite is a chlor-hydroxylapatite with ±25 mol.% Cl and ±75 mol.% OH.

As the apatite preparate from the included crystals in the spinel was too small to mix with NH_4Br, Mr. Overweel made another X-ray powder photograph of this material (No. m p 1018) with the same large camera and Cu-radiation and measured the relative distance between the reflections 004 and 140, using a Cambridge Universal Measuring Machine. This distance appeared to be 3·34 ± 0·01 millimeters.

For the Matale apatite (No. m p 1053) he found a relative distance between the reflections 004 and 140 of 3·90 ± 0·01 millimeters.

Further it is known that the same distance in a pure hydroxylapatite is 3·25 ± 0·01 millimeters.

From these data Mr. Overweel concluded that the apatite, included in the spinel, is a chlor-bearing hydroxylapatite. In Ceylon both apatite and spinel occur in the same type of rock, that is a crystalline limestone.

Occurrence

Regarding the presence of apatite crystals in spinel, it is known that both spinel and apatite may be formed during contact metamorphism. In Ceylon, especially, crystalline limestones occur in which both spinel and apatite are present. I visited a quarry at Matale (Pitakande Road), in Central Province, in which nice crystals of blue apatite, up to a few centimeters in length, could be found together with purplish spinel. On the other hand I collected crystalline limestones near Hakgala, in Central Province, in which blue spinel, blue apatite and forsterite were present. Anyway, the occurrence of spinel with apatite is common in Ceylon. It is important to note that the included crystals all have somewhat eroded crystal faces. This erosion effect is not likely due to erosion but rather to partial solution, after which the crystals were included in the spinel. The dendritic forms on some crystal faces also say much for that (Fig. 4). It is remarkable that in some of the included apatite crystals long tubes can be observed, being two-phase inclusions, together with distinct negative crystals (Fig. 3).

Finally, in this case shows again, apatite does not belie its name, for as is known, the name has been derived from the Greek word for "to deceive".

ACKNOWLEDGMENTS

I am indebted to Mr. C.F. Woensdregt, who was so kind as to make a rotation photograph of one of the inclusions. I also acknowledge the help of my colleague Mr. C. J. Overweel for the identification of the variety of the apatite.

Last, but not least, I am grateful to Mr. J. J. F. Hofstra and Mr. J. van der Linden of our technical staff, who prepared the X-ray powder photographs.

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2. Van der Veen, A. H. *A study of pyrochlore,* Verhandelingen van het Kon. Ned. Geol. Mijnbouwk. Genootschap, Geol. Serie, 1963, 22, 1-188.
3. Gottardi, G., et al. *La determinazione roentgengrafica del contenuto in fluoro dell'apatite delle ossa fossili,* Rivista di Scienze Preistorich, XII, fasc., 1957, 1-4, 1-37.

Gemmological Abstracts

ANON. *New Technique Grows Emeralds in Laboratory.* International Electronics, U.S.A., 1965, 10, 2, p. 5.

Scientists at the Naval Ordnance Laboratory, White Oak, Md., U.S.A., have created synthetic emeralds of gem quality in about 2 minutes. The crystals are attracting attention in the semiconductor electronics field because of the maser characteristics of emerald.

A high-temperature, high-pressure technique was developed to produce clear single crystals of emerald directly from beryl powder, and in far less time than is taken with the hydrothermal, flux or flame-fusion methods of synthesizing crystals.

Laboratory scientists also report that the colour of the crystals can be controlled easily by substituting various amounts of metallic oxides, particularly chromic oxide, in the basic beryl powder.

The pressure vessel used at the laboratory is made of several binding rings around a tungsten carbide cylinder to obtain up to 60,000 atmospheres of pressure in the test capsule. The capsule is of pyrophyllite material for the transmission of pressure, a carbon sleeve to serve as furnace, and a cylindrical capsule to isolate the beryl powder from the pyrophyllite during the crystallization. Pressure is transmitted to the test capsule through tungsten carbide pistons by means of a 300-ton press.

The capsule, which contains the beryl powder, is about 1/4-inch (6·34 mm) in diameter and about 3/8-inch (9.5 mm) in length, but this volume can be scaled upwards to obtain larger crystals.

