ARIZONA-IV

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ZONA
WULFEN

the Mineralogical Record

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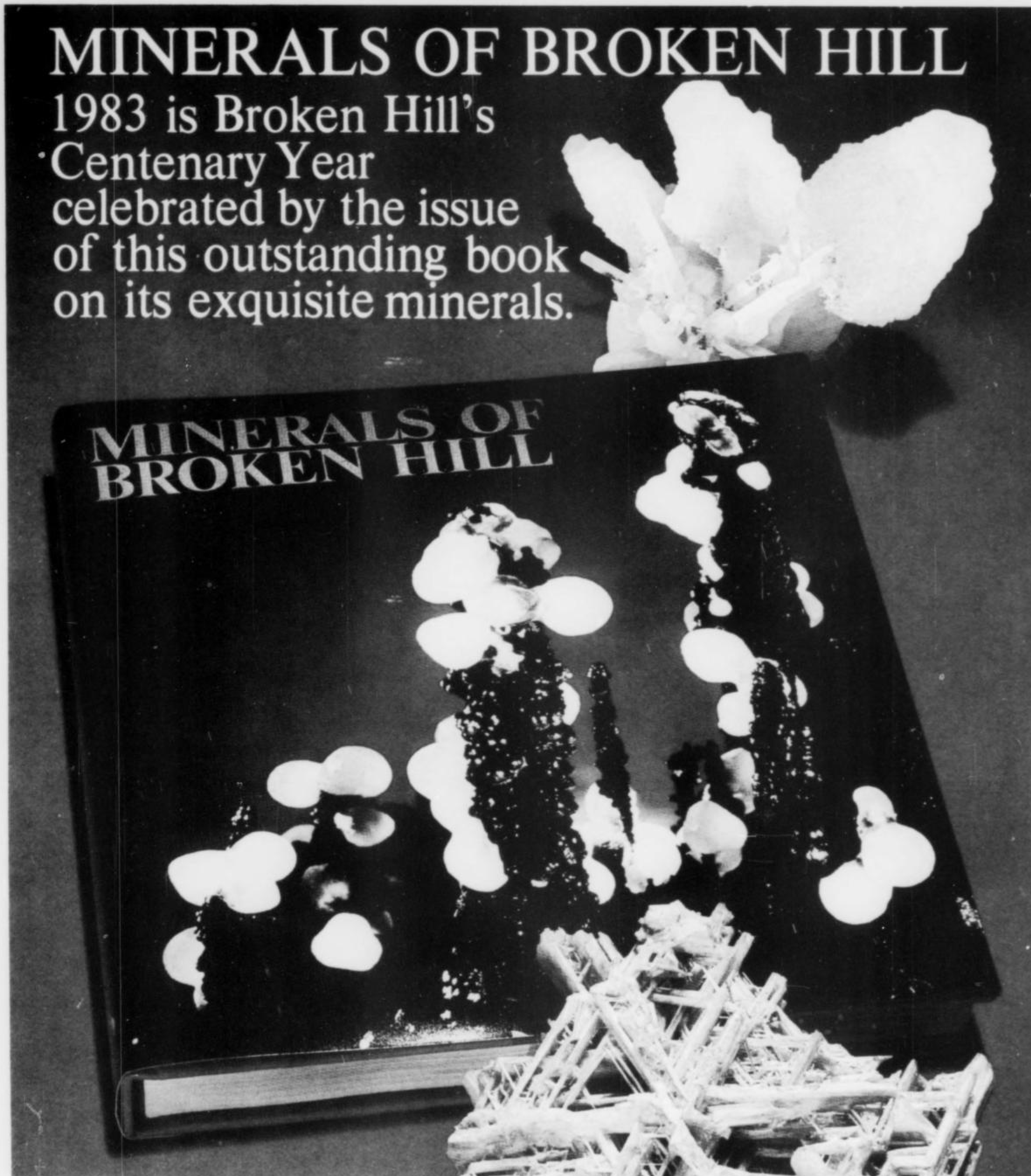
COVER: WULFENITE from the Old Yuma mine, Pima County, Arizona. The top crystal measures 1$^{1}/_{16}$ inches diagonally. This specimen, collected by Ed Over in 1929 is shown in its entirety on page 100. See the article by Dick Jones on the Old Yuma mine, beginning on page 95. Photo by Wendell E. Wilson.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(Top) Design from a Spanish silver 8-reales coin, or "piece of eight," minted in Mexico City in 1621. The inscription reads "King of the Spains and the Indies," in reference to Philip III of Spain.

Terra Incognita

The Search for Minerals in Spanish Arizona

by **William D. Panczner**
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Illustrations by Wendell E. Wilson

Nearly a century before the Pilgrims landed at Plymouth Rock, Spaniards were exploring what is now southern Arizona. They found a number of important deposits including those at Ajo and Jerome.

INTRODUCTION

The pre-Columbian inhabitants of Arizona mined a number of deposits for salt, clay, pigments, turquoise, flint and obsidian more than 2000 years ago. Evidence of their work in the form of mining artifacts occasionally turns up, and in one instance the actual body of an Indian miner was found preserved in a salt mine, where he had been killed in a cave-in (see Thompson, elsewhere in this issue).

The Spanish introduced themselves into Arizona in the early 1500's, and made it immediately clear to the Indians that what they were after was gold. As one conquistadore put it, "The Spanish have a disease that only gold can cure."

The Spanish maintained a nearly continuous presence in Arizona for more than 300 years. During that time they prospected with enthusiasm, despite the occasionally bloody opposition of local tribes. The Spanish Period saw the discovery of many deposits, and left a cultural imprint which endures to this day. The tales that have come down to us from those times make interesting reading.

THE SEVEN CITIES OF CÍBOLA

In 1530 an Indian named Tejoc told a remarkable story to Don Antonio de Mendoza, the Viceroy of New Spain (Mexico). Tejoc described seven fantastically wealthy Indian cities in the land to the north which the Spaniards called *Terra Incognita* ("unknown land"). The Seven Cities of Cíbola, he said, had streets paved with gold. The Viceroy must have been skeptical, because no expedition was made to find the fabled Seven Cities until additional reports were received.

Those additional reports came a few years later from four survivors of the Narváez colonizing expedition in Florida. The expedition had been driven out of Florida by hostile Indians and was subsequently shipwrecked in the Gulf of Mexico in 1528. The party, led by Álvar Núñez Cabeza de Vaca, included one slave by the name of Estevan who was either a negro or a dark-skinned Arab (historians are unsure). After being captured by natives in Texas, they had endured eight years of hardship as slaves and later medicine men, making their way from tribe to tribe. They finally reached Culiacán in

Spanish half-suit of armor, a popular style worn by both mounted and foot soldiers, including men of the Oñate expedition (1597–1605). Probably of German or Flemish manufacture. Collection of the Arizona Historical Society, Tucson.

1536, after having come close enough to Arizona and New Mexico to hear the tales of wealthy cities. These fantastic stories they passed on to the interested Mendoza.

Not wanting to start a mad gold rush, Mendoza publicly discounted Vaca's report, while quietly organizing an unostentatious expedition to check it out. Despite Mendoza's urgings, however, Vaca had had enough of that part of the world and was not interested in leading the expedition. Finally Mendoza purchased Estevan and assigned him as guide to Friar Marcos de Niza, a 38-year-old missionary-adventurer who was a veteran of the campaigns in Guatemala and Peru.

In 1539 the small exploring party left Culiacán, and headed into the Unknown Land. During his earlier years of wandering, Estevan had learned how to impress the natives; being large in stature and of a unique (to the Indians) skin color, he bedecked himself in brightly colored fabrics and feathers and proclaimed himself to be a medicine man of invulnerable strength. The Opata and Pima Indians of Arizona were overawed by the spectacle.

Friar Marcos sent Estevan ahead when they reached Vacapa. Because Estevan could not read or write, he was instructed to send back a wooden cross the size of a man's hand if the land ahead was moderately important; the size of two hands if exceptionally important; and larger if it were something "greater and better than New Spain." Imagine Friar Marcos' surprise when, a few days later, messengers returned with a cross the size of a man! Estevan had heard new stories of the Seven Cities and was urging the friar to hurry.

Estevan's luck lasted until he reached the Zuñi pueblo at Háwikuh. The Zuñi's were not impressed, and he was killed by a hail of arrows. Survivors from among his Indian retinue returned to the friar and broke the shocking news. Nevertheless, Friar Marcos was determined to see Háwikuh, which he took for granted was Cíbola. He proceeded onward until he was able to view the village from a distance, then beat a hasty retreat back to Culiacán and Mexico City. Unfortunately, his account to Viceroy Mendoza was pure fabrication. He told of gold and silver utensils, turquoise-decorated houses, giant pearls, gold beads and emeralds. Since Friar Marcos had witnessed the riches of the Incas, he may have been more susceptible to the stories of the Indians (and Mendoza more inclined to believe him).

That was good enough for Viceroy Mendoza, who lost no time in organizing a large military expedition to take charge of the new and wealthy lands. The Viceroy's friend, Francisco Vásquez de Coronado, was chosen to lead the venture. Three hundred men, most of them in their twenties and representing some of the bluest blood in New Spain, paraded out from Compostela amid great pageantry and splendor. Some wore coats of mail, others wore breastplates and steel helmets, while many others wore comfortable buckskin. Coronado himself wore gold-plated armor and a plumed helmet. They were accompanied by 1000 Indian warrior allies in full regalia, half a dozen cannon, 600 horses, and thousands of cattle, sheep, goats and swine. And of course there was Friar Marcos leading a small group of brown-clad Franciscan friars. It was the largest enterprise ever attempted by the Spanish in the New World. It was also one of their greatest failures.

Two years later the tattered remains of that magnificent army straggled back into Culiacán. They had traveled first to the Gila River in southern Arizona, where the Indians freely contradicted Friar Marcos' story of wealthy cities. Undaunted, they continued on through the rugged mountains of eastern Arizona, over almost impassable terrain. They camped by the fresh waters of the White River, near the site of present-day Fort Apache. Provisions were low, men and animals were worn out, and several Spaniards had died from eating poisonous herbs after their rations gave out. They called it the "Camp of Death."

With starvation close at hand they moved on, repelled one Indian ambush, and finally arrived at Háwikuh, the presumed Cíbola. What a disastrous disappointment it was: no golden streets, no turquoise-studded doors, only several hundred hostile warriors determined to defend their crumbling pueblo. The expedition's chronicler wrote: ". . . such were the curses hurled at Fray Marcos that I pray to God to protect him from them."

Though there was no profit in gold from Coronado's[1] expedition,

[1] Coronado passed through what was to become the Clifton-Morenci area and, in the late nineteenth century, the Coronado vein of that famous deposit was named in his honor. In 1904 the mineral *coronadite,* from the Coronado vein, was also named for him.

he did explore as far as Kansas before returning. And a scouting party led by Captain García López de Cárdenas traveled across northern Arizona to discover the Grand Canyon. Nevertheless, Coronado's report to the Viceroy was so discouraging that it was 40 years before another white man entered Arizona.

A silver-mounted Spanish spur dating from around the late 1700's. Arizona Historical Society; Aguirre collection.

ESPEJO'S MINE

Discovery of the rich silver deposits at Zacatecas in 1542 drew the Spaniards' interest away from Arizona for a time. Missionary work went on, however. In 1582, the Franciscans at Santa Bárbara, Mexico, became concerned for the safety of three of their brethren who had traveled to the Indian villages near present-day Albuquerque.

Antonio de Espejo, a wealthy miner from Zacatecas, volunteered to organize, finance and lead a rescue party. Upon arriving in the Rio Grande country, Espejo's party learned that the friars had been killed as soon as their military escort had left them to return to New Spain.

Too late to rescue the friars, Espejo and his men decided to do a little exploring and prospecting on their own. Hearing tales of rich mines to the west, Espejo and nine Spanish soldiers accompanied by 150 friendly Zuñis penetrated Arizona as far as the Hopi country near present-day Flagstaff. The Hopis were friendly, presenting the Spaniards with a variety of textile gifts and also piles of blue and green ore which had come from mines to the south.

Espejo was warned that the Indians to the south were barbarous and hostile, but he pressed on nevertheless. By a stroke of luck, the Indians turned out to be easily frightened by the Spaniards' horses and caused no trouble.

Arriving safely in the area east of modern Prescott, Espejo was told of a small deposit which the local Indians worked for dyes. Diego Perez de Luxan, the expedition's chronicler, reported that the group was lead up a narrow trail high into the mountains. Soon the guide pointed ahead to a pile of rocks and said, "This is the mine." A small tunnel, partially filled with boulders, led into the mountainside. The Spaniards found signs of ore outside. They removed the boulders from the tunnel and Espejo, carrying a torch, followed the Indian guide into the mine. After a short distance they entered a small room (stope); the ceiling sparkled with bright colors. Scattered about on the floor were several stone hammers and wedges. Samples were collected and taken out into the sunlight for better examination. At last Espejo announced to his expedition that "A large vein of ore has been opened. It is heavy with metal, but with copper only. (Nevertheless) it is a mine of great richness. We will take possession."

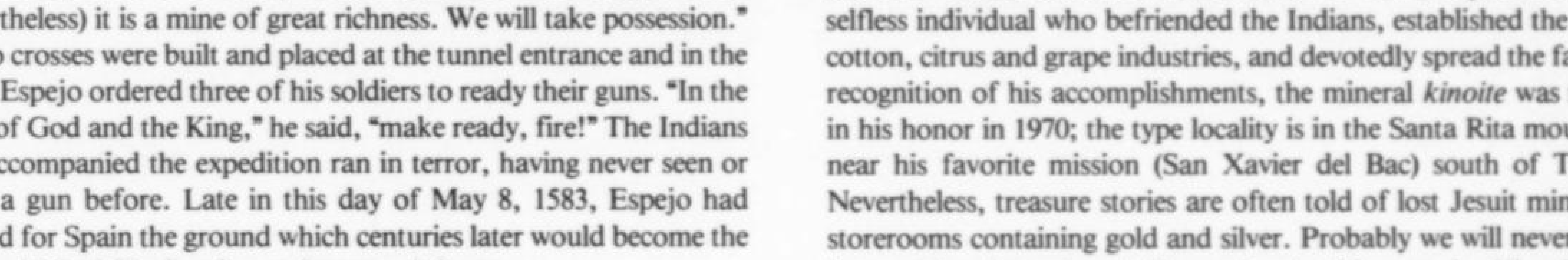
Two crosses were built and placed at the tunnel entrance and in the stope. Espejo ordered three of his soldiers to ready their guns. "In the name of God and the King," he said, "make ready, fire!" The Indians who accompanied the expedition ran in terror, having never seen or heard a gun before. Late in this day of May 8, 1583, Espejo had claimed for Spain the ground which centuries later would become the famous United Verde mine at Jerome, Arizona.

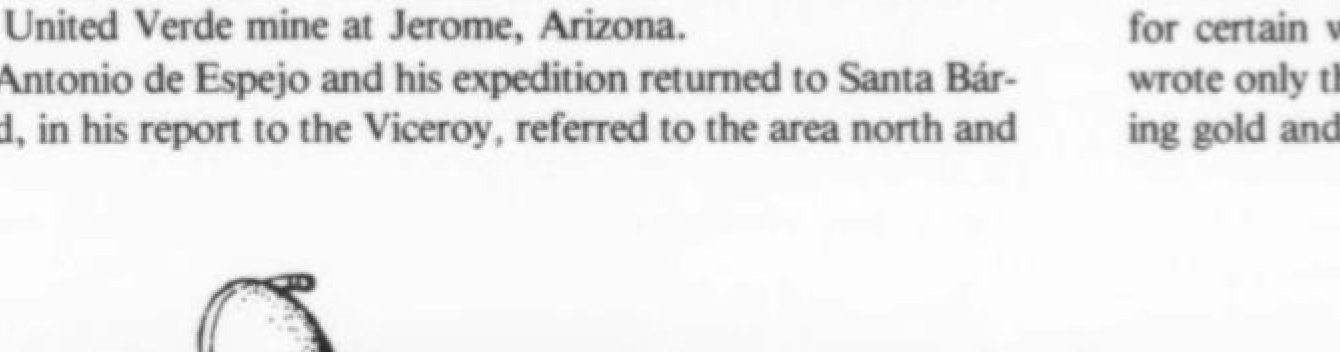
Don Antonio de Espejo and his expedition returned to Santa Bárbara and, in his report to the Viceroy, referred to the area north and west of the Rio Grande as Neuvo Mexico. The western area retained this name until 1863 when Arizona became a territory of the United States.

Another expedition, this one led by Juan de Oñate (whose wife was the granddaughter of Cortés) whose father discovered the silver deposits at Zacatecas, ventured into New Mexico in 1598. Oñate established his headquarters in the Zuñi and Hopi country, and sent Captain Marcos Farfán on exploratory missions into Arizona. Farfán, following Indian directions, discovered a huge saline deposit which may have been the one near modern Campe Verde, though historians remain uncertain. Farfán staked a number of claims, the exact locations of which have been lost, and found rich silver ore near Prescott. By the time he returned to Mexico in 1605, Oñate had covered more distance in Arizona than either Coronado or Espejo, and had done much to advertise the region's mineral wealth.

LAS PLANCHAS DE PLATA

The 1700's saw the establishment of a number of Catholic missions in southern Arizona, most of them founded by the Jesuit friar Eusebio Fancisco Kino. It is perhaps an injustice that so many legends persist regarding the mining of gold and silver by the friars and their Indian converts. Father Kino was an intrepid and totally selfless individual who befriended the Indians, established the cattle, cotton, citrus and grape industries, and devotedly spread the faith. In recognition of his accomplishments, the mineral *kinoite* was named in his honor in 1970; the type locality is in the Santa Rita mountains near his favorite mission (San Xavier del Bac) south of Tucson. Nevertheless, treasure stories are often told of lost Jesuit mines and storerooms containing gold and silver. Probably we will never know for certain what mineral discoveries the friars made. Kino himself wrote only that "There are many good veins and mineral lands bearing gold and silver."





(Top) Spanish cavalry saber inscribed "POR EL REY CARLOS III" ("For the King Charles III") and dated 1771. (Below) Spanish broad sword or *Espada Ancha* of the type carried by Spanish presidio soldiers in Arizona during the 1700's. Arizona Historical Society collection.

Kino's map of 1701 depicting the Gulf of California area. San Augustín (del Tucson) became present-day Tucson. Donald B. Sayner collection, Tucson.

One remarkable silver strike from the Jesuit period does stand out, however. In 1736 a Yaqui Indian miner named Antonio Siraumea stumbled across chunks of native silver lying on the surface near the *ranchería* of Arissona (or Arizonac). News of the find spread, and soon several thousand prospectors had turned the little mission town into a full-fledged mining district known as the Real de Arissona. The mine was called Las Bolas or Las Planchas de Plata . . . "the Plates of Silver." Huge balls and slabs of native silver were mined virtually at the surface. One such mass weighed 3500 pounds and was heated on four forges in order to cut it into manageable pieces.

The Spanish authorities tried in vain to collect the Royal Fifth or *quinto* tax due the King of Spain. Frustrated officials closed down the mine in 1741, but by that time it was exhausted. Prospectors quietly spread out over the surrounding rough country of northern Sonora and southern Arizona. Though no records exist of the occasional strikes they made, there was sufficient activity to support traders and herdsmen in the area for quite some time.

And despite the fact that the Real de Arissona ended up several miles south of the present Arizona border (established in 1854), its fame was sufficient to lend its name to the new territory of Arizona. Recent studies sponsored by the University of Arizona seem to indicate that there is unfortunately no underground extension of the massive silver deposit which became one of the early bonanzas of the West.

Around 1750 a group of Mexican prospectors came across the copper deposit at Ajo. They mistook "copper glance" (chalcocite) for "silver glance" (acanthite), and abandoned their prospect when assays revealed no silver. They named it for the garlic-flavored plant found nearby . . . *ajo* in Spanish. When the United States acquired the area in 1853, prospectors relocated the Ajo mines and shipped the first load of Arizona copper ore in 1855.

THE PERALTA MINES

For this last story we venture more into the realm of legend, but a very persistent legend known in at least 18 variations.

Near the end of the Spanish Period, a vast Spanish land grant which included the Superstition Mountains was in the possession of the Peralta family of Sante Fe, Sonora, Mexico. In 1847, Don Miguel Peralta and his son Pedro led an expedition of 400 into the Superstitions for the purpose of locating and mining as much gold as possible before their lands became part of the United States. Several base camps were established and prospecting teams sent out in a systematic search. They gleaned placer gold at the west end of the Superstitions (Goldfield area) and at least two veins were found in the nearby Pinal Mountains. A total of at least eight promising deposits were located by the Peralta prospectors; one discovery proved to be very rich in native gold.

Eventually the expedition packed up the gold they had mined and prepared to leave the Superstition Mountains for home. But they didn't get far before they were attacked and massacred by the Apaches, who wanted their guns, knives and livestock.

The pack animals scattered, and wherever the Indians caught up with them they cut loose the bags of gold ore and emptied them on the ground. In subsequent years small piles of obviously hand-sorted gold ore were found at various places in the Superstitions, and a large quantity of human bones was found at what became known as the Massacre Grounds near the northwest face of the mountains.

This is a fascinating enough story, but there's more. Most versions of the famous Lost Dutchman Mine story involve the Dutchman finding the Peralta mine in one way or another. Of course, there are plenty of *other* versions claiming that the Dutchman was simply a highgrader and fence for stolen gold who only pretended to have a mine in the Superstitions. Most likely we will never know for certain.

In any case, most of Arizona became part of the United States in 1848 following the war with Mexico, and the remainder was acquired as part of the Gadsden Purchase in 1853, bringing to an end three centuries of Spanish influence. In 1912 President Taft signed Arizona's statehood proclamation using a pen made of gold from Arizona mines.

SUGGESTED READING

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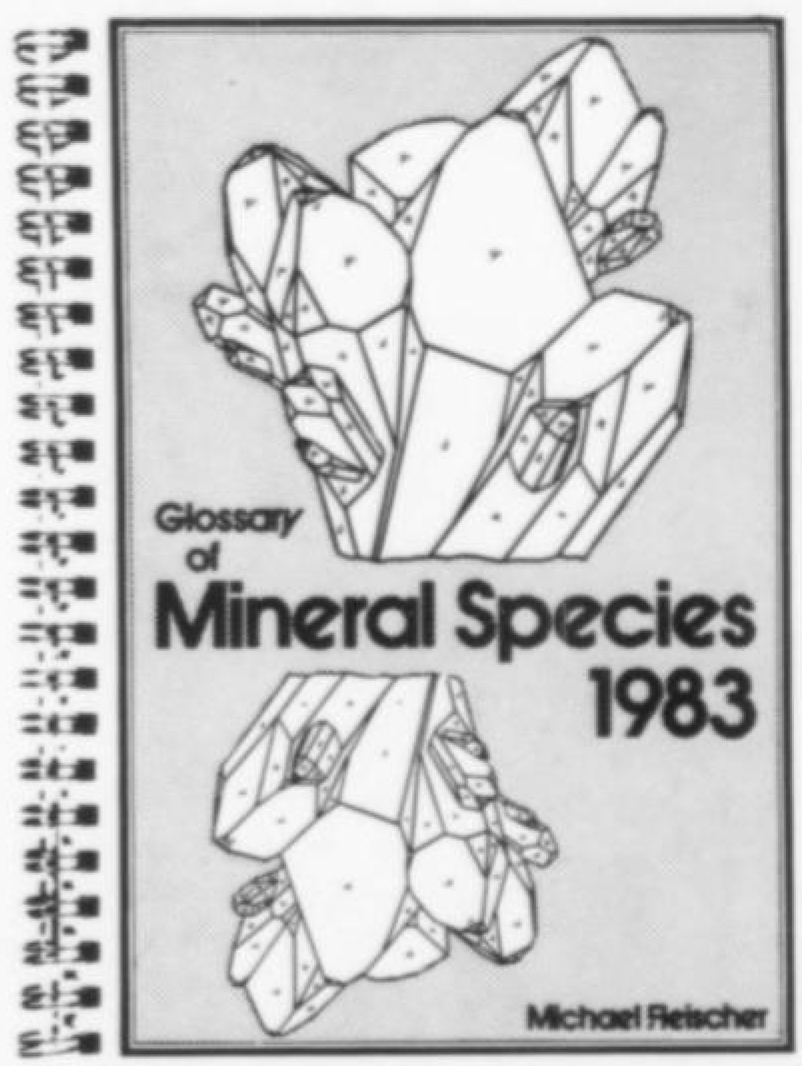

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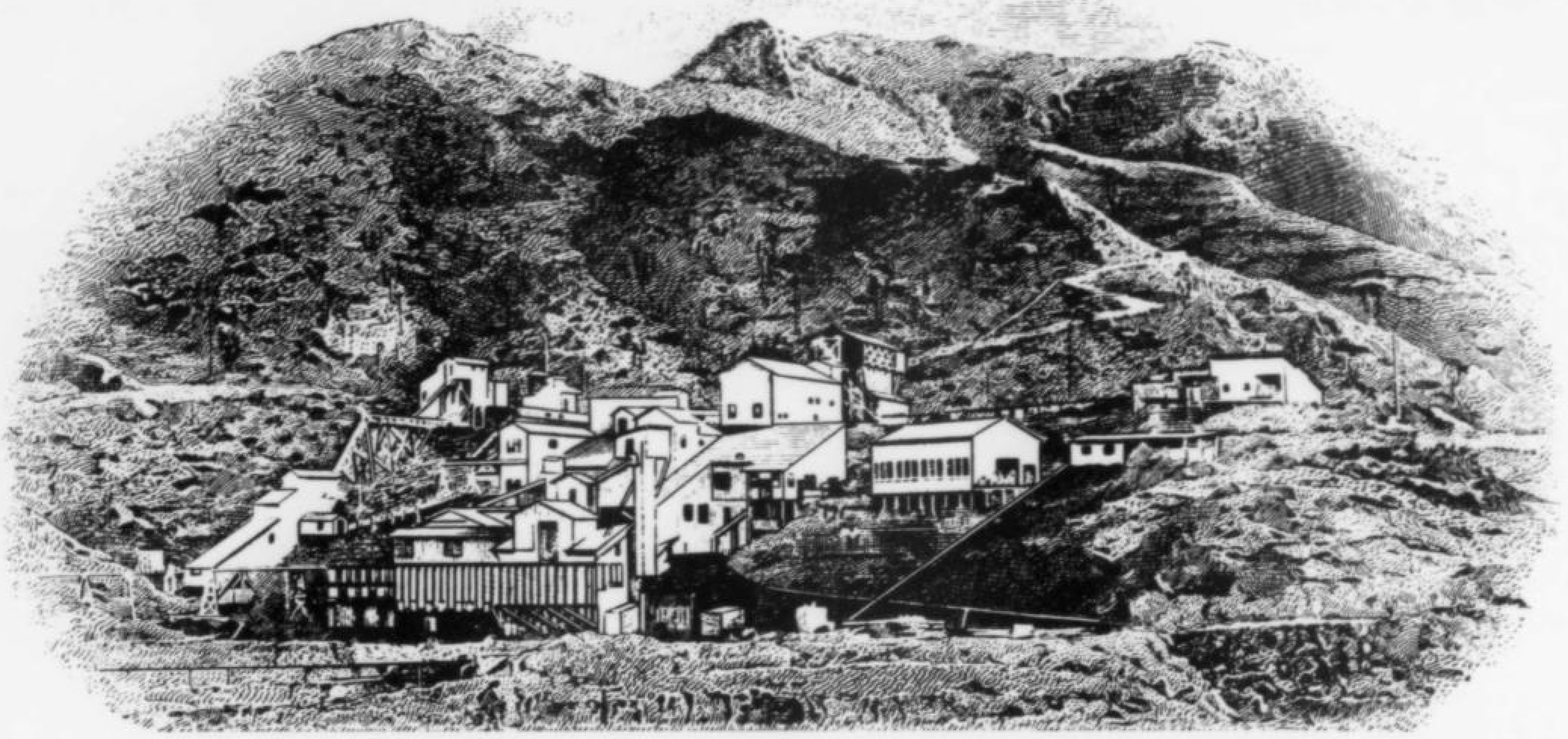

the Magma Mine

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The Magma mine is best known among collectors as the source of superb yellow barite which ranks among the world's most beautiful. Though closed in 1982, the mine yielded copper, silver, gold and a wide variety of crystallized species for more than a century.

LOCATION

The Magma mine is located in the Pioneer (Superior) mining district, about 70 miles east of Phoenix, in what F. L. Ransome (1914) termed "the little hamlet of Superior." The town, situated in Pinal County at an elevation of 2900 feet, has a population of about 4500.

Topography around the mine is characterized by rugged desert ranges and broad alluvial basins. Immediately east of Superior, the Apache Leap escarpment rises to a towering 4,900 feet.

HISTORY

As is the case with many mines, the Magma mine was discovered quite by accident. The discovery occurred in 1874 while a group of ranchers (turned prospectors) were searching the Queen Creek Canyon area for a lost silver outcrop. The group paid little attention to an iron-manganese-stained outcrop they found during the course of that search. Their quest eventually led them to the silver lode they sought; they named it the Silver King, later to become the most prolific silver producer in Arizona history.

In 1875 the group returned to the iron-manganese outcrop. Claims were staked and the property was named the Silver Queen. A shaft was sunk and, with limited development, a modest amount of silver was produced. But the great wealth of the Silver Queen lay much deeper in the ground and went unnoticed for years. Due to deflated silver prices the Queen closed in 1893. In 1906 she was reopened as a promising copper prospect. In 1910 the Magma Copper Company was formed, and the Queen's name was changed to the Magma mine.

To date, nine shafts have been sunk, with #9 being the service shaft. The mill and smelter were erected in 1914 and 1924 respectively. The smelter was closed in 1971, but a modern mill was

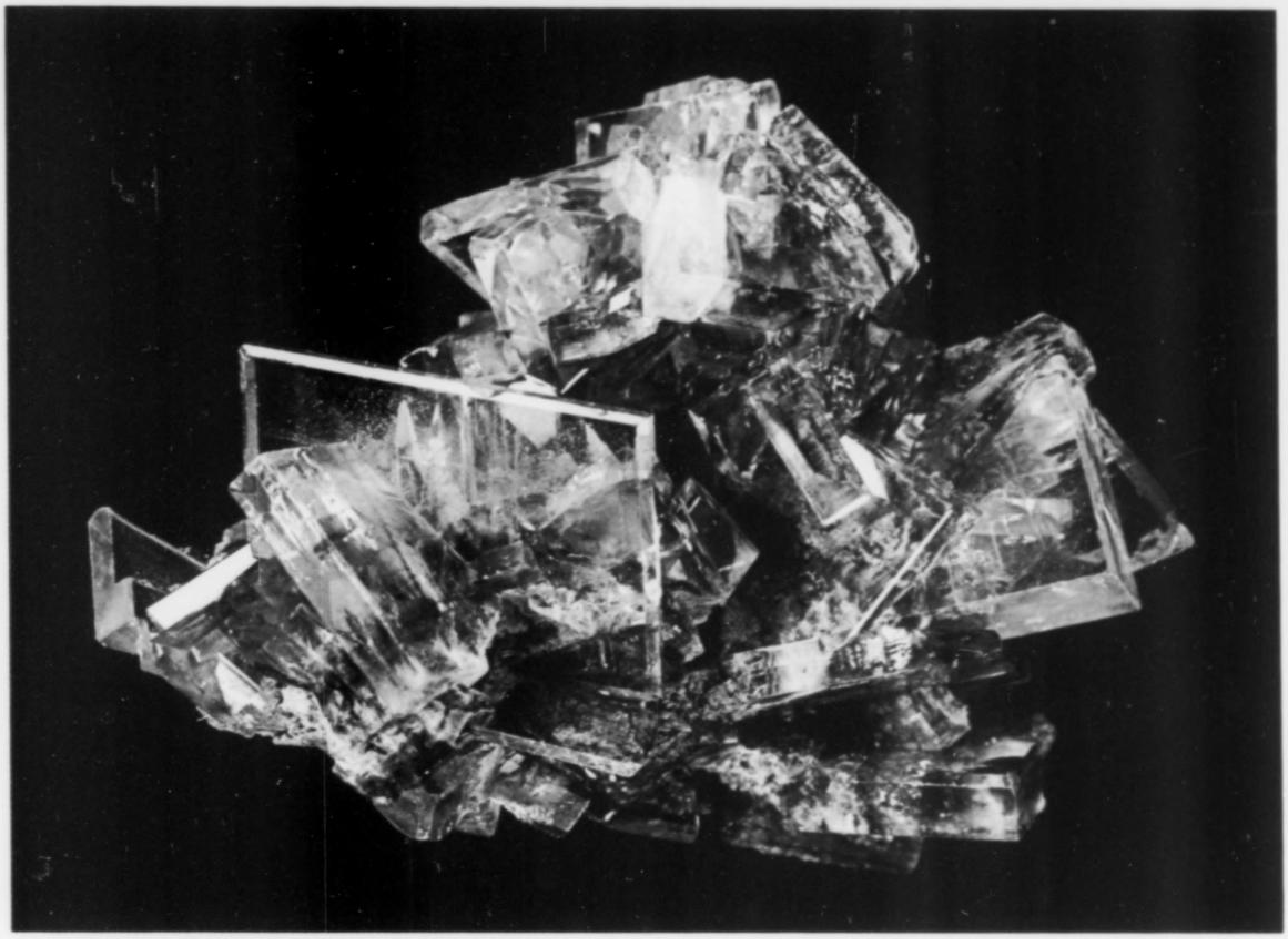


Figure 1. **Barite crystal cluster 1½ inches across, from the 'A' bed of the Martin limestone, Magma mine. R. Barnes collection; J. Scovil photo.**

in operation until the mine itself was closed in 1982. Concentrates were smelted at San Manuel, Arizona. The Magma mine has been developed to a maximum depth of 4900 feet, making it the deepest mine in Arizona. Most recent mining took place from roughly the 3300 to the 4000 level. During its last year of operation the mine produced about 2800 tons per day. To date, nearly 2½ *billion* pounds of copper have come from the Magma mine, along with lesser amounts of gold, silver and zinc. The Magma Copper Company is a wholly owned subsidiary of the Newmont Mining Corporation which, incidentally, also owns a share of the famous Tsumeb mine in Namibia.

GEOLOGY

A basic geologic understanding is fundamental to any study of an ore deposit. However, an in-depth discussion is beyond the scope of this work. The geology of the Magma mine has been treated in detail in several excellent published reports. Readers wishing more information are referred to Short, Galbraith, Harshman, Kuhn and Wilson (1943), or Hammer and Peterson (1968).

At the Magma mine a section of Precambrian and Paleozoic sediments (dipping eastward at 30° and overlying Tertiary volcanic rocks dipping eastward at 15°) lies on a basement of Precambrian schist. Diabase has extensively intruded the Precambrian sequence and porphyritic intrusions cut the Precambrian and Paleozoic sediments along east-striking faults. A pre-ore fault zone striking east-northeast hosted the major vein deposits and served as a plumbing system for the replacement-bed mineralization. A post-ore fault system striking north-northwest reflects the regional Basin and Range structural trend. The orebodies are classified as mesothermal deposits of vein and limestone replacement types.

ROCK TYPES

Only formations hosting ore are included in the following list. While rocks of Cenozoic and Mesozoic age are present, no ore has been found in them.

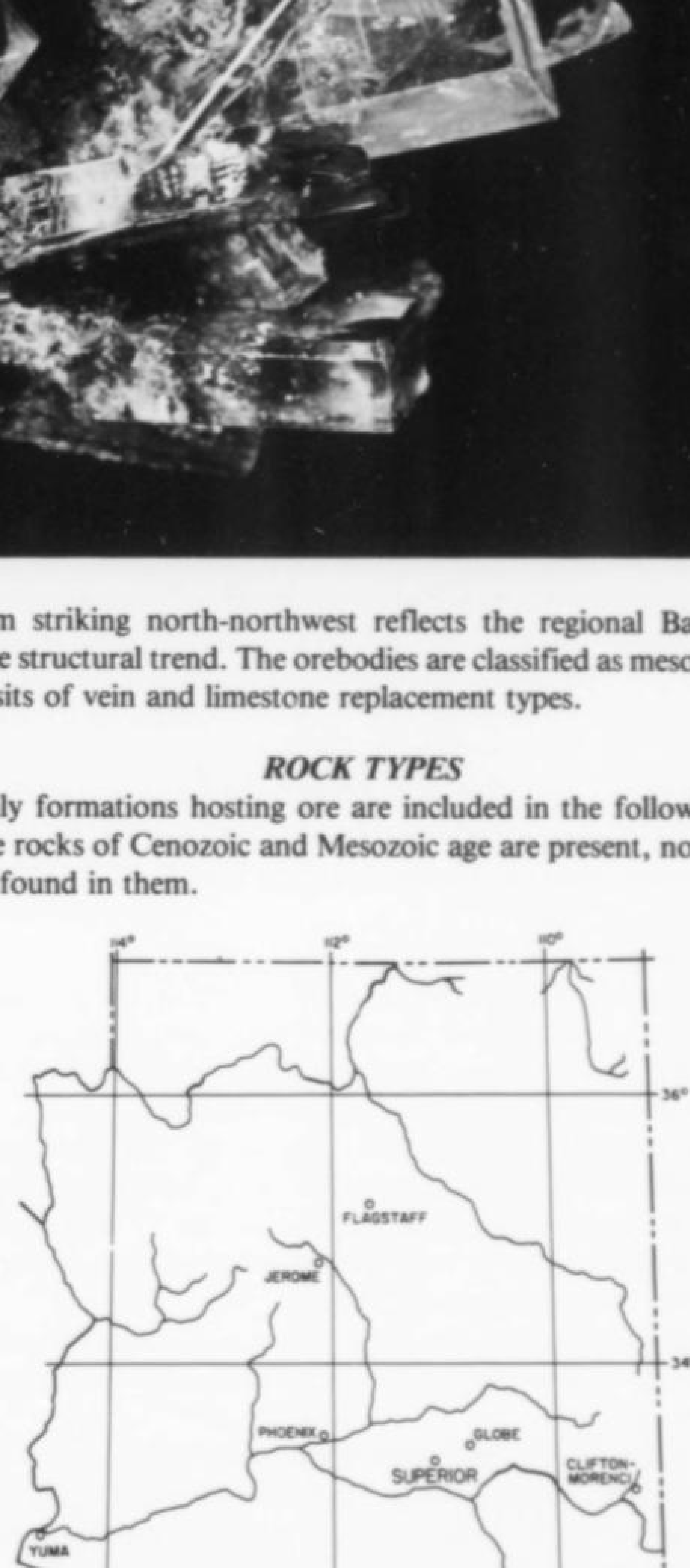


Figure 2. **Index map of Arizona.**

Figure 3. **The original Silver Queen mine (later renamed the Magma mine), no. 1 shaft, in 1907. The Apache Leap escarpment can be seen in the background; view looking southeast. Magma Copper Company photo archives.**

Pennsylvanian

Naco limestone – 0 to 1400 feet thick, medium- to thin-bedded, fossiliferous limestone. The 'E' replacement horizon lies in the lower Naco formation. With the exception of an isolated pocket of bornite crystals and an occasional calcite pocket, few crystals are found in the 'E' bed.

Mississippian

Escabrosa limestone – 500 feet thick, thick- to thin-bedded limestones of the Escabrosa formation commonly form prominent cliffs in the Superior area. The most prolific ore producer in the mine, the Escabrosa hosts three replacement beds.

The 'D' horizon lies just under the contact with the overlying Naco formation. The finest barite found in the last 15 years has come from pockets formed in flexures of the 'D' bed footwall. Pyrite, gypsum, quartz, hematite, sphalerite, chalcopyrite and chalcanthite occur as accessory minerals.

Beneath the 'D' horizon is the 'CC' horizon. A discontinuous orebody of minor importance, the 'CC' bed produces lesser specimens of pyrite and calcite.

The 'C' horizon in the lower Escabrosa formation holds the largest orebody mined in recent years. Small crystals of barite are sometimes found near the hanging wall and pyrite is common along the southern fringes. Calcite occurs as solid fillings in watercourses and occasionally as distinct crystals on brecciated fragments in fault zones.

Devonian

Martin limestone – 350 to 450 feet thick, thick- to thin-bedded limestone and dolomite with a large degree of clastic material either included within the carbonates or as distinct sandstone and shale units. Two replacement horizons have been exploited from the Martin formation. The 'B' horizon lies midway in the formation and the 'A' horizon lies just above the contact with the subjacent Bolsa quartzite. The 'A' bed was the first limestone replacement orebody exploited by the Magma Copper Company, and was also the most prolific source of fine specimens, principally barite and pyrite. 'A' bed mining ceased in 1969 at the 3600 level.

