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THE JOURNAL OF GEMMOLOGY

and

PROCEEDINGS OF THE GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN

GEMMOLOGICAL ASSOCIATION OF GREAT BRITAIN
SAINT DUNSTAN'S HOUSE, CAREY LANE
LONDON, E.C.2

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RAYNER GEMMOLOGICAL INSTRUMENTS

New Selling Arrangements

The Gemmological Association of Great Britain has pleasure in announcing that it has been appointed world distributing agents for all Rayner gemmological instruments and accessories. As a consequence of this new arrangement the Association will handle all sales, encourage the development of new instruments and the improvement of existing ones.

Messrs. Rayner & Keeler Ltd. have recently discontinued their sales direct to customers of various optical and general scientific instruments and has generously given the Association the agency for Rayner gemmological instruments, which will continue to be manufactured by Messrs. Rayner at their Sussex factory. The Association will continue for the time being to respect all overseas agency arrangements previously made with Messrs. Rayner.

Arrangements are also being made for the Association to act as United Kingdom agents for the gem testing instruments marketed by the Gemological Institute of America.

The National Association of Goldsmiths of Great Britain is kindly co-operating in the Association's new venture by undertaking certain financial and staffing arrangements

THE CHIVOR EMERALD MINE

By PAUL W. JOHNSON

COLOMBIA has five operating emerald mines. They are in descending order of size : Muzo, Chivor, Gachalá (Vega de San Juan), Buena Vista and Cosquez. There are two principal emerald districts in Colombia, Muzo and Chivor. The Muzo district is composed of the Cosquez and Muzo mines. The Chivor district comprises the Buena Vista, Gachalá and Chivor mines. Muzo and Cosquez are owned by the Colombian Government and are operated under contract by the Bank of the Republic. Buena Vista and Gachalá, under a law of 1959, are concessions from the Colombian Government and pay a 25 per cent royalty. Recently a new mine has been discovered near Muzo. The Chivor Mine, previously known as the Somondoco Mine, as Somondoco was the nearest town, is the only operating emerald mine in Colombia not controlled by the Colombian Government. Chivor is an Indian name, the original meaning of which is not known. It is situated in the township of Almeida, Department of Boyacá, Republic of Colombia, South America. Located at approximately 4° 52′ north latitude and 73° 22′ west longitude, Chivor is composed of two mining claims, each about one square kilometre and about 1,000 surface acres—including timber and pasture land. The mine is approximately 2,350 metres above sea level, at the junction where the Rucio and Sinai Rivers form the Guavio River.

Located in the Eastern Mountain System of the Colombian Andes, the Chivor Mine area is the only place in the Andes where the *llanos*, or " Plains of the Orinoco," are visible. A visitor most adequately described the area as " vertical real estate." The inaccessibility and ruggedness of the terrain make mining difficult. The slopes are extremely steep and very slippery when wet and muddy. Surrounding the Chivor Mine is a moderately populated agricultural area that is essentially self-sufficient.

The climate at the Chivor Mine is invigorating, with average mean temperatures ranging from seven to 18 degrees centigrade. There are two seasons at Chivor : the dry from October to March and the wet the remaining part of the year. The wet season brings an average annual precipitation of over four metres. The rains are cold and on most of the days during the wet season the operations are shrouded in mist and clouds. Drainage during this time is amazing ; an hour after a deluge most of the water has disappeared.

In the Guavio Valley are the Gachalá, Buena Vista and Chivor mines. On the western slopes of the Monte Cristo Range individuals are working small deposits of emeralds on their own property. Father Carlos Restrepo, local priest in Chivor Village, reported that microscopic emeralds had been found in the bedrock just west of Chivor Village. This proves that the emerald bearing fluid or vapour must have impregnated quite a large area, most of which was cut down by the combined action of the Sinai, Rucio, Guavio, Murca, Pedrera and Gachetá rivers.

The vegetation of the Chivor area is tropical. Varying in height from one to twenty metres, the growth includes a tree fern (genus *Cyathea**) left over from prehistoric times. Ferns of various types are abundant in the shaded areas around the mine. For visibility and security reasons, the overgrowth of this vegetation is controlled by periodic burning.

Historical Sketch

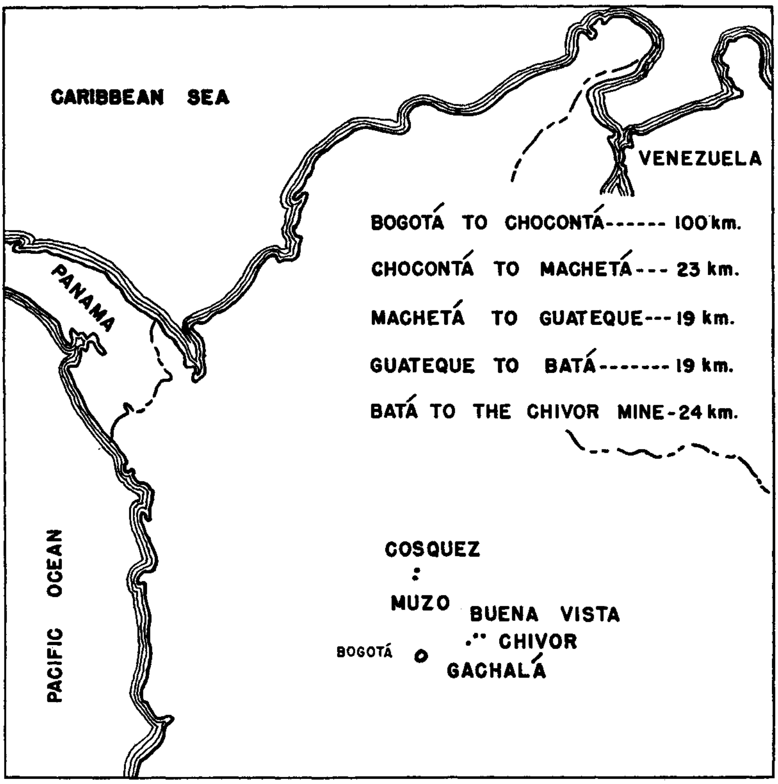
In Inca days the Chivor Mine was the only known source of emeralds in North and South America and was worked by the Chibcha Indians long before the Spanish conquest. No emerald mines have ever been found in Peru and it is assumed that the Incas, as well as the Aztecs and Mayas, received their emeralds from Chivor by trading. All the emeralds looted by the Spanish conquistadores must have been mined at the Chivor Mine, as the Muzo Mine had not then been discovered.

The Spanish General Jiménez de Quesada, conqueror of New Granada, presently the Republic of Colombia, detailed Captain Pedro Fernández de Valenzuela to search for the Chivor Mine. On 12th March, 1537, General Quesada, through the efforts of Captain Valenzuela, saw the first *esmeraldas* (emeralds) discovered by the Spanish in the Western Hemisphere. The Spaniards employed about 1,200 men to work the Chivor Mine. Caged in the tunnels, the miners were forced to produce emeralds as the price of their meagre rations and sometimes their lives. Many died under this treatment and the Spanish practically exterminated the local labour supply.

The first recorded grant on the Chivor property was given to Señor Francisco Maldonado de Mendoza, probably in the first part of 1592, by Antonio Gonzalez, the President of Colombia. The

* Personal communication with Dr. Jose Cuatrecasas

inhuman treatment of the local Indian labour force by the Spanish resulted in a thirty-nine article decree promulgated on 22nd September, 1593, by President Gonzalez, for the protection of the labourers. On 29th December, 1593, this decree was followed by a Spanish Royal Order insuring the liberty of the local Indians. King Felipe III, of Spain, in 1602, issued a writ calling for the enforcement of the laws protecting the Indians. In 1643, the Chivor Mine was leased by the heirs of Maldonado to Miguel Soriano for seven years. The mine became the subject of litigation and was finally closed by Charles II of Spain at the persistence of Pope Clement X and abandoned in 1675. After the Spanish abandoned the mine it became overgrown with dense tropical vegetation and was lost for two centuries. That the Spanish accomplished considerable work at the mine is testified by the



Location of emerald mines in Colombia ; and distances from Bogotá to the Chivor Mine.

shafts, adits and man-made canyons still visible to-day in the lower south-eastern section of the mine.

Don (Pacho) Francisco Restrepo, a native Colombian mining engineer, in 1896 rediscovered the emerald mine. In the National Archives of Colombia he read the Spanish description that the Chivor Mine was located at the only spot on the inner Andean range from which the *llanos* or " Plains of the Orinoco " were visible. With this seemingly insignificant description Señor Restrepo started his search. It would have been less arduous to have sought the elusive needle in the haystack. They chopped their way through the dense tropical vegetation and finally one day stumbled on a caved-in reservoir. Señor Restrepo sent a man up a tree and across the valley was the gap in the Monte Cristo Range with the *llanos* and 1,000 kilometres further the famous Orinoco River. Searching the immediate area Señor Restrepo and party found the overgrown mine terraces and thus a deserving Colombian was rewarded after a long and hard search.

Fritz Klein, from Germany, first visited the Chivor Mine in 1911. On 2nd August, 1912, and in August 1913 the Supreme Court of Colombia laid down a decision which exempted the Chivor Mine from further taxation or other obligation to the government. This decision was largely made possible through the efforts of Klein.

A German syndicate obtained an option on the mine, but subsequently lost it during the First World War. Americans became interested and purchased the option in 1919. Since then the Chivor Mine has changed hands among various American companies.

Chivor was managed by many famous managers, including Christopher E. Dixon from England and Peter W. Rainier, author of the book about the Chivor Mine, *Green Fire*.[10a]

Corporate Background

The Colombian Emerald Syndicate first gained control of the mine and subsequently sold out to the Colombia Emerald Development Corporation, which was later reorganized as the Chivor Emerald Mines, Incorporated. The Chivor Mine, at the present, is owned by the Chivor Syndicate, Incorporated, and the Chivor Emerald Mines, Incorporated. Currently Chivor is being operated by a trustee in receivership by order of the Colombian courts.