In one process for the synthesis of emerald, the pressure is increased to 15,000 atmospheres and the temperature is raised to 1500°C to melt the beryl. Then, the carbon is shut off abruptly. Since there is a large mass of steel surrounding the sample, the temperature is reduced to near room temperature in a matter of minutes. Under these conditions the melt fuses into a clear single crystal of beryl.

The crystals obtained by the high pressure method are, by outward appearance, clear crystals of beryl. X-rays indicate that the samples are single crystals. The addition of 1% of weight of chromic oxide produces a green colour identical to the colour of the best natural emeralds. The density of the samples was determined to be $2{\cdot}715 \pm {\cdot}005$ gm/cm^3.

The quality of the crystal depends on the pressure, the temperature, the time during which the temperature is applied, and the material of the capsule that contains the beryl powder.

S.P.

JONES (J. B.), SANDERS (J. V.) and SEGNIT (E. R.). *Structure of opal.* Nature, 1964, 204, pp. 990-991.

X-ray patterns of opal show a complete gradation from the α-cristobalite pattern, given generally by common opal, to amorphous patterns, given generally by precious opal. Electron micrographs of crystalline opals, however, show a relatively fine-grained surface, whereas amorphous opals have discrete areas of close-packed aggregates of uniformly-sized silica spheres. These differences may reflect differences of genesis.

R.A.H.

SANDERS (J. V.). *Colour of precious opal.* Nature, 1964, 204, pp. 1151-1153.

The close-packed array of regular silica spheres constituting the structure of precious opal (see preceding abstract) forms a three dimensional diffraction grating. The play of colours results from the satisfaction of the correct conditions for diffraction by different wavelengths of light at different angles.

R.A.H.

MILLEDGE (H. J.). *Synthetic diamonds.* Science Progress, 1963, 51, pp. 540-550.

A general survey is given of the experiments leading to the production of artificial diamonds. The "doping" of diamonds with impurities during or after growth is described and the possibility of producing diamonds by explosive processes is touched upon.

R.A.H.

NEUE EDELSTEINVORKOMMEN. *New gem occurrences.* Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1964/65, 50, pp. 34-35.

There is a new find of mitrax opal in Australia which is of the quartz matrix type. The opal is very porous and ideal for dyeing. In a mine in Arizona a fluorspar of 12·9cts of pink colour was found; this mine usually produces blue-green material which is usually kept in the sun and then turns first purple, then pink and after many years becomes colourless. When removed from the sun the colour of the stone stays constant. Dr. E. Gübelin called a certain albite feldspar Maw-sit-sit; he first found this stone with jade cutters in Burma. The material is dark green and black and the name is the native word for the stone. Work has begun on a new diamond mine 140 miles west of Kimberley; the mine was bought in 1963 by DeBeers from its discoverers. The pipe is circular and covers a district of 16,200 square miles.

E.S.

SEAL (M.). *Structure in diamonds as revealed by etching.* Amer. Mineral, 50, pp. 105-123, 23 figs. Jan.-Feb. 1965.

Several different types of structure have been observed in diamonds by etching polished sections with fused potassium nitrate Both rectilinear and curved line structures occur; layer growth parallel to $\{111\}$ is common. A difference is reported between the internal structures of type 1 and type 2 diamonds (infra-red classification). No correlation has been found between internal structure of natural diamonds and geographical origin.

R.A.H.

DEINES (W.). *Ein weiterer Beitrag zum Thema; echt oder synthetisch.* A further article on the subject of genuine versus synthetic, Zeitschr. d. deutsch. Gesell. f. Edelsteinkunde, 1954/65, 50, pp. 11-13.

A further article on the subject of genuine versus synthetic which was discussed by X. Saller. The author insists that the difference must be advertised and the advantages and disadvantages of possessing the real or synthetic article brought home to the public.

E.S.

BOOK REVIEW

SCHLOSSMACHER (K.). *Edelsteine und Perlen.* Precious stones and pearls. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, Germany, 1965. 4th revised edition, 368 pages, over 100 illustrations, several tables, plates and two colour plates.