Cambrian

Bolsa quartzite – 0 to 360 feet thick, medium- to thick-bedded arenaceous quartzite and clastic sediments. Mineralized portions of the 'A' replacement horizon sometimes extend into the upper Bolsa quartzite.

Precambrian

Mescal limestone – 350 feet thick, thin-bedded, cherty limestone. The Mescal replacement bed, while of high tenor, is rarely mined due to the discontinuous nature of the ore pods.

STRUCTURE

Two broad structural belts have had major effects on the geology and ore deposits of the Magma mine. The oldest, predating mineralization, is composed of east-striking faults dipping steeply to the south. This system has played a very important role in the ore deposits of the Pioneer mining district. First, most of the mineralized vein faults in the district, including the Magma vein, are components of this belt. Second, it is evident from relations with the replacement ore bodies that the east-striking faults served as conduits, bringing the mineralizing solutions into contact with the limestone beds.

The second and younger structural belt strikes north-northwest and dips steeply to the west. These faults are generally post-mineralization; consequently they determine the continuity and shape of the orebodies. The principal feature of this system is the Concentrator fault. It terminates the orebodies to the west of the mine, and is largely responsible for the dramatic Apache Leap escarpment east of Superior. A 30° eastward tilting of stratified rocks is probably related to faulting along this trend.

Figure 4. **Headframe of the no. 9 shaft, Magma mine, in 1982. R. Barnes photo.**

ECONOMIC GEOLOGY

Ore deposits in the Magma mine are of two types: vein replacement and limestone replacement. The largest ore deposit in the district is the Magma vein. A member of the east-striking fault system, this vein is known to be mineralized for a strike length of over 10,000 feet and to a depth in excess of 4,900 feet. Massive sulfide mineralization includes bornite, chalcopyrite, pyrite, sphalerite, enargite, tennantite, galena, chalcocite, digenite and stromeyerite. Smaller mineralized structures (the Koerner, North Branch and East Replacement veins) split from the Magma vein. The Magma vein was first mined around 1881, and ceased production in 1964. The South vein, discovered in 1971, appears to be an entirely separate structure. Striking east-northeast, the South vein fault contains quartz, pyrite, chalcopyrite, bornite, chalcocite and hematite mineralization. Mining started in the South vein in 1975 and continued until 1982. Almost no crystals are known to have come from any of the vein deposits at Magma.

Limestone replacement ore bodies or mantos are usually localized around an east-striking vein-feeder structure. Massive sulfide mineralization includes pyrite, chalcopyrite, bornite and rarely sphalerite and galena. Hematite occurs also, accounting for about 90 to 95 percent of the total mineralization (Sell, 1961). Mining started in the replacement beds in 1950 and continued until 1982.

The tenor of the two types of deposits is essentially the same, averaging around 5.5 percent copper. Unfortunately, the suite of secondary minerals usually found in the oxidation zone of Arizona copper deposits is absent in specimen-quality pieces at Magma.

MINERALS

The Magma mine has long been recognized as a producer of fine barite and pyrite specimens; however, many of the other crystallized mineral species which over the years have come from this classic locality are not well known among collectors. Our intent is not to cite every crystallized occurrence, but rather to note a few of the more significant finds. The emphasis is placed on recent finds from 1970 to the present. Many pages could be filled with flowery descriptions of great pockets of the past. However, only those specimens which we have personally viewed in museums, private collections and in the mine itself will be mentioned (with perhaps an old tale here and there, just to keep us from forgetting the past).

ELEMENTS

Gold

Gold is recovered at the Magma mine as a by-product of copper production. Though economically important, little gold is ever actually seen in specimens. Tiny blebs of native gold have been found in vuggy areas in bornite or quartz. But we are not aware of any crystallized occurrences of native gold at Magma.

Silver

As with gold, silver is produced as a by-product of copper production, and we are unaware of any crystallized occurrence of silver at the Magma mine. However, when the Koerner vein was mined (1952-1957) there were occasional discoveries of vein silver. One such incident occurred just below the 3600 level. It is reported that, after a blast, chunks of bornite were literally held together by veinlets of native silver (R. Webster, Magma Copper Company, personal communication, 1982). Many specimens from this stope have been saved and may be viewed in numerous local collections.

Copper

Oxidized zones in the orebodies have produced numerous fine specimens of native copper. Possibly the best were discovered just below the 2800 level in 2800 8D stope. In the footwall fringe of the 'D' bed, many large masses of crystalline copper were collected in 1970. The specimens are reminiscent of the Bisbee material. Large elongated crystals protruded from massive chunks of copper. Many of these specimens weigh over 10 pounds.

Another very nice group of specimens was recovered from the 3310 3C stope on the 3360 level of the 'C' bed. Arborescent crystals of copper protrude from plates of greenish white calcite, creating some very attractive display pieces. One of the finest specimens from this pocket now resides in the Arizona-Sonora Desert Museum.

In 1979 the Magma vein on the 4100 level was the source of some beautiful though quite delicate native copper crystals. These are also arborescent in form but spinel twins up to 1 inch in length were sparingly present.

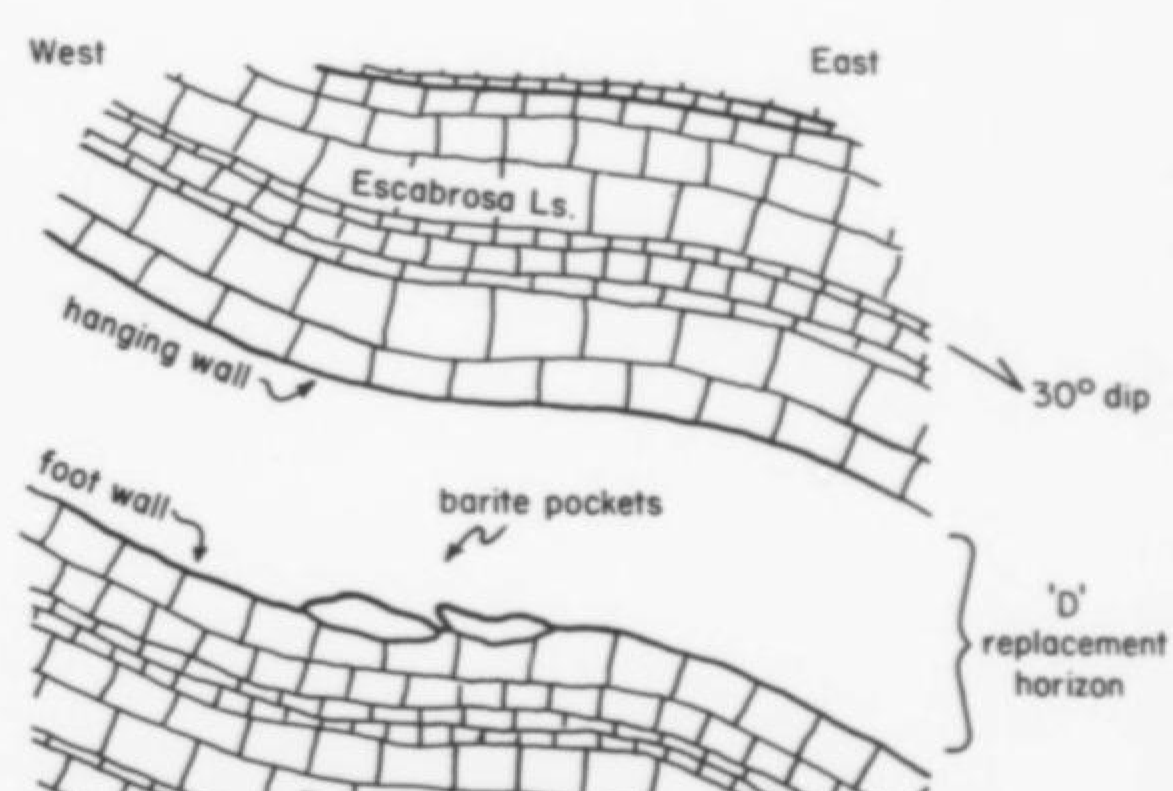


Figure 5. **Vertical east-west section showing barite crystal pockets in a flexure of the 'D' bed footwall.**

Figure 6. **Arborescent copper crystals on calcite from the 3360 level, 3310 3C stope. The view is about 3 inches across. Loren Ells collection; J. Scovil photo.**

SULFIDES

Chalcopyrite

Chalcopyrite is the major copper-bearing mineral found in the Magma mine. While abundant in massive form, it rarely occurs as crystals. The largest crystals were collected in the 'A' bed in the late 1950's and early 1960's. These crystals are beautifully formed tetrahedrons up to 1 inch on an edge, usually associated with crystallized sphalerite and quartz.

Another notable pocket consisted of a small vug of ½-inch crystals found in July of 1975. These rounded tetrahedrons were found in the 3200 5D stope on the 3200 level.

From time to time, minute crystals of chalcopyrite are found throughout the orebody, usually associated with quartz, but rarely are these pieces of good quality. The older specimens from the 'A' bed are by far the finest of the Magma chalcopyrites but, as is often the case, these older pieces can only be obtained from collections and are seldom available.

Bornite

Bornite is the second most abundant copper-bearing mineral found in the mine. However, bornite in crystallized form is very rare. The 'A' bed in the 1950's and 1960's produced a sparse number of dull black, highly modified crystals. We saw one of these specimens in which the crystals attained a maximum dimension of ½ inch.

The 'E' bed has been the only other source of crystallized bornite. In late 1975, several small vugs of bornite clusters were encountered in the 3500 6E stope on the 3500 level. Most of the crystals collected are less than ¼ inch across, with the largest approaching ⅜ inch. However, what they lack in size, they make up for in color. They range from a light blue to a dark purple, and are truly fine specimens.

Chalcocite

Chalcocite is the third of Magma's important copper minerals. In the massive form, chalcocite is always associated with bornite. Crystallized chalcocite from Magma looks very similar to the much more abundant hematite. In all probability, much crystallized chalcocite has been mistaken for hematite in the past. In early 1978, in

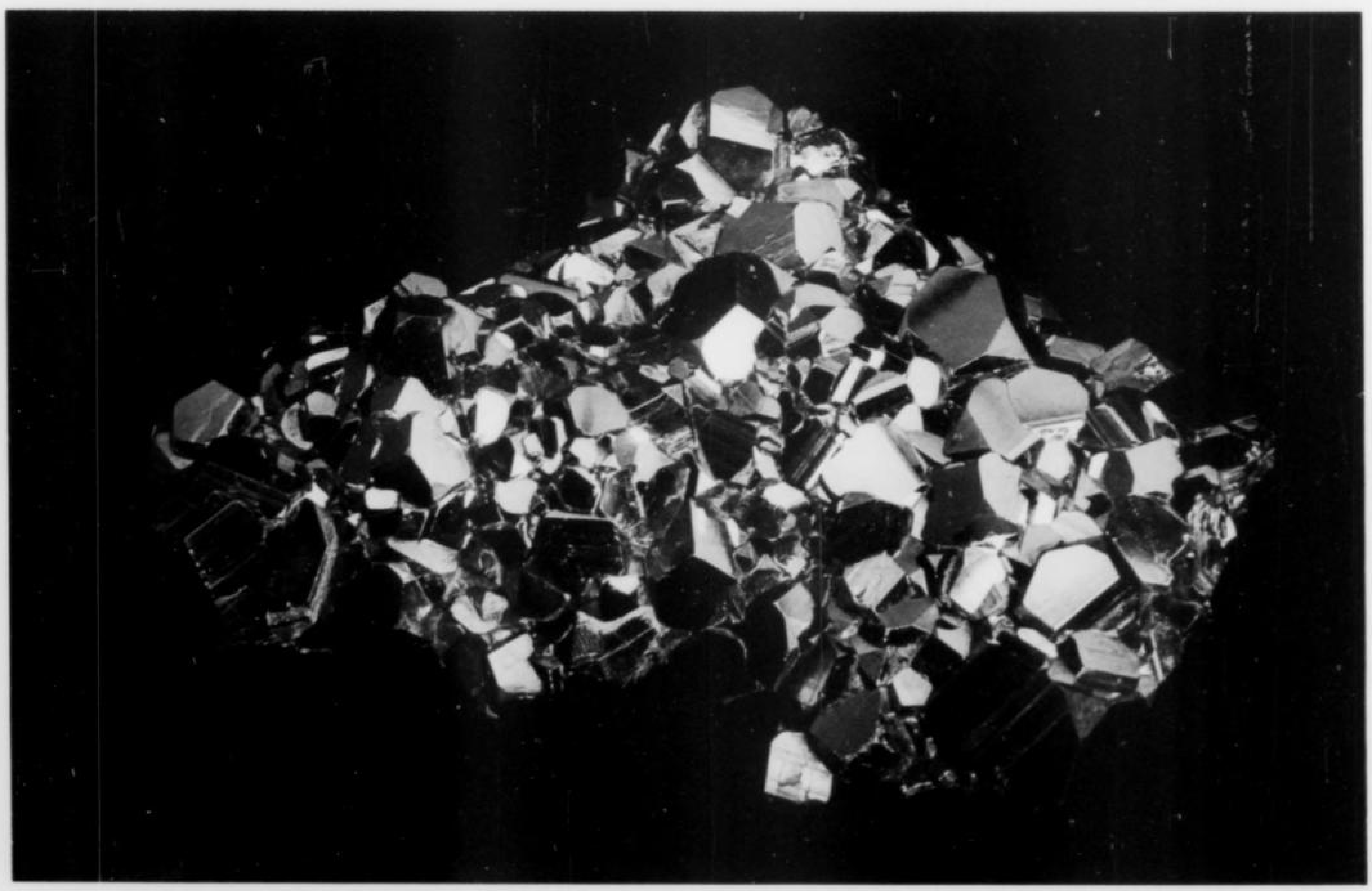


Figure 7. **Large pyrite cluster about 9 inches across, from the 'A' bed. A. L. Flagg Foundation collection; Bob Jones photo.**

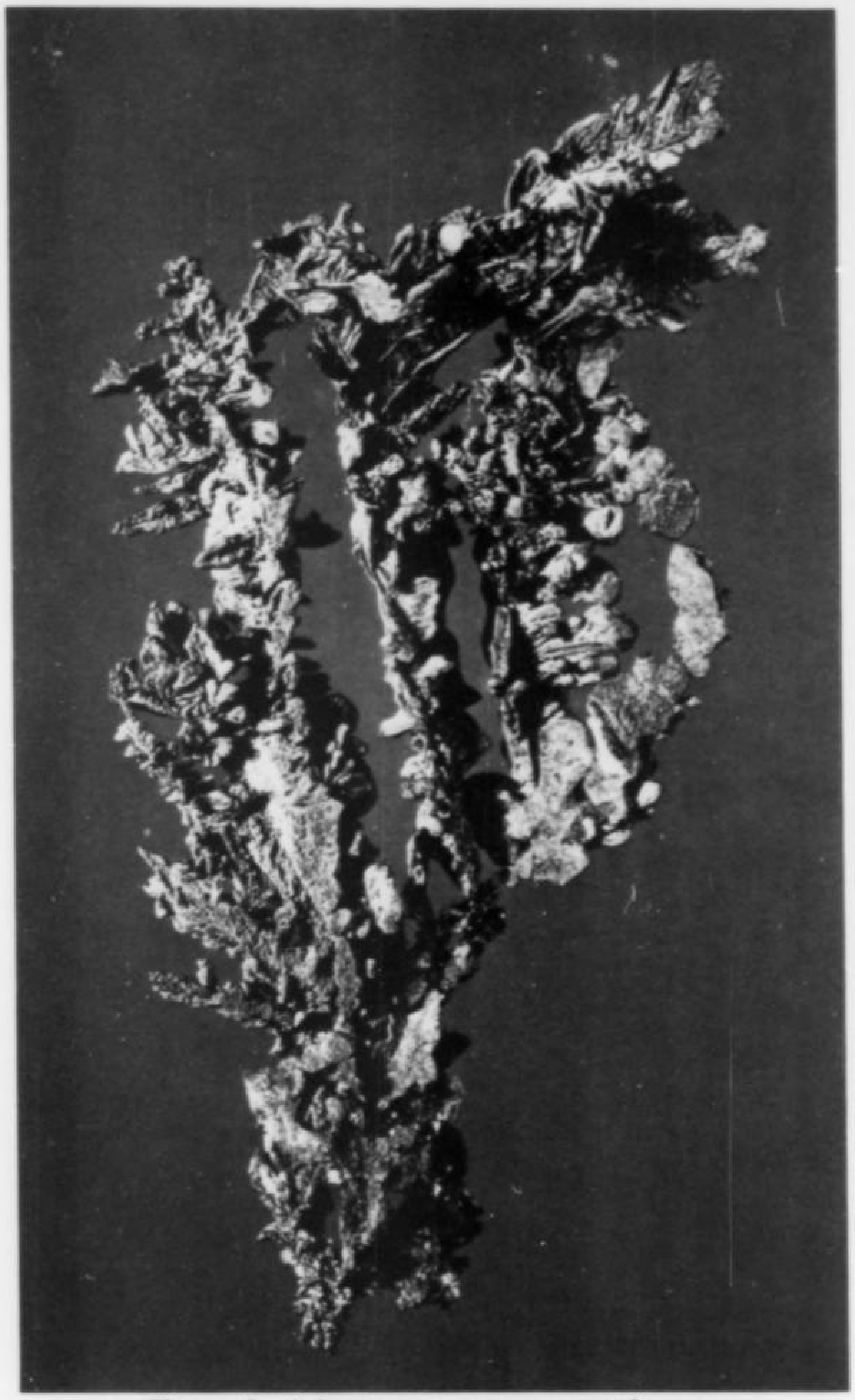


Figure 8. Arborescent copper crystal group about 3 inches tall, from the Magma vein, 106 Drift North, 4100 level. Don Atkinson collection; J. Scovil photo.

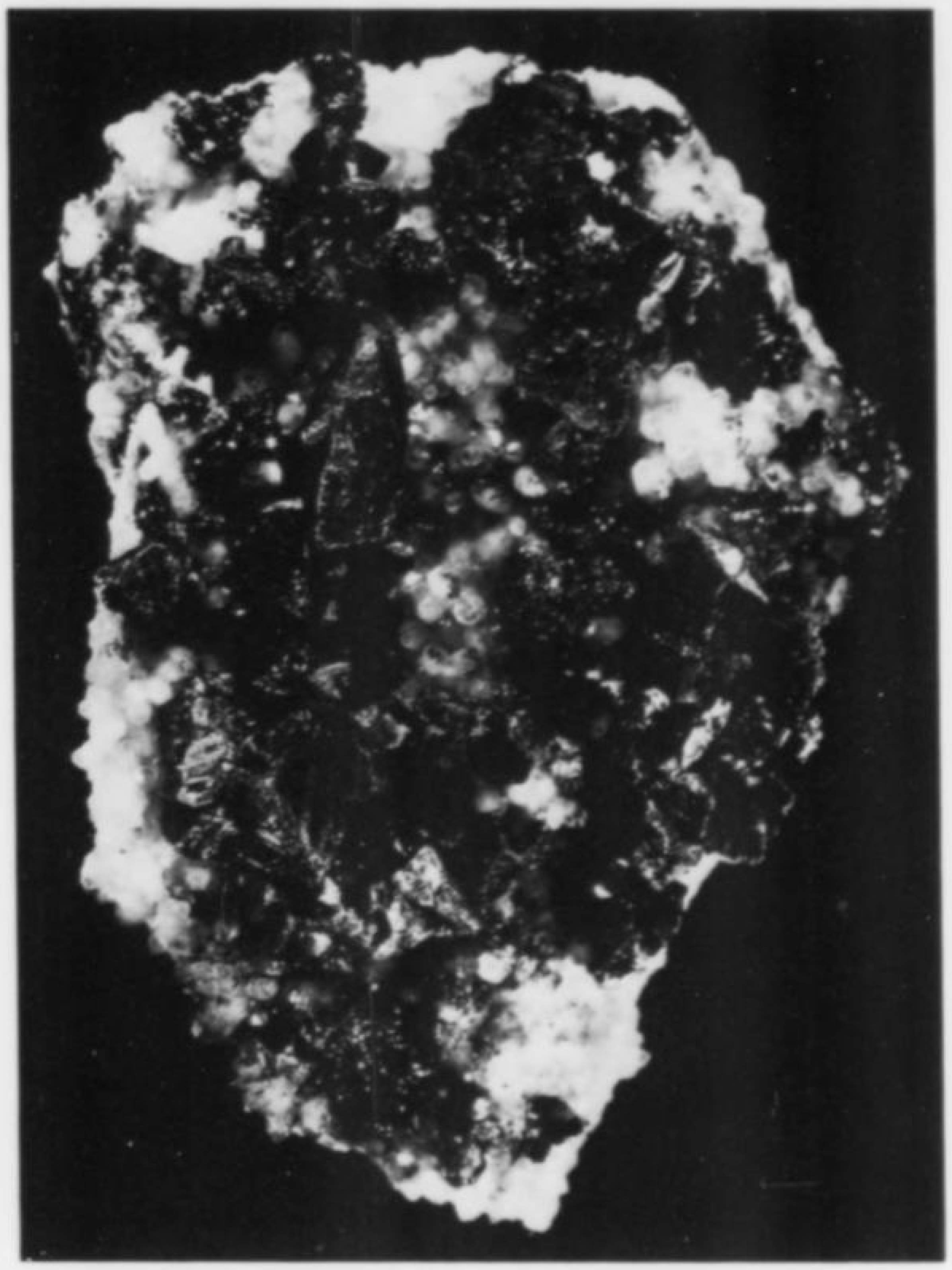
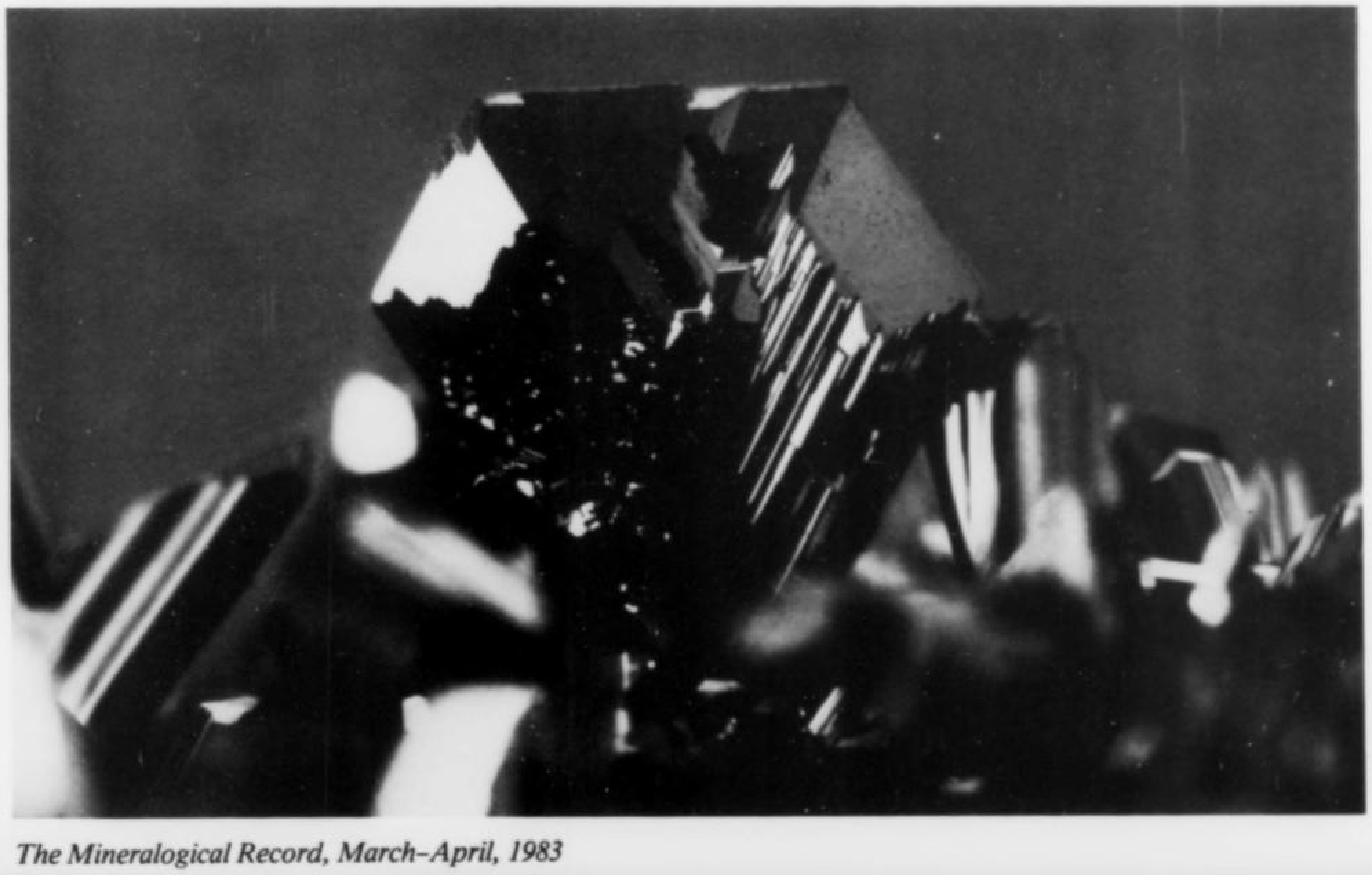


Figure 9. Chalcopyrite crystals on quartz crystal matrix 2½ inches across, from the 'A' bed, 2250 level. Roy Evans collection; J. Scovil photo.

Figure 10. A ¼-inch twinned crystal of chalcocite from the 3200 4E stope, 3260 level, 'D' bed, collected in 1978. Don Atkinson collection; J. Scovil photo.



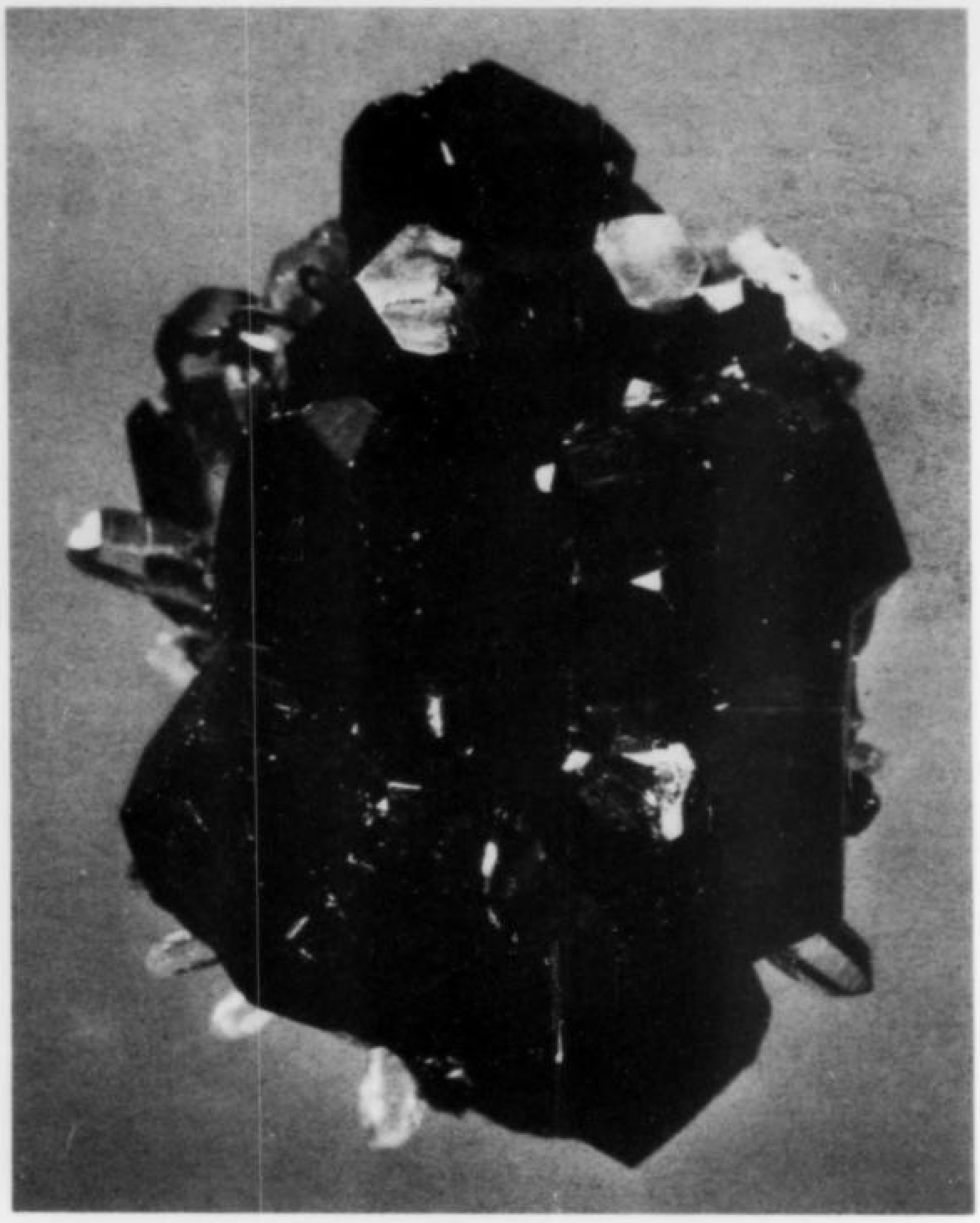


Figure 11. **Black chalcocite coating pyrite crystals with quartz, from the 3200 level. The specimen if about 2½ inches in size. M. Hay specimen; J. Scovil photo.**

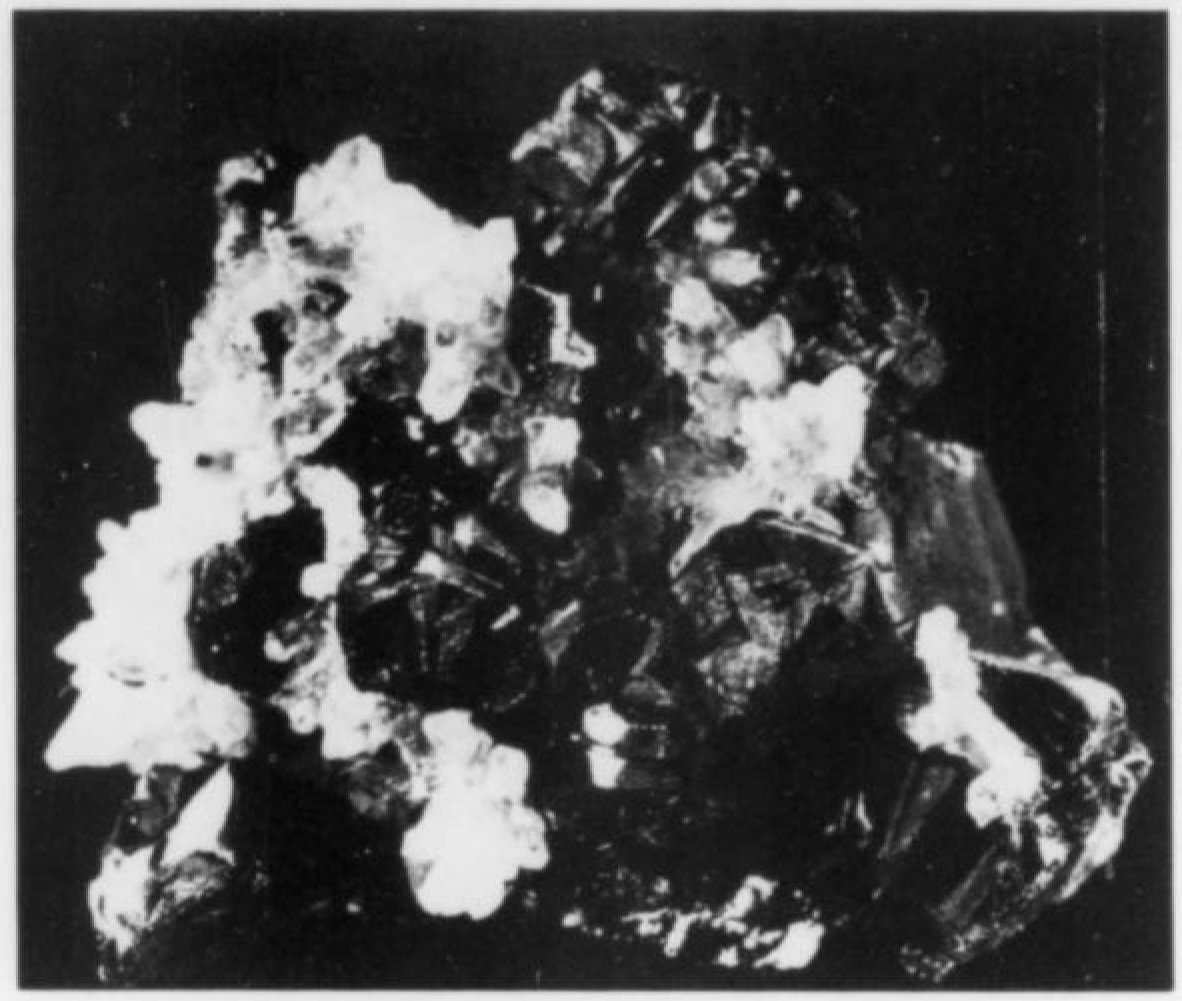


Figure 12. **Black sphalerite crystals with quartz and chalcopyrite, from the 'A' bed, 2610 level. Wayne and Sara Foster collection; J. Scovil photo.**

the 3200 4E stope on the 3260 level of the 'D' bed, a beautiful pocket of slender prismatic crystals was encountered. The pocket, measuring roughly 18 inches by 6 inches, was exposed by a miner "barring down" a freshly blasted face of rock. When the pocket was opened loose crystals reportedly cascaded down and unfortunately could not be collected. However, the inside of the pocket was completely lined with silvery, metallic, orthorhombic prisms to ¾ inch, and "V" twins to ¼ inch. The miners who collected the pocket thought it to be merely another hematite pocket. In spite of this, they did a commendable job of collecting and wrapping the material. Several months later we were shown the material. Suspicion led to an X-ray analysis of one of the specimens, and this confirmed the occurrence of truly fine crystallized chalcocite at Magma. This group of specimens probably represents not only Magma's finest, but the state of Arizona's finest crystallized chalcocite to date.

One other notable occurrence of chalcocite has been observed. In 1980, a small pocket of calcite was found in the 'D' bed in 104 Drift North on the 4100 level. Some of the specimens, when removed, were found to have small (¼ inch) black orthorhombic prisms of chalcocite protruding from the calcite.

Sphalerite

The Magma mine has produced some very fine crystals of sphalerite. The 'A' bed has been the most prolific source of good quality specimens. Clusters of crystals individually up to 1 inch were at one time fairly common. All of the larger specimens we have examined are dark (marmatite) in color, and are always in association with chalcopyrite and quartz. One particularly fine pocket of this type of material was encountered in a raise near the 2610 level of the 'A' bed. Beautiful green crystals of sphalerite have also been reported, but we have only observed them as minute groupings with ½ inch chalcopyrite crystals perched on drusy white quartz. These specimens were also found in the 'A' bed. Recent mining has revealed some fairly nice black crystals on the north fringe of the 'B' and 'C' beds. These, however, are no match for the older 'A' bed material.

Pyrite

Pyrite is the most abundant sulfide mineral found in the Magma mine. For many years Magma produced pyrite clusters that are comparable with many worldwide localities. Cubes, octahedrons, pyritohedrons and many modifications of these three basic forms are to be found in the orebody. Space does not allow a complete list of the stopes which have produced good pyrite through the years. Only those specimens which we have personally seen will be touched upon.

Few major American museums are without a pyrite from the Magma mine. Most of these outstanding crystal groups that were obtained before 1970 came from the 'A' bed. These beautiful pieces ranged from thumbnail size to large plates weighing nearly 100 pounds. It has been reported that some freshly blasted faces were entirely covered with sharp, highly lustrous crystals with faces several inches across. Unfortunately, the quest for copper does not allow many crystals to be saved, and most of these beauties went to the crusher.

In the 1970's and 1980's, the closest rivals to the previously mentioned pieces were found in the 'C' bed in the 3660 3C stope on the 3660 level. These specimens consist of groups of pyritohedral crystals with brilliant luster and individual faces up to ¾ inch across.

The 3200 level has also been the source of some very interesting material. These specimens consist of ½-inch to 1½-inch pyritohedrons coated with chalcocite (similar to the Rico, Colorado material) in association with clear quartz sprays.

The 'D' bed has produced some very lustrous groups of pyritohedrons. The best were found in the 3400 4D stope on the 3420 level, and the 3440 6D stope on the 3460 level.

Small but equally lustrous groups of modified pyritohedrons have been found in the 'E' bed. The 3440 4E stope on the 3440 level, and the 3480 5E stope on the 3480 level have been the sources of the best.

Single pyritohedral crystals were commonly found in the hanging wall of the 'D' bed. Thousands of these crystals have been collected over the years. Most are less than 1 inch in diameter, but some have been collected which measure up to 3 inches in diameter.

At the 1980 Tucson Gem and Mineral Show, a magnificent cabinet specimen of lustrous 1-inch octohedrons was awarded the prize for best Arizona pyrite in the species competition. This fine piece came from the 'A' bed.

OXIDES

Hematite

As stated previously, hematite composes approximately 90 percent of the total mineralization of the orebodies. In spite of this abundance, very little crystallized hematite has been reported. Occasionally, sharp, well-developed, silvery, bladed crystals were encountered. Other forms of hematite include specularite and botryoidal coatings and incrustations. We have seen very few display-quality specimens.

SILICATES

Quartz

Quartz is a common accessory mineral to bornite, chalcopyrite, pyrite, and sphalerite. It is in this association that quartz is at its best as specimens. As delicate sprays of crystals, quartz offers a nice contrast to the previously mentioned sulfides. There have been a few notable pockets in which quartz was found in fine clusters and groups. One such occurrence was the 3560 6D stope on the 3560 level. In April of 1976 several fine groups of white frosted crystals up to 3 inches were collected. These specimens are all sparsely covered with small tetrahedrons of chalcopyrite.

Another small pocket of quartz was encountered in the 3200 5D stope on the 3200 level. These groups consist of ½-inch water-clear crystals which are smoky at the tips. Protruding from these small crystals are 1-inch scepters, which are also smoky at the tips.

CARBONATES

Siderite

Siderite is infrequently encountered in the Magma mine. Rare masses of botryoidal siderite have been observed coating sulfides in vugs in the replacement beds (Hammer and Peterson, 1968). Light brown, slightly curved rhombohedrons to ½ inch were encountered on the 3300 level.

Rhodochrosite

While not observed in the replacement beds, rhodochrosite was reported in the Magma vein and is frequently seen in the South vein. Though usually massive in form, an occasional small crystal is observed in vuggy areas within the massive material. The color ranges from a pale pink to red. Vein quartz and chalcopyrite are always in association with rhodochrosite in the South vein.

Calcite

As would be expected in an orebody hosted by limestone, calcite is a very common gangue mineral at the Magma mine. However, some uncommonly fine crystallized calcites have been recovered in recent years. Without question, the best were discovered in August of 1977. Late one night in 94 Fan Drift North, on the 3700 level, an incredible watercourse was encountered. Absolutely water-clear twinned (twin plane 0001) crystals up to 6 inches across were found lying on the muck pile after a blast. Many of these beautiful specimens were destroyed by the same blast that had exposed the watercourse. Fortunately, enough survived to cause quite a stir among collectors. In 1981, calcite was chosen for the species competition at the Tucson Gem and Mineral Show. The miniature category prize was awarded to a calcite from this pocket.

In August of 1975, in 3500 6E stope on the 3500 level, a fine pocket of calcite was collected. The crystals, amazingly consistant in size (¾ inch), were highly lustrous, white, rounded rhombohedrons, attractively sitting on a chalcopyrite-hematite matrix.

