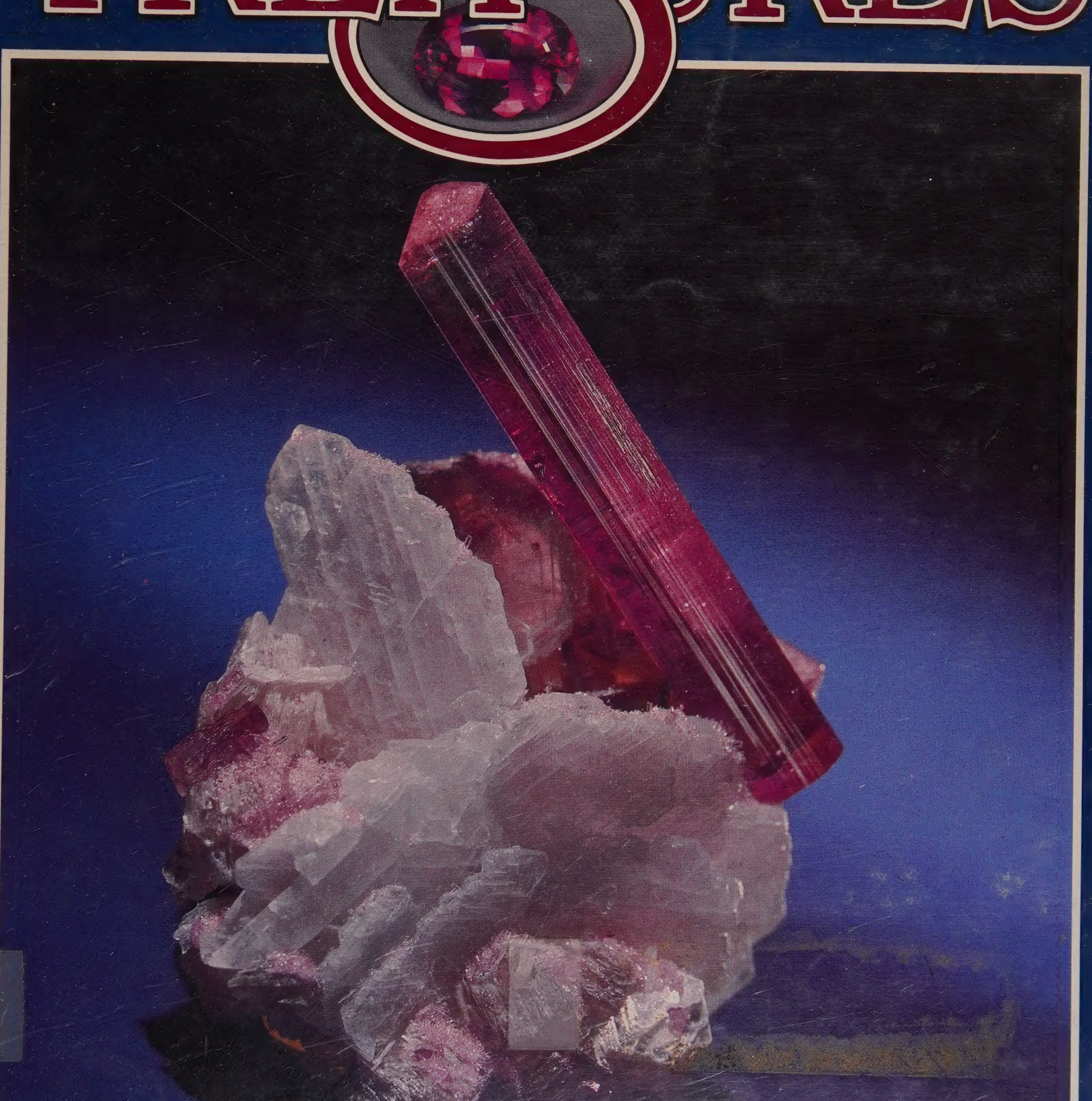
Gem & Crystal TREASURES



Peter Bancroft

Gem and Crystal Treasures

Peter Bancroft

Within these pages you will embark on 100 "field trips" to many of the world's most exotic gem and crystal mines. You'll relive the discovery and earliest days of each deposit, and meet those who worked in and about the mines—shopkeepers, sheriffs, miners, prostitutes, and bad men, all portrayed in 667 black and white illustrations and accompanying text.

Over 320 crystal and gemstone treasures gleaned from these deposits are depicted in full color. Each crystal has been selected as one of the choicest examples available. For the most part, specimens have been photographed in their entirety.

Dr. Peter Bancroft has assembled what may be the finest group of gemstone and crystal illustrations ever, augmented by photos of exquisite carvings, faceted gems, and stunning jewelry.

Step back in time and experience human drama as it was—incredible good fortune, stark tragedy, and every conceivable event inbetween. Marvel at a wealth of gemstones and naturally formed crystals—surely among God's greatest treasures.

FRONT COVER PHOTO:
Tourmaline, doubly terminated, on cleavelandite
Size: 7 by 5 cm
Locality: Joao Pinto mine, Brazil
Collection: William Larson
Photo: Harold and Erica Van Pelt

BACK COVER PHOTO:
Rhodochrosite
Size: 5 by 4 cm
Locality: N'Chwaning mine, So. Africa
Collection: Norman Pellman
Photo: Harold and Erica Van Pelt

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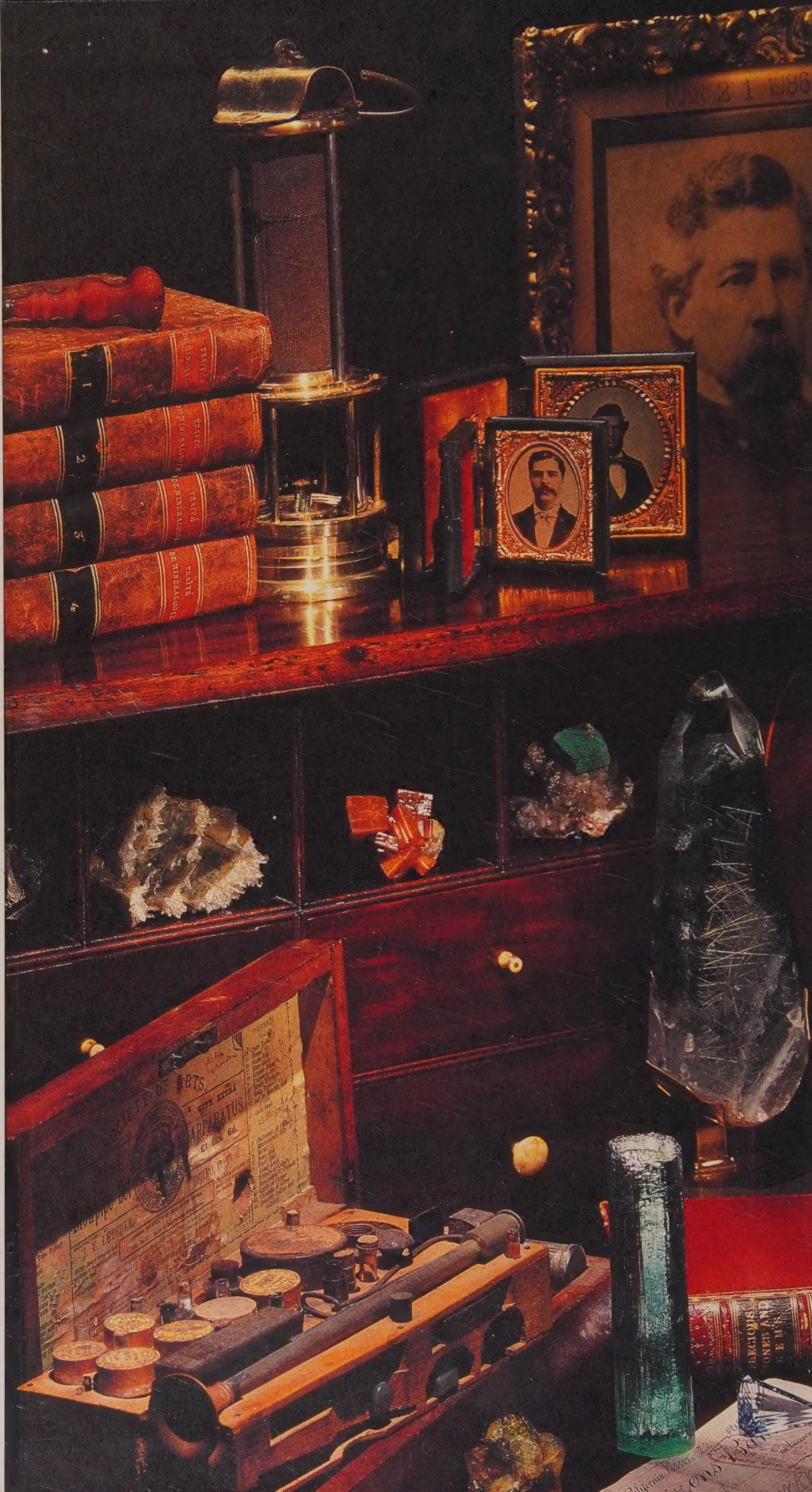

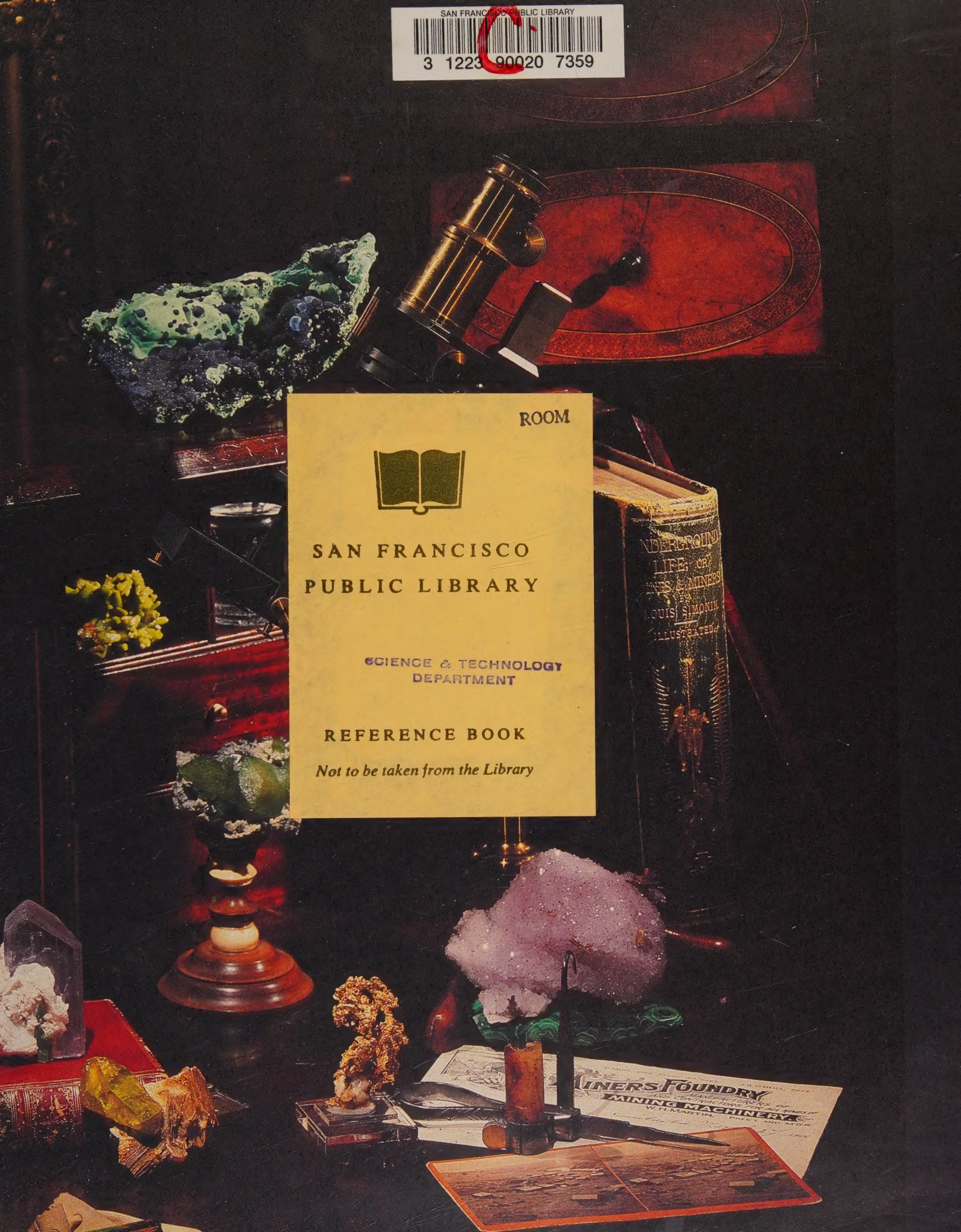
UNDERGROUND LIFE; OR, MINES & MINERS
LOUIS SIMONIN
ILLUSTRATED
MINERS FOUNDRY
MINING MACHINERY
W.H. MARTIN.

Gem & Crystal TREASURES

Peter Bancroft

AUTHOR: *THE WORLD'S FINEST MINERALS AND CRYSTALS*

PUBLISHED BY

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Preface

As a small boy I sometimes sat before glowing coals in the fireplace of our darkened living room listening to my father and two uncles spin yarns of the old days. Ours had been a mining family. A great grandfather was chief carpenter and a great uncle was superintendent of the Sutro Tunnel in Virginia City, Nevada. An uncle was paymaster for copper mines at Jerome, Arizona. Another uncle owned the La Noria silver mine in Michoacan, Mexico, and my father had surveyed the Tonopah-Tidewater Railroad into Death Valley, California.

Inspired, I started a modest mineral collection. High school and collegiate courses in mineralogy and geology provided technical background, but also exposure to the beautiful world of stunning gemstones and crystals. I read every available book on mineralogy and mining, but seldom found reference to the men who worked the mines or people who lived in mining towns.

In 1973 I outlined a format for a new book to be titled GEM AND CRYSTAL TREASURES. It would feature 100 of the world's classic crystal producing localities. Each of the 100 chapters would concentrate on the human side, the history and lore of these famous deposits. Technical data, extensively covered in treatises shelved in many scientifically oriented libraries, would be kept, for the most part, in low profile.

The finest crystals, carvings, gemstones and jewelry items would be sought out wherever they were to be found in the world, to be photographed in color for illustrations. This would require massive cooperation on the part of curators, collectors and photographers, as well as mining companies and various national and local governments.

Mysterious below-ground galleries and tunnels where men labored in constant danger would be profusely illustrated in black and white photography. Selected vignettes would portray the lives and times of miners and townspeople, some of whom were just plain characters.

I planned to visit many of the selected mines, as well as important museums, private collections and archives, and to seek interviews with those whose lives had been intimately connected with the mining of gemstones and crystals.

Eleven years after the project was envisioned, GEM AND CRYSTAL TREASURES is ready to go to press. Most of the 100 mines have been personally visited and hundreds of interviews conducted. Many miles were traveled in every conceivable type of conveyance and not a few were trod along dimly-lit, dank mine tunnels.

The remarkable experiences I have enjoyed while compiling materials for this book are largely due to the friendliness and cooperation of those with whom I have worked; miners, collectors, curators, dealers, jewelers, cutters, mineralogists and photographers. To them this book is dedicated with sincerest "Gluck auf." (Good Luck)!

Peter Bancroft

Peter Bancroft
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PROLOGUE...The Prospectors

For each mine there was a prospector, and, for the most part, gem and crystal producing mines discussed in this book were located by men who searched for riches. Keen of eye, unshaven, and clothed for the elements, these adventurers eagerly gave up their positions in the world's mainstream to search for the unknown. Their ranks included a few trained geologists, but they were more likely to have been farmers, smithies, physicians, lumbermen, sailors, storekeepers, trappers, miners, masons, itinerants and gamblers—a motley lot bound to the long trail by curiosity, adventure, and their thirst for treasure. Though they never planned to be heroes, and some were certainly scoundrels, many of their adventures were indeed heroic.

Long abandoned tunnels littered with debris, and overgrown mine dumps are scattered in many countries throughout the world. Evidences of early mining activity are common at locations on the shore of the Mediterranean Sea near Laurium in the province of Attica, Greece; in remote sections of the Ural Mountains in the Soviet Union; above windswept cliffs in Cornwall, England; and, in the jungle forests on the Cordillera de Bogota in Columbia. Many a successful prospector experienced the thrill of discovery and then in all probability faded away into the mists of time to remain unknown forever. His mine, exhausted and deserted, was soon forgotten.

Perhaps the first prospector of record was Philemon the Procurator, a Roman living in Egypt. He is credited with re-discovering the long neglected peridot mines on Zabargad (first known as Topazios, and later as St. John's Island) in the Red Sea. About 300 B.C., he presented a peridot crystal, which he had collected on the island, to Bareniket (Berenice) wife of Ptolemy I. History has not recorded the details of Philemon's visit to Zabargad, but the island must have been as bleak then as it is today.

That European prospectors were busy during the Middle Ages can be attested to by the discovery at that time of new tin and copper mines in Cornwall, England in the west; and gold mines in Transylvania, Hungary (now a part of Romania) in the east. Actual discoverers have remained anonymous, and it wasn't until recent centuries that successful prospectors were mentioned in the literature. We do know of Christoffer Grosvold, a 17th century Norwegian farmer, who made history by finding Norway's first great silver strike. He had found large masses of pure silver near his farm, and word of the discovery soon reached King Christian IV, who claimed the mine for the Crown. Grosvold was dismissed with a small reward, and the king enlisted local farmers to mine the silver. Grosvold drifted into obscurity, and nothing is known of his later life. After working for a year and a half without being paid for their labors, the men quit and returned to their farms. Infuriated, the king sent a troop of soldiers who captured 10 of the striking leaders and lined them up in front of the mine. The captain informed his prisoners that they were to be beheaded, but that if one of them would wield the sword he would be spared. One man stepped forward, slew his comrades, and was released. The site was adjacent to the now famous King's mine and the town of Kongsberg.

Unlike the kingdoms of Europe, early western America was a frontier with little government or law. Spanish explorers in the 1600s found many rich deposits of gold and silver. Sometimes they paid the king of Spain his "royal fifth," and sometimes not. In fact, Jesuit priests, aided by local native parishioners, were said to be so successful in finding gold and so reluctant to admit it and pay the royalty, that the king ordered them expelled from the New World. Legends still abound of rich mines which the Jesuits discovered and then concealed at the time of their expulsion in 1767; present-day prospectors still search for them.

Following the Spanish Period, a new wave of prospectors swept over western America. Instead of Spanish armor or a monk's habit, they wore red flannel shirts with sleeves rolled to the elbow, pants stuffed into boot tops, broad brimmed hats pulled down tight against

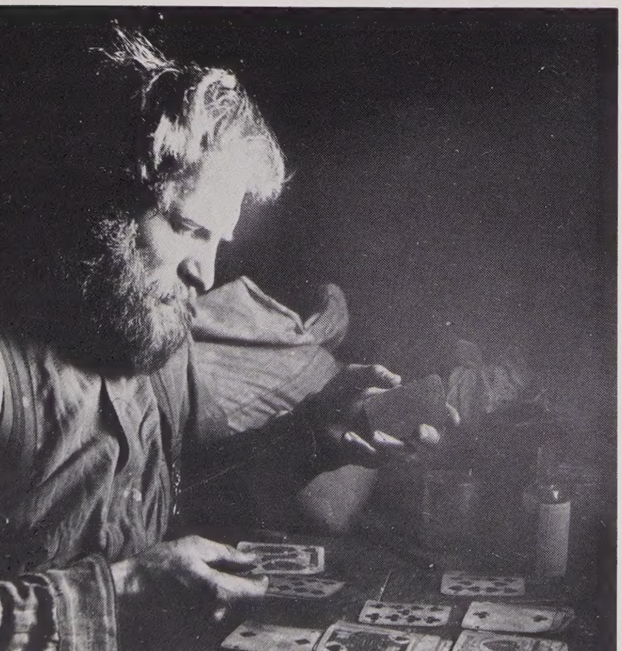
BELOW: Panning for gold in Glen Canyon, Colorado, CA 1890s. Courtesy: Los Angeles County Museum of Natural History

OPPOSITE: Gold in quartz Size: 12 by 9 cm Locality: Colorado Quartz Mine, Mariposa, CA Collection: David Wilber Photo: Harold and Erica Van Pelt

wind and sun, and pistols hung from the belt. These men were natural survivors (the weak and the naive never lasted long), men not to be taken lightly. Those who struck it rich wore fashionable suits with solid gold watches chained at the vest. Though they appeared cavalier, one look in the eye would tell you that their wealth was won and held by strength and not birthright.

From among the group emerged the Manuel brothers, Moses and Fred. Searching in the Black Hills of South Dakota in the fall of 1876, they came across a large quartz outcrop, rich with pure gold. They claimed it as the Homestake mine, and the hills soon filled with adventurers seeking a similar fortune. The town of Deadwood boomed to more than 10,000 people, including such legendary characters as Deadwood Dick, Wild Bill Hickock, Calamity Jane and Poker Alice. The Manuels sold their mine for a small fortune, but in time, it was to produce nearly a billion dollars in gold, and today is one of the oldest continually worked mines anywhere.

In January 1877, experienced prospector Edward Schieffelin joined a United States cavalry unit, composed of soldiers and Hualapai Indian scouts. The party planned to capture Cochise and Geronimo and their little bands of Apache warriers who roamed the rugged region of southeastern Arizona Territory. Early Indians were known to have mined silver in the area which they named Arizuma, meaning "silver-bearing." At first, Schieffelin felt he would be more secure with the cavalry, but after a while found he could not prospect while riding with the troop. As he left to search alone, a soldier called, "All you'll find is your tombstone!"



Schieffelin rode east from the San Pedro River toward a low group of mountains which seemed promising. He spent the summer in the mountains finding interesting bits of dark ore in various ledges. He also maintained a constant lookout for Apaches. The following spring, he found some important outcrops, staked two claims, and took samples to Tucson to be assayed. The assays proved to be rich in silver and Schieffelin promptly recorded the Graveyard and Tombstone claims. Shortly thereafter, Schieffelin formed a partnership with his brother Albert and a young assayer named Richard Gird. Following additional prospecting, another rich lode was discovered and named the Lucky Cuss. The lode was 18 centimeters wide and outcropped for more than 15 meters. Rich silver chloride samples assayed an astounding $1500 in gold and $15,000 in silver per metric ton. Next, the prospectors discovered the Tough Nut vein, about 2.4 kilometers to the northwest.

Out on a nearby flat, a tent camp had begun to grow. Miners, remembering the cavalryman's admonition to Schieffelin, "All you'll find is your tombstone," promptly named the new town Tombstone. Through the withering desert heat came miners, cardsharps, merchants, thieves, and "scarlet" sisters. In its heyday Tombstone boasted of "a man killed for every breakfast." Morticians were busy trundling off the unfortunate to Boot Hill (then known simply as the Old Cemetery) in one of the world's most expensive and elaborate horse drawn hearses. Perhaps no other western camp was home to so many famous and infamous personalities; Wyatt and Virgil Earp, Old Man Clanton, Bat Masterson, Big-Nosed Kate, Madam Crazy Horse Lil, Doc Holliday and John Ringo to name but a few.

Schieffelin sold his claims and moved to the east coast a wealthy man. In later life he confided to a friend, "It is my wish, if convenient, to be buried in the dress of a prospector, my old pick and canteen with me, about three miles westerly of Tombstone, — under no circumstances do I want to be buried in a graveyard." Upon his death in May 1897, his body was shipped back to Tombstone for burial. The funeral was the most elaborate in the town's history, and a marker on the cairn over his grave reads "This is my Tombstone."

In the summer of 1896, a Canadian named Robert Henderson, was prospecting the Thron-Diuck River in Canada's Yukon Territory. Unable to pronounce the Tagish Indian name, he called the river "Klondike." On one of its

BELOW: Yukon Territory (Canada) prospector whiles away long winter in his cabin playing solitaire. c. 1898 Photographer: Charles Ainsworth Courtesy: University of Washington photo collection

OPPOSITE TOP: Prospectors climbing "the icy steps to hell" on Chilkoot Trail, Alaska, 1898 Courtesy: Suzzallo Library, University of Washington Photo: E.A. Hegg

OPPOSITE BOTTOM: Opal prospector at Coober Pedy, Australia, 1921 Courtesy: Australian Bureau of Mines tributaries Henderson found gold, not a lot of it, but enough for him to be acclaimed one of the discoverers of the Klondike goldfield. Other strikes were rapidly made until it appeared the whole Yukon Territory must be made of gold. Because of the area's isolation, it took more than a year for news of the strikes to reach the outside world. The gold rush which followed, known as the Klondike Stampede, became one of the greatest efforts and at the same time the most fruitless search for gold in history. Dawson grew to become the main supply town for a vast goldfield spread over a harsh land.

The route to the goldfields was a monumental obstacle course which winter made worse. Sailing ships docked at Skagway Bay, Alaska, and because of an acute shortage of mules, most prospectors proceeded on foot up "the icy steps to hell" (a name given to the 1000 notches carved by hand into a solid sheet of ice which covered the western mountain slope leading to the Chilkoot Pass) by a miner who had been over the route. Many impatient adventurers, declining to wait for spring thaws, disembarked at Skagway in the dead of winter and set out on the 800 kilometer route to the goldfields at Dawson.

Canadian Mounted Police waited at the summit (the border between Alaska and Canada's Yukon Territory). Each prospector was required to have in his possession one metric ton of food and supplies before he could enter Canadian territory, and prepared lists were furnished by shipping companies. A typical purchase included: 100 kilograms of bacon, 50 kilograms each of dried potatoes, beans, fruit and sugar, 250 kilograms of flour, and another 250 kilograms of miscellaneous foods. In addition, his outfit included tools, mining supplies, cooking utensils, rope, clothing, guns and ammunition, bedding, whiskey, tobacco and soap. It is estimated that the average man who trekked to the Yukon during the late 1890s and early 1900s spent three times more on supplies and transportation than he ever recovered in gold. Men were forced to backpack nearly endless trips up the "icy steps" in getting their supplies to the top of the pass. There, many made sleds from green boughs and pulled them by hand to Lake Bennett, the next stop on the trail. Those fortunate enough to have pack animals lost so many that a part of the route was named Dead Horse Trail.

Camped along the lake, the prospectors cut trees and from them made boats with sails of

canvas, blankets, and even ladies' bloomers. The final portion of the trip was across Lake Bennett and down the tributaries of the Yukon River to Dawson. Men were buried by avalanches in the mountains, froze to death along the trail, and drowned in Lake Bennett and the rivers.

Layers of alluvial gold were found beneath strata of permafrost (rock-hard frozen ground which never thawed). Miners built fires to penetrate the permafrost so they could bring out piles of rock and sand which they hoped would contain gold.

Each man who agonized on the roundtrip over the Chilkoot Pass and the trail to Dawson had fully tested his endurance. Each had participated in and was a factor in "the last great adventure of its kind the world will ever know." One miner was quoted, "Only a fool would come to the Yukon, and here we are!" But for each prospector who struck it rich, ten got nothing for their efforts.

The lives of many latter-day prospectors, as well as their discoveries, are known today, and this introduction contains only a random sampling from history. But one particular type of prospector deserves mention: his kind searches not for ore which might yield bullion, but for natural crystals and mineral specimens to add to his collection. Among the many such specimen hunters was Arthur Russell, born in England in 1878 and later knighted. For most of his 76 years, Russell, pipe clenched tightly between his teeth, gleaned the quarries, mines, prospects and dumps of his native country. He explored every major mine in England and collected more than 14,000 specimens. He discovered new mineral species, located others previously unknown in England, purchased the major collections of John Ruskin and Phillip Rashleigh to add to his own, and was eventually awarded an honorary doctorate from Oxford University. When Sir Arthur Edward Ian Montague Russell died in 1964, he bequeathed his entire collection to the British Museum of Natural History, where his specimens may now be viewed.

Thus, for each mine there was a prospector, and for each beautiful crystal on display in some cabinet, there was a discoverer. Some, in the long line of intrepid seekers, are still alive today. You'll find them climbing rocks and taking samples in remote areas of the world which are not quite as foreboding as the frontiers of previous centuries. Some are anachronisms, hoping to find a bonanza with a little more than a hammer, a sharp eye, and a pack full of food and water. Others are armed with an incomprehensible array of equipment and an unprecedented technical education. Perhaps the old-timers would snort at the new breed, with their university diplomas and sophisticated equipment. But the trick today is to find ore that doesn't outcrop. The prospectors of old were rather thorough in spotting ore on the surface, but no one is certain now how much still lies a few meters or a few kilometers underground, giving precious little hint of its existence. New methods of prospecting evolve to fit new circumstances. Nevertheless, the average person still lacks the temperament to face remote jungles, deserts, and mountain ranges in search of mineral wealth. Those few who venture out on the quest share a common heritage with the searchers of the past, whose sacrifices and discoveries have made them the true patrons of civilization; explorers of yesterday and today — these are the prospectors!

BELOW: Unlucky prospector ravaged by coyotes, Amargosa Desert, Nevada, 1907
Collection: Peter Bancroft

OPPOSITE TOP: Lepidolite crystal
Size: 12 by 6 cm
Locality: Cruziero Mine, Brazil
Collection: Jules R. Sauer
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM: Abandoned graveyard of prospectors and miners, c. 1880
Near Queenstown, Tasmania
Photo: Peter Bancroft

1 Mt. Mica/Dunton Quarry, South Paris/Newry, Maine

Hundreds of gemstone pits, quarries, and mines dot the rocky state of Maine. Two localities in Oxford County merit special attention. Mt. Mica, at Paris Hill, has yielded substantial quantities of beautiful gemstones and also has considerable historical significance. The Dunton quarry, a major gem producer located near Newry, recently yielded an astounding volume of gem quality tourmaline.

While hiking in Mt. Mica in the late fall of 1820, two young boys, Elijah Hamlin and Ezekiel Holmes, found a green crystal protruding from the roots of an uprooted tree. Nearby the boys were amazed to find other crystals scattered over the ground about an outcrop of rock. But that night a snowstorm covered all trace of the gem deposit and forced the boys to wait until spring for further exploration.

When neither the boys nor the residents of nearby Paris could identify the crystals, they sent samples to Professor Silliman at Yale University who identified them as tourmaline. Elijah's younger brother, Hannibal (who later became Vice President of the United States under Lincoln), dug into the outcrop and found a score of pink and green tourmaline crystals. Still, no one seemed to realize the gems had value, and most were given away.

Over the years many people leased the property and found gem pockets; however, the rock ledges were very hard, and little profit was realized for the work involved. In 1871 Augustus Hamlin, son of one of the original discoverers, dug out a pocket containing a few achroite (colorless tourmaline) crystals, the largest measuring 11 by 4 centimeters. It had a green termination and was acquired by Harvard University. In 1881 Hamlin formed the Mt. Mica Company and for the next 10 years found many more pockets of gem tourmaline, the best of which also went to Harvard. Sometimes fine groups of smoky quartz were mined, and a pocket of clear white beryl crystals, one of them measuring 20 centimeters, was located. In the 1950s a small vug was opened; it was filled with golden yellow herderite crystals, the largest being 8 centimeters.

Roxbury antiquarian Dean McCrillis owns Hamlin's original ledger, which catalogues his transactions. Among them:

> *Private account of gems & minerals bought and sold by A.C. Hamlin since 1872 up to Sept. 1902.*
>
> *June, 1892, sold to Tiffany and Co. gems and minerals $4,156.50; Nov. 1893 sold to Pol, a lot of perles [sic] for a ring and $11.00; 1896 sold to Kunz, lot of minerals, $70.00; Dec. 14, 1901 Tiffany 53 kt, $525.00.*

Under purchases and expenses:

> *April 1895 bought of Mt. Mica Co. lot of beryls, $10.00; 1895 alligator skin bag, $11.00; pd. on lot at Mt. Hope cemetery, $100.00; eye and ear infirmary, $5.00; 1896 bought silver filigree purse of Tiffany, $6.00; March 1893, bought music box, $55.00 and tunes $12.50; Sept. 1897 bought 3 suits of clothes for miners, $16.14; Jan. 1903 for portraits of Dr. Cyrus Hamlin and wife Anna, $100.00; June 1903, bought for library at Paris 24 bookcases and bases, $58.00.*

BELOW: Miners locate gem pockets with sticks on Mt. Mica, 1890s
Courtesy: Edson Bastin, USGS

OPPOSITE TOP: Dean McCrillis in Rumford bank vault with boxes of big tourmalines, 1978
Photo: Peter Bancroft

OPPOSITE MIDDLE: Sifting gem-laden ore at the Dunton quarry for tourmaline, 1972
Photo: Dean McCrillis

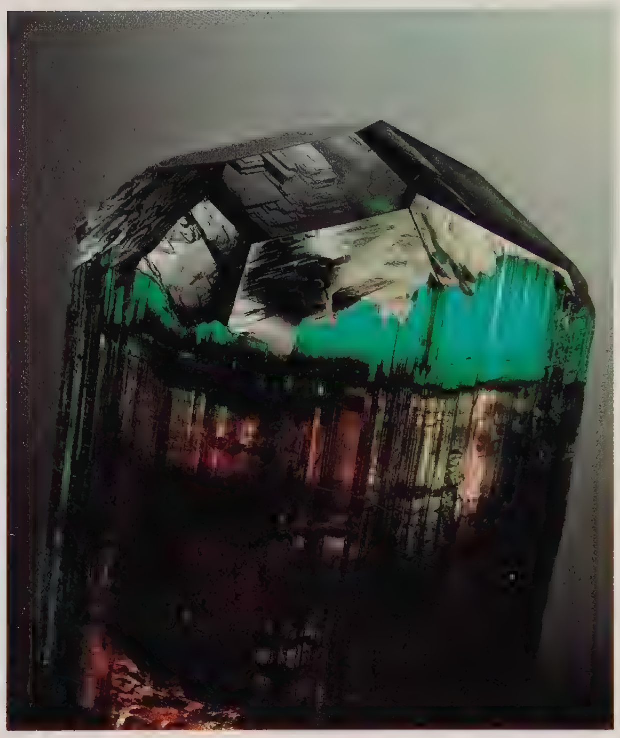
OPPOSITE BOTTOM: Boy's wagon used as ore car in Dunton's low tunnels, 1972
Photo: John Sampson White

In 1965 Frank Perham, a West Paris gem miner, leased the mine and immediately returned to areas which hadn't been worked since 1913. A bulldozer removed waste dumps and overburden. Empty pockets were extended by blasting until new pockets were encountered which contained smoky quartz, watermelon tourmaline (green rinds with pink centers), cucumber colored tourmaline (green skin and white centers), and flawless green and blue-green tourmaline which was cut into beautiful stones, some weighing more than 50 carats.

Geologists and miners who studied the Mt. Mica deposit believe that the remainder of the main pegmatite zone is gem-bearing and that its length continues for a considerable distance. Since 1976, and particularly in 1978, some important pockets of gem crystals have been discovered by Rene Dagenais working for McCrillis' Plumbago Mining Corporation. In the fall of 1979, a large pocket was breached in which were found enormous quantities of altered tourmaline; quartz crystals weighing up to nearly 250 kilograms, and "pocket beryl" crystals. The largest of the latter weighed about 10 kilograms, was very gemmy, and had color bands ranging from blue to white to pink. The pocket also produced some fine quality gem tourmaline crystals. One crystal was cut into a 256-carat flawless green gem of great beauty. Not surprisingly, the Plumbago Corporation intends to continue mining at Mt. Mica.

The Dunton quarry, located 64 kilometers to the west of Mt. Mica, in the eastern corner of Newry Township near Rumford, is another notable gem deposit. In 1898 a mineral collector named Edmond Bailey prospected a ledge on the back side of Hall's Ridge with little success. In 1902 miner Horace Dunton obtained mining rights to the property, and thereafter the quarry bore his name although he neither discovered the outcrop nor participated in its first development.

Early miners at the Dunton quarry location found small pockets of transparent pink and green tourmaline which were cut into nice stones. In 1926 the General Electric Corporation took a lease on the property and put W.D. Nevel in charge of mining. He built a road up the very steep mountain, a bunkhouse for the miners, a small kitchen, and a separate shed for the blacksmith. Horse-drawn wagons filled with supplies toiled up the mountain, then returned loaded with ore. During the next two years, General Electric mined pollucite, a cesium mineral which was much in demand for the manufacture of radio vacuum tubes. After



THIS PAGE
TOP LEFT:
Tourmaline (256 carats, largest fine stone from this locality)
Locality: Mt. Mica
Cut by: Arthur Grant
Collection: Arthur Sexauer
Photo: Harold and Erica Van Pelt

THIS PAGE
TOP RIGHT:
Tourmaline
Locality: Dunton Quarry
Size: 13 by 10 cm
Collection: William Larson
Photo: Harold and Erica Van Pelt

THIS PAGE
BOTTOM LEFT:
Tourmaline
Size: 13 by 7 cm
Locality: Dunton Quarry
Collection: Richard Webster
Photo: Harold and Erica Van Pelt

THIS PAGE
BOTTOM RIGHT:
Tourmaline
Locality: Mt. Mica
Courtesy: George Kunz, Gems and Precious Stones of North America, *1890*

OPPOSITE: Dean McCrillis, Vincent Manson, and Raymond Mateer evaluate gem tourmaline
Photo: "Brad Crafts"

General Electric closed its operation in the early 1930s, Nevel worked the Dunton on his own and also opened a mineral store in South Paris. A few years later, a young woman named Priscilla Bryant visited the mine and, intrigued with the beautiful gems being mined, sometimes cooked for the mining crew. Resourceful miners added to their meat supply by clubbing porcupines and woodchucks which Priscilla prepared for the table. Today she owns the Winthrop Mineral Shop, and sustains her lifelong interest in mineralogy. In 1938 Nevel was killed by a premature dynamite explosion while searching for a gem pocket he "knew" he was about to find.

One of the most astounding gemstone discoveries in history occurred at the Dunton in 1972. Toward the end of August, George Hartman, Dale Sweatt, and Jim Young were searching for gems around an old dump in the Dunton next to a ledge Nevel had been working at the time of his death. They unearthed a small pocket, but it contained only low grade tourmaline. Two days later, a vug with somewhat better material was found. Convinced they were entering an extremely rich gem area, and realizing they were unprepared either to venture into a large mining project or to be able to safeguard their new find, the men solicited the advice of McCrillis. Liking what he saw, McCrillis suggested they form a partnership and petition International Paper Company, current owner of the property, for a lease. Young left the group, and the partners (now including McCrillis) formed a company called the Plumbago Mining Corporation and obtained a nine-month lease. Frank Perham was hired to direct the mining operation.

In the fall, Plumbago miners removed dumps and waste before mining began in earnest. When the main wall of the vein was exposed, "NEVEL" was found written across its face in red letters. With Nevel as a beacon, the miners broke through less than half a meter of rock to find the greatest gem pocket in the mine's history. Watermelon-banded tourmalines "the size of beer cans" were found in piles. The terminations were usually green, with rich red centers encased in green exteriors. As the crystals piled up, security became a problem. Strongboxes rented in the local bank were filled in two days, so the entire basement vault was leased. The daily "take" would be 50, 100, or even 150 kilograms of gem crystals. Before long it was necessary to lease the entire second floor above the bank. Bags and boxes cluttered all available space.

Eventually the miners excavated two rooms within the mine which produced 1000 kilograms of tourmaline matrix, broken segments of tourmaline, and crystals of quartz and feldspar. Another 1000 kilograms of gem tourmaline suitable for faceting, cabochons, carvings, and choice crystal specimens were also recovered. The Dunton property, relatively small in size, had become one of North America's greatest gem localities.

LEFT:
Tourmaline
Size: 10 by 9 cm
Carved by: Gerhard Becker
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Feldspar and gem quarry on Mt. Apatite, 1913
Photo: D.B. Sterrett, USGS

OPPOSITE BOTTOM:
Tractor in Pulsifer under lease by Terry Szenics and Frank Perham, 1966
Photo: Terry Szenics

2 Pulsifer Quarry, Mt. Apatite, Auburn, Maine

The Pulsifer quarry lies on a low tree-covered hill in the far northeastern corner of the United States. In the late 1800s the little-used Hatch Road wound through the woods and past a few small farms about 10 kilometers west of Auburn, Maine. Hatch Road separated the farms belonging to G.C. Hatch on the east side and Pitt P. Pulsifer on the west. In the years to come, both farms would yield choice crystals of purple and pink apatite, smoky and citrine quartz, cookeite, tourmaline, spodumene (kunzite), herderite, blue topaz, beryl (morganite and aquamarine), rhodochrosite, columbite, cassiterite, albite (cleavelandite), and lepidolite.

Initially farmers found gem crystals scattered under trees and in ditches and dry creeks. Sometimes a plowshare would raise bits of green or blue glasslike material to the surface, but not knowing what they were, farmers ignored them. It was not until 1883 that Nathaniel Perry, a prominent South Paris mineral collector, attempted serious mining. Over 1500 pink, white, green, and blue tourmaline crystals, 8 to 1.5 centimeters in length, were dug from a single pocket.

In 1901 Pitt Pulsifer began to exploit pegmatite outcrops in the wooded land on his farm. He made two excavations at what were later known as the Wade and Pulsifer quarries. During the first year or so, Pulsifer discovered a number of tourmaline and apatite pockets, the contents of which brought him $2000, a large amount of money for those times.

Pulsifer was a conservative man who had seen other miners make good strikes, sell their hard-won crystals, and then squander their money. He was determined to spend only what was necessary and to conserve his pegmatites so his crystal output would last for many years. He continued to work his farm, and each year after the hay was up, he returned to his gem ledges for more crystals, many of which he sold to Harvard University. Pulsifer's tourmaline was excellent specimen material but he recovered only a little that was gemmy. It was the repeated occurrence of apatite in the gem pockets that brought reknown to his quarry. Pulsifer apatite crystals are a rich purple in color; crystal faces are sharp and very lustrous. One pocket produced a kilogram of fine, loose apatite crystals and a dozen large crystal groups, including a marvelous multiple crystal which is 5 by 4 centimeters and is considered the single best apatite specimen in existence. It later was purchased by Colonel Washington A. Roebling, who gave it to the Smithsonian Institution.

Other quarries along Hatch Road were worked primarily for feldspar and mica. Gemstones were sometimes mined in addition to the routine of rock mining, but many pockets were lost because the miners needed to use large amounts of explosives to blast out big chunks of feldspar. The miners had little interest in slowing down their work to recover a few gem crystals.

About 1945 Stanley Perham and Hillard Nevin leased the Pulsifer quarry and found a large pocket which yielded bluish cleavelandite, big sections of lepidolite, a few large garnet crystals, a lot of reddish brown tourmaline (some of which was gem quality), and a few crystals of good quality blue apatite.

In 1964 and 1965 the Irving Groves family of Poland, Maine, leased the Pulsifer quarry. Their efforts opened a number of pockets from which they took gem tourmalines of a fine deep green color and some that were rich salmon-pink, light pink, gray, and light blue. The Groves also recovered a substantial quantity of "royal purple" apatite crystals, one of which is a gemmy transparent piece 2.5 by 2 centimeters. Their prize was a 5-centimeter green tourmaline crystal, its base coated by a

BELOW: Szenics finishing a round of holes prior to blasting in Pulsifer
Courtesy: Terry Szenics

OPPOSITE TOP: Frank Perham and Szenics in Pulsifer with "royal purple" apatite crystals from rear of pocket, 1967
Courtesy: Terry Szenics

OPPOSITE BOTTOM: Raymond Woodman and daughter, Mary, search Pulsifer dump for crystals, 1978
Photo: Peter Bancroft

druse of quartz crystals sprinkled with small, dark, purple apatite crystals.

The most recent mining done at Pulsifer was in 1966 and 1967 by Terrence (Skip) Szenics and Frank Perham, both experienced gemstone miners. They leased a tractor fitted with a loading bucket and, by blasting and scraping, removed the overburden that covered the remaining section of pegmatite ledge. Many gem crystals were removed from the black mud which filled eight tiny pockets. In October 1967 Szenics and Perham located their final gem pocket, and now the deposit appears to be mined out. This last vug was about 30 centimeters in length and produced 1700 carats of facet-grade green tourmaline; the largest crystal, 15 centimeters long, was found in three sections. Also, 170 carats of fine dark purple apatite were recovered, as well as a rare pseudomorph of apatite after tourmaline.

Good quality purple apatite crystals have also been found at the Siglo XX mine, Bolivia; Mesa Grande, California; Panasqueira, Portugal; Schlaggenwald, Czechoslovakia; Ehrenfriedersdorf, German Democratic Republic; and a few other localities. Nowhere other than at Pulsifer have apatite crystals been found so bright, perfect, and of such fine color.

As a gem crystal producer, the Pulsifer quarry is considered worked out. Because the quarry is full of water, collecting in the bottom or on the walls is impossible. Rockhounds still search the dumps, however, like thousands of collectors before them, for crystals that were missed. Royal purple apatite crystals are rare indeed, and it is a fortunate collector who is offered the opportunity to buy a fine apatite from the Pulsifer—at any price.

THIS PAGE TOP:
Apatite with quartz
Size: 3 by 1.5 cm
Locality: Pulsifer Quarry
Collection: Patterson (New Jersey) Natural History Museum
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM:
Apatite in Cookeite
Size: (crystal) 3.2 by 2 cm
Locality: Pulsifer Quarry
Collection: Richard Kosnar
Photo: Earl Lewis

OPPOSITE:
Norbergite in quartz
Size: 11 by 5 cm
Locality: Sterling Hill
Collection: American Museum of Natural History
Photo: Arthur Singer

3 Franklin-Sterling Mines, Franklin, New Jersey

Franklin and Sterling Hill, two separate ore bodies, lie only a short distance apart. They are treated here as one district—the greatest crystal-producing zinc mining district of all time. Located 80 kilometers northwest of New York City and surrounded by forest-covered hills, the rich lode has produced more than 250 mineral species, 25 of which are found nowhere else. The district is famous for its output of beautiful crystals, several of exceptional size. Rare minerals abound, some with tongue-twisting names like chlorophoenicite, glaucochroite, leucophoenicite, and margarosanite. Striking crystals of rare species, unequalled elsewhere, include zincite, franklinite, and norbergite.

The Lenni Lenape Indians are known to have used bright-colored minerals from the Franklin area for pigments before the 16th century, and Dutch prospectors are credited with discovering the Sterling Hill deposit in 1640. In 1770 a furnace was erected at Franklin to smelt iron ores but was ineffectual and closed. No profitable use for zinc existed at that time, iron was readily attainable in nearby bog iron deposits, and a technique to separate zinc from iron had not been developed. Zincite, a deep red zinc ore, while attractive as a pretty mineral, had no commercial value. It was found in great quantities in Sterling Hill and Franklin mines but was discarded as worthless until 1838 when the United States Customs Department began using refined zinc in brass weights. After 1865 zinc was used as a protective coating for sheet iron and as a component in various alloys. As the need for refined zinc increased, zincite became a profitable mineral for Franklin district mines.

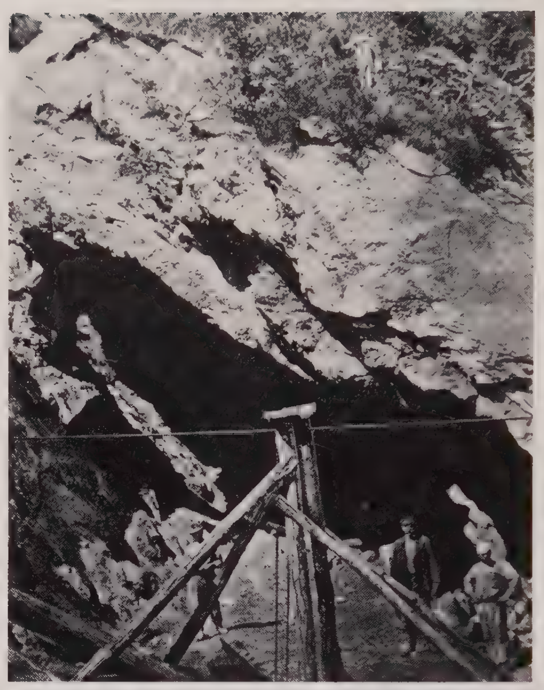
The black mineral commonly associated with zincite was thought to be magnetite, and unsuccessful attempts were made to smelt it as an iron ore. French chemist Pierre Berthier identified it as a mineral of zinc and named it franklinite after the town whose name honors American statesman-scientist Benjamin Franklin. Finally the Wetherill furnace was invented, which roasted off zinc oxide from franklinite, and later a magnetic separator was developed to enhance the ore dressing process. Franklinite had joined zincite as another major source of zinc.

Franklin veins were finally exhausted, and the mines closed September 30, 1954. Plans were under way in 1981 to clear away the old mill area for a housing project, and in the process, remaining mine buildings would be

destroyed. The Sterling Hill mine is still working; and ore bodies are expected to last until about 1988. The 800-meter-deep workings are now abandoned below the 530-meter level, and present operations are confined to higher levels.

At Franklin, extremely large pyroxene crystals occur up to 30 centimeters in length. Unusual crystals include 8-centimeter green tremolite, 5-centimeter edenite in calcite, 2-centimeter cahnite interpenetration twins, 9-centimeter blue apatite, and 13-centimeter dodecahedral andradite. Small transparent crystals of willemite and facet-grade zincite were sometimes found. Hendricksite in 30-centimeter sheets has been reported from Franklin, as have 3-centimeter sections of facet-grade pale green sphalerite.

Sterling Hill has contributed gigantic lustrous octahedral crystals of franklinite up to 21 centimeters on a side, gahnite crystals to 13

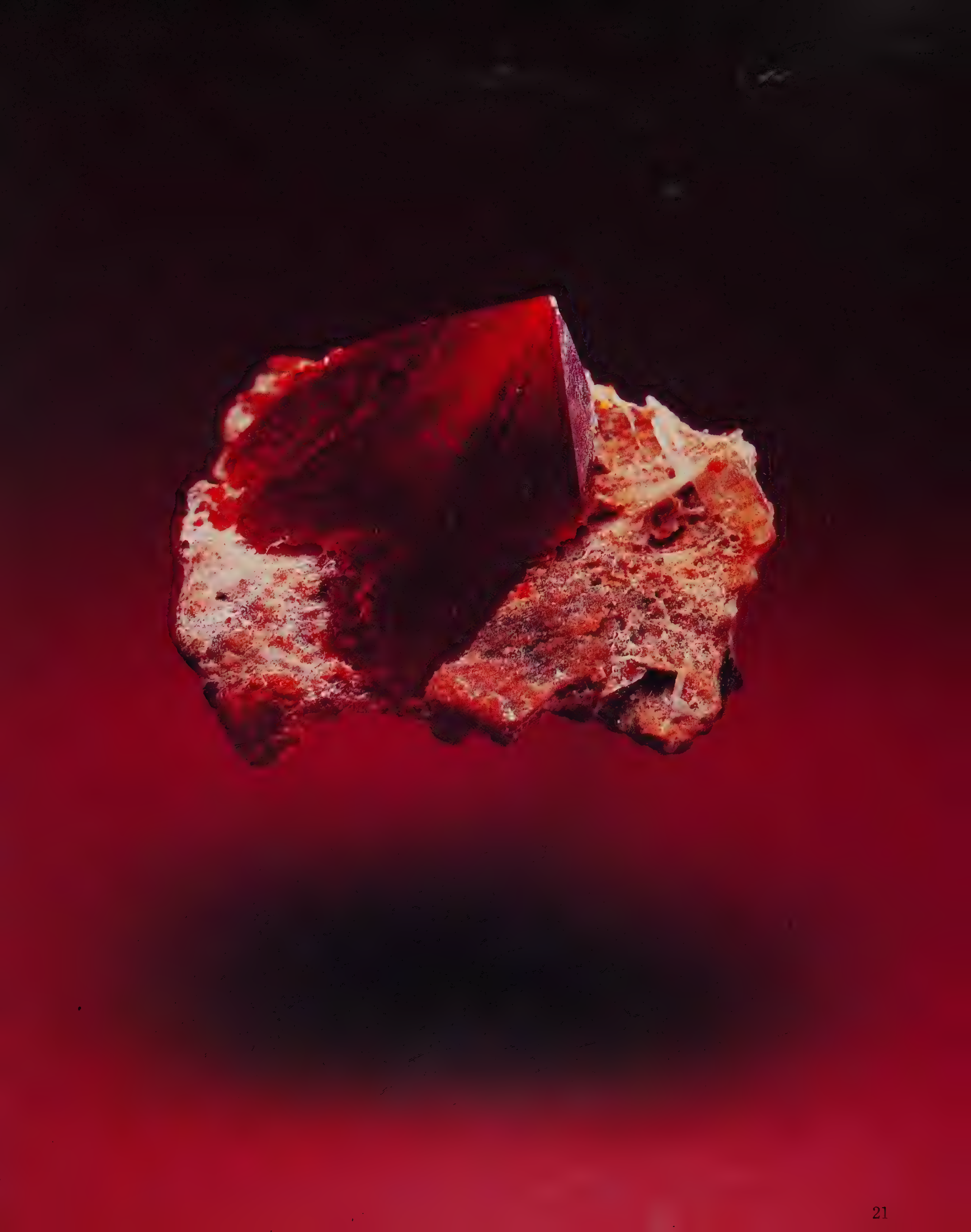


THIS PAGE TOP:
The beginning of extensive mining at Franklin, 1879
Courtesy: Franklin Mineral Museum

THIS PAGE MIDDLE:
Franklin, c. 1870s
Courtesy: Ewald Gerstmann Museum

THIS PAGE BOTTOM:
Mine office at Sterling Hill, 1875, owner W.A. Leavite in top hat
Courtesy: G.W. Baker

OPPOSITE:
Zincite on limestone
Size: 4 by 3 cm
Locality: Franklin Hill
Collection: Smithsonian Inst.
Photo: Dane Penland



centimeters along an edge, and a 31-centimeter jeffersonite crystal owned by Ewald Gerstmann. Sterling deposits also produced willemite crystals up to 11 centimeters and ruby-red corundum crystals to 3 centimeters in length.

The village for which franklinite was named was known throughout its early history as Franklin Furnace, but in 1913 was renamed. Franklin's most colorful years were probably the turbulent 1910s and 1920s, when it was still small, tumultuous, and, at times, a violent town. Clarence Haight, a mining engineer, was superintendent of the Franklin mine for many years and also a leader in the community. He wrote the following comments about Franklin's early days.

> *Miners worked 10 hours a day, seven on Saturdays, and we worked most holidays including New Year's Day. The minimum rate of pay was 18.5 cents an hour. The Zinc Company paid in cash. Miners could be easily identified from farmers because they had $20.00 bills to spend. Franklin had no sidewalks, forcing miners to walk in the streets. When they visited Newton, the county seat, they walked down Newton's streets and everyone knew they were Franklin miners. We didn't get a bank in Franklin until 1919.*
>
> *On Saturdays, many miners wanted shaves at local barber shops. In order to accommodate those needing shaves and to discourage time-consuming haircuts, the price of haircuts was doubled to 50 cents on Saturdays. When bills were paid at the company store, a man received a pack of cigarettes as a bonus. If a woman paid, she got a box of candy free. Movies were the principal entertainment and admission was 10 cents; but to see the "Perils of Pauline" in 20 sequences cost $2.00.*
>
> *In 1913, a volunteer fire company was formed using hand-pulled equipment. With Franklin's topography, it was an uphill pull either going to or returning from a fire. Gasoline was bought at the general store (we didn't have a service station) and cost 12 cents a gallon. Those were the days!*

John Baum, a specialist in Franklin history, supplied the following anecdotes.

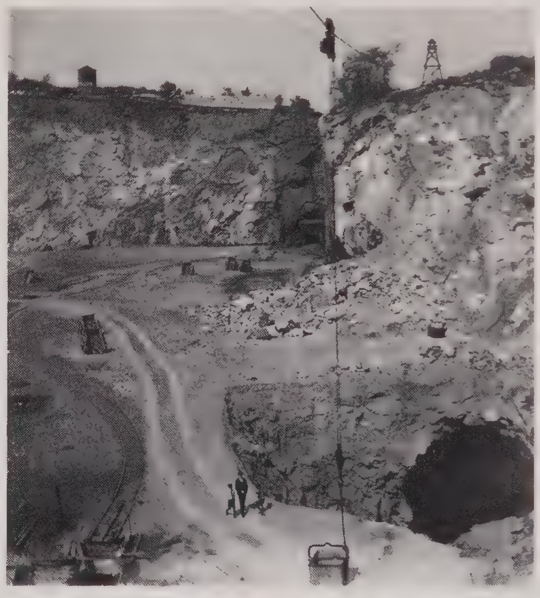
> *In 1916 Zinc Company workmen, while working on a construction project, crossed water with sewage lines, contaminating the supply of drinking water. A large number of mine employees came down with typhoid fever and some died.*
>
> *Some miners had little better to do than drink, fight, and steal when not working. It didn't surprise anyone when a skeleton was found in an abandoned shaft on Main Street. It seemed likely an old score had been settled. It was time for law and order so Herbert Irons was hired as Chief of Police (he was the only policeman). When apprised of a fight, the Chief saddled his horse, rode into the fray, lassoed the guilty party and led him off to jail on the short end of the rope. The town had no Bill of Rights, but the Chief's tactics sure were effective.*

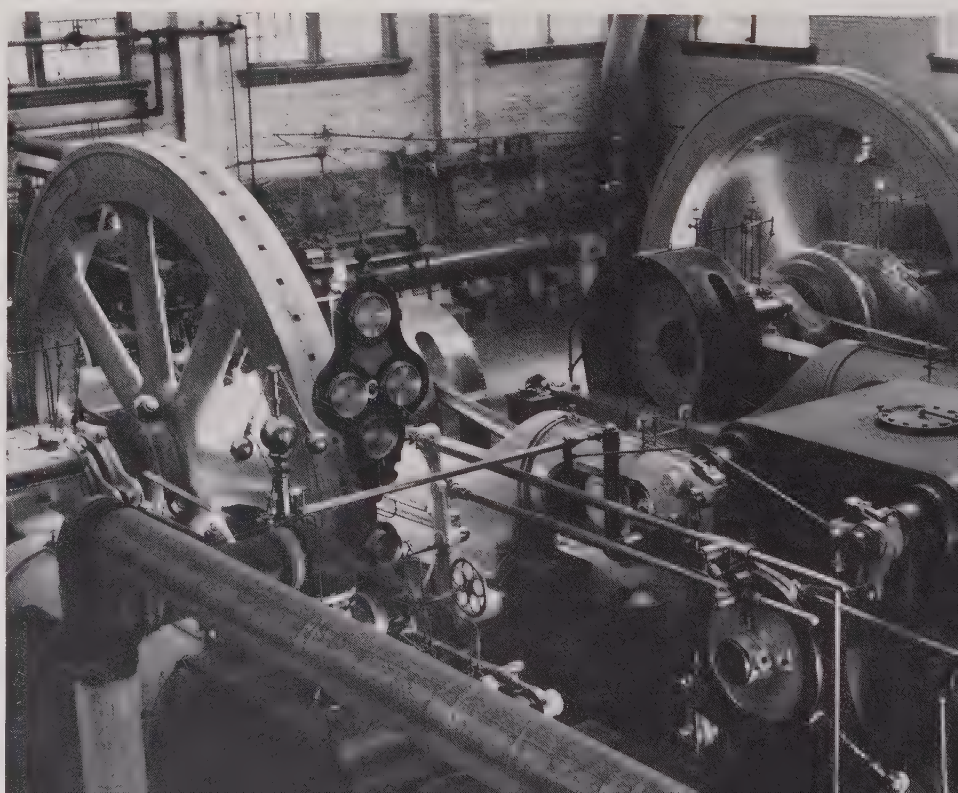
THIS PAGE TOP:
Buckwheat Pit near Franklin, 1910
Courtesy: Richard Hauck

THIS PAGE BOTTOM:
"Big wheel" machinery, New Jersey Zinc Co., c. 1920s
Courtesy: Richard Hauck

OPPOSITE TOP:
Franklin mill and head frame, c. 1945
Courtesy: Richard Hauck

OPPOSITE BOTTOM:
Remains of Franklin Hill mine, 1979
Photo: Peter Bancroft

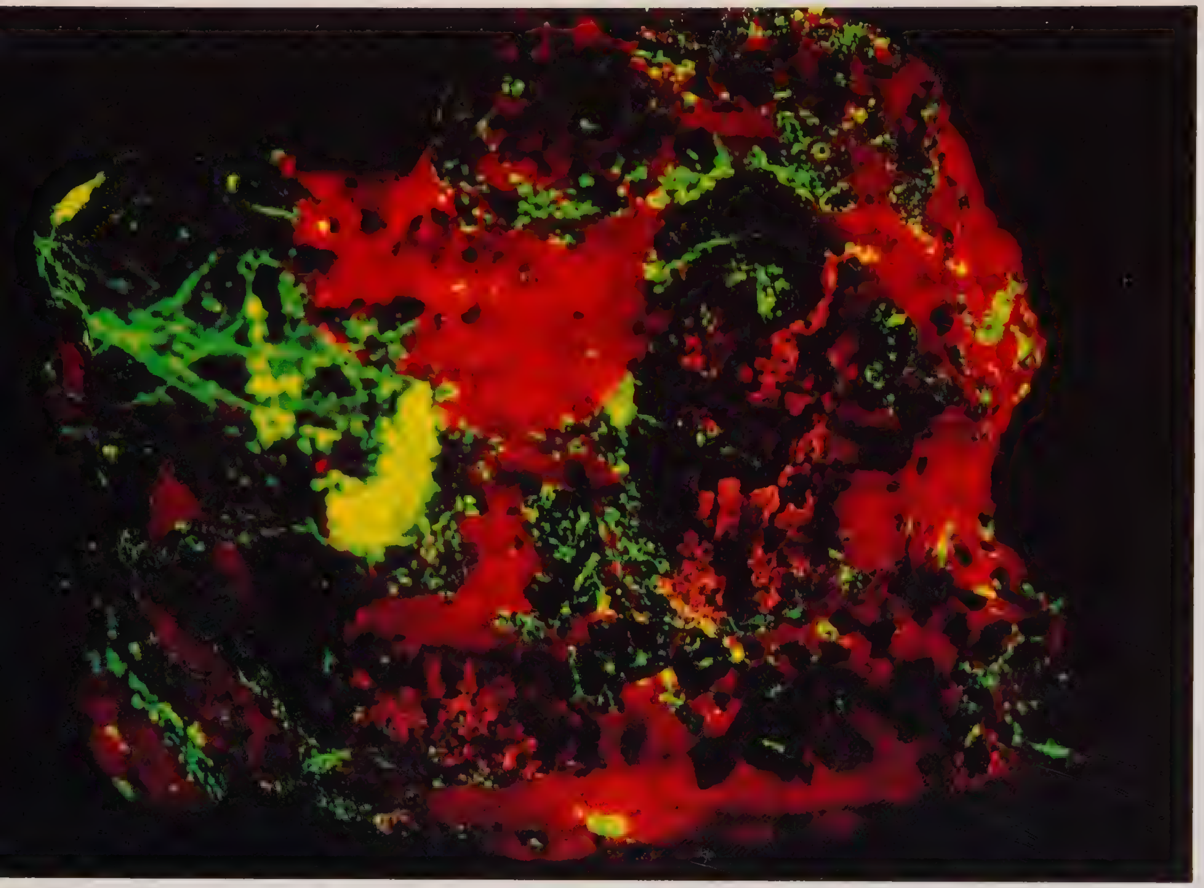


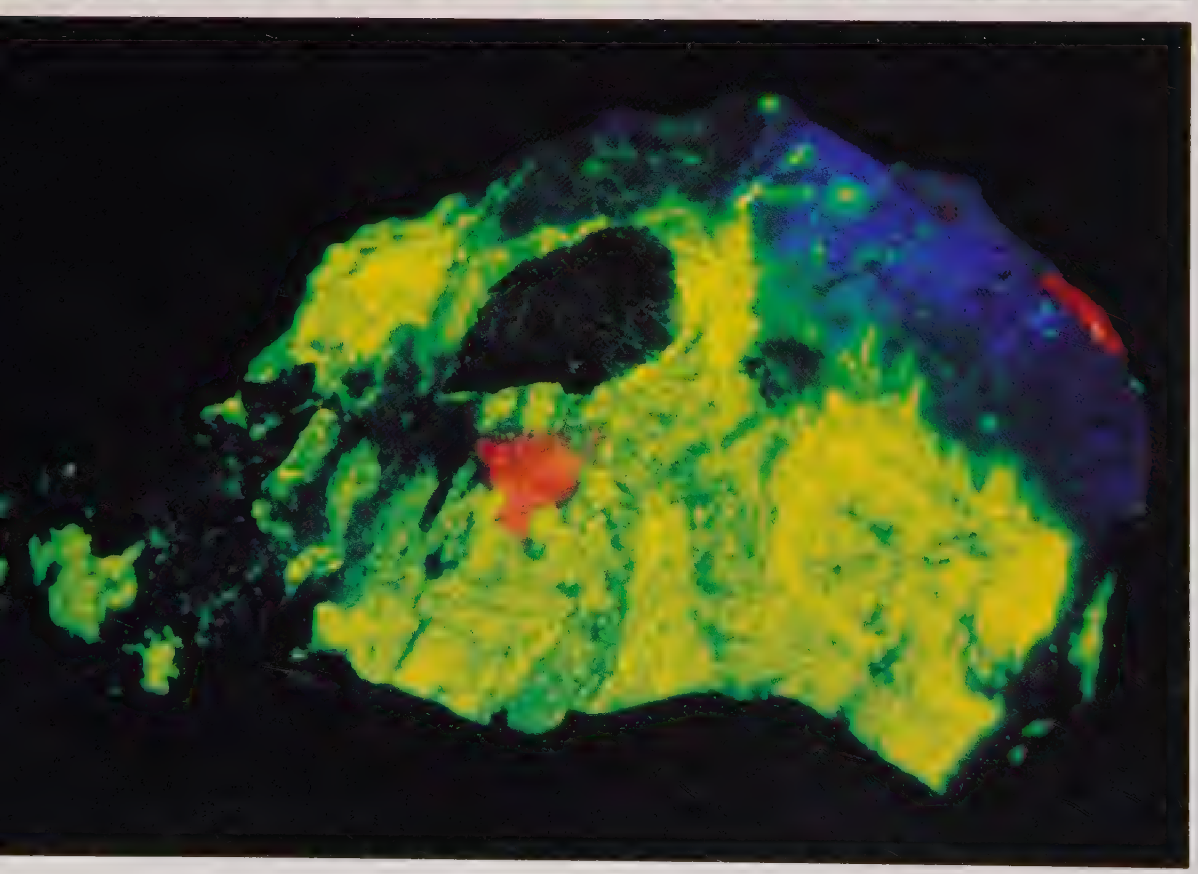


The mining camp's biggest case was when the Cat Swamp Gang murdered the driver and helper of a wagon-load of silk cloth and stole their goods. The bandits were trailed to a farmhouse. Irons commanded the murderers to come out—all did, but the leader came out shooting. When he was well enough to stand trial with the others, all members of the gang were sentenced. Two were executed, two received life, and two got 20 to 30 years. There is much to be said for the good old days.

Many of the most beautiful fluorescent minerals on earth were mined in the Franklin-Sterling district. Particular minerals aided by short- and long-wavelength ultraviolet lamps change from dull uninteresting rocks to gaudy colored specimens unrivaled in nature. Particularly eye-catching are wollastonite (fluoresces orange), esperite (yellow), hydrozincite (blue), svabite (orange), pectolite (yellow), barite (white), and margarosanite (blue white). Most outstanding is a breathtaking combination of calcite (shocking red) and willemite (green) concoction that must be seen to be believed.

Very large crystals from the Franklin-Sterling district are in the collections of the School of Mines in Paris, Harvard University (part of the A.F. Holden collection), Smithsonian Institution (parts of the Washington A. Roebling and Frederick A. Canfield collections), Trinity College at Hartford, Connecticut (part of the John H. Caswell collection), and the American Museum of Natural History (part of the Clarence Bement collection). Excellent collections of Franklin-Sterling minerals are displayed in the Franklin Mineral Museum in Franklin, which is operated as a service project by the local Kiwanis Club with John Baum as its curator. (This museum also operates the nearby famous Buckwheat dump, where collecting is permitted for a small fee.) Other excellent collections are at the Gerstmann Franklin Mineral Museum, also in Franklin; the A.E. Seaman Mineralogical Museum in Houghton, Michigan; and Rutgers State University at New Brunswick, New Jersey. These museums are open to the public. Richard Hauck in Bloomfield, New Jersey, has a fine private collection of Franklin-Sterling minerals as well as old mine memorabilia.





LEFT TOP:
Fluorescent minerals under ultraviolet light
calcite (red), svabite (orange), willemite (green), esperite (yellow)
Locality: Franklin
Collection: Ultra-Violet Products, Inc.
Photo: Ultra-Violet Products, Inc.

LEFT BOTTOM:
Fluorescent minerals under ultraviolet light
willemite (green), esperite (yellow), hardystonite (blue), franklinite (black), calcite (red)
Locality: Franklin
Collection: Ultra-Violet Products, Inc.
Photo: Ultra-Violet Products, Inc.

OPPOSITE LEFT:
Hiddenite
Locality: Hiddenite mine
Size: 4 by 1 cm
Collection: Cranbrook Institute of Science
Photo: Earl Lewis

OPPOSITE RIGHT:
Hiddenite
Locality: Hiddenite mine
Size: 6 by 2 cm
Collection: Harvard Univ.
Photo: Alphonse Coleman

4 Hiddenite Mine, Hiddenite, North Carolina

In 1879 P.L. Warren was plowing his father's field near Stony Point, North Carolina, and uncovered a number of "green bolts," as these yet unidentified emerald crystals were called locally. William E. Hidden was in North Carolina looking for platinum, which Thomas Edison could use to tip the steel needles of his latest invention—the "talking machine." Learning of the emerald discovery on the Warren farm, Hidden went to investigate the deposit.

In addition to the emeralds, Warren found some slender, heavily striated, green crystals that Hidden could not identify. Hidden sent them to a chemist, Dr. J. Lawrence Smith, in Louisville, Kentucky, who identified them as a green variety of spodumene, which he named hiddenite in 1881.

At about the same time, J. Adlai Stephenson, a Statesville, North Carolina merchant, began to collect gem and mineral crystals. Upon hearing of a gem discovery, he sent agents to the spot to gather crystals for him. He promised handsome rewards for fine crystals. Stephenson probably was the first serious collector of emeralds in the region, and his personal collection rapidly grew in importance.

In October 1881 Hidden wrote an article "Emeralds, Their Occurrence in Alexander County, North Carolina."

The site now being worked for emeralds was originally covered with a dense primitive forest. Less than 10 years ago this country was, mineralogically, a blank. The prevailing rock is gneiss. A very natural conclusion would have been that where pale emeralds were found in the top soil, darker and purer ones would be found by mining for them.

A corps of men was engaged to dig ditches to cut the strata at different angles. Five weeks were spent in 1880 before, at a depth of eight feet, a "blind vein" bearing small emeralds was encountered. In this same vein, and outnumbering emeralds 50 to one, we found the new emerald-green mineral which was such a surprise to the scientific world and is now known as hiddenite.

The J.D. Yerrington Co. of New York now markets the crystals, and has given liberal financial aid to the mining project.

Hidden, intrigued by the beauty of the emerald and hiddenite crystals, formed a partnership to buy the Warren farm along with some nearby land (a total of 300 acres), and the Emerald and Hiddenite Mining Company began operations. The local village, Salem Church, changed its name to Hiddenite in

LEFT TOP:
Hiddenite open pit mine, 1881
Courtesy: Peter Bancroft

LEFT MIDDLE:
Hiddenite mine, 1889
Photo: D.B. Sterrett
Courtesy: USGS

LEFT BOTTOM:
Hiddenite mine, full of water and undergrowth, 1976
Photo: Peter Bancroft

OPPOSITE TOP:
Mr. and Mrs. Edward Zorrin with quartz crystals which they found at Rist mine, July 1971
Courtesy: Dal-An Mines, Inc.

OPPOSITE BOTTOM:
"Green Rush" for emeralds on Adams Farm, 1970
Photo: A. Haynes Dunlap
Courtesy: Boyd S. Mattison

honor of the new gemstone. The Alexander Railroad, which passed through Hiddenite, built a station on the town's outskirts in 1887, and a post office was dedicated on February 10, 1888. Hiddenite, which had consisted of only a chewing tobacco factory and a small store when the mine was started, had reached maturity.

Emeralds were encountered infrequently, but there was a steady production of hiddenite, rutile, aquamarine, transparent quartz crystals, apatite, and calcite. The matrix was decomposed gneiss impregnated with layers of a reddish clay, which made digging very easy.

For the next 26 years, the Hiddenite mine was worked sporadically, and a number of fine crystals were found: a 21-centimeter emerald crystal weighing 255 grams; numerous quartz crystals containing water bubbles; quartz crystals with inclusions of rutile, goethite, tourmaline, and byssolite; and, of course, many kilograms of high quality emerald and hiddenite crystals.

In 1907 the mine closed. Infrequent efforts have been made to reopen the old workings, and gem crystals have always been found, but not in sufficient quantities to pay operating costs. In 1926 J. Edward Turner found an outstanding 7 by 2-centimeter hiddenite crystal and, from the same pocket, took 450 carats of gem hiddenite crystals.

An interview in 1976 with John Thomas (Tom) Adams, then 85 years old and the owner of the mine, produced valuable information not found in the literature. Adams, who was the mine supervisor from 1927 to 1929, said:

> *It would take us a few days to pump out the mine and then we could really dig. The gem veins run east and west and we found plenty of hiddenite and emerald crystals in open cavities and pockets. There were many more hiddenite crystals than emeralds, and we mined quartz crystals up to 200 pounds each. We sank a shaft that was 6 feet by 8 feet across and 58 feet deep. When we stopped working, we were still in hiddenite. I think there is plenty more left!*

Between 1965 and 1971, Adams' wife Ruby opened the property for the first time to outsiders who could dig to their hearts' content and keep all they found for just $3 a day per person. Adams recalled:

> *They found a lot, probably millions of dollars in gem crystals, in our fields and out in the timber. No one really knows how many crystals were found. I'm certain*

a lot of diggers didn't publicize their findings so as to avoid reporting their good fortune to the Internal Revenue Service. For a while we sure had a gem rush going.

The Hiddenite mine is located 0.8 kilometers west of Hiddenite. About the same distance to the east of the town is a number of other mines which also became famous. Best known were the Rist and Ellis mines, which over the years produced substantial quantities of exceptional emerald crystals, among them the famous 10-centimeter, 2-crystal group which can be seen at the Smithsonian Institution and a 59-carat emerald crystal found in 1969 by Wayne Anthony. This crystal produced a deep green 13.14-carat faceted stone, possibly the largest and finest emerald ever mined in the United States.

The area in and about Hiddenite has been prolific in producing substantial quantities of gem crystals of a variety of species. About 2 kilometers to the north, the Old Revis farm had deposits of rose quartz, smoky rutilated quartz, emeralds, and hiddenite. The Sharpe farm, 3 kilometers northeast of town, contributed richly colored rose quartz. The Old Ellis mine, 80 meters north of the Hiddenite School gave emerald, blue beryl, rose quartz, and rutile. Nearby, rutilated quartz and rutile crystals came from the Lackey place. Beryl, quartz, garnet, tourmaline, feldspar, and quartz with inclusions were taken from the O.F. Patterson mine, located 1.2 kilometers southeast of Hiddenite. South of town, the Mulholland Mill mined rutile, xenotime, and monazite crystals, while mica and beryl were found on the Charles Payne property.

The Rist and Ellis workings, now known as the Emerald Valley mines, are operated by Dal-An Mines, Incorporated, which keeps them open to amateur collectors during the summer season for a small fee. Hosts Dale and Ann Curtis are most helpful in showing visitors the "best places to dig." They also operate a fine mineral museum and, if asked, can direct their customers to a country restaurant where "you can get all the fried catfish and hush puppies you can eat for $3."

Old-timers tell many yarns about the early days of the Hiddenite mine, but one of the most interesting was an observation made by George Washington Warren just before his death in 1947: "When I was a boy on Dad's farm, I used some of them queer-looking green rocks in my slingshot. Throwing thousands of dollars worth of gems at the birds. Just like a boy, ain't it?"

BOTTOM LEFT:
Emerald on Ankerite
Locality: Rist mine
Size: 9 by 5.2 cm
Collection: Dal-An Museum
Photo: Wendell Wilson

BOTTOM RIGHT:
Emerald
Locality: Rist mine
Size: 10.5 by 2.7 cm
Collection: David Wilber
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Phoenix mine stamp mill, CA 1890s
Courtesy: Jean Kemp

OPPOSITE MIDDLE LEFT:
Michigan copper mining stock
Collection: Seaman Museum
Courtesy: Jean Kemp

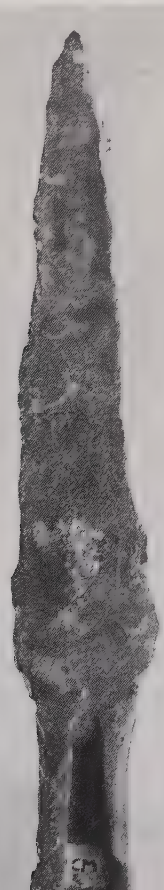
OPPOSITE BOTTOM LEFT:
4000-year-old hand-beaten copper spearhead found on Keweenaw Peninsula
Collection: Seaman Museum
Courtesy: John Barlow

OPPOSITE TOP RIGHT:
Mechanical man-ladders, whose alternate up and down movement permitted miners to quickly ascend or descend, CA 1890s
Courtesy: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Underground in the Quincy in 1920s
Courtesy: Michigan Technological University

5 Quincy Mine, Hancock, Michigan

Carbon 14 tests of stone tools found in northern Michigan copper mines indicate that America's oldest digs were probably in use as early as 2000 B.C. Archaeologists know little about the early people who worked the clusters of deposits at McCargoe Cove on Lake Superior's Isle Royale and along a 160-kilometer stretch of Keweenaw Peninsula from the Porcupine Mountains to the northernmost tip of land. Only a few tools and weapons — some of them 4,000 years old — have been found. But not a single skeleton or burial site has been discovered; no traces of houses, farms, pottery, cookware or personal items remain. Whoever these people were, whence they came or wherever they went, they reportedly dug more than 10,000 pits and removed an estimated 2,270,000 kilograms of copper in prehistoric times.



Because open pit mines would have been impossible to work during winter, these earliest miners probably traveled to northern Michigan during the warmer months, recovered the copper and left with it. Little more can be said with any certainty. Henriette Mertz, author of *Pale Ink,* notes that ancient manuscripts suggest the early Michigan miners were Chinese seeking copper for their bronzes. Though this theory finds little support elsewhere, the copper artifacts of native Americans found in burials and kitchen middens to the east and south don't account for the amounts of copper mined in Michigan. Many mysteries remain, yet some things are clear:

The early people cold-wrought the copper they mined on Lake Superior. There is a peculiarity about Superior copper in that some of it contains visible silver, and all Michigan copper includes some silver. Charles Whittlesey wrote in the November 15, 1852, *Annals of Science:*

> *Copper has been found in the mounds in Ohio and elsewhere in which specks of silver are plainly visible. This shows conclusively that it came from Lake Superior.*

Whittlesey also wrote:

> *In the old works near the forks of the Ontonagon River there was found at a depth of 18 feet a mass of copper weighing 11,588 pounds which had been taken out of the vein by the ancients. It had been raised a few feet and rested on cob-work made of logs cut from a black oak tree.*

These unknown ancients uncannily located surface copper deposits which required the least effort to work. Their mining tools were water-worn diorite rocks carried from the beaches to the pits. One or two grooves were ground as girdles about each rock, to which a handle was tied with gut thongs. In a crude way, these stone hammers or mauls, which weighed from 1 to 17 kilograms each, were effective tools. According to Lauri Leskinen in *4000 Years of Copper Country* (1974), an estimated 900 tons of mauls were used at McCargoe Cove alone.

The early miners used wooden shovels that resembled small Indian paddles, wooden bowls

BELOW LEFT: Copper
Size: 7 by 3.5 cm
Locality: Quincy
Collection: Seaman Museum
Photo: Harold and Erica Van Pelt

BELOW RIGHT:
Silver
Size: 16 by 7 cm
Locality: No. Kearsarge #4 shaft
Collection: Richard Webster
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Copper on quartz
Size: 10.5 by 5 cm
Locality: Quincy
Collection: Seaman Museum
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Silver on copper
Size: 9 by 8 cm
Locality: Calumet
Collection: John Barlow
Photo: Harold and Erica Van Pelt

for bailing water, wooden troughs of cedar bark to carry away wastewater, and wedges, axes, and spearheads of copper. Because smelting was unknown, all copper implements were crudely hammered into shape. The people who mined this area left little else. Engineers have estimated from the number and size of their pits that it would take 1000 men 1000 years to accomplish what they did. For a people who labored so hard and accomplished so much, we know remarkably little about them! More than 2000 years passed before Chippewa Indians began to rework some of the early pits. As late as the 1700s, weapon points and tools were still made by hammering copper into desired shapes.

In the early 1600s, Brule and Grenoble paddled their birch canoe into Keweenaw Bay, followed a few years later by Father Claude Allouez. The first two white men wished to exploit the newly discovered area for the fur trade and Father Allouez to convert its Indians to Christianity. While following these pursuits, they inadvertently discovered copper. Allouez wrote of seeing the Ontonagon boulder, a 1700-kilogram mass of native copper now on display in the Smithsonian Institution.

In 1830 Douglass Houghton, a young engineer, discovered promising copper and iron deposits. He had the region surveyed and encouraged mining development. Probably the first miners to work the rediscovered copper fields were backwoodsmen Jim Paull and Nick Miniclerque who began mining in 1843. Large-scale copper mining did not begin in the area until the Cliff and Minesota mines were opened about 1848, followed shortly thereafter by more than 1000 mines along the Peninsula. Most of these failed, but the survivors include some of the world's greatest copper mines: the Calumet and Hecla, Wolverine, Tamarack, Osceola, Mohawk, Baltic, Isle Royale, Painsdale, Hancock, Central, and the Quincy. One by one many of these old mines shut down between 1930 and 1955, leaving the region in a state of depression.

In 1955 the White Pine Mining Company, a subsidiary of the Copper Range Company, obtained a $66 million loan from the United States Government. Using the latest technology the firm mines huge deposits of copper sulfide ores. Work by this company is expected to continue for many more years. The Copper Range mines, now owned by Louisiana Land and Exploration Company, also are doing well.

The Quincy, a series of mines, shafts, smelters, and mills, produced billions of

kilogams of copper during its 97 years. Production was so consistent that it was known as the "old reliable." The Quincy was one of the few amygdaloid (volcanic rocks containing gas pockets filled with secondary minerals) deposits not discovered by the ancients. By 1904, the mine had 61 levels to a depth of 1610 meters with some drifts directly under the city of Hancock and others extended under Portage Lake. Samuel W. Hill, a superintendent of the Quincy mines, was known to be so profane in his conversations that his name became popular in "What the Sam Hill!"

In 1945, the Quincy mines closed. Today, Quincy No. 2 and its huge Nordberg steam winding hoist, the world's largest, are part of a historical museum. The mine remnants have been designated a National Historical Site.

The Quincy produced many outstanding copper specimens in extravagantly distorted crystallized plates, and scalenohedrons of calcite containing copper-coated phantoms. Infrequently, single crystals or small clusters of native copper occur with quartz druses and epidote. Equally unusual are stunning water-clear calcite crystals up to 12 centimeters within which mirror-bright arborescent native copper crystals have grown, like strands of seaweed. It is interesting to note the contrast of fresh unoxidized copper that is imbedded in calcite with the darker and duller extensions of the same clusters that are exposed to the air.

"Half-breed" masses and crystals of silver and copper in the same piece occur in a number of Michigan mines. Exceptionally fine silver crystals have been found in the Kearsarge and Calumet-Hecla mines. Delicately colored datolite, some a light pink from infusions of copper, were collected at the Delaware, Caledonia, and Arcadian mines. Colorful red and yellow nodules considered the finest ever found came from Quincy mines.

The Keweenaw Peninsula is a wonderful collecting vacationland during summer months. There are mine relics, camps, swimming spots, and museums to visit. Copper is literally everywhere; Houghton's main street is paved with stamp sand from copper mills, and from the tar base, tiny chips of pure native copper gleam. The A.E. Seaman Museum, one of America's best, is located on the fifth floor of the new Electrical Energy Resources building on the Michigan Technological University campus in Houghton. Curator Jean Kemp conducts tours through the collections.

In memory of old copper mines and vanished miners, Lauri Leskinen wrote a poem published in 1938:

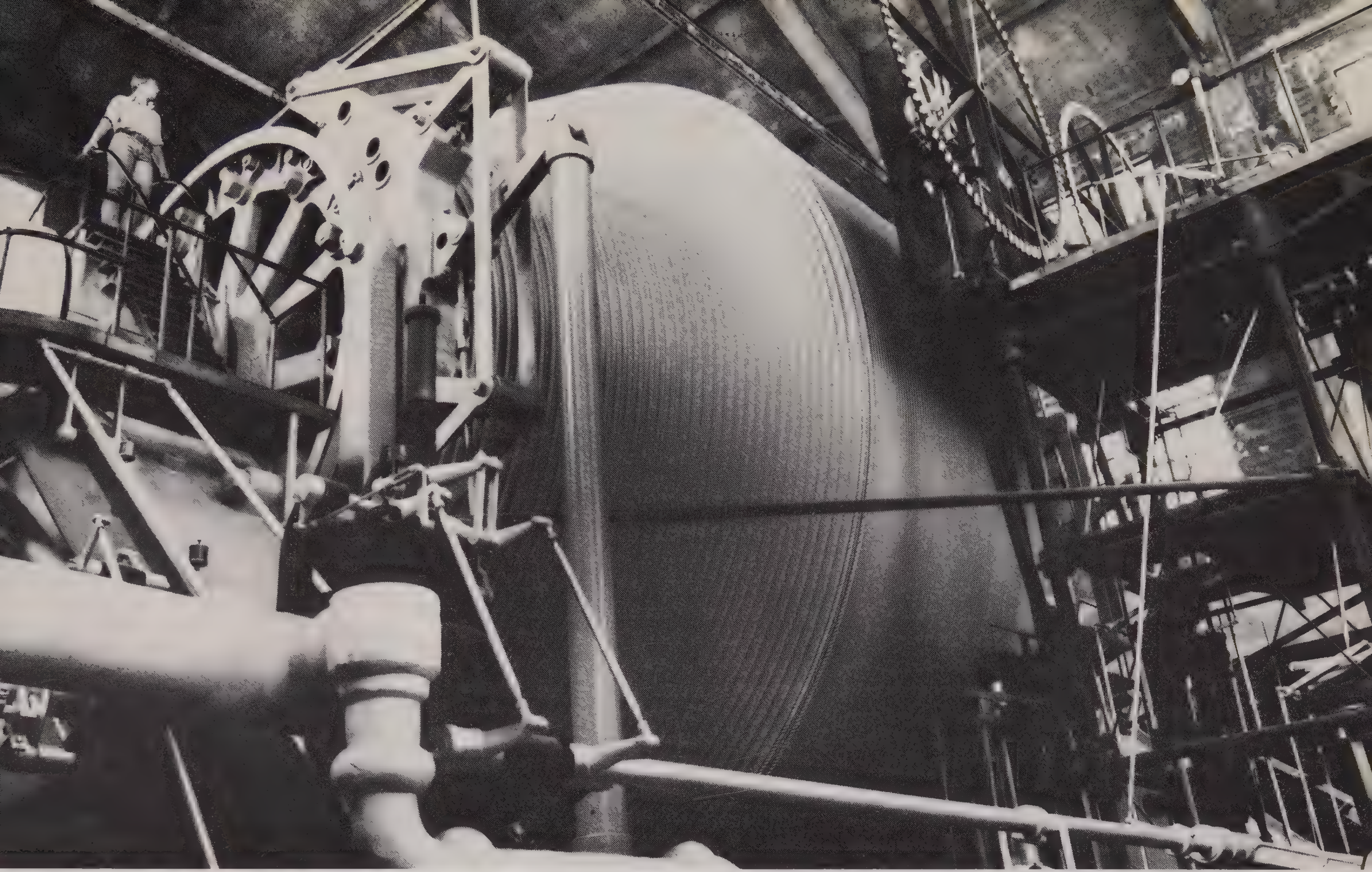
Times past, these ruins grim and gray
Looked too, on manhood robust, gay
Echoed to the teamster's cry
Heard boots of miners hurry by.

Now their bulk looms strange and still
Silence envelopes deserted hill
Only these grim, gray sentinels stay
To remind us of a bygone day.

BELOW: Quincy shaft house #6 in 1913
Photo: Myrno Petermann

OPPOSITE TOP: Nordberg Hoist, the world's largest steam mine hoist. Built in 1920 for the Quincy, it could raise a nine-ton load up an incline from a depth of 2800 meters.
Photo: Peter Bancroft

OPPOSITE BOTTOM: Remains of Quincy No. 2 in 1979
Photo: Peter Bancroft



6 Minerva I Mine, Cave in Rock, Illinois

River pirates and Indian skirmishes, fluorspar and lead mines, cave hideouts for murderers and prostitutes—people, places, and events—all have roles in the history of an area in southern Illinois about 100 kilometers northeast of the confluence of the Ohio and Mississippi Rivers.

Today during the winter months the river towns of Golconda, Rosiclare, Elizabethtown, and Cave in Rock seem sleepy little country villages. In summer they become modest tourist attractions. Beyond these towns, in Hardin County's Shawnee National Forest, wooded hills surround America's largest fluorspar industry. Natural vales and hilltops bear quaint designations such as Cadiz, Dogwood Hollow, One Horse Gap, Rose Bud, Hick's Dome, High Knob, Hooven Hollow, and Indian Kitchen—reminders of a rambunctious past. Although mining enterprises are declining, scores of workers still labor in scattered mines and mills. Hardin County mines produce large quantities of fluorspar for use as a flux in steelmaking; in the manufacture of hydrofluoric acid, ceramics, and colored glasses; in the development of high energy fuels for rockets and intercontinental missiles.

Two types of fluorspar deposits, veins and bedded, occur in this mining area. Vein ore bodies of fluorspar lie in the Rosiclare mining district and occur in fissures along a complex system of faults. The veins originate under the Ohio River and emerge near the town of Rosiclare. Most fine mineral specimens came from vein deposits in the Rosiclare district, but when ore bodies gave out in the 1950s, bedded deposits were discovered to the north of Cave in Rock. Mines in this area have been producing beautiful mineral specimens ever since. Bedded deposits overlying horizontal beds of limestone formed through a reaction between fluorine-bearing solutions and the calcium carbonate of the limestone.

Many of the southern Illinois fluorspar mines have produced outstanding crystals of at least a half dozen species. From the Rosiclare mine have come giant purple and yellow fluorite crystals, 15-centimeter dogtooth calcite crystals with phantom intergrowths, large cubic galena crystals, and quartz crystals sprinkled with

THIS PAGE TOP:
Rosiclare, CA 1895
Courtesy: Otis Lamar

THIS PAGE BOTTOM:
Rosiclare Mining Co. river steamer used to haul ore, 1918
Courtesy: Rosiclare Fluorspar Museum

OPPOSITE TOP:
These boys carried lunches to miners underground. Bryan Davis (hand on reclining boy) drowned in mine lake two years later. CA 1898
Courtesy: Rosiclare Fluorspar Museum

OPPOSITE BOTTOM:
Blue Diggings mine, 1922
Photo: R.H. Moore

black sphalerite or small purple cubes of fluorite. At nearby Blue Diggings, unusually large calcite and fluorite crystals appear. The Gaskins mine in Pope County contributed outstanding straw-yellow barite crystals on purple fluorites. The best example, an 18-centimeter specimen, is now in the Funk Gem and Mineral Museum at Illinois State University, Normal, Illinois. Near Elizabethtown a number of mines have yielded striking purple and gold crystal combinations of fluorite. North of Cave in Rock, at least five mines, including the Lead Hill, Crystal Victory, and North Green mines became fine crystal producers. In 1953 North Green mine brought forth magnificent 10-centimeter sphalerite crystals on yellow fluorite.

Probably the district's most notable crystal mine is the Minerva. A major fluorspar producer for the past 30 years, it is still quite active with its engineers estimating a 1.8-million-kilogram reserve in 1979. It has contributed quantities of fine fluorite crystals in colors of yellow, blue, white, rose, and gray. More rarely, blue-green fluorites form as simple cubes on snow-white calcite. Also from the Minerva mine have come exceptional crystals of witherite ranging in size to 8 centimeters, pale yellow rhombohedral crystals of benstonite (sometimes coating calcite), and the first recorded American occurrence of tiny pyramidal alstonite crystals. The 200-meter level produced some of the finest examples of banded barite-fluorite ore ever discovered. The Minerva mine also contributed rare fluorite crystals containing water bubbles in which float globules of petroleum.

Southern Illinois fluorite may not exhibit the crystal perfection of Swiss specimens nor the crystal face brilliance of English clusters, but the vivid colors, commonly banded along growth planes, from Rosiclare and Cave in Rock fluorite are equal to any in the world.

Prehistoric clues indicate the Mound Builders, a primitive people dating back at least 8000 years, were probably the first visitors to historic Cave in Rock, a great natural room 61 meters long, 20 meters wide, and 8 meters high. The cave entrance can be seen for miles along the Ohio River. Much later, Tecumseh and the Shawnee Indians had a large camp near Cave in Rock. With the advent of white settlers in the late 1700s, the Ohio River became an artery for flatboats. Not only were Shawnee warriors to be reckoned with along the river at Cave in Rock, but a new menace by the name of Samuel Mason set up housekeeping in the cave sometime during the 1780s. He hung a sign over the entrance, "Rock Cave Inn and House of Entertainment," announcing that he would provide food, liquor, and women for weary travelers. Once inside the cave entire families were murdered, their goods and boats stolen. Months after Mason was murdered by his own men for the reward on his head, a large pile of approximately 60 human skeletons was uncovered in a remote section of the cave.

River pirates plagued the Ohio River. Posing as pilots, these infamous characters guided river craft to dangerous shoals where waiting outlaws came aboard, killed all hands and made off with the booty. Probably the most

wanton men ever seen on the Ohio were the "Horrible Harpe" brothers, Big Harpe (Micajah) and Little Harpe (Wiley). Using doxies (prostitutes) to lure travelers to the cave, the Harpes murdered newcomers "for the fun of it." So bloodthirsty was Big Harpe that he is said to have smashed his infant nephew's head against a tree because the child annoyed him with its crying. A favorite procedure of the Harpes was to disembowel their victims, load their stomachs with rocks, and then sink them in the river. Both men, accused of at least 25 killings were caught in 1799, executed, and then beheaded. Big Harpe's head was impaled on the sharpened end of a tree limb and left as a warning to other bandits. The road by the tree is still called Harpe's Head Road.

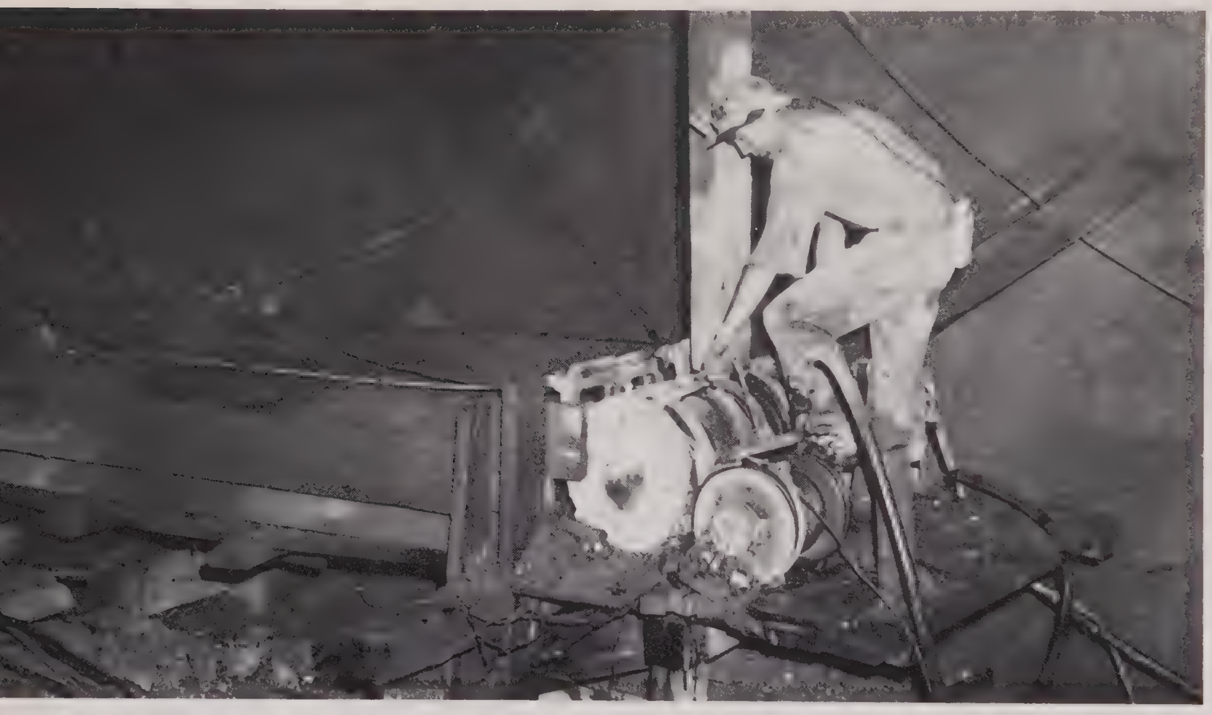
Other robbers, murderers, and counterfeiters used the cave as a hideout until 1834 when the last of them were driven away and the Cave's bloody history came to an end. The story was told by Rosiclare geologist Gilbert Montgomery

THIS PAGE TOP:
Electric slusher machine in Minerva, CA 1945
Photo: Gill Montgomery

THIS PAGE BOTTOM:
Underground water breakthrough, Good Hope mine, 1953
Photo: Taylor

OPPOSITE TOP:
Fluorite on calcite
Size: 8 by 6 cm
Location: Minerva mine
Collection: Rex Bannister
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Fluorite
Size: 13 by 8 cm
Location: Elizabethtown
Collection: American Museum Natural History
Photo: Harold and Erica Van Pelt



that when the cave was peaceful in later years, a European violinist lived in it for a while. When he played his violin, crowds gathered outside to listen. One day he disappeared and was never seen again; to this day some insist they can still hear the "lost violinist" playing in the cave.

The Rosiclare mine, about 16 kilometers downriver from Cave in Rock, was opened in 1854, 19 years after a mining company headed by President Andrew Jackson established the first mine in the area, just across the Ohio River in Kentucky. Working continuously since it opened, the Rosiclare expanded operations in 1915 and became the largest producer of fluorspar in the district. Its concentrate was hauled by narrow-gauge rail through town to the river where it was put aboard a steamship for the trip upstream to the smelter at Evansville, Indiana.

In 1924, large flows of water were encountered at the Rosiclare mine's 220-meter level, probably coursing downward from the Ohio River. Each year thereafter at the river's flood stage, the mine took in more water. Eventually it could no longer be pumped clean and the mine was forced to close its Fairview-Rosiclare vein. Water was a problem in the remaining workings also. In 1949 management decided to use cement to seal off the collar of a shaft which literally gushed water. A pipe was run down to the forms set in the collar and a cement company hired to deliver cement until an engineer signaled enough. After the first load was poured into the collar, the engineer went to lunch and was delayed for three hours. By the time he returned, many tons of concrete had been dumped down the shaft, ruining everything in sight.

On May 1, 1950, Rosiclare's Hillside and Daisy mines closed, ending a century of prosperity for the community. Some of the bedded deposits north of Cave in Rock, including the Minerva I, are still in operation, but many mines lie dormant, primarily because cheaper fluorite currently comes from Mexico.

Rosiclare's mines are closed, and the town is relatively quiet, but any visit must include a stop at the Hardin County Fluorspar and General Museum managed by 92-year-old curator Otis Lamar and his volunteer staff of senior citizens. These old-timers will gladly show and tell you how it was "when Hardin County was really humming."

7 Joplin District, Missouri; Millikin Mine, Sweetwater, Missouri

During the Civil War both the Union and Confederate Armies coveted lead deposits at Joplin in Jasper County and at various locations in the Viburnum Trend lead belt extending through Reynolds, Iron, and Washington Counties of eastern Missouri. Because lead was sorely needed for pistol and rifle balls, Confederate forces would take over a deposit, only to be run off by Union troops. Later the Confederates would return, to be ousted yet again. The deposits changed hands many times throughout the war because political loyalties were divided in Missouri.

Outlaw Jesse James rode with Southern raiders under Bloody Bill Anderson and Fletch Taylor (later known as Charles F. Taylor, who made a fortune in the lead and zinc mines at Joplin). Anderson said of Jesse, "For a beardless boy of 16, he is the best fighter in my command." After the Civil War, Jesse became a bandit and, in March 1874, robbed a stagecoach at Gads Hill, 35 kilometers southeast of Reynolds near the Millikin mine. An Ironton posse gave chase but failed to catch the James band. The outlaws reportedly cast their own bullets from Viburnum Trend galena, which they found scattered about in the forests.

Although they are 320 kilometers apart, it is impossible to separate the two Missouri lead districts of Joplin and Reynolds when describing fine galena crystals. Joplin produced the greater tonnage in specimens; yet Reynolds produced crystals of superior quality.

Joplin, in the early days known as Prairie Diggins, represents the eastern edge of one of the greatest lead-zinc deposits on earth. The area, known as the Tri-State District, is bounded by Galena and Baxter Springs, Kansas, to the west; by Picher and Commerce, Oklahoma, to the south; and by Webb City, Missouri, to the north.

Trappers apparently discovered Prairie Diggins lead in 1838. In those days the area was a "howling wilderness," home to only trappers, hunters, and Indians. Later a young slave located another outcrop nearby, which

THIS PAGE TOP:
Jesse James, Missouri bandit who robbed stage near Sweetwater mine area in 1874
Collection: Missouri Historial Society

THIS PAGE MIDDLE:
The Butterfield Stage Route passed just to the east of Joplin. Stages frequently carried American Express Company goods.
Collection: Peter Bancroft Western History Collection

THIS PAGE BOTTOM LEFT:
Boodle Lane in calcite cave at Galena, Kansas, c. 1955
Courtesy: Marie Kennedy

THIS PAGE BOTTOM RIGHT:
Jigging ore, a back-breaking process, near Webb City, Missouri, 1891
Photo: W.P. Jenny, USGS

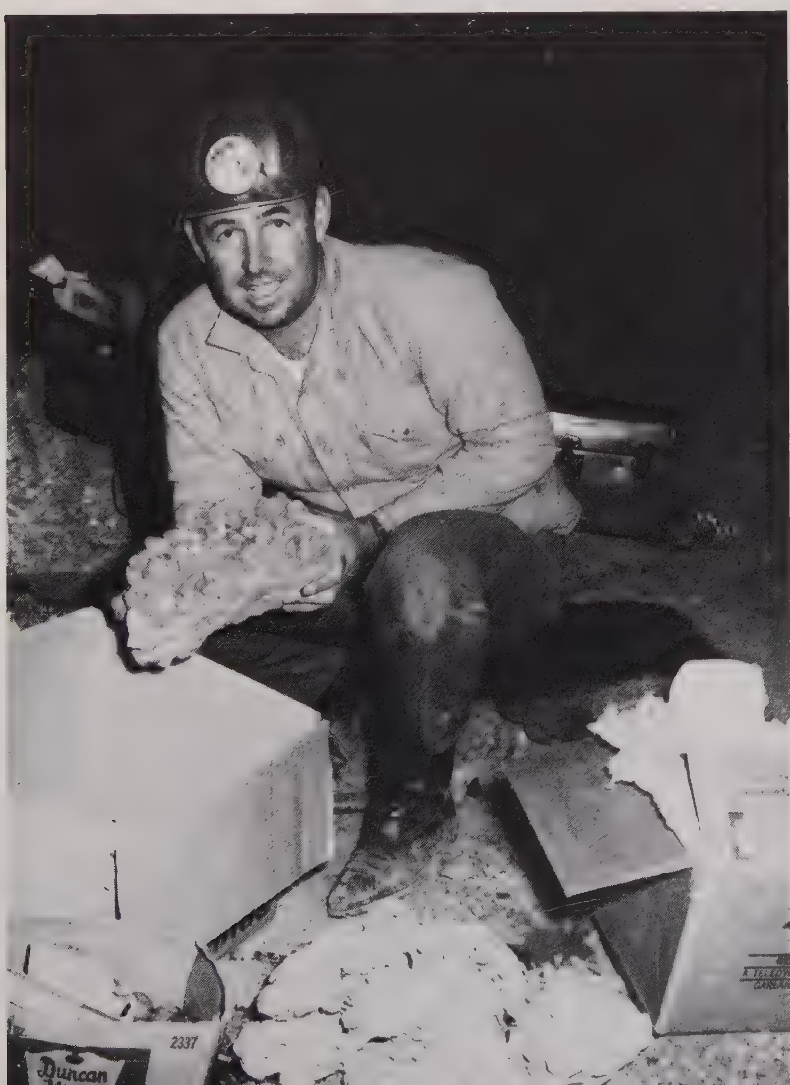
OPPOSITE TOP:
Chink Enders (dec.), Pitcher, Oklahoma collector, drives jeep through miles of Tri-state haulage tunnels, 1968
Photo: Gerry Blair

OPPOSITE BOTTOM LEFT:
Gerry Blair, Arizona collector, collecting underground at Tri-state District, 1968
Courtesy: Gerry Blair

OPPOSITE BOTTOM RIGHT:
Scaler machine in Millikin mine, 1977
Photo: Don Green, Kennecott Copper Corporation

was called Nigger Diggins. However, official discovery credit was given to prospector William Tingle, who made a major strike in 1848. The two little settlements merged, and from then on the new town was known as Joplin. By 1860 there were 30 shafts around the city, none exceeding 16 meters, because the veins at that time were worked only to a shallow depth. Colorful mine names included Poor Boy's mine, Fighting Wolf, Lucky Jew, Rosebud, Once More, Bonehead, Never Sweat, Damfino, and Damfuno. In town, saloon and street fights were common, and there were frequent shootings—store windows were favorite targets. Most saloons never closed; those that did only shut their doors at noon on Sunday.

The Tri-State District has yielded the greatest aggregate of good quality mineral specimens of any area in the United States. Galena came in cubes up to 25 centimeters and in sharp octahedrons. Frequently the lead sulfide crystals were attached to a layer of saddle-shaped, cream-to-pink-colored dolomite crystals. Galena sometimes formed as hollow



skeletal crystals within which minerals of a later generation had grown.

Sphalerite occurred in jet black crystals known locally as "black jack" ore. Commonly specimens are of a resin-like color, but most popular was ruby-hued sphalerite (locally known as ruby jack). These tiny jewels are bright, transparent, and incredibly perfect in form, so much so that natural single crystals have been set into jewelry. Small crystals of chalcopyrite attached to crystal surfaces of galena, sphalerite, dolomite, and calcite enhance the beauty of all minerals involved.

Cockscomb-shaped sprays of marcasite, some highly iridescent, have an identifiable appearance unlike those of any other source, and this area has produced the best specimens known to collectors. The finest marcasite crystals were found in the Treece mine near Treece, Kansas, on the Oklahoma border. Calcite, the most prevalent of Joplin minerals, crystallized in 30 or more forms. The crystals are found from tiny microsize specimens to 60-centimeter dog-tooth shaped crystals filling whole caves.

Boodle Lane, most active of the Joplin dealers, once advertised "calcite, galena, and sphalerite crystals—top quality—at 50 cents a pound in 200-pound lots, shipped F.O.B. in oil drums." A jeep trip through miles of abandoned drifts and galleries with Boodle narrating past adventures was a marvelous experience. Boodle died in 1962, but even today Joplin's old-timers recount past field trips or dealings with him. After Boodle's death, Chink Enders of Picher, Oklahoma, continued the jeep trip tradition until 1972, when the mines flooded and exploration ceased.

Ozark Lead Company operates the Millikin mine (located at Sweetwater, 13 kilometers southeast of Bunker on the western edge of Reynolds County, Missouri), which was discovered in January 1962. Seventy-five kilometers of test drilling established an

BELOW: Hemimorphite (probably containing cadmium) pseudomorphous after calcite
Size: 75 by 40 cm
Locality: Joplin, Missouri, mined 1870
Collection: Carnegie Museum of Natural History
Photo: Delbert Oswald
Courtesy: Gary Hansen

OPPOSITE TOP: Galena on limestone
Size: 11 by 8 cm
Locality: Sweetwater mine
Collection: Rex Bannister
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM: Galena on chalcopyrite
Size: 10 by 8 cm
Locality: Viburnum mine, Reynolds Co.
Collection: Rex Bannister
Photo: Harold and Erica Van Pelt

enormous body of high quality lead ore so pure it is in demand for fabrication of maintenance-free automobile batteries.

Mining is by pillar-stope method. Rooms opened from the stopes are nearly 10 meters wide and range up to 18 meters high. No timbering is required, and only rarely are rock bolts used. Highly automated jumbo rigs bore 100 holes a shift with high speed drills, directed from an operator's console. The Millikin employs 380 people, many of whom work in a veritable underground city of warehouses, shops, and offices. Fully automated, 17-metric-ton capacity ore skips in the main production shaft travel from the mine's bottom at 382 meters to the surface in about 1 minute. Rubber-tired vehicles haul ore over 16 kilometers of underground roadways to the main haulage tunnel, where it is transferred to ore cars (each with a 17-metric-ton capacity) pulled by high speed rail diesel engines to the hoist.

Handsome galena crystals—some positioned on a matrix of limestone, others resting on chalcopyrite—are the trademark of Millikin mine specimens. Some cubes measure 30 centimeters on an edge and are found with attached calcite crystals. One giant brilliant cube, discovered in 1971, weighed nearly 1000 kilograms. Too large to remove intact, the crystal was "blasted for ore." During December 1971 outstanding siegenite crystals growing on white dolomite were discovered. At about the same time, pockets were found containing superb calcite scalenohedrons, as single crystals and in clusters. Individual crystals showed three main growth planes, each coated with microscopic marcasite crystals. Millikin geologists predict a long future for the mine. "The only thing we are short of," they point out, "is a supply of those pretty galena crystals."

Other area mines have contributed fine mineral specimens. The Brushy Creek mine, 16 kilometers to the north of Reynolds, produced unique grayish calcite crystal groups dusted with tiny iridescent marcasite crystals; the nearby Fletcher, Cominco, Buick and Viburnum 27 mines of Iron County, and the Indian Creek mine in Washington County have produced exceptional galena, calcite, and pyrite specimens.

8 Yogo Gulch Mine, Utica, Montana

Sapphires of a fine cornflower blue were found in Yogo Gulch and along the Missouri River as early as 1860, when gold miners complained that blue stones cluttered the gold in their pans. The little blue pebbles were discarded as worthless at Emerald Bar, Magpie Gulch, American Bar, El Dorado Bar and French Bar, all on the Missouri River in the general vicinity of Helena, Montana. Unknown to these Missouri River miners, the same blue pebbles occurred 100 kilometers to the east on the Yogo and Judith rivers.

Prospector Jake Hoover, after working the Yogo River sandbars in 1894, sent a pill bottle filled with gold and a few of the pretty blue stones to a friend in Maine. Her answering letter thanked him for the gold "and the sapphires." "What the hell is a sapphire?" Jake exclaimed. His partner, S.S. Hobson, curious enough to take samples of the blue stones to a lapidary shop in Helena, confirmed the Maine lady's identification and learned their value. The partners shipped a small box of stones to Tiffany and Company in New York City and received a check for $3750 for the lot. Best of all, Tiffany wanted more. In 1898 Hobson, who later became a senator in the Montana Legislature and had a town named for him, organized the New Mine Sapphire Syndicate. Access to the river mines was through a man-made cut in a steep canyon. Dudley Richards and his Indian wife operated a toll gate at this point, charging 50 cents a person and $1 a vehicle for those who wished to pass.

A London-based firm, Johns, Tolhurst and Walker, Ltd., with sapphire investments in Sri Lanka and Burma, heard of the Syndicate and determined to own the new Montana mines.

THIS PAGE TOP: Hydraulically working Yogo sapphire deposit. Earliest known photograph, CA 1895 Courtesy: Sapphire-Yogo Mines, Inc.

THIS PAGE BOTTOM: Original Yogo shaft, 1896, being constructed by the New Mine Sapphire Syndicate Courtesy: Sapphire-Yogo Mines, Inc.

OPPOSITE LEFT: Sluicing ore at the English mine, 1899 Courtesy: Sapphire-Yogo Mines, Inc.

OPPOSITE RIGHT: Ore from the English mine is dumped from trestles to weathering floors below to erode and disintegrate, CA 1899 Courtesy: Sapphire-Yogo Mines, Inc.

With this purchase, Johns, Tolhurst, and Walker would establish a worldwide monopoly of sapphires and control world prices, just as De Beers controls world diamond prices by owning most diamond properties. An offer was made, and in 1901 the British interests attained complete control of the Syndicate and its Yogo mines.

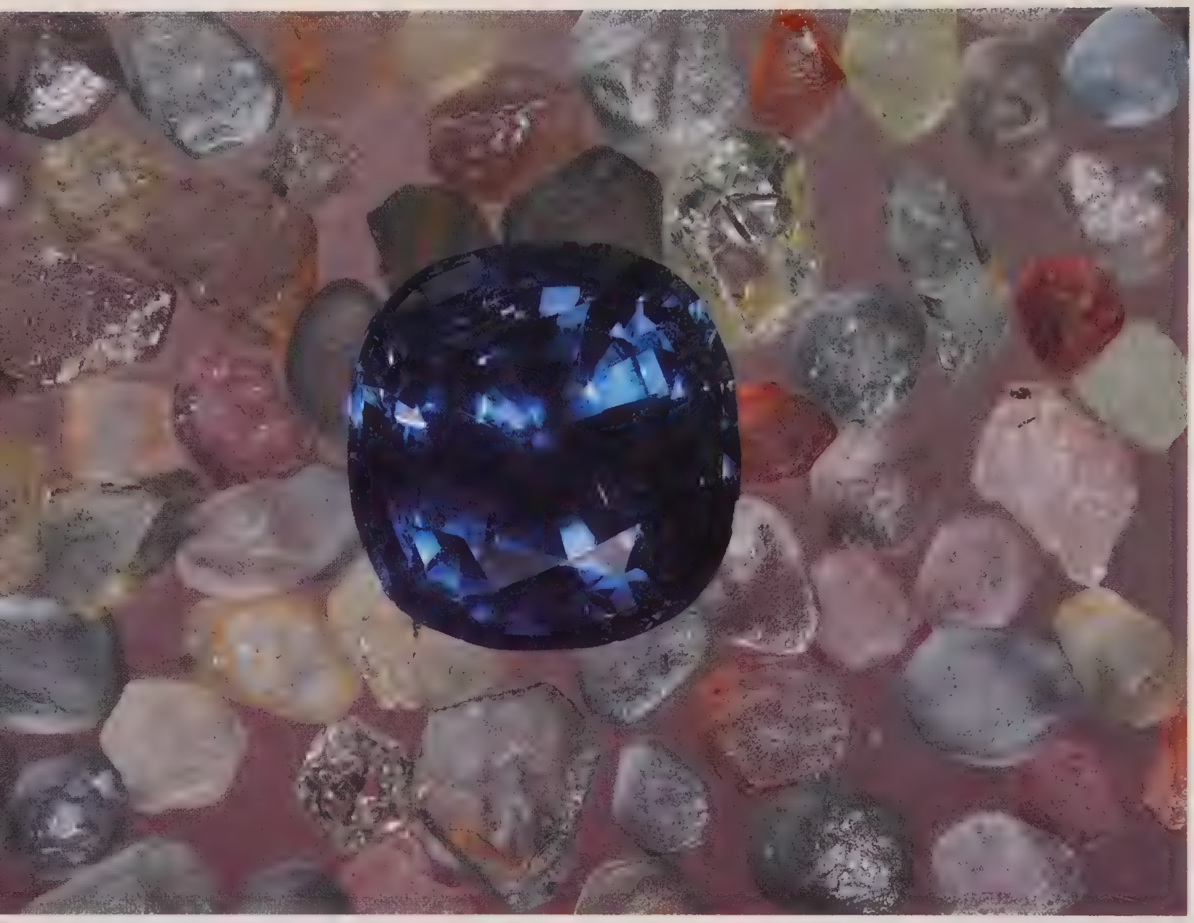
Included in the sale were the following patented claims: Gold Cross, 4th of July, Klondike, Blue Diamond, Jewel, Snowdrift, Gem Survey, and the Hope and Dud placers. Only the American mine and a few other claims remained outside the Syndicate's control.

Englishman Charles Gadsen became mine manager in 1901. British engineers could not mechanically separate pyrite from sapphires in the mill, so Gadsen devised a method of heating the concentrate until the pyrite became magnetized and was easily extracted by a homemade electromagnetic separator. Gadsen exhibited ingenuity again when he placed a patrol of boys along the ditch which brought water 17 kilometers to the mine. Each boy carried a homing pigeon, and if a break was found in the canal—which had cost $38,000 to dig—a note detailing the difficulty was dispatched. In a few minutes, Gadsen knew of the problem and had a repair crew on its way, thus avoiding a shutdown that could idle his work force of 50 men.

Open pit mining proved to be more economical than tunneling, but the severe winters restricted sluicing and open pit operations to the months between May and November. When snow lay on the ground, miners drove long tunnels along the lode and stockpiled the ore until spring when it could be sluiced in the river. An average ton of ore yielded 22 carats of sapphires.

Gadsen personally supervised the cleanup of the crystals and placed recovered sapphires in a vault within his home. Stolen Yogo Gulch sapphires were easy to identify. If a worker attempted to sell gems, word soon reached Gadsen; the miner was discharged and had to walk out to civilization 24 kilometers away.

When the sapphire market collapsed and the New Mine Sapphire Syndicate closed its property in 1929, Gadsen began raising mink, and became internationally known for fine pelts. He and his wife lived in the United States for many years, but remained English and never really accepted America or its customs. Although the Montana Rockies had plentiful game, Gadsen traveled to England to hunt. Because neither of them liked American radio programs, the Gadsens tuned their receivers to Canadian broadcasts. During the 1930s and 1940s, as neighbors moved away, the Gadsens stayed on and became recluses.



THIS PAGE TOP:
"Big Sky Sapphire" with various colored sapphire crystals
Size: 12.54 carats (largest fine quality sapphire found in U.S.)
Locality: French Bar, Missouri River
Collection: MacDonald Mader II
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM LEFT:
Sapphires
Size: setting 5 by 4 cm
Locality: Missouri River, Montana
Collection: Margaret Reed (self-collected)
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM RIGHT:
Sapphire
Size: 3.58 carats
Locality: Yogo Gulch
Collection: Pala Properties, Inc.
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
American Sapphire mine and mill in Yogo Gulch, 1905
Photo: D.B. Sterrett, USGS

OPPOSITE BOTTOM:
Mine manager, Charles Gadsen and wife, Maude, 1905
Photo: D.B. Sterrett, USGS

In one span of three years, Maude Gadsen never went to Utica, the nearest town. Both Gadsens are now buried in nearby Lewistown.

The Yogo sapphire deposit comprises horizontal sedimentary layers of limestone and shale, through which a nearly vertical dike of igneous rock intrudes for nearly 8 kilometers. In contrast to alluvial sapphire deposits along the Missouri River, Yogo sapphires are found *in situ* within the main dike. At least one other dike nearby is devoid of sapphires.

The gem dike is composed mainly of an intrusive pyroxene-basalt in which occur biotite, zeolites, pyrite, apatite, magnetite, hematite, calcite, quartz, zircon, spinel, kyanite, and dolomite. The sapphires are evenly distributed throughout the dike so that the entire vein is gem-bearing ore. Crystals form in flat undistinguished disks, and crystal faces are quite rare.

The fortunes of the Yogo Gulch area rose and fell over the years. An estimated $2.5 million in gems were mined, but the mines lost money because of high recovery costs and unstable markets. The English mine continued to use a crude method of spreading out the ore on large wooden weathering floors to dry in the sun until it disintegrated and freed the sapphires. The American mine built more modern mills and recovered equally fine gems, but had difficulty marketing its stones on the controlled market. In 1914 the British Syndicate bought out the American mine and promptly closed it down.

Yogo sapphires, although never large, occur in abundance. But fewer than 5 percent of all stones can be cut into clean gems of more than 1 carat. Most crystals produce facet-grade gems of less than 0.75 carat. Nearly all gems found at Yogo are sapphires, and most are blue, although a few gemstones have been found in colors of yellow, purple, pink, and red. In one span of 30 years, only 4 rubies were found. Even though most sapphires from Yogo mines are small, the richly and uniformly colored gems are free of flaws. The rough is usually cut in Bangkok, and the small faceted stones are beautiful indeed, when set in clusters around a diamond. Larger sapphires encircled by diamonds bring high prices and are much in demand. The clarity and rich royal blue color of Yogo stones are equal or superior to gems from most other localities. The largest faceted Yogo sapphire is a 10.2-carat hexagonal gem, now on loan to the Smithsonian Institution.

In 1977 an American company, the Sapphire-Yogo Mines, Inc., assumed control of the property and produced a reported 250,000 carats a year until September 1980. At that time the Saturn Exploration and Mining Company of Denver, Colorado, acquired title to the mines and commenced open cut mining on the east end of the property. Ore is blocked out for years to come, and, if management and markets remain stable the venture shall have a long successful future.

On the Missouri River at French Bar, due east of Helena and about 100 kilometers west of Yogo Gulch, MacDonald Mader operates a gold and sapphire dredge with good results. His boat, which vacuums gold and gems from the river bottom, received the approval of Montana's Departments of State Lands and

Fish and Game, as well as environmentalists. Mader found America's largest gem quality sapphire in a sluice-box mixed with smaller sapphires, garnets, and some gold. This sapphire is a remarkably clear deep blue 24-carat crystal which Mader named "Big Sky Sapphire." While much smaller than stones from foreign localities (for example, sapphires from Sri Lanka often exceed 100 carats), Mader's sapphire caused a sensation in Helena. The well-formed crystal produced a clean, bright, cushion-shaped, rich blue gem weighing 12.54 carats.

Each summer hundreds of amateur rockhounds and some professionals work the Missouri River about 10 kilometers north of French Bar in a section known as El Dorado Bar. Countless sapphires have been recovered, and proud owners have cut and set them in jewelry, which is frequently displayed in mineral and gem shows throughout the northwest.

THIS PAGE TOP:
Remains of Gadsen home, once one of the best houses in rural Montana. It was built so Gadsen could observe operation of American mine (dumps are in background) from his windows, 1980
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Elmer "Tug" Taurman sorting sapphires at Yogo in 1980, a job he has performed for more than 40 years.
Photo: Peter Bancroft

OPPOSITE:
Death of the Leonard gallows frame, destroyed by dynamite in 1964
Photo: Allan G. Hooper

9 Leonard Mine, Butte, Montana

Gold was discovered and mined at Butte in the 1860s. As the gold played out, silver mining became important, but the camp did not really boom until the discovery of vast copper, lead, and zinc deposits in the early 1880s. Butte, one of the most important copper mining complexes in history, has enjoyed over the years a number of nicknames, especially "the richest hill on earth." Miners of many races were employed by the Butte mines, as Protestants, Jews, and Catholics learned to live and work together in relative harmony. By the turn of the century, however, various groups bitterly fought each other. The Mountain View mine was nicknamed the "Saffron Bun," because it employed only Cornish miners who had introduced yellow bakery goods to Butte. (Bread was colored from the aromatic stigmas of the saffron plant.) The Anaconda and Neversweat mines employed only Irish workers. In the early 1900s there were three major riots between the two factions. Later, the Cornish and Irish miners joined forces to oppose the inroads of southern Europeans. At the same time, some residents went to unusual lengths to get along with each other; a Rabbi killed Sabbath chickens in front of his Main Street store; merchants "locked-up" on Jewish and Christian holidays alike, and a Jewish merchant owned a horse named "Jesus Christ."

When substantial numbers of Chinese arrived in Butte to work as wood cutters, the French-Canadians, who monopolized this trade, strongly resented the intruders. Violence broke out and many Orientals were killed. The remaining Chinese reverted to more peaceful enterprises, such as *washey-washey houses* (laundries) and restaurants. Others operated stores in Chinatown selling souvenirs, herbs, drugs, and foodstuffs. Dealing in slave girls was a brisk business, as was operating opium dens where

a pipeful cost between $10 and $20. Gambling houses featuring chuck-a-luck, birdcage, and fantan were also popular.

Mining claims overlapped. There was much cheating with boundaries; confusion reigned as to who owned which mine or what part of which, and the "apex law" was fully reviewed in the courts. ("Apex" means outcrop, and the law states that the owner of the apex also has mining rights to the vein no matter whose land it penetrates. The complexity of Butte veins made it virtually impossible to determine which veins "apexed" on which claims.) All this resulted in millions of dollars in lawsuits. Fortunately, the mines were enormously profitable and survived the troubled times.

From its earliest days Butte was recognized as a sportsman's town which also attracted important "cultural" events. Maude Adams and Eddie Foy, Jr. appeared on stage; horse races and cockfights were popular; and there was one bull and bear fight before public opinion prohibited another. In later years, legitimate boxing drew some of the greatest fighters of the time to Butte: Jack Johnson, Kid McCoy, John L. Sullivan, and Jack Dempsey.