The fourth edition of Professor Schlossmacher's "Precious stones and pearls" is a largely increased version of his well received book (first edition 1954—280 pages). This is due only partly to the incorporation of his "Guide for the exact Determination of Precious Stones" in the present publication. Additions were required by developments in the fields of synthesis, imitations, doublets, improvements of colour and new occurrences. Inevitably the book had to lean a bit more to the scientific side, but the author still manages to keep it a book of the middle road which caters for all those with an interest in gems, whether jeweller, goldsmith, lapidary, gem and pearl merchant or novice gemmologist. Some overlapping and repetition is slightly disturbing to the reader but probably beneficial in a text book for students in gemmological classes.

In the sections on diamond (p. 126) and diamond polishing (p. 336) the "art of cleaving" is considered to be obsolete and superceded by sawing. In reality "cleaving" is a thriving industry, though not at Idar-Oberstein, where the author is head of the Gem Testing Institute. Prior to polishing, a large quantity of rough diamonds has to be shaped by cleaving. The "sawables" are usually only closed goods which are sawn into two "halves" ready to be girdled. In many other cases cleaving along an octahedral plane (without weight loss) is the better proposition.

In a book which covers the whole field of gemmology one or the other error of this kind is unavoidable and does not distract from the great interest of this publication for any gemmologist or enthusiast who can read German. Amongst the tables in the appendix are two new ones; one listing pleochroism, the other (prepared by Dr. E. Gübelin) listing abosrption lines and bands in Ångstrom units. Three plates with 16 photomicrographs and 2 X-ray diffraction patterns have also been added.

W.S.

LIGHT SOURCE FOR SPECTROSCOPE

By C. M. ROBB,

IT is just two years ago that last year's Tully Medal winner Fred Dowie showed me a parcel which had been released by H.M. Customs. It contained a Beck prism spectroscope which, according to the various books on gemmology and the diagrams we had studied, would aid us in the identification of certain gemstones. Alas, we tried night after night to see at least some sort of line in the spectrum but nothing eventuated. We were getting desperate —Mr. Dowie wrote to Mr. R. Keith Mitchell and I wrote to a good friend, Mr. J. R. Jones of Sydney, Australia, whom I had met on a short visit to Australia some two months earlier. He had spoken of the use of the spectroscope in gemmology. I pointed out to him the difficulties we were experiencing and that over here it was a case of the blind leading the blind. Could he give us some help as our nearest gemmologist was some 700 miles away? Most helpful replies were received to our queries and we were also advised to see Dr. M. J. Frost, of the Geology Department at the University in Christchurch.

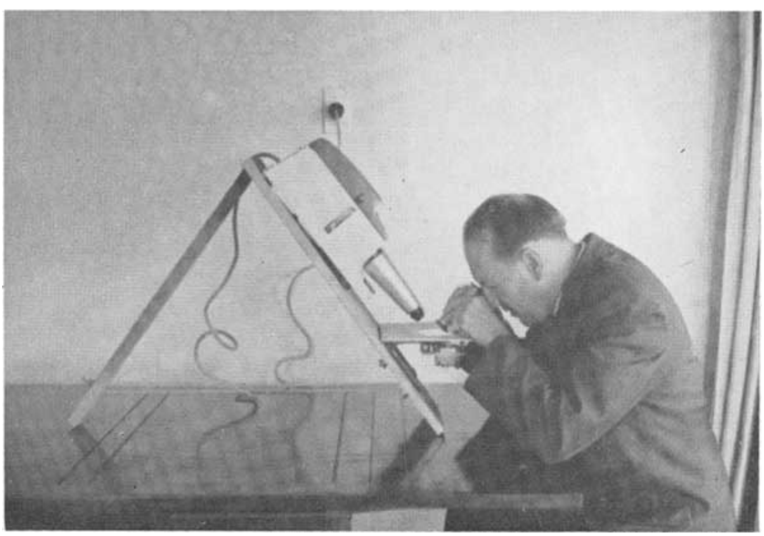
Dr. Frost adjusted the slit, used a high intensity light source and the absorption spectrum was seen of one of the stones, which up till that time had not let us see anything of note in the spectrum. We were now on the road to progress. This was the beginning of experiments in light sources for our own use. It must be realized that here in New Zealand owing to import restrictions, one cannot just walk into a supplier and try out two or three different makes of high intensity lamps to see which is the most suitable for one's need. Not feeling like placing a firm order for an unknown item it was a case of experiment and improvisation. We tried 230 volt lamps of 100, 150 and 200 watts and low voltage high intensity lamps fitted with suitable holders and various types of reflectors but still did not obtain the results for which we were striving. We then tried using a projector and this was the break which was needed. A watchmaker's eyeglass held in front of the projector lens gave even better results.