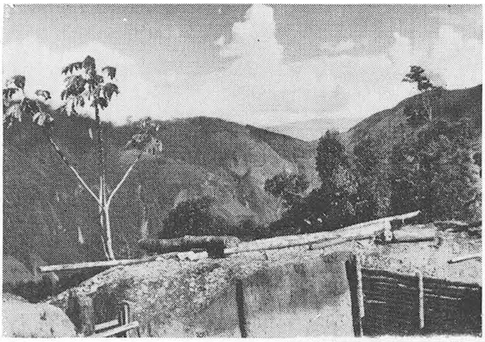


FIG. 1. *With a partially completed reservoir in the foreground, used for the mining operation, the* llanos *or "Plains of the Orinoco" are seen through the notch in the Monte Cristo Range. The* llanos *are grass plains which stretch from the foot of the Andes to the Orinoco River—1,000 kilometres to the eastward.*

FIG. 2. *On the trail by horseback to the Chivor Emerald Mine; Willis F. Bronkie, left, trustee and Dr. Pedro Moreno, a mining consultant.*

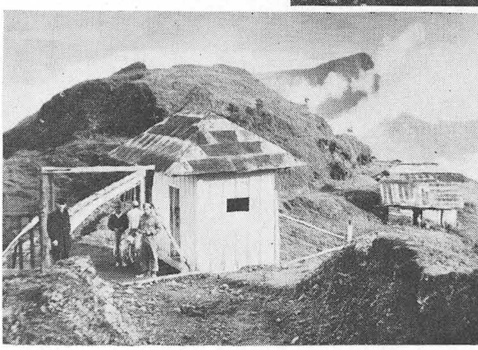


FIG. 3. *Main entrance to the Chivor Mine, which is guarded at all times by the Colombian National Police. The wooden flume framed by the mine gate is part of the canal which brings the water from a river source 18 kilometres from the mine.*

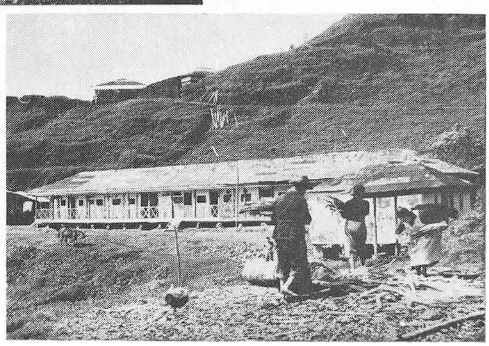


FIG. 4. *The administration building and quarters consisting of 12 rooms, a main office and dining room with a fireplace. The fireplace is used to advantage every evening throughout the year as the mine is at an altitude of about 2,350 metres above sea level.*

Transportation and Administration

The road from Bogotá, Colombia to Batá (Puente Batá), a distance of 161 kilometres, passes through the towns of Chocontá, Machetá and Guateque. The road is paved from Bogotá to Chocontá. From Chocontá to Batá a graded gravel road is passable and fairly well maintained, though it becomes a little muddy in the rainy season. The town of Somondoco, the name of which was previously used for the Chivor Mine, is by-passed on the way to Batá. Pack horses are obtained at Batá for the final 24 kilometre horse-back trip to the mine, which usually requires from four to seven hours, depending upon the weather and condition of the trail. Three-fourths of the way to the mine there is a settlement called Chivor Village, which has a population of approximately a hundred.

The administration building has twelve rooms with a dining room, kitchen, office and two showers. The dining room, with a radio for nightly news and entertainment, has a fireplace which is used to advantage every evening throughout the year. A two-way radio is used for communication with Bogotá. All water except drinking is obtained from a gravity flow water system. The manager or trustee, chief inspector, inspectors and visitors reside in the administration building.

People of the District

The Colombians of the Chivor area, mainly of Chibcha Indian extraction, are of a primitive nature. Most of them are hard-working and industrious. They have been relatively unaffected by the encroachment of civilization. As always, courtesy, gentleness and an awareness of their timidity before strangers, will help to ease the gap of time and custom.

The miners, like many of us, do not conform to any set pattern. Some work well, others are indolent. Every miner carries his own *peñilla* (belt knife), usually about 25 to 50 cm long, with which he is sometimes prone to settle his arguments. Most of the older miners have worked at the Chivor Mine since they were 14 to 16 years old. In 1928 there were as many as 500 men working the ridge. To-day no more than a hundred miners are employed. They work an eight-hour day, five and one-half days per week, finishing at noon on Saturday.

The miners generally live in a wooden or a log and mud constructed one-storey house. Some houses have a wooden floor,

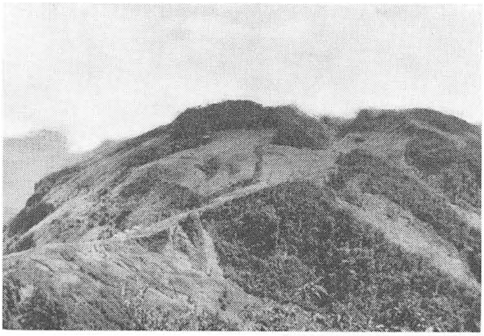


FIG. 5. *The Buena Vista Emerald Mine located across from Chivor. The mine dump and buildings can be seen in the lower left portion of the picture. The Buena Vista Mine is a concession from the Colombian Government and pays a 25% royalty.*

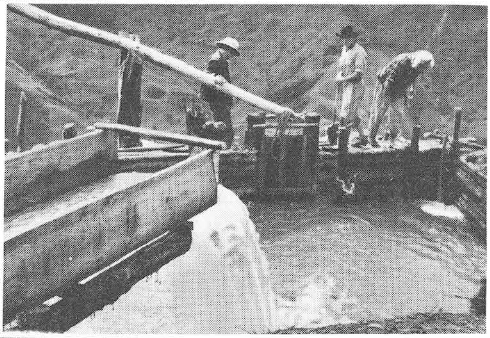


FIG. 6. *A reservoir being filled with water from the canal. When the reservoir is full the gate is raised by means of a lever thus creating a man-made flash-flood which is used to wash the overburden and debris of mining into the Guavio Valley, shown in the background.*

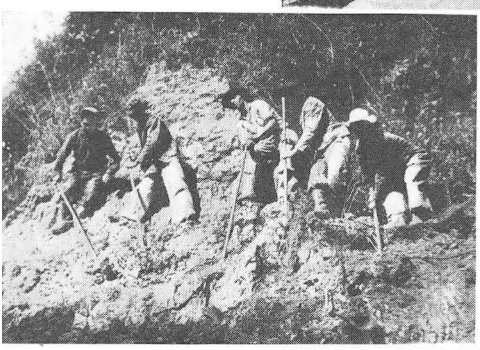


FIG. 7. *Emerald miners using the bar in the typical manner in which the Chivor Mine has been worked for centuries. To-day about 100 miners are searching for the elusive emerald.*

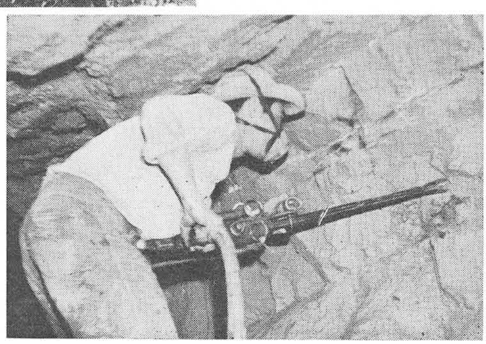


FIG. 8. *Senor Argemiro Vaca, a 25 year old miner, uses a compressed air drill to remove part of an emerald vein in the* Coliflor *tunnel. He has worked at Chivor for 12 years.*

while others have only dirt. The sides of the houses are usually rough sawed boards with some type of a rusting galvanized iron roof. They are built by the miners on company-owned property. Their bed customarily consists of a rough lumber frame with a woven mat of straw-like material for a mattress.

Chivor's manager must be versatile, as he is boss, counsellor, judge, jury, and doctor to the miners. The manager hires the inspector force, store keeper, cooks, house boys, labourers, mechanic and bulldozer operator. The labourers are paid about 34 cents per day. Each tunnel area has an inspector who is on the company's pay roll. The company also has a chief inspector for all the tunnel areas. The mine is patrolled by regular members of the Colombian National Police. The company pays the Colombian Government and the government reimburses the police according to their rank.

On most tasks the company tries to contract for the work. The contracting tends to improve manager-employee relationships, since the miners are working for a fellow Colombian and not a foreigner. The mining *contratistas* (contractors) are provided with only a place to work. The miners furnish their own clothing, shelter, tools and usually their food. The contractor hires his own men, rents the heavy power equipment from the company and purchases his own dynamite. Each mining contractor signs a 50-50 per cent division of the find contract with the company. The 50 per cent is based on the sale of the emeralds by the company. Each contractor divides his half differently among his miners. Some keep 25 per cent for themselves and distribute the remainder evenly among their men.

Security

Security at the Chivor Mine is strict. The National Police maintain 24 hour surveillance 365 days per year. By hiring trustworthy men, burning the thick tropical vegetation and constantly watching the miners by means of the inspectors, police, manager and chief inspector (inspector of the inspectors), highgrading and theft are kept at a minimum. In the past, however, bands of roving *contrabandistas* (highgraders) have worked Chivor at will during periods when the mine was not being operated. Individual miners have on occasion broken down the doors at the entrance to the tunnels and worked all night. In the morning they fled. The *lista negra*, or black list, of these men is posted on the bulletin board. They will never again be hired by the Chivor Mine.

Mining Methods

Some of the production methods to-day are essentially the same as those employed by the Chibcha Indians, with refinements introduced by the Spaniards. Tunnelling has been practised intermittently. However, step-cutting or terracing is favoured as being cheaper and more efficient, for the emeralds occur so irregularly in a formation that adits and drifts are likely to pass within centimetres of a rich pocket or vein without any indication of its presence. Policing the miners in the tunnels is always more difficult than when outside in broad daylight.

The Chivor Mine is being step-mined (terraced), tunnelled and bulldozed simultaneously. The tunnelling will soon be stopped. Then the top of the ridge can be worked with the bulldozer and the steeper areas exploited by step-cutting.

Originally the tropical forests were cut down and burned before the mining operations started. In working the slopes or banks the steps are first cut from the top of the bank to the bottom and obliterated on the return up the ridge. Occasionally beds of indurated shale are encountered and have to be blasted. In blasting a vein the shots are angled in and a low-powered dynamite or black powder is used, so as to minimize damage to any emeralds that might be encountered. The steps are worked from side to side with the miners lined up next to each other. They use a hoe or steel bar three metres long, which weighs about 14 kilograms. The bars are wedge-shaped at one end and pointed at the other. The debris and overburden are washed into the valley below by a flood of water from the reservoir. The steps are again cut into the side of the ridge and the process is repeated. By this method very deep V-shaped cuts are formed. Most of the cuts are over 50 metres in vertical height and give an imposing effect to the landscape.

When emeralds are encountered in the veins the operation slows down and the emeralds are carefully hand-removed by one of the inspectors and put in a leather bag. The *peñilla* (belt knife) is sometimes used as a digging tool to remove the emeralds from the vein.

In the past when an emerald-producing vein was being worked and had to be left at night, it was sealed with clay on which the foreman would write his signature. Then several tons of material were deposited over the vein. In the morning the overburden was removed and the signature examined to see if any attempts at theft had been made during the night.