Mine owners sponsored drilling contests and offered large purses. The "double-hand" matches involved two men; one held the drill while the other struck it with a sledge hammer. In "single-hand" competition one man held and struck his own drill. Champion drillers could strike up to 90 blows a minute without a miss. The "double-hand" team of Mike Davei and Harry Rodda really brought out the crowds. Both had been blinded in a mine explosion, but they could still drill with uncanny accuracy; so well in fact that they were asked to give a "double-hand" performance in New York's Madison Square Garden.

High stakes were bet on a crude sort of entertainment borrowed from the Mexicans, called "pogrom in a hen coop." A chicken was buried in the ground with only its head exposed. Horsemen rode by at full gallop and attempted to decapitate the chicken or, better yet, pull the whole bird out of the dirt. Frequently as many men as chickens were hurt in the process.

Butte's "brides of the multitude" (prostitutes) operated in "Venus Alley," the red-light district bordering Galena Street. Some of the more opulent parlor houses included Lou Harpell's Place, The Casino, Molly De Murska's House, and Mabel Loy's Studio. The house with the greatest activity was The Casino, which combined a brothel, restaurant, saloon, dance hall, theater, and prizefight ring. In numbers of prostitutes, Butte was supposed to have the biggest "line" west of Minneapolis/St. Paul.

Street and saloon fights were commonplace, but murders infrequent. There were many ways to separate a miner from his wallet, which many times included drugging, rolling, and

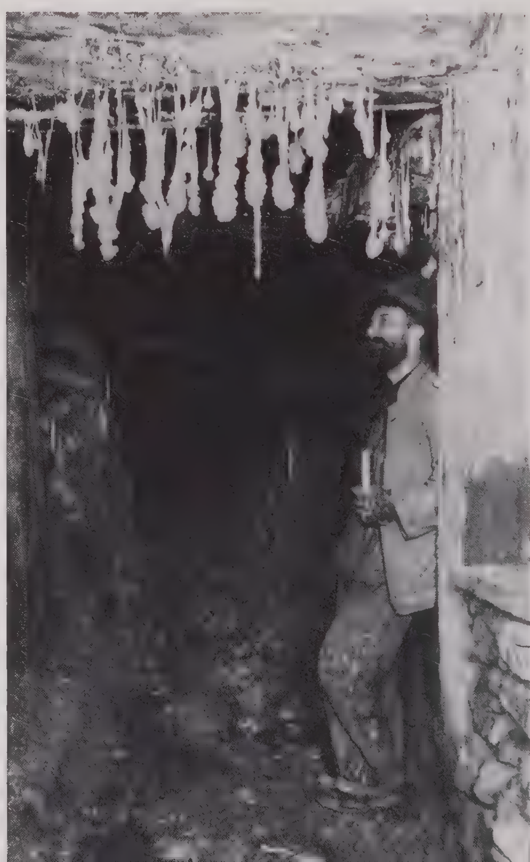
BELOW LEFT:
Butte miners lighting fuses (spitting the round), 1890s
Photo: Allan G. Hooper

BELOW RIGHT:
Miner in old Butte mine, CA 1890
Courtesy: Allan G. Hooper

OPPOSITE TOP LEFT:
Covellite
Size: 6.5 by 5 cm
Locality: Leonard mine
Collection: George Holloway
Photo: Earl Lewis

OPPOSITE TOP RIGHT:
Pyrite
Size: 9 by 7 cm
Locality: Leonard mine
Collection: Peter Bancroft
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Chalcocite on quartz
Size: 6.5 by 5 cm
Locality: Leonard Mine
Collection: David Eidahl
Photo: Harold and Erica Van Pelt





then heaving him into the street. The Chief of Police, "Jerry the Wise," built a reputation on never forgetting a face and never coddling a criminal. He and his men kept busy because the saloons never closed. The owner of the Colousa Saloon might have been the first mineral collector in Butte. Miners either gave him crystal specimens for his collection or traded them for drinks. Over the years the saloonkeeper's collection grew in size and quality. It is now a feature display in the Montana Technical University Museum.

Mules and horses almost outnumbered people in Butte, causing feed and sanitation problems. It was estimated that as many as 3000 animals worked underground in the mines. A mule would be carefully "bagged" in canvas, loaded onto a cage, and lowered into the mine. There it would work in the dark pulling as many as six ore cars, each loaded with a ton of "muck." However, the mule soon learned never to pull more than six cars. Eventually the mule could operate almost independently without its "skinner" (driver), seeming to know when the cars were full and when to pull to the hoist. Some miners felt that management took better care of mules than men. When a mule had been underground for a few months, he was hoisted to the surface and put out to pasture. Later he was again lowered into the mine for more work. Electric engines began to replace mules about 1913 and the changeover was completed in 1930.

The Leonard mine opened in the 1890s and became a big producer of copper, eventually employing 1600 men. It produced many thousands of outstanding specimens of rhodochrosite, chalcocite, pyrite, and enargite, and its covellite crystals are generally considered to be the world's best. Rhodochrosite crystals occurred in large masses of pink rhombohedrons, sprinkled lightly with tiny chalcopyrite crystals. Individual rhodochrosite crystals generally did not exceed 2 centimeters on an edge. Bornite crystals up to 2.5 centimeters were infrequently found in pyrite. Well-formed, tabular crystals of chalcocite measuring 2 centimeters in length were found growing from white quartz. Hexagonal crystal plates of covellite were discovered in considerable quantity, some with a width of more than 8 centimeters and some with crystal surfaces frequently colored with iridescent shades of brass yellow, purple, and red.

Like many mines, the Leonard had its share of disasters. In 1912 a cage in its main hoist "ran away" when the braking system failed, dropping 450 meters down the shaft, killing 12 men. Fires underground were a continual problem, some burning for many years.

Other calamities occurred in Butte. In 1895 a warehouse fire spread to a dynamite storeroom stocked with 350 boxes of high explosives. The blast was so powerful that an iron railroad car wheel was found eight blocks away. More than 60 died in the conflagration.

BELOW: Miner-skinners operating horse-drawn trains deep in Butte mine, c. 1905
Photo: Courtesy Allan G. Hooper

OPPOSITE: "Shoestring Annie," character of early Butte who sold shoestrings for a living. Her cussing "would make a mule skinner blush."
Photo: Smithers Studio, Butte

In 1915, 12 cases of dynamite blew up at the surface works of the Granite Mountain mine; parts of the 13 victims were discovered 1600 meters away. Butte's worst disaster occurred in the Granite Mountain shaft on June 8, 1917. A carbide lamp started a massive fire in the shaft, trapping hundreds of miners working below. Some lived through the ordeal by "bulkheading" themselves in blind crosscuts for three days. Not so fortunate were 164 others who lost their lives in the most disastrous metal mine fire in United States history.

The Leonard became a world leader in the production of choice mineral specimens with unique characteristics that easily identified their origin. Ed McDole, a longtime Leonard miner, was also a dealer, carefully collecting and preserving thousands of fine crystals. During the 1950s it was a rare treat to visit Ed in his little hotel room, absolutely littered with boxes of glittering specimens. At times Ed would invite a visitor to take a trip underground, where he would point out locations that had produced exotic crystals. If he were not available for a trip into the mine, the visitor could arrange with the mine office for a guided tour into the Leonard, one of the few large working mines in the world which permitted such tours.

The Leonard closed in 1962, and two years later the steel gallows frame (the surface hoisting structure) was blasted into oblivion. Its sheave wheels, 3 meters in diameter, are currently being used at a mine in Utah, but historians hope they can be returned to one of Butte's museums.

Of the many other mines in and around Butte, probably the most famous was the Anaconda, originally developed as a silver mine in 1875. Vast deposits of high grade copper were encountered within a few hundred meters of the surface. In later years the Anaconda became the single largest producer of copper in the world, but it never yielded crystals comparable to those from the Leonard.

The great mining days of Butte appear to be over. Most of its mines are closed, and in September 1980 the smelter at nearby Anaconda shut down, a severe blow to the remaining mines, the area's miners, and to Butte itself. All of Butte's ore bodies are not exhausted. Remaining ores in the old Leonard mine are scheduled to be removed through another shaft.

Butte has survived disasters, depressions, and exhaustion of many of its ore bodies, but if determination and faith—integral traits of many Butte residents—prove to be factors, Butte just may still have a mining future. Old-time miners and businessmen recently created a new museum on the grounds of the old Orphan Girl mine. From the 1890s to 1956, this lead, zinc, and silver mine was a good producer. Now its headframe stands watch over groups of tourists who come to inspect mining machinery, memorabilia of the past, and a modest mineral collection. Admission is free.

10 Gem Mines, Crystal Peak Area, Colorado

Crystal Peak, one of Colorado's many gifts to the mineral collector, has been actively prospected for more than 100 years. Located about 6 kilometers north of Florissant at nearly 3000 meters above sea level, Crystal Peak is a sharply pointed mass of granite covered with timber. Farther north other peaks of granite extend irregularly northward toward the Platt River. The country rock is coarse granite penetrated by small and large pegmatite dikes which produce a large variety of mineral specimens. Scores of rockhounds have dug into the flanks of Crystal Peak, thousands of nature lovers have trod its forests with gun or camera, and many visitors have dangled a foot in the clear little streams, one of which is Crystal Creek. In winter, the mountain is covered with snow, confining the few local residents for weeks at a time; winds are often strong and unfriendly. With the coming of late spring, however, grass and flowers begin to appear, and it is time for the collector to return to that crystal cavity hurriedly deserted when the big storm came in last fall.

Crystal Peak has many rock outcrops of pegmatite dikes and decomposed rubble of

THIS PAGE TOP:
Reconstructed amazonite and quartz pocket
Size: 1.6 x 1 meters
Location: Denver Museum of Natural History
Photo: Jack Murphy

THIS PAGE BOTTOM:
Amazonite with smoky quartz
Size: 13 by 9 cm
Locality: Crystal Peak
Collection: William Larson
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
A portion of Crystal Peak diggings with Mt. Tarryall in the background, August, 1913
Photo: Douglas Sterrett, USGS

OPPOSITE BOTTOM:
Crystal Peak Gem Company camp with J.D. Endicott, G.W. Weed and dogs, 1913
Photo: Douglas Sterrett, USGS

granites and pegmatites—the ingredients for deposits of fine crystals. Good specimens are found as float (crystals separated from the parent vein by weathering). Because there are no ore bodies and metal deposits in the Crystal Peak area, no large mining company has ever encroached upon the land, and in recent times the major landholder has been the United States Forest Service. Crystal Peak itself is privately held and much of the nearby area that has good collecting spots is in the Pike National Forest. Most of these spots are staked as mining claims, and permission to dig should precede any activity. Collectors, dealers, and at least two Colorado gem and mineral clubs have staked private crystal claims. Where prime spots have been staked out as mineral claims and patented, signs warn trespassers to "Keep out." However, open locations remain and with a bit of persistence the collector can find a place to dig.

Still prolific, the Crystal Peak area yields countless beautiful clusters of crystals. The most common minerals are amazonite (the green variety of microcline), smoky and amethyst quartz, goethite, fluorite, topaz, albite, hematite, cassiterite (twin crystals 3 centimeters long), columbite, biotite, zinnwaldite, and phenakite. One amazonite crystal, a Baveno twin, measured 36 centimeters long and weighed 20 kilograms.

Although many prospectors have fared well in the area, the adventures of a few stand out. Through hard work and a measure of good fortune, they accomplished what others have only dreamed of doing—finding beautiful crystals on Crystal Peak.

Long-forgotten trappers and frontiersmen may have first discovered crystal treasure on Crystal Peak during the 1830s, for it is known that white men reached the area at that time; yet no record of such events survives. In the 1870s, A.E. Foote, a mineral dealer in Philadelphia, sent skilled prospectors to the region. They located a big pegmatite dike on the northwest slope of Crystal Peak and dug out large quantities of richly colored amazonite and smoky quartz which were shipped to the Foote laboratories. George Reeser, an avid collector and former resident of Florissant, recalled seeing 19 men working many pockets for Foote in 1874.

In the early 1880s, a veteran prospector named Arsene Thiebaud homesteaded a parcel of land near Crystal Peak, built a sizeable ranch, and collected crystals in his spare time. The Reverend R.T. Cross, another avid collector who frequented Crystal Peak and Pike's Peak in the late 1800s, publicized the lore of amazonite by recounting his exploits in sermons and a book, *Clear as Crystals.*

In 1908, miner cowboy Albert E. Whitmore built a log cabin north of Crystal Peak, staked out claims called the Gem Mines, and established the Crystal Peak Gem Company. Whitmore eked out a living selling crystals in a curio store he had built near his cabin. On September 15, 1932, the aging Whitmore was robbed of $30 by a masked bandit who beat him severely with a gun. The next year when Whitmore returned from a trip to Cripple Creek for supplies, he couldn't find a new hole he was developing near his cabin. It was as if it had vanished. Searching the area, he saw a

human foot sticking out of a pile of rocks. The foot was cold, and two toes had been nibbled away, probably by coyotes. Whitmore hastily left for town, got Sheriff Ed Vinyard, and the two men dug out a 55-year-old woman, later identified as Ida Hanson of Osceola, Nebraska. The woman had eloped with Charles Neal, a bootlegger in Cripple Creek. Apparently while the two "highgraders" were robbing Whitmore's gem mine, Hanson lost an argument and was interred in the gem pocket. Neal was captured and found guilty of murder.

In the summer of 1934, high school freshman Jerome Hurianek went to work for Whitmore, who taught the boy all he knew about searching for amazonite. The two remained close friends until the old man died a few years later at the age of 90. During this time a gem quality smoky quartz crystal, measuring 31 by 18 centimeters and weighing 24 kilograms, was found in the main gem mine. The crystal is now part of the Smithsonian Institution collection. Whitmore's Gem Mines property involved many pockets which yielded thousands of crystals. Most notable were sharply pointed smoky quartz prisms and stocky green amazonite crystals. In combination, these two minerals form display specimens of unusual beauty.

During the 1970s, after a century of mining activity in the Crystal Peak area, great new discoveries were made. Jerry Hurianek and his wife, Thelma, opened up a series of pockets on land they bought just north of Crystal Peak. These pockets produce many outstanding smoky quartz and amazonite combinations. H.H. "Tom" and Ann Odiorne also succeeded in discovering fine crystals on their properties at Crystal Peak and at Harris Park, 60 kilometers to the north. From one pocket alone they took 350 amazonite crystals, 150 smoky quartz prisms, large clusters of orange stained albite crystals, and a few geothite pseudomorphs after siderite. Eighty percent of the amazonite crystals were "white caps": their ends coated with white-to-cream overgrowths of microcline. Odiorne's enthusiasm for collecting on the Peak is detailed in his book, *Colorado Amazonstone* (1978).

Richard Kosnar, a Colorado mineral dealer, relates a curious event that occurred in 1972. Late one October evening, Dorothy Coil began to worry about the absence of her husband. Clarence Coil of Colorado Springs often went prospecting in the Crystal Peak area, but he had never been this late returning home. When he did arrive, his face told of an extraordinary find. While on one of the ridges that day, Coil

BELOW: Albert Whitmore at his Crystal Peak cabin, 1920
Photo: Carl Mathews

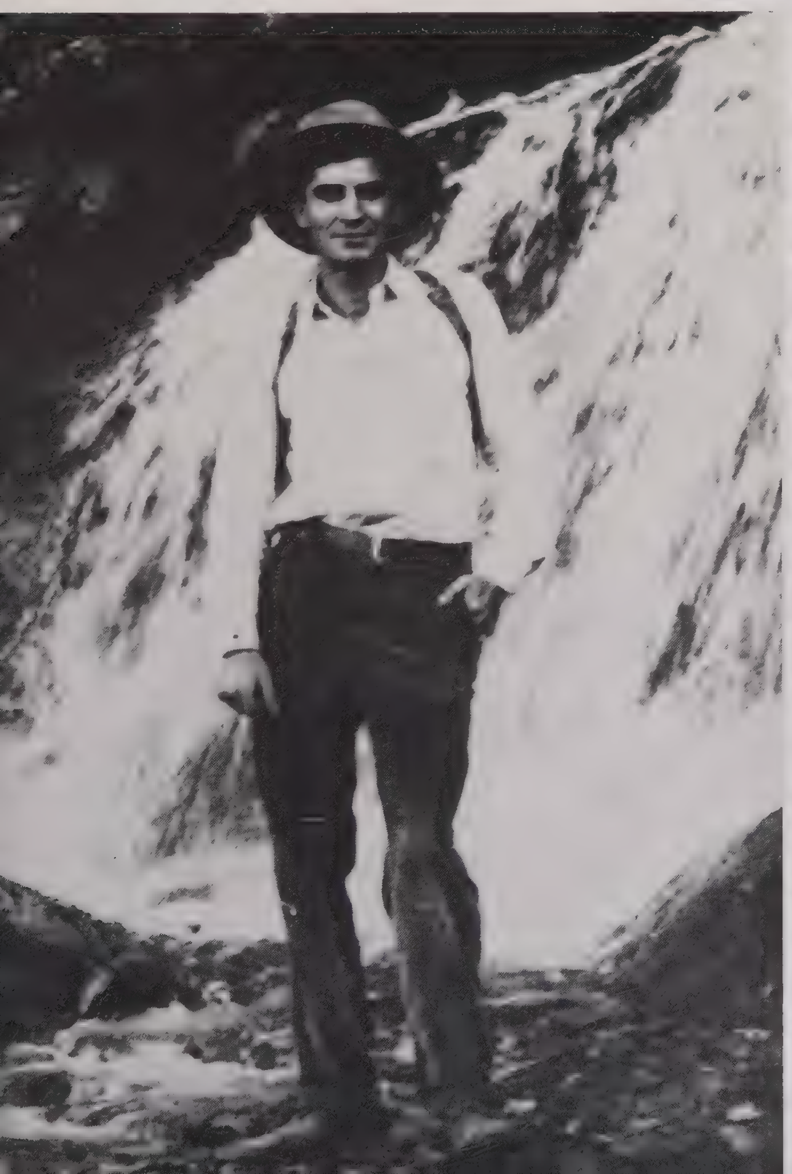
OPPOSITE TOP: H.H. (Tom) and Ann Odiorne in pocket which produced hundreds of amazonite crystals, June 1971
Photo: Donald Odiorne

OPPOSITE BOTTOM LEFT: Edwin Over on Crystal Peak in 1931
Photo: Willard Wulff

OPPOSITE BOTTOM RIGHT: Jerome Hurianek drilling holes for explosives on Whitmore property, 1935
Courtesy: Jerome Hurianek

had broken through massive granite to a cavity large enough for him to crawl into and sit up. Around him were large, white-tipped dark green amazonite crystals, some weighing as much as 3 kilograms. There were also quantities of albite, geothite, columbite, and smoky quartz crystals. Coil (now deceased) had worked the region off and on for 30 years, but had never before seen anything like this. His greatest find, it required many days to work out the pocket, and the contents eventually filled a stack of large wooden boxes. Some believe that the amazonite crystals Coil found are among the world's best.

Outstanding amazonite and smoky quartz crystal clusters are in the Harvard University Mineral Museum, the American Museum of Natural History, the Smithsonian Institution, and the Denver Museum of Natural History. Richard Kosnar of Golden, Colorado, has superb amazonite crystals in his private collection.



11 Home Sweet Home Mine, Alma, Colorado

The South Park mining district, in the rugged Mosquito Range about 96 kilometers southwest of Denver, Colorado, rests at a lofty elevation between 3200 and 4150 meters. A cluster of old mining camps within the district, famous for gold and silver, includes Fairplay, Buckskin Joe, Horseshoe, Mosquito, Tarryall (Whiskey Hole), and Alma. The area in and about Alma had its share of characters: Buckskin Joe, Father Dyer, Prunes, and Silver Heels — colorful figures of past years whose deeds will long be remembered as historical events.

Kiowa, Apache, and Ute Indians first lived in what is now known as South Park. Eventually the Utes gained control of the region and strongly resisted intruders. The first strangers to venture into this beautiful but hostile region were Spanish. Their search for gold was successful, and along Buckskin Creek in the 18th century they built seven primitive mills made of large stones used for grinding ore (arrastras). During the next 120 years, scores of gold claims and mines were worked in the Alma area by those who followed.

An important gold discovery was made in 1859 at a place 4.3 kilometers up the canyon from what is now Alma. The boom camp that grew up overnight was named Buckskin Joe after an eccentric leather-garbed character who established one of the first claims. Buckskin Joe later traded his claim for a revolver, a pony, and payment of a whiskey debt. About the same time, rich gold placers were found along the rivers to the south and gold camps sprang up in the nearby mountains. Fairplay was named for the fair treatment miners received there in contrast to many other western gold camps. Alma, established a little later, was named for one of at least four women among the early residents. Built on the site of a Ute campground and boasting a smelter, three or four saloons, a dance hall, and a number of stores and shops, Alma became one of the area's leading supply centers.

Buckskin Joe, Fairplay, and Alma were not only close to one another but also shared commerce, good fortune, and many difficulties. In the early 1860s John Dyer, a priest, frequented these towns. Still a hardy man at 50, Father Dyer did his best to keep "Satan" away from rowdy miners, a nearly impossible task. Because he had no church of his own, Dyer preached in the saloons and gambling halls of the three towns and out at the mining claims. One autumn he walked 800 kilometers through the high country calling at isolated

BELOW: Mining crew and wives of Home Sweet Home mine, 1896
Courtesy: Peter Bancroft
Western History Collection

OPPOSITE TOP:
Old Alma check.
No trace remains of the Bank of Alma.
Courtesy: Peter Bancroft

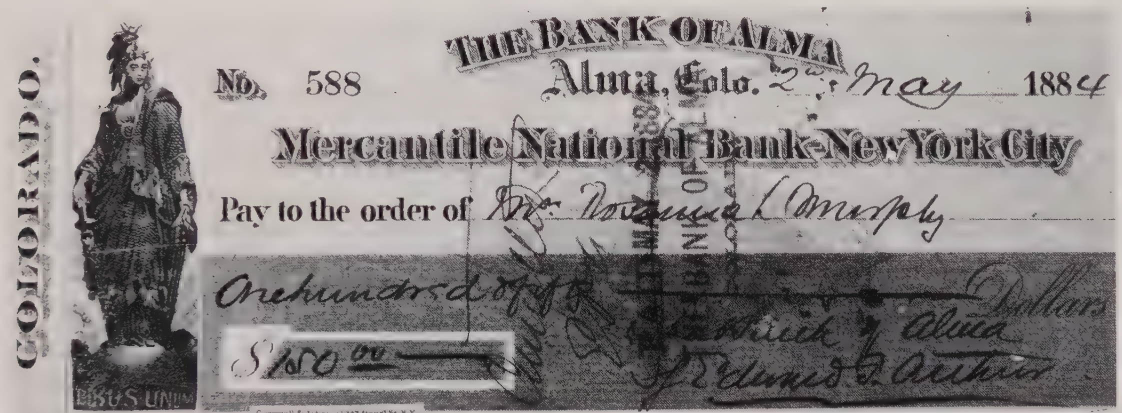
OPPOSITE BOTTOM:
Mules hauling lumber to mines, CA 1880
Courtesy: Jack Murphy

cabins or tents — wherever he could find someone to listen to "The Word." He carried a 37-pound (17-kg) pack containing a buffalo robe, dried food, coffee, sugar, and bacon. Father Dyer rapidly became one of the most respected and beloved figures in South Park.

Even better known, perhaps, was Josie Dillon, a young girl who had come West searching for her sweetheart and got a job dancing in a Buckskin Joe saloon. Virginia Thibedou, born in Alma in 1890, can recall stories told by her parents about the girl. Pretty and always well dressed, Josie danced on the bar and table tops, captivating all who saw her. She was discreet with her private life although many men were said to be in love with her. One admirer had sterling silver heels made and engraved in Denver for her slippers. From her next dance on, she was known as Silver Heels.

In October 1861, two Mexicans drove a herd of sheep into Buckskin Joe and one of the men died of smallpox. Within a few days the dread disease infected a large number of townspeople. Many men and nearly all the women left immediately, hoping to avoid the epidemic; one woman remained, Silver Heels, who went from tent to cabin treating the ill and dying. Physically exhausted, she too contracted the disease but recovered.

After the epidemic subsided, grateful miners and businessmen took up a $5000 collection of


COLORADO.
THE BANK OF ALMA
No. 588 Alma, Colo. 2nd May 1884
Mercantile National Bank-New York City
Pay to the order of Mr. [illegible] Murphy
One hundred & fifty Dollars
$150.00
[illegible]
Carswell & Johnson 247 Pearl St. N.Y.

LEFT: Mine Foreman, Dave Bergman, working in Home Sweet Home #2 stope, August, 1977
Photo: Richard Kosnar

OPPOSITE TOP: Buckskin Creek at the Home Sweet Home site, 1978
Photo: Peter Bancroft

OPPOSITE BOTTOM: Home Sweet Home portal still closed by snow in June, 1978
Photo: Peter Bancroft

gold dust, nuggets, and cash (including $1000 from Senator Edward O. Wolcott) and sent a committee to her cabin to make the presentation. Silver Heels, probably disfigured by the malady, had vanished and was never seen again. In a concerted effort to show their appreciation, local residents petitioned the Colorado Legislature to name the highest peak behind Alma in her honor. Mt. Silver Heels, snow-tipped year round, stands as a reminder of a captivating and courageous woman whose name lives on.

Prunes, Shorty, and Bosco were burros, called "Rocky Mountain canaries" by some miners. They lived long and useful lives in and about the mines and when retired, were permitted to live "on the town." The three burros wandered about seeking handouts of food and were loved by the people of Fairplay and Alma. Upon their deaths, each was given a full burial and a marker. Prunes lived for 63 years. Robert Sherwood, his last master, died in 1931. At his request, Sherwood was cremated and his ashes were interred alongside his burro. It is small wonder that Fairplay is now known as the Burro Capital of the world.

In 1895 a silver prospect named the Home Sweet Home mine was established 5.6 kilometers northwest of Alma on Buckskin Creek. Relatively unknown in mining circles, the property became famous in later years for its production of remarkable rhodochrosite crystals. In the 1930s, Edwin Spray extended old workings in the Home Sweet Home by nearly 3 kilometers and dug two main stopes. The No. 1 stope was constructed about 90 meters into the mountain from the main portal, and the No. 2 was hollowed out 210 meters beyond. The country rock was hard granite, and as silver ore and mineral crystals diminished, Spray was forced to close the property.

During the 1960s and until 1977, highgraders extended the No. 2 stope. They were rewarded for their unauthorized work, according to Colorado mineral dealer Richard Kosnar, with "probably the best rhodochrosite crystals ever recovered from this mine." Two miners, Ed McDole and Warren Good, entered a partnership and enlarged the No. 2 stope. In 1964 they hit two fine pockets of rhodochrosite crystals; the largest pocket was 2.4 by 0.7 meters. An old mattress was placed below the vein to cushion falling crystals, and a round of explosives was fired which exposed some extraordinary rhodochrosite crystals. Many were broken or separated from the matrix but,

when repaired, ranked with the world's best specimens of any species. The partners divided their acquisitions into two lots. McDole sold most of his on the West Coast, and Good, after selling his share, left the country.

In 1977, Richard Kosnar and John Saul formed Intercontinental Mining Corporation (IMC), leased the Home Sweet Home mine from Leonard Beach of Denver, and worked the No. 1 and No. 2 stopes from May to October. They finally stopped because of a lack of promising ore and "a deadly developing situation wherein the highly altered rock of the hanging wall became so unstable it could be disastrous." Highgraders had discovered most of the good specimens before the IMC lease. IMC found one good pocket of large and very fine rhodochrosite rhombohedrons, which were sold in Paris. Kosnar commented, "We also found some nice pale green apatite crystals. It seemed as though we spent most of our time cleaning up the mess which had been left by highgraders." IMC bought many mineral specimens from various highgraders. These included specimens with 1-centimeter tetrahedrite crystals; lustrous ruby-red huebnerite crystals; fine twinned stromeyerite crystals; good crystals of goyazite and svanbergite; fluorite dodecahedrons in colors of lilac, deep purple, white, sky blue, greenish blue, mint green, and, rarely, orange, some of which measured 4 centimeters in diameter.

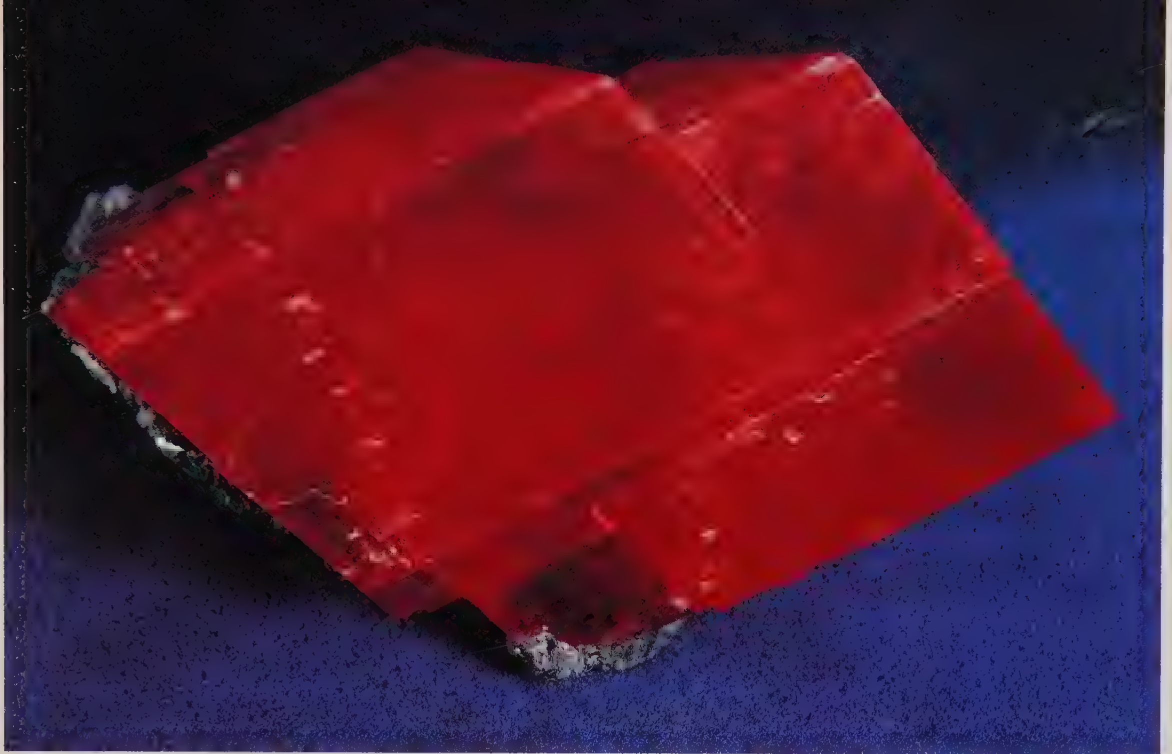
Outstanding rhodochrosite specimens from the Home Sweet Home are in the collections of the Denver Museum of Natural History, New York's American Museum of Natural History, and in the private collections of Edward Swoboda and Richard Kosnar.

The Home Sweet Home is now closed; Silver Heels, Prunes, and Father Dyer are gone; a few grave markers up among the aspens are all that remain of Buckskin Joe. But South Park remains prime mountain country. For those who wish to relive a bit of its past, curator Erik Swanson is pleased to show them his South Park City Museum on the outskirts of Fairplay. This little antique-filled museum, composed of original cabins from Alma and Buckskin Joe, and all of pretty South Park are well worth visiting.

BELOW: Alma's Silver Heels Saloon still does a good business, 1978
Photo: Peter Bancroft

OPPOSITE TOP:
Rhodochrosite
Size: 12 by 7 cm
Locality: Home Sweet Home
Collection: Denver Museum of Natural History
Photo: John Muntyan

OPPOSITE BOTTOM:
Rhodochrosite on quartz, pyrite, and tetrahedrite
Size: 14 by 12 cm
Locality: Home Sweet Home
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt



12 Cresson Mine, Cripple Creek, Colorado

"That creek sure is named right!"...a cowboy said in the 1880s. Another cowhand had driven a steer up the draw when his horse fell, breaking the mount's leg and rider's arm, and the canyon became known as Cripple Creek. The first town along its banks was called Fremont, but after Bob Womack discovered gold in Poverty Gulch in 1890, people remembered the earlier accident and the town was renamed Cripple Creek. Once an isolated mining camp at an elevation of 2900 meters, it is located 56 kilometers due west of Colorado Springs and 16 kilometers south of Pikes Peak. Ten years after gold was discovered, the town had grown from a couple of stores to a full-blown city of 20,000 people, one of the last great mining camps of the American West. In 1893, nearby Victor was established as the district's second city and its population also boomed, but at a slower pace.

For a frontier town of the 1890s, Cripple Creek had amazing amenities. More than 30 passenger trains arrived daily. The first newspaper was the *Crusher*, and 13 more appeared within ten years including *The Colored Tribune* for the large black population. A number of hotels included the elegant five-floor brick Imperial which still accepted guests in this decade.

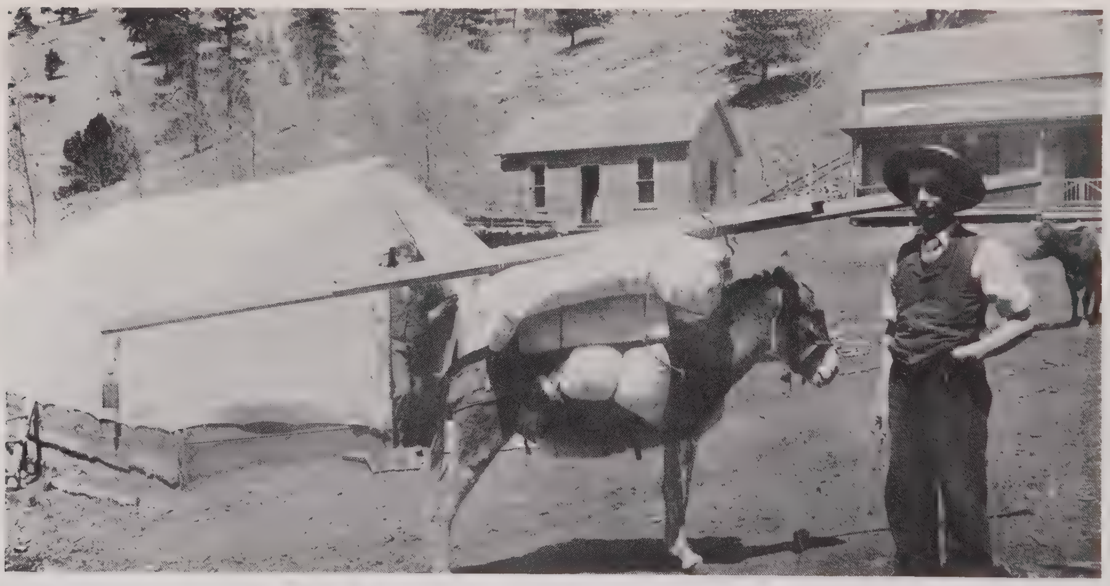
Disastrous fires struck in rapid succession—the first on the afternoon of April 25, 1896. A "lady of the night" got into a fight in the Central Dance Hall and knocked over a stove. The blaze quickly spread to nearby wooden

THIS PAGE TOP:
Prospector heading for the hills of Cripple Creek, c. 1890s
Courtesy: Dayton Lummis, Jr., Cripple Creek Museum

THIS PAGE BOTTOM:
Stope in Half Moon Mine, Cripple Creek, 1899
Courtesy: Cripple Creek Museum

OPPOSITE LEFT:
Miss Catherine H. Rea, secretary-treasurer of the Cresson, visiting the mine in 1914
Courtesy: Russell MacFall

OPPOSITE RIGHT:
Dick Roelofs, Cresson General Manager, at Cresson Mine in 1915
Courtesy: Dayton Lummis, Jr.

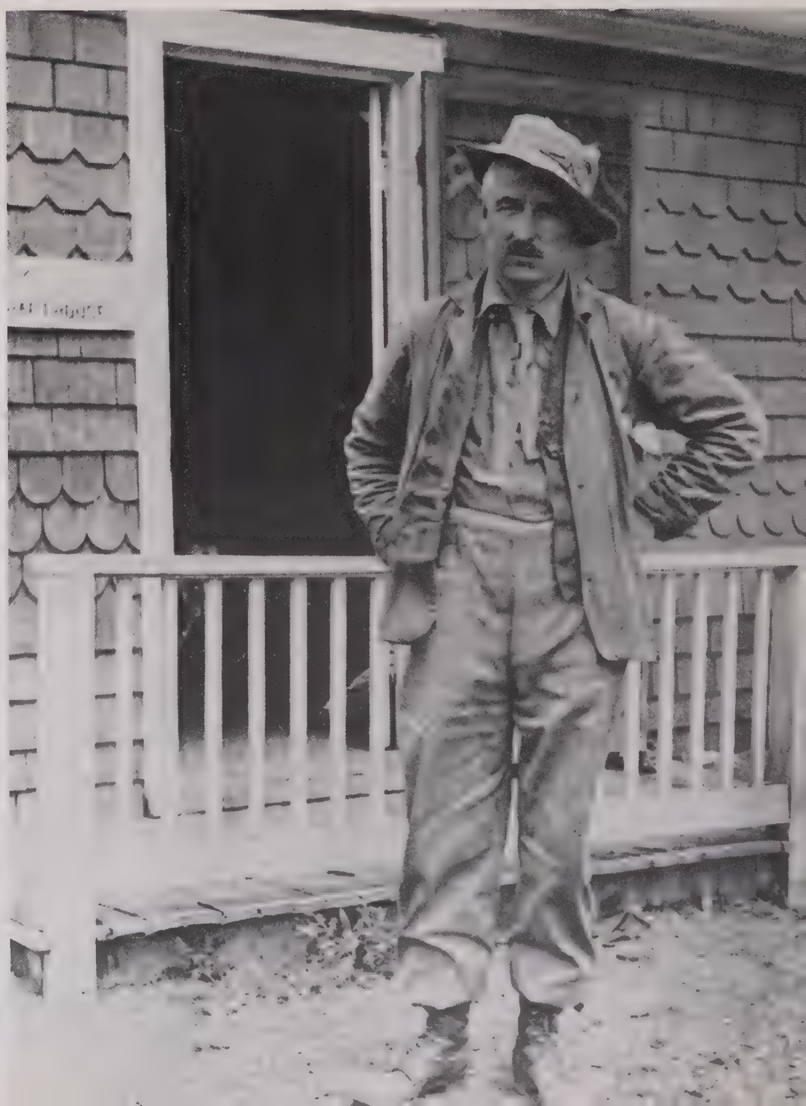


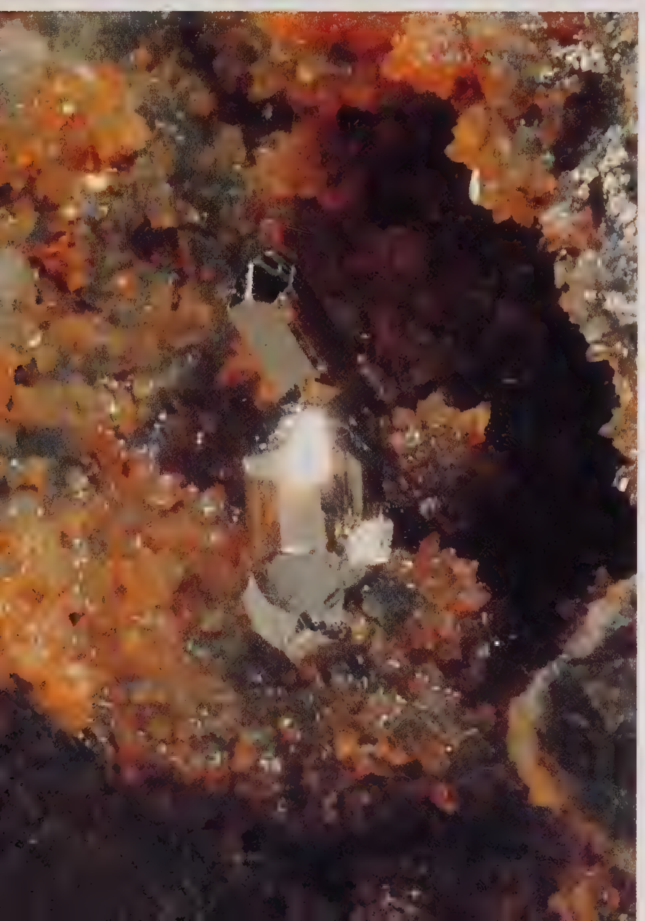
buildings as a brisk wind fanned the flames and 15 acres of the town were destroyed. Four days later a second fire leveled the remaining structures. Amazingly, only six people died, but damage ran into millions of dollars. Three years later a fire started in Victor's 999 Dance Hall and wiped out the entire town in a few hours. While embers from this fire still glowed, courageous citizens in Victor and Cripple Creek planned reconstruction programs with brick buildings, many of which stand today.

Another sensational event occurred on June 5, 1897, when Pearl De Vere died from an overdose of morphine. Pearl was madame of the Old Homestead parlor house and had hundreds of friends in Cripple Creek. The funeral cortege bound for Mt. Pisgah Cemetery included scores of horses, buggies, and people afoot. The Elks Club band was forced to withdraw from the entourage at the last moment when wives of members objected to their husbands' attendance. Flowers were sent from as far away as Denver, most of them anonymously. In 1978 the Chamber of Commerce held a Pearl De Vere Day, and the winning verse in a citywide contest was:

Pearl De Vere why didn't you stay?
You didn't have to go away
Were you hiding in some miner's shack?
With Tom or Harry, Duke or Mac?
The other day I did hear tell
That you were seen still raising hell
I wish that it were true, my dear
For you brought life to the miners here.

In 1894 when mine owners lengthened the miner's working day from 8 to 9 hours, large numbers of men went out on strike. In retaliation, the owners brought in scabs from as far away as Denver and conflict was inevitable. Mills and shafts were blown up. Leading agitators were rounded up and shipped in boxcars to New Mexico and Kansas where they were released on the prairies. The Western Federation of Miners allegedly hired Albert E. Horsley, alias Harry Orchard, to blow up the Florence and Cripple Creek railroad depot. With deadly efficiency Orchard accomplished this task. On the morning of June 6, 1904, a violent explosion shattered the





depot and killed 13 strikebreakers coming off shift. More shootings and deportations followed while citizens lived in fear. Finally 1000 federal troops were sent to Cripple Creek under General Sherman Bell; order was restored and the mines reopened. The mines had suffered losses (from sabotage and lost income) totaling millions of dollars, 3500 miners had been idle, and 33 lives were taken during the strike. Cripple Creek and Victor would never again be the same.

In the early 1900s, more than 400 mines were operating in the Cripple Creek district. The greatest was the Portland, producing more than $60,000,000 in gold during its 50-year-lifetime. Other mines were the Gold Coin, Cash-on-Delivery, Elkton, Vindicator, Independence, Prince Albert, Mary McKinney, C.K.&N., El Paso, Christmas, Half Moon, Wild Horse, Sitting Bull, Joe Dandy, and the Cresson.

Much of Cripple Creek's high-grade ore consisted of telluride minerals—fabulous combinations of gold and tellurium, the most important of which were sylvanite, calaverite, and krennerite (the first occurrence of this mineral in the United States). Tellurides typically form flat, ingrown aggregates in seams and also uniquely occur as pseudomorphs of melonite and native gold after calaverite. Crystals of these species are extremely bright and well formed, but because they are brittle, relatively few have survived mining. Tiny perfect crystals are a micromineral collector's delight, especially when formed in a matrix of purple fluorite. Telluride minerals occurred in nearly all Cripple Creek mines; many of the best came from the Cresson mine located in Eclipse Gulch, east of town.

In 1911 the owner of the Cresson got drunk in a Chicago saloon with two insurance salesmen, J.R. and Eugene Harbeck, and, on a spur-of-the-moment bet, put his mine up as collateral. Losing the bet, the erstwhile owner must have heaved a sigh of relief at unloading his "worthless" mine. The Harbecks put every dollar they had into the mine and hired Richard Roelofs as general manager. He immediately instituted money-saving techniques and started mining large quantities of low-grade ore. Within months the Cresson was operating in the black and paying dividends.

On November 24, 1914, miners were working on the 12th level of the Cresson when, without warning, they broke into a large cavity. Thrusting magnesium flares into the hole, they were bedazzled by a huge chamber sparkling

THIS PAGE TOP:
Calaverite on fluorite
Size: 4.5 by 3 cm
(matrix shown)
Locality: Dr. Jackpot mine, Cripple Creek
Collection: Smithsonian Institution
Photo: Dane Penland

THIS PAGE BOTTOM:
Calaverite
Size: Largest crystal 3.5 millimeters
Locality: Cresson mine
Collection: Smithsonian Institution
Photo: Dane Penland

OPPOSITE TOP:
First great fire in Cripple Creek, April 25, 1896
Courtesy: Cripple Creek Museum

OPPOSITE MIDDLE:
Skip dumping sacks of calaverite and sylvanite crystals from "Million Dollar Vug," on loading dock, 1914
Courtesy: Cripple Creek Museum

OPPOSITE BOTTOM:
Cresson mine in Eclipse Gulch, elevation 3057 meters, 1905
Courtesy: Cripple Creek Museum

with crystals of gold, calaverite and sylvanite. The cave, 12 meters high, 6 meters long, and 5 meters wide, was covered with crystals—walls, floor, and ceiling. Roelofs installed steel bank vault doors at the entrance and mounted armed sentries around the clock to prevent looting.

The giant vug was an international sensation. Called "Aladdin's Cave," the "Jewelry Store," the "Treasure Chest," and the "Million Dollar Vug," its walls were scraped free of crystals. High-grade ore was sacked and sent to the smelter in locked boxcars on which rode guards armed with rifles and sawed-off shotguns. More than $1.2 million in gold was removed from the Cave, but photographs were prohibited, and only a few crystals survived as specimens. The Denver Museum of Natural History owns a collection of telluride mineral crystals from the great vug.

Frank Peck, president of the Portland mine, was invited by the Cresson's president, A.E. Carlton, to visit Aladdin's Cave just a few days after its discovery. As he left, Peck exclaimed to reporters: "As I stood in this wonderful chamber, I was trying to figure out how such a creation of nature could have been brought about, rather than think of its intrinsic value. I have no word to describe it, but the strike will go down in history as a recordbreaking find in the entire world of gold mining."

Julian Street, a writer for *Collier's Magazine,* went to Cripple Creek in 1914 to gather material for a feature story. Ignoring the better parts of town, Street wrote only about the red-light district on Meyers Avenue and incensed the citizenry. Shortly thereafter the City Council changed the name of Meyers Avenue to Julian Street.

On a cold and windy day in 1964, the Cresson closed forever. During its lifetime it produced $50 million worth of gold; now it produces only memories. Cripple Creek also established an enviable record. From its earliest days to 1959, the mining district had yielded 19 million ounces of raw gold, second in the United States only to the Black Hills area of South Dakota.

As the price of gold increases, so does interest in some of the old mines at Cripple Creek and Victor. There is a strong possibility of some mines being reworked for gold, but many in the "lace boot brigade" (a western term for mining engineers) are skeptical about finding more telluride crystals, at least in any quantity.

13 Mammoth Mine, Schultz/Tiger, Arizona

Arizona is a delightful country in every respect, except in climate, soil, production, and inhabitants. The natives have a pleasant way of slaughtering every stranger who attempts to stay there, and sometimes, when they refrain from their amusement for a few months, the strangers fall to killing each other.

Thomas Knox made these observations in *The Underground World* in 1882 after visiting the Arizona Territory a few years earlier. Many frontiersmen were only too willing to recount for Knox the deeds and depredations of those who lived in that strange land in the early days.

During the late 1870s and through the next decade the southeastern portion of Arizona Territory was one of America's last frontiers. As many as 4000 Coyotero, Mescalero, and Chiricahua Apache Indians were confined to the San Carlos Reservation. Still others lived in the Dragoon and Chiricahua mountains to the south and the White and Mogollon mountains to the northeast. The wildest of the Apaches were true renegades as wild and tough as the land of their birth. When white prospectors came looking for riches in the mountains, conflict was inevitable. The white man, greedy for raw land, reneged on nearly every treaty made with the Indians. Apaches could live on lizards and snakes, travel 50 kilometers on foot between sunup and sunset, and could go without water for days. Following their code, the Indians treated captives heartlessly, only infrequently sparing children and women. Mangas Coloradas, Cochise, Nachee, Geronimo, and their little bands kept hundreds of U.S. cavalrymen busy for years. Tricked by President Cleveland and General Sheridan in 1880, Geronimo with 21 warriors surrendered to General Miles in Skeleton Canyon; they were exiled to prison in Florida, and never allowed to return to their native land. Their absence brought comparatively safe travel in Apache country from then on.

During 1879 Frank Schultz, an enterprising and fearless prospector, discovered promising outcrops of gold ore in the Black Hills on the San Pedro River in Apache land. In 1881 Schultz located the Mohawk claim and the Mammoth a year later. He listed his discoveries in the name of the Old Hat Mining District of Pinal County, Arizona Territory. In 1885 he sold his Mammoth claim to George Fletcher, who began building a stamp mill on the San Pedro River and established the town of Mammoth nearby. Lack of water at the mine had forced the mill's location on the river. Ore was carried from mine to mill in huge wagons pulled by teams of 20 mules.

The Mammoth ore bodies intersected faults in a number of places rendering the ground somewhat unstable. Trees were harvested for mine timber in the nearby Santa Catalina mountains, but lumbering costs were high and some mine tunnels which normally would have been timbered went without. In other sections of the mine, stopes of great size were timbered in the square set method, but waste rock was

BELOW:
Wulfenite and dioptase
Size: 6.6 millimeters
Locality: Tiger
Collection: Arizona Sonora Desert Museum
Photo: Arthur Roe

OPPOSITE TOP:
Fluorite on dioptase
Size: 3 millimeters
Locality: Tiger
Collection: Arizona Sonora Desert Museum
Photo: Arthur Roe

OPPOSITE BOTTOM LEFT:
Linarite
Size: 2.14 millimeters
Locality: Tiger
Collection: Arthur Roe
Photo: Arthur Roe

OPPOSITE BOTTOM RIGHT:
Caledonite
Size: 5.4 millimeters
Locality: Tiger
Collection: Arizona Sonora Desert Museum
Photo: Arthur Roe

not used to fill the vast caverns and unstable overburden began to pose serious problems. In July 1893 the inevitable occurred—a major cave-in collapsed an area between the 61- and 122-meter levels. Damage to ventilation, water, and haulage systems was so extensive that the mine closed for three years.

The Mammoth reopened in 1896, the mining town of Schultz was built, and an 8-kilometer cable tram line constructed from the mine to the Mammoth mill on the San Pedro. Buckets carried ore to the mill on the river and carried water back to the mine and town. As many as 1000 men were employed at one time to remove large amounts of gold from rich ores. Through the years a number of claims and mines merged with the Mammoth, the most important being the Collins in 1896 and, in 1934, the Mohawk and the New Years. Although part of the Mammoth complex, each mine retained its separate identity.

In 1901 a great section of the Mammoth mine down to the 215-meter level collapsed to create a surface depression 10 meters deep. Once again the mine closed; this time for 13 years.

In later years the Mammoth was worked for molybdenum, vanadium, more gold, and base metal sulfides. The mining property and the old town of Schultz were acquired by Sam

Houghton, and in 1939 the Federal Government agreed to reestablish a post office on the property as soon as a new town name could be determined. Asked for nominations, the miners came up with two names: St. Anthony, the title of Houghton's mining company, and Tiger, in honor of mine manager Wilton Lloyd Smith's tobacco pouch, which was made from the scrotum of a tiger. Long-time miner Harvey Williford polled each worker, and Tiger won by a landslide. Tiger reached a peak population of about 1800 people. Between 1938 and 1943, large amounts of oxidized ores were mined to produce incredible quantities of beautiful crystals, many of them rare.

The author visited a huge open gallery at the 155-meter level of the Collins in 1938 with a friend, Walter Ziegler. Shining our lamps up into the dark void which reached 30 meters, we were astounded to see the walls bursting with 2- to 4-centimeter bladed wulfenite crystals of incredible brightness and beauty. Many had phantom growth planes separating the lighter-colored interior portions from dark orange exteriors, and not a few crystals were nearly transparent. Broken wulfenite crystals 15 centimeters deep covered the floor; it was like walking on broken shards of glass. Because miners only stopped work for 15 minutes at a stretch, we didn't have much time to explore the astounding cavern. To make matters worse, the wulfenite crystals were paper thin, making collecting impossible. We had not thought to bring a camera so the spectacular sight was not recorded.

With Sylvestre Ayalla as his guide, William Sanborn visited the Mammoth mine in 1947 and reported:

> *On one trip into the Collins—and in an adit—I noticed a cerussite vein in the ceiling. Standing on a dynamite box, I could reach the concentration with ease. As luck would have it, my pocket probe disappeared in a small opening. With Sylvestre's assistance, we enlarged the opening to about 7 by 25 centimeters. A peculiar purplish and lavender combination of powder and granules began to pour out of the opening. The more we gently agitated the pocket, the more material poured out. We then noticed that this material included excellent clusters, singles, and twins of silky cerussite crystals. All were "floaters"! We continued to open up the pocket, which literally poured out specimens! One of us would hold a sack*

THIS PAGE
TOP TO BOTTOM:
Apache Chief Geronimo, nearly prevented others from prospecting in his area, CA 1880
Courtesy: Library of Congress

20 mule team wagons hauling Mammoth mine ore, 1891
Courtesy: Arizona Historical Society

Mammoth mine, CA 1907
Photo: W. Lindgren, USGS

Interior of stamp mill at Mammoth, 1895
Courtesy: University of Arizona, Special Collections

OPPOSITE
TOP RIGHT:
Miners drilling at Tiger, 1940
Photo: Frederick Houghton

OPPOSITE LEFT:
Miner's homemade chair in underground station at Tiger
Photo: Grant Richards

OPPOSITE
BOTTOM RIGHT:
Tiger tunnel collapsed from great overhead weight, 1950
Photo: Grant Richards

under the opening and the other wiggled the probe. We filled five large sacks with the pocket's contents. Since the material was very heavy, we left it where found and returned another day to bring it out. Once washed out, this yielded about 900 small, but very choice, specimens of cerussite so characteristic of this locality. Several of the twinned crystals were also associated with tiny brilliant wulfenites. It was a great collecting experience. I came home with 18 dynamite boxes full of specimens. I wonder what it must have been like in the old days!

The Mammoth mines have produced an incredible amount and variety of micromount-sized crystals. The singular beauty and dainty construction of these tiny crystals has created a worldwide demand for Mammoth specimens.

Collector Wayne Thompson has compiled a list of outstanding crystals from the Mammoth: R. Jelk's collection, 2.5-centimeter leadhillite; Edward Swoboda, 7-centimeter linarite; John Jago, 3-centimeter diaboleite (reportedly stolen); Arizona-Sonora Desert Museum, 7-centimeter wulfenite, 3-centimeter diaboleite on matrix, 7-centimeter linarite, 5-centimeter azurite crystal group, 5-centimeter phosgenite cluster of crystals; Thomas McKee, 8-centimeter malachite pseudomorphs after azurite; and Curt Van Scriver, 3-centimeter paralaurionite.

In 1952 the Mammoth mine closed again, and shortly thereafter the Collin's Shaft burned, making re-entry by that route impossible. Collecting is not permitted on the property at the present time.

14 Red Cloud Mine, Trigo Mtns., Arizona

John Nummel, Edwin Over, and Erle Stanley Gardner had one interest in common: all three were intrigued with a small silver mine nearly lost in the nondescript Trigo (Spanish for flour) Mountains of southwestern Arizona. The Red Cloud mine was discovered about 1862 and received its name from a nearby trail used earlier by Spanish explorers. From 1880 to 1890 the Red Cloud Mining Company, with headquarters in New York, developed the upper workings and, in the process, recovered a reported $1 million in silver.

John Nummel had immigrated from Germany to Arizona during the 1870s and began prospecting the Colorado River area north of Yuma. Young, strong, and restless, Nummel frequently ranged 30 kilometers in a day, often under a merciless sun. He was doing assessment work on some of his claims when he learned that a strike of high-grade silver had been made at the Red Cloud. Nummel went to work at the mine and stayed until it closed in 1890. He then took a job as watchman for the Red Cloud, a position he liked because it gave him ample time to prospect. On two separate occasions, Nummel found bonanza quality outcrops — "one of pure gold in yellow quartz and the other black with silver." His locations were somewhere between the Red Cloud and the Colorado River, 15 kilometers away, but he was never able to retrace his steps and relocate them. What information he had died with him at the Prescott Pioneer's Home in 1948.

Specimen collector Edwin Over first visited the Red Cloud late in 1937 and spent 45 days searching for wulfenite crystals. Excerpts from his letters to university professor and long-time partner, Arthur Montgomery, graphically illustrate the success of his efforts.

Yuma, Arizona, January 1938

Dear Art:—Got into the Red Cloud but didn't have time for a thorough examination. I think chances there are excellent. That I can produce lovely little matrix specimens and beautiful little clusters of loose wulfenite crystals I am certain.

Regards, Ed

BELOW: Wulfenite on limonite
Size: 5.5 by 5 cm
Locality: Red Cloud
Collection: Wayne and Donna Leicht
Photo: Harold and Erica Van Pelt

OPPOSITE TOP: Wulfenite on quartz
Size: 6 by 6 cm
Locality: Red Cloud
Collection: Louis Schwartz
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM: Wulfenite on limonite
Size: 10 by 6 cm
Locality: Red Cloud
Collection: Harvard University
Photo: Earl Lewis

Red Cloud, Yuma, Arizona,
Feb. 14, 1938
Dear Art: Am going to town tomorrow for mail, supplies, and to ship specimens via Model T. On the 19th I tried another brecciated seam which pocketed three times, and each pocket is bigger and better. I have an estimated fifteen feet I can raise before being cut off by old workings. I can't compare this stuff with anything I've seen before, but I will say that these single crystals and clusters are the finest wulfenites I've ever seen, and the most beautiful stuff I've ever taken out.
Regards, Ed.

Over's wulfenite crystals arrived in good condition, and the delighted Montgomery distributed them to museums and collectors throughout the world. They are still recognized as the best of the Red Cloud's wulfenites, and some collectors go so far as to say they are the best wulfenites found anywhere. Montgomery agreed and, in an article for *Rocks and Minerals Magazine* (March-April 1964), wrote:

After blasting his way along the seam for eight feet, Over suddenly broke into a large cavity. Directing his carbide lamp into the jagged opening he let out a gasp. On the floor, lying as if placed there with painstaking care on a soft bed of earthy black material lay a number of loose crystals and crystal clusters of incredible size and beauty. Nothing like this has ever been seen. For this mineral they are by far the world's finest.

The largest of the red-orange crystals measured an incredible 5 centimeters on an edge. For many years after Over's death in 1963 a memorial case containing some of his specimens greeted visitors at the entrance to the mineral hall of the Smithsonian Institution.

During the early 1960s, mystery writer Erle Stanley Gardner traveled to the Red Cloud by helicopter and used the old mine dumps as a base for aerial exploration. Gardner was looking for the Lost Arch mine and was also interested in Nummel's lost outcrops of gold and silver. Unsuccessful in his search for the lost mine but delighted with his expedition, he wrote *Hunting Lost Mines by Helicopter* and a magazine version "The Desert is Yours." These works have helped keep the lost mine legend alive. Prospectors of a later generation, equipped with dune buggies and trail bikes, still pocket one of Gardner's books and head out into the Trigos in search of lost silver and gold mines.

In its heyday, the Red Cloud was a busy place. A little town, built in 1879 out on a flat, was named Silent, after Judge Charles Silent. It featured one or two stone buildings, a few dugout dwellings scooped out of nearby

BELOW LEFT:
Erle Stanley Gardner inspects old Red Cloud headframe, 1963
Courtesy: Mrs. Erle Stanley Gardner

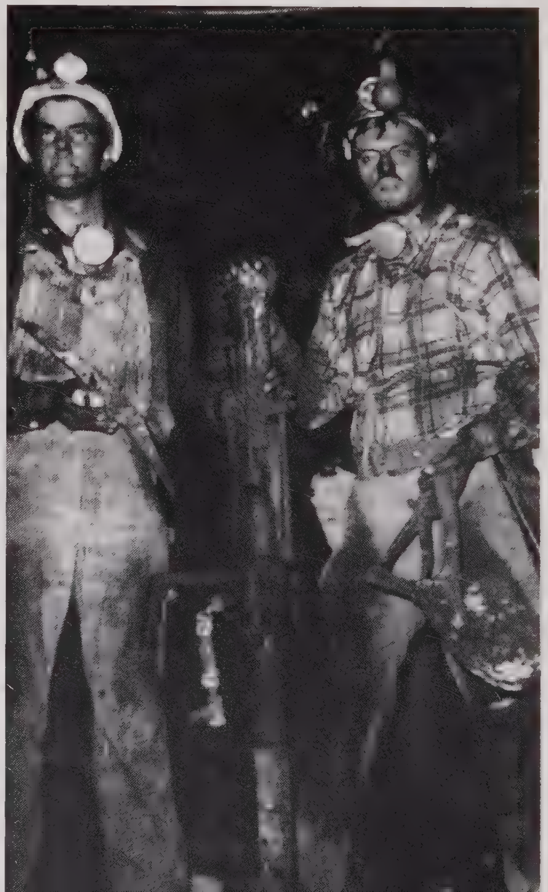
BELOW RIGHT:
Phillip Strittmatter and Frederick Rasp after day's work mining for wulfenite crystals
Photo: Garth Bricker

OPPOSITE
TOP TO BOTTOM:
Red Cloud from helicopter
Photo: Erle Stanley Gardner

Garth Bricker recovers 100 year old rat-chewed ore bag
Courtesy: Garth Bricker

Ronald Korn in rubble of inclined shaft
Photo: Garth Bricker

Timbered "glory hole" in Red Cloud
Photo: Garth Bricker



hillsides with only a locked door exposed, and a number of flimsy structures put together from packing crates and scrap iron. Possibly the town's most important edifice was the La Cantina Plata, a store-saloon. The town, later named Pacific City, became a way station for stages on the Yuma-Ehrenberg run. Today nothing remains. There is no ghost town, not even corner posts left of the colorfully named claims: Cochise, Bald Eagle, Emily, Silver Bell, Lone Star State, and Geronimo.

Between 1890 and the present, the mine has been worked intermittently with little success. The last employee of the Red Cloud was the caretaker, Walter Nelson, who in 1955 tried to drive out from the mine, got stuck in deep sand 8 kilometers down Red Cloud Wash, and died of heat exhaustion near his car. During the 1960s and 1970s, eager rockhounds entered the old workings in search of wulfenite crystals. Garth Bricker, Robert Bartsch, Terry Szenics, and Wayne Thompson, all gathered many good crystals. But none matched those discovered by Edwin Over. It was not unusual to see grimy, red-dust-covered collectors emerge from the old shaft carrying boxes of carefully wrapped crystals, the size of their smiles indicating the degree of their success.

In addition to wulfenite crystals, the Red Cloud has yielded some very good micro-specimens of vanadinite, willemite, cerussite, red mimetite, pyrolusite, and needles of black plattnerite on fluorite. Interesting mineral associations are sometimes encountered, such as elongated quartz crystals capped with violet-colored fluorite cubes growing out of white radiating willemite.

Surface machinery, hoists, and buildings have been removed or vandalized, and only concrete foundations remain. The old mine has also given up many mining artifacts of yesteryear—candle holders, powder boxes, lamps, candles, and rawhide ore buckets, once hand-carried up the inclines.

In late 1979 rapidly rising silver prices encouraged a mining company to obtain new leases on the Red Cloud. Plans called for extensive renovation of the shaft and the installation of a new hoisting works. In June 1981, a mill was under construction, and debris dumped into the main shaft by scores of collectors had been cleared out down to the water table. The management plans to rework the dumps, unwater the mine, and commence mining the most likely areas. Collectors hope that mine development may expose more of the bright orange-red wulfenite crystals that have given the little Red Cloud world fame.

15 Copper Queen Mine, Bisbee, Arizona

Bisbee's century-long history includes all of the turbulence and high drama of a four-star western movie. Strong men lived fast lives and many died tragically. Wooden cribs and granite markers in the cemeteries pay tribute to departed miners and their families, the carved and painted legends gradually faded away under the ceaseless onslaught of scorching days, cold nights, and frequent winds.

Silver and copper deposits had been reported in the early 1870s, but it wasn't until the summer of 1877 that rich outcrops were found. Three scouts of the 10th U.S. Cavalry, searching for water in a desolate Mule Mountains canyon, discovered high-grade copper ore. Sgt. George Dunn, impressed with the discovery but lacking time to adequately prospect the area, grubstaked George Warren and gave him a handmade map of the discovery site.

Immediately after Dunn hired him, Warren got drunk in the Bruneko Saloon near Tombstone, sold his outfit for more liquor, and proceeded to tell others about the strike. He managed to record the claim officially but did so in his own name. Shortly thereafter Warren put up his share of the mine in a race against a horse! On foot Warren raced the horse and rider to a post, and back to the starting point. Ahead at the post, Warren fell behind and, in only a few seconds, lost one of the greatest stakes in horse racing history: what was to become the $20-million Copper Queen mine against a $20 horse. Warren's partner, a man named Adkins, had him declared insane in 1881 and committed to the state asylum in Phoenix. Adkins was appointed administrator of Warren's estate, which he promptly squandered, thinking his ward would never be released.

Warren's life was never easy. When he was young, his father was killed by Indians and George taken captive. He lived several years with the Apaches and joined their raiding parties. Finally a group of miners learned of his plight and bought his freedom with a 15-pound sack of sugar.

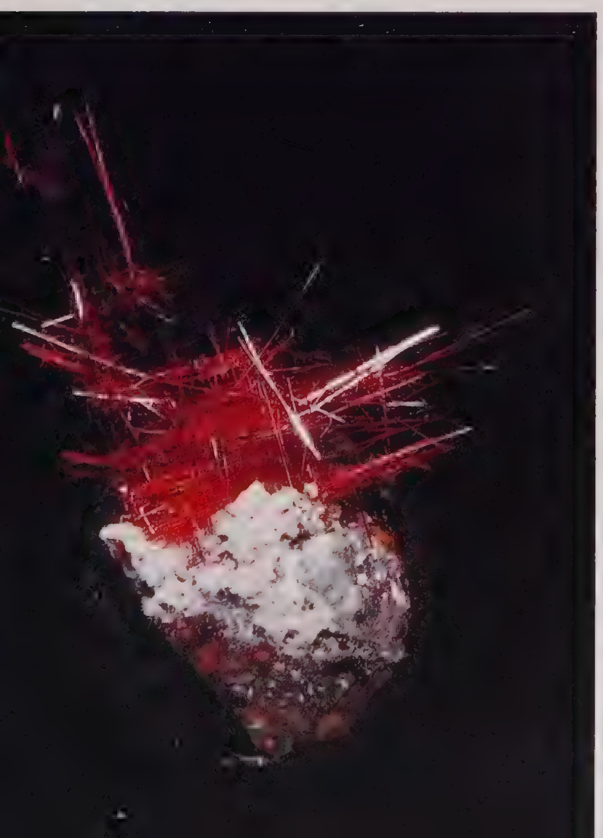
After emerging from the insane asylum penniless, Warren wandered into Mexico and was thrown in jail. On Christmas Eve 1892, he returned to Bisbee, found work as a janitor in the Azurite Saloon and became the town drunk. One cold night, George Dunn, Jr., son of the man he'd cheated, found him soused and freezing in the bottom of a canyon. Carrying Warren on his back to his cabin, Dunn tried to save the man's life but days later Warren died of pneumonia in the Bisbee hospital and was buried in a Brewery Gulch Cemetery. Thus ended one of the more bizarre lives of the Old West.

In 1880 Benjamin and Lewis Williams and Judge De Witt Bisbee, three San Francisco investors, leased and bought several claims, including the Copper Queen. In June the local camp, by now sprawling up steep mountainsides, was named Bisbee after the judge.

BELOW LEFT:
Chalcotrichite
Size 1.5 cm
Collection: Willard Perkin
Photo: Willard Perkin

BELOW RIGHT:
Paramelaconite
Size: 4 by 1 cm
Collection: American Museum of Natural History
Photo: Arthur Singer

OPPOSITE:
Azurite on malachite
Size: 14 by 8 cm
Collection: William Larson
Photo: Harold and Erica Van Pelt



The Copper Queen's discovery site was first quarried until a huge pit formed. At the "glory hole," a shaft and tunnels were constructed from the pit to follow the rich copper veins. The old hole was located just 100 meters from the town's main street and, in later years, the Bank of Bisbee. Eventually many hundreds of kilometers of tunnels and stopes were developed until nearly all Bisbee mines became connected underground. The new mining area was named the Warren Mining District in honor of George Warren.

During the 1890s various Warren District mines produced large quantities of beautiful mineral specimens. Unfortunately this desert region attracted few real collectors; miners told of getting their most spectacular samples from "the tops of ore cars as they wheeled by." Nearly all crystals mined in the early days went to the smelter.

The Copper Queen was particularly prolific in its botryoidal azurites and soft tufts of malachite. Frequently specimens occurred completely covered with acicular malachite crystals upon which azurite "roses" had grown. Probably the most striking azurite and malachite stalactites known—from 3 to 8 centimeters in diameter—came from the Copper Queen. Polished cross sections revealed exquisite concentric rings alternating azure-blue azurite, blue-green malachite, and brown limonite. Rare cuprite crystal groups, found in cubes measured up to 2 centimeters along an edge. The Copper Queen produced many mineral species including great quantities of gypsum crystals, aragonite stalactites, and the world's finest bluish-green spangolite crystals nestled in small vugs in cuprite which were lined with velvet malachite.

Other mines in the Bisbee area also contributed outstanding crystals, many of them rare and exotic. The Campbell produced fine malachite pseudomorphs after azurite. The

THIS PAGE TOP:
George Warren just after his Copper Queen strike, 1878
Photo: Fly's Gallery, Tombstone, Arizona

THIS PAGE MIDDLE:
Mule drawn ore wagons, Bisbee's Tombstone Canyon, 1887
Courtesy: Bisbee Historical and Mining Museum

THIS PAGE BOTTOM:
History's only Masonic meeting in a mine.
Copper Queen's Jewel Crystal Cave, 1897
Courtesy: Bisbee Historical and Mining Museum

OPPOSITE TOP RIGHT:
Mule tram in Copper Queen, 1902
Courtesy: Bisbee Historical and Mining Museum

OPPOSITE LEFT:
"Powder monkey" (miner who handles dynamite), Bisbee, CA 1915
Courtesy: J. Stewart and Robert Jones

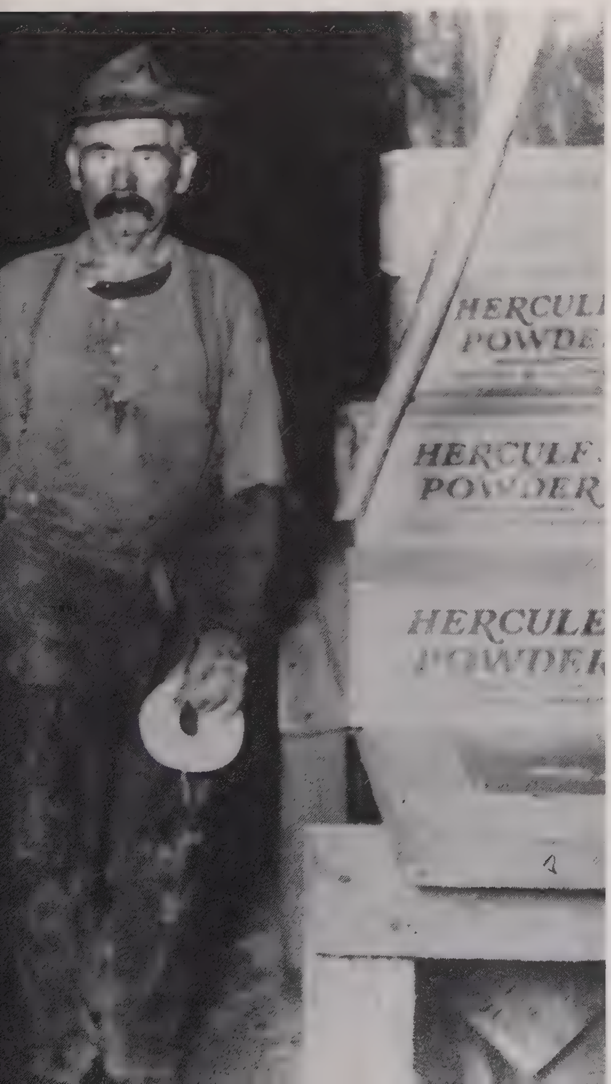
OPPOSITE BOTTOM RIGHT:
Visitors finish tour in old Copper Queen, 1978. Mike Bednorz is trainman.
Photo: Peter Bancroft

Cole produced radiating clusters of azure-blue needle-shaped crystals of connellite and fine spangolite crystals. Pretty azurite "roses" up to 7 centimeters in diameter were found in the Czar.

Bisbee area mines have produced 214 individual species of primary, rock forming, gangue, alteration, and oxidation minerals. Unusual minerals include bisbeeite (named for the town), famatinite, shattuckite (named for Bisbee's Shattuck mine), delafossite, djurleite, pumpellyite, sengierite, graemite, hisingerite, tyuyamunite, and many others. Surely the most prized of all Bisbee materials are the nearly endless combinations of azurite and malachite forms, many unique and easily identified as originating from Bisbee.

The booming camp attracted many tough characters. One gang, headed by John Heath, robbed and murdered until chased out of town. In February 1884 irate Bisbee citizens traced Heath to Tombstone, where they took him from the jail and hanged him from a telegraph pole. On the lighter side, 155 members of a local Masonic Order hiked 560 meters into the Queen and had a full-dress ceremony in the fabulous "crystal cave." In later years Bisbee High School students held a graduation prom in the cavern.

Labor difficulties developed in Bisbee mines during World War I. The International Workers of the World (known by anti-union factions as the "I Won't Work" union and the "Wobblies") gained strength and threatened to shut down the mines with a massive strike. County Sheriff Harry Wheeler marshaled a large group of deputies and marched 1200 strikers to the Warren ball park where they were loaded onto a train and shipped to Columbus, New Mexico. Wheeler and his chief deputy were later brought to trial as kidnappers. Wheeler testified that he feared the



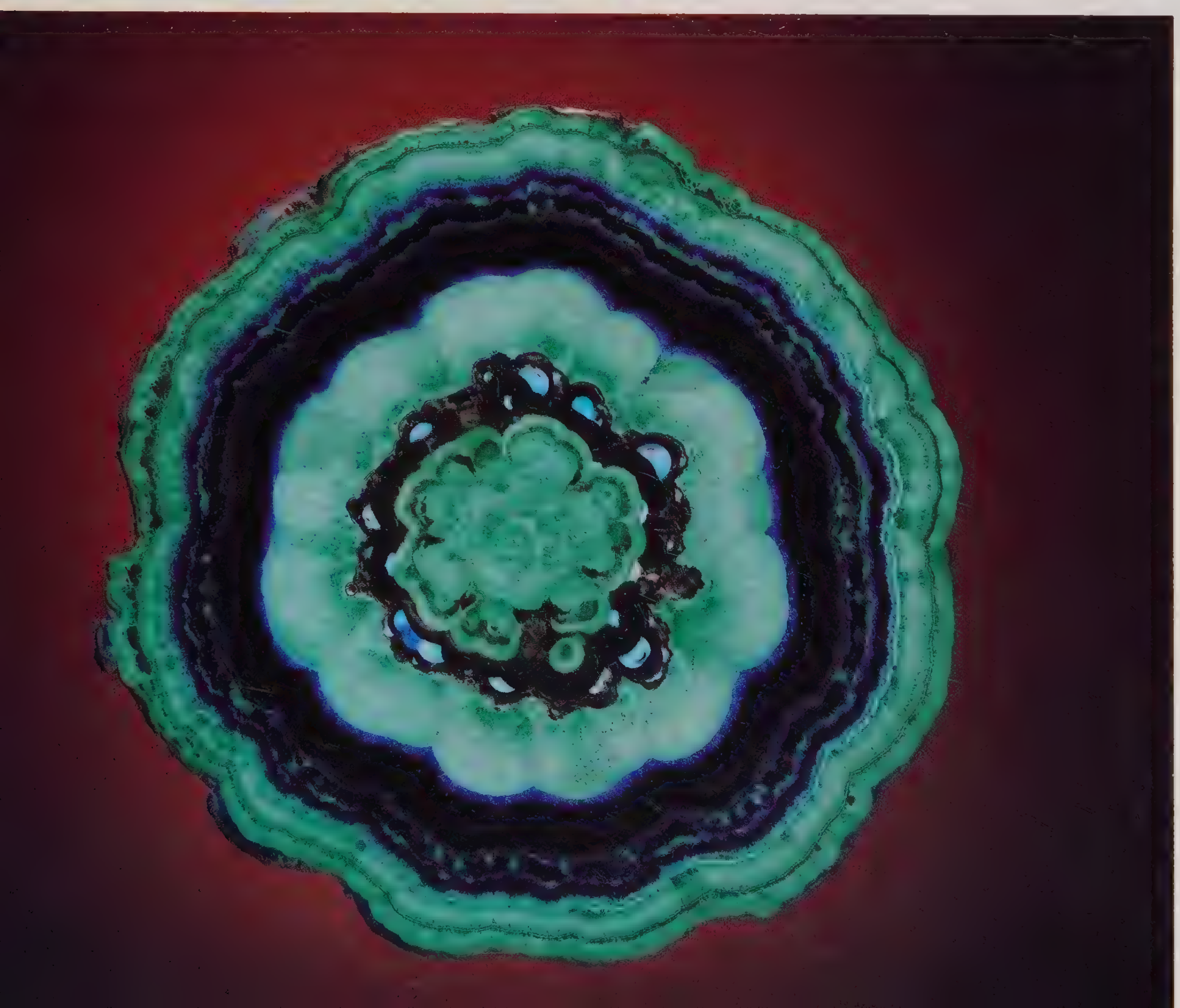
Wobblies would dynamite the shafts and the judge ruled in his favor, stating that kidnapping was necessary "to save the community." An appeal was taken directly to President Woodrow Wilson who admonished the strikers with "Go home and be good boys!"

Underground, lode after lode was discovered, and the Phelps Dodge Corporation, convinced the mining camp had a long and fruitful future, began to acquire mining properties next to the Queen. By 1931 Phelps Dodge had gained title to all of the major mining sites: Czar, Sacramento, Dallas, Cole, Campbell, Shattuck, Irish Mag, Silver Spray, Keystone, and the Copper Queen. The company also built a large smelter in nearby Douglas.

Open pit mining ceased in 1974, and underground work stopped the next year. Except for leaching copper in some old mine sumps and from the bottom of the Lavender Pit, the main operations appear finished. Most of the miners moved away, except for some old-timers who hang on.

In its time Bisbee was one of the greatest copper camps on earth, producing more than $6 billion in metals. Even today its grandeur is not lost, for the great tailings and dumps remain, and the old town is still one of Arizona's premier tourist attractions. The town and its dedicated Chamber of Commerce promote tourism and foster an arts and crafts colony. The refurbished Copper Queen Hotel is open for business. There is an excellent historical museum, and a realistic trip into the old Copper Queen mine includes a ride on an underground electric train to rekindle images of the historic past.

THIS PAGE TOP:
Azurite
Size: 7 by 4 cm
Collection: David Eidahl
Photo: Harold and Erica Van Pelt



THIS PAGE BOTTOM:
Malachite-azurite
Size: 7 cm
Locality: Copper Queen
Collection: William Larson
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Portion of Virginia City's Cemetery, 1972
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Silver on quartz
Location: Hale and Norcross Mine, Virginia City
Collection: California Federation of Mineral Societies
Photo: Harold and Erica Van Pelt

16 Hale and Norcross Mine, Virginia City, Nevada

Scores of books have been written about Virginia City, Nevada, and the fabulous Comstock Lode. Space here permits only a recounting of the highlights of history's greatest silver camp, and what events they were!

In the summer of 1858 two groups of placer miners searched for gold on the bleak sides of Mt. Davidson and neighboring Sun Mountain. James Finney, known to his buddies as "Old Virginny," Alec Henderson, Jack Yount, and John Bishop discovered a gold ledge on a low knoll which they named Gold Hill. Little did they know that their claim marked the southern end of the Comstock Lode.

Shortly thereafter Patrick McLaughlin and Peter O'Riley camped near a tiny spring as they were "placer hunting" a few miles north of Gold Hill at the head of Six-Mile Canyon. Upon enlarging the spring to get more water, they were astounded to find a heavy concentration of gold flakes mixed in a bluish-black sand on the spring bottom. Later in the day when fur trapper and prospector Henry Comstock rode by, he craftily declared he had staked a claim on the area weeks before. The resulting hassle was settled by making Comstock a partner on land they named the Ophir, later recognized as the northern boundary of the Comstock Lode.

The new claims produced plenty of gold but the ever-present black mud and rock clogged the rockers and irritated the miners, who threw debris aside by the ton. Finally, reports by assayer James Ott of Nevada City, California, disclosed that samples contained $3876 a ton: one-third silver and two-thirds gold. The prospectors had been throwing away almost pure silver!

During the next six years, all the land between Gold Hill and the Ophir proved one vast silver-gold ore body. The sagebrush-covered surface was graded and laid out with streets, along which blossomed tents, wooden buildings, and finally large structures of brick, marble, and iron. The lusty young camp, named Virginia Town after "Old Virginny," grew into Virginia City, where 20,000 people crowded every cranny of Mt. Davidson's east side and filed more than 16,000 claims. Successful mines employed thousands of miners, used the latest hoisting and ventilating equipment, and extracted hundreds of millions of dollars in high-grade ore. Mark Twain, reporter for the *Territorial Enterprise,* wrote: "Think of a city with not one solitary poor man in it!"

Virginia City rapidly changed from a rough desert camp to a sophisticated mining city. In one year, its 100 saloons dispensed 75,000 gallons of whiskey "exclusive of beer and wine." Miners smoked Havana cigars, leaving cigarettes to the Mexicans and "brides of the multitude" on D street. Life was one great adventure in pleasure, and everyone participated in the frequent parades, prize fights, horse races, picnics, and funerals. Miss Lotta Crabtree, internationally known actress, entertained in Maguire's 1600-seat opera house. From the belfry of St. Mary's church pealed a bell cast in Spain of solid silver from the Lady Bryan mine. A saying commonly heard in the town was: "Every man has a right to go to Hell in his own way."

As miners tunneled deeper in the ore bodies, they encountered grave problems. Temperatures increased at an alarming rate, up to 2.8°C for each 30 meters of depth, and subsurface water poured into every working. The largest available pumps were installed, giant fans were mounted in strategic locations, and when ore bodies reached 9 meters in width, German-born engineer Philipp Deidesheimer developed a method of protecting the miners from cave-ins in the vast stopes. He invented the "square-set" system of using 36-centimeter-thick timbers placed in hollow cube formation. The technique became popular throughout the world in mines that had poor ground. The Comstock system required so much wood that the forests of California's High Sierras were denuded for many kilometers in all directions from Lake Tahoe.

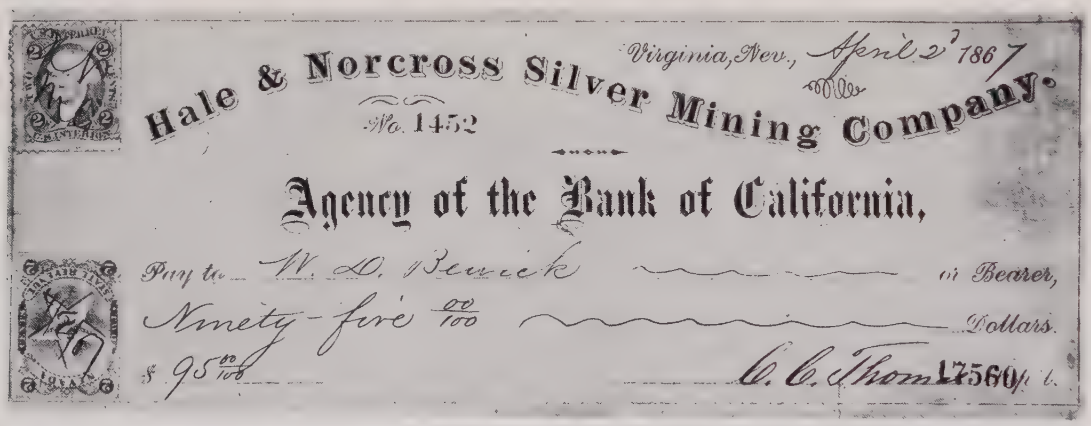
In 1869, Virginia City's "big four" multimillionaires, James G. Fair, William S. O'Brien, James C. Flood, and John W. Mackay (Irishmen all and each a Mason), commenced their first joint venture by acquiring control of the Hale and Norcross mine. Charles C. Thomas (the author's great-uncle) was hired as superintendent. The Hale and Norcross never became the wealthiest mine on the lode, only one of the largest and deepest which during the next 10 years produced many of the Comstock's best mineral specimens. Principal

THIS PAGE TOP:
Hale and Norcross check signed by C.C. Thomas, author's great uncle, 1867
Courtesy: Mackay School of Mines

THIS PAGE BOTTOM:
Wells Fargo offices, "C" Street, Virginia City, c. 1860s
Courtesy: Wells Fargo Bank History Re

OPPOSITE TOP:
Curtis Shaft, 1867, Virginia City
Courtesy: Bancroft Library, University of California

OPPOSITE BOTTOM:
Massive ground movement caused collapse of square set timbers in Hale and Norcross, 1868.
(Note: leg of visitor, not a trapped man.)
Courtesy: Bancroft Library, University of California


Virginia, Nev., April 2 1867

Hale & Norcross Silver Mining Company.

No. 1452

Agency of the Bank of California,

Pay to W. D. Bewick or Bearer,

Ninety-five 00/100 Dollars.

$ 95 00/100

C. C. Thom 17560

minerals were stephanite, galena, and silver. Minerals of secondary importance were pyrargyrite, pyrite, amethyst, cerargyrite, polybasite, and argentite.

Adolf Sutro, a Prussian-born engineer, merchant, and principal of the Sutro Tunnel Company, drove a 10-kilometer tunnel designed to intersect the mines at a depth of 610 meters. It was supposed to flush out water above that level, lower mine temperatures, provide for cheaper discard of wastes, and facilitate the haulage of men and supplies. Sutro hired Thomas as tunnel superintendent and C.A. Bancroft, the author's great-grandfather, as chief carpenter. Both men moved their families into the Sutro mansion at the mouth of the Sutro tunnel after Sutro moved to San Francisco where he later became mayor. Thomas converted the mansion's largest downstairs room into a museum and faced the fireplace with crystals and high-grade ore. Upon his death, his despondent widow accepted the first offer she received. She sold the collection and the minerals in the fireplace for $10,000, reportedly one-tenth of the collection's bullion value.

A major undertaking to increase mine production, the Sutro tunnel took six years to build but did not save the mines. At least 13 shafts were already operating below the tunnel level, and working conditions were almost unbearable. At the 915-meter level, temperatures ranged between 53° and 55°C. Water spurting from cracks and drill holes, hot enough to cook food, ranged between 60° and 63°C—a world's record for working mines. Miners wore gloves to keep their fingernails from being charred and could work for no more than 15 minutes an hour in the steamy tunnels. Hoses played cool water on the men as they worked, and each man drank an average of 8 liters of water daily. Pumps carried away 13,300 liters of hot water a minute to keep the mines from flooding. In April 1877, John Exley fell into a Hale and Norcross sump where water registered 61°C. "Though the water only covered his hips, and he was immediately pulled out, the skin fell off his limbs, and unremitting care could not save his life."

Nine men were killed when the steel cable hoisting their cage broke. The heavy cable which piled on top of the cage proved too much for the safety clutches, and it dropped to the bottom. In a single year, in addition to 28 deaths from mine accidents, the Virginia City coroner's office reported 31 deaths from pneumonia and two from gunshot wounds.

Mine accidents affected city life also. In downtown Virginia City, a part of "C" Street collapsed into the upper level of a mine, just as a milk wagon was going by. The wagon plunged out of sight into the gaping hole. The wagon and milk were destroyed, the horse was killed, and the driver climbed out shaken but unhurt.

Virginia City's most famous madame, Julia Bulette, was a Creole. She operated a carriage-trade parlor house named "Julia's Palace." Her girls came from San Francisco, and as each Wells Fargo stage arrived with a new batch of "soiled doves," a crowd would gather to inspect the merchandise. In times of depression, Julia fed many a miner who was "off his luck," and she tended the ill during epidemics. Miners, gamblers, and businessmen gave her a fortune in money and jewels. In the dead of night one John Millain relieved Julia of her valuables and strangled her, throwing Virginia City into an uproar. Julia's funeral was the most elaborate ever seen on the Comstock. As she was lowered into an unmarked grave, the Brigade Nevada Militia Band played "The Girl I Left Behind Me." After the burial Millain's hanging was the city's second-greatest event. Mines and businesses closed to allow their employees to attend.

Virginia City and the Comstock had survived bonanzas, depressions, fires, Indian wars, and hurricanes. But once the mines failed, that was very nearly the end. Virginia City of the 1980s still looks a little like the days of old—its 100-year-old saloons stay open day and night, and tourists come from great distances to gamble on the "tables of green." There is an occasional performance in Piper's Opera House. But headboards in the cemetery lean, and their epitaphs become illegible. The mines are ghosts, and the strong men of the past—the O'Rileys, the Fairs, the Mackays, and the Mark Twains—the men who made it happen—have ridden over the pass for the last time.

THIS PAGE TOP:
John Mackay candelabrum still in use after 100 years. One of 1250 items ordered from Tiffany and Company in 1879 for his wife, Marie. It took one million man hours turning one-half ton of Comstock silver into ornate table settings. Courtesy: University of Nevada (Reno) Library

THIS PAGE BOTTOM:
Remains of Hale and Norcross Mine, 1978
Photo: Peter Bancroft

OPPOSITE TOP:
Mathewson opal mine in Virgin Valley, August, 1913
Photo: D.B. Sterrett, USGS

OPPOSITE MIDDLE:
Mathewson camp, miners and families, 1913
Photo: D.B. Sterrett, USGS

OPPOSITE BOTTOM:
Deb Roop (foreground) digging around opalized log on Monarch opal claim in Virgin Valley, 1913
Photo: D.B. Sterrett, USGS

17 Rainbow Ridge/Royal Peacock Mines, Virgin Valley, Nevada

Legend has it that a Pony Express rider discovered opal in Virgin Valley in 1905. He happened to glimpse bright flashes on the stony ground as he rode through the valley. Another version tells of cowboys riding across the range in search of stray cattle and finding chips of rock showing brilliant streaks of color. Marsden Nanson, a mining engineer in the valley at about the same time, reported sighting opal in several spots. The Opal Queen was soon located and filed as the first opal claim in Virgin Valley; soon all likely ground in the vicinity was staked. The Bonanza was filed in 1906 and five years later the Rainbow Ridge, known locally as the McGhee claim after its discoverer Ed McGhee.

In the summer of 1917, a young reporter for the *San Francisco Chronicle* went to Virgin Valley to do a story about the opal mines. Flora Loughead Gutierrez became so enthralled with the beautiful stones found in many claims that she bought a half-dozen or so properties, giving them such descriptive names as the Peacock, the Northern Lights, and the Pebbles. Gutierrez selected some of the richest ground in the valley, which in later years produced many of the world's most magnificent opals.

From 1920 to 1945, as worked-out surface deposits became idle, lonely tranquility returned to the valley. Jackrabbits, ravens, and rattlesnakes once again became the most common inhabitants of this desolate and remote region. But in 1945 the H.B. Wilson family bought the Peacock, Pebbles, and other claims following their "effervescent desire to uncover precious opal." H.B. Wilson says, "the more you search the more intense the feeling gets." In 1949 the Hodson family bought the properties grouped within the Rainbow Ridge Mining Company. Since then the Hodsons, their children, and even grandchildren have worked the Rainbow with considerable success. When Glenn Hodson died in 1959, his ashes were placed beneath a small monument at the entrance to the underground workings, "the mine and valley he loved so much." His son, Keith, has said, "I have a great love for the Rainbow and the valley. It is my happy place."

Virgin Valley, located in the northwest corner of Nevada about 32 kilometers southwest of Denio, is in the Charles Sheldon Antelope Range, a wild and lonely region. Summer days can be hot but generally the nights are cool. The cold winters are long and windy. Violent blizzards can be dangerous and men caught in the open have perished. Death has occurred also in the mines. One mining property was named the Dead Man's claim as an epitaph to a miner named Miller who was killed many years ago in a cave-in. The valley, about 16 kilometers long and 1.6 kilometers wide, is surrounded by mesas which rise 420 meters above the floor. The opal mines are about 1525 meters above sea level and the rarified air saps the strength of unaccustomed visitors.

Opal occurs in various Virgin Valley deposits as a replacement of wood, known locally as "casts." At one time, probably during the

Miocene, a forest of spruce, pine and cryptomeria (a cone-bearing tree like some existing in Asia), covered the area. When they died the trees fell into canyons or washed up on lake beaches as driftwood, where ash from nearby volcanoes covered them. The wood of many logs and limbs was replaced wholly or in part by silica gel, thus forming petrified wood, common opal (without fire), chalcedony, and gem opal which emits bright flashes of spectral colors. Some logs wholly or partly invested with silica gel measured 7 meters in length. Preserved pine cones are not uncommon. Fossilized fish eggs, various marine shells, and even camel teeth have been unearthed in the valley.

Opal mining is a costly and tedious task because great amounts of overburden must be removed. In the early days, when the overburden was less then 3 meters deep, miners sometimes resorted to drilling and blasting, but now tractor blades and rippers make short work of waste rock with less damage to unmined opal. In 1981 Keith Hodson faced overburden in excess of 20 meters. The alternative of tunneling is expensive and time consuming, and as Hodson put it, "government regulations are so complicated that it is nearly impossible to tunnel at a profit." Mined by any method, when opal seams or "nests" are encountered, all work must be done by hand so that gems will not be shattered or lost in the waste.

Some opal, for reasons not entirely understood, seems to remain free of cracks. Historically, Virgin Valley opals have proven unstable, demonstrating a tendency to craze and crack. Opals from this locality have a water content up to 20 percent of their volume—considerably higher than opal from nearly all other deposits in the world. When removed

THIS PAGE TOP:
Mark Foster at stone cabin at Rainbow Ridge, 1941
Courtesy: G. Keith Hodson

THIS PAGE MIDDLE:
Black opal in situ at the Rainbow Ridge
Photo: G. Keith Hodson

THIS PAGE BOTTOM LEFT:
Surface mining at the Royal Peacock mine, 1977
Photo: Harry Wilson

THIS PAGE BOTTOM RIGHT:
Keith Hodson underground in Rainbow Ridge mine with grandsons Scott and Chad, 1978
Courtesy: G. Keith Hodson

OPPOSITE TOP:
Opal
Size: 11 by 8 cm
Locality: Virgin Valley
Collection: Gemological Institute of America
Photo: Tino Hammid

OPPOSITE BOTTOM:
Bonanza Opal
Size: 5 by 0.8 cm;
ring by Brian Hodson, stone 13 carats
Locality: Rainbow Ridge/ Bonanza mines
Collection: G. Keith Hodson
Photo: Robert Jones

from the ground, much Virgin Valley opal tends to develop minute surface cracks. If allowed to lose water, the stone may develop larger cracks until the opal is ruined. Many attempts have been made to solve the problem. Some collectors keep their opals emersed in liquids such as glycerine, water, mineral oil, and silicone. Others spray opal surfaces with lacquer or other clear finishes. Someday a method to halt opal deterioration may be discovered, but for the present, no technique seems foolproof. The surface sections of "logs" are most susceptible to cracking; interior portions demonstrate more stability.

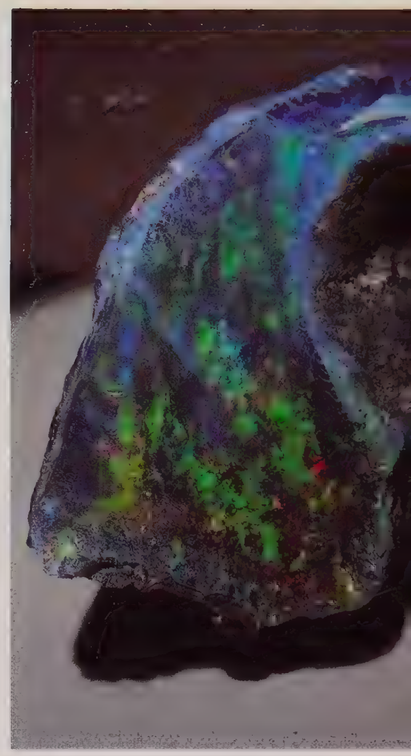
The owner of a fine opal from Virgin Valley has the privilege of enjoying the matchless beauty of one of nature's most dramatic creations. Virgin Valley precious black fire opal is considered the premier of all. Its streaks and flashes of red, green, orange, yellow, blue, and, more rarely, violet, frequently in combination, dazzle the eye. The colors, in contrast to opal from other localities, are bold, fresh, and raw. Indeed, the difference is so marked that opals with these hues are easily identified as of Virgin Valley origin.

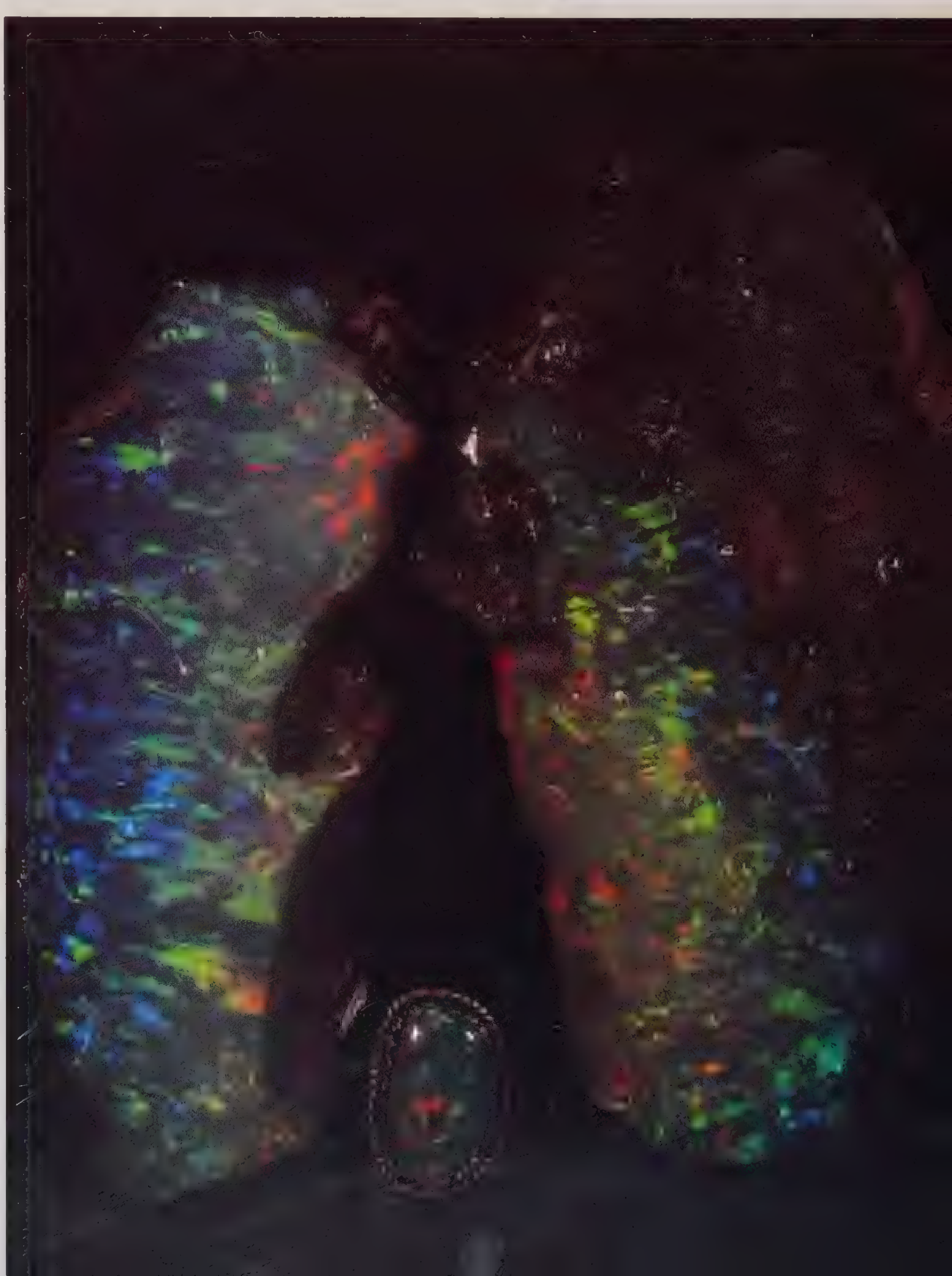
One of the most famous Virgin Valley opals is the 3.2-kilogram "Hodson," which was discovered in 1952 in the Rainbow Ridge mine. It measures 24 by 14 centimeters, is nearly transparent and wholly of gem quality. Individual streaks of red, blue, green, and yellow are as large as 2.5 by 0.7 centimeters. The stone is currently on display in the Hodson gem store in Scottsdale, Arizona. The Bonanza claim also produced the fabulous Bonanza opal, "which came in five main pieces and some chips, with a total weight of nearly 3 kilograms." The Bonanza opal also belongs to the Hodsons. A 12-kilogram giant opal from Wilson's Peacock mine is a part of the Los Angeles County Museum of Natural History collection. The Peacock also produced the stone bearing its name, a marvelous pear-shaped cabochon of 160 carats.

The American Museum of Natural History houses a polished section of Virgin Valley opal named the Grubstake. Left as security for a grubstake of food and supplies, the opal was never redeemed. Its owner, an old Nevada prospector, vanished into the mountains not to be seen again.

The Colonel Washington A. Roebling Opal is a half kilogram black section of a tree limb streaked with deep red flashes. Mined by the Rainbow Ridge Mining Company in 1917, the gem has been on display for more than 60 years in the Smithsonian Institution. The stone, which never cracked, is in "mint condition," just as it was mined.

There is much activity in Virgin Valley today. Nearly every acre of ground has been staked as a mining claim. Not all claims produce fire opal, but most miners feel their strike is "just around the corner." Bentonite, the surface rock, turns to sticky clay during the rainy season and makes driving or walking practically impossible. June to September may be hot months, but with little or no rain the ground remains dry, making the summer the best time to visit Virgin Valley.





18 United States Borax Co. Mine, Boron, California

More than 4000 years ago Babylonians reportedly used borax as a flux in soldering gold. In recent years, borax has been used in thermal absorbers of atomic reactors, in soaps and cleaners, and in fiberglass and heat-resistant glass.

Some 25 million years ago, as volcanic activity subsided in the area now known as Boron, boron-impregnated water from thermal springs began to settle in a flat depression surrounded by an arid plain. Small bivalves and crustaceans lived in profusion in the small lake, but as the waters began to evaporate under years of hot sun, mineral concentration increased, killing the freshwater animals, which never again appeared. Continued precipitation formed borate deposits containing crystals of ulexite and borax, some of which ultimately changed into the secondary minerals kernite, colemanite, and a number of rare borate minerals.

The first important borate deposit in California was discovered in the late 1870s by a prospector named Aaron Winters. He filed a claim containing the mineral ulexite, then sold out to William T. Coleman. The site, later known as the Harmony Borax Works, was located at Furnace Creek in the center of California's Death Valley. The mine became a good producer of borates, but the harsh climate restricted its operation. Summer temperatures can reach 57°C in Death Valley, and work was limited to cooler months. The ulexite was refined into borax and shipped by 20-mule-team wagons out of Death Valley over the steep Panamint Mountains, an incredible distance of 264 kilometers to the railhead at Mojave. The wagon outfits measured about 30 meters in length from the lead mules to the tailgate of the last wagon, and when fully loaded with borax and water weighed 36 tons. During the 1880s, wagons traveled the long dusty route from mine to rail and back. Little did the teamsters and swampers know that just a short distance off the rutted road, near Kramer, California, lay a deposit so immense that it would become the greatest borax mine on earth.

In 1913 Dr. John Suckow, a Los Angeles physician, was drilling a water well on his homestead near Kramer in the Mojave Desert when he hit a thin layer of the borate minerals colemanite and ulexite. It wasn't until 1925 that a deeper drilling effort below the colemanite seam pierced a thick layer of borax with large zones of an entirely new borate species—kernite. Samples were submitted to Pacific Coast Borax Company geologists, who recognized the mineral as a borate and realized its potential commercial value. Additional testing by Pacific Coast Borax indicated a large ore body in an old lake bed of the Kramer Mining District. Located about 100 meters below the desert surface, it measured 4 kilometers long and 1.6 kilometers wide and was filled to a depth of 50 to 100 meters with rich kernite and borax.

Operations in Death Valley were suspended in 1928, when the new mine at Boron came into production. Shafts were sunk into the

BELOW: Twenty-mule team outfit on its way back to Death Valley, 1892
Photo: Courtesy U.S. Borax and Chemical Corp.

OPPOSITE TOP: Using electric augurs in pure kernite, Baker mine, Boron, 1940
Photo: Ann Rosener

OPPOSITE MIDDLE: James Minette gathering crystals from saturated borax solution at Boron
Courtesy: James Minette
Photo: Walter Miller

OPPOSITE BOTTOM: Miners going on shift, Baker mine at Boron, 1950
Photo: Ann Rosener

kernite, and the deposit was worked by blasting out long tunnels while maintaining pillars for support. Kernite shatters upon impact into long, briliant white needle-shaped particles. The water spray which was used to clean the air of needles covered everything in the tunnels with snow-white kernite, until the area resembled a winter snow scene.

In 1943 the author worked as a mucker in the Baker mine and was able to collect perfectly clear cleavages of kernite as large as 30 by 12 by 10 centimeters.

In 1957 when open pit mining replaced the old shafts, it was necessary to remove 9 million tons of overburden before reaching the borax. Although this was an expensive process, it was less costly than the shaft tunnel system of mining. With the open pit came a treasure house of boron minerals unsurpassed anywhere in variety and quality. The same ulexite and colemanite layer which overlaid the borax became fully exposed in the new pit. It had fine pockets of razor-sharp colemanite crystals, sometimes sprinkled with realgar, calcite, or both. Other fine specimens in the zone over the borax included kurnakovite crystals to 37 centimeters on an edge, inderite crystals to 20 centimeters, tunellite, inyoite, and others. The only known natural fiber optic, ulexite, commonly called "TV stone," in masses of long parallel crystals, some 30 centimeters thick, became instantly popular with lapidarists. Ulexite cuts a fine cat's eye for cabochons, which are used in earrings, ring settings, and other jewelry. Kernite crystals, many transparent, grew to 2.5 meters in length. Some kernite crystals occurred with inclusions of realgar and green shale. Three Kramer District borates made debuts in the mineral world—probertite, kernite, and tunellite.

After the old shaft mines were abandoned, secondary crystal deposits began to form wherever water seeped into the old workings. Magnificent borax crystals have been found, some 31 centimeters in length. Others occur in beautiful groups showing many crystal habits. These alter in dry air to form white pseudomorphs of tincalconite after borax. Although the peak of collecting at Boron was from the 1950s to the mid-1970s, there is every indication that fine crystals will be found for years to come. A similar deposit was discovered in the 1960s in Kirka, Turkey, and already excellent borate crystals have reached the collector's market.

On May 31, 1956, Pacific Coast Borax Company turned over its operations to the

United States Borax and Chemical Corporation, but there was still one last task to perform. Back in Death Valley, a cairn of native stone was erected over the graves of two famous old-time prospectors, Jim Dayton and "Shorty" Harris, and Pacific Coast Borax Company representatives helped with its construction. The epitaphs read "Here lies Jas. Dayton, Pioneer, perished 1898," and as the deceased requested, "Here lies 'Shorty' Harris, a single blanket jackass prospector—1856-1934." The Pacific Coast Borax Company added: "To these trailmakers, whose courage matched the dangers of the land, this bit of earth is dedicated forever."

THIS PAGE TOP LEFT:
Colemanite colored by realgar
Locality: Boron open pit
Size: 1.5 cm
Collection: Werner Lieber
Photo: Werner Lieber

THIS PAGE TOP RIGHT:
Colemanite on calcite
Size: 2.8 by 2.5 cm
Collection: James Minette
Photo: Richard Kean

THIS PAGE BOTTOM:
United States Borax mine from the air
Courtesy: U.S. Borax Co.

OPPOSITE TOP:
Gold with root still imbedded
Size: 13 by 12 cm
Locality: Red Ledge mine
Collection: Wayne and Donna Leicht
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Crystallized gold
Size: 7 by 6 cm
Locality: Red Ledge mine
Collection: William Larson
Photo: Harold and Erica Van Pelt

19 Red Ledge Mine, Washington, California

"Gold! Gold! Gold everywhere!" So wrote a young Argonaut to his mother in 1849. Half-planted fields were abandoned, houses were left partially built, and ledgers went unfinished as young men from all over the world left their jobs to seek excitement and fortune in the great California gold rush. Mining camps sprang up overnight, many with names reflecting their origin: Whiskey Slide, You Bet, Hangtown, Lousy Ravine, Rattlesnake Bar, Rough and Ready, and Git-Up-And-Git. But for every new tumultuous beginning another town, old and withered in just a few years, vanished.

In the heyday of the 1850s and 1860s, California's Mother Lode was a region where its inhabitants fought for survival. In spite of murders (many unreported), claim jumpings, and fires that consumed entire camps, most men struggled to eke out a living in a frontier land of hot summers and deadly winters. For each prospector who struck it rich, a score couldn't pay for groceries and left the field. Newspaper reporters and syndicated writers described the exciting virtues and vices of the goldfields but most often failed to inform the reader of the unending hardships and privations suffered by miners and townspeople alike.

Illicit mining stock promotions frequently outnumbered legitimate ones. Mark Twain defined a mine as "a hole in the ground owned by a liar." The Chinese and Mexicans were frequently scorned, mistreated, or at best given menial and dangerous jobs by the "freebooting" miners.

By the mid-1860s, surface gold deposits were largely exhausted, and operations were carried out in huge open pits by water monitors. (A mounting holds a nozzle that directs a stream of water on gravel deposits.) Hard rock miners followed quartz veins deep inside the mountains.

Stagecoach robberies occurred often during the 1860s and 1870s. Jack Williams became the first well-known bandit on the highroads. His gang specialized in stopping stages on the Nevada City, Washington, Grass Valley, You Bet, and Auburn runs. In May 1866 they stopped a stage north of Nevada City and stole its strongbox. A six-man posse chased the gang, and caught and killed all three bandits. The most accomplished of the highwaymen was the "Homer of the Holdup," Black Bart. Twenty-nine times Bart appeared, head covered by a flour sack with cut-out eye holes, carrying an ominous double-barreled shotgun. Detectives later learned that it was never loaded. His

order to "Halt and throw down your guns" was invariably obeyed. Bart frequently left a scrap of paper on which he had written a verse; the most famous was

I've labored long and hard for bread,
For honor and for riches,
But on my toes too long you've tred,
You fine haired sons of bitches.
Signed: Black Bart, the PO8

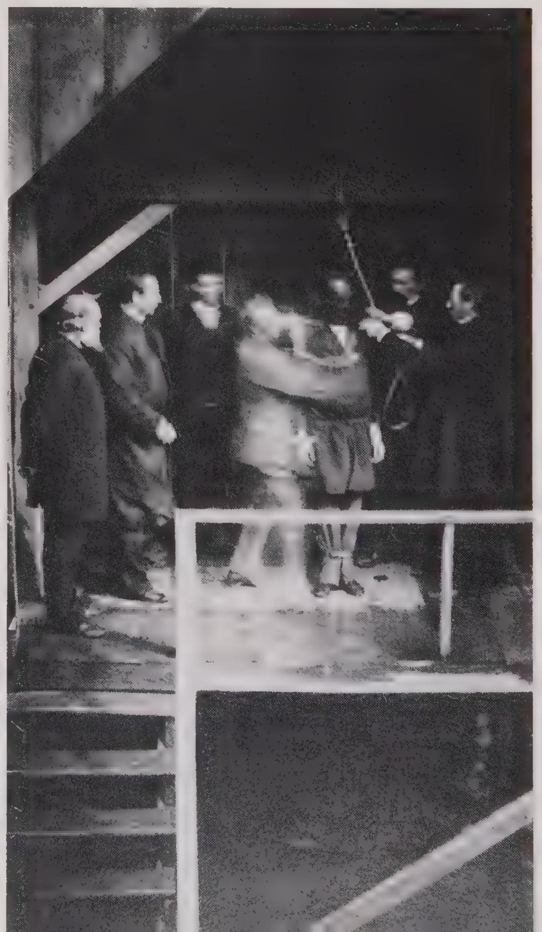
Bart carelessly dropped a handkerchief at his last holdup, and the laundry mark led authorities to his laundry in San Francisco. After his arrest and imprisonment in San Quentin for four years, Bart was released on January 21, 1888, and was never heard of again.

The little town of Washington had its share of incidents. In 1850 the citizens, many of them Chinese, lacked a cannon with which to celebrate the Fourth of July. They improvised one from an old quartz stamp mill. By drilling a hole in the mass of iron, which weighed 90 kilograms, and charging it with gunpowder, they contrived an artillery piece which lived up to expectations with its blast. On the third charge, however, it blew up, tearing a hole in the ground and blowing down a fence. Fortunately, no one was hurt.

Two Chinese were seriously injured in 1880 while attempting to blow up a large boulder. After drilling a hole, they put in a charge of black powder, tamping it with a sledge and an iron bar. An explosion blew the boulder to pieces as one of the men sat on the boulder.

The Red Ledge gold mine, located just southwest of Washington about 24 kilometers northeast of Nevada City, was discovered in 1907 long after many other famous mines in the district. Gone now are the Empire, North Star, Pennsylvania, Idaho-Maryland, Brunswick, North Bloomfield, and Malakoff Diggins, but the Red Ledge hangs on, occasionally producing more of its marvelous gold crystals.

First developed as a gold mine, then worked during World War I for chromite, the mine fell idle from 1937 until 1952. It was reopened as a gold mine by long-time miners Sam Tracy and J.K. Wadley. Once again it contributed specimen gold of great beauty. Some of the better matrix pieces were recovered in raises



THIS PAGE TOP:
Black Bart, stage robber, worked near Washington in 1870s
Courtesy: Wells Fargo Bank History Room

THIS PAGE BOTTOM LEFT:
Washington, California in 1907. Shacks along the river were a part of Chinatown.
Courtesy: Lila Yokum
Photo: Robert Slyter

THIS PAGE BOTTOM RIGHT:
Hanging of George Butts for murder over a mining claim, Nevada City, California, October 1, 1878
Courtesy: Bancroft Western History Collection

OPPOSITE TOP:
Sam Tracy inspecting a raise in Red Ledge, 1951
Courtesy: Stella Tracy

OPPOSITE MIDDLE:
Gold pan with fancy gold on Red Ledge dump, 1928
Courtesy: Stella Tracy

OPPOSITE BOTTOM LEFT:
Red Ledge portal and buildings, 1980
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Miners at Red Ledge's Cabin tunnel, c. 1920s
Courtesy: Stella Tracy

driven upward from the mine's 200 meters of tunnels and stopes. These pieces were blasted from solid "sugar" quartz. Another outstanding group of specimens came from decomposed quartz at the surface directly above the mine. Only the great weight could indicate to the finder that the mud-covered, root-entwined glob in his hand would, after a few minutes of washing, emerge as a glorious shiny mass of native gold blinding in the sun. One large sheet of burnished gold still had a root grown through its crystallized plates. Because of its flowery shape it was dubbed the "corsage."

The press found plenty of news in the Red Ledge and its gold specimens:

> Nevada City Nugget, *March 22, 1918*
> *R. Foster Williamson was displaying a fine looking piece of rock freely studded with gold the past week which was taken from the hanging wall side of the tunnel being run at his property, the Red Ledge, at Washington.*
>
> In a later report:
> *One of the Williamson brothers was killed by a falling tree during a storm, and work at the Red Ledge has ceased.*
>
> Nevada City Union, *Dec. 6, 1929*
> *The beautiful specimens from the Red Ledge Mine near Washington, which have been in the custody of the two branches of the Bank of America and its predecessors for a number of years, were sold on Monday to a Mr. Pohndorf of Denver, Colorado. The price paid was $50 per ounce. The new owner states that they are some of the finest he has ever seen in his long experience as a collector of such things. It is much to be regretted that these beautiful specimens, exemplars of the mineral wealth of Nevada County, should leave the boundaries of the county.*
>
> Sacramento Bee, *July 3, 1934*
> *Dr. Carl P. Jones of Grass Valley has purchased a large feather-shaped specimen of jewelry gold taken from the Red Ledge Mine in the Washington district. The purchase was made from C.J. Horn the leasee of the property. The specimen is 43 centimeters long and the gold weighs nearly 1.5 kilograms. Dr. Jones did not reveal the price he paid for the gold but it is estimated the piece is valued from $1,200 to $1,500.*

Outstanding examples of Red Ledge gold have recently been sold by mineral dealers Wayne and Dona Leicht and by David Wilber. Superb display specimens are in the Cranbrook Institute of Science near Detroit and the Smithsonian Institution.

At this writing, Red Ledge owner Stella Tracy is optimistic about the future, saying "There's plenty of specimen gold in the Red Ledge, and the way the price of gold is today, someone is going to get a bargain." The mine is currently under lease to the Red Ledge Mining Company, whose workmen intend extensive development of the property both at the surface and deep within the mine. In 1983 company engineers were busy blocking out ore and were predicting a rewarding future for their operation. However, in March 1984 it was reported that the mine was up for sale.

20 Benitoite Gem Mine, San Benito County, California

LEFT: Benitoite
Size: 2.5 cm
Collection: Robert Gill
Photo: Harold and Erica Van Pelt

OPPOSITE: Benitoite mining camp, buggy in foreground, 1909
Photo: D.B. Sterrett, USGS

For many years experts anticipated the ditrigonal dipyramidal class of crystallization which didn't appear in any mineral species until the discovery of benitoite. Not only did the new gemstone fill a void in the system of crystals, but it formed in triangular-shaped crystals of an intense sapphire-blue color. Extremely rare, large crystals are found only in San Benito County.

Story has it that in the winter of early 1907, Jim Couch and L.B. Hawkins rode their horses up a small stream until they entered a valley studded with miniature pines. For the last three days, they'd ridden 55 kilometers from the small oil town of Coalinga in California's San Joaquin Valley and spent the previous night at Aker's Ranch down by Los Gatos Creek. Couch had been "grubstaked" by oilman R.W. Dallas who sent Hawkins with him because of his knowledge of minerals. The men were prospecting for copper and any other minerals they might find in the area. They had not seen a person or habitation since leaving Aker's Ranch. They were tired, and the sylvan beauty of the remote glade seemed an ideal spot to camp.

The next morning the men lounged in their bedrolls, waiting for the sun to warm the morning chill. Streams glaze with ice at that 1370-meter elevation in February, and snow is not uncommon. Glancing across the tiny brook, a tributary of the San Benito River, Couch noticed little flashes of light resembling reflections from broken glass. Upon investigation he was astounded to see "thousands of blue gems" scattered about the hillside where they had weathered out of a snow-white material later identified as natrolite.

The samples returned to Dallas were sent to Professor George Louderback at the University of California in Berkeley, who determined the crystals were a new species. Louderback arranged for a trip to the gem deposit and, as he rode back to Aker's Ranch, commented to Couch, "That is quite a discovery. I think I'll name the gemstone benitoite, after the San Benito River." Louderback also received samples of natrolite in which were embedded shiny black prismatic crystals. Thinking he found a new mineral, he named it "carlosite" after nearby San Carlos peak. Later the mineral was identified as neptunite, previously found at Narsarsuk, Greenland. Small amounts of the copper minerals djurleite, digenite, and chrysocolla were also found bordering the seams of natrolite.

Dallas worked his mine from 1907 to 1912, developing an incline and drift and later a vertical shaft. Benitoite crystals were found in numerous thin veins of natrolite and were chiseled out with hand tools and a punch press (one generally used for cutting or shaping metal). The process destroyed many crystals and additional quantities of crystals were lost through the use of high explosives. In later years it was learned that the natrolite could be dissolved in acid, leaving the gem crystals undamaged.

As boys Edward Swoboda and the author, who avidly collected minerals, read of the Benitoite mine and the rare gems it produced. Fortunately the exact location was pinpointed on a topographic map enabling us to estimate how long it would take to reach the mine on foot. The first opportunity came during Easter vacation in 1938 when Frank Gulick, a sympathetic high school teacher, drove us from Glendale, California, to Coalinga. After loading two backpacks with food, blankets, cooking utensils, mining tools, dynamite and caps, rifles and pistols, we began the 36 kilometer hike into the Diablo Mountains.

Entering the tiny "valley of gems," we felt some of the same excitement Jim Couch experienced 31 years before. An old cabin stood in a grove of tall pines, its floor dirty with rat droppings. The aged wood stove was intact, cabin walls and roof still weathertight. The tiny stream trickled past the front door. Dove, quail, and shrill-voiced killdeer called from the hills.

The first evening and dead tired, we rolled out our sleeping bags on the cabin floor and immediately fell asleep. Around midnight a rustling noise awakened us. Flashlight beams revealed four small rattlesnakes which had come up through cracks in the flooring, possibly in search of rats. Our .22 caliber rifles dispatched three of the snakes; the last got away, prompting a thorough floor inspection each successive night.

The next day, we discovered mine walls crossed with natrolite veins but found them devoid of gems after drilling and blasting. We also found a decomposed section of the mine which was extremely rich in weathered-out benitoite crystals. The dumps still contained numerous good crystals and collecting began. Each day the collection grew as we graded stones according to the estimated flawless gem weight each would produce.

Two weeks later we filled our backpacks with gem-laden rock and crystals—each pack weighing approximately 45 kilograms. Tired from the strenuous mining, we left in high spirits after living the good life in an almost unknown collecting locality. On the trail down, even under weighty packs, we laughed, joked,

LEFT: Open cut and tunnel, 1909
Photo: D.B. Sterrett, USGS

OPPOSITE: Miner Thomas Hayes and family at Benitoite mine bunkhouse, 1908
Photo: R. Anderson, USGS

and sang bits of "Little Old Sod Shanty On My Claim." Thus ended what was to be a first of six trips to that mine. At home, crystals were worked loose from the matrix with hydrochloric acid, and a number of particularly fine gems appeared including flawless deep blue stones of 4.45 and 4.25 carats.

In 1947 a disastrous forest fire swept the Benitoite mine area, burning the forest and the cabin to the ground. This region remains desolate and has never recovered its former beauty.

In 1967 Elvis Gray and William Forrest, gemstone cutters and miners, leased the Benitoite mine, named it the Benitoite Gem mine, and systematically worked the total deposit—dumps, drifts, and even some new ground at the surface. Three years later they discovered an enormous block of veined blue schist which produced many of the best neptunite crystals ever found. Using improved collecting and preparation techniques, Gray and Forrest produced a record output of undamaged crystals. Dotting the blue schist matrices were outstanding examples of tiny orange joaquinite crystals (named for nearby Joaquin Ridge and Joaquin Rocks—hideouts for Joaquin Murieta, a Mexican bandit who roamed the region in the 1850s). Later, crystals of a new mineral, snow-white jonesite, were discovered in the acid baths used to recover benitoite crystals. Three other rare minerals have been found at the Benitoite Gem mine—baotite, fresnoite, and banalsite.

In 1972 William McDonald, a Fresno jeweler, designed an elaborate necklace fashioned in platinum, gold, and diamonds. The piece featured 66 stones of faceted benitoite, remarkable in quality and size, which Elvis Gray spent four years cutting. The featured stone, set as a pendant, was a flawless deep blue benitoite of 6.53 carats, second in size to the record 7.6-carat gem on display in the mineral hall of the Smithsonian Institution. The finished jewelry was offered for sale and shipped by air to Switzerland. While in bond at the Zurich airport, a Swiss security official stole it. Eventually, Interpol arrested the official and recovered the necklace, but the missing pendant portion has never been found.

Gray and Forrest believe the famous blue gem deposit is rapidly becoming exhausted. Thus the mine, as a collecting area, will soon join the burned-out mountain and valley as a place of little interest to the hobbyist and lover of nature. It will become a poor reminder of the time not so many years ago when the headwaters of the San Benito River cradled one of the prettiest and finest gem collecting areas on earth.