The writer feels that there must be many gemmologists and gemmological students who have a projector and, by a small amount of "do it yourself" woodwork and metalwork, could make up a light source which is far superior to that obtained from four commercial types of high intensity light sources with which this set up has recently been compared. The only drawback is that the home-made outfit takes up so much room. Maybe someone will use a prism and suitable holder and do away with having to set the projector up at an angle of 45°.

The final arrangement which I now have in use is shown in the Fig. 1. It consists of a baseboard of seven ply, 25 inches by nine inches with a 24 inch strut of 2 inch by 1 inch dressed timber. This is hinged at the top and a length of picture cord is attached between the board and strut to keep the angle at 45° to the table top on which the set up is used. Near the top, two holes are drilled through the baseboard and two more are drilled part way through to enable the back and front legs of an Aldis 303 projector to sit in same so that the projector needs no further fastening to hold it in position.

Ten pairs of $\frac{1}{4}$ inch holes, spaced 1 inch apart are drilled 1 inch in from each side of the base board. These permit the metal brackets holding the 9 inch by 8 inch viewing table to be raised or lowered to suit.

A metal cone 5 inches long with a $1\frac{1}{2}$ inch focus watchmaker's eyeglass fitted to the lower end is a push fit onto the front lens



mounting of the projector. By this means a concentrated spot of light is directed on to the stone to be tested. As a further refinement I have fitted a 12 volt A.C. synchronous reversible motor to the underside of the viewing table. This turns a $\frac{1}{2}$ inch diameter revolving table set flush with the viewing table. I did this after reading in various publications to "turn the stone" to get the brightest spectrum. Two small push-switches set in a wooden box and operated by one's foot complete the installation.

It is a real joy to be able to concentrate on viewing the spectrum and not worry about turning the stone manually. If a line is noted when the stone is turning, it is only necessary to remove one's foot from the switch, depress the other switch and the stone goes back the other way and the line is seen again. There is no taking one's hand off the spectroscope, shifting one's field of view or turning the stone by hand and looking again.

There is one interesting phenomenon which I have noticed when electrically rotating a sythetic sapphire and a pink tourmaline and using copper sulphate solution in a flask. A "flash" appears at the red end of the spectrum as the stone goes round. When these stones are viewed through crossed filters or under long wave ultra-violet light no fluorescence is noted. On viewing under short wave ultra-violet light the stones fluoresce. Perhaps a reader will be able to suggest the reason for this.

In conclusion I trust that the above information will save others from hours of frustration and that, if they own a projector, by spending very little time and money they can have a light-source for spectroscopy which gives excellent results.

ASSOCIATION NOTICES

GEMMOLOGICAL EXAMINATIONS, 1965

Centres for the 1965 examinations of the Gemmological Association of Great Britain were established in Australia, Austria, Brazil, Canada, Ceylon, Channel Islands, Cyprus, Egypt, Germany, Hawaii, Holland, Hong Kong, India, Ireland, Japan, Malaysia, New Zealand, Norway, South Africa, Southern Rhodesia, Spain, Switzerland, United States of America, Zambia, apart from the United Kingdom. 265 candidates sat for the preliminary and 176 for the diploma examinations. The entry for the diploma examination was the largest in the history of the Association.

In the diploma examination there were two candidates eligible for the Tully Memorial Medal who obtained equal marks and upon the recommendation of the examiners two medals have been awarded, one to Miss Christa Cannawurf, of Frankfurt, and one to Mr. Andrew W. Taylor, of Exeter. The Rayner prize has been awarded to Miss Sheila Heffernan, of London.