The tunnels are mostly shallow and penetrate less than 80 metres. Little timbering is required as the hard argillite supports the tunnels very well. During the rainy season water is usually found in the bottom of most of the tunnels. The water seldom exceeds one-third of a metre in depth, and the miners by wearing rubber boots up to the knee can proceed with normal mining operations. When drilling in the tunnels the dust and noise are quite bothersome to the miners. Chivor has several large compressors to furnish the power required by jack hammers.

To-day only one tunnel area (*Piedra de Cal*) is in operation. This will be stopped soon and open cut operations started there. In the past eight tunnel areas were worked. Facing south clockwise around the ridge they were: *Piedra de Cal* (limestone), *Coliflor* (cauliflower), *Peña Negra* (black rock), *El Taladro* (the drill rod), *El Martillo* (the hammer), *El Cristal* (the crystal), *Klein* (for Fritz Klein, a former German manager), and *Numero Cuarto* (number four). In April of 1958 there were 96 men and nine contractors working all but the *El Cristal* and *Numero Cuarto* tunnel areas. Some of the tunnels are dangerous and have been caved-in to protect the miners.

A bulldozer is used by the company to remove the overburden and also to follow the emerald veins. With a large quantity of soft overburden and the majority of the veins occurring in material soft enough to be worked by the bulldozer, it is definitely used to advantage. The bulldozed overburden is washed away by a man-made flash-flood from the reservoir.

By terracing and bulldozing every square inch of dirt is moved with less chance of missing the elusive emeralds. Emerald mining is extremely haphazard and sporadic. Mining may go on for months without a single production; one never knows when a vein will develop into a real producer or a pocket will appear.

The Canal

The present day canal follows for the most part the course of the old Spanish canal, which aided greatly in constructing the new. This ancient waterway supplied the old reservoirs with water brought from a river source about ten kilometres from the mine. The old Spanish canal was approximately two-thirds of a metre wide and one-third of a metre deep. The present day canal, which

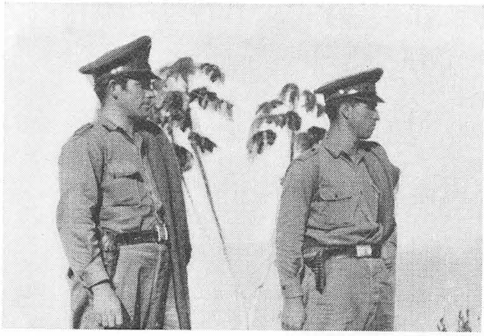


FIG. 9. *Members of the Colombian National Police maintain a constant guard at the Chivor Mine. Shown on the left is Alfredo Vargas and Marcos Fuentes. Notice the* ruana, *the Latin American version of our coat, thrown over their left shoulder. The* ruana *is a four foot square piece of hand-woven material with a diagonal slit, through which the head is inserted. Hanging down in front and behind, like a poncho, it protects the wearer from the high Andean rain and cold.*

FIG. 10. *Terracing or step-cutting is an efficient mining method used by the Chibcha Indians before the Spanish conquest of South America. Each terrace is about two metres high and two-thirds of a metre wide. The present surface level is estimated to be three metres lower to-day than it was originally over one solid square kilometre.*

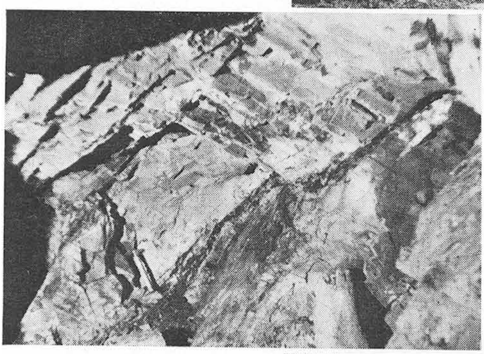


FIG. 11. *Interior view in the* Coliflor *tunnel. A production worth about $7,000 (£2,467) was taken from the area that is shown in this photograph. In September 1957 over $100,000 (£35,714) was taken from a vein within two metres of this area. Just to the right of the geologist's pick is a goethite stained emerald vein.*

FIG. 12. *Bulldozer pulling an air compressor and making its own road through Cretaceous shale on the way to the mine. The bulldozer is used during the mining operation to remove the overburden.*

feeds all of the reservoirs, flows through natural ground in part and in a wooden flume with the same dimensions previously mentioned, for a total distance of 18 kilometres.

A reservoir, or as the Spanish called it a *tambre*, is used to create a man-made flash-flood in order to wash the overburden and debris from the mining operation into the valley below. The steep slopes are ideal for this purpose. Each reservoir is an area excavated in a strategic location so that the rush of water can be delivered to a particular mine area being worked.

Previously the reservoirs were established in areas which would withstand water pressure on as many sides as possible. The remaining sides of the reservoirs were reinforced with logs packed with clay on both front and back. Currently, however, the reservoirs are made of concrete and have completely replaced the older type. The reservoir gate is raised by a lever which requires from five to six men to open. Lack of water during the dry season makes the use of the reservoirs impossible.

The average reservoir holds approximately 100 metric tons of water. A reservoir is only filled prior to use, in about one-half hour, and requires less than five minutes to empty.

Description of Emeralds

Emerald, the green variety of beryl, is chemically a beryllium aluminium silicate, with the formula $Be_3Al_2Si_6O_{18}$. At Chivor the emeralds crystallize in both hexagonal and dihexagonal prisms. The terminations are usually flat, but domed and pointed terminations also occur. Refractive indices taken on 12 specimens ranged from 1·565 to 1·579 (see table I). The specific gravity on 11 different stones varied from 2·646 to 2·730 (see table II).

The colouring of emerald is due to a small amount of chromium oxide, probably less than one per cent. (See spectrographic analysis). The colour of Chivor beryl varies from colourless to a dark green with the gem quality ranging from grass-green to a verdant green fire. Emeralds sometimes occur with colour zoning. The amount of chromium present during the crystallization of emerald was not always constant, as some from this mine have a core of almost pure white beryl upon which was grown outward successive layers of darker material. The depth of colour is dependent on the amount of chromium oxide. The more chromium present at the time of crystallization the deeper the green colour imparted to the beryl. Chromium disrupts the beryl lattice and causes internal strain. The more chromium the greater the strain on the lattice. It is believed that chromium ions fail to mesh well within the crystal lattice and tend to poison it with what is called "chrome-ion poisoning."

Emeralds with a pointed termination have rarely been found at Chivor. (Fig. 17.) They are usually very small and seldom exceed one-half carat. The pointed terminations occur on a beautifully clear six-sided prism.

Tapered emeralds, some of which have a hollow interior, have been found only sparingly at the Chivor Mine. (Fig. 16.) They have been found in the *Coliflor* tunnel. Some of the tapered emeralds have a hollow cavity in the centre which extends from an opening on the termination the entire length of the crystal. Completely tapered emeralds are rare since the cavity in the centre causes most of them to fracture in the middle along a plane perpendicular to the c-axis. Most of these emeralds do not exceed 2 cm in length. All of the tapered emeralds formed six-sided prisms with a single flat termination, some of which have the S, P and O faces developed. Specific gravity of the tapered specimens cannot be determined accurately due to the cavity in the interior of the crystals.

The emerald was probably deposited from a hydrothermal fluid or vapour. Where conditions were favourable, it crystallized and formed the clear emerald, while elsewhere it appears as the opaque *morralla*, which means rabble or trash in Spanish and is very appropriately named. Side growths and twinning occur in the *morralla* specimens. One *morralla* crystal was found with a quartz crystal which had crystallized on its surface. This is a rare mineral association at Chivor. Most *morralla* is cut in India where labour costs are lower than in Colombia.

Morralla is a diagnostic indicator that gem quality emeralds may be found. Acicular crystals of emerald are reported by Gilles as a possible indicator of gem-quality stones. However, the entire vein which contains *morralla* and or small needlelike emerald crystals could be completely devoid of gem-quality material.

Flattened *morralla* crystals have been found in the *Coliflor* tunnel area at Chivor. They are about 20 mm wide, 10 mm thick and of various lengths up to 50 mm. The flat crystals, which look as if they had been squashed, occur on a gray argillite matrix, with albite and pyrite present on the surface.

X-ray diffraction has shown that the *morralla* has a smaller unit cell than a high quality emerald, as shown by the peak shift. The emerald peak was 22·40 degrees and the *morralla* peak was 22·46 degrees. The *morralla* crystals have a broader diffraction peak than single emerald crystals, indicating either a smaller crystallite size or higher degree of disorder.

Inclusions

Inclusions in emeralds from Chivor include the microscopic three-phase, quartz, albite, pyrite and goethite (limonite) type. The brown inclusion in the emeralds is goethite formed by the alteration of pyrite. Quartz is sometimes a common inclusion and can on occasion be found as well formed crystals. Albite is the rarest of the inclusions found in the emeralds from Chivor. A pyrite crystal is occasionally found as an inclusion in a Chivor emerald, thus providing a focal point from which a unique gem can be faceted.

The three-phase inclusion is characterized by having an elongated or jagged outline. It is part of a healing fissure, sometimes called a " feather." The solid in the three-phase inclusion is halite.[4] The liquid is probably water, or a saturated solution of sodium chloride. The gas has not yet been identified. Three-phase inclusions can usually be found near the base, or the termination, and are generally oriented parallel to the c-axis. Most bubbles in the three-phase inclusions from Colombia are stationary. After leaving the microscope light on an emerald from Chivor for about five minutes, the gas bubble started to move periodically back and forth in the liquid ! The movement in this interesting specimen was probably caused by the heat from the microscope light.

Scattered and irregular groups of almost invisible liquid inclusions occur beside the characteristic three-phase ones. These usually have a jagged and elongated outline with tail-like formations.