THIS PAGE TOP:
Elvis (Buzz) Gray and William (Bill) Forrest work benitoite pit in 1978
Photo: Michael Gray

THIS PAGE MIDDLE LEFT:
Edward Swoboda packing into Benitoite mine, 1935
Photo: Peter Bancroft

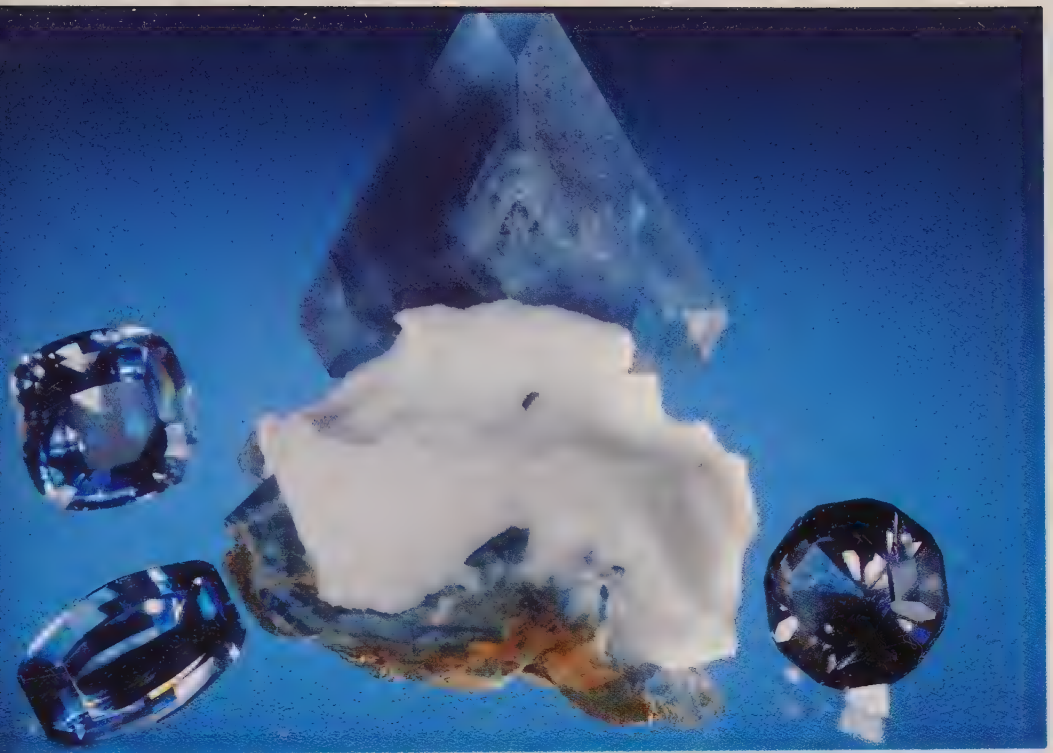
THIS PAGE MIDDLE RIGHT:
Edward Swoboda's Model "A" Ford in trouble in Los Gatos Creek, 1938
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Swoboda at home in benitoite cabin, 1938
Photo: Peter Bancroft

OPPOSITE TOP LEFT:
Benitoite specimen, 2 cm wide
Faceted benitoite, UL 3.98 carats, LL 3.03 carats, LR 3.53 carats
Collection: Robert Gill
Photo: Harold and Erica Van Pelt

OPPOSITE TOP RIGHT:
Benitoite (52 stones set in 14 karat gold)
Largest stone: 4.2 carats
Locality: San Benito Co.
Collection: Robert Gill
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Neptunite on natrolite
Size: 7 cm wide
Locality: Benitoite mine
Collection: Robert Gill
Photo: Harold and Erica Van Pelt



., Mesa Grande, California

boys was playing ...ear Mesa Grande's ...ilometers northeast of ...wn during the 1880s was ... center in an area of small, ... A salesman riding by on ...ed the exceptionally bright ...nd red colors of some of the ... their appearance and feel convinced him ... they were not glass. He bought a few marbles (probably with sticks of candy) and showed them to a San Diego jeweler, who found them too hard for glass and assumed they must be gemstones.

Word spread that attractive colored gems had been found in San Diego's north county at Mesa Grande. Eventually some of the stones reached J.L. Tannenbaum, a gemologist at Tiffany and Company in New York who recognized them as tourmaline. His colleagues offered an explanation for their marble-shaped forms. They reasoned that when a gem quality tourmaline crystal lies in the sun for long periods, the transparent section fractures just below the termination to form round nodule-like balls that break away from the crystal.

Before the "marbles" were identified as gems, life in the Mesa Grande region was simple. One of the first settlers was Bill Dameron, a cowboy turned homesteader. He came to the area in the early 1890s seeking good cattle range near the established Angel ranch. In 1898 a prospector named Gail Lewis discovered and staked out the Himalaya gem mine on the far northern slope of a small mountain, Gem Hill, next to the Angel ranch about 4.4 kilometers northwest of the Mesa Grande store. The next year Lewis discovered the San Diego property located between the Himalaya dike and the Gem Hill summit.

Word reached Tannenbaum in New York that fine tourmaline was being recovered at Mesa Grande, but no stones were offered to him. Even worse, he didn't know the mine's exact location. Now anxious, Tannenbaum traveled to San Diego in 1902 as Tiffany's representative. He hired a negro, J. Goodman Bray, who called himself "The Black

THIS PAGE TOP:
The beginning of the Himalaya mine in 1900.
A miner named Heighway is at left, and cattle rancher, Vance Angel, stands at center top.
Courtesy: Union Title Company, San Diego, California

THIS PAGE BOTTOM:
Himalaya in 1905, three miners and cook (far right)
Courtesy: Union Title Company, San Diego

OPPOSITE LEFT:
Main Himalaya adit in 1950s
Photo: Ralph Potter

OPPOSITE RIGHT:
Tourmaline broken, bent, and "healed" (recemented) by nature
Size: 8 by 8 cm
Collection: Bryant Harris
Photo: Michael Havstad

Millionaire," rented a buckboard and arrived at the Mesa Grande store posing as a tubercular in need of a mountain cabin for his health. In short order, Tannenbaum bought Dameron's homestead for $400 and then jumped Lewis's mine, claiming it had been filed improperly. He put Bray to work, hired Vance Angel and a couple of other men, and began to mine.

At once Tannenbaum struck gem vugs. The pockets, filled with tourmaline, looked as though someone had thrown buckets of the gems into the cavities. Most of the crystals were doubly terminated prisms, smaller than those found the year before at Pala, 45 kilometers to the northwest, but with much larger gemmy sections. Colors ranged from grass-green to light green, yellow-green, yellow, pink, red, and, (rarely) blue.

Lewis fought in court for the Himalaya claim and won, forcing Tannenbaum to pay him $40,000 for a clear title. However, Tannenbaum ultimately emerged the winner. In 1904 Tiffany's George F. Kunz reported that the company received nearly 6 tons of tourmaline from the Himalaya, of which 182 kilograms were "fine nodules and pencils of the very highest grade."

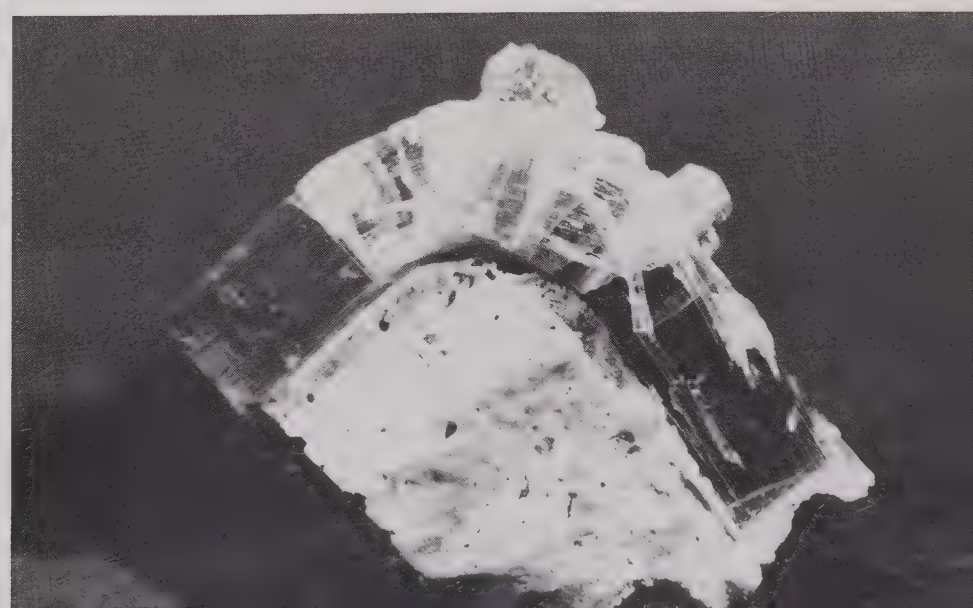
The nearby San Diego mine, on the southern extension of the Himalaya dike system, also produced noted tourmaline. Other gem mines in the Mesa Grande district were the Cota, Green Ledge, Mesa Grande, Esmeralda, Payne, and Trask and Trail.

The San Diego mine's faceting-grade crystals were cut and marketed in San Diego. Material suitable for carving was shipped to China. Tzu Hsi, the Chinese Dowager Empress, developed a strong liking for carved tourmaline and, upon learning of the San Diego County discoveries, sent emissaries to Mesa Grande and Pala.

Between 1902 and 1911 the Himalaya prospered. In 1905 a large pocket was discovered near the surface, and the tailings from this excavation, as well as from a portion of the mine, became known as the "flagpole dump" for the staff erected nearby. A good supply of wood and water was at hand. Amenities included a "dwelling house, barn, tool houses, and blacksmith shop, as well as a windmill with water piped to all." The 1.5-meter-thick ledge produced a seemingly endless series of gem pockets. The pockets were large and were filled with clay containing gem crystals of quartz, tourmaline, and beryl.

Tiffany displayed a fine collection of Himalaya crystals at the Pan-American Exposition at Buffalo in 1901 and later sold the gems to the Museum of Natural History in Paris. Other remarkable Himalaya crystals, a part of the Ernest Schernikow collection, were exhibited at the California State Mining Bureau in San Francisco in 1904.

Between 1902 and 1910, Mesa Grande's 400 pegmatite dikes produced 120 tons of gem tourmaline valued at $800,000. Of these, 90 tons came from the Himalaya, the world's premier source of tourmaline until Brazil's great tourmaline deposits began heavy production about 1963.



THIS PAGE TOP LEFT:
Tourmaline
Size: Longest crystal 9 cm
Locality: Himalaya mine
Collection: David Wilber
Photo: Harold and Erica Van Pelt

THIS PAGE TOP RIGHT:
Morganite
Size: 12 by 7 cm
Collection: David Wilber
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM LEFT:
Tourmaline
Size: 17 by 3 cm
Locality: Himalaya
Collection: David Wilber
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM RIGHT:
Tourmaline with quartz
Size: 12 by 8 cm
Locality: Mesa Grande
Collection: David Wilber
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Ralph Potter in rich gem pocket, 1957
Courtesy: Ralph Potter

OPPOSITE MIDDLE:
Range fire burning directly below Himalaya mine, 1960
Photo: Ralph Potter

OPPOSITE BOTTOM:
Pala Properties' miner working Himalaya, 1980
Photo: Michael Havstad

China became the largest buyer of carving-grade tourmaline, but the collapse of the Imperial Government in 1911 brought hard times to many San Diego County gem mines, forcing some to close.

Prospector and miner who cut many fine stones, Frederick Ryerson wrote in *Exploring and Mining for Gems and Gold in the West:*

> *It was not until 1919 that fine specimens of gemstones brought more than their cutting value. Before that time there were wonderful specimens destroyed in getting the gems out of them. I was guilty of this waste along with others. But we were after tourmaline for cutting, not specimens. Specimen pieces wouldn't bring the money the tourmaline crystals would when cut, and cutting was my job. I have broken tourmaline crystals 3 centimeters thick and 11 centimeters long, half pink and half green, selling the pink piece to the Chinese for more than I could get for the whole crystal from others.*

Herbert Hill, an old-timer who had worked as a mucker for Tannenbaum and Rynerson, became caretaker of the Himalaya and died in 1952. That year Ralph Potter, miner and collector, bought the Himalaya from the Quinn family. Using Mexican labor, he mined many fine pockets of both gems and specimen crystals, including a 17- by 3-centimeter doubly terminated tourmaline crystal (half grass-green and half dark pink), a rich orange-pink highly etched beryl (morganite), and well-formed crystals of manganotantalite, stibiotantalite, and pink apatite. Potter also mined a tourmaline which produced a 110-carat bicolored stone of fine pink and yellow-green colors. Perhaps Potter's favorite crystal was one he never mined or owned: a 19- by 2-centimeter doubly terminated tourmaline prism of five colors, pink, yellow, white, yellow-green, and green, it was found in the Himalaya in 1917 and has since disappeared.

In 1963 Potter sold the Himalaya to a syndicate later named the Himalaya Gem Mines, Inc. and retained a one-fifth interest. In 1978 Pala International of Fallbrook, California leased the Himalaya and immediately began to extend old tunnels in search of new pockets. The first two years of work produced several hundred kilograms of gem material, including excellent tourmaline crystals up to 25 centimeters in length. Good specimens of microcline, stibiotantalite, and apatite were recovered. In 1980 a tunnel large enough to accommodate small trucks was driven an estimated 215 meters from the portal in hopes of intercepting the pegmatite. Within a year the tunnel extended far into the mountain and uncovered a number of small gem pockets. Prospects for new discoveries of gem crystals at the Himalaya appear excellent.

The world's finest collection of San Diego County gem crystals and faceted gemstones was assembled by dealer David Wilber of Ouray, Colorado. In 1981 he sold this assemblage to Perkins Sams, a Texas collector.

22 Pala Chief Mine, Pala, California

Early in 1901, while hunting crystals on Heriart Hill with sons Frederick and Allen, Marian Sickler discovered quartz and lepidolite crystals scattered about a pegmatite ledge. A bit later Fred found, as float, fragments of light pink heavily striated crystals, which he assumed were tourmaline. Their find lay approximately 4 kilometers northeast of the Pala mission in north-central San Diego County. On July 8, 1901 Sickler's father helped him stake a claim named the White Queen. Fred Sickler, who had studied mineralogy at San Diego's Russ High School, was acquainted with eminent geologists and mining engineers. He eventually became an authority on California crystal mining.

The Sicklers intended to mine purple mica (lepidolite), which they found sparingly in the pegmatite outcrops. But, they became intrigued by repeated occurrences of gem beryl in the veins. While working on the Katerina, another of their prospects, they encountered a deposit of pink clay, then large quartz crystals, some weighing as much as 45 kilograms. Shards of a bright lavender gemstone, much the same as those found at the White Queen mine, occurred near the quartz crystals. Still unable to identify the puzzling crystals, the Sicklers submitted samples to gem experts in San Diego and Los Angeles who were as mystified as the owners. Next, specimens were sent to Tiffany and Company where gemstone advisor Dr. George F. Kunz determined that the samples were spodumene, a mineral heretofore unknown in gem quality crystals of this color. Dr. Kunz published his findings and extolled the new gem before the New York Academy of Sciences, saying "for purity and quality of color it is unrivaled by any other mineral in North America." In 1904 the new gem was appropriately named kunzite by University of North Carolina Professor Charles Baskerville.

Kunzite was also found at the Pala Chief prospect on Chief Mountain, a claim established in May 1903 by Pala storekeeper Frank Salmons and three others. The main horizontal ledge consists of an upper portion of coarsely crystallized feldspar and quartz; a lower stratum of compact granite "line rock" contains black tourmaline, mica, and small garnets. Between the two layers lies a zone of pockets filled with white and pink clay, lepidolite, tourmaline, and morganite (pink beryl). Of particular interest was the discovery of large amounts of fine kunzite crystals, as well as crystals of colorless and green spodumene.

An old miner told of the time he and a buddy highgraded one of Frank Salmon's mines. They were on the mine dump when they noticed Salmon driving up in his car. Salmon saw them, jumped out of his car, drew a pistol and fired three or four shots into the sky. As the highgraders ran over the hill, they noticed Salmon's car rolling swiftly backward down the hill with Salmon in frantic pursuit. They never learned the fate of the automobile!

Later, Mrs. Frank Salmons took over the Chief and hired a man named Rene as her foreman to oversee a crew of Indian muckers.

BELOW: Mexican miner with kunzite crystals at George Ashley's Vandenberg mine on Heriart Hill, c. 1950
Photo: George Ashley

OPPOSITE: Kunzite
Size: 14 by 11 cm
Locality: Pala Chief
Collection: William Larson
Photo: Harold and Erica Van Pelt

Rene, an opportunist, recognized a potentially rich gem area where the Indians worked, told them the ground was no good and sent them to another section of the mine. The next day there was a big hole where the Indians had been working, indicating a substantial amount of kunzite had been removed from a major pocket.

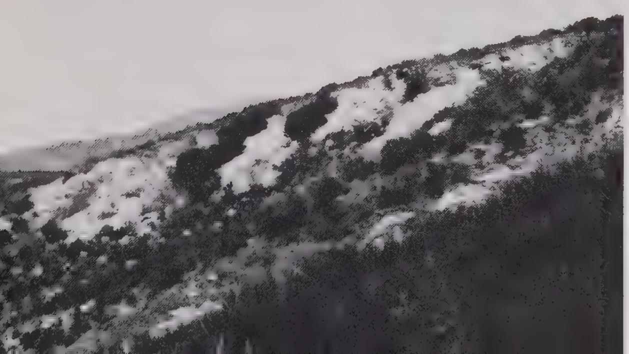
One problem at the Chief was highgraders. After the miners went home at night, the mine became the object of nocturnal visits to such a degree that highgraders were called the "night shift."

One of the Chief's greatest pockets was named the "bridal chamber," because when dug out it resembled a large bed. Other pockets were round or elongated. Once when a miner was digging into an overhead pocket, sandlike pegmatite grains began to pour from the opening. Next, gem crystals began to "roll out" including kunzite, green tourmaline, and beryl—a most unusual occurrence of these three gemstones in a single vug. Later the pocket produced blue and rose-pink bicolored beryl crystals, "the best ever found in San Diego County," rivaling the fine bicolored beryl crystals from Minas Gerais, Brazil.

Tourmaline from the Chief ranged in color from light pink to the rich red rubellite variety and in sizes up to 30 by 8 centimeters. San Diego jeweler Hom Bing bought many large tourmaline crystals for "$20 a pound" and sent

them to his father in China. Bing was not interested in facet grade tourmaline, only in cabochon quality which could be used in carvings.

At that time, the greatest quantity of large lustrous gem-quality kunzite crystals was mined at the Chief. The largest weighed 1.37 kilograms, and six crystals approached 36 centimeters in length and 13 centimeters in width. Imposing examples are displayed in the collections of Harvard University, the American Museum of Natural History, the Smithsonian Institution, and the California Institute of Technology in Pasadena.



The Chief closed in 1914, because World War I created a shortage of hard rock miners at a time when colored gems glutted the world market. The mine remained dormant for many years.

In 1947 George Ashley became the dominant force in San Diego County kunzite mining. He acquired the San Pedro, Anita, Katerina, Vandenberg, Fargo, Naylor, Heriart, El Molino, and White Queen claims, all on Heriart Hill. Immediately Ashley found kunzite. He took a basketful from the Katerina and 60 kilograms of gem bluish-purple kunzite from the Vandenberg, including a 1-kilogram specimen and a marvelous gem rough from which he faceted flawless stones of 215 and 177 carats. In 1948 Ashley sold the San Pedro to Charles Reynolds, who discovered a huge pocket containing 130 kilograms of high quality kunzite. The largest crystal weighed 2 kilograms.

In 1959 the Chief was reactivated by Fielder Fitzsimmons and William Adams; in 1966 by Albert C. Ordway and partners; and in 1976 by Pala International, each with only modest success. The Pala International operation was extensive, and the entire lode was disturbed by a bulldozer. It is reasonable to conclude that

THIS PAGE TOP:
Fred and Allan Sickler, later to discover the White Queen mine, sit on "Dolly" in front of Pala Mission, 1894
Courtesy: George Ashley

THIS PAGE MIDDLE:
Pala Chief mine at its beginning, 1904
Courtesy: Gemstones of California, State Mining Bureau

THIS PAGE BOTTOM LEFT:
Pala Chief mine ledge, c. 1909
Photo: D.B. Sterrett, USGS

THIS PAGE BOTTOM RIGHT:
Promotion of kunzite, 1905
Courtesy: California State Mining Bureau

OPPOSITE LEFT:
Frederick Sickler just before his death at age 82
Photo: George Ashley

OPPOSITE TOP RIGHT:
Two Frenchmen and an Indian guarding the Pala Chief, c. early 1900s
Courtesy: Beulah Rynerson

OPPOSITE BOTTOM RIGHT:
Early miner screening for gems, Pala Chief dump
Courtesy: Ralph Potter

major pockets in the Chief's ledge are exhausted.

In 1980 limited mining continued on Heriart Hill by George Ashley, Norman Dawson, William Magee (now deceased), and Roland Reed, who believe good kunzite crystals probably can still be found. But the miners do not expect to find more of the giant prisms for which the mountain and its neighbor, Chief Mountain, are famous.

23 Tourmaline Queen Mine, Pala, California

Few people passed through the Rincon Indian Reservation and for those who did, like Fred Rynerson in 1904, conversation at the store remained casual until Frank Salmons' name was mentioned. When this happened, storekeeper Bill Clark got sore and ranted at length about an experience he'd had in 1903.

Clark and a friend were driving a wagon up a canyon north of the Pala Mission. When they stopped to rest the horses, they scanned the nearby hills through binoculars for signs of minerals. High on the hill to the left, a long whitish vein streaked across the surface. Leaving their wagon, the men hiked up to the vein, which proved to be a pegmatite dike. Because small tourmaline and quartz crystals lay about, Clark suspected that more were locked within the vein. Having neither pencil nor paper, Clark planned to return the following day and file a claim on the ledge. When he did he found newly erected monuments with cans inside containing location notices. "Someone was watching us," Clark commented, "and after we left, located the claim before we could get back." Frank Salmons, John Giddens, Pedro Peiletch, and Bernardo Heriart had filed a claim and named it the Tourmaline Queen.

The Queen was first developed as an open pit. Initially dug to a width of 10 meters and a depth of 3 meters, this hole produced 36 kilograms of gem tourmaline in yellow, green, light pink, and ruby red. Gem-bearing veins, between a layer of albite and solid granite, contained large pockets of rose and lavender lepidolite and whitish-to-pink clay. Some tourmaline crystals had opaque green exteriors or skins and centers of rich pink to red. Within the pockets, piles of tourmaline lay scattered about, many of them broken in pocket explosions which resulted from intense pressures developed during crystallization. Pocket material was passed over screens, which eliminated dirt and small pieces. The material

BELOW: Tourmaline, variety rubellite
Size: 42 carats
Collection: Fallbrook Collector Shop
Photo: Harold and Erica Van Pelt

OPPOSITE: Tourmaline on quartz and cleavelandite
Size: 32 x 27 cm
Locality: Tourmaline King mine (about 200 m above the Tourmaline Queen mine)
Collection: Smithsonian Institution
Photo: Earl Lewis

which remained in the screens could then be easily washed in the search for gems. The Queen became the Pala district's leading gem producer between 1904 and 1914. Large quantities of carving-grade pink tourmaline were exported to China to be fashioned into carved figurines, snuff bottles, and ornaments. San Diego jeweler, Hom Bing, a steady buyer of tourmaline from the Queen mine, shipped the material to his father in China. Facet-grade gem material went to domestic lapidaries, among them Fred Rynerson, a gem cutter and prospector for the San Diego Gem Company.

Nearby tourmaline-producing mines on Tourmaline Queen Mountain were the Tourmaline King, Ed Fletcher Jr., Mission, Alvarado, Douglass, Canyon Cut, Gem Star, White Cloud, and the Stewart Lithia. Large shipments of facet-grade tourmaline were shipped to New York City's jewelry firms: Tiffany and Company and the American Gem and Pearl Company. From 1911 to 1968 the

THIS PAGE TOP:
Miner on dump of Queen, 1909
Photo: Waldemar Schaller; Courtesy Gene Foord

THIS PAGE MIDDLE:
Earliest known photo of the pegmatite ledge below the Tourmaline Queen mine. Dump at extreme left is Stewart Lithia mine.
Photo: Waldemar Schaller; Courtesy Richard Jahns

THIS PAGE BOTTOM:
San Diego Gem Co. where Fred Rynerson worked, 1906
Courtesy: Beulah Rynerson

OPPOSITE:
Tourmaline on quartz and cleavelandite
Size: 18 by 10 cm
Locality: Tourmaline Queen mine
Collection: Josephine Scripps
Photo: Harold and Erica Van Pelt

Queen was dormant, except for visits by unauthorized collectors.

Between 1933 and 1950, the author made numerous trips to Pala with friends. The Tourmaline Queen was always on the list of mines to be visited. We drove over a winding dirt road from the Pala Mission northward up a narrow canyon to a small eucalyptus grove. We would set up camp under the trees and begin the steep ascent up Tourmaline Queen Mountain. If we planned to work inside the abandoned mine, weather was never a problem. When we wanted to work the dump, we tried to arrive immediately after a heavy rain. It was then that the freshly washed surfaces of pink and green tourmaline were easiest to find. We never failed to collect a handful of gemmy crystals from the dump or to find some good quality crystals deep in the Queen's tunnels.

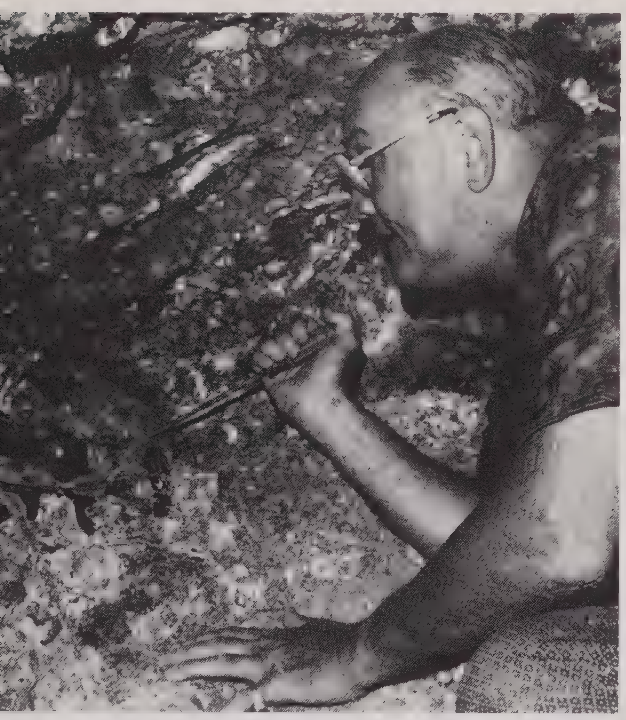
The old mine remained dormant until 1969, when Edward Swoboda and William Larson, partners in the newly organized Pala Properties International, bought the Queen and built a tortuous 3.2-kilometer road up and over the mountain to the mine. They installed a compressor and mining commenced. Within two months, chief miner John McLean exposed a series of small gem pockets, one containing a significant number of indicolite (blue tourmaline) crystals, the largest a doubly terminated prism 8 by 5 centimeters. After the main tunnel was extended another 12 meters through barren pegmatite, more small vugs were discovered; a major pocket might lie ahead. Small charges of powder were set off, exposing a soft, wet, clay material in the tunnel face.

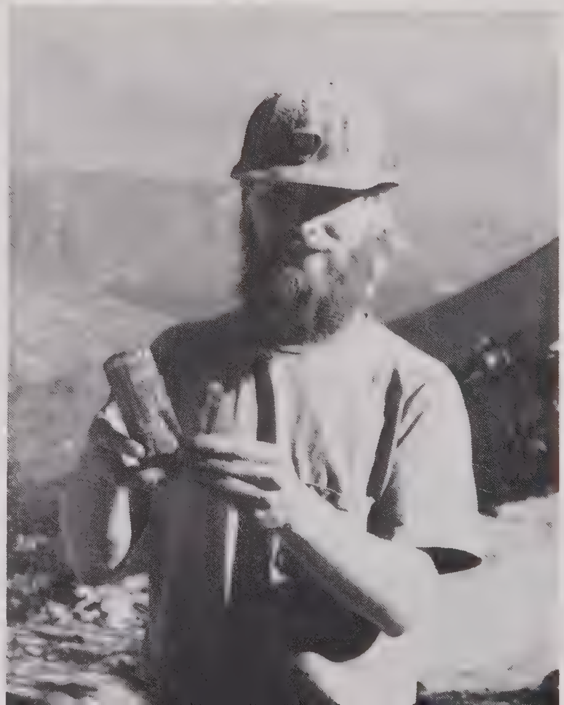
On January 19, 1972, carefully using screwdrivers as probes, the miners encountered large quartz crystals followed by tourmaline. The gem crystals were imbedded in the soft clay which also harbored hundreds of razor-like shards of broken quartz. As fingers became lacerated, blood increased the difficulty of locating gems, but with plenty of water from canteens, new prisms emerged: stunning blue-tipped rubellite (pink tourmaline). Larger crystals measured to 10 centimeters in length, and in the dim light, each crystal reflected rich colors of dazzling beauty. When it appeared the strike had major importance, the company invited nearby curators and collectors to witness the exceptional find.

As work progressed, newly mined crystals were carefully transported down the mountain for cleaning in the company's shops at nearby Fallbrook. Some tourmalines were attached to

quartz crystals; others grew from feathery bases of cleavelandite. Two specimens of blue-tipped rubellite had peach-colored morganite crystals attached to their sides, probably a unique occurrence in the world of gems. Finally, a 30-by-23-centimeter matrix of quartz crystals with three 14-centimeter rubellite prisms was uncovered. The piece, immediately dubbed the "candelabra" after its shape, eventually went to the Smithsonian Institution. Vincent Manson, then curator of Mineralogy at the American Museum of Natural History, was deeply impressed: "In terms of color and degree of perfection, this is the find of the century."

From 1973 to 1976 other gem pockets produced nearly a ton of tourmaline, but never such exquisite specimens as before. Finally, after years of work and 150 meters of barren tunnels, the Queen was closed for what may be the last time. The 2-centimeter-thick steel door clanged shut and was locked, signaling the end of an era. Today the Queen's legacy enhances many collections throughout the world.





THIS PAGE TOP LEFT: John Barlow, mineral collector and dealer, digs out gem pocket in Queen Photo: Peter Bancroft

THIS PAGE TOP RIGHT: Entrance to Tourmaline Queen, 1972 Photo: Dean Luxton

THIS PAGE BOTTOM LEFT: Large tourmaline removed in matrix, 1972 Photo: William Larson

THIS PAGE BOTTOM RIGHT: Chief miner, John McLean with tourmaline on Queen dump, 1972 Photo: Peter Bancroft

OPPOSITE: Jumbo mine debris on Copper Mountain, c. 1925 Photo: J.C. Read, USGS

24 Green Monster Deposit, Prince of Wales Island, Alaska

One of the world's most inaccessible collecting areas is Prince of Wales Island in southeastern Alaska, which harbors two epidote deposits. Men who have searched these deposits have shared their experiences in graphic stories. Because many of them have been published in mineral trade journals and club bulletins, the reader may know of this wild and forbidding spot. Seldom have such remote crystal deposits been so well documented.

Epidote occurs on two neighboring mountains on the island, Green Monster and Copper. These peaks stand near the head of the fjord, Hetta Inlet, on the lower portion of Prince of Wales Island, part of the Alexander Archipelago. The port city of Ketchikan lies 65 kilometers to the east on Revillagigedo Island. Copper Mountain, home of the Jumbo copper mine which operated from 1902 until 1923, is abandoned. The little mining towns of Sulzer, Jumbo Mine, and Copper Harbor are in ruins.

Fortunately for armchair collectors, the hardy adventurers who explored Copper and Green Monster Mountains left behind their detailed impressions. In 1935 miner C.B. Ferguson, then in his late seventies, joined an expedition to Prince of Wales. During the trip he shared his early experiences with Arthur Montgomery, former mineralogy professor at Lafayette College, the late specimen collector Edwin Over, and Smithsonian curator, E.P. Henderson:

> *I was prospecting on Green Monster Mountain back of Copper Mountain in 1900 when I made my first find of epidote. I stumbled on crystals lying all over a portion of the mountain just waiting for the first discoverer to pick them up. Ages of weathering away the rock had left the epidotes both as loose crystals and wonderful groups up to a great size, partly exposed on the surface. W.C. Hart of Manitou, Colorado, sold my specimens. In later years, I found other types of epidote, as well as various associated minerals, on Copper Mountain, but Green Monster Mountain produced by far the finest material and appeared to be the likeliest locality to work.*

Montgomery described his trip in detail in the July 1937 issue of *Rocks and Minerals:*

> *Last Summer . . . [we] . . . made the trip to Prince of Wales Island with the object of collecting further epidote and exploring for other minerals.*
>
> *We planned to remain on the island for at least three months, and we had to have*

THIS PAGE TOP:
Margaret Meyers netted against the flies on Green Monster Mountain, July, 1977
Photo: Lee Meyers

THIS PAGE BOTTOM:
Epidote with quartz
Size: 7 by 6 cm
Location: Copper Mountain
Collection: Smithsonian Institution
Photo: Dane Penland

OPPOSITE: Lee Meyers, Sharp Osmundson and pilot on Josephine Lake, 1965
Photo: John Hufford

provisions to last throughout our stay. . . . it was a surprise to all of us to see how much was needed. We took along nearly a ton of provisions alone.

Suitable clothing also was a matter to occupy our minds. Everything must be waterproof. . . . Luckily for us we decided to buy . . . [mosquito] nets for we had heard stories of the biting prowess of the Alaskan flies.

For the fourteen hour trip from Ketchikan to Hetta Inlet we chartered a small gasoline boat which had difficulty finding room for all our baggage.

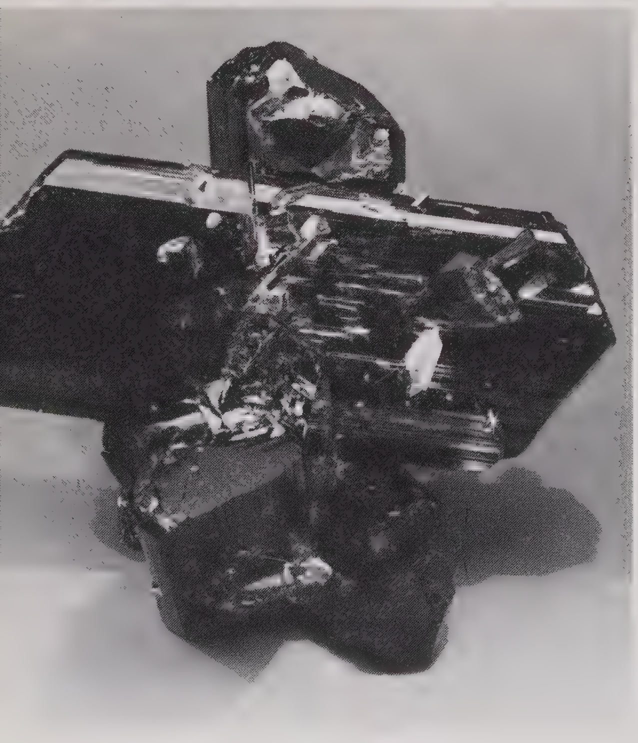
We started one cold morning at 4 a.m. By late afternoon we were dropping anchor in Hetta Inlet, opposite the few old buildings on the shore which represented all that was left of the Jumbo Mine settlement . . . . We were able to utilize two old buildings, still more or less intact, one suitable for a cookhouse and the other for sleeping quarters . . . .

Finally we were ready to start work. . . . The very trip into this back country was a problem, for although the distance was only five or six miles, it was steep, rugged terrain with all the old trails completely overgrown, and there were three sizeable lakes which had to be crossed . . . .

Our work in the mine tunnels did not produce much outstanding material. Ferguson showed us where he had opened up some cavities in the walls of certain drifts, and Over and I commenced a little dynamiting. In a week's time we had had enough of it, for the results were not good enough to warrant serious effort in an atmosphere far colder, wetter, and nastier than the very worst weather outside . . . .

These tunnels were weird places to be in, as are all abandoned mines far below the surface, with a maze of passages and drifts twisting off in all directions, water always underfoot and overhead, and the continual, often-unearthly sound of it dripping on solid rock. Flickering candles and lamps did not penetrate very far into the eerie blackness, and one would be sometimes only a footstep away from the tunnel floor into a black abyss . . . .

While Over and I had been getting our fill of underground mining, Henderson had



been opening some surface pockets higher up the mountain and finding some good uralite and adularia. The uralite, a rare amphibole occurring in square-shaped crystals made up of fibers and representing an alteration from pyroxene, came out in excellent groups . . . .

After some minutes . . . [Over] . . . exposed a surprisingly large cavity, which, sadly enough, seemed empty of anything but mud. All at once he let out a shout and held up a long black crystal. After this there came whole handfuls of loose epidote crystals, and as he commenced working down into the bottom of the pocket, groups made their appearance. Some of the best were quite splendid, and when the pocket had been exhausted we could look at the assemblage of specimens laid out on the grass and realize proudly that few epidotes had ever been found to equal these.

Omaha mineral collector John Hufford wrote in *Rocks and Minerals,* (May 1966):

In July 1965, our small PA-11 float plane settled down on Josephine Lake less than a mile from the diggings on Green Monster. Sparpe Osmundson, Lee Meyers, and I had joined forces to collect on the Monster and here we were. First discovering a lot of loose quartz crystals, some doubly terminated, we next found a small cavity lined with beautiful crystals of epidote and quartz. Most prominent was a treasure specimen, a splendid water-clear Japanese twin quartz a little over an inch high perched beautifully upon a fragment of epidote crystal for a base. The finding of a precious gem could trigger no greater emotion. You calm down slowly.

Under the aegis of the Smithsonian and National Geographic Society Peter Leavens, Richard Thomssen, and Douglas Toland visited the locality in 1967 and reported in *Mineralogical Record* of February, 1977:

Condensed notes are quoted here:

Can you imagine digging through bushy hedge on a steep roof in a spring rain at home, that is what we spent our summer on Green Monster doing. We counted at least eight kinds of biters. The worst were the black flies which have an anesthetic and anti-coagulant in their saliva—you don't know that you've been bitten until you notice you are bleeding. The itching, which is terrific, starts later.

THIS PAGE TOP:
Typical weather on Josephine Lake, October 1975
Photo: Doug Toland

THIS PAGE BOTTOM:
Epidote
Size: 5.5 by 5 cm
Locality: Copper Mountain
Collection: Smithsonian Institution
Photo: Wendell Wilson

OPPOSITE LEFT:
Richard Thomssen in front of pockets which produced large epidote crystal in his hand, 1967
Photo: Peter Leavens

OPPOSITE TOP RIGHT:
Virgil Gile hiking up Green Monster from Josephine Lake, 1973
Photo: Lee Meyers

OPPOSITE BOTTOM RIGHT:
Epidote pocket on Green Monster with 4# hammer, 1977
Photo: Frank Maier

Crystals within the pockets we found were few and far between but we did find a single epidote crystal over 10 centimeters long and weighing more than 1 kilogram.

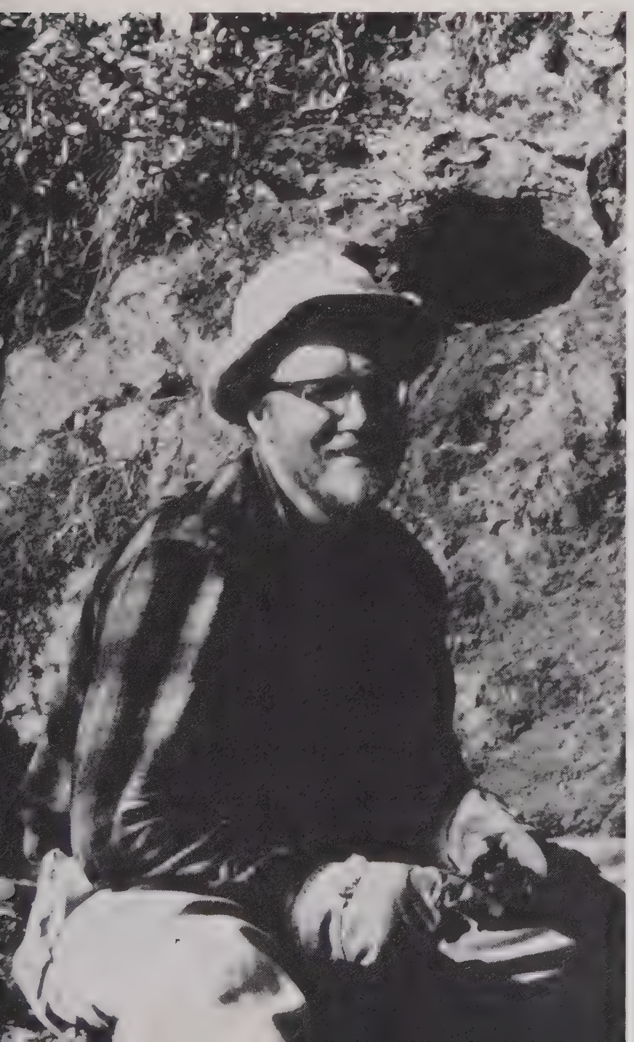
Douglas and Frances Toland of Juneau, Alaska are the current leaseholders. Toland's diary for August 21, 1979 reads:

Did find a small pocket today containing clear quartz with dozens of thin acicular terminated needles forming outline of epidote. Sparkly. Largest group has a 3 centimeter quartz twin extending from the top.

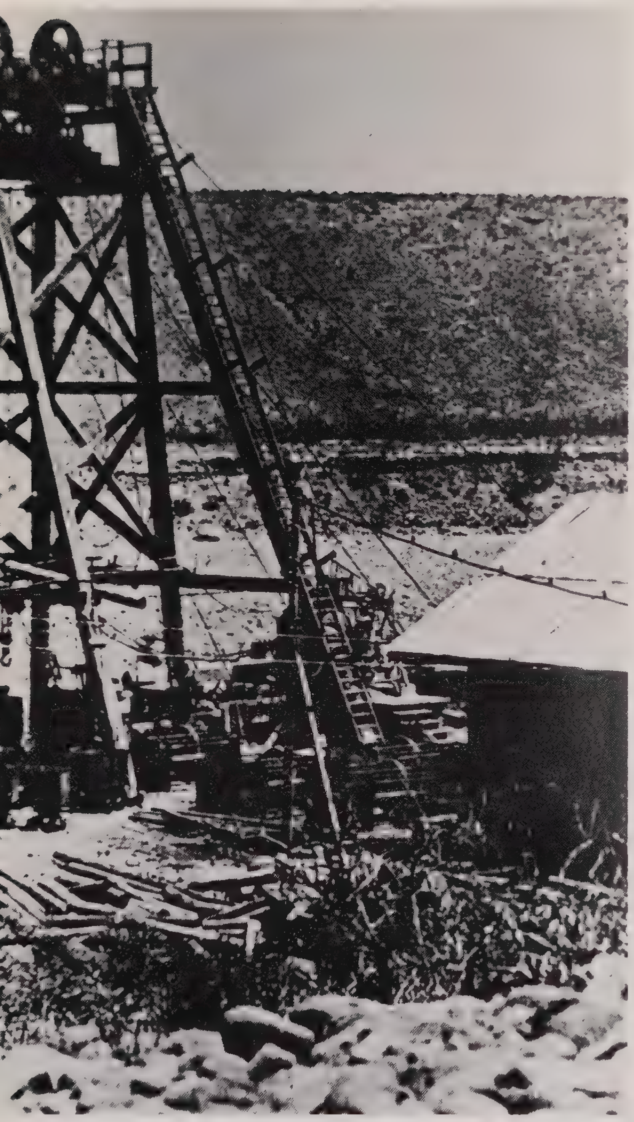
From other notes:

I have found quartz prisms with as many as six phantoms. I have also found a few glassy translucent mottled pink, muddy green and clear doubly-terminated quartz crystals, the largest was 0.5 by 3 inches in size. Magnetite has been a delightful surprise. Looking much like hematite "iron roses" my largest specimen was a cluster of sub-parallel plates 1.5 by 2 inches studded with clear chloritic quartz perched on a friable epidote matrix. One inch xanthophyllite crystals of a deep green color and some fine uralite prisms were found near the Green Monster summit.

Copper and Green Monster are big mountains. In spite of considerable prospecting and blasting, chances remain good that more splendent epidote crystals still await their release from veins and pockets in the tough garnet-amphibole country rock beneath snowfields, scree, and dense vegetation. However, the area is closed to collecting, except with written permission from the lessees.



25 Amelia Mine, Santa Rosalia, B.C., Mexico



Bright green streaks of oxidized copper crisscrossed old lava flows in the mountains behind Santa Maria, a tiny port on the Sea of Cortés in Baja California. For centuries goat herders and fishermen collected pretty green rocks and brought them down from the mountains for use as flower garden borders or to face fireplaces. Mexicans assumed the rocks, though attractive, were worthless. In the 1860s geologists became certain that high-grade copper ore deposits could be found just below the surface of the lava flows in what was to become the Boléo mining district, named for green malachite "balls" found locally.

A number of small mines opened but because there was no smelter, only high-grade veins were followed. The 30-kilogram loads of ore were placed in rawhide pouches carried from headbands, and barefoot workers toted the loads up steep shafts to the surface. There the rock was transferred to burro trains for the 7-kilometer trip to Santa Maria.

In 1886 Compagnie du Boléo, a French mining company controlled by the Rothschilds, obtained title to the little mines and a right-to-mine charter with considerable privileges, including exemption from taxes for 20 years and freedom of duties for 50 years. The company immediately began systematic development of the area, built a smelter, and constructed the town of Santa Rosalia about 13 kilometers south of Santa Maria. The new site at Santa Rosalia was selected because it was far simpler to build a deep-water harbor there than in the comparatively shallow waters off Santa Maria. Two new breakwaters made

THIS PAGE TOP:
Cumenge shaft, 1890s
Courtesy: School of Mines, Paris

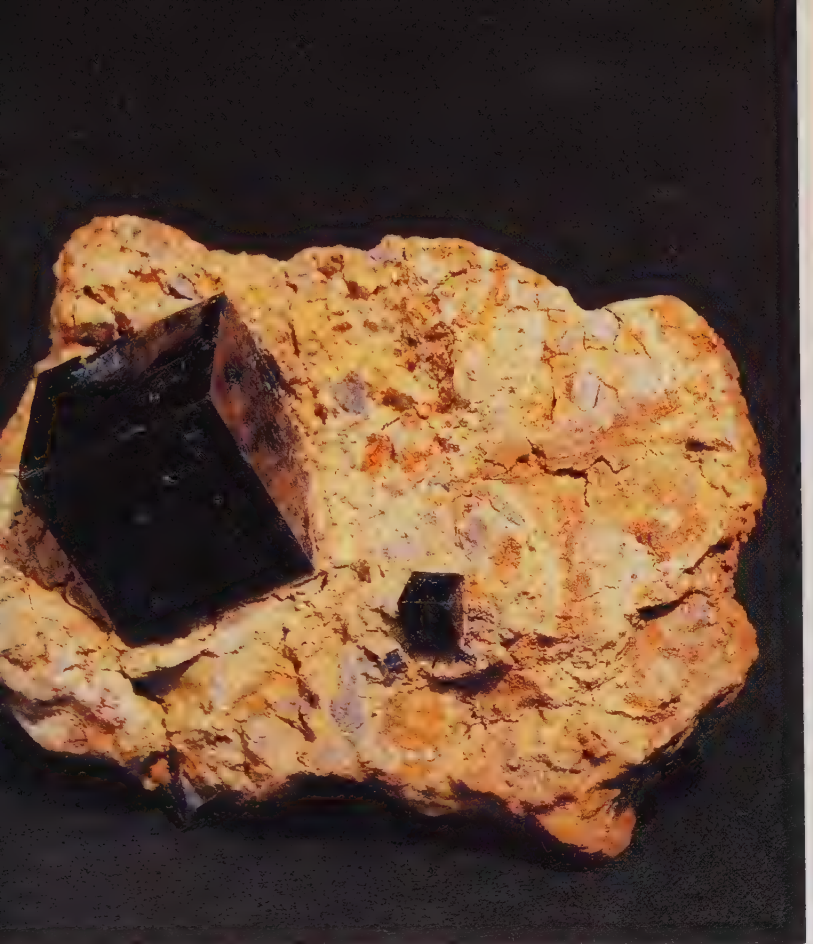
THIS PAGE BOTTOM:
Edouard Cumenge (with hat) on porch of mine superintendent's house, Santa Rosalia, 1890s
Courtesy: Pedro Mahieux

OPPOSITE TOP LEFT:
Boleite
Size: Largest crystal 2.5 cm
Locality: Amelia mine
Collection: Azurite Corporation
Photo: Henri Janson

OPPOSITE TOP RIGHT:
Boleite with atacamite (green)
Size: 7 by 7 cm
Locality: Amelia mine
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
(L) Cumengite on similated matrix, largest known crystal
Size: 3.5 cm
Locality: Amelia mine
Collection: University of Paris
Photo: Nelly Bariand

(R) Boleite
Size: 2.5 cm
Locality: Amelia mine
Collection: School of Mines, Paris
Photo: Nelly Bariand



from hand-hewn slag blocks formed a harbor near the smelter which served four principal mines: the Soledad, Providencia, Purgatorio, and the Amelia. Nine little Baldwin rail engines, built in Philadelphia and shipped to Santa Rosalia by sea, hauled supplies and copper ore from the various mines to the smelter and port. The company also built a 16-kilometer pipeline from the Yaqui Plateau to carry potable water to the mines.

Each sailing ship brought new miners to Santa Rosalia: Italians, Japanese, and Chinese. In addition to Santa Rosalia's isolation from the rest of the world, working conditions were terrible in the oppressively hot and humid tunnels. As a result, as many men arrived, nearly that number took the next ship out. The company projected a work force of 3000, but payrolls seldom exceeded 1600 employees. In the long run, Mexican labor proved the most reliable. As one mine official observed: "Locals are slow but steady." Every few years *chubascos* would hit the mining camps located in canyon bottoms where the land was flat. These violent rains and windstorms wiped out whole blocks of dwellings. Sometimes walls of water roared down normally dry ravines, inundated tunnels, and drowned the miners below.

French engineer Edward Cumenge, a consultant to Compagnie du Boléo, made studies of ore reserves, timbering, and haulage systems. He made recommendations to relieve the stifling temperatures encountered in the long drifts. As a result, a vertical shaft (bearing his name) was built to improve ventilation through the labyrinth of tunnels 75 meters below.

As the mine grew, so did Santa Rosalia. By 1900 there were several general stores, a sawmill, four schools, a hospital, and two wharves. The Amelia operated profitably until 1919, when ore reserves became exhausted and large-scale mining ceased. Cheaper

THIS PAGE TOP: Roman Catholic church in Santa Rosalia, 1890s made entirely of iron, designed by A.G. Eiffel of Eiffel tower fame Courtesy: Pedro Mahieux

THIS PAGE BOTTOM: Sailing ships in Santa Rosalia harbor, c. 1900 Courtesy: Pedro Mahieux

OPPOSITE LEFT: Mexican miners in Amelia, 1976 Photo: Edward Swoboda

OPPOSITE TOP RIGHT: Mules going to work in Santa Rosalia mine Courtesy: Pedro Mahieux

OPPOSITE BOTTOM RIGHT: Frederick Pough on Amelia dump, 1979 Photo: Ted Nichols

"minimum support structures" were constructed so that when an area was mined out the rotting timbers eventually gave way under pressure from above and tunnels caved in.

In 1974 Edward Swoboda began a mining program. His company, Pala Properties International, sunk a new inclined shaft 162 meters inside Curuglu Mountain. The new shaft connected with the old caved workings of the Amelia, an area not worked since 1919.

Swoboda was not primarily interested in copper ore. He was searching for the boleite group of minerals previously discovered in record sizes near the bottom of the Cumenge shaft. The Amelia possessed all the geological prerequisites for formation of the boleite suite of lead-copper oxychlorides. Concentrations of chloride salts at the surface moved downward in solution until they merged with heavy primary sulfide ores below, reacting to produce four rare species of dark blue crystals: boleite, pseudoboleite, percylite (not fully accredited), and cumengite. Named for Cumenge, cumengite is an intriguing and beautiful mineral. Its crystals selectively attach themselves as overgrowths on cube-shaped crystals of boleite or pseudoboleite. Such combinations of minerals into a single compound crystal result in one of the more striking crystal forms in the mineral kingdom. Some members of the boleite suite have been found in at least 18 worldwide localities, but only the Amelia mine has produced the beautifully formed large crystals, prized by curators and collectors.

The Swoboda venture accomplished many of its goals: a classic crystal locality was successfully reworked to unearth boleite crystals measuring up to 2.5 centimeters (equaling the largest known specimens), and superbly formed pseudoboleite crystals. Fine cumengite crystals were also mined, but none reached the magnitude of the incredible specimens mined at the Amelia in 1893, the largest of them 3.5 centimeters. Of particular importance was Swoboda's insistence that, whenever possible, boleite suite minerals would be mined in matrix. As a result, this enterprise yielded the best-known matrices of boleite cubes imbedded in montmorillonite and sometimes atacamite.

Today the Amelia is closed. Ancient and recent dumps bake in the sun and, up in the flats, winds born in the Sea of Cortés rustle thorn-covered bushes bordering low rock-covered mounds of forgotten graves. Sheets of gypsum still await the adventurer in lonely canyons, and antique oil-burning lamps are sometimes uncovered on abandoned dumps. But the Amelia sleeps once again, possibly forever.

26 El Potosí/Buena Tierra Mines, Aquiles Serdán, Chihuahua, Mexico

Second only to the Fresnillo mine at Zacatecas in all of silver-rich Mexico, El Potosí has produced more than $200 million in silver in its 277 years of operation. It is located at Aquiles Serdán (formerly Santa Eulalia), 11.2 kilometers southeast of the city of Chihuahua, Mexico. The town's ambience combines the modern and the antique. Deeply weathered wooden doors stand ajar in roofless adobe houses that border the landscaped gardens of the miners' new homes.

El Potosí, in addition to its bullion, is rich in good crystals. It has turned out very bright pyrrhotite crystals up to 5 centimeters in diameter which are well-formed, hexagon-shaped plates usually found in groups. Creedite is mined as small, sharply pointed white and lavender crystals, strongly resembling those from Colquiri, Bolivia. Records indicate the rather frequent occurrence of silver wires during the mine's early years, yet nearly all have been lost to the mills. Well-formed acanthite crystals to 2 centimeters are known, as well as good quality crystals of barite and hemimorphite. Copper-stained dolomite, quartz, and calcite specimens are very bright in color.

In addition, most of the Santa Eulalia mining district's 89 distinct mineral species are found in El Potosí.

In 1912 a remarkable cavern was discovered deep in the mine where cretaceous limestones had been hollowed by percolating waters into a series of caves. Those caves were lined with remarkable growths of calcite and gypsum. Miners delighted in lighting the largest cavern with scores of candles to produce a snow-like scene of great beauty. Within a few years the cave was stripped of its stalactitic wonders, which were sold to collectors and museums; it now lies destroyed and abandoned.

Discovered in 1979, a series of connected caves known as Caverna de Santo Domingo contains jumbo gypsum crystals measuring to an incredible 2 meters in length and 25 centimeters in width. These slender prisms are mostly water-clear, shading from colorless to light tan. More caves, located in the West Ramp Extension mine and the Buena Tierra mine near El Potosí, were discovered in 1981. The caves are protected by padlocked doors.

The walk down into the mine is through a cool, dark, sloping tunnel large enough to accommodate 10-ton ore trucks. One kilometer into the mountain and 100 meters down, a drift curves off to the left. At its end, a wooden door leads to another smaller door a bit further on. The last door signals entry into a world so different that one could think it another planet. As electric lamps clamped to hardrock hats penetrate the darkness, strange and wonderful forms take shape. Protruding from the floor, like toothpicks stuck in styrofoam, hundreds of giant gypsum crystals

BELOW:
Erythrite on limonite
Size: 2 cm
Locality: Valensuela's mine, some distance west of Aquiles Serdan
Collection: Willard Perkin
Photo: Willard Perkin

OPPOSITE TOP:
Creedite
Size: 8 by 6 cm
Locality: El Potosi mine
Collection: Miguel Romero
Photo: Rock Currier

OPPOSITE BOTTOM:
Mimetite
Size: 9 by 8 cm
Locality: El Potosi mine
Collection: Miguel Romero
Photo: Rock Currier

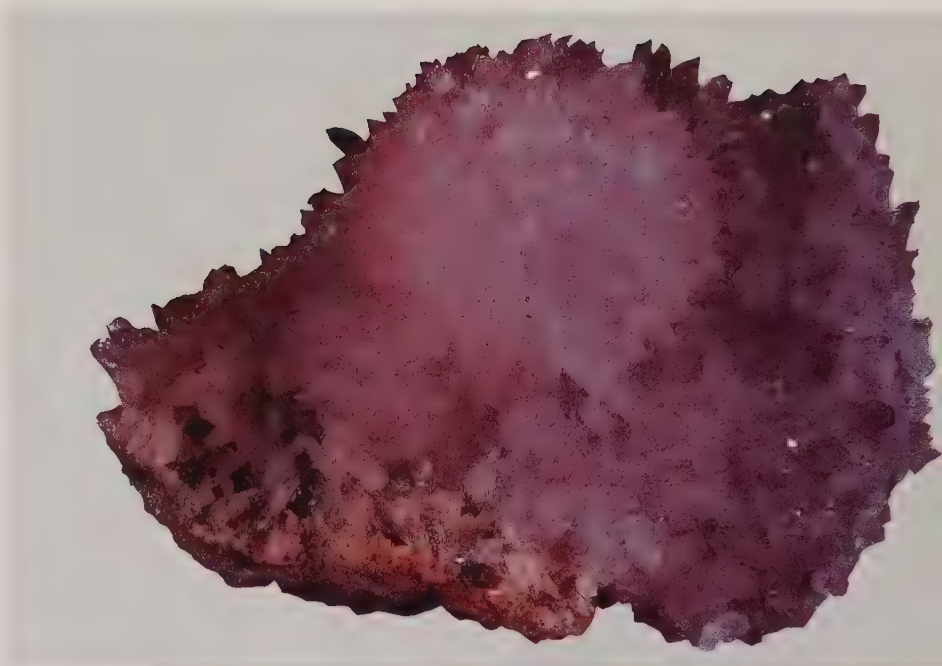
appear in jackstraw arrangement. Most crystals have distinct undamaged "v"-shaped terminations. In the main cavern, approximately 100 meters long, 15 meters wide, and 6 meters high, long clusters of tiny gypsum crystals, white and sparkling, grow in gentle curves from the ceilings.

Even though only a few people have visited the gypsum caves, destruction of crystals has already occurred. The soft terminations of some crystals, used as stepping stones along a path through the caves, have begun to collapse into handfuls of whitish flakes. Although mine engineers talk freely of plans to preserve the caves as they are, crystals have been offered for sale in the United States, and others are on display in at least one Mexican mine far away. Industrial Minera de Mexico (mine owner) and the Arizona-Sonora Desert Museum intend to preserve the largest cave in its entirety; in return for a miner's agreement to "leave the big room alone," management would unofficially relax surveillance on some other rooms. Carefully maintained against theft and damage, the gypsum crystal caverns of the Buena Tierra—not now open to visitors—could become one of Mexico's most unusual tourist attractions.

The San Antonio, a sister mine 8 kilometers farther east, is most unusual because of its diversified metal output. It was here, in 1929, that the San Antonio became North America's first productive tin mine. Santa Eulalia mills, working San Antonio concentrates, recover good values in gold, silver, lead, zinc, copper, vanadium, and tin.

Discovered in 1591, Aquiles Serdán has produced enormous wealth and considerable prosperity, as well disease, labor strife, and political turmoil. Important events both good and bad easily spilled over into the old mining town from nearby Chihuahua, the state capital.

In 1892 a radical Texas newspaperman named Garza headed an unsuccessful attempt to overthrow Mexico's President Porfirio Diaz. Garza tried to raise a band of revolutionaries in the state of Chihuahua but when nearly captured fled to Nicaragua where he joined another revolutionary movement and died in battle. In 1895 Doroteo Arango, later better known as Pancho Villa, joined a gang of bandits led by Ignacia Parra and helped rob a stagecoach carrying a mine payroll near Chihuahua. When Parra was killed, Villa took command of the bandits, made repeated raids on Mexican cattle ranches and sold the livestock in the United States. When not



rustling, his band lay in wait for silver trains coming from the mines. In 1910 the bandits became "respectable" and joined other revolutionaries helping to overthrow President Diaz.

In 1913 Pancho Villa teamed up with a ruthless Indian revolutionary, Emiliano Zapata; between them they controlled vast sections of Mexico. Villa ruled all of Chihuahua, and his troops laid waste to farms, mines, and towns, including parts of Aquiles Serdán. With Mexican and American military cavalry at his heels, Villa's band broke up into groups of terrorists who concentrated on extortion, kidnapping, looting, and murder. Villa lasted until 1923 when he was gunned down in the tiny village of Parral some distance south of the city of Chihuahua. Both Villa and Zapata are now honored as patriots throughout Mexico; in Aquiles Serdán, Villa is a folk hero.

A few years ago, Mariano Valenzuela bought the El Potosí and the Inglatierra mines from the Mexican corporation, Penoles. Valenzuela was born in a mining village at the famous bridge near Mapimi. An experienced miner, he worked at Aquiles Serdán and became active in union affairs. Before long he was elected chief of the miners' union. It was big news in Mexico when he bought the two very valuable properties for a reported $30,000, an amount exceeded by each day's output of metal. In a relatively short time, Valenzuela had become the wealthiest mine owner in the state of Chihuahua.

In recent years Aquiles Serdán has entered stable times. Children attend school, churches are filled on Sunday, and stores do a thriving business. The mines are still productive and appear to have a very promising future.

THIS PAGE TOP:
Apache prisoners working at Chihuahua silver mines, c. 1860s
Courtesy: L. Simonin, Underground Life, 1868

THIS PAGE MIDDLE:
Troops of Pancho Villa enter a town in Chihuahua, c. 1913
Courtesy: Peter Bancroft

THIS PAGE BOTTOM:
Town of Santo Domingo, 1979
Photo: Peter Bancroft

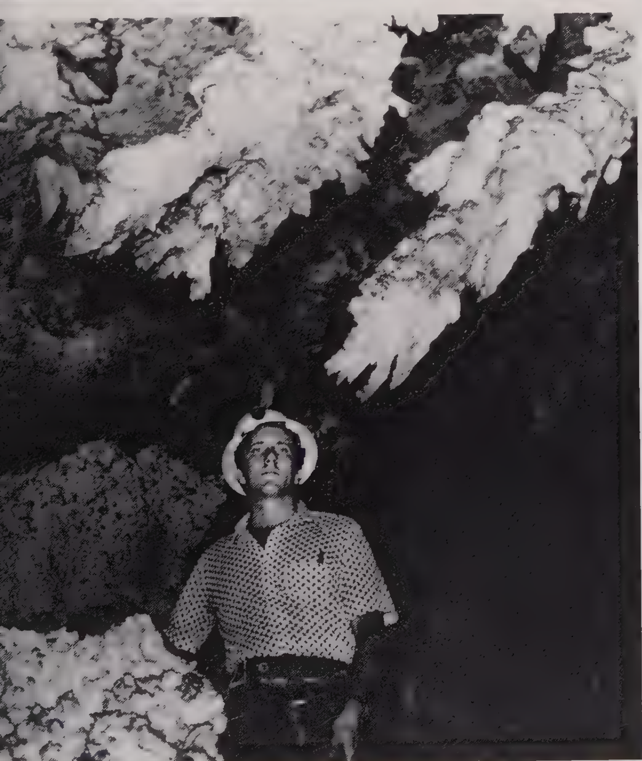
OPPOSITE TOP LEFT:
Delma Perry at entrance to gypsum cave in Buena Tierra mine
Photo: Peter Bancroft

OPPOSITE TOP RIGHT:
Hauling aragonite stalactites hewn from their bases in the Potosi mine, 1912
Photo: Carlos C. Harris
Courtesy: Denver Museum of Natural History

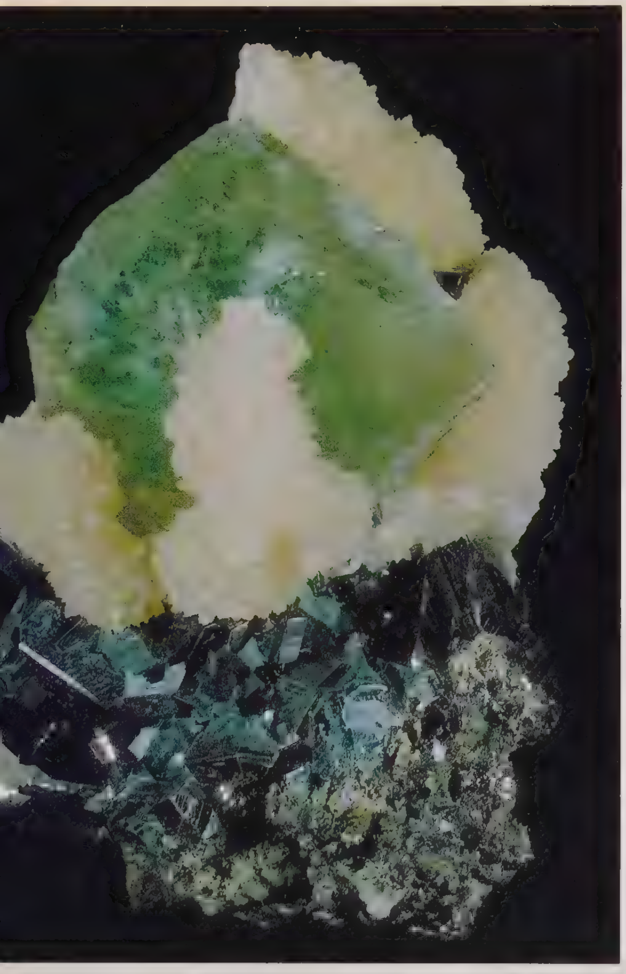
OPPOSITE BOTTOM LEFT:
Scott Carl with gypsum crystals curving from cave's ceiling
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Two-meter-long gypsum crystals in Buena Tierra cavern
Photo: Peter Bancroft

Fine mineral specimens from the Santa Eulalia mining district are featured in many private and public collections. The Miguel Romero suite of crystals in Tehuacan, Mexico, is outstanding, and the Arizona-Sonora Desert Museum houses a fine series of crystals including an exceptional rhodochrosite specimen.



27 Maravillas/Gibraltar Mines, Naica, Chihuahua, Mexico



The Sierra de Naica mountains long belonged to fierce warrior Indians who guarded the ramparts and discouraged visitors from entering the area. But danger never seemed to deter the prospector in search of precious metal.

In 1828 Mexican miners, believing there could be silver lodes in the mountains, slipped in on prospecting expeditions. Records do not mention clashes, but certainly the Indians were aware of the intruders and took measures to expel them. Promising outcrops were discovered and a group of well-organized and heavily-armed miners entered the mountains and set up camp. The men split into three groups: one to mine, a second to stand guard, the third to rest. Supplies and equipment were hauled to the mine during the wet season. When the miners exhausted their water and supplies they built signal fires which could be seen in Concho, 25 kilometers to the east. Friendly people commandeered all available *carretas* and the large oxcarts carried a heavily-armed relief party to Naica. Newly-mined ore and everything of value was loaded aboard the carts, leaving the camp deserted until miners returned next fall.

Crude mills at Concho processed rich silver ores. Buyers who arrived in huge ore wagons from Chihuahua, 113 kilometers to the north, bought concentrates from the hills. Crafty

THIS PAGE TOP:
Fluorite, frosted by aragonite, on base of galena
Size: 8 by 5 cm
Locality: Gibraltar mine
Collection: Miguel Romero
Photo: Rock Currier

THIS PAGE BOTTOM:
Gypsum
Size: 13 by 13 cm
Locality: Maravillas mine
Collection: Miguel Romero
Photo: Rock Currier

OPPOSITE TOP:
Oldest known photograph of Naica, 1911
Courtesy: Compania Fresnillo, S.A. Unidad Naica

OPPOSITE MIDDLE:
Mine manager's autovia, a model "T" Ford chassis converted to rail, 1950
Photo: Allen Bassett

OPPOSITE BOTTOM:
Allen Bassett doing topographic work at Naica. Bassett commented: "The flying ants were a huge nuisance.", 1950
Courtesy: Allen Bassett

buyers soon learned that Naica concentrates mined for silver also carried good values in gold. But many years passed before local miners found out they had been cheated.

Indians frequently raided mines and haciendas for horses, weapons, food, and drinking water. Because the nearby Santa Gertrudis Ranch was repeatedly attacked, all cowboys worked fully armed. Ranch owner Don Dolores Solis became interested in the new silver deposits and grubstaked some of his "hands" who eventually discovered the rich Dolores mine. One Sunday night in 1861 Indians crept into the mining camp, captured three miners, and took them to the top of the mountain. The men were tortured and killed; parts of them were eaten. A rescue party found their mutilated bodies staked to the trees as a warning. Taking heed, the party hurriedly buried the victims, erected a cross, and left. The mines were closed for nearly four years until the military contained the Indians. During this time, the mine and all its buildings were destroyed.

In recent years the old mines of the area—Dolores, Maravillas, Gibraltar, Lepanto, and Ramon Corona–have been consolidated and nationalized into the single operation, Compania Fresnillo, S.A., Unidad Naica.

Naica, an important source of fine crystals, has produced well-formed galena, calcite, quartz, pyrrhotite crystals resembling stacked plates in a pyramid, gypsum, and sphalerite crystals, frequently in combination. More than 80 species have come from its vaults including wollastonite, hedenbergite, silver, covellite, magnetite, anglesite, matildite, aurichalcite, cosalite, cerargyrite, copper, cinnabar, bournonite, jordanite, light blue anhydrite, exceptional tennantite-tetrahedrite crystals, and native mercury attached to rusty masses of gossan. Fine crystals are still forthcoming. During 1977 vugs of transparent grass-green fluorite crystals up to 5 centimeters were discovered with galena, sphalerite, and calcite in sulfide veins deep in the Gibraltar.

Naica is best-known for its "Cave of Swords." While extending a drift on the 120-meter level, miners broke into a large cavern studded with strange prismatic forms. At first the miners thought they had entered an old room used years ago for the storage of mine timber, because the forms seemed too large to be minerals. Closer inspection revealed them to be giant gypsum crystals, far larger than any ever before seen or reported. Some crystal shafts measured an unbelievable 2.5 meters in length

and 18 centimeters in thickness. Most were beautifully terminated and occurred in clear white, light tan, and light gray.

A nearby cave, the Xochitl, had thousands of gypsum crystals resembling barbs on a porcupine. Slender prisms about 30 centimeters long protruded from every crevice and wall. Some had longitudinal water-filled cavities containing a bubble of gas in water. Miners of yesteryear, short of surveying equipment, supposedly used these water bubble crystals much as a carpenter uses a level today. Other crystals displayed phantom lines, namely shadowy forms inside the prism which show former stages of the crystal's growth. One 36-centimeter crystal contained a bubble that moved 10 centimeters; it also featured six partial and three full phantoms.

During the 1940s the Naica mine manager was a giant of a man called the "licenciado" who'd once been a divorce lawyer in Mexico City. He openly wore two pistols on payday. Tough as he was, he had to back down in the face of the miner's superstition about women in the mines—they bring bad luck. The licenciado brought his girl friend into the mine one day and nearly caused a riot. From the reception she received, the licenciado realized he was about to have a strike on his hands and he put her back on the cage for a quick ride to the surface.

In 1950 geologist Allen Bassett was at Naica doing field work for his doctoral degree. He learned that the mine manager was about to pump out 52°C water to clear the bottom of the mine for further development. Bassett knew the discharged water would percolate through the caves on its way back to the bottom of the mine and many wonderful crystals would be damaged. Having made arrangements with the hoistman to let him ride the ore bucket during off hours, Bassett collected many grand gypsum crystals and safely transported them from the cave. After several days of collecting, lightning struck the mine's power lines, cutting off electricity to the pumps. At the time of the outage Bassett was deep in the lowest workings of the mine. Water began to fill the tunnels and stopes at a rate of 10,000 gallons per minute. With hot water at his chest, Bassett fought his way to a ladder and escaped. This all happened a few days after the licenciado's girl friend's visit; maybe the miners were right—something worse could have happened had she stayed longer!

In Naica, now a bustling little city of 12,000 people, weekdays start with the mine whistle at

THIS PAGE TOP:
Mexican geologist and Scott Carl support gypsum crystal about 2 meters long, 1979
Photo: Peter Bancroft

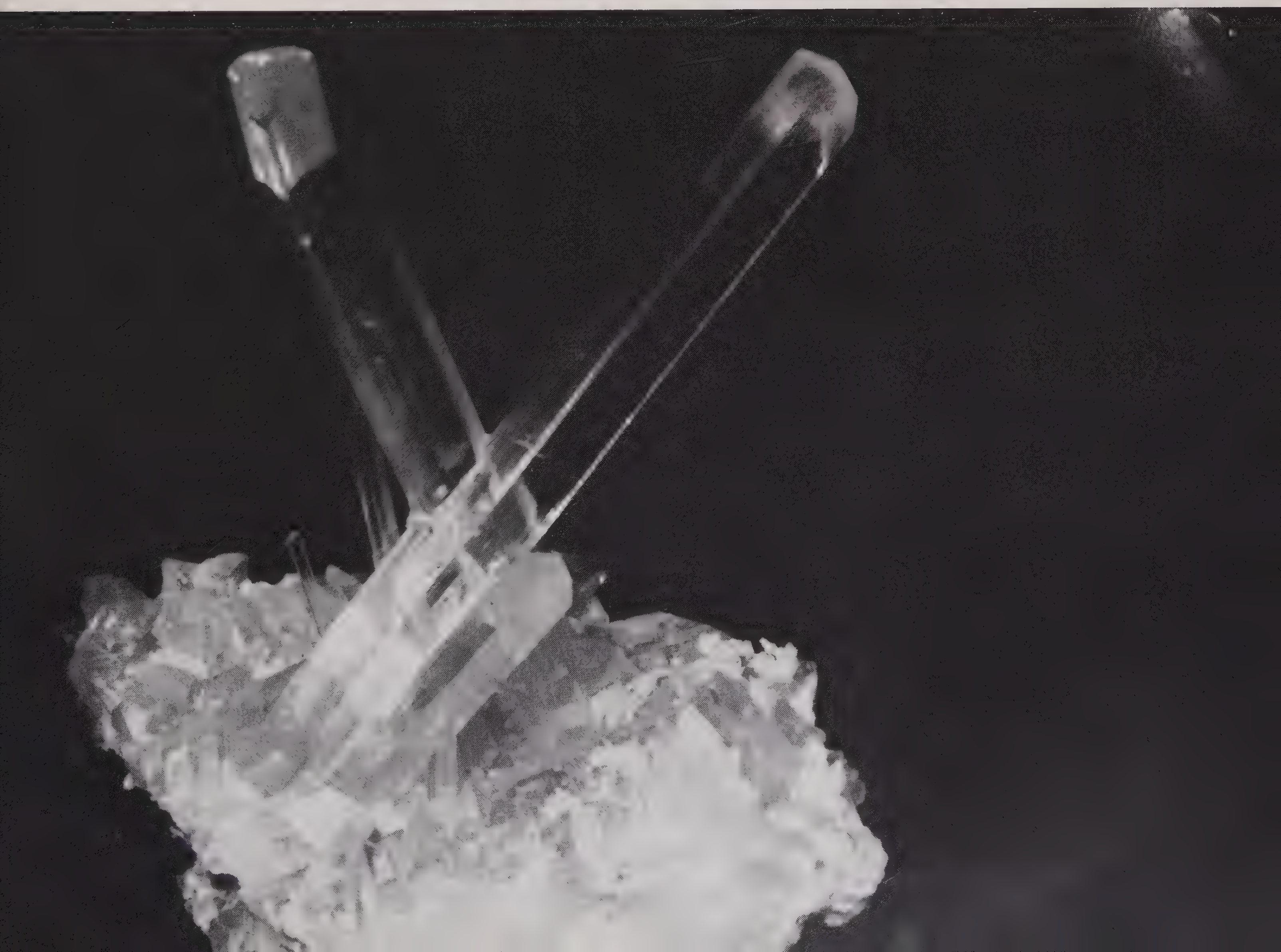
THIS PAGE BOTTOM:
Stubby gypsum crystals in Xochitl cave of Gibraltar mine
Courtesy: Enrique Garcia Milan

OPPOSITE TOP:
Maravillas miner waiting to go on shift, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Water-clear 25 centimeter gypsum crystals on display in mine manager's office at Naica
Photo: Peter Bancroft

7:00 a.m. On Sundays church bells toll even earlier. The sun is hot, and there is a constant shortage of water. Bands of goats attack sparse vegetation in the area. The pervading silence is broken only by lonely calls of the white-winged dove.

The Maravillas and Gibraltar mines are still working and employ 1500 miners. Three-kilometer-long tailings attest to the great volume of rock that has been removed. Unfortunately, the crystal caves have been plundered, with many gypsum crystals hacked from their bases by chain saws. Some of these crystals may be seen in reconstructed caves in the museums at Harvard University and the Smithsonian Institution. In 1979 the Gibraltar caves were occasionally opened to visitors. Even though beautifully formed crystals remain in profusion, the obvious damage to many of the great crystals was a depressing sight.



28 Ojuela Mine, Mapimí, Durango, Mexico

One of Mexico's man-made wonders is a 325-meter-long suspension bridge strung across a great canyon 4 kilometers southeast of Mapimí. Frail in appearance yet amazingly strong, this graceful engineering masterpiece attracts few tourists; it is virtually unknown. The turnoff to Mapimí from Highway 49 is 843 kilometers south of El Paso, Texas, and 40 kilometers north of Torreón. From that point, a paved road heads due west about 25 kilometers to the Sierra de Mapimí mountains rising abruptly from the desert.

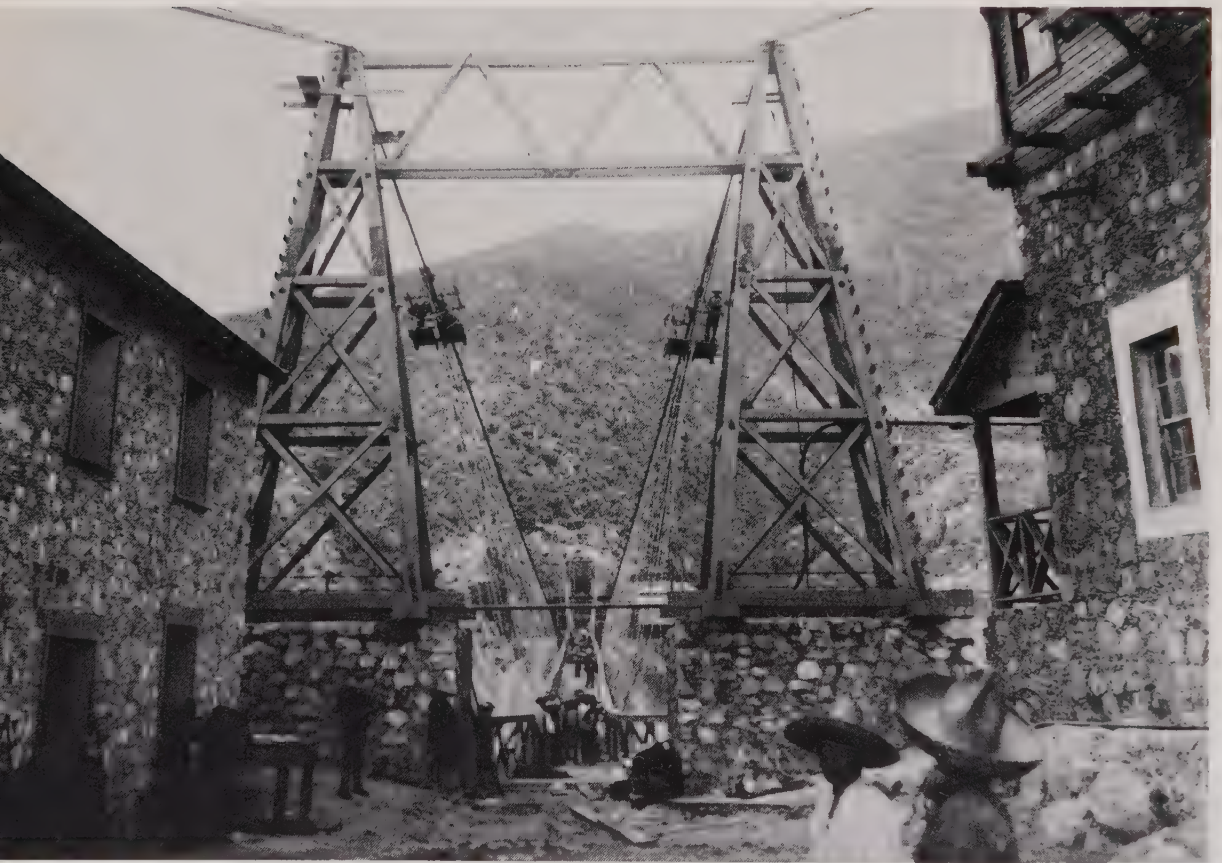
Nearing Mapimí, the vast ruins of the old smelter cover an area of perhaps 5 square kilometers. Abandoned in 1930, the smelter had been stripped of its machinery, its lintels, even many of its bricks and hand-hewn stones. But remnants of the past still survive: 3-meter-deep canals of solid stone, 30-meter-tall palm trees, and huge roofless adobe buildings.

THIS PAGE TOP:
Completion of Ojuela suspension bridge, 1895
Courtesy: John Whitmire

THIS PAGE BOTTOM:
A day off for miners at Ojuela, 1896
Courtesy: John Whitmire

OPPOSITE TOP:
Ojuela Bridge, 1979
Nearly all buildings of old Ojuela are gone. Dark hole (center below bridge) is a bat-filled cave which was the "discovery hole" and entrance to the Ojuela lode.
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Completed bridge; view from south, 1896
Courtesy: Mapimí History Museum



Mapimí, once a bustling town of 9000, now has but a third of its earlier population. To the south jagged mountains encircle the Ojuela mine. The nearest peak, Bufa de Mapimí, has a hole extending through its tip, resembling the eye of a needle or *ojeula*—little eye. The mine is supposedly named for this hole, but there are two other explanations. Galena from the mine has a leaf-like texture called *hojuela* in Spanish, which might later have been misspelled. Then again, old Mapimí miners will tell you the name honors Don Pedro de Ojuela, the town's missionary more than two centuries ago. Whatever its derivation, the eye, visible for kilometers, leads travelers directly to the mine.

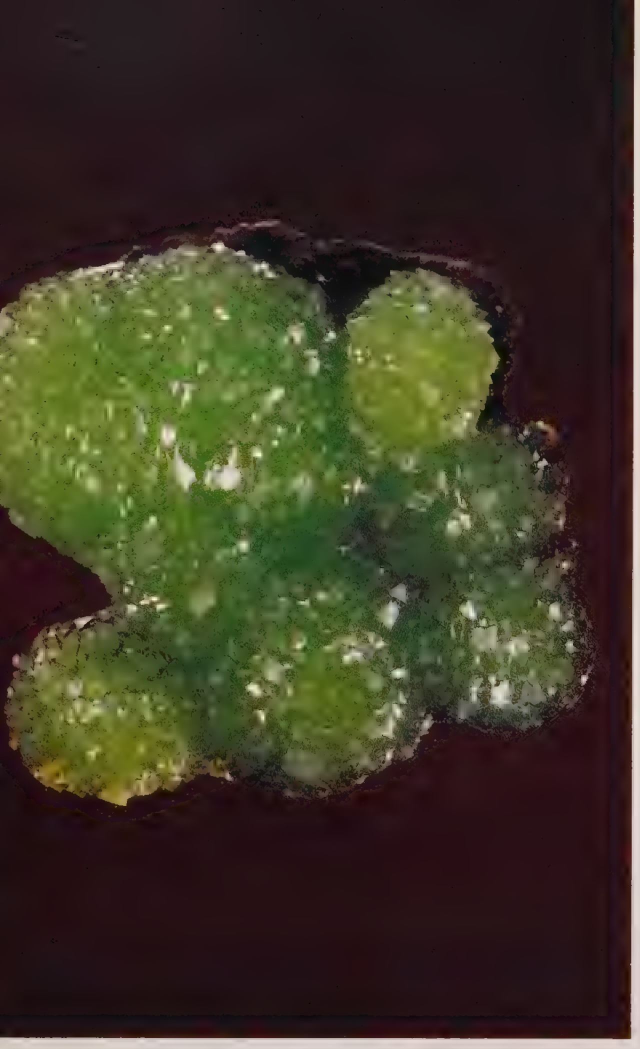
In 1598 rich secondary silver ores were discovered at the site. For almost 300 years small companies mined the lode; then in 1893 a subsidiary of the American Metal Company, Compania Minera de Penoles, bought and modernized the Ojuela. The company built an entire town on top of a peak honeycombed inside by many kilometers of old tunnels. There were two casinos, *cantinas,* stores, a dance hall, a school, a hospital, mills, homes for 2000 workers, and a cog railroad operated by Baldwin steam locomotives.

In 1899, to connect the new town and railhead with the main portal across the canyon, the John A. Roebling Company designed and built a bridge supported by hundreds of steel cables. It was the second-longest suspension bridge in the world. Penoles operated the Ojuela until 1946 when depletion of ore reserves and a mounting volume of underground water forced closure. Thousands of Penoles miners and a million tons of high-grade silver ore passed over the bridge. Neglected now for decades, its oak handrails deeply weathered by the elements, the Ojuela engineering marvel still spans the deep chasm, charming and secure.

During its prime Ojuela held many dances, religious festivals, and athletic events. The ardor for festive occasions was dampened in 1905 when a tramway cable parted, sending an entire baseball team to its death. Tragedy struck again in 1940 when 20 miners died in a cave-in. By 1979 only a few rock foundations and an occasional wall remained at Ojuela, where once 2000 people lived. The mills, casinos, *cantinas,* brothels, hospital, and school are gone. The railroad track has been torn up and removed, but its narrow winding roadbed, which cuts through solid limestone, is now a road for trucks and jeeps. The scene is one of silence and tranquility.

The Ojuela mine portal is now sealed off, but the old workings may be reached by the America Dos shaft down in the canyon. About 20 Mexican miners operate the Ojuela as a cooperative, each man receiving a percentage of the profits or sharing the losses.

The Ojuela has produced numbers of beautiful yellow to green to lavender adamite crystal clusters from 23 meters below the fifth level where the world's finest legrandite crystals were found. Brownish ore is hauled away in mule-drawn ore cars, the same system in use for more than 100 years. At lunchtime the mules are unharnessed and fed, and miners gather in a little room next to the shaft's sump. In an area dimly lit by candles before a tiny handmade wooden cross, the miners make sandwiches of beans, cheese, and chile peppers. Talk is mostly of yesteryear, for today



the Ojuela only grudgingly gives up a few remaining treasures. Now in hard times, miners are reluctant to openly discuss their ailing mine.

But there was an era when the Ojuela was the mineral collector's premier specimen locality in all Mexico. Particularly outstanding are 3-centimeter snow-white hemimorphite crystals, calcite rhombohedrons harboring tufts of malachite, legrandite clusters of golden yellow hues measuring to an astounding 23 centimeters, aurichalcite in bright aquamarine colors, pale yellow 1-centimeter paradamite crystals, marvelous dark red micro-size carminite crystals, cubes of wine-red and purple fluorite, yellow globular masses of mimetite, lustrous well-formed six-centimeter azurite crystals, and groups of small brilliant yellow and green adamite crystals on limonite matrix. When the Ojuela produces crystals in large quantity, miners carefully wrap them in tissue paper and stack them in lettuce crates for storage and shipping. Mexican businessman and mineral collector Miguel Romero has compiled a list of 108 mineral species found in the Mapimí district. Many of the beautiful crystal specimens originated in an area of the mine directly beneath the Ojuela bridge.

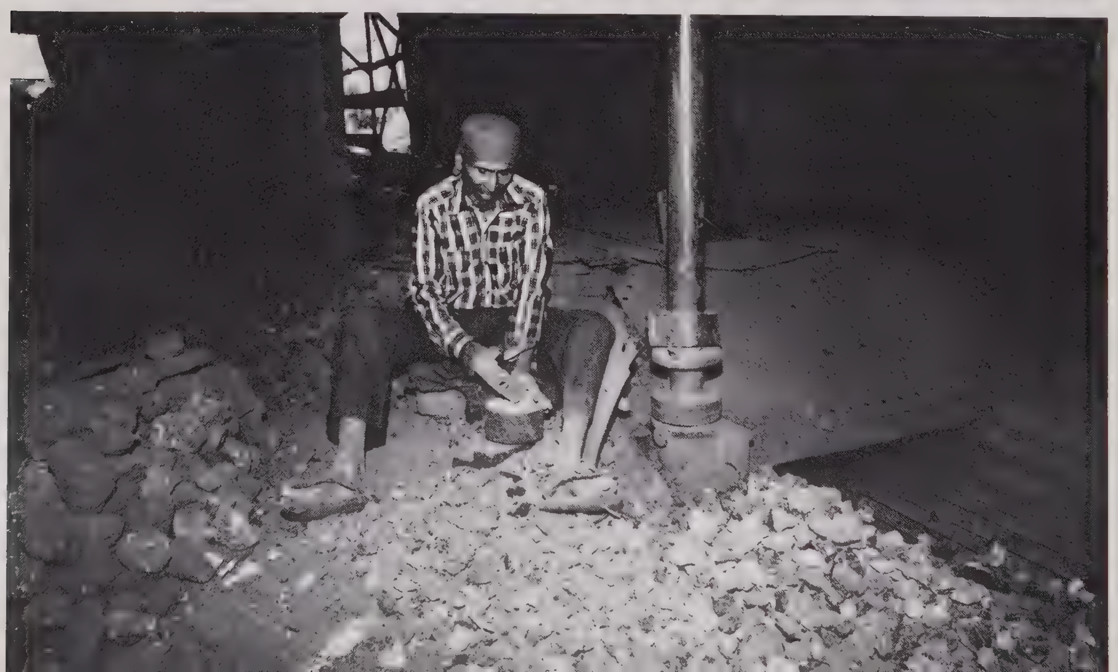
THIS PAGE TOP:
Adamite
Size: 6 by 6 cm
Locality: Ojuela mine
Collection: Norman Pellman
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM:
Legrandite on limonite
Size: 4 by 3 cm
Locality: Ojuela mine
Collection: James Minette
Photo: Rock Currier

OPPOSITE TOP:
Aurichalcite on limonite
Size: 2.5 cm
Locality: Ojuela mine
Collection: Willard Perkin
Photo: Willard Perkin

OPPOSITE BOTTOM LEFT:
Wulfenite with adamite
Size: 11 by 9 cm
Collection: Thomas McKee
Photo: Robert Jones

OPPOSITE BOTTOM RIGHT:
Adamite
Size: 3.2 by 2.5 cm
Collection: Perkins and Ann Sams
Photo: Harold and Erica Van Pelt



THIS PAGE TOP:
Mule drawn ore car, one of the last in the world, in Ojuela, 1979
Photo: Peter Bancroft

THIS PAGE MIDDLE:
John Whitmire and Santos Parga in Ojuela pocket where giant legrandite crystals were discovered, 1979
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Mexican miner cobbing silver ore, America Dos shaft, 1979
Photo: Peter Bancroft

OPPOSITE TOP:
Old house in El Cobre made in part with hand-hewn black bricks from the smelter's slag
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Scorodite on quartz
Size: crystal 1.5 cm
Locality: El Cobre mine, Concepción del Oro
Collection: American Museum of Natural History
Photo: Arthur Singer

29 Aranzazú/El Cobre Mines, Concepción del Oro, Mexico

Concepción del Oro is one of Mexico's greatest gold, silver, and lead mining districts. Concepción is a name commonly given to many places in the Christian world, but there is only one Concepción del Oro. The most important town in the district bears the same name and is on the western edge of the vast Zacatecas plain in northeastern Mexico. Concepción del Oro's sister town, Mazapil, lies over the mountains about 25 kilometers to the west. In between and high in the Temeroso Mountains are the tiny ghost towns of El Cobre and Aranzazú.

Approaching Concepción, the Temeroso Mountains loom just beyond the town, stark yet beautiful. Rising from the plain, sharp peaks dominate the skyline, and each peak has a soft-sounding Spanish name—Cerro de la Cruz, La Sierpe, La Pena Cargada, La Caja, and the grandest of all, El Temeroso (the timorous one). Legend tells of a witch doctor who lived on the mountain, cast spells upon the miners, then threw the miners to destruction in a deep cave within the mountain.

Concepción del Oro combines baroque style and semi-modern buildings. Its narrow cobblestone streets are busy with automobiles,

trucks, bicycles, pedestrians, and an occasional donkey-drawn cart. For the most part, shops are tiny and dark, and there is an ornate church on the town square. Concepción is headquarters for Macocozac, S.A., the Mexican mining company which operates nearby mines including the Aranzazú, Cabrestante, San Carlos, La Mexicana, El Cobre, and El Tajo (an open pit). Mazapil, once the bustling milling center for many of the district's mines, is relatively quiet today.

Long before the Spanish arrived in Zacatecas in 1568, Indians found gold in the mountains, and hammered it into images of their gods and objects for personal adornment. The Spanish, attracted by the golden amulets, discovered gold and silver outcrops high in the mountains and established the tiny towns of Aranzazú and El Cobre.

The mines prospered and, in time, became some of the richest in Mexico. The "one in five" regulation was observed; the King of Spain received one-fifth of all gold and silver recovered. Access to the outside world in those early years was by mule train over long, tortuous, and often dangerous trails.

By the 1890s other interests started operations in Mazapil. The management of the Mazapil Copper Company, based in Manchester, England, began to work mining concessions in and near Concepción acquired in 1891 and shortly thereafter a fabulous

THIS PAGE TOP:
Pancho Villa at the head of his troops, 1912

THIS PAGE BOTTOM:
Ruins of El Cobre, a virtual ghost town in 1979
Photo: Peter Bancroft

OPPOSITE TOP:
Remains of old headframe at Aranzazú, 1979
Photo: Peter Bancroft

OPPOSITE MIDDLE:
A burro contests the right-of-way on road between Concepción del Oro and Mazapil, 1979
Photo: Peter Bancroft

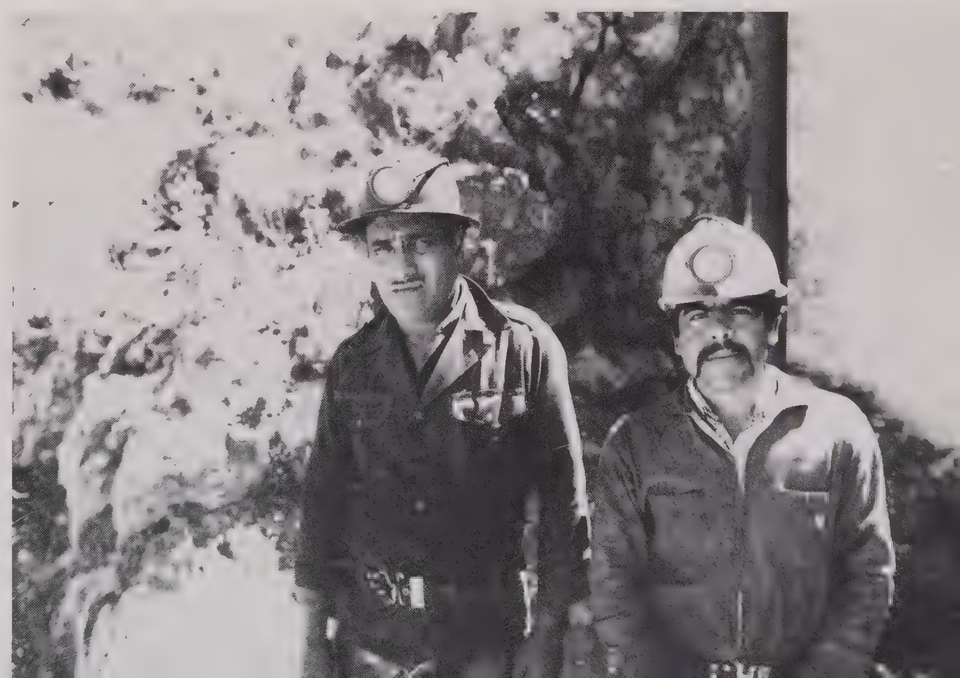
OPPOSITE BOTTOM:
Mexican miners going on shift at Aranzazú, 1979
Photo: Peter Bancroft

deposit of gold was discovered in the Las Conchas mine. Buoyed by continued successes, the British company replaced the burro trails with a narrow-gauge railroad that ran from the mines to Saltillo. Plans were made to extend the line 550 kilometers to Mazatlan on the Pacific Ocean. But not even incredible profits could finance such a grand scheme, and the project was abandoned. Until 1965 the only way to Concepción was by the little railroad, and from there to Mazapil by burro. In that year the narrow-gauge railroad was abandoned in favor of a road connecting both towns to cities in the east and west.

During the middle 1890s independent contractors took over the mines. While experienced in mining, they could neither read nor write, so no records were kept on mine production, supply inventories, or payrolls. On payday, laborers lined up at the contractor's table on which he'd piled bags of silver and gold coins. The contractor would ask each miner, "How many days did you work?" and pay him one coin for each workday. There was no paper money, no records, and each man was expected to tell the truth.

In the early 1900s the twin towns of El Cobre and Aranzazú began to reflect the ebb and flow of politics. Miners banded together, and there were rumors of impending strikes. Management countered with word of a retaliatory lockout. Then in 1911 news came that the bandit Pancho Villa was raiding in the states of Chihuahua and Zacatecas in his attempt to overthrow the government. His forces had been seen near Saltillo, but Concepción residents felt secure because of their isolation and also because Mazapil Copper Company controlled the railroad, the only means of access. In spite of difficulties, Villa's well-mounted troops advanced over the desert in record time, sacked Concepción del Oro, and burned a portion of the company's facilities. After the *rurales* (mounted state police) and *federales* (government military police) had routed the terrorists, peace returned to the towns and mining continued.

Concepción mines have contributed many fine crystals. Numerous specimens with labels showing origins as being Zacatecas, Sombrerete, and Fresnillo are in fact the products of Concepción del Oro, Aranzazú, and El Cobre. Splendid specimens from the mines include rich pink sphaerocobaltite in rounded groups of 1-centimeter crystals; clusters of green calcite crystals, frequently forming on quartz; fine combinations of



tetrahedrite and sphalerite crystals; bournonite crystals to 2.5 centimeters; beautiful white calcite and quartz groups; particularly deep blue-green scorodite crystals of 1 centimeter and more on quartz crystals. Usually developed as gossans in numerous worldwide mineral deposits, scorodite crystals from Aranzazú are very large and highly prized by collectors. Few more than a dozen outstanding scorodite crystal groups have been mined. Crystal-laden vugs are seldom opened in Concepción veins, but the tunnels, some 460 meters in length, have areas rich in molybdenite and scheelite, thus ensuring a future for the old camps. The old Santa Rosa mine, extremely unsafe today, is frequently worked by unemployed miners who risk their lives for small amounts of high-quality turquoise.

Today, Concepción is a bustling little town, and the Macocozac mines are very busy. Government-owned Macocozac, S.A. is investing millions of dollars for a new mill which will double concentrate capacity. Plans are being drawn for facilities to process molybdenum and tungsten. But up in the canyon, El Cobre and Aranzazú sleep through the long clear days and cool nights. Most adobe dwellings lack roofs, doors, and window panes. The few remaining stores are boarded shut or abandoned, and gnarled peach and apple trees peek from behind tumble-down structures. Three or four buildings out on the flat and in the draws are still occupied, keeping the ruins from ghost town status. While strolling weed-filled streets, one conjures images of days when miners sat in the shade of verandas, hand-rolled cigarettes drooping from the corners of their mouths, contemplating each person who passed by.

BELOW:
(Pink) sphaerocobaltite, (black) bournonite on pyrite, (green) calcite on quartz
Size: each specimen about 5 by 5 cm
Locality: Concepción del Oro, (bournonite—Noche Buena)
Collection: Kerith Graeber
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Pyrargyrite crystals on quartz
Size: (crystals) 5.5 by 5 cm
Location: Guanajuato
Collection: Smithsonian Institution
Photo: Wendell E. Wilson

OPPOSITE BOTTOM:
Pyrargyrite on amethyst
Size: 12.2 by 7.8 cm
Locality: Valenciana (mined 1870)
Collection: British Museum Natural History
Photo: Peter Green

30 Valenciana Mine, Guanajuato, Mexico

Guanajuato, aptly called the "treasure house of Mexico," at one time in history produced three-fifths of the world's silver. In all probability early Aztecs mined silver here as far back as the 13th century, but it remained for the Spaniards, after Cortés's conquest in 1519, to commence systematic development of the immense ore deposits. Cortés was impressed with the potential riches of Guanajuato and praised its virtues to his king. Since then, according to estimates, more than $2 billion in silver has been removed from the Veta Madre vein, the "backbone lode of Guanajuato."

The *pueblo* of Guanajuato, lying at the bottom of a bowl formed by steep-sided mountains, is about 250 kilometers northwest

THIS PAGE TOP:
Old portal at the Valenciana mine, c. 1900
Courtesy: Percy F. Martin, Mexico Treasure House

THIS PAGE BOTTOM:
Miners in hot Valenciana gallery, c. 1890
Courtesy: Rickard, Journeys of Observation

OPPOSITE TOP:
Horse-whim lift at Guanajuato, c. 1880
Courtesy: Martin, Mexico Treasure House

OPPOSITE BOTTOM:
Mummies of miner's daughters (deaths c. 1900) on display in Pantheon museum, Guanajuato
Photo: Peter Bancroft

of Mexico City. Crags in the surrounding mountains cradle the great silver mines of Rayas and Valenciana. At this writing both mines still operate and the history of the older Valenciana dates back to 1760 when a shaft was sunk on the main vein and tunnels were extended by the fire-set method. (Wood is burned against the face of a tunnel until the wall is hot. The wall is then quenched with cold water, causing portions of the rock to splinter.) In later years *buscon* (independent mining contractor) leases were arranged; company-owned property was leased to a *buscon* who employed his own crew to work the mine. High-grade ore was stacked into two equal piles, one for the company and the other for the *buscon.*

In 1807 the Valenciana's great El Tiro General shaft, 550 meters deep, became the wonder of Mexican mining. The shaft was shaped to octagonal form and faced with hand-set stones. Visitor Robert Bunsen of Leadville, Colorado, said in 1881: "A man can read his paper at the bottom of the shaft by direct light from the sun, because here in the tropics during the summer solstice the sun is vertically overhead."

From its beginning the Valenciana was a rich mine, and a succession of owners became wealthy from the steady outpour of ore. Antonio Obregón, a Mexican rancher of modest means, helped a poor peon who was down on his luck. In return, the peon promised to find a strike for him and did—the Valenciana! Obregón became, at the time, the wealthiest man in the world. He spent a million dollars constructing the Valenciana church with the most ornate altar in Mexico. Obregón could have been far wealthier had he known while his mills recovered silver from Valenciana ores, he was discarding a fortune in gold to the rivers below. Years later when the metallurgical error was discovered, others got rich working the sands downstream. In the mid-1880s the United Mexico Company recovered great wealth from lower-grade ores at depths below the 300-meter level.

The Valenciana also yielded great quantities of fine crystals, many belonging to various silver species. Most famous are argentite, polybasite, proustite, pyrargyrite, stephanite, milarite, quartz, orthoclase, and pure silver. In 1889 mineral dealer A.E. Foote described "a truly great example of a rose calcite twin, the finest ever seen." Foote asked $50 for the 17-centimeter specimen, a very large sum in those days. Nailhead calcite crystals were

common, occasionally forming on drusy amethyst.

Outstanding crystal specimens from Guanajuato are in the collections of Miguel Romero of Tehuacan, Mexico, and the Smithsonian Institution. One of the most attractive mineral specimens of any species comprises four separate pyrargyrite crystals, each measuring at least 1.5 by 1.5 centimeters, and a number of smaller pyrargyrite crystal groups imbedded among medium-colored amethyst crystals. This remarkable specimen, mined in the Valenciana mine in 1870, is displayed at the British Museum of Natural History.

Guanajuato mines have contributed two new mineral species: guanajuatite and aguilarite. The very rare naumannite occurs sparingly. Bright pink apophyllite crystals have been mined at the El Refugio, while amethyst appears in considerable quantity in a number of Guanajuato mines, principally the San Juan de Rayas and the Valenciana.

Devout Mexican miners frequently decorated mine grottos with candle-lit altars; 128 meters into the Valenciana, miners built an entire church and kept lamps burning continually. No miner

THIS PAGE TOP:
Milarite, feldspar
Size: 13 by 10 cm
Locality: Valenciana mine
Collection: Miguel Romero
Photo: Rock Currier

THIS PAGE BOTTOM:
Polybasite on calcite
Size: crystal 3 cm
Locality: Guanajuato mine
Collection: Miguel Romero
Photo: Rock Currier

OPPOSITE TOP:
Valenciana miners on the 550 meter level, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT:
Remains of ovens and shaft, Valenciana mine, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Old drift in the Valenciana as it looked in 1979
Photo: Peter Bancroft

would pass without bowing to the painted images.

Downtown Guanajuato features the prison as a famous landmark. More than 170 years ago, a priest named Miguel Hidalgo led his revolutionary army into Guanajuato, massacred scores of people, and looted the city. Riding beyond in search of other cities to conquer, he was captured in the city of Chihuahua and executed with three lieutenants. Their heads were sent to Guanajuato and stuck on poles atop the prison. The poles, still in place, may be seen today while Hidalgo is revered as a Mexican patriot.

Around 1950 the Valenciana shut down and its staff moved to the more prosperous San Juan de Rayas mine. The historic old mine remained closed for 25 years and appeared finished. In 1975, however, engineers entered the El Tiro General shaft and limited mining began again amid optimistic reports. The nearby Torres mine currently produces large quantities of high-grade silver and is reported to be the richest mine in Mexico.

Although relatively unknown to tourists, Guanajuato is one of Mexico's greatest attractions. It offers old mines, new mines, ore dumps, gracious hotels, picturesque scenery, the very good University of Guanajuato mineral collection, and of course, the Municipal Pantheon. Undraped mummies at the Pantheon cemetery draw the curious, and the marketplace overflows with artwork, crafts, fruits, and food. Colorful, gay, and retaining the flavor of the old world, Guanajuato can be a truly charming way station for the mineral collector and traveler.

31 Demix Quarry, Mont St. Hilaire, Canada

The town of St. Hilaire, located 3 kilometers south of Trans-Canada Highway 20 on Highway 116, lies about 30 kilometers east of Montreal. Just east of town is Mont St. Hilaire, a prominent undulating mound and one of 10 hills in the Monteregian chain extending for 120 miles across the St. Lawrence Lowlands. Around 1960 Richard Poudrette opened a quarry bearing his name on the north side of the hill to mine nepheline syenite rock for use as an aggregate in concrete. In 1961, just east of the Poudrette quarry, a larger operation began under the name of the Uni-Mix quarry. Today the two quarries have been consolidated under Demix Concrete, a division of Independent Cement, Incorporated.

Mont St. Hilaire, except for the quarries, was bequeathed to McGill University with the mandate that the area be preserved as a park. The quarries border university property; thus most guidelines prohibit surface expansion. It is questionable whether the quarries can continue to be profitable, though they're being worked at deeper levels.

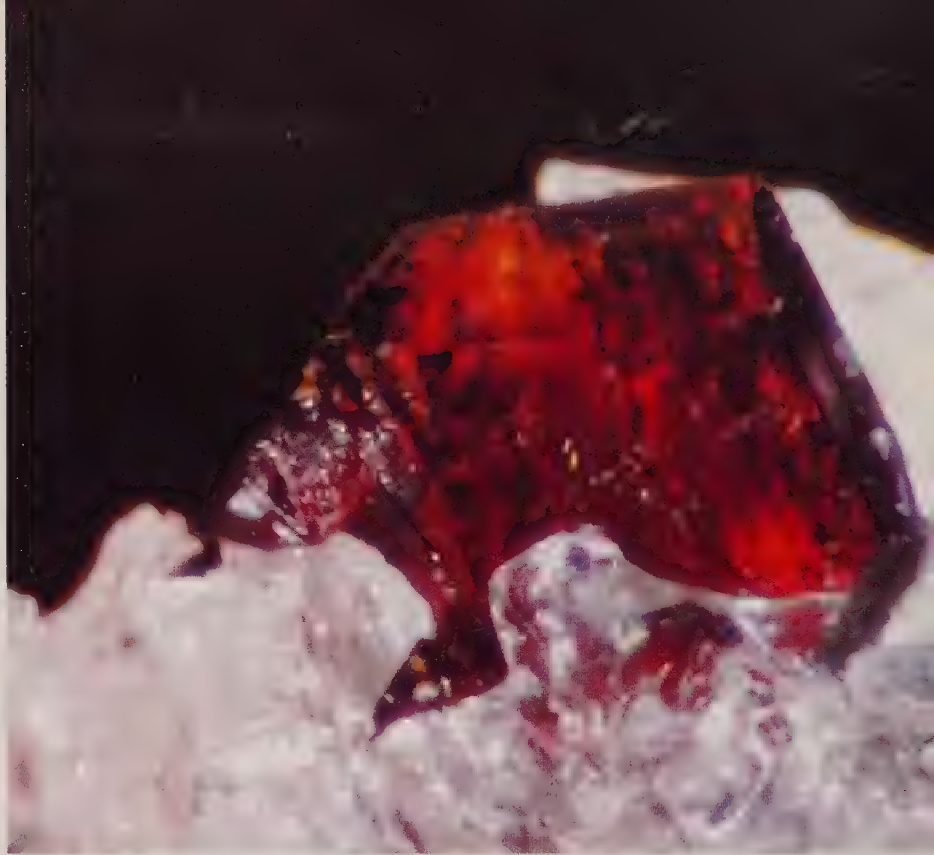
The main structure of Mont St. Hilaire comprises magmatic intrusions, stringers of primary and altered pegmatite dikes. Most of the rare mineral species occur within the dikes,

BELOW: Serandite with analcime
Size: 5 by 3 cm
Locality: Demix
Collection: Edward Bancroft
Photo: Harold and Erica Van Pelt

OPPOSITE TOP: Mangan-neptunite
Size: 1 millimeter (crystal)
Locality: Demix
Collection: Peter Tarassoff
Photo: Violet Anderson

OPPOSITE BOTTOM LEFT: Serandite with analcime
Size: 23 by 13 cm
Locality: Demix, 1977
Collection: Canadian National Museum, Ottawa
Courtesy: Canadian National Museum, Ottawa

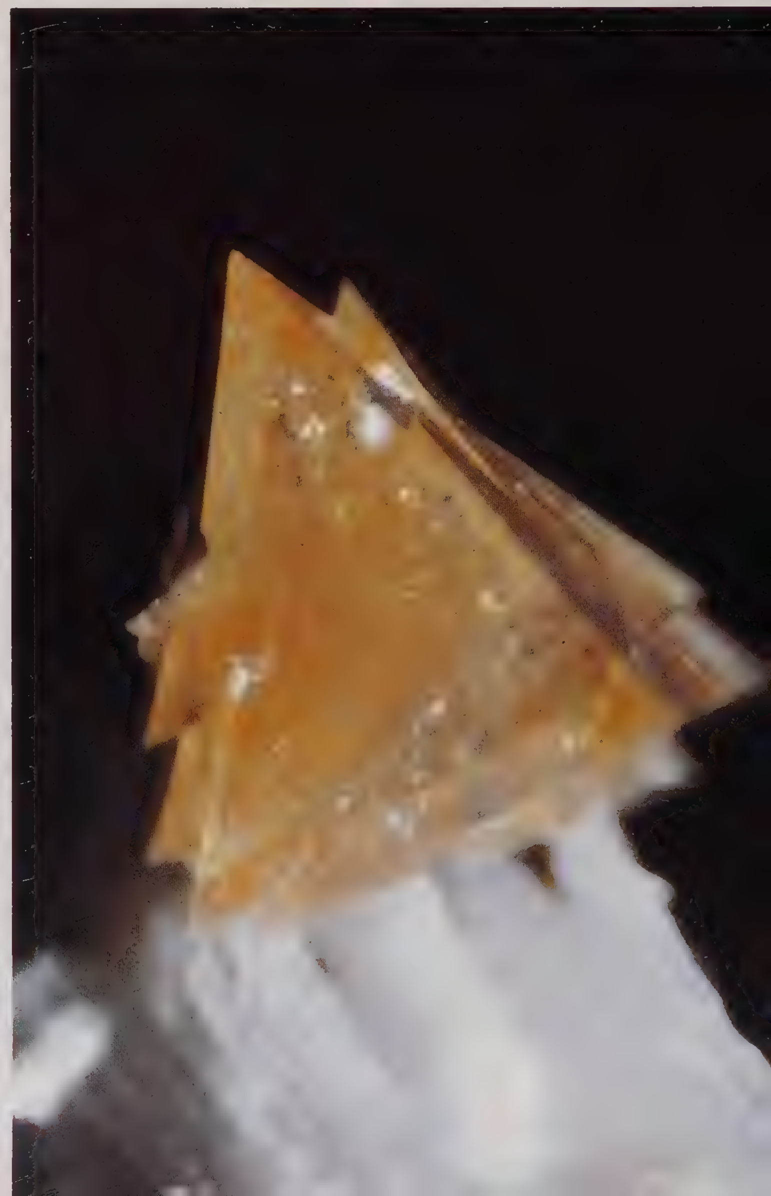
OPPOSITE BOTTOM RIGHT: Genthelvite
Size: 1.7 millimeters
Locality: Demix
Collection: Peter Tarassof
Photo: Violet Anderson



many of which are quite small and measure from 2 to 40 centimeters in thickness.

St. Hilaire first attracted attention in 1962 as a source of unusual minerals when Frank Melanson, then a salesman for a paper products company, began to collect at the quarry. The next year members of the Montreal Gem and Mineral Club visited the property. Melanson and club members began to encounter a variety of unfamiliar minerals, some of them particularly pretty. Melanson brought a selection to Professor Guy Perrault in the Department of Geological Engineering at Ecole Polytechnique in Montreal for identification.

Soon thereafter work on other crystals from St. Hilaire began at McGill University, the Royal Ontario Museum in Toronto (by J.A. Mandarino), and at Carleton University in Ottawa (by George Chao). The first published descriptions of St. Hilaire minerals appeared in the *Canadian Mineralogist* in 1964 when



McGill University's G.B. Pendlebury described catapleiite and J. Boissonnault and Guy Perrault of Ecole Polytechnique discussed serandite. The first reference to St. Hilaire microminerals appeared in Neal Yedlin's Micromounter column in *Rocks and Minerals* in 1965.

At the beginning quarry owners tolerated visits by individual collectors, groups, and the Montreal Gem and Mineral Club. Each group took care of its own safety programs. As the quarries expanded, overburden became steeper and more dangerous, and by 1966 the company prohibited anyone under the age of 18 to hunt specimens. Adults could still collect, provided they paid "the salary of a watchman" to stand guard. In 1967 the attorney for Demix advised the new owners to close the quarry to all collectors because, despite the rules, children were seen in the quarry and hardhats were not worn. An exception was made for a short time when the Montreal Gem Club successfully argued that the quarry should be open for collecting during Expo '67. In 1973 a stray collector's hammer was taken up with rock, passed through the crusher, and caused $3000 damage to the machinery. The company's interest in cooperating with collectors dropped to a new low. Ecole Polytechnique negotiated a policy of controlled access and now handles all arrangements for field trips. Organized groups may still apply for a permit to collect at the Demix provided they carry substantial liability insurance.

Demix, a micromounter's dream, has produced more than 160 different species of

THIS PAGE TOP:
Demix quarry being mined for rock aggregates in 1971
Photo: Rock Currier

THIS PAGE BOTTOM:
View of Mont St. Hilaire and quarries
Photo: Laura Marble

OPPOSITE LEFT:
Ekanite pierced by acmite
Size: 1.75 millimeters
Locality: Demix
Collection: Royal Ontario Museum
Photo: Violet Anderson

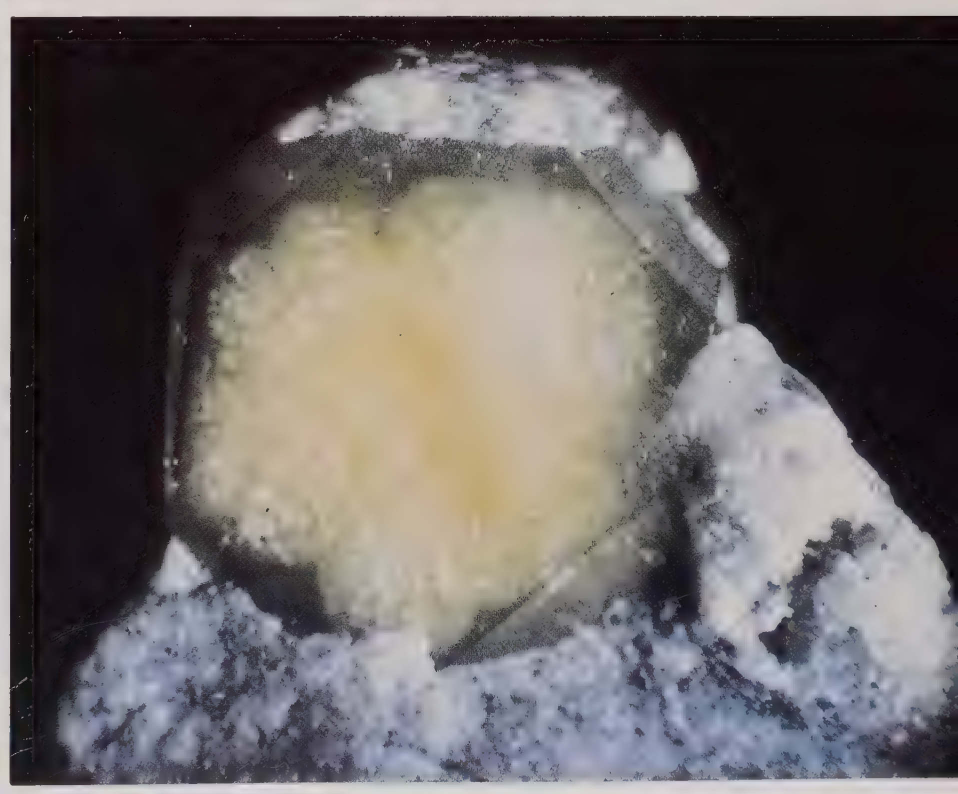
OPPOSITE RIGHT:
Narsarsukite
Size: 1 millimeter (crystal)
Locality: Demix
Collection: Laura Marble
Photo: Delbert Oswald

minerals and researchers feel that more will be identified shortly. Many species occur as tiny beautifully-formed crystals of delicate hues. A few of those noted in various articles by micromounters Violet Anderson and Laura Marble include: water-clear wafers of catapleiite; pale yellow monteregianite; light gray synchysite; tiny prisms of acmite of dark green, brown, and black; tetragonal forms of honey-yellow narsarsukite; coral-pink nordstrandite; blue apatite with flat pinacoid terminations; tetrahedrons of pale yellow genthelvite; gemmy yellow crystals of zircon; tan-colored ekanite crystals; prismatic yellow wulfenite; and tiny labuntsovite sprouting colorful orange-red crystals resembling projecting antennas on a spaceship.

Anderson's personal collection contains a remarkable group of minerals, each skewered upon acmite crystals. These include albite, analcime, catapleiite, ekanite, fluorite, genthelvite, nenadkevichite, rhodochrosite, and pyrochlore, "each spiked by acmite."

Nine new minerals from Mont St. Hilaire were recently established: gaidonnayite, hilairite (named after the locality), carletonite, donnayite, lemoynite, monteregianite, paranatrolite, petarasite, and yofortierite. Several other new species will shortly be named, and at least 15 other minerals collected at Mont St. Hilaire remain unidentified. Many of them may turn out to be new. Siderite crystals, in record size, were taken from the old Poudrette quarry, and large analcime crystals were recovered from the Demix quarry. A group of giant siderite crystals that weigh nearly 50 kilograms is in the Smithsonian Institution collection.

Orange tabular crystals of serandite studded by snow-white analcime crystals occur in exceptional sizes at the Demix quarry. In 1973 Rolland Bouhelier dug into a pipe-like vug and found a few serandite crystals of unique quality. The magnificent specimen in the Canadian National Museum of Natural Sciences in



Ottawa came from the pocket. Later, Gilbert George penetrated further into the vug and made another sensational find of serandite crystals, the best of which went to Harvard University and Smithsonian collections.

The great Mont St. Hilaire quarries, prolific producers of uncommon and exotic mineral species in past years, seem destined to continue as sources of outstanding microsized crystals. Quite possibly they may still contain unknown minerals.

THIS PAGE TOP:
Collectors working the face of a siderite pocket in the Demix, 1971
Photo: Rock Currier

THIS PAGE MIDDLE:
Rockhounds search for serandite in the Demix
Photo: Rock Currier

THIS PAGE BOTTOM:
Theodore Agos and Richard Kosnar in the Demix
Photo: Rock Currier

OPPOSITE:
In 1879 wooden boxes lowered men and raised rock in the Jeffrey Quarry
Courtesy: Canadian Johns-Manville Co., Ltd.

32 Jeffrey Mine, Asbestos, Quebec, Canada

During the early 18th century, farmers' wives in southern Quebec discovered they could remove long fibers from rocks found in their pastures and weave them into mittens, pot holders, and bits of clothing. The cloth from this material proved to be durable and uniquely fireproof. But the Canadian ladies, knowing little of mineralogy, failed to recognize the silky fibers as chrysotile, the mineral name for high-quality asbestos. They never dreamed that the farming ground they knew as Webb's ledge covered one of the world's greatest asbestos deposits. This knoll stands 160 kilometers east of Montreal in a region of low-rolling, tree-covered hills.

Early in the 1800s Charlie Webb attempted to sell his tract to Jim Gifford for $50.00, but the numerous outcrops and loose rock in the soil discouraged Gifford who noted "the land isn't worth it." In 1881 Evan Williams, a visiting Welsh miner, realized the importance of the chrysotile deposit and persuaded W.A. Jeffrey, an affluent local farmer, to buy the property and finance a mine.

Jeffrey worked his property using crude methods for 14 years with some small success and paid Webb a royalty of $10 a ton for fiber collected in the summer and $5 a ton for winter fiber. He drilled the rock with hand steel and sledge. When drill holes reached 5 meters, they were loaded with black powder and blasted. Fiber was hand-chiseled from the rock, and the cobbed material was put into trolleys, which traveled wooden rails to the cobbing shed. Refined ore was bagged and shipped by horse and wagon to Danville, 5 kilometers away, weather permitting. In 1895 Jeffrey sold his interests to Feodor Boas, who

formed the Asbestos and Asbestic Company.

The new firm constructed wooden towers as tall as 24 meters to support aerial cableways operated by hoist engines. Men were lowered and raised from the deepening pits in the same open wooden boxes that carried ore to the surface. Production increased dramatically in 1900 when pneumatic drills were introduced. A system to recover short-fibered asbestos also increased output.

With the widening of the pit, special alloy, 5-centimeter steel ropes began to break with increasing frequency. By the time the pit was 610 meters wide, the overhead cable system was abandoned completely. A spiral benching technique was used, providing a ramp that circled the interior of the pit to the bottom. A standard-gauge track and bulb-stacked steam locomotives carried ore and waste from the bottom of the pit to the surface. Later a haulage system utilized trucks with capacities up to 200 tons. By 1977 the pit reached 2 kilometers in diameter and more than 310 meters in depth while producing 2200 tons of fiber a day. The town of Asbestos, on the east edge of the mine, grew with the mine.

BELOW: Grossular
Size: 35 by 26 millimeters
Locality: Jeffrey quarry
Collection: John Barlow
Photo: Olaf Medenbach

OPPOSITE TOP:
Grossular
Size: 8 by 6.5 cm
Locality: Jeffrey quarry
Collection: John Barlow
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Prehnite
Size: 2.5 millimeters
Locality: Jeffrey quarry
Collection: Violet Anderson
Photo: Violet Anderson

Extensive crushers and mills developed to the south. The town, housing hundreds of miners and their families, had recreation centers, markets and shops, parks, a trade school, swimming pool, post office, hotel, town hall, and health clinic.

In 1918 Canadian Johns-Manville Company Limited (C.J.M.) acquired control and management of the Jeffrey mine. This company, known as Johns-Manville Canada Inc. since 1979, still operates the property. A three-way improvement plan increased ore production, modernized equipment and improved safety and health standards for miners and their families. This mode of operation continues today. Every effort is made to make the recovery of asbestos a dust-free operation. Water trucks spray road and work surfaces, and drilling machines are fitted with bag filters. Johns-Manville is proud of its dustless mills.

Until recent times no one knew that mine dust, whether silica or asbestos, was unhealthy. Nowadays, many major mines, and particularly the Jeffrey, have instituted industrial hygiene techniques, and the danger for miners and townspeople is practically nonexistent.

As the mine grew, ground control became a major problem. A few years ago a major slide of overburden occurred, carrying some houses and machinery into the pit though no one was hurt. To avoid such slides in the future,

THIS PAGE TOP:
Buildings and open pit at Jeffrey in 1900
Courtesy: CJM Co.

THIS PAGE BOTTOM:
Old workings at Jeffrey, 1905
Courtesy: CJM Co.