The following is a list of successful candidates arranged alphabetically:—

Diploma Examination

Tully Memorial Medals

Cannawurf, Christa, Frankfurt, Germany

Taylor, Andrew William, Exeter

Qualified with Distinction

Baxendale, Paul Donovan, Birmingham
Cannawurf, Christa, Frankfurt, Germany
Kerez, Christoph J., Baden, Switzerland
O'Sullivan, Timothy, Dublin, Eire
Parker, Lovell Wilfred, Dublin, Eire
Riding, Frank, Preston
Smout, William Walter, Rhyl
Taylor, Allan Maurice, Melbourne, Australia
Taylor, Andrew W., Exeter
Thomas, Graham Anthony, Mold

Allan, Christine Mary, Colchester
Allan, Ian Edward, Birkenhead
Armour, Anthony James, Beckenham
Bailey, Ronald, Dudley
Bana, Homi Ratansha, Bombay, India
Barratt, Susan Mary, Birmingham
Beaumont, Gordon, Huddersfield
Bethel, George Clayton, Hialeah, U.S.A.
Bird, Albert James, Liverpool
Borrini, Lusia, Horw/Lu, Switzerland
Brimelow, William, Southport
Bulley, Michael John, London
Carr, Philip Wood, Blackburn
Clarkson, Roland Norman, Shepperton
Clough, M. B., Bolton
Cole, Kenneth Charles, Salisbury, S. Rhodesia
Cook, Murray E., Vancouver, Canada
Cooper, Revd. S. B. Nikon, Staines
Cross, William George, Moor Park
Davies, James Meredith, Worthing
Drew, William Henry, Wellington, New Zealand
Dunkley, Peter John, Leeds
Edmunds, Ronald Charles, Plymouth
Evans, John, Birmingham
Farley, Peter Frederick, Bath
Franke, Lois E., Hollywood, U.S.A.
Frost, Allan Robert, Cardiff
Gadebusch, Dedo A., Koln, Germany
Gasser, Joseph, Lucerne, Switzerland
Gauntlett, Gillian, Haslemere
Goode, Alastair Richard, Solihull
Hanebach, Stanley, Scarborough, Canada
Hanna, Joe D., St. Louis, U.S.A.
Heaven, John Peter, Birmingham
Hesse, Kenneth R., Oceanside, U.S.A.
Hogervorst, Lia Angelique, Gouda, Holland
Holmes, Milton John, Owen Sound, Canada
Howarth, Harry, Altrincham
Imai, Taichiro, Tokyo, Japan
Inkersole, Denis, London
Jackson, David, Watford
Jones, Alfred, Coventry
Jones, Robert John, Ross-on-Wye
Laing, John, London
Lee, Joseph Ira, Raleigh, U.S.A.
Lewis, Kenneth, Rainham
Lewis, Leslie John, London
Lloyd, Philip Samuel, Chester
Millar, Maurice Alan, Dannevirke, New Zealand
Mole, Christopher John Sherwood, Blackheath
Moore, Henry, Solihull
Morley, George Kenneth, Sutton Coldfield
Myers, Leah Miriam, Sydney, Australia
Nicolau, Jose G., Madrid, Spain
O'Donnell, Arthur Lewis, London
Oesterlin, Wilhelmina Pearl, St. Mosm, Australia
Ogden, Glendower Morritt, Harrogate
O'Grady, Royston Joseph, Stafford
O'Shea, John Patrick, Worthing
Podhorodecki, Josef, Nottingham
Randle, Rodney Charles, Birmingham
Sher, Morris Michael, Glasgow
Simmonds, Stephen Maurice John, London
Smith, Stephen Spencer, Hull
Stern, Marion Judith, Wembley Park
Soma, Erling, Stavanger, Norway
Stocker, Christobel, London
Thomson, Harry, Lichfield
Toole, John Lewis, Stouffville, Canada
Ungar, Michael Scott, Ruislip
Wetton, Roy Nevil, Burton-on-Trent
Wheeler, Jennifer Mary, Bristol