Spectrographic Analysis

A spectrographic analysis on a dihexagonal crystal of emerald with a full basal pinacoid on one end, conchoidal fracture opposite end, from the Chivor Mine was made. The sample was from the

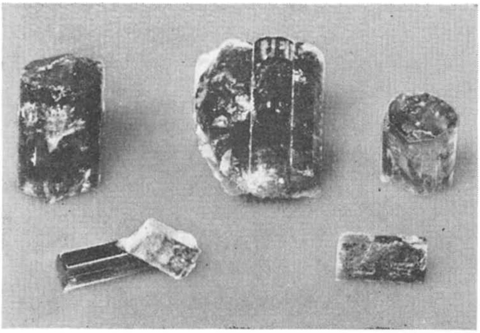


FIG. 13. *Fifty carats of rough emerald crystals from the Chivor Mine. The fine gem quality crystal in the lower left weighs 2·5 carats, the crystal in the upper left weighs 11·4 carats and the emerald in the upper centre weighs 26·6 carats.*

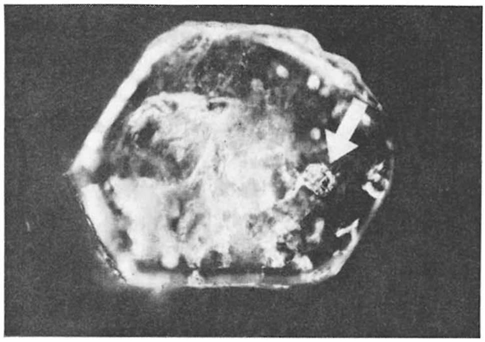


FIG. 14. *Pyrite crystal (arrow) inclusion in a 1·4 carat emerald from the* El Taladro *tunnel area. Pyrite inclusions are characteristic of Chivor emeralds.*

El Taladro tunnel area, and weighed 0·0846 grams.

Determinations:

Silica : (SiO_2)	60 to 70%
Alumina : (Al_2O_3)	15 to 20%
Beryllium oxide : (BeO)	10 to 15%
Magnesium oxide : (MgO) ...	·01 to ·1%
Lime : (CaO)	Nil
Iron oxide : (Fe_2O_3)	·001 to ·0001%
Chromium oxide : (Cr_2O_3) ...	·0001 to ·00001%
Vanadium oxide : (V_2O_5) ...	·00001 to ·000001%
Sodium oxide : (Na_2O)	·00001 to ·000001%
Manganese oxide : (MnO) ...	Nil
Potassium oxide : (K_2O)	Nil
Copper : (Cu)	Nil
Nickel : (Ni)	Nil

Spectrographic analysis was made for the author by the San Diego Testing Laboratories; analyst, M. P. Christensen.

Grading and Valuation of Emeralds

No two emeralds are exactly alike and they are difficult to classify. The Colombian Ministry of Mines divides the emeralds into six colour grades each with subdivisions. In grading emeralds in Colombia the numerical part designates colour. Number one is the best colour, number six the poorest. The alphabetical part of the grading designates the freedom from flaws. " A " would have very few flaws, whereas " D " would have many.

The highest grade of emerald is in Colombia called *gota de aceite*, which translated means literally " drop of oil." Small pencil-like crystals of emerald are called *cañutillos*. These long slender crystals can be of any quality as the name describes the shape only. *Cañutillos* are used for making religious crosses and sometimes for lower priced jewellery. Poor quality opaque emerald is called in Colombia *morralla*, which has a commercial value as inexpensive jewellery.

The value of an emerald depends upon transparency, freedom from flaws, evenness of colour, weight and shade of green. Colour is the most important factor. A rough idea of uncut retail emerald prices would include: 1B—$1,000 per carat; 1C—$500 per carat; 2B—$300 per carat; and 3A—$60 per carat.

Emerald Veins

The emeralds are found commonly in veins—rarely in pockets, and occur in thick beds of shale. The veins are usually filled fissure cracks, which resulted from the folding and faulting. They generally run parallel to each other along the strike of the structure, as that is the point where the hydrothermal fluid or vapour had a chance to fill up the then existing fissures and joints. Cross veins along fissures formed by folding occur between the veins and often contain emeralds, particularly at intersections. At that point the fluid or vapour had freedom for growth because of release of pressure, time to cool and a gradual loss of heat.

The veins vary from a fine line to 15 cm in thickness, usually not exceeding 65 metres in length or 35 metres in depth. A thin section on an emerald vein from the *Piedra de Cal* tunnel area showed that the black argillite had been metamorphosed by the fluid or vapour that formed the emerald and albite to a depth of 3·4 millimetres.

Emerald veins can be divided into three groups : pyrite, albite and pyrite with albite. Each of the three vein types occur with *morralla* and where conditions were favourable—emerald. So far no emeralds at Chivor have been found in calcite and calcium carbonate has never been found in an emerald vein.

In a vertical cross section running from the top of the ridge upon which the mine is located, the sedimentary deposits are separated by three horizontal layers known as " iron bands." These bands are easily located, running as they do straight across the face of the hill, where they appear as red streaks in a yellow to grey shale background. The productive emerald veins do not extend more than 50 metres below the lower " iron band."

The emerald pockets generally occur associated with the vein. It appears sometimes that emeralds are found imbedded in shale in pockets, but on close examination one can always find a small stringer, sometimes practically invisible, that served to carry the fluid or vapour. Occurrences of this type are generally under a cap of impervious harder material that served to localize the deposition. There is nothing definite about the pockets and no two occur exactly the same. They may be as small pockets with goethite, albite and pyrite, or in vugs or larger pockets. The emeralds in the pockets or vugs are frequently found incrusted with iron oxide and sometimes occur loose within the cavity. A pocket will generally produce stones of the same quality. Some pockets have been good producers while others have yielded entirely " frozen " emeralds which will crumble apart in one's hands.

Associated Minerals

The common minerals of Chivor include albite, pyrite and emerald. The principal gangue minerals of the emerald-bearing veins are pyrite and albite. Other common minerals are goethite (limonite) pseudomorphous after pyrite, hematite and goethite (limonite). Moderately common are calcite and quartz crystals. Less commonly occurring minerals include massive quartz, halloysite, goshenite, allophane, muscovite, fuchsite, specularite and hyalite. Other than albite and pyrite the only minerals found in association with emerald are goethite (limonite) pseudomorphous after pyrite and very rarely massive quartz. As the albite alters to clay it would also be possible to find the emeralds in association with clay minerals.

Albite is a very common vein mineral usually occurring as white streaks on both sides of the veins with the emeralds and *morralla* in the middle. The bladed variety of albite known as cleavelandite occurs with the emeralds and is common in the *Piedra de Cal* tunnel area. Under hot acid conditions it is possible for the albite to be altered to kaolinite, sericite, halloysite, allophane, etc.

Pyrite is quite abundant at Chivor and occurs in attractive cubes, octahedrons and pyritohedrons, or combinations of these three forms. Some of the faces on the cubes are striated and slightly curved. Most of the pyrite crystals are less than 7 cm in diameter. Pyrite crystals are found quite commonly in the *Coliflor* tunnel. The pyrite alters to goethite ($HFeO_2$), most of which was formerly called limonite,(2) and then to hematite (Fe_2O_3).

Goethite (limonite) pseudomorphous after pyrite is found in the " iron bands." Some of these specimens are only partially altered and still contain a bright pyrite core.

Calcite in typical white rhombohedrons is common at Chivor. Showy specimens of white calcite with included crystals of pyrite, from the Klein tunnel area, make attractive cabinet specimens.

Quartz crystals occur in the *Peña Negra* tunnel area. The quartz is usually a well terminated clear prism less than 10 cm in length and five cm in width. Some doubly terminated smaller crystals can be found as well as internal phantom crystals. In the past evidently larger quartz crystals were found. Gilles(3) reports five or six pound quartz crystals were sometimes found in the " iron bands."

Geology

The emerald zone runs about ten kilometres east and west, and five kilometres north and south. The Chivor deposits are mainly on a sharp north-south trending ridge which passes through both of the two mining claims owned by the corporations. The ridge is composed of sedimentary clay and shale of Cretaceous age with a small amount of limestone. The limestone which occurs at Chivor may be float material. The most prominent feature of the ridge is the loosely consolidated yellow shale, which makes up a great portion of the upper stratigraphic sequence. The ridge is highly folded and faulted and the strike and dip of the beds is variable. Much of the ridge surface has been destroyed by previous intermittent mining operations over approximately the last 500 years.

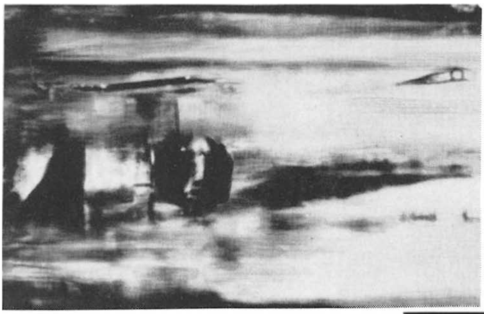


FIG. 15. *Three-phase inclusion in a Chivor emerald. To the left of the black round gas bubble is the square outline of a halite crystal. Notice the elongated outline of the inclusion cavity. These inclusions are part of a healing fissure. Usually the bubble in a Colombian three-phase inclusion is stationary. Recently a moveable bubble has been found.*

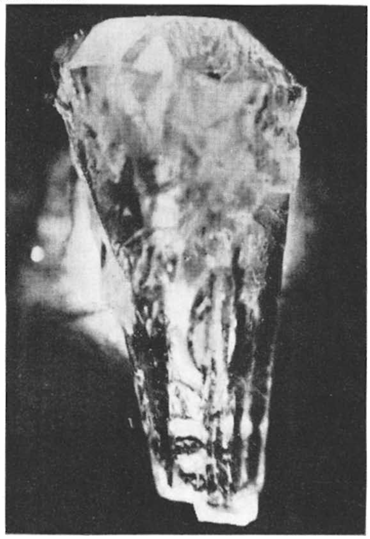


FIG. 16. *Tapered emerald, a rare specimen, from the* Coliflor *tunnel. Notice the peculiar growth along the sides of this crystal which weighs 2·3 carats and is 12 mm long.*

Tightness of fold curvature is an index of gem possibilities, the more compressed synclinal structures being considered most favourable. If a vein is discovered travelling in the trough of a syncline the production of stones may be immense.

The petrological sequence of the Chivor area from the top of the ridge to the bottom includes: white and tan clay, loosely consolidated yellow shale, black limestone, white to buff argillite, grey argillite, pyritiferous black argillite, black laminated silty shale and black argillite.

The occurrence of emeralds in veins traversing shale at Chivor is in sharp contrast to the world-wide occurrence of beryl minerals in pegmatites. Gilles has reported that no igneous rock was observed on the Chivor property nor at any place in the vicinity of the mine. Granite has also never been found at the Chivor Mine.

The " iron bands " previously mentioned are about 50 metres apart. In these bands are found large pyrite crystals which are being altered to goethite pseudomorphous after pyrite. The noticeable red colour of the bands is caused by the oxidation of the pyrite. No emeralds have been found in the bands themselves, but rather between them. Very few have been discovered above either the upper or the middle bands, more between the middle and lower, with the great bulk below the lower. From the lower band downward, for a distance of about seventy metres, is located the area where most of the development has been done. Gilles reports that up to 1930 three-quarters of the emerald production had been produced below the lower " iron band." It is in this area that the greatest future production hopes lie.