OPPOSITE TOP:
Jumbo 200-ton ore carrier at the Jeffrey
Courtesy: Canadian Johns-Manville Co., Limited

OPPOSITE BOTTOM:
Reinforcing drift with concrete, 1960
Courtesy CJM Co.

overburden slopes are now kept between 17 and 24 degrees. In order to maintain these slopes and still mine ore at desirable depths, the pit had to be expanded. A five-year pit expansion plan required relocation of machine shops, storage facilities, electrical shop operations offices, and the sewage plant. It all cost $77 million. A major part of the town has also moved to a new location. Hundreds of buildings have been involved. Modernization programs continue today. The company is moving toward large truck haulage; the newest additions carry 200 tons each. Ammonium nitrate "slurries," considered the best type of explosive for the Jeffrey, are mixed on the plant site and fed into holes in controlled proportions. Radio communications link all mobile equipment and mobile workshops facilitate field repairs.

Most chrysotile occurs in a stockwork of fiber veins in serpentine. Countless fissures through which mineral-laden waters flowed contain beautiful crystals, representing a large number of mineral species.

Famous at the Jeffrey mine are the grossular (garnet) crystals which most frequently occur in colors of honey, cinnamon, and brown, but also shades of pink and apple green. The crystals, growing to 3 centimeters, are bright and well-formed dodecahedrons and trapezohedrons, each frequently marked with splendid striations. Grossular crystals usually occur in clusters with each crystal striving to dominate its neighbors. Colorless, brown, brandy-colored, and green grossular have been found in clear crystals, which may be cut into beautiful flawless gemstones. In rare instances, grossular appears with other species such as diopside, allanite, thomsonite, albite, and zoisite, and pleases the eye when it does. Other attractive Jeffrey crystals are pectolite, diopside, heazlewoodite, apophyllite, aragonite, clinozoisite, prehnite, magnetite, wollastonite (some of them facet-grade), and ripidolite. Recent discoveries include prehnite crystals in elongated blades, individual white prehnite crystals on deep emerald-green grossular crystals, and green vesuvianite crystals terminated in pink and deep purple (the longest measuring 11 centimeters), while others are pale green and gemmy brown. In December 1980 spertiniite, a new navy-blue copper hydroxide, was discovered by Francisco Spertini, a Jeffrey mine geologist.

Because of safety considerations, collecting is not permitted in the pit. But Johns-Manville is seriously interested in helping museum curators and amateur collectors. When a new mine area produces crystals, truckloads of rock are gathered and deposited just outside the mine property. Here collectors can work to their hearts' content, free of "keep out" signs and permits.

The Jeffrey mine, second in size only to the Asbest mine in the Ural Mountains of the Soviet Union, has vast chrysotile asbestos reserves blocked out, indicating a long and productive future.

33 Arsuk Fjord Mine, Ivigtut, Kalaallit Nunaat, Greenland

Cryolite, one of the most unusual species in the mineral kingdom, has nearly the same refractive index as water. When placed in water, some samples almost disappear. Much cryolite contains inclusions of air bubbles which become visible when the specimen is immersed in water. During the 17th century, "Greenlander" fishermen used cryolite as weights on their lines and nets. (It is not known if they used it because of the ease with which it could be fashioned or, as some assume, because the weights were invisible to fish.) A sawn section of cryolite-containing quartz crystals, when placed in water, becomes a marvel—the matrix cryolite is nearly invisible, and small quartz crystals (some to 5 centimeters and doubly terminated) seem to float in the water. Very rare, well-developed cryolite crystals are ordinarily cuboidal in form. Two specimens with fine crystals and a sample in water are displayed in the Mineralogy Museum at the University of Copenhagen.

Cryolite is known from 19 localities worldwide, but only Pike's Peak, Colorado, and Miask, Soviet Union, have produced larger pieces. The Arsuk Fjord deposit at Ivigtut, Greenland, remains the only source with enough of the mineral to have been mined commercially. Ivigtut, a most remote and unique mineral deposit, is located near the southern tip of Greenland just north of the 61st parallel at about the same latitude as Helsinki and Anchorage. The town has about 150 inhabitants. Its amenities include a small hospital, school, radio station, tennis and badminton courts, bowling alleys, and a shooting range. All supplies except fish are imported. The harbor freezes during winter months and the ocean is rough the rest of the year. Until 1870, Ivigtut miners received mail only once a year. As late as World War I, ships from Denmark arrived but once or twice annually.

Cryolite from Ivigtut was analyzed in 1799 and named from the Greek words for frost and stone, or ice-stone. The deposit was not exploited until 1859 when the Danish chemist Julius Thomsen, discovered a method of making soda from cryolite. A small amount of silver-rich galena on the east edge of the

BELOW:
Ivigtut Quarry, 1975
Photo: Ole Petersen

OPPOSITE:
Cryolite with limonite
Size: 12 by 9 cm
Locality: Ivigtut
Collection: Mineral Museum, University of Copenhagen
Photo: Olaf Medenbach

deposit was mined by British mining engineer J.W. Tayler, but never became important commercially.

In 1868 Søren Fritz, a Danish army engineer, came to manage the open pit mine and did so with considerable efficiency. He built a dam along the sea to keep out the ocean. When the time came to work part way up the pit face, he let in seawater to the proper level where it would freeze and remain as a miner's platform from November to March. With the coming of warmer weather the ice would melt, seawater would be pumped out, and the bottom of the pit could be worked once again. A haulage ditch carried ore from the pit to the dock. The ditch was deepened a little and converted to a canal, bringing seawater to the pit in the fall and removing it in spring. Fritz's master plan was successfully used for nearly 50 years.

New uses for fluorine-rich cryolite were discovered in the glass, enamel and aluminum industries. (Powered bauxite is dissolved in molten cryolite and, when electrolyzed, metal

aluminum results.) Because of cryolite's importance in the aluminum refining process, the Arsuk Fjord deposit attracted global attention.

Compared with giant copper ore masses in Zambia and Zaire, and iron deposits in Minnesota and Minas Gerais, Ivigtut is very small indeed. The granite stock measures 300 by 550 meters, and the cryolite ore body in the top of the mass was much smaller—only 80 by 200 meters. Core drilling accurately defined its boundaries and to date no new stringers or deposits have been discovered.

Cryolite occurs at Ivigtut in fine crystal form, but other minerals also appear: canfieldite, hessite, galena, sphalerite, chalcopyrite, fluorite, topaz, quartz, siderite, weberite, jarlite, tantalite, cryolithionite, arsenopyrite, cassiterite, molybdenite, thomsenolite, pachnolite, ralstonite and chiolite.

THIS PAGE TOP LEFT:
Ivigtut and Arsuk Fjord from doctor's house, 1869
Courtesy: Mineral Museum, University of Copenhagen

THIS PAGE TOP RIGHT:
Mine manager Søren Fritz (front) with doctor, marine engineer, storekeeper and wife. May, 1868
Courtesy: Mineral Museum, University of Copenhagen

THIS PAGE BOTTOM:
Assistant manager's house with ships Argenta, Soduine *and* Fluorine *at piers. October, 1890*
Courtesy: Mineral Museum, University of Copenhagen

OPPOSITE TOP:
Snug miners' houses in Ivigtut, 1978
Photo: Flyngsie Jacobsen

OPPOSITE BOTTOM LEFT:
Quarry in 1937, upper pillars date to 1880
Photo: Richard Bødvad

OPPOSITE BOTTOM RIGHT:
In 1950s much of the mining was at the end of a rope
Photo: Hans Pauly

Ore was shipped 3000 kilometers to the modern Kryolitselskabet Øresund mineral refinery in Copenhagen aboard diesel-powered freighters that replaced 19th century barks, like the *Soduine, Argenta* and *Fluorine.*

After 103 years, mining ceased in 1962. Ore from Ivigtut stockpiles is still shipped to Copenhagen. How long the stockpiles will last is not known, but probably not for more than a few years—and then all activities involving cryolite will cease.

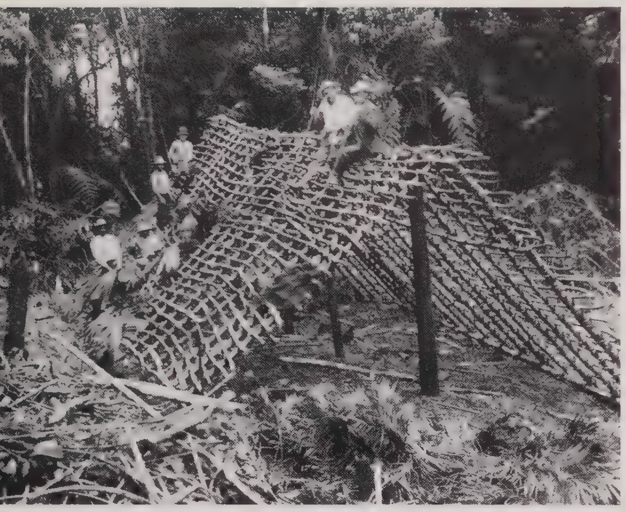
34 Chivor Mine, Chivor, Colombia

Possibly as early as the 13th century, Chibcha Indians mined emeralds in South America's northwest territory now known as Colombia. Chibcha chiefs and priests, enchanted with the beauty of the green gemstones, used them to placate angry gods and honor friendly spirits. Crystals set in solid gold were used for personal adornment. Other Indian cultures, notably the Mayas, Aztecs, Toltecs, and Incas, sent emissaries to barter for the prized green stones. Emeralds became talismans of various religious groups throughout Central America and much of South America. The Incas dearly loved their treasures, poetically referring to gold as "sweat of the sun" and emeralds as "tears of the moon goddess, Fura." It is said that Montezuma II, Emperor of Mexico, attended important functions bedecked from head to foot with deep green emeralds.

Early in the 16th century, Spanish *conquistadores* came to the Americas, searching for wealth. Displaying gifts and gestures of friendship, the explorers—soldiers, priests, sailors, and agricultural specialists—embarked upon a looting and murder spree seldom rivaled in history. If treasures were not promptly offered, the conquerors tortured natives until they revealed their hiding places. Suspicious Spaniards, uncertain as to the authenticity of many of the emeralds, frequently resorted to "testing" by placing a stone on an anvil and striking it with a hammer. If the stone survived, it was judged an emerald. How many priceless stones were lost with this process cannot be known, but the number must have been substantial.

BELOW:
Emerald in quartz
Size: 4.5 by 3 cm
Locality: Chivor
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE: Emeralds (15) and diamonds (more than 360) make up the "Inquisition necklace"
Age: 300 years;
treasure of the Spanish and French courts
Collection: Smithsonian Institution
Photo: Dane Penland



Treasure was placed aboard galleons and shipped to Spain from Cartagena, Colombia, and Esmeraldas, Ecuador. Francisco Pizarro accumulated enormous amounts of emeralds and gold, assembled his treasure in Peru and, in 1533, sent perhaps the greatest shipment of all back to Spain: four chests of emeralds, tons of gold, and other booty.

As emerald jewelry and artifacts became exhausted, the Spaniards searched for the original emerald mines. Indians refused to reveal the locations, although many were tortured in attempts to gain information.

In the spring of 1536, General Gonzalo Jimenez de Quesada and a tiny army of Spanish soldiers marched south from the port city of Santa Marta, Colombia, in search of emeralds. They spent more than a year hacking a way through the jungle and finally arrived at Guacheta, an Indian village near the site of Bogotá. The Chibcha's king thought these mounted, armored, and bearded soldiers with guns that roared like thunder were demons from the sky. He gathered all the emeralds and gold he could transport and fled. Quesada's men eagerly divided the remaining treasure, reserving one-fifth for the crown. Next they marched on Tunja, a village whose chief, Quimuinchatecha, was caught trying to conceal his treasure. In three hours the Spaniards "had piled gold, ornaments, turquoise, and emeralds in a heap in the courtyard of the palace, until the loot was breast-high to a man on horseback."

Returning to Bogotá, the Spaniards noticed some of their horses were shoeless and footsore. Lacking the necessary iron, the Spaniards proceeded to beat gold into the proper shape and shod their mounts with pure gold.

Again the Spaniards searched for the source of the emeralds, a place known as Somondoco, the Indian name meaning "god of green stones." Quesada sent Captain Pedro Fernandez Valenzuela and a troop of 40 soldiers into the mountains to the east. Within a few days, Valenzuela's men discovered the Somondoco mine (later known as Chivor). Reinforcements were sent and the mine taken from the Indians. Soldiers told of a gap in the mountains to the south through which one could see the great Orinoco plains which were visible only from the mine, a fact that proved useful then and valuable later.

Realizing large quantities of water would improve the mining process, the Spaniards built an incredible 11.2-kilometer canal around

THIS PAGE TOP:
Hauling mining supplies to Chivor, c. 1890
Photo: Hans Klein

THIS PAGE MIDDLE:
Constructing a worker's hut in the jungle at Chivor, c. 1890
Photo: Hans Klein

THIS PAGE BOTTOM:
Starting a new search for emeralds, c. 1890
Photo: Hans Klein

OPPOSITE TOP:
Armed guards and dogs guard Chivor, 1970
Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT:
Guards gamble away the hours when not on duty
Photo: Peter Bancroft

OPPOSITE BOTTOM MIDDLE:
Flumes pass over area worked ages ago
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Mining under watchful eyes of mine foremen and guards, 1970
Photo: Peter Bancroft

peaks, through forests, and alongside cliffs from the Rucio River to reservoirs constructed at the mine. When an area was cleared of vegetation, reservoir gates were opened and the water washed away the topsoil and debris, exposing the emerald veins.

Twelve-hundred Indians were conscripted to work in the mines under terrible conditions. Underfed, tortured, and caged in dark tunnels, many died. Over the years influential Spaniards sickened of working conditions in Chivor. Under pressure from them as well as Pope Clement VIII, in 1602 Spain's Philip II ordered better treatment of the Indians. Native workers continued to be abused, however, until Charles II ordered the mine closed in 1675.

Jungle growth crept over the old workings until they were covered and lost for more than 200 years. While studying old documents in Quito, Ecuador, a Colombian mining engineer, Don Francisco Restrepo, came upon a reference to Chivor. Writing in 1588 Father Martin de Aquado had noted that from the mine site one could see the distant Orinoco plains through a gap in the Andes known as Guavio Canyon. Just as this description had helped early travelers reach the mine, in 1896 it enabled Restrepo to rediscover Chivor.

Located about 100 kilometers northeast of Bogotá, the mine property now covers a 2-kilometer quadrangle perched at the top of a large jungle-covered mountain more than 2000 meters above sea level. Trees about the mine were removed to facilitate surveillance as well as mining. The old Spanish canal was abandoned, and in its place powerful pumps draw water from the river below through large pipes to the old reservoirs. Large wooden flumes cut through hills and over canyons to bring water to mine faces.

In 1971 all the workings were open pits, some more than 100 meters across and 30 meters deep. The rock from these pits was removed by hand. As Chibcha Indians had centuries ago, modern miners lined up in rows and, standing side by side, used 2-meter bars to pry away the rock. A bench or terrace was dug and the broken rock searched for emeralds. Waste was pushed over the side and a new bench started. Eventually the entire hill took on a terraced appearance.

The miner's day started at dawn with the "hee-haws" of donkeys closely followed by the clang of the mine bell. Miners entered the

main gate under the watchful eyes of armed guards and were closely supervised during the entire shift. Inspectors watched every move the miners made. When an emerald was uncovered, a nearby inspector immediately placed the stone in an iron safe. Chivor, the only privately-owned mining company in Colombia, spent great energy and expense trying to prevent theft but many fine stones were spirited away to buyers outside the compound anyway.

Terrace mining techniques were recently abandoned in favor of underground tunnels. Fifteen to twenty men work in a particular adit, using pneumatic hammers and dynamite. Some tunnels already extend 600 meters into the mountain. The search for emerald occurs both at the work face and outside at the dumping site. Miners look for emerald-bearing white quartz veins and work them out with picks, being careful to notice any trace of green color. The principal associated minerals are quartz, feldspar, and pyrite.

Emeralds are "hawked" on the streets of Bogotá and sold in jewelry stores; but uncut stones of great value repose in Bogotá's bank vaults. Nearly all large emeralds are sent to the lapidary, but the most famous Chivor emerald now belongs to the American Museum of Natural History. Found in 1966 and named the "Patricia Emerald," the rich green, well-terminated prism measures 6.6 by 3.1 centimeters.

Geologists predict a long and productive future for Chivor. As more crystals of "green fire" are mined, surely specimens of museum quality will continue to be unearthed along with substantial quantities of facet-grade emerald.

BELOW:
Chivor - top of the workings, 1970
Photo: Peter Bancroft

OPPOSITE:
Emerald in quartz
Size: 3.9 by 3 cm
Locality: Muzo
Collection: Julius and Miriam Zweibel
Photo: Harold and Erica Van Pelt

35 Muzo Mines, Muzo, Colombia

There is no color so pleasing to the eye as that of the emerald. Whoever delights in the verdure of herb and leaf must enjoy infinitely more the contemplation of emeralds; for no verdure can compare to theirs. They are the only stones that charm the eye without wearying it.

—Pliny the Elder, 23-79 A.D.

The Roman scholar obviously was enamored of emeralds. But the Egyptian stones he admired were of inferior quality compared to the green beryls discovered a millennium and a half later in Colombia. Were he alive today, Pliny's esteem for the limpid green New World crystals would know no bounds.

From 1531 to 1535, Francisco Pizarro and his troops conquered the Inca Empire. Other *conquistadores* campaigning northward subdued the Indians of modern-day Colombia.

Before the Spaniards came, Muzo Indians in central Colombia's Sierra Oriental (100 kilometers north of Somondoco) worked their own emerald mines. The Muzos resisted the Spanish invaders fiercely and defeated them once in a battle in the Itoco Mountains before being vanquished in 1559. The Spanish wanted

control of the region to exploit vaguely-described emerald mines and to keep their supply routes open. Settlers began to farm the area and established the settlement of Santisima Trinidad de los Muzos. At this time the Spanish had not seen emeralds which with certainty came from Muzo nor had they encountered any vestige of the actual mines.

Historians report several ways in which Spaniards were supposed to have found Muzo emeralds: A *conquistador,* wading across a stream, saw an emerald at his feet. Small emeralds appeared in the crops of chickens. The most popular story tells of a Spanish settler who rode into the little town of Muzo on August 9, 1564. His horse was lame, and when he checked the animal, found an emerald embedded in the hoof. The discovery caused great excitement. Everybody in the village retraced the trail, examining every rock until they found an outcrop rich with emeralds. However it occurred, the Muzo emerald mines were finally located.

The Spanish forced Muzo and Caijma Indians to work in the mines under dreadful conditions and recovered many marvelous emeralds. But at what cost!

Muzo is just north of the equator (about 150 kilometers north of Bogotá) at an elevation of 600 meters. The climate is tropical and hot,

THIS PAGE TOP:
Closeup of Muzo mine, c. 1900
Courtesy: Julius Petsch

THIS PAGE MIDDLE:
Mummy of Francisco Pizarro, Lima, Peru Cathedral
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Mine headquarters at Muzo, 1979
Photo: Peter Keller

OPPOSITE TOP:
Guaqueros *(scavenger miners) working waste, 1979*
Photo: Peter Keller

OPPOSITE MIDDLE:
Muzo miners, 1979
Photo: Peter Keller

OPPOSITE BOTTOM:
A horde of miners—what they find is theirs!, 1979
Photo: Peter Keller

the land covered with dense rain forest, and the area far removed from human habitation. To make matters worse, the long dark mine tunnels were hot, humid, and unventilated. Many Indians died, and most survivors fled, leaving the mining operation without labor. The mine finally closed. Apprehensive natives talked freely of a dragon who guarded it and "poured forth thunder and lightning" on those who dared ascend the river. The Spanish never reopened the property and it lay idle.

A century later, the old Muzo mine was rediscovered and new emerald-bearing ground was found and developed. Sporadic mining continues to the present. Over the years, various government agencies, corporations, and individuals worked the famous locality. But each venture has had its share of intolerable conditions, corruption, thievery, and killings. Colombians refer to it all as "emerald fever." In 1972, 900 miners died in a series of murders, which led the government to shut the mines again.

Muzo emeralds are equal or superior to those from other deposits. They tend to form in larger crystals, display greater sections of unblemished gem material, and have a slight yellow-green cast. By comparison, stones from nearby Chivor appear a bluish-green. Crystals seldom exceed 3 centimeters in length. Most emerald crystals are heavily veiled and flawed; it is exceptional when transparent sections exceed 1 carat. Relatively clear emeralds are faceted in rectangular-shaped step-cut gems, while cloudy stones or those of inferior color are frequently cut *en cabochon.* Accessory

minerals are: calcite, pyrite, and sometimes feldspar and parisite (a rare earth mineral).

Outstanding Colombian emeralds include: the 225-gram Duke of Devonshire in the British Museum of Natural History; a limestone matrix encrusted with rich-colored emerald crystals, each 3 centimeters in diameter (reported to be in the church in Loretto, Italy); a very large crystal once belonging to the Elector of Saxony, now a part of the Green Vaults of Dresden, German Democratic Republic; the great Montezuma emerald, a simulated matrix specimen covered with large crystals, in a vault of the Museum of Natural History in Vienna; and many fine specimens reportedly owned by the government and some Colombian priests. At least a half-dozen jumbo-size emerald crystals from Muzo are stored in the vaults of the Banco de la República in Bogotá. The largest and finest uncut crystal from Muzo has a deep green color, exceeds 8 by 6 centimeters, and weighs 1759 carats.

The mine area, once again reopened, comprises 9.39 square kilometers of thick layers of black Villeta shales rich in organic matter. Streaking through the shale are many white calcite veins, some of them invested with emerald crystals. Overburden is removed by

BELOW: Emerald
Weight: 1759 carats
Locality: Muzo
Collection: Banco de la República, Bogotá, Colombia
Photo: Harold and Erica Van Pelt

OPPOSITE:
Mogul Emerald, c. 1695
(Koran carved in calligraphic detail on reverse side)
Weight: 217.8 carats
Collection: Allan Caplan
Photo: Harold and Erica Van Pelt

dynamite and large bulldozers, and when calcite veins appear, mining continues by hand until each vein is exhausted.

Today, Muzo has embarked upon a mammoth development. The property has been leased to nine principals. At present at least 10 bulldozers and 500 to 1000 miners carve away great sections of the mountain. Workers sort for gems by hand. In addition some 10,000 men, women, and children frantically turn every bit of gravel in the rivers below in a search for overlooked "green fire." Surely the nonstop confusion in the river bottom represents a most amazing event in the history of mining. Some visitors feel that the stripping operation will destroy the great Muzo mine; others say the present method is faster, more profitable, and involves more workers. But all agree on one point: despite large numbers of armed soldiers and guard dogs posted everywhere, high-graders manage to spirit away a substantial portion of emeralds. Murder and general depravity continue—and probably will for as long as "green fire" smoulders at Muzo.

36 Unificada de Potosí Mine, Potosí, Bolivia

In 1544 Diego Hualca was chasing a goat when he came to a steep ledge on the side of Cerro de Potosí (Potosí Mountain). Reaching for a bush, Hualca tried to pull himself up. The bush gave way, and he fell backward, clutching it in his hand—with silvery wires entangling its roots. The ground proved to be covered with pure silver. In time, the Cerro de Potosí mine became the world's greatest producer of silver; local Quechua Indians named it "Potojchi," which means "fountain of silver." In the 16th century the Spanish mined enough silver from this one source to finance their great Armada which vainly sailed to England in 1588.

A mint was constructed in Potosí, and for centuries Spanish pieces of eight were struck on giant machines. Made of nearly pure silver, the coins became accepted currency throughout the world.

While the Potosí was being mined for silver, a heavy black mineral associated with the silver caused continuing problems for the mills. Considered worthless, the black concentrate was passed into the tailings. Finally recognized as cassiterite, a high-grade tin ore, the tailings were worked by a dredge.

When the deposits of silver finally gave out, miners turned their attention to masses of other minerals still locked within the mountain. The Cerro became one of the world's great tin mines and, in the process, poured out a variety of finely crystallized mineral specimens including lazulite, proustite, wolframite, pyrargyrite, silver, cassiterite, ferberite, and phosphophyllite.

On a cold windy day in March 1957, the author arrived before the mine manager's office at the Unificada de Potosí mine. Weeks before, arrangements had been made to visit the mine in an attempt to find some of the elusive, beautiful blue-green phosphophyllite crystals. Large, high-quality crystals of this extremely rare zinc phosphate occur only at Potosí. Permission was given for a one-day visit and, because supervisory personnel could not be spared, he would work alone. Processing for the trip underground required but a few minutes. The author was shown to the change room, where he put on his old work clothes, selected a hardhat complete with

BELOW: Ancient bridge on road to Potosí in 1958
Photo: Peter Bancroft

OPPOSITE TOP: Skyline of Potosí
Photo: Anthony Jones

OPPOSITE BOTTOM: Entrance to Potosí; mines in background
Photo: Terrence Szenics

electric lamp, picked up an ore sack, pry bar, pick, and a bottle of water, and walked through the portal to the cage station.

Stepping onto the cage, he closed the gate, and the cage boss grabbed the cord and signaled the engineer in the hoist house to lower the skip to the 535-meter level. Almost silently he dropped into the center of the mountain, into a dark world of hissing air and dripping water. His ears popped two or three times during the descent, and within a few minutes the cage slowed and stopped at the 535. Waiting a moment for the cage to stop the up-and-down motion caused by its weight stretching the iron cable, the author stepped out into a musty-smelling room known as a level station, his headlamp glowing eerily. Men no longer worked in this section of the mine; the 535 had been abandoned for more than four years. As he threw a corroded light switch, the room and adjacent tunnel became dimly lit by a few bare light bulbs. Rusty mine rails disappeared down the tunnel into obscurity. The air was oppressively hot and humid.

Gathering his tools, he trudged 100 meters down the tunnel to an air door. When this level of the mine was operating, the door conserved the fresh air pumped behind it. With the air shut off, the door now worked in reverse and prevented the better air in the shaft from reaching the old mine workings farther out in the tunnels. The door slammed shut behind him, and he continued down the tunnel for another 200 meters until he came to a zone where the walls gleamed like burnished gold. Fifteen, possibly 20, meters of the left wall were solid chalcopyrite. Close inspection revealed a few tiny seams green with phosphophyllite, the mineral he had come far to find.

In a burst of excitement, he attacked the veins, hoping they would enlarge into pockets where crystals might be found. His pick rang against the hard rock, echoing in the otherwise mysterious silence. As his blows crushed the chalcopyrite, the strong odor of sulfur rose, an unpleasant addition to the dead air.

The author worked hard, stopping only occasionally for a drink of water. He was soaked with perspiration, for the temperature at the working face was close to 60°C, and the humidity approached 98 percent. To make matters worse, he had entered the cage at 5000 meters above sea level, dropped 535 meters, and was still working at an elevation of more than 4 kilometers above sea level. There was precious little oxygen in the air.

THIS PAGE TOP:
Potosí miner dumps waste by hand
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Cheeks puffed with coca leaves, miners work in the sweltering heat of a lower level in the Unificada de Potosí mine
Photo: Peter Bancroft

OPPOSITE:
Phosphophyllite matrix
Size: 15 by 11 cm
Locality: Potosí, Bolivia
Collection: Smithsonian Institution
Photo: Harold and Erica Van Pelt

Noticing a little green vein about 50 centimeters from the floor, the author got down on his knees and worked for nearly five hours. Never did the tough little stringers of phosphophyllite open up into pockets which might contain crystals. Finally stopping to rest, he was astounded to find he had become absolutely exhausted and could not get back on his feet. With sudden alarm, he left his tools and crawled laboriously on hands and knees to the air door and with his remaining strength opened it far enough to get his head through and breathe the slightly improved air.

He had found only traces of the elusive phosphophyllite—nothing worth returning to the little veins for—and he could dispense with his tools. Staggering to his feet, he returned to the station, signaled the operator, and was whisked to the surface, convinced that if any phosphophyllite crystals remained, an organized mining operation would be required to locate them.

Since March 1957 no notable phosphophyllite crystals have been mined, and crystals from the

old discovery are seldom offered for sale. Fortunate is the collector who possesses a good crystal of this rare mineral. Truly exceptional crystals of phosphophyllite include the 7-centimeter twin in the Perkins Sams collection and the extraordinary 13-centimeter crystals embedded in a matrix of tiny cassiterite crystals in the Smithsonian Institution collection.

Today, ancient Potosí Mountain has given up most of its riches and is in danger of being abandoned. The baroque town of Potosí, sprawling along one of the Cerro's flanks, however, still appears much as it did in former years. The antique mint is a museum open to visitors. Winding narrow streets are cobbled with stones set by hand hundreds of years ago. Balconies of elegant ironwork grace the second levels of tile-roofed adobe homes. Quechua women, descendants of the Incas, amble along winding streets, still wearing white stovepipe hats styled centuries ago.

Picturesque, antique, remote Potosí and its famous Cerro slumber in memories of the past. Today's miners ponder the notion that the old mountain may awaken once again and produce yet another mineral bonanza, as it has done before during its long and colorful history.

*THIS PAGE TOP:
Sacking high-grade tin concentrate at Potosí
Photo: Peter Bancroft*

*THIS PAGE BOTTOM:
Miners on guard duty during one of Bolivia's frequent revolutions
Photo: Peter Bancroft*

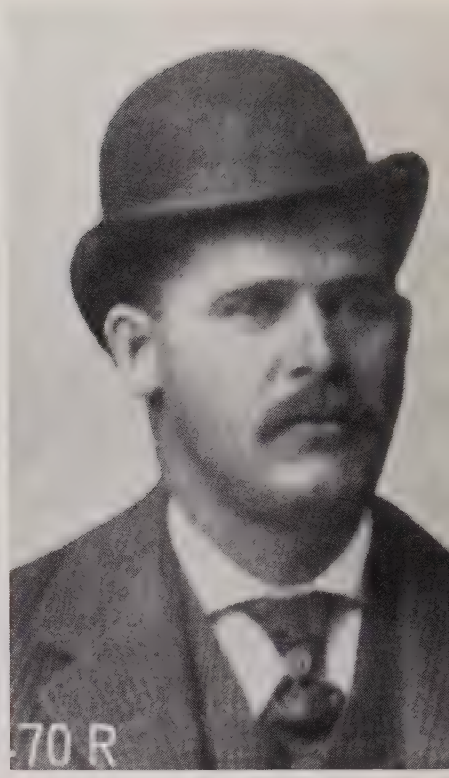
*OPPOSITE TOP LEFT AND TOP RIGHT:
Butch Cassidy and Sundance Kid
Americans Leroy Parker "Butch Cassidy" and Harry Longabaugh "Sundance Kid" robbed mine payrolls near Llallagua in 1900
Photos: Pinkerton's Detective Agency*

*OPPOSITE BOTTOM:
Siglo XX portal; house where Mark Bandy lived is left center, 1936
Photo: Mark Bandy*

37 Siglo XX Mine, Llallagua, Bolivia

One of the most inhospitable mining areas in the world is Llallagua, Bolivia, located 200 kilometers northwest of the Bolivian capital of Sucre, and 275 kilometers southeast of La Paz. Barren, cold, remote, treeless, and high, the region frustrates the miner, the schoolteacher, the shopkeeper, and the housewife.

The Llallagua-Catavi mining area ranges from 3600 to 4880 meters above sea level. Rain is rare, strong winds common, and the air is so thin that any form of work requires considerable effort. Perhaps because of these adverse conditions, many miners chew coca leaves; pistachio-colored spittle dripping from the corners of the mouth is a common sight. Miners insist that cocaine ingested from the coca leaf eliminates high-altitude headaches, increases strength, encourages sexual prowess, and, in a way, substitutes for food. Tests by the Bolivian government have shown, however, that continued use of coca slows reaction time and dulls the senses, thus possibly contributing to the high frequency of mine accidents. To make matters worse, the mine tunnels at depth are incredibly hot and humid, and working



conditions are quite difficult. A health study of the 1950s reported the average life span of career miners in Bolivia is 29 years.

Legend has it that in 1903 a mining machinery firm in Oruro sent its bill collector, Simon Iturbi Patino, to collect an overdue payment from a prospector working in the Salvadora Mountains of Central Bolivia. The enraged miner, insisting that he could not settle the debt with cash, threw his claim documents at Patino, who scooped them up and hurriedly left. When Patino returned to Oruru, his employers would not accept the claim notices as payment for the debt, nor would the former owner take them back. Patino had to pay his employer the miner's small debt. Now flat broke, he took his documents and set up housekeeping in a tent on his claims.

For eight years Patino worked the bleak mountainside, and his wife cobbed the ore; they barely eked out enough good ore to sustain themselves. Then Patino discovered a bonanza lode of high-grade cassiterite which ultimately would account for half the annual Bolivian production of tin, one-tenth of the world's supply. By 1929 Patino had become one of the 10 wealthiest persons in the world.

Patino's tin complex became known as the Impresa Minera Catavi, the world's largest tin mine. Its subsidiaries are the Siglo XX, Cancaniri, Catavi, Miraflores, and the Colquechaca mines.

The Llallagua assemblage is within a core of quartz porphyry, about 1.6 kilometers in diameter through which extends a network of rich mineral veins. From 1900 to 1944 Llallagua yielded 15 percent as much tin as all of Cornwall, England, produced in 3000 years. Individual stopes at Llallagua have produced more tin than the historical total for all of North America. By 1955 Llallagua shafts were down more than 800 meters, and at the end of drifts, temperatures frequently exceeded 49°C, and the moisture-laden air was nearly unbearable. Galleries were difficult to ventilate and almost impossible to cool. Miners alternated work shifts at 15-minute intervals. Still, the mine was rich and could operate at a profit under such conditions.

BELOW:
Endless mountains stretch for miles beyond a Catavi dump
Photo: Peter Bancroft

OPPOSITE:
Wolframite on quartz
Size: 9 by 6.5 cm
Collection: Peter Bancroft
Photo: Harold and Erica Van Pelt

The enormous outpouring of wealth attracted men of all types. Two notorious bandits from the United States, Butch Cassidy and the Sundance Kid, moved into the Bolivian mining region in the early 1900s. They worked for the Concordia Tin Mines, but frequently took time off to continue their roles as robbers, holding up stagecoaches, trains, banks, and pay wagons. Eventually their luck ran out. After robbing the Cocaya Tin Mine payroll, they were traced to an adobe hut in the tiny mining town of San Vincente and killed in a trap set by Bolivian soldiers.

Llallagua (the Quechua Indian name for *mammae*—twin peaks) has rewarded its miners with a long list of glittering minerals. Foremost among these are the rare phosphates: sky-blue vauxite, and light green paravauxite and metavauxite. (These minerals were named between 1880 and 1927 after Pennsylvania's George Vaux, Jr., one of America's most successful mineral collectors.) Llallagua also produces extraordinary crystals of transparent, beautifully-formed vivianite to 15 centimeters in length; wavellite; marcasite fans up to 26 centimeters; exceptionally well-formed and attractive pink, purple, and white apatite crystals up to 8 centimeters; orange and red greenockite crystals; orthoclase twins in sharp Carlsbad twins up to 9 centimeters in length; small but beautiful cassiterite crystals, sometimes growing on transparent quartz crystals; fine crystallized specimens of andorite, franckeite, bismuthinite, stannite, wurtzite, childrenite, and wolframite. (Brilliant doubly terminated crystals on water-clear quartz crystals are princely examples of the species.) Forty-five distinct mineral species have been observed from Llallagua's Salvadora Mountain.

As has been the history of so many crystal-producing mines, the larger and richer veins of Llallagua and Catavi were worked out before mineralogists became aware of the tons of choice specimens which had been sent to the smelter. Friedrich Ahlfeld, noted Bolivian mineralogist, said, "I believe we have collected less than 1 percent of the fine crystallized minerals once available in Bolivian mines."

Now that specialists and collectors have created a demand for Llallagua crystals, only a few are being found, mainly because most high-grade ore is gone. The remaining ore is mined by block caving methods which make the collecting of existing crystals virtually impossible.

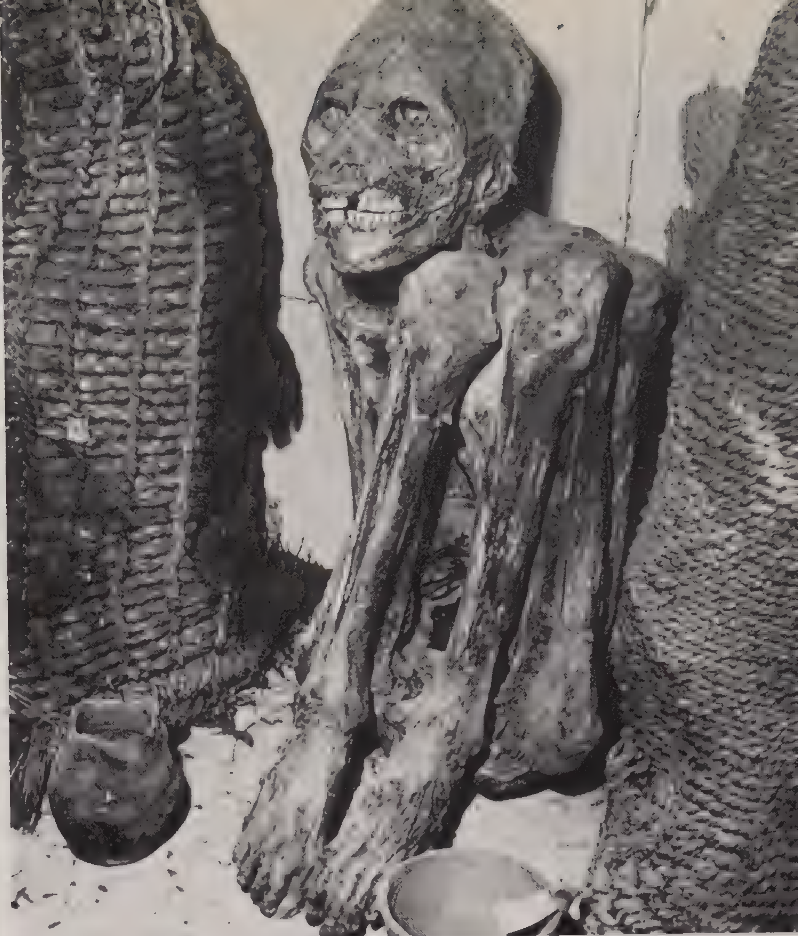
THIS PAGE TOP:
Indian women palliris
(ore sorters) scavenger
low-grade ore, 1958
Photo: Peter Bancroft

THIS PAGE BOTTOM:
"Birdcage" sized skip being
lowered into the Siglo XX
Photo: Peter Bancroft

OPPOSITE TOP LEFT:
Injured miner on his way
to the hospital, 1960
Photo: Peter Bancroft

OPPOSITE TOP RIGHT:
Inca mummy in a La Paz
museum. His brethren
worked the ores at Catavi
more than 800 years ago.
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Stream miners working
canyon at Catavi, 1977
Photo: Anthony Jones


38 Dolores Tercera Mine, Chanarcillo, Chile

Prospector Juan Godoy lived for years on the side of a dreary, treeless mountain in the Andes of northern Chile because he was certain that within its bowels lay a fortune in minerals. One day in 1832, while hunting for *llamas,* Godoy stopped to rest in the shelter of an enormous rock outcrop. Noticing a dark and waxy vein, he pried some of the material loose with his knife and found it "cut like cheese." Certain that the vein was high-grade silver ore, he took samples to nearby Copiapo to be assayed; sure enough, the values in silver were exceptionally rich. Godoy entered into partnership with another prospector, Miguel Gallo, and their mine was baptized the Descubridora "that which is discovered." The mining district became known as Chanarcillo. The town of Chanarcillo was established in the flat below Chanarcillo Mountain, on which there were other mines as well as Juan Godoy's tiny mining camp. The partners became immensely wealthy. Callo expanded his fortune and became one of the richest men in Chile, but Godoy began to drink, got into debt, and ended his life as a pauper. The Descubridora yielded the finest and largest specimens of silver and chlorargyrite (silver chloride) from Chanarcillo's mountain.

Nearby, the Bolados brothers made another good silver discovery, a large fissure containing an enormous block of silver ore. It produced a treasure of silver weighing 1360 kilograms which they sold for approximately $280,000. A great mass of chlorargyrite and silver weighing 20,450 kilograms lay at the end of a new drift. By 1850, 1750 miners were working in the Chanarcillo district.

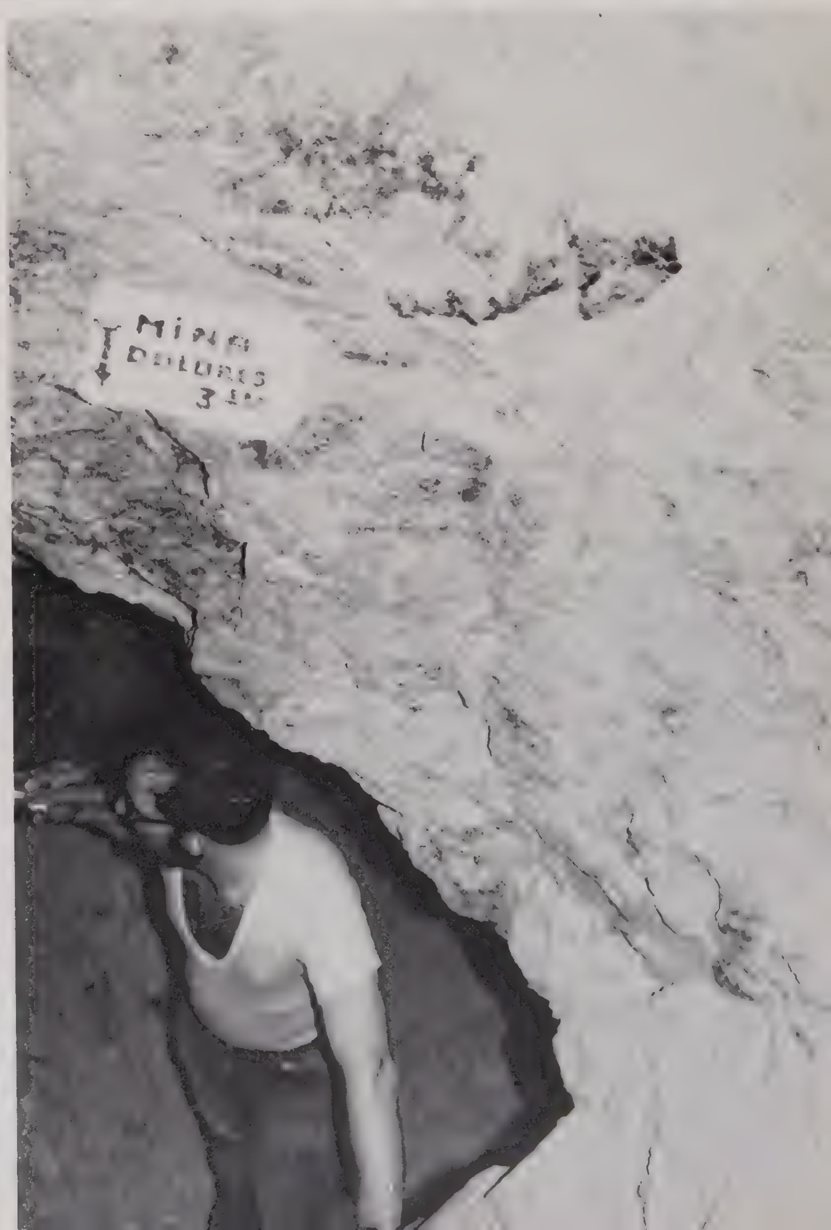
The Dolores Tercera mine, famous for its abundance of high-grade silver ore, became even more celebrated for its high-quality mineral specimens. During the 1850s miners working on the third level began to encounter a zone of vugs within which grew an astounding variety of crystals; a few were exceptionally large for their species. Some vugs contained 1- and 2-centimeter crystals of argentite (acanthite) growing on calcite. Within other pockets clusters of brilliant pyrargyrite crystals measured up to 1 centimeter. Occasionally a vein contained large amounts of bromargyrite and chlorargyrite. Other gold and silver minerals found at Chanarcillo are stephanite, dyscrasite, stromeyerite, pearceite, polybasite, moschellandsbergite (in small silver-colored cubes), iodargyrite, and tocornalite. The silver occurs in beautiful arborescent and wire forms, equal in quality but smaller than those found at Kongsberg, Norway. In addition to these finds, miners reached a series of cavities resplendent with matchless cherry-red proustite crystals. A number of crystals averaged 6 centimeters, all beautifully terminated and, for the most part, undamaged. The largest crystal found reportedly measured 9 centimeters in length and 4 centimeters in width. Fortunately, the miners appreciated what

BELOW: Chilean miners as depicted by L. Simonin in Underground Life, *1868*

OPPOSITE TOP: Remains of Juan Goday townsite, and Dolores Tercera mine on hill in background, 1978 Photo: Anthony Jones

OPPOSITE BOTTOM LEFT: Tumbled rock at entrance of Dolores Tercera, 1979 Photo: Terrence Szenics

OPPOSITE BOTTOM RIGHT: Terrence Szenics exploring area where proustite crystals were found in the Dolores, 1979 Courtesy: Terrence Szenics


MINA
DOLORES

they found and preserved these astonishing specimens in their pristine beauty. Because proustite surfaces tend to tarnish and dull when exposed to light, nearly all of the great Chanarcillo crystals remaining have been carefully wrapped and stored in museum vaults.

Nineteenth-century miners at Chanarcillo worked under terrible conditions. They suffered great hardship and frequent loss of life. Food consisted of bread, beans, dried figs, wheat, and *charqui* (similar to dried beef).

The major mines of Chanarcillo, including the Dolores, shut down in the 1880s because good ore was exhausted and water was filling the lower levels. Later, the mines were worked sporadically by a handful of men. In 1935 American mineralogist Mark Bandy visited Chanarcillo and kept a voluminous diary. Some of his comments:

> *More or less promptly at eight I left Copiapo and started out for Chanarcillo. This was a trip I had been looking forward to for four years, and at last, I was on it! . . . I ate lunch in a great series of wide and high stopes in the Dolores. The walls gave the impression of high-grading but the most diligent search failed to reveal a trace of any visible silver mineral. Today the mines have little or no ore at depth. According to some, there is good grade ore in the bottom, but I doubt it . . . The remarkable feature of Chanarcillo is the great number of mining property owners. There are literally thousands of people that own Chanarcillo, and because of family lineage, each generation increases the number of owners several fold.*

Bandy was also interested in the life of the few remaining miners:

> *Coca leaves serve as a food and drink to the Indian. He can go for days without food and with only a minimum of water if he has plenty of coca. For a 24-hour shift a miner required only ½ pound of coca, a pint of water and possibly a small roll of bread. The miner packs both cheeks with leaves and, to increase capacity, uses a small blunt stick to pack the leaves in tight. After the leaves are soaked with saliva, he places a chunk of quicklime in his mouth and lets it react with the leaves. The resulting solution passes into his system.*

By 1979 the Chanarcillo mining town of Juan Godoy had been deserted; the large mines were closed, and only the occasional roar of a truck, hauling its load of loose rock from the mine dumps to a concentration mill down in the valley, breaks the eerie silence. These sounds echo a once-bustling mining camp that employed thousands of workers, brought untold wealth to mine owners, and, in its time, shared with the world its treasures of incredible silver crystals.

BELOW: Bones of miners disinterred by wolves in abandoned graveyard at Chanarcillo, 1978
Photo: Anthony Jones

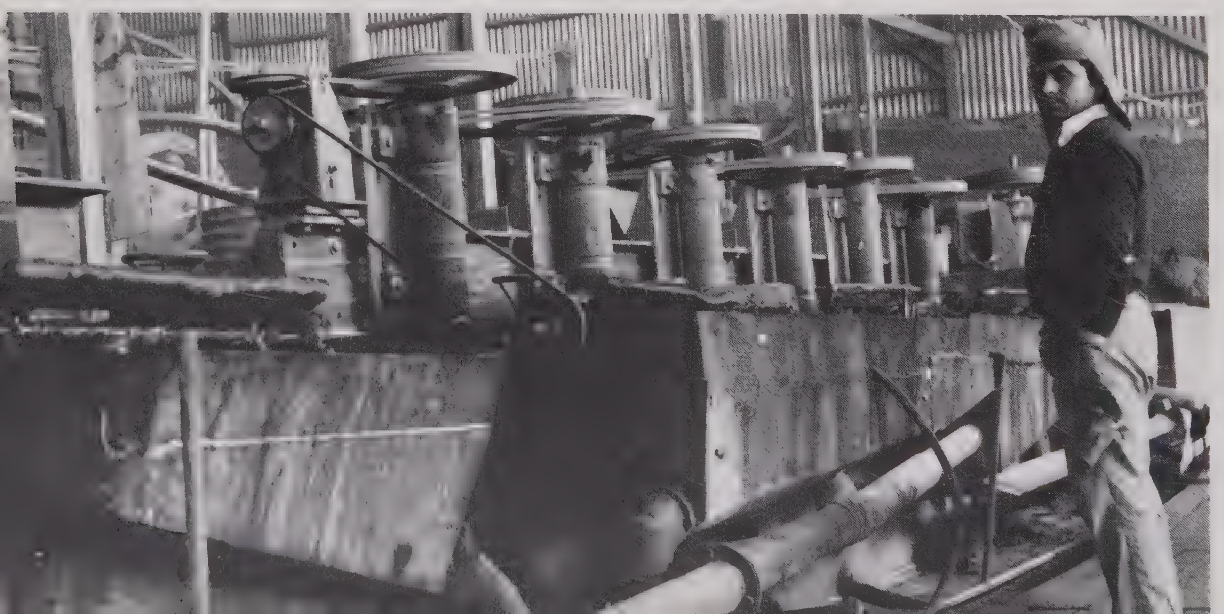
OPPOSITE: Proustite
Locality: Dolores Tercera mine
Size: 9 by 3.8 cm
Collection: American Museum
Photo: Henri Jansen

In 1980 a new company made plans to reopen some of the Chanarcillo mines. Rock Currier, mineral collector and dealer, visited Chanarcillo in December 1980 and reported:

> *A concentration mill was going full blast near the mines. Roads to the mines had been newly graded, permitting brisk truck traffic which was rapidly diminishing remaining dumps. The mines had been pumped free of water down to the 300-meter level and mining is to begin in late 1981. The mine section of the Dolores we visited was in excellent shape with many rocks in the manways polished by the hands of countless miners. The stopes we saw were narrow and very high, but showed few signs of caving. There were veins of calcite and on one we saw a smear of proustite (our guide said it was native arsenic). One exploratory adit showed small tight vugs of calcite but no crystals of any interest. All the country rock was very hard. On one wall, beautifully-written in chalk, was the drift number and date 1887—looking like it had been written only yesterday.*

As mining progresses, Chilean miners just possibly may enter new areas of the Dolores and find more proustite specimens which would be immediately snapped up by eager mineral dealers.

THIS PAGE TOP:
Truck hauling remains of Dolores dumps to Chanarcillo smelter for recycling, 1979
Photo: Terrence Szenics



THIS PAGE BOTTOM:
Dormant flotation mill in Chanarcillo, 1979
Photo: Terrence Szenics

OPPOSITE TOP:
Peruvian ore-bearer as depicted in the 1860s
Courtesy: L. Simonin,
Mines and Miners

OPPOSITE BOTTOM LEFT:
Miner's graves are above ground at Pasto Bueno
Photo: Rock Currier

OPPOSITE BOTTOM RIGHT:
Every bit of space is utilized for mine buildings and living quarters at Pasto Bueno, also known as "Consuzo"
Photo: Rock Currier

39 Huallapón Mine, Pasto Bueno, Peru

The Huallapón mine is at the end of a little-used narrow road blasted from the side of precipitous cliffs in the mountains above the mining camps of Pasto Bueno and Consuzo. The roadbed was surfaced with crushed rock from the road excavation. (Larger boulders were pushed over the side to crash to the bottom hundreds of meters below). The Pacific Ocean is 90 kilometers due west, and the nearest coastal town, Chimbote, lies 160 kilometers down the winding road. The Huallapón huddles in an alpine canyon at an elevation of nearly 4500 meters, where rarified air saps the strength of even the hardiest miner. Craggy treeless peaks are barren of snow because they lie only 8° south of the equator. Less than 100 kilometers to the south, giant mountains, perennially ice-tipped, peak at more than 6100 meters. This is a land to try the patience of the laborer and property owner alike. Yet in the last few years, incredibly beautiful crystals have emerged through dreary adits and raises deep in the Huallapón. These crystals rank quite favorably with their counterparts from other localities.

Miners were pleased to encounter *bolsonadas* (pockets) because the best grade of ore was found within them. Huebnerite crystals up to

15 centimeters in length grew among quartz and pyrite crystals. These crystals were easily removed and crushed on the spot by miners unaware that beautiful mineral specimens could be worth many times their value as concentrates.

Pretty green fluorite crystals, sometimes forming with pyrite, occur in the Huallapón mine. Fairly common are crystals of brown and green sphalerite, tetrahedrite, siderite, pyrite, galena, enargite, calcite, and dolomite. Nice purple apatite crystals are quite rare as are small specimens of scheelite and molybdenite.

Huebnerite and rhodochrosite crystals from the Huallapón mine rank among the best in the world. Both grow in combination with snow-white prismatic quartz crystals measuring up to 11 centimeters and becoming transparent toward the termination. Quartz crystals occur in abundance in the centers of ore veins. Huebnerite crystals grow in long prismatic shapes, sometimes resembling bundles. They may measure 15 centimeters in length. Huebnerite often leaves the mine coated with siderite and other secondary minerals which can be dissolved in hydrochloric acid. Considerable quantities of arsenic occur here in rare botryoidal masses up to 13 centimeters in diameter. Arsenic also coats some huebnerite with globules resembling little gray balls. However, many uncoated huebnerite crystal groups require no treatment.

This deposit produces outstanding rhodochrosite crystals. Frequently found growing among clusters of quartz crystals, these rhodochrosite crystals include the largest fine-quality rhombohedrons in the world, some measuring an astounding 16 centimeters on a side. Huallapón rhodochrosite nearly matches the red of the best specimens from Alma, Colorado, and their brilliant luster surpasses the Alma material. Crystals from Huallapón are not abundant and cannot begin to meet the demand.

The Pasto Bueno mining region was recognized as a potential source of copper, lead, silver, gold, tungsten, wolfram, and molybdenum early in the 19th century. But high elevations, a lack of dependable labor, remoteness, and excessively rugged country retarded major development.

Good quantities of tungsten minerals were discovered in 1910, but mining efforts remained desultory, and the mines were closed for long periods. In 1934 a Peruvian company, Fermin Malaga de Santolalla, reopened the Huallapón with some success. However, mining

THIS PAGE TOP:
Rhodochrosite with quartz
Size: 9 cm (two views of same crystal)
Locality: Huallapón mine
Collection: Richard Webster
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM:
Huebnerite with quartz
Size: 11 by 7 cm
Locality: Huallapón mine
Collection: Azurite Corporation
Photo: Harold and Erica Van Pelt

OPPOSITE:
Rhodochrosite with quartz
Size: 9 by 8 cm
Locality: Huallapón mine
Collection: Smithsonian Institution
Photo: Harold and Erica Van Pelt

methods remained crude, and little thought was directed to blocking out ore bodies as reserves for the future. Miners searched for the richest ore, hauled it to the surface and cobbed out the best sections by hand. Whenever possible they left waste in the mine, a procedure which littered the tunnels. Poor ventilation and lighting contributed to low morale in the work force. Within a short time, the Santolalla company leased the mine to local miners known as *operadors.* Later, as metal prices increased, Santolalla once again resumed operations, which continue today.

Once an area of *bolsonada* was reached, the mine *operador* contracted *metaleros* (miners especially trained at cobbing out high-grade

THIS PAGE TOP: Miner's houses in Pasto Bueno where crystals may be bought Photo: Terrence Szenics

THIS PAGE BOTTOM: Nerve-wracking road carved in cliff leads to Huallapón mine Photo: Terrence Szenics

OPPOSITE TOP: Mining camp of Huara with Huallapón mine above Photo: Rock Currier

OPPOSITE BOTTOM: Huallapón miners on their way to work Photo: Rock Currier

ore), who earned a flat rate for each kilogram of concentrate. *Metaleros* were given drill steel, hammers, leather bags, dynamite, and carbide, and the costs were deducted from their earnings. Because all drilling and mining was by hand, it is no wonder that every effort was made to recover top-grade ore—inevitably in the form of crystals. Miners, most of them descendants of the Tupa Incas, were short of stature and made their tunnels just large enough to crawl through on hands and knees. (They used ropes for ladders in the stopes.) However, enlisting people to work the mines was always a problem. An *enganchadore* (recruiter), hired by the mine owner, traveled to farms and towns and enticed laborers by lending them money as advanced pay. The recruits tired easily of mine work and always managed to return home in time for planting or harvest.

Today the Huallapón is under new management which enlarged or bypassed the tiny tunnels, installed modern equipment and improved working conditions. But best of all, the modern miner knows good crystals are worth far more than crushed ore, and wonderful huebnerite, pyrite, and rhodochrosite specimens now surface to find a ready market—frequently represented by mineral dealers patiently waiting at Huallapón's portals.

40 Soledade Mining Area, Rio Grande do Sul, Brazil

The farmer had shown great patience. For five years during the 1860s, he and two partners cleared land for his new *fazenda* in the back country near Soledade in Brazil's southernmost state, Rio Grande do Sul. First, paths through the heavy brush were cut with large heavy-bladed knives, then great trees girdled and toppled. When limbs were dry enough to burn, they were cut, pulled into giant piles, and set afire until pillars of white smoke clouded the sky. As soon as a space was cleared and wooden fences erected, newly-introduced cattle kept the lush vegetation down. Gradually the *fazenda* took shape and the time came to plant corn and other crops. But still another problem remained: rocks. The soil was rich enough, but round rocks—seemingly everywhere—plagued the farmers. At first they piled the stones into mounds scattered around the valleys until the land

BELOW: Amethyst
Size: 15 by 5 cm
Locality: Rio Grande do Sul
Collection: Roger Williams
Photo: Harold and Erica Van Pelt

OPPOSITE: Agate
Size: 6 by 4 cm
Locality: Rio Grande do Sul
Collection: Hein Gaertner
Photo: Karl Hartmann

appeared clear and ready for the plow. But the plows struck more rocks and rolled them out on top of the furrows. The ever-larger piles of stones took up precious hard-won space needed for crops. A gang of hired men moved the mounds to the edge of the property and built them into fence rows. With the fields cleared and secured by sturdy walls, the *fazenda* prospered and the years passed.

In far-off Idar-Oberstein, West Germany, another scene had been taking place. For many years, the gem industry at Idar acquired large amounts of agate and amethyst from nearby sources on the Nahe River. But as deposits played out, cutters went idle and many of the great grinding wheels were stilled. Some of these cutters and their families emigrated to Brazil to start new lives. One of the Germans, an accomplished accordionist, found he could make a living by traveling from *fazenda* to *fazenda,* entertaining with his music. Visiting the Soledade property, he was astounded to discover that the stone walls were made of banded agate and amethyst geodes. He contacted relatives in Idar, raised sufficient funds, bought the walls and replaced them with new wooden fences. The farmer was pleased, and the musician made a fortune. More Germans came to Rio Grande do Sul, found other deposits of agate, established a new mining industry, and revitalized Idar-Oberstein.

They shipped tons of agate and amethyst geodes to Germany in cattle hides as ballast aboard sailing ships. As word of the strikes spread, other deposits were discovered along a 640-kilometer front south of Artigas, Uruguay, and beyond to Salto on the Uruguay River. Much of this region was nearly impenetrable due to dense forests and constant rains. Roads, where they existed, were usually quagmires that could not support heavy wagons. As a consequence, accessible areas were mined first and even today new deposits of considerable size are being found.

History's greatest amethyst geode was discovered in 1900 in the Serra do Mar, about 140 kilometers north of Santa Cruz in Rio Grande do Sul. The geode was far too large to remove intact—10 meters long, 2 meters wide, 1 meter high, it weighed about 35 tons. Ten sections weighing 15 tons were shipped to Idar, reassembled, and shown in the Dusseldorf Exhibition of 1902 where the deep violet-colored crystals, averaging 4 centimeters in diameter, caused a sensation.

New discoveries were made in the district of Lajeado along the Rio Forguetta. Amethyst and

agate were found in abundance. Artigas, Uruguay, just across the border from Rio Grande do Sul, became a mining and distribution center for amethyst. The lavender gemstones occurred in geodes which weighed from 1 to 50 kilograms. As late as 1950 rich-colored amethyst crystals lining thin-walled geodes could be bought in Artigas for $3 (U.S.) a kilogram. Artigas and Rio Grande do Sul deposits also contributed large quantities of water-filled agates called *enhydros.* The water, sealed within its host for possibly a million years, was potable although tasteless because of its purity. Sizes of the *enhydros* were 2 to 20 centimeters in diameter.

Perhaps 130 million years ago, Rio Grande do Sul's plateau, ranging in elevation from 460 to 1200 meters, was covered by a vast lava flow. Silica-rich solutions entered innumerable gas pockets in the lava, crystallizing into crystal-lined geodes or as banded agate. Ages of weathering have exposed considerable agate and softened the lava's hold on much more. When mined, a top layer of soil 30 centimeters to 5 meters thick is removed. This was formerly done by hand, but now bulldozers or backhoes expose the underlying clay, which may contain agate. Agate clay beds range in thickness from 1 to 8 meters. Some very rich mines produce a ton of agate per meter, but others yield only 1 or 2 kilograms.

The Germans have graded agate into three basic types. "Blackskin," generally flat in shape, has excellent banding, and is considered best in quality. However, supplies of this type are nearly exhausted. "Rainbow" agate, usually comprising many fine bands within the mass, may be naturally-colored light shades of white to gray, brown, yellow, red, or rarely green and blue. When light passes through thin slices, the bands frequently break up the spectrum into rainbow-hued colors. "Dyeing agate," the third type, is favored by the Germans. These unattractive agates, previously thought to be worthless, may be dyed black, yellow, red, blue, and green when placed in hot solutions of such materials as sugar, hydrochloric acid, nickel, iron, and potassium salts. The best of this material is favored for the carving of cameos. The outside "skin" of these agates is mostly gray and greenish. The best deposits are on the Umbu *fazenda* near the village of Jacquizinho.

As the better deposits are exhausted, remaining mines produce smaller agates of lesser quality. Even though present supplies in warehouses and at the mines seem inexhaustible, experts predict a time not too many years away when fine-quality agate will become a rarity and choice stones will command substantially higher prices than today's.

BELOW LEFT:
Warehouse of fine quality amethyst geodes in Artigas, Uruguay, 1953
Photo: Peter Bancroft

BELOW RIGHT:
In agate country a farmer and daughter still travel his farm on muleback
Photo: Julius Petsch

OPPOSITE TOP LEFT:
Sturdy miner at work near Soledade
Photo: Julius Petsch

OPPOSITE BOTTOM LEFT:
Mined agates, looking like coconuts, continue to pile up near Soledade
Photo: Julius Petsch

OPPOSITE TOP RIGHT:
Agates ready for shipment in jungle near Jacquizinho, Rio Grande do Sul, 1970
Photo: Julius Petsch

OPPOSITE MIDDLE RIGHT:
Agate cutters in Lajeado
Photo: Julius Petsch

OPPOSITE BOTTOM RIGHT:
Girls grade tumbled amethyst in Belo Horizonte, 1968
Photo: Peter Bancroft

THIS PAGE TOP:
Amethyst
Size: 11 by 9 cm
Locality: Rio Grande do Sul
Collection: Hein Gaertner
Photo: Karl Hartmann

THIS PAGE BOTTOM:
Agate dish carved as a cameo (Three Graces of Greek mythology)
Size: 13 by 10 cm
Locality: Rio Grande do Sul
Collection: Alfred Buranek
Photo: Harold and Erica Van Pelt

OPPOSITE:
Tourmaline in lepidolite
Size: 15 by 10 cm
Locality: Santa Rosa
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

41 Santa Rosa Mine, Itambacuri, Brazil

Itambacuri in 1950 was a small frontier town at road's end and a source of supplies for miners and farmers. The daily bus, always late and dust-covered, was greeted by a pack of barking dogs. The few visible townspeople were usually smoking as they lazed in the shade.

On a hot summer morning the author, together with Edward Swoboda and two black guides, were in front of the town's only mercantile store packing two mules and saddling four others for the long-awaited trip to the Santa Rosa tourmaline mine. We were in good spirits and ready for the five-day journey.

Our tiny expedition passed through a few *fazendas* (farms) growing sugar cane and Brahman cattle. Now and then we rode by crude water-powered mills noisily crushing sugar cane or grinding grain. The dumps of numerous worked out mines attracted our attention, and provided good quantities of schorl and quartz crystals, as well as respite from the saddle.

By early afternoon our trail began to pass through small sections of jungle where we seldom saw another person. Crossing streams was a problem. Our capricious mules raced with abandon into rushing water of unknown depth, but balked at a rivulet. Rigorous use of sharp-rowelled spurs evoked little response and it soon became apparent that we could walk the trails with greater efficiency and lower blood pressure.

Nights were spent in native huts, lighted by small oil lamps. Uncomfortable beds were made of tree limbs covered with thin mattresses of pussy willow fibers and a coarse cotton blanket. Before bed a thorough search of our bodies for ticks inevitably resulted in removing at least a score of the tiny blood suckers. Sounds of the night—vigorous snoring, a suckling baby, dogs barking, chickens rustling in a nearby tree, and

*THIS PAGE TOP:
Warehouse in Itambacuri
did big business in hides
before jungle was destroyed.
Photo, 1953
Photo: Peter Bancroft*

*THIS PAGE BOTTOM:
Author with poisonous
snake killed on trail
to Santa Rosa, 1953
Photo: Edward Swoboda*

*OPPOSITE: Tourmaline
Size: 16 by 12 cm
Locality: Santa Rosa
Collection: Hein Gaertner
Photo: Karl Hartmann*

the faraway mysterious call of a loon—all of this plus saddle-sore muscles assured fitful sleep.

The Santa Rosa mine, long abandoned, was well hidden by trees, bushes, and vines. No buildings remained, mine entrances were caved in, and dumps covered by jungle undergrowth. Cleaning the area with *facaos* (machetes) was not difficult, but we used great caution to avoid poisonous snakes. Fortunately, only one was encountered, and it measured more than 2 meters in length and had 3-centimeter curved yellow fangs. Dumps were littered with mica, broken feldspar, black tourmaline, quartz fragments, and occasional chips of green and pink tourmaline which we collected. Unfortunately, time did not permit our mining the deposit, but we knew tourmaline of good quality could be purchased back in Itambacuri. However, just the thrill of being at the renowned Santa Rosa made the trip worthwhile.

First discovered in 1938, the Santa Rosa produced good quantities of watermelon tourmaline (green exteriors enclosing red centers). Slender crystals usually provided better gem material with some green and pink sections being used for faceted stones. Big

crystals with ragged form were used for cabochons, carvings, and slices. Large Santa Rosa bicolored tourmaline crystals have been relatively inexpensive when compared with similar crystals from other localities, and in 1984 were still available in dealer showrooms. Fortunately, most of the best crystals have been preserved and specimens may be seen in many museums, including: the Joaquin Folch Museum in Barcelona, Spain; The American Museum of Natural History in New York; the Smithsonian Institution in Washington, D.C.; the Museum of Natural History, Paris; and the School of Mines, Paris.

While prospecting the backside of Santa Rosa hill in 1968, Tiao Matias came upon a series of black ant holes and armadillo burrows containing chips of bicolored gem tourmaline. Digging down, Matias discovered a small pocket of *caldeirao* (tourmaline druses). Continuing downward, he uncovered a mass of quartz crystals surrounded by gemmy pink and green bicolored tourmaline. This strike was the most important in Santa Rosa's history;

THIS PAGE TOP:
A night was spent in an adobe house hosted by these Brazilian farmers, 1953
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Swoboda working the dumps, and always on the lookout for poisonous snakes
Photo: Peter Bancroft

OPPOSITE TOP RIGHT:
Religious shrine constructed of quartz crystals at Santa Rosa, 1979
Photo: Pierre Bariand

OPPOSITE MIDDLE RIGHT:
Swoboda (glasses) revisits Santa Rosa stope in 1980
Photo: Harold and Erica Van Pelt

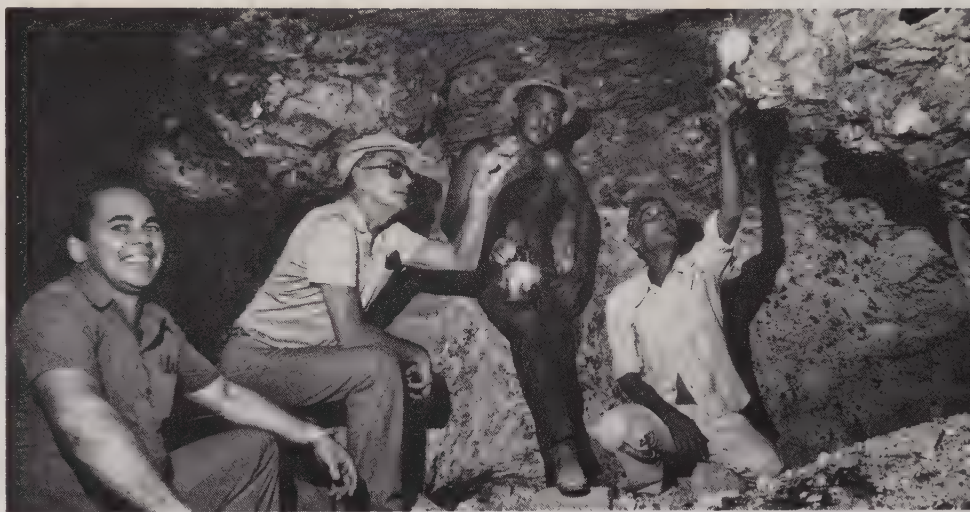
OPPOSITE BOTTOM LEFT:
Miners preparing to reopen old Santa Rosa adit, 1980
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM RIGHT:
Tiao Matias, Santa Rosa owner with bag of tourmaline. He maintains key to safe while his partner keeps key to bag.
Photo: Harold and Erica Van Pelt

hundreds of kilograms in fine tourmaline were ultimately recovered.

Matias established strict rules for his miners; no guns, knives or hard liquor, and thieves would be arrested and sent to prison. In spite of these regulations, fights were commonplace and tourmaline was bartered furtively to foreign buyers in Itambacuri. Most spectacular of the newly-mined crystals were green tourmaline prisms with red centers over 25 centimeters in length and more than 10 centimeters thick. One miner unloaded a 17-kilogram quartz crystal on the dump, believing it worthless. Later, another miner broke it open to find the interior crisscrossed with pink and blue tourmaline. This he sold to a German buyer for $10,000.

Today the Santa Rosa is closed again. A fortune in hardwood timber supports long-abandoned tunnels and stopes deep within the mine; however, this lumber cannot be removed without causing disastrous cave-ins. A new road near the mine makes access easy, and most of the surrounding jungle has been cleared for farming. The famous Santa Rosa now appears to be exhausted, and even its dumps have been hand-picked with pitifully few finds remaining.



42 Urupuca Mine, Fazenda Anglo, Brazil

Light amethystine to lilac-colored spodumene, first discovered in 1901 in the Pala district in Southern California, was named "kunzite" after Dr. George F. Kunz, a renowned gem expert who worked for Tiffany Company. A few years later, kunzite was encountered in other San Diego County deposits at Mesa Grande, Pala, and Rincon. It also appeared at a number of gem deposits in Madagascar at Maharitra, Vanakarata, and Anjanaboana. That seemed to be the end of worldwide kunzite discoveries. Supplies of the material were consumed, and only museums and a few collectors displayed kunzite crystals.

Then in 1932 a small amount of good-quality kunzite was discovered at the Barra do Cuieté mine near the Rio Doce river between Conselheiro Pena to the south and Galiléia to the north in the state of Minas Gerais, Brazil. Water-clear spodumene occurred in complete crystals of 6 by 2 centimeters along with a few yellow spodumene prisms and a small quantity of stocky green spodumene crystals measuring up to 9 by 5 centimeters. Fine large spessartine dodecahedrons were reported from the Barra do Cuieté, an unusual association with kunzite. A few medium pink kunzite crystals were unearthed, and shortly thereafter the pockets ceased and the mine closed. Gem dealers forgot the locality and redirected their energies to buying tourmaline from a host of new mines in the area.

BELOW: Kunzite
Size: 18 by 5 cm
Locality: Urupuca
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE: Kunzite
Size: 31 by 5.3 cm
Locality: Urupuca
Collection: Smithsonian Institution
Photo: Earl Lewis

Kunzite was not rediscovered in Brazil until 1961, when a large pegmatite was entered on the Frigorifico Anglo *fazenda* near Sao José da Safira, 60 kilometers northwest of Governador Valadares. The mine was named the Urupuca after the nearby river. At first a series of pockets was encountered which contained pink and green tourmaline, mica, and quartz crystals. Next a zone rich in lepidolite was found, and finally pockets containing deep-colored lavender crystals of a type unknown to the miners. The area was quite remote and the huge quantities of lilac crystals found no buyers. Few dealers had heard of the discovery, and none could identify the new stones.

Shortly after the discovery a buyer for Levon Nercessian, a gem dealer in Rio de Janeiro, encountered what was being offered as purple topaz at Galiléia. But because it was unlike any topaz he had seen and because he feared it was a synthetic stone, he had not acquired any. Nercessian's curiosity was aroused and he set out for Galiléia. Although he could not identify the new stone, he liked the material and bought a large lot at a very low price. The samples he showed to a friend in Governador Valadares were identified as kunzite, and the rush to the Urupuca began. Many buyers still purchased the new stones as topaz, but knowledgeable ones, like American dealer Martin Ehrmann, knew it for kunzite. Ehrmann bought a large quantity of gem-quality crystals and used the better pieces to barter with museums throughout the world.

A ton and then another ton of kunzite crystals were uncovered, making this strike the greatest of its kind in history. Prices escalated, fences were built around the mine, armed guards were posted, and cameras and visitors were prohibited. Wealthy Brazilian gem dealers bought huge flawless crystals weighing up to 3 kilograms and retired them to bank vaults as legacies for their children.

It is not known today how many kilograms of fine crystals remain banked for safekeeping, but some Brazilian dealers believe that more material rests in safe deposit boxes than in all mineral collections and jewelry combined. The new kunzite crystals were frequently dichroic—displaying a rich purple when held in one direction, but changing to green when rotated 90 degrees.

Paulo Nercessian, Levon's father, acquired the greatest crystal of all, a flawless gem of 31 by 15 by 9 centimeters. It was of the deepest violet and weighed 7.5 kilograms. This magnificent crystal was purchased by Ehrmann,

THIS PAGE TOP:
Miners' houses at Urupuca, 1962
Photo: Julius Petsch

THIS PAGE BOTTOM:
Urupuca glory hole in 1962
Photo: Julius Petsch

OPPOSITE LEFT:
Brazilian miners deep in Urupuca mine, 1962
Photo: Julius Petsch

OPPOSITE TOP RIGHT:
Edson Froede, gem dealer in Governador Valadares with lot of kunzite from the Urupuca, 1961
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Paulo Nercessian with world's greatest kunzite crystal weighing 7.5 kg, 1963
Photo: Peter Bancroft

who traded it to the Smithsonian Institution.

Kunzite was seldom found in complete crystals, most frequently occurring in blocks or crystal segments. Most of the material, free of excessive cracks and tubes, yielded a substantial portion of facet-grade kunzite of a very rich color.

The third and last of the big Brazilian kunzite discoveries was made in 1965 at the Córrego do Urucum (big honey bee) near Galiléia, just 10 kilometers away from the first find at Barra do Cuieté. From this deposit came crystals of kunzite which were both gemmy and of good color, some weighing 1.5 kilograms, yellow-clear spodumene crystals to 20 centimeters in length and small green spodumene crystals. Two giant pockets, one as large as a two-story house and the other which could enclose a three-floor dwelling, were filled with typical gem-deposit rubble consisting of clay, mud, gem chips, and crystals. It took two years to remove the clay, which contained great quantities of gem kunzite and morganite. The mud rubble also held Baveno-twinned orthoclase crystals, 10-centimeter gray apatite crystals, a few dozen rosettes of the rare stokesite up to 2.5 centimeters in diameter, and large quantities of quartz crystals. An incredible 3 tons of gem spodumene crystals were mined, of which a half-ton was deep-colored gemmy kunzite. The pockets also produced a few-hundred bicolored, tabular morganite crystals. At least three-fourths of each morganite plate was complete, banded from pink on the outside to salmon-pink in the interior. Some crystals were complete, and a few were penetrated by lavender and green tourmaline crystals. These crystals weighed up to 4 kilograms and measured to 24 by 14 centimeters across. Córrego do Urucum became one of the greatest gem mines on earth.

The Barra do Cuieté and Urupuca mines, apparently exhausted, are now closed. But kunzite crystal treasures still stored in vaults will periodically make their appearance as reminders of the days when kunzite crystals were mined by the ton. Since the Córrego do Urucum deposit is presently being worked for feldspar, another kunzite pocket may be encountered in the future.

BELOW: Kunzite
Size: 515 carats
Locality: Urupuca
Collection: Arthur Sexauer
Photo: Harold and Erica Van Pelt

OPPOSITE: Brazilianite
Size: 5 by 4 cm
Locality: Corrego Frio
Collection: Edward Bancroft
Photo: Harold and Erica Van Pelt

43 Córrego Frio Mine, Divino das Laranjeiras, Brazil

Frederick Pough, then curator of the American Museum of Natural History, was staying in Rio de Janeiro's fashionable Gloria Hotel in 1942 when his phone rang. Oswaldo Correia, a Brazilian gemstone dealer who specialized in chrysoberyl, wished to see him. Correia unwrapped two large yellowish-green crystals, each containing some facet-grade material which he thought to be deformed crystals of chrysoberyl. Pough had never seen anything like these crystals and promptly bought them.

Reasonably certain he had a new phosphate, Pough returned home and showed his crystals to E.P. Henderson at the Smithsonian. The attractive mineral's amazingly large crystals would make fine display items, and its gem sections would facet into remarkable cut stones. The single negative feature was the gemstone's hardness of 5½—too soft for wear in most jewelry.

American scientists studied the unusual gemstone. In the meantime Pough returned to Brazil to gather more samples which would be of help in establishing the gem's chemical and optical properties. In Rio de Janeiro he visited the Divisao do Geologia e Mineralogia Museo and noticed a large gemmy cleavage of the same material on display. The curator, Evaristo Scorza, had attempted to identify the crystal and felt it was fremontite. Pough offered to have the largest clear section faceted, and return the gem to the museum for display. The offer was accepted. Pough had the piece cut into two gems. The larger, a fine 23-carat stone, was sent to the geological museum. When the gemstone proved to be a new species, Pough and Henderson named it brazilianite in honor of the country of origin.

Late in 1944 Edward Swoboda, then living in Rio de Janeiro, learned of the new stone. At the first opportunity, he took a train to Governador Valadares and on to Sao Tomé, a small station on the Rio Doce River. Crossing the river in a dugout canoe, Swoboda rented a mule for the two-day trip to Jose Raimundo's farm in an area called Córrego Frio (cold stream) about 21 kilometers north of the village of Divino das Laranjeiras. Swoboda learned from Raimundo that in 1942, when

some of his helpers were clearing off a hilly slope to plant rice, they had found a few yellowish crystals. He sold them to a gem buyer who made periodic trips into the area on horseback to buy aquamarine rough for faceting. The mine was worked for a short time but when the operation proved more costly than the rewards, it was abandoned.

Swoboda studied the adit and tailings halfway up the hill and decided there could be more crystals in the deposit. After completing arrangements with Raimundo to work the area, Swoboda returned to Rio to file a claim to the property and gather necessary supplies. He then returned to Córrego Frio and hired a couple of farmers to clean out the main tunnel. The search for crystals was under way.

While prospecting downstream from the discovery site, Swoboda came upon another

THIS PAGE TOP LEFT:
Brazilianite deposit at Córrego Frio with old dumps in foreground
Photo: Jacques Cassedanne

THIS PAGE TOP RIGHT:
Farmers at home near Córrego Frio
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Fazenda *(farm) near Córrego Frio recently burned to permanently destroy jungle vegetation and permit grasses to grow for cattle feed.*
Photo: Wendell Wilson

OPPOSITE TOP:
Swoboda returns to spring, now nearly dry, in which in 1942 he discovered new brazilianite deposit.
Photo: 1980
Photo: Harold and Erica Van Pelt

OPPOSITE MIDDLE:
Miners at entrance to old brazilianite mine adit, 1980
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Rough and cut brazilianite, 1943
Photo: Edward Swoboda
Possibly the earliest photograph of brazilianite rough and cut

promising outcrop where the stream had cut through a small pegmatite dike. He dug into the deposit, enlarging a hole until it reached the stream and filled with water. Next he dug underwater and came up with some pocket material, including a handful of brazilianite crystals. The pocket was enlarged and Swoboda had to dive into the new pool to extract more brazilianite crystals. Those who know him well suspected that Swoboda, an accomplished diver, delayed diverting water from the hold as much to combine his diving and mining talents as to get some relief from the hot Brazilian sun.

Finally, a diversion dam was built upstream and a flume constructed around the pool to direct the stream away from the dike. In June 1945 William Pecora of the U.S. Geological Survey visited Corrego Frio and gave Swoboda valuable advice regarding mining techniques for the brazilianite deposit. In the few months Swoboda worked the property, he recovered many of the most important brazilianite crystals ever found. An adit was driven into a pegmatite outcrop about 45 meters up a steep nearby slope. The exterior of the vein was composed of massive feldspar and mica which

graded into a central core of quartz. Brazilianite was found in small mica-filled cavities on the edge of the quartz core and next to the schist on the hanging wall. Brazilianite crystals attached to the brittle muscovite and albite matrix were difficult to recover intact, resulting in many loose crystals. Pockets also contained albite, green spinel, slender blue-green apatite crystals, beryl crystals, eosphorite (one giant crystal reportedly 20 centimeters in length), childrenite, muscovite, deep blue scorzalite, quartz, and the rare phosphate souzalite (a hydrothermal alteration product of scorzalite). Fortunately for the collector, most brazilianite crystals were gemmy only under termination faces; the balance of the crystals were heavily flawed, and thus not cut into gems. Usable gem material was worth less than the crystal itself. The best large gemmy brazilianite crystals ever found are from the upper working at Córrego Frio. Some measure up to an astounding 16 centimeters in diameter. Superb crystals are in the collections of Herman Bank of Idar-Oberstein (West Germany), the Smithsonian Institution, the American Museum of Natural History, and the Azurite Corporation of New York City.

While on a mineral-buying trip to Brazil in the early 1960s, the author stopped before a small store in Governador Valadares. Two showcases and a number of shelves were stocked with pale yellow-green prismatic crystals, some of which measured to 20 centimeters in length. The shopkeeper identified the crystals as a new form of brazilianite and offered the largest crystals and groups for about $100 each. Crystal faces were dull, the color bland, and there were no transparent sections. Because the material was inferior to the beautiful brazilianite crystals found 20 years before, no deal was made, though this collection later proved to contain most of the largest brazilianite crystals ever found!

Other localities in Brazil reported to have produced brazilianite are Pamarol, a short distance from Córrego Frio, a mine near Teófilo Otoni, Limoeiro, Mendes Pimental, and Linopólis in the region east of Governador Valadares. The gemstone was subsequently found in a number of localities around the world, but never in large, gemmy crystals.

The Córrego Frio deposit produced many fine "books" of muscovite crystals, only a few of which harbored brazilianite. Unscrupulous individuals glued brazilianite crystals into clusters of muscovite leaves, cleverly creating fakes.

Quite rare, fine crystals of brazilianite are seldom offered for sale. When a good crystal is made available, the asking price is usually very high.

BELOW: Brazilianite
Size: 16 by 10 cm
Locality: Córrego Frio
Collection: Azurite Corporation, New York
Photo: Jeffrey Kurtzman

OPPOSITE LEFT: Aquamarine with feldspar
Size: 13 by 10 cm
Locality: Virgem da Lapa
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE RIGHT: Topaz on cleavelandite
Size: 12 by 9 cm
Locality: Xandá
Collection: William Larson
Photo: Harold and Erica Van Pelt

44 Xandá/Limoeiro/Morro Redondo/Toca da Onca Mines, Virgem da Lapa, Brazil

Four relatively small but mineralogically important gem mines are clustered in steep hills 15 to 25 kilometers from Virgem da Lapa near Aracuai in the northeastern portion of Brazil's state of Minas Gerais. Virgem da Lapa and the four mines, the Xandá, Limoeiro, Morro Redondo, and the Toca da Onca, lie between two rivers, the Jequitinhonha to the north and Aracuai in the south. When Brazilians call the track from Virgem da Lapa to the mines a "bad road," they use the kindest terminology. In winter when frequent rains flood the area, it can be impassable. Automobiles make the trip in the dry season but four-wheel-drive vehicles are recommended; during the rains, they are essential.

The hills of the area continue monotonously for hundreds of kilometers in all directions, interrupted at times by *chapadas* (high plateaus) covered with brush and thorny trees. The better areas have been cleared for farming, but poor soil conditions make lackluster *fazendas*. The steep-sided canyons and ravines, once covered with hardwood trees and dense vegetation, still discourage the construction of trails and roads. Water is always in short supply on the farms, many of them scarred with holes and dumps from old gem-mining operations. Efficiency is substantially reduced by two serious health hazards which plague the area: intestinal worms and Chagas, parasites which cause chronic wasting illnesses.

The mines, discovered between 1939 and 1945, were first exploited for industrial beryl. Each deposit had similar characteristics: long, thick, nearly horizontal dikes. At first, pegmatites were mined in open pits, but it soon became apparent that beryl could best be recovered from tunnels following the veins.

Between 1960 and 1973 the mines produced beryl almost continuously. As commercial beryl deposits began to play out and veins became thin, only occasional gem pockets were found. At times crystal vugs occurred one after another, not more than a meter apart. Vein structures streaked with lavender and pinks, became shorter, thicker, and lenticular in shape. Black tourmaline was abundant; this was considered a good omen by *garimpeiros* (miners) who believed the black crystals, as well

THIS PAGE TOP:
Giant blue beryl crystal found near Aracuai, 1936
Photo: Edward Swoboda

THIS PAGE BOTTOM:
Aracuai dealer with box of morganite, 1953
Photo: Peter Bancroft

OPPOSITE TOP:
Blowouts were a constant problem on up-country Minas Gerais roads, 1952
Photo: Peter Bancroft

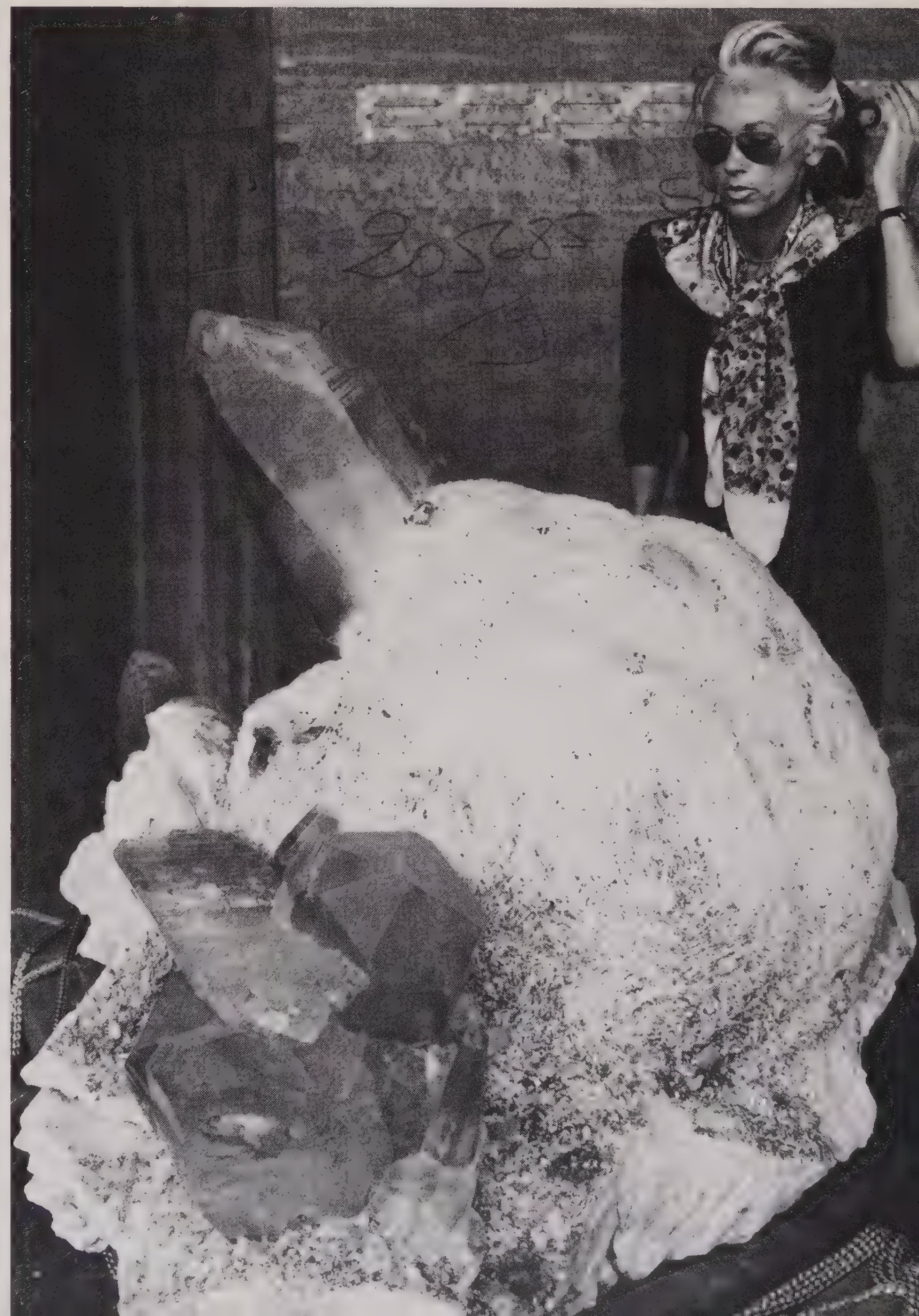
OPPOSITE BOTTOM:
Quartz on cleavelandite, with Erica Van Pelt. Specimen is now in Israel.
Photo: Harold and Erica Van Pelt

as lepidolite and albite, would lead to valuable gems. In the four claims, miners' beliefs became reality. Many cavities were lined with quartz crystals and lepidolite plates surrounded by large masses of feldspar and muscovite. Some pockets were tiny, measuring only a few centimeters in diameter; others were cavernous holes up to 2 meters and more. Vugs were frequently filled with gem and cabochon-grade tourmaline as well as with a variety of mineral specimens.

Most of the pegmatites were fresh. In contrast with most Minas Gerais pegmatites which are soft from having been altered to clay, Virgem da Lapa dikes are consistently hard and difficult to mine. In an effort to accelerate the process, however, miners brought in diesel compressors and began to use dynamite carelessly, which destroyed many fine crystals. Furthermore, many *garimpeiros* were farmers by trade and only worked the mines during the dry season. These inexperienced hands, unfamiliar with explosives, ignored standard safety precautions. Three men were killed in an avoidable accident when one man, thinking a blasting cap was a dud, jokingly threw it at a box of dynamite. In another case one *garimpeiro,* unhappy with a miner who had "jumped his claim," shot him to death. Displeased with the disorder at Virgem da Lapa, the Brazilian government shut down the mines in 1976 by revoking permits to use explosives and forcing the workers back to their farms.

Months later the mines reopened. The Xandá, already a maze of connected tunnels, extended its main adit until it resembled a giant "s". The tunnel drifted straight into the hill for some 60 meters, took a right turn for another 15 meters, and then turned left to the original heading for another 60 meters. There seemed no rhyme nor reason for the tunnel's meandering, but as one expert explained, "These men can smell gems, and they simply follow their instincts."

At the end of these "s" turns, pockets containing blue topaz crystals of great beauty and perfection were found among quartz and albite crystals fastened to the walls. Unfortunately, matrix material was so tough that many wonderful crystals were damaged during the mining process. Mineral dealer Jack Lowell was at the Xandá in October 1978, the day after a fine pocket of blue topaz was removed. The crew, returning after a party, went to the pocket and stuffed a stick of dynamite into a convenient hole. The blast



THIS PAGE:
Indicolite with quartz
Size: 10 cm
Locality: Morro Redondo
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE TOP RIGHT:
Miner working pegmatite in Virgem da Lapa area
Photo: Gerhard Becker

OPPOSITE MIDDLE RIGHT:
Miners at entrance to a lower workings of the Xandá, 1980
Photo: Jack Lowell

OPPOSITE BOTTOM LEFT:
Interior of Xandá mine, 1976
Photo: Jack Lowell

OPPOSITE BOTTOM RIGHT:
Miners in the Xandá, 1980
Photo: Jack Lowell

opened another pocket, destroying much of its contents including a chunk of microcline and quartz and ten good-sized blue topaz crystals. Some beautifully-terminated topaz crystals of fine blue colors were up to 16 centimeters long and 12 centimeters thick. Many transparent ones contained misty veils that coursed through their centers, resembling nebulae in space.

As the adit pushed further into the hill, hydroxyl-herderite crystals appeared in colors and sizes never before encountered anywhere. Normally the hues of hydroxyl-herderite, brown and yellowish-brown, are quite nondescript. Here a few brilliant, well-formed crystals measured to 17 centimeters, in subtle shades of lavender and blue. In sharp contrast to the squat bow-tie-type crystals so typical of the Golconda area, many Xandá hydroxyl-herderite crystals are prismatic in habit.

Most crystals offered for sale are loose, but a few specimens with a matrix of heavily-etched microcline and green mica have reached the market. One of the most unusual and attractive combinations of minerals was the Xandá occurrence of light-tan, bow-tie-shaped hydroxyl-herderite crystals of about 2 centimeters from which protruded beautifully-terminated gem-green tourmaline crystals up to

7 centimeters in length. The find astounded collectors and curators. Unfortunately supplies of the better-colored crystals proved to be very limited—far short of the demand. A huge 50-kilogram topaz crystal was found in the Xandá, as was an incredible 9-centimeter geocronite "V" twin crystal, at first thought to be tantalite.

The Limoeiro mine also produced fine blue topaz, while the Morro Redondo specialized in wonderful multicolored tourmaline crystals of red, pink, green, and blue. All three mines yielded aquamarine, colorless beryl, albite (cleavelandite), fine lepidolite, microlite, quartz, fluorapatite, and cassiterite.

The Toca da Onca (lion's cave), close by the Xandá, has produced many crystal specimens: gigantic fluorapatite crystals up to 15 centimeters in diameter, columbite crystals in association with albite, cassiterite, microlite, elbaite (seldom gemmy), and etched quartz.

High costs of dynamite and diesel oil, as well as inefficient methods, have closed most of the once busy mines, and crews work only infrequently. Dealers who used to journey to Virgem da Lapa now stop at more accessible Barra das Salinas and Coronel Muerta (a short distance to the north). These mines currently produce good quantities of tourmaline and aquamarine. While most miners feel there are more fine crystals in the Virgem da Lapa mines, none is sure they can be mined profitably.

THIS PAGE TOP:
Topaz
Size: (cut stone) 182 carats
Locality: Xandá
Collection: Pala International
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM LEFT:
Hydroxal-herderite on feldspar
Size: 8 by 4 cm (crystal)
Locality: Xandá
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM RIGHT:
Tourmaline var. indicolite
Weight: 52 carats
Locality: Morro Redondo mine
Collection: Decarly Rosa Xavier
Photo: Harold and Erica Van Pelt

OPPOSITE:
Pyrite inclusions in quartz
Size: 16 by 13 cm
Locality: Buenopolis
Collection: Peter Bancroft
Photo: Harold and Erica Van Pelt

45 Maria Nunez Mine, Diamantina, Brazil

It has been said that Brazil is paved with diamonds and quartz. In fact, the occurrences of these gem species are both widespread and prolific. Certainly no other country has produced so many carats of diamonds and so many tons of quartz from such a vast geographical area.

Major diamond deposits occur in Brazil's northernmost state of Roraima, in the vast tablelands of the Mato Grosso, in the southern portion of the state of Piaui, and in the Jequitinhonha River Valley of central Minas Gerais. Nearly 3000 kilometers separate the Roraima deposits from those in the south.

Quartz, while not mined so widely, is found in far greater concentrations than diamonds. Amethyst and agate occur in abundance in Rio Grande do Sul, the southern state of Brazil. Quartz is mined in thousands of deposits north from Sao Paulo to Fortaleza in the state of Ceara. Between these two points, quartz occurs as pure-white, optical-grade material, as the world's largest quartz crystals; in shades of rose, amethyst, and yellow; and in specimens which contain a delightful variety of inclusions such as rutile, pyrite, garnet, beryl, sulfur, water, and tourmaline.

The historic Maria Nunez diamond mine seems to best represent the fabulous Diamantina mining district and will be discussed within this chapter. In 256 years the Diamantina district produced millions of carats in

diamonds, countless tons of quartz, and large quantities of mineral specimens including quartz phantoms, diamonds on matrix, quartz with inclusions of rutile and pyrite, and a variety of other gemstones.

Just 190 kilometers northwest of Belo Horizonte in the state of Minas Gerais, Diamantina is still a small, back-country town. But during its long life, it has seen an incredible stream of precious and semiprecious gemstones pass along its streets and out of its little railroad station. Quite possibly it has produced a greater tonnage and value than any other town in South America.

Diamantina nestles in the center of a vast jungle-covered region interlaced with low mountains and roaring rivers. Its 1220-meter elevation provides a comfortable climate. Originally named Tejuco, the settlement was renamed Diamantina in 1725 when diamonds were discovered in nearby stream beds. Deeply rutted roads, made impassable during much of the rainy season, leave the place nearly inaccessible. Miners, panning for gold, discovered bright little stones in their wooden pans. Thinking the stones worthless, the miners discarded them with the waste. Finally some of the white pebbles were sent as curiosities to the Governor of Brazil, who in

THIS PAGE TOP:
Convoy of diamonds, 1868, at Diamantina
Courtesy: L. Simonin Mines and Miners

THIS PAGE BOTTOM:
Washing diamond cashcalho *(ore gravels), c. 1895*
Courtesy: Farrington, Gems and Minerals

OPPOSITE:
Quartz, with inclusions of rutile and hematite
Size: 10 by 9 cm
Locality: Bahia, Brazil
Collection: Hein Gaertner
Photo: Karl Hartmann

shades of blue, green, yellow, and lavender. Euclase forms in prismatic crystals hard enough to serve for jewelry, but cutters must be alert for nearly perfect cleavage planes along which crystals readily part. The stone is quite rare, and gemmy colored sections rarer still. Author L. von Eschwege described a long-lost euclase crystal unearthed during the 19th century at Boa Vista, which weighed 750 grams. Few crystals exceed 4 centimeters in length. Associated minerals have little economic importance or significance as crystal specimens. The following occur: ilmenite, smoky and milky quartz, schorl, the rock itacolumite (a micaceous flexible sandstone), and topaz. Two species form in exceptional crystals: hematite "roses" growing in topaz-laden veins have measured up to 20 centimeters in diameter. Small but beautiful rutile crystals also sometimes appear.

As late as 1965, a wood-burning locomotive pulled freight and passenger cars over the 80-kilometer route between Belo Horizonte and Ouro Preto. Packed with people, crates of chickens and ducks, and piles of cargo, the train stopped at every little hamlet along the way. The trip which took a little over four hours by train, can be accomplished by automobile in about an hour today.

Considerable activity continues along the Ouro Preto topaz belt. A bulldozer scrapes away the overburden at the Vermelhao mine near Saramenha, sometimes breaking into old meandering tunnels which for scores of years have harbored lost lunch pails, lamps, and tools. The Capao mine near Rodrigo Silva also bustles with activity. Miners work with picks and shovels at Dom Bosco—just as other miners did before them more than 200 years ago. The gem shops of Ouro Preto, Belo Horizonte, Rio de Janeiro, and Sao Paulo sell beautiful topaz crystals. Recently mined crystals of topaz are equal in quality and may match in size the best found years ago. A few 10- to 12-centimeter gemmy crystals of a deep rich golden brown were offered for sale in 1980 in the United States and Europe. Best of all, gem topaz production is at an all-time high, and optimism pervades the entire topaz mining district.

47 Lavra da Ilha/Sapucaia Mines, Brazil

Twenty years ago Frederick Pough wrote in *A Field Guide to Rocks and Minerals:* "Rose quartz crystals are scarce; they have been found at Newry, Maine, and at one or two Brazilian localities. The failure to find large well-formed crystals of rose quartz is a geological mystery." Little more was known of rose quartz crystals until two remarkable discoveries were made in Minas Gerais, Brazil. The two mines, approximately 220 kilometers apart, contributed the only important fine rose quartz crystals known today.

Sapucaia do Norte lies about 8 kilometers south of Divino das Laranjeiras. In the late 1950s, miners working a promising pegmatite for mica and tourmaline began to encounter small stringers of little white and smoky quartz crystals. Because the veins resembled hundreds in the Governador Valadares region, they attracted no particular attention. As tunnels were extended, pockets of smoky quartz crystals appeared. As larger pockets were encountered, so were larger crystals. Laborers ignored the smallish light pink quartz crystals which appeared. Next the miners came upon an area of large muscovite sheets and stocky quartz prisms; behind them was a big pocket filled with bright rose quartz crystals. Although the vug was some 16 to 10 centimeters wide and not more than 32 centimeters high, it extended for more than 5 meters.

Fortunately, the *garimpeiros* (local miners) fully appreciated the stunning quartz crystals, even though they could not identify them with certainty. The first lot, carefully recovered and packaged, caused a sensation when it reached Governador Valadares. As more lots arrived, it became apparent that a large strike had been made, and experts authenticated the crystals as rose quartz. Nearly all occurred in clusters; some grew in halos around a single smoky quartz termination. These were magnificent crystals reaching a length of 4 centimeters. Without question, the dark pink specimens from Sapucaia do Norte are the best rose quartz crystals ever found; it's a pity that none have been recovered from this deposit in recent years. Regrettably, someone started a rumor that the crystals were not colorfast and would gradually fade in daylight to a pale pink. Although early experience has shown the color to be secure, the rumor depressed prices for nearly a decade. Today fine clusters known for their purity of color, rarity, and beauty command premium prices. In addition to rose quartz, Sapucaia do Norte also produced

BELOW: Rose quartz
Size: 10 by 7 cm
Locality: Sapucaia
Collection: John Barlow
Photo: Harold and Erica Van Pelt

OPPOSITE: Rose quartz
Size: 17.5 by 10.2 cm
Locality: Sapucaia
Collection: H. Rudolf Becker
Photo: Karl Hartmann

commercial quantities of columbite and tantalite. The Sapucaia do Norte was abandoned in October 1980, and in January 1981 only three *garimpeiros* were seen working the dumps.

Improbably, the second occurrence of rose quartz, in far northeastern Minas Gerais at the Lavra da Ilha (island mine), appeared on a small island in the center of the Rio Jequitinhonha upriver from Itaobim (itself north of Teófilo Otoni on the Rio de Janeiro-Salvador highway). Access is west of Itaobim through Itinga to the tiny village of Taquaral, a distance of 47 kilometers. The miners live on an orange farm next to the river. In winter the river floods the island to make mining impossible. But in June the water subsides and

THIS PAGE TOP: Remains of Sapucaia open pit after major cave-in Photo: Jacques Cassedanne

THIS PAGE MIDDLE: Old workings at Sapucaia Photo: Jacques Cassedanne

THIS PAGE BOTTOM: Nearly all work is by hand and big pools of water must be pumped away Photo: Richard Hauck

OPPOSITE: Rose quartz Size: 18 by 11 cm Locality: Sapucaia Collection: Smithsonian Institution Photo: Dane Penland

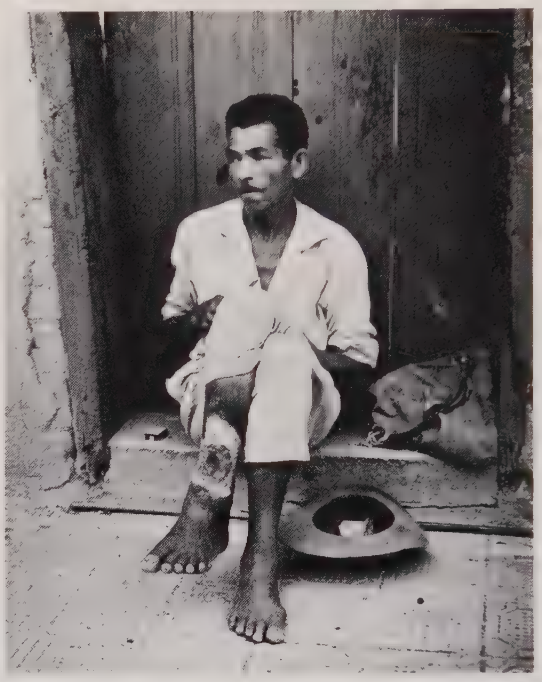
the pegmatite can be worked until October. Visitors reach the island in dugout canoes poled by *garimpeiros.* During this short working season, the deposit bustles with activity. The forty or so miners have only about five months before their workings flood once more.

Nearly all rose quartz druses on the market today originated at Lavra da Ilha, which was discovered in 1970 and remains open today. If a specimen is splashed with radiating clusters of transparent yellow to brownish eosphorite crystals, it unquestionably came from here. Rose quartz from the island is generally paler than crystals from Sapucaia do Norte. The specimens are brilliant, well formed, and quite pretty. Crystals vary from opaque to facet-grade transparency. Rose quartz is most attractive when it forms as a wreath of brilliant pink doubly-terminated prisms around the termination of a white or smoky quartz crystal. Representing an even later stage of development within the pegmatite, many rose quartz crystals appear dusted with clusters of the rare phosphates wardite, roscherite or even less frequently rockbridgeite, whiteite, and beryllonite. Eosphorite of exceptional quality, known locally as *"cabeludo"* (long hairs), occurs as tiny dark brown, tan, and orange crystals in irregular groups scattered over the

surfaces of rose and white quartz, feldspar, and mica. A large pocket of associated minerals, mined in 1969, produced bright dark brownish tetrahedrons of beautiful sphalerite, beryl, very fine amblygonite, vivianite, cassiterite, and blue and black tourmaline.

Today *garimpeiros* struggle to free the pits and pockets of water because nearly all workings have reached below the river water level, even in the dry season. In January 1979 a catastrophic flood nearly destroyed all of the workings on Lavra da Ilha, casting some doubt on future mining. The Lavra da Ilha may soon be abandoned in favor of newly-discovered pegmatites along the banks of the Jequitinhonha.

Another deposit of crystallized rose quartz, known as the Laranjeira, was reported by French geologists and authors Jacques and Jeannine Cassedanne. It was found in May 1979 on a low hill not far from the site of the Lavra da Ilha workings. In the quartz core of the pegmatite vugs containing rose quartz crystals measure up to 1 meter in length. Associated minerals include rose and green tourmaline, beryl, cassiterite, wardite, and frondelite; strangely lacking are the crystallized phosphates and translucent amblygonite so typical of the Lavra da Ilha. The Cassedannes feel the Laranjeira has a fine future and will produce considerable quantities of good crystals.



THIS PAGE TOP: Ulcerated garimpeiro, *no longer able to work, begs for cruzeiros in 1952*
Photo: Peter Bancroft

THIS PAGE BOTTOM: Garimpeiros *cleaning up debris on Lavra da Ilha, 1972*
Photo: Richard Hauck

OPPOSITE TOP: Mineral dealer and his secretary with one of the world's largest muscovite crystals from the Golconda, 1958
Photo: Peter Bancroft

OPPOSITE BOTTOM: Alice Keller studies a gem at Golconda
Photo: Peter Keller

48 Golconda/Itatiaia Mines, Brazil

The Golconda, one of Brazil's older mica and gem mines, is located 34 kilometers northwest of Governador Valadares. Other old tourmaline mines, including the Joao Pinto and the Quiero Vilca, cluster 65 kilometers southeast of Governador Valadares. Both mine areas have developed outstanding tourmaline and beryl (aquamarine), along with other gem and mineral species. Each has a fascinating history.

Nestled in low hills bordering the Rio Doce valley, the Golconda is a typical Minas Gerais gem mine of waste dumps sparkling with discarded mica and surrounded by cattle ranches. Discovered in 1908, the Golconda produced a wide variety of valuable crystals. Reddish-brown spessartine was abundant in crystals up to 1 centimeter. Almandine was also found. Morganite in light shades of pink and orange occurred in masses of irregularly shaped crystals of 24 to 10 centimeters. Highly-malformed crystals were seldom complete, but faces were bright and colors appealing so that collectors eagerly sought specimens. Crudely-formed and frequently broken bluish green aquamarine containing gem sections was of lesser interest. Nearly all of this material was cobbed and sent to lapidaries.

A few tiny honey-yellow-colored microlite octahedrons were found with other gem materials in two or three pockets. Beautifully formed manganotantalite prisms 1 centimeter in length were uncovered intermixed in clay with bits of tourmaline and muscovite. Prism faces of these reddish brown to black crystals show deep striations without loss of brilliance. Terminations are flat. Pale lavender masses of cookeite were common, and white and smoky quartz occurred in well-terminated prisms up to 70 centimeters in length. Of great interest to the crystal collector was a pocket of hydroxyl-herderite which produced a few matrices of beautifully twinned light brown crystals in sizes up to 5 centimeters.

During World War II the Golconda produced mica principally. Crude books of mica were found in shades of green, yellow, brown, and black. "Ruby muscovite" was found in yellow-brown to red-brown hues, the only variety which could be used commercially, and was mined in large quantities.

In 1962 an offshoot pegmatite stringer of the Golconda was discovered on the Sitio Espirito *fazenda.* One huge pocket contained 1 ton of gem-quality emerald-green tourmaline. Local police reportedly wanted to get in on the discovery and encouraged local miners to

THIS PAGE TOP:
Tourmaline variety rubellite
Size: 19 carats
Locality: Joao Pinto
Displayed on: faceted petalite
Collection: John Ramsey
Photo: Laura J. Ramsey

THIS PAGE BOTTOM:
Tourmaline on albite
Size: 7 by 4 cm
Locality: Golconda
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

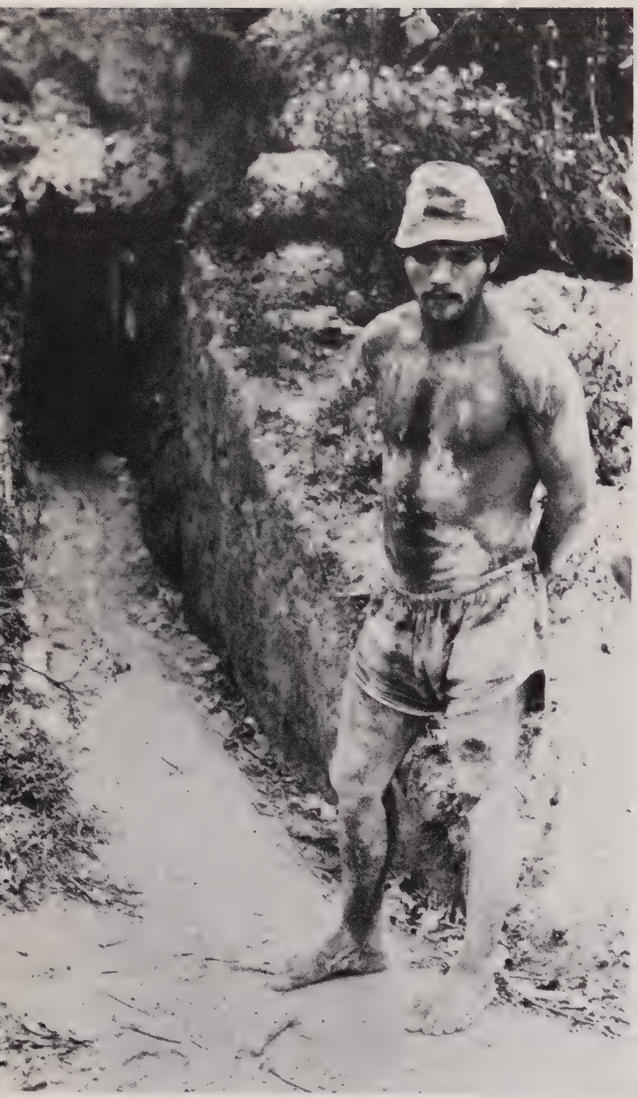
OPPOSITE: Tourmaline, variety rubellite on cleavelandite
Size: crystal: 21 by 11 cm; specimen: 40 by 36 cm
weight: 27 kilograms
Locality: Joao Pinto
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

invade the mine property. In the melee that followed three miners were killed, a number wounded, and the invasion repulsed. But the police, staying on to prevent further hostilities, got an illegal share of the mine's production. Many tourmaline crystals were flawless, with good form and bright colors. Mine owners noticed prostitutes in local bars vending some of the best crystals. Thereafter each Monday a representative of the owners would visit the prostitutes and buy back gems the girls had received for their services over the weekend.

During the early 1960s the Golconda produced a wide variety of outstanding crystals, including green tourmaline, columbite, quartz, beryl, and some of the largest and most unusual hydroxyl-herderite crystals ever seen. The latter occurred as extraordinary light to dark brown twins, frequently resting on flat, doubly terminated quartz crystals.

In 1964 Golconda presented its last major pockets, one filled with bottle-green tourmaline and the other containing a vug of pink tourmaline prisms tipped in green. Levon Nercessian, a Rio de Janeiro gem dealer, owns the Golconda and remains optimistic regarding its future. "There are more gemstones in there;" he said, "we just have to find them."

In April 1978 an astounding find of cranberry-colored tourmaline appeared at the Itatiaia mine, 5 kilometers west of Conselheiro Pena and not far from the Rio Doce River, in the Itatiaia mining district. The new pegmatite was only 1 kilometer from the old Joao Pinto



mine, a good producer of tourmaline in its day. Two Brazilians, Jonas Lima and Ailton Barbosa, formed a partnership to work new areas near the Joao Pinto mine; Lima would provide funds and Barbosa would develop the operation. Months went by, and the exploratory tunnel reached 80 meters into barren ground. Lima wanted to quit, but Barbosa felt they were near good pocket material and their venture should be continued. Lima agreed to fund the project for 10 more days. Shortly thereafter signs of a large pocket began to appear—feldspar, mica, and quartz crystals in profusion. Finally a cavity was breached, with sufficient height to permit a man to enter and stand erect. As lanterns flashed light about the chamber, miners were astonished to see giant tourmaline crystals in sizes up to 1 meter in length, protruding from the ceiling. They dubbed the cavern the "bamboo pocket." Even in poor light, crystal edges emitted a rich red color. When Lima rushed to the mine and stepped into the pocket, it is said he required 20 milligrams of Valium to calm down.

Realizing the crystals must be removed from the walls and ceiling without damage, Lima ordered his men to place stacks of automobile tires beneath each crystal as it was worked loose. A burlap pad was draped over the highest tire to soften the impact. The system allowed at least a half-dozen of the largest crystals to be removed without damage.

Nearly all of the giant tourmaline crystals were colored a deep violet-red (rubellite) identified in the trade as "cranberry." Most material was cabochon quality, but vibrant

THIS PAGE TOP:
Garimperio after day's work in Golconda
Photo: Peter Keller

THIS PAGE BOTTOM:
Jonas mine: mechanized light, hand haulage
Photo: Peter Keller

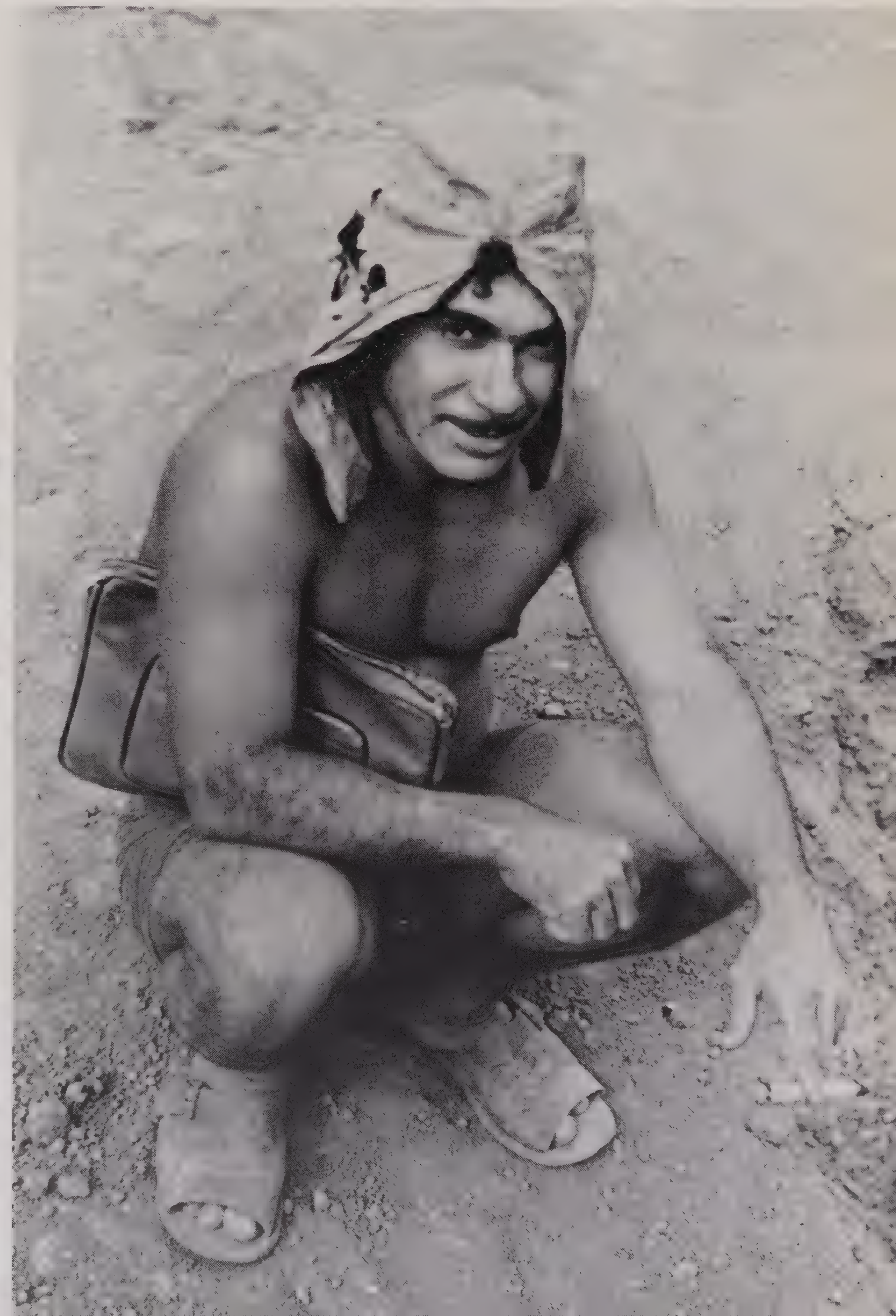
OPPOSITE LEFT:
Children search for gems in stream below Golconda
Photo: Gerhard Becker

OPPOSITE RIGHT:
Brazilian gem buyer waits for stones to appear
Photo: Peter Keller

colors assured immediate popularity. Some flawless facet-grade sections fetched more than $200 a carat. Finely-terminated crystals, nestled among snow-white plates of cleavelandite and clear quartz crystals, were priced at $4000 to $50,000 each. One man offered a mint condition Rolls Royce for a specimen but was refused. The largest tourmaline, named the "rocket," reportedly 20 centimeters in diameter and 1.6 meters long, is valued at more than $2 million. One of the most beautiful specimens Lima and Barbosa found was a 27-kilogram matrix of bright cleavelandite crystals (43 by 33 centimeters) surrounding a perfectly-formed 25-by-11-centimeter rich red rubellite crystal. Hanging loosely from the cavern's ceiling, almost qualifying as a "floater," the piece was carefully removed and now belongs to collector Keith Proctor. Named "The Flower of Brazil," it is one of the better large museum specimens in the world. American consulting engineer Richard Gaines described the largest specimen:

> *Protruding from a cluster of clear cleavelandite blades are two huge red tourmaline crystals surrounded by gem microcline crystals and a large quartz crystal. This is the best large specimen ever found. It has the perfection one would expect to find in a micromount, yet it weighs nearly 400 kilograms. At this moment it is not for sale, but then, everything has a price.*

An estimated 4 tons of gem and mineral crystals have been removed from the single pocket. Disenchanted with hordes of visitors and the confusion they caused, Lima blasted shut the entrance to his mine in July 1978. However, new owners reopened the Itatiaia in the spring of 1979.



49 Teófilo Otoni Mining Region, Minas Gerais, Brazil

Aquamarine (from the Latin *aqua marine,* meaning sea water) is the varietal name for greenish blue to blue beryl of gem quality. The color of some aquamarine so closely resembles the tints of the sea that many years ago it was commonly thought that an aquamarine would become invisible when placed in the ocean. The rarest and most desirable color is a deep, rich, pure blue. When gemstones lack purity of hue, they are commonly placed in an oven and heated to 400°C. This process can alter the pigmentation within the stone, permanently removing some of the yellow tint. Only faceted flawless stones are treated this way because imperfections within the crystal can fracture and destroy the stone.

Gem aquamarine is usually found in pegmatite dikes, though beryl may occur in other types of rocks. Aquamarine is capricious. Crystals may cluster together in pockets, but even in rich seams there is no guarantee that more pockets will appear. Isolated aquamarine crystals have been discovered with no other crystallized beryl in the vicinity. Gem aquamarine has been recovered from road cuts, drainage ditches, foundation trenches for buildings, and water wells. It is nearly impossible to select the single aquamarine mine that best represents Brazil. One location may have produced a single outstanding crystal; another outcrop contributed tens of thousands of carats in rich blue gems but cannot now be found. As new deposits appear and capture collectors' interest, the older ones slip into obscurity and legend. Their tombstones are the whitish tailings, which slowly disappear beneath the grass of some farmer's hillside. Most aquamarine claims never earned mine status and were identified only by the name of a local *fazenda.*

The greatest of all aquamarine-producing regions is the state of Minas Gerais. This vast landlocked territory, covering an area of 870,000 square kilometers, is crisscrossed by innumerable pegmatite dikes. Some dikes measure a few meters and contain only granite minerals, but an occasional mineralogically complex dike can yield other gemmy stones such as topaz, tourmaline, and beryl. In some areas rivers have cut through gem dikes, releasing crystals to bounce and grind as they tumble downstream until they become waterworn pebbles.

BELOW: Petronio Miglio holds fine aquamarine amid morganite and other beryls, 1962
Photo: Peter Bancroft

OPPOSITE TOP:
Aquamarine
Size: 8 by 2.5 cm
Locality: Mina Belo Oriente
Collection: Keith Proctor
Photo: Earl Lewis

OPPOSITE BOTTOM:
Beryl, variety goshenite
Size: 7 by 4 cm
Locality: Lavra do Criminoso
Collection: University of Paris (Sorbonne)
Photo: Nelly Bariand

Although gem aquamarines reportedly have been found within Rio de Janeiro, the largest known belt of aquamarine-bearing dikes occurs near Mar de Espanha, about 120 kilometers north of the city. This belt extends northward through the areas of Conselheiro Pena, Governador Valadares, Teófilo Otoni, Aracuai, Salinas, the Jequitinhonha River basin, and Pedra Azul. Teófilo Otoni, in the geographical middle of the aquamarine region, is the center for dealing and cutting of aquamarine rough.

The great Marambaia Valley, 70 to 100 kilometers north of Teófilo Otoni, has thousands of aquamarine prospects. In 1910 David Mussi discovered a 110-kilogram crystal measuring 48 by 38 centimeters in the Papamel mine near Marambaia. Much of the crystal was a greenish-blue. It was purchased by two German buyers for 85,000 marks and shipped to Germany. Cutters heated stones cut from the crystal and improved their color in what is believed to have been the first successful treatment of this kind. As recently as 1964 the Pedroso mine near Padre Paraiso (Agua Vermelha) produced a 7-kilogram aquamarine crystal of fine quality which was purchased by the Brazilian jewelry firm, H. Stern. In 1967 at Tres Barras, a 1-meter-long aquamarine crystal of gem quality was encountered in a road cut. This find precipitated a gem rush, and the discovery of a new field.

The Jequitinhonha River basin has produced much aquamarine, tourmaline, topaz, quartz,

THIS PAGE TOP:
Alfredo Heuberg (deceased) in Rio de Janeiro in 1951 with aquamarine matrix from the Palmital mine. Now in the Smithsonian Institution
Photo: Peter Bancroft

THIS PAGE MIDDLE:
Gemstone dealer, Petronio Miglio's niece with aquamarine crystal in Teófilo, Otoni, 1965
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Blacksmith shop in mining town of Campos, 1965
Photo: Julius Petsch

OPPOSITE TOP:
A pegmatite outcrop north of Teófilo Otoni
Photo: Henry Kennedy

OPPOSITE MIDDLE:
Mining aquamarine near Sao Pedro do Jequitinhonha
Photo: Henry Kennedy

OPPOSITE BOTTOM:
Going down in river bed for aquamarine near Itinga
Photo: Henry Kennedy

and diamond. The river runs from the southwest portion of Minas Gerais to the northeast corner of the state and empties into the Atlantic Ocean. Important gem regions begin in the zone of Diamantina. Aquamarines occur in good quantity near the river towns of Aracuai, Berilo, Virgem da Lapa, Turmalina, Itinga, Sao Pedro de Jequitinhonha, and Barra de Salinas.

In 1905 a 9-kilogram aquamarine of fine blue color was discovered at Ilha Alegre, 20 kilometers east of Itaobim. The piece, when sold for $910, proved to be the finest of many choice gems found over the years at Ilha Alegre.