RAYNER PRIZE

Heffernan, Sheila, London

Qualified

Adams, Robert, Johannesburg, S. Africa
Ansar, Mohamed Jabir Mohamed, Beruwela, Ceylon
Armstrong, John Henry, Honolulu, Hawaii
Ashby-Crane, Paul Robert, Exeter
Ashwell, Paul, London
Astley-Sparke, Jeremy Peter, London
Barrett, Mrs. Francis Irene, Stockport
Barrett, Roger, London
Bastos, Francisco Muller, Minas Gerais, Brazil
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Bennett, Peter, Enfield
Berge, A. V. D., Hoofddorp, Holland
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Blom, Karin Schrøder, London
Blondel, Vera Audrey, Guernsey
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Bosch, Hilmar Dirks, Salisbury, Rhodesia
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Brookes, Jacqueline, Coventry
Brooks, Pauline Mary, London
Buchanan, Alistair McKenzie, Edinburgh
Buckingham, Lionel James, East Croydon
Burgess, Clifford, Little Neston
Butland, William Martin, Pietermaritzburg, S. Africa
Byworth, David Roy, Brookmans Park
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Cannawurf, Christa, Frankfurt, Germany
Chamberlain, David Alan Victor, Wallasey
Charles, Lesley, Edinburgh
Chatterley, David Michael, Egham
Chikayama, Akira, Kofu, Japan
Clifford, Geoffrey Roy, Maidstone
Collier, Alan, Burscough
Collier, Rowley Walter, Hornchurch
Collings, Christopher John, Romiley
Connolly, John Patrick, Wilmslow
Cook, John William, Chelmsford
Cremer, Viktor, Munchen, Germany
Crombie, Michael S. I., London
Cross, William George, Moor Park
Cunningham, J. Lester, Chicago, U.S.A.
Cupitt, James, W., Droitwich
Dickson, David Wishart, Kilmarnock
Di-Nitto, Gordon Frank, Sheffield
Dipchand, Punjabi Lal, Hong Kong
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Downes, Bryan, Silkstone
Dryden, John Francis, Spalding
Edleston, Carolyn Isabel, Liverpool
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Ford, John F., West Ewell
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Graham, John Franklin, Richmond
Gray, Alexander H., Toronto, Canada
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Green, John Stanley, Shipley
Grimsley, Sally Joanna, Solihull
Guthu, Steinar, Sandefjord, Norway
Hammervold, Alf, Molde, Norway
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Hay, Samuel, Glasgow
Heffernan, Sheila, London
Helman, Karin, Oslo, Norway
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Hemsworth, John Alan, Manchester
Hesse, Kenneth R., Oceanside, U.S.A.
Holliday, George Charles, Edinburgh
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Husselman, L. J., Haarlem, Holland
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Ranasinghe, Vernon Victor Clement, Colombo, Ceylon
Rayner, Denise Ann, Cuffley
Reekie, Robert James, Edinburgh
Rees, Paul William, Newport
Reiter, Peter O., Lucerne, Switzerland

Richards, David, London
Rigby, Charles Martin, Rowton
Rigby, John Edward, Rowton
Riley, Gwendolin Ann, Stourbridge
Roos, Lucien Roy Peter Marie, Amstelveen, Holland
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Salt, Thomas E., Fort Nelson, Canada
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Scott, Colonel Conroy, Salisbury, Rhodesia
Sermon, Peter, Eccles
Sheffield, Keith Winter, London
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Southworth, Michael Thomas, Preston
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Sutton, Andrew Leece, London
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Taylor, Roger Victor, Birmingham
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Ward, Mrs. Muriel Joyce, West Perth, Australia
Weber, Adolphe, Geneva, Switzerland
Widnall, Harry, Sheffield
Wilkins, Robert F., Playa Del Rey, U.S.A.
Winkler, Gunter, Augsburg, Germany
Withington, Kenneth H., Manchester
Wong, Brian Peter, Liverpool
Wood, Frederick Arthur, Basildon
Woodall, Christopher, Streetly
Woodhead, William Webster, Montreal, Canada
Woods, Norman Ronald, Stocksbridge
Zara, Louise Vida, Leicester
Zwollo, Paul, Oosterbeek, Holland

GIFTS TO THE ASSOCIATION

From Mrs. G. van Starrex, a collection of corundum crystals.

GEM DIAMOND EXAMINATIONS

In the 1965 gem diamond examinations of the Association, which were held in June, at the School of Jewellery and Silversmithing, Birmingham, the following were successful in obtaining the qualifying standards:—

Peter Bryan Cook, Birmingham
William Edgar Cooper, Middleton
Kenneth Richardson, Birmingham
George Christopher Walters, Oadby
Peter John West, Birmingham
Philip George Wyer, Birmingham.

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Names of authors are printed in small capitals, subjects in lower case

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