Recently, as a result of the bulldozer operations, a small production of emeralds above the upper " iron band " was recorded. The " iron bands " have been described by Gilles(3) as horizontal faults, while Mentzel claims they are not !

Paleontology

In the Colombian Bureau of Mines in Bogotá, three species of fossils are recorded from the Chivor Emerald Mine area. They were labelled: *Astieria astieri valanginiense* d'Orb., an ammonite ; *Trigonia hondaana* Lea, a bivalve; and *Cladophlebis dunkeri* (Shimper), a fern.

Taxonomically at the present time these three species would probably be: the ammonite *Olcostephanus astierianus* (d'Orbigny)*; a bivalve *Trigonia hondaana* Lea, 1940** and the fern *Cladophlebis dunkeri* (Shimper) Seward.***

Theory on the Origin of the Tapered Emeralds

Experimental growth of beryl in the laboratory indicates that pressure, temperature, changing composition of the solution, and the dilution or strength of the melt—all these and other factors can singly or together affect the habit.† The taper in the Chivor emerald undoubtedly finds its source in the above-mentioned factors and in particular to diminished nourishment during growth.

* Personal communication with Dr. Ralph W. Imlay
** Personal communication with Dr. Norman D. Newell
*** Personal communication with Dr. G. Arthur Cooper
† Personal correspondence with Dr. Richard H. Jahns

FIG. 17. *Pointed termination, rare and characteristic of Chivor emeralds. This tiny hexagonal crystal is 5·6 mm in length and weighs 0·36 carats. Emeralds with a pointed termination were probably grown under optimum conditions.*

FIG. 18. *Justo Daza, now 71 years old, has worked at the Chivor Mine intermittently since 1912. Justo, affectionately known as Tío Justo, found in 1920 the largest emerald (Fig. 19) discovered thus far at the Chivor Mine.*

THEORY ON THE ORIGIN OF EMERALD

A geosyncline formed in the eastern part of what is to-day the Republic of Colombia, South America. The geosyncline, which was formed about 120 million years ago during the Cretaceous Period, was filled with marine sediments including a few ammonites, etc. The sediments reached a depth of over 10,000 metres. As the sedimentary material became deeply buried the strength was reduced by heat and pressure. The trough was filled until a state of balance was reached and the thickness of the sediments could not be increased. The argillaceous sediments were indurated to shale, and as the strength was reduced the sediments were folded. After the relaxation of the forces which produced the geosyncline the Eastern Cordillera of the Andes in Colombia was formed. During or just after the folding aqueous fluid or vapour introduced the chemical components of pyrite, albite and emerald. As the pressure built up the fluids or vapours were forced upward through the path of least resistance: the joints, fractures and weak areas in the shale—caused by faulting and folding. Where two or more fissures crossed, the possibility of pressure release was greater and the chance for crystal precipitation increased.

Some pyrite probably began crystallization first, followed by the albite and then emerald. Pyrite has been found as inclusions and growing on the surface of the emeralds; thus suggesting that the pyrite was formed both before and after the formation of the emerald. Along the fissures where the magmatic fluids or vapours were still under pressure and were rapidly cooled, they crystallized as the massive opaque *morralla,* while elsewhere, maybe even in the same vein, crystals of gem quality emerald were formed.

Published Errors

Numerous authorities have published errors on emeralds and emeralds from the Chivor Mine. The biggest fallacy seems to be the story that emeralds flaw, fracture and splinter upon exposure to the air. This is not true. Secondly, all emeralds from Colombia are not found in calcite or limestone veins as reported by many authors who have used the Muzo Mine, where this is true, in generalizing about the whole Republic of Colombia. Neither do the emeralds from Chivor occur in a pegmatite, but rather in veins or pockets in a thick section of shale.

The Largest Emerald

The largest and most famous emerald from Chivor, weighing 632 carats, was found by Justo Daza, in December 1920. (Fig. 19.) Justo was in charge of a group of men working in the hard rock area on the south-east side of the Klein wash, about a hundred metres down from the top. Holes had been drilled in the hard buff argillite. Justo was asked by Fritz Klein, then in charge, to remove his men from the area since they had found nothing. Justo removed his men as ordered, but stayed behind himself and blasted the holes that had already been drilled. In the area that had been ripped apart a single pocket with the large emerald inside was found. Justo said, " The emerald was lying in the sand as though it were asleep in bed." Also that, " The ends of the emerald were covered with a brown (goethite) stain that was easily rubbed off with my handkerchief." The outside edge of the pocket was covered with a goethite stain.

This emerald sold for $60,000 (£21,400) early in 1921. Known as the " Patricia " emerald, it is owned by and on display at the American Museum of Natural History in New York City. Justo's

TABLE I

REFRACTIVE INDEX ON EMERALDS FROM THE CHIVOR MINE, COLOMBIA, SOUTH AMERICA

Number	*Collection Number*	*Gem Refractometer*	*Rayner Spinel Refractometer*	*Remarks*
1	C-87	1·569 – 1·576	1·570 – 1·576	1·815 carat rough crystal
2	C-88		1·572	2·531 carat rough crystal
3	C-89	1·575	1·575	3·093 carat rough crystal
4	C-92	1·569 – 1·575	1·572 – 1·579	11·437 carat rough crystal
5	C-93	1·57	1·579	26·596 carat rough Xl. with Qtz. inclusions
6	C-94	1·57	1·565 – 1·571	0·789 carat cut stone
7	C-96	1·575		11·515 carat rough Xl., goethite inclusions
8	C-102	1·565		4·115 carat rough Xl., best tapered specimen
9	C-102	1·57		rough crystal
10	C-102	1·57		rough tapered crystal
11	C-102	1·572		rough tapered crystal
12	C-102	1·575		rough crystal

Data by Charles J. Parsons, C.G., F.G.A.

TABLE II

SPECIFIC GRAVITY ON EMERALDS FROM THE CHIVOR MINE, COLOMBIA, SOUTH AMERICA

Number	*Collection Number*	*Weight in Carats*	*Specific Gravity*	*Remarks*
1	C-85	1·545	2·646	doubly terminated hexagonal crystal
2	C-86	1·771	2·725	doubly terminated dihexagonal crystal
3	C-87	1·815	2·663	doubly terminated hexagonal crystal
4	C-88	2·531	2·681	single termination on a hexagonal crystal
5	C-89	3·093	2·701	single termination on a hexagonal crystal
6	C-90	3·753	2·652	single termination on a hexagonal crystal
7	C-91	5.642	2·687	single termination on a dihexagonal crystal
8	C-92	11·437	2·684	single termination on a hexagonal crystal
9	C-93	26·596	2·675	doubly terminated, with quartz inclusions
10	C-94	0·789	2·730	faceted stone, emerald cut
11	C-95	1·393	2·663	doubly terminated, with pyrite inclusion
12	C-100	4·545	2·593	*morralla* from the *El Taladro* tunnel area

Data by the author using a Voland analytical balance calibrated in carats.

bonus for finding the emerald was ten pesos (about ten dollars, £3 12s.).

The " Patricia " emerald was probably found in the centre of the pocket as described by Señor Daza, but was originally grown attached at one end. The opaque " Patricia " emerald is dihexagonal with a single flat termination and fractured on the bottom, with three side growths.

After the find the men were called back to work the area. Four days later a heart breaking discovery. A second pocket was found which appeared to have contained a larger emerald crystal. This pocket was blown apart in the blast and nothing was recovered except small pieces. Both pockets contained green sand (probably *morralla*) and both had a single large crystal. Large boulders came down on the work area from above and finally work was terminated when a slide completely engulfed the area. Both pockets were about a foot in diameter and are the only ones that were ever found in the Klein tunnel area.

Early Operation Costs

Gilles in his 1930 unpublished report on the Chivor Mine lists the following early operation costs. Notice that from 1926 through 1929 the mine registered a deficit of $10,785.42.

Table III

Total cost of operation in 1926	$40,557.19
Total cost of operation in 1927	$95,523.83
Total cost of operation in 1928	$56,523.84
Total cost of operation in 1929	$83,696.90
Total cost of operation from 1926-1929	$276,301.76
Total selling value of emeralds produced from 1926 to 1929	$265,516.34
Average price received per carat for the period 1925 to 1929	$1.99

Production Statistics

Mine costs sometimes exceed the value of the emeralds mined. Production is sporadic and mining may continue for months without a single production.

Emerald production, like all other gem production, is variable. Production figures are never accurate since intermittent operation and the frequent change of administrators contribute greatly to inaccuracy. Records have been lost, never recorded at all, or if noted are lower than the actual production. The recorded produc-

Table IV

Recorded Production of the Chivor Mine, Colombia, South America

Year	*One B*	*One C*	*Two A*	*Two B*	*Two C*	*Two D*	*Three*	*Three A*	*Three B*	*Three C*	*Three D*	*Four A*	*Four B*	*Four D*	*Five*	*Five A*	*Five B*	*Five C*	*Six A*	*Total Emeralds*	*Total* Morralla
	Carats	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*	*Carats*
1921																				30,207	
1925																				4,234	
1926			1,020	2,150				400				5,600	5,900			28,400				43.470	76,000
1927			420	4,192				1,597	10,339			3,038	12,516			5,443				37,545	70,000
1928			300	205				2,784	944	6,940		1,964		2,335	7,240					22,712	
1929	769		3,015	1,745				5,885	1,360	3,055	4,915		125					8,575		29,444	35,035
1930		350	930	2,380				1,100	6,745			6,420				3,220	14,360			35,505	30,000
1931		1,200			6,300					8,710		1,400	11,840			600	16,200			46,250	21,585
1937–1940					298	383	1,242	2,044	2,652	85		2,051	1,479			12,743	5,860			28,837	73,633
1948			1,638	3,044	1,450	1,144		3,644	3,857	1,751	1,062	17,941	3,028			11,176				49,735	38,766
1949			1,467	933	269			5,351	4,010	343		22,967	371				30,735	4,070		70,516	47,299
1950			16					58	21	192		1,762				8,166			292	10,507	12,102
1951												2,462				7,547	423		2,024	12,456	16,453
1952												1,816				13,317			3,797	18,930	5,027
1953												2,813				4,057			8,965	15,835	3,118
1954												471	193			5,036	403		1,122	7,225	31,628
1955												2,131				3,669			1,758	7,558	154,717
1956								447				2,049				6,624				9,120	198,700
1957								1,940				7,461				12,878				22,279	287,819
Totals	769	1,550	8,806	14,649	8,317	1,527	1,242	25,250	29,928	21,076	5,977	82,346	35,452	2,335	7,240	122,876	67,981	12,645	17,958	502,365	1,101,882

Compiled by Willis F. Bronkie.