One of the richest placer areas along the Jequitinhonha is the 200-kilometer section extending from Barra de Salinas in the west to Jequitinhonha downriver to the east. Fortaleza (presently Pedra Azul Township) has produced so many rich blue aquamarine pebbles that Brazilian cutters use the term "Fortaleza" to identify a particular shade of aquamarine. The Lavra Laranjeiras deposits near Fortaleza are particularly rich. An outstanding crystal of 12 kilograms was presented to the National Museum in Rio de Janeiro. Stolen in 1915 along with other valuable gem crystals, it has never been recovered. Brazilian Foreign Minister Oswaldo Aronha presented a flawless rich blue faceted 1285-carat aquamarine from Laranjeiras to President Franklin D. Roosevelt at the time of his visit to Brazil.

The Rio Piaui enters the Jequitinhonha between the towns of Aracuai and Itinga. In the Piaui valley, the Maxixe mine gained notoriety in 1917 when a strange alkali aquamarine of an incredible deep blue was discovered. Unfortunately, upon exposure to sunlight the color faded to a whitish yellow within a few days. Some lots of the new Maxixe material had reached Germany when cutters learned the gemstone's colors were not fast and "there was hell to pay." Natural radiation of Maxixe beryl, caused by bombardment of charged particles from a radioactive element, had provided the extraordinary color. Artificial radiation can restore color lost to sunlight but neither process assures color permanency in this particular gem.

The hills surrounding Teófilo Otoni have produced large amounts of aquamarine. As one miner stated in 1951, "Our houses are built on top of aquamarines." An uncommonly dark blue 34-kilogram crystal was found on a *fazenda* near Teófilo Otoni in 1954. Its owner, impressed by both the stone and Brazil's

reigning beauty queen, named the crystal the *Marta Rocha.* Today the term describes the epitome of color in aquamarine, the hue with which all others are compared.

Teófilo Otoni's Petronio Miglio owned one particularly large and choice aquamarine crystal measuring 71 by 14 centimeters for more than 30 years. During those years he offered it for sale at a price of $30,000, but no farsighted buyers came to Miglio's shop to purchase the crystal. Finally in 1979 the giant crystal was sent to a cutter, and more than $250,000 in faceted stones were realized from the piece. With the cutting of this beautiful display crystal, a prize aquamarine was lost forever.

Jumbo faceted aquamarines are on display in the Los Angeles County Museum of Natural History; Harvard University; the Smithsonian Institution; the A. Ruppenthal showroom in Idar-Oberstein, West Germany; the American Museum of Natural History in New York City; and the Franklin Delano Roosevelt Museum at Hyde Park, New York.

THIS PAGE TOP:
Beryl (var. aquamarine, heliodor)
Size: cut stones approximately 40 carats each
Locality: Teófilo Otoni
Collection: Pala International
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM LEFT:
Aquamarine
Size: 286 carats
Locality: Teófilo Otoni
Collection: Private
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM RIGHT:
Aquamarine
Size: 14 by 7 cm
Locality: Teófilo Otoni
Collection: James Dzurus
Photo: Benjamin Shaub

OPPOSITE:
Opalized clam shells
Matrix size: 10.5 by 7.5 cm
Locality: Coober Pedy
Collection: Private
Photo: Harold and Erica Van Pelt

50 Olympic Opal Field, Coober Pedy, Australia

The Coober Pedy opal mining district, 750 kilometers northwest of Adelaide, Australia, lies in a land so barren and arid that travel can be hazardous even today.

Late in December 1914 a man named Hutchinson and his 14-year-old son Bill rode camels as they prospected for gold in Australia's bleak outback. The year was one of the most critical in Australia's history because World War I broke out and the most severe drought in memory occurred. The Hutchinson party's camels were in bad shape and Bill left camp in search of a water hole. Fortunately he found water, but he also picked up a few interesting lightweight chips of rock nearby. The parched terrain was covered with these fragments of white rocks resembling the bleached bones of animals. Back in camp Hutchinson's companions identified the white rocks as opal, although the sun had bleached away any "fire" the stones may have had. Digging just below the surface, the prospectors discovered patches of opal which reflected a beautiful play of colors.

Despite the significance of Hutchinson's find, no opal rush followed because few men dared try their luck in an area so formidable that even the Aborigines gave it a wide berth. No trees grew on the land; the only things that moved were reptiles and rare prospectors. Two unpaved roads connected the opal field with the outside world. In 1916 maps warned that travel should be attempted only in the cool, wet months of the year when the few and inconsistent water holes might not be dry. Prospectors choosing the southern route rode the transcontinental railway to Tarcoola and made certain that the 11 water holes along the way held enough of the precious liquid for a safe journey. However, not all wells offered good water. For example, the Birthday Well contained a large supply of brackish water, and the next waterhole, 35 kilometers away at Carringallana Creek, "retained water for four to five months when filled by rain." The road from Alice Springs to the north was even more dangerous and dreary.

The gem area, first called the Stuart's Range Opal Field, got its lasting name from the Kokato tribe of Aborigines. Coober Pedy, from *kupa-pita,* translates as "white man in a hole."

Because there was no water in Coober Pedy, it was hauled in 115-liter wooden tanks aboard camels from holes as far as 60 kilometers away. Although every available container in Coober Pedy became a catch basin during the infrequent rains, there was barely enough water for drinking, and none left for washing "man, beast, or opals."

Obviously the field could not be worked properly until a viable water supply was secured. Deep wells were drilled, and the brackish water thus obtained in quantity was processed by a solar-heated treatment plant. Today potable but costly water comes from a reverse osmosis apparatus.

From the beginning, miners constructed dugouts in which to live or set up housekeeping in their mine tunnels. As one oldtimer put it, "Outside we have 100°[F] and flies, while in the dugout it is 70°[F] and no flies."

Early miners first encountered fire opal from 7 centimeters to 1.5 meters below the surface. By 1919 most gems were found in deeper strata 4 to 6 meters down. Opal occurred in such substantial amounts that a miner named

THIS PAGE TOP: Arthur Cheyene on lead camel bringing water in 115 liter tanks to Coober Pedy, 1916 Photo: Courtesy James Cheyene

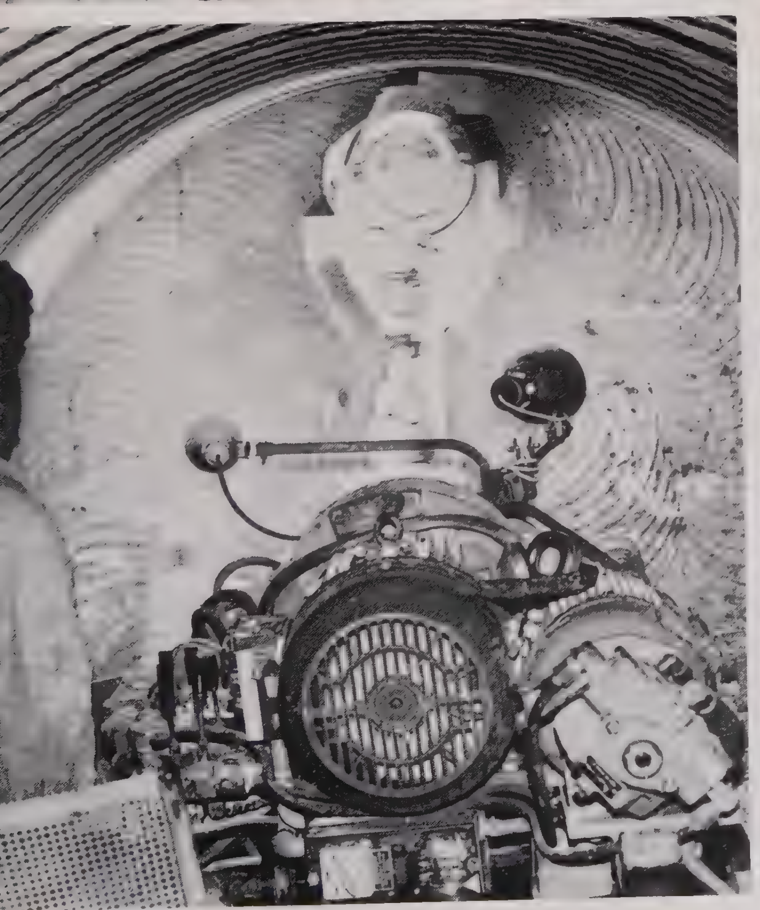
THIS PAGE BOTTOM: Camp in Stuart's Range opal field (Coober Pedy) in 1921 Photo: Courtesy Australian Geological Survey

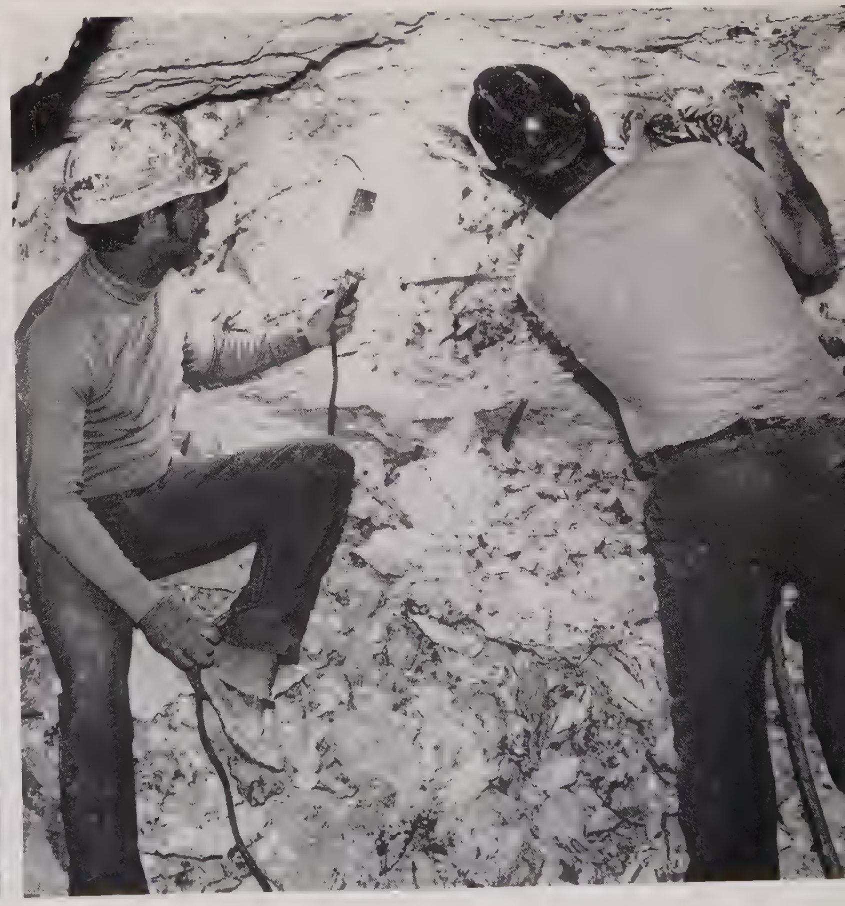
OPPOSITE TOP LEFT: Members of Adelaide Mineral Society being lowered 25 meters down shaft, 1978 Photo: Peter Bancroft

OPPOSITE TOP RIGHT: Author's wife, Virginia, talks with miners in maze of tunnels Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT: Boring machine at work Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT: Some opal mining is still done with a small jackhammer Photo: Peter Bancroft





O'Neil filled 12 kerosene cases and sold his material for 20 cents a gram.

A high percentage of fine gems came from opalized fossils—clams, cockleshells, wood, and reptile bones found within sedimentary strata. "Potch" meant opal without fire, and "crystal" referred to nearly transparent fire opal. The largest chunk of top-quality opal found in the early days weighed 300 grams, and an enormous mass of blue potch weighing 32 kilograms was unearthed close to the surface.

As the production of high-quality fire opal increased, more miners came to Coober Pedy to try their luck. At the present time, Coober Pedy is a thriving frontier town of more than 5000 people and serves a mining area of 15,000 square kilometers. There are motels, restaurants, a school, an airport, and a half-dozen rock shops which sell everything from souvenirs to opals.

The Coober Pedy mines produce gem opal valued at many thousands of dollars each week. The best gems come from the largest of the fields, the Olympic, where opal occurs at depths between 18 and 29 meters. Some miners remove the great overburden with huge tractors and then work all the opal-bearing strata below. Most diggers, however, use the "boring method." They drill a 1-meter hole downward until it intersects the opal-bearing strata. At the bottom of the hole, they dig a small room in which they assemble a $60,000 boring machine. A miner then climbs upon the machine's metal seat, switches on two lights to illuminate the tunnel face, and starts the electric motor. Slowly but steadily, two discs studded with carborundum-tipped teeth cut a 2-meter circle in the wall ahead. The boring machine produces a vacuum which sucks in the rock chips and pushes them through a tube up to the surface, thus keeping the mine floors free of rubble and the air clear of dust. The machine can cut through 3 centimeters of ground a minute. The miner may drive his machine in any direction, but when he encounters a chip of fire opal in the wall, he backs off and removes the gem material by hand.

A visit to the underground workings of a Coober Pedy opal mine is memorable indeed. From the time the visitor descends down the tiny shaft until he returns to the surface and daylight hours later, he is a part of an incredible subterranean world; a world of long, dimly-lit tunnels which have produced some of nature's most stunning masterpieces—beautiful fire opals.

BELOW:
Opalized tree limb
Size: 5 by 3 cm
Locality: Coober Pedy
Collection: Archie Kalokerinos
Photo: Archie Kalokerinos
Courtesy: Bruce M. Bowles

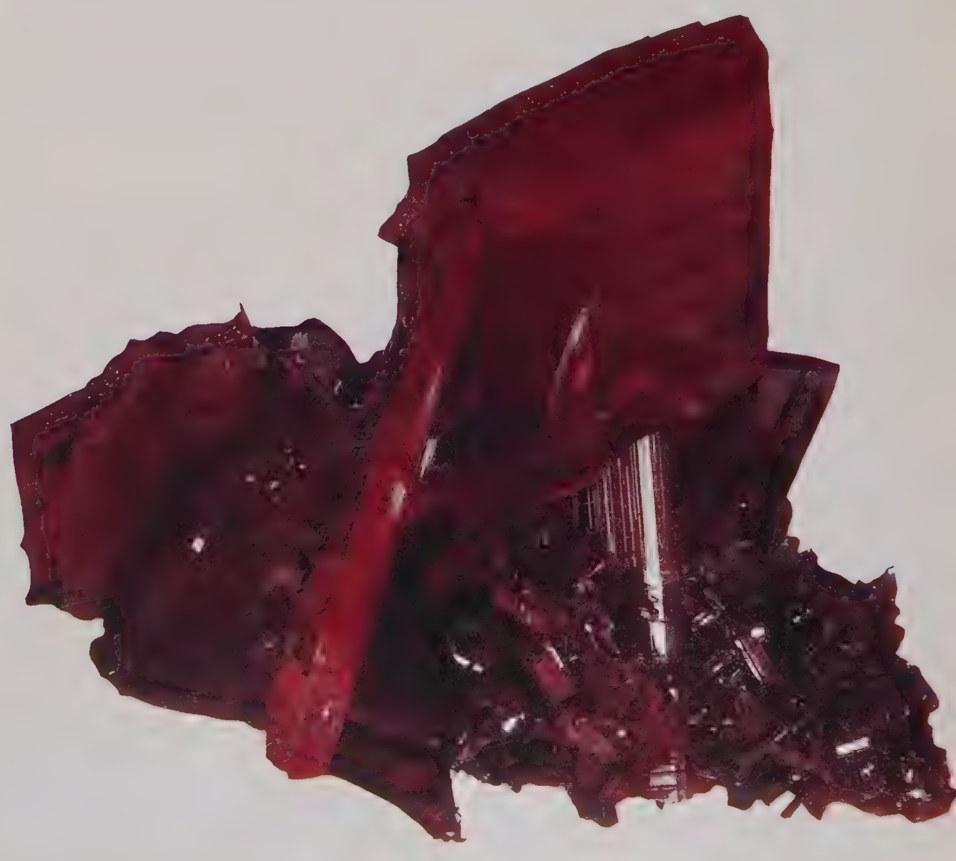
OPPOSITE LEFT:
Cerussite
Size: 33 by 26 cm
Locality: Proprietary Block 14
Collection: Australian Museum, Sydney
Photo: Charles Turner

OPPOSITE RIGHT:
Rhodonite
Size: 5 by 4 cm
Locality: Broken Hill
Collection: Albert Chapman
Photo: Rock Currier

51 Proprietary Block 14 Mine, Broken Hill, Australia

Broken Hill is a classic locality for fine crystals. Since 1883 an astounding 180 mineral species, superbly crystallized, have been unearthed in its 10 major mines. The Broken Hill array reveals every color of the spectrum, many in scintillating specimens that combine distinct species which give off several individual hues. Unfortunately, the great majority of crystals have been treated as ore and trucked to the mill. No one thought to photograph the remarkable crystal-filled caverns in the early days when vast oxide zones were first mined. Collecting was not in vogue on the rugged desert frontier, yet a few pieces did survive and their glorious beauty is dazzling. Some Australian museums possess riches in Broken Hill material: Sydney's Australian Museum; the Mining and Geological Museum; Albert Chapman's private collection, a veritable mineral museum in itself.

Exceptional crystals from Broken Hill, many of them unique in the world, include wine-red spessartine in bright dodecahedrons up to 10 centimeters occuring in galena; pyrrhotite crystals altered to pyrargyrite, magnetite, marcasite, and pyrite; silver in sheets 1 meter long and in aborescent groups of elongated crystals up to 5 centimeters in length, some with yellow goethite; perfectly formed 10-centimeter twinned green orthoclase crystals (the trace element which imparts their color is still a mystery); fragile columns of limonite to which are attached small cigar-shaped white cerussite crystals, themselves hosts of transparent blue-green smithsonite crystals; light pink bustamite prisms up to 14 by 5 centimeters; bluish green apatite crystals up to 10 by 1.5 centimeters embedded in pink bustamite; siderite rhombohedrons coated with rhodochrosite druses; stalactites up to 30 centimeters long constructed of radiating fibrous crystals of goethite; perfectly formed azurite crystals of fine color with individual crystals up to 5 centimeters; green smithsonite encrusted with wires of silver or copper; azurite crystals pseudomorphed by tenorite, malachite, and linarite; 3-centimeter lustrous azurite groups intergrown with white adamantine cerussite twins; reticulated white cerussite featuring interstitial spaces filled with lemon-colored embolite, malachite, or both; bright yellow-orange anglesite crystals; emerald-green crystals of brochantite associated with copper and linarite; canary-yellow pyromorphite crystals in skeletal form; rhodonite blocks 1 meter in width and transparent gem crystals up to 5 by 1 centimeters; transparent, stout, yellow and brownish-orange crystals of the very rare stolzite, some measuring to 2.5 centimeters. Those are but a few of the many



marvelous crystals from this world-renowned source.

Earliest records in the City Library at Broken Hill are inconclusive; a survey party may have visited the jagged outcrop on the Mount Gipps Run (now Broken Hill) as early as 1879. The group, searching for potential farmland, failed to notice minerals. Charles Rasp, a boundary rider at the local sheep station, had visited the ridge a number of times. Rasp was no geologist but he had ridden to some of the nearby silver claims—the Pioneer, Hen and Chickens, Terrible Dick, and Daydream—and learned the characteristics of good mineral veins. He believed the black gossan outcrops on the "ridge" to be rich in tin. Accordingly, he formed a "syndicate of seven men" and in 1883 "pegged out a claim" on the spot now known as Block 11. Eventually the syndicate claimed more blocks on both sides of Block 11 until it controlled the whole ridge.

THIS PAGE TOP: Loading silver ingots on bullock-pulled wagon, c. 1886 Courtesy: Broken Hill Proprietary Corp.

THIS PAGE BOTTOM: Proprietary Block 14 mine in 1890s Courtesy: Broken Hill Proprietary, Melbourne

OPPOSITE TOP: Approaching dust storm at Broken Hill, c. 1900 Courtesy: John Gough, Broken Hill City Library

OPPOSITE MIDDLE: Underground drive at Junction North mine, 1905 Courtesy: Broken Hill Proprietary, Melbourne

OPPOSITE BOTTOM: Federal militiamen in Broken Hill to protect mines, 1909 Courtesy: Broken Hill City Library

The first year was most difficult. No housing was available; water and provisions were scarce; winds blew dust much of the time. Surface ore proved to be low-grade, and the syndicate lost heart. Miners finally discovered a rich vein of silver-lead ore—not the tin they sought—and in the years to come Broken Hill became "the richest silver-lead mine on earth." Tall brick smelter chimneys, wooden headframes, engine houses, and mills covered the rocky slopes for a distance of 3 kilometers. At the foot of the ridge, the town of Broken Hill grew to 22,500 inhabitants. Rasp became one of Australia's wealthiest and most influential men.

During the early days of Broken Hill, newspapers faithfully reported all sorts of events. 1899—"Camels are becoming a nuisance in the township, being allowed to run free by their Afghan and Indian owners." "John Penrose's house was relocated at 472 Chapple Street to be used by the Salvation Army as a maternity home for fallen girls, whose not inconsiderable numbers warranted such action." 1901—"Valuable consignments of opals from the White Cliffs field are being dispatched regularly through Broken Hill to the capital cities." "On September 1 the stagecoach driven by Andrew Pedrana was robbed at gun point." 1903—"The Proprietary Mine had 52 horses in use underground. There were harrowing stories of the animals becoming blind or taking 'lead fits' because of staying underground too long." "On January 20 a stagecoach bound for Broken Hill was robbed of a mail bag containing opals worth £3000. The robbery suspects were freed for lack of evidence and the opals were never recovered." 1903—"Broken Hill, in continued drought and desperate for water, hired a professional rain-maker, Dr. C. de Lacy McCarthy, who, amid a welter of publicity, floated balloons filled with chemicals and fired cannonballs into the atmosphere. After weeks of intense activity McCarthy conceded defeat and left Broken Hill, blaming his failure on 'the unyielding dryness of the atmosphere.'" "Sanitary pans and cesspits were constantly overflowing and the effluent ran unchecked down Crystal Lane." 1904—"An inspection of the Burke Ward school by town aldermen revealed that sand-drift had reached the top of the school fence, making it scalable from outside." "In a gambling raid, nine policemen descended upon the Tattersalls Club on Chloride Street, arrested 63 men and marched them, handcuffed, in double file to the police station." 1906—"Horses in the streets were

startled at the appearance of a seven-horsepower Oldsmobile car roaring about town." 1907—"The Broken Hill gaol carried out its first (and only) execution on January 29, by hanging Peter Sadeek, aged 63, who had stabbed to death a prostitute named May Cooney." "In October a fire claimed the life of W.J. Eddy at the Block 14 mine. Eddy had descended a winze on a rope to warn other miners of the fire but was overcome by smoke and gas." 1909—"Striking miners set up mock graves about town bearing derogatory 'epitaphs' mostly directed at scab shift bosses." One marker read:

Soft as the Fading Vesper
At the breaking of the day
In answer to the Union's Whisper
Past his Scabby life away.

Where he's gone We cannot tell
But we think the B______ gone to
Hell

THIS PAGE TOP:
Rhodonite on calcite
Size: 3 by 2 cm
Locality: Zinc Corporation, Broken Hill
Collection: Doreene Chapman
Photo: John Fields

THIS PAGE BOTTOM:
Cerussite
Size: 25 by 22 cm
Locality: Proprietary Block 14 mine
Collection: Noel Frank
Photo: John Fields

OPPOSITE TOP:
Union erected mock grave of strike breaker, 1909
Courtesy: Broken Hill City Library

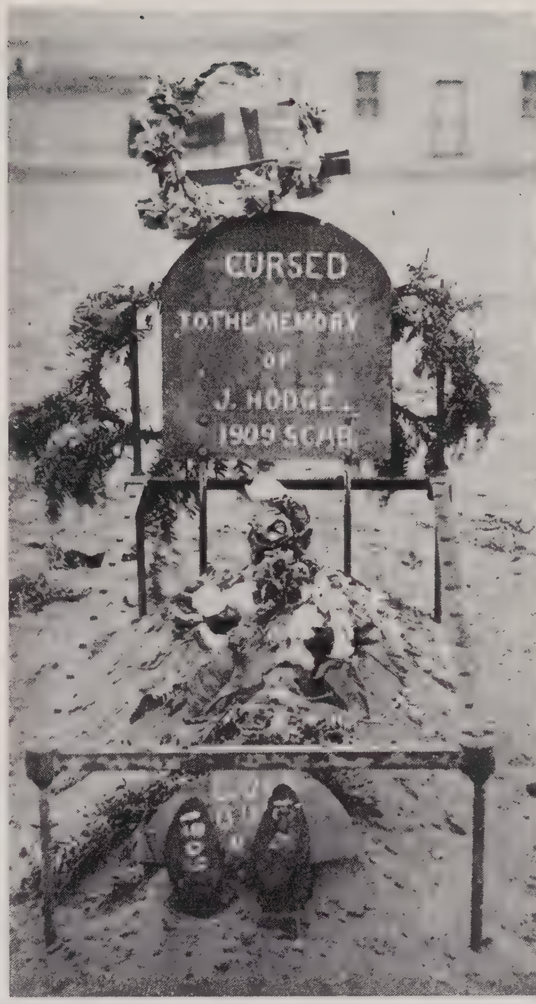
OPPOSITE BOTTOM:
Remains of Proprietary Block 14 mine, 1978
Photo: Peter Bancroft

Attractive today, Broken Hill has become one of Australia's largest inland cities. As its mines close for lack of ore, new water sources are predicted that may ultimately turn the desert into productive farms and housing developments, and bring a prosperous future.

But the mines are not closing unnoticed. When the South mine announced two months in advance that it was pulling its electrical switches for the last time on June 7, 1977, Broken Hill's *Barrier Daily Truth,* voice of the Miners' Union, stated:

> *All workers must realize now that promises made over the years, the cooperation and breaking down of prejudices, handshaking and good fellowship practiced by some company officials is just a thin veneer to lull their workers into a fool's paradise which they will snatch back when profits fall. The leaders of the trade union movement hope that common sense may yet stave off this evil day.*

Every effort to postpone the inevitable closing day failed. Broken Hill's last operating property, the North mine, faces a similar fate within a few years. Miners will be replaced by farmers, tradesmen, and merchants as the deserts become vast farms. Australian government planners predict Broken Hill will continue to grow. The city will always be a monument to the tunnels and stopes beneath its streets.



52 Four-Mile Field, Lightning Ridge, Australia

Pliny the Elder admired the opal: "It is made up of the glories of the most precious gems, and to describe it is a matter of inexplicable difficulty."

Innumerable superstitions have been ascribed to the opal. In early history it was believed that an opal assured its wearer good health, love, and wealth. Later however, possibly during the 17th century, the opal's popularity diminished, and eventually it was thought the gem brought evil to its owner. The beautiful opal has since regained its popularity, and superior-quality gems command premium prices throughout the world.

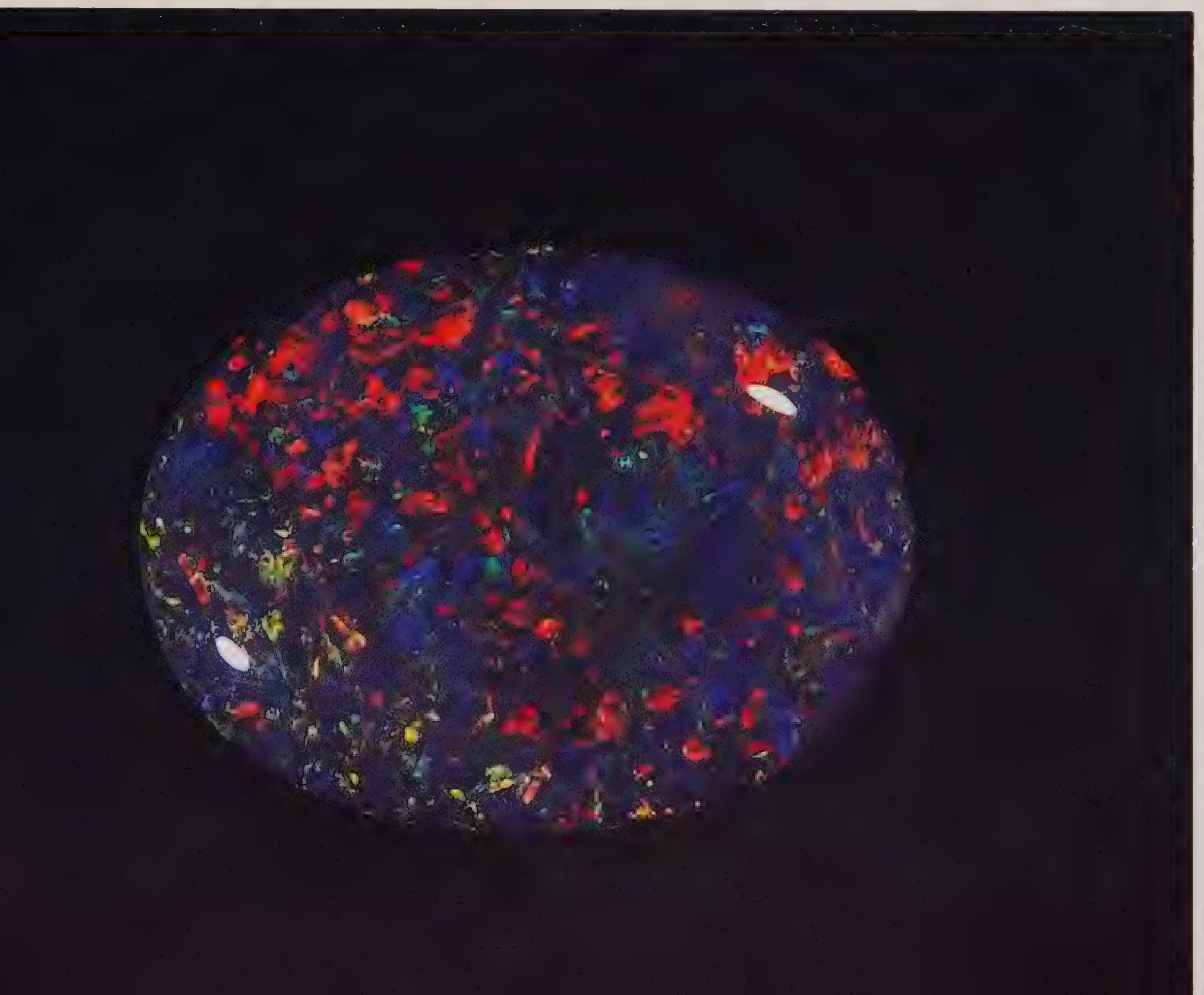
Black opal, quite possibly the most spectacular of all gemstones, frequently exhibits a display of colors unmatched in nature. A single black opal may possess flashes of spectral colors from flaming red to deep violet-blue including vibrant yellows, oranges, and greens—all in a remarkable kaleidoscope of striking hues. The term "black opal" is reserved for opals with a dark body color ranging from gray to nearly pure black. This natural background is a perfect foil for setting off the vivid colors.

Most black opals come from famous Lightning Ridge, about 800 kilometers northwest of Sydney. Tons of dirt and rock may be moved and processed before a single fine opal is found, and many kilograms of fire opal may be mined before a good black opal is uncovered. Machines drill shafts until opal "dirt" is reached, from a few meters to more than 20 meters below the surface. Machines, or men with jackhammers, dig lateral drives until distance for waste haulage becomes a problem; then they sink a new shaft. Most opal occurs in dirt overlain by layers of sandstone and gravel. Many gemstones occur as hard elliptical nodules or *nobbies* about the size of olives. Frequently found in groups, *nobbies* also occur singly. Nodules may contain only potch (opal without fire) or may have a central core of precious opal surrounded by potch. Opal at the Ridge fills voids resulting from the leaching of organic material. Thus, opal preserves the fossil morphology of mollusk, wood, and reptilian remains. Sometimes these are beautiful fire opals.

Much of the opal found in recent years was recovered from old dumps. *Puddling machines,* constructed from perforated steel drums, contain rotating shafts fitted with leather or rubber paddles and driven by an old automobile engine. Opal-bearing dirt placed in

BELOW: Queen of Gular black opal
Size: 42.80 carats; 35 by 27 millimeters
Locality: Lightning Ridge
Courtesy: Ronald Pingenot
Photo: Earl Lewis

OPPOSITE: Black opal
Size: 2 cm
Locality: Lightning Ridge
Collection: Archie Kalokerinos
Photo: Archie Kalokerinos



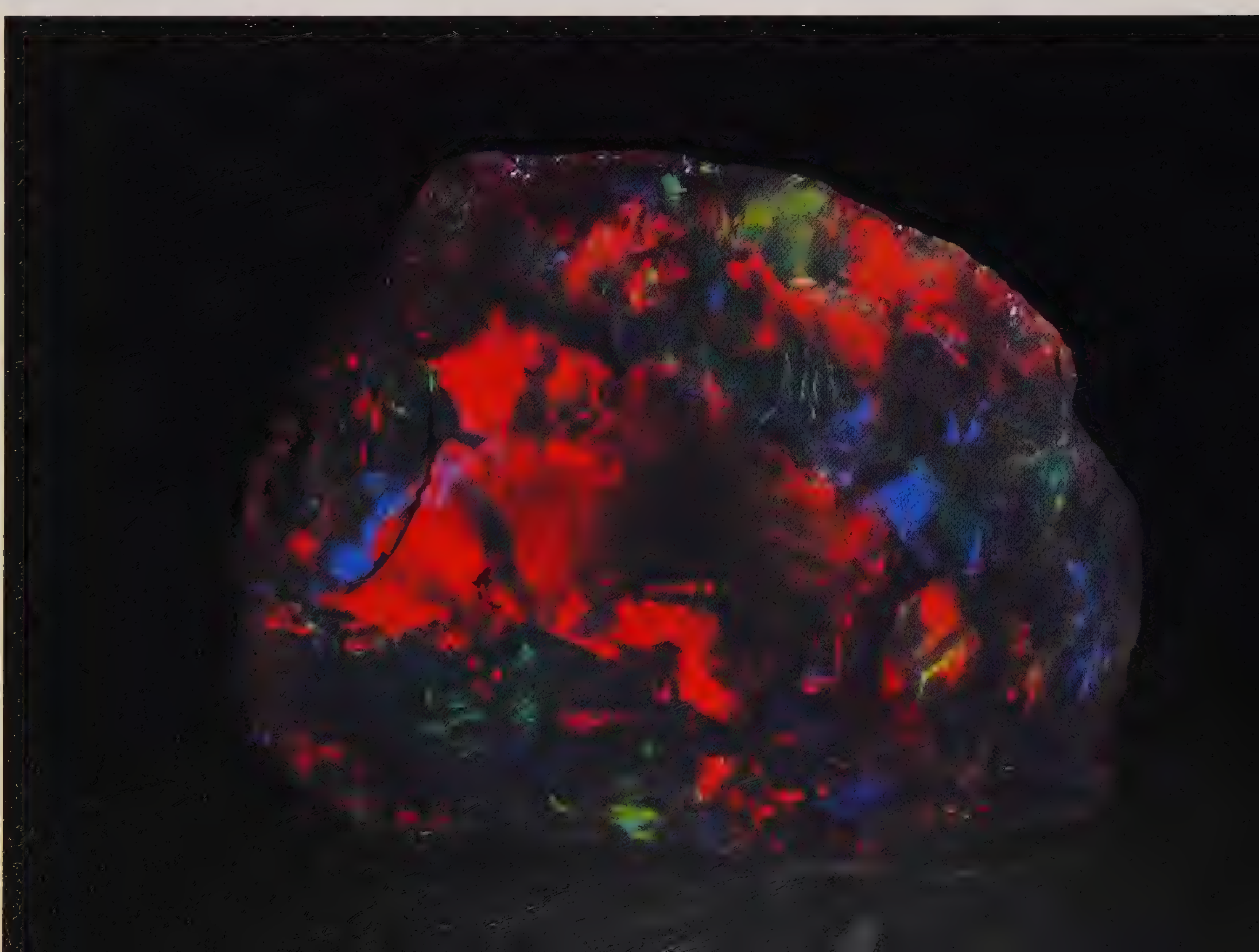
the drum is battered by the paddles. Waste sifts through perforations in the revolving drum, leaving the hard *nobbies* inside. Because of a shortage of water, the first *puddlers* were operated dry, but today improved water supplies allow the use of more efficient *wet puddlers.*

Both children and boundary riders are credited with the discovery of opal in the 1880s. There were stories of "pretty stones" lying about on the surface of a raised narrow strip of land near Wallangulla. But more than 20 years passed before two pioneers saw the stones, identified them as opals, and commenced mining operations. Jack Murray sank two shafts on his property in 1902. At about the same time Charles Nettleton, an experienced miner from Bathurst, rode by the ridge and discovered opal. The two men became partners and began to mine. At first buyers were suspicious of the dark stones, saying "the opal was too young and was on a black matrix." Nettleton eventually sold 17 ounces of gem-quality opal to Ted Murphy in White Cliffs for $30.

Before long, European buyers determined the black opals to be the "fanciest" they had seen. Durable opal *nobbies* were not inclined to craze or crack. Prices rose and the rush to the Ridge was on. The new mining region became known as Lightning Ridge, a name derived from an incident decades before when shepherds had corralled their sheep in the shelter of the ridge during a bad storm and lightning struck, killing more than 300 of the flock.

From the beginning the camp lacked water and food was difficult to obtain. Wages were low; miners worked for as little as $2.00 a week and "tucker" (board). Mayhem was a continual problem—fights and murders were commonplace, claims were jumped and water holes poisoned. Eventually law and order prevailed.

Charlie Nettleton was 40 years old when he arrived on the Ridge. A tall, slim, mustached bachelor, Charlie was a born miner. In 1907 he discovered Three Mile Field, the major "working" in the area. At one time more than



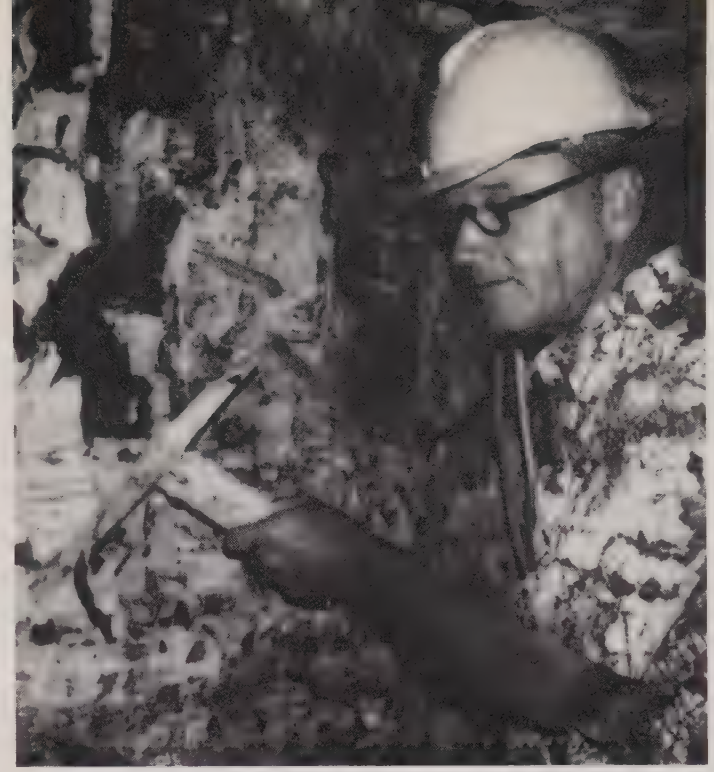
THIS PAGE TOP:
Opal gougers underground at Three Mile Field in 1907
Courtesy: Australian News and Information Bureau

THIS PAGE BOTTOM:
1958 "puddling machine." Jigger is vibrated by truck engine, water takes away sand and clay nobbies (nodules) which may contain precious opal.
Courtesy: Australian Geological Survey

OPPOSITE TOP:
Joseph Ferdyn working 25 meters down in Lightning Ridge mine at Four Mile Field, 1977
Courtesy: Joseph Ferdyn

OPPOSITE MIDDLE:
Hoist machines, each operated by a single miner below ground, 1958
Courtesy: Australian Geological Survey

OPPOSITE BOTTOM:
Visitors inspect "blower machine" which vacuums dirt from bottom of mine to surface, 1978
Photo: Joseph Ferdyn



1000 men labored there, producing more opal than all the other Lightning Ridge properties combined. Most opals were obtained by "gougers" (miners) working underground in tunnels and stopes.

Charlie Nettleton, in later years blind and unable to see the beautiful stones which he supplied to the world, died in 1946. He was buried in a pauper's grave in Sydney. Today there is talk of bringing him home to a final burial at the Ridge in appreciation of his "pioneering exploits" and "for the attraction his grave would be to visitors."

Now the Three Mile workings are closed. Miners have moved on to develop new areas such as Four Mile Field, Poverty Point, Hawk's Nest, The Butterfly, Indian Lookout, Frying Pan, The Phone Line, Six Mile, Nine Mile, and Old Chum. The Four Mile Field, one of the

most prolific at the Ridge, still produces large quantities of fine opal.

Famous Lightning Ridge opals include: the Empress, Black Prince, Pride of Australia, Crystal Princess, Flame Queen, Pandora, Light of the World, and probably the most striking of all, the Butterfly or Red Admiral, found in 1922 by "Canada" Bill Etheridge.

In 1979 the *Lightning Flash,* the camp's bimonthly newspaper, portrayed Lightning Ridge as a cosmopolitan town with paved streets, an elementary school, glider club, unisex barber shop, and airport. But the age-old problem of water lingers. A letter to the editor complains:

> *Doesn't the Council realize that it is a noxious-smelling liquid that has to stand for 24 hours before it is drinkable and that it comes out of the COLD water tap up to 108° Fahrenheit? The Ridge is getting a raw deal when one compares the quality of the water here to that in other parts of the Shire.*

The Lightning Ridge Tourist Association publishes a little pamphlet for the visitor. Items of information and advice include:

> *Party ice is available at the rear of the bakery on Opal Street, and in Crocodile Park; the main road from Sidney is bitumen sealed right into the town itself; the Walk-In-Mine invites visitors, especially the elderly or those who have misgivings about descending steel ladders into mine shafts, to see how a real opal mine works; picnic races for horses, twice a year at Easter and October Long Weekend; local graziers are empowered to shoot any dog actually caught worrying or killing sheep on their property; and, Safety on Fields—visitors are reminded of the hazards of strolling about the opal fields, and are strongly urged to keep children under strict supervision.*

The old-timers who gouged for opal in the early days of Lightning Ridge are gone and with them their tales. The fabulous bonanza days were summarized by 75-year-old Mick Canfell in 1948: "We struck it all right. At times it was like putting yer pick into a jeweler's shop. Migawd, if I had that gem stuff today I'd buy Sydney Town Hall and the clock with it."

BELOW: Aborigine with freshly killed lizard in the "outback" near the Ridge, 1971
Photo: Peter Bancroft

OPPOSITE TOP:
Crocoite
Size: 30 by 18 cm
Locality: Adelaide, Dundas, Tasmania
Collection: Harvard University
Photo: Alphonse Coleman

OPPOSITE BOTTOM:
Crocoite and Chrome Cerussite
Size: each 6.5 by 5 cm
Locality:
Adelaide mine (cerussite)
Red Lead mine (crocoite)
Collection: David Ellis
Photo: David Ellis

53 Adelaide Mine, Dundas, Tasmania

Beautiful orange-red crocoite contains two elements rarely found together in nature: lead and chromium. Known from the Soviet Union, Romania, Brazil, the Philippines, and a few other places, crocoite crystals occur abundantly only in Dundas, Tasmania. Most of the really striking specimens seen in museums and private collections today came from the Adelaide mine near Dundas.

The silver-lead district, located 11 kilometers due east of Zeehan, was discovered in 1886 by George Lambie. At that time the region was mantled with a brushy forest so dense that a man could hardly walk through it. In addition, Zeehan and Dundas marked a frontier almost isolated from the rest of the world. Living conditions were difficult at best. Nevertheless in short order a number of mines were "pegged" including the Bonanza, Palace, Success, Energetic, Good Intent, Fauntleroy, Grand Prize, Madame Melba, and Moore's Pimple. None lasted long or produced much ore. Fortunately other mines had far greater commercial importance, and some of them produced marvelous mineral specimens. John Maestri's diggings, discovered in 1888, and the West Comet mines, opened in 1890, yielded

clusters of long white cerussite crystals growing from bases of black gossan (hydrous iron and manganese oxide) and very good crocoite crystals. The Red Lead mine became a major contributor of rich reddish-colored crocoite crystals. Crystals were especially abundant during the 1910s and 1920s when horse-drawn trucks were loaded with thousands of kilograms of crocoite "blinding in the sun." Some chunks of crocoite crystals, too large to lift by hand, were broken down before loading. All this material went to the smelter at Zeehan.

From the beginning the Adelaide mine furnished an incredible array of crystallized minerals including: gibbsite, chromiferous canary-yellow cerussite, dundasite, phosgenite in fine crystals, jamesonite, pyrite, stichtite, bindheimite, sphalerite, galena, and of course, crocoite. This mine was located on the west end of Stichtite Hill; the mineral was named for American metallurgist, Robert Carl Sticht, one of the most important figures in early Tasmanian mining.

The Adelaide's ore body, composed primarily of ferromanganese gossan, produced incredible crocoite crystals within the mass. Some measured over 15 centimeters in length and some crystal groups weighed 2 kilograms or more. Nearly all crocoite was shipped to the smelter as a flux, but specimen material spirited away by the miners ended up in homes throughout Tasmania. Most specimens had been carelessly handled and, although of bright color, were hardly desirable as quality crystals suitable for mineral collections.

A serious problem plagued the Dundas silver-lead mines: none had substantial reserves of ore. By 1900, many operations had closed, and the remainder were in trouble. For the next 70 years, the Dundas mines saw little or no activity. Then in 1970 Frank Mihajlowits, "Mr. Crocoite of Zeehan," leased the Adelaide and went to work. For two years he reworked the dumps, prospected old workings, and drove new tunnels. One day without warning the face wall of his tunnel gave way, exposing a dark hole directly ahead. Pushing his light into the cavity he was astounded to see a small cavern,


Certificate No. 18 THE ONE SHARE.

Dundas East Prospecting Association, No Liability.

Mount Dundas, Tasmania.

Registered in Tasmania under "The Mining Companies Act, 1884."

CAPITAL: £2,000 IN 200 SHARES OF £10 EACH.

This is to Certify that ... of ... is a member of the abovenamed association and the proprietor of ONE share in the said association, numbered 18 which is issued as paid up to FIVE POUNDS at date hereof, subject to the rules and regulations of the said association.

Dated this First day of November, 1890.

Manager Directors.

N.B. – This Certificate must be given up to the Manager on Transfer of any of the Shares. TRANSFER FEE, SIXPENCE.
CALLS PAYABLE SECOND WEDNESDAY IN A MONTH ONLY.

THIS PAGE TOP:
Dundas East Prospecting Assn. stock share, 1890
Courtesy: Queenstown Museum

THIS PAGE BOTTOM:
Main street of Dundas in 1892
Courtesy: Zeehan Pioneer Museum

OPPOSITE: Crocoite
Size: 11 by 4.5 cm
Collection Edward Swoboda
Photo: Earl Lewis

possibly 2 meters long, ablaze with orange reflections from crocoite crystals. The cave was large enough for him to enter, but to do so would crush many of the crystals which lined every wall. He had worked for two years for his strike; now he could be patient. He gave no thought to photographing the vug, for to do so might reveal the find to high-graders who'd steal much valuable material. Mahajlowits spent weeks removing thousands of orange, terminated crocoite crystals, some over 8 centimeters in length. Unquestionably this was the greatest crocoite strike since the early days, and clusters of crystals from his Adelaide vug now grace museums throughout the world.

The future of crystal collecting at Dundas seems bleak. The known oxidized ore zones have been mined out. Old stopes and drifts are either flooded or caved, and extending tunnels in search of crystals would require great effort. Many Tasmanian crystal collectors feel that a serious search would not be worth the trouble. So today the old mines remain deserted, with heavy brush encroaching on dumps and covering the sagging portals. Within a few years Tasmania's classic crocoite localities will disappear completely.

The town of Dundas is gone; only a rock foundation or two remain in the fields of weeds. But in 1892 shopkeepers, children, miners, harlots, and mule skinners passed along its busy streets. The Zeehan-Dundas

THIS PAGE TOP:
Zeehan School of Mines mineral museum, c. 1893
Courtesy: Zeehan Pioneer Museum

THIS PAGE BOTTOM:
Part of Dundas at its peak, 1896
Courtesy: Zeehan Pioneer Museum

OPPOSITE TOP:
One entrance to the Adelaide mine, 1978
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Frank Mihajlowits inspecting crocoite deposit in the Adelaide, site of "great pocket."
Photo: Peter Bancroft

Tramway was extended westward toward a new station in the township. H. Johnson was building a "commodious" hotel, and Robert McKimmie had opened a general merchandise store. The Evershed brothers sold magazines and books in another establishment. There was a "red-light district," livery stable, school, church, and several pubs. Some businesses still operated in tents, but most establishments had been modernized and built of wood. Of a Sunday morning, "respectable" individuals walked down to the church or lounged in the shade of store porches. Representing the "opposition," Chinese Pete, a brothel operator, chose the same hour to parade his harlots through town in carriages. (There is no record of the townspeople's reactions to this weekly event.)

Today sheep graze the old town site, the mines of Dundas are closed, and the Dundas Tramway operates only in memory. Old-timers have gathered what relics they could and have presented them to Zeehan's Pioneer Museum. Among the memorabilia is a poem written in honor of a miner who lost his sight in a mine accident. Like so much of Dundas, the name of the poet has been lost.

JIM GOLDBY THE BLIND MINER
Not always blind; no, once to me
Each morning brought its light,
But fate stepped in, cut out the day
and left me only night.

In fancy oft I see my mates
And grip each kindly hand,
The miner—generous to a fault,
The best man in the land.

God will surely richly reward
The miner and his kind,
Who from the fullness of his heart,
So nobly helps the blind.

Kind acts and thoughtful words
Are to me as rays of light;
They help to keep my courage up,
And keep my spirits bright.

'Twould be a better world today,
If we only helped each other;
I'm blind, but if of help to you,
Just tell me so, my brother.

My wife and I, and family too,
Do pray to God to bless
The donor who so cheerfully gives,
To make my burden less.

May God watch o'er, protect and guard
Your sight—most precious gift,
May darkness only come at night,
For the morning sun to lift.

54 Ichinokawa Mine, Saijo, Japan

One of the most famous yet least publicized crystal sources on earth is the Ichinokawa antimony mine, located 7 kilometers southeast of the Saijo railway station on the central coast of Japan's Shikoku Island. Almost a century ago it produced nearly all the largest and most spectacular stibnite crystals which remain on exhibit anywhere today. Most of the giant crystals were mined between 1882 and 1886, though stibnite crystals came from the Ichinokawa mine much earlier. S. Kiuchi, Japan's first mineral collector and author of *Unkonshi,* the oldest Japanese mineral book (1773), had a stibnite crystal from Ichinokawa.

Southwest Japan's greatest tectonic feature is a factor at the Ichinokawa mine. A major fault between two tectonic plates separates the mine's basic formations: Cretaceous sandstones and shales, and Permo-Carboniferous slates, phyllites, and schists. Antimony ore bodies in the fracture zones of the Ichinokawa were caused by heavy faulting. Within the core of antimony veins large vugs sometimes formed and incredible stibnite prisms grew into them. During the growth process, crystals attached themselves to neighbors. Because of that, and because of the great profusion of soft, brittle crystals growing from vug walls, it was virtually impossible to remove the giant stibnite clusters without some damage. In exasperation many miners broke single prisms loose from their matrix and carried them in their pockets from the mine. Trays of a dozen or more single crystals have been offered for sale at bargain prices. Some crystals exceed 60 centimeters in height and 10 centimeters in diameter—absolute giants in comparison with specimens from other localities. (Fine stibnite crystals, though smaller, also have been found in the Tsugu mine in Aichi Prefecture and the Nakase mine in Hyogo Prefecture.)

Ichinokawa stibnite crystals have developed in a great variety of different crystal forms; 45 distinct configurations were recorded by Japanese mineralogists, and 40 more were discovered by the American, E.S. Dana. An Austrian, J.S. Krenner, identified three and a German, G. Seligmann, discovered another. Finally Daisuke Tanaka of Omachimura, Nii-gun, contributed 18. Thus, there are an astounding 107 separate crystal forms of stibnite. Ichinokawa crystals, usually heavily striated and lightly tarnished, have a dull gray or even an iridescent bluish to purplish cast.

BELOW: Stibnite
Size: 15 by 13 cm
Locality: Ichinokawa
Collection: Smithsonian Institution
Photo: Dane Penland

OPPOSITE TOP: Stibnite
Size: 24 cm
Locality: Ichinokawa
Collection: Richard Webster
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM: Stibnite
Size: 29 cm
Collection: Wada (on display Mitsubishi Metal Mining Co.)
Photo: I Sunagawa

Terminations tend to display steep pyramids and, because of the mineral's softness, most show some damage. Relatively few stibnite crystal clusters remain in Japan, but most of the world's major museums exhibit several examples.

Fine stibnite crystals and groups of exceptional size are displayed in the University of Tokyo Museum and in the T. Wada collection housed at the Central Research Laboratory, Mitsubishi Mining Company, Yono, Saitama Prefecture. The Wada mineral collection, considered the best in Japan, contains more than two dozen single stibnite crystals exceeding 20 centimeters in length; one is 60 centimeters long.

Nearly all records and photographs of the Ichinokawa mine were destroyed during World War II and in a subsequent earthquake. However, Saijo Mayor Hitoshi Ito and his staff located a few remaining documents. They provided nearly all data and photographs reproduced here.

The Saijo Museum, a handsome series of modern buildings, borders the Kamo River. It houses attractively displayed collections of artifacts, antiques, guns, birds, and minerals. One case exhibits a 31-centimeter group of stibnite crystals and a single beautifully terminated crystal 18 centimeters long. Between the two specimens, a cigarette case bearing the word "peace" provides a scale for the size of the specimens.

According to *Ancient Chronicle of Japan,* in the second year of Emperor Monmu (698 A.D.), antimony was presented to the Imperial Court from Iyo. (A much more important city than Saijo in those days, Iyo was given as the mine location although it was considerably farther away.) A Korean family named Yakaramaro probably mined the first antimony in Japan; however, there is no record of crystals being either recovered or saved during those early days.

Some 453,736 kilograms of copper and 7571 kilograms of antimony were used to cast the Great Buddha of Nara in 748 A.D. The antimony, used in lieu of tin, was mined near Iyo. Because the Ichinokawa locality was the only major producer of antimony in Iyo Province, the fabrication date of the Buddha indicates that the mines were operating in the 8th century, A.D.

In 1867 the Meiji government began to industrialize Japan. Europeans introduced advanced mining techniques and the Ichinokawa was modernized. The government

commissioned an Englishman named Freshwill to investigate the mine and suggest improvements. He found miners encroaching illegally on Ichinokawa land and working without authorization. In order to prohibit illegal mining, the prefecture appointed 50 local residents to manage the mine. This group contracted with the firm of Fujita-jumi of Osaka to do the actual mining. Fujita constructed mills, a smelter, and the mining village of Ichinokawa. During its lifetime, the Ichinokawa mine became a relatively large operation. Its main adit alone was more than 1200 meters in length.

At Ichenoka, 3 kilometers south of Saijo, another antimony mine, the Yokohi, was discovered in 1908, and operated until 1916. This deposit comprised four principal veins extending through crystalline schists. Fissure stringers of pure stibnite were found scattered in quartz gangue. Some stibnite crystals were encountered, but those were of less importance than crystals from the Ichinokawa.

By 1910 ore reserves in the Ichinokawa were exhausted and the mine shut down. It remained dormant until 1955 when the owners undertook a complete investigation including core drilling. The results were not encouraging, all portals were sealed off, and there is no reason to believe the mine will ever reopen.

THIS PAGE TOP:
The mill of the Ichinokawa mine, c. 1890
Courtesy: City of Saijo

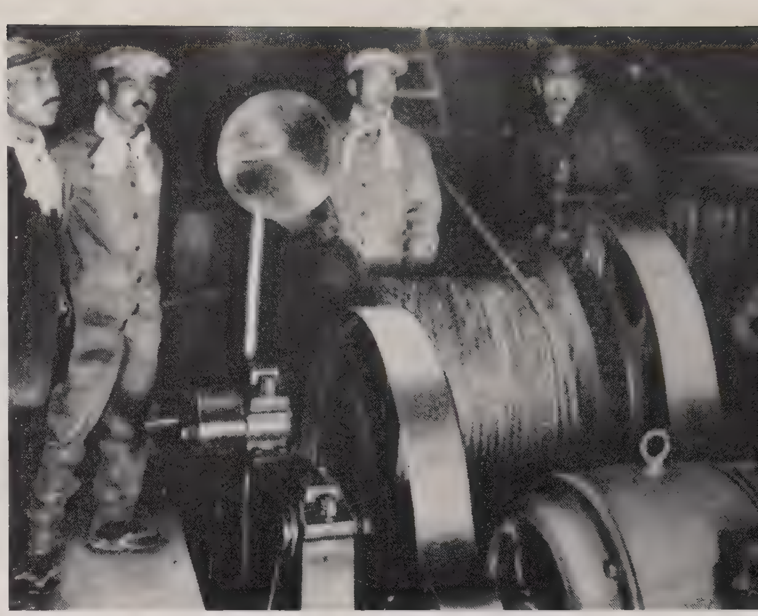
THIS PAGE BOTTOM:
Ore selecting at Ichinokawa, c. 1890
Courtesy: City of Saijo

OPPOSITE TOP LEFT:
Ichinokawa mine complex, c. 1900
Courtesy: City of Saijo

OPPOSITE TOP RIGHT:
"Lifting machine" in the mine, c. early 1900s
Courtesy: Saijo City Museum

OPPOSITE BOTTOM LEFT:
Morning Sun portal at Ichinokawa in 1890s
Courtesy: Saijo City Museum

OPPOSITE BOTTOM RIGHT:
Logging ore deliveries at Eel mine portal, 1898
Courtesy: Saijo City Museum



55 Taehwa Mine, Neungam-Ri, South Korea

During the last half-century, Korea has produced a substantial percentage of the world's best scheelite crystals. These specimens are consistently better than scheelite crystals from such famous localities as Traversella in Piedmont, Italy; Cornwall, England; Kwangtung Province, China; and Cochise County, Arizona. The colors are richer, the crystal faces larger, brighter, and sharper. Appealing to collectors, Korean scheelite crystals tend to occur attached to clusters of quartz crystals. As a result these constitute the most striking scheelite specimens on display in collections throughout the world.

Fine scheelite crystals have been produced by at least six different Korean mines including the Tonsan, Mino, and Taehwa. But attributing a particular crystal to a specific mine is an uncertain business. In some cases mineral dealers gave erroneous locality names to specimens probably in an attempt to keep sources secret. It is reasonably certain, however, that most of the fine scheelite crystals marketed in the last 12 years came from Taehwa.

The Taehwa mining region lies approximately 75 kilometers southeast of Seoul. The mine is reached by a paved road from Seoul to just beyond Changhoweon,where a dirt road turns east and passes through scenic country dotted with small farms set among rolling hills. Upon entering the tiny mining village of Neungam-ri,

BELOW:
Scheelite on quartz
Size: 11 by 6.5 cm
Locality: Taewha
Collection: John Barlow
Photo: Harold and Erica Van Pelt

OPPOSITE:
Scheelite with quartz
Size: 18 by 15 cm
Locality: Taewha
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt

a driver must slow down on the narrow cobblestone streets to avoid countless children and dogs. To the south, large mine dumps drape down hillsides, indicating the Taehwa mine's location. The trip from Neungam-ri to the mine is a very rough drive or a pleasant hike. Visitors can find lodging in Chunju, a small city south of Neungam-ri, and either drive or take a public bus to Neungam-ri.

According to Jae Choon Um, the mine manager, the Taehwa mining region was probably first prospected in the 1890s. Since then little has changed; the mine remains unpretentious; the dumps get a little larger. Around 1902 a quartz vein containing wolframite, scheelite, and molybdenite was discovered as an outcrop near Tongmak-ch'i, just east of Poryon-san. Miners opened the deposit, which would have a long and turbulent history. It was worked first by the Koreans, then by the Japanese, and again by the Koreans who continue today. It has had many names: Taika, Nungdong, Poryon, Kodo, Mitsui, Hungdong and, since 1927, its enduring title Taehwa.

Tungsten was the chief product of the Taehwa mine from 1902 until 1938, when molybdenite was first produced. By 1944 the Taehwa mine had become Korea's largest producer of molybdenite.

Long, narrow ore veins range in width from 1 to 40 centimeters and reach lengths of about 750 meters. Technically they are described as "pegmatitic quartz veins." Molybdenum-bearing veins are often separate from those rich in tungsten. Molybdenite usually occurs in filled veins as opposed to the tungsten minerals which are found in vugs. Because molybdenite crystals are easily sheared during removal, good crystal specimens remain rare. Scheelite

crystals, however, form in open vugs frequently lined with terminated, clear quartz crystals which separate relatively easily from pocket walls. Scheelite crystals most often form as pseudo-octahedrons, although intergrowth and modification commonly occur. The frequency of sharp, bright crystal faces, and scheelite's tendency to form in large crystals sets the Korean material apart from all the rest. Crystals measure to 14 centimeters on an edge, and occur in a wide variety of colors: white, gray, black, brown, orange, yellow, reddish-brown, and noteworthy violet-brown to nearly purple hues. Probably the most appealing trait of Taehwa scheelite is its assocation with quartz crystal clusters. When cleaned and trimmed, scheelite matrix

THIS PAGE TOP:
Inshik Oh in one of main tunnels
Photo: Peter Bancroft

THIS PAGE MIDDLE LEFT:
Male miner and lady "nipper" push ancient ore car
Photo: Peter Bancroft

THIS PAGE MIDDLE RIGHT:
Japanese geologists and miners at Taewha, 1917
Courtesy: Inshik Oh

THIS PAGE BOTTOM:
Main dumps at Taewha, 1978
Photo: Peter Bancroft

OPPOSITE TOP:
Mine manager, Jae Choon Um holding scheelite matrix
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Miners at lunch break in change room
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Miners waiting to go on shift. Carbide lamps are still in use.
Photo: Peter Bancroft

specimens make handsome additions to the collector's cabinet.

The mine proved safe for the author's visit, even in the areas which had been blasted the previous day, and ventilation was excellent. (In 1927 the Japanese drove a 460-meter tunnel clear through the mountain; leaving both entrances unobstructed assured a continual flow of cool, fresh air.) Fifteen- to 35-centimeter-thick white quartz veins spaced between layers of Precambrian biotite and granite gneiss appear at the working faces; veins contain pockets every meter or two but produce scheelite crystals only infrequently. The largest scheelite mined during our visit was a 2.5-centimeter loose brown crystal.

Associated minerals at the Taehwa mine include wolframite; chalcopyrite; pyrite; calcite; beryl; muscovite; fluorite in light green 13- to 6-millimeter cubes attached to scheelite and quartz and also gray, purple and white crystals to 4 centimeters not on scheelite; cassiterite in brilliant twinned crystals to 1 centimeter frequently associated with wolframite; an acicular crystal of galenobismutite over 3 centimeters in length (probably the largest known freestanding crystal of its species); excellent bertrandite crystals; dolomite; galena; arsenopyrite; and stannite.

Because the mine has no mill, miners cob out high-grade molybdenite, scheelite, and wolframite concentrations by hand. Women "nippers" perform much of this labor at the surface.

During a "chopsticks only" luncheon, we learned that to local miners Taehwa means "100,000 steps," and after climbing the hills we felt the place well named. In Korean, Taehwa literally means "great flower."

The miners worship Po Ryun Mountain, which they believe contains a god. Because the god is feminine, sacrificial food must be masculine. Offerings of pig, fruit, and dried fish are made at least twice a year. The miners also place incense and candles before their mountain each Thanksgiving Day (August 15) when they pray for prosperity and safety. One miner said his crew did not like women (though they cobbed ore), dogs, or deer around the mine. But rats did not bother them.

Taehwa enjoyed "golden years" from 1969 to 1971, when world prices of molybdenum and tungsten encouraged recovery of large quantities of high-grade ore. In recent years neither the prices nor production levels seem to warrant continued operation. Should the mine close, a major source of fine crystal specimens will be lost.

56 Wan-Shan-Ch'ang Mine, Tung-Jen, China

One of the least-known crystal producers, the Wan-Shan-Ch'ang mercury mine, lies 30 kilometers southeast of Tung-Jen, on the eastern border of Guizhou (Kweichow) Province in the People's Republic of China about 1280 kilometers southwest of Shanghai. The mine complex, 1000 meters above sea level, covers nearly 3000 square kilometers. The extremely irregular terrain features small mountain peaks separated by gorges coursing with roaring streams. The few barely negotiable old roads that traverse the area wind tortuously; however, a new all-weather road and a railroad reportedly now serve the area.

The ancient Chinese knew of the mercury ores probably as early as 3600 years ago. Artifacts coated with cinnabar powder have been found in the Yangshao and Lungshan cultural digs. Native mercury "moved by machinery" flowed in miniature rivers through a diorama in the elaborate mausoleum of the First Emperor, Ch'i-Haung-Ti, who died in 210 B.C. Cinnabar has been used as pigment, ink, paint, and dyestuff since the Yin Dynasty. It was also used to make "pills of immortality." In 1021 A.D. Su Sung reported that

> *Cinnabars come from outcrops in mountain cliffs. Cinnabars are found as large as eggs and lesser ones as small as jujube fruits. Their shape is like that of the blossoms of the rose hibiscus—with arrowheads in clusters [the earliest reference to the remarkable penetration twin crystals in cinnabar]. One can find crystals with fourteen surfaces, each looking as bright as a mirror. On gloomy or rainy days humidity like a red juice forms on the broken surfaces. Further,*

BELOW:
Cinnabar on quartz
Size: 6 by 6 cm
Locality: Wan-Shan-Ch'ang
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Cinnabar on quartz and dolomite (flesh-colored)
Size: 11 by 6.5 cm
Collection: Mineralogical Museum, Oslo, Norway
Photo: Gotfred Teigen

OPPOSITE BOTTOM:
Cinnabar on calcite
Size: crystal 2.5 cm
Locality: Wan-Shan-Ch'ang
Collection: British Museum of Natural History
Photo: Peter Crabb
Chinese box containing cinnabar chips for inlay into backs of brass mirrors. Acquired 1906

cinnabar breaks as straight as walls and splits as mica flakes. It is found in association with a kind of white stone on which it grows.

The Wan-Shan-Ch'ang complex consists of four principal adits—Sheng-Hsi-Hsien, Hei-Lung-Tzu, Lao-Shan-Keng, and Ta-Tung—and a number of smaller nameless tunnels. It dates back to the beginning of the 14th century when as many as 5000 workers labored in and about the mine. Ming Dynasty miners employed the crudest of methods. Ore was broken by means of hammer and gad and, in larger stopes, by the suffocating fireset method. Mine workings were entered by a main adit from which numbers of drives extended into a complex of stopes and working faces. Men carried loads of ore averaging 27 kilograms to the surface in small bamboo baskets attached to both ends of a pole. Selected high-grade ore was crushed into about 6-millimeter fragments and panned in wooden bowls. Final concentrates were retorted for their mercury. Liquid mercury was poured into handmade bamboo flasks which were stacked for shipment to the nearest river and eventual use in the amalgamation of gold. Cinnabar crystals, which had no other value, were ground with the ore. The enormous tailings extending into canyons below indicate the ancients mined thousands of tons of rock.

Underground workings were not timbered, because of strong and stable ground. Because each mine usually had only one portal, air circulation was insufficient. Conditions did not change much throughout the years, and in 1920, F.R. Tegengren reported in "The Quicksilver Deposits of China":

The atmosphere is often nearly choking from smoke, oil, gases from exploding gunpowder, and human perspiration and waste. The smoky flame of the tung oil lamps can sometimes be distinguished only when approaching to a distance of a few meters. As a consequence of the horrible atmosphere in the mines where many of the workmen are living day and night and of the poisonous effect of the quicksilver vapours, the health conditions among the workmen are most deplorable.

During the 1870s gunpowder, which was introduced by Szechuanese miners, proved a boon as an explosive, and greatly increased ore production. It was made at the mine from nitre, sulfur, and charcoal, produced in nearby areas. Safety standards did not exist and fatal

accidents occurred frequently. Miners were expected to sharpen their own drills before entering the mine, then drill and fire two 40-centimeter holes—tasks which took about six hours. The men took each fifth day off to receive their pay and go to market.

In 1899 the Compagnie Anglo-Francaise des Mercures et Concessions Minieres de la Chine purchased the mines at Wan-Shan-Ch'ang. The firm built a smelter, mill, and other buildings, and sank a deep shaft designed to locate new ore bodies. None were found, but miners penetrated the old workings of an abandoned area.

With the coming of the 1911 revolution, the local mine crew and garrison revolted, the Compagnie staff was forced to leave, and the facilities fell to ruin. After the rebellion, the mine reopened under the so-called private "tribute" system; a "tributer" controlled each working face and engaged his own miners. Women and children searched the great dumps for overlooked cinnabar.

Henry Brelich wrote of his journey to Wan-Shan-Ch'ang:

> *The principal route to the mines is from Shanghai, along the Yang-tze-kiang to Shasi (903 miles), which is covered by river steamers, thence by junk along one of the numerous canals, and skirting the north-west corner of the Tung Ting lake, to the Yuen river, which is followed to Senchi (315 miles). From Senchi, the Mayang river, a tributary of the Yuen, is followed*

THIS PAGE TOP:
Miners search huge dumps for overlooked cinnabar
Courtesy: F.R. Tegengren

THIS PAGE MIDDLE:
Miners working cinnabar mine near Wan-Shan-Ch'ang, 1979
Courtesy: Russell Behnke

THIS PAGE BOTTOM:
Ruins of quicksilver furnace of Anglo-French Co., Wan-Shan-Ch'ang
Courtesy: F.R. Tegengren

OPPOSITE TOP:
Miner's town of Wan-Shan-Ch'ang, c. 1915
Courtesy: F.R. Tegengren, Quicksilver Deposits of China, 1920

OPPOSITE MIDDLE:
Part of miner's village at Lao-Chan-keng
Courtesy: F.R. Tegengren

OPPOSITE BOTTOM:
Entrances of a mine in Wan-Shan-Ch'ang canyon
Courtesy: F.R. Tegengren

to Toon-Yen (85 miles), thence overland to the mines (21 miles). The journey may be accomplished under favourable conditions in twenty-five days.

The most recent detailed accounts of Wan-Shan-Ch'ang appeared in the early 1920s, when the complex was regarded as the most important quicksilver mine in China. Few westerners have visited the mine since and there is speculation that major cinnabar reserves may be nearly exhausted. However, reports in 1948 indicated substantial reserves of cinnabar still remained in China's mercury-producing provinces. Because of the mine's rugged isolation and the difficulty in entering China, the author has not visited this mine.

Many of the world's finest cinnabar crystals were apparently discovered in Wan-Shan-Ch'ang between 1860 and 1890 but their source is not certain. Numerous museums exhibit older specimens labeled the Tsar Tien Mine, Yunnan Province, China. Other labels name sources as Chingachuan, Sha-tsu-ling, Hunan Province, and Kweichow Province. It is possible that fine cinnabar crystals are found in all of these localities and more, but most references designate the Wan-Shan-Ch'ang mines in Kweichow as the source.

Spectacular cinnabar crystals from Wan-Shan-Ch'ang are displayed in mineral collections through the world. Notable examples may be seen at the British Museum of Natural History, the Museum of Natural History at Oslo, the American Museum of Natural History in New York, and the Smithsonian Institution. Russell Behnke, a Connecticut collector, owns a 9-centimeter quartz crystal with inclusions of cinnabar.

In 1980 and 1981 fine crystals of a number of mineral species from China began appearing in dealer showcases. These included stibnite, cuprite, and cinnabar. Available information suggests that Chinese miners are once again conserving crystals, and some export channels have opened. Cinnabar crystals from Wan-Shan-Ch'ang and other mines are well formed, and some are embedded among quartz crystals. The quality is excellent and, predictably, prices high. The Tongren mine about 16 kilometers from Wan-Shan-Ch'ang produces fine stibnite crystals up to 15 centimeters in length. Dealers express optimism about the future of mineral specimens from classic Chinese localities. Photographs and current information about the Wan-Shan-Ch'ang mines should be available in the not-too-distant future.

57 Mogok Ruby Mines, Mogok, Burma

The road to the Burmese ruby mines winds due north from the capital city of Rangoon through beautiful countryside. During the 19th century, the excursion took 44 days, and bandits were frequently a problem. Today, the flight by small jet aircraft from Rangoon to Rudyard Kipling's Mandalay takes but a few hours. The traveler completes the trip by bus in another day to Mogok—and bandits still watch the road.

From Mandalay the road climbs through the Irrawaddy Valley up and over tree-clad mountains, finally descending into the long narrow valley of the rubies. The village of Mogok borders a picturesque lake, the site of ancient gem pits.

Mogok's houses, for the most part, are constructed of bamboo and hardwood; living conditions are quite simple. Nearly everyone works with gemstones and, in contrast to Rangoon where few rubies appear for sale, red gems are displayed along the streets of Mogok.

No one knows exactly when rubies were discovered here, but many Burmese believe the Kun-lung family mined them during the 6th century A.D. In 1630 a Burmese farmer traveled to Mogok and offered a basket of tamarinds for sale. He exchanged part of his fruit for a large red stone, later identified as a ruby, which he presented to the King of Ava, Burma's Upper kingdom. Realizing the value of the ground where the stone was discovered, the king acquired a large area, later to be known as the Ruby-tract, which included the towns of Mogok, Katha, and Kyatpyin.

Little was known of ruby mining in Burma during the 17th and 18th centuries, but fabulous new stones appeared from time to time. French jeweler J.B. Tavernier traveled in the Middle East during the middle 1600s and wrote briefly about the rubies of Pegu (upper Burma). He said, "They are found in a mountain twelve days or thereabouts from Siren in a northeast direction and it is called Capelan" (probably today's town of Kyatpyin).

During the 19th century, Chinese, Mongols, and Turks came yearly to Kyatpyin to obtain precious stones in trade for nutmeg, cloves, colored cloth, and carpets. King Thibaw (1878-1885), the last independent Burmese

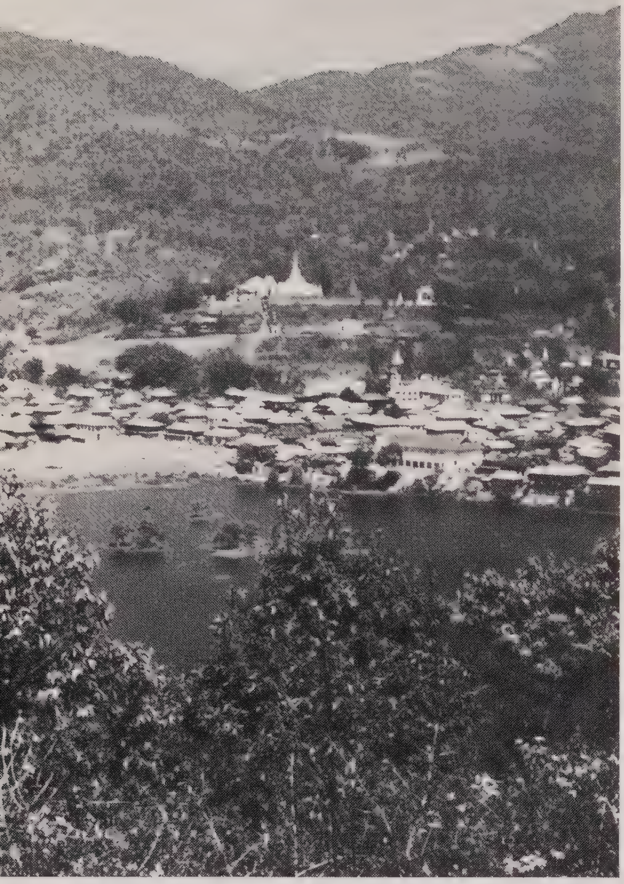
BELOW: Very large rubies and sapphires for sale in Mogok in 1952
Photo: Edward Swoboda

OPPOSITE:
Ruby crystal matrix
Size: matrix 7.6 by 5.6 cm
crystal 3.8 cm
Locality: Burma
Collection: British Museum of Natural History
Photo: Frank Greenaway

ruler of Ava, decreed that any ruby worth more than $140 belonged to the crown. Many large stones were reportedly broken into smaller pieces to avoid confiscation by the king. But ingenious gem merchants circumvented the law and smuggled two large rubies—45 carats and 37 carats—to London. Both were recut to enhance their beauty, the larger reduced to 38 carats and sold for about $40,000. The two gems were considered to be the most important rubies in Europe.

In 1886 the British annexed Burma. Shortly thereafter the Burma Ruby Mines Company, Ltd., was formed and headed by Edwin W. Streeter. He introduced modern machinery and methods, and the company prospered for a few decades until production fell off and the mines were liquidated in 1925. Since that time natives have done the mining, most of it by hand.

Originally, ruby crystals at Mogok occurred in crystalline marble in a zone nearly 160 kilometers in length. However, these deposits proved unrewarding because of the relative scarcity of gems per ton of ore. For millions of years the mountains had eroded, leaving gems deposited in layers of gravel along valley floors. At first rubies were found on top of the ground, and nearly all mining occurred near



the surface. Eventually it became necessary to construct shafts and mine the lower strata to a maximum depth of 12 meters. Men loaded baskets with *byon* (the gravel layer which contained gems) and hauled them to the surface for washing and sorting, a method still used today.

Washing the *byon* is absolutely necessary for recovery of all gemstones. Fortunately in Mogok there is usually enough water throughout the year. In Katha, an important mining center 11 kilometers west of Mogok, the dry season requires storing the *byon* until summer monsoon rains provide enough water for the washing process. Waste dumps are thoroughly searched for overlooked gems by *kanesema*, young girls and women who may keep any gems they scavenge.

Red gem corundum is called ruby, and the other colors, including the blue variety of corundum, are sapphire. Strangely, most gem corundum deposits feature either rubies or sapphires, and seldom do the two gems occur in equal amounts together.

In sharp contrast with Sri Lanka and Montana deposits, Mogok mines produce more rubies than sapphires, sometimes in a ratio of 500 to 1. At Kyaukpyatthat, sapphires are found in profusion.

Ruby occurs in shades of pink to deep red, but the carmine-red hue resembling the blood of a freshly-killed pigeon is most prized. Although the color of a stone may not be uniform, the intensity of a ruby is not lost under artificial light. The "pigeon-blood" ruby has many favorable characteristics. In addition to its remarkable color, it is next to the diamond in hardness, possesses a fine brilliance, and is extremely rare. Above all, it is considered the most valuable of all gemstones. In the middle of the 16th century, sculptor and goldsmith Benvenuto Cellini stated that "a carat ruby was eight times the value of a carat diamond." Because of their great value, rubies of good quality are cut immediately, thus removing them from the crystal market. Strong stream action inevitably separates the gem from its matrix, making a ruby matrix specimen an object of considerable rarity.

Gemstones associated with the ruby and sapphire are blue apatite, pebbles of cordierite, phenakite, epidote, chrysoberyl, moonstone, various species of garnet, yellow danburite, and steel-blue sillimanite. Some gem fields produce spinel in profusion, making it the most common of all gemstones recovered. The ratio may be as high as five spinels for each ruby

THIS PAGE TOP:
Mogok village on Lake Mogok
Photo: Edward Gubelin

THIS PAGE BOTTOM:
Kanesema *(female scavengers) searching for overlooked rubies in washing basin*
Photo: Edward Gubelin

OPPOSITE TOP:
Baskets of ruby-laden byon *(ore) being winched to the surface*
Photo: Edward Gubelin

OPPOSITE MIDDLE RIGHT:
Mining a ruby trench
Photo: Edward Gubelin

OPPOSITE BOTTOM LEFT:
Burmese women dealing in gems at the mine
Photo: Edward Gubelin

OPPOSITE BOTTOM RIGHT:
Edward Gubelin buying rubies in Mogok
Courtesy: Edward Gubelin

mined. Peridot is erroneously thought to occur with the ruby at Mogok. The extraordinary large, clean peridot gemstones from Burma are found in serpentine on a slope of Kyavkpon Mountain far north of Mogok.

Most crystals recovered in the Mogok area are fashioned into gems in the villages of Mogok, Kyatpyin, and Katha. Women and children facet the smaller stones, while important gems are set aside for the men to cut. Faceting equipment and methods remain crude; most gems require recutting to satisfy western tastes.

In an effort to obtain higher prices, many of the better gemstones are smuggled out of the country to Thailand and India. Burmese government regulations and army controls do little to encourage honesty among the miners and buyers. Domestic political problems and a diminishing supply of rubies seem to ensure continuing price increases for this beautiful Burmese gemstone.

58 Pashan Quarries, Khadakvasla, Poona, India

For a brief few years, British engineers and Indian railroad workers knew a fabulous tunnel ablaze with the reflected light from millions of crystals lining its walls. Early in this century they blasted a railroad passageway through solid volcanic basalt in the mountain range separating Bombay and Poona. As the work progressed men entered pocket after pocket, each filled with sparkling crystals of apophyllite, quartz, and heulandite. Fittingly this crystal wonderland was named the Jewel Tunnel. Soon after the tunnel's completion the small caverns of beauty were obscured by continual clouds of soot from coal- and wood-burning engines.

The Jewel Tunnel introduced the world to the crystal riches of the enormous Deccan basalt, a volcanic blanket more than 100 meters thick which covers 1.5 million square kilometers of western India. This vast tract south of the Narbada River lies between the Eastern Ghats and the western coast of India.

BELOW: Fluorapophyllite on heulandite
Size: 15.5 by 12.5 cm
Locality: Pashan quarry
Collection: Peter Bancroft
Photo: Harold and Erica Van Pelt

OPPOSITE: Mesolite
Size: 7 by 7 cm
Locality: Poona
Collection: William Wise
Photo: Harold and Erica Van Pelt

Basalts result from volcanic flows of lava spewed forth from fissures in the earth. The lava flows spread out as layers which hardened into dark, fine-grained rock over broad areas of the land. Bubbles of dissolved gases in the lava leave pockets in the hardening stone. As the lava cools, it becomes invested with percolating waters carrying dissolved minerals. With cooling, brilliant crystals grow in vugs in the rocks, awaiting only the drills and explosives of quarry workers to extract them.

Three areas in India are well known for the production of beautiful crystals: Nasik, Bombay, and Poona. Of the three localities, the Pashan quarries nestled in the Pashan hills near Khadakvasla and Poona produce especially interesting material. From these quarries superlative grass-green apophyllite crystal clusters of great beauty have been recovered, some of them exceeding 4 centimeters. The green color results from the presence of a small amount of vanadium. Even though the Pashan quarries are quite small (a large one being 100 meters long and 50 meters high), in the past 20 years they have produced hundreds of kilograms of the zeolite minerals stilbite, heulandite, and mesolite as well as apophyllite. Once a pocket zone is reached, workers take time to collect, particularly the dark green apophyllite crystals. But because the quarries are operated for rock and not for specimens, the management tolerates only brief collecting. Valuable crystals may be lost when the miners return to work.

Vugs at most Indian locations are generally hemispherical in shape, the top rounded and the bottom flat, though some are round or oblong. Pashan pockets are irregular and can

be found in long, winding forms or short angular ones. Some vugs seem overflowing with crystals, while others hold but a few. Crystals that line exposed pockets are quickly damaged by weathering and are thus lost to the collector.

The greatest crystal pocket in the history of the area was breached in 1978. Rustam Kothavala, a dealer in Indian minerals, and Paul Desautels, former Curator of Mineralogy at the Smithsonian Institution, were there at the time. Neither could know the size of the vug as the hard basalt was chipped away. Workmen brought a mirror which reflected the sun's rays into the pocket. A large cave of astounding beauty appeared. Glittering green apophyllite crystals lined the walls of a narrow grotto that eventually proved to be 7 meters deep, "large enough to hold a small bus." Tufts of snow-white mesolite crystals dotted parts of the surface or peeked out from cracks in the walls. The find was breathtaking for Desautels, who said, "This is the greatest mineral experience of my life." It took nine months for miners to clean out the pocket, and shortly thereafter dealer displays at mineral shows in Europe took on new importance with the addition of brilliant Pashan apophyllite and mesolite crystal clusters.

Most quarries in India are worked for road ballast. Only the more dense basalt has proven durable enough for streets and highways, so when areas containing crystal vugs occur in a quarry, workers avoid this "weaker" material. Permission to search for crystals in abandoned quarries is easily obtained, particularly if a dollar or two passes the palm.

The typical Indian quarry miner probably earns less than $2 a day. To survive, it is not

THIS PAGE TOP:
Pashan Hills and Poona quarries
Photo: Rustam Kothavala

THIS PAGE BOTTOM LEFT:
Six miners stand on and around giant 7.6 meter vug which collapsed during removal attempts
Photo: F. Makki
Courtesy: Paul Desautels

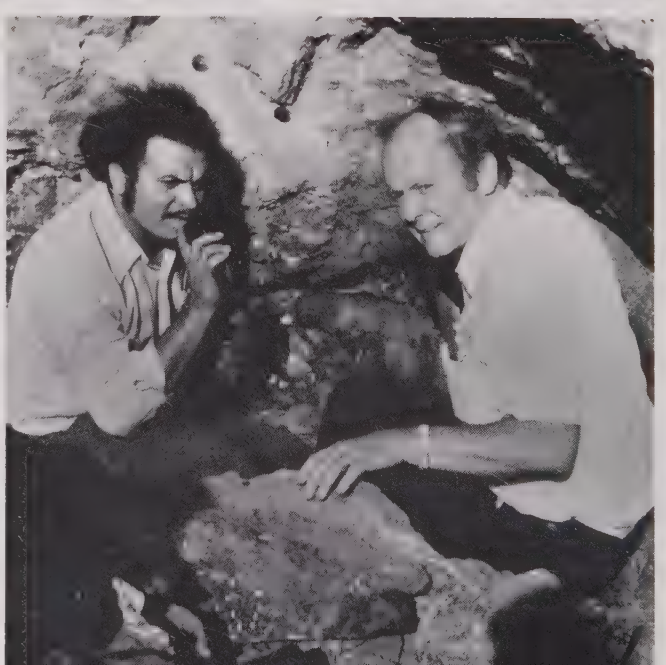
THIS PAGE BOTTOM RIGHT:
Paul Desautels (R) and miner, F. Makki, at giant apophyllite vug, November 1978
Photo: Rustam Kothavala

OPPOSITE TOP LEFT:
Massive boulders dropping at Poona
Photo: Rock Currier

OPPOSITE BOTTOM LEFT:
Lady miner at Khadakvasla greets Currier
Photo: Rock Currier

OPPOSITE TOP RIGHT:
Miner offering prize apophyllite for sale
Photo: Rock Currier

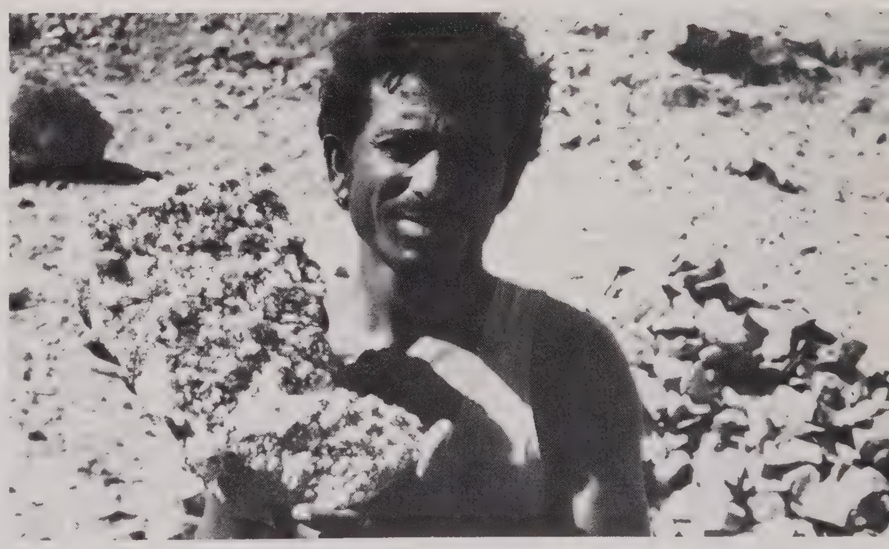
OPPOSITE BOTTOM RIGHT:
Okenite and gyrolite pocket at Bombay quarry
Photo: Rock Currier



unusual for the whole family to work. Crystals of good quality provide a bonanza for these laborers. Ingenious young girls, given the opportunity when stilbite is available, sometimes gather the material and crush it into fine powder which is used as a base for cosmetics.

People in and about the quarries are friendly and readily help travelers. Generally local people do not speak English, but many of Poona's storekeepers do. Getting to and from the quarries is not a problem. Gaining admittance to the Pashan quarries is another matter because the Makki brothers who own the mines secure the premises, keep a watchman on duty, and prohibit collecting without their permission.

Mineralogists who have visited the Deccan Plateau of western India believe that as long as basalt is needed for construction, quarries will operate, and beautiful zeolite and associated mineral crystals will be found—perhaps for hundreds of years.



59 Pelmadulla Mine, Ratinapura, Sri Lanka (Ceylon)

One of the world's most beautiful and exotic islands, Sri Lanka, (formerly Ceylon) lies just below the southern tip of India. This pear-shaped bit of tropical paradise, about the size of Sicily, is a tourist's delight offering British teahouses, rubber plantations, and gem mines.

Marco Polo wrote of his visit in 1292: "I want you to understand that the island of Ceylon is, for its size, the finest island in the world, and from its streams comes rubies, sapphires, topazes, amethyst and garnet." Little has changed since Marco Polo's time except that Sri Lanka faces overpopulation and a faltering economy.

Its gemstones, however, seem to occur in endless supply. Known as the "Jewel Box of the Indian Ocean," Sri Lanka, like possibly no other locality on earth, has yielded precious stones and fine gems in a great profusion of gem species and varieties.

The island was known in the ancient world as Taprobane (copper colored in Greek). Native *Veddahs*, bathing in smooth flowing streams, noticed colored pebbles scattered in sandy bottoms. It was not until 500 B.C. that conquering Buddhists from northern India also discovered gems in the rivers and began to set rough stones into crude jewelry. They bartered stones with traders from abroad and eventually the treasures found their way to the marketplaces of Asia and Europe. Ancient Greek and Chinese historians referred to the beautiful gems of Ceylon, and King Solomon reportedly wooed the Queen of Sheba with Ceylonese precious stones.

Geologically, gemstones originated within a broad belt known as the Highland Series which runs through the center of Sri Lanka. The

BELOW: Sapphire
Size: 3.5 by 2 cm
Locality: Ratnapura
Collection: Harold and Erica Van Pelt
Photo: Harold and Erica Van Pelt

OPPOSITE TOP: Pelmadulla mine near Ratnapura
Photo: Peter Bancroft

OPPOSITE MIDDLE: Looking down 25 meters into a gem shaft
Photo: Gerhard Becker

OPPOSITE BOTTOM: "Gemming" a river. Disturbing the gravels with poles causes waste to float away, leaving gems to be gathered from river bed.
Photo: Edward Gubelin

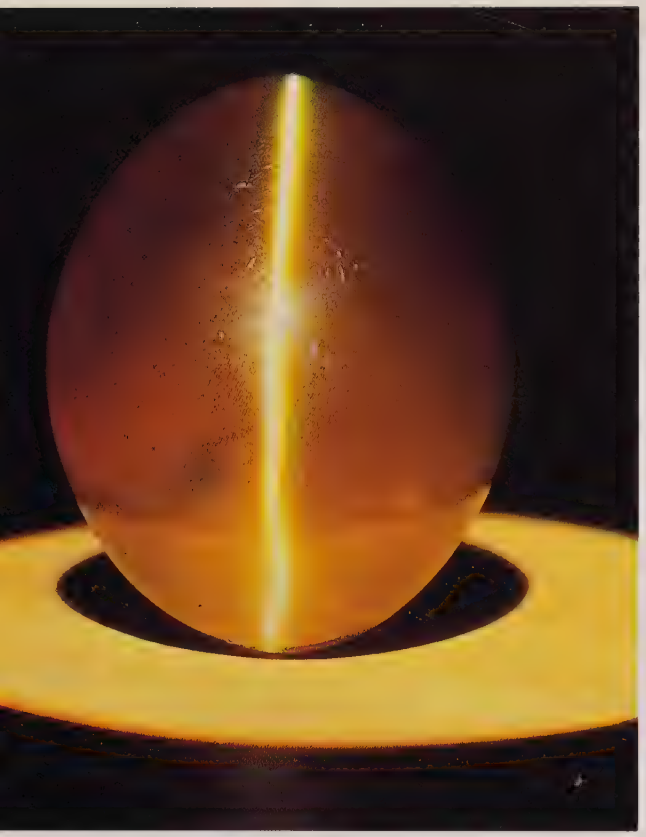
edges of the belt form a trough bordered by chains of mountains and peaks. The trough, made up of highly crystalline Precambrian metamorphosed rock, featured components of schists, quartzite, marbles, and sometimes pegmatite deposits. Rock erosion resulted in the formation of extensive gem-laden placer deposits along stream beds in lower valleys.

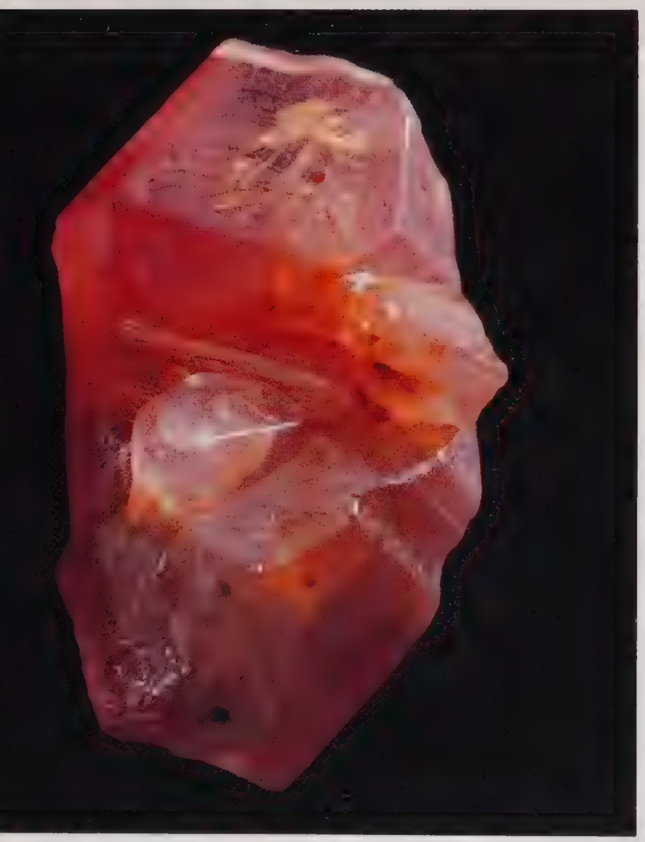
Miners soon learned the richest deposits were composed of blue and yellow clays called *illam* which lay just below the surface of lush valley farmlands. During their tortuous journey downstream, most gem crystals were worn to rounded pebbles, but harder than host minerals, they managed to retain much of their size.

Every available square meter of stream bed was mined until all known gem areas were exhausted. The miners discovered that the rivers they were working were in reality "surface streams" and that by digging downward from 7 to 30 meters, "ancient streams" could be encountered. Unfortunately most of the ancient streams lay beneath cultivated fields. Prospecting and mining operations caused great destruction to crops and created considerable animosity between farmer and miner.

Eventually new mining methods were devised whereby the gem hunter could operate at a profit and still leave the farmland virtually intact. A vertical shaft was dug downward until the *illam* was reached. Feeder tunnels extended in a number of directions like the spokes on a wheel. The shaft and tunnels were carefully supported by wood and bamboo timbers. The miners dug along the tunnels, loaded the gravel into knapsacks, and then climbed to the surface with their loads. Washing, screening, and sorting occurred on the surface. Usually pumps operated full time to keep the tunnels free of water. When a mine played out, the tunnels were closed off, the shaft filled, the buildings removed, and new topsoil spread over the area. As another growing season approached, all vestiges of the mine vanished.

In 1974 when the author visited Sri Lanka, the Pelmadulla mine was in operation about 15 kilometers west of Ratnapura. It proved to be a good producer of white and cornflower-blue sapphires. Like all gem gravel mines on the island, when the Pelmadulla was worked out, its shafts were filled, its sumps removed, and rice was planted over the old workings. Today it might be impossible to locate the old mine site.





Ratnapura (Singhalese for "gem town") lies about 100 kilometers southeast of Colombo. Its mining region has produced an incredible variety of gemstones, many of them outstanding in comparison with stones from other regions. Sapphire occurs in all hues of blue, as well as yellow, violet, green, pink, and the remarkable pinkish-orange "padparadsha." Other gemstones include topaz in bright yellow with a reddish tinge; brownish yellow to cinnamon-colored grossular; orange-yellow spessartine; blood-red pyrope; red to brownish red almandine; the world's finest zircon in a broad spectrum including brown, yellow, orange, green, and colorless (known locally as "Matara diamond"—a misnomer); green, yellow, and brown tourmaline; yellow, green, and brown chrysoberyl; yellow chrysoberyl cat's-eye; the unique white translucent variety of microcline with a blue sheen known as moonstone; and great quantities of spinel in brown, green, blue, purple, violet, yellow, pink, and red. Unusual and rare stones from the same area include sillimanite, andalusite, scapolite, enstatite, kornerupine, diopside, and sinhalite. Recently a 5000-carat cat's-eye chrysoberyl, the size of a man's fist, was taken from a mine near Ratnapura.

The crown jewels of many monarchs gleam with extraordinary spinels, sapphires, and zircons mined from Sri Lanka streams. The Imperial Treasury of the Soviet Union houses a 400-carat red spinel of great beauty which was once given to Catherine the Great. The British Imperial Crown features a giant oval-cut spinel (previously supposed to be a ruby), known as the "Black Prince." Crowns in the Green Vaults of Dresden are covered with sapphires from Sri Lanka.

Local lapidaries cut most of the island's gem rough. Striving for maximum weight in each finished stone, cutters frequently align the faces poorly with the center of the stone. Therefore, many stones must be recut, causing a weight loss, before reaching their full potential.

The forests of Sri Lanka are being felled in the vanguard of an expanding population. As natural habitat vanishes, so go the remaining wild elephants, pythons, crocodiles, bears, leopards, wild boars, and other wildlife. With these changes, much of Sri Lanka's primitive charm will disappear. But many untouched gem areas remain and await exploitation. In all probability the Jewel Box will continue to give up its precious treasures for centuries to come.

THIS PAGE TOP:
"Maharani"
Chrysoberyl cat's-eye
Locality: Sri Lanka
Weight: 58.2 carats
Collection: Smithsonian Institution
Photo: Dane Penland

THIS PAGE BOTTOM:
Sapphire
Size: 8 by 5 cm
Locality: Sri Lanka
Collection: Paul Ruppenthal
Photo: Studio Hartmann

OPPOSITE:
Faceted Sapphires
Size: largest is 27 carats
Collection: Los Angeles County Museum
Photo: Harold and Erica Van Pelt

THIS PAGE TOP:
Recovering gems from rattan basket
Photo: Gerhard Becker

THIS PAGE MIDDLE:
Cutting sapphires on primitive machine
Photo: Edward Gubelin

THIS PAGE BOTTOM:
Ratnapura museum curator holding sapphire crystal
Photo: Peter Bancroft

OPPOSITE TOP:
Pack train in high, desolate and very cold Kokcha Valley
Photo: Pierre Bariand

OPPOSITE MIDDLE:
The Sar-e-Sang is high on a cliff but has produced the largest Lapis Lazuli crystals of all time
Photo: Pierre Bariand

OPPOSITE BOTTOM:
Visiting party at entrance to the Sar-e-Sang
Photo: Pierre Bariand

60 Sar-e-Sang Mine, Jurm, Afghanistan

Royal blue lapis lazuli, the gem variety of lazurite and one of the most beautiful opaque gemstones, is a sodium and aluminum mineral of considerable complexity. Known as "sapphires" by the ancients, the stone occurs in only a few major deposits around the world, notably Lake Baikal in Siberia, Ocalle in Chile, and the rugged Kokcha Valley of northern Afghanistan.

The ancient royal Sumerian tombs of Ur, located near the Euphrates River in lower Iraq, contained more than 6000 beautifully executed lapis lazuli statuettes of birds, deer, and rodents as well as dishes, beads, and cylinder seals. These carved artifacts undoubtedly came from material mined in northern Afghanistan. Later Egyptian burial sites dating before 3000 B.C. contained thousands of jewelry items, many of lapis. Powdered lapis was favored by Egyptian ladies as a cosmetic eye shadow and in later years it was used as a pigment for ultramarine paints. Pliny the Elder described the stone as "a fragment of the starry firmament."

The most prized lapis is a dark, nearly blackish blue, much deeper than turquoise and more intense than sodalite or azurite. Lazurite occurs most frequently in lighter shades commonly mixed with streaks of calcite. Although attractive, this material is less desirable and consequently fetches a lower price. Pyrite, a commonly associated mineral, is often liberally sprinkled throughout lapis specimens, to create a striking combination of rich blue and brassy gold.

The route to the lapis mines in the Kokcha Valley is long, tortuous, and dangerous. From Feysbad, capital of Afghanistan's northeast province of Badakhshan, a poor road stretches southward through tiny hamlets of mud-walled huts standing on uneven ground wracked by the earthquake of 1832. After motoring as far as Hazarat-Said, the traveler must spend another full day on horseback before reaching Kokcha Valley. The small Kokcha River is the eastern tributary of the River Oxus which Marco Polo traversed and wrote: "There is a mountain in that region where the finest azure [lapis lazuli] in the world is found. It appears in veins like silver streaks."

The lapis is mined on the steep sides of a long narrow defile sometimes only 200 meters wide and backed by jagged peaks that rise above 6000 meters. Sparsely populated and covered with snow for much of the year the barren region is inhabited by wild hogs and wolves. The summer sun is scorching, but

temperatures drop below freezing at night. British Army Lieutenant John Wood reached the lapis mines for the East India Company in 1837, and wrote in his *Journey to the Source of the River Oxus*, "If you do not wish to die, avoid the Valley of Kokcha." This is surely not one of the world's better sites for a field trip!

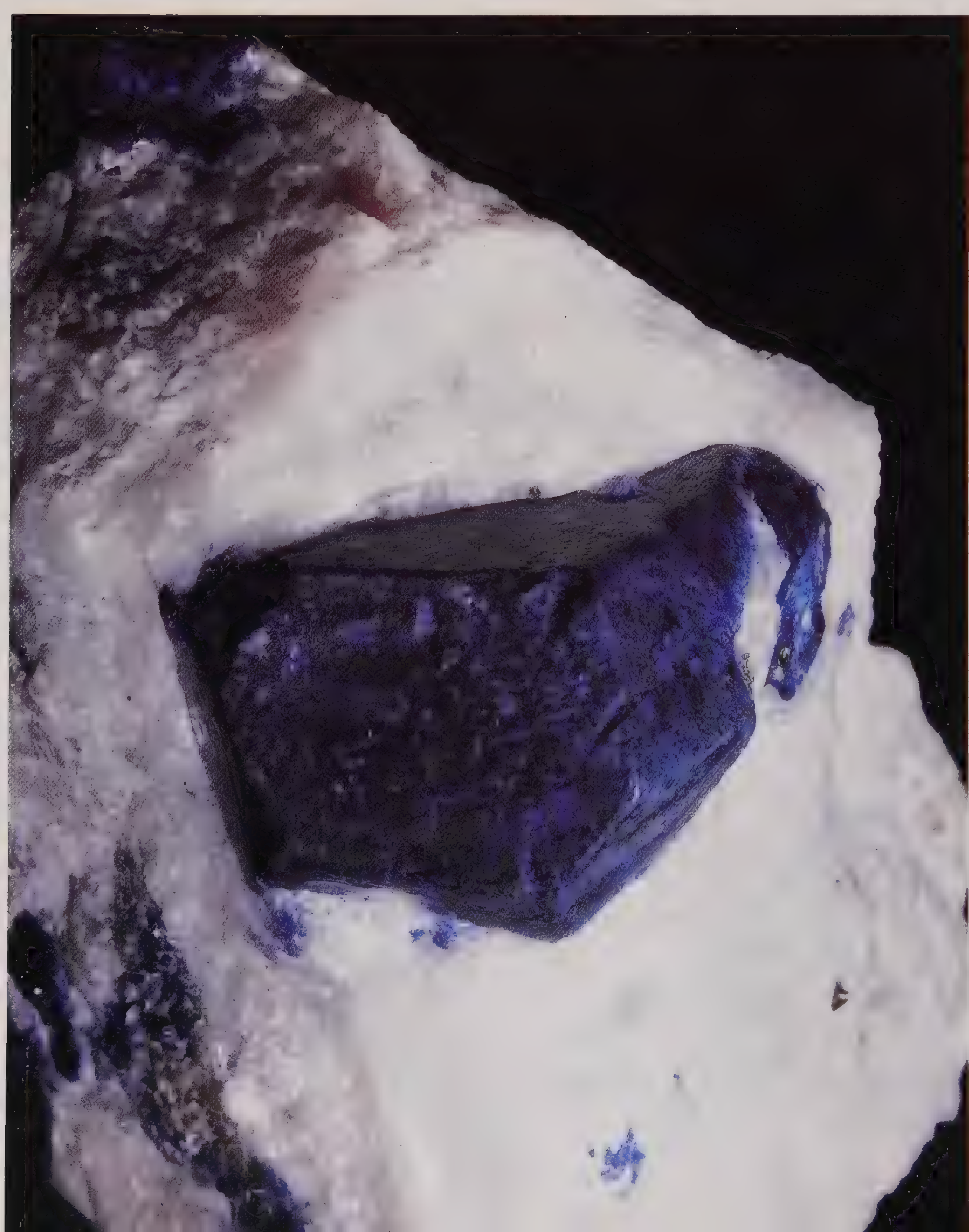
Darreh-Zu, one of the oldest mines along the Kokcha, is now closed and presumably exhausted. The nearby and relatively new Sar-e-Sang mine currently yields substantial amounts of good quality gem material and has produced rare 5-centimeter lazurite crystals. The largest found thus far, a well formed dodecahedron imbedded in calcite, was collected in 1964 by Pierre Bariand, mineral collection curator at The Sorbonne.

Lazurite gem deposits occur in white and black marbles hundreds of meters thick. The gem veins, seldom exceeding 10 meters in length, lie in snow-white calcite. Associated minerals include pyrite, diopside, sodalite, forsterite, phlogopite, garnet, dolomite, apatite, and afghanite, a relatively new species of the cancrinite group. Gem lazurite is found in three Persian color classifications: *nili* (dark blue), *assemani* (light blue), and *sabz* (green).

During the 1880s and early 1900s, lazurite

BELOW: Lazurite crystal in marble self-collected by Pierre Bariand
Size of crystal: 5 cm
Locality: Sar-e-Sang
Collection: Faculty of Sciences (Sorbonne)
Photo: Nelly Bariand

OPPOSITE:
Lapis lazuli
Size: 9 by 6 cm
Locality: Sar-e-Sang
Collection: Private collection
Photo: Harold and Erica Van Pelt



was mined by the "fire-set" method: large fires were kindled at the tunnel face and then quenched with water. The sudden cooling caused face rocks to shatter, simplifying removal of the ore. The gem material was then cobbed away from its matrix. A critical shortage of wood and the availability of explosives eventually rendered the technique obsolete.

Many leading museums feature carvings and jewelry fashioned from Kokcha lapis. But nowhere is the gem more lavishly displayed than in Leningrad's Hermitage Museum, where deep-blue figurines and vases stand 2 meters high.

The Sar-e-Sang mine has reserves of high-grade lapis lazuli and possibly more of the very rare lapis crystals. But political instability in Afghanistan clouds the future for both mining and distribution of the noble blue gem.

THIS PAGE TOP:
Tailings of the Darreh-Zu mine
Photo: Pierre Bariand

THIS PAGE BOTTOM:
Portal of the Darreh-Zu mine now exhausted
Photo: Pierre Bariand

OPPOSITE: Turquoise
"Western Chamber"
Size: 36 by 19 cm
Locality: Maden, Iran
Collection: A. Ruppenthal
Courtesy: Paul Ruppenthal
Photo: Karl Hartmann

61 Abdurrezzagi Mine, Maden, Iran (Persia)

Although turquoise was used extensively in Pharaonic jewelry, the Egyptian name for the gemstone has been lost. Pliny called it *kallait* (after the Greek *kalos lithos* "beautiful stone"), but the French coined its present name, because the gem reached them through Turkey by caravan from Persia.

It is not certain when the famous turquoise mines in Persia were discovered. Eastern Lore portrays Isaac, the patriarch of Israel and son of Abraham, as having located and worked turquoise mines near Nishapur about 2100 B.C. Through the centuries, these gem deposits have been known as Isaac's mines. Turquoise beads worn by peoples of great antiquity have been found in the Turkestan ruins at Anau and turquoise ornaments recovered from 1st century tombs in the Caucasus Mountains. The proximity of both discoveries to the mines, the probability that bright blue turquoise was abundantly scattered about the surface, and the fact that trade routes were well established in and about Nishapur all suggest that the mines were worked before the time of Christ. Indeed they could have been discovered by Isaac.

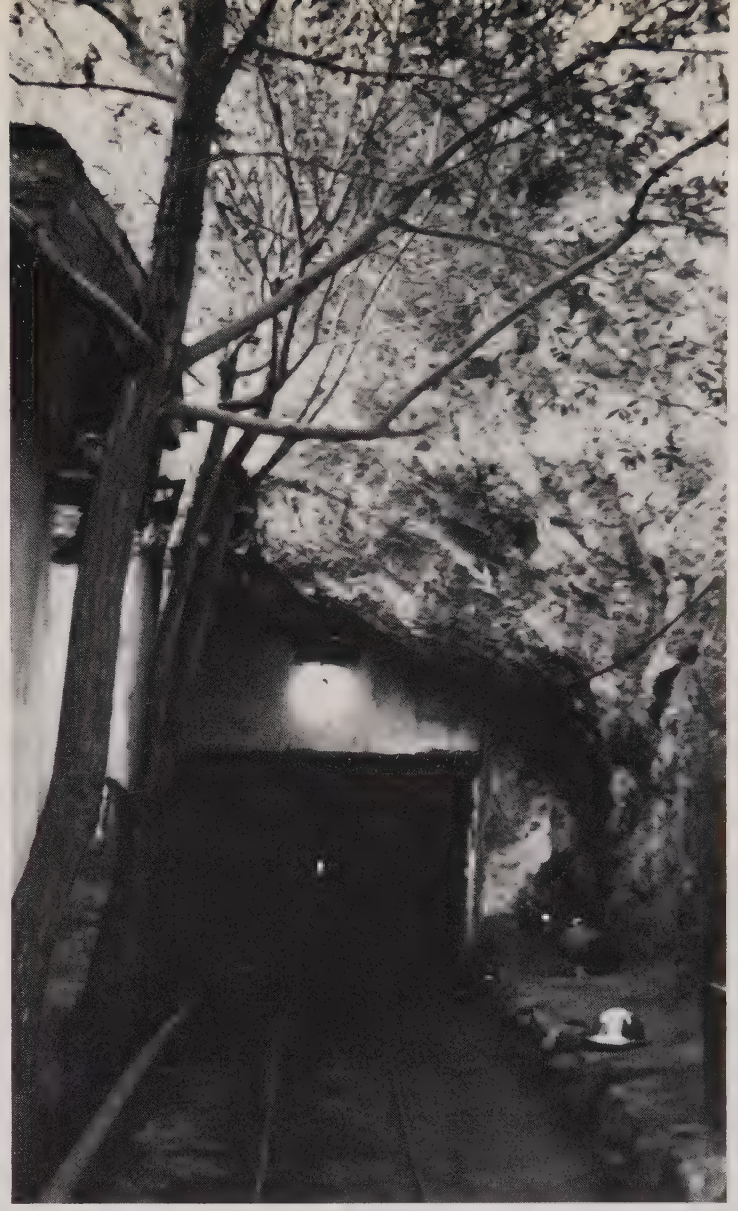
Written records reveal in considerable detail the active exploitation for turquoise at Nishapur during the 10th century. At this time Nishapur, the principal city of the area, was credited as being the source of turquoise. Actually Nishapur, the birth and burial place

THIS PAGE TOP:
Separation of turquoise from its ore
Photo: B. Bachet

THIS PAGE BOTTOM:
Young man polishing turquoise in Maden
Photo: Edward Gubelin

OPPOSITE TOP:
Working entrance of the Abdurrezzagi mine, 1972
Photo: Edward Gubelin

OPPOSITE BOTTOM:
Dromedaries passing a village on the route to Maden
Photo: Edward Gubelin



of Persian poet Omar Khayyam, stands 59 kilometers southeast of the mines. The nearest town to the workings is the tiny village of Maden, located in the Province of Khorasan about 200 kilometers northwest of the common border point of Iran, the Soviet Union, and Afghanistan.

The Persian mines produced some of the oldest known occurrences of turquoise (second only to Sinai Peninsula mines developed by Egyptians) and experts consider gems from these deposits the world's best. Stones of a deep sky-blue color called "angushtari" are prized most. A turquoise matrix, highly valued in the West, is found in nearby old mines in the Kuh-i-Binalud mountains. Here porphyritic trachyte intruded into layers of limestone and sandstone. Along the contacts, brecciated trachyte developed minute cracks 2 to 20 millimeters thick; these were later filled with turquoise. Each tiny segment of turquoise became accented by a lining of brownish-black limonite, creating the popular "spider-web" turquoise matrix that so intrigued the Parisian jeweler Tavenier in 1676. Today, both pure sky-blue turquoise and finely veined matrix are set in contemporary jewelry of the highest quality. To please Persian dealers and be considered choice, a turquoise must possess a property called "zat" which is similar to "luster" in a pearl.

Turquoise readily lends itself to carving and polishing enhances its soft lustrous blue to

greenish blue colors. Some Orientals accomplish a most unusual achievement with turquoise by carving verses from the Koran into the stone and then filling the characters with gold.

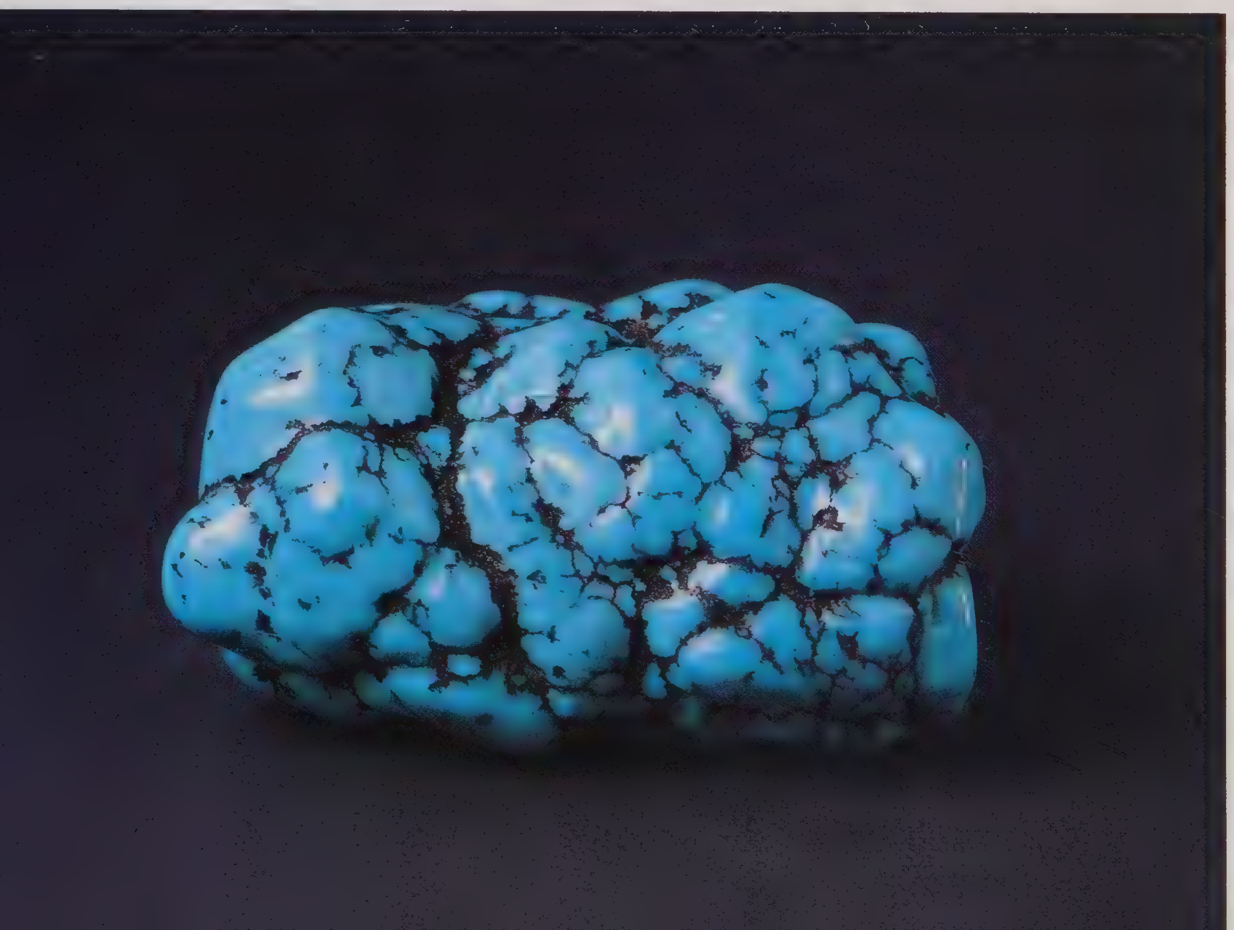
The largest quantity of choice turquoise has come from the Abdurrezzagi mine. This deposit, formerly called the Abu Ishagi, is the most easterly vein in the gem field. The workings, oldest in the area, could well be the fabled mine of Isaac. Its tunnels and stopes honeycomb the mountain to a depth of more than 50 meters, and miners still labor in its remote areas. Other mines on 2031-meter-high Ali-Mirsai peak are the Surkh, Shaperdar, and Aghali. Once very large operations, they are now caved-in and abandoned.

For many centuries various shahs operated the turquoise mines. Development was planned to preserve the mine structure and to provide safe working conditions. Early engineers left a sufficient number of pillars in place to support the ceilings and built ventilation shafts. They made every effort to construct tunnels and stopes which would allow easy haulage of high grade material in sheepskin bags to the surface and equipped some shafts with winches consisting of wooden wheels turned by the feet of supine men.

During the 18th century, management of the mines was transferred from the royal government to the villagers of Maden. Even though miners believed turquoise veins extended through the mountain, the new workers sought quick results and began to mine pillars. As they removed roof supports whole mines collapsed, killing those underground and destroying the facilities.

At last report, a dozen or so mines, including the Abdurrezzagi, are still operating. The stronger men of Maden dig the stopes with pick and shovel or occasionally use explosives. All others—the infirm, the aged, women and children—cob the ore or work the dumps. Lower and medium quality gemstones, cut into cabochons as a Maden cottage industry, are then shipped to Mashad in eastern Iran. The best turquoise is also sent to Mashad for cutting. Because turquoise mined in the deeper levels may be unstable and lose its color when exposed to light, some clever dealers keep these stones in moist soil until sold. Others of unsavory reputation use dyes to enhance a stone's color. These procedures have clouded the turquoise market, but turquoise from Iran still commands top prices as one of the most popular of all opaque gemstones.

BELOW: Turquoise
Size: 5 by 3.5 cm
Locality: Maden, Iran
Collection: Museum of Natural History, Bern, Switzerland
Photo: S. Rebsamen



OPPOSITE: Peridot (gem quality forsterite)
Size: faceted stone, 146 carats; largest crystal, 4.5 by 3.5 cm
Locality: Zabargad (St. John's Island), Red Sea, Egypt
Collection: Institute of Geological Sciences, London
Courtesy: Institute of Geological Sciences
Photo: Martin Polsford

62 Zabargad Mines (St. John's Island), Red Sea, Egypt

By the dawning of ancient Egypt, swarthy sailers had landed on a tiny island in the Red Sea. Treeless and scorched by a brutal sun, the bleak land offered no food or water—but glittering olive-green crystals lay scattered about the ground. Explorers gathered a few which eventually came to the attention of Egyptian royalty in the capital city of Thebes.

According to Agatharchides in his *De Mare Erythraeo*, Egyptian kings ordered the discoverers to collect gems and deliver them to the royal gem cutters for polishing. In *Naturalis Historia,* Pliny tells of the first specimen presented to Berenice, Theban queen of Lower Egypt, about 300 B.C.

First called the Serpent Isle, then the Island of Topazos, followed by St. John's Island, and currently Zabargad (Arabic for peridot), the oft-named island was systematically worked for hundreds of years, possibly as early as 1500 B.C. by the Pharaohs. Later before the time of Christ, the Ptolemies who ruled Egypt also worked it. Officers of Egyptian courts directed mining activities and used slaves for labor. Workers reportedly died by the hundreds and few ever left the island.

The green stone was first called *topazion,* and this name remained until the 18th century when the British began to refer to the gem as peridot. Today the gem variety of forsterite of the olivine group still bears that name.

Like other gems, peridot was believed to offer special powers to the wearer. Marbodei mentioned in *De lapidibus* that peridot would dispel the terrors of the night: "If it were to be used as a protection from the wiles of evil spirits, the stone had to be pierced and strung on the hair of an ass and then attached to the left arm." In the Middle Ages, the belief persisted that peridot would dissolve enchantments and put evil spirits to flight.

Although no records survive, significant work

must have taken place during the 11th and 12th centuries. Christian crusaders are known to have returned home with large peridots as part of their loot. Fine gems from these mines remain today in a number of European sanctuaries including the Treasury of the Three Magi in Cologne and the Vatican. The precious stone and jewelry collection in the Tower of London also contains large peridot gems.

In the early 1900s new peridot crystals began to appear in European mineral collections, and fine faceted stones were once again offered for sale by important jewelers. Turkish rulers of Egypt apparently directed a series of successful mining ventures until 1922, when the Red Sea Mining Company acquired a lease and located new sources of the gem material. Ismalum Bey, managing director of the company, sold history's largest peridot crystal—actually only a crystal half—to Cairo businessman Max

THIS PAGE TOP:
View of main peak on Zabargad, 1914
Courtesy: F.W. Moon Saint John's Island

THIS PAGE BOTTOM LEFT:
On the Red Sea with felucca-type sail set
Photo: Peter Bancroft

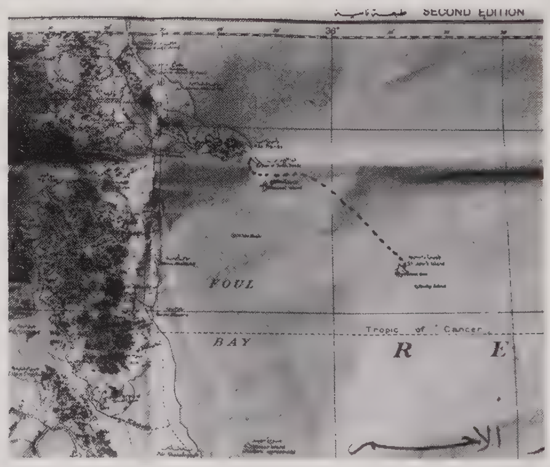
THIS PAGE MIDDLE RIGHT:
The map used to plot our course to Zabargad
Photo: Peter Bancroft

THIS PAGE BOTTOM RIGHT:
Egyptian skipper, Shasli, checks boat's engine
Photo: Peter Bancroft

OPPOSITE TOP:
Ship's crew comes ashore to make bread
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Only a few shore birds visit reef-protected beaches on Zabargad
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Main gem pits near bottom of peridotite hill
Photo: Peter Bancroft



Ismalun. Measuring 6.6 by 5.1 by 2.5 centimeters, the well formed, nearly flawless specimen, has fine deep green color. Ismalun took the crystal to London and sold it for $100 to the British Museum of Natural History where it may be seen today. The Red Sea Mining Company abandoned its operation with the outbreak of World War II, and since that time the peridot deposit has been worked only sporadically. For the past 20 years, it has been abandoned.