The 3440 6C stope also has produced some very attractive calcite. Beginning in July of 1977, a continuing zone of pockets has been encountered in this 'C' bed stope. The first pockets were on the 3440 level. The doubly terminated crystals are a composite of numerous smaller crystals elongated on the c-axis to form a "bow tie" or "wheatsheaf" shape. Most of the crystals are about 1 inch in length, highly lustrous and white to pale pink in color. A few are colored by limonite and malachite inclusions creating some very

Figure 13. **Transparent, colorless calcite crystals on Escabrosa limestone matrix, 4½ inches across, from the 94 Fan Drift North, 3700 level. Bruce McDavid collection; J. Scovil photo.**

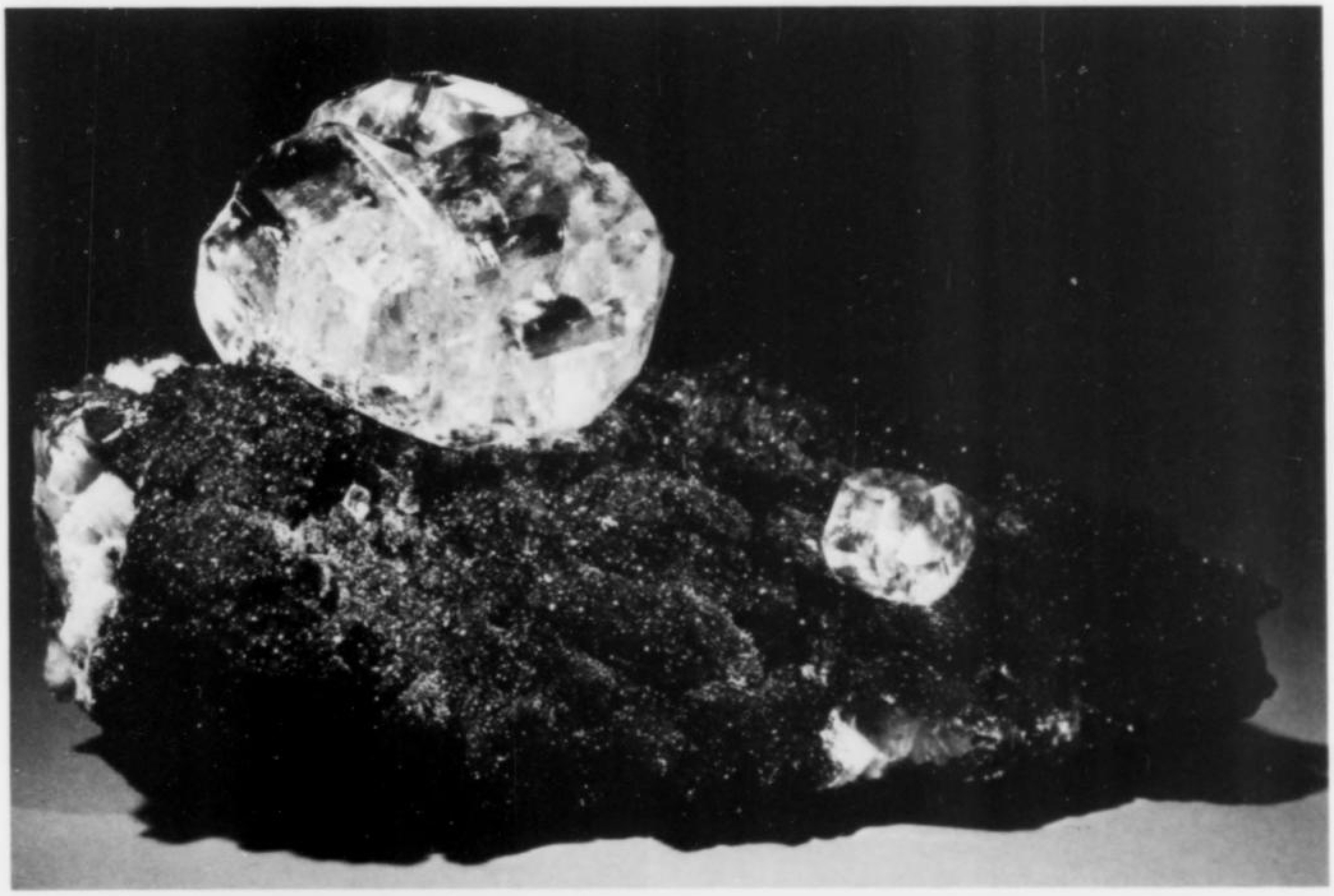


Figure 14. **Transparent, colorless, twinned calcite crystal 1¾ inches across, from the 94 Fan Drift North, 3700 level. This piece won the miniature category in the calcite competition at the 1981 Tucson Show. R. Barnes collection; J. Scovil photo.**

Figure 15. **Calcite crystals with curved rhombohedron faces, on chalcopyrite-hematite matrix, about 1⅔ inches tall, from the 3500 6E stope, 3500 level, 'E' bed. R. Barnes collection; J. Scovil photo.**

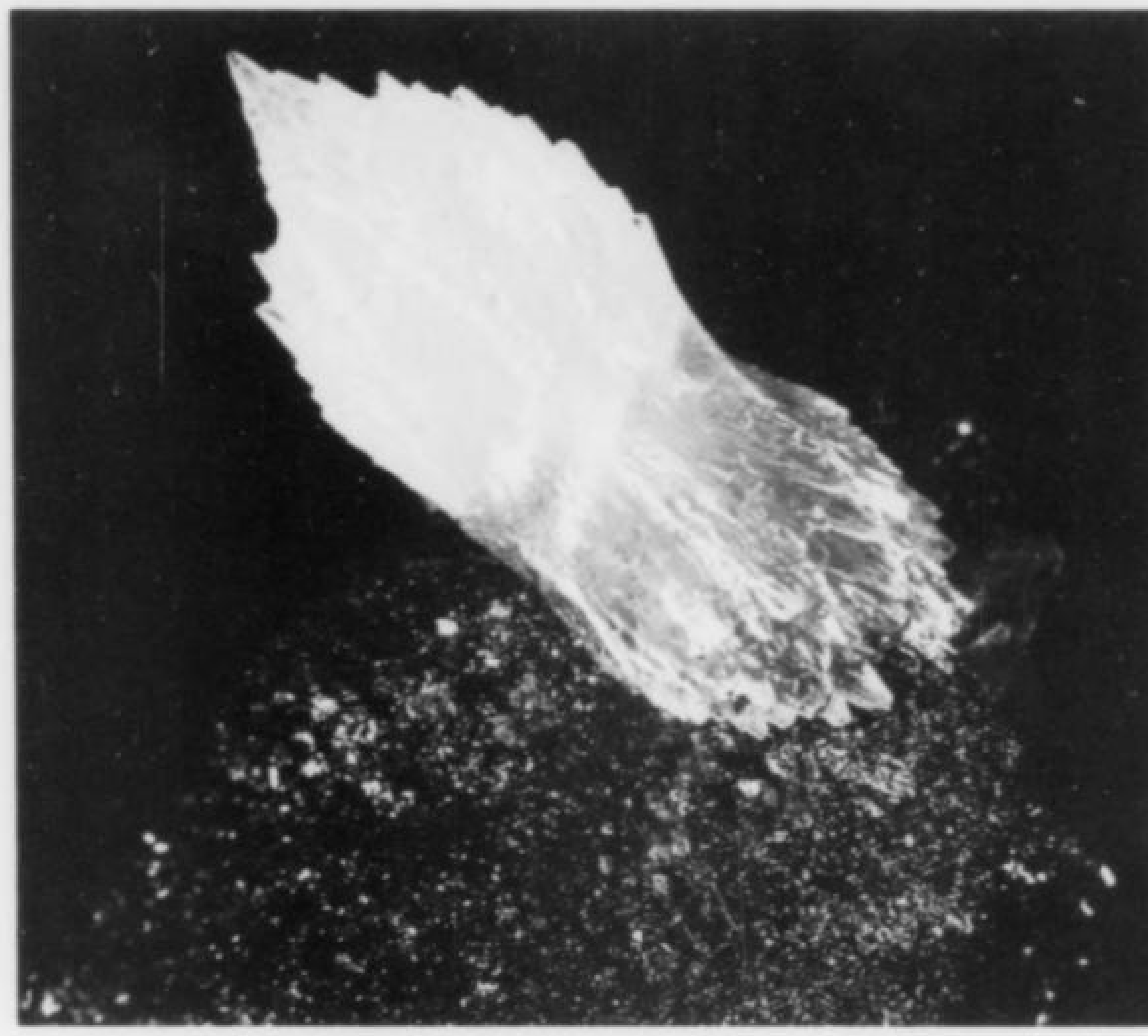


Figure 16. **Sheaf-like calcite on specular hematite matrix 1⅛ inches long, from the 3440 6C stope, 3440 level, 'C' bed. R. Barnes collection; J. Scovil photo.**

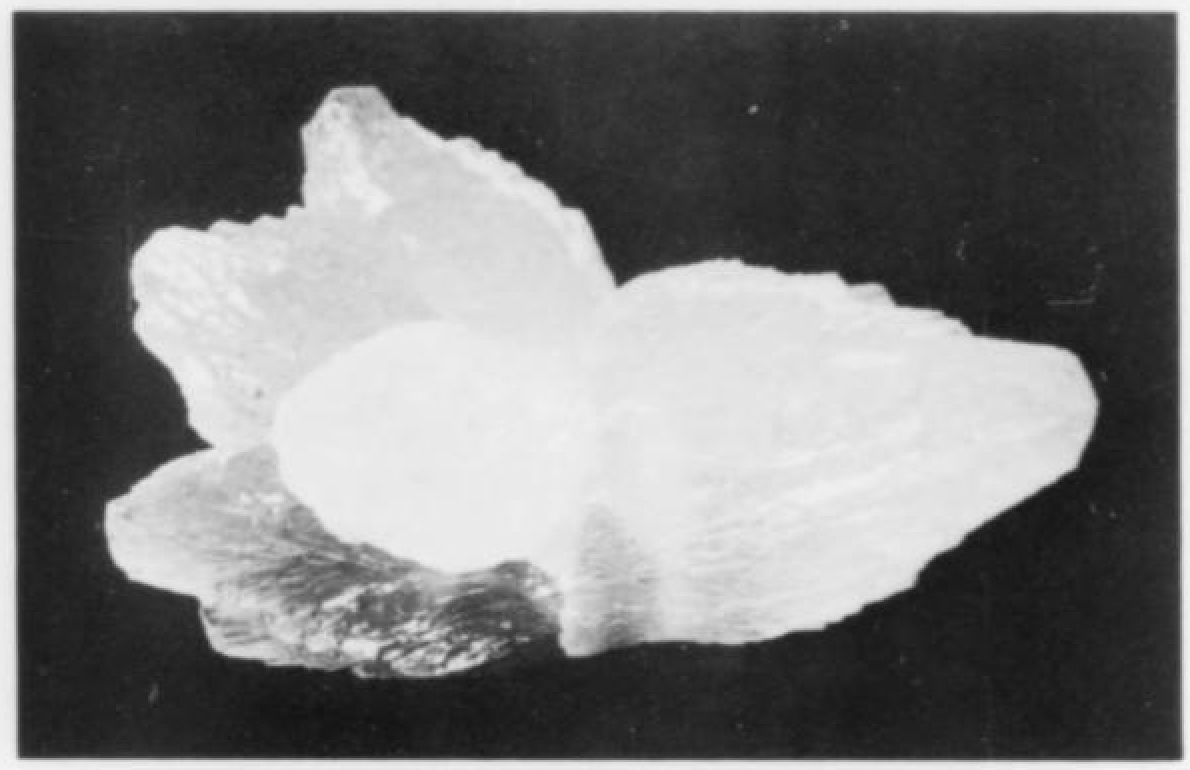


Figure 17. **Colorless calcite on specular hematite matrix about 1⅓ inches across, from the 3500 2C stope, 3512 level, 'C' bed. R. Barnes collection; J. Scovil photo.**

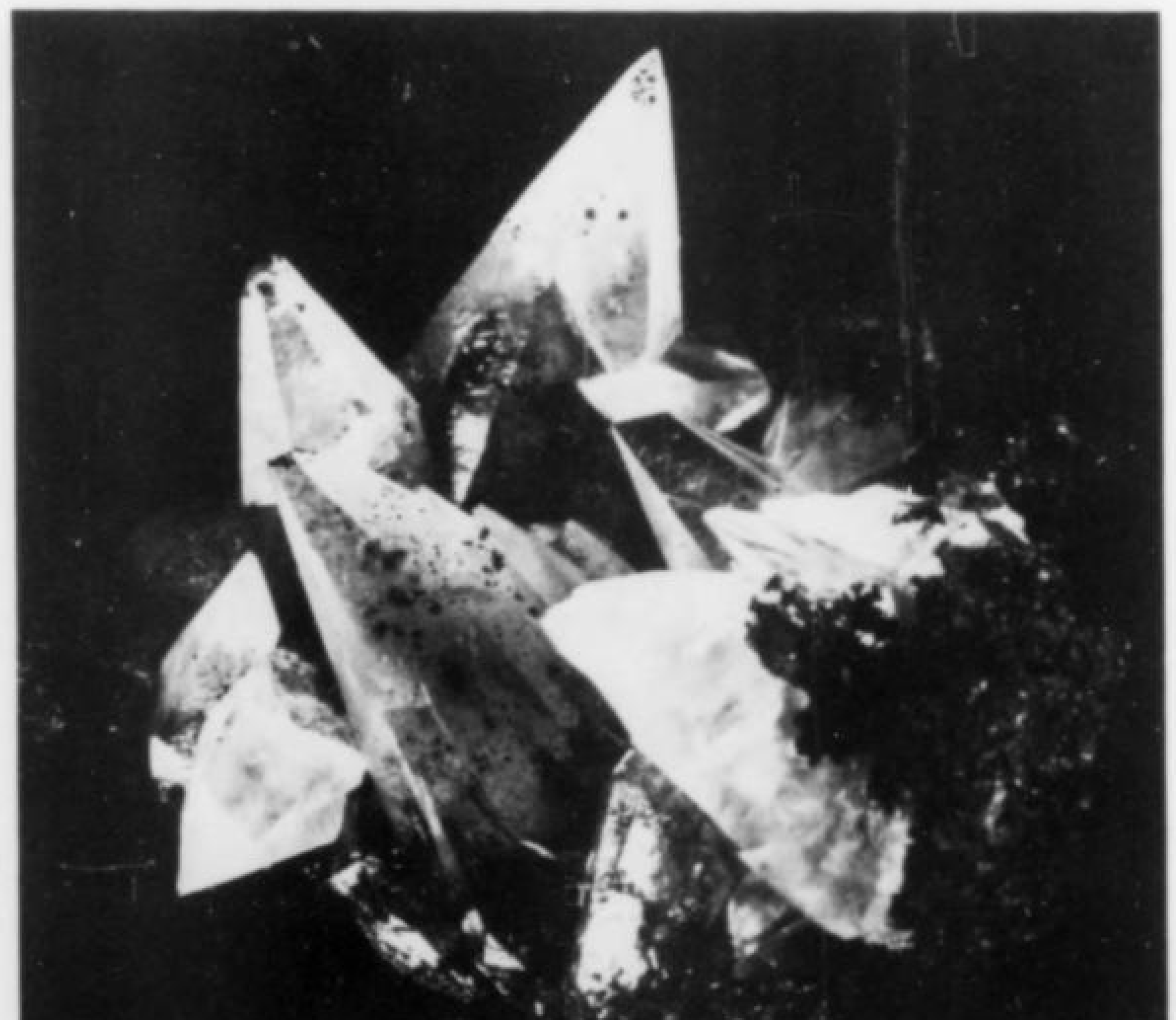


Figure 18. **Colorless calcite with native copper inclusions, 2¼ inches across, from the 3270 5D stope, 3270 level, 'D' bed. Bruce McDavid collection; J. Scovil photo.**

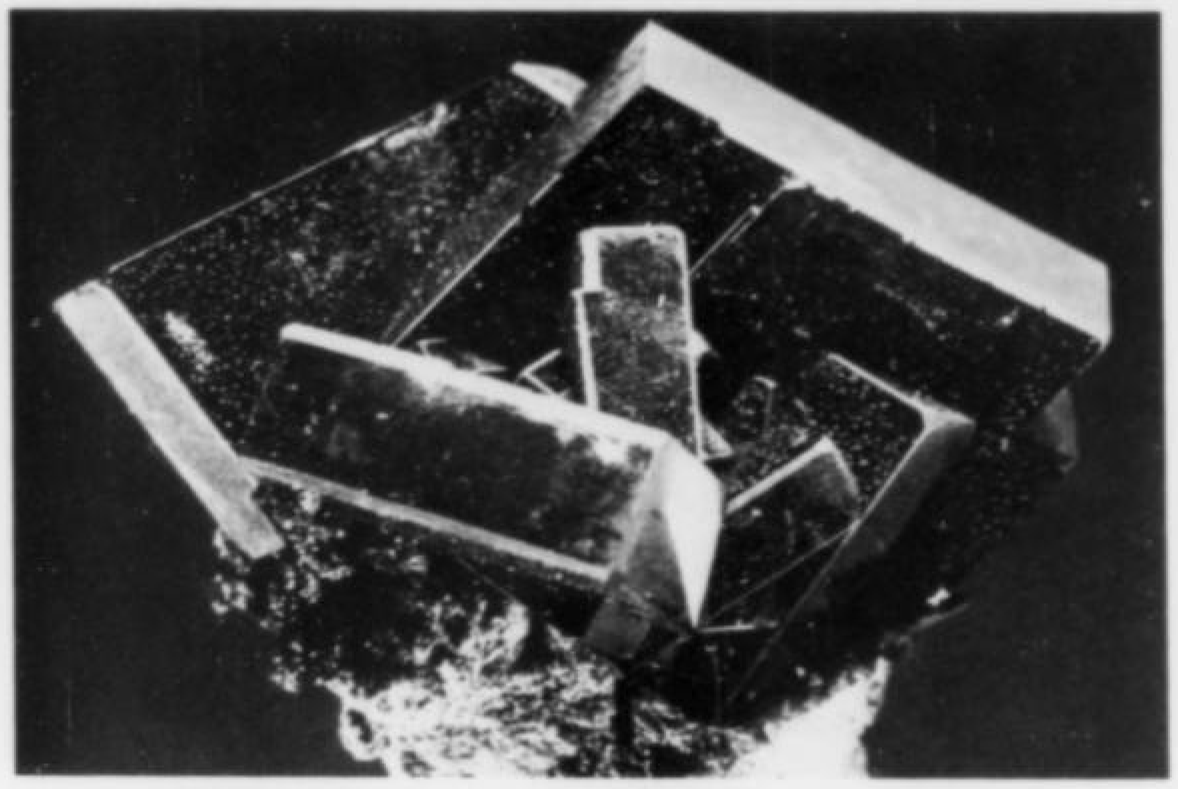


Figure 19. **Barite crystal cluster, transparent yellow with opaque black inclusions, 1¼ inches across, from the 3600 4D stope, 3620 level, 'D' bed. M. Hay collection; J. Scovil photo.**

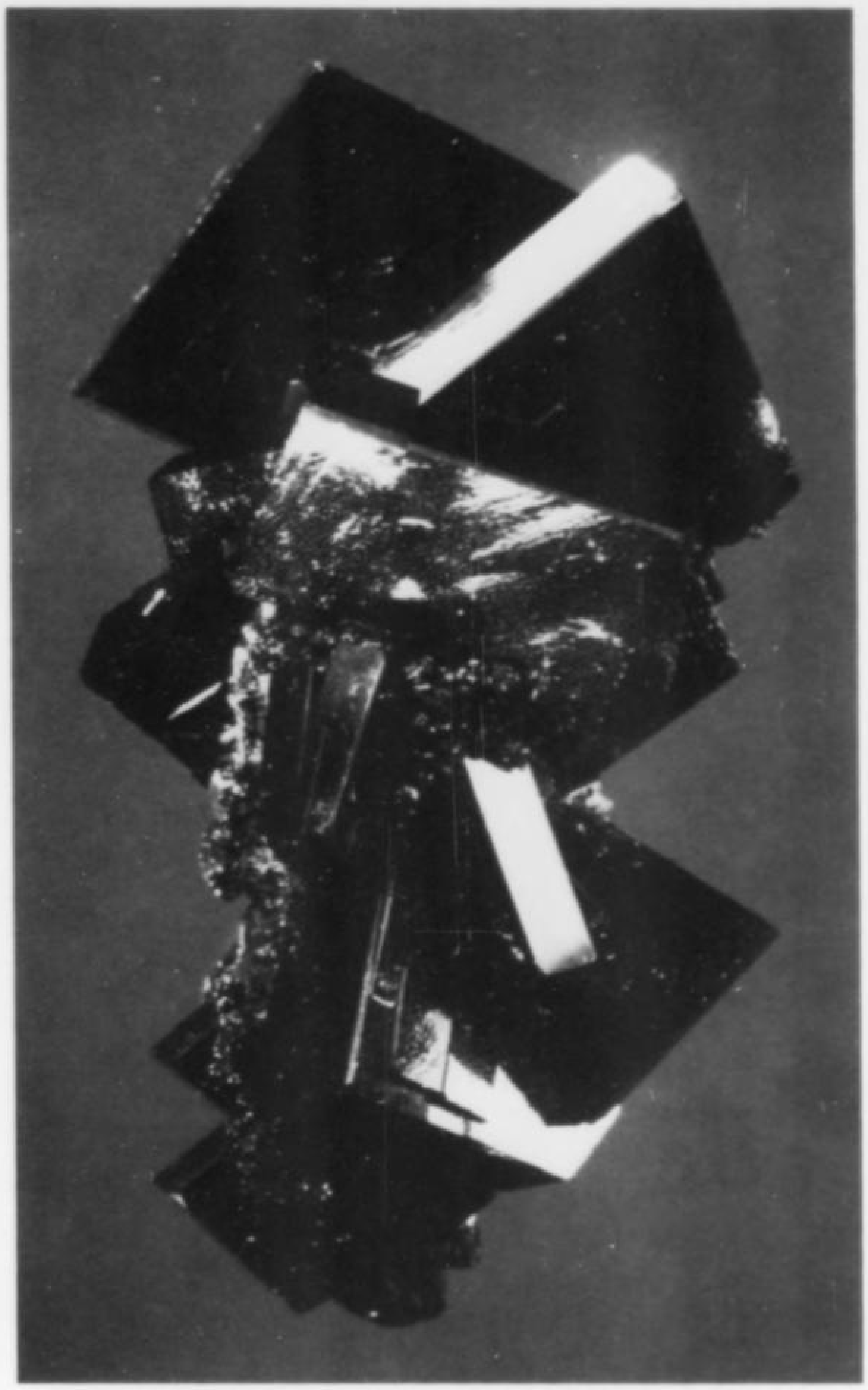


Figure 20. **Barite crystal cluster, opaque black with transparent yellow areas, 2¾ inches across, from the 3600 4D stope, 3620 level, 'D' bed. M. Hay collection; J. Scovil photo.**

nice specimens. The material from this pocket can be distinguished from others in the zone by very sharp terminations. The zone was next encountered in December of 1979 and in July of 1981 on the 3460 level. The material from the second pocket differs from the first in that there is less elongation, with many of the specimens having the appearance of white spheres. The third pocket was similar to the first, however: the crystal terminations are much less pointed, often being nearly rounded. Crystals in these second and third pockets contain none of the limonite or malachite inclusions present in the first. Much of the material is again light pink in color. This pink color was at first attributed to iron impurities, but some of the material was subjected to an analysis which revealed the presence of manganese, suggesting that they are actually manganoan calcite (Richard Jones, 1981, personal communication).

An occurrence of similar material was found in July of 1976, in the 3500 2C stope on the 3512 level. The calcite from this pocket so resembles the previously described material that there is hope the zone first encountered on the 3440 level actually extends down to at least the 3512 level.

Fine scalenohedral crystals up to 2 inches, with included native copper, have been produced in the 'A' and 'D' beds. These are not the quality of the famous Michigan specimens but they are nonetheless quite interesting.

SULFATES

Barite

If the Magma mine is to be remembered for one mineral, it surely will be barite. The beautiful tabular crystals have been sought by collectors for years. Sharp crystals up to 2 inches on an edge and ½ inch thick have been found in a spectrum of colors (black, brown, maroon, green, gray, white, yellow and golden). In the 1950's and 1960's, barite clusters were found in such large numbers that it was thought they would never cease to be abundant. These early specimens all came from the 'A' bed. Stories of mud-filled pockets containing clusters of barites have been told and retold many times by the miners. In 1975 at the Tucson Gem and Mineral Show, a fine black barite with white calcite was awarded the prize for best miniature in the species competition; this piece was from the 'A' bed.

After 1969 when mining in the 'A' bed ceased, it appeared that there would be no more barite. For the most part, barite became a thing of the past at Magma. Fortunately, a few scattered pockets have been encountered since then.

In April of 1976, in the 3200 5D stope on the 3220 level, a very nice pocket of gray barite clusters was found. The individual crystals are up to 1 inch on an edge, and the luster is superb. Some of this material is of the quality of the older 'A' bed pieces.

In May of 1980, in 6 Cross-Cut West, on the 3900 level, a large watercourse of beautiful, lustrous, black barites was encountered. Clusters were certainly the exception, but the large single crystals on a granular quartz pyrite matrix make for a nice contrast and some very attractive specimens.

In 1981, on the 3410 level of the 'CC' bed, in the 3400 4D stope, a nice series of small vugs of brown to golden colored barites was encountered. These occurred as clusters and druses of ⅛-inch to ½-inch crystals. Some interesting specimens were collected which were associated with limonite and chalcanthite.

Probably the best barite since the 1960's was found in the 'D' bed a week before Thanksgiving of 1981. This fine barite came from the 3600 4D stope on the 3620 level. Golden, brown and black crystals up to 1½ inches on an edge and highly lustrous were produced as singles, clusters and rosettes both on and off matrix. Many of the specimens were associated with clear sword-like crystals of gypsum. Most collectors agree that these are the best barite specimens collected at the Magma mine in the last 15 years. The pocket from which many of these beauties came is still intact, with many crystals remaining; but this part of the stope had to be backfilled with sand so that mining in the area could continue. At least we can say with

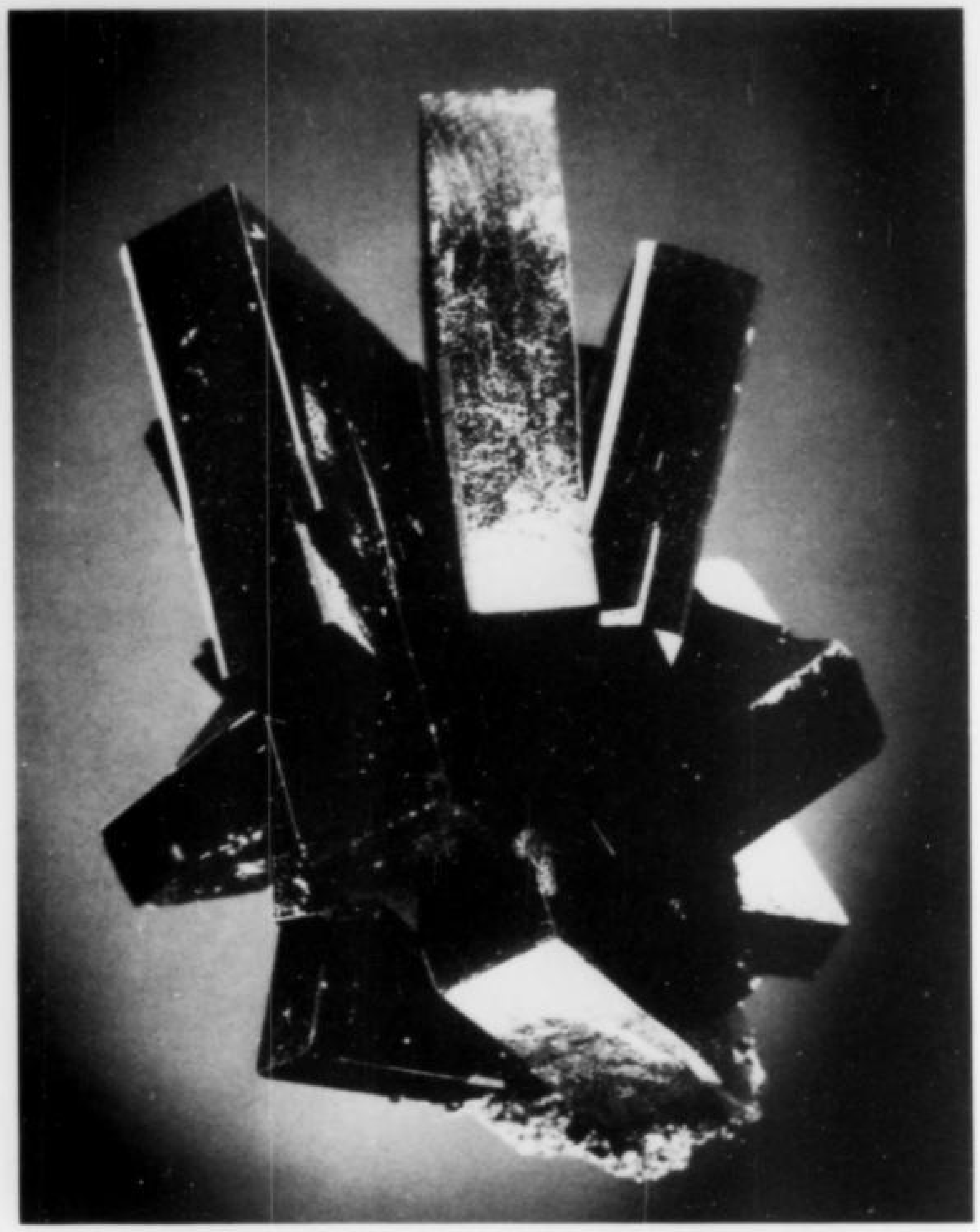


Figure 21. **Barite crystal rosette, black, 1¾ inches tall, from the 3600 4D stope, 3620 level, 'D' bed. R. Barnes collection; J. Scovil photo.**

certainty that there is indeed good specimen material left in the Magma mine.

ACKNOWLEDGMENTS

First and foremost, the authors wish to thank the management of the Magma Copper Company and Newmont Mining Corporation for their consent and cooperation in the preparation of this paper. Special thanks are offered to Russell Webster (Chief Geologist, Magma Copper Company, Superior Division), who unselfishly shared his immense knowledge of the geology of the Magma mine.

We offer grateful thanks to Jeff Scovil and Bob Jones for their splendid photography, and a note of gratitude is given to those many mineral collectors who made their collections available for viewing and photographing.

Thanks are extended to Russell Webster, Frank Florez (General Manager, Magma Copper Company, Superior Division), and Mary Ellen Dirlam for reviewing this paper.

Lastly, we wish to thank the miners who thought it worthwhile to take time to save those minerals pictured here.

Table 1. **Minerals Occurring in the Magma Mine**

Name	*Formula*
Ankerite	$CaCo_3(Mg,Fe,Mn)CO_3$
Azurite	$Cu_3(CO_3)_2(OH)_2$
Barite	$BaSO_4$
Bornite	Cu_5FeS_7
Brochantite	$Cu_4(SO_4)(OH)_6$
Calcite	$CaCO_3$
Chalcanthite	$CuSO_4 \cdot 5H_2O$
Chalcocite	Cu_2S
Chalcopyrite	$CuFeS_2$
Chrysocolla	$CuSiO_3 \cdot H_2O$
Colusite	$Cu_3(As,Sn,V,Fe)S_4$
Copper	Cu
Coronadite	$PbMn_8O_{16}$
Covellite	CuS
Cubanite	$CuFe_2S_3$
Cuprite	Cu_2O
Digenite	Cu_9S_5
Dioptase	$CuSiO_2(OH)_2$
Enargite	Cu_3AsS_4
Famatinite	Cu_3SbS_4
Fluorite	CaF_2
Galena	PbS
Gold	Au
Grossularite	$Ca_3Al_2(SiO_4)_3$
Gypsum	$CaSO_4 \cdot 2H_2O$
Halloysite	$Al_2Si_2O_5(OH)_4$
Hematite	Fe_2O_3
Hemimorphite	$Zn_4Si_2O_7(OH)_2 \cdot H_2O$
Hydrozincite	$Zn_5(CO_3)_2(OH)_6$
Limonite	Hydrated Iron Oxides
Magnetite	Fe_3O_4
Malachite	$Cu_2(CO_3(OH)_2$
Manganite	MnO(OH)
Olivenite	$4Cu_2AsO_4(OH)$
Psilomelane	MnO_2
Pyrite	FeS_2
Quartz	SiO_2
Rhodochrosite	$MnCO_3$
Sericite	$KAl_2Si_3O_{10}(OH)_2$
Siderite	$FeCO_3$
Silver	Ag
Sphalerite	ZnS
Stromeyerite	CuAgS
Tennantite	$(Cu,Fe)_{12}As_4S_{13}$
Tenorite	CuO
Tetrahedrite	$(Cu,Fe)_{12}Sb_4S_{13}$
Wittichenite	Cu_3BiS_3
Wulfenite	$PbMoO_4$

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Camp Verde Evaporites

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The Camp Verde salt mine in central Arizona has been known since pre-Columbian times, and is visited at one time or another by almost every Arizona collector. Fine glauberite crystals and pseudomorphs are abundant and easily collected at the surface. Thenardite and blue halite occur there as well.

INTRODUCTION

The chance eruption of a volcano about 13 million years ago resulted in the formation of one of Arizona's unique and historically significant mineral deposits – the Camp Verde evaporites. Just about everyone who collects rocks or minerals in Arizona has visited the area, usually ending up with a bountiful cache of crystals and unfortunately little insight into the relatively extensive history of the deposit.

Officially listed by the Arizona Department of Mineral Resources as the Graham-Wingfield sulfate ground, the Camp Verde salt mine, as it is known by most people, is located about 1 mile southwest of the town of Camp Verde, in Sec. 1, T.13N, R.4E. The white salt cliff is easily visible from a distance.

A number of significant aspects characterize the deposit. (1) It is one of the oldest known underground workings in the United States – earliest workings date back to pre-Columbian times. (2) Relatively uncommon minerals (thenardite, glauberite, blue halite) occur in the deposit. (3) The deposit has large quantities of good single crystals and crystal groups – it makes a great location for taking visitors where you can predictably find crystals in abundance. And (4) there has been little, if any, hassle between mine owners and mineral collectors – truly an uncommon combination for a collectable mineral deposit.

HISTORY

Because of a limited number of pre-Columbian (i.e. before the time of Columbus) artifacts, the earliest history of the Camp Verde salt deposit is somewhat obscure. Speculation dates the first use of the salt at the beginning of the occupation of the Verde Valley, perhaps 2000 years ago, in aboriginal times (Morris, 1928; Bartlett, 1935). Certainly salt, being a necessity in any diet, was one of those things most desired by the local inhabitants, and was utilized at a very early date. The nearest other salt deposits of any consequence are far away.