Fig. 19. *The " Patricia " emerald found by Justo Daza at the Chivor Mine in December 1920. It was found in a pocket in a hard buff argillite of the Klein tunnel area. This 632 carat dihexagonal crystal is now owned by and on display at the American Museum of Natural History, in New York City.*

tion from 1921 to 1957 is shown in table IV. In 1929 Rainier reported 480,000 cubic metres of earth and rock were removed producing 29,444 carats of emeralds, or 16 cubic metres per carat. The ratio of emeralds to overburden is then about one to 90 million.(3)

From the first of June to the first of December 1921 the mine was managed by Christopher E. Dixon. During this period 30,207 carats of emerald were recovered worth at that time an estimated \$179,911.75.(3)

Acknowledgments

I am deeply indebted to Willis F. Bronkie, Trustee of the Chivor Mine, for his hospitality, sincere interest and encouragement in this project. He made it possible for the author to do field work at the Chivor Mine.

At the United States National Museum I wish to thank Drs. Jose Cuatrecasas, G. Arthur Cooper and Ralph W. Imlay. For the identification of the clay mineral to Dr. Ralph E. Grim, Dept. of Geology, University of Illinois. For the information on inclusions the help of Dr. Edward J. Gubelin, F.G.A., of Lucerne, Switzerland, has been invaluable. At the American Museum of Natural History I wish to express my appreciation to Drs. Brian Mason and Norman D. Newell. Dr. Gustav Arrhenius and Miss Clio Hood at Scripps Institution of Oceanography, University

of California, kindly did X-ray diffraction curves on unidentified minerals. The refractive indices were taken through the generosity of Charles J. Parsons, C.G., F.G.A.

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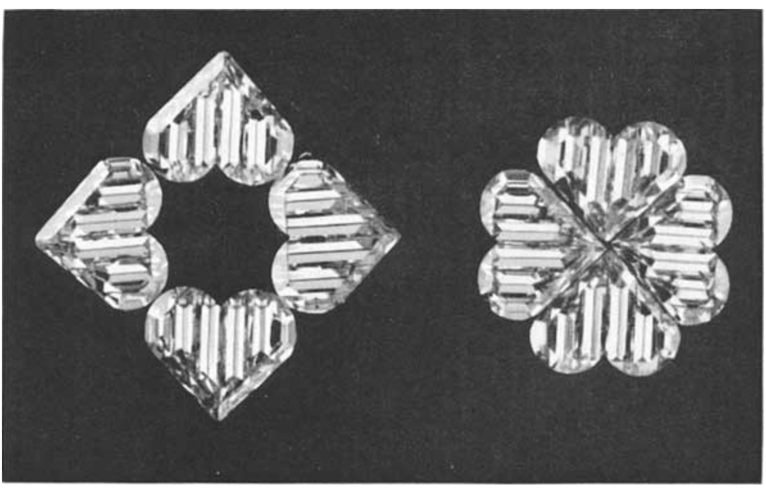
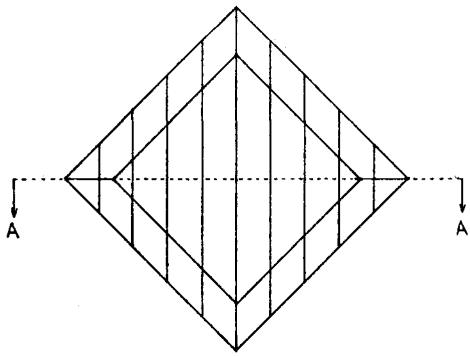
NEW STYLE OF DIAMOND CUTTING

A NEW style of diamond cutting was exhibited at Messrs. Garrard, the Crown Jewellers, at a jewel exhibition held in October. The name of the new cutting style is Princess cut and it is claimed that it is the most important development in the more than 480 years old history of gem diamond cutting. The outstanding feature of the cut is its constant diamond thickness of 1·50 mm. At this thickness stones display fine brilliance. The patented cutting process makes it possible to produce a range of attractive modern diamond shapes not used before. The cut is distinctive and will be used for genuine diamonds only, the patent safe-guarding against competition from cheap imitations.

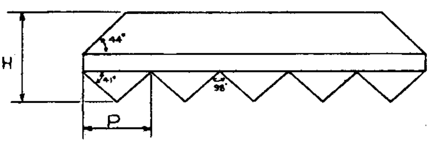
Carving of diamonds is also now possible from the new cutting methods which have been developed by Mr. Arpad Nagy, managing director of Diamond Polishing Works Limited, who are marketing the Princess-cut diamonds. Mr. Nagy has spent many years in developing his new cutting technique. An important factor for the diamond mounter is that the high precision necessary in the new process means that stones can be supplied which are extremely accurate in size.



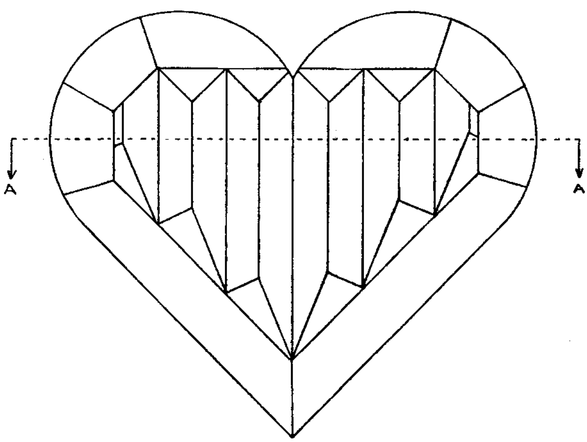
PRINCESS CUT FOR DIAMONDS



Elevation of A - A



Square Stone Profiled



Elevation of A - A

Heart-Shaped Princess

Gemmological Abstracts

SINGH (LAKHBIR). *The colour problem of ruby.* Nature, Vol. 181, pp. 1264-1265, 1958.

The critical concentration of 8 mol.% Cr_2O_3 in synthetic ruby compositions appears to have the same magnetic significance as the Curie temperature.

1 fig. R.A.H.

WHITE (E. A. D.). *Synthetic gemstones.* Quart. Reviews, Vol. XV, No. 1, pp. 1-29, 1961.

Following a discussion of the various crystallization processes used in the synthetic production of gemstones, details are given of the production of diamond, corundum, spinel, rutile, strontium titanate, quartz, garnet, emerald, and blende. The physical properties of gemstones are reviewed and future trends discussed.

4 figs, 4 pls. R.A.H.

HOLMES (R. J.). *Synthetic and other man-made gems.* Foote Prints, Vol. 32, No. 1, pp. 3-25, 1960.

Following a discussion on the nature of gems and their identification, details are given of imitations, assembled and reconstructed stones, the Verneuil flame-fusion process and the production of synthetic corundum and spinel and their identification.

R.A.H.

ANON. *New emerald find in Colombia.* Gems and Gemology, Vol. X, No. 5, pp. 142 and 158. Spring 1961.

Reports on the examination of some emerald crystals from a new source near Borur about 100 miles north-west of Bogatá. The colour of the stones was a clear deep-green and the crystals showed prism faces and, with those which showed terminations, the basal pinacoids had small bi-pyramidal faces of the same order as the prisms. The refractive indices were found to be 1·569–1·576 and the density, taken on a twenty-carat crystal, was 2·704. Three-phase inclusions were noted and one crystal contained two large cavities with movable bubbles. The stones were found to fluoresce somewhat more strongly than other natural emeralds.

1 illus. R.W.

WILSON (A. F.). *Zircon—the mineral and gemstone of rising fame.* Australian Gemmologist, No. 5, pp. 6, 7, 14. May 1961.

The report of the Presidential address to the Gemmological Association of Australia. In 1789 Klaproth isolated the element zirconium from zircon. Most common rocks contain zircon and erosion of these rocks produces the zircon sand and rolled pebbles. Zircon sand consists of crystals of four-sided prisms capped with four-sided pyramids and are only about three-tenths of a millimetre long. The characters of zircon are given as well as its commercial use.

R.W.

FUNSTON (W. E.). *Working conditions in a South African diamond mine.* Australian Gemmologist, No. 5, pp. 8-9. May 1961.

The natives are hired under contract and must live in the compound for not less than four months. The mine shaft (Premier mine) is located within the compound. The natives usually cook their own food which is bought from the non-profit making compound store. Continuously running stoves are made available for this cooking. Underground the workers are formed into groups of four to twenty men under a " boss boy ". Operation is continuous by working three eight-hour shifts. Sleeping accommodation is in dormitories, each being under the control of a " boss boy ". Educational and sports facilities are provided.

R.W.

ANON. *Making diamonds.* Gemmologist, Vol. XXX, No. 360, pp. 130-131. July 1961.

At the open day of the National Physical Laboratory it was disclosed that diamonds had been made during experiments with high pressures. A tetrahedron of pyrophyllite containing the test material is squeezed uniformly by an anvil pressing on each face. Under high pressure the pyrophyllite flows and applies pseudo-hydrostatic pressure to the test sample. Diamond was synthesized using nickel as a catalyst.

1 illus. R.W.

MAHAJAN (B. S.). *Gifts from India for the Queen.* Gemmologist, Vol. XXX, No. 360, pp. 122-123. July 1961.

During their visit to India H.M. the Queen and Prince Philip were the recipients of several gifts, among which were an agate bangle contained in an agate box which was presented to the Queen by the State of Gujarat, His Royal Highness received a symbolic gift of a ship and lighthouse carved from chalcedony. A crescent in yellow jasper on a pedestal of green jasper was another gift made to the Royal visitors. The material used was obtained from the Little Desert of Cutch.

1 illus. R.W.

LIDDICOAT (R. T.). *A report on European laboratories.* Gems and Gemology, Vol. X, No. 5, pp. 131-141 and 157. Spring 1961.

Describes visits the author paid to the gemmological laboratories in Italy, Germany, France, Switzerland and England. In every case, except that in London, these laboratories provide training facilities. There are four laboratories in Italy, the one visited, that run by Professor Cavenago-Bignami at Valenza-Po, near Florence, was found to be well equipped with up-to-date instruments including X-ray, endoscope and photographic equipment. Unlike the other laboratories, except that in Paris, the stones submitted for testing are identified by number rather than by the owner's name, and they are sealed in a transparent envelope. Prof. K. Schlossmacher's laboratory in Idar-Oberstein was also visited. This laboratory is well equipped and has a diffraction and radiographic unit for pearl testing. Comment is made on the horizontal polarizing microscope which was designed by Prof. Schlossmacher. The Paris laboratory under the direction of Mons. G. Göbel was also found to be well-equipped and much emphasis is placed on the use of inclusions both in routine testing and in teaching. A very full description is given of the laboratory run by Dr. E. Gübelin. There are actually three laboratories. One is in the main sales floor of the Gübelin firm and is mainly used for diamond grading. The other laboratory on the firm's premises is probably the most efficiently equipped laboratory the author visited. Many of the instruments are of Dr. Gübelin's own design. The third laboratory is the Director's own private laboratory. Photography plays an important part in the work of these laboratories and most of the optical instruments were found to be equipped with Leica cameras. The London laboratory, directed by B. W. Anderson, has equipment which is less elaborate but which has been used to great advantage. Mention is made of the contributions to gemmology made by the staff of this laboratory. The

history of this laboratory and its staff, and notes on the research work carried out are given.
16 illus. R.W.