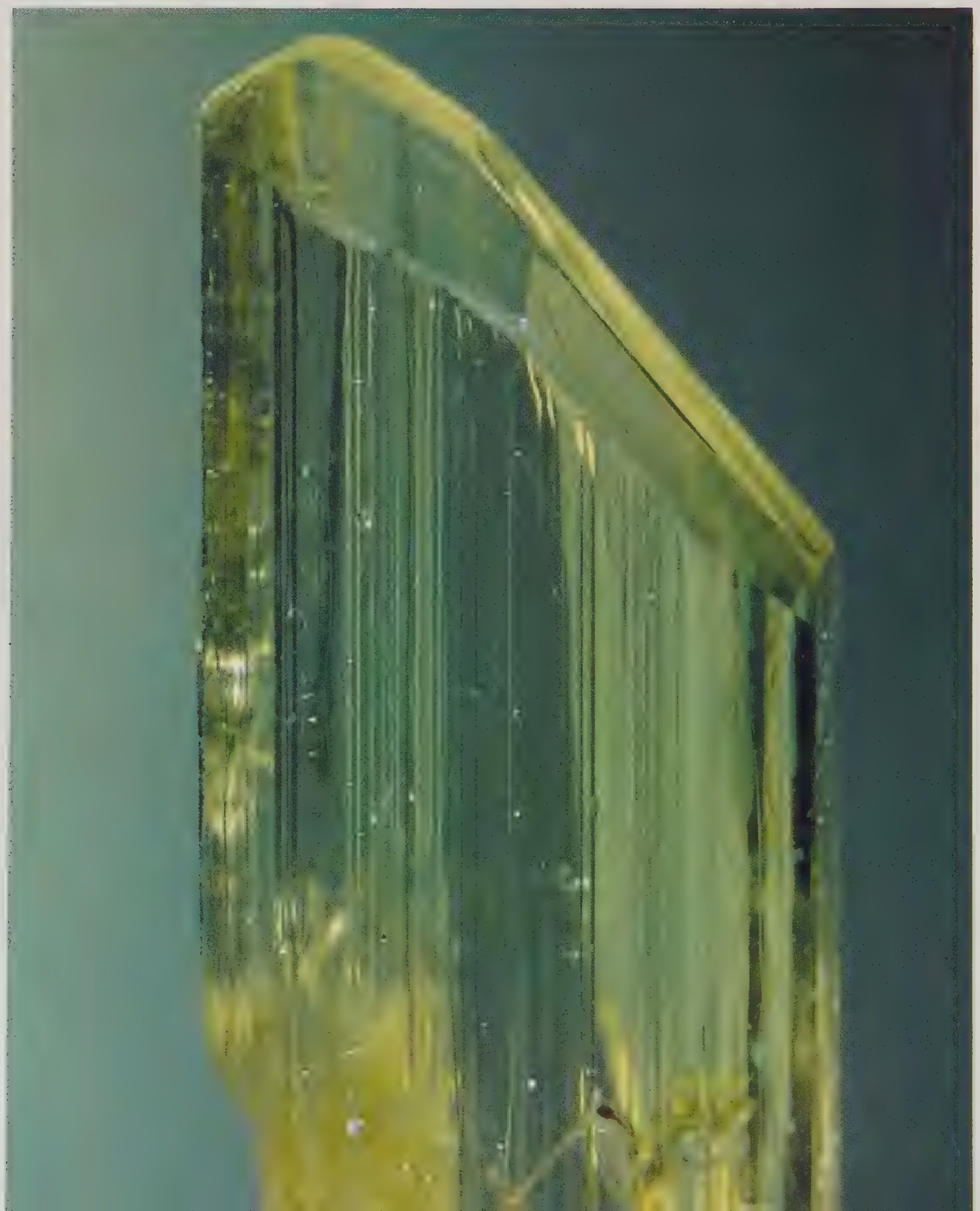
Mineralogists know that large peridot crystals initially formed in faulted cracks—some of them 25 meters deep—which penetrated the basic country rock, peridotite. Poorly attached to crack walls, the crystals may have been loosened by seismic action or weathering, after which they tumbled to the bottom of the fissures where miners found them mixed in the rubble of broken rock. While crystal faces are usually clean and bright, they frequently show fresh fractures, lending credence to the theory that seismic movement damaged them.

Peridot is found in a number of localities around the world, but large gem crystals are unique to Zabargad. Crystals most often are flattened and tabular in form. Doubly terminated examples are very rare.

It was the author's good fortune that Swiss gemologist Edward Gubelin shared his enthusiasm for an expedition to Zabargad in 1980. The Egyptian Ministry of Police issued our permits and assigned an officer to accompany us as guide and interpreter. In Cairo we packed a rented car for the 2000-kilometer round trip with 20 gallons of water, 30 extra gallons of gasoline, mining tools, bedding, clothing, cameras, and dehydrated food for at least two weeks. Our route led up the Nile River to Beni Suef, across the Eastern Desert to Za'farana on the Gulf of Suez, and south along the Red Sea to the little port of Ras Banas. There we chartered a *felucca* (a sailboat of ancient Egyptian design) equipped with a small rusty engine for the 54-kilometer voyage which required seven hours.

As we neared Zabargad, the island appeared larger than its 4.5 square kilometers. Hundreds of old dumps clustered about the base of the main peridotite hill, as clearly visible as the few remaining walls of the mine headquarters just above the beach. A long stone pier jutting into the lagoon was in such disrepair that we landed our dingy on the sandy beach.

While the boat's four-man crew paddled equipment and supplies ashore, we began



THIS PAGE TOP:
Zabargad lies dead ahead
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Peridot
Size: 5 millimeters
Self-collected by the author
Photo: Violet Anderson

OPPOSITE TOP:
Edward Gubelin at entrance of an old tunnel
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Ruins of mining camp on Zabargad built in 19th century
Photo: Peter Bancroft

OPPOSITE BOTTOM:
View of old peridot workings from camp
Photo: Peter Bancroft

searching the area. The beach was littered with light bulbs and wooden pallets—even a plastic Brut Cologne bottle—all blown to the island by prevailing winds. The only life appeared to be a few shore birds and clusters of tiny land snails. To avoid the wind we set up our camp within the roofless brick walls of the old mining office. The crew returned to the boat to live on board and we were alone on Zabargad for the following days and nights.

The chief peridotite deposits lie on a slope toward the bottom of the largest hill about 1000 meters south of our camp. Rock tailings cover the entire area and most tunnels have been obliterated by dumps. Because these cover even older dumps, it is possible that all of the oldest workings lie beneath newer waste rock. Previous miners had used large screens to sift out crystals from the ore, and a careful search failed to reveal a single large crystal. Overlooked, however, were tiny peridot crystals of up to 0.5 centimeters in length which were scattered about a few of the tailings. We collected a score or so of these little crystals—exact microminiatures of the larger crystals seen in museums.

From our observations it seems evident that because of the great size of the deposit some peridot crystals must have been overlooked and remain in deep fissures underneath the dumps. But a large-scale mining operation on Zabargad would require enormous effort. Potable water would have to be converted from seawater; pumps, wash tables, water lines, and tractors could be landed on the island only at great expense. The problems of establishing a base camp, of recruiting a viable and trustworthy crew, of obtaining official mining rights effectively prohibit a successful mining venture.

The unique moments of our last night on Zabargad will not soon be forgotten. After finishing dinner and a bottle of Cleopatra brand Egyptian wine, we were lying on our sleeping bags and gazing upward found ourselves surrounded by countless incredibly bright stars hanging low in the evening sky. Not a sound nor the slightest movement of air disturbed our mood. What was it like 4000 years ago when dark-skinned men slept on the same ground and wondered about the same stars? Perhaps one day Zabargad would support cities and industry; but for now it is still a tiny deserted island, hardly a speck in the vastness of the Red Sea.

63 Sikeit (Cleopatra's Emerald Mine), Wadi Nugrus, Egypt

A narrow winding road still follows part of the ancient Egyptian route east from Apollinopolis Magna (Idfu) on the Nile to Berenice on the Red Sea. The old road which appears on the Turin Papyrus, one of the oldest maps in the world, leads on to Barramiya and Sukari, possibly Egypt's greatest ancient gold mines. This area in the huge and barren Eastern Desert, was just south of the famous mines of Sikeit and Zabara, known as Cleopatra's emerald mines.

Maps indicate that Sikeit lay about 10 kilometers off a modern macadam road bordering the Red Sea. After our visit to Zabargad in 1980 Edward Gubelin and the author considered driving our rented automobile through the Sikeit and, if the route became impassable, to walk the rest of the way. This decision could have been disastrous, because the distance to Sikeit is almost 47 kilometers—too far to walk in the hot desert. Two English geologists, Ashley Shephard and David Melnyk, were working near Marsa Alan. They had the only overland vehicle in the area, and fortunately, agreed to take us to Sikeit.

Remnants of the great flood of November 1979, the area's first major rain in 14 years, were apparent as we drove. The flood obliterated nearly all tire tracks and carved out gullies in the desert's low spots. Our four-wheel-drive was in use much of the way. Traveling due west we entered the Wadi Gimal, a rock-strewn wash leading into the Zabara Mountains. Fortunately the geologist's topographical maps safely steered us through a maze of desolate canyons. There was no evidence of animal life anywhere nor water holes. Thirty kilometers up the *wadi* on a small knoll to the right stood the stark remains of a lonely Bedouin grave; a low mound covered with a row of rocks and sticks. Another 9 kilometers farther, the Wadi Gimal forked with the Wadi Nugrus, which we followed northward. Around one sharp bend of the Nugrus the remains of a two-story stone building perched on a huge rock promontory. The structure, seemingly out of place in the rugged canyon, was the first evidence that man had once lived in this inhospitable region. The walls of the building, constructed of beautifully shaped brownish shale, had retained their crisp corners for more than 2000 years. Stone lintels remained intact, but wooden items such as rafters and doors were gone. One small room was still roofed with 2.5-meter slabs hewn of mica schist. The shelter, probably used before

BELOW: Emerald
Size: each about 10 by 8 cm
Locality: Near Sikeit
Collection: National Geological Museum, Cairo
Photo: Peter Bancroft

OPPOSITE TOP:
Necklace with naturally shaped emerald crystals and amethyst
Size: 7 x 18 cm
Locality: Reportedly found in Pharaoh Tutankhamen's tomb
Collection: Edward Gubelin

OPPOSITE BOTTOM:
Emerald bracelet with agates, etc.
Size: 11 by 9 cm; weight: 0.5 kilogram
Construction: of badly tarnished silver
Locality: bracelet found at Qustul, Nubia
Collection: Egyptian Antiquities Museum
Photo: Peter Bancroft

the time of Christ, was unquestionably a lookout commanding the *wadi* to the south. This was the entrance to the famous emerald mines at Sikeit.

On both sides of the canyon we found the remains of Sikeit itself, possibly 100 separate walls scattered over the jagged hills, surrounded by light-colored dumps of talc and schist. These walls, approximately a half meter thick, were built in an obvious attempt to avoid chilling night winds and summer temperatures which soared to 61°C.

Most mine entrances were caved-in, but historical records indicate some tunnels extended as far as 26 meters into the hills. Miners followed the glittering dark mica and talc schists in their search for emeralds. Having little or no timber for mine supports, they left strong stone pillars as supporting structures. Careful examination of the dumps produced only two tiny bits of light-colored emerald, mute evidence to the thoroughness of the mining process.

Just across the *wadi* a temple had been carved into the cliff in Ptolemaic times (323 to 30 B.C.). Three other shrines had been dug into the same cliff, one of which bore a Greek inscription nearly illegible from weathering. Gubelin translated the legible portions:

> *"In the year 261 A.D., a man named Polyranos, under the Egyptian prefect Petronius, erected this sanctuary in the image of his wife, Berenike. He then offered two silver bowls in thanks to the Egyptian goddess, Isis."*

Standing before the temples in the absolute silence of the ancient ruin, we conjured up visions of scantily clad miners wearily leaving tunnels on their way to the simple rock huts they called home two millenia ago—an eerie fantasy of the past.

Authorities differ as to when Cleopatra's emerald mines were first worked. A. Lucas, in *Ancient Egyptian Materials and Industries* (1926), states that he could not uncover a single emerald in ancient jewelry dating before the Ptolemaic era. (Many writers have erroneously called green stones set in Pharaonic jewelry emerald when in fact they are other gems such as green jasper, malachite, chrysocolla, feldspar, fluorite or even green glass.) Edwin Streeter, in *Precious Stones and Gems* (1898), wrote "The true emerald was known and held in esteem by the ancients. Emeralds have been excavated from the old Roman cities of Pompeii and Herculaneum and were found on Egyptian mummies.

Historical references in Cairo's Antiquities Museum indicate Pharaoh Seti I personally traveled to the Eastern Desert region during the 19th Dynasty (1400 B.C.) in search of gold and emeralds. Further, tools dating to the region of Rameses II (1333 B.C.), were discovered in the ancient tunnels at Sikeit and Zabara. More recently Gubelin acquired a necklace of emeralds and amethyst reportedly found in the tomb of the boy-king Tutankhamen (1600 B.C.). Because the earliest known emeralds were mined at Sikeit, it presumably produced Tutankhamen's emeralds. Undoubtedly the mountains of Sikeit and Zabara were thoroughly searched for gold during Pharaonic dynasties and it's unlikely that emeralds could have been overlooked. It is reasonable to assume, therefore, that Sikeit was being worked for emeralds at least 3500 years ago.

Cleopatra developed a personal liking for the precious green jewel and favored visiting ambassadors with emeralds bearing carved portraits of herself. During her reign (51 to 30

THIS PAGE TOP: Early drawing of emerald mines and camp at Sikeit, 1822 Courtesy: M. Frederic Cailliaud, Travels in the Thebes Oasis, *1822*

THIS PAGE BOTTOM: Cleopatra in her palace, c. B.C. 35 Courtesy: U.S. Library of Congress

OPPOSITE TOP LEFT: Inside a temple built in Ptolemaic times (before Christ) at Sikeit, 1980 Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT: View of Sikeit from lofty emerald mine dump, 1980 Photo: Peter Bancroft

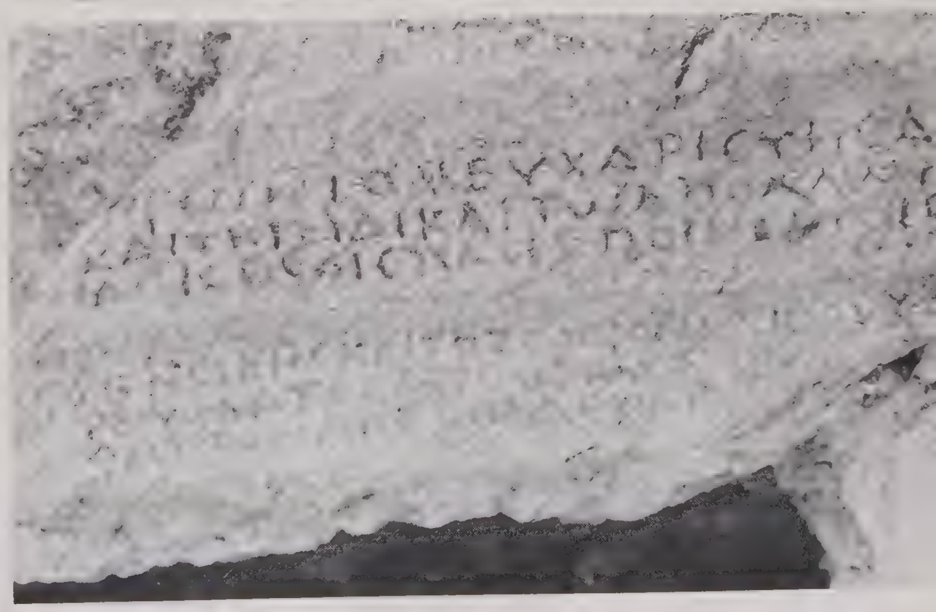
OPPOSITE TOP RIGHT: Ashley Shephard and David Melnyk atop ancient Sikeit building with stones perfectly aligned as if put in place yesterday, 1980 Photo: Peter Bancroft

OPPOSITE MIDDLE RIGHT: Old emerald adit nearly filled with rubble, 1980 Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT: Greek inscription over temple at Sikeit Photo: Edward Gubelin

B.C.) she declared emerald production to be a strictly royal prerogative and had the emerald mines named after her.

Abandoned for centuries, the mines of Sikeit and Zabara were reworked unsuccessfully by M. Frederic Cailliaud in 1822. He wrote of his experiences and cautioned mine visitors against sleeping over the tunnels, as they "were the refuge of snakes, wolves and other beasts of prey; and the abode of demons, who would resent the intrusion."



64 Lualenyi Mine, Voi, Kenya

The great Tsavo plain stretches in all directions untouched by man except for the winding scar of a road connecting Kenya's port city of Mombasa with the inland capital, Nairobi. A few tiny villages of the pastoral Masai people dot the land, but that is all. Oryx, gazelle, springbok, giraffe, and buffalo graze, always alert for carnivores. Migrating herds of zebra and wildebeest cast swirling dust clouds into the sky. And in the background rises perenially snowcapped Mt. Kilimanjaro, Africa's tallest peak.

Across the border in Tanzania, the first of a series of gem mines was discovered in 1967. Ruby was found in the Matabatu Hills; gem zoisite (tanzanite) appeared near the Usumburu Mountains and chrysoprase on Hanety Hill. Garnets, rubies, and sapphires were screened from gravels in the Umba River. Quantities of grossular garnets of every shade of yellow, green, tan, and brown were found in Lala Taima.

Successful miners like John Saul and Peter Morgan became convinced that gemstone

BELOW: Green vanadium grossular
Size: Cut stone - 7.59 carats
Locality: Lualenyi mine
Collection: Pala International
Photo: Harold and Erica Van Pelt

OPPOSITE: Masai warriors change author's tire
Photo: Peter Bancroft

occurrences were not necessarily confined to the Tanzanian side of the border. Precambrian metamorphic graphite-bearing gneisses, similar to those commonly associated with gem deposits in Tanzania, were found in the hills and low mountains of southeastern Kenya.

Working independently, Saul and Morgan sent out prospecting teams in search of gems. Masai and Kikuu tribesmen who knew the country well joined the teams. Morgan and his African partner, Kimani, moved into the Mgama Mountains. Search parties spread out to examine float in canyon bottoms and outcrops in the draws. At times they moved roots, dug under clumps of grass, and dislodged bushes. Nothing was overlooked. One day one of the prospectors carried back to camp some green grossular (garnet) he had found in the bottom of the ravine. Early the next morning, Morgan and Kimani followed their guide up to the spot of discovery. Soon other float grossular chips were traced to beds of graphite schist where specks of green grossular glistened in the dull rocks. A major gemstone discovery had been made.

The new green grossular mine stands on the southwestern portion of Kide Hill, a part of the Taita Hills district. A road was bulldozed due north to connect with the Mombasa-Nairobi highway. Trees were downed for mine timber after exploratory digging indicated the best portion of the deposit dipped steeply into the hill. A tent camp was set up under trees on an adjoining hillock. An aging but wise 70-year-old African, Mezee Adam, became chief mine engineer; 30 Masai were employed as miners, and the recovery of gems was under way. Dogs patrolled a fence surrounding the property from within, though these animals were short-lived as marauding lions negotiated the fence in search of prey.

Mining here was tedious business. The inclined shaft reached a depth of 137 meters, and lines of miners shoveled material up the dimly lit passage from man to man until the loose rock reached the surface. The aggregate was screened by hand and green stones were dropped through a slot in a small iron "safe" secured with a padlock.

The first kilogram of green grossular was accumulated in 1973 and taken to Nairobi. When the lot was poured onto a bathroom scale, William Larson, owner of Pala International, made the first large purchase of Kenya green grossular.

Laboratory tests by Edward Gubelin and Max Weibel in Switzerland proved the grass-green stone to be colored by vanadium. Though not distinct enough to be considered a new species, this was obviously a new variety of garnet quite different from the yellow-green demantoid found in Italy and the Soviet Union. In order to enhance merchandising, the gems received the varietal name tsavorite, after the Tsavo area in which they occur.

Green grossular, a very beautiful stone, has features that surpass those of the emerald. The green garnet has a much higher index of refraction, which results in superior brilliance, tends to greater transparency, and occurs with fewer inclusions. Green grossular is extremely rare, and fine stones of over 5 carats are considered collector's items. Gubelin owns one good crystal and Herman Bank of Idar-Oberstein, West Germany, owns another.

The green gem usually occurs in shattered sections of large porphyroblasts, and attempts to salvage anything resembling a complete crystal of display quality have been nearly fruitless. Much material is unsuitable for gems,

which means that grading or marketing the rough requires great skill.

The largest known faceted green grossulars, reported to weigh more than 30 carats, are usually flawed and therefore are not too attractive. The largest fine quality stone known is a nearly flawless 16.67-carat emerald-cut stone in Richard Webster's collection.

Spurred on by the discoveries, John Saul (who had witnessed the first sale) redoubled his efforts to discover new commercial gem deposits. In 1974, a bag of small crude reddish corundum crystals was brought to his office. Tracing them to a hill within the Tsavo Game Preserve, Saul began mining. He was unprepared for the extraordinary successes as well as inordinate degrees of intrigue which dogged his venture.

Saul's partner, James Miller, supervised mining activities and the removal of hundreds of kilograms of ruby corundum. A small but

THIS PAGE TOP:
Metal "safe" half full of green grossular
Photo: William Larson

THIS PAGE MIDDLE:
Main camp at the Lualenyi mine, 1975
Photo: William Larson

THIS PAGE BOTTOM:
Foreman Mezee Adam (white hat) greets visitors at mine portal
Photo: William Larson

OPPOSITE: Green grossular (tsavorite) and diamonds
Size: pendant stone 10.7 carats
Locality: Lualenyi mine
Collection: A.H. Stange
Photo: Harold and Erica Van Pelt

important percentage was facet-grade gem ruby, the first to be found in Africa. Colors ranged from hot pink to deep red, and some material faceted into gemstones weighing an amazing 10 carats.

Unfortunately, problems involving mining rights led to claim jumping and friction between Saul and Jomo Kenyatta, then president of Kenya. The mine was abandoned and is not being worked today.

THIS PAGE TOP:
Young men sift for garnets
Photo: William Larson

THIS PAGE MIDDLE:
Cheetah with cub in veld near Voi
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Jeanne Larson admires green gems at the Lualenyi, 1979
Photo: William Larson

OPPOSITE TOP:
Small landing field near Mt. Kilimanjaro
Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT:
One of the original claim holders who lost his property when the Tanzanian government nationalized the mine
Photo: Edward Swoboda (1967)

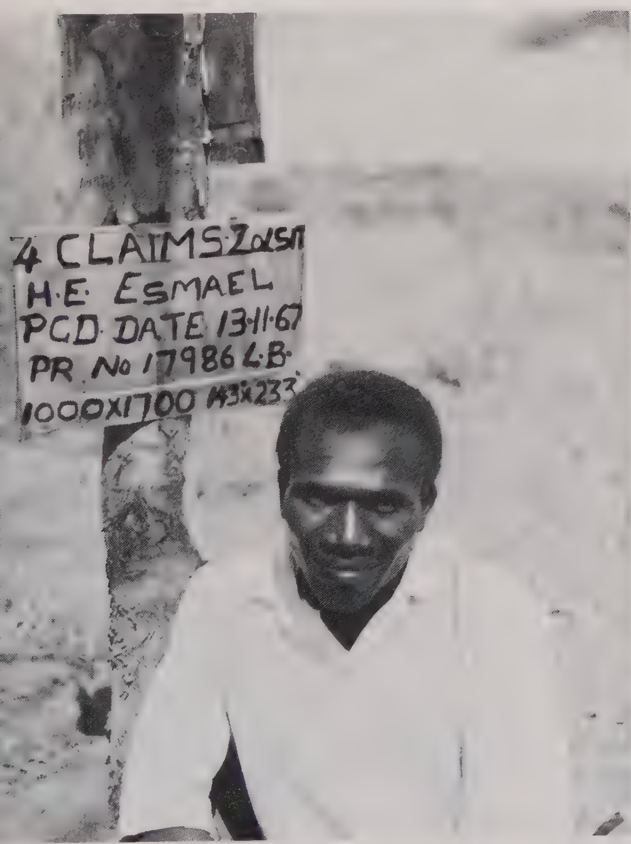
OPPOSITE BOTTOM RIGHT:
Masai family near Merelani mine
Photo: Peter Bancroft

65 Merelani Mine, Arusha, Tanzania

Zoisite was the mineral name for a series of opaque to translucent varieties, of which only two are used as gemstones: massive pink-colored thulite and a brilliant apple-green zoisite (which also occurs in grayish-white, gray, yellowish-brown, and greenish-gray). Named for Czechoslavakian Baron Zois von Edelstein, zoisite never really achieved prominence as a gem material.

Then in March 1966, an Arusha tailor named Sousa discovered a deep blue gemstone at a place later known as the Merelani mine. Using sophisticated equipment experts found that the gem was not "sapphire" as suspected, but an astounding variety of zoisite. Tiffany and Company, in a vigorous sales promotion, named the stone "tanzanite" after the country of origin, and the name has since been generally adopted.

The Merelani deposit was difficult to reach in the Usumburu Mountains which border the Umba Valley of northern Tanzania. This region, a vast arid plain broken by hills and small mountain peaks, is inhabited by the pastoral Masai people. The Merelani lies between two landmarks just south of the Kenya border—Mt. Kilimanjaro and the Olduvai Gorge made famous by paleoanthropologist Louis Leakey. The nearest town of any



consequence is Arusha, about 50 kilometers to the northwest.

In 1975 the author met A.H. (Brick) Stange who provided a pilot and a single-engine airplane for the flight from Nairobi to Arusha. We planned two trips—first a visit by plane to the ruby mine near Longido and the second in jeeps to the tanzanite mine in Merelani.

The trip to the ruby mine was uneventful except for a painful bite from a tsetse fly. Even though my seat belt was fastened, I jumped hard enough to bang my head on the cockpit ceiling and the pilot lectured me on how dangerous it was to make such a violent movement while flying at a low altitude. Just as he concluded his rebuke, a fly bit him on the neck. There was an immediate plethora of epithets, somewhat superior to mine, but no more lectures! Upon reaching the mine we noticed a great wall of schist marked by green streaks of zoisite. Closer inspection revealed bright red, nearly opaque 2 to 4-centimeter ruby crystals imbedded in the zoisite. Large chunks of the red and green material were blasted loose for shipment by truck to Arusha.

A few days later our party left in two jeeps for Merelani. Our route passed through a brushy countryside dotted with trees, and from time to time, we passed Masai villages and herds of Brahman cattle tended by one or two small boys. Upon reaching the mine, we were admitted by armed guards. The tsetse flies were replaced by numerous nonbiting flies which landed upon any part of the body which exuded moisture—the corner of the eye or mouth and exposed parts when relieving

BELOW: Tanzanite
Size: 220 carat faceted, cushion cut stone
Locality: Merelani
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt

Tanzanite
Size: 5 by 3 cm
Locality: Merelani
Collection: Los Angeles County Museum of Natural History
Photo: Harold and Erica Van Pelt

OPPOSITE TOP: Miner breaking tanzanite from mother rock
Photo: Edward Gubelin

OPPOSITE BOTTOM LEFT: Following tanzanite vein into hill
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT: Miner examining tanzanite crystal
Photo: Edward Gubelin

oneself. They were a constant irritant and a real nuisance.

Guards armed with rifles and shotguns were conspicuously posted at vantage points about the workings. Digging was by the open-pit method, with a few veins being explored by short tunnels. A small padlocked iron box sat nearby. When a miner discovered a crystal or segment, he was to drop it into the box. However, the chances are that many were swallowed or thrown into a bush for recovery later. Miners were paid next to nothing, and this provided the incentive to high-grade stones.

Tanzanite crystals occur sparsely in a heavily metamorphosed zone of tough rock. They are prismatic, heavily striated, and often possess good terminations. The mineral is fairly soft (6 to 6.5 on Mohs hardness scale) and fractures rather easily. It is common to expose a fine crystal deeply imbedded in rock, then watch it break into small pieces during removal. The search for crystals is accomplished with picks, iron bars, shovels, and compressed-air jackhammers, a system which takes a high toll of fine gems. Clean stones which will facet 2 carat or larger gems are quite rare, and days pass between discoveries.

Tanzanite occurs in colors of gray, brown, violet, blue, reddish-purple, and tints of green. The gem is of interest because of its exceptional pleochroism. Rotated in different directions a single stone will exhibit three

outstanding changes of color, from reddish purple to blue to deep purple. When placed in ovens and heated to 620°C, the reddish purple crystals alter to a rich violet-blue; some turn to a deep blue resembling sapphire. But heating reduces pleochroism.

Tanzanite in large flawless sections appeared with some regularity during the early days of mining. Lovely gems of 20 to 50 carats were not unusual. One of the largest stones, a splendid faceted flawless gem weighing 122.7 carats, is part of the Smithsonian Institution's collection.

When first mined, fine stones could be purchased in Tanzania, Kenya, and the United States for as little as $20 a carat. By 1984 clean gems wholesaled at better than $1000 a carat, an indication of increasing interest in a gem already in short supply. In 1978 a massive cholera epidemic struck northern Tanzania and interrupted production of rubies, garnets, sapphires, chrome tourmaline, chrysoprase, and tanzanite. In addition, most of the known gem deposits were playing out. As a result, decreasing production has caused a scarcity of quality gemstones and a rapid rise in their value.

THIS PAGE TOP:
Miners working a Merelani vein under watchful eye of armed guard
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Screening days output of tanzanite
Photo: Peter Bancroft

OPPOSITE: Torbernite
Size: 7 by 5 cm
Locality: Musonoi
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

66 Musonoi Mine, Kolwezi, Zaire

The largest copper belt in the world extends northward from Kabwe, Zambia (formerly Broken Hill, Northern Rhodesia), to a series of mines arching through the province of Shaba, Zaire (formerly Katanga, Belgian Congo); from the west around Kolwezi, and to the Lubumbashi region in the southwest. There are 30 major mines in all including Mine de l'Etoile, the oldest. The belt is 525 kilometers long and, while major ore bodies are not contiguous, spectacular copper lenses measure 1000 meters in length.

For hundreds of years Africans mined malachite from brightly colored deposits that appear as streaks across the jungle-covered 1200-meter-high plateau. From one of the ancient pits, 215 meters long, 125 meters wide, and 10 meters deep, natives carried out an estimated 500,000 tons of malachite on their backs. Man rather than animals hauled the malachite because sleeping sickness spread by the tsetse fly made it impossible to keep beasts of burden.

These early people roasted pure malachite in furnaces made from the clay found in the small round anthills which are so abundant in the region. The furnaces, about 2 meters high, were fitted with antelope skin bellows at the base of each quadrant. The green ore was placed on a bed of charcoal and the furnace sealed. After ignition and strenuous operation of the bellows, a small stream of copper poured from a spout. The copper was refined, and the nearly pure metal cast into ingots shaped like

THIS PAGE TOP:
Incline haulage system in Shinkolobwe mine, c. 1910
Courtesy: Atlas du Katanga, C.S.K.

THIS PAGE MIDDLE:
Traction engine hauling supplies to Katanga, 1910
Major Sharp (second from left) who discovered Shinkolobwe and after which sharpite is named
Courtesy: Union Miniere Company

THIS PAGE BOTTOM LEFT:
Native African hammering copper, illustrating how it was done years ago
Courtesy: Union Miniere Company

THIS PAGE BOTTOM RIGHT:
Bantu casting copper in form of cross just as it was done 300 years ago
Courtesy: A. Francois, Geological Service, Union Miniere Company

OPPOSITE LEFT:
Cuprosklowdowskite
Size: 15 by 8 cm
Locality: Musonoi
Collection: Los Angeles County Museum of Natural History
Photo: Harold and Erica Van Pelt

OPPOSITE RIGHT:
Carrollite
Size: (crystal) 5 cm
Locality: Musonoi
Collection: University of Paris
Photo: Nelly Bariand

St. Andrew's cross. These ingots appeared before 1789, when an Angolan governor made the earliest references to Katanga copper. The origin of the cross design is not known. These crosses, first used for dowries and later used as money, have been found from the Ivory Coast to Mozambique and from Zimbabwe (Rhodesia) to the Sudan.

Copper was also cast into bar-shaped ingots, then hammered into hoes, bracelets, and weapons; it was also drawn into wire. Each process was accompanied by magical words, dances, and ritual songs. The reigning king received a duty on all production. Apprentice workers served under master craftsmen who jealously guarded the secrets of their metallurgy. The furnaces were often constructed in the form of a woman who would "give birth" to a flow of glittering copper.

During the 17th century, one Mwatayamvo ruled the Lunda Empire (comprising the upper Katanga and Zambesi river watersheds), and controlled copper production. For at least 20 years, he sent caravans laden with refined copper to Portuguese traders on the Angola coast who sent the copper to Europe.

Although African copper was traded in Europe for two centuries, it was not until 1873 that Sir Henry Stanley made an exploratory journey across "Darkest Africa." He discovered the source of African copper in the upper Congo basin. Recognizing the vast size of the copper deposits, Stanley encouraged King Leopold II of Belgium to develop the ores in the area. The King, however, considered the magnitude of the effort and money it would require. There were no roads or railroads for hauling supplies, the nearly endless marshes produced myriads of malaria mosquitos, and an even more deadly threat in the tsetse fly.

Eventually British colonial administrator, Cecil Rhodes, obtained concessions to the Belgian copper territory and sent his trusted friend Robert Williams to organize a mining program. Williams, a soldier of fortune and an accomplished engineer, selected George Grey as an assistant to accompany him. Because there were no railroads, all supplies and

equipment were hauled by ox carts from Lombito Bay in Angola. The 2000-kilometer journey through swamps and insect-infested jungles took one year!

In 1908 huge traction engines replaced oxen materially shortening the time of each trip. Life for Europeans in the African jungle was difficult at best. Young English and Belgian geologists and engineers came to the Congo to make their fortunes; many died and are buried in unmarked graves. Grey, mauled by a lion, also died in the jungle. Hundreds of others returned home disillusioned and sick. The nightly rounds of "sundowners," a concoction of whiskey and antimalarial quinine, left many a good man an alcoholic.

To bring in coal for the furnaces and to haul out the copper, a railroad was built. In 1910 the Katanga extension joined the Rhodesian Railway line at Broken Hill, Northern Rhodesia. The Katanga mines became large producers, and Williams was recognized internationally for breaking the American monopoly on copper.

One of the more important areas to be developed was the Musonoi complex located at the northwestern end of the copper belt in the province of Shaba. The Musonoi mine is surrounded by other mines—all open pits—which may eventually merge. If that occurs, there will be one gigantic hole. To the west are the Kamoto and the Dikuluwe mines; to the north, the Ruwe mine (where gold was found) and the North Kamoto; to the south, the Kolwezi. The Belgian firm Union Miniere du Haut Katanga had concessions for these mines and operated them with ultra-modern equipment, producing 16 percent of the world's copper. In 1966 the mines were nationalized by the Congo government (currently Zaire) and the Societe Conglaise des Mineraux took over their operation.

The Musonoi open-pit has been a prolific producer of fine crystals. Most important is the series of metatorbernite specimens encountered from the surface to about 30 meters deep. The dark green crystals are probably the world's finest. Some crystals reach 2 centimeters on an edge, and crystal clusters have a greater brilliance than metatorbernite from other localities. A characteristic of torbernite is that when exposed to normal humidity and temperature, it loses part of its water content, becoming a new mineral—metatorbernite. Fortunately, during the alteration the Musonoi crystals do not lose their brilliance, color, transparency, or their value as mineral specimens.

The Musonoi mine also has yielded incomparable cuprosklodowskite which forms within narrow vugs as yellow-green needle-like crystal sprays up to 2 centimeters in length. The world's best carrollite octahedrons were discovered in the mine's upper levels. Rare minerals from Musonoi include demesmaekerite, guilleminite, marthozite, vandenbrandeite, derriksite, and oosterboschite.

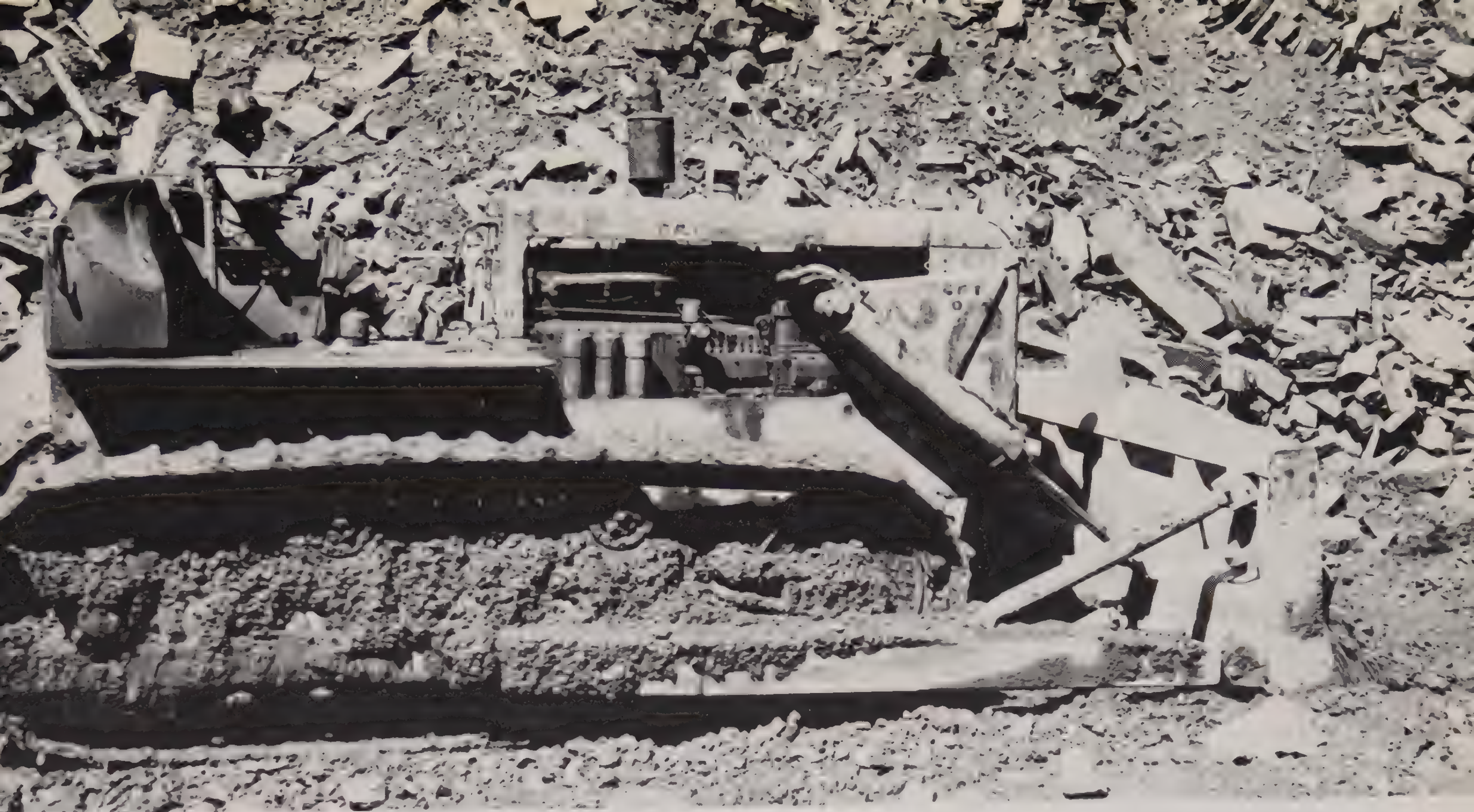
Fine crystals of cornetite have come from the Dikuluwe mine, and parts of the North Kamoto property were invested with large deposits of malachite banded in various shades of green.

BELOW LEFT:
Termite mounds in jungle near Musonoi provided clay used by natives for small copper smelters
Photo: Peter Bancroft

BELOW RIGHT:
Deadly black mamba killed in road
Photo: Peter Bancroft

OPPOSITE TOP:
Miner working caterpillar D8 at Musonoi
Courtesy: Union Miniere Company

OPPOSITE BOTTOM:
Musonoi open pit in 1976
Courtesy: Union Miniere Company



The Kamoto and Kolwezi pits unearthed splendid caverns lined with layers up to 3 meters thick of banded gem quality malachite.

The Shinkolobwe mine deposit, 145 kilometers to the southeast of the Musonoi mine, was found by a Major Sharp in 1915. While searching for copper, he discovered this enormous deposit of uranium. The subtropical climate at the mine is probably responsible for the deep weathering of primary pitchblend into an astounding series of rare and colorful secondary uranium-nickel-cobalt minerals including curite, kasolite, soddyite, uranophane, vandendriesscheite, iriginite, phosphuranylite, and at least 25 others. Shinkolobwe produced more high-grade uranium ore than all other world deposits combined. Refined products from that stockpile were used in developing the first atomic bombs. Many fine specimens from Shinkolobwe, currently displayed in mineral cabinets, were not collected directly from the mine, but salvaged from a truck disabled in an accident on the road between Shinkolobwe and Likasi. The mine is now flooded.

As the oxide zone in the upper levels of the Musonoi and other nearby mines is worked out, fewer top quality crystal specimens will appear. Mine staff mineralogists predict diminishing supplies of torbernite and cuprosklodowsite and shortages of malachite. However, expansion of present pits could expose new oxide areas and within them new crystals. Belgian geologist, P. Van Wassenhove, summed up future possibilities: "the last story about Shaba [in the Katanga mining region] has not been told!"

BELOW: Malachite
Size: 17 by 15 cm
Locality: Kambowe, Shaba
Collection: University of Paris
Photo: Nelly Bariand

OPPOSITE: Topaz
Size: 7.25 cm
Locality: St. Anne's
Collection: American Museum Natural History
Photo: Henri Janson

67 St. Anne's Mine, Miami, Zimbabwe

The color of topaz has been traditionally thought of as straw yellow to light brown. During the 18th century, a considerable quantity of light-yellow topaz crystals were mined at Schneckenstein in the Erzgebirge mountains, which then separated Saxony (now Sachsen, German Democratic Republic) and Bohemia (now Cechy, Czechoslovakia). This find increased the popularity of topaz in Europe. Golden brown topaz was discovered in 1760 at Ouro Preto, Brazil, and named "Imperial topaz" to stengthen the popular belief that all topaz was tan or golden. When miners found topaz in pink, orange, violet, green and blue colors, they incorrectly assumed they had discovered gems of other species. Even when topaz of unusual color was correctly identified, gem rough was difficult to market. The public wanted only yellow to brownish topaz.

Today, unusually colored topaz commands prices well above the ordinary hues. Most blue topaz crystals are light in color and flawed or veiled internally. Natural blue topaz is pure and bright and lacks the hint of green typical of aquamarine. Fine crystals of blue topaz have been found at a number of localities including Virgem da Lapa, Brazil; Mursinka, Soviet Union; Spitzkopje, Namibia (South-West Africa); and Ramona, California. Crystals from the Soviet Union's Ural Mountains occur as squat prisms, frequently growing from matrices of smoky quartz, feldspar, and mica. Topaz from this classic locality is one of the most prized of all gem crystals.

A major source of blue topaz crystals was the St. Anne's mine located at Miami about 180 kilometers northwest of Salisbury in Zimbabwe (formerly Southern Rhodesia). Few mineral collectors know St. Anne's mine, which is rarely listed as a source in gem and mineral books. In addition, many labels incorrectly identify St. Anne's topaz as being from Brazil or other localities, thus distracting attention from the true source.

During the late 1950s, Rhodesia's Atomic Energy Board explored the Miami area for commercial grade beryl. Promising deposits were discovered, and shipments of crude beryl sent to Germany where Berthold Bracher noticed gem quality aquamarine mixed with the other beryl. Tracing the material to the St. Anne's mine, Bracher bought the property and successfully worked it until he died in an automobile accident.

In 1975 the author decided to visit the St. Anne's mine. Upon arriving in Salisbury, he contacted a number of gem cutters and mineral merchants. But none would venture into the northern territory where hundreds of guerrillas were raiding farms and settlements. Just the week before, a land mine blew up a truck near St. Anne's and killed six people. Few pilots wished to jeopardize their lives or aircraft by flying into the region. Insurgents using heat-seeking surface-to-air rockets reportedly had downed two aircraft in previous weeks. The author finally located Hilmar Bosch, a young gemologist and mineral dealer who quickly made arrangements with a bush pilot.

At dawn our chartered single-engine Cessna took off from a private field on the outskirts of Salisbury and climbed rapidly to 2000 meters. After an hour's uneventful flight, we arrived over a tiny dirt airstrip at St. Anne's mine and received landing clearance. Tipping the wing on edge we spiraled down, "feathered out" for a short approach, and landed. The mine staff greeted us warmly because the mine had been

THIS PAGE TOP:
St. Anne's from the air, airstrip lower left, 1975
Photo: Peter Bancroft

THIS PAGE MIDDLE:
Miner searching for aquamarine and tourmaline in second gallery at St. Anne's
Photo: Edward Gubelin

THIS PAGE BOTTOM:
Bantu workers searching for gems at conveyor belt; Hilmar Bosch in foreground
Photo: Peter Bancroft

OPPOSITE TOP:
Miners dumping ore car
Photo: Peter Bancroft

OPPOSITE:
BOTTOM LEFT:
Quartz crystal and gem pocket in St. Anne's
Photo: William Larson

OPPOSITE
BOTTOM RIGHT:
Native rondovos (huts) at St. Anne's
Photo: William Larson

cut off from the outside world for a solid month.

The St. Anne's compound was a busy place. One hilltop was being cut away by a D-7 tractor and, according to the Portuguese foreman, promised to develop into a rich area for aquamarine. Miners pushed ore cars loaded with pocket material to conveyor belts which were worked by women and children who hand-picked gems from the waste.

Most of the shafts and tunnels that had produced topaz were under water. However, display cases and boxes in the foreman's office contained medium blue well formed topaz crystals and a few bright, terminated aquamarine crystals.

Gem crystals at St. Anne's occur in decomposed pegmatite altered to soft white kaolinite. Topaz crystals still attached to matrix occur rarely. Doubly terminated crystals are sometimes found, to the collector's delight. St. Anne's blue topaz, seldom of facet grade, is prone to internal feathers and bubbles. The light to rich blue colors are very pretty and without a tint of green. Crystals usually measure 6 to 5 centimeters in length but occasionally grow to 10 centimeters. Large stones are in demand for cabochons and carvings. A few superb blue

topaz crystals bear gemmy green tourmaline crystals as inclusions. During the 1960s, the Green Walking-Stick mine, a few kilometers from St. Anne's, produced nearly pure heliodor (golden beryl) up to 7 centimeters. Between 1969 and 1974 some very good blue topaz crystals on feldspar were discovered, and St. Anne's sold "fist-sized" massive blue topaz by the ton. A small amount of transparent greenish blue albite also appeared.

Other gem species found in this mine and the surrounding area include garnet, chrysoberyl (cat's-eye), some of the world's best euclase in fine deep blue colors, tourmaline in shades of pink, green, and blue, and smoky and citrine varieties of quartz.

St. Anne's has a constant security problem. Because all workers are searched before leaving the compound, one enterprising miner lobbed gems over the fence into bushes beneath a large tree and a conspirator collected the crystals that night. The foreman commented "Sure we know what is going on, but we can't just sit all night under the tree waiting for someone to come."

After my visit in 1975 the St. Anne's mine deteriorated. Guerrillas destroyed some of the property; the mine was devastated, and the shafts flooded. In 1978, P.J. Klopper bought the mine, but died the next year though his estate still holds ownership. During 1978 and 1979 meager "official" production was limited to a few kilograms of aquamarine, green tourmaline, and blue topaz. Poor mining techniques have created dangerous conditions underground, and it seems unlikely that additional good quality blue topaz crystals will be found.

BELOW:
Conveyor belt
at St. Anne's
Photo: Julius Petsch

OPPOSITE TOP:
View from Muiane dump
Photo: Julius Petsch

OPPOSITE MIDDLE:
Beryl mine near Muiane
Photo: Edward Gubelin

OPPOSITE BOTTOM:
Large beryl and quartz
crystals at Muiane, 1949
Photo: Mark Bandy
Courtesy: Rocks
and Minerals

68 Alto Ligonha Mining District, Gilé, Mozambique

One of the earth's greatest pegmatite regions covers 300 square kilometers of northern Mozambique about 300 kilometers inland from the Indian Ocean. The principal mine, the Muiane, lies about 100 kilometers southwest of Ribaue, near the town of Gilé and not far from Alto Ligonha in the province of Zambezia. Thick clumps of speargrass clog slow-moving streams and impede transportation throughout the area during the rainy season from November to April. Gently rolling hills overlook the valleys, and a few mountains rise about 900 meters. A wide variety of large animals including elephants inhabit the area. Ebony, sandalwood, and other hardwood trees cover much of the mining zone. Spheroidal weathering has created granite *dwala,* the prominent rounded hill-like rock knobs typical of African topography. Lying between 360 and 460 meters above sea level, the region is hot, but not unpleasantly so. Substantial numbers of Bantu tribesmen populate the valley.

The Portuguese first settled at Angoche on the Indian Ocean about 1650 and sent expeditions inland in search of gold. They located quantities of gold and mica near Alto Ligonha but exact mine localities are unknown today.

Pegmatite veins generally occur in schists which metamorphosed from granite. Most pegmatites have quartz cores and high concentrations of mica. Where these easily recognized veins outcrop, they have been focal points of mining activity. So many pegmatite veins have been discovered at the surface that there has been no urgent need for further exploration. American geologist, Mark Bandy, visited the Muiane in 1949 and wrote: "Should modern geophysical prospecting methods be employed many new pegmatites could be found." Hundreds of pits, quarries, and worked-out veins as well as a few underground tunnels testify to considerable, if not exhaustive, mining activity over the years.

The pegmatites found between Ribaue and Alto Molócue more than 100 kilometers to the south, are rich in columbite, tantalite, bismuth, feldspar, beryl, and gemstones. The big pits near Ribaue have produced large quantities of crushed rock used as surfacing material for roads and ballast for railroads. Mica, the principal mineral mined in the district, is sorted and graded, usually within sheds on the property. Important mica deposits occur at Murrapane and Boa Esperanza. Alluvial concentrations, frequently adjacent to host pegmatite veins, have been the source of rare heavy minerals, gold, and gems.

Many Mozambiquan Bantus have worked in South Africa's Rand gold mines. These experienced men quickly learn how to cob and handpick gems and ore. Because labor is cheap, drilling is frequently done by hand and selective mining occurs where gemstones may be found. Gem crystals of tourmaline and beryl are cobbed from rock by hand, a somewhat wasteful but inexpensive process.

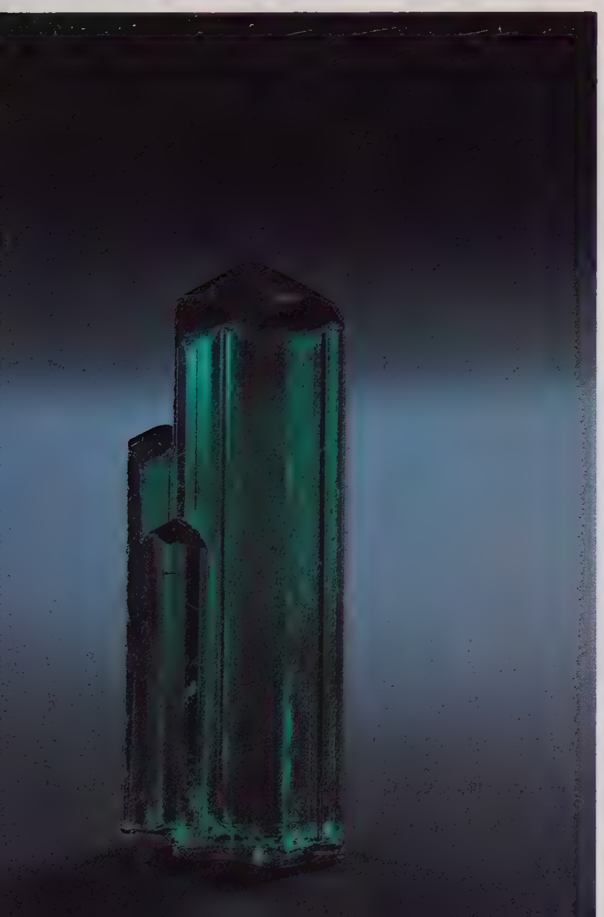
Muiane, 5 kilometers south of Alto Ligonha, one of the most important gem mines in Mozambique, has been worked for years. The deposit comprises a compact pegmatite made up primarily of albite and cleavelandite. Fresh mine walls are snow white and blinding in the sun. The principal gemstone is tourmaline, primarily found in pink and green colors. Rubellite and bicolored tourmaline up to 40 centimeters in length and 8 centimeters in diameter have occurred at the Muiane. Green tourmaline is smaller, with crystals seldom larger than 13 by 4 centimeters. Other minerals include garnet and lepidolite in

THIS PAGE TOP:
Manganotantalite
Size: 5.5 carats
Locality: Alto Ligonha
Cut by: Elvis Gray
Collection: Elvis Gray
Photo: Joel Arem

THIS PAGE BOTTOM:
Tourmaline
Size: 2.8 by 2 cm
Locality: Muiane
Collection: Herman Bank
Photo: Hartmann Studios

OPPOSITE TOP:
Tourmaline, scepter form
Size: 9 by 5 cm
Locality: Muiane
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Tourmaline
Size: 3 by 1 cm
Locality: Muiane
Collection: William Larson
Photo: Harold and Erica Van Pelt



lavender cleavages up to 30 centimeters in diameter. Gem quality beryl (aquamarine and morganite) occurs infrequently. One deep pink morganite with sharp crystal faces measuring 8 by 5 centimeters belongs to the Smithsonian Institution. Beryl crystals usually form in hues of light blue, but colors also include deep blue to nearly black. Crystals in these shades often contain white alteration zones at the deeply eroded surface. Well defined samarskite crystals up to 4 centimeters are the largest from Mozambique.

Monazite usually occurs in irregular shapes and tiny crystals and is associated with another rare-earth mineral, allanite. However, a few large crystals measuring up to 10 centimeters have been found. Bismutotantalite and stibiotantalite generally form as crystals not larger than 2 centimeters, but one jumbo stibiotantalite crystal with sharp brilliant faces measures 14 by 12 centimeters. It also is in the Smithsonian collection. Bismuth occurs both as bismuthinite and in native form. Fine quartz crystals, including large smoky quartz crystals with varied inclusions, occur commonly in sizes to 40 by 26 centimeters, but clusters appear rarely. The principal product of Muiane is a great quantity of kaolin clay. Insignificant numbers of choice albite crystals and gold also come from Muiane. Between 1960 and 1975, the mine produced thousands of kilograms of tourmaline, much of it gemmy.

From the scores of gem deposits in the vicinity of Muiane, a number have produced outstanding gem crystals. The Maria II near Morrua gave large quantities of small but deeply colored emeralds, and the Morrua mine has yielded good gemmy morganite. Fine quality aquamarine has been mined at the Monapo mine. A bed of nearly pure lepidolite measuring more than 11 meters long and 3 meters high was discovered at Naipa. Large lavender tapered lepidolite crystals measure 18 by 10 centimeters. Fine sharp crystals of samarskite come from Macotaia. Gem grade green fluorite cleaving into 10-centimeter octahedrons comes from Piteia. Quartz crystals more than a meter in length and weighing over a ton are from Nahia. Fine quartz crystals up to 15 centimeters in diameter and associated with tabular albite crystals were found at Cavala.

A large emerald mine near Gilé yielded some exquisite giant emerald crystals in sizes from 25 to 13 centimeters in length and 3 centimeters in diameter. Unfortunately, little gem quality material resulted from this find.

A beryl mine near the Muiane has been prolific in flesh-to-peach-colored morganite, some of it in quite large pieces. Fine goshenite (colorless beryl) crystals have also been located at this mine.

Gem dealer and miner Berthold Bracher obtained many of the finest tourmalines mined in Alto Ligonha. One of Bracher's greatest acquisitions was 10 kilograms of flawless dichroic tourmaline nodules called *gemmas* (Portuguese for yolk). Each gemstone gave a chartreuse-green color on one direction and a fine sherry hue in the other. These striking nodules occurred in dark green tourmaline "logs" from the Nuaparra mine, which reportedly has also produced 14 tons of rubellite.

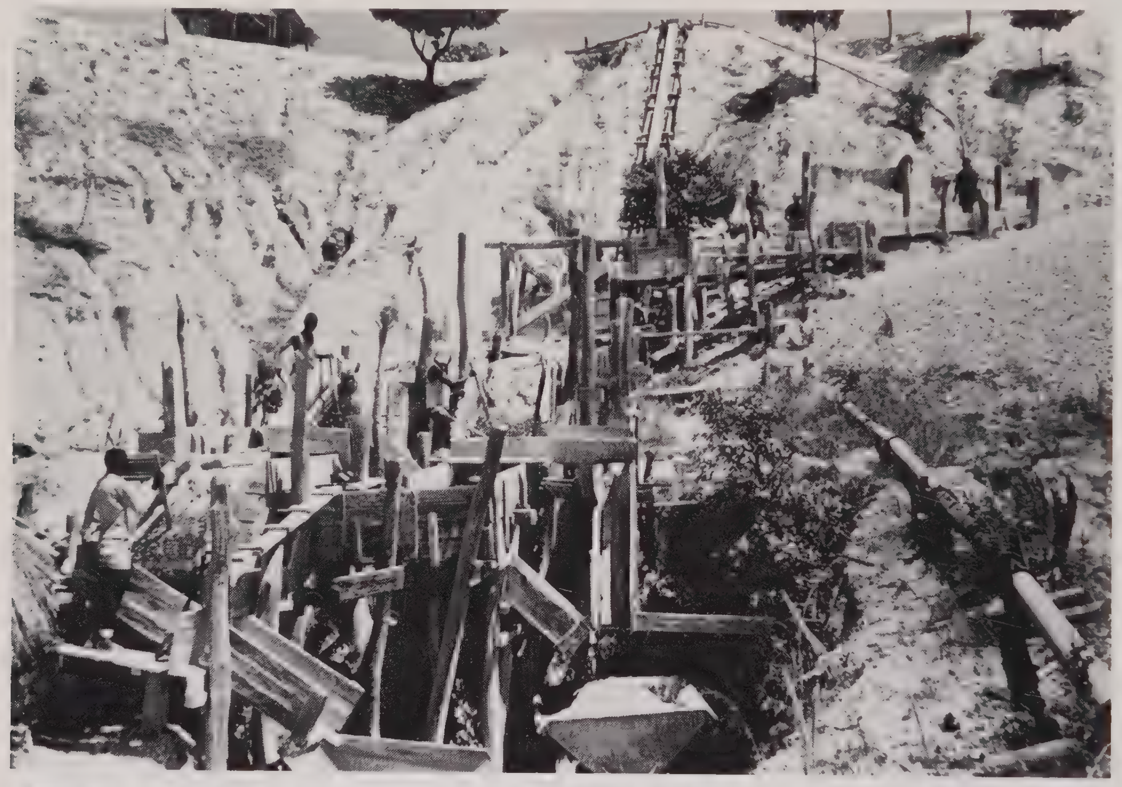
The Muiane has fallen on hard times since

THIS PAGE TOP:
Recovery plant at foot of Muiane hill
Photo: Edward Gubelin

THIS PAGE BOTTOM:
Quartz mine near Muiane
Photo: Edward Gubelin

OPPOSITE TOP:
Bantu boys and young men search for emeralds at Maria III
Photo: Edward Gubelin

OPPOSITE BOTTOM:
Miners working bottom of a chamber on Muiane hill
Photo: Edward Gubelin



the mines were nationalized in 1977. Mismanagement, graft, and lack of interest in gemstones has caused many mines, including the Muiane, to close. In 1981 an engineer, Dr. Carlos Garcia dos Santos, was employed to supervise the mine properties, but his administration attempted only small-scale work from time to time. As roads continue to deteriorate, access to Muiane becomes increasingly difficult. Experts predict that substantial reserves of feldspar still exist along with kaolin, mica, tourmaline, beryl, and the heavy metals.

69 Anjanabonoina Mine, Antsirabe, Madagascar

For more than 100 years, Madagascar has brought forth a great variety of rare-earth minerals and gemstones. Labels usually only list the country as the point of origin without an exact locality. The island, lying in the southern Indian Ocean off the eastern coast of Africa, is only a litte larger than California and has a population of nearly 10 million. Because of its remote location, Madagascar is hard to reach through aerial gateways at Mauritius and Nairobi. Dominated by France since 1885, the island gained independence in 1960, and experienced a coup in 1972 by a junta which nationalized foreign commercial interests including many mines.

The earliest settlers arrived on Madagascar 2000 years ago from Indonesia. Much later, large numbers of Africans emigrated to the island and intermarried with the Indonesians. Each people brought its own customs, but with the passage of time traditions have merged into a Madagascar culture.

Blocks of flawless colorless quartz up to 8 centimeters in diameter were discovered in Madagascar near the end of the 18th century. In the Befoure Mountains blocks of clear quartz weighing up to 45 kilograms occurred in such profusion that world prices for quartz declined. Some chunks of quartz contained long crystals of manganite which exhibited a

THIS PAGE TOP:
Tourmaline, variety liddicoatite
Size: 17.5 by 8.7 cm
Collection: Jack Halpern
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM:
Tourmaline, variety liddicoatite
Size: 15 by 12 cm
Locality: Anjanabonoina
Collection: Julius Petsch
Photo: Karl Hartmann

OPPOSITE LEFT:
Tourmaline
Size: 11 by 3 cm
Locality: Anjanabonoina
Collection: Harvard University
Photo: Alphonse Coleman

OPPOSITE RIGHT:
Morganite
Size: 11 by 6 cm
Locality: Anjanabonoina
Collection: American Museum of Natural History
Photo: Arthur Singer

bright metallic luster. Other areas of the island produced large quantities of translucent rose quartz, some of it ranking with the world's best.

Gemstones from Madagascar appeared in the latter part of the 19th century. Farmer's plows turned up tourmaline, mica, and beryl, and prospectors discovered pegmatite veins along the sides of mountains.

In 1900 Frenchman Leon Krafft discovered the Anjanabonoina deposit near the Mania River some 65 kilometers south of Antsirabe which is 125 kilometers southwest of the capital city of Tananarive. Krafft worked the mine with local labor until 1927. The mine yielded good quantities of bicolored tourmaline and, in later years, large lots of fine deep rose colored beryl (morganite), probably the world's best. The mine also produced bismuth, spodumene (kunzite), microcline (amazonite), albite (cleavelandlite), lepidolite, spessartine, zinnwaldite, magnetite, danburite, and tourmaline in hues of green, pink, yellow, black and, infrequently, blue.

Julius Petsch knew of the Anjanabonoina's long list of beautiful crystals and high quality gem materials. Following a hunch that the mine could still be worked successfully, in 1970 he left his gem business in Idar-Oberstein, West Germany. In Antsirabe he met the owner, Leon Krafft's daughter, and arranged for a five-day trip to the mine. Many changes had occurred at Anjanabonoina since its closing 43 years earlier. Tunnels had caved and exterior pits had sloughed in. But small gem tourmaline lay scattered about the dumps and old tailings, and there were still tourmaline crystals embedded in tunnel walls. Impressed

with the mine's potential, Petsch bought it. He then invited German gem expert Hugo Strunz to visit and evaluate the property. Mining resumed in 1972.

French geologist George Heurtebize, a Petsch employee, prospected the vicinity. Results were good as substantial quantities of green, pink, and bicolored tourmaline appeared. (Morganite proved to be very scarce.) By 1974 Petsch employed 100 miners and there was every indication of a strong future, but in 1977 the mine was nationalized, and Petsch lost the property he had improved. He dismissed his crew and closed the mine, which remains closed today.

Some experts believe that Madagascar pegmatites still contain fortunes in gem crystals. White streaks crisscross red fields. Farmers recover gemstones on top of the ground from time to time, but show little inclination to search for the pegmatites which could be just below the surface.

In Idar-Oberstein, gem dealer, Gerhard Becker, inspected some old sealed crates

THIS PAGE TOP: Madagascar's capital city of Tananarive Photo: Peter Bancroft

THIS PAGE BOTTOM LEFT: Manager of "Le Quartz" mineral firm in Tananarive, holding a vug of celestite Photo: Peter Bancroft

THIS PAGE BOTTOM RIGHT: Packing tourmaline crystals for shipment in Tananarive, 1970 Photo: Peter Bancroft

OPPOSITE TOP: 1700-meter-high hills and savanahs near Anjanabonoina, 1972 Photo: Julius Petsch

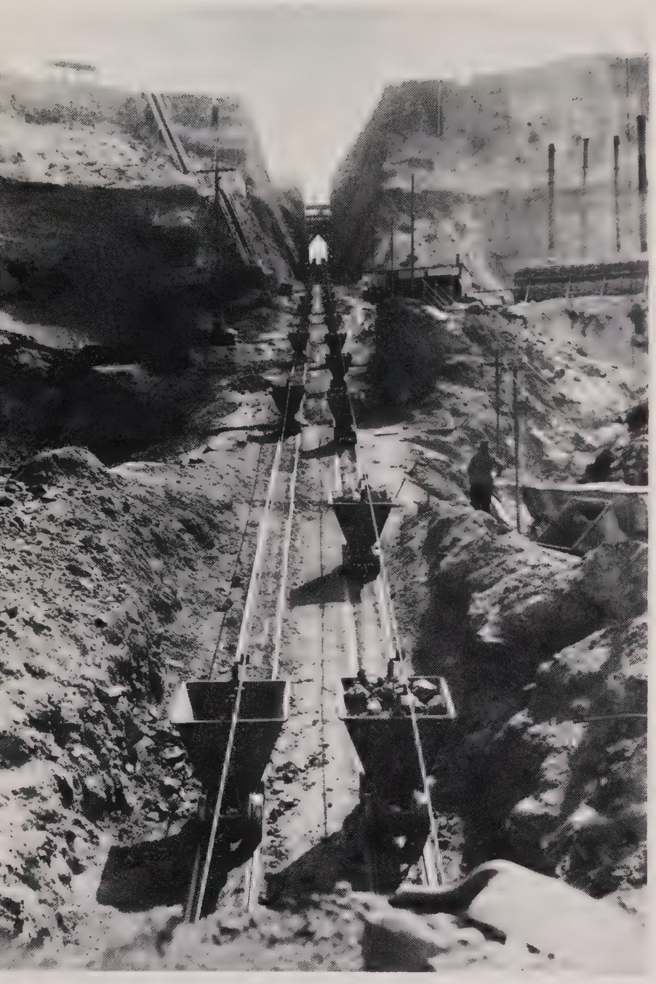
OPPOSITE MIDDLE RIGHT: Tunnels and open pit at Anjanabonoina, 1975 Photo: Julius Petsch

OPPOSITE BOTTOM LEFT: Working Anjanabonoina pegmatite with jackhammer Photo: Julius Petsch

OPPOSITE BOTTOM RIGHT: Aquamarine mine near Betafo Photo: Julius Petsch in the rear of a mineral warehouse. One box contained a huge 32-kilogram tourmaline that appeared black with a termination reminiscent of crystals he had seen from Madagascar years before. Those crystals had multicolored interior zones showing triangular patterns of growth as the crystal enlarged its diameter and length. Following a hunch, Becker bought the stone and cut off one end. Inside the all-black exterior was an extraordinary array of vibrant growth lines in green, brown, yellow, black, pink, and red. The triangular patterns indicate variations in the compositions of successive layers during growth. Becker sliced the entire crystal to create some of the finest tourmaline growth sections ever seen. When they compared his slices with those from crystals mined by Petsch, both men agreed that Becker's tourmaline probably originated in the Anjanabonoina.

Madagascar gem tourmaline ranks with the best, and its deep rose morganite is matchless. Many dealers and collectors hope that Madagascar mines will reopen and produce a new supply of beautiful gems for world trade.

70 Premier Mine, Cullinan, South Africa



Thomas Cullinan, native South African son of a wagon maker and contractor, inherited a flourishing construction business in Cape Province. Intrigued with the diamond and gold strikes farther north, in 1887 he moved his business and family to the Witwatersrand area just south of Johannesburg. He became wealthy and influential, then sold most of his holdings so he could pursue his greatest passion—prospecting. He had seen small but beautiful diamonds, reportedly found in an area northeast of Pretoria. Hitching up his wagon, he set out to investigate the source of the diamonds.

For weeks Cullinan roamed the Transpoort and Byenespoort farms on the *veld* of the Transvaal. In 1898, he met another prospector, Jim Pippin, who casually said: "If you sit on the crest of the southern Elandsfontein hillocks and look out across country you cannot help seeing another Kimberley"—South Africa's greatest diamond complex, 483 kilometers to the southwest.

Cullinan decided to buy the Elandsfontein farm, 38 kilometers east of Pretoria, but owner Joachim Prinsloo refused to sell and threatened to shoot him.

Prinsloo died soon after, however, and on November 7, 1902, Cullinan acquired the farm from his heirs for the ludicrous price of about $100,000, both a small fortune at that time and a steal. When the deed was signed,

THIS PAGE TOP:
Haulage system in Premier, c. 1915
Photo: Courtesy De Beers

THIS PAGE BOTTOM:
Miners climbing out of mine at end of shift, c. 1910
Photo: Courtesy, De Beers Consolidated Mines Limited

OPPOSITE:
"Dutoitspan" world's largest uncut diamond on bed of three carat diamond crystals
Size: 616 carats;
6 by 5.5 cm
Locality: Dutoitspan mine
Collection: De Beers, London
Photo: Courtesy De Beers

Cullinan told his wife that he would present her with the biggest diamond in the world. Within three years, he would own a mine which produced such a stone.

Cullinan's Premier Diamond Mining Company began work in December 1902 and it was soon apparent that the Premier mine would exceed all expectations. Exploration revealed a pipe of kimberlite, the volcanic rock in which diamonds occur, to be one of the greatest high-grade diamond masses in the world. Geologists later estimated the ore body originated 1.7 billion years ago, and is the oldest of all known diamond deposits. The pipe extended downward to a depth of 425 meters where it terminated in barren gabbro, a dark brown layer of heavy rock. Open pit development of the pipe reached 355 meters, creating one of the deepest man-made holes in history. In 1978 exploratory drilling punched through the gabbro layer and beyond, revealing more kimberlite pipe extending downward for hundreds of meters more. The gabbro was merely a massive sill, and discovery of the lower treasure chest ensured many more decades of life for the Premier.

From 1903 to 1905 the Premier produced 1.6 million carats of diamonds including 10 top quality stones ranging from 70 to 3106 carats. The latter, a fist-sized stone of incredible beauty, was found less than a meter below the surface. Mine manager Frederick Wells,

THIS PAGE TOP:
Miners coming off shift at Premier
Photo: Courtesy De Beers

THIS PAGE BOTTOM:
Ore car being loaded from overhead draw hole
Photo: Courtesy De Beers

OPPOSITE TOP:
Grease table removing diamonds from muck
Photo: Edward Gubelin

OPPOSITE BOTTOM:
Premier mine, c. 1915
Photo: Courtesy De Beers

learning of the discovery, rushed to the spot and dug out the gem with his penknife. The jumbo diamond, completely transparent and resembling pure ice, created a sensation. Named "the Cullinan Diamond," its overall shape indicated it was only the smaller half of a large crystal. What became of the other half? It must exist somewhere since nature would be unable to destroy it.

The Transvaal Legislative Assembly purchased the Cullinan and presented it to England's King Edward VII. The giant stone was cut into 96 small stones and nine major gems, including the world's two largest cut diamonds: the 530.2-carat Great Star of Africa and the 317.4-carat Lesser Star of Africa. Both were set as part of the British Crown Jewels and are on permanent public display in the Tower of London. Cullinan was knighted, became a member of the Transvaal Legislative Assembly, and then the Union Parliament. Sir Thomas died in Johannesburg in 1936.

As of June 1981, 288,586,430 tons of blue ground had been removed from the Premier yielding 88 million carats of diamonds in 75 years. Other major stones include the 426-carat Niachos and the superlative 354-carat Premier Rose. Typically the very large stones were of such fine quality that the greatest return results from faceting them into gems rather than retaining them in crystal form. Only a few giant diamonds have been spared the cutter's saw. Exceptions include two exquisite crystals mined in the Dutoitspan mine southwest of Johannesburg. The Oppenheimer, a stunning rich yellow diamond crystal weighing 254 carats, is a spectacular part of the gemstone display in the Smithsonian Institution. The largest surviving crystal, the Dutoitspan diamond, weighs 616 carats. Of inferior color and containing internal impurities, it has a beautiful crystal form and is on display at the Open Mine Museum at the Big Hole, Kimberley, South Africa.

Today, De Beers Consolidated Mines Limited, a cartel with enormous influence in the diamond industry, controls more than 80 percent of the world's diamond mines, including the Premier. Known ore reserves project the working life of the mine to the year 2038. It is estimated that 17 million carats of diamonds still lie within the Premier and every year a dozen or so stones the size of pigeon eggs each weighing 100 to 200 carats will be unearthed.

71 N'Chwaning Mine, Kuruman, South Africa

One of the richest manganese fields on earth is situated in the Kalahari desert, a vast undulating sandy plain extending for hundreds of kilometers across north-central South Africa. The principal town of any consequence, Kuruman, is 70 kilometers to the southeast of the N'Chwaning mine. Each working mine in the Kalahari manganese field supports a small town; the towns in turn depend solely on the mines.

P.J. Truter and W. Somerville explored the then virgin Kuruman area in 1801 on an expedition that included six wagons and two missionaries who established a settlement and worked among the Bechuana people. In 1841 the famous missionary-explorer David Livingstone arrived in Kuruman and used the town as a base for exploratory journeys.

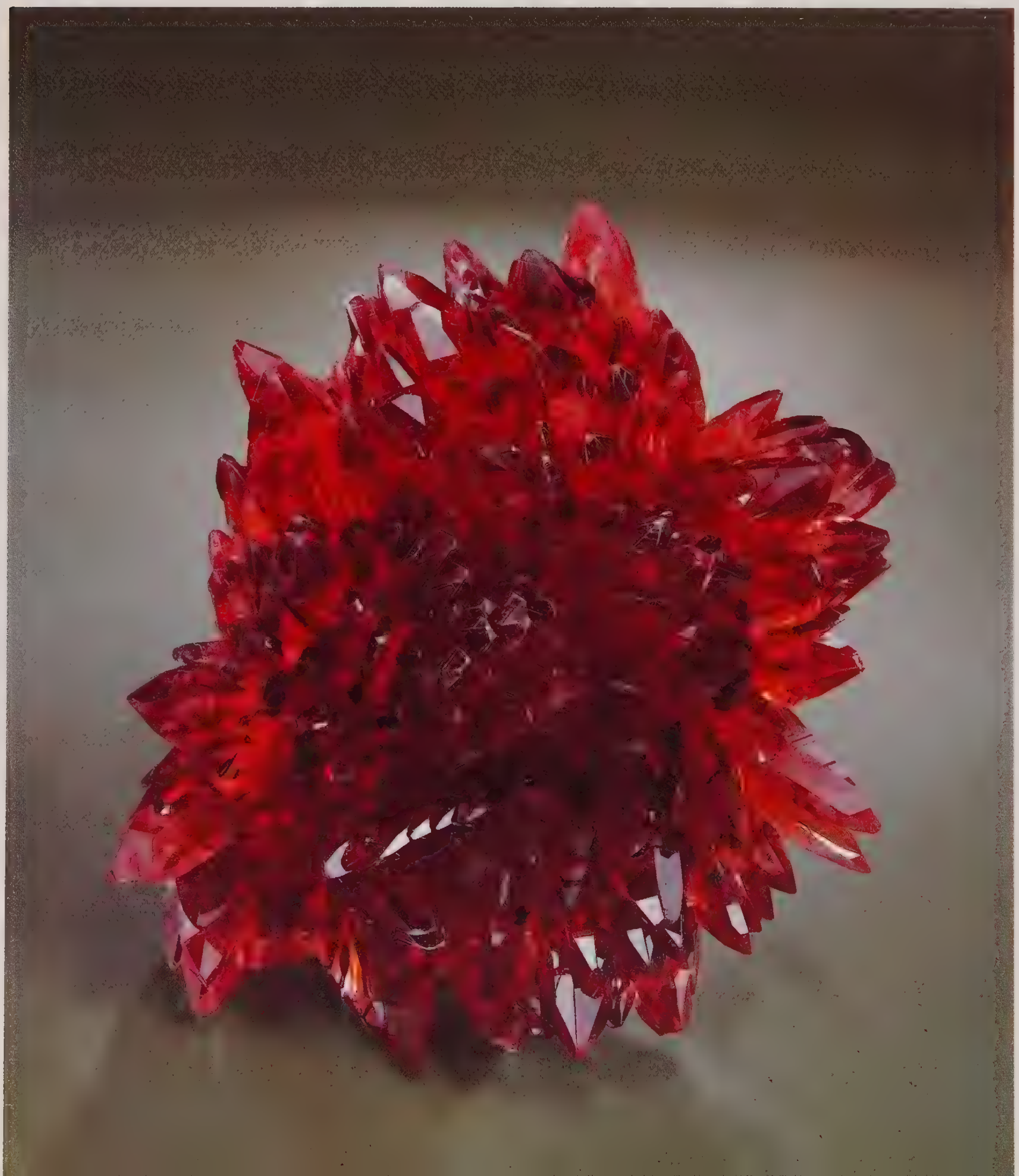
Captain T.L.H. Shone discovered manganese ore in 1922 and subsequently a pair of very large manganese-bearing bands were found extending northward from two small railroad towns, Koopmansfontein and Postmasburg. Desert sands covered the region except for a small ridge not more than 27 meters high, known locally as Black Rock. Rich in manganese, the ridge's folding suggested an ore body of larger dimensions below and the likelihood of other deposits. Exploratory drilling in the region revealed enormously rich manganese lodes at Wessles, Gloria, and N'Chwaning, which today operate as large underground mines.

The manganese zones of the Kalahari field contain perhaps 40 percent of known world manganese reserves. This important base metal, used in alloys of copper, zinc, iron, and aluminum, is also essential in making bronzes for gears, steamship propellers, and a host of

BELOW: Rhodochrosite
Size: 10 by 8 cm
Locality: N'Chwaning
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE LEFT: Rhodochrosite
Size: 5 by 4 cm
Locality: N'Chwaning
Collection: Norman Pellman
Photo: Harold and Erica Van Pelt

OPPOSITE RIGHT: Rhodochrosite
Size: crystal 5 by 2 cm
largest cut stone: 12.5 carats
Locality: N'Chwaning
Collection: David Eidahl
Photo: Harold and Erica Van Pelt



mechanical parts.

The first mines on the field were the Smartt, Black Rock, York, Hotazel, Langdon, and Devon though the Smartt, York, and Langdon played out decades ago. During 1961 and 1962, the Hotazel caused a sensation in mineral circles when it produced a large number of bright red rhodochrosite crystals formed as druses, scalenohedrons, rhombohedrons, and aggregate bundles of slender prisms. Frequently, rose-red clusters stood in a striking contrast to their jet-black manganite bases. Individual scalenohedral crystals of rhodochrosite from Hotazel reached lengths up to 5 centimeters. The portion of the Hotazel mine contributing these specimens was mined out by 1963 and no important crystals have been found since that time.

Near these mines banded ironstone beds run parallel to the manganese zones for 20 kilometers to the east. These beds extend from Prieska in the south to the Botswana border in the north and contain the world's largest deposits of Cape Blue asbestos (crocidolite).

In 1975 The Associated Manganese Mines of South Africa Limited, the largest manganese producer in South Africa, opened a new high-grade deposit east of Black Rock called N'Chwaning. Several hundred men perform the underground mining, screening, and sorting of ore.

Early in 1976 vugs filled with rhodochrosite crystals of great beauty were encountered in the upper levels of N'Chwaning. Mine director Desmond Sacco has best described this important crystal find:

THIS PAGE TOP:
General view from top of incline headgear
Photo: Desmond Sacco

THIS PAGE MIDDLE:
Entrance to N'Chwaning mine
Photo: Desmond Sacco

THIS PAGE BOTTOM:
Mine workers drilling at manganese face
Photo: Desmond Sacco

OPPOSITE TOP:
Working high-grade manganese ore by hand
Photo: Desmond Sacco

OPPOSITE BOTTOM LEFT:
Arthur Heuck, in front of Kuruman bank faced with blocks of gem tiger-eye quartz
Photo: Harriet Heuck

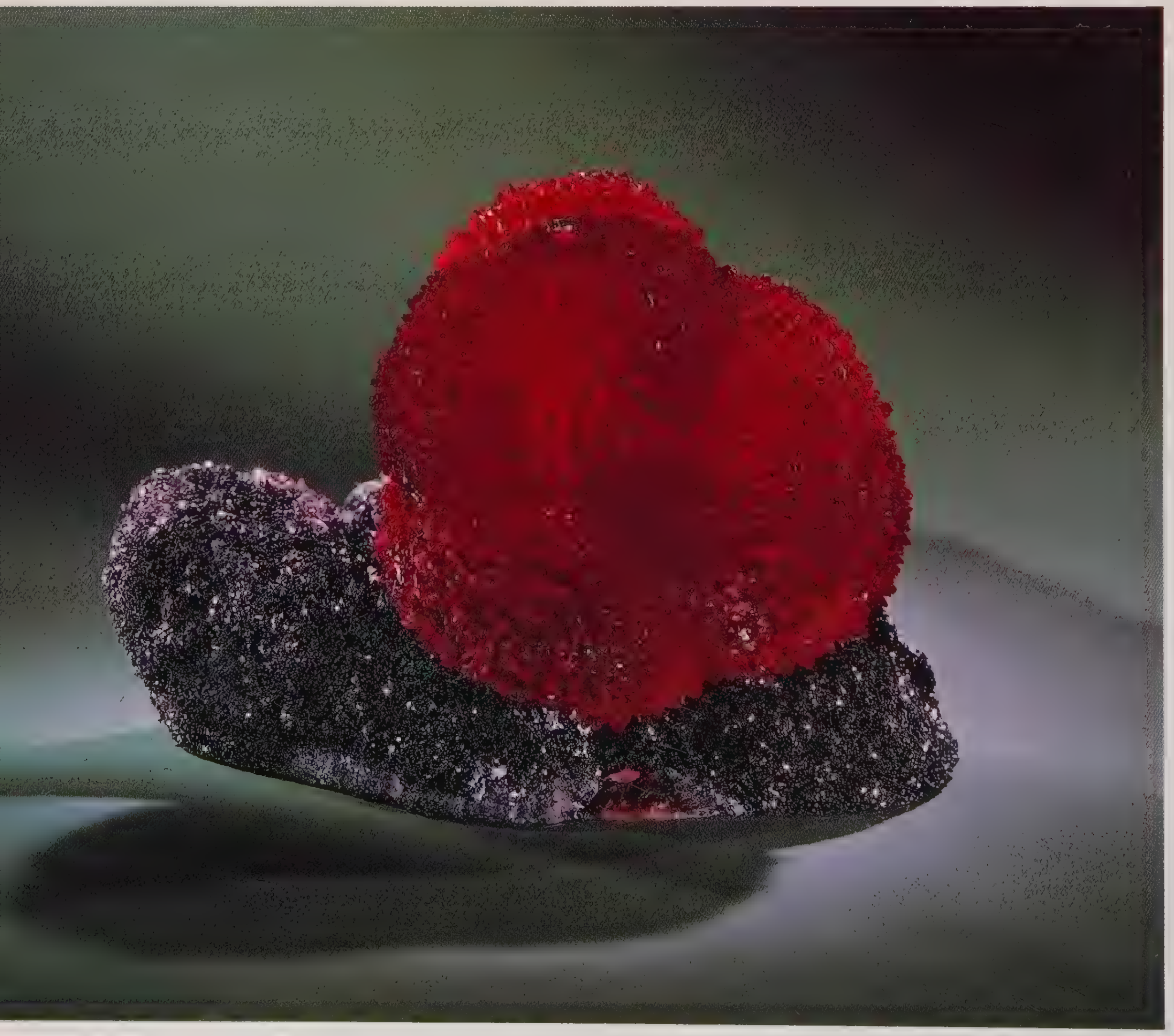
OPPOSITE BOTTOM RIGHT:
Mine captain at No. 1 shaft
Photo: Desmond Sacco

We hit these fantastic jewel-like pockets a few hundred feet from the surface. The rhodochrosite occurred in small vugs and cavities in hausmannite and was associated with minerals like calcite, manganite, chalcedony, gypsum and mauve aragonite. A while later a host of other minerals like parahopeite, kutnohorite, inesite and pyrochroite were found. Generally the pockets were small—the most spectacular encountered was about 0.5 by 1 meter in size which took three days to carefully dig out. The largest specimen weighed over 100 kilograms and is at present displayed in a Pretoria museum. N'Chwaning crystals are renowned for their size, clarity and exceptional color and to have had the opportunity to see them underground, in situ, *was a sight I will never forget. So far no further occurrences of any significance have been found.*

Rhodochrosite crystals from N'Chwaning differ uniquely from their counterparts in most other localities. Many form as scalenohedrons, while most crystals from other sources are rhombohedral. N'Chwaning crystals occur in at least 10 variations of crystal habit, many of an unusual wine-red color quite apart from the usual pink to red hues. Probably the world's greatest concentration of unflawed large rhodochrosite crystals—some measuring to 7 centimeters—came from N'Chwaning pockets.

South Africa, one of the greatest mineral-producing nations in the world, leads the rest in production of manganese, gold, gem diamonds, platinum, antimony, and chromium. It places second for vanadium and asbestos; third for uranium; sixth for nickel; seventh for copper; and eighth for lead. This nation, a vast storehouse of strategic minerals, has also produced its share of beautiful crystals and gemstones.

BELOW:
Rhodochrosite on manganite
Size: 8 by 6 cm
Locality: N'Chwaning
Collection: William Larson
Photo: Harold and Erica Van Pelt



OPPOSITE: Wulfenite
Size: 6.5 by 5.5 cm
Locality: Tsumeb
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

72 Tsumeb Mine, Tsumeb, Namibia (S.W. Africa)

The greatest crystal producing mine on earth is located along a strip of low jagged hills bordering the Kaukau Veld in the northeast corner of Namibia. Called Otjisume by early Herero tribesmen, the copper-lead-zinc deposit is now known as Tsumeb.

By the 1870s word had reached Europe that warriors of the Bergdama, Herero, and Ovambo tribes had mined and smelted copper ore from deposits in northern Namibia possibly for as long as two centuries. Grave problems faced those who would seek treasure in this remote and inhospitable land. Search parties would explore vast regions of little water, no roads, and warring nomads.

Aware of these dangers, German financiers formed the South West Africa Company in 1892. This firm sent an expedition under Mathew Rogers to investigate ore occurrences in the area bordering Ovamboland on the north and Damaraland to the south. The next year Rogers stumbled on a copper outcrop which the natives called "Sumeb." Astounded, he wrote his company:

> *The outcrop of copper here is the finest mineral outcrop I have ever seen. In my 24 years of experience as a geologist and prospector in various countries of the world, I have never seen such a sight as was presented before my view at Soomep [sic], and I very much doubt if I ever shall again!*

By 1895 extensive prospecting had been completed but a severe outbreak of a livestock disease called rinderpest cut off supply trains. The first consignment of copper ore was

shipped in December 1900. In 1906 a narrow-gauge railroad reached Tsumeb from the Atlantic Ocean and production materially increased. Imported canned goods and beer came from Germany, butter from Australia, and potatoes from the Canary Islands. During 1918 a flu epidemic killed 125 men. In 1919, 500 carbide lamps were ordered to replace oil lamps and candle holders. As late as 1926 oxen pulled some ore cars.

The mine survived both World Wars, underground fires, floods, depressed world markets and bloody brawls in front of crystal pockets as miners tried to enter the specimen business. In 1947 a consortium of American, British, and South African companies, known as the Tsumeb Corporation, Ltd., bought the mine and modernized its operation. By 1962 a combined lead-copper smelter had been completed, and the town of Tsumeb boomed into an attractive small city. Seen from the air, Tsumeb's tree-lined streets appear as a giant oasis in an otherwise bleak desert.

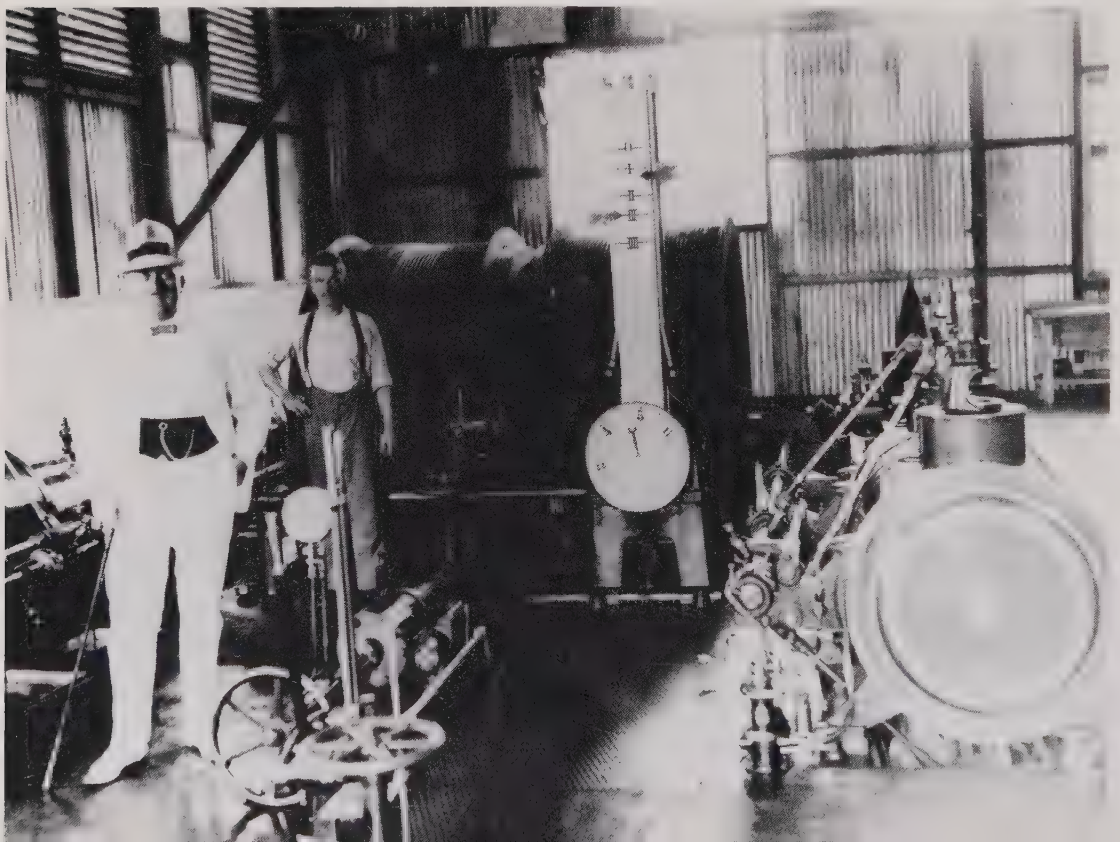
Tsumeb has produced more mineral species, each with matchless crystals, than any other single source. Hundreds of kilograms of splendid crystals from here enhance collections throughout the world. Crystals fortunate enough to have survived blasting, the mucking process, and company rules which prohibit collecting, are but remnants from an almost endless series of crystal pockets. Calcite crystals, many with wonderful inclusions, occurred in such profusion that miners tended

THIS PAGE TOP:
"Jacob's Ladder" inclined haulage in dangerous opencast at Tsumeb, c. 1906
Courtesy: Mrs. Wolfgang Schatz

THIS PAGE BOTTOM:
Derailed Tsumeb ore train, Feb. 1909
Courtesy: Mrs. Wolfgang Schatz

OPPOSITE TOP:
Dioptase on calcite
Size: 2.7 by 2.5 cm
Location: Tsumeb
Collection: Leonard Bedale
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Azurite on smithsonite
Size: 16 by 16 cm
Locality: Tsumeb
Collection: William Severence
Photo: Harold and Erica Van Pelt



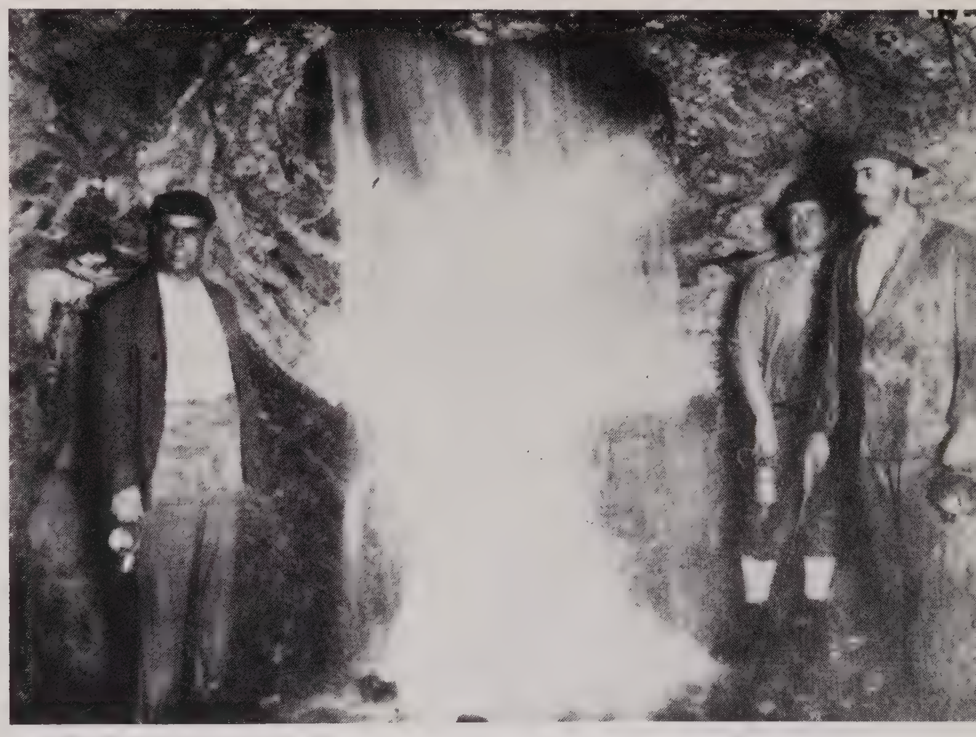
THIS PAGE TOP:
Opencast workings at Tsumeb, 1909
Courtesy: Mrs. Wolfgang Schatz

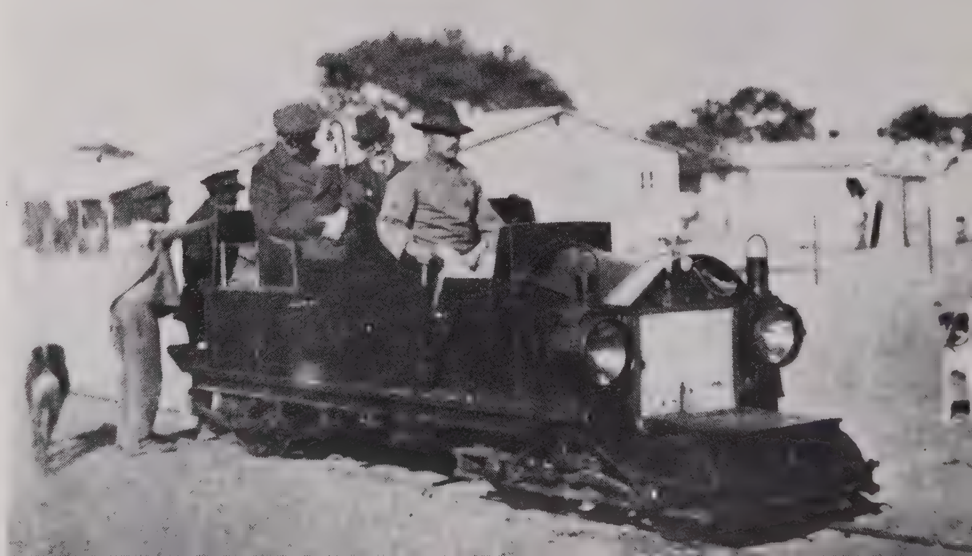
THIS PAGE BOTTOM:
Tsumeb - Steam hoist, main shaft, Director W. Thometzek in immaculate white suit, c. 1912
Courtesy: Mrs. Wolfgang Schatz

OPPOSITE TOP:
Tsumeb shaft, c. 1913
Courtesy: Government Archives, Windhoek

OPPOSITE MIDDLE:
Water pouring from break in wall, Tsumeb mine, 1924. Director F.W. Kegel at left, after whom kegelite is named.
Courtesy: O.M.E.G. photo collection

OPPOSITE BOTTOM:
The "pay corps" in their motor railcar. Bell summoned employees, c. 1925
Courtesy: G. Sohnge, Tsumeb





to pass them by while searching for more valuable crystallized minerals. Enormous quantities of well crystallized cerussite and smithsonite occur throughout the mine.

Bright azurite crystals, superior in size and form to those from Bisbee, Arizona, and Chessy, France, measure to 16 centimeters. Many have razor-sharp edges and mirror faces of great beauty. Azurite specimens of this quality are very rare and highly prized. In 1971 a few incredible crystal specimens of mimetite were found at Tsumeb. Unique in beauty and size, the stout hexagonal prisms—some of them 6 centimeters long—are transparent brilliant yellow and beautifully terminated.

Other factors contribute to Tsumeb's lofty status. Of the more than 150 species that abound, at least 20 are found only here. Numbers alone cannot reflect the remarkable variety of elements found at Tsumeb nor the superiority of many crystals. Some species occur in an unprecedented array of colors. Anglesite comes in hues of yellow, brown, white, gray, blue, and green in doubly terminated crystals up to 5 centimeters in length. Wulfenite, typically yellow or brown elsewhere, is mined here in pale brown, pink, yellow, orange, brownish red, white, sherry brown, greenish brown, light blue, and dark blue. Smithsonite, rarely crystallized in other zinc-lead deposits, occurs at Tsumeb in a variety of colors and crystal forms, some surpassing 10 centimeters in length. Typical colors are pink, yellow, turquoise blue, grass green, white, and black. In contrast to stately opaque cerussite crystals which helped memorialize the lead-zinc deposit at Broken Hill, Australia, Tsumeb cerussite is found in colorless reticulated crystal groups measuring up to 60 centimeters in length.

The elfin world of micromounts is well represented with a profusion of minute, brightly colored crystals of many species such as caledonite, tsumebite, mimetite, carminite, aurichalcite, azurite, malachite, linarite, ludlockite, and cuprite, to name but a few. Diminutive clusters of crystals combine two, four, and up to eight different species, gathered together in unknown company until viewed under the microscope.

Deposits of strategically significant gallium, vanadium, cadmium, and germanium enrich the Tsumeb geochemistry which has produced the rare species kegelite, schultenite, otavite, and keyite. Tsumeb has also yielded fine crystals of leadhillite, olivenite, stottite, sohngeite, scorodite, bayldonite, adamite, and willemite.

THIS PAGE TOP:
Mimetite
Size: 9 by 8 cm
Locality: Tsumeb
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

THIS PAGE BOTTOM:
Anglesite
Size: 7 by 3.5 cm
Locality: Tsumeb
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Herr Krummel with native miners, 1930
Courtesy: Mrs. Wolfgang Schatz

OPPOSITE BOTTOM LEFT:
Tsumeb and De Wet headframe in background, 1970
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Native miner on 29th level, 1970
Photo: Peter Bancroft

The mineralogist will always treasure Tsumeb for its vast numbers of unique crystals. The geologist, however, remains astounded at Tsumeb's unique second oxidized zone. A geological "plumbing accident" occurred when a fracture zone, originating at the surface, intersected the ore body at about the 900-meter level. Groundwaters flushed downward to mix with deep-seated sulfides and, in the process, created a second oxide zone at an unprecedented depth.

Miners now tunnel below the 1220-meter level. But when they find good crystals their orders are to ignore them and keep on mining or risk dismissal. There are reports that very sharp explosives are being used to shatter crystal areas, thus removing the temptation to collect.

Even though the main ore body extends below present operations and some crystals find their way to dealers, Tsumeb must be nearly finished as a collector's paradise. Yet each time such a statement is made, new vugs of marvelous treasure are encountered in the lower workings. In December 1980 a large

THIS PAGE TOP:
Cerussite
Size: 14 cm
Collection: Miriam and Julius Zweibel
Photo: Wendell Wilson

THIS PAGE BOTTOM:
Ludlockite with zincian siderite
Size: 4 by 4 cm
Locality: Tsumeb
Collection: British Museum Natural History
Photo: Frank Greenaway

OPPOSITE TOP:
Cuprite on calcite
Size of xl: 5 mm
Collection: E. Heinrich
Photo: Olaf Medenbach

OPPOSITE BOTTOM LEFT:
Smithsonite var. cuprosmithsonite
Size: 7.4 by 6 cm
Collection: Miriam and Julius Zweibel
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM RIGHT:
Smithsonite
Size: 8 by 5.5 cm
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

pocket was discovered on the 31st level which yielded azurite crystals including a 26-kilogram specimen of exceptional beauty. This is the first time that large azurite crystals of high quality have been mined anywhere at such a depth. Tsumeb will probably continue to produce fine crystals of many mineral species for as long as mining in its lower stopes continues. Mine mineralogists anticipate discovery of good crystals when support columns are removed prior to the mine's closure. Collectors may not fully appreciate the world's greatest crystal mine until Tsumeb is finally finished.

73 Mibladen/Bou Azzer Mines, Midelt/Bou Azzer, Morocco

Morocco, an arid land a little larger than California, is rich in phosphates and has substantial deposits of cobalt, manganese, zinc, antimony, and lead. Three of the most highly regarded crystal mines in this nation on Africa's northeast corner are at Mibladen, Bou Azzer, and Touissit.

The Mibladen-Aouli lead mines, situated 15 kilometers northeast of the small desert town of Midelt, were worked on a small scale perhaps a century ago. But it was not until the early 1900s that efforts were made to recover ore in large quantities. The French operated the mines profitably until the lead seams began to thin out deep in the mountain. In 1966 the French sold the mines to Moroccan firms. Since that time production has been sporadic.

While lead mining remained the principal source of income, miners knew the value of the beautiful vanadinite crystals occasionally encountered while digging new tunnels. In 1976 the government became aware of the large vanadinite crystals previously mined at Mibladen and sent a crew to collect crystals for the museum in Rabat. Excellent crystals were reported from the Boulmaadine tunnel on one of the lower levels. An out-of-work Berber miner named Moha Ben Ali Benikhlaf, locally known as the "Moto man" because he drove a small moped, bribed a guard to admit him to the mine at night so he could secretly work the

THIS PAGE TOP:
Open pit at Mibladen, 1975
Photo: Victor Yount

THIS PAGE BOTTOM:
Moroccan mineral dealer displays wares at roadside, 1974
Photo: Anne Voileau

OPPOSITE TOP:
Anne Voileau in Mibladen
Courtesy: Anne Voileau

OPPOSITE MIDDLE:
Mine and village of Aouli, 1974
Photo: Anne Voileau

OPPOSITE BOTTOM LEFT:
Moroccan with load of hay, a precious commodity
Photo: Victor Yount

OPPOSITE BOTTOM RIGHT:
Mine tailings at Bou Azzer, 1974
Photo: Anne Voileau

crystal deposit. Digging furtively, Ben Ali removed some of the best vanadinite crystals ever found. For more than six months he sneaked into the mine, worked his crystal vugs, carefully wrapped his prizes, and vanished into the night.

Ben Ali was careful in offering his collection for sale. Word could not get to the mine guards or, worse yet, to the authorities, that he had highgraded fine crystals. Secretly selling to a few selected foreign mineral dealers, he profited greatly. To the surprise of his friends who knew nothing of his clandestine activity, he bought a Volvo truck among other luxuries.

Ben Ali's good fortune was short-lived. One day in 1977, he picked up a load of hay and headed home with a friend perched on the top of the load. As he drove up into the mountains, the hay began to slip out of the truck. His friend shouted a warning which distracted Ben Ali who drove off the road and over a steep cliff, destroying the truck, killing himself, and seriously injuring his passenger.

Mibladen has yielded large quantities of well formed bright cerussite crystals, with some sixling crystals measuring as much as 10 centimeters. Attractive barite groups sometimes form crystal bases for vanadinite crystals in beautiful combinations. Mibladen vanadinite varies in color from nearly black to brown, yellow, orange, and rich bright red.

Nearby mines at Touissit produce beautiful cerussite crystals on pink barite. Good crystals of fluorite on barite, azurite and malachite, chalcopyrite, pyrite, and quartz have been mined at Aouli. The Les Dalles mines have contributed attractive wulfenite crystals on barite.

Mineral dealer Victor Yount tells of a spectacular find in the Acif mine at Mibladen in the spring of 1980 when "pocket hunters" discovered some superb vanadinite crystals. Cherry red in color and ranging in size to 3 centimeters in diameter, bright vanadinite crystals were found on white barite in striking combination. Two hundred high quality specimens occurred in a single unique pocket. Acif is now flooded and closed.

The Aouli mines are the lode's largest and wealthiest. The Henri II shaft, the deepest, reaches downward 160 meters and employs 350 men underground. Galena veins produce about 28,000 tons of lead and 12,000 tons of zinc each year, but few crystals of any importance. Some azurite and malachite crystals to 2.5 centimeters, along with silver, are reported from the deposit.

THIS PAGE TOP:
Erythrite
Size: 16 by 11 cm
Locality: Bou Azzer
Collection: School of Mines, Paris
Photo: Jacques Six

THIS PAGE BOTTOM:
Vanadinite
Size: 6 by 3 cm
Locality: Mibladen
Collection: Wendell Wilson
Photo: Wendell Wilson

OPPOSITE LEFT:
Vanadinite on barite
Size: 8 by 6 cm
Locality: Mibladen
Collection: Victor Yount
Photo: Harold and Erica Van Pelt

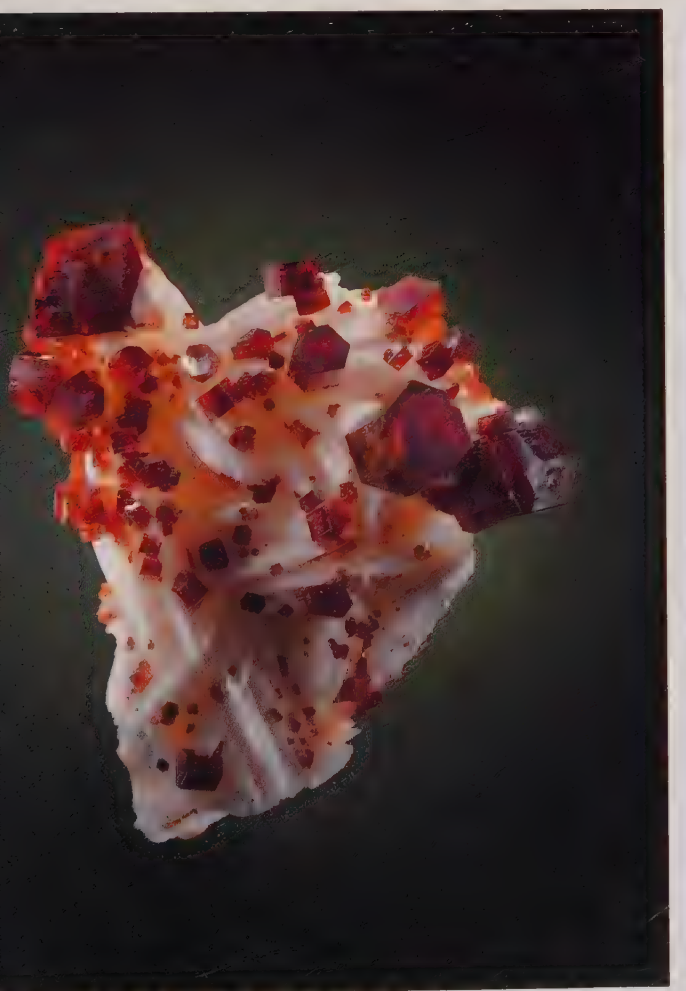
OPPOSITE RIGHT:
Vanadinite
Size: 7 by 5 cm
Locality: Mibladen
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt

Hot and windy Bou Azzer, 330 kilometers to the southwest of Mibladen and 125 kilometers due south of Ouarzazate, produces cobalt and nickel. Ore is shipped from Bou Azzer on roads considered by travelers to be "abominable." In 1981 they were blacktopped, and it is now easier to get to Bou Azzer.

Fragile, crimson-red erythrite crystals are found in tough rock at Bou Azzer, making recovery of perfect crystals extremely difficult. Erythrite crystals, 6 centimeters in length, have been mined at Bou Azzer from the "Number 7 vein." Some of the best are displayed at the School of Mines and the Sorbonne in Paris.

Outstanding roselite crystals came from Bou Azzer in druses of brilliant rose-red crystals, probably the world's best. Both erythrite and roselite occurred in the mine's upper reaches. Lower levels produced the finest known skutterudite crystals. Exceptionally bright, well formed crystals formed in calcite, which may be dissolved away with acid to expose undamaged crystals. The record is a 9.5- by 6.5-centimeter crystal now on display at the School of Mines in Paris.

Victor Yount reports that collecting in Morocco is quite difficult. Back-country roads challenge the traveler, poor health conditions are commonplace, and housing is primitive. But for collectors whose temperament and tolerance can adjust to such conditions, good crystals remain available: skutterudite from Bou Azzer, gypsum from along the Algerian border, amethyst and colorless quartz geodes from the Eureka Valley, and fine quality fossils from Erfoud.



74 Barroca Grande Mine, Panasqueira, Portugal

The narrow macadam road from Lisbon to Panasqueira meanders northeast for 340 kilometers through an arid countryside sprinkled with vegetable farms, cork plantations, goat and cattle ranches, and small towns. Mules and horses still provide transportation. The closest town to the Panasqueira mines is Fundao, a village of narrow winding streets whose people continue to wear the dark suits and black dresses in styles of yesteryear. In the nearby hamlet of Alpedrinha the Portuguese government operates an inn which offers comfortable lodging, good food, and Grandjo white wines.

For the last 40 kilometers of the journey from Lisbon, a traveler crosses a mountainous region deeply cleaved by gullies and canyons. Rio, the first of the mining camps, is easily identified by the huge waste dumps, created by the town's concentration plants, along the Zerere River. From there the road snakes up through jagged mountains to the headquarters and main portal for the Panasqueira mines, Barroca Grande, a modern town boasting rows of stuccoed apartments, the company-owned homes of the miners. The main gate guarding the office compound bustles between shifts. Buses and families clog the roadway, and the noise is deafening as dozens of miners crank up muffler-free motorcycles and race away with abandon.

The main adit, level "0," is situated directly

THIS PAGE TOP:
Ore cars on dump of Panasqueira mine, c. 1910
Courtesy: Beralt-Tin and Wolfram, Ltd.

THIS PAGE BOTTOM:
Setting timbers
Panasqueira, c. 1950s
Photo: Rosel

OPPOSITE TOP:
Apatite on quartz
Size: large crystal
11 by 5 cm
Locality: Barroca Grande
Collection: Smithsonian Institution
Photo: Dane Penland

OPPOSITE BOTTOM LEFT:
Joaquin Folch with apatite on quartz from Panasqueira
Photo: Francisco Bedmar

OPPOSITE BOTTOM RIGHT:
Wolframite (black), apatite (purple), quartz (white), coated with cookeite
Size: 11.3 by 10.5 cm
Locality: Panasqueira
Collection: Joaquin Folch
Photo: Francisco Bedmar

behind the clothes-changing room. At one time miners rode ore trains inside the mine, but frequent arm and head injuries ended this form of transportation. Now miners spend an hour and a half of each shift walking to and from the work faces.

The nearly dark main adit leads straight into the center of the mountain. Miners trudging along wet and slippery rails pass a small bare light bulb every 200 meters or so, the next one appearing down the passage like a tiny star in the night.

In the mining area, ventilation becomes adequate and lighting is good. Drifts and stopes follow the tungsten veins. Tiers of stacked 16-centimeter-thick logs form pillars built on 7-meter centers to support the roof. Work rules forbid miners to collect crystals on pain of firing. Even so choice crystals are occasionally smuggled out and sold to local storekeepers.

Quartz crystals, frequently coated with siderite and muscovite, are found in such quantity that they are ignored. Panasqueira

is best known for tabular green and lavender apatite crystals measuring to 10 centimeters and considered among the world's best. This mine also produces brilliant jumbo-size ferberite crystals, some exceeding 15 centimeters in length, and sparkling groups of arsenopyrite crystals containing individuals which measure 3 centimeters. Because these species grow upon clusters of quartz crystals, spectacular display specimens result. Brilliant black cassiterite crystals shaped like tiny drill bits are highly prized. Mouse-ear shaped siderite crystals, tan in color and attached to ferberite, appear commonly. The high quality and artistic arrangement of these species on matrix help identify Panasqueira as the source.

The Panasqueira mountains were probably first worked for tin by the Romans and next by the Moors. It was not until 1894 that mining for tungsten began. Depressed world markets and the two world wars caused erratic production and discouragingly low profits.

In 1927 Beralt Tin and Wolfram Ltd., a primarily British corporation, introduced new technology, and Panasqueira began to operate profitably. The company built a hospital, reduced the dangers of silicosis, constructed new housing for miners, and improved safety conditions in the mines. Coring tests indicate at least a 20-year supply of ore remains. The future of Panasqueira seems quite promising.

THIS PAGE TOP LEFT: Preparing sacks of high-grade tungsten ore Photo: Rosel

THIS PAGE TOP RIGHT: Mine geologist in quartz crystal pocket, 1979 Photo: Peter Bancroft

THIS PAGE BOTTOM LEFT: Barroca Grande ore cars at portal, 1979 Photo: Peter Bancroft

THIS PAGE BOTTOM RIGHT: Quartz crystals just recovered in Barroca Grande Photo: Peter Bancroft

OPPOSITE TOP: Sicilian miners carry sulfur in bags on their backs, c. 1800 Courtesy: Pier Bruno Scortecci

OPPOSITE BOTTOM: Grottacalda mine extraction shaft near Enna, Sicily, c. 1909 Courtesy: Pier Bruno Scortecci

75 Cozzodisi Mine, Casteltermini, Sicily, Italy

No other locality produces pristine sulfur crystals as large, as brilliant, and as well formed as Sicily. Even the names of the island's major crystal mine areas excite the collector: Girgenti (Agrigento today), Grotte, Cattolica, Favara, Enna, Racalmuto, Cianciana, and Cozzodisi.

Sulfur occurs over a wide area extending from Centuripe in the east to Gibellina in the west that includes the island's south-central provinces. Within the area, the beds are restricted to isolated basin-like deposits. Sulfur-bearing strata, 1 to 100 meters thick, exist in a series of different layers, requiring construction of mine tunnels to considerable depths.

Typically the shallowest sulfur-bearing bed contains clay followed by yellow sands and sandstone. Below this is found a layer of shell breccia resting upon a thin stratum of blue clay. These two strata typically contain a variety of marine fossils. The next layer of true ore is composed of gypsum and sulfur and occurs in beds varying in thickness from 1 to 30 meters. Some deposits show multiple layers of sulfur separated by gypsum strata. Most mines "bottom out" with a zone of tripoli, a silicious material used as a polishing powder. The tripoli bed may contain clay zones that are salty to the taste and even lenticular masses of pure salt.

Sulfur originated in enormous deposits on the island as a result of bacterial action in layers of anhydrite and gypsum. When the Greeks and Romans found sulfur in the volcanic formations of Mt. Etna, they incorrectly assumed the volcano created these large deposits. The "stone that burns" was first mined in Sicily about 1250 A.D., but large-scale operations awaited the late 1700s when sulfur was sought for the production of gunpowder.

Early recovery involved dangerous and wasteful methods. The richest deposits were worked by digging an irregular maze of galleries, leaving poorly designed columns which frequently collapsed on the gangs of boys and women who carried the ore in baskets to the surface. During the 18th and 19th centuries hundreds of miners were injured and many died each year.

"Pick men" performed the mucking with hand tools—shovels, picks, and bars. These men, laboring far from home sometimes for many months, camped near the mines, or lived in the tunnels. Each had an assistant, a boy between 8 and 14 who was "rented" from his family for a small sum which had to be repaid if the boy returned home. Many such boys never saw their parents again. They worked from dawn to dusk carrying 600 to 1500 kilograms of sulfur from the tunnels each day. After dark they collected firewood and water for the evening meal—usually bread soaked in oil, onions, and perhaps some cheese. Port Empedocle, one of Sicily's few sulfur shipping points, had no harbor or docks so stevedores waded chest deep through the surf to load sulfur onto small boats. These methods continued until this century when more efficient techniques were introduced.

Fragile, sparkling Sicilian crystals occur in lens-shaped vugs along the sulfur beds. Crystallized minerals commonly associated with crystalline sulfur include gypsum, aragonite, celestite, and calcite. Mines at Agrigento and Cianciana have also produced beautiful twinned aragonite crystals. Those from Cianciana—considered Sicily's best aragonite crystals—have been found as pseudohexagonal crystals up to 15 centimeters long. Racalmuto produces outstanding gypsum crystals, as does the Gallitono mine, while Caltamissetta has contributed superior crystals of celestite. Some 10-centimeter celestite crystals were found in the Floristella mine near Enna. The limestone area above the sulfur seams frequently contains voids in which calcite crystals attach themselves to the hanging wall with their points projecting downward. The walls of many fissures and vugs are lined with bright crystals of sulfur, celestite, gypsum, aragonite, and (rarely) quartz.

The greatest of the crystal-producing sulfur

BELOW:
Sulfur on aragonite
Size: 7 by 6 cm
Locality: Cozzodisi mine
Collection: George Holloway
Photo: Harold and Erica Van Pelt

OPPOSITE: Sulfur
Size: 8 by 7 cm
Locality: Girgenti
Collection: American Museum of Natural History
Photo: Henry Janson

mines are those at Cozzodisi on the outskirts of Casteltermini near the Campofranco Station. Here sulfur crystals reach majestic size and beauty; individual crystals exceed 9 centimeters. The better crystals—large perfect individuals—form in bituminous calcite layers. Celestite, aragonite, and gypsum also occur in singularly attractive crystals, frequently in association with double pyramids of sulfur. Imposing sulfur specimens have been mined in nearby deposits of Agrigento, Ciavalotta, and Favara. Small cubes of the rare melanophlogite growing on sulfur crystals come from the Mount Cimicia and Pernice-Cannatone mines at Racalmuto and Grotte.

A colorful bedding in alternate layers of pure yellow sulfur and whitish limestone extends for hundreds of meters in the Great Sulfur Bed of the Sommatino mine. People living near the Sommantino mine still discuss a horrible underground catastrophe which occurred when a great interior fire started in 1854 and burned for many years. Unable to extinguish the blaze, miners sealed off the area and worked other sections of the mine. In 1874 a mine crew unwittingly blasted through a wall confining a small lake of molten sulfur and ten men died in the outpouring of yellow liquid.

As sulfur supplies dwindle, only 10 or so sulfur mines still operate in Sicily, which has known some 1400 diggings. A technique developed by Herman Frasch, a German-born American chemist, pumps superheated water down wells to deep-seated sulfur beds. After melting the mineral for 24 hours, the water is pumped back to the surface bearing sulfur. More efficient and cheaper than tunnel or open pit mining, the Frasch method is used on the Isthmus of Tehuantepec, Mexico, at Louisiana's Grande Ecaille, in the great mine at Tarnobrzeg, Poland, and other locations.

In 1979 the hills surrounding the Agrigento and Favara mines were being converted to housing developments. Mine dumps and smelter ruins had been leveled nearly obliterating the old facilities.

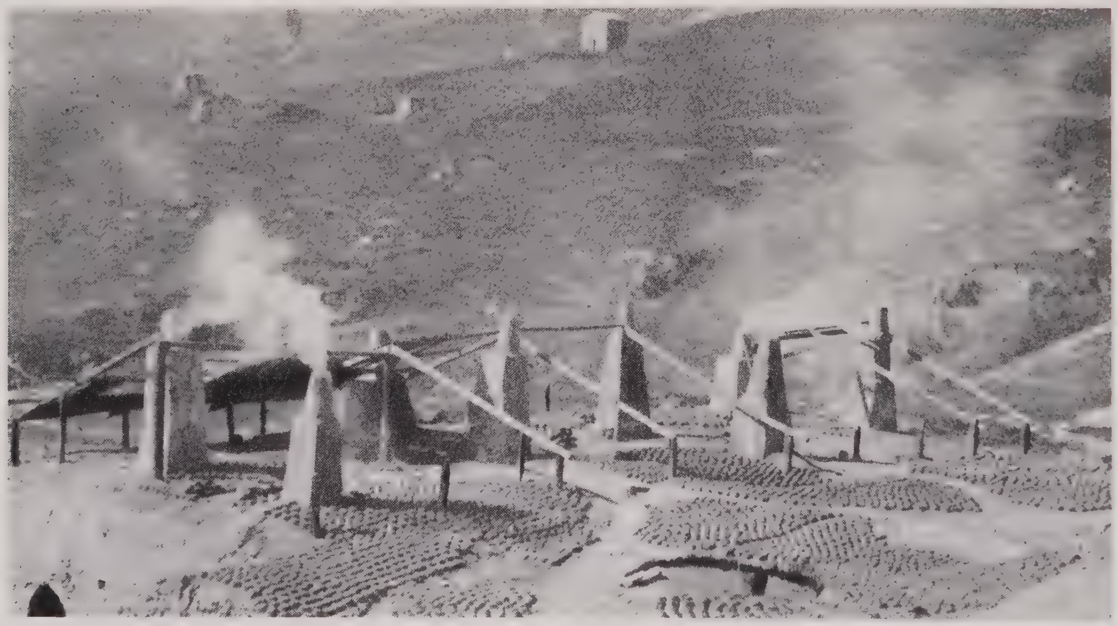
THIS PAGE TOP:
Caltanisetta sulfur furnace, c. 1929
Courtesy: Pier Bruno Scortecci

THIS PAGE BOTTOM:
Miners working sulfur dumps at Agrigento, 1933
Photo: Frederick Pough

OPPOSITE TOP:
Sicilian miner and his family are dealers in sulfur crystals, 1970
Photo: Edward Bancroft

OPPOSITE MIDDLE:
Ruins of sulfur mine at Favara, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Incline shaft in new Favara mine, 1979
Photo: Peter Bancroft



76 Grotta d'Oggi/Rio Marina Mines, Isle of Elba, Italy

Iron deposits on the tiny island of Elba have been worked without interruption for 3000 years. In earliest recorded history, Ligurians dominating the island called it Ilva; the Greeks who followed named it Aethalia. Passing to the Etruscans, it became part of the Roman Empire. Attracted by its natural beauty, sandy beaches, thermal baths, and gentle climate, the Romans created a pleasure resort. They built villas in abundance, laid out orchards, gardens, and vineyards, and constructed a network of good roads. During the Middle Ages, Pisans governed Elba, then the Appians and Medici. Over the centuries various powers left traces of their civilizations in the island's cultural heritage and ruins. In 1814 Elba had its greatest historic moment during Napoleon Bonaparte's 100-day reign.

Exiled there, Napoleon ruled the island and lived in relative splendor. Taking an interest in its natural resources, he showed considerable curiosity about the gemstones and crystals found in Elba's mines. Some believe he may have collected specimens, though no evidence of his collection survives.

Elba's enormous and fabulously rich iron deposits have produced many tons of bladed hematite crystals, some up to 10 centimeters on an edge. Black hematite crystals occur with iridescent coatings in bright hues of green, brown, gold, red, lavender, and blue; sometimes a single specimen contains all these colors. Hematite blades also form as flounces around the base of bright pyrite cubes and

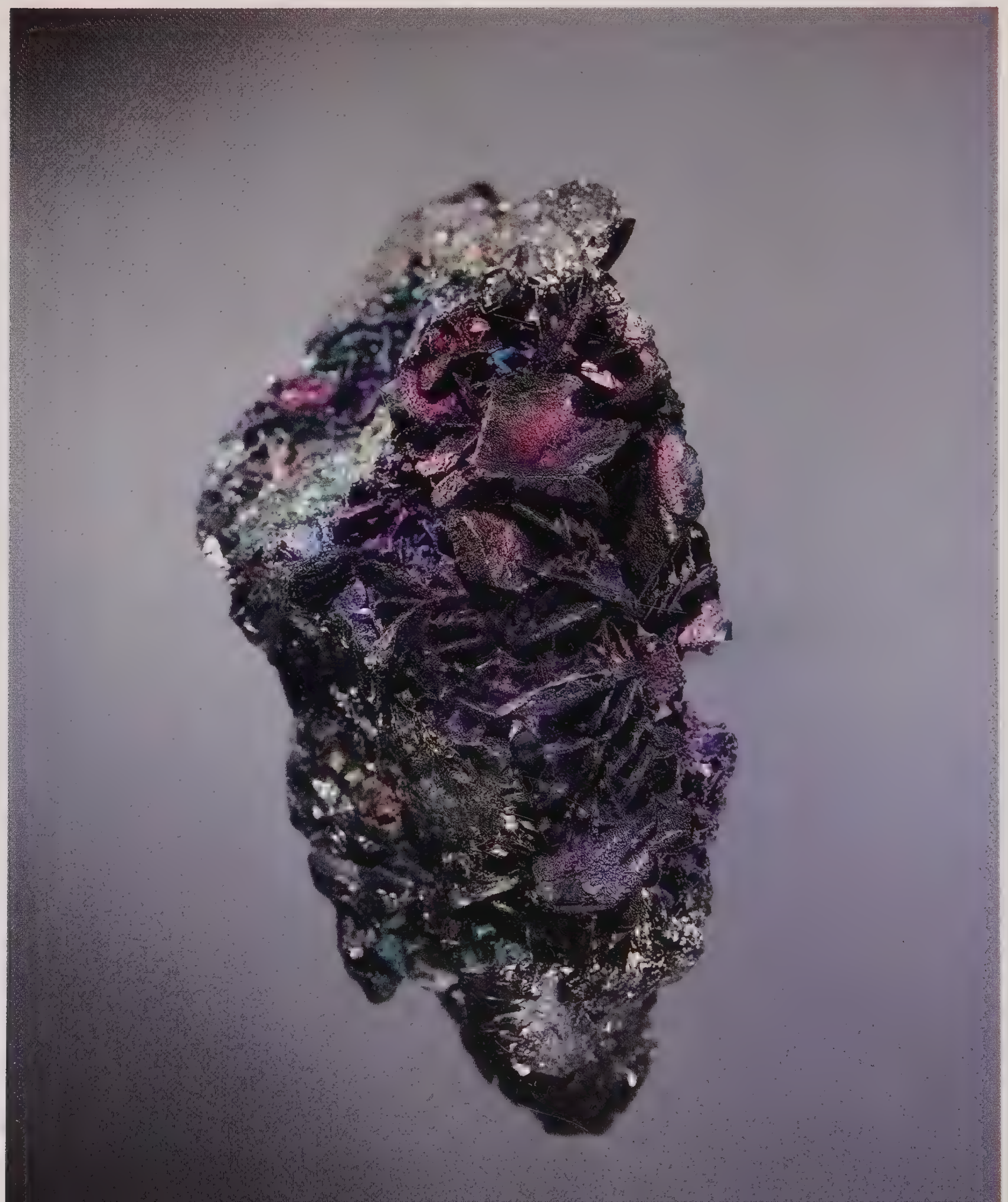
BELOW: Hematite
Size: 13 by 7 cm
Locality: Rio Marina
Collection: Harvard University
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
Rio Marina iron mine in 1909
Courtesy: Pier Bruno Scortecci

OPPOSITE MIDDLE:
Grotta d'Oggi pit is difficult to find and there are no visible crystals of any kind, 1979
Photo: Pier Bruno Scortecci

OPPOSITE BOTTOM LEFT:
Napoleon Bonaparte exiled to and administered Elba (1814)
Courtesy: U.S. Library of Congress

OPPOSITE BOTTOM RIGHT:
Hematite flakes gleam in sun at Rio Marina, 1977
Photo: Pier Bruno Scortecci



pyritohedrons, some measuring 14 centimeters in diameter. Many Elba pyrite crystals are highly modified and striated, giving them a rounded appearance. Unfortunately many beautiful specimens prove to be highly unstable and in a few years decrepitate into bits.