Numerous more recent objects, including cedarbark torches,

(Top) Camp Verde salt cliffs and ruins, 1970. (WEW)

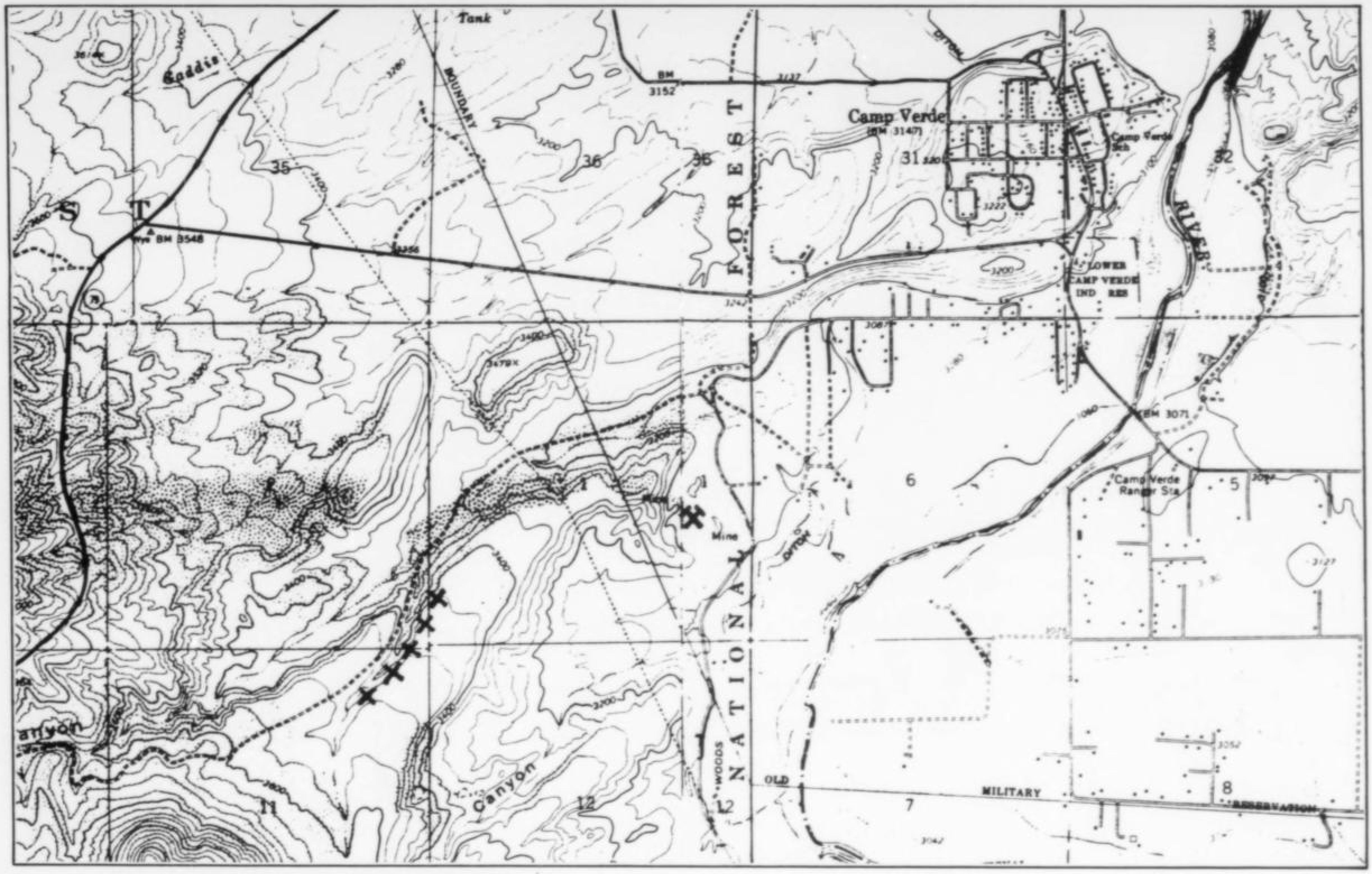


Figure 1. **The Camp Verde salt mine is located just south of the town of Camp Verde in central Arizona. Evaporite minerals (including aragonite and calcite pseudomorphs after glauberite) also occur in Copper Canyon about a mile to the west (crosses). Scale: 1¾ inch = 1 mile.**

Figure 2. **The mine concentrator in 1930. Photo courtesy of Edwin Sturges.**

sandals, stone picks, pick hafts, and various other oddities have been utilized to date a second period of mining by local Indians during the Pueblo IV time, in the 14th and 15th centuries (Bartlett, 1935). The ancient mines were tunnels burrowed into the hill at four or more levels, following strata relatively rich in salt (halite). A few thousand cubic yards of material were removed by the early miners in timberless, pillarless cavities. The mummified (or at least well-pickled) body of a pre-Columbia miner was found in the

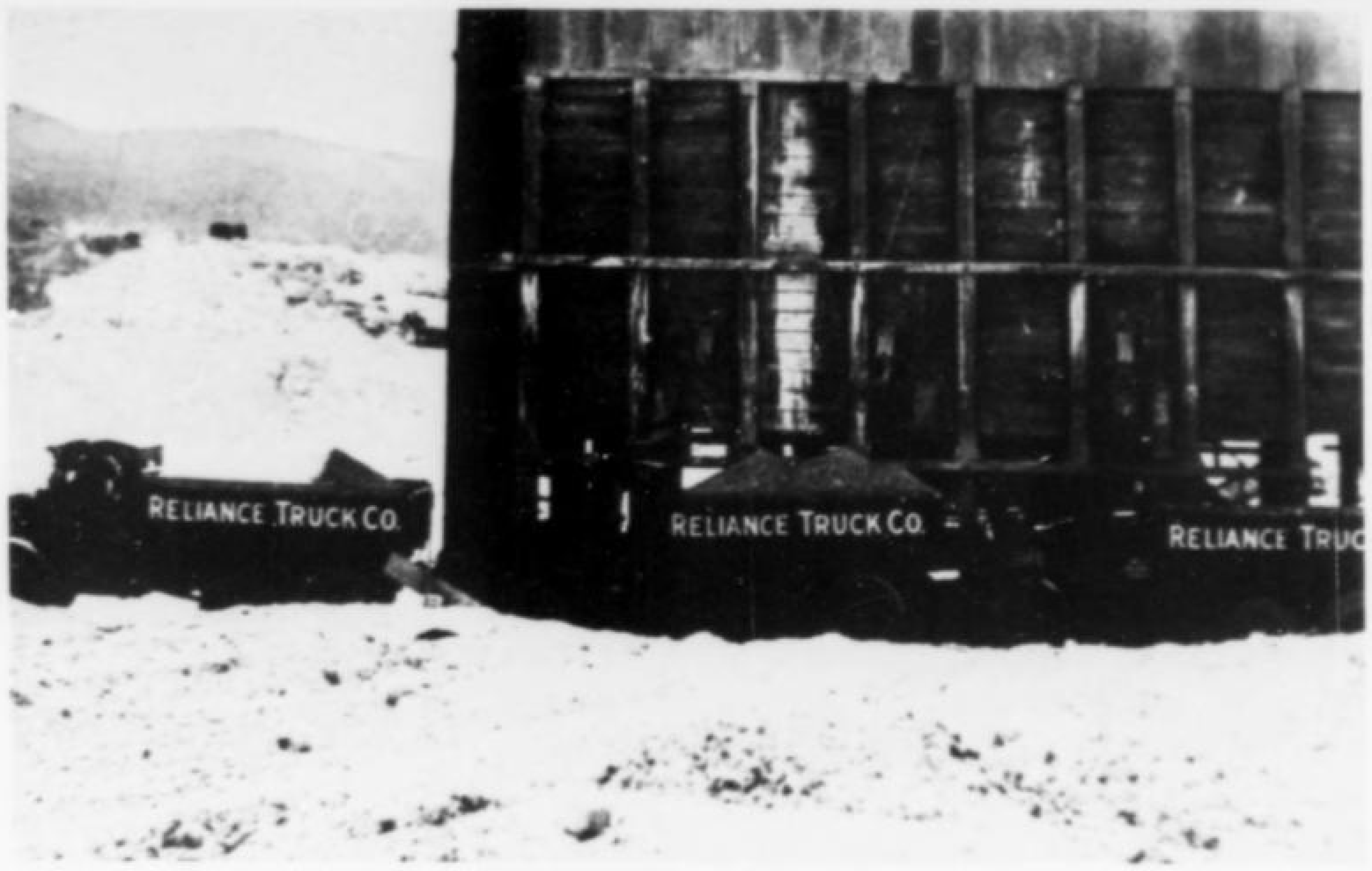
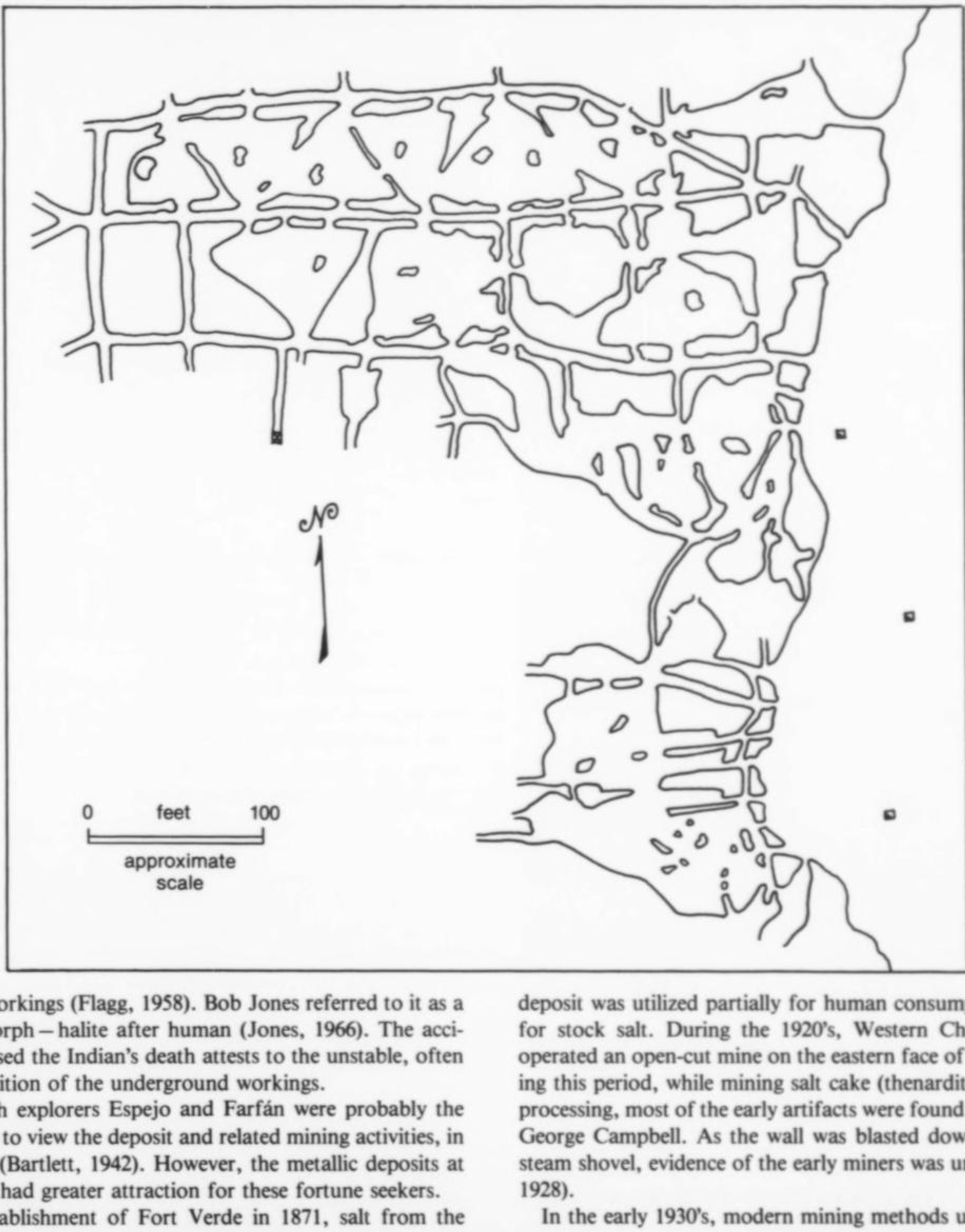


Figure 3. **Hauling the "salt cake" in 1930. Photo courtesy of Edwin Sturges.**

Figure 4. **Map of one level of the underground workings as of 1933. Courtesy of Edwin Sturges.**



underground workings (Flagg, 1958). Bob Jones referred to it as a large pseudomorph – halite after human (Jones, 1966). The accident which caused the Indian's death attests to the unstable, often collapsing condition of the underground workings.

Early Spanish explorers Espejo and Farfán were probably the first Europeans to view the deposit and related mining activities, in 1583 and 1598 (Bartlett, 1942). However, the metallic deposits at nearby Jerome had greater attraction for these fortune seekers.

With the establishment of Fort Verde in 1871, salt from the deposit was utilized partially for human consumption, but mostly for stock salt. During the 1920's, Western Chemical Company operated an open-cut mine on the eastern face of the deposit. During this period, while mining salt cake (thenardite) for paper pulp processing, most of the early artifacts were found by mine manager George Campbell. As the wall was blasted down in front of the steam shovel, evidence of the early miners was uncovered (Morris, 1928).

In the early 1930's, modern mining methods utilizing room and

Figure 5. **Geology students collecting gypsum pseudomorphs after glauberite on slopes of the open cut. Photo by the author.**

Figure 6. **Decomposing underground timbers encrusted with halite and thenardite. Photo by Stan Celestian.**

Figure 7. **Gaining hazardous entrance to the underground workings. Photo by Stan Celestian.**

pillar techniques and timbering were undertaken by the Arizona Chemical Company, jointly owned by American Cyanamid and International Paper Company. Approximately 75 men, about half of whom were Apache Indians, produced 100 tons of "salt cake" daily, making the mine the largest producer in the United States. Fourteen tunnels extending back 500 to 600 feet in almost horizontal strata were mined, as horse-drawn ore cars moved the ore to a conveyer belt. The salt cake was processed at a mill on the site, then trucked about 20 miles to Clemenceau (near Cottonwood) where it was put on railroad cars for distribution (Sturges, 1981, personal communication). When purer German material entered the market, free of duty, in 1933 the Camp Verde mine was unable to compete and ceased production.

Attempts in the 1960's to interest paper and pulp companies in the deposit failed, principally because the deposit is dwarfed by othes in California, Wyoming, Texas and Saskatchewan, and is limited to 92 percent purity; the market demands 99 percent purity. The property remains dormant today.

GEOLOGY

Following a complex mid-Tertiary episode of massive silicic volcanism and metamorphic core-complex formation, much of central Arizona was faulted into deep basins and high ranges by steeply dipping faults with tremendous vertical displacement. Grabens that subsided during basin and range crustal extension eventually accumulated extensive deposits of clastic and basaltic rocks. During extended periods of interior drainage, thick deposits of lacustrine carbonates were deposited. Nations and Stump (1981) have expanded on these points:

"One of the best known examples of Tertiary basin fill sequences is the Verde Formation in the Verde Basin. It contains the best exposed record of Tertiary history in Arizona with about 1600 feet of Tertiary-age sedimentary and volcanic rocks exposed as a result of erosion by the Verde River and its tributaries. . . . The basin was

Figure 8. **Calcite pseudomorphs after glauberite crystals, the largest measuring about 3½ inches. Photo by the author.**

Figure 9. **Mirabilite crystals *in situ* in a drainage area of the open workings. Photo by Stan Celestian.**

Figure 10. **Halite and thenardite stalactites from the underground workings. The longest is about 6 inches, although stalactites to 3 feet have been collected. Photo by the author.**

formed by Oligocene time as a result of faulting on the Verde Fault and probably other faults, and erosion by the ancestral Verde River. By Miocene time the drainage system was blocked at the southern end of the valley by faulting and volcanism, resulting in a closed system. Sedimentation proceeded within the basin with marginal clastic materials grading laterally to lacustrine limestone toward the center where ponded water accumulated periodically. During especially dry periods, the water became hypersaline or completely evaporated, leaving deposits of gypsum and salt in the lowest portion in the southern end of the valley south of Interstate Highway 17. Evaporites and volcanic sediments continued to be deposited in the southern end of the basin throughout the Miocene while the drainage continued to be blocked by faulting and volcanic eruptions in the Hackberry Mountain and Thirteen-mile Rock volcanic center about 12 miles southeast of Camp Verde."

Ponding and resulting deposition ceased by early Pleistocene times as external drainage became better developed, and erosion became the dominant process in the basin. Erosion has continued, exposing the evaporite deposits as we see them today.

COLLECTING

Collecting in and around the Camp Verde salt mine is basically open and unimpeded. Surface collecting is extremely easy and productive. One can always find more specimens than can be carried, particularly of glauberite and its various pseudomorphs. Walls of the mine cut and the narrow arroyo west of the mine are by far the best areas for collecting. Halite is less common, being found only on the weathered walls of the mine or underground. Specimens with blue or purple phantoms are a real treat! After moist periods, beautiful and fragile mirabilite crystals may be observed in pools and along the banks of the shallow dendritic drainages in the lower southeast part of the deposit.

The underground workings are another story altogether. A few people dig down and crawl in without qualms. However, as far as this author (and numerous others who value their hide more than a few specimens of salt!) is concerned, sky divers with worn-out parachutes have a safer pastime than mineral nuts in the underground salt workings. Support timbers (12 by 12 inches) have rotted to the strength of stale bread, so crumbly that a 2-year-old could tear one up. Cave-ins are frequent (they were even fairly common during the commercial mining period, killing one worker during a lunch break). In order to gain entrance to the underground workings one must dig and crawl through about 15 feet of very loose, shifting talus. This author has been in lots of shaky old mines, but nothing has come close to providing the lack of confidence (FEAR!) experienced in these underground salt diggings.

When visiting this area it is beneficial to wear old clothes and high-top shoes. The sticky, salty clays play havoc with shoes, socks and vehicle interior, sticking to everything and eating away at leather and metals with equal gusto.

MINERALS

Aragonite $CaCO_3$

Found as (1) ball-like clusters of brown crystals in the top layer of sediments at the salt mine site, (2) needle-like crystals after glauberite, and (3) total replacement of glauberite. The best pseudomorphs can be found in a narrow wash located about 1 mile southwest of the salt mine (in the SE¼ of Sec. 2 and NE¼ of Sec. 11).

Calcite $CaCO_3$

Found as buff to white, opaque pseudomorphs after glauberite, formed either by glauberite contacting ground water [$Na_2Ca(SO_4)_2 + CO_2 + H_2O \rightarrow CaCO_3 + Na_2SO_4 + H_2SO_4$] or from gypsum pseudomorphs after glauberite altering to calcite by accumulation of carbonated surface or ground water [$CaSO_4 \cdot 2H_2O + CO_2 \rightarrow CaCO_3 + H_2SO_4 + H_2O$].

Glauberite $Na_2Ca(SO_4)_2$

Tabular, transparent, gray single crystals found in loose clay or embedded in thenardite masses. Alters rapidly after being collected – must be sprayed with a plastic coating to retard alteration. May display a weak greenish phosphorescence under shortwave ultraviolet light.

Gypsum $CaSO_4 \cdot 2H_2O$

Found as lenses of clear material in slopes and creek beds and as white pseudomorphs after glauberite on the loose clay slopes of the salt mine.

Halite NaCl

Found as lens-like masses in the walls and particularly in the underground workings, as beautiful, clear to white stalactites hanging from the ceiling, and as formless masses on the debris slopes of the open cut – sometimes with purple phantoms, reportedly due to manganese. Fluoresces yellow under both shortwave and longwave ultraviolet light.

Mirabilite $Na_2SO_4 \cdot 10H_2O$

Found mostly as white, powdery masses in the talus slope of the salt mine. Also, after rain, as beautiful, white, needle to spear-like crystals in pools and along the banks of drainage below the mine. Very fragile. Must be heavily sprayed with a plastic coating in order to preserve it.

Thenardite Na_2SO_4

Found as large, colorless, transparent masses in the talus slope of the salt mine. Soluble in water. May be formed from glauberite contacting carbonated water [$Na_2(CaSO_4)_2 + CO_2 + H_2O \rightarrow CaCO_3 + Na_2SO_4 + H_2SO_4$] with the H_2SO_4 being rapidly neutralized by the alkaline sediments.

ACKNOWLEDGMENTS

The author is indebted to the Museum of Northern Arizona, the Arizona Department of Mineral Resources, and to Edwin Sturges for assistance in preparing this article.

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tr

ferroan dolomite from the
Vekol Mine

by **David M. Shannon**
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LOCATION

The Vekol mine is located in the Vekol Mountains, about 30 miles southwest of Casa Grande, within the Papago Indian reservation. The mine itself is patented, however, and is not part of the reservation. Collectors should obtain a copy of the *Vekol Mountains, Arizona* 15-minute quadrangle before attempting to find the mine, as the pipeline road leading to the mine from Indian Route 15 is not on highway maps.

HISTORY

In 1864, John D. Walker organized a company composed of Pima Indians for the purpose of fighting the Apaches. He remained among the Indians as a trader, learned their language and became a trusted friend. In 1880 the Pimas told Walker about an old Indian silver mine, and showed him and his brother Lucien the location one night. The Walker brothers formed a partnership with their friend Peter R. Brady (who was also involved in the mine at Ajo), and soon discovered that their silver mine was very rich. Three years later they were offered $150,000 for the mine but refused to sell. By 1886 a mining town had developed around the site; it contained about 30 families and, remarkably, not a single saloon. By 1909 the ore had been exhausted and the settlement became a ghost town (Granger, 1960; Sherman and Sherman, 1969). A total of several million dollars in silver was produced. Remnants of four adobe buildings, rock foundations and mill ruins remain.

Records indicate over 9 miles of tunnels, shafts and stopes, little of which follow a straight line (Arizona Department of Mineral Resources file data, Phoenix). Recent leaching operations closed the locality to collecting for a while, but today the mine is again abandoned.

MINERALS

In some areas of the mine the predominant silver mineral was chlorargyrite, and some fine specimens can still be collected. Flagg (1958) reported thin coatings of oily green chlorargyrite on fracture surfaces as large as one's palm. Anthony *et al.* (1977) described millimeter-size crystals on jarosite from a specimen in the American Museum of Natural History, New York. A variety of other lead and silver minerals may be collected at the mine, some of them making fine micromounts.

Splendid crystals of chocolate-brown dolomite have come from the Vekol mine for many years, and are represented in many collections. Unfortunately they are often incorrectly labeled as siderite, ankerite or calcite. In order to resolve the question of their identity, Bret Sharnow and I ran an atomic absorption analysis on a number of specimens of the darkest material, and found an average iron content of 0.92 percent. Subsequent specific gravity measurements utilizing heavy liquids were performed on specimens from throughout the mine, and resulted in measurements between 2.80 and 2.95, indicating the material to be ferroan dolomite.

The brilliant luster and sharpness of the crystals, combined with their pleasing range of brown colors, make these Vekol mine specimens attractive additions to any collection.

Figure 1. **Chocolate-brown ferroan dolomite, 5 x 7 cm, from the Vekol mine. Photo by the author.**

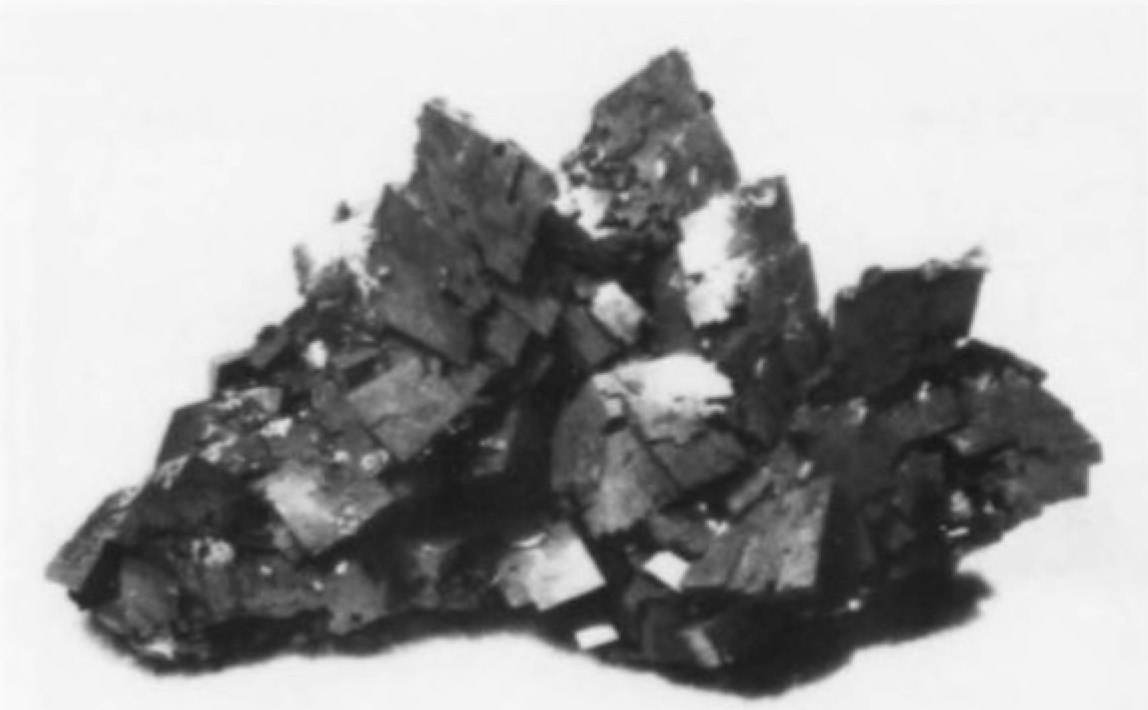

Figure 2. **Chocolate-brown ferroan dolomite crystals, 4 x 6 cm, from the Vekol mine. Photo by the author.**

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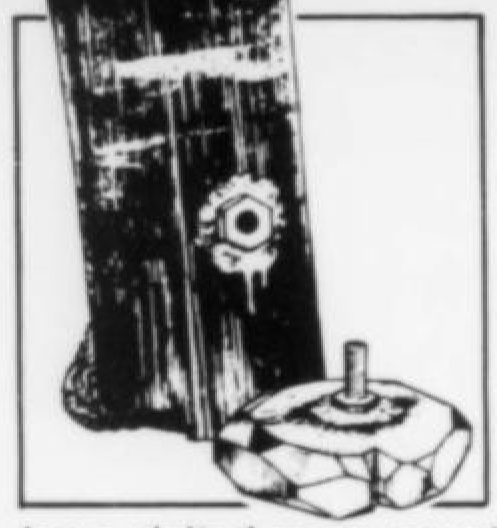

famous mineral localities:

the Old Yuma mine

by **Dick Jones**
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The Old Yuma mine, near Tucson, has produced North America's finest vanadinite specimens and is also well known for large and beautiful yellow wulfenite crystals. Sizeable pockets of these minerals have been found since the 1880's and are still being found today.

LOCATION

The Old Yuma mine is located in the Tucson Mountains, Pima County, Arizona, about 8½ miles by road northwest of the Tucson city limits. Access is by way of Ina Road west from Interstate Highway 10, then left on Wade Road through Contzen Pass on Picture Rocks Road. About ¼ mile past Contzen Pass is a dirt road leading to the left. It runs a winding path to the mine for about 1½ miles, through typical Arizona desert studded with mesquite, creosote bush, prickly pear cactus, and giant saguaro cactus reaching 40 feet tall and more. The mine is located at the edge of the Saguaro National Monument, near the top of a small hill, and can be recognized from a distance by the old concrete foundation blocks near its summit. The deposit appears as the "Yuma Mine" on the Jaynes 7½-minute quadrangle published by the U.S. Geological Survey.

HISTORY

The first recorded claim on the deposit was filed on August 3, 1885, by C. C. Stephens. Little is known of Stephens, but he did serve as a Tucson city councilman. The Tucson *Citizen* supported him in that election, but then had a change of heart after he failed in a mission to obtain State Capitol status for Tucson. He did obtain permission to locate the proposed Territorial University (later the University of Arizona) in Tucson, but that didn't count for much with the *Citizen:*

"It is a dirty bird that befouls its own nest, yet we are compelled to admit that Tucson possesses in the person of C. C. Stephens the dirtiest of such dirty birds.

"It is said that nothing was made in vain, but we can't think what this fellow Stephens was made for unless to make the horse thief feel respectable by comparison." (March 12 and 18, 1885)

Stephens named his claim the "Old Yuma mine" (not simply the "Yuma Mine" as shown on current topographic maps). Yuma is the name of an Indian tribe living about 200 miles to the west; they are not indigenous to Pima County where the mine is located. It is possible that the mine name is related in some way to a white man named "Yuma." His real name was Thomas McLain, a graduate of West Point. He had served as quartermaster at the Fort Yuma military post on the Colorado River but was cashiered for misconduct. In disgrace he joined the Yuma Indian tribe, and married a Yuma woman . . . from then on he was known to whites only as "Yuma." He became an Indian trader, traveling between the various tribes, and he established a small cattle range in Papago country west of Tucson, not far from where Stephens later located the Old Yuma mine. Yuma was killed by the Papagos around 1861. He had, incidentally, discovered an Indian gold mine north of Tucson but the location died with him and "The Lost Yuma Mine" became part of the Southwest's lore of lost mines (Dobie, 1930; Mitchell, 1933).

The Old Yuma claim was originally filed for gold, but the presence of abundant vanadinite, wulfenite and some galena suggested the possibility of producing vanadium, molybdenum, lead and perhaps silver as well. (The ore later proved to contain about 1 ounce of silver and 0.1 ounce of gold per ton; Keith, 1974).

The first article to appear about the Old Yuma mine was written in 1910 by F. N. Guild (published in 1911), who was then working in the mineralogy department of the University of Arizona; it appeared, in German, in *Zeitschrift für Krystallographie und Mineralogie*. Guild gave a brief description of the geology of the deposit and went on to describe in detail the wulfenite, vanadinite, mottramite and cerussite crystals found there, including with the descriptions some excellent crystal drawings (reproduced here). He indicated that the locality was well known at the time, and that it had produced some galena ore.

By November of 1913 the west inclined shaft had been sunk to a depth of 300 feet. Around 1914 the property was acquired by Colonel John H. Martin and the Honorable William H. Barnes, two law

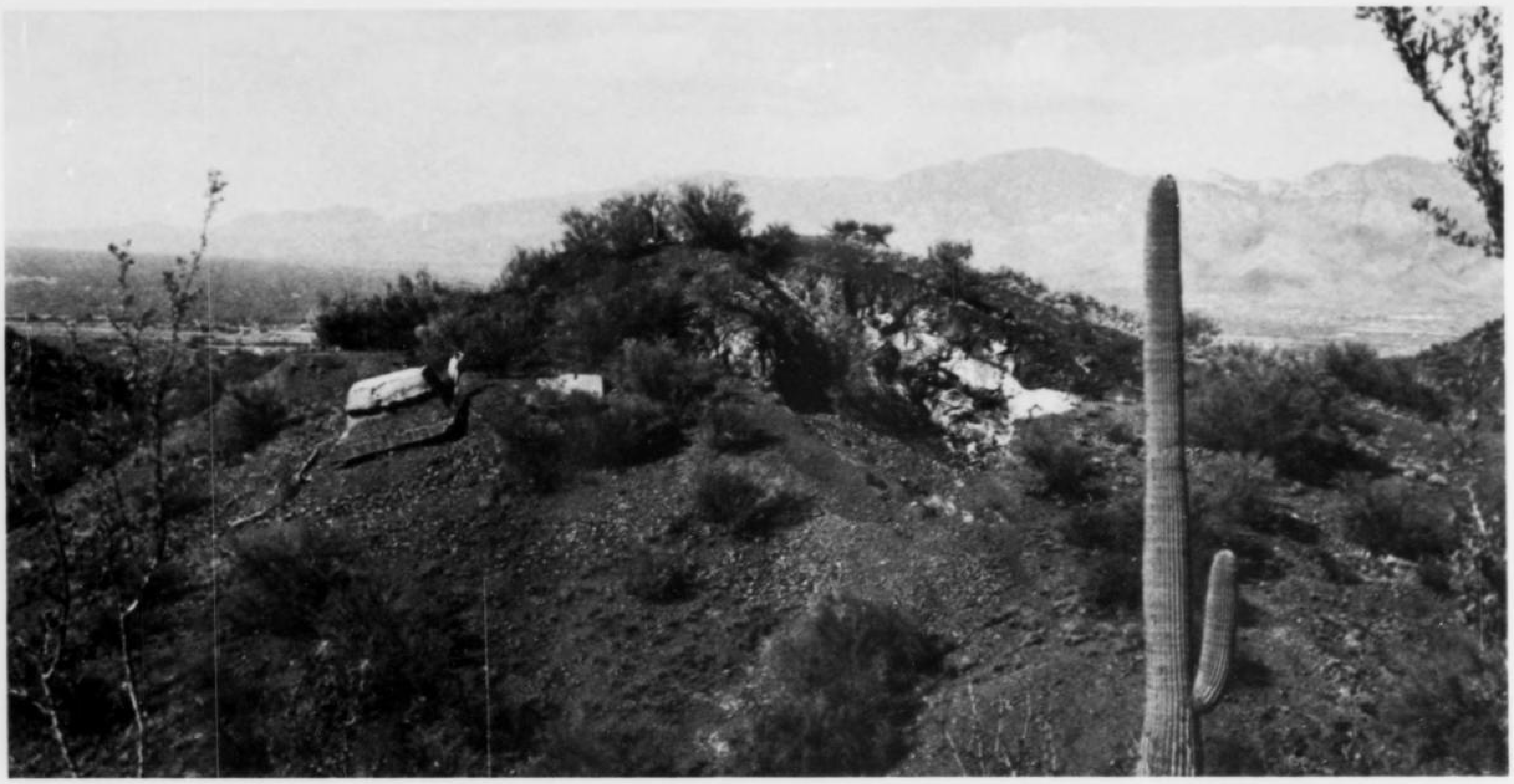

Figure 1. **The Old Yuma mine in 1982; a portion of Tucson is visible in the far distance, to the right of the mine hill. From the inside of the open pit workings the west incline and the glory hole stope plunge downward and to the right; the dark area in the pit is just a shadow and not an adit. Note the person standing next to the concrete foundation block for scale.**

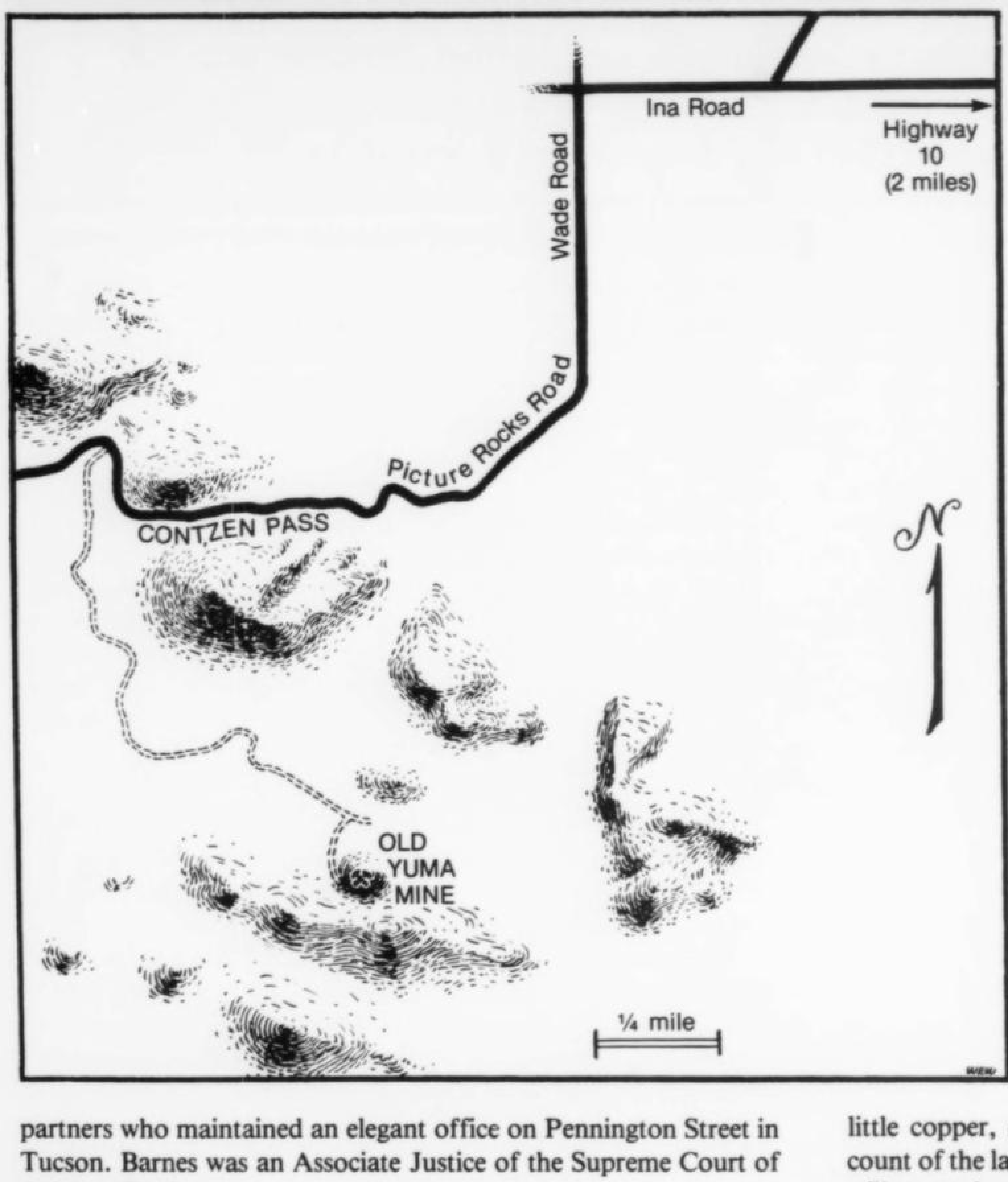

Figure 2. **Location of the Old Yuma mine, in the Tucson Mountains northwest of Tucson. Ina Road crosses Highway 10 to the east and passes directly into the northern suburbs of Tucson.**

partners who maintained an elegant office on Pennington Street in Tucson. Barnes was an Associate Justice of the Supreme Court of Arizona Territory.

In 1915 the Old Yuma mine was bonded by Colonel Epes Randolph and associates, who shortly thereafter constructed a mill on the site for the concentration of gold, molybdenum and vanadium. An article in the *Tombstone Epitaph* (April 2, 1915) reported: "The ore is andesite feebly mineralized and carries small value in gold, a little copper, molybdenum and vanadium. It is expected, on account of the large bodies of low-grade gold ore, that the latter metal will prove the most profitable metal to be extracted. The market for molybdenum and vanadium has been injured on account of the war but may improve later."

Eleven months later an article in the *Tucson Citizen* (February 29, 1916) reported that: "The mill of the Old Yuma mine, which is now under construction, will be ready to operate within a month,

Figure 3. **Blocky vanadinite crystals to ¼ inch. George Godas collection.**

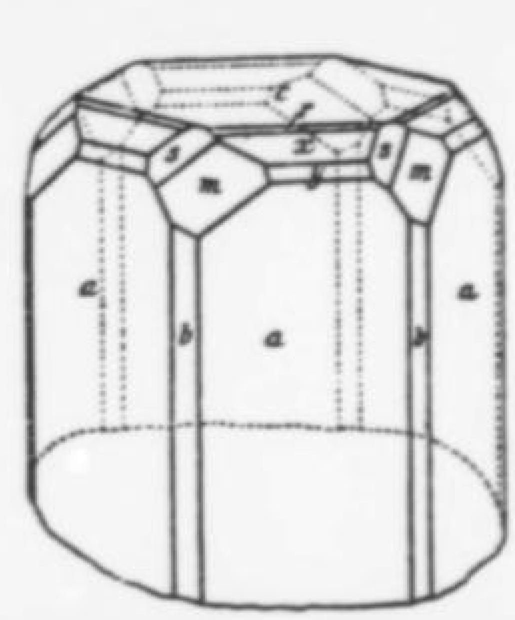

Figure 4. **Vanadinite from the Old Yuma mine (Guild, 1911).**

Figure 5. **Vanadinite crystal groups to 1 inch. George Godas collection (found at V_{75} location on Figure 9 map, by George Godas).**

Figure 6. **Complex, cavernous single crystal (or parallel growth) of vanadinite, 1½ inches tall. Chris Panczner collection (found at V_{72} location shown on Figure 9 map, by Chris Panczner).**

according to Col. Epes Randolph. The mill will be capable of handling 100 tons a day. The mining engineer Courtenay DeKalb was associated with Randolph in the development of this property, and has patented a process for refining the concentrates. Randolph expects a steady increase in the use of molybdenum and vanadium which could be used in the manufacture of cannon and armor plate."

No records could be found documenting the amount of vanadinite and wulfenite removed and milled by Randolph, but it must have been significant. Allen (1919) reported that: "During the brief period of high price of molybdenum in 1917 the Old Yuma mine in the Amole District was worked for wulfenite in the oxidized zone of the orebody. This old property has produced a large tonnage of lead ore in the past."

According to J. F. Weadock (1965), the mine once figured in the capture of a kidnapper. In February of 1932 a man named Cliff Adkins kidnapped Gordon Sawyer, a banker employed by the Southern Arizona Bank, and held him for $60,000 ransom. They were followed to an abandoned ranch; shots were fired at police and deputies, and the kidnapper subsequently escaped. Sawyer was found alive in an abandoned well nearby. One-eyed Joe Baker kept a goat herd at the Old Yuma mine, and was watchman for the rusting machinery and buildings there. Adkins made his way to the mine, and forced One-eyed Joe to shelter and feed him. About a week later, Joe's stepson Pancho wandered out of the mesquite brush to the homestead Rancho del Charco, and reported that there was a man at the mine whom Joe was afraid of. The word was passed to Tucson police, who went to the mine and found Adkins' car hidden under an old tarp. Adkins walked out of one of the mine buildings, hands in the air, and surrendered peaceably. After a second trial he was sentenced to 40 years in prison, but was later paroled.

In the 1930's the mine was acquired by the Yuma Mining Company and was leased to Grady Wilson of Tucson. Wilson occasionally produced dump ore and surface material from the late 1930's to 1954. It was during the early 1950's that I met Grady Wilson and began to dig specimens from the Old Yuma. Grady was one fine gentleman, and loved to prospect and tell tales of treasure-

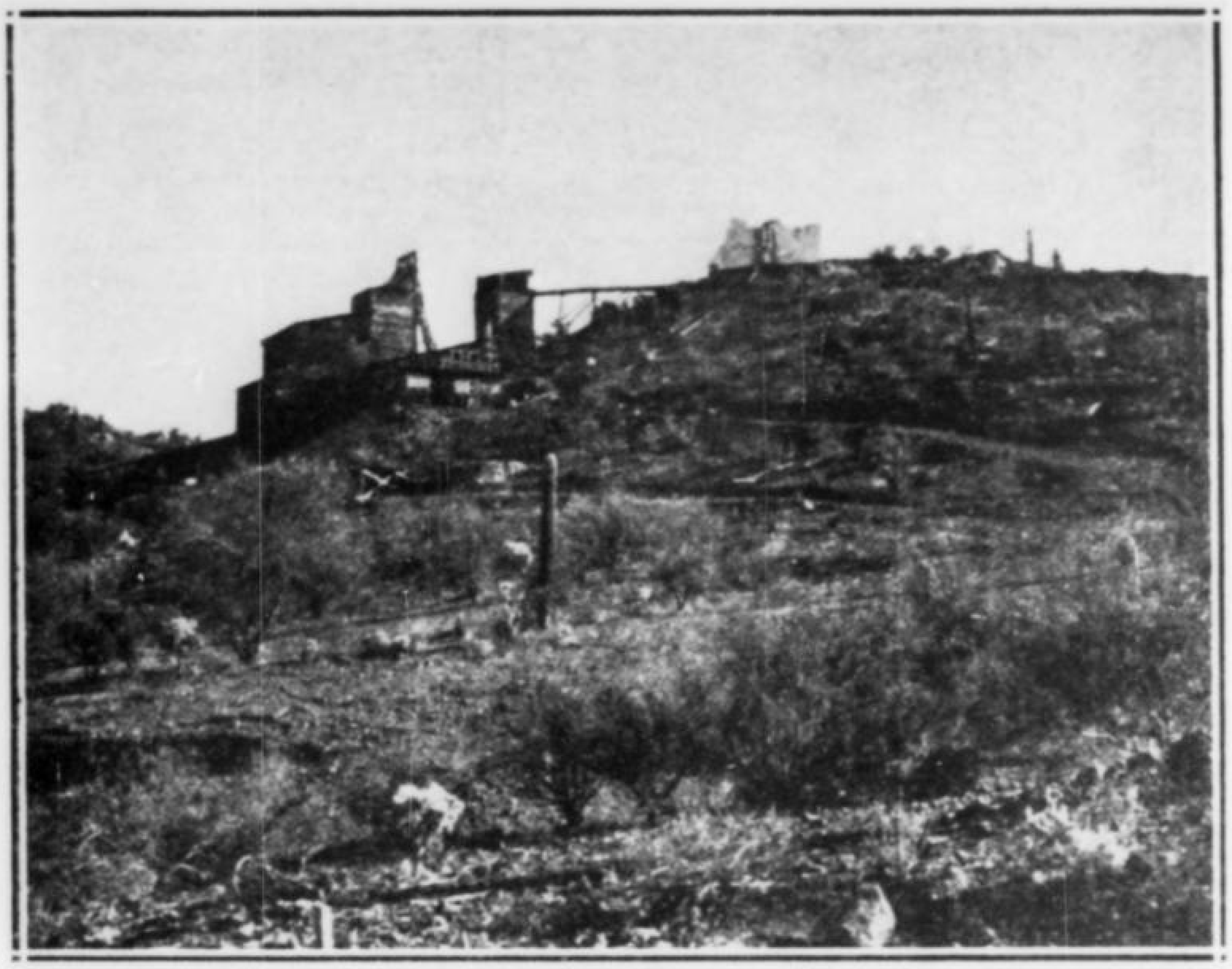

Figure 7. **This photo of the Old Yuma mine was taken around 1919 (Jenkins and Wilson, 1920), apparently from the northwest, and shows the mill constructed by Colonel Epes Randolph in 1916 for crushing and concentrating wulfenite and vanadinite.**

Figure 8. **By 1931, as this photo taken from the west-southwest shows, the mill had been removed (Schmeltz, 1931). The headframe stands above the west incline, and two old mine buildings remain.**

hunting in Mexico. I spent many enjoyable hours listening to him. He later abandoned his work at the Old Yuma; the last I saw of him was at the Orizaba mine, south of Casa Grande, Arizona, on the Papago Indian Reservation. The former Chief of Police at Casa Grande said that Grady, accompanied by another person, went into Mexico around 1965, searching for mission treasure,[1] and disappeared with his friend in the Yaqui River country of Sonora.