Ruff (E.). *Jade of the East.* Gemmologist, pp. 41-47; 84-88; 117-120; 133-138; 147-152; 170-176 and 187-191 of Vol. XXIX (March to October 1960) and pp. 11-16; 30-35; 54-59; 70-75 and 91-96 of Vol. XXX (Jan-May 1961).

A very extensive series of articles covering many aspects of jade. A vast amount of information is given on the history of jade, on the localities where it is found, on the various colours and types of jade, the symbolism of jade and notes on the carving of this material.
10 illus. R.W.

Anderson (B.W.). *Cultured pearls with split nuclei.* Gemmologist, Vol. XXX, No. 358, p. 86. May 1961.

Describes a peculiarity found in some cultured pearls in which the bead core had apparently cracked.
1 illus. R.W.

Kennedy (N.W.). *Gold in Wales.* Gemmologist, Vol. XXX, No. 358, pp. 87-89. May 1961.

A short account of the gold resources in Wales. The richest deposit was said to be in the Mawddach river area between Dolgelly and Barmouth where extensive faulting has caused the veins of auriferous alluvial to peter out. A general discussion of the gold mining prospects of the area is given.

R.W.

Hunek (E.). *Regenerated precious opals.* Gemmologist, Vol. XXX, No. 359, pp. 101-102. June 1961.

Details some experiments in the regeneration of precious opals from the Hungarian National Museum, which had been heavily damaged by fire during the 1956 uprising. The stones were treated by using water under vacuum. Slight success was noted using a vacuum of 350 mm but a more satisfactory result was achieved by using a vacuum of 700 mm for eight to twelve days. Up to the present time the regeneration appears to be permanent.

R.W.

PING-HENG (P.). *Jade carving to-day.* Gemmologist, Vol. XXX, No. 369, p. 106. June 1961.

Written by the Deputy Director of the Pekin Arts-Crafts Research Institute the article is a reprint from The Australian Gemmologist. (Abstract Journ. Gemmology, Vol. VIII, No. 3, p. 109).

R.W.

ANDERSON (B. W.). *Spessartite garnets.* Gemmologist, Vol. XXX, No. 359, pp. 108-109. June 1961.

A comment on F. S. Tisdall's article on the spessartite garnet from Ramona, California. (Abstract Journ. Gemmology, Vol. VIII, No. 3, p. 104).

R.W.

DEANE (N.). *Gold in Wales.* Gemmologist, Vol. XXX, No. 360, pp. 121-122. July 1961.

Describes a visit paid to the Clogau St. Davids mine at Bontddu near Dolgelly in North Wales. The gold occurs in quartz veins in a band of " Clogau shale " which extends in a curve from Barmouth round to Dolgelly and then in a northerly direction towards Bala lake. Associated minerals are listed. Speculations as to this and other probable gold resources in the British Isles are made. Spessartite garnet is said to be present in the district.

R.W.

BENSON (L. B.). *Developments and highlights at the Gem Trade Lab. in Los Angeles.* Gems and Gemology, Vol. X, No. 5, pp. 143-147. Spring 1961.

Synthetic spinel doublets in a variety of colours were examined. These stones are said to be obtainable in sixteen different colours. A crystal of hambergite is commented upon and the finding of hexagonal crystals in three-phase inclusions in emerald is mentioned. A natural pearl which showed a greenish overtone when viewed under a standard fluorescent tube lamp, but not under tungsten light, provided a very puzzling effect. A new opal substitute comprised a rock crystal cabochon backed by a piece of abalone shell. A new Gemological Institute of America spectroscopic unit is described.

3 illus. R.W.

CROWINGSHIELD (R.). *Developments and highlights at the Gem Trade Lab. at New York.* Gems and Gemology, Vol. X, No. 5, pp. 148-153 and 158. Spring 1961.

A synthetic quartz of tourmaline-green colour; beryl to beryl doublets, and a star-sapphire doublet consisting of two parts of natural sapphire are reported. Notes on a black dyed cultured pearl in which the nucleus had moved, and a hollow centred cultured pearl are mentioned. Examples of treated turquoise and ruby in green zoisite are other specimens referred to.

9 illus. R.W.

BOOK REVIEWS

SINKANKAS (J.). *Gemstones and minerals. How and where to find them.* Van Nostrand Co. Inc. 67s. 6d. pp. 387. 133 photos and figs. Princeston, 1961.

The U.S.A. and Canada are rich in gem minerals and prospecting is enthusiastically undertaken by many thousands of collectors and lapidaries. John Sinkankas's lucidly written book provides a wealth of information about methods of prospecting and collecting, preparation of specimens, storage, exhibition and marketing. There are chapters about the use of tools, the classification of rocks and field features of mineral deposits.

Once again Mr. Sinkankas has made a good book and, although it will appeal mainly to readers in North America, there is much in it which will inform collectors in any country where the finding of gem minerals is possible.

S.P.

BRUTON (E.). *Diamonds.* True Books. London. 1961. 144 pages. 8s. 6d.

This volume is one of a series of " True Books ", which are written on many subjects, and which are primarily intended for the teenager. In this work Eric Bruton has covered the subject adequately and lucidly in twelve chapters and with 28 illustrations. The nature of diamond; conjectures on the formation of diamond, and something of its occurrence and its uses are told. There are stories about the finding of diamonds in India, Brazil and South Africa, and entertainingly recounted are the early days in

South Africa and the battle for power of Cecil Rhodes and the Barnato Brothers. The histories of some of the South African mines and of the Williamson mine in Tanganyika are given, and there is a chapter on the more important famous diamonds. The mining of diamonds by the primitive methods as used in South America and the more modern equipment used in the South African mines, as well as something of the Russian mining techniques of diamond mining are described. There is an interesting chapter on the sorting and marketing of the rough crystals, on the cutting of diamond crystals into gemstones and the methods used in selling the fashioned stones to the jeweller. The various uses to which diamonds have been put in industry, some scientific facts, and the synthetic production of diamond, form the bases of other chapters. Stories of diamond smuggling help to make the book even more interesting, and in conclusion there is told something of Hatton Garden, the laboratory of the London Chamber of Commerce and the Diamond Research Laboratory in Johannesburg, and some ideas on how to tell a diamond from other gems. Hints on cleaning are given. This book can be recommended, as it is easily read and most absorbing. It should be a valuable addition to a student's library, for the information given is accurate.

P.B.

ASSOCIATION NOTICES

MIDLANDS BRANCH

A party of 30 members and friends visited Luton Hoo on 2nd July, 1961. The collection of fine arts belonging to Sir Harold and Lady Zia Wernher enchanted the visitors, especially the works of Carl Faberge, the Russian collection and the tapestries and tableware of the dining room. Other interesting features were the Brown Jack trophies, carved ivories and examples of fine porcelain.

WEST OF SCOTLAND BRANCH

The well-attended summer outing of the West of Scotland Branch to Leadhills, Lanarkshire, was held on Sunday, 28th May, 1961.

As the name implies, the Leadhills have been worked for their lead, and the written history of lead mining goes back to the 13th century, although they are believed to have been worked for at least 200 years prior to this. Subsequently, silver was mined quite extensively, the ore having been sent to Belgium for refining. A substantial amount of gold has also been found there.

It is not surprising, then, that numerous crystals of Galena were found. Great quantities of clear colourless quartz were also picked up; but no single crystals of any great size. Calcite was prolific in its distribution and many crystals of pyrites were unearthed. One member discovered a large piece of this latter mineral weighing well over a pound but unfortunately displaying no crystal form. Although the lapidaries are unlikely to see any of the specimens collected, the mineral collections of the members present received some useful additions.

MEMBERS' MEETINGS 1961

Dec. 4 Reunion of members and presentation of awards, Goldsmiths' Hall, London, E.C.2. Reunion 6 p.m., presentation 7.15 p.m. Mr. Herbert Tillander, Chairman of the Finnish Gemmological Association had kindly consented to present the awards.

Meetings of the Midlands Branch will be held in November, January and February and branch members will receive details in due course. The November meeting will be a visit to the stone cutting department of Shipton & Co., Birmingham.

OBITUARY

Lester B. Benson, Jr.

In the sudden death of Lester B. Benson, Jr., at the age of 39, the Gemological Institute of America have lost a brilliant and creative gemmologist. Lester Benson was responsible for the development of many of the Institute's instruments and he devised the method of taking curved-surface readings on the refractometer. He was a patient and understanding teacher and was an unfailing inspiration to co-workers and students.

SOLE DISTRIBUTING AGENTS — RAYNER GEMMOLOGICAL INSTRUMENTS

The Gemmological Association of Great Britain has been appointed sole distributing agents for gemmological instruments and accessories manufactured by Messrs. Rayner & Keeler, Ltd.

COUNCIL MEETING

A meeting of the Council was held at the Association's offices on 28th June, 1961. Mr. F. H. Knowles-Brown presided.

The following were elected :—

Fellowship

Edge, William S.,
Glenelg, S. Australia. D.1960

Kelly, Allen E.,
S. Harrow, Middlesex. D.1939

Ordinary Membership

Azevedo, M. Arthur, California, U.S.A.
Bhushan, Vidya, New Delhi, India.
Burns, Robert, California, U.S.A.
Crank, Helen E. (Mrs.), London.
Davis, Merle, New Jersey, U.S.A.
Garg, Satya P., Jaipur City, India.
Ketelaar, Johann G., Holland.
Males, Pamela A. (Miss), Dulwich Hill, N.S.W., Australia.
Reymer, Hans W., Montreal, Canada.
Schweder, Richard P., Christchurch, New Zealand.
Zeff, Clive M., Johannesburg, S. Africa.

Probationary Membership

Roca, Rogelio, Jr., Barcelona, Spain.
Searle, Ian V. H., Norwich.
de Silva, S. P. R., Singapore, Malaya.
Vogel, Georg, Lucerne, Switzerland.

A revised syllabus of examinations was approved for use commencing with the 1962 examinations.