While miners remove the best specimens to sell to museums and dealers, for a small fee collectors may dig for hematite and pyrite at Valle Ciove near the big iron mine of Rio Marina. Fine hematite also occurs at Miniera Rio Albano, north of Rio Marina on the road toward Davo. The Bacino mine near Rio Marina has produced crystals of hematite up to 10 centimeters. Fine ilvaite crystals, some measuring to 13 centimeters, and good hedenbergite crystals are found at nearby Torre di Rio. In 1977 Giuseppe Agozzino, an Italian collector, found 2-millimeter crystals of anatase and brookite at an undisclosed location. In 1979 he also found 1.5-centimeter plancheite "balls" attached to chrysocolla at a "private location." A small museum houses a collection of Elba crystals, and at least two shops in Rio Marina sell local crystals.

The real thrill is found in personally collecting bladed hematite crystals. A number of iron sites along the east coast of the island have no "keep out" signs. Leonard Fuller, an English cattle breeder, who ships his house trailer to Elba and parks it on the beach at Terranera each summer, observes:

Where else can you dig hematite to your heart's content, swim, fish, camp and loaf in a beautiful setting? Why just last week I found enough hematite crystals to fill six boxes. But two Germans did even better. They found a 36-centimeter hematite vug and took it out intact. It was loaded with 3-centimeter blades and was worthy of a museum.

Pink and green tourmaline, named elbaite after the island, was first found near San Piero about 1825. Lieutenant Giovanni Ammannati is credited with that discovery, and one of the open pits bears his name. Rich pegmatites are situated immediately below San Piero and through the hills and ravines to the Grotta d'Oggi about 1.6 kilometers north of San Piero.

In Genoa, Giuseppe Agozzino tells of a grandfather who befriended a miner working on a pegmatite vein just down the hill from San Piero more than a century ago. The miner had just knocked down a wall of feldspar, which exposed a small cave studded with small pink tourmaline crystals. It was lunch time and the miner went home to eat. During his absence a group of women who had been washing clothes in a nearby stream became curious about the hole. Knowing nothing of gem crystals and believing the pocket abandoned, they knocked crystals off the walls and took most of them home as trinkets for their children. Upon his return, the distraught miner found his jeweled cavern in a shambles. He salvaged only a few loose crystals but no matrix specimens.

BELOW: Tourmaline, smoky quartz, and albite
Size: 2.5 cm
Locality: Grotta d'Oggi
Collection: Leonard Bedale
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM LEFT:
Pyrite
Size: 9 by 7 cm
Collection: William Larson
Photo: Harold and Erica Van Pelt

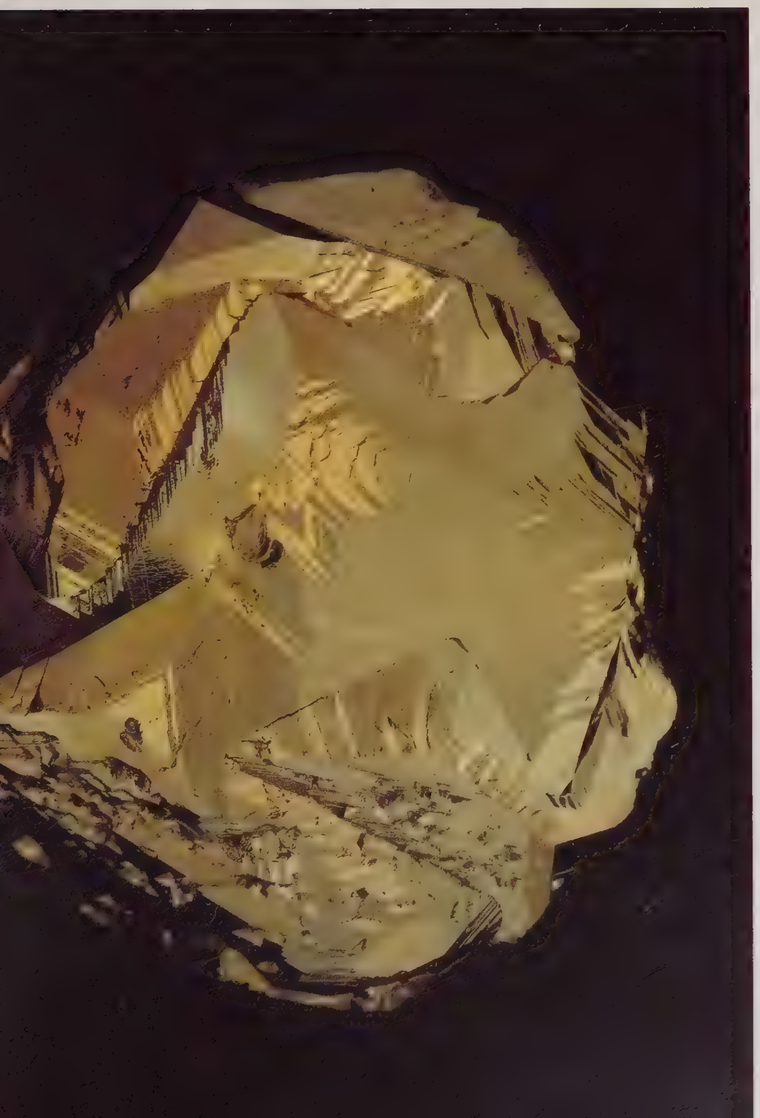
OPPOSITE BOTTOM RIGHT:
Tourmaline, quartz, albite
Size: 6 by 5 cm
Locality: Grotta d'Oggi
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

The Grotta and nearby deposits have produced a fine array of gems and minerals: groups and single crystals of pink and green elbaite, many with characteristic black flat terminations; white orthoclase; brilliant white albite; quartz crystals, sometimes in parallel position; aquamarine in pale blue and light green colors; goshenite; lightly hued morganite; spessartine in good colored crystals; lepidolite; biotite; muscovite; pollucite, petalite; stilbite; the very rare mordenite, epistilbite, and heulandite.

Exceptional tourmaline, pyrite, and hematite crystals from Elba may be seen at Italian mainland museums in Pisa and Milan. The Florence University Museum houses a fine mineral collection containing outstanding examples of Elba's pyrite, hematite, and tourmaline. The four best tourmaline specimens are displayed in a group and called the "four evangelists."

On Elba the tiny town of San Piero has flower-bedecked buildings around which a few stoic storekeepers and elderly shoppers sit clothed in black. The nearby pegmatite pits are now devoid of crystals; even bits of black tourmaline and mica are rare now. For 160 years sharp-eyed collectors have dug in the walls and thoroughly searched the dumps. It has been decades since Elba tourmaline appeared on the market in any quantity. Even some of the old pits are disappearing beneath refuse from San Piero. But once in a while, a new pocket appears. Usually small in size and importance, the new discoveries have produced tiny tourmaline in black-capped pink prisms typical of Elba. In 1977 collectors discovered a thin quartz vein in granite 15 kilometers south of San Piero and recovered tourmaline crystals 3 centimeters long.

Elba may be reached by hydrofoil or car ferry from Piombino and by air. The weather is good and the crowds small in April and September, probably the best months of the year to visit the charming island.



THIS PAGE TOP LEFT:
Italian collector at rich hematite vein
Photo: Peter Bancroft

THIS PAGE TOP RIGHT:
Leonard Fuller with self-collected hematite vug
Photo: Peter Bancroft

THIS PAGE MIDDLE:
San Piero in Campo with granite and pegmatitic veins below
Photo: Pier Bruno Scortecci

THIS PAGE BOTTOM:
San Piero in Campo, 1979
Photo: Peter Bancroft

OPPOSITE TOP:
Packing in mining supplies to La Gardette, 1906
Courtesy: Pierre Bariand

OPPOSITE BOTTOM:
A cold day on the way up to La Gardette, 1979
Photo: Peter Bancroft

77 La Gardette Mine, Le Bourg d'Oisans, France

In the Dauphine Alps of eastern France, the charming little town of Le Bourg d'Oisans nestles against the mountains. For mountaineers, skiers, and rockhounds it is headquarters for expeditions. Gaily decorated stores vend fresh bread, sharp cheese, and white wines—wonderful ingredients for a mountaintop picnic. Sidewalk cafes offer excellent soups and full meals. There are numerous hotels, camps, and collectives in and about town. There is even a mineral and jewelry shop, La Cristalliere de la Gardette, which offers directions to mines of the region. In late spring wild lupine pokes through drifts of ice and snow, as streams bubble with exuberance. The air is pure and sharp.

The trail to La Gardette mine climbed upward 360 meters until Le Bourg d'Oisans appeared as a handful of tiny squares nearly lost in the great valley below. We hiked through a misty rain, never encountering another person. Just inside the small portal

ice stalactites hung from damp ceilings of the muddy tunnels. Cracks in the walls revealed tiny quartz crystals, the largest measuring 5 centimeters, but no twin crystals. Because some drifts had caved in, many portions of the mine cannot be explored. Tailings cannot be searched either, because rock waste dumped outside the tunnels has simply crashed down the steep mountainside.

Two important very old mines in the Le Bourg d'Oisans area, La Gardette to the south and Chalanches in the north, were known to farmers for water-clear quartz crystals glittering in outcrops along cliff faces. Old records indicate that a mineral of commercial value was first discovered in the region in 1717 when a farmer found a 187-gram nugget of pure gold on the surface. Further attempts failed to find more gold. In 1765 another farmer, Laurent Garden, discovered an outcrop containing free gold and showed a sample to the chief engineer at the Chalanches gold mine which had just opened. The engineer was not impressed with the ore but his successor, Johann Gottfried Schreiber, thought the samples rich enough to mine. His employer, the Count of Provence, P.E. Moitte, gained control of La Gardette in 1781 and began mining for gold. The mine struggled for seven years then closed. Emperor Napoleon I, hoping to revive the French mining industry, ordered La Gardette and a number of other mines to reopen in 1805 but his government fell. Though never a good mine, La Gardette still proved to be the most important gold mine in the French Alps.

In 1767 a young shepherdess looking for lost animals near the Chalanches mine, picked up a rock which proved to be rich silver ore. The discovery site was added to the Chalanches mine, and over the next 25 years the combined operation produced 10 tons of silver. Some masses of pure silver weighed up to 14 kilograms but production fell off rapidly during the early 1800s, and the silver mine shut down in 1813.

Chalanches contributed 60 separate minerals including two entirely new species, valentinite and allemontite, though no specimens of display quality. Associated minerals included

BELOW:
Quartz on siderite
Size: 10 by 16 cm
Locality: Allevard
Collection: Faculty of Sciences, Paris (Sorbonne)
Photo: Nelly Bariand

OPPOSITE:
Quartz (Japan-law twin)
Size: 17 by 11 cm
Locality: La Gardette
Collection: British Museum of Natural History
Photo: Peter Green

sphene, calcite, quartz, epidote, ankerite, dolomite, and siderite.

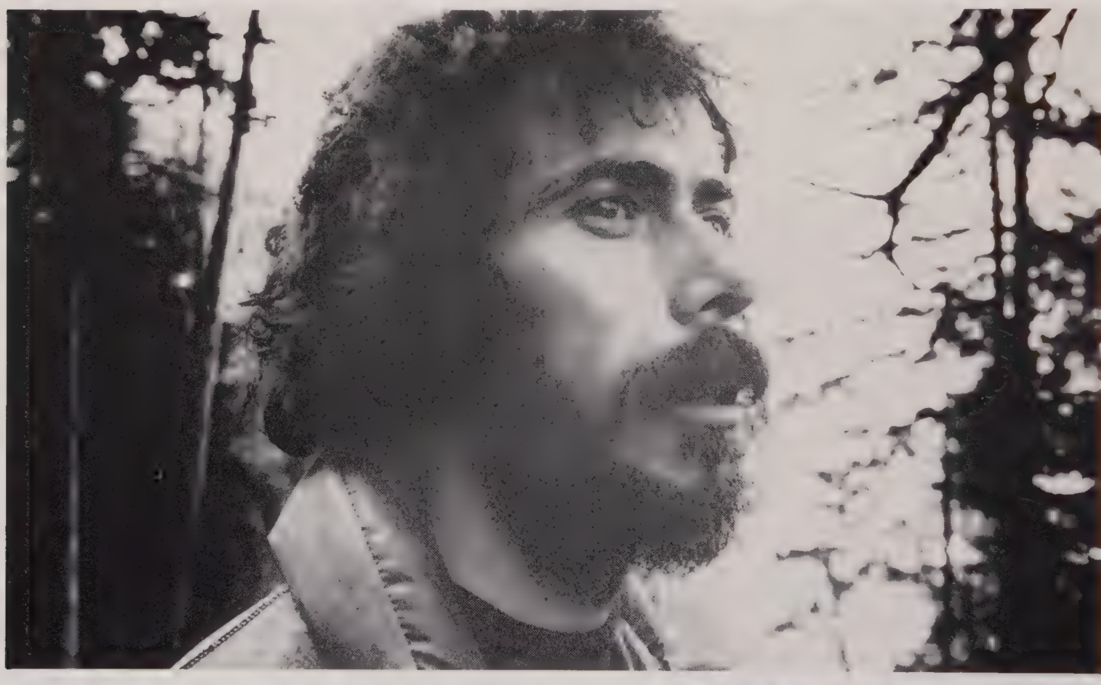
In the early 1880s, La Gardette reopened to reveal a series of great lens-shaped cavities, the largest over 100 square meters, lined with sparkling quartz crystals. Some crystals measured to 20 centimeters while others formed as near right angle twins like ones C.S. Weiss described in 1829. Later La Gardette twins were referred to as having grown according to the Gardette Law, Weiss's Law, and finally, Japan Law after similar quartz crystal forms were found in Japan's Otome mine. Because many of the best specimens were taken and sold privately by free-lance miners there are no reliable quartz production reports for La Gardette.

At the beginning of the 19th century, facet-grade quartz from La Gardette was cut into "Briancon diamonds" at the Briancon Lapidary Works near the Durance River. But cheaper Brazilian quartz soon doomed the fledgling Alpine industry.

Superb examples of La Gardette twinned quartz crystals are in the Natural History Museum in Paris and in the British Museum of Natural History. The old gold mine did contribute a number of minerals in addition to gold and quartz, notably superb chalcopyrite crystals with slightly oxidized crystal faces, associated with quartz and barite. Mostly 5 to 10 centimeters in diameter, some crystals were an astounding 20 centimeters. The mine also produced aikinite in black needles; brannerite, sometimes intermixed with gold; rose-shaped crystals of barite, sometimes in association with chalcopyrite and quartz.

Unfortunately, La Gardette and Chalanches, have been closed for many years along with Allevard, 40 kilometers to the north, which has produced some of the world's finest siderite and quartz crystal combinations. It is a lucky collector who can dig quartz crystals today which approach even 5 centimeters in length.

THIS PAGE TOP:
Old adit of La Gardette;
icy stream to right
Photo: Peter Bancroft



THIS PAGE MIDDLE:
Didier Duclos, crystal
collector and mountain man
Photo: Peter Bancroft

THIS PAGE BOTTOM:
In the chill chambers of
La Gardette, 1979
Photo: Peter Bancroft

OPPOSITE: Pyromorphite
Size: 6.5 by 3 cm
Locality: Les Farges
Collection: David Eidahl
Photo: Harold and Erica
Van Pelt

78 Les Farges Mine, Ussel, France

Les Farges, a silver and lead mine of recent vintage relatively unknown as an ore-producer, is already recognized for having yielded many of the world's most beautiful pyromorphite crystal clusters.

Located in the province of Correze a few kilometers southeast of Ussel, a small village on the highway halfway between Bordeaux and Lyon, the Les Farges mine is well hidden in the middle of low rolling granitic hills. Between the hills lie rock-fenced farms and centuries-old buildings, durably constructed of hand-hewn stone walls and slate roofs. Cows and horses graze contentedly in the fields, and it is a surprise indeed to come upon a small sign before an open gate which reads: "La Mine des Farges—Correze."

A gravel road enters a small forest and ends abruptly at the mine complex. A leveled area of less than 2½ hectares contains various modern shops, mills, offices, a mine headframe, and a change room.

Under the trees the dim outlines of Roman excavations are still in evidence. Small surface cuts, too straight to be natural, extend through the hills with small dumps on either side; all are covered with thick vegetation. Occasional bits of galena and barite can be found scattered about the surface, just as Roman miners left them. Ancient Rome had little use for lead and the veins were probably exploited for their silver. History explains neither the presence of Roman miners in Correze, nor gives reasons for their departure. Their superficial workings remained undisturbed until rediscovered in 1922.

The next four decades saw a little prospecting and some digging first by a man named Desgrange, then by V. Lassale. But these efforts were unproductive, and once again grass and trees grew over the workings. In 1963, the French Bureau of Geological and Mining Research (BRGM) began to explore the vein with diamond corings. Certain that valuable reserves of silver-bearing galena and barite existed just below the surface, BRGM ceded its rights to the Asurienne des Mines development company in 1969. Serious mining began in 1972.

Mineralogists were not aware that well crystallized pyromorphite occurred in the Les Farges. But at 100 meters miners encountered

BELOW: French farm next door to the Les Farges mine
Photo: Peter Bancroft

OPPOSITE TOP:
Les Farges gallows frame with sheaves at two different levels
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Miners about to descend into the Les Farges
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Jean-Claude Thomas, school professor, with self-collected specimen of fine green pyromorphite
Photo: Peter Bancroft

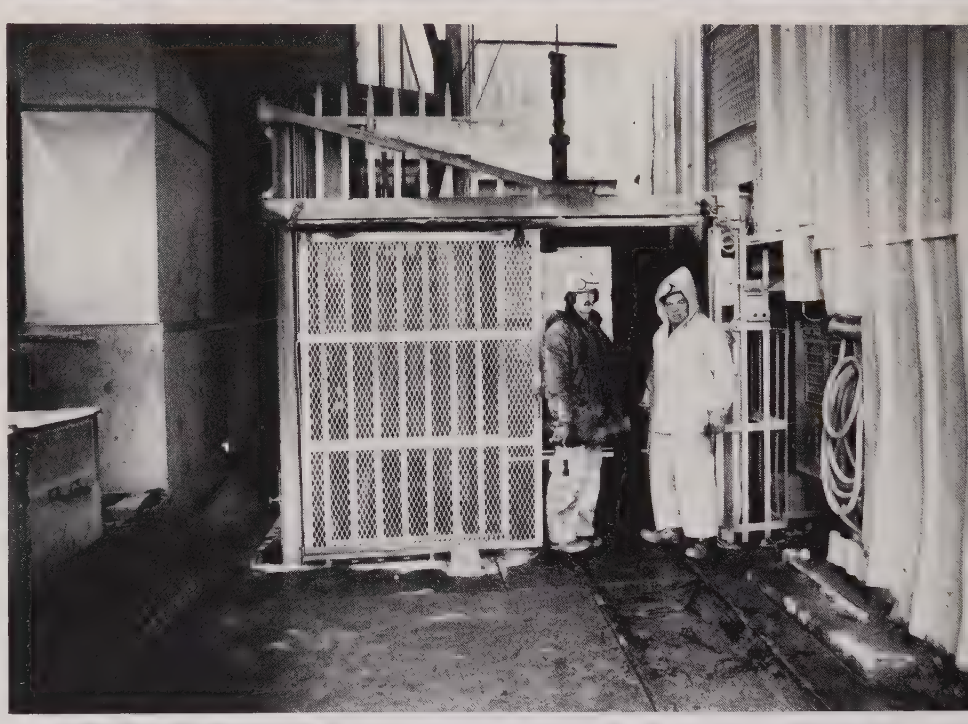
sizeable pockets of exceptionally bright pyromorphite crystal groups. Colors include orange, olive green, brown, transparent white, yellow, and the remarkable grass-green shade that has drawn worldwide attention to Les Farges. Miners eagerly collected the bright green clusters and disposed of them at continually escalating prices to European and American dealers.

During the great years from 1976 to 1978, it seemed that nearly every round of explosives exposed pyromorphite crystals—some poor quality, some good but always more. Miners began to collect during lunch breaks. Then men would slip away from work assignments, causing considerable confusion at the work face. Rivalries developed when miners insisted upon sharing the contents of a single pocket and fought over collecting territories. Up to that point, management had looked the other way but enough was enough. Directives forbade collecting, and violation of the order resulted in dismissal. Overt differences of opinion seemed to vanish, but the trade in specimens continued.

One night, three men were cleaning blast rubble when they broke into a huge vug. A large chunk of rock covered with gem green hexagonal pyromorphite crystals—a real beauty—projected into the vug wall. The next few hours were spent in meticulously removing the piece that weighed over 40 kilograms, getting it into the hoist, and finally removing it to an automobile. The miner who reported this event to the author concluded "I can guess that the mineral after passing from hand to hand will soon belong to some museum, probably La Sorbonne."

When miners reached the 250-meter level, they no longer encountered top quality crystals. Yet the demand for pyromorphite crystals steadily increases. As the Les Farges mine probed deeper for silver, experts found the lower levels barren of pyromorphite, at least of specimens containing the beautiful green hues.

A report in April 1984 indicated ore-bearing veins had been exhausted and the mine closed. All machinery and buildings were removed, the collar of the shaft cemented over, dumps leveled, and the whole site covered with top soil and planted to farming. Visitors will find little evidence of the Les Farges mine. The old Roman pits and dumps have once again become the most prominent features of the area.



79 Florence/Frizington Mines, Egremont, England

As a boy in the 1840s, John Graves moved to the village of Frizington, then the center of feverish iron mining in England's northwest county of Cumberland (now Cumbria). Young Graves was fascinated by the abundance of sparkling crystals scattered about the dumps of more than 50 mines. He gathered hundreds of fancy specimens and took them home, thus becoming one of the first serious mineral collectors of his time. He soon realized that many of his treasures had been damaged during the mining process. If he wanted undamaged specimens, he would have to mine them himself. Graves found work in the mines and recovered superb crystal groups of barite, fluorite, calcite, quartz, and dolomite.

Quitting his miner's job, Graves dealt in Cumberland minerals until his death in 1928. Among his customers were the British Museum of Natural History, Henry Ludlam, and Sir Arthur Russell, as well as many other museums, dealers, and collectors throughout the world.

From the early 1700s the value of Cumberland crystals was recognized, even by an Egremont clergyman who wrote:

> *In that great variety of ore at the Langhorn outcropping, I did not only meet with spar, as transparent as the clearest crystal, but stones embossed with bastard diamonds near as sparkling as the real. I also found bloodstones some of which I carried up to London, and were well approved of, as not inferior to the best.*

The reverend gentleman's bloodstone was undoubtedly hematite to which quartz crystals were attached.

During the 16th century, northern Cumberland lead miners at Roughton Gill stacked pyromorphite in large piles as a worthless mineral. About 1945 these mounds were discovered to have commercial value but no specimens survived when all the "good lead ore" went to the mill. Through the years, mimetite crystals (formerly known as campylite) were recovered at Roughton Gill and Drygill for use as an ingredient of flint glass and paint pigment. High quality crystals assured superior quality glass and pigment; popularity of the better crystals for commercial use made them scarce and nearly unattainable by collectors.

BELOW: Miners, covered with red hematite slime, working deep in the Florence mine in 1976
Photo: Brian Hammond
Courtesy: British Steel Corporation

OPPOSITE LEFT:
Barite on dolomite
Size: 17 by 15.3 cm
Locality: Mobray mine
Collection: British Museum Natural History
Photo: Philip R. Crabb

OPPOSITE RIGHT:
Barite
Size: 28 by 21.4 cm
Locality: Dalmellington mine
Collection: British Museum Natural History
Photo: Frank Greenaway

Perhaps the world's best calcite and barite crystals occurred in the Egremont mining district approximately 70 kilometers southwest of Carlisle in the Lake District. Two of the most important villages are Cleator Moor and Frizington. A few mines became famous for the exceptional crystals they produced: the Bigrigg (for white and black calcite), the Mowbray (blue barite, green fluorite), the Florence (turquoise-blue fluorite, calcite, galena), the Dalmellington (galena, golden barite, brown dolomite), the Pallaflat (crystal-clear calcite), and the Frizington (black and white calcite).

The Florence mine, about 5 kilometers south of Egremont, began as a few small disconnected pits and tunnels. The No. 1 shaft, built in 1880 to facilitate systematic development of the ore body, was used until it collapsed in the early 1900s. Today only a few 100-year-old cement foundations remain of the original workings, and even the dumps are gone to road ballast. The old Florence mine office, the only surviving building, currently houses a motorcycle business. In 1914 a new shaft, the Florence No. 2, was dug down to the 304-meter level. Although seldom used for hauling miners, the 5-meter-in-diameter shaft still serves as an air vent and emergency exit.

The British Steel Corporation currently operates the Florence property, known today as the Beckermet mine. The mine is still rich, and the main ore body reaches 41 meters in width. Within this mass of iron ore lie veins—some nearly 2 meters thick—of pure kidney iron frequently interlaced with calcite. Mine manager Frank Johnston continues "An incentive scheme" begun in 1907 "to encourage miners to isolate and handle with care any crystal finds of obvious quality." Some finds at the Beckermet are breathtakingly beautiful . . . "the encrusted fluorite occurring in perfect cubes, the sparkling quartz in distinctive diamond shapes, spectacular hematite ore with its gleaming array of circular

nodules, and the delicate tabular formations of leaf shaped barite."

High-grade hematite of jewelry quality is shipped in substantial quantities to the continent, and the company maintains a raw materials officer to prepare mineral specimens for sale. Prime specimens are occasionally offered at Sotheby's in London.

The Beckermet employs 200 men, but mining in the deeper levels is not an easy task. Because the mine is wet with dripping and running water everywhere, the humidity is very high. This water mixes with the powdered hematite to form a reddish-brown mud that sticks to everything it touches. Miners are readily identified in local pubs because their fingernails and facial wrinkles remain clogged with iron pigment.

Exceptional crystal clusters of barite, calcite, galena, fluorite, and dolomite from the Egremont district are featured in most major museums and private collections throughout the world. The best specimens were recovered during the early days of the Cumberland mines, and although collectors prize crystals found today, their importance does not approach that of earlier finds.

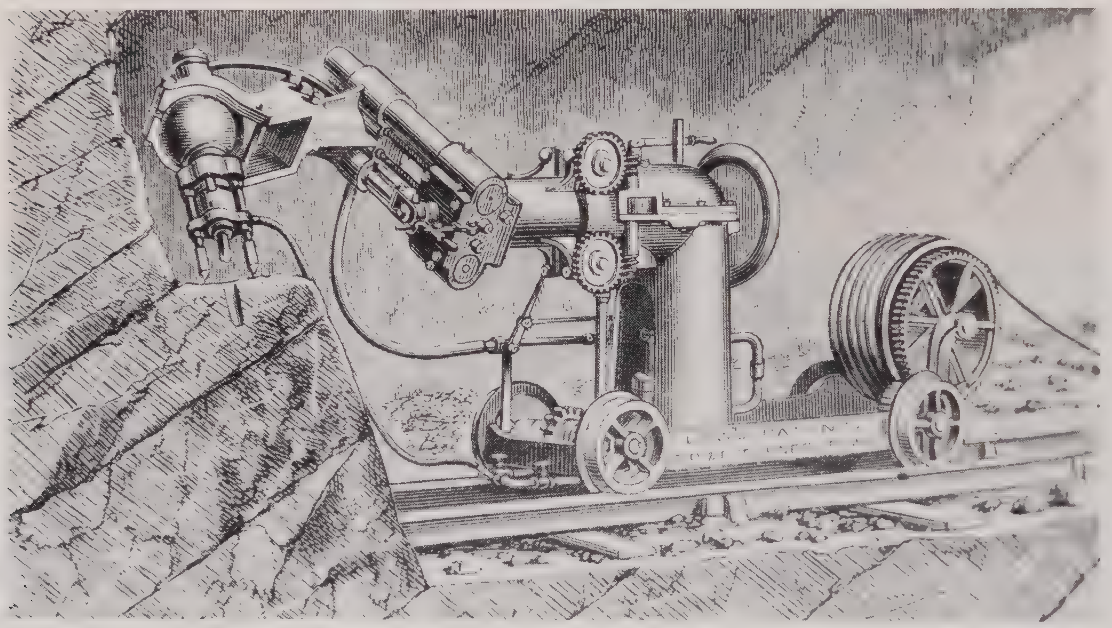
THIS PAGE TOP:
British rock-boring machine, 1868
Courtesy: L. Simonin Mines and Miners

THIS PAGE BOTTOM:
Old church and cemetery near Frizington
Photo: Peter Bancroft

OPPOSITE TOP:
Entrance to Florence mine, 1979
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Operating Florence #2 shaft, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Remote control mucking machine in Florence
Photo: Peter Bancroft



80 Height's Mine, Alston, England

England has produced a long list of distinguished mineral species but may be best known for fluorite of perfect form and grand colors. Associated with other attractive minerals, it has been found in hundreds of English mines.

Important crystal-producing areas include Cornwall to the far southwest, Derbyshire in central England, and the Wear Valley near the Scottish border. Cornwall fluorite concentrations occur in various copper and lead mines, outstandingly the Caradon mine at Liskeard. This deposit has contributed green and purple octahedrons frequently associated with sparkling chalcopyrite. But the most striking combination consists of bright transparent yellow fluorite cubes resting precariously on milky quartz spires attached to a base studded with chalcopyrite crystals. Particularly fine examples of these rare and remarkable clusters are in the fluorite crystal suite at the British Museum (Natural History).

The greatest variety of colorful English fluorite crystals comes from mines and quarries along the Wear Valley, 25 kilometers east of the tiny hilltop village of Alston. Lester Jackson, a Carlisle mineral collector, once believed that collecting days were numbered at the old Height's mine. Accidents in and about the quarry had caused the owners to begin closing all entrances except those their miners used. Jackson arranged a hasty "last"

BELOW:
Fluorite with quartz
Size: 3 cm
Locality: Height's mine
Collection: Cal Graeber
Photo: Harold and Erica Van Pelt

OPPOSITE TOP:
English mine disaster, c. 1860s
Courtesy: Simonin, Mines and Miners, *1868*

OPPOSITE MIDDLE:
The town of Alston, a center for northern English mines
Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT:
Mining in the Wear Valley, c. 1600s
Courtesy: Carlisle Museum and Art Gallery

OPPOSITE BOTTOM RIGHT:
Shopkeeper in Alston displays old and very prized "mineral scene", c. 1880s
Photo: Peter Bancroft

expedition for March 1979, and the author accompanied him. The winter had been particularly severe; helicopters were ferrying hay to stranded cattle and equipment to crews repairing storm-felled power lines. Les parked his car at the top of Height's quarry (now called Ogden's) just north of the Wear River between the villages of Westgate and Eastgate, and we walked through the snow over the hilltop into a swale below. Taking rough bearings on nearby landmarks, he located an area he believed to be over the tiny entrance to the old mine. Digging vertically through the snow and then using long poles to probe for the entrance below, he eventually breached the opening three meters down.

A small stream of ice water poured into the entrance, soaking us as we slithered down headfirst. At the bottom of the entrance, a tiny drift, nearly filled with mud and rubble and with no more than 0.5 meter of clearance, forced us to crawl in slime for nearly 30 meters. The tunnel entered a large gallery supported by columns of carefully stacked rock. Rotted timbers and mining debris from a century ago lay scattered about. A careful search along cracks and seams revealed groups of transparent light green penetration twins of fluorite up to 2 centimeters on a side. With a few good crystals carefully wrapped we made our way back through the snow drift.

True to Les's prediction, a few weeks after that visit the Height's tunnels were blasted shut and cemented over. Collecting is no longer possible there.

Mining in North England began before 1130 A.D., when manuscripts by the Pipe Rolls of the Exchequer referred to the lead mines near Carlisle as "the mynes of Carliol." Since the Norman conquest, lead was in great demand for the roofs of some 1500 castles, halls, and churches. Deposits throughout the region were exploited, and by 1696 Weardale mines were producing good quantities. In 1861 the Height's Pasture mine was established, and a massive 7.5-meter vein filled with fluorite and quartz developed as a surface deposit. But no lead was discovered. In 1847, at the east end of the property, the Weardale Iron Company started the Height's quarry by exploiting the Coulthard's String vein to a depth of over 450 meters. Great veins, some 360 meters long, produced fine fluorite, siderite, quartz, and galena crystals. Classic vivid green penetration twin crystals of fluorite are perhaps the most sought after of all fluorite specimens, and the best are from the Height's mine. The Blackdene mine, in continuous operation since 1401, has produced light purple cubes—some measuring to 13 centimeters, smaller light green and yellow crystals, and showy specimens dotted with dolomite, calcite, and quartz crystals. Outstanding pinkish lavender fluorite

BELOW:
Fluorite on quartz
Size: 10 by 7 cm
Locality: Weardale Valley
Collection: Institute of Geological Sciences, London
Photo: Martin Polsford

OPPOSITE: Witherite
Size: 9 by 7.2 cm
Locality: Nentsberry mine near Alston
Collection: British Museum of Natural History
Photo: Peter Green

crystals, some measuring an astounding 30 centimeters on a face, occurred at the Boltsburn mine 8 kilometers north of the Height's mine. Fine fluorite crystals of the same color, an important part of the Ludlam Collection in London's Institute of Geological Sciences Museum, are probably from the Boltsburn.

Innovative British collectors still find high quality fluorite specimens in old stopes of the northern mines, but the financial return is usually small and the effort can be dangerous. Les Jackson was nearly killed in a lead-fluorite mine in 1980 when a large section of tunnel collapsed without warning. Badly injured when dug from the rock rubble, he was evacuated by helicopter to a hospital where he eventually recovered.

The demand for English fluorite crystals and other species far exceeds the supply. Respect for beautiful English crystals is further enhanced by awareness of the difficulties involved in their acquisition. It is amazing that such a small land could be such a treasure chest of museum-quality specimens of a great variety of species, each with colorful and beautifully formed crystals.

THIS PAGE TOP:
Searching for entrance to old Height's mine
Photo: Peter Bancroft

THIS PAGE MIDDLE LEFT:
Digging down to the entrance in bitter cold
Photo: Peter Bancroft

THIS PAGE MIDDLE RIGHT:
Abandoned workings in the Heights, perhaps over 100 years old
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Lester Jackson works a vein still containing fine green fluorite penetration twin crystals
Photo: Peter Bancroft

OPPOSITE LEFT:
Dolcoath mine raise, c. 1880s
Courtesy: Pioneer Museum, Zeehan, Tasmania, Australia

OPPOSITE TOP RIGHT:
Wheal Sisters engine house struck by lightning, April 1886
Courtesy: Truro County Museum

OPPOSITE BOTTOM RIGHT:
Herodsfoot engine house remains, 1951
Courtesy: Geoffrey Ordish, Charleton Marshall and Blandford Dorset

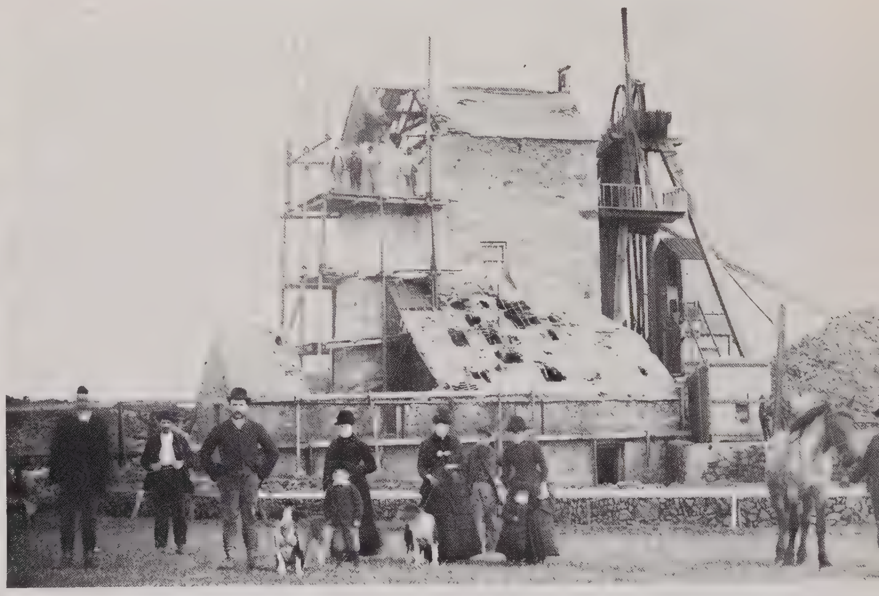
81 Herodsfoot Mine, Liskeard, Cornwall, England

Bournonite at its best occurs only in the Herodsfoot mine, 3.6 kilometers southwest of Liskeard in Cornwall. This old lead and silver mine dates from the 18th century. The ore lode extends more than 1.7 kilometers. The South Herodsfoot, an extension of the Herodsfoot, probably opened about 1850. Records of the old mines are quite sparse, and photographs of the early diggings do not exist.

Another mine, founded in 1853 to the south on Tallard Bay, was also named South Herodsfoot in an attempt to capitalize on the more famous workings. This mine, a lesser producer, did not contribute any outstanding crystals and has only caused confusion over the years.

None of the original Herodsfoot veins was high grade, but most produced large amounts of low-to-medium grade lead ore in veins up to a meter thick. Mineral fissures were mostly quartz, some very white and finely grained, in which substantial amounts of pyrite and sphalerite occurred. The white veins streaked through the country slate, making attractive patterns when exposed in mine tunnels and galleries. Outstanding crystals of iridescent tetrahedrite and superb bournonite crystals were found in the upper levels of the South Herodsfoot mine about 1860. Associated minerals found in good crystals were calcite, ankerite, pyrite, dolomite, and chalcopyrite. Vugs carrying the various crystals were reportedly very pretty and bright.

Not all went well with management of the Herodsfoot. In 1826 the *West Briton* paper carried an advertisement announcing the dismissal of the Captain/Superintendent. Problems continued, and by 1855 poor construction around "slidy ground" left the area in a dangerous condition. Twenty meters of water had been allowed to rise in the 275-meter-deep mine, rendering the lower levels inoperable.



THIS PAGE:
Liroconite (blue)
Size: 6 by 4 cm
Collection: B.M.N.H.
Locality: St. Day, Cornwall
Photo: Philip R. Crabb

Metatorbernite (green)
Size: 7 by 5 cm
Collection: B.M.N.H.
(personally collected by Sir Arthur Russell)
Locality: Old Gunnislake mine
Photo: Philip R. Crabb

OPPOSITE LEFT:
Bournonite
Size: 28 by 14 cm
Collection: B.M.N.H.
Locality: Herodsfoot
Photo: Peter Green

OPPOSITE RIGHT:
Tetrahedrite coated with chalcopyrite
Size: 20 by 15 cm
Collection: B.M.N.H.
Locality: Herodsfoot
Photo: Frank Greenaway

With the appointment of a capable manager in 1855 a new shaft and engine house were constructed. The shaft penetrated to the 254-meter level, and drifts were driven to connect with old tunnels to the north. Some areas in the new development were highly brecciated and exceptionally rich in silver. By 1870 the mine reached a depth of 300 meters and employed 170 men. Thereafter ores depleted rapidly, and by 1884 the mines were shut down. The complex has been exhausted as a commercial enterprise, and fine mineral specimens may never again be found here.

Bournonite was discovered at Wheal Boys, Endellion, England, and named "endellion" by Count J.L. de Bournon, a French mineralogist. Later the species was renamed bournonite in the discoverer's honor. Good crystals have occurred at Neudorf, East Germany; Pontigibaud, France; and Park City, Utah; but the large cog-wheel crystals are the trademark of Herodsfoot. Fine bournonite specimens are part of the collections of the Geological Museum in London, Harvard University, the Smithsonian Institution, and the American Museum of Natural History.

The grandest bournonite on matrix, displayed in the Mineral Gallery at the British Museum (Natural History), measures 28 by 14 centimeters and weighs nearly 10 kilograms. Its largest crystal an astounding 11 by 2.5 centimeters, this cluster was mined at the Herodsfoot in the 1860s. Richard Talling, a British dealer, apparently had a monopoly on bournonite crystals and sold a number of specimens to the British Museum in 1868, including the "great one."

The road to Liskeard and the Herodsfoot mines passes farms lush with summer crops, moors gaily colored with lavender heather, and little villages, quiet and serene as yesteryear. The narrow road to the quaintest of hamlets, Lanreath, winds steeply down to the tiny Looe River. The chimney of the old engine house in Herodsfoot stands only a little taller than nearby trees, and vines mat the roofless stone mine buildings. Shafts are sealed and surface traces obliterated. Farmers plow fertile fields

beside the brick tower which still keeps lonely vigil over the few remaining landmarks.

Old mining relics seem to cover most of Cornwall—old buildings, engine houses, and endless dumps. A short distance from Herodsfoot, historic Truro has many old buildings in good repair and a County Museum and Art Gallery staffed by well informed, friendly specialists. This fascinating repository of books, paintings, antiques, and crystals provides the visitor with glimpses of the days when nearby mines were active.

THIS PAGE TOP:
"Skip Jumping" Cook's Kitchen mine, c. 1890
Courtesy: Truro County Museum

THIS PAGE MIDDLE:
Cook's Kitchen mine, Illogan, c. 1890
Courtesy: Truro County Museum

THIS PAGE BOTTOM:
Cornish mine barber at work, c. 1907
Courtesy: J.H. Trounson

OPPOSITE TOP:
Fluorite on quartz
Size: 10 by 5 cm
Locality: Goschenen, Switz.
Collection: Bern. Nat. Hist. Mus.
Photo: Karl Buri

OPPOSITE BOTTOM:
Swiss Alps near Guttannen
Photo: Peter Bancroft

82 Grimsel Region, Oberhasli, Bern, Switzerland

Few crystal collecting areas are more remote, capricious or dangerous than the mineralized clefts of the Swiss Alps, but no other region has more beautiful collecting spots. It is fitting that one of the loveliest crystal combinations to favor any display cabinet—dainty pink fluorite octahedrons nestled among water-clear quartz prisms—occurs in the highest reaches of alpine peaks.

Pink fluorite crystals are practically the exclusive property of a region north of the Grimselpass-Andermatt Highway in central Switzerland. The entire zone encompasses an area of less than 715 square kilometers, but access remains extremely difficult because of the rugged terrain. Important locations include Gelmerhorner, Sommerloch, Nollen, Juchli, and Gerstenhorner, all in the Grimsel region; and Sandbalm, Gwuest, and Bratschi in the Goschener Alp zone. In 1964 outstanding pink fluorite octahedra on quartz appeared in the clefts at Bratschi during construction of hydroelectric tunnels.

The pink fluorites are associated with adularia, calcite, chlorite, hematite, stilbite,

and apatite. Extremely rare are the well formed brilliant pink fluorite crystals on quartz prisms. Fluorite crystals often measure up to 3 centimeters; crystals over 8 centimeters are most unusual.

Public acceptance of the dainty pink fluorite crystals seems to be universal. In 1978 a specimen owned by Fricke Reinhard took top honors at the annual mineral show in Munich, West Germany. Affection for pink fluorite has established monumental prices whenever it is offered for sale. However, care must be exercised to ascertain that all Swiss fluorite crystals are naturally affixed to the matrix. From time to time striking specimens—to which the fluorite crystals have been cleverly attached—appear on the market and it takes a sharp eye to detect the offending adhesive.

Switzerland's largest octahedral fluorite, a pale green one, was found at Sommerloch during construction of an underground power station. The crystal measures 16 centimeters on an edge. Larger fluorite crystals in cubes are reported from sedimentary deposits in the northern Alps.

One of the first to mention pink fluorite in

THIS PAGE TOP:
Kaspar Fahner (lower right) working on cliff with friend
Courtesy: Kaspar Fahner

THIS PAGE BOTTOM:
Mining quartz on the Tiefengletscher in 1970. Note ingenious conversion of skis to a ladder.
Photo: Kaspar Fahner

OPPOSITE LEFT:
Swiss strahler and family
Painting depicts family cleaning quartz crystals, c. 1880s
Owner of painting: Mr. Gross of Schweizer Heimatwerk, Zurich
Photo: Hans Gamma

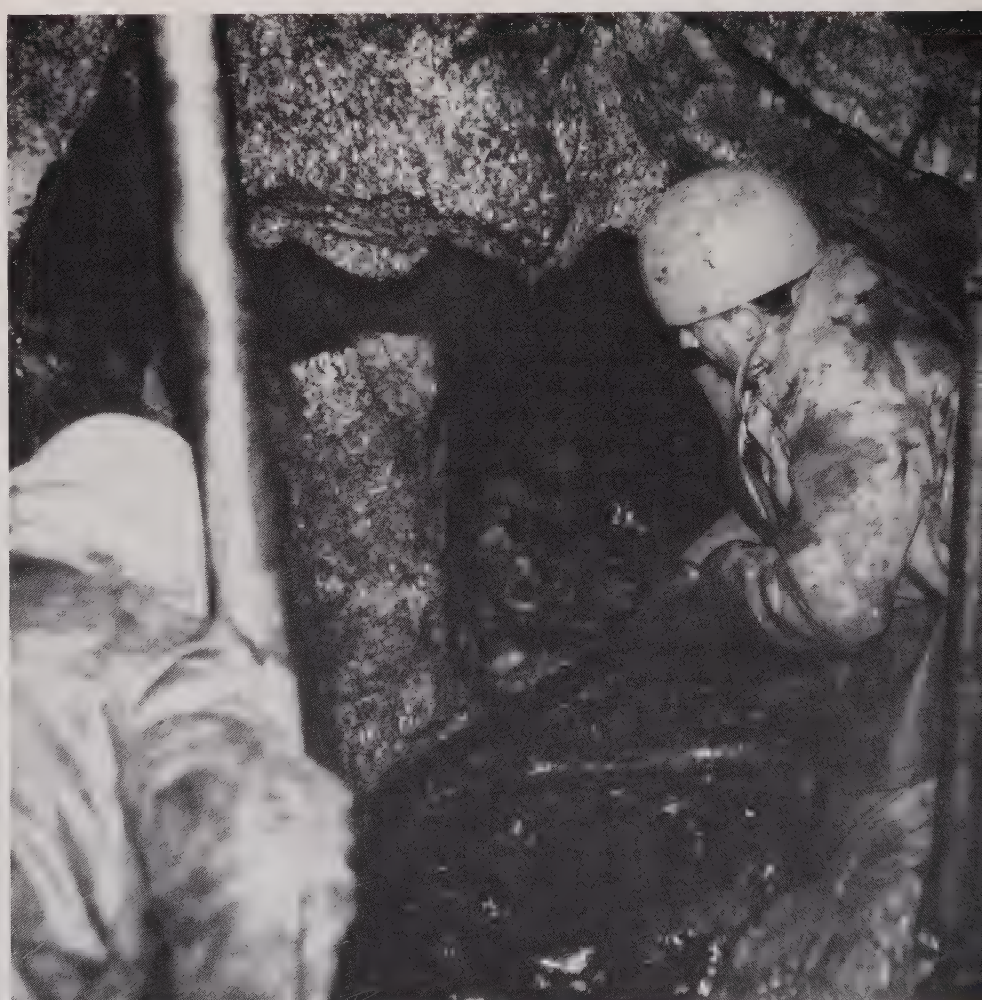
OPPOSITE RIGHT:
A quartz cleft—cold, wet and unstable—grudgingly gives up its treasure
Courtesy: Ernst Rufibach

Swiss literature, G. vom Rath described a specimen with 7.5-centimeter crystals on quartz in 1862. Pink fluorite crystals do not occur in large veins or lodes where continuous digging may cause the deposit to be referred to as a mine. Fissures, or clefts, bearing the tiny pink sparklers are generally small and widely spaced on only a few Swiss mountains. A few fine examples have come from the French Alps at Chamonix and elsewhere nearby. Pink fluorite crystals are also reported from mountain areas of northern Italy, a region better known for crystals of demantoid, grossular, vesuvianite and diopside.

David Friedrich Wiser (1802-1878), one of the first and the most famous of Swiss mineral collectors, collected hundreds of outstanding crystals, most of them from Switzerland. Frequently leaving his hardware business when news of a new find reached him, he had a fondness for unusually shaped smoky quartz crystals and pink fluorite. He bequeathed his collection to the Swiss Federal Institute of Technology in Zurich, which displays a small portion today.

The Swiss collectors who have superior pink fluorite specimens gathered their best pieces themselves. Valentin Sicher, a highway contractor living in Gurtnellen, Uri, has a dozen specimens, some to 30 centimeters in length, each containing many pink fluorite octahedrons with white quartz crystals on leached granite. Kaspar Fahner, Swiss ski champion and proprietor of a ski complex at Hasliberg helicopters into lofty alpine reaches to locate some of the best fluorite groups on quartz crystals known.

Years ago Swiss crystal collecting was the realm of peasants and shepherds who found specimens scattered about pastures or in talus below the peaks and rarely resorted to digging. Now amateur and semiprofessional collectors climb the mountains in search of crystals. Successful *strahlers* generally have at least a



THIS PAGE TOP:
Kaspar Fahner with self-collected fluorite
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Fluorite on quartz
Size: fluorite 3 cm in diameter
Locality: Ziggenstock
Collection: Ernst Rufibach
Photo: Max Weibel

OPPOSITE TOP:
Fluorite on quartz
Size: 7 by 5 cm
Locality: Galenstock, Switz.
Collection: Swiss. Fed. Inst. Tech.
Photo: Markus Graf

OPPOSITE BOTTOM:
Fluorite with quartz
Size: 8.7 by 5.5 cm
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

rudimentary knowledge of geology, are experienced alpine climbers, and well equipped for the Alps, as well as for mining. The short prospecting season in the higher mountains runs from June to October.

Each year the search for pink fluorite continues. *Strahlers* will tell you not to expect more because the clefts are exhausted. But then word leaks out that at some point high in the Alps a new cleft was found containing pink treasure. Exorbitant prices are asked and paid and collectors settle down to await a new find. The cycle has been a phenomenon for decades, and the growing number of *strahlers* in the field each year lends credence to the belief that more crystals exist, but recovery will be just a bit more difficult.

Fine pink fluorite crystals, some growing on galena, were recently found at Huanzala, Peru. Singly and in clusters, the crystals occur as well formed, nearly transparent octahedra in limpid to bright lavender-pink hues. They are no match for the best vivid pink Swiss crystals.

83 Tiefengletscher Mining Area, Andermatt, Uri Canton, Switzerland

In Switzerland the legend of Haslital, known to young and old alike, tells of a mountain king who rules his world from a cave deep in the mountains lined with sparkling crystals which glow in subdued light. Bearded dwarfs attend the king who has never been seen, though many are convinced he exists. They are just as certain that he rules innumerable caves full of crystals and it only remains for an enterprising adventurer to discover these bejeweled hollows and become rich forever.

Such a legend did little to diminish the zeal of Swiss mountain people in their search for hidden crystal treasure. When a find was made, entire families, and sometimes whole villages hiked to the site armed with tools to open caverns filled with crystals.

Central Aar Massif, an extremely rugged and

THIS PAGE TOP:
Strahler *with newly found smoky quartz crystal*
Photo: Kaspar Fahner

THIS PAGE BOTTOM:
Strahlers *(crystal hunters) labor in extremely cramped quarters*
Courtesy: Ernst Rufibach

OPPOSITE LEFT:
Hans Rufibach, a life-long strahler. Here as a young man with quartz crystal he collected near the Oberaar glacier. At the age of 49 he was killed digging quartz.
Photo: Ernst Rufibach

OPPOSITE RIGHT:
Andreas Rufibach, killed with his father, Hans, on the Zinggenstock, August 29, 1971
Courtesy: Ernst Rufibach

beautiful range of mountains between the Furka Pass and the small town of Sedrun, contains many alpine clefts of smoky quartz, some with pink fluorite crystals. In 1719 four members of the *Zinggische Societet*, a group of prospectors, investigated a promising spot high on the side of Mount Zinken (Zinggenstock) just west of the Grimsel Pass and broke through solid granite into a cavern of incredible beauty. The walls of one room measuring 3.5 by 6 meters were covered with water-clear quartz crystals totaling many tons. Individual prisms weighed up to 300 kilograms.

Many people visited the discovery, including Lucerne mineralogist Maurice Cappeller who wished to see for himself how so many crystals, all with six sides, could have grown in one spot. Because they had little knowledge of mineralogy, most people referred to quartz prisms as "rays," believing them frozen water which was not capable of thawing. At ready markets in Milan and Venice cutters faceted and carved the crystals into goblets, bowls, jewelry, and cut beads for chandeliers. Nearly all of the smoky quartz crystals were cut, but three survived for display in the Bern Natural History Museum.

In 1868 crystal hunters from Guttanen, Bern, came upon a quartz vein high in a cliff above the Tiefengletscher just across the canton border of Uri to the east. With hammers and black powder they followed a fissure containing smoky quartz crystals, until night fell. They were still tied to ropes on the precipice when a violent thunderstorm arrived with hail and snow. Unable to get down they spent the night on the rock wall huddled together to avoid freezing. Almost miraculously, the men survived and continued their work the next day. Finally blasting into a giant cavern, they

were bitterly disappointed to see nothing but barren walls and a black dirt floor. But scraping the dirt away, they discovered many beautiful smoky quartz crystals. Throughout the ages they had been carefully preserved, unspoiled and undamaged.

Returning to Guttanen the elated discoverers mobilized nearly the whole male population who spent eight days emptying the cave of its contents. Ten tons of crystals packed in cloth were lowered down the cliff, then hauled down a glacier and across ravines to the Furka road whence a Grimsel innkeeper provided horses to pack out the gems. The largest of the "smokies," weighing 130 kilograms, and named "the Grandfather," went to the Museum of Natural History in Budapest, where Soviet artillery shells severely damaged it in 1956.

Two other outstanding crystals went elsewhere: a fine prism, first sent to the British Museum (Natural History), was returned to the Bern Natural History Museum in 1970; the finest of all, "the King," is now displayed in Bern also.

Typical alpine quartz crystals appear as normal hexagonal prisms in penetration twin form. Crystals from the Tessin region in southern Switzerland tend to taper at the termination. *Gwindel* (twisted quartz crystals) happen infrequently in the Central Aar Massif. Most twisted crystals are transparent and a light to dark smoke color. The Swiss Federal Institute of Technology in Zurich and the Natural History Museum in Bern display some of the best.

Alpine quartz frequently has inclusions of chlorite and, more rarely, actinolite, rutile,

BELOW: Mining for smoky quartz on the Tiefengletscher, 1868 Courtesy: Bern Museum of Natural History

OPPOSITE TOP RIGHT: Smoky quartz from the Tiefengletscher, mined in 1868. Largest crystal is one meter high. Collection: Bern Museum of Natural History

OPPOSITE BOTTOM LEFT: Ernst brings out a slab of mud-covered quartz crystals under gate which guards his pocket Courtesy: Ernst Rufibach Photo: Trachsel

OPPOSITE BOTTOM RIGHT: Peter Indergand selling smoky quartz crystals to a German family in his shop at Goschenen, 1972 Photo: Peter Bancroft

jamesonite, anhydrite, or pyrite. Crystals with bright, clear faces form on walls and ceilings, while those which grow on pocket floors are generally frosted with chlorite.

One of the most remarkable examples of smoky quartz is a 214-kilogram cluster of brilliant, well terminated crystals housed in Peter Indergand's mineral store in Goschenen, Canton Uri. This undamaged mineral masterpiece was mined by Indergand's father, a *strahler,* in 1946 at an elevation of 2562 meters on a jagged peak near the Tiefengletscher. The elder Indergand worked alone and exerted extraordinary effort to carry his prize down the mountain in a blizzard. His remarkable feat, under most unfavorable conditions, perhaps contributed to his premature death soon thereafter. Had he known the price he would pay for his crystal treasure, he probably would have made the same decision—to bring it in alone. He was that kind of a man, and crystal collecting was his obsession. Today the glistening cluster of quartz crystals represents a monument to the courage and indomitable will of a rare breed of man—the *strahler.*

In Switzerland nearly all quartz specimens are gathered by the *strahlers,* for various reasons. Many live in the mountains as farmers, mountain guides, hydroelectric workers, or shopkeepers. They understand the idiosyncrasies of the high country and not only survive most weather, but do so in relative comfort. More important, these mountaineers can dangle at the end of a rope fastened by pitons to the sheer face of a cliff as they probe for the elusive cleft. Many *strahlers* hunt crystals for the joy of the search rather than for love of the specimens themselves. Others seek to augment the family income. However, a substantial number of prospectors have a passion for self-collected crystals, and their better pieces are not available at any price. The wife of one well-known collector was seriously considering divorce when she told the author, "Enough is enough! Like clockwork each Saturday and Sunday he is gone to his

mountains in any kind of weather. He loves the peaks and his crystals above everything else. It is hardly flattering to be so far down in his interests."

Many *strahlers* are injured in pursuit of their hobby; a few die. In 1971, Hans Rufibach, his two sons, Andreas and Alfred, a brother, and a large group of friends climbed to the lofty parts of the Zinggenstock to remove a giant group of quartz crystals weighing hundreds of kilograms. The idea was to keep the specimen intact, possibly by taking it from the mountain by helicopter. Working on the edge of a great cliff, the party secured a rope across a wide chasm, like a tramway cable and tied another rope around the quartz. Without warning, the quartz broke in two and plummeted downward, triggering an avalanche of rock which hurled some of the party to their deaths including Hans, his two sons and another couple. Two others were seriously injured. All were experienced mountaineers, long-time collectors, and well known *strahlers,* and the tragedy was felt throughout Switzerland. Today the finest crystals from the giant specimen are displayed at Guttanen in the private museum of Ernst Rufibach, Hans's brother.

THIS PAGE TOP:
Gwindel (twisted) smoky quartz
Size: 12 by 7 cm
Locality: Tiefengletscher
Collection: Bern Museum of Natural History
Photo: P. Vollenweider

THIS PAGE BOTTOM:
Smoky quartz
Size: (smallest crystal) 5 by 3 cm
Locality: Val Giuv, Sedrun, Switzerland
Collection: Swiss Federal Institute of Technology
Photo: Marcus Graf

OPPOSITE: Binna brook and the town of Binn, 1969
Photo: Peter Bancroft

84 Lengenbach Quarries, Binn, Wallis, Switzerland

The Binna River Valley, one of the loveliest localities for a mine, is situated in Switzerland just 3 kilometers north of the Italian border. The highway south from Zurich crosses up and over the breathtaking Furka and Grimsel passes and down the Rhone Valley to the tiny village of Fiesch. From there a narrow winding road climbs over a small range of mountains and then enters the narrow Binna Valley. The little village of Binn straddles a picturesque crystal-clear stream called Binna Brook. From Binn an unpaved road ascends the final few kilometers to a dolomite outcrop surrounding the Lengenbach quarry. Tiny as mines go, this small hole—only 40 meters across—has produced an astounding number of mineral species, many of them previously unknown.

In 1728 the Governor of Wallis Canton employed two Englishmen to explore the Binna Valley for ore deposits. They found a rich ledge of pyrite and dug a tunnel to probe its depths. However, Catholic residents of the valley resented the intrusion of Protestants and forced them to abandon the venture. The find lay dormant until the early 1800s when a number of unidentified minerals were discovered in the Englishmen's dump. Samples sent to universities and museums throughout Europe caused considerable excitement. About 1833 Charles Lardy conducted the first scientific investigation of Lengenbach minerals, especially realgar and orpiment. In 1875 A.A. Damour described dufrenoysite, a lead arsenic sulfide, as a new mineral species, the first of a number of now well-known minerals discovered at the Lengenbach quarry. Curators and collectors were intrigued with the perfection of their crystal forms. The quarry became a popular collecting locality and many of the rare, fragile crystals were lost to inexperienced visitors.

In 1899 Binn pastor Theodore Walpen put the quarry off limits to the public, organized a consortium of local men who claimed

ownership of the deposit, and began mining for mineral specimens. Under Franz Jentsch's direction the quarry flourished until 1907 though mining techniques were crude and laborious. Drilling was done by hand. Black powder instead of high explosives was used for blasting in an effort to conserve crystals. Waste rock was removed in wooden wheelbarrows. Crystals were carefully gathered and hauled down to Binn where they were placed on tables in a drafty building where specialists sorted, cleaned, labeled, and priced each specimen. Income from sales was divided into shares, one for each miner and worker. Extensive mining produced hundreds of fine crystals. Englishman R.H. Solly described no less than eight new sulfosalt species. But the Binn association was dissolved in 1908 when Jentsch died in a sledding accident.

THIS PAGE TOP:
Mining the Lengenbach Quarry, 1906
Courtesy: Basel Natural History Museum
Photo: Paul Bohny

THIS PAGE BOTTOM:
Main street in Binn, 1969
Photo: Peter Bancroft

OPPOSITE TOP:
Lengenbach Quarry in 1969
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Max Weibel (center) and mine foreman, 1969
Photo: Peter Bancroft

During and after World War I, a series of avalanches nearly destroyed the Lengenbach quarry. In 1957 a working partnership of Swiss universities, museums, and individuals reopened the quarry to mine rare minerals for scientific studies. Today miners still gather more of the tiny unique crystals which continue to be in great demand by collectors everywhere.

Many Swiss alpine minerals are so perfect in form and appearance that characteristics may identify their origin. This is particularly true of crystals from the Lengenbach quarry, whose mineral combinations resemble those from no other locality. Thousands of isolated crystals have been recovered locked in snow-white saccharoidal (granular) dolomite, a unique occurrence in the mineral world. These beautiful crystallized minerals are brittle sulfosalts and sulfides.

To date 70 mineral species have been identified from the quarry, the type locality for 18 of them. Eleven minerals have been found only here: hatchite, lengenbachite, marrite, rathite, trechmannite, sinnerite, sartorite, baumhauerite, wallisite, nowackiite, and imhofite. Many are so rare that few major mineral collections have examples. Species in exceptional crystals from Lengenbach include sartorite crystals of 1 centimeter, lustrous dark brown and honey-brown sphalerite crystals, and 1-centimeter tennantite crystals. Others are jordanite, dufrenoysite, baumhauerite, liveingite, realgar, orpiment, hyalophane and goyazite.

Other fine deposits near the Lengenbach have produced rare minerals. In particular the Lercheltini gneiss fissures, now known as the Binneltini deposit, 1.5 kilometers to the northeast, have contributed exceptional hematite, rutile, perfect magnetite octahedrons, monazite, xenotime, and the world's largest well formed anatase crystals, some of which measure to 5.5 centimeters. Crystals here form in gneissic rocks.

A visit to the Binna Valley, the village of Binn, and the Lengenbach quarries, particularly in early summer or early autumn, can be combined into a collecting trip and an unforgettable vacation.

Collecting is prohibited in the quarries, but permitted on the waste dumps. Small crystals, some quite rare, are for sale in Binn mineral shops.

THIS PAGE TOP:
Anatase
Size: Anatase 3.1 by 2 cm
Locality: Lengenbach
Collection: Vienna Natural History Museum
Photo: Olaf Medenbach

THIS PAGE BOTTOM:
Anatase with calcite
Size: Anatase 3.75 by 3.25 cm
Locality: Binnatal
Collection: British Museum of Natural History
Photo: Peter Green and Frank Greenaway

OPPOSITE LEFT:
Epidote
Size: 18 by 8 cm
Locality: Knappenwand
Collection: Edward and Betty Harrison. On loan to Los Angeles County Museum of Natural History.
Photo: Harold and Erica Van Pelt

OPPOSITE RIGHT:
Epidote with apatite
Size: 8 by 3 cm
Locality: Knappenwand
Collection: William Larson
Photo: Harold and Erica Van Pelt

85 Knappenwand Mine, Neukirchen, Austria

Knappenwand on the upper Poperg Ridge of the Untersulzbachtal is remote, aloof, and serene. This locality on the northern approach to the majestic Venediger Group in the Hohe Tauern Alps attracts skiers in winter and mountain climbers and mineral collectors during summer months. The grandest epidote crystals in the world occur here.

Crystallized epidote is fairly common throughout the world. Fine crystals occur at Traversella, Italy; Bourg d'Oisans, France; Ticino, Switzerland; Haddam, Connecticut; and Prince of Wales Island, Alaska. But the brilliant rodlike crystals from Knappenwand are the classics. Highly prized by collectors, Austrian epidote has mirror-bright shafts topped by clean and sharp terminations. From Knappenwand 183 different crystal forms of epidote have been identified, many of them in complex combinations. Giant crystals grow to 50 centimeters in length and 8 centimeters in thickness. Epidote frequently forms in clusters with masses of byssolite (a fibrous variety of actinolite-termolite) matted about the point of attachment to the matrix. Although epidote at the Knappenwand is generally the traditional pistachio-green color with shades darkening to nearly black, some completely transparent crystals were found and faceted into rare if rather undistinguished gems. In reflected light most Knappenwand epidote appears to be very dark green or black. Gemmy sections frequently appear brown from one direction in transmitted light and green when rotated 90°—a striking example of dichroism. Pale yellow epidote also occurs. Commonly associated minerals are white lustrous clear apatite crystals, calcite, and feldspar. Some apatites containing byssolite hairs as inclusions are among the best apatite crystals in the world.

Alois Wurnitsch, a mountain guide, discovered Knappenwand in 1865. He was attracted by the pretty crystals exposed at the bottom of a cliff and offered them to a mineral dealer in Innsbruck, who in turn sent them to Professor Victor Ritter von Zepharovich of Charles University in Prague. Impressed with their exceptional brilliance, perfection, and size, Zepharovich described the crystals as the "most beautiful epidote crystals ever found" in a paper, "New Mineral Finds in Salzburg."

The epidote site was still considered a prospect, and only the outcrop was worked when weather permitted. In 1869 a collection of crystals was sent to the Natural History Museum in Vienna where an agent of Austria's Emperor Franz Joseph saw them on display. He made arrangements for a large collection of crystals to be mined and sent to the Vienna museum. A tunnel was drifted into the cliff following the vein which was from 1 to 2 meters in height and width. Scores of crystals made their way to Vienna's museum.

In the meantime, assistant miner Trojer Sebastian, a part-time farmer, took particular care in recovering epidote crystals, then wrapping them, to preserve many fine undamaged specimens. Andra Bergmann assembled a large collection, personally presented it to many of Europe's museums and collectors and sold nearly all of it for "thousands of gold coins." The natural history museums in London, Vienna, and Budapest acquired the best of the material and the first two still display their collections. But the grand mineral collection at the Budapest Museum was burned in 1956 by invading Soviet armies whose cannon and rockets destroyed fabulous displays of epidote, opals, and other gems.

On a cold clear day in March 1980, the author hiked from the tiny village of Neukirchen to the epidote mine at Knappenwand. The snow covered trail was difficult to follow as it wound through the spruce forest. The mountain was silent except for the gurgle

THIS PAGE TOP:
Working top of Knappenwand cave for epidote in 1930s
Courtesy: Vienna Natural History Museum

THIS PAGE BOTTOM:
Drilling with gasoline jackhammer in hard rock in epidote mine, 1930s
Courtesy: Vienna Natural History Museum

OPPOSITE TOP:
Epidote
Size: 4 by 4 cm
Locality: Knappenwand
Collection: William Larson
Photo: Harold and Erica Van Pelt

OPPOSITE BOTTOM:
Apatite (with byssolite inclusions)
Size: 5.5 by 3 cm
Locality: Knappenwand
Collection: David Eidahl
Photo: Harold and Erica Van Pelt

THIS PAGE TOP: Winter view of the Untersulzbachtal, site of the epidote mine, taken from ancient ruins near Neukirchen, 1979
Photo: Peter Bancroft

THIS PAGE BOTTOM: Looking west at the Obersutzbachtal from the epidote cave, 1979
Photo: Peter Bancroft

OPPOSITE: Old cabin built in side of cliff at epidote mine to avoid avalanches, 1979
Photo: Peter Bancroft

of streams, the thump of snow falling from trees, and the echoing crash of an occasional avalanche. About 3 kilometers into the mountains, a tiny metal sign announced that the property above had been leased to the Vienna Museum of Natural History. There was no track to the epidote deposit, and the climb continued steeply through waist-deep snow for another 300 meters around the ruins of an old log cabin and the main cave. The dumps lay beneath deep snow. Although the cave walls showed no sign of epidote, small crytals could be collected on the floor.

The dump offered incredible views. Off to the left rose ridge after ridge, ending with the jagged 3674-meter Grossvenediger, the region's highest peak. Because the terrain is too rugged for skiing there were no hiking huts in the vicinity, and absolutely no human movement or sound. Back in the mountains the Habachtal emerald mine lay hidden, as did granite outcrops which have produced adularia, quartz, calcite, and brilliant transparent yellow sphene crystals. To the east behind the Grossglockner, a handful of old gold mines were still blanketed in winter. Even after generations of collectors have roamed the valleys, ravines, and crests, quality specimens can still be found in this rugged region.

The Mineralogical Department of the Vienna Natural History Museum, under the direction of Gero Kurat, is currently reopening Knappenwand which has been worked only infrequently during the last 110 years. Sections of a 10- by 4-meter building have been winched up the steep slope and reassembled as living and storage quarters on the site to permit year-round operation. Currently the cave-like tunnel extends into the cliff about 30 meters. It will be rapidly deepened with special heavy-duty machinery and explosives. Museum officials express optimism about Knappenwand's future.

86 Lovisin Mine, Tunaberg, Sweden

The very old cobalt-copper mines at Tunaberg are located 14 kilometers southwest of Nykoping in Sweden. Historical references fail to indicate the discovery date of these mines, two shafts called the Lovisin and the Goran near the ancient church.

In the early days the ore deposit was worked for copper, while cobalt (if discovered at all) was overlooked as worthless. The deposit was such an important source of copper that local officials created a special mining district so that the ore body could be properly exploited. The oldest remaining document pertaining to the antique deposit is a letter dated 1420 in which King Erik of Pommern extended special privileges granted to Tunaberg miners some years before, such as reduced taxes and exemption from military service. The extension was valid "until further notice."

King Johan III owned the mine from 1568 to 1570, and it was operated with modest success. Then King Karl IX took over the Tunaberg operation, and shafts reached the 52-meter level. The main cavern was cleaned out, but little ore was found. Water filled the lower levels faster than it could be bailed out, so work ended. When surface pockets of copper were exhausted, the mines were left idle for the next two centuries. Miners moved away, leaving the area to the farmers.

In 1753, mining experts reassessed the old site and concluded that valuable ores still

BELOW:
Smaltite in pyrite
Size: 12 by 8 cm
Locality: Tunaberg
Collection: Stockholm Royal Museum of Natural History
Photo: K.E. Samuelsson

OPPOSITE: Smaltite
Size: 8 cm
Locality: Hakansboda, Sweden
Collection: Stockholm Royal Museum of Natural History
Photo: K.E. Samuelsson

remained at depth. These men formed a mine owners association and in effect leased the property to a man named Seippel who received government approval to mine. When Seippel extended the tunnels downward, he encountered several large caverns which produced a considerable amount of copper. Seippel worked the deposit for 18 years and, surprisingly, arranged with the mine owners to make no payments from his profits.

In 1760 the mine was bought by Gerhard de Besche, who made major underground extensions. During the 40 years he worked the deposit, copper production increased to an average of 30 tons annually. Toward the end of the 18th century, cobalt was discovered near the main Storgrufvan cavern (later called De Besche), the largest pit on the lode. With copper production falling off, the discovery of substantial amounts of smaltite and cobaltite was encouraging.

During the first half of the 19th century, Tunaberg ores contributed an important portion of the world's cobalt concentrates, which were used primarily for smalt or cobalt blue, a coloring agent and pigment in inks and deep blue glass. In 1845 the discovery and manufacture of artificial ultramarine depressed cobalt prices forcing many factories and mines to close. Tunaberg was worked off and on under a number of owners until it closed for the last time in the 1880s, when a massive cave-in destroyed much of the underground workings.

Today, pit holes, partially filled with water and surrounded by brush and trees, outline the old workings which horizontally measured 1400 by 900 meters. Tailings covered with brush, trees, and grass have been nearly obliterated with the passage of time. Miners of another year sleep peacefully under leaning markers in the little church cemetury.

The rich ore beds at Tunaberg formed as intrusions in a huge mass of limestone. The

metamorphic country rock of gneiss and marble carry the minerals galena, chalcocite, smaltite, cobaltite, and chalcopyrite. In contrast to nearly all other cobalt mines where crystals are small at best, they were common here and included large fine crystals of cobaltite. Cobaltite crystals form in beautiful cubes (sometimes heavily striated) and as pyritohedrons resembling pyrite. Some crystals measured to 5 centimeters in diameter but two problems made it difficult to recover them intact. Because the crystals occurred in the best of the ore, nearly all went to the mills. Secondly, the larger crystals tended to form in solid chalcopyrite and removal from their matrix was nearly impossible without fracturing brittle crystal faces. A large cobaltite crystal with clean and unmarked crystal edges is rare indeed. The finest collection of cobaltite

THIS PAGE TOP:
Gunnar Lindberg, Lovisin mine manager, 1860s
Courtesy: Tunaberg Museum

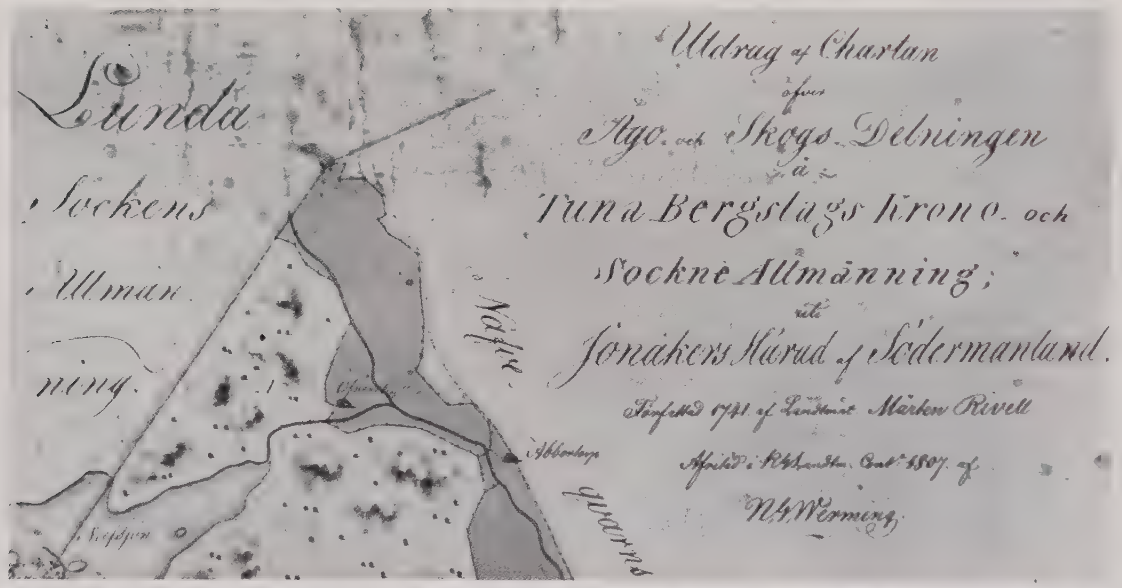
THIS PAGE MIDDLE:
Early map of Tunaberg Mining District, 1807
Courtesy: Tunaberg Museum

THIS PAGE BOTTOM:
Swedish miners "with their bucket," c. 1895
Courtesy: Royal Swedish Museum of Natural History, Stockholm
Photo: A. Karlsson

OPPOSITE TOP RIGHT:
Main Lovisin workings filled with water, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT:
Worked out Lovisin vein, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Markers near museum commemorate miners of yesteryear
Photo: Peter Bancroft



crystals is displayed in Stockholm's Museum of Natural History; cobaltite dodecahedrons of exceptional quality measure to 8 centimeters.

Associated minerals were erythrite (infrequently found as pretty druses within small vugs), calcite, zoisite, scapolite, titanite, magnetite, sphalerite, galena, allanite, and smaltite crystals.

Both mineralogists and nature lovers enjoy visiting Tunaberg between June and October. Rolling, tree-bordered farms separated by small lakes extend to the sea where many inlets, bays, and small beaches await the sports enthusiast. The tiny museum at Tunaberg staffed by Ingrid Flemk, the old mine buildings, and the surface pits partially filled with water are well worth the 80-kilometer drive from Stockholm.

87 King's Mine, Kongsberg, Norway

In 1623 two Norse farm children watched a bull gouge moss from a rock at a place now called Kongensgruvehaugen (King's Mine Hill). The youngsters, Christoffer Grosvold and Helga Verp, found the animal had exposed a vein of shining silver. Helga's father then tried to sell the metal and was arrested as a thief. To clear his name, he disclosed his source of treasure and before long King Christian IV claimed the lode for the crown, naming it the King's mine. He invited highly skilled Germans from the Harz mining district to introduce the latest mining techniques to Scandinavia. Today many Kongsberg families bear the names of their German ancestors.

As shafts were dug, 12-meter wooden wheels raised waste water from the depths. (In about 1730, the water-powered wheels were adapted to raise ore buckets on chains.) But the mountain lacked sufficient water to operate the machinery and near the peak mine director Heinrich Schlanbusch built dams of marsh mud squares confined between parallel stone walls a meter apart. Thirty dams, some of them 5 meters tall, were built between 1660 and 1690, and the project was considered one of northern Europe's engineering marvels. Some of these dams still hold water and supply the city of Kongsberg 500 meters below.

When the last mine closed in 1956, Kongsberg had produced 1350 tons of pure silver. The largest single mass reportedly weighed 500 kilograms. The story of incredibly rich, extensive veins and 300 years of arduous, sometimes extremely dangerous work is grist for a full volume, but excerpts must suffice here.

By 1771, 80 mines, 24 crushing plants and 2 foundries were operating. As many as 4259 men worked for the mine company, and Kongsberg became one of Norway's largest towns.

Popular lore holds that for every three kilograms of silver exposed in the mines one

THIS PAGE LEFT:
Silver
Size: 21 by 14 cm
Locality: Kongsberg
Collection: Oslo Geological Museum
Photo: Gotfred Teigen

THIS PAGE RIGHT:
Silver
Size: 4.5 by 3.3 cm
Locality: King's mine
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE LEFT:
King Christian IV, first owner of the King's Mine, c. 1620
Courtesy: Kongsberg Mining Museum

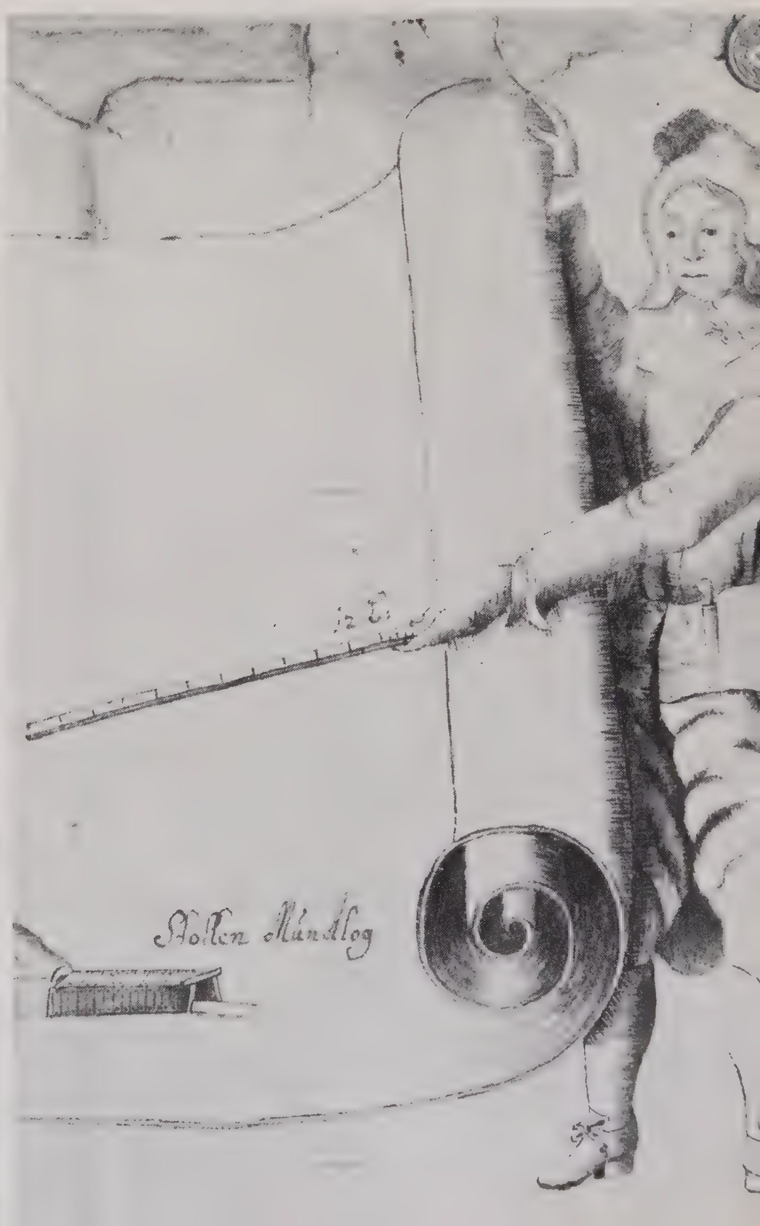
OPPOSITE RIGHT:
Mining engineer portrayed on mine map dated 1706
Courtesy: Kongsberg Mining Museum

was lost to the dumps and one stolen by poorly paid miners. The penalty for theft was heavy—a miner caught could be hanged or, for a small amount, lose a hand. (Few hands were lost and no one hanged, but many convicted thieves became slaves in castles throughout the realm.) Much of the pilfered ore was sold to silversmiths in Telemark and Setesdalen, areas famous for beautiful silver work. Questioned about their sources, the smiths would tell of buying from anonymous prospectors who had found the metal high in the mountains in dense fog and were unable to retrace their steps.

Kongsberg mountain contains a variety of gneiss formations which run almost due north and dip at about 70° to 80° east. Because banding and foliation run consistently throughout the mine, miners find their bearings simply by studying mine walls. *Fahlbands* (sulfide-impregnated zones within the gneisses) are easily recognized in the mountain by their rusty appearance, caused by the decomposition of iron sulfide minerals. East-west striking calcite veins intersecting the *fahlbands* frequently contain silver. This phenomenon was so predictable that old-timers often said, "Without fahl and vein, there is no silver." Calcite veins varied from 1 millimeter to 1 meter in thickness, and miners quickly learned that when they encountered *drusroms* (hollow vugs) they would often find them filled with beautiful specimens of silver and other minerals.

Miners experienced great difficulty with the gases and smoke produced by the fire-set method until the problem was partially solved by constructing exhaust shafts to the surface. Brick vaults built at the top of drifts carried most of the gas to the exhaust shaft, while fresh air flowed into the working areas along tunnel floors.

The miner's incredibly long and complicated day began at the town church as early as three



in the morning with daily prayers. The 12-hour shift started when the men left the church. Then they trudged 7 kilometers up to the mine shaft, walked into the mine a kilometer or so, and climbed down ladders to their working stations. Many miners were also farmers, so a 5-day workweek was introduced in the early days.

Old-timers still recall priceless information and witty anecdotes. Ragnvald Dusterud, a pensioner who labored in the King's and other mines, remembers preparing to fire a round in the Mildigkeit Gottes (the munificent god's mine) in 1938. While waiting, he came across some pretty calcite crystals along the floor of the tunnel. Reaching down into murky water, he brought out silver wires imbedded in calcite. One mass of silver weighed 100 kilograms and was so heavy that he got it into an ore car with great difficulty. Thor Nilsen recalled extending a shaft downward in the

THIS PAGE TOP:
Silver
Size: 16.5 by 11.4 cm
Collection: Richard Webster
Photo: Earl Lewis

THIS PAGE BOTTOM:
Silver
Size: (Upper Left)
Crystal matrix 6 by 3 cm
Locality: Kongsberg
Collection: (Upper Left and Upper Right)
William Larson
(Lower) David Eidahl
Photo: Harold and Erica Van Pelt

OPPOSITE:
Silver with calcite
Size: 11 by 9 cm
Locality: King's mine
Collection: David Wilber
Photo: Harold and Erica Van Pelt

THIS PAGE TOP:
Miners skeiding (cobbing out the richest pieces of silver), c. 1900
Courtesy: Kongsberg Mining Museum

THIS PAGE MIDDLE:
Sagrenda portal, entrance to King's mine, 1912 (adit, 2.3 kilometers long, was finished in 1855)
Courtesy: Kongsberg Mining Museum

THIS PAGE BOTTOM:
King's mine washroom about 1910
Courtesy: Kongsberg Mining Museum

OPPOSITE TOP:
Mineral collector Per Halvor Solebakke in "gopher hole" entrance to King's old workings
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Thor Nilsen, former King's miner, at calcite vein in King's
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Only entrance to an abandoned section of the King's mine
Photo: Peter Bancroft

Saxon mine and blasting into a huge deposit of silver. He exposed a small mountain of bright crystals from which he eventually mined 1500 kilograms of pure metal. In living memory miners were paid for the distance they mined. A lazy man put aluminum foil from candy wrappers in holes and was able to continue working an area of softer ground. His boss thought the foil was silver. There was also the tongue-in-cheek story of an open pit on the mountain's side into which a shaft vented cool air. Cows would seek the cold draft to get away from insects. When a tourist asked why the cows stood there he was told, "We put them there to keep the milk cool." Dusterud also told of a miner who always beat his horse. One day the miner tethered the animal at the portal while he went to lunch, and upon returning was told his horse had eaten half a case of dynamite. "The miner didn't dare beat his horse for fourteen days."

Today mine tours conducted on original trains enter the old King's mine at the Sagrenda portal alongside the antique ore dressing plant. The two-hour trip into the old workings is one of the best mine visits anywhere.

The Mining Museum, alongside a beautiful river, is located in the original smelting house. A dozen large rooms contain a marvelous array of working models and mining antiques. Most memorable, the Silver Room, boasts at least 20 cases displaying one mineral species—silver. And what silver it is! There are wires up to 45 centimeters long, one of the world's best miniature specimens—a unique 5-centimeter twin silver crystal and a wire mass weighing 17 kilograms. In the next room, objects like an iron-studded cabinet in which native silver was stored before smelting and a large smelting pot remind visitors of the tons of beautiful silver wires and crystals that were melted into ingots. This marvelous collection and the fine mine tour, lure visitors seeking something very special to Kongsberg and its environs.

88 Himmelsfurst Mine, Freiberg, German Democratic Republic

During the latter part of the 12th century, silver was discovered at Freiberg, now part of the German Democratic Republic. Outcrops appearing in all directions led to a series of enormous ore bodies below the surface. Riches from the mines poured forth in such amounts that it was difficult to assess the total production. The Dukes of Saxony who owned the mines built elaborate castles and outfitted them with the finest furnishings. Cupboards, chests, and wall cases were laden with collections of silver vessels made from Freiberg metal and the region flourished.

In Dresden, 40 kilometers to the east, the Cabinet of Curiosities was created in 1560. One of Europe's earliest museums, the Cabinet displayed crystal and jasper cut and polished in Italy, various items of silver and gold, and paintings. Later the nearby Green Vaults of Dresden developed one of the most fabulous gemstones and wrought gold collections ever assembled; much of this accumulation survived both World Wars and exists today.

The world-famous *Bergakademie* (Mining Academy) at Freiberg, the first institution of its type in the world, was established in 1765 and became a mecca for the new science of mineralogy under the imaginative leadership of Abraham Gottlob Werner. During the 1850s Rudolf Benno Wappler filled a room of the Academy with minerals and fossils which he sold to students and faculty alike. Wappler's

THIS PAGE TOP:
Argentite
Size: 19 by 6 cm
Locality: Freiberg (Gersdorf mine)
Collection: Bergakademie Freiberg
Photo: Frantisek Tvrz

THIS PAGE BOTTOM:
Polybasite
Size: 6 by 4.7 cm
Locality: Freiberg
Collection: Bergakademie Freiberg
Photo: Frantisek Tvrz

OPPOSITE TOP:
Fluorite
Size: 10.5 by 10 cm
Locality: Freiberg (Halsbrucke mine)
Collection: Bergakademie Freiberg
Photo: Frantisek Tvrz

OPPOSITE BOTTOM:
Pyrargyrite
Size: 6 by 5 cm
Locality: Himmelsfurst
Collection: Bergakademie Freiberg
Photo: Frantisek Tvrz

thriving business established him as one of Europe's first mineral dealers. During the 19th century, a long list of distinguished professors taught at the Academy, including Humboldt, von Buch, Lyell, Bernhard von Cotta, d'Orbigny, Elie de Beaumont, and Murchison. By the 1870s hundreds of kilometers of tunnels, stopes, and shafts, some reaching downward to 700 meters, lay beneath Freiberg.

Hard-rock miners of the 1800s were highly skilled with hand tools and worked long hours. They dressed neatly in elaborate mining costumes of the day, wore stiff felt caps to protect their heads, and many smoked pipes. One thrifty old-timer, when offered a cigar, promptly put it into his pocket for safekeeping. When asked why he didn't smoke it, he answered with epicurean logic: "I'll save mine. I can get the good from your smoke now. If I should smoke at the same time, it would be like putting eggs on buttered bread."

Among the famous Freiberg mines, three stood out as producers of fine crystals. The Himmelfahrt mine, about 1 kilometer northeast of Freiberg, is renowned for the spectacular crystals of silver minerals taken from the Gottlob, Jung-David, Abraham, and Frisch-Gluck lodes. Owned and operated by the Saxon crown, in 1899 this mine employed more than 1100 men in one of Freiberg's largest operations.

The Elizabeth mine, whose tailings are on the northern edge of Freiberg, produced good grade ore as well as superior crystals. When it closed its workings a few decades ago, the property was kept as a training facility for apprentice miners. Today visitors may tour the surface installations which include a shaft house, warehouse, and mining museum.

At the Himmelsfurst mine, 8 kilometers southwest of town, remaining buildings resemble old farmhouses. Vegetable gardens surround the structures; grass and shrubs cover the dumps. No remnants of machinery or implements remain leaving the imagination to envision times when this farming scene bustled with hundreds of hard-rock miners, and its vugs produced an endless variety of prime crystals. The Himmelsfurst mine incorporated the famous Felix, Beschert Gluck, and David lodes, ore bodies still held in awe by specimen collectors.

Freiberg miners, like others everywhere, were superstitious. Many believed that both kindly and malevolent gods ruled the subterranean domain in which they worked. Regardless of their formal religious preferences, underground

workers frequently left food and small coins just to be certain they were not in conflict with the spirits of the depths.

More than 1100 separate silver ore bodies were discovered and developed in the Freiberg area. Veins varied from 30 centimeters to about 2 meters in width. Various deposits carried high values in silver, lead, copper, arsenic, and zinc. Fine crystals of a wide range of minerals occurred in vugs or "nests" scattered along veins at most of the mines.

Of the scores of mineral species found in the Freiberg district, those which formed in significant crystals include: clusters of pyrargyrite with individual crystals measuring more than 5 centimeters; masses of silver wires, many protruding from calcite; arsenopyrite; tetrahedrite; miargyrite; stephanite; wonderful yellow-orange groups of fluorite crystals; calcite; dolomite; siderite; barite in an assortment of colors such as brown, white, gray, and golden; proustite; cerargyrite; 3-centimeter polybasite crystals; xanthoconite; pyrostilpnite; stacks of argentite cubes reaching more than 17 centimeters high. The *Bergakademie* houses an incomparable collection of Freiberg minerals.

By the 1960s nearly all mines had closed including the famous Halsbrucke, Freiberg and Brand complexes, and Freiberg became a quiet little city of 20,000 people. In the late 1970s, new factories attracted immigrants and by 1980 50,000 inhabitants overflowed the town. New

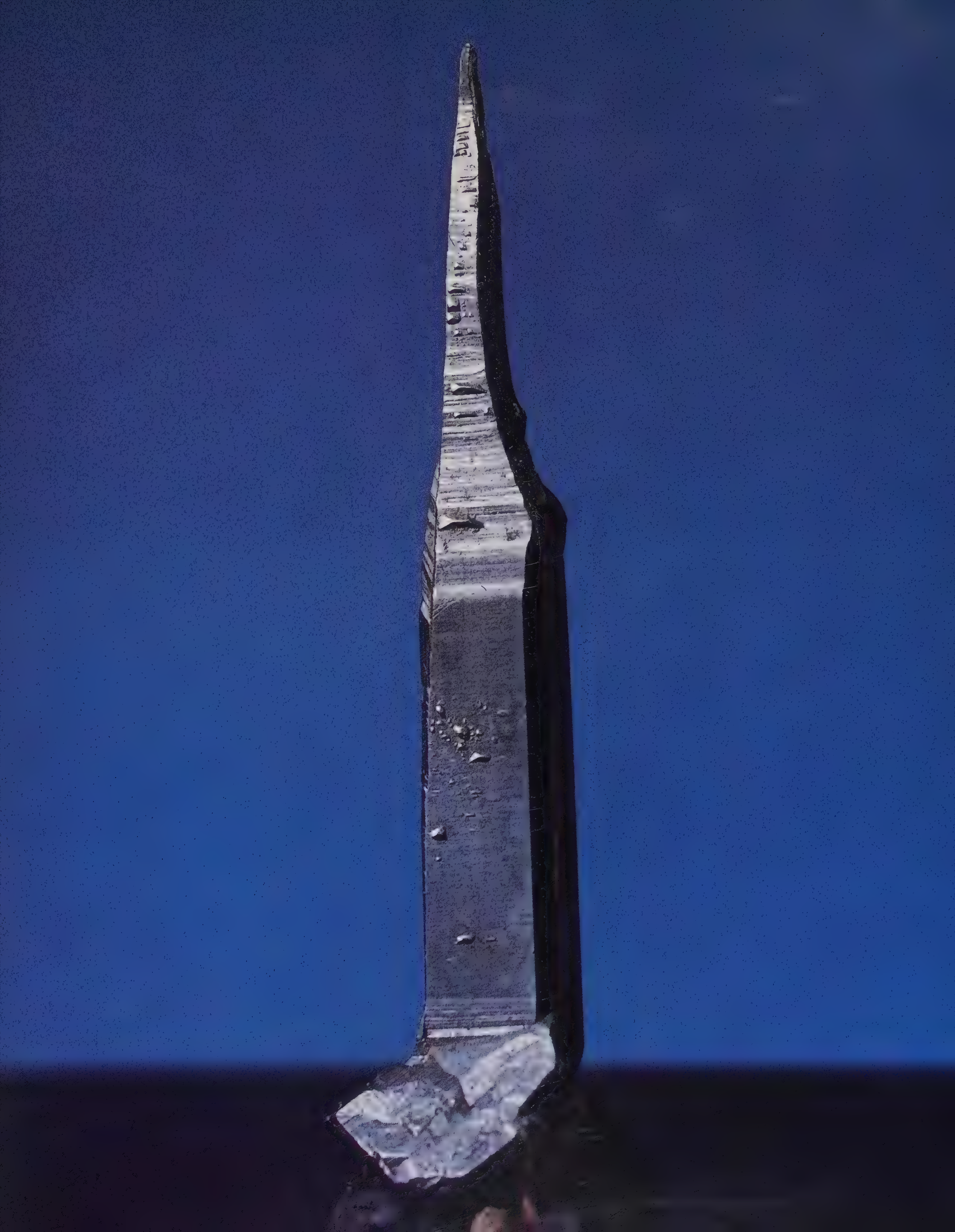
THIS PAGE TOP: Elizabeth shaft, Freiberg, 1906 Courtesy: Stadt-und Bergbaumuseum, Freiberg

THIS PAGE MIDDLE: Protestant miners at prayer before day's work in the Elizabeth, c. 1898 Courtesy: Stadt-und Bergbaumuseum, Freiberg

THIS PAGE BOTTOM LEFT: Ore train at Himmelsfurst, 1906 Courtesy: Stadt-und Bergbaumuseum, Freiberg

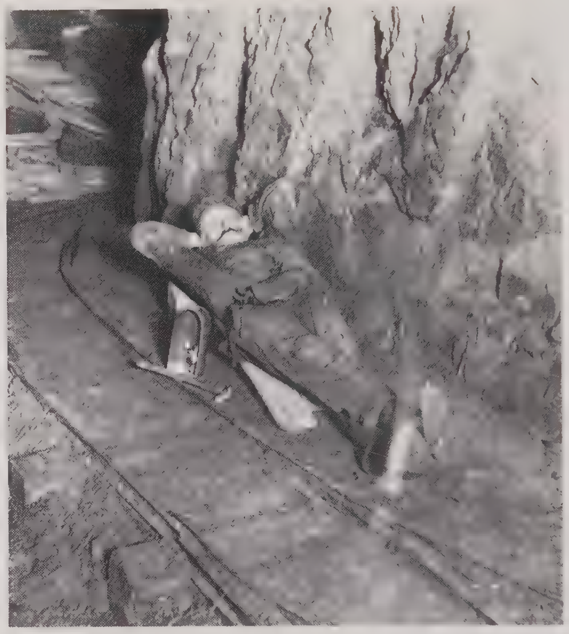
THIS PAGE BOTTOM RIGHT: Well-dressed Himmelsfurst miner, 1913 Courtesy: Stadt-und Bergbaumuseum, Freiberg

OPPOSITE: Acanthite Size: 5 by 0.5 cm Locality: Freiberg (Brand mine) Collection: Bergakademie, Freiberg Photo: Frantisek Tvrz



plants produce light bulbs, household utensils, and various types of machinery. Smokestacks throw a pall of smoke and blasts from nearby quarries add to the noise. The few major ore mines still producing comprise the most important lead-zinc district in East Germany.

Freiberg's old town is still well worth a visit. It features an Italian renaissance cathedral, 14th century town hall, quaint stone-paved squares, houses dating from the 13th century, long turreted walls in excellent condition, the historic Bergbaumuseum and library, and—possibly the greatest attraction of all—the Academy. Freiberg remains one of Europe's outstanding attractions for the mineral hobbyist.



THIS PAGE TOP LEFT: Fritz Hofmann stands in front of the remaining buildings of the Himmelsfurst, 1979 Photo: Peter Bancroft

THIS PAGE TOP RIGHT: Hobnailed-booted miner relaxing on "resting board", 1919 Courtesy: S.B.

THIS PAGE BOTTOM: Mine dump and mills at Freiberg, 1970 Photo: Peter Bancroft

OPPOSITE TOP LEFT: Meiseberg shaft at Neudorf, 1896 Courtesy: Harz Museum, Wernigerode

OPPOSITE TOP RIGHT: Group of miners in "full dress," Neudorf, 1899 Courtesy: Harz Museum, Wernigerode

OPPOSITE BOTTOM LEFT: Engineers, in typical dress, surveying mine near Neudorf in 1911 Courtesy: Harz Museum, Wernigerode, Hartmut Knappe, Curator

OPPOSITE BOTTOM RIGHT: These miners have just closed the Meiseberg mine for the last time (photo 1954) Courtesy: Harz Museum, Wernigerode

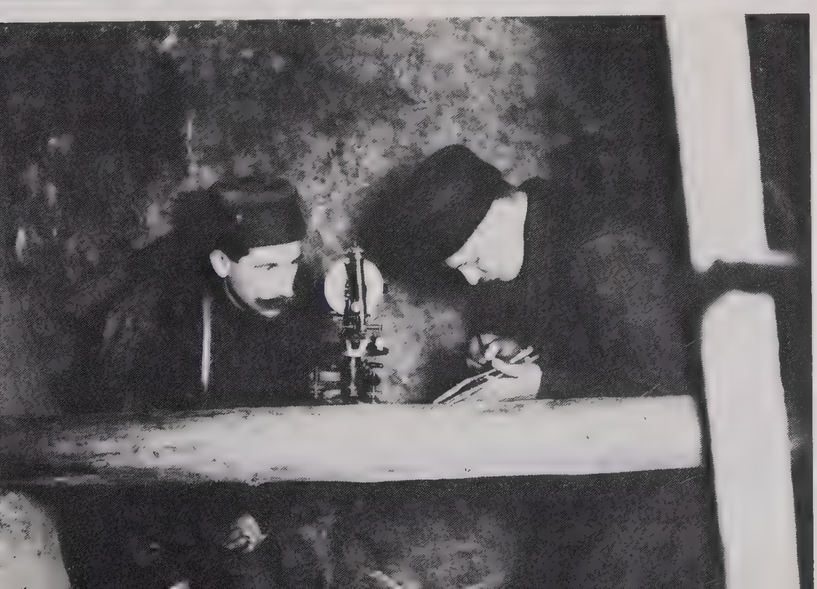
89 Appenrode/Neudorf Mines, Ilfeld/Harzgerode, German Democratic Republic

Wherever an exceptionally well crystallized manganite specimen is displayed, its place of origin proves to be Ilfeld in the Harz Mountains of the German Democratic Republic. No other locality has produced crystals of such luster, perfection, and size. Manganite is synonymous with Ilfeld.

The manganese deposits, located about 6 kilometers northwest of town, were explored and superficially worked during the 19th century. At first the deposits seemed so small they were not named; if they were, records have vanished. The main ore beds streak the hills bordering the small Eller and Fuhr rivers west of the Bere (Behre) River. The veins with concentrations of manganese occurred in a hornblende porphyry, principally in sections lacking quartz. Manganite was the principal ore; major associated minerals include hausmannite, barite, and calcite. Veins were only a few centimeters thick with the widest being about 60 centimeters and most terminated at a depth of 10 to 12 meters. Too small to interest important mining companies, they were numerous enough to encourage small-scale development. Two or three miners worked each vein with hand tools, uncovered a few good crystals, then bartered them for staples in Ilfeld.

The manganese lode at the nearby Monchenberg mine was so traversed by stringers of manganese ore that the whole deposit was worked as an open pit. Barite and calcite were the principal vein minerals in most Ilfeld mines, but rhodochrosite, rhodonite, and wad occurred throughout the district.

Outstanding manganite crystals were discovered during the 1880s and additional specimens unearthed until about 1920; nearly



all occurred near the surface. Usually forming in clusters, the flat-terminated, heavily striated, glossy black crystals measure up to 5.5 centimeters in length and 2 centimeters in width. A few manganite crystals grew with sharply contrasting white barite crystals.

The Appenrode, Harzeburg Braunsteinzeche, and Silberbach mines produced abundant supplies of the famous manganite crystal groups. Other crystals found at Ilfeld include tabular white barite crystals, fine brownish black hausmannite crystals, statactitic and botryoidal psilomelane, brilliant fibrous masses of gypsum (satin spar) popular with German collectors for cabochons, crystallized braunite, and brilliant 5-centimeter crystals of pyrolusite pseudomorphs after calcite.

A relatively small producer in world circles, between 1916 and 1920 Ilfeld processed only about 3360 tons of manganese. By 1923 the streaks of ore were gone; no manganite crystals were forthcoming, the mines were finished, and the miners had gone away.

Just south of Ilfeld the mountains change geologically from porphyrys to anhydrite through which run fissures of satin spar. During World War II German troops enlarged natural caves to form a huge labyrinth. In this subterranean fortress, Dr. Werner von Braun headed a staff of scientists and prisoners of war to produce the prototype of sophisticated rockets later used with deadly effect.

Few people know of the Ilfeld mines, but Hartmut Knappe, curator of the Harz Museum of Wernigerode, showed the author the few visible remains. Our party collected diminutive crystals on the dumps and in open cuts running through pretty forests of beech trees. Knappe discouraged my visiting the famous lead and silver mines at Neudorf. He said all the machinery has been removed and the dumps gone, to landfill in swampy areas.

The abandoned mineral locality of Neudorf, just south of Harzgerode, is about 25 kilometers east of Ilfeld. Once a productive silver-lead area, it was prospected and partially worked during the 18th century. Mining continued until the 1950s when ore bodies pinched out. (Other important Neudorf mines included the Pfaffenberg and Meiseberg.) Best known for its galena crystals—faultless cubo-octahedrons up to 8 centimeters frequently growing on beds of siderite and quartz crystals—Neudorf is also famous for tabular bournonite crystals, some exceeding 3 centimeters in length. Fine crystals of tetrahedrite, chalcopyrite, pyrite, quartz, and stibnite as well as some silver minerals have

BELOW:
Galena on siderite, quartz
Size: 6.5 by 4.5 cm
Locality: Neudorf
Collection: American Museum of Natural History
Photo: Arthur Singer

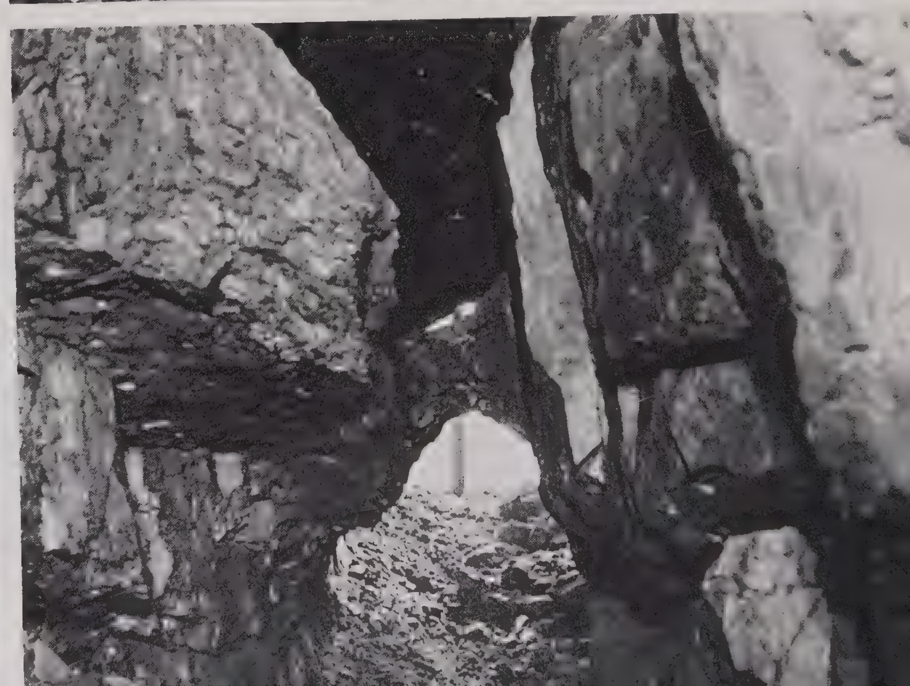
OPPOSITE TOP LEFT:
Solid silver miners' cup, symbol of miners' importance, Harzgerode-Neudorf, 1912
Courtesy: Harz Museum, Wernigerode

OPPOSITE BOTTOM LEFT:
Old Church of the Miners at nearby Stolberg, 40 kilometers southwest of Neudorf
Photo: Hartmut Knappe

OPPOSITE TOP RIGHT:
Ilfeld, quiet and filled with the elderly, 1979
Photo: Peter Bancroft

OPPOSITE MIDDLE RIGHT:
One of old dumps at Appenrode; manganese may still be found. 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Solberbach mine at Appenrode-Ilfeld which was last worked in 1923
Photo: Hartmut Knappe



come from the same mine.

The Harz mountains run northeast to southeast, roughly between Hannover, in West Germany and Leipzig, in East Germany. The border bisects the range, and the centuries-old silver-lead mines now lie in two countries. The renowned Samson mine at St. Andreasberg is just 20 kilometers west of Ilfeld in West Germany but the old road connecting the two has been closed at the border since Germany's partition after World War II. To drive to the Samson from Ilfeld or Neudorf, one must travel north to Expressway 8, turn west to the border checkpoint and then south to St. Andreasberg, a distance of 193 kilometers. The border creates considerable inconvenience for the tourist but fails to diminish the camaraderie between mineralogists in both Germanys and those who visit.

BELOW: Manganite
Size: 11.5 by 8 cm
Locality: Appenrode, Ilfeld
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt

OPPOSITE:
Pyrargyrite on calcite
Size: 7 by 4 cm
Locality: Grube Samson
Collection: George Holloway
Photo: Harold and Erica Van Pelt

90 Samson Mine, St. Andreasberg, Federal Republic of Germany

St. Andreasberg, about 25 kilometers southeast of Clausthal-Zellerfeld in the Harz Mountains of West Germany, has traditionally been a mining town. In recent years it has become a tourist resort. Throughout the year it is a place of beauty: gently rolling hills, small farms, narrow winding roads, and footpaths—a vacationer's country for summer strolling and bicycling. In winter its snow-clad slopes attract skiers.

St. Andreasberg lives in the past glory of its mines: the Grube Samson, the largest and deepest at 820 meters; the Gluckaufer, the Andreas Kreuzer; and the Catharina Neufanger. Their main shafts were connected by underground tunnels to facilitate ore haulage and ventilation. There were many other mines of lesser importance but little remains of their facilities or records.

In 1127 noblewoman Adelheid Klettenberg built the Kloster Walkenried monastery in the area of present-day St. Andreasberg. Its monks showed great curiosity for mining and are credited with developing the area's first ore deposits. They also named a nearby mountain St. Andreasberg after the regional patron saint of the mines. The Grube Samson came into being near the end of the 12th century on an immense silver-lead lode, and the town of St. Andreasberg grew up around the mine.

During the next century Count Hugo von Dorrefeld acquired numerous mines in the area and proceeded to greatly expand them. In 1287 local politics forced him to cede his properties to the citizens of Goslar, a place just north of St. Andreasberg. In 1347 a great plague struck the region killing thousands of farmers and miners. The mines were closed for a hundred years.

Gradually old mines were reopened and new ones discovered, but few people wanted to do underground work. In 1520 a group of noblemen from Lohre and Klettenberg joined forces with the princes of Honstein, took control of the region's mineral deposits, and offered valuable rights to any who would work the mines. Miners were permitted to cut the forests for firewood, and use open land for free pastures and crops. Exempt from military service, they could hunt and fish at will. Many

people responded to the lavish offers, and the mines prospered. Substantial numbers of emigrants came from the Tyrol region of Austria, and their dialect is still heard today in the beer parlors of St. Andreasberg.

Huge watermills powered the mines. Water to drive the machines came through sloughs from the Rehbergen Mountains, but too many wheels caused a shortage of water. For nine years workers toiled on dams and canals designed to deliver additional water to mine workings.

The Grube Samson showed great promise from the beginning and over the years it lived up to expectations by producing great quantities of silver and lead minerals. As the main shaft extended downward, heat increased and ventilation diminished. In 1777, Johann Wolfgang von Goethe, the German poet and

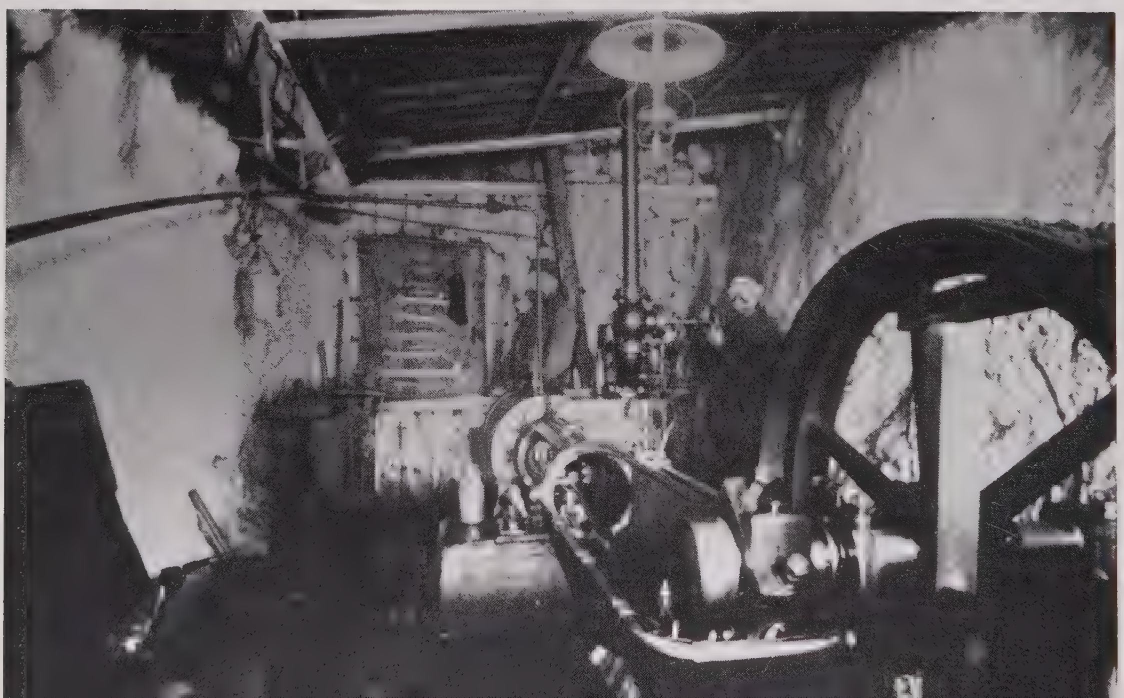
THIS PAGE TOP:
Dress costumes of a miner and wife of the Harz Mts., c. 1830
Courtesy: Grube Samson Museum

THIS PAGE MIDDLE:
Samson miners showing mining tools, lamps, and saws for cutting mine timbers, 1896
Courtesy: Grube Samson Museum

THIS PAGE BOTTOM:
Main hoist engine of Samson, 1878
Courtesy: Grube Samson Museum

OPPOSITE TOP:
Apophyllite
Size: 5 by 4 cm
Locality: St. Andreasberg
Collection: Ruhr Universitat Bochum
Photo: Olaf Medenbach

OPPOSITE BOTTOM:
Stephanite
Size: 5 by 4 cm
Locality: Grube Samson
Collection: John Barlow
Photo: Olaf Medenbach



dramatist, visited the Grube Samson. He noted that rock in the mine "was very hard, and life was quite difficult for the laborers." Yet Grube Samson tunnels were carved by hand into solid rock.

The mine maintained a work force of 200 men. No explosives were used in the early days and timbering was unnecessary. From the main shaft many tunnels were driven; both the Grunhirschler Stollen and Sieber Stollen stretch some 12 kilometers and connect the Grube Samson with nearby shafts. There are more than 120 kilometers of vaults and passageways.

By the end of the 19th century, the Samson was Europe's only silver mine surviving from the Middle Ages, and its main shaft had reached a depth of 810 meters to become one of the deepest shafts in the world. Big iron-banded wooden buckets raised ore to the surface and hauled men up during emergencies, though ordinarily miners climbed stationary ladders to and from work: A 90-minute descent was followed by a 150-minute climb back out. Obviously the system wasted both time and energy. Dangerous as it was, the mechanical walking ladder, developed in 1837, reduced travel time to about 25 minutes each way.

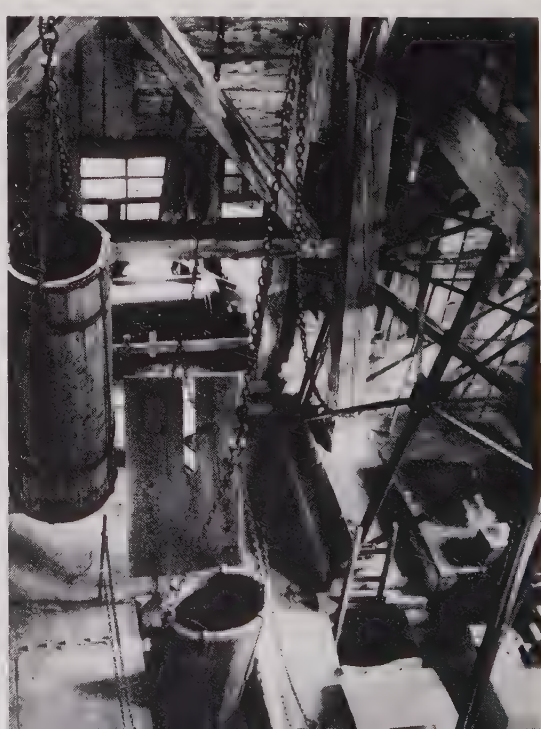
By 1862 St. Andreasberg was also becoming known as a health resort. People came great distances to be treated for asthma and heart disease. It was here that the famous "therapeutic health bath" of pine needles in goat's milk was devised.

The Samson produced an amazing variety of minerals, many of them beautifully crystallized: barite in a variety of colors; pyrite; apophyllite; green, blue, and golden fluorite; well formed bladed and "nailhead" calcite clusters; malachite; quartz; marcasite; galena; bournonite; pyrargyrite crystals up to 2 centimeters in length, some forming in beautiful combinations on white calcite; samsonite; stephanite; polybasite; cerargyrite; tetrahedrite; datolite; stilbite; analcime; argentite in fine cubic forms; siderite; smithsonite; agate; sulfur; gypsum; cobalite; copper; gold; silver; bornite; chalcopyrite; nickeline; schorl; celestite; proustite; realgar; and orpiment.

The mine's crystallized sulfosalts are particularly outstanding. Museums and private collections throughout the world feature Grube Samson's superb crystals of pyrargyrite, stephanite, and polybasite. Until the great finds of zeolites in India, pink apophyllite crystals

from St. Andreasberg were considered classics. (They are still highly regarded.)

Today the old Grube Samson is a working museum under the knowledgeable direction of Jochen Klahn. A tour features old mine machinery; demonstrations of the walking ladder and buckets; a collection of old photographs, miner's gear and clothing; a 50-meter climb down into the old mine workings; and a visit to the little gift shop. The town retains its fame as the center for breeding Harzer Roller canaries, and as a health and recreation resort for asthmatics and people with heart problems.



THIS PAGE TOP:
Miners in end of drift using strap iron mine rails, 1910
Courtesy: Grube Samson Museum

THIS PAGE MIDDLE:
Samson mine buildings, 1910
Courtesy: Grube Samson Museum

THIS PAGE BOTTOM LEFT:
Tiny mining scenes inside walnut shells, handmade by miners, c. 1850
Collection: Bergbau Museum, Bochum
Photo: Olaf Medenbach

THIS PAGE BOTTOM RIGHT:
Wooden ore buckets in Samson, vintage 1890
Courtesy: Grube Samson Museum

OPPOSITE TOP LEFT:
Antique all-wood ore car displayed in Bergbau-Museum, Bochum
Photo: Olaf Medenbach

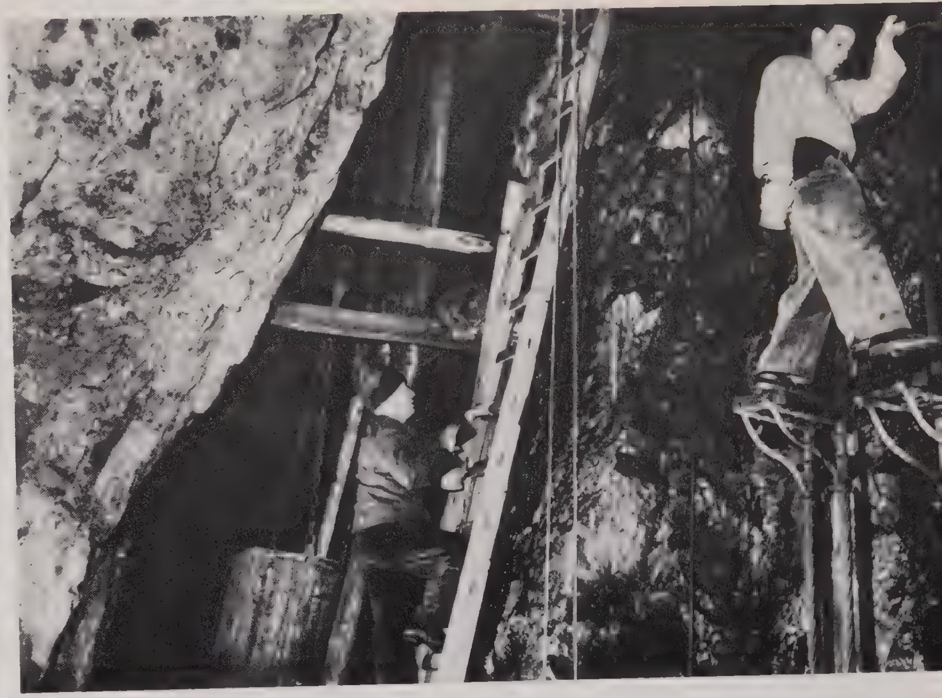
OPPOSITE BOTTOM LEFT:
Underground waters freeze into icicles in the Samson
Courtesy: Grube Samson Museum

OPPOSITE TOP RIGHT:
Grube Samson miners in winter, c. 1890
Courtesy: Grube Samson Museum

OPPOSITE MIDDLE RIGHT:
Traditional and "walking ladders" in Samson used in 1800s
Courtesy: Grube Samson Museum

OPPOSITE BOTTOM RIGHT:
Original Samson shaft building still stands in 1979
Photo: Peter Bancroft




91 Steinkaulenberg Mine, Idar-Oberstein, Federal Republic of Germany

During the Middle Ages, abundant amethyst and agate chips and boulders were discovered in the stream bed of the Nahe River flowing through the tiny twin cities of Idar and Oberstein. Enterprising Germans, wishing to use the plentiful water supply, located their lapidary shops along the stream's banks and established a thriving gemstone industry by the 1550s. Craftsmen created agate bowls, boxes, and jewelry, which became popular throughout Europe. A busy trade route was established to Frankfurt, 125 kilometers to the northeast.

As alluvial supplies of gem material diminished, miners found that surrounding hills contained rich deposits and dug a number of tunnels in search of subterranean treasure. They found great quantities of almond-shaped geodes, many full of bright druses of smoky quartz, white quartz, and amethyst. Red, yellow, and multicolored chunks of jasper weighing up to 30 kilograms, common in the mines, are still turned up by highway builders and farmer's plows.

Important Nahe district mines included the Baumholder, Grunbach, Ronneberg, Uzenbach, Hoppstadten, Rimsberg, Burbach, Mackenrodt, and Steinkaulenberg/Galgenberg (the latter a part of the Steinkaulenberg agate mine complex). The name Galgenberg means "hanging-tree hill." Celtics constructed an

BELOW:
Agate interlined with amethyst
Size: 12.5 cm
Locality: Steinkaulenberg
Collection: Hein Gaertner
Photo: Karl Hartmann

OPPOSITE LEFT:
Agate, gold trimmed
Size: 10 by 5 cm
Locality: Idar-Oberstein
Collection: German Gemstone Museum
Courtesy: Paul Ruppenthal
Photo: Karl Hartmann

OPPOSITE RIGHT:
Agate cameo, set in gold
Size: 4 by 3 cm
Locality: Idar-Oberstein
Collection: Hein Gaertner
Courtesy: Paul Ruppenthal
Photo: Karl Hartmann

open-air theater atop this rise centuries before the Christian era. The Nahe district, formerly part of Prussia, extended into Oldenburg. Today it is known as Rhenish Palatinate in the state of Rheinland-Pfalz.

More than 50 mines were developed in the hills about Idar-Oberstein, but production of high-quality material declined by 1800. Because much of the local lapidary industry depended upon neighboring mines, many mills and shops closed, throwing hundreds of craftsmen out of work. Even the two largest mines, the Baumholder and the Steinkaulenberg, were running out of good gem material. These mines had made numerous technical improvements since the early days when miners worked by hand with hoes, picks, hammers, ladders, candles, oil lamps, and crude winches. Shafts had been built, and many "mouth holes" were dug to the outside to improve ventilation. Still, the crooked tunnels and pits remained dangerous, and serious accidents were common.

In 1827 mammoth agate deposits were discovered in Rio Grande do Sul, Brazil. German buyers traveled to the new fields and acquired enough mines, farms, and stockpiles to control the new Brazilian agate industry. Cheaper Brazilian material forced the closure of the Nahe mines but revived the flagging Idar-Oberstein lapidary business.