Joe Brooks Davis and associates of Tucson (husband of the late well known mineral dealer Suzie Davis of *Davis Minerals*) filed three placer claims across the Old Yuma property in 1958, and 21 more claims (named the Contzen 1 through Contzen 21 claims) in 1959. To my knowledge, little work was done at the Contzen claims save for sporadic specimen mining.

As of October 22, 1979, the Bureau of Land Management (BLM) Organic Act required that all unpatented claims be refiled or they would be considered abandoned. This gave others the right to claim or relocate any such unpatented claims that had not been refiled by that date. Upon checking with the BLM on December 27, 1979, I found that the claims covering the Old Yuma property had not been refiled as required, so I filed a new claim on the mine.[2]

GEOLOGY

The deposit is a porphyritic andesite or latite dike occupying a dip-slip fault plunging at about 43° south through Cretaceous andesite (Knight, 1967). Scattered pods of argentiferous galena in the dike have altered to anglesite and cerussite, which provided lead for the crystallization of vanadinite and wulfenite. Molybdenum and vanadium were most likely supplied to the deposit by groundwater which had dissolved the metals from weathering igneous rocks (Newhouse, 1934). Wulfenite and vanadinite will precipitate

[1] Many tales of hidden treasure in the Southwest hinge on the belief that early Jesuits supervised the mining of much silver and gold, which they were forced to hide when they were expelled from America in 1767.

[2] The claim is named the Comet, situated in the NW¼ of the SE¼ of Section 9, and the SW¼ of the SE¼ of Section 9, T.13S, R.12E, GSRBM.

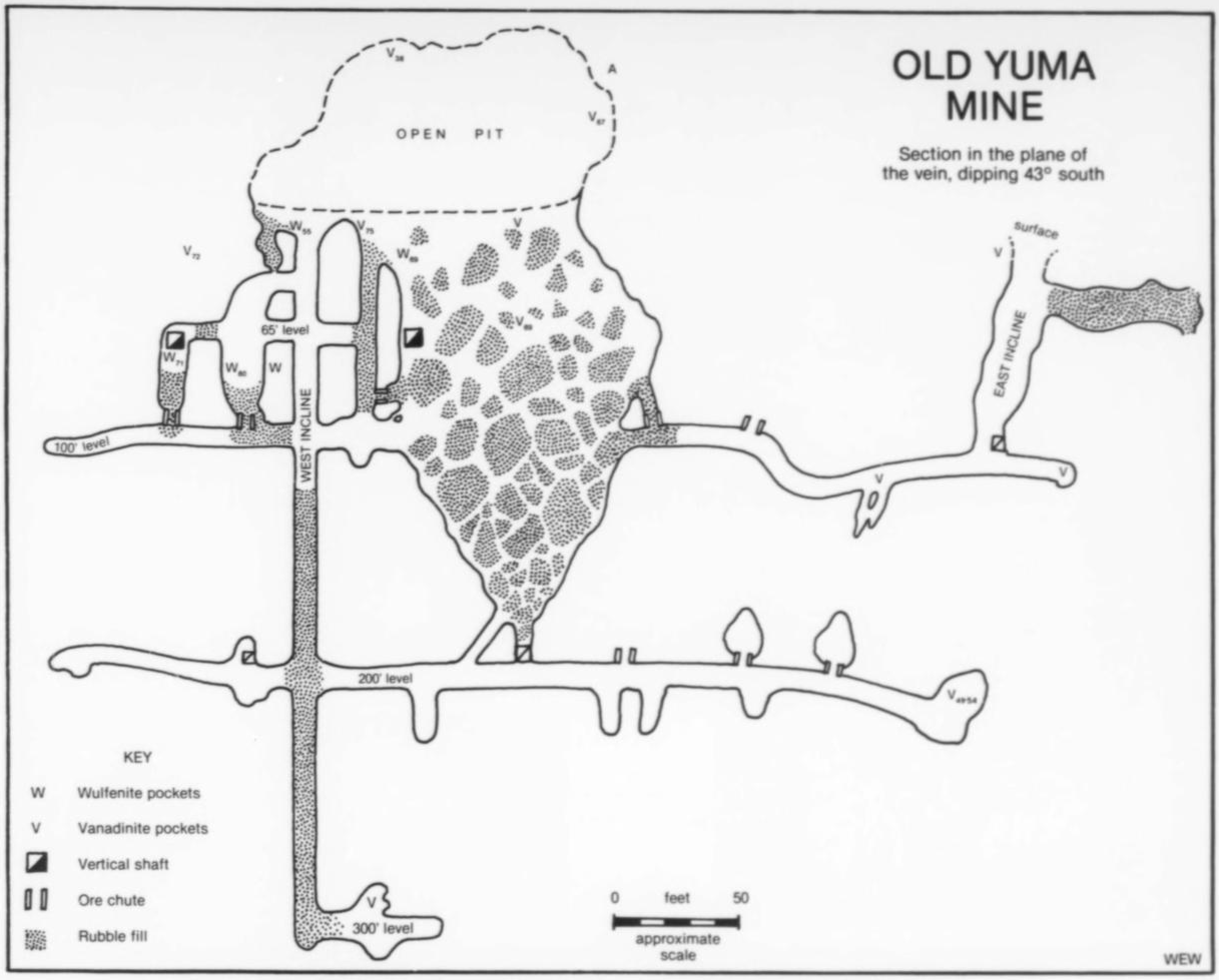

Figure 9. **Underground workings at the Old Yuma mine. The map is drawn in the plane of the vein, dipping 43° south. The glory hole stope is caved in, as shown, and although entrance may still be gained by climbing down through the rubble it is extremely dangerous and should be avoided. The location of some of the major pockets of wulfenite (W) and vanadinite (V) are shown and their discovery dates indicated. The vanadinite pocket of 1949-1954 is that of Richard Bideaux and others; that of 1967 is the author's; that of 1969 is Gene Schlepp's; that of 1972 is Chris Panczner's; that of 1975 is George Godas's; many others have been found by other collectors, especially in the area of the 1967 pocket where the vanadinite occurs with abundant calcite. The wulfenite pocket of 1955 is the author's; that of 1969 is Jackie Schlepp's (and Gene Schlepp's and John Cesar's); that of 1971 is Gene Schlepp's; and that of 1980 is George Godas's. The highest concentration of pockets probably occurred in the stoped areas, though there is still in the mine much potentially productive rock which is cut by numerous cracks and small fissures containing wulfenite. No one knows where the Ed Over pocket of 1929 was located. Some inaccessible areas are drawn from an unpublished 1930 map by C. J. Saerle (Arizona Department of Mineral Resources file, Phoenix).**

when solutions bearing molybdenum, vanadium and chlorine encounter a weathering lead deposit.

Wulfenite and vanadinite occur in fairly distinct zones at the Old Yuma mine. Wulfenite is found mostly in the western portion of the fissure, and vanadinite on the opposite side, though exceptions have been encountered (see Fig. 9). This was noted in an early recommendation regarding milling (unsigned and undated) which said, "The mixing of all the ores from the mine has been inexcusable – the vanadium and molybdenum occur generally separate and can be mined so, and there should be two bins at the top of the mill" (Arizona Department of Mineral Resources file). The two minerals occur together sparsely, mostly in a rather restricted space in which the two zones overlap, running roughly down the center of the old glory hole stope.

According to Horton (1916), the average width of the vein or dike is approximately 8 to 10 feet, but reaches 20 feet in a crosscut on the 65-foot level.

MINE WORKINGS

The mine was first developed as a small open pit with an inclined shaft; then a glory hole stope emptying onto the 200 level was created. Drift levels occur at 65 feet, 100 feet, 200 feet and 300 feet, though most are presently inaccessible. Regrettably, the 200-foot level leading to the small, collector-dug stope where the best vana-

Figure 10. **Large wulfenite crystals to 1 inch on matrix. Richard Bideaux collection; collected by Ed Over in 1929.**

Figure 11. **Large, thick wulfenite crystals 1⅔ by 1⅞ inches. Wayne and Dona Leicht collection (found at W_{71} location on Figure 9 map, by Gene Schlepp).**

Figure 12. **Complexly surfaced wulfenite crystals; the left specimen is 1⅛ inches tall (George Godas collection; found at W_{80} location of Figure 9 map, by George Godas).**

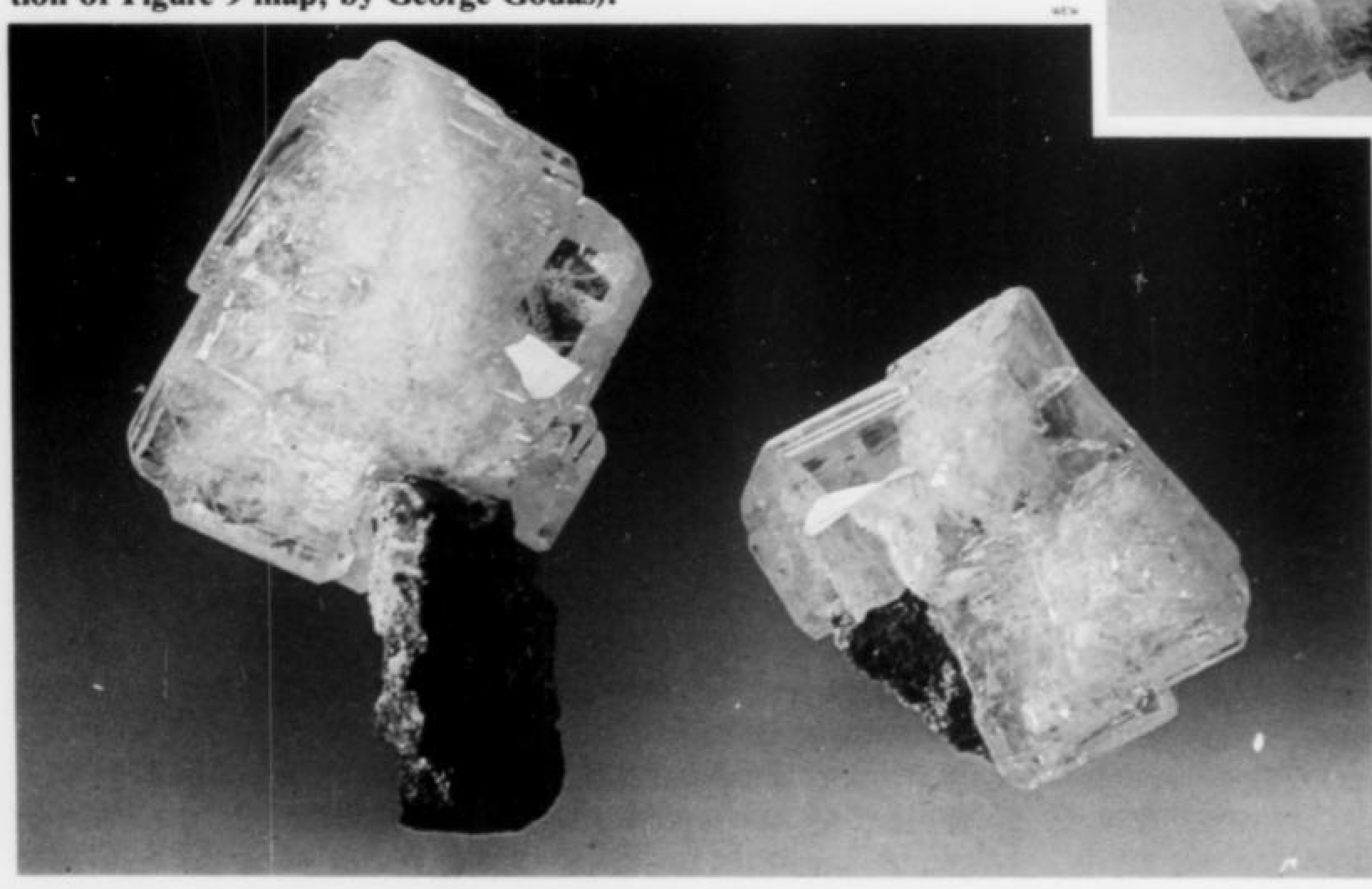

Figure 13. Half-inch, color-zoned wulfenite crystals with white cerussite twins. Gene Schlepp specimen, now in the Arizona-Sonora Desert Museum collection, Tucson.

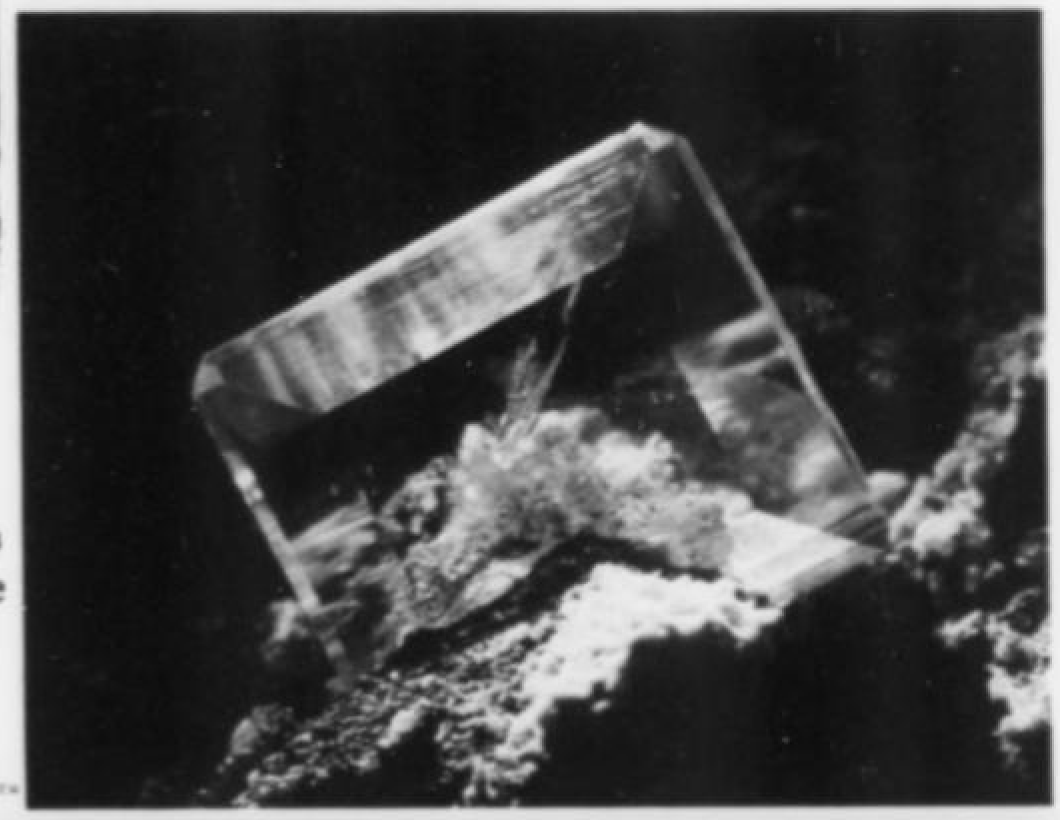

Figure 14. A water-clear wulfenite crystal (⅓ inch) showing refracted spectral colors. George Godas collection.

Figure 15. A group of brilliant yellow wulfenite crystals nearly 2 inches across (George Godas collection; found at W_{80} location on Figure 9 map, by George Godas).

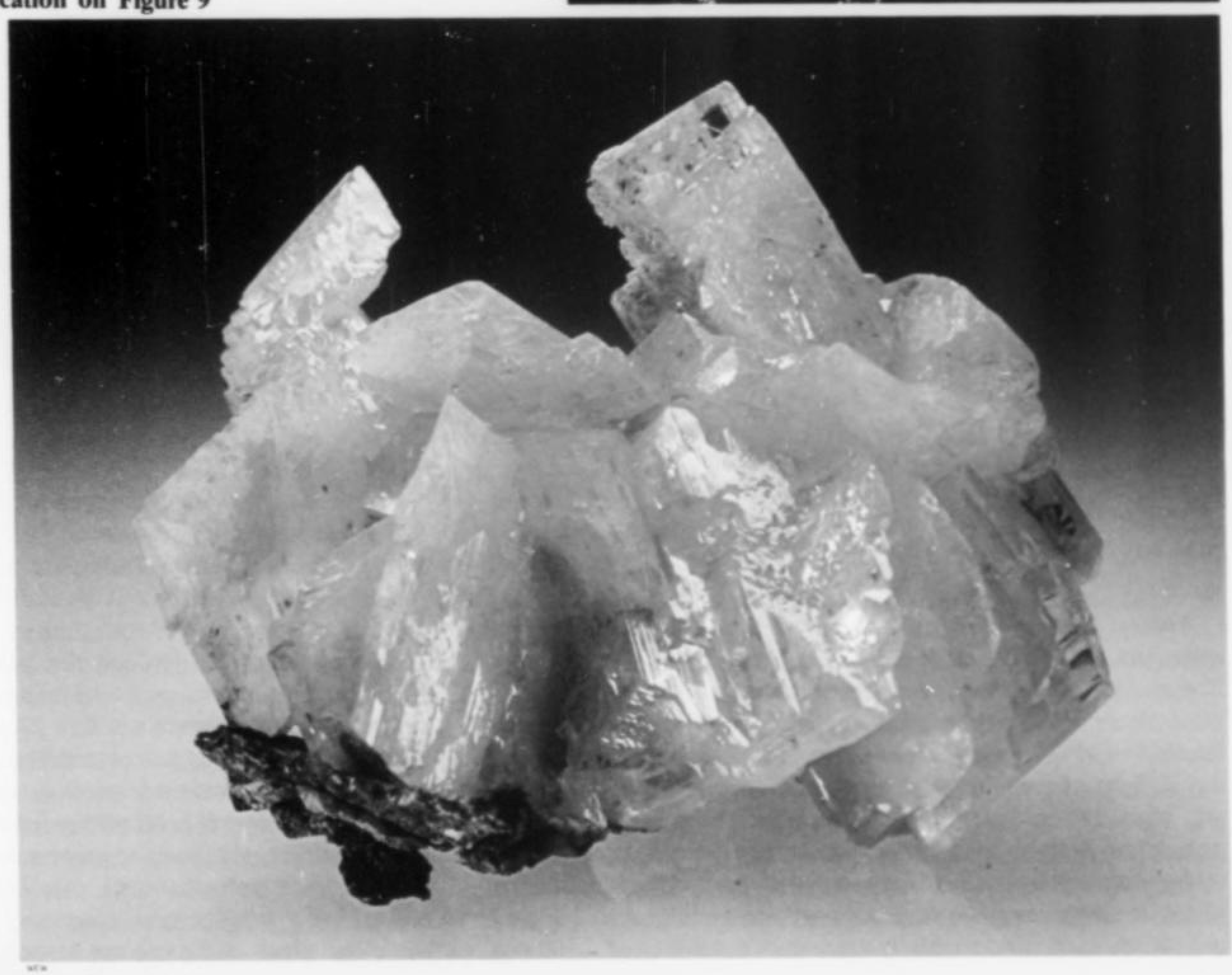

Figure 16. **This photo, taken in 1981, shows the west incline entrance at far right, the smooth surface of the hanging wall clearly visible above it. Left of it is the caved and nearly blocked entrance to the glory hole stope. The photo was taken from the position marked "A" on the map of the workings, Figure 9.**

Figure 17. **This photo, taken in 1957, shows the cribbing built over the entrance to the west incline. The cribbing was built to allow specimen mining in the hanging wall near where the author's 1955 wulfenite pocket was found. Later collapse of the rubble-filled cribbing resulted in the clogging of the incline below the 100-foot level. (Gene Schlepp photo.)**

dinite was found is among those inaccessible. The mine is completely dry.

The mine as a whole is in a sad state of deterioration. The crusher and concentrating plant as well as mine buildings have completely disappeared, except for scattered foundation blocks of concrete. The main incline was fully timbered, with a ladder giving access to all levels as late as 1948, but was later completely burned out. The incline has been filled nearly to the 65-foot level now, blocking entrance to the lower levels. The remaining portion is steep and dusty . . . easy to slide into and extremely difficult to crawl back up out of without assistance or a rope.

Around January of 1969 the ceiling (back) of the glory hole stope gave way in a major cave-in. For at least 20 years previous, a 35-foot-long crack had crossed the ceiling, open at least 18 inches in most places. What a thunderous roar this must have made when it finally let go! (There have been no reports of missing collectors to date.) Slabs of rock 10 by 20 by 40 feet came down in one piece, and many others as large as cars lie piled on each other in precarious positions. I shudder to think of my many collecting days under this juggernaut, and I imagine many other collectors do too. I'll bet the mine varmints were bug-eyed for a while after this one, and there's sure to be a white-haired one or two around.

COLLECTING

In the late 1940's the Old Yuma mine was popular with local collectors because of its nearness to Tucson. One group consisted of Richard Bideaux, Hugh Thompson and Jonathan Browne, all in their middle-teens and too young to drive a car; they would visit the mine as often as one of their fathers could be imposed upon to drive them out there. On one visit in 1949, just at the end of the day, Hugh Thompson pounded a rock at the end of the 200-level drift and thought it made a hollow sound. After more work, a rock measuring about 1 by 1 foot came out, exposing a fine pocket of vanadinite. The pocket was relatively thin where they intersected it, and extended an unknown distance left and right. Short on time and equipment, and being too inexperienced to fully appreciate the magnitude of their discovery, they just picked out loose crystals and crystal-covered breccia fragments. These they took, along with the block which had come out to open the pocket (it was coated

Shortly following that initial discovery of the pocket, Dan Caudle and Clayton Gibson of Tucson decided they'd visit the mine, though they had heard nothing of the Bideaux group's discovery. Once at the mine, they explored various areas until coming to the end of the 200-level drift, where they found the 1-foot opening to the pocket lined with vanadinite, just as Bideaux had left it. After widening the opening they were able to look up inside, and saw that it went for some distance, completely coated with crystals. Caudle still remembers what a beautiful sight that was, so many ruby-red crystals sparkling vividly in the light of their carbide lamps. In fact, it was so beautiful that they went home and brought their wives back to see the sight before they worked on it further.

The pocket proved to contain a great deal of vanadinite. Loose crystals ¼ to ½ inch were everywhere, and rained down by the dozens from up above every time a hammer blow was struck anywhere near the pocket. Caudle scooped up a bottle-full of loose crystals, weighing a pound or two, which he still has. Other collectors came upon the pocket, even while Caudle and Gibson were there; some brought dynamite.

The pocket zone was mined by many collectors and the little stope grew steadily. Around 1953, Bideaux again visited the mine, in the company of a German exchange student, and together they removed more good specimens, one of which the exchange student took back to Germany and donated to the Berlin Museum, and another of which Bideaux still has. By that time the exposed area of the pocket zone was huge and still productive.

While in the company of another beginning collector, I went down to that area myself and found some fine, fist-sized specimens where Bideaux had just been working. A few weeks later Dick and I visited the mine together, and ran into Dan Caudle and Clayton Gibson working the same area again. A few days later, Albert Haag came on the scene and began working the pocket zone too. So we all started alternating, three shifts a day, trying to stay out of each

Figure 18. **The entrance to the east incline (1981 photo).**

Figure 19. **Looking downward into the east incline one can still see wooden stulls or timbers in place (1981 photo).**

with crystals on one side), and left, leaving the pocket open. (The cap-piece to the pocket was eventually donated to the University of Arizona.)

It was several weeks before Bideaux and his young friends could compel one of their fathers to drive them out to the mine again. A scene of chaos greeted their return. The floor at the end of the drift was covered with debris and newspapers, and blasting wires were strung from the ceiling. The pocket zone (actually a long and contorted water-course) could now be seen extending up into the ceiling, with crystals still visible.

other's way and still get specimens. Al Haag took out the best and most beautiful specimens, some of which Dick and his father bought from him and are still in Dick's collection.

Just before this escapade I got my first introduction into the proper use of dynamite the hard way. Dick and I had spent all day *hand*-drilling holes around a pocket zone. I was up on the tip of a ladder, perspiring like mad because of poor ventilation and the heat from our carbide lamps, while I removed dynamite from its wrapping paper, rolled it in my hands and packed it into our holes. Once in a while I had to wipe the perspiration from my face; soon I got a

Figure 20. **A red-orange micromount-size crystal (about ⅛ inch) of wulfenite. George Godas collection.**

pounding headache from the nitroglycerine absorbed directly through my skin, but kept on working. We finished filling the holes, retired to a safe distance, and set them off. Being as fond as I am of a good boulder, I couldn't wait for the smoke and dust to clear before taking a look, so I went back in immediately. Unable to hold my breath long enough to get a good look, I made the near-fatal mistake of trying to breathe back there. When I returned to where Dick was waiting my eye-balls were turning over backwards from having breathed the fumes. Dick wasn't sure exactly what was wrong with me, but he dragged me up the 200-foot incline to the surface, loaded me in his car, and took off for Tucson. I'm telling you, I saw all kinds of things on that highway that weren't there! Before we reached Tucson my head started to clear, but if good old Dick hadn't hauled me out I would probably still be down there pestering collectors. (I'm sure glad I was skinnier in those days than I am now.)

Later on in 1955, Al Haag and I worked again in the ceiling of the little vanadinite stope (it was becoming a stope solely due to the excavations of collectors). One Sunday afternoon I got tired of working down below and came up for some fresh air. I sat down at the top of the west incline and happened to notice a yellow-orange spot on the front of the overhang. I got my 22-caliber pistol out and started shooting at it.[3] Finally, after expending half a box of shells and getting nowhere, I threw a rock at the spot. The rock around the spot broke away and fell, and wulfenite crystals rained down all over the place! I ran down to where they were falling and tried to catch the crystals in my outstretched T-shirt but they just bounced off onto the ground. I rounded up everything that had fallen out and yelled for Al, but he couldn't hear me, so I went down after him and showed him what I had found. Because the pocket was so difficult to reach, we finally ended up with Al hanging down over the incline from the ledge above while I held onto his feet. He gathered the remaining crystals from the hole, which was about the size of a 5-gallon bucket. The largest crystal recovered is about 2½ by 1½ inches, and a half inch thick (it went to John Jago's collection in San Francisco). We took many other fine singles and groups from that pocket.

The next real find, for me at least, came around 1967 when Kermit Lee and I opened a wash-tub-size pocket of vanadinite on a ledge at the back and east side of the old glory hole. We collected about 35 flats of cavernous, skeletal vanadinite crystals on white calcite there, including one single crystal just over an inch (now in the Jim Bleess collection, Tucson).

In 1969, only a day or two following the cave-in of the glory-hole stope, Jackie Schlepp found a large pocket of wulfenite. The pocket could be seen several feet down in a crack in a very large block of fallen rock. Her husband Gene (*Western Minerals,* Tucson) and John Cesar spent three days collecting the pocket carefully from its awkward location. Many large and fine crystals came out, somewhat thin and a brilliant yellow; the largest is a semi-parallel growth of crystals measuring about 6 inches . . . probably the best group ever collected at the mine, and among the finest wulfenite specimens in the world (Fig. 21).

Figure 21. **Six-inch crystal of wulfenite from the pocket found in 1979 by Jackie Schlepp. (Bob Jones photo.)**

In 1971, Gene Schlepp made a big find in the westernmost stope, on the 65-foot level. Following a narrow seam into the hanging wall, he and Jerry Meyer encountered three successive widenings of the vein which proved to contain over a hundred excellent crystals of thick yellow wulfenite. Crystals rained out unexpectedly when he broke into the first pocket area, bouncing off his arms and body and landing, undamaged for the most part, in soft sand at his feet.

There have been many sporadic finds of wulfenite and vanadinite made by numerous collectors over the years. Julius Geisler, George Godas and Wayne Thompson have all made discoveries there. The late Ed McDole spent several days at the mine but found absolutely nothing (even the greats strike out from time to time). Before that, Edwin Over (most famous for collecting the best red wulfenite ever found at the Red Cloud mine) once told me that he paid a one-day visit to the Old Yuma mine in 1929 and found an excellent pocket of wulfenite. Though earlier collectors are not known by name, Jenkins and Wilson (1920) reported that "Quantities of very beautiful and interesting crystallized mineral specimens have been obtained from this property."

[3] *Ed. note: ballistic prospecting is not especially common, even in Arizona.*

Vanadinite, Old Yuma Mine, Arizona. The small closely grouped red crystals of this mineral make really handsome specimens that every collector will want. Small size cabinet specimens about 2 x 2", $2.50, $2.00 and $1.50.

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THE FRANK A. WARD FOUNDATION OF NATURAL SCIENCE OF THE UNIVERSITY OF ROCHESTER

Advertisement in *Rocks & Minerals*, December 1940.

VANADINITE

Bright orange-red hollow prismatic vanadinite crystals on white calcite make a colorful bright spot for your collection. Fine specimens of vanadinite have never been common and these are no exception. From the Old Yuma Mine, Yuma County, Arizona. Specimens about 1" **50c**, 1½" **75c** and **$1.00**. A few larger at **$2.00** and **$2.50** each.
From the same mine, we also offer groups of sparkling red hexagonal crystals densely coating rock 1" **25c**, 1½" **50c** and **75c**, 2" **$1.00** and **$1.50**, larger specimens at **$2.00** each.

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We first introduced sparkling emerald-green crystal groups of dioptase from the Mammoth Mine in Tiger, Arizona, more than two years ago. They proved very popular and we are pleased to offer a "select lot" from the original "find" at 1" **35c** and **50c**, 1½" **$1.00** and **$1.50**, 2" **$2.00** and **$2.50**, 2½" **$3.00** and **$3.50**. Larger specimens in stock at **$5.00, $7.50** and **$10.00** each.

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Advertisement in *Rocks & Minerals*, October 1942. (Erroneously indicated as in Yuma County.)

MINERALS

Wulfenite

Wulfenite was one of the main ore minerals at the Old Yuma mine, and production figures suggest that tons were processed. Horton (1916) states that wulfenite was greatly in excess of vanadinite and cerussite at the mine, though specific figures for each are unavailable. In a mine owner's report dated 1940, Grady Wilson estimated the dump reserves at 17,000 tons of ore averaging 1 percent MoO_3 and 75,000 tons more averaging 0.7 percent MoO_3. If Wilson's estimates are to be believed, that ore would contain 695 tons of MoO_3 in the form of *3½ million pounds* of wulfenite. This figure does not include wulfenite which had already been milled as ore, approximately 130,000 pounds judging from production estimates for molybdenum (Keith, 1974).

The crystals are typically lustrous, thin to thick tabular (usually thick), in simple combinations of first order pyramid and base, but rarely also with other forms. They range from opaque to perfectly transparent. Crystals perhaps as large as 6 inches have been found, although 2 inches is considered outstanding and most crystals measure an inch or less. The color ranges from bright yellow to pumpkin-orange to (very rarely) bright red, and may also range from brown to greenish black and black. Some individual crystals are multicolored: black centers with orange edges, tabularly zoned crystals black on one side and orange on the other, orange in the center and black on the edges, and orange with red, square phantoms have all been seen. Black wulfenite seems much rarer than the other colors, judging from conversations with collectors, and probably came from the earliest workings.

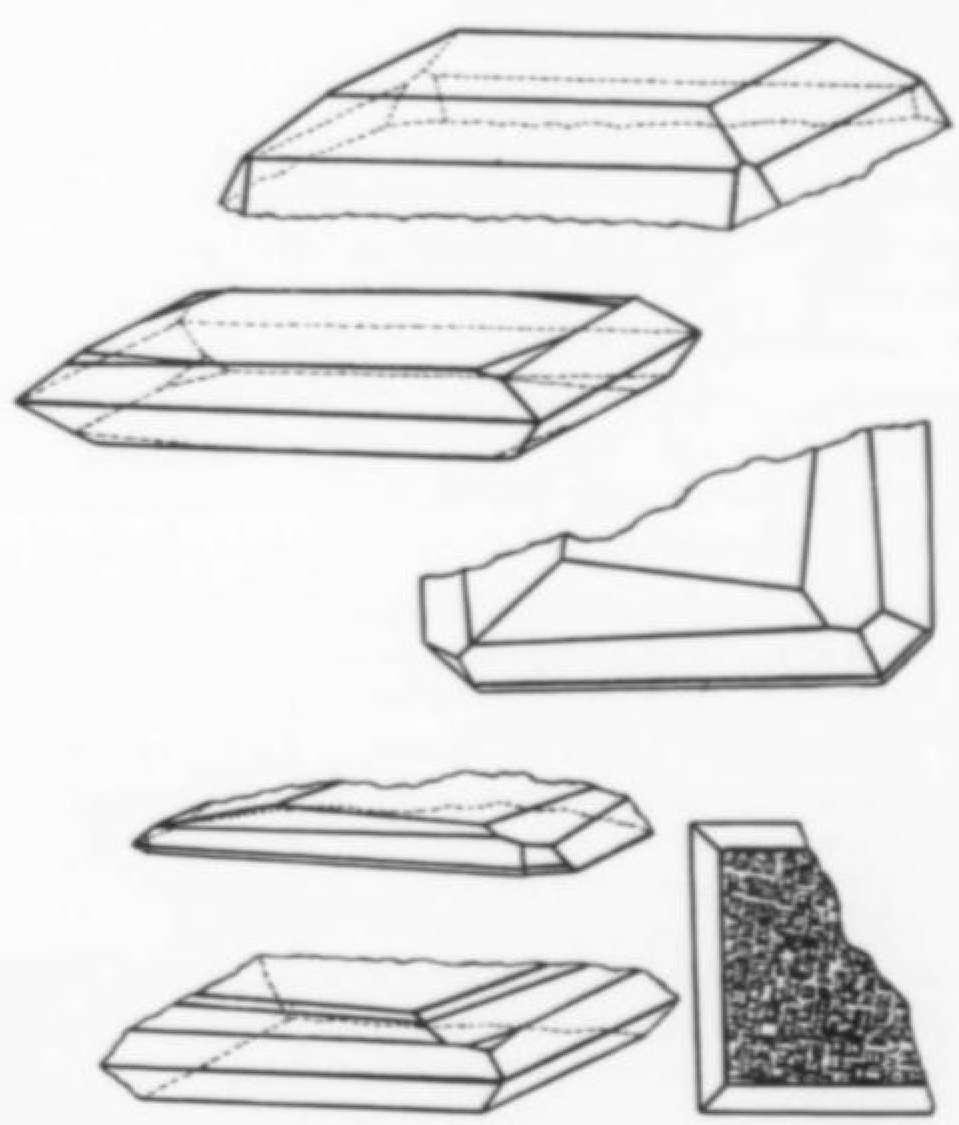

***Figure 22.* Wulfenite from the Old Yuma mine (Guild, 1911).**

The black color is noteworthy in that it is apparently due to finely divided gold, which is visible under magnification in some crystals. An analysis of auriferous black wulfenite by Horton (1916) indicated that it contains 140 ounces of gold per ton, whereas an analysis of the yellow crystals (both samples from the Old Yuma mine) yielded not even a trace of gold. A ton of wulfenite, incidentally, would occupy a cube about 20 inches on an edge . . . not really as large as one might guess. At today's prices this would yield about $60,000 in gold!

Associations include cerussite, vanadinite and, in some cases, calcite, though these are typically absent. Wulfenite is found filling large pods rather than attached as a lining to them, and also in veins and fractures. Loose crystals and clusters are far more common than matrix pieces.

Vanadinite

The Old Yuma mine has yielded what are probably North America's finest specimens of vanadinite. The crystals range in color from brilliant red to orange, straw-yellow and brownish red. Simple crystals having only a hexagonal prism and pinacoids are most common; the hexagonal pyramid is present on some crystals too. These smooth-faced crystals have been found to ½ inch, some of them containing a range of reds and oranges, and scattered gemmy areas. Rarely they are color-zoned parallel to the pinacoid. Compound and cavernous or skeletal crystals to 1½ inches long and across have also been found. In one area of the mine, brilliant, transparent, highly modified crystals to ¼ inch were found in association with hyalite opal. At their best, these crystals are blood-red and may theoretically have as many as 74 faces resulting in an almost spherical habit. Crystals commonly coat walls of pockets and fissures, and loose breccia fragments; only rarely is vanadinite found as clusters without matrix.

Near the surface vanadinite occurs imbedded, for the most part, in caliche grading into small, crude, white calcite crystals. Other associations noted include wulfenite and cerussite, the rarer plattnerite, black mottramite, brown descloizite in spear-shaped crystals to ¼ inch, and mimetite as orange crystals in parallel overgrowth and as dusty yellow coatings (Thomssen, 1957; Bideaux, 1978). Vanadinite pseudomorphs after wulfenite have been reported (Frondel, 1935); this indicates that, though the ranges of chemical stability for each mineral may overlap, they are not identical.

Other minerals

Willemite occurs as tiny, opaque, white to pale green hexagonal prisms. One specimen having small, deep olive-green **fornacite** crystals was found on the dump. Fornacite has also been found in the west side wall of the west incline, with quartz crystals in hematite (R. W. Thomssen collection). Remnants of argentiferous **galena** altering to **anglesite** and **cerussite** can be found sparingly throughout the mine. Rare crystals of cerussite have been found as loose, pseudohexagonal, cyclical twins and as reticulated groups, in some cases associated with wulfenite or vanadinite. Traces of **chrysocolla** and **malachite** occur rarely. **Calcite,** in small crude rhombohedrons and as formless caliche, and also **quartz** in small crystals have been found. Guild (1911) reported finding **mottramite** ("cuprodescloizite") in thin crusts of tiny crystals. And Bideaux (personal communication, 1981) found a very large **descloizite** crystal which is now in the University of Arizona collection.

CONCLUSIONS

The Old Yuma mine still has potential as a specimen producer. The vanadinite workings on the 200-foot level, the collecting history of which was cut short years ago by the incline becoming closed, could be reopened. And wulfenite might still be extracted from several areas on the west side of the workings, and on the surface. Prospects nearby have the same mineralogy and might also eventually yield discoveries.

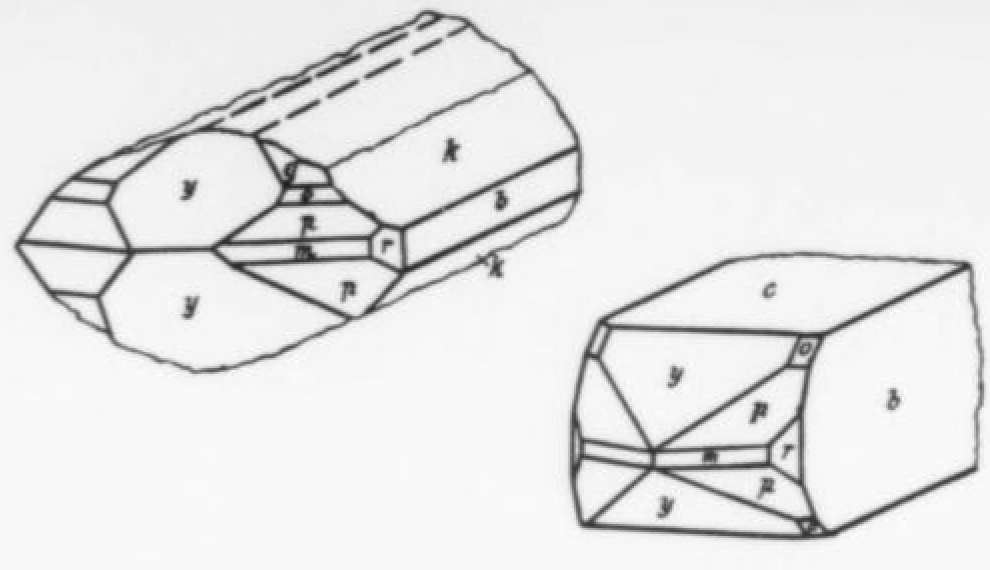

Figure 23. **Cerussite from the Old Yuma mine (Guild, 1911).**

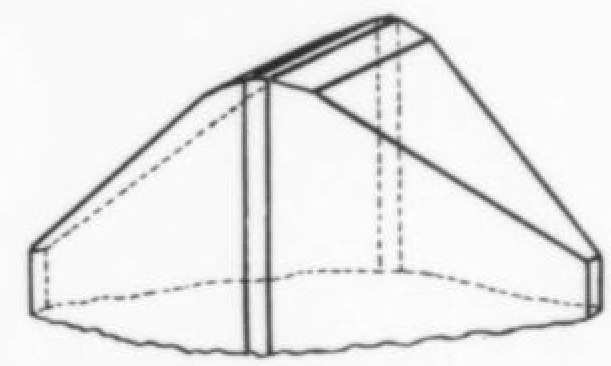

Figure 24. **Mottramite ("cuprodescloizite") from the Old Yuma mine (Guild, 1911).**

ACKNOWLEDGMENTS

My thanks to Richard A. Bideaux for providing an English translation of his article (1978) in *Lapis,* and to the Arizona Department of Mineral Resources (Phoenix) for making their files on the mine available. Thanks also to the various people who loaned their specimens for photography, and who provided historical information: Gene Schlepp, Dan Caudle, George Godas, Richard Bideaux, Wayne Thompson, Chris Panczner, William Panczner and Robert Middleton of the Arizona-Sonora Desert Museum.