Arrangements were made for the presentation of awards to be held on 4th December, 1961, at Goldsmiths' Hall (by kind permission of the Wardens of the Goldsmiths' Company).

COUNCIL MEETING

A meeting of the Council of the Association was held at the Association's offices on 23rd August, 1961. Mr. F. E. Lawson Clarke presided.

The following were elected to membership :—

ORDINARY

Elze, Jacques Hercules, Bussum, Holland.
Fraley, Lawrence, Wheelersburg, Ohio, U.S.A.
Smith, Benjamin Henry, Jr., Wilmington, N. Carolina, U.S.A.
Spink, Brian Stanley Francis, Barrow in Furness.

PROBATIONARY

Camberg, Michael Ralph, Johannesburg, S. Africa.
Grant, James Ros, Carlisle.
Humphreys, Alan Lewis, Andover.
O'Mahony, Michael Dennis, Epsom.
Quick, Rodney John Anthony, Torquay.
Statton, Richard Herbert David, Taunton.

The Council received details of an offer by Messrs. Rayner & Keeler, Ltd., to appoint the Association as sole distributing agents for all Rayner gem testing instruments and accessories. It was resolved to accept the offer, upon terms to be agreed, and the Council recorded appreciation of Messrs. Rayner's gesture. The Council also accepted the services of the National Association of Goldsmiths in connexion with the organization of the agency.

TALKS BY MEMBERS

KENNEDY, N. : " Gemstones and gem materials," British Assoc. Chemists (Merseyside Section), 20th October, 1961.

BAGLEE, G.: " Gemstones," West Hartlepool Ladies' Circle, 11th September, 1961.

EXAMINATIONS IN GEMMOLOGY, 1961

In the 1961 examinations in gemmology 182 candidates presented themselves for the preliminary examination and 106 for the diploma. Centres for the examinations were established in Norway, Switzerland, South Africa, Kenya, Ceylon, Canada, Holland, Finland, New Zealand, Southern Rhodesia, Sweden, Poland, Italy and the United States of America, apart from the United Kingdom.

The Rayner Prize in the preliminary examination has been awarded to Mr. Ernest W. Penner of Islington, Canada. Upon the recommendation of the examiners the Tully Medal and Prize were not awarded.

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

DIPLOMA

Qualified with Distinction

Ainsworth, Kenneth John, Blackburn
Beasley, Barbara Ann, Windsor
Butler, William Charles Finlay, Paisley
Cozens, Jonathan Roper, Taunton
Green, Leslie, Rainhill, Nr. Liverpool
Harrold, David John, Southend-on-Sea
Hayes, Denis, London
Hodgkinson, John Alan William, Aberdeen
Keller, Jean-Pierre, Lucerne
Stout, Cornelius Andries, Rotterdam
Synan, Martin Thomas, Slough
Wallington, Laurie, Scarborough, Canada
White, John Anthony, Frome
Whitehead, Bernard, Birmingham

Qualified

Aarne, Eino Leo, Helsinki, Finland
Abdeen, Mohammed Maharoof Zainul, London
Agius, Frank J., Sliema, Malta
Allen, Michael H., Ilford
Arkiomaa, Pia Gunnari, Helsinki, Finland
Axon-Ryder, Albert Roy, Bolton
Bacon, Frank Hedley, Bedford
Badrutt, Reto J. P., Geneva, Switzerland
Bills, Raymond Frederick, Solihull
Bishop, Trevor, London
Bradley, Czeslawa, Nairobi, Kenya
Conyers, William Edgar, Stockport
Ellis, John Rodney, Norwich
Francis, Roger, Birmingham
Gray, Eleonora, Paris
Greeph, Mayer, Manchester
Heasman, David John Alfred, Colchester
Heesom, Thomas Henry, Altrincham
Hewson, Robin John, Egham
Hill, Dennis Alan, Glasgow
Hiscox, Sieglinde Elsa, Solihull
Hunter, John Waddell, Garrowhill
Jean, Wilmer Francis, Pittsburgh, U.S.A.
Joseph, Timothy Richard, Knowle
Kaksonen, Yrjö Edvin, Helsinki, Finland
Ketelaar, Johann Gottliel, Heemstede, Holland
King, Archibald Vallance, Edinburgh
Lusty, Kenneth Charles, London
McCarty, Fay Veronica, Birmingham
Micinski, Czeslaw Zbigniew, Manchester
Morris, Clive Raphael, London
Musoeus, Hans Bjarne, Oslo, Norway
Nuttall, John, Manchester
Piper, Robert William, Guernsey
Preston, Iris Winifred, Iver
Price, Denis Edward, Smethwich
Rouvier, Andre Edmond, London
Rowe, Alan David, East Molesey
Sanford, Peter, Hatfield
Siltanen, Ismo Kalevi, Jyväskylä, Finland
Silva, Edward Herbert Leslie de, Colombo, Ceylon
Sundqvist, Arvo Johannes, Helsinki, Finland
Sloman, Peter, Southend-on-Sea
Smith, Lawson Bathgate, Birmingham
Smith, Reginald Albert, Oxford
Snaddon, James, Sale
Stirton, Kenneth Geekie, Ripon
Szymczyk, Joseph, London
Webb, Herbert H., London
Wiik, Viggo Harald, Oslo, Norway

Preliminary Qualified

Aho, Risto Aleksander, Helsinki, Finland
Angell, David John, Tonbridge
Asprey, Maurice, London
Bacon, Stephen Jasper, London
Berkel, Joannes Victor Maria van, Utrecht, Holland
Blanshard, Philip John Anthony, Croydon
Blyth, Elizabeth Rhoda, Nanaimo, Canada
Borgen, Annemarta, Oslo, Norway
Bradley, Czeslawa, Nairobi, Kenya
Bradley, Robert Charles William, Didcot
Carlman, Rolf Ryno, Stockholm, Sweden
Chesebrough, Rosser, Sherman Oaks, U.S.A.
Coop, Norah Marian Nita, London
Crank, Susan Elizabeth, Bolton
Cropp, Alan Reginald, Cambridge
Dahl, Leiv Eyvinn, Oslo, Norway
Dahlsveen, Jon Olav, Trondheim, Norway
Dahlsveen, Eirik, Trondheim, Norway
Dale, Rita Olive, Birmingham
Davidson, Terence Malcolm John, London
Donaldson, Helen E. J., Toronto, Canada
Dowse, John Edward, Birmingham
Egli, Ernest, Geneva, Switzerland
Elze, Jacques Hercules, Bussum, Holland
Farrant, Eric Raymond, London
Feltell, Raymond, Birmingham
Fine, Jay, Orilla, Canada
Foulkes, Peter Clarence Albert, London
Frey, Erich, Pretoria, South Africa
Fraleigh, Jack Philip, Toronto, Canada

Gillougley, James Hugh, Glasgow
Glendinning, Harold, Newcastle-upon-Tyne
Gould, Henriette, Johannesburg, South Africa
Griffiths, John Arthur, Kidderminster
Gronqvist, Tarmo, Helsinki, Finland

Harper, David Charles, Sutton Coldfield
Hencher, Brian, Blackpool
Hinton, Bernard A., Toronto, Canada
Hodgetts, Patricia Marion Ann, Birmingham
Hollens, John Frank, Pinner
Hudson, Douglas Geoffrey, Whitstable

Irwin, Eric, Liverpool

Johne, Vera Asta, Oslo, Norway
Johne, Thor Aksel, Oslo, Norway
Jokinen, Pertti, Helsinki, Finland
Jones, David Colin Barry, Leamington Spa
Jones, Kenneth Peter, Stourbridge
Jørgemsem, Per, Oslo, Norway

Keller, Jean-Pierre, Lucerne
Kern, Edward E., West Hartford, U.S.A.
Klerk, Anthonius Franciscus C. de, Oud-Gastel, Holland

Lahtinen, Åke Johannes, Vartokylä, Finland
Lappalainen, Ritva, Helsinki, Finland
Lee, Raymond George, Torquay
Leimu, V. Heikki K., Hämeenlinna, Finland
Lieberman, Ian Stuart, Ilford
Lodge, John William, Newcastle-upon-Tyne

MacKenzie, Iain Fraser, Manchester
Malone, Michael A., Leeds
Marno, Raimo Atte Uolevi, Helsinki, Finland
Marshall, John Frederick, Sutton Coldfield
Marshall, Nigel Francis, Birmingham
McChlery, George Michael, Glasgow
Merritt, Helen Claire, Toronto, Canada
Micinski, Czeslaw Zbingniew, Manchester
Moi, Gerd, Oslo, Norway
Morgan, Ralph John Alfred, Torquay
Mullen, Joseph, Glasgow
Musoeus, Hans Bjarne, Oslo, Norway

Nadort, Edward Adri, New Westminster, Canada
Nash, Roy, Birmingham
Newberry, Bianca Elizabeth, London
Nolan, Constance Jessie Cowlam, Gomersal, Nr. Leeds

Parker, David John, Birmingham
Parviainen, Aira Annikki, Matinkylä, Finland
Petzall, Ossi George, Ilford
Pochee, Farouk Ozair, Edinburgh
Porter, Joseph David, Rochdale
Potterat, Raymond, Geneva, Switzerland
Pressley, Charles Reginald, Worthing
Preston, Iris Winifred, Iver
Pudner, Robert Arnold, Liverpool
Pulkka, Helka Elina, Oulu, Finland
Pulkka, Hilkka Irene, Oulu, Finland

Ranger, Clive James, Bromley
Robinson, David Michael, Liverpool

Sealey, Roger Malcolm, Totton
Selvon, Dennis Ralph, Woodford Green
Slaven, Ronald William, Loanhead
Smart, Lawrence Paul, Birmingham
Solomon, Anthony Leopold, Harrow
Stanley, Edward, Manchester
Stewart, John Linn, Edinburgh
Stockall, Collin John, Richmond
Sweet, Alfred William, Plymouth

Thompson, Colvin Graham, London
Thurlby, Paul Anthony, Birmingham
Travis, Denis John, Esher
Turnbull, Elizabeth, Sunderland
Turton, Philip John, Solihull

Virkkunen, Marjatta, Roihuvuori, Finland

Walker, Leslie, Liverpool
Wallington, Laurie, Scarborough, Canada
Ward, Charles John, Harrogate
Waters, Peter Aloysius, Manchester
Weinstein, Eric, Surbiton
Werkhooven, Piet J. K. van, Hilversum, Holland
Weston, Raymond, Lapworth
Whitehead, David, London
Wiik, Viggo Harald, Oslo, Norway
Wijkstrom, Gunna, Stockholm, Sweden
Wilkins, David, Swindon
Woodhouse, Michael Lesley, London

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