Compared to amethyst from Namibia, Brazil, and Uruguay, the Steinkaulenberg material is lighter in color but equal in brilliance and clarity. Nahe agates are generally smaller than those from Brazil (one Brazilian stone weighed a colossal 2 tons), and many contain a finer banding. Local agate occurred in charming natural pastel colors of pink, blue, yellow, and green.

Idar's gem merchants had learned from the Romans how to dye agate black; they developed techniques to produce other colors. Porous zones in agate accept foreign solutions

which impart color, depending upon the particular solution, and formulas became jealously guarded secrets. By 1819 agates were dyed black by immersion for three weeks in a hot syrup of honey or sugar followed by a bath in sulfuric acid. Soaking certain agates in warm hydrochloric acid for two weeks produced lemon yellow stones. Blue, in shades from indigo to azure, resulted from several dyes; a common process was to soak stones first in potassium ferrocyanite then ferrous sulfate. Nickel salts and chromic acid imparted green colors, and red was induced by iron vitriol. German agate received dyes grudgingly, but Brazilian agate was more porous and easier to stain. Idar-Oberstein craftsmen hold virtual monopolies in dyeing agate and in working the stone into elaborate carvings, cabochons, desk sets, picture frames, bowls, and objets d'art.

In May 1979, the old Steinkaulenberg mine, 2 kilometers northwest of Idar-Oberstein, reopened as part of a national park. Walking paths through a heavily forested canyon lead the visitor to the main portal. For a modest fee, tourists may stroll along cool, well-lighted tunnels where miners of past generations labored. Water drips into crystal-clear pools

THIS PAGE TOP:
Idar-Oberstein from old engraving, c. 1825
Collection: Hein Gaertner

THIS PAGE MIDDLE:
Cutter working in prone position, c. 1895
Collection: Gerhard Becker

THIS PAGE BOTTOM:
Grinding mill in Oberstein, c. 1860
Courtesy: Gustav Presser

OPPOSITE TOP LEFT:
Miners working for agate near Idar-Oberstein, 1975
Photo: Rudolf Druechel

OPPOSITE BOTTOM LEFT:
Amethyst geode in situ, deep inside the Steinkaulenberg mine
Photo: Peter Bancroft

OPPOSITE TOP RIGHT:
Gerhard Becker with mine manager at entrance to the Steinkaulenberg, 1979
Photo: Peter Bancroft

OPPOSITE MIDDLE RIGHT:
Becker observes amethyst and agate geodes in situ along walls of Steinkaulenberg mine, 1979
Photo: Peter Bancroft

OPPOSITE BOTTOM RIGHT:
Millhouse and waterwheel as it looked in 1976
Courtesy: Gustav Presser

along wide dry concrete walkways. The Steinkaulenberg is one of the world's few mines open to tourists which features a variety of agates and amethyst geodes *in situ*—still embedded in basalt as they were formed perhaps 10 million years ago.

Modern Idar-Oberstein retains much of its old-world charm. Small shops, vending works of lapidary art, line two streets which wind

through the canyon. Two important museums attract professional jewelers, hobbyists, and tourists. The Heimatmuseum features a good gem and mineral collection and major items of memorabilia. Rising amid 200-year-old buildings the ultramodern 22-story Diamond and Gem Trade Exchange houses a post office, bank, and the Deutsches Edelsteinmuseum featuring crystals and finished stones from localities around the world as well as offices and showrooms of more than 200 lapidary merchants. Idar-Oberstein is a "must" on a list of places to visit in Germany.

THIS PAGE TOP:
Agate (cut in A.D. 1750)
Size: (front bowl) 10 cm
Locality: Idar-Oberstein
Collection: German Gemstone Museum
Courtesy: Paul Ruppenthal
Photo: Karl Hartmann

THIS PAGE BOTTOM:
Currency printed in Idar-Oberstein by H. Albert Becker for use in Brazil, c. 1890
Collection: Paul Ruppenthal

OPPOSITE BOTTOM LEFT:
Miners at portal of Zinnwald mine, 1912
Courtesy: Stadt-und Bergbaumuseum, Freiberg

OPPOSITE TOP RIGHT:
Main shaft of Cínovec in winter
Courtesy: History Museum at Teplice

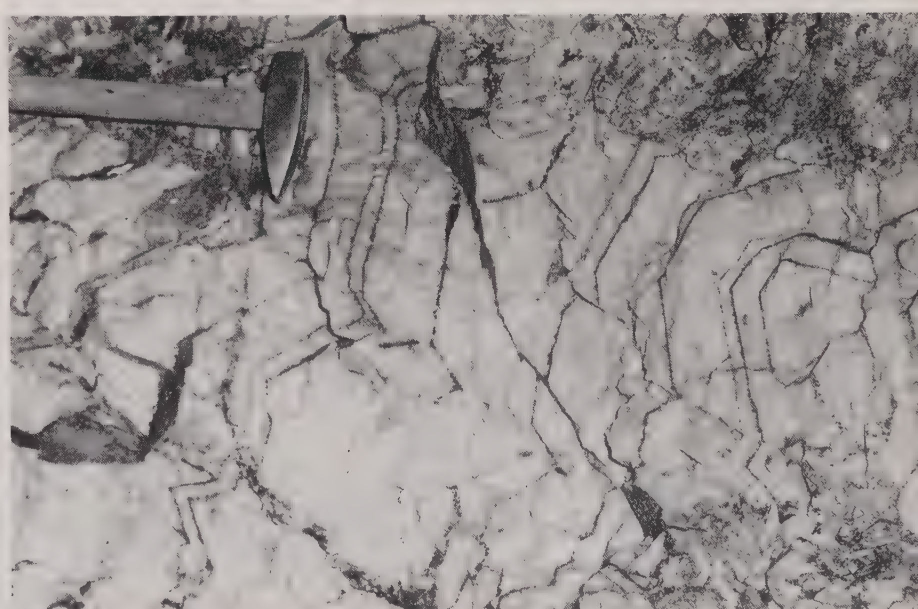
OPPOSITE MIDDLE RIGHT:
Pegmatitic containment of quartz crystals each bounded by zinnwaldite
Courtesy: History Museum at Teplice

OPPOSITE BOTTOM RIGHT:
Old Cínovec mine from highway, 1975
Courtesy: History Museum at Teplice

92 Cínovec-Zinnwald Mines, Teplice, Czechoslovakia

About 500 years before Christ, rich cassiterite (tin oxide) placers were found in rushing brooks below the Krusne Hory Mountains in Bohemia (now Czech.). As these deposits were exhausted of tin, miners followed streams up into the mountains and eventually discovered the famous primary outcrops of Cínovec-Zinnwald. The exact year of discovery is unknown. Some 850 meters above sea level, the actual mine site lies in the middle of a giant tableland atop the Krusne Hory range, 11 kilometers north of the vacation spa, Teplice, and 2 kilometers south of the East German border.

The oldest record of tin mining in the area is dated 1305. A document from 1378 refers to the miner's settlement (later to be called Cínovec-Zinnwald). The most important mining center in the region was Krupka. When mines there began to decline, many miners headed north to Cínovec. Others became prospectors and, in 1458, discovered the Altenberg deposits in northern Saxony (now Sachsen, East Germany). During the 15th century, the noble Lobkovic family acquired the Bohemian portion of Cínovec. The crown became interested in the wealthy mining operations, and Krupka was frequently called King's



THIS PAGE TOP:
Natrolite
Size: 24 by 11 cm
Collection: University of Copenhagen
Photo: Preben Nielsen

THIS PAGE BOTTOM:
Cassiterite on zinnwaldite
Size: 3.5 by 2.5 cm
Locality: Zinnwald
Collection: Olaf Medenbach
Photo: Olaf Medenbach

OPPOSITE LEFT:
Gilded figurine of St. Barbara, patron saint of miners, c. 1500
Courtesy: Slovenské Banské Mining Museum

OPPOSITE RIGHT:
Mining grant document presented to towns of Cínovec and Krupka by Czech King Vladislav II, Jan. 13, 1418
Courtesy: National Archives, Prague

Mining Town. Over the years, ownership of the properties changed hands frequently and the mines experienced alternating periods of prosperity and decline.

By 1880 when major Cínovec tin deposits were nearly exhausted, metallurgists discovered tungsten could be used for light bulb filaments and to harden steel for high speed tools. Cínovec's abandoned stopes were full of wolframite and scheelite, and a new era was born. In 1882 3 tons of tungsten were produced; in a decade the yield grew to 35 tons. Due to the richness of the ores a small force of only 20 miners could handle all the work. During both World Wars, Italian, French, and Russian captives produced large quantities of tungsten, tin, and lithium (the latter from zinnwaldite, a lithium-rich mica).

In 1978 exhausted mines were finally abandoned. Photographers took pictures of the workings and remaining veins as records for posterity before the portals were sealed and laborers dismissed. New bodies of rich ore-bearing greisens (igneous rocks consisting mainly of quartz and white mica) were recently discovered in a new location bordering Cínovec and assure renewed prosperity for the area.

The unusual ore deposit at Cínovec-Zinnwald involves a giant granite massif within which at least eight central ore veins dip slightly in a huge body of quartz porphyry. Vein thickness varies from 2 meters to 35 centimeters. Ore mineralization is dispersed in some parts of the greisens and in regular veins. Zinnwaldite forms in veins of 1 meter and more with great regularity within the ore body and in lesser veins along gangue contact zones. The first zinnwaldite was discovered at Cínovec-Zinnwald, but has later been found in many other mines throughout the world. No other locality, however, exceeds Cínovec-Zinnwald for the size or quality of individual zinnwaldite books and veins. Four stages of mineralization have been recognized: (1) a barren quartz stage; (2) a greisenization stage where mineral crystallizations include zinnwaldite, cassiterite, wolframite, scheelite, topaz, apatite, and hematite; (3) a potassium-feldspar stage which produced adularia, amazonite, and albite; (4) a sulfide stage, most prolific where penetrating quartz porphyry, in which grew arsenopyrite, bornite, chalcocite, tetrahedrite, tennantite, enargite, stannite, galena, sphalerite, molybdenite, and many other materials.

More than 50 mineral species and varieties exist at Cínovec, many of them in beautiful

crystal form. Zinnwaldite is abundant in druses of tabular crystals, some more than 6 centimeters in diameter. Euhedral crystals of scheelite appear up to 1 centimeter, some growing on quartz crystals. Wolframite is found in thick tabular crystals up to 20 centimeters. Some wolframite is zonal, partly altering to scheelite. Bright, sharp-edged, 3-centimeter cassiterite crystals are sometimes located, and 2-centimeter fluorite crystals of many colors are commonly found in vugs. Substantial quantities of clear smoky quartz were produced for the gem market. Cínovec is famous for "kappenquarz," a mineralogist's delight, in which large quartz crystals consist of a stacking of cones separated by thin films of mica so they may be readily separated.

Other species of lesser importance include autunite, torbernite, azurite, amethystine quartz, pyromorphite, zeunerite, topaz, huebnerite, loellingite, and bismuthinite.

Today, the main route from Prague to Dresden passes through the older mining villages of Cínovec and Zinnwald on the Czechoslovakia side, and Altenberg on the East German side. Great whitish tailings backed by pine forests identify old mines along the road. But the tranquil mining scene is disrupted along the border by long lines of watchtowers, strings of electrified wires, concrete tank barriers, and groups of armed guards. The long wait for inspection and clearance has one advantage for those entering and leaving the German Democratic Republic. The stalled tourist has time to notice old mine buildings and other mementos of the past, relics which might be overlooked had he been able to drive on through.

THIS PAGE TOP:
18th, 19th century lamps used in Czechoslovakian mines
Courtesy: Ivan Ladziansky

THIS PAGE BOTTOM:
Czech miner with vein of zinnwaldite in Cínovec
Courtesy: History Museum at Teplice

OPPOSITE TOP:
Stephanite
Size: 3.5 by 2 cm
Locality: Příbram
Collection: Narodni Museum
Photo: Frantisek Tvrz

OPPOSITE BOTTOM:
Scheelite, with calcite on quartz
Locality: Příbram
Size: 5.5 by 4 cm
Collection: Narodni Museum
Photo: Frantisek Tvrz

93 Anna Mine, Příbram, Czechoslovakia

One of history's great mining regions, the Brezové Hory district is at Příbram about 60 kilometers southwest of Prague, Czechoslovakia. Miners first worked the area during the 13th century. By the 16th century, Brezové Hory mines produced enormous amounts of silver from the 200-meter levels. In some zones the concentration of pure silver amounted to 40 percent of the total gangue volume. Silver occurred in the form of wires, sheets, and dendritic crystal groups attaining a maximum width of 10 centimeters. The ore veins were nearly vertical so horizontal tunnels connected the mines and provided ventilation. In 1553 more than 500 kilograms of silver were produced, but it all went to the smelters.

As the shafts were dug deeper, high-grade silver ore nearly disappeared and the mines began to operate at a loss. But Jan Antonín Alis, a bright mining engineer from the abandoned silver district of Kutná Hora, was hired in 1772 to locate new ore bodies. Alis theorized that the greatest silver deposits lay at considerable depth. Three "modern" shafts were constructed: the Vojtech in 1779, the Anna in 1789, and the Jarosovka in 1799. Lower diggings confirmed Alis' theories as vast new high-grade ore bodies were uncovered. However, they lacked large amounts of silver.

Other new shafts included the Franz Josef, Maria, Adalbert, Prokop, Stefan, August, Ferdinand, Strachen, and Lill, and the whole area bustled with wagons clattering along stone-paved roads. In 1875, for the first time in history, miners achieved a depth of 1000 meters at the Vojtech mine. In 1849 the Mining Technical University was established in Příbram. Its staff and students developed considerable interest in collecting and preserving crystals from local mines.

Principal ore zones were made up of quartz called *krusek*. In the upper levels, zones consisted of coarse-grained veins, while extremely fine grained *krusek* at lower levels included calcite and siderite. Upper levels proved to be a treasure trove of spectacular crystals which began to fill display cases at the university and reach collectors throughout the world. Included were columnar crystals of pyrargyrite up to 2.5 centimeters; proustite crystals to 2 centimeters; exceptionally fine pyrostilpnite in needles to 0.5 centimeter; tabular xanthoconite found crystallized in cavities; tabular polybasite crystals to 1 centimeter thick; beautiful clusters of prismatic stephanite to 4 centimeters; tiny, thick crystals of diaphorite (Příbram being the classic

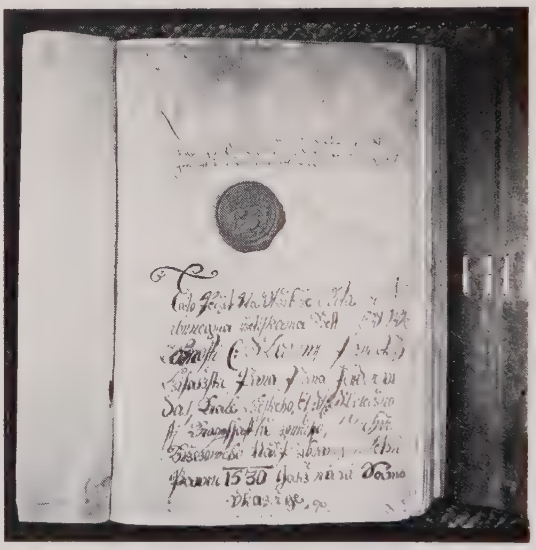
locality); small, quite common crystals of freieslebenite; rare crystals of miargyrite and brass-colored sternbergite; abundant argentite crystals up to 2 centimeters; silver crystals frequently found in vugs resulting from galena decomposition; boulangerite in hair-like crystals of 30 centimeters in length (found during World War II); valentinite crystals to 2 centimeters; and fine crystals of kermesite; amethystine quartz; scheelite; lillianite, cronstedtite, and bournonite. The list of Pribram mineral species totals more than 110. The mines were a collector's paradise!

By 1890 more than 5500 employees worked in the Pribram mines. The "father of metallogeny," professor Frantisek Posepný, traveled through the mines gathering data for his classic book, *Genesis of Ore Deposits* (1893).

Through the centuries the Anna mine became famous among mineralogists not only for its great ore deposits, but for the astounding variety and quality of choice crystals found in its stopes and tunnels.

Like workers in other mines, the men here had their own superstitions. For example, no one would think of killing a cockroach. These insects were considered friends because when a cave-in was imminent, roaches ran from cracks in the rocks by the hundreds and warned the miners.

Tragedies were also a part of the Brezové Hory district's history. In 1892, a fire in the Maria shaft, next door to the Anna, ignited one of the world's worst mine disasters. A carpenter, just going off shift dropped a



THIS PAGE TOP:
Mr. Smrcek in 1868, the last "counter of mine trucks" at the Anna mine
Courtesy: Marek Korinek

THIS PAGE MIDDLE:
Ancient mine recording book for Brezové hory district dated 1530.
One rule: If a miner did not work for two weeks he forfeited his claim.
Courtesy: Prague National Archives

THIS PAGE BOTTOM:
Oldest known photograph of the Adalberg shaft, nearest neighbor to the Anna, in 1865
Courtesy: Marek Korinek

OPPOSITE TOP LEFT:
Slik-Thaller made of pure argentite, c. 1590
Courtesy: Narodni Museum

OPPOSITE BOTTOM LEFT:
Headframe of Anna on last day of its operation June 30, 1978
Photo: Pavel Kryl

OPPOSITE FAR RIGHT TOP TO BOTTOM:
Installation of steam engine at Anna shaft, 1914
Courtesy: Marek Korinek

Transporting new steam engine components to the Anna during the winter of 1914
Courtesy: Marek Korinek

1000 meters down in the Anna, Czechoslovakian luminaries pose before "last car of ore" bearing words "good luck."
Photo: Pavel Kryl

Galena crystals deep in the Anna, 1973
Photo: Peter Bancroft

burning lamp wick into the sump at the bottom of the main shaft. The timbered walls of the shaft caught fire; flames sucked into the lower levels and galleries, ignited wooden supports until a vast area was ablaze. Though the alarm was given and exit tunnels connected to other shafts, miners first thought it was a small blaze in the underground storage rooms where wooden beams were kept. When the fire's real dimensions became apparent, the miners were cut off from every exit. Many men retreated into remote galleries to avoid the smoke and

heat. Deadly gases held back rescue crews and of 835 miners at work 319 lost their lives within a day.

Over eight centuries the Pribram mines have produced huge amounts of metals: 750,000 tons of lead, 100,000 tons of antimony, 4000 tons of silver. The value of these metals over so long a span is incalculable.

On June 30, 1978, its ore bodies exhausted, the historic Brezové Hory district closed. Its shafts had been driven to depths of 1500 meters. Mining dignitaries from all over Czechoslovakia gathered for a final ride down into the Anna. At the 1000-meter level, the group posed before a symbolic "last car of ore," on which was hastily printed "Zdar Buh," the traditional mining salute "good luck." In honor of all the Brezové Hory mines, a mining museum was opened in Pribram. It contains ancient machinery, a mineral collection, and mementos of the old-time miners including some of their original homes with antique furnishings.

Despite the death of the mines, newly discovered deposits of good quality uranium ore may provide jobs to idle miners. The 800-year-old mining region of Pribram could once again produce high-grade ores and pretty crystals for many years to come.

THIS PAGE TOP:
Barite
Size: 7 by 6 cm
Locality: Pribram
Collection: Narodni Museum
Photo: Frantisek Tvrz

THIS PAGE BOTTOM:
Pyromorphite
Size: 12 by 10 cm
Locality: Pribram
Collection: Narodni Museum
Photo: Frantisek Tvrz

OPPOSITE TOP RIGHT:
Scene depicting Slovakian mining in the 16th century
Courtesy: Ivan Ladziansky

OPPOSITE BOTTOM LEFT:
Catholic priest, Johannes Mathesius, who in 1530 preached for miners' rights in Jáchymov
Courtesy: Okresni Vlastivedne Museum, Jáchymov

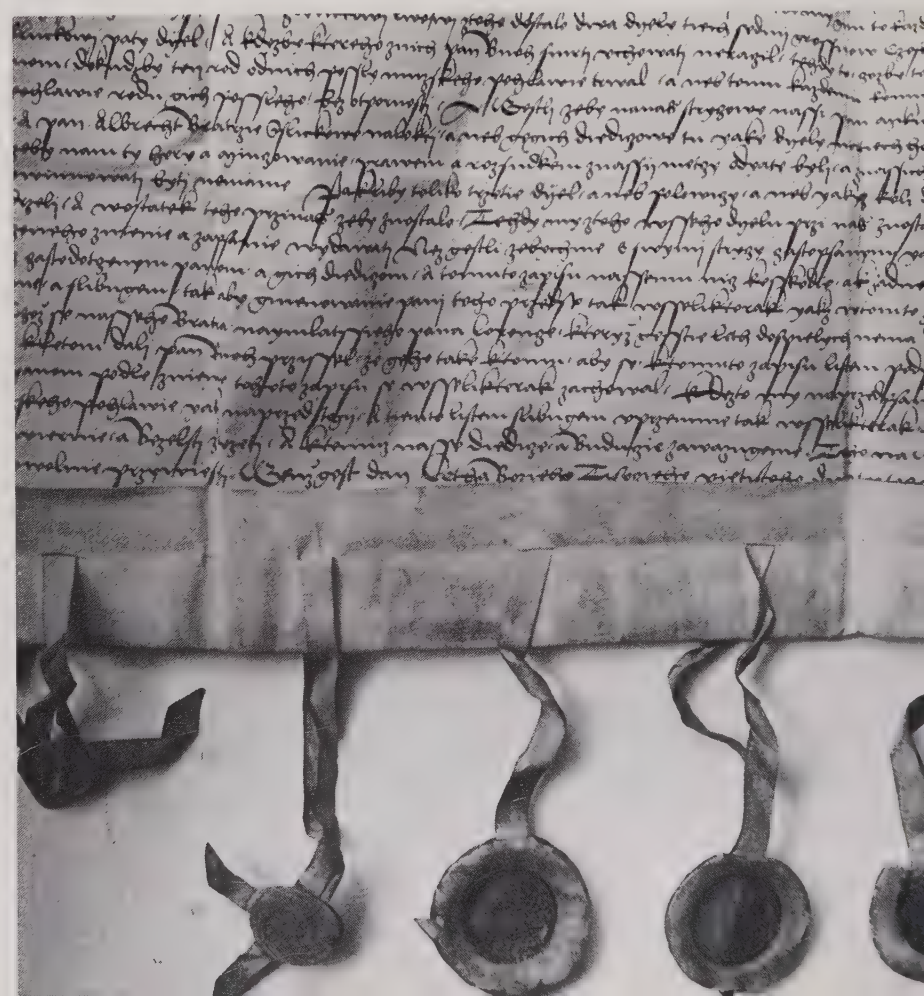
OPPOSITE BOTTOM RIGHT:
Official document, with stamps still affixed, dated January 21, 1520, granting the Slik brothers (the mine owners) the right to establish a mint in Jáchymov to coin Thallers.
Courtesy: National Archives, Prague

94 Svornost Mine, Jáchymov (Joachimsthal), Czechoslovakia

In 1516 an incredibly rich silver deposit was discovered at the village of Konradsgrun in western Bohemia (Czechoslovakia) on the southern rim of the Krusné Hory Mountains, 20 kilometers north of the town of Karlovy Vary. The town's name was soon changed to Joachimsthal then to Jáchymov. By 1530 the population of Jáchymov was 18,000, one of Europe's largest cities—and 13,000 miners were working in 800 mines.

During this first phase of mining at Jáchymov, the mines produced 5 tons of silver a year. Silver frequently occurred as wires in "bush" form in lengths to 15 centimeters and weights up to 1.5 kilograms. The king conferred coining rights on Count Stepan Slik, owner of the mines. Original coins were called "Slik's-*Thaller*" or "Joachim's-*Thaller*" (from which "dollar" derives). Between 1520 and 1528 more than 2 million thallers were struck from 60,000 kilograms of fine silver, some of it so pure that it was made directly into coins.

Several notables worked at Jáchymov. Georgius Agricola, the town physician from 1527 to 1533, became world famous through his books, *Bermannus sive de re Metallica Dialogus* (1530) and *De re Metallica Libri XII* (1546). These publications remain unique



sources of knowledge about old mining methods and the beginnings of mineralogy as a science. Agricola's contemporary, Reverend Johannes Mathesius, developed an interest in his flock far beyond their spiritual requirements. His intense curiosity about mine operation and concern for miners' safety led to sermons on such topics as miner's rights, freedom from danger, and group organization. They were published in *Sarepta oder Bergpostilla* (1562).

Fabulously rich proustite, pyrargyrite, and silver deposits of the upper levels gradually pinched out and Jáchymov's second phase began with the discovery of vast masses of bismuth, arsenic, and cobalt ores. Budding ceramics and metal industries were assisted by the abundance of cobalt for use in enamels.

In 1852 chemist Adolf Patera discovered a use for pitchblende ores found readily in three of the major mines: the Rovnost, the Svornost (formerly the Einigkeit), and the Bratrství. Pitchblende, or massive uraninite, derived its name from its pitch-like color and luster. When uraninite was found in ore veins, silver disappeared, thus, "pitch" meant bad luck when exploring for silver ores. Uranium salts, which produce beautiful vivid colors in glass, were shipped to new factories built to satisfy the demand for colored glass.

In Paris in 1898 Marie and Pierre Curie experimented with nearly 1000 kilograms of rock waste donated by a glass factory at Jáchymov which had been using uranium as a coloring agent. Before the year was out, the Curies had isolated two new radioactive elements: polonium (named after Marie's native land, Poland) and radium. Following the discovery of the uranium fission process and World War II, mining engineers from Czechoslovakia and the Soviet Union began extensive exploration in the Jáchymov mines. Surface exploration revealed new rock outcrops heavily colored by green and yellow stains of torbernite and autunite. For more than 15 years, large amounts of pitchblende were recovered; Jáchymov became one of the world's important sources of radioactive raw materials and a principal source of uranium concentrates for the Soviet Union. Political prisoners have been mining ore at Jáchymov since 1948.

The Svornost became rich in secondary

BELOW: Proustite
Size: Single 4.5 cm; cluster 7.5 by 5.5 cm
Locality: Svornost, Jáchymov
Collection: Narodni Museum
Photo: Frantisek Tvrz

OPPOSITE:
Map: Hrebecna mine, at Jáchymov, 1562, showing winches and ore veins
Courtesy: Prague National Archives

uranium minerals when the mining process admitted air to ore bodies containing uraninite and marcasite. The oxidation of dull black uraninite creates a series of strikingly beautiful yellow, orange, and green crystallized secondary uranium minerals including zippeite, uranopilite, johannite, torbernite, autunite, walpurgite, liebigite, voglite, cuprosklodowskite, schroeckingerite, and others.

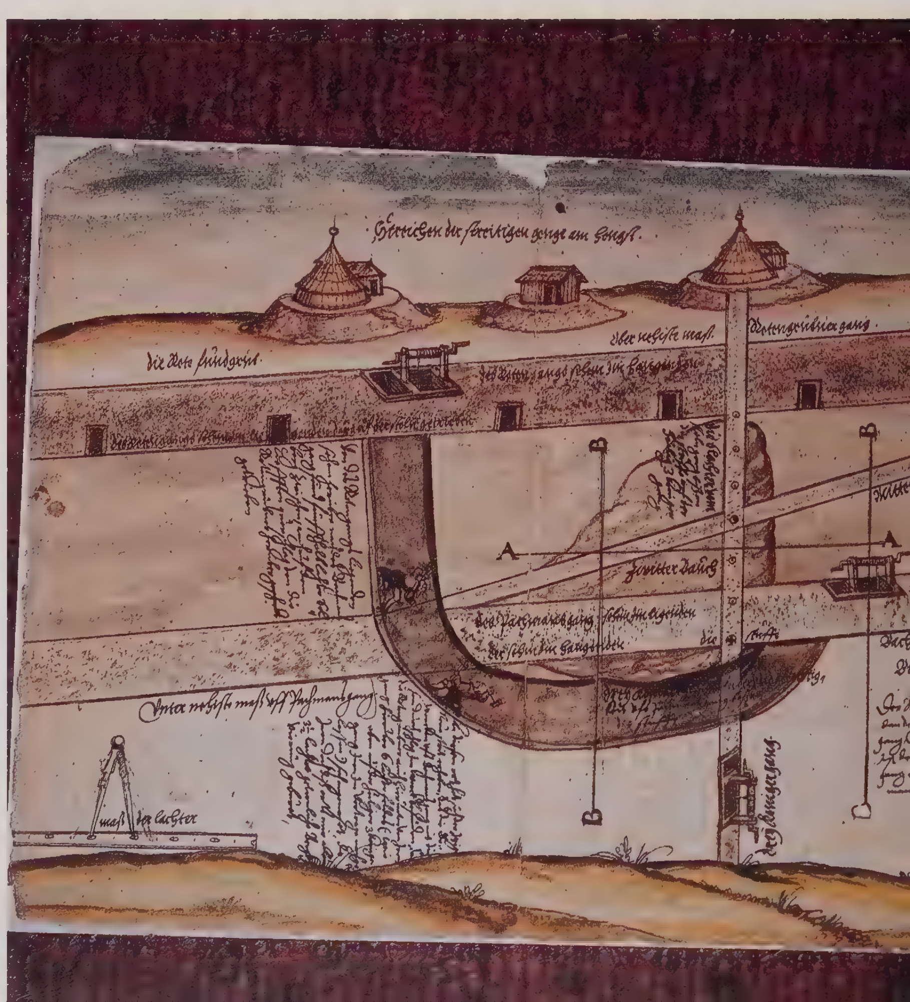
Today, balneology represents the third stage of Jáchymov's development and offers a promising future for the Svornost. Surface waters percolating down through kilometers of pillars, galleries, and tunnels combine with radioactive minerals encountered en route. From there, water laden with radium and radioactive radon gas is pumped into surface tubs and pools scattered about Jáchymov. These baths attract thousands of ailing people from around the world who seek relief cures for their disabilities.

Jaroslav Svenek, associate curator of mineralogy at Prague's Narodni Museum, arranged a trip to the bottom of the Svornost for a small group of Czechoslovakian and Soviet mineralogists and the author. Our cage stopped at the 150-meter level so that ancient sections of the mine, some dating from the 16th century, could be inspected. A heavily rusted iron door set in concrete barred the way to the tunnels. Attempts to pry open the door caused it to crash inward as the corroded hinges and lock gave way. Entering a long-abandoned tunnel proved to be a step backward in time. The air was heavy with odors of rotted timbers, rusted rails, and oxidized minerals. Drifts seldom more than a meter wide and 1.5 meters high accommodated the shorter miners of yesteryear, but were a painful nuisance for our party. Ceilings were crowned with hand-set schist. Each stone had been formed by hand and placed into a self-sustaining arch. The ceilings of tunnel intersections resembled small naves. An empty nitch hollowed into a corner wall bore an inscription carved into solid rock: "St. Barbara, 1542" in honor of the miners' patron saint.

Returning to the hoist, we were lowered to the bottom of the mine to see pumps and pools of mineral-laden water. Along some tunnels, olive-green, 8-centimeter-long stalactites dripped mineralized water so rich that a drop in the eye could cause blindness. Vadose waters from an overhead aeration zone are collected in cement tanks and pumped to the surface to be used in health spas. Upper levels of the Svornost no longer produce the beautiful crystals found years ago when nearly all crystallized silver minerals were considered "high-grade ore" and sent to the crushers.

Proustite, in pretty crystals to 4 centimeters, was occasionally mined, and a very good druse is displayed in the Narodni Museum, a gift of Emperor Franz Josef I in 1892. Fine crystals of numerous species gathered at Jáchymov include stephanite, sternbergite, argentopyrite, and xanthoconite. Bismuth and arsenic were found in great abundance. More than 130 mineral species are known, and many are represented in various collections throughout the world. The Narodni Museum is especially rich in Jáchymov material.

Although beautiful crystals are no longer mined in the Svornost, radium-enriched waters deep in the bowels of the old mine are still gathered for use by the infirm and probably will be for hundreds of years.



THIS PAGE TOP:
Shaft house, Jáchymov, c. 1885
Courtesy: Jan Urban

THIS PAGE BOTTOM LEFT:
Madam Marie Curie in Jáchymov, 1925
Courtesy: Jan Urban

THIS PAGE BOTTOM RIGHT:
Jáchymov miners in costume, 1890
Courtesy: Jan Urban

OPPOSITE TOP:
Soviet and Czechoslovakian mineralogists at bottom of the Svornost, 1980
Photo: Peter Bancroft

OPPOSITE MIDDLE:
Czechoslovakian miner in 400 year-old tunnel in the Svornost mine
Photo: Peter Bancroft

OPPOSITE BOTTOM:
Long abandoned ore cars and rotting timber in Svornost, 1980
Photo: Peter Bancroft

95 Herja Mine, Chiuzbaia, Romania

Clusters of brilliant jet-black prismatic stibnite crystals, famous throughout the world, occur in several mines of the Romanian Baia Mare region about 100 kilometers southeast of the border point joining Russia, Hungary, and Romania. Baia Mare, a thriving and rapidly growing industrial city, still services the area's many mines. Before World War I when the region of Siebenburgen (Transylvania) belonged to Hungary, mines and nearby towns had Hungarian names. Now a part of Romania, new town and mine names on mineral specimen labels cause considerable confusion. "Baia" is frequently used as a prefix by Romanians to designate the locations of rich ore deposits. Some older miners still refer to their cities and mines in Hungarian.

Mines at Baia Sprie (formerly Felsobánya), 11 kilometers east of Baia Mare, produced excellent crystals of gold, silver, barite, bournonite, quartz, tetrahedrite, stibnite, realgar, and galena. Baia Mare (Nagybánya) mines yielded gold, amethystine, quartz, and bournonite. From Capnic (Kapnikbánya) came crystals of sphalerite, tetrahedrite, rhodochrosite, bournonite, amethyst, realgar, galena, and chalcocite. Strimbu, 80 kilometers southeast of Baia Mare, produced fine large crystals of stibnite.

The Herja mine, near the tiny village of Chiuzbaia (formerly Kisbánya), 6 kilometers northeast of Baia Mare, ranks as the greatest crystal-producing mine in the area. For decades the upper levels contributed many tons of remarkable stibnite crystals, most of which were crushed and roasted in the smelter.

BELOW: Stibnite
Size: 20.3 by 12.7 cm
Locality: Herja mine
Collection: Keith Proctor
Photo: Harold and Erica Van Pelt

OPPOSITE:
Barite with stibnite
Size: 11 by 8 cm
Locality: Baia Sprie
Collection: Peter Bancroft
Photo: Harold and Erica Van Pelt

Crystals of pyrrhotite, vivianite, sphalerite, and siderite of excellent quality are also found in the Herja. Allowed to collect here, miners have saved many fine specimens and spirited them out of Romania to collectors throughout the world. But the process is laborious and fraught with danger. In 1971 a law was passed to protect national cultural property, particularly from exploitation by foreigners. Crystals of all species were considered "national treasures," to be sold or purchased only with official authorization. Furthermore, all crystals kept in homes, offices, warehouses, and museums must be recorded. Border guards search for specimens. Should a foreigner possess crystals without a permit, confiscation of the minerals is inevitable and detention or arrest a possibility.

Stibnite crystals grow on a flinty hard rock base which is particularly difficult to remove without damage to the crystals. The slender shafts of stibnite are extremely brittle and easily destroyed. Traditionally, Herja miners donated their spare time to the preservation of as many crystals as possible. These men developed a love for stibnite clusters and many decorate their homes with specimens of fine quality. In times past, mine workers often gave showy stibnites to visitors as gestures of friendship. It came as a shock when miners learned that others were reaping handsome profits from the sale of crystals acquired as gifts. Embittered, the miners ceased collecting

THIS PAGE TOP:
Adit of Herja in winter
Courtesy: J. Savery
Photo: Deak Ioan

THIS PAGE BOTTOM LEFT:
Miners leaving cage at Herja
Courtesy: J. Savery
Photo: Deak Ioan

THIS PAGE BOTTOM RIGHT:
Herja miner loading ore cars from a controlled ore pass, 1975
Photo: Deak Ioan

OPPOSITE TOP:
Romanian miner with drill machine in Herja, c. 1965
Photo: Deak Ioan

OPPOSITE BOTTOM LEFT:
Main portal of the Herja, c. 1969
Courtesy: J. Savery
Photo: Deak Ioan

OPPOSITE BOTTOM RIGHT:
Century-old miner's house—still in use Baia Sprie, 1979
Photo: Peter Bancroft

and when they entered a particularly beautiful pocket they blasted it into oblivion. As a result, few specimens of any quality are collected today.

Before the time of Christ, ancient Romanians known as Daks mined the Baia Mare area for gold. Superior to most gold found elsewhere in Europe, Baia Mare metal was minted into coins and jewelry by skilled Dak goldsmiths.

When Roman legions overran northern Romania in the 1st century A.D., their generals established Dacia as the Empire's newest province. They called Baia Mare, Rivulus Dominarum, and Baia Sprie, Mon Medius. The conquerers carted to Rome more than 300 tons of pure gold. On Dealul Crucii (Hill of the Cross), just north of Baia Mare, Roman miners sank a vertical shaft which produced more gold in considerable quantity. In later years the old workings were reopened to contribute not only gold but sizeable amounts of lead, copper, and antimony. Good crystals of semseyite, fizelyite, andorite, and cronstedtite were found along with, in 1929, a new mineral, fuloppite.

Ancient literature mentions Baia Sprie as one of the oldest mining towns in eastern Europe, dating to the beginning of the 14th century, and located the town on the Rivulus Dominarum—"River of Young Girls." Local historians lament the disappearance of the oldest mining documents once a part of the Baia Mare archives, but now believed to be in either Vienna or Budapest.

Romania's western region of Transylvania is a dense network of mineral veins. With upper mine levels worked out, local mineralogists are pessimistic about recovering additional crystals but comfortably predict "our metal mines will be operating for a long time to come."

96 Golden Tetragon Region, Transylvania, Romania

Seldom visited by collectors but well known to mineralogists, Romania's Golden Tetragon is the principal gold-bearing region in Europe. This mining area, only 55 kilometers long and 28 kilometers wide, occupies a small portion of the Transylvanian plateau approximately 280 kilometers northwest of Bucharest.

Each point of the geometric figure is a famous mining district. At the northernmost point is Baia de Aries (formerly known as Offenbánya), at the west Brad, at the south Sacarimb (Nagyág), and at the east Zlatna. Within the Tetragon are many important mining districts; the two most significant are Rosia Montana (Verespatak) and Botés Hill (Botésbánya). Each mining district made important crystal contributions.

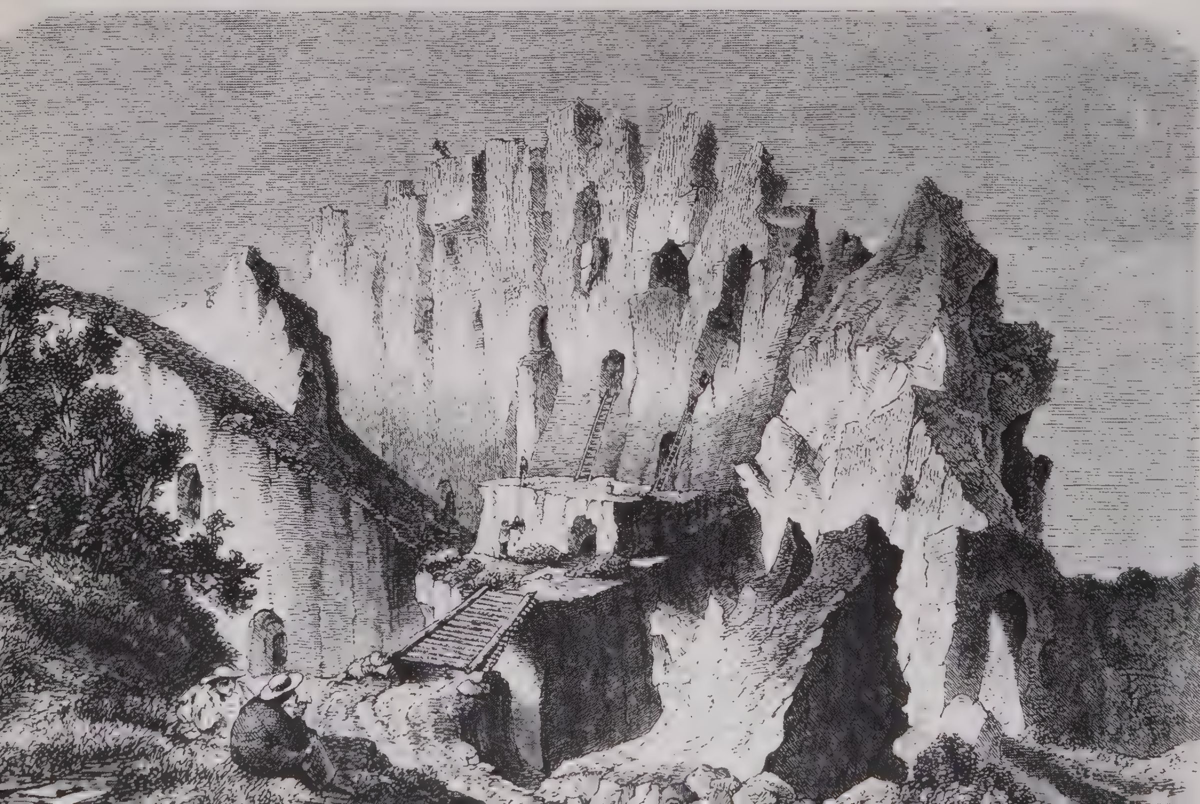
Throughout its long and turbulent history, Romania has been one of Europe's least developed nations. Little is known of Romania's indigenous culture, but exquisite examples of gold and bronze work dating from the 15th century B.C. have been traced to Transylvania. The Greek historian Herodotus tells of Darius Hystaspes raiding Agathyrians "whose members wore splendid gold ornaments" on the banks of the Maris River (now the Mures) in 513 B.C. Dacians farmed the land and mined gold as early as 300 B.C. Romans conquered the region about 106 A.D. By 271 A.D., when forced to withdraw by Vandals and Asiastic tribes, they had shipped

THIS PAGE TOP:
Gold mine tunnel at Rosia Montana built with Roman slave labor in A.D. 173
Photo: Peter Bancroft

THIS PAGE BOTTOM:
Rosia Montana; Cetatea, known locally as the "fortress," artist's conception in 1862
Courtesy: Martin Bohátý

OPPOSITE TOP:
Miners' graves at Sacarimb
Photo: Martin Bohátý

OPPOSITE BOTTOM:
One of main adits at the Maria mine at Sacarimb
Photo: Martin Bohátý



more than 165,000 kilograms of gold to Aurelianus' coffers in Rome.

In the following centuries the country was overrun by Goths, Vandals, Huns, Ovars, Slavs, Bulgars, Cumans, Magyars, Mongols, Turks, and Russians. Its resources and people constantly exploited, unstable Romania has suffered, and the country has remained poor.

Transylvanian mines were incredibly rich in commercial-grade ores and in quality mineral and crystal specimens, most of them lost in the mining process. Many collections feature surviving specimens with species from the gold, silver, and tellurium families being most prominent.

The richest deposits occurred in a country rock of dacite (frequently rich in hornblende) and/or andesite. The lodes consisted chiefly of auriferous quartz, some of which contained silver minerals, principally pyrargyrite. Vein

BELOW: Hessite
Size: 2.6 cm
Locality: Botés, Romania
Collection: American Museum of Natural History
Photo: James Coxe

OPPOSITE TOP: Abandoned main mine building at Sacarimb
Photo: Martin Bohátý

OPPOSITE MIDDLE: Zlatna Smelter, portions of which were built in 1742
Photo: Martin Bohátý

OPPOSITE BOTTOM: Old miners at Rosia Montana, 1983
Photo: Peter Bancroft

material, usually made up of quartz and carbonates, was rich in the sulfides pyrite, sphalerite, galena, and tetrahedrite (the latter two in industrially important quantities). Veins constituting one of the world's greatest concentrations of tellurium were found near surface and, as a result, have been completely exploited.

The countryside is mountainous and rural. During winter months many roads to the mines are difficult if not impossible to traverse with automobiles. Baia de Aries is reached by driving along the Crisulalb (gold) River. The Franciscus mine produced the first sylvanite (then called schrifterz) which was analyzed in 1798 by M.H. Klaproth, a German mineralogist. It is found abundantly here as gray, silver, and white crystals, some of which measure several centimeters in length and 1 to 3 millimeters in thickness. Associated minerals include hessite, nagyagite, silver, alabandite, sphalerite (in brown, red-brown, and greenish crystals), pyrite, rhodochrosite, calcite in pretty crystals up to 5 centimeters, dolomite, gypsum in beautiful white and green crystals, aragonite, cerussite, and barite. J.F. Fichtel in *Mineralogische Bemerkungen von den Karpathen* (1791) describes a crystal cave in the Emerich mine:

> *On the bottom of the cave there were heaps of barite in large flowers and arborescent groups up to 30 centimeters in size. On the ceiling and the walls, covered with white, large crystals of calcite, there were large and heavy clusters of greenish crystals of barite.*

Some historical discovery sites may still be seen, including the old Roman excavation "Csetatye mare" and the Katroncza chimney. Most facilities, constructed when the mines flourished from 1860 to 1880, are in decay.

Rosia Montana is a small mining town in the valley of the Valea Rosie (the Red Brook—named for its hematite-colored waters). The slopes on both sides of the valley are so marked with abandoned mines (some appearing as ruins of castles) that local inhabitants refer to them as *cetatea* (fortresses). Today only an open cast mine operates while hundreds of abandoned dumps gleam snow white in the sun.

Rosia Montana is best known for its gold specimens of wires, blades, and beautiful whole or skeletal crystals. Brilliant metallic gold occurred in flattened octahedral plates, cubes, and dodecahedral forms as well as in mossy,

wiry, and dendritic masses. Between 1780 and 1800, a number of caverns lined with quartz crystal were entered, and masses of gold weighing from 5 to 6.5 kilograms were found. So much pure gold was mined that Rosia Montana was called Eldorado Siebenburgens. In 1862, the Maria Himmelfahrt mine produced 10 kilograms of 12- to 6-millimeter gold crystals, and in 1886 5- to 4-millimeter single and twin gold crystals. During the 1800s several hundred stamp mills operated in the small valley, and the noise must have been terrible. Horses brought small bags to the mills, where the ground ore was panned by hand.

Important associated minerals at Rosia Montana included large white quartz crystals and amethyst (some with movable water bubbles), beautiful clear dolomite crystals, polybasite, proustite, sphalerite from the Rakasi mine, large masses of bright pink rhodochrosite heavily streaked with wires and dendrites of native gold.

Of the many mines near the villages of Botés and Bucium, 11 kilometers northwest of Zlatna, the most important are the Botés Mountain, Vilcoi Mountain, Corabia, Arama, Anna and Jacobi, and the Contu. All yielded good quantities of gold and other minerals, but the Anna and Jacobi proved exceptional specimen sources. From its galleries came large crystallized masses of cerussite and

BELOW:
Hessite on quartz
Size: 7 by 4 cm
Locality: Botés, Romania
Collection: John Barlow
Photo: Harold and Erica Van Pelt

OPPOSITE:
Gold on quartz
Size: 12 by 8 cm
Locality: Brad, Romania, Muszari mine
Collection: School of Mines, Freiberg, D.D.R.
Photo: Jurgen Karpinski

pyromorphite. In 1879 outstanding crystals of hessite (at first thought to be galena) in elongated crystals to 5 centimeters appeared on druses of quartz. A few hessite crystals were associated with chalcopyrite, sphalerite, pyrite, and gold.

The fourth mining district is near the village of Zlatna. Mines in this area were of considerable interest to the mineralogist if not to collectors. In 1782 miners found masses of an unknown metal, at first thought to be either bismuth or antimony, in the Fata Baii mine. In 1798, Klaproth isolated the new metal and named it tellurium, after Tellus, the Roman goddess of the earth. Between 1879 and 1883 the same mine produced quartz vugs completely covered with short needle-like bluish and iridescent tellurium crystals. Tellurite, a rare tellurium oxide, was mined in bunches and spheres of yellowish and gray-white needle-like crystals in the Fata Baii, Maria Hilf, Sigismundi, and Maria Loretto mines. Beautiful crystals and druses of pyrite came from the Valisoara mine.

The town of Brad, sometimes erroneously credited as being the source of fine crystals, has no mines. But the town boasts the Muzeul Aurului (the Museum of Gold) and the best gold specimens remaining from the Golden Tetragon. Visitors are not permitted in the museum, but the author obtained permission from the Minister of Mines in Bucharest. He observed many remarkable gold crystals, each identified by the mine of origin.

Unusual quantities of gold piled in one place were found in the Musariu Nou mine, 5 kilometers southeast of Brad. (One yielded 60 kilograms of pure gold. In other sections of the mine, chunks weighing 1 kilogram were not unusual.) Fine gold specimens also came from the Zdraholt, Bradisor, Palatin Mountain, and Valea Morii mines. The Musariu mines produced

beautiful gold crystals containing 28 percent silver. So much pure gold was available in the Brad area that it was not until 1910 that mineralogists realized even the iron pyrite carried up to 10 grams of gold per ton. The age-old tradition of dumping pyrite into the river was stopped. At present the Twelve Apostles mine produces 1600 to 1900 kilograms in gold each year. Even today, microscopic sheets of gold still show up during mining.

Sacarimb is the most picturesque mining district in the Golden Tetragon! Tree-covered hills slope down to the Muresul River; white cottages and churches contrast pleasantly with the greenery. But strangely, little native gold occurs in Sacarimb mines, which are rich in telluride ores. Mining, which commenced at Sacarimb in 1747, has been extensive, with a number of mines now being worked from the 5012-meter-long Franz-Joseph adit. Further operation may be in jeopardy, however, because only low-grade ore is being produced.

Sacarimb is the type locality for nagyagite which was found in abundance and mined as gold ore in the Carolina, Magdalena, Anastasia, and Adam mines. Individual sheets of nagyagite measured up to 7 by 3.5 centimeter, and the mineral was also found in thin tabular crystals on drusy quartz. Krennerite crystals up to 2 millimeters long came from the Longhin mine. Aggregates of tellurium found in the Carolina mine reached 3 by 1 centimeter. Sacarimb also yielded fine crystal specimens of bournonite, galena, alabandite, stibnite with crystals of amethyst and also on rhodochrosite, 2- to 3-centimeter transparent deep red realgar crystals, quartz, amethyst, and druses of rose-red rhodochrosite.

The famous and prolific Golden Tetragon mining region is in serious decline as a producer of fine crystals. Visiting old mines and waste dumps, collecting specimens, and photographing remaining relics is forbidden. Thus the demise of a classic mining region goes nearly unnoticed by collectors and professional mineralogists alike.

BELOW: Brad miner with Czechoslovakian geologist Martin Bohátý
Courtesy: Martin Bohátý

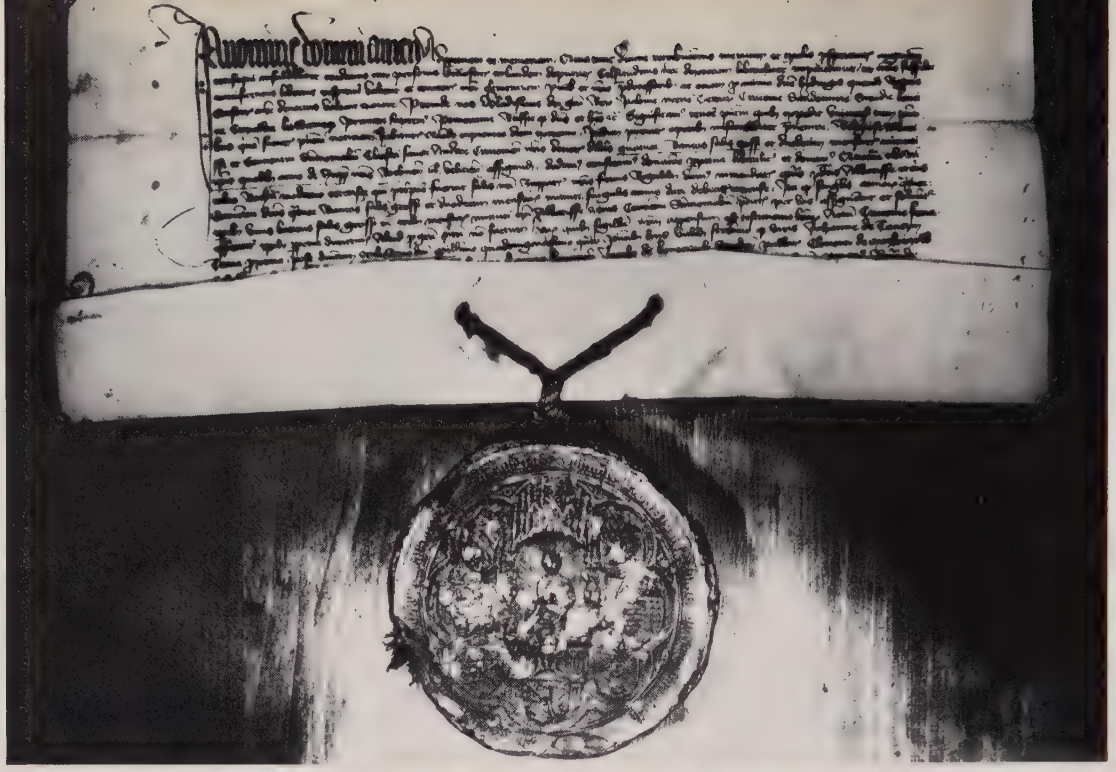
OPPOSITE: Halite
Size: 18 by 11 cm
Locality: Krakow Saltworks
Collection: American Museum of Natural History
Photo: Arthur Singer

97 Krakow Saltworks, Wieliczka, Poland

The Krakow saltworks, unquestionably the greatest salt mine in the world, is one of the most impressive of all mining excavations. Underground galleries extend through an area more than 3 kilometers long and 1 kilometer wide and vary in depth from 183 to 335 meters.

The enormous salt beds were created during the Miocene period, about 20 million years ago. It is not known when these salt deposits were first mined. But here archaeologists have discovered the oldest known brine-boiling devices dating from the neolithic age (circa 3500 B.C.), and sets of stone tools of the Lengyel Culture, dating from 3000 B.C. People of that time gathered brine from surface springs at Wieliczka and boiled the solution on open aboveground furnaces. When surface springs dried up, they sunk wells in search of more liquid. In the 13th century masses of pure rock salt were discovered. Since that time the salt deposit has been mined by underground methods. Recognizing the economic, political, and military value of such a deposit, Polish king Boleslaw the Bashful claimed the enterprise as his private property. Other kings kept title to the property until the 18th century. Wieliczka's salt mine was rated the biggest industrial establishment in Poland, and during the 14th century produced one-third of all state revenues. Located in southern Poland, about 65 kilometers north of the Czechoslovakian border and about 15 kilometers southeast of Krakow, the salt mines have intrigued other countries as well. At the end of the 18th century, Prussia, Russia, and Austria partitioned Poland and Austria gained the salt mine as a prize.

There are three general grades of Krakow salt: the lowest, "green salt," contains 6 to 7 percent clay; "spiza" is a natural mixture of salt and sand; and high quality "szybikowa" is



THIS PAGE TOP:
Deed from Wladyslaw/Ladislaus II, King of Poland, ordering transfer of salt from Krakow to St. Andrew's Monastery. Date 1405
Courtesy: Krakow Saltworks

THIS PAGE BOTTOM:
Miners descend into Krakow in the 1600s
Courtesy: Krakow Saltworks

OPPOSITE TOP:
A 17th century hoisting machine still intact at Wieliczka
Courtesy: Antoni Jodtowski

OPPOSITE MIDDLE:
Chandelier hanging in one of the great rooms at Krakow. Beads are hand-cut from pure halite.
Photo: Peter Bancroft

OPPOSITE BOTTOM:
"Polish whim" horse-drawn mill with horizontal rope
Courtesy: Krakow Saltworks

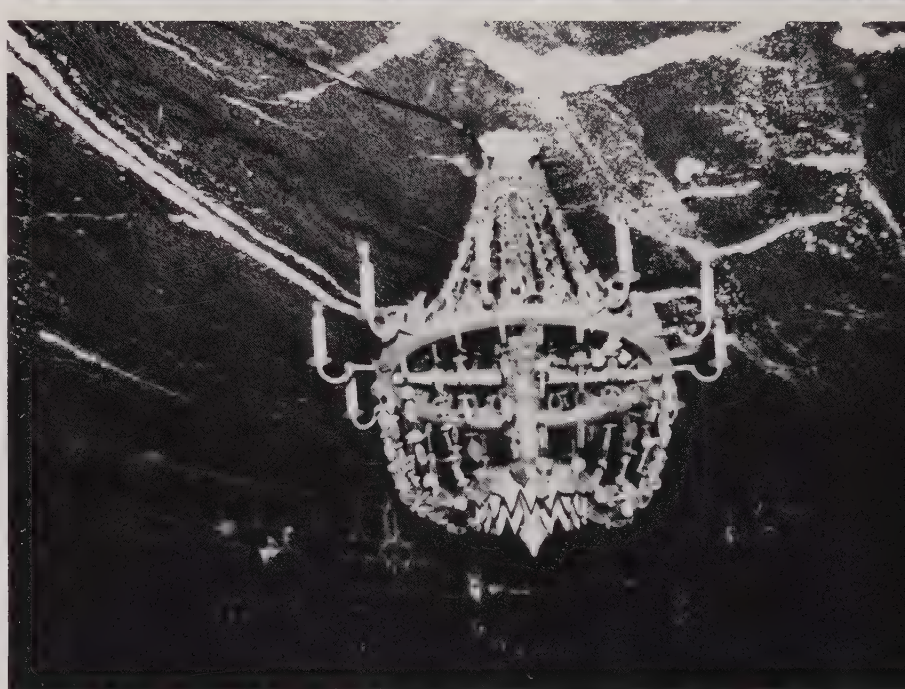
nearly pure salt sometimes forming in beautiful crystals most of which occur in lower mine levels. Some halite crystals are distorted or form with cavernous faces, but Krakow crystals usually occur in uncomplicated cubes and many are water clear. Most crystals are white, but a few are tinted reddish and yellowish by impurities. In the famous Crystal Grotto, some halite crystals measured 40 centimeters on an edge. In old abandoned stopes, secondary efflorescent salt forms resembling "Christmas trees" festoon the ceilings.

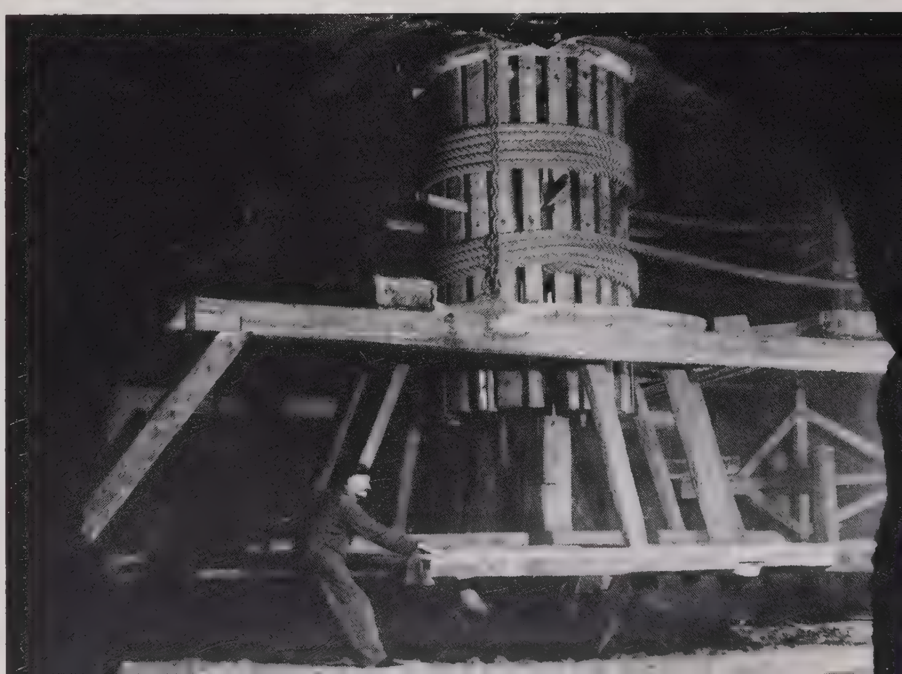
Early digger's tools were pickaxes and wedges of wood. Wooden haulage devices called "hoisting wheels" raised buckets filled with brine. These machines were first muscled by men, but beginning in 1443 horses did the pulling. In 1644 a terrible fire broke out in the mine, raged out of control for eight months, and took a heavy toll in human lives.

In 1690 Wieliczka mine workers staged a major rebellion, primarily because salt allowances had been curtailed. Punishment was severe and immediate. Offenders were marched to "Passion of Christ" hill at Wieliczka, and their sentences carried out. Four ringleaders were impaled; six had their heads cut off and bodies quartered; twelve, including a woman, simply lost their heads; and four other women and a man were publicly flogged.

During the 18th century, miners discovered that salt ceilings of great height could easily support themselves, so fewer support columns were left and giant rooms, some 30 meters high and 100 meters long, remain today. The mine contained half a dozen major streams and lakes in its caverns which were crossed in small boats. Of these, Infernal Lake is outstanding: an underground body of saltwater 244 meters long, 125 meters wide, and 50 meters deep. During the 1840s, visiting dignitaries were entertained with white and red flares which created an atmosphere of mysterious beauty.

Devout Polish and Austrian miners turned half a dozen of the big rooms into chapels. The oldest chapel, known as early as 1518, is located in the "Boczaniec Stall" (room), on the first level. Life-size figures of the Blessed Kinga (the salt miner's patron saint), St. Anthony, Christ, and the Virgin Mary were carved from solid salt. Chandeliers adorned with garlands of hand-cut salt prisms were suspended from ceilings to create an ethereal atmosphere of unique beauty. Tourists clamored to visit the old mine, necessitating construction of enormous balconies, steps, and landings of 18-centimeter-thick stripped logs carefully





bound together with strap iron.

During the 1800s, the work force increased to 1500 men, and more than 700 horses were used. Scientific investigation revealed an abundance of fossils in the salt strata including crabs, fish, urchins, coral, fruit, corn, and pine cones. Matchless groups of gemmy halite crystals were sent to museums throughout the world. Outstanding samples are in the Natural History Museum in Vienna, Prague's Narodni Museum, and the American Museum of Natural History. Halite crystals of this quality are no longer found in the mine.

The Krakow salt works is both a museum and a working mine. A tour of the works begins with a ride in a clean and quiet mine cage down the Danilowicz shaft, then continues through a series of well lighted and ventilated tunnels into vast rooms displaying ancient wooden machines, chandeliers, display cases, and priceless documents. The Wieliczka underground museum in a third-level gallery is unique. Astounding curiosities include the sets of steps carved from solid natural halite which connect the various grand chambers. Although the stair treads have been in use for 85 years and millions of people have moved down each flight, there is no visual evidence of wear. In Krakow, halite seems tougher than granite!

A miner told the author the story of young Johann Gergreitz, a miner in the Krakow works from 1825 to 1851. He never missed a day's work and was a favorite with fellow miners, children, and especially the ladies of Wieliczka. At 30 he married pretty Elisa Doskrinski, a cobbler's daughter, and gave up flirting. They lived happily together for 10 years. One day, a large block of salt fell, killing him instantly. His wife was wild with grief. As the body was prepared for burial it was discovered, to the whole town's amazement, that Johann was a woman! The miner, with a wink, added, "Some women really *can* keep a secret."

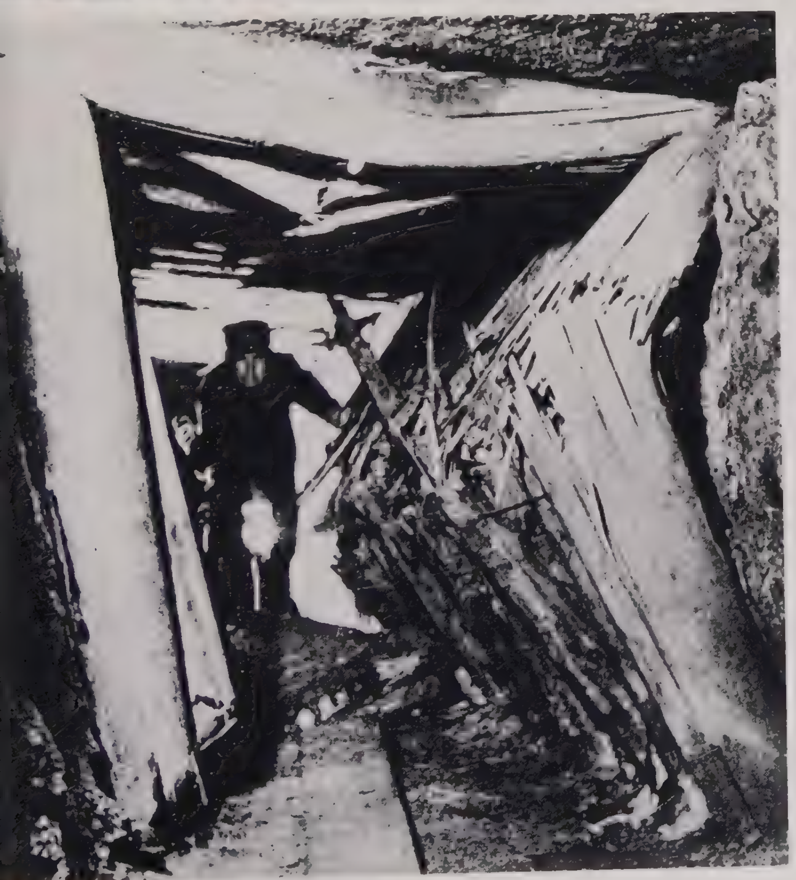
BELOW: Halite
Size: 30 by 23 cm
Locality: Krakow Saltworks
Collection: Vienna Natural History Museum
Photo: G. Niedermayr

OPPOSITE TOP LEFT:
Mining solid salt about 1910
Courtesy: Krakow Saltworks

OPPOSITE TOP RIGHT:
Old headframe is now used for salt mine tours
Photo: Peter Bancroft

OPPOSITE BOTTOM LEFT:
Enormous shifting weight crushing 30 centimeter timbers, 1940
Courtesy: Antoni Jodtowski

OPPOSITE BOTTOM RIGHT:
Polish salt miners in the Krakow, 1979
Photo: Peter Bancroft



98 Mursinka/Nerchinsk Mines, Sverdlovsk/Urulga, U.S.S.R.

The Soviet Union is famous for its topaz. Blue crystals, frequently on matrices of quartz, mica, and feldspar, occur in classic pegmatite deposits near Mursinka, 120 kilometers north of Sverdlovsk in the Ural Mountains. A second classic region, 3400 kilometers southeast of Mursinka in the Borshchovochnyy Mountains near the Urulga River, is known for wine-colored crystals with faultless terminations. The closest city to the eastern gem pegmatites is Nerchinsk, about 225 kilometers equidistant from the Mongolian and Manchurian borders of China.

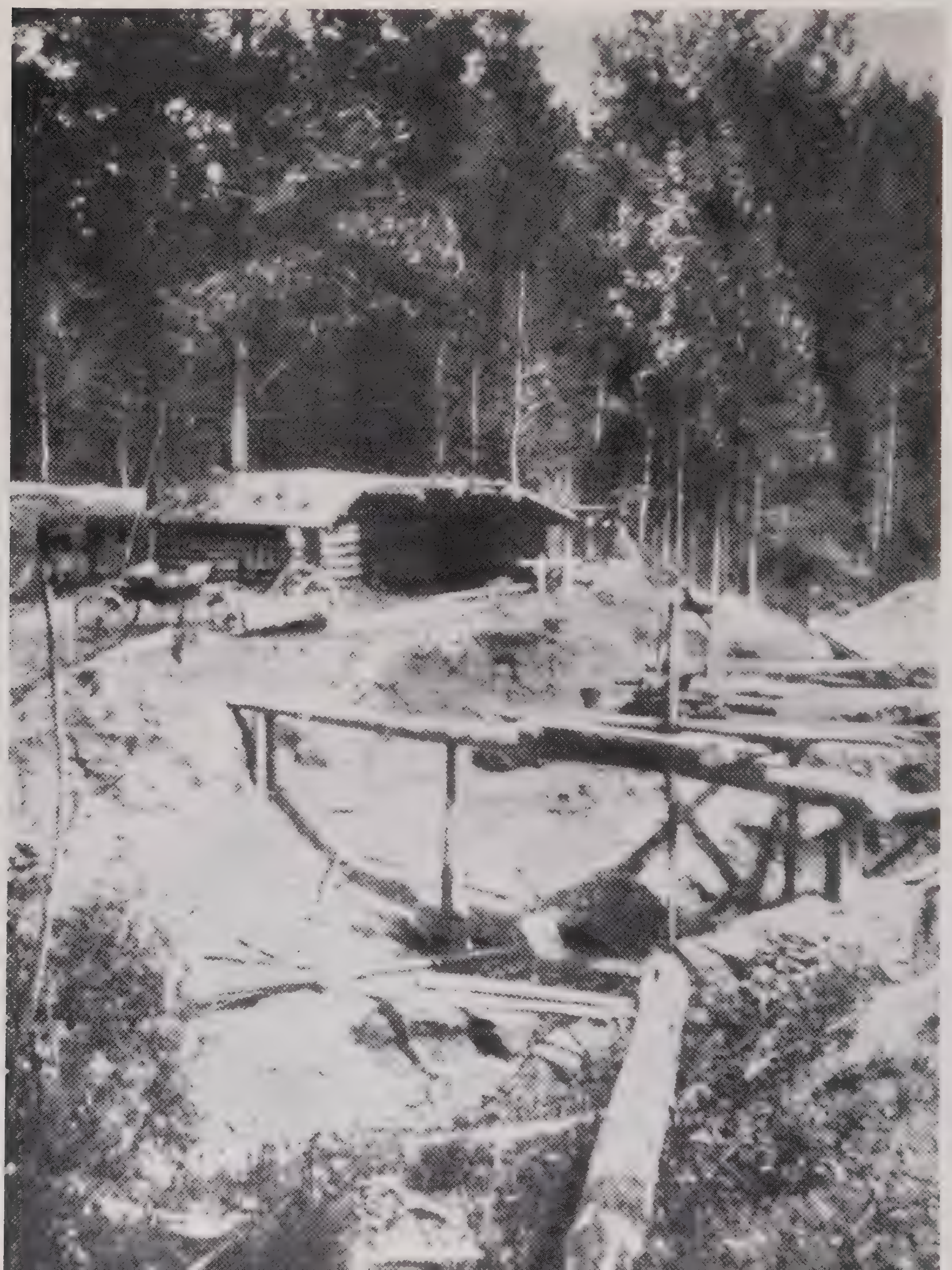
Information on these areas is difficult to gather. It is not easy for visitors to enter the middle Urals or the far-off southeastern region of the Soviet Union and Soviet scientists failed to provide contemporary photographs.

Mursinka is a large village located on a plain near the confluence of the Alabashka, Neiva, Ambirka and Shilovka Rivers. The nearby forested hills, particularly to the north, east, and south, surround numerous pegmatitic outcrops that have been mined sporadically for

BELOW: Gem mine in forest north of Mursinka which has produced blue topaz, aquamarine and smoky quartz, 1915
Courtesy: A.Y. Fersman, Unterhaltende Mineralogie, *1931*

OPPOSITE TOP: Mursinka, a small village in the Ural Mountains near the topaz and aquamarine mines, 1912.
Tourists are not permitted in this area today.
Courtesy: A.Y. Fersman,

OPPOSITE BOTTOM: Miner's house at topaz mine in winter, 1925
Courtesy: A.Y. Fersman




more than 100 years. Mursinka has been a center of gem mining. Most stones of gem quality have been shipped to lapidaries in Ekaterinburg for cutting.

The principal blue topaz deposits lie northeast of Lower Alabashka, a tiny village north of Mursinka. Most blue topaz crystals are found attached to the matrix. (Loose single crystals commonly result from damage to the matrix during mining.) Crystals occur in open vugs (some filled with brownish clay) in pegmatite veins. Associated minerals are crystallized, producing stately and highly prized clusters of blue topaz, muscovite, smoky quartz, and feldspar in combination. Topaz crystals are stubby prisms in form, topped by flat terminations and steep dome faces. Colors range from nearly colorless to rich baby-blue and bluish gray. Most crystals are bright, sharply formed, and tend to be internally flawed. This saves many from the cutter's saw—a boon to the collector.

Red and dark pink colored tourmaline of exceptional quality (locally known as "Siberian ruby") is found at Shaitanka (discovered in 1815), Yushakova, and Sarapulka. The prisms are short and thick with flat teminations.

Beryl, in a variety of colors, is found near Mursinka, Shaitanka, Kornilova, and Yushakova. The best of the Russian beryls are mined just east of Mursinka. Colors include blue, green, blue-green, yellowish green, yellow, and light amber. A large cluster of yellowish green crystals 27 centimeters long is a part of the gem collection in Leningrad's Institute of Mines.

Amethyst in rich hues and fine pointed crystals occurs at Mursinka, Yushakova, Alabashka, and Sarapulka. Clumps of amethyst were discovered just below the surface, sometimes intertwined with roots and moss.

Topaz, amethyst, tourmaline, and beryl have been found in all of the major gem deposits nearly encircling Mursinka. However, all four minerals never occur together. Amethyst and tourmaline usually occur alone; beryl and topaz commonly in association.

BELOW: Topaz with smoky quartz
Size: 10 by 8 cm
Locality: Mursinka
Collection: Edward Swoboda
Photo: Harold and Erica Van Pelt

OPPOSITE: Nikolay V. Vladykin, Soviet mineralogist
Photo: Jaroslav Svenek

In far southeastern Siberia, just 225 kilometers east of Genghis Khan's wall (running near China's Manchurian border), is Nerchinsk, a small city in the center of the Chita district. To the northeast flows the Urulga River from the Borshchovochnyy Mountains. The Adun-Cholon and Kukuserken ranges lie to the south. The Adun-Cholon gemstone area, discovered in 1723, was mined for flawless aquamarine of good color and for brown, tan, and blue topaz. Hoppevskaya Gora, the highest peak in the Adun-Cholon range, has flanks deeply scarred from gem mining. An exceptionally fine transparent beryl from this mountain, 31 centimeters in length and 5 centimeters in diameter, is in the British Museum of Natural History.

Topaz from the Kukuserken Mountains, a southern continuation of the Adun-Cholon range, was discovered in the 1850s. It differs markedly from Mursinka crystals. Here topaz is yellowish in color and generally transparent. Crystals are uncommonly large—up to 11.4 kilograms. Nearly all topaz crystals occur singly, but where groups are found, the crystals are nearly always parallel. Topaz and aquamarine, very abundant in both the Kukuserken and Borshchovochnyy Mountains, frequently occur with one another. Beryl here tends to be deeply striated along prism faces and occurs in a wide assortment of colors: yellowish green, colorless, wine-yellow, greenish blue, and sky-blue. Mining for topaz and aquamarine is most often confined to open pits, timberless shafts not deeper than 5 meters, or crude trenches.

Wonderful wine-colored topaz has been found near the Urulga River, along with fine aquamarine crystals, many of gem quality. Some topaz occurs in jumbo sizes of from 5 to 14 kilograms. Unfortunately, the wine color easily fades upon exposure to strong light. The British Museum of Natural History has a superb and well-preserved collection consisting of a half dozen of these crystals obtained nearly a century ago.

Blue topaz matrix specimens from the Urals appear in collections throughout the world. Noteworthy examples are in the Fersman Mineralogical Museum in Moscow, Leningrad's Institute of Mines, the Irkutsk (Siberia) Technical Institute, the School of Mines and the Sorbonne in Paris, the British Museum of Natural History, Humbolt University in East Berlin, and in numerous American collections including Harvard University, the Field Museum in Chicago, the American Museum of Natural History, the Smithsonian Institution, and in private collections of Norman Pellman and Edward Swoboda.

The mountains of Adun-Cholon and Borshchovochnyy may be one of the world's best remaining gem topaz areas. But its remoteness and the difficulty in obtaining permission to travel there effectively remove it from the collector's world.

THIS PAGE TOP:
Topaz
(with form-fitting covers to protect color from fading)
Size: (largest) 9 by 5 cm
Locality: Borshchovochnyy Mts., Siberia, U.S.S.R.
Collection: British Museum of Natural History
Photo: Phillip R. Crabb

THIS PAGE BOTTOM:
Topaz
Size: 12 by 7 cm
Locality: Borshchovochnyy Mts., Siberia, U.S.S.R.
Collection: British Museum of Natural History
Photo: Frank Greenaway

OPPOSITE: Emerald
Size: 11.5 by 6 cm, 2800 carats
Locality: Tokovaya
Collection: American Museum of Natural History
Photo: Harold and Erica Van Pelt

99 Tokovaya Mines, Sverdlovsk (Ekaterinburg), U.S.S.R.

One of the best gem mines on earth is the seldom-visited Tokovaya. The little group of mines, located on the Tokovaya River which gently flows into the Pyshma on the Asiatic slope of the Urals, is about 91 kilometers east of Ekaterinburg, as the town was known until the Soviets named it Sverdlovsk. Factories in and about Sverdlovsk manufacture politically sensitive articles, and visitors are discouraged from entering the region though travel is physically easy. Over the years the Ekaterinburg sector's pegmatites and metamorphosed zones have been rich in amethyst, aquamarine, blue topaz, quartz, phenakite, chrysoberyl, emerald, and alexandrite. Nearly all gem varieties and species found there occur in fine crystals. Some are exceptional.

By the early 1800s, Ekaterinburg was already a fair-size city on the great road from Russia to Siberia. It was named for Empress Catherine II, whose love affairs rated at least equal billing in Ekaterinburg along with stones from the new gem finds. Most of the city's residents were connected in some way to mining. Russian coins were minted there, and large and efficient lapidary shops constituted a major industry. Cutters were expert at faceting, engraving seals, and carving gemstones. Prices were relatively low and street merchants annoyed visitors with offers of stones for sale.

In October 1830, a peasant charcoal-burner was making his way through the forest along the banks of the Tokovaya River when he came upon a large tree felled by a storm. In the exposed roots he found a number of green stones which he took to the gem cutting works in Ekaterinburg, then controlled by Czar Nicholas. The stones were identified as emeralds, and in 1831 the mica-schist deposit was developed as a mine. In many ways the new Tokovaya gemstone deposit geologically resembled the age-old Cleopatra emerald mines at Sikeit in Egypt's Zabara Mountains, except that the Egyptian mines produced only emerald. Here phenakite, aquamarine, fluorite, apatite, and rutile occurred as well.

Emeralds from the Urals generally have fine dark green color but are so flawed and interspersed with mica that usable stones are very rare. Emeralds of lighter hue tend to contain fewer flaws. Crystals do not form with the perfection of Colombian emeralds and, therefore, command much less attention. Russian emeralds do come in grand sizes, however. Some crystals reportedly reach dimensions of 40 by 25 centimeters. A choice,

rich green emerald crystal in the Fersman Mineralogical Museum vault measures 12 by 8.5 centimeters, and another in the American Museum of Natural History is 11 by 6 centimeters.

Czar Nicholas decreed that the imperial lapidary in Ekaterinburg receive the best available gems, cut or carve the gem material, then send finished stones to the palace in St. Petersburg. For some reason, a small collection of the best emeralds seen up to that time did not reach St. Petersburg, but instead arrived in Germany where they were sold to a prince. Some time later, the prince's wife, wearing her emeralds, visited St. Petersburg. When the Czarina admired the stones the wearer confided that they came from Siberia. Astounded, the empress sent an officer to search the lapidary director's house in Ekaterinburg. He found several emeralds of great value hidden away and the director was sent to prison.

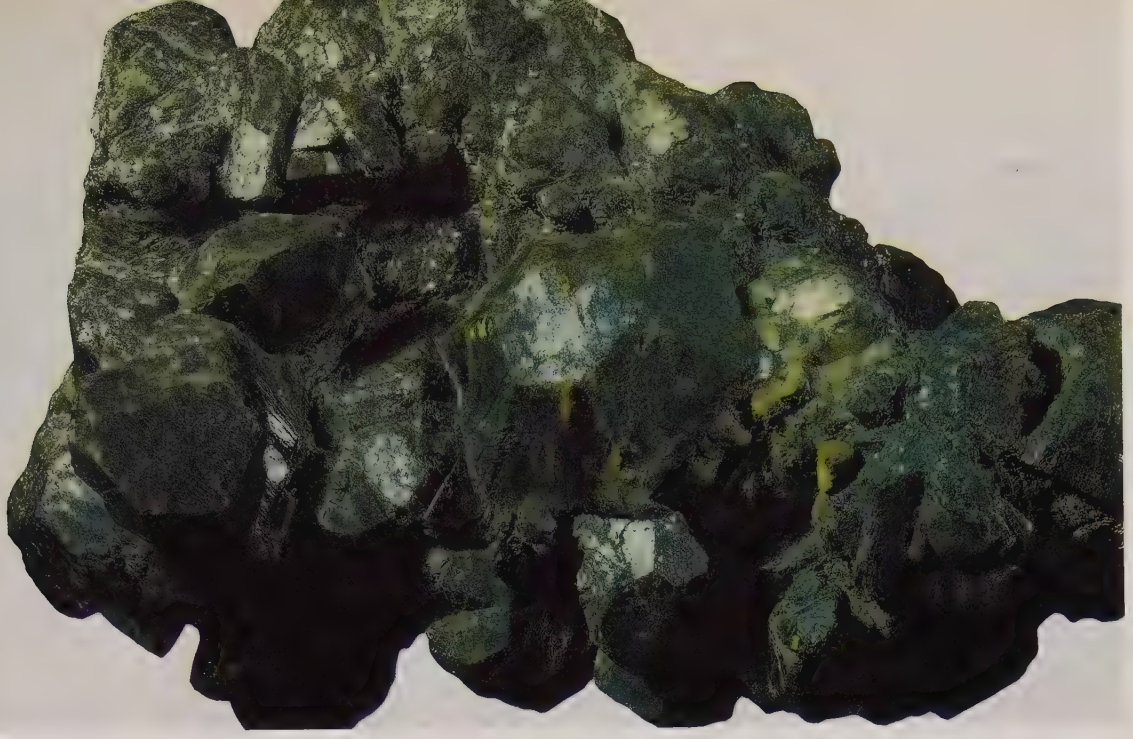
An entirely new gemstone discovered in Tokovaya's mica schists had the strange ability to change color under prevailing light. In daylight, rich green colors reflected from its dark background, while at night, under artificial light, it emitted red hues. Ostensibly

THIS PAGE TOP:
Czar Alexander I, 1830
(after whom alexandrite was named)
Courtesy: Helmut Leithner

THIS PAGE BOTTOM:
Tokovaya mine; the earliest known photograph, c. 1890
Courtesy: A.Y. Fersman, Geochemische Migration der Elemente, *1931*
Photo Provided By: Helmut Leithner

OPPOSITE TOP:
Alexandrite
Size: 18 by 13 cm
Collection: Fersman Mineralogical Museum, Moscow
Photo: Courtesy Y.L. Orlov

OPPOSITE BOTTOM:
Alexandrite
Size: 12 by 7 cm
Locality: Tokovaya mine
Collection: British Museum of Natural History
Photo: Frank Greenaway



found on April 23, 1830, the day young Czarevitch Alexander Nicolajevitch came of age, the new gem (a variety of chrysoberyl) created a sensation. It was named "alexandrite" in honor of the youth who would become Czar in 1855. To ensure even greater popularity, alexandrite's colors of red and green were Russia's national military colors.

Miners worked the emerald and alexandrite deposits under very primitive conditions. They worked best in spring, summer, and fall, mining known deposits and searching for new ones. But the long, harsh winters with mountainous snowdrifts and biting cold slowed mining activities to a virtual standstill. Most mining occurred in trenches or open pits but small tunnels sometimes followed the narrow veins.

The largest and finest alexandrite crystals ever found are from the Tokovaya deposit. Edwin Streeter wrote in *Precious Stones and Gems* (1898): "The wonderful alexandrite is an emerald by day and an amethyst at night. Its market value is extremely variable, and sometimes as much as £20 per carat is paid for a fine stone." In 1980 a gem with the same qualities would be worth many thousands of dollars.

THIS PAGE TOP: Gathering water in Tokovaya River to wash gems Courtesy: A.Y. Fersman

THIS PAGE BOTTOM: Bridge across the Tokovaya River, c. 1905 Courtesy: A.Y. Fersman

OPPOSITE TOP: Separator jigs and screens at the Tokovaya Courtesy: A.Y. Fersman

OPPOSITE BOTTOM LEFT: Worked out section of emerald mine Courtesy: A.Y. Fersman

OPPOSITE BOTTOM RIGHT: Factory for sorting and grading emeralds, 1927 Courtesy: A.Y. Fersman

Unfortunately for the lapidaries, larger crystals, usually highly fractured, yielded little facet-grade material and some crystals would not facet at all. Large (over 3 carats), clean alexandrite gems are among the rarest and most costly of all gemstones. The greatest of all alexandrite specimens known to the author is housed in Moscow's Fersman Mineralogical Museum. The 18-by-13-centimeter matrix contains at least 22 large alexandrite crystals. The largest, in the specimen's center, measures more than 6.5 centimeters across. Single crystals have been reported measuring 12 centimeters, but their current location is unknown. Max Bauer in *Precious Stones* (1896) stated

> *Large star-shaped triplet crystals often measure as much as 9 centimeters across, and sometimes even more; one group was found with 22 large crystals and many small ones of the same kind [possibly referring to the Fersman Museum specimen].*

Large alexandrite crystals have not been found in modern times, but good alexandrite crystals about 3 centimeters across of gem quality have been found recently.

100 Kop Krom Mine, Askale, Turkey

A substantial amount of the world's chromium ore comes from the remote and desolate mountains of eastern Turkey. Chromite, found as veins in massive serpentine, was discovered there in 1848. From 1860 to 1893, the country led the world in chromite production. Although economic depressions slowed or stopped chrome mining, 20th century wars created demand for greatly expanded production. Attempts were made to mine by open pit methods, but only low-grade ore was found. Foreign customers prefer high-grade concentrates, so the open workings have closed.

Kaemmererite, the chromium variety of clinochlore, belongs to the chlorite group of minerals. Named for the Russian mining director A. Kaemmerer of St. Petersburg (1789-1858), the mineral produces some of the most exotic crystals in the mineral kingdom. A beautiful deep raspberry-red, some kaemmererite crystals form in exquisite elongated pyramids with diameters increasing outward from the point of attachment. These crystals, often so tiny they require magnification to be seen, delight micro-mounters. Examples of simple or twinned crystals reaching 2 centimeters are extremely rare. Associated minerals include: druses of brilliant green uvarovite which line fissures of the ore body; quite rare bright uvarovite dodecahedrons and trapezohedrons up to 2 millimeters occurring with kaemmererite crystals; filmy sheets of chrysotile which loosely hang upon kaemmererite crystals; tiny, doubly terminated white calcite crystals; tiny white blades and spheres of hydromagnesite tip kaemmererite; pseudomorphs after brucite resembling those from California's benitoite locality; clusters of rhombohedral brucite formed in delightful minute transparent "roses" which dot kaemmererite crystals; silky snow-white needles of artinite commonly found in vugs; and hydroxylapatite rarely found in bright thin prisms.

Small kaemmererite crystals found in Turkey

BELOW: Kaemmererite
Size: crystals 20 by 15 millimeters
Locality: Kop Krom
Collection: Roland Dietrich
Photo: Olaf Medenbach

OPPOSITE TOP:
Archaic method of grinding grain is still in use
Photo: Roland Dietrich

OPPOSITE MIDDLE:
Santiya camp, 1978
Photo: Arthur Heuck

OPPOSITE BOTTOM:
Countryside near Erbas
Photo: Roland Dietrich

decades ago failed to attract much attention because of their size, shortage of supply, and the inaccessibility of the mines. The early kaemmererite mines were small—two- or three-man operations which probably destroyed most crystals in the mining process. Miners little appreciated the beauty or value of crystallized minerals associated with chrome ore. In this bleak land every energy must be exerted toward survival; gathering and storing crystals hardly put bread on the table.

German chemist-mineralogist Roland Dietrich first saw a small kaemmererite specimen in the early 1970s and was intrigued with the beauty of these rare crystals. Patient research of skimpy literature revealed a general mine location, which had been long abandoned. In 1975, Dietrich and his wife, Margot, embarked upon their first trip to Turkey. They crossed the Black Sea to Hopa, the last Turkish harbor before the Soviet border. In a rented car, they went through the high mountains of the Pontus to the eastern part of Anatolia, traveling through a region of nearly treeless plains and mountains to the town of Erzurum. A day was devoted to little villages near the Kop Dag mountains in search of an English-speaking miner who knew the area and who could serve as guide and interpreter.

They spent the first night in an extremely poor shelter shared by dozens of natives who, from dusk to dawn, recounted the verses of Ramasan, the Islamic Shrovetide. The next day a driver and a miner with an old dilapidated truck took the Dietrichs over deeply rutted, dangerous roads. Finally reaching the small mining camp of Santiya, the party was greeted by a throng of friendly miners. For the next few weeks, a dried mud hut was the Dietrichs' home.

Local natives still use the donkey as a beast of burden, as they have for more than 2000 years. Shepherdesses with long rifles strapped to their backs watch small flocks of lean sheep on bleak hills and in dry canyons. Santiya lies under a blistering sun for most of the year, and little rain falls. During hard winters snow can bury the village. It is then that packs of starving wolves invade the area and must be repulsed with rifles. The mountains about Santiya are treeless. Wood obtained at great distance is very costly. The impoverished miners do without wood for long periods, during which the mines become dangerous and close.

The mines are guarded by armed men; but they proved friendly and helpful to the

THIS PAGE:
Kaemmererite
Size: 120 by 90 mm
Collection: Roland Dietrich
Photo: Olaf Medenbach

OPPOSITE:
Kaemmererite crystal vug
Size: 12 by 9 mm
Locality: Kop Krom
Collection: Roland Dietrich
Photo: Olaf Medenbach

THIS PAGE TOP:
Kop Krom miners in main tunnel of Kop Krom mine
Photo: Roland Dietrich

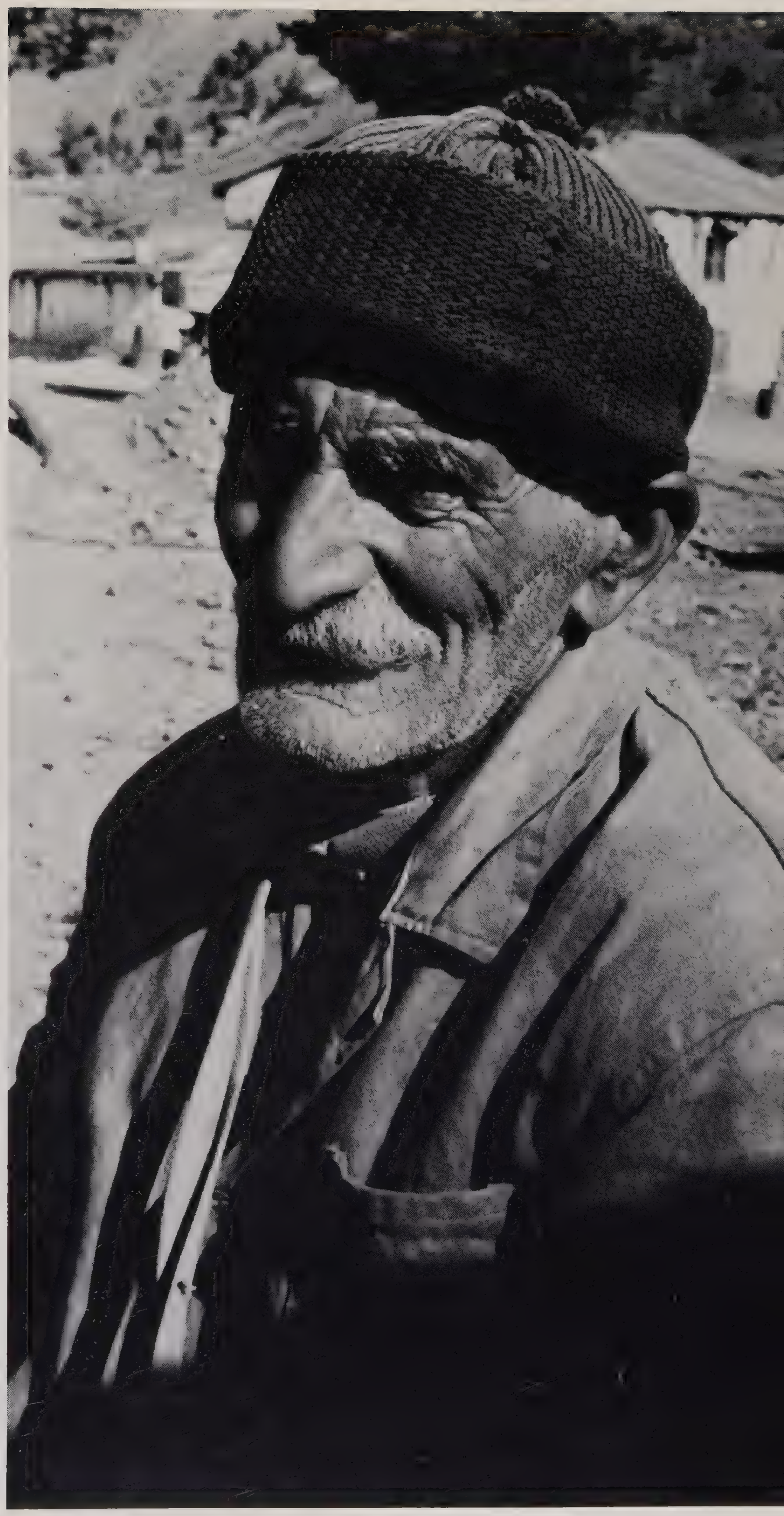
THIS PAGE BOTTOM:
Roland Dietrich (white hat) with miners at Kop Krom portal
Courtesy: Roland Dietrich

OPPOSITE: Aged Turk miner at Kop Krom
Photo: Roland Dietrich

Dietrichs. While visiting one of the Kop Krom mine tunnels, Dietrich followed cracks in the walls and located small kaemmererite crystals; then larger specimens 100 meters beyond. Convinced that many fine crystals could be obtained, Dietrich returned to Germany.

Both Dietrich and his wife started to learn the Turkish language in order to communicate with their friends at Santiya. During the next year, entirely through correspondence, they trained miners in the art of collecting without damaging crystals and encouraged them to collect as many as they could. They mailed hammers, chisels, safety hats, plastic foam, and shipping materials to the miners.

The following year the Dietrichs returned to Santiya and the Kop Krom mine loaded with gifts, supplies, and equipment, to barter for kaemmererite crystals. The miners had collected a considerable quantity of material. Best of all, most crystals were undamaged. The Dietrichs' many boxes of clothing, lamps, tools, hard hats, radios, a tape recorder, and a treadle sewing machine delighted the miners, who readily exchanged their supply of kaemmererite crystals for the goods from the outside world. The Dietrichs have made three more trips to the Kop Krom mine, and their efforts have produced most of the high quality kaemmererite specimens currently displayed throughout the world. Some of the best specimens are in the Smithsonian Institution and in other large American and European museum collections. Other dealers and collectors have since traveled to the Kop Krom mine. They have thrown their money around, raising the price of good crystals to such a degree that now the miners offer to exchange crystals for dishwashers and television sets, even though electricity is still more than 60 kilometers away.



FAMOUS MINING LOCATIONS

IDENTIFIED BY CHAPTER NUMBERS


30°
15°
60°
45°
30°
15°
0°
15°
30°
45°
60°
33
86
87
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89
92
97
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Thomas, Michael
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Suggested Reading

Prologue

BREAKENRIDGE, W.M. (1928) *Helldorado.* Houghton Mifflin Co., Boston, 89-98.

WALLACE, R. (1976) *The Miners.* Time-Life Books, 1-240.

Chapter 1

McCRILLIS, D.A. (1975) Gem tourmaline Rediscovered at Newry. *Mineralogical Record,* 6, 14-21.

HAMLIN, A.C. (1895) *History of Mount Mica.* 1-57.

Chapter 2

STEVENS, J.P. (1972) *Maine's Treasure Chest.* 1-211.

WILSON, W.E. (1977) The Pulsifer Quarry. *Mineralogical Record,* 8, 72-77.

Chapter 3

BAKER, G.W. (1881) *Geological Report on the Mineral Belt of Sussex County New Jersey, Sterling Hill—Mine Hill.* Manganese Iron Ore Company, Philadelphia.

PALACHE, C. (1935) Minerals of Franklin and Sterling Hill, Sussex Co., New Jersey: *U.S. Department of the Interior, Professional Paper 180.*

Chapter 4

HAMLIN, A. (1976) The Emerald. *Mineral Digest,* 3, 24-25.

SINKANKAS, J. (1960) *Gemstones of North America.* D. Van Nostrand Co., Inc., 75-78.

Chapter 5

LESKINEN, L. (1974) *4000 Years of copper country history.* Greenlee Printing Co., 1-21.

BUTLER, B.S., BURBANK, W.S. (1929) Copper deposits of Michigan. *U.S.G.S. Professional Paper 144,* 1-238.

Chapter 6

BASTIN, E.S. (1931) The fluorspar deposit of Hardin and Pope Counties, Illinois. *Illinois State Geological Survey Bulletin No. 58,* 9-71.

MAGEE, J. (1973) Cavern of crime. *Livingston Ledger,* Smithland, Kentucky, 1-79.

Chapter 7

GIBSON, A.M. (1972) *Wilderness bonanza, The Tri-State District of Missouri, Kansas and Oklahoma.* Stoval Museum Publication, University of Oklahoma Press, 1-362.

WHARTON, H.M. *et al.* (1975) Guidebooks to the geology and ore deposits of selected mines, the Viburnum Trend. *Missouri Geological Survey, Report 58,* 60.

Chapter 8

BROWN, D.L. (1977) *Photographs of early day operations at the Yogo Sapphire Deposit, Montana.* Privately published, 1-77.

KUNZ, G.F. (1897) Sapphires from Montana. *American Journal of Science,* 4, 4th Series.

Chapter 9

PERRY, E. (1923) The Butte mining district. *XVI International Geological Congress Guidebook,* 1-23.

SHOEBOTHAN, M. (1956) *Anaconda, the life of Marcus Daily, Copper King.* The Stackpole Co.

Chapter 10

FOORD, E., MARTIN, R.F. (1970) Amazonite from the Pike's Peak batholith. *Mineralogical Record,* 1, 373-384.

ODIORNE, H.H. (1978) *Colorado amazonstone.* Forum Publishing Company, 51.

Chapter 11

EBERHART, P. (1959) *Guide to the Colorado ghost towns and mining camps.* Sage Books, 118-140.

KOSNAR, R.A., MILLER, H.W. (1976) Crystallized minerals of the Colorado mineral belt. *Mineralogical Record,* 7, 278-291.

Chapter 12

FEITZ, L. (1978) *Cripple Creek.* Little London Press, 68.

LEE, M.B. (1958) *Cripple Creek days.* Doubleday and Company, 270.

Chapter 13

BIDEAUX, R.A. (1980) Famous mineral localities; Tiger, Arizona. *Mineralogical Record,* 11, 155-181.

Chapter 14

EDSON, G.M. (1975) Famous mineral localities; the Red Cloud mine. *Mineralogical Record,* 11, 141-152.

WILSON, E.D. (1933) Geology of mineral deposits of Southern Yuma County, Arizona. *University of Arizona Bulletin 134,* 64-66.

Chapter 15

BAILEY, L.R. (1983) *Bisbee, Queen of the Copper Camps.* Westernlore Press, Tucson, 159 p.

GRAEME, R.W. (1981) Famous mineral localities; Bisbee, Arizona. *Mineralogical Record,* 12, 258-319.

Chapter 16

SMITH, G.H. (1943) The History of the Comstock Lode. *Nevada State Bureau of Mines, University of Nevada Bulletin,* 37, 297.

WALLACE, R. (1976) *The Miners.* Time-Life Books, 57-91.

Chapter 17

SINKANKAS, J. (1960) *Gemstones of North America.* D. Van Nostrand Company, 116-123.

ZEITNER, J.C. (1971) Precious Opal from Nevada. *Lapidary Journal,* March issue, 1534-1542.

Chapter 18

MORGAN, V., and ERD, R.C. (1969) Minerals of the Kramer Borate District. *California Division of Mines and Geology, Min. Info. Serv., Part I,* 143-153; Part II, 165-172.

PUFFER, J.H. (1975) The Kramer borate mineral assemblage. *Mineralogical Record,* 6, 85-91.

Chapter 19

SLYTER, R.J. and G. (1972) *Historical notes of early Washington, Nevada County, California Mining District,* 1-163.

CLARK, W.B. (1970) Gold districts of California. *California Division of Mines Bulletin 193,* 1-128.

Chapter 20

LAUDERBACK, G.D. (1909) Benitoite, its paragenesis and mode of occurrence. Univ. Calif. Bull. Dept. of Geol., 331-380.

WISE, W.S., GILL, R.H. (1977) Minerals of the Benitoite Gem mine. *Mineralogical Record,* 7, 442-456.

Chapter 21

FOORD, E.E. (1977) The Himalaya dike system. *Mineralogical Record,* 7, 461-474.

RYNERSON, F. (1967) *Exploring and mining for gems and gold in the West.* Naturegraph Company, 1-204.

Chapter 22

FLETCHER, C.R. (1905) California's precious stones. *Los Angeles Mining Review,* 3.

SINKANKAS, J. (1960) *Gemstones of North America.* D. Van Nostrand Co., 150-166.

Chapter 23

BANCROFT, P. (1977) The Famous Tourmaline Queen Mine. *Australian Gems and Crafts,* Aug.-Sept., No. 24, 130-133.

LARSON, W. (1972) The "Queen" Reigns Again. *Lapidary Journal,* Oct. issue, 1002-1006, 1028-1032.

Chapter 24

LEAVINS, P.B., and THOMSSEN, R.W. (1977) Prince of Wales Island, Alaska. *Mineralogical Record,* 8, 4-12.

MONTGOMERY, A. (1937) The epidote localities of Prince of Wales Island, Alaska. *Rocks and Minerals,* 7, 195-208.

Chapter 25

SWOBODA, E. (1976) Boléo—a Classic Locality Reworked. *Lapidary Journal,* Jan. issue, 1814-1830.

WINCHELL, R.E., and ROUSE, R.C. (1974) The mineralogy of the boleite group. *Mineralogical Record,* **5**, 280-287.

Chapter 26

JOHNSON, P.W. (1965) *Field guide to the gems and minerals of Mexico.* Gembooks, 21-23.

HEWITT, W.P. (1968) Geology and mineralization of the main mineral zone of the Santa Eulalia District, Chihuahua, Mexico. *American Inst. Mining Engineering,* **241**, 228-260.

Chapter 27

BLAIR, G. (1970) A mineral collector visits Mexico. *Gems and Minerals,* January issue, 22-27, 49.

WHITE, J.S. (1972) Tennanite—tetrahedrite from Naica, Chihuahua, Mexico. *Mineralogical Record,* **3**, 115-119.

Chapter 28

JOHNSON, W.P. (1965) *A field guide to the gems and minerals of Mexico.* Gembooks, 29-34.

HOFFMANN, V.J. (1967) The mineralogy of the Mapimi mining district, Durango, Mexico. *University of Arizona Masters Thesis.*

Chapter 29

BUSECK, P.R. (1966) Contact metasomatism and ore deposition, Concepción del Oro, Mexico. *Economic Geology,* **66**, 97-136.

ROGERS, C.L. (1956) General geology and phosphate deposits of Concepción del Oro District, Zacatecas, Mexico. *U.S.G.S. Bulletin 1037-A,* 1-102.

Chapter 30

MARTIN, P.F. (1906) *Mexican treasure house.* 40-47; 188-205.

JOHNSON, P.W. (1965) *Field guide to the gems and minerals of Mexico.* Gembooks 39, 40.

Chapter 31

ANDERSON, V. (1979) Microminerals. *Mineralogical Record,* **10**, 103-108.

CHAO, G.Y., BAKER, J. (1979) What's new from Mont St. Hilaire, Quebec. *Mineralogical Record,* **10**, 99-101.

Chapter 32

GRICE, J.D., and WILLIAMS, R. (1979) The Jeffrey mine. *Mineralogical Record,* **10**, 69-80.

RIORDON, P.H. and LALIBERTE, R. (1972) Asbestos deposits of southern Quebec. *24th International Geological Congress, Guidebook B-08,* 1-21.

Chapter 33

PETERSON, E.H. (1974) Natural Greenland cryolite, Kryolitselskabet *Øresund A/S,* Copenhagen, 1-24.

PAULY, H. (1974) Kryolitforekomsten Ivigtut. *Presented to Symposium Metallization, Karlovy Vary, Czechoslovakia,* 1-7.

Chapter 34

CHIVOR—*Somondoco Emerald Mines of Colombia* (c. 1975), Colombian Emerald Syndicate, Ltd., New York City, 1-32.

BANCROFT, P. (1971) The Lure of Chivor. *Lapidary Journal,* April issue, 128-131.

Chapter 35

TENHAGEN, J.W. (1973) Muzo emerald mine—Colombia's hidden gem. *Lapidary Journal,* April issue, 56-58.

OPPENHEIM, V. (1948) The Muzo emerald zone, Colombia, S.A. *Economic Geology,* **43**, 31-38.

Chapter 36

AHLFELD, F. (1954) *Los yacimientos minerales de Bolivia.* Bilboa, Imprenta Industrial, S.A., 1-227.

DELGADO, B. (1957) *Resena Historica y Geologica del Cerro Rico de Potosí.* Corporacion Minera de Bolivia, 7-25.

Chapter 37

AHLFELD, F. (1954) *Los yacimientos minerales de Bolivia.* Bilboa, Imprenta Industrial, S.A., 227.

_______________ and MUNOS, R.J. (1943) *Los minerales de Bolivia.* Direccion General de Minas y Petroleo, La Paz, 276.

Chapter 38

COOK, R.B. (1979) Chanarcillo, Chile. *Mineralogical Record,* **10**, 197-200.

SEGERSTROM, K. (1962) Regional geology of the Chanarcillo silver mining district and adjacent areas, Chile. *Economic Geology,* **57**, 1247-1261.

Chapter 39

KNOX, N.B. (1945); Tungsten deposits of Peru. *Engineering and Mining Journal,* **146**, 95-98.

LANDIS, G.P. (1974); Geologic studies of Pasto Bueno. *Economic Geology,* **69**, No. 7, 1025-1059.

Chapter 40

BAUER, M. (1978) *Precious stones.* Charles E. Tuttle Co., 483, 484; 515, 516.

SCHALLER, W.T. (1918) Amethyst and other gems of Uruguay. *U.S. Bureau of Mines, Minerals Year Book,* **10**, 627.

Chapter 41

POUGH, F. (1971) Tourmaline. *Lapidary Journal,* **25**, No. 1, April issue, 60-66, 74-80.

_______________ (1968) The Santa Rosa Brazilian tourmaline mine. *Lapidary Journal,* **22**, No. 7, 890-895.

Chapter 42

ROLF, A. (1969) A new spodumene find in northern Brazil. *Lapidary Journal,* **22**, No. 11, 1450-1455.

SWOBODA, E.R. (1946) Spodumene, Brazil. *Jewelers' Circular-Keystone,* 250, 305, 307, 309.

Chapter 43

POUGH, F.H., and HENDERSON, E.R. (1945) Brazilianite, a new phosphate mineral. *American Mineralogist,* 30, 572-582.

CASSEDANNE, J.P. (1983) The Corrego Frio mine and vicinity. *Mineralogical Record,* **14**, 227-237.

Chapter 44

CASSEDANNE, J.P., and LOWELL, J. (1982) The Virgem da Lapa pegmatites. *Mineralogical Record,* **13**, 19-28.

Chapter 45

JOHNSTON, W.J. Jr., and BUTLER, R. (1946) Quartz crystals in Brazil. *Bulletin of Geological Society of America,* **57**, July, 601-650.

ROLFF, A. (1968) Brazilian diamond field at Diamantina. *Rocks and Minerals,* **43**, 3-8.

Chapter 46

BAUER, M. (1978) *Precious stones.* Charles E. Tuttle Co., 325, 334-337.

LEITHNER, H. (1979) Sherrybraune topase von Ouro Preto in Brasilien. *Lapis,* May, 26-29.

Chapter 47

CASSEDANNE, J.P., and J.O. (1973) Minerals from the Lavra de Ilha pegmatite, Brazil. *Mineralogical Record,* **4**, 207-208.

LINDBERG, M.L. (1958) The berylium content of rocherite from the Sapucaia pegmatite mine. *American Mineralogist,* **43**, 824-838.

Chapter 48

KELLER, P.C. (1979) More on rubellite from the Itatiaia mine, Brazil. *Mineralogical Record,* **10**, 33, 34.

PECORA, W.T., SWITZER, G., BARBOSA, A.L., and MEYERS, A.T. (1950) Structure and mineralogy of the Golconda pegmatite, Minas Gerais, Brazil. *American Mineralogist,* 35, 889-900.

Chapter 49

GAINES, R.V. (1976) Beryl—A Review. *Mineralogical Record,* **7**, 211-223.

JONES, R.W. (1976) Brazil, 1976. *Rock and Gem,* March issue, 52-61, 70-73.

Chapter 50

HIERN, M.N. (1967) Coober Pedy opal field. *Mining Review,* **109**, 36-44.

LEECHMAN, F. (1961) *The Opal Book.* Ure Smith, 80-94.

Chapter 51

KEARNS, R.H.B. (1973) Broken Hill, 1883-1893, **I**, Broken Hill Historical Society, New South Wales, Australia, 1-62.

WORNER, H.K., and MITCHELL, R.W., editors (1982) *Minerals of Broken Hill.* AM&S Ltd., Melbourne, 259 p.

Chapter 52

LEECHMAN, F. (1961) *The Opal Book.* Walkabout Pocketbooks, Australia, 66-80.

SMITH, G. (1923) Report on Lightning Ridge opal field. *Department of Mines, New South Wales, Annual Report.*

Chapter 53

CHAPMAN, A.H. (1972) On a spectacular find of crocoite in the Adelaide mine. *Mineralogical Record,* **3**, 111-113.

LANCASTER, K. (1977) Crocoite and its increasing scarcity. *Mineralogical Record,* 8, 24-26.

Chapter 54

Ichinokawa Mining Company (1917), *The Ichinokawa mine, present and future,* 1-18.

KUMON, N. (1966) *History of Saijo City.* Saijo City, Ehime Province, Japan 795-798.

Chapter 55

Staff Report (c. 1965) Bando Industries, Ltd. *Korean mines,* 38-42.

BANCROFT, P. (1979) The Taewha Mine, Korea. *Mineralogical Record,* **10**, 133-136.

Chapter 56

BRELICH, H. (1904) Chinese methods of mining quicksilver. *Institute of Mining and Metallurgy,* **14** (1904-05), 483-485.

TEGENGREN, F.R. (1920) The quicksilver deposits of China. *China Geological Survey, Bulletin 2,* 36.

Chapter 57

GUBELIN, E. (1965) The ruby mines in Mogok in Burma. *The Journal of Gemmology,* Oct., 1-15.

WEBSTER, R. (1975) *Gems: Their Sources, Descriptions and Identification.* Butterworth & Co., 29.

Chapter 58

CURRIER, R.H. (1976) The production of zeolite mineral specimens from the Deccan basalt in India. *Mineralogical Record,* **7**, 248-264.

SUKHESWALA, R.N., AVASIA, R.K. and GANGOPADHYAY, M. (1972) Observations on the occurrences of secondary minerals in the Deccan Traps of western India. *The Indian Mineralogist,* 50-68.

Chapter 59

BAUER, M. (1978) *Precious stones.* Charles E. Tuttle Co., 287, 288, 295-299, 341-345.

PEARL, R.M. (1978) Ceylon, jewel case of the Indian Ocean. *Mineral Digest,* **3**, 45-52.

Chapter 60

BARIAND, P., and GIRAUD, R. (1968) Une nouvelle espece minérale: l'afghanite de Sar-e-Sang, Afghanistan. *Bull. Soc. fr. Minéral. Cristallography* **91**, 34-42.

HERRMANN, G. (1966) The source, distribution, history and use of lapis-lazuli in western Asia. *D. Phil. thesis, Oxford University.*

Chapter 61

GUBELIN, E. (1975) *The Color Treasury of Gemstones.* Thomas Y. Crowell Co., 120-123.

POGUE, J.E. (1915) The turquoise. *Memoirs National Academy of Sciences, 3rd Memoir,* **12**, Part 2, 34-40.

Chapter 62

WILSON, W.E. (1976) St. John's Island, Egypt. *Mineralogical Record,* **7**, 310-314.

MOON, F.W. (1923) Preliminary geological report on Saint John's Island. *Geological Survey of Egypt,* 1-36.

Chapter 63

LUCAS, A. (1926) *Ancient Egyptian Materials and Industries.* Edward Arnold and Co., 161, 446.

HUME, F.W. (1922) *Geology of Egypt.* Part I, 2, Government of Egypt, 107-125.

Chapter 64

BANK, H., BERDESINSKI, W., and OTTEMANN, J. (1970) Durchsichtiger smaragdgruner grossular ans Tansania. *Z. Dt. Gemmol,* 4-7.

GUBELIN, E.J., and WEIBEL, M. (1975) Green vanadium grossular garnet from Lualenyi near Voi, Kenya. *Lapidary Journal,* May issue, 402-414, 424, 426.

Chapter 65

HURLBUT, C.S. Jr. (1969) Gem zoisite from Tanzania. *American Mineralogist,* **54**, 702-709.

THOMPSON, T. (1969) Tanzania to Tiffany's. *Life Magazine,* **66**, No. 18, May 19, 70-76.

Chapter 66

DELIENS, M., PIRET, P., and COMBLAIN, G. (1981) *Les Mineraux Secondaires d'Uranium du Zaire.* Royal Museum of Central Africa, Tervuren, Belgium, 113 p.

UNION MINIÉRE DU HAUT—KATANGA (1964) La Maxquette Bruxelles. (yearly report) 10-21.

Chapter 67

THOMAS, A.E. (1973) Gem Trails of Rhodesia. *Lapidary Journal,* **26**, No. 11, 1654-1661.

Chapter 68

BANDY, M.C. (1951) The Ribaue—Alto Ligonha pegmatite district, Portuguese East Africa. *Rocks and Minerals,* **26**, 512-521.

POUGH, F.H. (1971) Tourmaline. *Lapidary Journal,* April issue, 60-80.

Chapter 69

BECKER, G. (1971) 70-pound tourmaline crystal. *Lapidary Journal,* April issue, 72, 74.

LACROIX, A. (1922) *Minéralogie de Madagascar.* Librairie Maritime et Coloniale, Paris, 3 v.

Chapter 70

WARD, F. (1979) The incredible crystal diamonds. *National Geographic,* Washington, D.C., 84-113.

JORGENSEN, A. (1978) The Premier Mine. *Optima One,* 1-26.

Chapter 71

de VILLIERS, P.R. (1973) The geology and mineralogy of the manganese ore deposits of the Northern Cape. *Abstracts of the 15th Congress of the Geological Society of South Africa, Bloemfontein,* 34-37.

WILSON, W.E., and DUNN, P. (1978) The Kalahari manganese field. *Mineralogical Record,* 9, 137-153.

Chapter 72

SOHNGE, G. (1967) *Tsumeb, a Historical Sketch.* Committee of the S.W.A. Scientific Soc., Windhoek, 92.

WILSON, W.E. (1977) Tsumeb. *Mineralogical Record,* 8, no. 3.

Chapter 73

BOULADON, J. (1952) Geologie des gites mineraux Marocains. *19th International Geological Congress, Regional Monograph No. 1,* Chapter 8.

GUESSOUS, A. (1970) Major lead-zinc producing mines in Morocco. *American Institute of Mining Metallurgical Engineers,* 195-203.

Chapter 74

GAINES, R.V., and THADEAU, D. (1971) The minerals of Panasqueira, Portugal. *Mineralogical Record,* **2**, 73-78.

Chapter 75

HUNT, W.F. (1915) The origin of the sulphur deposits of Sicily. *Economic Geology,* **10**, 543-559.

de MICHELE, V. (1974) *Guida Mineralogica d'Italia.* Instituto Geografico De Agostini, Novara, **2**, 128-137.

Chapter 76

DILLEN, M.H. (1975) La Pyrite de l'ile d'Elbe. *Le Monde et les Minéraux.* N. 6, 128-130.

de MICHELE, V. (1974) Guida Mineralogica d'Italia. Instituto Geografico de Agostini, Novara, 2, 58-62.

Chapter 77

CHERMETTE, A. (1979) La Gardette (Isere). *Monde Et Minéraux,* Jan.-Feb., 27-30.

POTY, B. (1969) Le Croissance des cristaux de quartz sur l'exemple du filon de la Gardette. *Sciences de la Terre,* 17-96.

Chapter 78

BROUSSE, A. (1982) The Les Farges mine. *Mineralogical Record,* 13, 261-268.

Chapter 79

CANTRILL, T.C., *et al.* (1919) Iron ores. *Spec. Rep. Min. Res. Great Britain, Mem. Geol. Survey, IX.*

ECKEL, E.C. (1914) *Iron Ores, Occurrence, Valuation and Control,* McGraw-Hill.

Chapter 80

DINES, H.G. (1956) Geology of northern Pennine orefield, **I**, *Geological Survey of Great Britain.*

DUNHAM, K.C., *et al.* (1952) Fluorspar. *Mem. Geol. Survey of Great Britain,* 4th Ed., London.

Chapter 81

DINES, H.G. (1956) The metaliferous mineral region of southwest England, **II**, *Geological Survey of Great Britain,* 616.

BIRD, R.H. (1958) *Britain's Old Metal Mines.* Trethellan House, Truro, Cornwall, England, 59-65.

Chapter 82

STALDER, H.A., EMBREY, P., GRAESER, S. and NOWACKI, W. (1978) *Die Mineralien des Binntales.* Naturhistorisches Museum der Stadt, Bern, 143.

WEIBEL, M. (1966) *A Guide to the Minerals of Switzerland.* Interscience Publishers, London, 123.

Chapter 83

SANBORN, W.B. (1976) *Oddities of the Mineral World.* Van Nostrand Reinhold Co., 22, 23.

WEIBEL, M. (1966) *A Guide to Minerals of Switzerland.* Interscience Publishers, London, 123.

Chapter 84

NOWACKI, W. (1970) Uber einige Mineralien der Grube Lengenbach (Binnatal). Collected reprints of articles published in *Urner Mineralienfreund,* 1969-1970, V.B. Sicher-Dittli, Gurtnellen, Switzerland, 61 p.

STALDER, H.A., EMBREY, P., GRAESER, S., NOWACKI, W. (1978) *Die Mineralien des Binntales.* Naturhistorisches Museum der Stadt, Bern, 143.

Chapter 85

BAUER, M. (1978) *Precious Stones.* Charles E. Tuttle Co., 417-19.

SEEMANN, R. (1978) Die Knappenwand. *Lapis,* July issue, 47-53.

Chapter 86

BEYSCHLAG, F. and VOGT, J.H. (1896) *The Deposits of Useful Minerals and Rocks,* 1137-1140.

TEGENGREN, F.R. (1924) Sveriges Adlare Malmer och Bergverk. *Kungl Boktryckeriet,* Stockholm, 283-291, 307-309.

Chapter 87

BANCROFT, P. (1972) The silver of Kongsberg. *Lapidary Journal,* November issue, 1146-1150.

SANNESS, S. (1969) Kongsberg Sølvverk. *Buskerud Andelstrykkeri,* Kongsberg, Norway, 1-35.

Chapter 88

BAUMANN, L. (1965) Problems of post magmatic ore deposition; of the Frieberg ore district, **2.** *IAGOD Symposium,* Prague, 56-65.

PUMPELLY, R. (1918) *My Reminiscences, Freiberg-1855.* Henry Holt and Company, 119-129.

Chapter 89

BEYSCHLAG, F. and VOGT, J.H. (1896) *The Deposits of Useful Minerals and Rocks.* Reprinted by Macmillan and Co., Ltd., London, 857-859.

ZODAC, P. (1946) Ilfeld, Germany manganese occurrence. *Rocks and Minerals,* **21**, no. 8, 489.

Chapter 90

SCHNORRER-KOHLER, G. (1983) Das Silbererzrevier St. Andreasberg im Harz. *Der Aufschluss,* **34**, part 1: 153-175, part 2: 189-203, part 3: 231-251, part 4: 317-332.

LEUDECKE, O. (1896) *Die Minerale des Harzes,* Berlin, 643.

Chapter 91

GAERTNER, H. (1971) *Achate.* Alles and Brillant Fachverlag, 1-71.

GUBELIN, E. (1975) *Color Treasury of Gemstones.* Thomas Y. Crowell, Co., 124-129.

Chapter 92

BEYSCHLAG, F., VOGT, J.H. and KRUSCH, J.H. (1914) *The Deposits of the Useful Minerals and Rocks, Their Origin, Formation and Content,* Macmillan and Co., 536-542.

STELZNER, A.W. (1905-06) *Die Erzlagerstatten,* edited by Bergeat, Leipzig, **2**, 926.

Chapter 93

STOBBE, J. (1981) Pribram, Czechoslovakia. *Mineralogical Record,* **12**, 157-165.

STOCES, B. (1934) Genesis of the fissure veins at Pribram. *Economic Geology,* **29**, 40-45.

Chapter 94

AGRICOLA, G. (1530) *Bermannus sive de re Metallica Dialogus, in Mining Lore* (1970) by W. Paul.

NOVACEK, R. (1935) Study on some secondary uranium minerals: *Zulastni Otisk. Z Vest. Kral. Ces Spol. Nauk Tr. 11 Roc. 35.*

Chapter 95

BEYSCHLAG, F., VOGT, J.H. and KRUSCH, J.H. (1914) *The Deposits of the Useful Minerals and Rocks; Their Origin, Formation and Content.* Macmillan and Co., 536-542.

GHITULESCU, T.P. (1935) Distribution de la mineralization dans les Gisement d'age Tertiare de Transylvanie, *Bull. Societatii Romane de Geologie,* **2**, 1-42.

Chapter 96

SZELLEMY, G. (1896) *Erzlagerstatten des Vihorlat—Gutin—Trachytgebirges.* Montangeol, Millennium Kongress, Budapest.

CIOFLICA, G., *et al.* (1973) *Alpine volcanism and metallogenesis in the Apuseni Mountains.* Geological Institute of Budapest.

Chapter 97

DLUGOSZ, A. (1975) Muzeum Zup Krakowskich Wieliczka. Wieliczka Muzeum, 1-135.

SZYBÍNSKI, Z. (1977) *Museum of Krakow Salt Works at Wieliczka.* Wieliczka Muzeum, 1-30.

Chapter 98

BAUER, M. (1978) *Precious Stones.* Charles Tuttle Co., 320-323.

FERSMAN, E. (1949) *Erinnerungenansteinen,* Moscow, 135-137.

Chapter 99

LEITHNER, H. (1980) Alexandrite from the Urals. *Lapis,* #4, 25-28.

BAUER, M. (1978) *Precious stones.* Charles E. Tuttle Co., 305, 315, 316.

Chapter 100

DIETRICH, R. (1978) Kaemmererite from the Kop Krom mine, Kop Daglari, Turkey. *Mineralogical Record,* **9**, 277-287.

KRAUSE, H. (1964) Chromchlorit vom Kop Dag, Turkei. *Neues Jahrbuch Mineralogisch Abhandlung,* 31-38.

General Index

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Mineral Index

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THIS PAGE TOP:
Matchless mine headframe (previously owned by Horace and Baby Doe Tabor) and second in gold production at Leadville, Colorado
Photo: Edward Bancroft

THIS PAGE BOTTOM:
Gold nugget
Weight: one kilogram
Size: 9 by 6 cm
Locality: Atlantic City, Wyoming
Collection: Los Angeles County Museum of Natural History
Photo: Larry Reynolds


50LBS.
APACHE EXPLOSIVES
L.F. DYNAMITE
AMOGEL
APACHE POWDER COMPANY
AMOGEL
GOLD MEDAL

Dr. Peter Bancroft is the author of *The World's Finest Minerals and Crystals* and has written for many publications in Europe, Australia and the United States. He is a well known lecturer on mines, minerals and gemstones.

In contrast to many "armchair authors" who merely recycle what has appeared in other books, Dr. Bancroft has spent years travelling the world like a modern-day Herodotus, visiting hundreds of remote and fascinating mineral and gem deposits, and interviewing miners and local inhabitants. Bancroft has uncovered a wide range of information, some of it never before published. This and his extensive knowledge of the literature have combined to produce an authoritative and highly readable text.

Although many fine specimens reside in public collections such as the Smithsonian Institution and the British Museum, Bancroft has searched further through a vast number of private collections worldwide in order to assemble this suite of magnificent photographs. Many specimens in these collections are rarely, if ever, available for public view.

Dr. Bancroft has done graduate work in...geology at the University of Southern California, The University of California at Santa Barbara, and at Stanford University. His doctorate, in Education Administration, is from Colorado State University. During his long professional career he has served as teacher, principal, and superintendent of schools in California; as a White House consultant on education; as a professional photographer; as a gemstone buyer; as Curator of Mineralogy at the Santa Barbara Museum of Natural History; and as Director of Collections for the San Diego Gem and Mineral Society.

His personal mineral and crystal collection has won state and national honors. In 1984 he was selected as an Honorary Awardee for the American Federation of Mineral Societies' Scholarship Foundation.