Finally, my thanks to editor Wendell Wilson who provided a great deal of assistance in the preparation of this paper. His help in translating articles, providing photography, preparing and researching the underground map and the collecting history, and preparing the final draft is much appreciated.

EDITOR'S NOTE

The author passed away in 1982. Shortly before doing so, he sold the Comet claim to R. A. Bideaux of Southwest Mineral Associates, Tucson, who currently operates the mine. A new headframe has been erected, and the main incline is being cleared in order to obtain access to the 200-level. The site is continuously occupied, and collecting without written permission is prohibited.

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the minerals of Malpais Hill pinal county, arizona

by **Richard W. Thomssen**
P.O. Box 1656
Carson City, Nevada 89702

INTRODUCTION

In 1957, Dick Jones, of Casa Grande, Arizona, discovered a thin vein of manganese oxide minerals cutting brecciated andesite. The vein was exposed in a railroad cut of the newly constructed San Manuel railway about 2 miles south of the Gila River–San Pedro River confluence (Fig. 1). Jones (1957) reported finding manganite, heulandite and stilbite within the vein. Subsequently, he took Richard Bideaux and the author to the area and additional material was collected from various railroad cuts in the vicinity of Malpais Hill, a 350-foot hill on the west side of the San Pedro River. Species found in this material included black manganese oxides as well as psilomelane, heulandite, phillipsite, calcite and an unidentified prismatic mineral which was believed to be aragonite. Later investigation disclosed the presence of chabazite and a mineral referred to as celadonite. No stilbite was found.

In 1959, William C. Oke of the California Institute of Technology sent some newly acquired zeolites to the author. This material had been collected by Oke in the area of Rock Island Dam, near Wenatchee, Washington. A new zeolite, paulingite, was found by Oke in this material and it was later described by Kamb and Oke (1960). Associated with the paulingite and other zeolites were small, prismatic, hexagonal crystals identified as erionite. These crystals immediately brought to mind the "aragonite" from Malpais Hill. Optical comparison by Sydney A. Williams, then a graduate student at the University of Arizona, suggested that the two minerals are identical.

Many localities for erionite were reported in the literature prior to 1960; all but two, Malpais Hill and Rock Island Dam, are in altered Cenozoic tuffaceous sediments. Of the two which occur in volcanic rocks, the Malpais Hill occurrence is in situ, while at Rock Island Dam zeolite-bearing boulders were excavated from the Columbia River channel. Subsequently, a number of additional occurrences of erionite, and the closely related species offretite, have been reported in vesicular volcanic rocks throughout the western U.S. (Wise and Tschernich, 1976).

OCCURRENCE

The volcanic rocks exposed in the railway cuts in Malpais Hill have been correlated with the lower part of the Galiuro volcanics several miles to the east in the Galiuro Mountains by Krieger (1966, personal communication). A K-Ar radiometric date on these rocks in the Saddle Mountain area gave a mid-Tertiary age of 23.5 m.y.

Simons (1964) described the Galiuro volcanics from the Klondyke quadrangle, which covers a portion of the Galiuro Mountains to the southeast of Malpais Hill. He noted that the lower andesite unit is predominately made up of a monotonous succession of red,

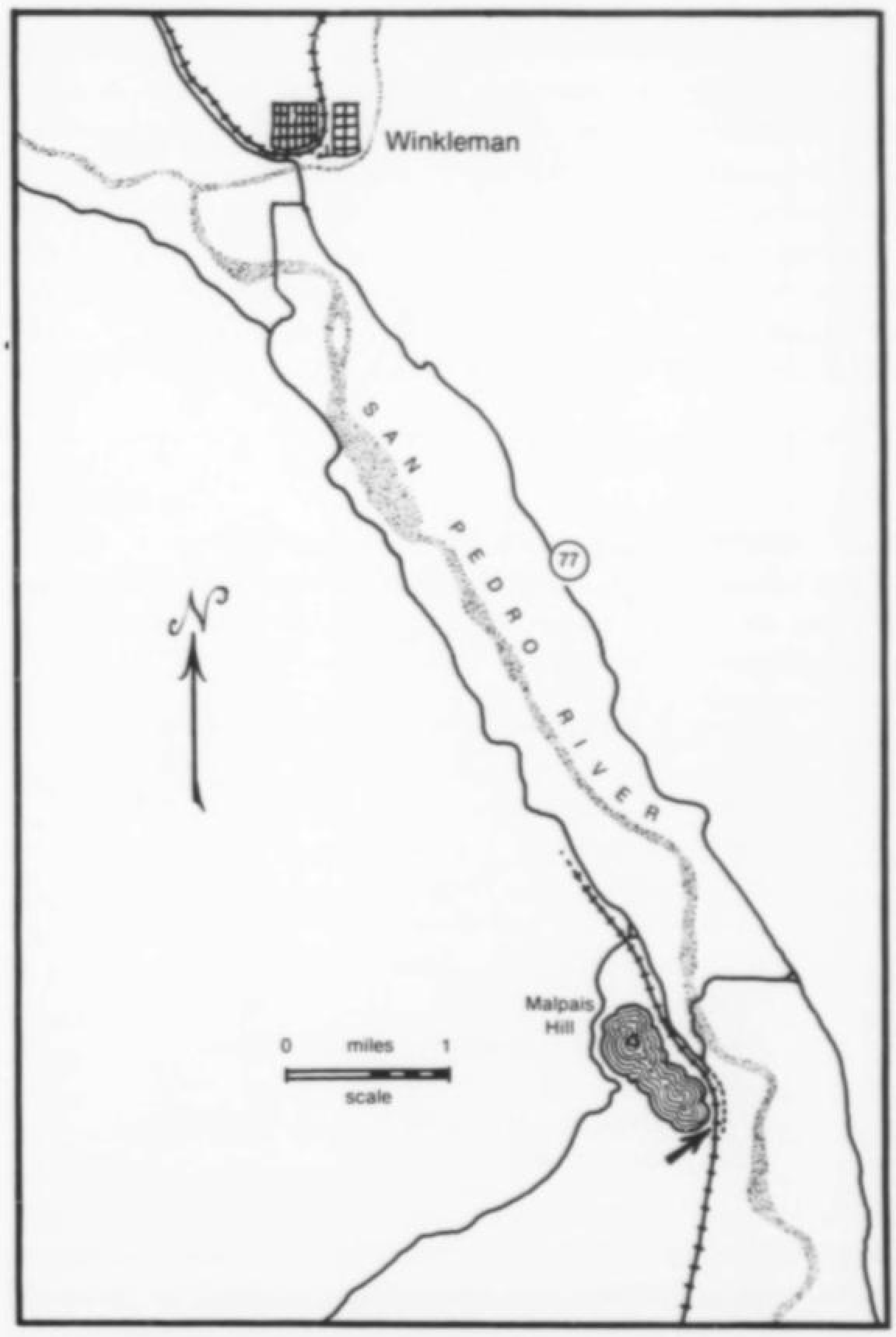
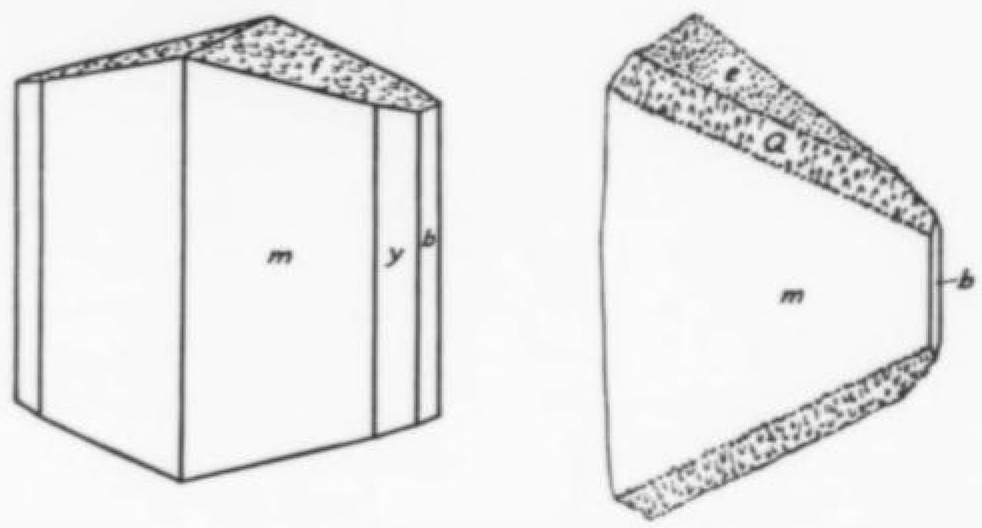


Figure 1. **Location Map – Malpais Hill, Pinal County, Arizona. Scale: 1:62,500.**

Figure 2. **West side of railroad cut on southeast end of Malpais Hill. Volcanic breccia below, basaltic andesite flow above.**

Figure 3. **Ramsdellite pseudomorphs after groutite, from Fleischer *et al.* (1962). (Left) Ramsdellite after groutite, Gavilan mine, Baja California, Mexico. *b*{010}, *m*{110}, *y*{120}, *f*{011}. (Right) Ramsdellite after groutite, Lake Valley, New Mexico. *b*{010}, *m*{110}, *e*{021}, *q*{241}. Drawings by Evans.**



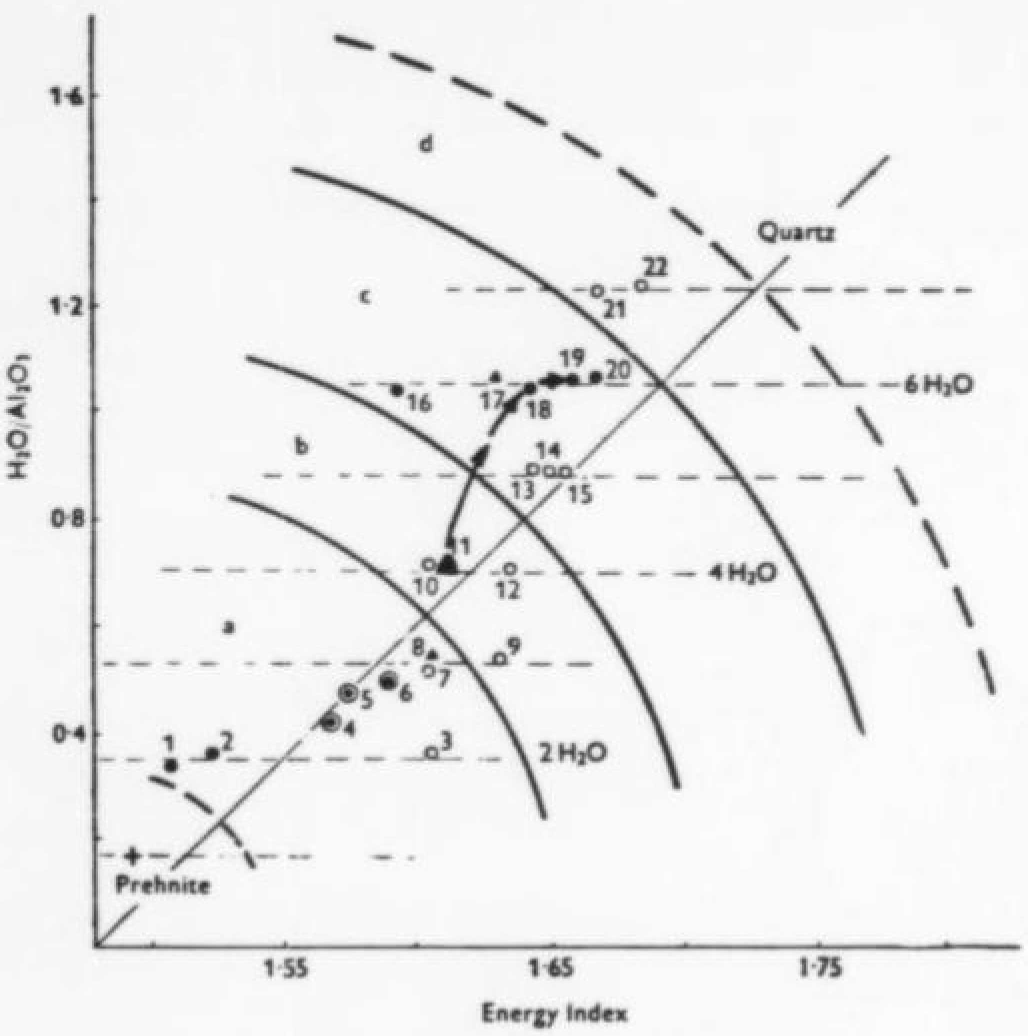


Figure 4. **Relationship between Gruner's energy index and H_2O/Al_2O_3 ratio of the zeolite minerals. Arrow shows trend of Malpais Hill zeolites formation. 1 – Natrolite, 2 – Analcite, 3 – Wairakite, 4 – Thomsonite, 5 – Mesolite, 6 – Faroelite, 7 – Scolecite, 8 – Edingtonite, 9 – Yugawaralite, 10 – Gismondine, 11 – Phillipsite, 12 – Laumontite, 13 – Levyne, 14 – Faujasite, 15 – Epistilbite, 16 – Gmelinite, 17 – Harmotome, 18 – Chabazite, 19 – Erionite, 20 – Heulandite, 21 – Stilbite, 22 – Mordenite; from Kostov (1965).**

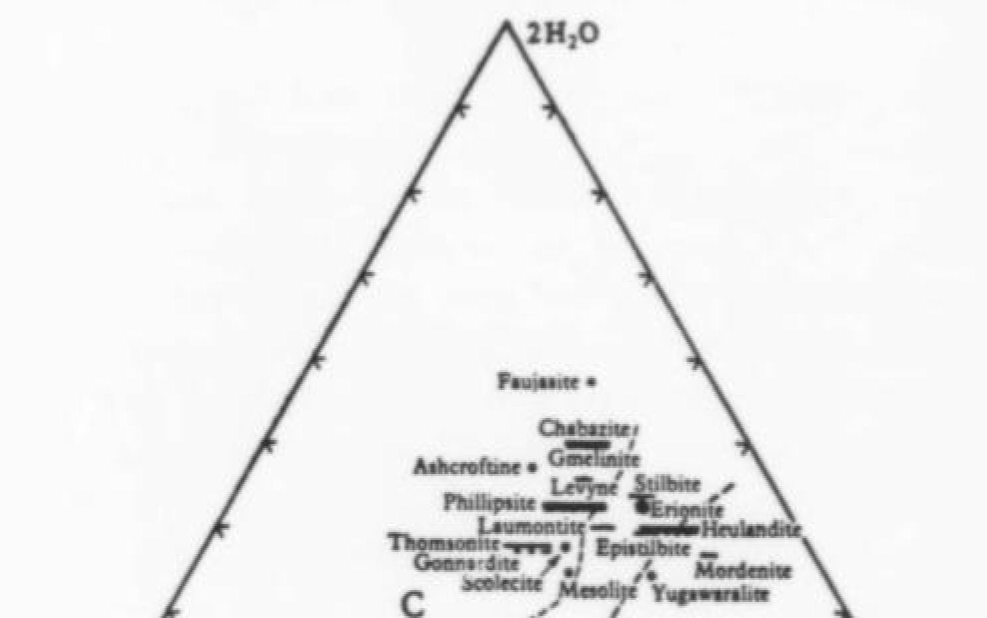


Figure 5. **Compositions, in molecular proportions, of the calcium zeolites and other Ca-Al silicates. Malpais Hill zeolites underlined. For the zeolites and anorthite $(Ca,Na_2)O$ is numerically equal to Al_2O_3. A = field of phases favored by supersaturation with respect to silica. B = field of phases commonly coexisting with silica minerals. C = field of phases favored by a silica-poor environment (from Coombs *et al.*, 1959).**

purple or gray andesite or basaltic andesite flows, flow breccias and agglomerates. The lavas are dense, fine-grained rocks, generally containing small phenocrysts of olivine, and many are vesicular or amygdaloidal. The flows commonly have a red or orange flow-breccia at the base and a scoriaceous top.

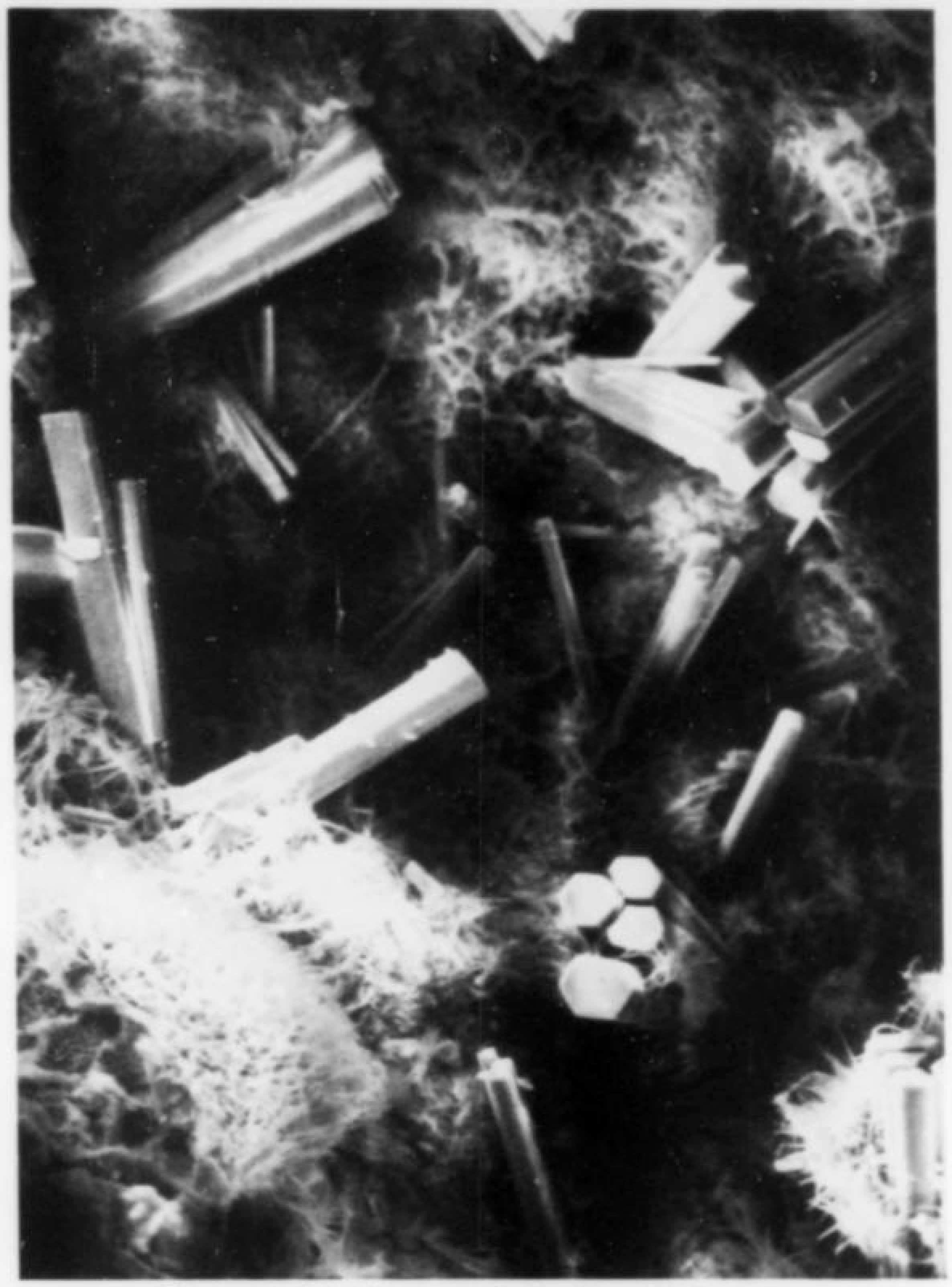


Figure 6. **Erionite on celadonite. SEM photo, 200X; by J. D. Stephens.**

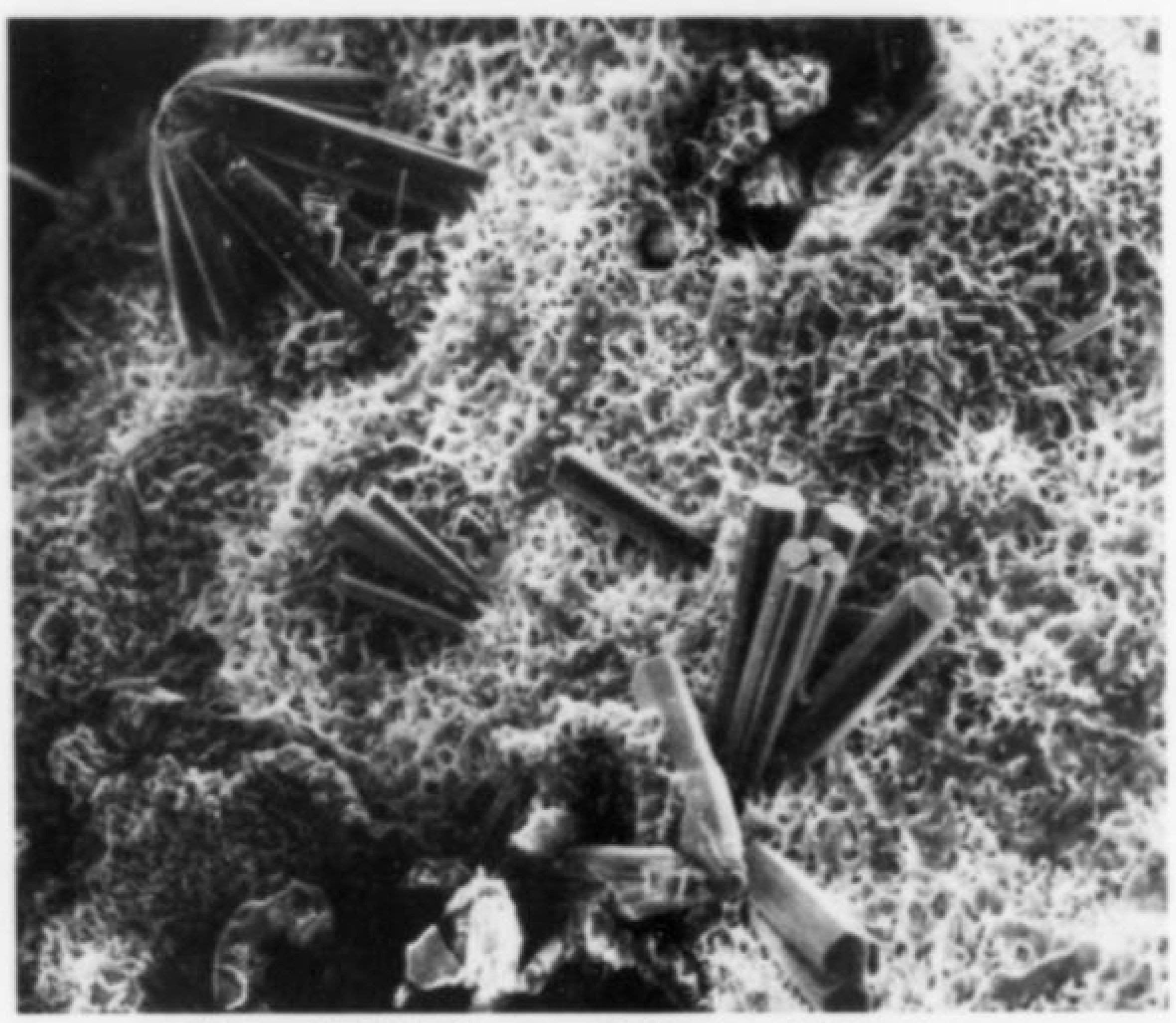


Figure 7. **Erionite on celadonite. SEM photo, 100X; by J. D. Stephens.**

The zeolites at Malpais Hill are most abundant in the southernmost railway cut on the southeast slope, in the SE¼ of Section 17, T6S, R16E, and it was in this area that collecting was concentrated (note arrow, Fig. 1). Zeolites were found to be most easily collected in large, altered and iron-stained vesicular blocks within a breccia unit on the west side of the railway cut. Unfortunately, the walls of the cut are nearly vertical, and much of the exposure is inaccessible. Collecting along the base of the west side of the cut (Fig. 2) yielded abundant material containing zeolites. The east wall of the cut was

Figure 8. **Celadonite crystal groups on heulandite. SEM photo, 100X; by J. D. Stephens.**

most productive of the irregular, discontinuous, northwest-trending veins carrying manganese minerals with calcite and heulandite.

The structural control on the distribution of the various minerals in the west wall of the cut appears to be, in large part, the interstices between, and vesicles within, blocks in the volcanic breccia unit. However, the flow unit immediately beneath the breccia contains thin (less than 1 inch) veins of manganese minerals within fractures generally trending N25°–35°W. Weathering of the volcanic breccia unit on the east wall of the cut and nearest the original ground surface has been extensive and details of the structure are obliterated. However, much the same control by interstices between blocks was noted, yielding irregular, discontinuous veins of manganese minerals (although thicker veins, up to 3 inches, were found in this wall).

MINERALS

Both X-ray diffraction and infrared spectrophotometry were employed to verify the sight identification of the zeolites and to identify the manganese species present in the veins. X-ray patterns for three of the zeolites (phillipsite, chabazite and heulandite) gave excellent matches for JCPDS standards. Some difficulty was encountered in grinding the erionite, so the patterns obtained are spotty and the lines are relatively broad and indistinct. The results compare favorably with X-ray diffractometer data for erionite from Jersey Valley, Nevada, given by Deffeyes (1959); however, the spacings for Malpais Hill erionite are slightly larger than those for Jersey Valley erionite.

A pale green mineral resembling celadonite occurs early in the paragenetic sequence providing a mat on which erionite crystal clusters have grown, as well as late "fuzz balls" on heulandite. Infrared spectra of these materials yield patterns like celadonite, but with sufficient differences that some compositional variation from that of celadonite appears likely.

An X-ray examination of the manganese minerals was concentrated on crystals which gave the appearance of pseudomorphs; i.e., they are cracked, with mottled faces. A pattern was obtained for these crystals which agrees well with the JCPDS standard for ramsdellite, MnO_2, an orthorhombic dimorph of pyrolusite. Fleischer *et al.* (1962) discussed the occurrence of ramsdellite

Figure 9. **Phillipsite crystal clusters on celadonite. Photomicrograph by G. Stanley Alexander; 19X.**

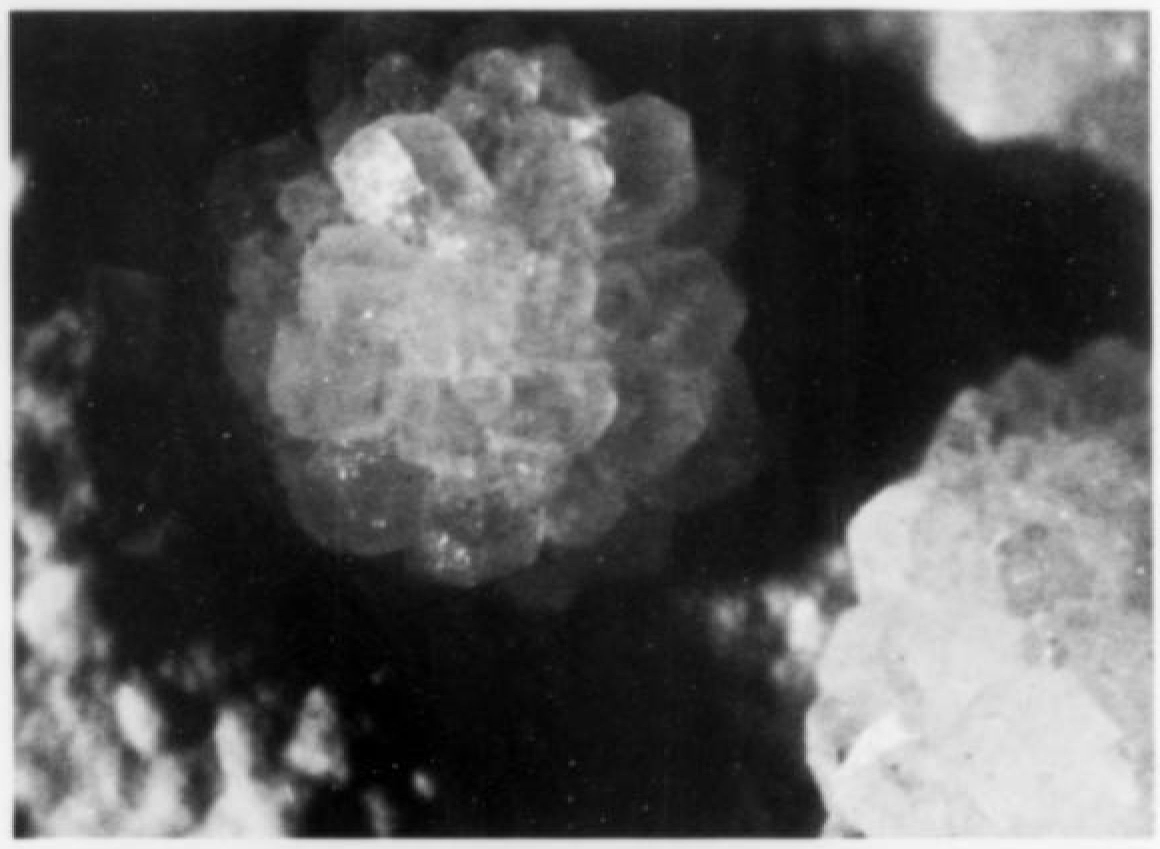


Figure 10. **Closeup of phillipsite crystal cluster. Photomicrograph by G. Stanley Alexander; 62X.**

pseudomorphs after groutite, MnO(OH), from the Gavilan mine, Baja California, Mexico, and Lake Valley, New Mexico. Figure 3 portrays the crystals described by Fleischer *et al.* (1962). The Lake Valley pseudomorphs are very similar to the Malpais Hill crystals.

Additional manganese minerals have been found on Malpais Hill specimens. The species include black, botryoidal crusts assumed to be psilomelane, and a black, fibrous, euhedral mineral resembling cryptomelane, identified by S. A. Williams from Blake Place in the Galiuro Mountains.

PARAGENETIC SEQUENCE

A review of the paragenesis of the zeolites in various hydrothermal deposits in the Balkans has been made by Kostov (1965). Figure 4 is from Kostov's paper and presents the relationship between H_2O/Al_2O_3 content and Gruner's energy index (an inverse function of the energy of formation). The four zeolites found at Malpais Hill plot along a slightly curved line, trending from phillipsite at low H_2O/Al_2O_3 ratio and low energy index through chabazite, erionite and heulandite at progressively higher H_2O/Al_2O_3 ratio and energy index.

Coombs *et al.* (1959) plotted the compositions of the calcium

Figure 11. **Erionite and heulandite on celadonite. Photomicrograph by G. Stanley Alexander; 110X.**

Figure 12. **Erionite crystal spray on celadonite. Photomicrograph by G. Stanley Alexander; 110X.**

zeolites (Fig. 5). Three fields – supersaturated, saturated, and undersaturated with respect to silica – are superimposed on the composition fields. The Malpais Hill species fit the fields in the following manner: phillipsite and chabazite in the field of phases favored by a silica-poor environment, while erionite lies in the field of phases commonly coexisting with silica minerals (saturated), and heulandite lies in the field of phases favored by an excess of silica.

Observations on the paragenetic sequence of the Malpais Hill zeolites are not conclusive in all respects. However, erionite is definitely later than all phillipsite and frequently has grown at the expense of phillipsite. Chabazite is rare and its sequential relationship to the other zeolites is undetermined. However, it appears to be contemporaneous with celadonite which coats the walls of vesicles, as does phillipsite. Erionite and heulandite occur on celadonite, while the latter species also coats fractures. The indicated sequence from these observations is phillipsite and chabazite early, with erionite and heulandite later, in that order.

The paragenetic sequence, phillipsite-chabazite-erionite-heulandite appears to demonstrate, on the basis of the data presented by Kostov (1965) and Coombs *et al.* (1959), that with time the solutions responsible for the formation of the zeolites became enriched in H_2O and SiO_2 with respect to Na_2O, K_2O, CaO and Al_2O_3. Progressive alteration by hot water of the basaltic andesites in which the zeolites are now found may represent the source of the zeolite components.

ACKNOWLEDGMENTS

James D. Stephens, Kennecott Minerals Company, kindly undertook the infrared spectrophotometry identifications and made available the SEM photographs. Special thanks are due G. Stanley Alexander, Santa Ana, California, for the fine photomicrographs of exceptionally difficult subjects, white and clear crystals on a light-colored background. The text benefited greatly from critical reviews by W. E. Wilson and J. S. White. Special thanks to my wife, Gale, for her assistance.

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zeolites and associated minerals from Horseshoe Dam, arizona

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LOCALITY

An alkali olivine basalt flow is exposed in a roadcut approximately 1 mile south of Horseshoe Dam, which is located about 40 miles north of Phoenix. The area is located on the U.S.G.S. 7½-minute *Horseshoe Dam, Arizona* quadrangle. Large quantities of basalt boulders from the roadcut, which have been dumped below the road, should continue to supply specimens for decades to come. The improved dirt road leading to the popular Horseshoe Reservoir recreation area provides easy access for any vehicle.

The basalt boulders require heavy sledges to break open, but to offset this physical exertion is the Verde River flowing just a few meters away. Frequent breaks to go swimming or tubing are an enjoyable means of "keeping your cool" in the desert heat.

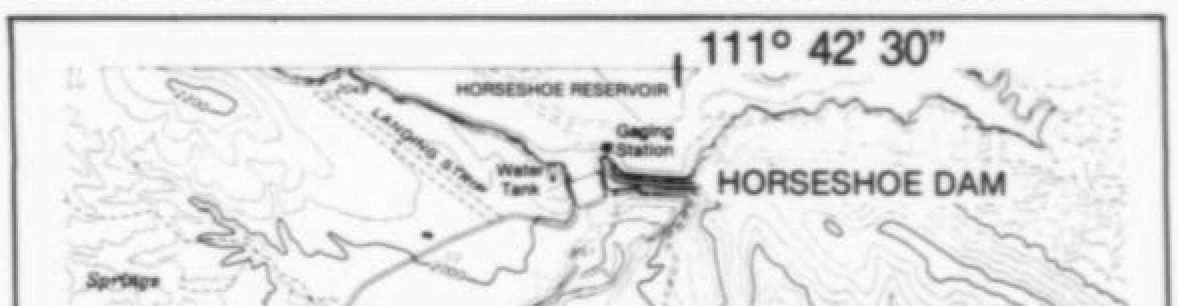


Figure 1. **Topography and location of the Horseshoe Dam locality north of Phoenix, Arizona. "I" is the Natrolite Area; "II" is the Herschelite Area. (Illustration by Rena Shannon.)**

MINERALS

There are two distinct areas of interest to the mineral collector: the natrolite and the herschelite areas.

The Natrolite Area

In basalt boulders below the roadcut, the following minerals have been found, in order of relative abundance:

Natrolite

Natrolite is by far the most abundant mineral, found in vugs lined with crystals up to 1 cm long, in radiating hemispheres. These clusters range from transparent to snow-white, to a pleasing orange-pink in color, and from tightly compacted with only the ter-

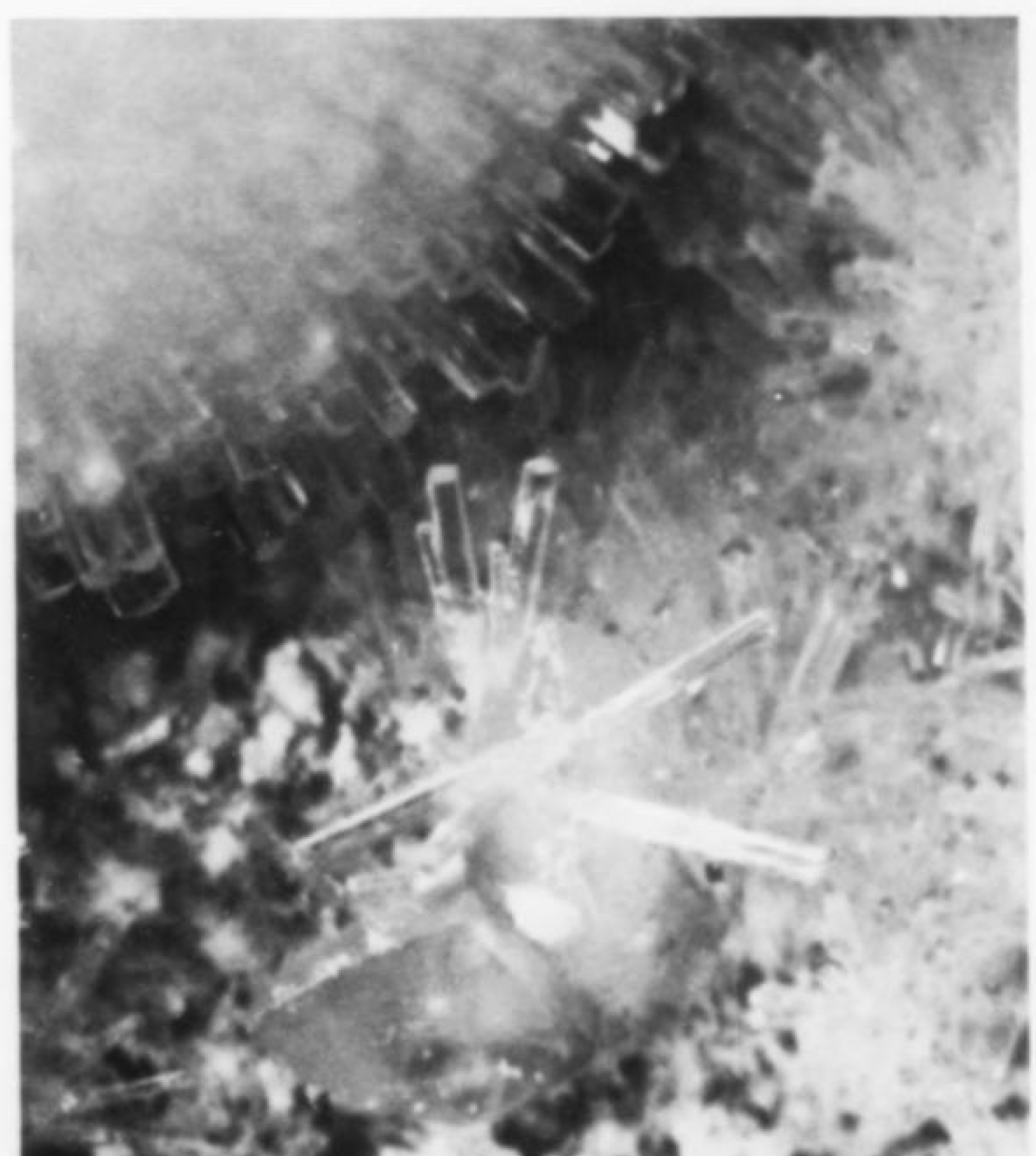


Figure 2. **Clear 3-mm natrolite crystals on calcite crystals. (All photos by the author.)**

Figure 3. **Light flesh colored herschelite 1 mm crystals on saponite.**

Okenite

Occasionally okenite forms a snow-white lining of microscopic crystals on vug walls. (Identification by R. Tschernich, by optical means.)

Gyrolite

Gyrolite is rare at this locality. It is found as 2-3 mm rose-like crystal clusters associated with apophyllite. (Identification by R. Tschernich.)

Calcite

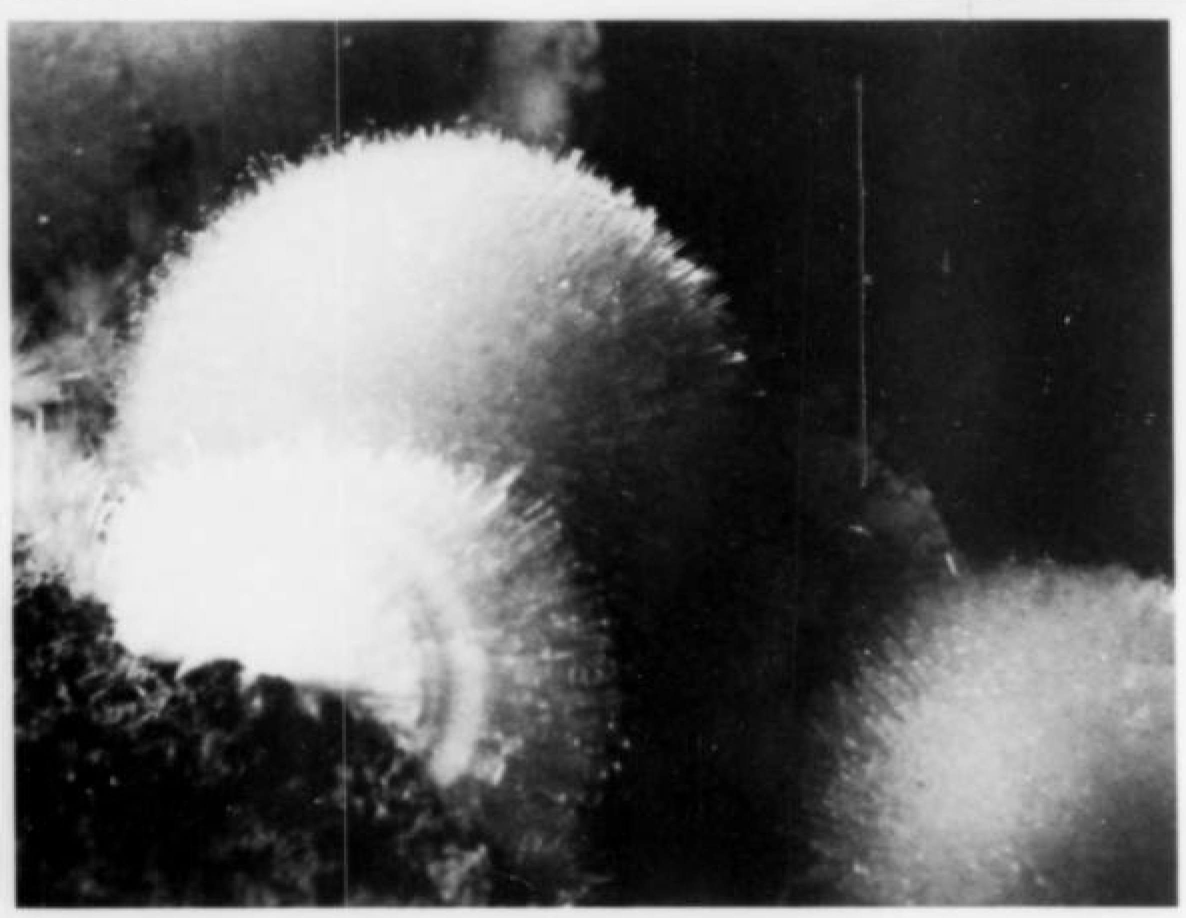
Pale orange, scalenohedral microcrystals of calcite are found rarely in the natrolite vugs.

The Herschelite Area

Just south of the natrolite locality is a (usually) dry wash. Up this wash, about 100 meters along its north side, is a 5-meter cliff outcrop of relatively decomposed basalt. All crystals found at this location are small and make excellent micromounts.

Figure 4. **Natrolite Area. The view is from the Verde River looking towards the roadcut and basalt boulders.**

Figure 5. **White natrolite hemispheres to 2 cm in diameter.**



minations of the individual crystals showing, to loosely radiating crystals. Vugs up to 50 cm have been found lined with natrolite hemispheres from 1 to 3 cm in diameter.

Apophyllite

Clear, tabular crystals of apophyllite up to 10 mm, but usually less than 2 mm, are found in the same natrolite vugs. Many of these vugs are full of the water.

Analcime

Analcime is found as transparent, trapezohedral crystals, many containing attractive hematite or saponite inclusions.

Calcite

Transparent to translucent scalenohedral, and also acute white rhombic crystals of calcite completely line vugs.

Gismondine

A photo of gismondine is shown in *Mineralogy of Arizona* (Anthony *et al.*, 1977). Similar appearing crystals have been found to be phillipsite by X-ray analysis (W. Wise, personal communication).

Herschelite

Herschelite is found as choice micro hexagonal plates. This rare zeolite is found sparingly, associated with analcime and phillipsite. The crystals range from transparent to translucent in a pleasing flesh color. Herschelite from this locality bears a striking resemblance to levyne.

Natrolite

Natrolite occurs as snow-white balls and as doubly terminated radiating groups of crystals, resembling bow-tie stilbite. No stilbite has been identified from this location (R. Tschernich, pers. comm.).

Phillipsite

Phillipsite forms as cream, orange, and red balls up to 5 mm, usually in association with analcime. Phillipsite also occurs as

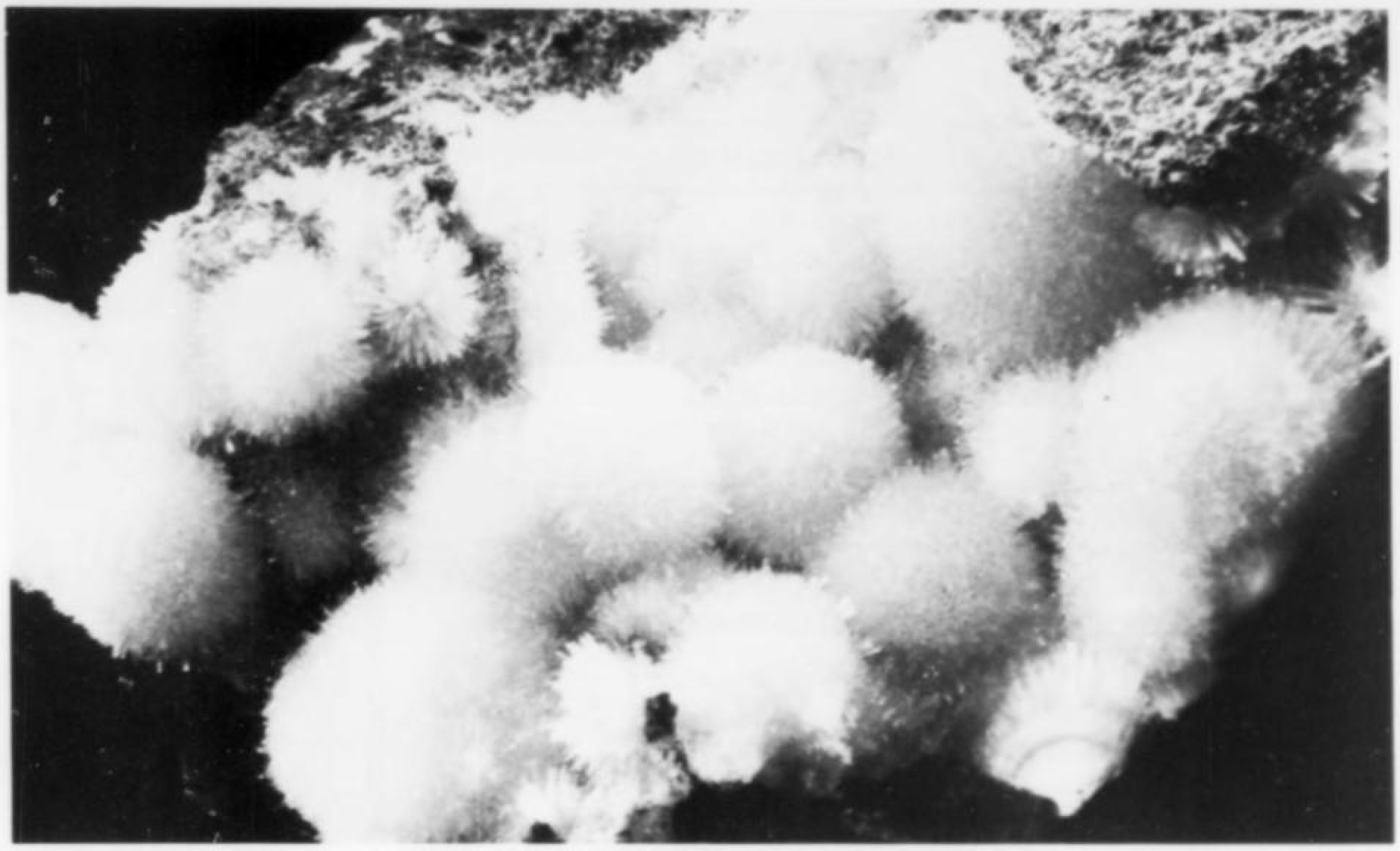


Figure 6. **Light orange-pink natrolite lining a 10 x 15-cm vug.**

orange-yellow, octahedral-appearing, complexly twinned crystals. Many of these crystals are completely hollow. The identity of the missing mineral species in the voids is not known.

Garronite hasn't been identified at this locality, though material has been collected that was suspected to be garronite. Microprobe analysis has shown such material to be phillipsite (Tschernich, 1975).

Saponite

Most vugs containing phillipsite are lined with green or brown spherical microcrystals of saponite. (X-ray and chemical analysis by W. Wise.)

This is one of those unusual mineral collecting localities that can be enjoyed by the whole family. While you are collecting nice specimens, your not-so-mineral-oriented spouse and children can enjoy swimming or tubing the rapids (a favorite summer activity of Arizona residents). If this isn't enough, get out the fishing poles; there are some nice catfish to be caught.

ACKNOWLEDGMENTS

I am indebted to Rudy Tschernich for his valuable aid in identifying the numerous zeolites from this locality; and to William Wise for his knowledge of the Horseshoe Dam locality, identification of minerals, and reviewing this paper. His suggestions are appreciated.

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tr

Calciovolborthite

from the new water mountains yuma county, arizona

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Calciovolborthite and other copper-bearing minerals have been found in small amounts in fractures within Tertiary volcanic rocks in the north end of the New Water Mountains, Yuma County, Arizona. The best occurrence is in a small prospect pit in the SW ¼ of Section 8, T3N, R16W.

Chrysocolla is the most abundant mineral, and occurs partially in the form of pseudomorphs. One type of pseudomorph is after an acicular mineral, possibly malachite, and the other is in the form of casts after a monoclinic mineral, probably azurite. Calciovolborthite is scattered on and around the pseudomorphs as dark green scales, single crystals and rosettes with a maximum dimension of 0.5 mm. Identification was made by X-ray diffraction analysis in the laboratory of Otto C. Kopp, University of Tennessee at Knoxville.

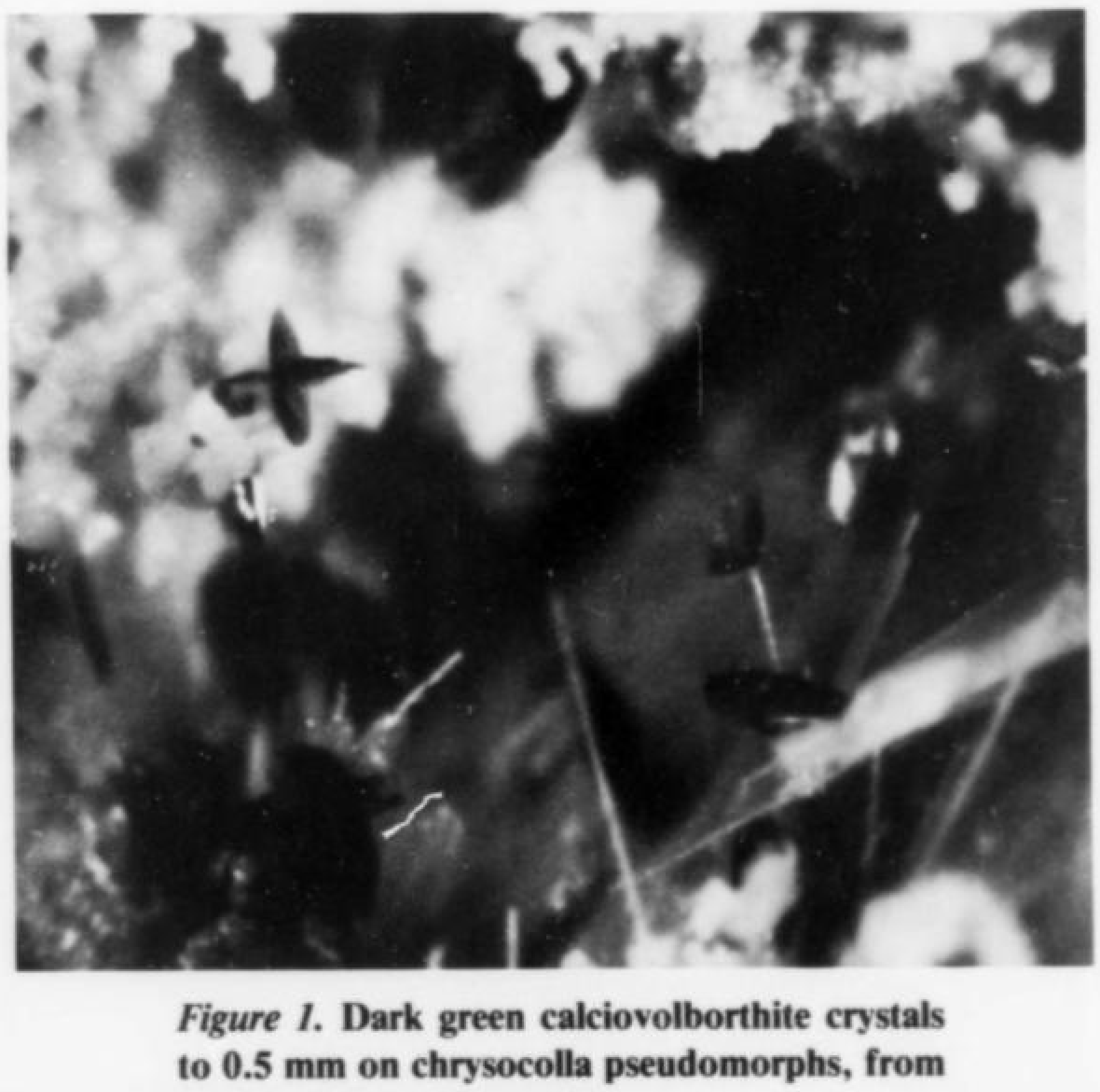

Figure 1. **Dark green calciovolborthite crystals to 0.5 mm on chrysocolla pseudomorphs, from the New Water Mountains.**

Examinations of other prospects and old mines in the area revealed a wide variety of microminerals including adularia, calcite, chlorargyrite, chrysocolla pseudomorphs after quartz and adularia, conichalcite, dioptase, fornacite, heulandite, mimetite, murdochite, quartz, shattuckite, stilbite, thompsonite and wulfenite.

Two as-yet unidentified minerals were found. One is in a foil-like habit reminiscent of the classic tenorite from Mount Vesuvius. The other occurs as very small, dull green prisms associated with heulandite and stilbite in vesicles in basalt.

Collecting in this area in the future may be restricted, because it has recently been included in the Kofa Game Refuge. *Sic gloria mundit!*

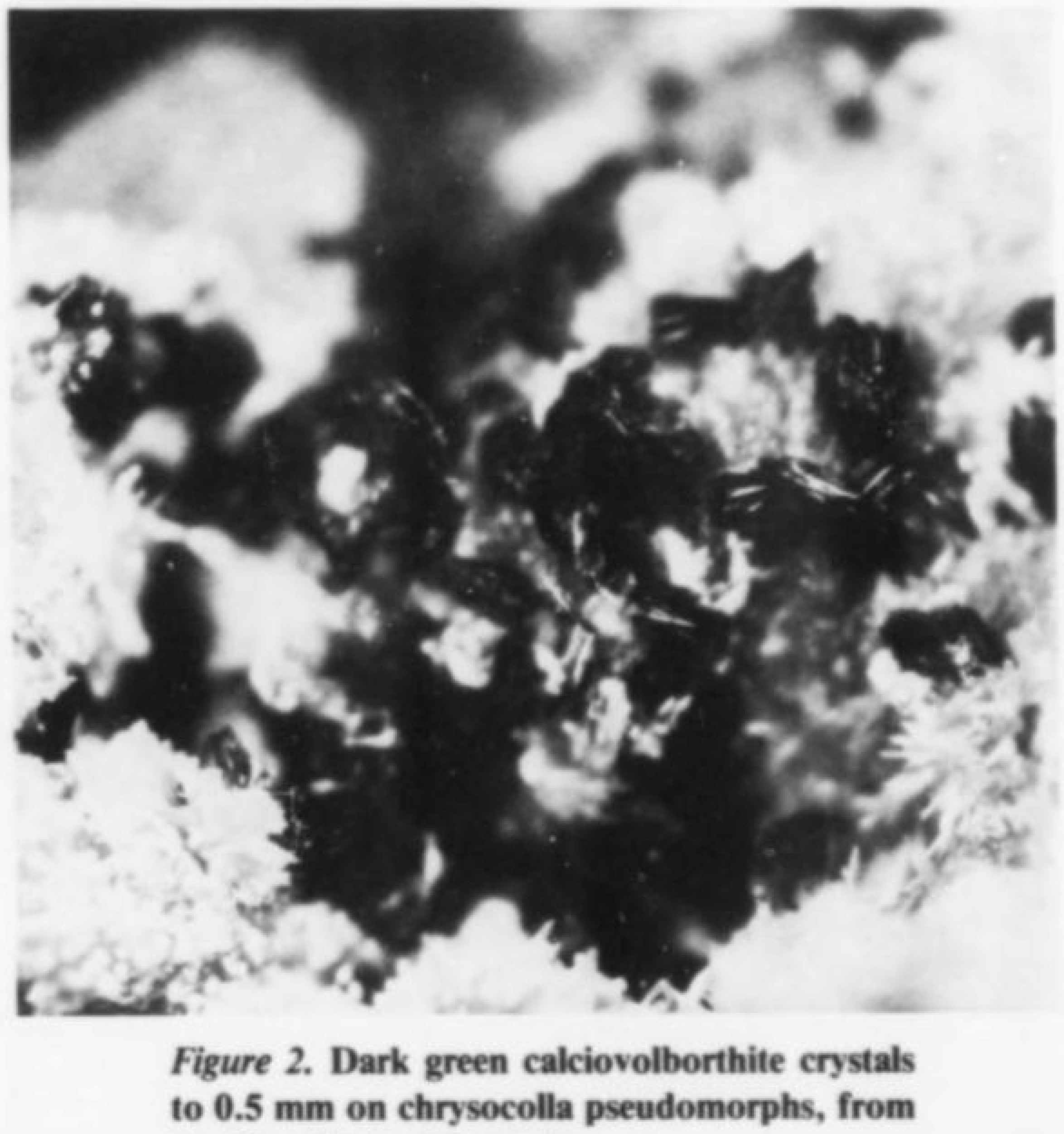

Figure 2. **Dark green calciovolborthite crystals to 0.5 mm on chrysocolla pseudomorphs, from the New Water Mountains.**

famous mineral localities:

the Hilltop Mine

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The Hilltop mine, in the beautiful Chiricahua Mountains of Cochise County, Arizona, has been famous since the 1920's as a source of superb lemon-yellow wulfenite. Fine specimens have not been found there for many years, but Hilltop wulfenite remains among Arizona's best.

INTRODUCTION

Arizona can boast of eight major wulfenite localities. Each has produced distinctive, museum-quality specimens which most collectors can recognize on sight. Six of these have been described in the *Mineralogical Record:* the Defiance mine (Thompson, 1980), the Old Yuma mine (Jones, this issue), the Red Cloud mine (Edson, 1980), the Rowley mine (Wilson and Miller, 1974), the 79 mine (Keith, 1972), and Tiger (Bideaux, 1980). The seventh, the Glove mine, will be described in the next Arizona issue. Completing the group is the Hilltop mine. Of course, Arizona has many other wulfenite occurrences, some of which have produced small numbers of fine specimens. But these eight are the major ones. Fine pieces from these localities are represented in major collections and museums throughout the world. The other seven localities have produced good specimens during the last decade and some are active even now. The Hilltop mine, however, has not yielded good specimens for at least 25 years.

LOCATION

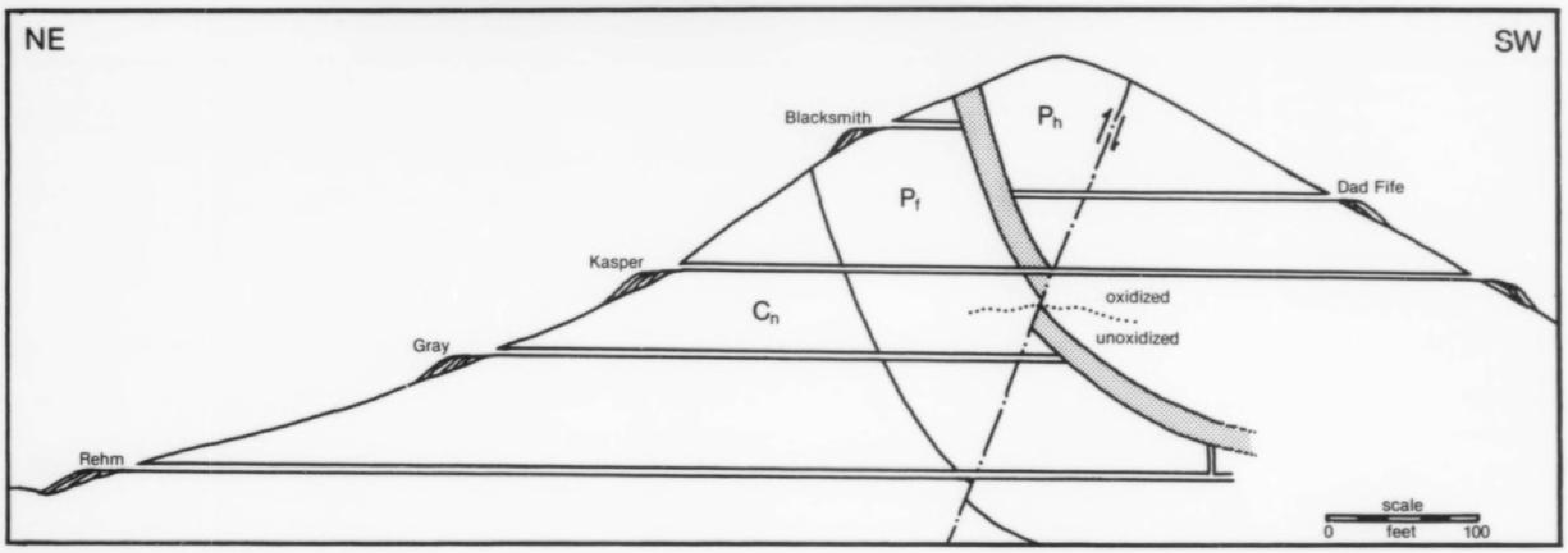
The Hilltop mine, once composed of approximately 80 unpatented lode claims, is situated in the Chiricahua Mountains near Shaw Peak, in the California (Chiricahua) mining district, within the Coronado National Forest. The claims covered about 2 square miles in Sections 32 and 33, T.16S, R.30E, and Sections 3, 4 and 5, T.17S, R.30E, in Cochise County, Arizona. The Hilltop townsite and most of the adits may be reached by a dirt road which runs south from Interstate 10 beginning at a point 3 miles east of San Simon. Seventeen miles south of the highway the Hilltop Road branches to the west, following Whitetail Creek, and reaches the turnoff to Hilltop in 5 miles. The town was originally situated on the southwest side of the mountain. After a tunnel was put through, a larger town was established on the northeast side. The townsite and tunnel are shown on the Chiricahua Peak 15-minute quadrangle.

The area is semi-arid, except at the highest elevations, and temperatures exceeding 100°F are common from May through September. Typical desert vegetation consisting of mesquite, creosote bush, ocotillo, agave and prickly pear cactus gives way to pine and fir trees in the higher elevations.

***Figure 1.* Old ore chutes near the Rehm dump. Miller photo.**

Figure 2. **Prickly pear cactus near the Gray dump, looking east. Miller photo.**

Figure 3. **Geologic cross-section, Hilltop mine. Tunnels projected onto one plane; workings not shown (after Brittain, 1954). Rock units: P_h – Hanging-wall limestone. P_f – Footwall limestone. C_n – Naco-group limestone. Shaded – Hilltop quartzite (limestone).**



HISTORY

The original Hilltop claim was filed by Jack Dunn in the early 1880's (Papke, 1952). Dunn, incidentally, had previously filed the first claim in the Bisbee area in 1877 (Graeme, 1981). Unfortunately, Indian troubles prevented much work from being carried out. In fact, nearby Jhus Canyon is named for a leader of the Chiricahua Apaches who led many destructive raids throughout southeastern Arizona during the 1880's (Granger, 1960).

Around 1897 the property was acquired by Frank and John Hands, who came to the area from England in 1888 (Granger, 1960). They prospected intermittently for several years and sank a number of small prospect holes. Between 1902 and 1911 the Blacksmith workings produced high-grade oxidized lead-silver ore which was packed by burro to the mills at Willcox and Paradise, and from there to the smelter at El Paso, Texas (Brittain, 1954).

The Hands brothers sold their claims to the Hilltop Metal Mining Company in 1913, under management of which most of the development and mining took place. The pride of the company was a 1913 seven-passenger, six-cylinder Cole automobile. A spacious garage was constructed exclusively for the company car, and was stocked with all the necessary tools (Sherman and Sherman, 1969).

The small mining camp on the southwest side of Shaw Peak was gradually moved to the northeast side of the mountain in 1916–1917, following completion of the Kasper level through the mountain. For a while, it is said, school children walked through the mountain to and from their classes until all residences had been moved (*Western Prospecter and Miner,* January 1975). A powerhouse, bunkhouse, manager's house, dance hall, pool hall and restaurant soon embellished the new townsite.

Most of the ore produced came from stopes on the Kasper and Gray levels between 1924 and 1926. About 11,000 tons of ore were removed during this period, yielding 5 million pounds of lead and $50,000 worth of silver. Due to a drop in the price of lead, however, mining was curtailed after 1926 (Brittain, 1954).

In the following years the mine changed hands several times. Piedmont Mines Inc. acquired the property in 1948 and produced a little ore from the Blacksmith tunnel in 1949 (Brittain, 1954).

In 1951 the American Zinc, Lead and Smelting Company leased the mine from Piedmont Mines Inc. Employing about a dozen men largely for development work, the company nevertheless shipped about 8000 tons of ore while driving 600 feet of drifts and 6150 feet of raises. Most ore shipped was lead carbonate, though some was galena. Additional ore was stockpiled underground in raises. In 1955 the company laid off its miners and pulled out (Arizona Department of Mineral Resources file data). During the late 1950's the abandoned mine often served as a summer training ground for student geologists and mining engineers (Dunning and Peplow, 1959).

From 1968 to 1975 small amounts of oxide ore were produced by HRM Investment Company, working with only two or three men in the winze of the Blacksmith tunnel. Since that time the property has been idle (Arizona Department of Mineral Resources file data).

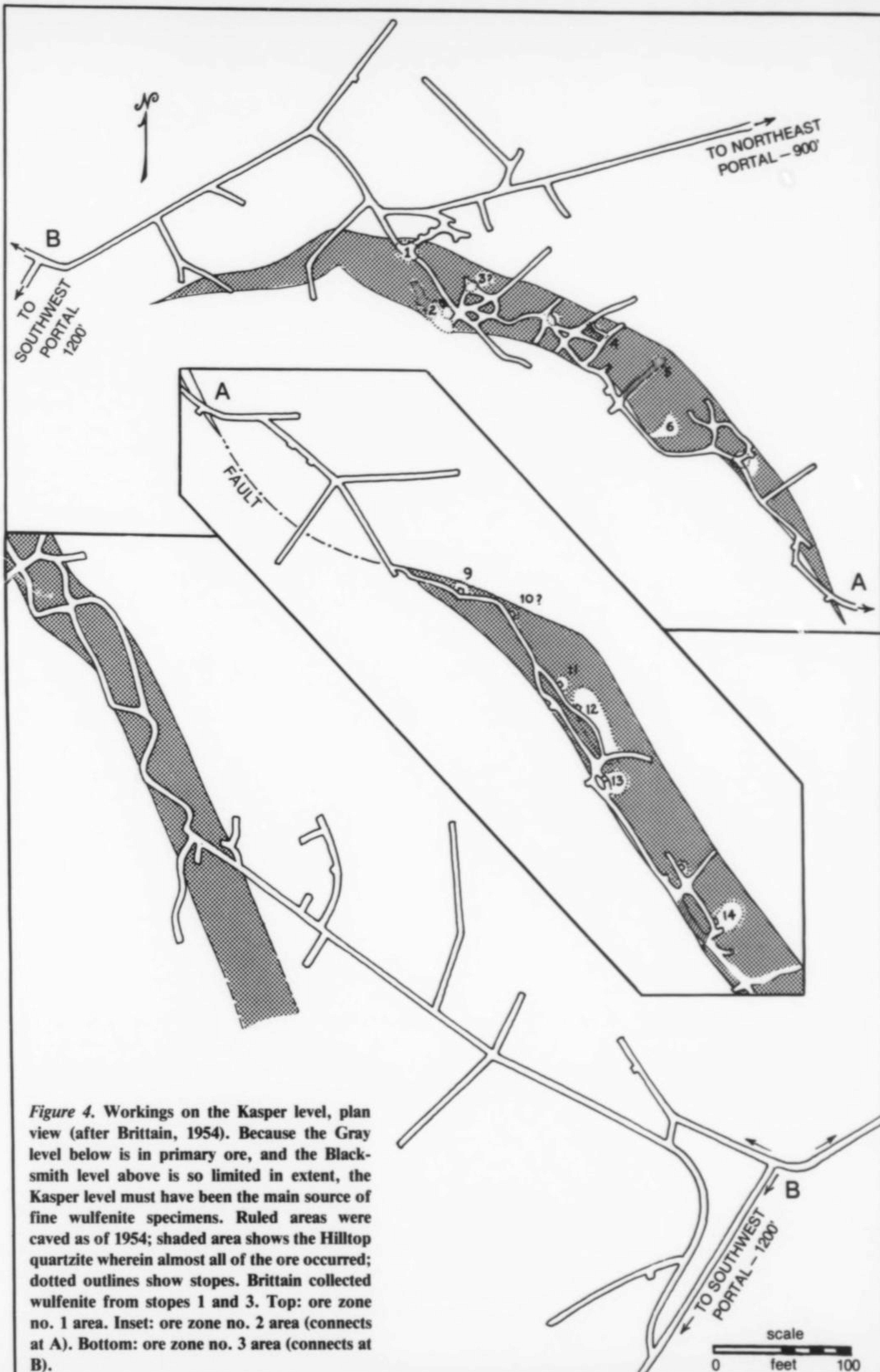


Figure 4. **Workings on the Kasper level, plan view (after Brittain, 1954). Because the Gray level below is in primary ore, and the Blacksmith level above is so limited in extent, the Kasper level must have been the main source of fine wulfenite specimens. Ruled areas were caved as of 1954; shaded area shows the Hilltop quartzite wherein almost all of the ore occurred; dotted outlines show stopes. Brittain collected wulfenite from stopes 1 and 3. Top: ore zone no. 1 area. Inset: ore zone no. 2 area (connects at A). Bottom: ore zone no. 3 area (connects at B).**

MINE WORKINGS

There are four main levels in the Hilltop mine. The uppermost is the Blacksmith adit, which is at an elevation of 7220 feet; 503 feet below the Blacksmith adit is the Kasper level; 795 feet below the Blacksmith adit is the Gray level; and 1205 feet below the Blacksmith is the Rehm level. Only the Kasper level penetrated all the way through the mountain to the southwest side of the ridge. Portals for the other three levels are on the northeast side. A fifth level, the Dad Fife, was driven northward from the southwest side of the ridge 270 feet below the Blacksmith adit, but is now caved near the portal and inaccessible (Papke, 1952).

The Dunn shaft (the discovery location) was sunk near the top of the mountain in a mineralized and brecciated zone about 100 feet above the Blacksmith adit. The Blacksmith adit penetrates the mountain for about 100 feet to strand no. 1 of the Blacksmith fault zone, at which point a chimney of ore was exploited downward by a winze for about 135 feet and upward by a raise to the surface. Several tons of ore were removed from this chimney in 1951.

The Kasper tunnel passes completely through the mountain for a distance of about 3200 feet. Along its length on both sides about 2 miles of drifts and crosscuts were developed, intersecting three major ore zones exploited by a number of large stopes.

The Gray level extends about 1750 feet to the main fault, where lateral workings along the hanging wall of the Hilltop quartzite exploit two of the three major ore zones which extend downward from the Kasper level (Papke, 1952; Brittain, 1954).

The fourth and lowest level, the Rehm adit, was driven a distance of 3850 feet but failed to intersect the Hilltop quartzite. Near its end, two raises were driven 165 and 170 feet upward; they did intersect the Hilltop quartzite where a small amount of low-grade sulfide ore was removed (Brittain, 1954).

In all, about 5 miles of tunnels, adits, drifts and crosscuts, and more than 2 miles of raises, winzes and stopes were developed in the Hilltop mine (Arizona Department of Mineral Resources file data).

GEOLOGY

The Chiricahua Mountains are composed of a series of tilted and eroded fault blocks. The Hilltop mine deposits are located within the "Hilltop block," a mass of bedded limestones exposed over a 2 by 4-mile area (Brittain, 1954).

The sedimentary units dip steeply to the southwest but level out at depth. The Permian Pinery or Hanging-Wall limestone forms the crest of the mountain. Beneath that is the main ore-carrying member, the Hilltop quartzite (actually a siliceous limestone; Dale *et al.,* 1960), which is approximately 65 feet thick. Beneath that is the Permian Hardluck or Footwall limestone, and below that the Pennsylvanian Naco-group limestone. Igneous intrusions and volcanic deposits cut the area (Brittain, 1954).

Compression of the Hilltop block resulted in a multitude of low-angle faults. The Blacksmith and Eureka faults provided the main channels for ore-forming solutions, but many small cross-faults, particularly in the brittle Hilltop quartzite, were important in localizing ore deposition. All of the mine workings are within the Hilltop, Hardluck and Naco-group units, and were directed primarily to ore deposits in the Hilltop quartzite (Brittain, 1954; Papke, 1952).

ORE DEPOSITS

Mineralization at the Hilltop mine consists of mesothermal replacement and vein deposits which are irregular in size and shape. Some deposits form well-defined chimneys of roughly circular or elliptical cross-section. Others form vein deposits or bed replacements, most more or less within the Hilltop quartzite, especially on the Hanging-Wall side (Papke, 1952; Brittain, 1954).

The main primary ore mineral was galena, with lesser amounts of sphalerite, pyrite and chalcopyrite. Most of the ore deposits above the 6580-foot level (about halfway between the Kasper and Gray levels) are oxidized to secondary minerals, primarily sandy-textured cerussite and anglesite. In a few heavily fractured areas secondary mineralization extends all the way down to the Rehm level, though this is uncommon. Similarly, isolated areas of unaltered sulfides were encountered around the Kasper level and above (Brittain, 1954).

MINERALS

A number of different species have been reported from the Hilltop mine (see Table 1). Pough (1941) reported twinned crystals of cerussite and small, white to rose-colored crystals of willemite. One of us (DKM) found willemite crystals to ⅛ inch on the southwest Kasper dump. Most species, however, occur only as poor-quality specimens.

The mineral for which the Hilltop mine is justly famous is wulfenite. Crystals were found up to 5 inches in size, though crystals ½ to 1 inch are prized today. Color ranges from dirty brown to amber, orange, pale yellow and canary-yellow. The best and most easily recognizeable specimens consist of canary-yellow wulfenite in square, tabular crystals having a frosty luster on the large pinacoidal faces and a bright luster on the small pyramidal faces rimming the edges. Typically these are perched individually or in groups on snow-white druses of calcite on limestone.

King (1940) reported that the active mining period of 1924–1927 was very productive of specimens. The crystals were collected from vugs, pockets and small caverns by the miners, with company approval, and were then given to the mine superintendent. A boarded-off recess of the mine served as the official "treasure room" where specimens were stored under lock and key until a collector or mineral dealer would visit the mine and arrange to purchase them. The specimens brought significant prices at the mine, even in those days.

In December of 1928, after the mine had closed, "a New York City mineral dealer" obtained permission to search for specimens (King, 1940). He opened a cavern which yielded several hundred fine crystal groups, with crystals to nearly an inch on white calcite. (Ed. note: do any readers know who this dealer was?)

In December of 1939, Ed Over, a well-known commercial mineral collector of the 1930's, found a pocket which yielded about 200 fine specimens. The largest cabinet piece weighed 72 pounds. This has long been considered one of the finest wulfenite pockets ever found in Arizona, but present-day collectors disagree on its location within the mine. Over died in 1963, and the exact location was lost. Richard Thomssen has a letter from Over dated December 14, 1956, in which Over attempts to remember and describe the location of his find of 17 years earlier. He wrote:

"What I got was all in a limestone cave and alongside one of those sloping, low-grade lead orebodies. Surrounding limestone very dangerous. Seems that it was in the middle tunnel, the one through the mountain. Then turn into the left-hand drift, soon crawl through 50 feet of caved ground (just a rat-hole cleared there), then maybe 300 yards to where an underhand stope is seen, etc."

Unfortunately, Over's letter is too sketchy to be of much help. It is reasonable to assume that he was referring to the Kasper tunnel, that being the only level which passes all the way through the mountain. A thumbnail sketch on the letter indicates he entered from the portal near the Hilltop townsite, but at the time there may have been town ruins on *both* sides of the mountain. About all we can be sure of is that the pocket was several hundred feet left or right of where the Kasper tunnel intersects the Hilltop quartzite.

Richard Brittain, author of a 1954 Master's thesis on the mine, was superintendent there from 1953 to 1955 and sold many wulfen-

Figure 5. **Wulfenite from the Hilltop mine; the crystal is about ½ inch across. Miller collection.**

Figure 6. **Wulfenite from the Hilltop mine; the large crystal is 1 inch diagonally. Richard Bideaux specimen.**

Figure 7. **Wulfenite from the Hilltop mine, 5.6 inches across. Smithsonian specimen #125230. Miller photo.**

Choice Specimens

AZURITE—Bisbee, Arizona. Irregular mass of small deep colored lustrous crystals. 3½" x 4½". Price **$7.50**.

VANADINITE—Yuma County, Arizona. Rock coated with thousands of small brilliant crystals varying in color from yellow to red. 4½" x 4½". Price **$10.00**.

WULFENITE—Hilltop, Arizona. Did you ever desire a real fine wulfenite? One that was equal to any displayed in any museum? Here's one! A multitude of beautiful wax-yellow tabular crystals up to ⅝" distributed nicely on minute white crystalled calcite make this one of the showiest of specimens. 5½" x 6" x 2½". Price **$20.00**. If you should happen to want a better and larger specimen from this locality we have them! Up to **$100.00** each in price!

Schortmann's Minerals

6 McKinley Avenue **Easthampton, Massachusetts**

Schortmann's Minerals **advertisement in *Rocks and Minerals*, August, 1943.**

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Wulfenite, Hilltop, Arizona. This is a mineral with a great appeal to mineral collectors because of its gorgeous color and beautifully developed crystals. The specimens offered have numerous tabular orange-yellow crystals attached to quartzite. The range in size is from 4 x 4" to 2 x 3" at prices of $2.00; $1.50; $.75; $.50; and $.35.

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THE FRANK A. WARD FOUNDATION OF NATURAL SCIENCE OF THE UNIVERSITY OF ROCHESTER

Ward's advertisement in *Rocks and Minerals*, February, 1941.

COLOR Illustrations in LIFE

July 21, 1941 issue

Mineral collectors were pleasantly surprised to see two full pages in color devoted groups from this original discovery. Sizes from 1" to 4" at 75c, $1.00, $1.50,

We are pleased to advertise for the first time, gorgeous RED WULFENITES, Red Cloud Mine, Arizona, from Edwin Over's find of two seasons ago. This, without doubt, was the most beautiful lot of brightly colored wulfenites ever found! A few matrix specimens are still available at $1.00, $2.00, $3.00, $5.00 and $7.50. Bright red single xls at 50c, $1.00, $2.00 and $3.00. Excellent single crystals of exceptional color and quality at $5.00, $7.50, $10.00 and $15.00 each.

Once again we offer choice YELLOW WULFENITES, Hilltop, Arizona. The specimens we offer are from the original find by Edwin Over several seasons ago. Many specimens of inferior quality have been produced since but we still offer unexcelled groups from this original discovery. Sizes from 1 to 4" at 75c, $1.00, $1.50, $2.00, $3.00 and $5.00. Larger and museum sized specimens in stock.

We also have in stock a great variety of VARISCITES, Fairfield, Utah, AURICHALCITES, Bisbee, Arizona and AZURITES from Bisbee, Arizona and Tsumeb, South West Africa.

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Schortmann's Minerals **advertisement in *Rocks and Minerals*, September, 1941. (Reprinted with permission.)**

ite specimens to *Schortmann's Minerals* in Massachusetts (Dick Jones, personal communication, 1976). Brittain's specimens came from small pockets, each about football-size, found in stopes no. 1 and no. 3 on the Kasper level.

Collecting in recent years has failed to locate any fine wulfenite at the Hilltop mine. The underground workings are extremely complex, dangerous and forbidding. Many areas are now inaccessible, and it is probable that no more of the exquisite yellow wulfenite specimens will be collected there.

ACKNOWLEDGMENTS

Our thanks to Richard Bideaux, Wayne Thompson and the late Dick Jones for useful discussions on the collecting history of the mine; and to Richard Thomssen for reviewing the manuscript and locating for our use the letter from Ed Over. Thanks also to those who loaned specimens for photography.

Table 1. **Minerals identified at the Hilltop mine (after Papke, 1952; and Brittain, 1954, with additions).**

Primary	Epidote	Chrysocolla
Arsenopyrite	Garnet	Copper
Calcite	Magnetite	Dolomite
Chalcopyrite	Scheelite	Gypsum
Galena	Tremolite	Hematite
Pyrite	Wollastonite	Jarosite
Quartz		Limonite
Sphalerite	*Secondary*	Malachite
	Anglesite	Psilomelane
Pyrometasomatic	Azurite	Pyrolusite
Actinolite	Calcite	Smithsonite
Chlorite	Cerussite	Willemite
Clinozoisite	Chlorite	Wulfenite

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tr

the Silver Bill mine
Gleeson, Arizona

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The Silver Bill mine has yielded what is perhaps the world's finest rosasite, as well as interesting specimens of wulfenite, smithsonite and malachite. Though the deposit was discovered 100 years ago, the author was able to locate a remove a mass of high-grade ore and crystals in 1978.

LOCATION

The Silver Bill mine is located about ¾ mile northeast of Gleeson, Arizona, on the western slope of Gleeson Ridge. It is approximately 400 feet south of the Defiance mine, which has been previously described in the *Mineralogical Record* by Thompson (1980). The mine is marked on the Outlaw Mountain quadrangle, in Section 32, T.19S, R.25E.

INTRODUCTION

The Courtland-Gleeson mining district consists of at least 25 mines, but to collectors the district is most well known as the home of the Defiance mine. A mere 400 feet away, however, is another mine, the Silver Bill, which has recently produced fairly large quantities of fine mineral specimens.

Like the Defiance, the Silver Bill mine produces wulfenite. Since 1977 substantial quantities of wulfenite have been produced from a newly discovered ore shoot in the mine. This material is very attractive (and saleable!), but is not of the quality of the best Defiance mine pieces.

Unlike the Defiance, however, the Silver Bill mine also produces secondary zinc and copper minerals. Most noteworthy of these is rosasite, which rivals in quality the specimens from Bisbee and Mapimi. Of interest also are the malachite pseudomorphs after azurite that are commonly coated with rosasite, aurichalcite or smithsonite.

PRODUCTION HISTORY

The general history of the Courtland-Gleeson mining district was presented by Thompson (1980). Only the history of production for the Silver Bill mine will be given here.

The Silver Bill mine lies within portions of three mining claims: the Defiance, the Whoop Up, and the Silver Bill. These claims were staked about 1883 and patented at the turn of the century by Martin C. Costello of Bisbee, Arizona. The Costello group of claims, which includes both the Defiance and Silver Bill mines, still remains in possession of the heirs of Martin Costello to this day.

The Silver Bill shaft was sunk in 1890 and substantial ore production was realized during 1893–1896 (Wilson, 1927). Although no production records have been found, the size of the stopes mined during this period indicates that, at most, 15,000 tons of ore (of unknown grade) were produced. In 1922 a dump-sorting operation yielded up to 900 tons of ore per month that averaged 10 percent lead, 10 ounces silver and a little gold per ton (Wilson, 1927).

Production after 1900 has been very sporadic, totaling at most a few thousand tons of ore. The original surface facilities and hoist were apparently removed early in the 1900's. Underground production was thus impossible until 1923, when the Mystery tunnel was completed and intersected the 200 level of the Silver Bill mine. All ore production after 1925 has been trammed out the Mystery tunnel.

In 1925 lessees shipped 920 tons of ore (Wilson, 1927). During 1940 and 1941 several hundred tons of ore were produced and shipped to the Asarco smelter in El Paso. This ore varied in grade from 10 percent to 20 percent lead and generally under five ounces of silver per ton (Asarco smelter returns). Only one stope in the Silver Bill has produced copper and zinc ore. During the late 1920's, two carloads of ore were shipped from a stope below the 200 level that averaged 32 to 34 percent zinc and 1.5 to 2.0 percent copper (Wilson, 1951).

The last ore production from the Silver Bill mine occurred in 1978 when the Gleeson Heights Mining Company (a partnership of the author and Robert Jeffrey) shipped a carload of lead-silver ore from a new stope just off the Silver Bill shaft. This ore averaged 28.8 percent lead, 3.4 ounces silver and 0.05 ounces of gold per ton. During this venture, wulfenite proved to be a very profitable byproduct of the mining.

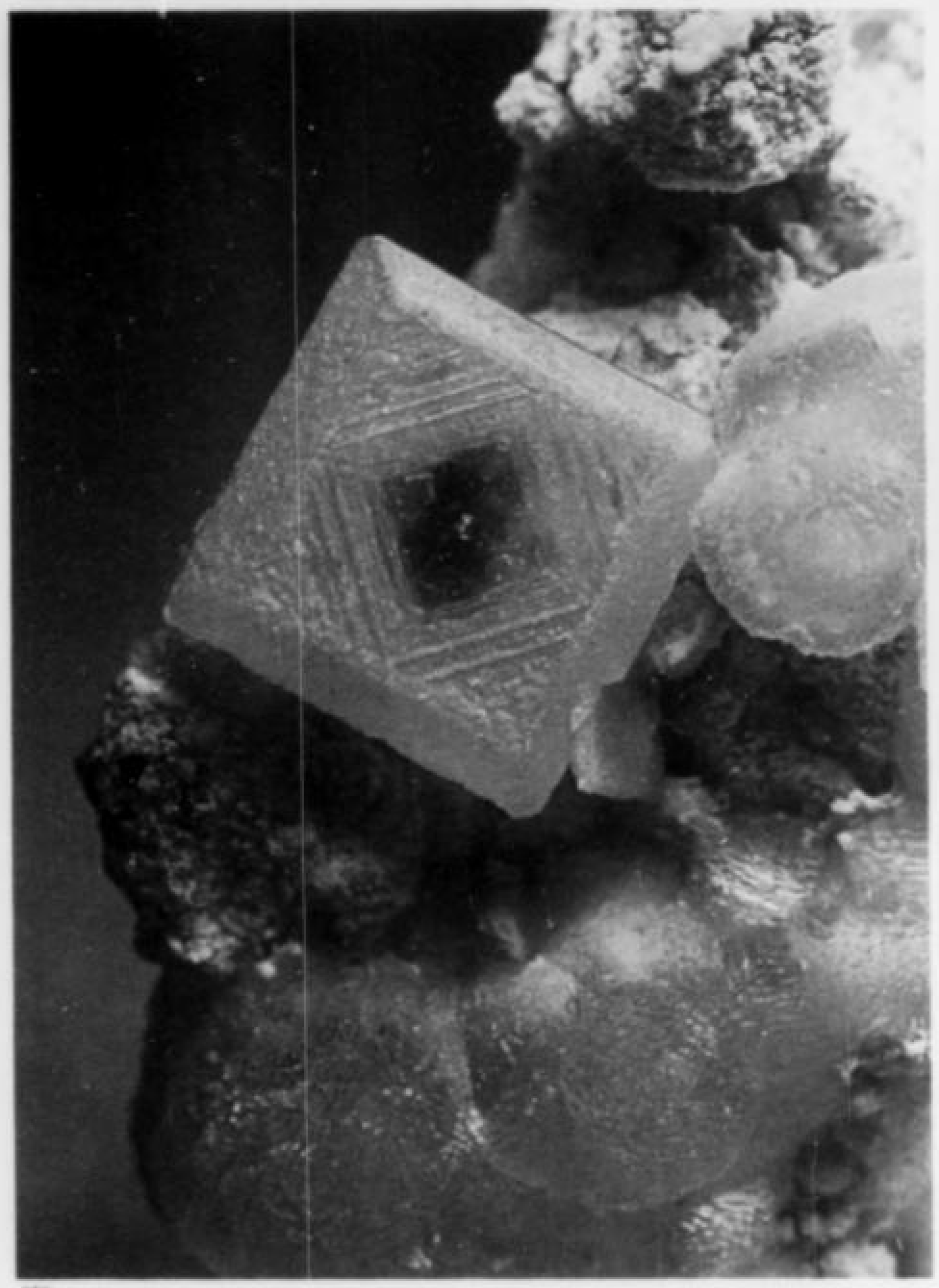


Figure 1. **Bicolored wulfenite from the Silver Bill mine, on smithsonite. The crystal is about ⅓ inch in diameter. P. Knudsen collection.**

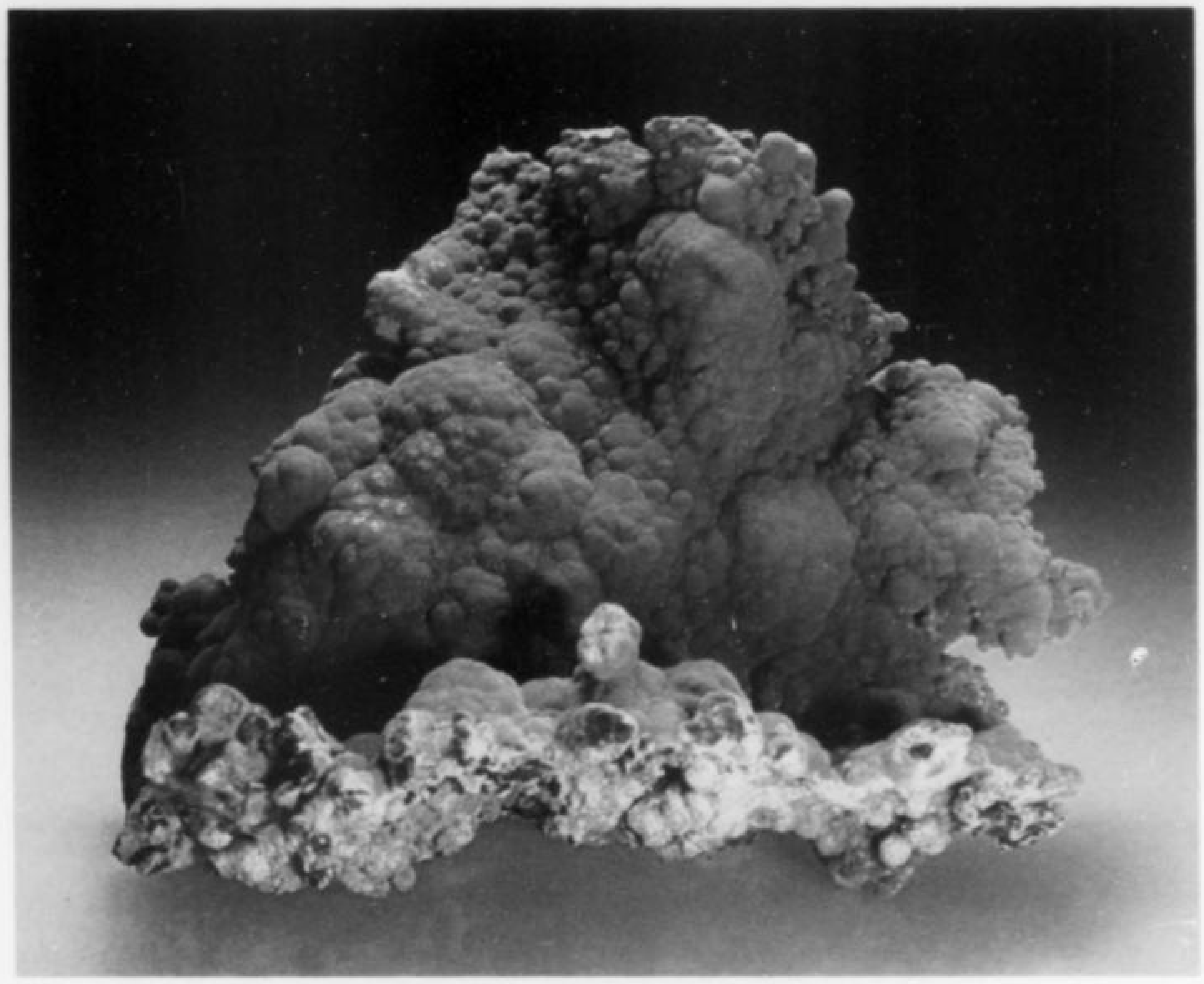


Figure 4. **Rosasite from the Silver Bill mine; the specimen is about 4 inches across. Richard Bideaux collection.**

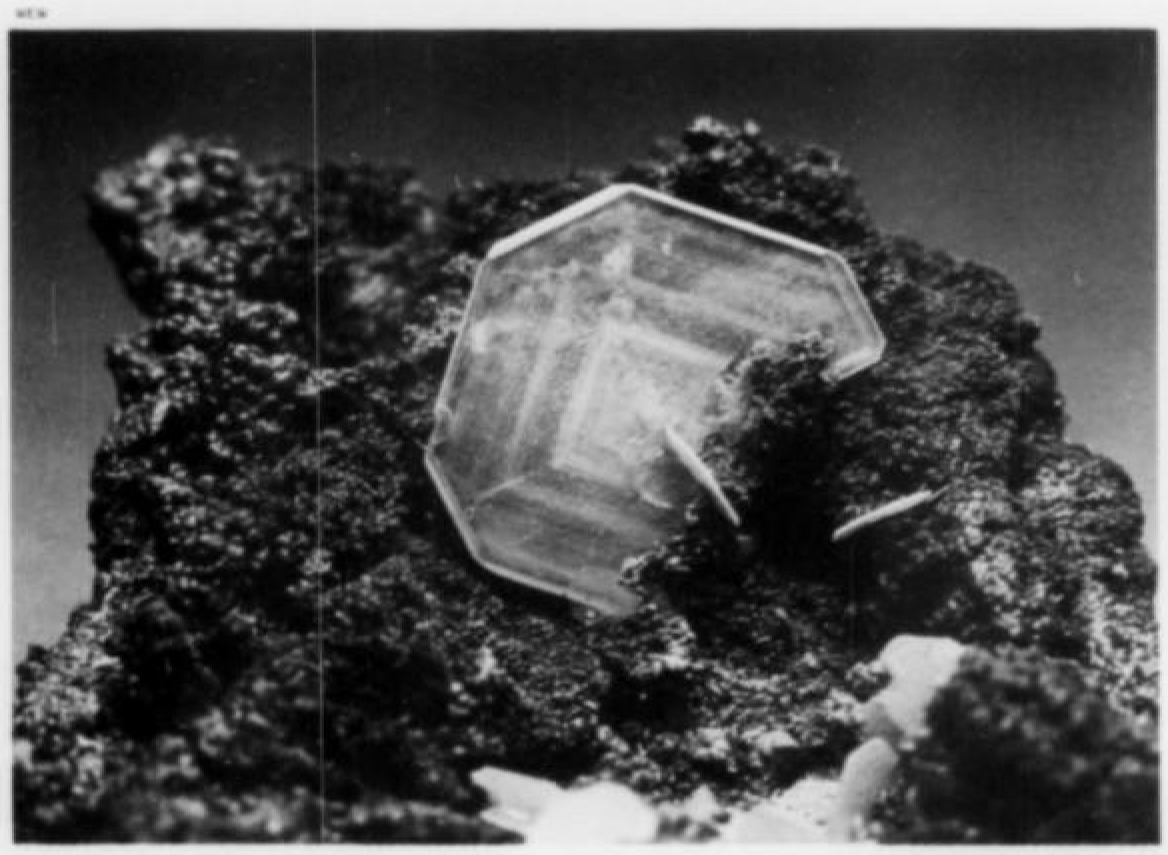


Figure 2. **Wulfenite from the Silver Bill mine. The crystal is about ½ inch in size. P. Knudsen collection.**

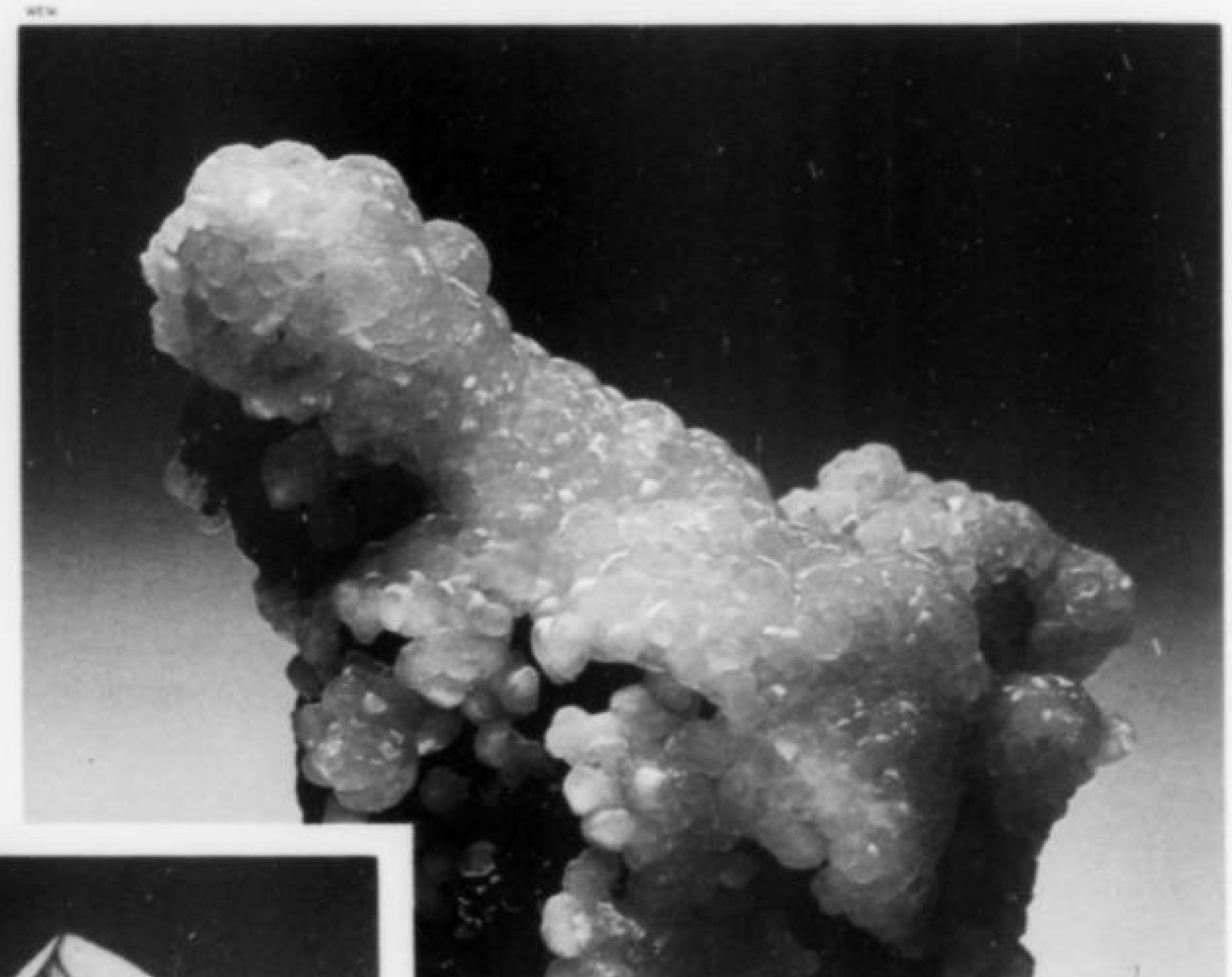


Figure 5. **Smithsonite on manganese-oxide matrix from the Silver Bill mine. The specimen is about 2¾ inches across. P. Knudsen collection.**

Figure 3. **Malachite pseudomorph after azurite, coated by a thin layer of rosasite, from the Silver Bill mine. The crystal is about ⅔ inch tall. P. Knudsen collection.**

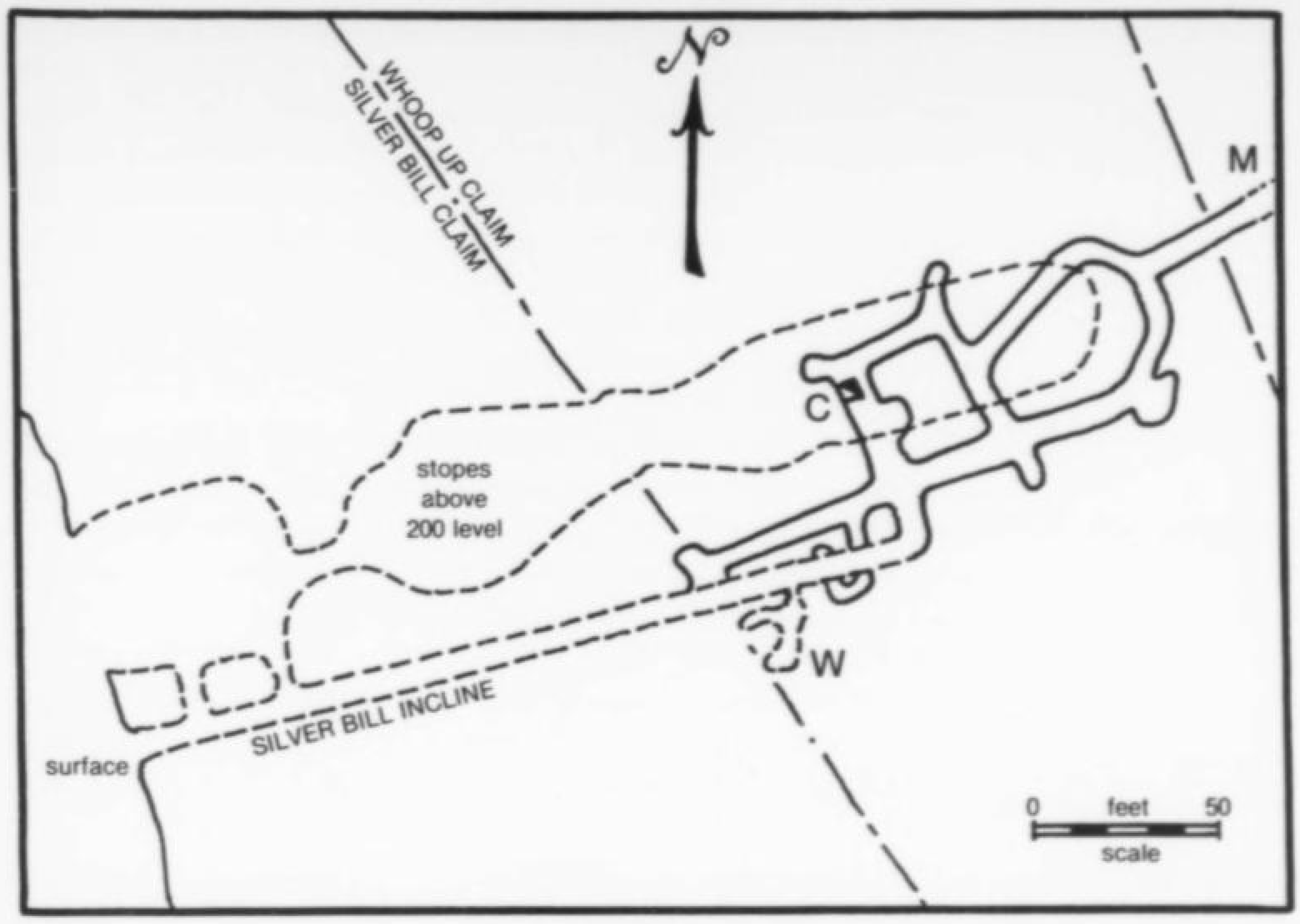
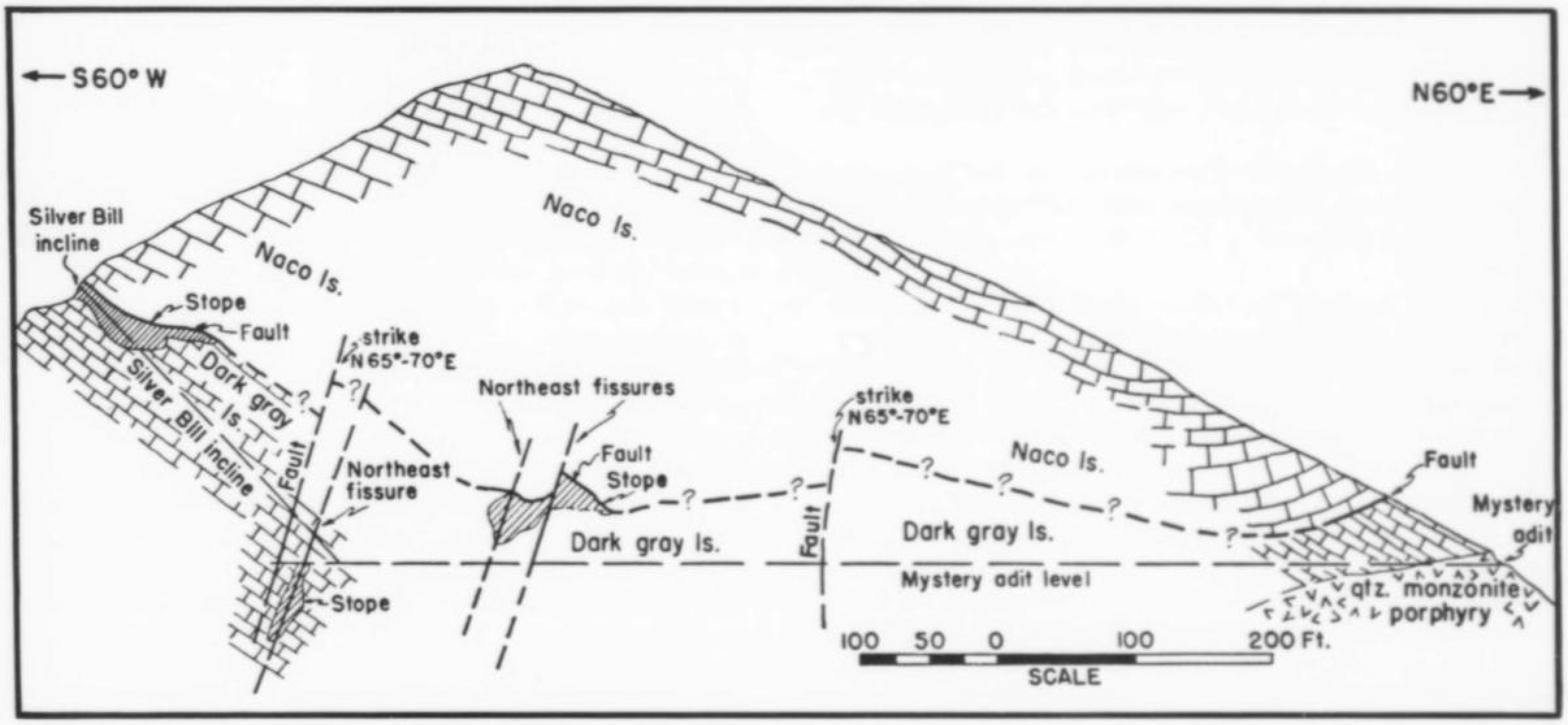


Figure 6. **Sketch map of the 200 level of the Silver Bill mine, showing most recent workings (W), and connection with the Mystery Tunnel (M). (Modified from Wilson, 1927.)**

Figure 7. **Cross section of Gleeson Ridge through the Silver Bill and Mystery mine stopes, looking N 30° W (Wilson, 1951).**



PRESENT STATUS

In 1981 Houston Mining and Resources obtained an exploration lease on all the Costello claims in the Courtland-Gleeson mining district. No production occurred and the lease has now been dropped. Although the properties are now inactive, all the Costello claims are patented and are thus private property. The owners wish to emphasize that these properties are *not open to collecting or trespassing*.

MINE WORKINGS

Workings in the Silver Bill mine consist of an inclined shaft 271 feet deep, several hundred feet of drifts on the 200 level and several large stopes and winzes. The major workings are shown in Figure 6. The stope marked by a W is the site of the most recent mining and the site of substantial wulfenite production. The winze marked with a C leads to a stope commonly referred to as the copper stope. Many fine specimens of rosasite, malachite, hemimorphite and smithsonite have been found there.

The Mystery tunnel connects with the Silver Bill workings at point M. This tunnel (actually an adit) is about 900 feet long and has its portal on the east side of Gleeson Ridge. The Mystery mine is owned by Union Oil Company.

ORE DEPOSITS

The lead-silver and copper-zinc deposits of the Silver Bill mine occur chiefly as replacements in the Pennsylvania-age Naco limestone. Individual orebodies seem to be localized in limestone immediately below a bedding plane fault that dips to the east (Wilson, 1927) or associated with numerous northeast-trending faults and fractures (see Fig. 7). The ore is completely oxidized.

The ore probably originally consisted of galena, sphalerite, pyrite and chalcopyrite (Wilson, 1927). Upon oxidation, the lead and silver apparently stayed essentially in place and formed rich deposits of almost pure cerussite. In the stope mined during 1978 by the author and his partner, boulders of cerussite up to 10 feet thick were found. It is interesting to note that the ore mined in 1978 contained only a trace of zinc and copper. Wilson (1927) reports that most of the lead ore mined in other areas of the mine contained up to 2 percent zinc.

Both copper and zinc apparently migrated during oxidation of the ore, and were deposited some distance below the lead ore. In the copper stope which lies below the 200 level, copper and zinc minerals occur along fractures and solution cavities up to 50 feet below the last signs of lead mineralization.

MINERALS

Minerals of special interest to collectors or that are important ore minerals are listed below.

Lead minerals

anglesite	plattnerite
cerussite	wulfenite
coronadoite	

Copper minerals

azurite	malachite

Zinc minerals

aurichalcite	rosasite
hemimorphite	smithsonite

Silver

chlorargyrite

The lead minerals are widespread throughout the Silver Bill, both on and above the 200 level. Based on the 1978 mining experience, wulfenite was probably abundant during the earlier mining. Likewise, experience in the copper stope indicates it was probably a collector's dream, but it is unknown whether any of the copper or zinc specimens were saved when this stope was mined during the late 1920's.

The following descriptions of the minerals and their occurrences are based principally on field observations made by the author during the course of mining at the Silver Bill in 1978.

Anglesite $PbSO_4$

Anglesite is reported by Wilson (1927). None of the large cerussite boulders encountered in 1978 contained any remnants of anglesite or galena.

Cerussite $PbCO_3$

Cerussite is the dominant lead ore in the Silver Bill mine. It occurs as massive boulders of coarse-grained cerussite. Occasional zones of "sand" cerussite are encountered. The "sand" consists of small ½ to ¾-inch clusters of reticulated crystals which make very interesting micromounts.

Coronadoite $Pb(Mn)_8O_{16}$

Coronadoite has been found by George Godas, a Tucson collector. As micromounts the coronadoite occurs as long, thin needles impaling quartz crystals (Roe, 1980).

Plattnerite PbO_2

Plattnerite occurs frequently in cavities that overlie the cerussite orebodies. The crystals are quite small, less than 1/16 inch, and are usually associated with calcite. One pocket of smithsonite found in the copper stope contained abundant plattnerite.

Wulfenite $PbMoO_4$

Wulfenite occurs in many areas of the Silver Bill, but the greatest abundance has been found in the newest workings of the mine where it is intimately associated with cerussite. In this new stope wulfenite was found surrounding cerussite boulders in the footwall of the ore zone, and in solution cavities inside the large masses of cerussite. It is in these cavities that the most desirable wulfenite has been found. The cavities are usually completely filled with almost free-floating clusters up to 6 by 6 inches of yellow to yellowish orange wufenite. The crystal size in these clusters is usually under ¼ inch, but the profusion of crystals and the color make for very attractive specimens.

Wulfenite found in the wall between the boulders or in the footwall tends to form in slightly larger crystals, but the color is often not as pleasing as the wulfenite from within the boulders. One particular pocket yielded three flats of specimens having crystals up to ¾ inch on edge and up to 1/16 inch thick.

Much of the wulfenite from the Silver Bill is distinguished by well-formed phantoms. Popular opinion seems to be that the phantoms are due to the oscillations of the water table on Gleeson Ridge during formation of the wulfenite. The crystal morphology often changed during the growth of the crystals. Several examples of wulfenite having a distinctive red dot in the center of the crystal were found by the author and Tom Hughes in the copper stope. These are reminiscent of the red-dot wulfenite from the 79 mine, but the red dot is much more apparent in the Silver Bill specimens.

Azurite $Cu(CO_3)_2(OH)_2$

Although the mines near Gleeson are sometimes cited as a source of Bisbee-type azurite and malachite, there is no evidence that the Silver Bill mine ever produced good azurite specimens. In the copper stopes, azurite is sometimes found in the center of incompletely replaced pseudomorphs of malachite after azurite.

Malachite $Cu_2(CO_3)(OH)_2$

Malachite is found principally as pseudomorphs after azurite and rarely as botryoidal specimens. Almost all the malachite specimens produced from the copper stope are coated to some degree by rosasite, aurchalcite, or, rarely, smithsonite. These coatings result in very interesting and attractive malachite specimens. Because of the distinctive coatings, it is doubtful that these would be mistaken for Bisbee specimens.

The malachite pseudomorphs vary in size from ⅛ inch to about 1¼ inches in largest dimension. The specimens have been typically of small cabinet or smaller in size, although the Arizona-Sonora Desert Museum has one plate measuring 4 by 12 inches, composed of pseudomorphs 1 to 1¼ inches in size.

Aurichalcite $(Zn,Cu)_5(CO_3)_2(OH)_6$

Aurichalcite is common in the copper stope, but is rarely found as good specimens other than micromounts. As micromounts the aurichalcite is superb, especially when in association with rosasite and hemimorphite.

Hemimorphite $Zn_4Si_2O_7(OH)_2H_2O$

Hemimorphite occurs in several forms. The most attractive specimens are white balls up to an inch in diameter associated with rosasite. Rarer, but very interesting, are hollow hemispheres up to an inch, but these specimens are very difficult to collect whole because they are so fragile. Crystals up to ¾ inch can be found, but they are fairly rare.

Hemimorphite and aurichalcite in general appear to have formed later than rosasite.

Rosasite $(Cu,Zn)_2(CO_3)(OH)_2$

The Silver Bill rosasite rivals or surpasses the material from Bisbee and Mapimi. The color is an especially attractive blue green, although it can vary from light blue to dark green. Specimens range from isolated balls up to ⅜ inch in diameter, on a "wad" matrix, to large uniform masses up to 6 by 9 inches with no matrix.

Rosasite also occurs as pseudomorphs after azurite although only rarely is the replacement complete. Usually the pseudomorphs are part malachite and part rosasite.

Rosasite from the Silver Bill mine has a very soft surface and can be easily bruised and marked. Fortunately, these bruises and marks can sometimes be removed by spraying the specimen with a very fine water spray such as from a common spray bottle with a variable size nozzle. Best results are obtained by holding the specimen very close to the spray bottle. The spray seems to "fluff up" the surface layer of rosasite and to erase any bruises or marks.

Smithsonite $ZnCO_3$

Probably the most abundant zinc mineral in the copper stope is smithsonite, but good specimens are rare. Most of the smithsonite is the massive dry-bone type and is easily mistaken for massive limestone.

Of most interest to collectors is the sky-blue botryoidal smithsonite that is difficult to distinguish from the famous Kelly mine material. Unfortunately, very little of this high-quality smithsonite has been found. More likely to be found are smithsonite and rosasite associations or, occasionally, a pale blue or green smithsonite in the form of small ⅛-inch curved rhombohedrons.

Chlorargyrite AgCl

This silver mineral is certainly not abundant in the Silver Bill workings. A few micromount specimens have been found in recent years (Roe, 1980).

ACKNOWLEDGMENTS

The author wishes to thank Madeline Lewis and Scott Lewis of Tucson, Arizona, for permission to publish this paper.

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cuprian fraipontite and sauconite from the Defiance-Silver Bill mines Gleeson, Arizona

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INTRODUCTION

Samples of the various minerals from the Defiance-Silver Bill mines, near Gleeson, Arizona, were collected on the dumps by W. E. Dibble in 1973. The Defiance mine area and its mineralogy have been described recently by Thompson (1980), and the Silver Bill mine by Knudsen (1983). Our X-ray diffraction studies of fine-grained, light blue-green, material previously identified as "chrysocolla" or "turquoise" showed much of the material to be the rare mineral species fraipontite, $(Zn,Cu,Al)_3(Si,Al)_2O_5(OH)_4$, with or without admixed sauconite (Zn-montmorillonite). Fraipontite has been described from only three other world occurrences (Moresnet, Belgium; Laurion, Greece; and Tsumeb, Namibia). Additional material was collected from the Defiance dump by E. E. Foord and W. E. Dibble in 1977.

DATA and DISCUSSION

At the time this study was begun on the Defiance material (1973) the status of the mineral fraipontite was in doubt. It was described by Cesaro (1927) from near Moresnet in the Vielle Montagne mines in eastern Belgium. A definitive study was carried out on type material by Fransolet and Bourguignon (1975). Subsequently, an article was published on a cuprian (11.6 weight percent CuO) fraipontite from Laurion, Greece (Dimitriadis, 1977). Recently, Keller and Bartelke (1982) described an occurrence of fraipontite from Tsumeb, Namibia.

With the publication of the paper by Fransolet and Bourguignon (1975), and that of Dimitriadis (1977), further stimulation was given to complete study of the material from the Defiance-Silver Bill mine dumps. A microprobe analysis (by EEF) and an X-ray fluorescence analysis (JET) gave the following average analysis: **SiO_2** 24.8, **Al_2O_3** 17.3, **CaO** 0.34, **CuO** 5.2, **ZnO** 40.95, **H_2O** (total) as LOI (loss on ignition) at 900°C 12.8, **total** 101.39. The microprobe analysis was done using an ARL EMX instrument, 15 KV, 0.03 microamps sample current, 10 micron beam diameter, with garnet as a standard for Ca, quartz as a Si standard, Al_2O_3 as the Al standard and pure metals for Zn and Cu. Data were reduced by the MAGIC IV program of J. W. Colby. The XRF analysis was done on a 0.08 gram sample, fused with 8 grams of lithium tetraborate at 1120°C for 17 minutes, on a PW1600 instrument.

Calculation of a structural formula using gram equivalents (as per Fransolet and Bourguignon, 1975) yielded: $(Zn_{1.84}Al_{0.77}Cu_{0.24}\square_{0.13}Ca_{0.02})_{3.00}(Si_{1.51}Al_{0.49})_{2.00}O_5(OH)_4$ on the basis of seven oxygen equivalents. The ideal formula of fraipontite, allowing for substitution of Cu for Zn, is $(Zn,Cu,Al)_3(Si,Al)_2O_5(OH)_4$ or $([Zn,Cu]_{3-x}Al_x(Si_{2-x}Al_x)O_5(OH)_4$. Semiquantitative emission spectrographic analysis (NMC) of the cuprian fraipontite showed: **Fe** 0.007 percent, **Mg** 0.01 percent, **Ca** 0.07 percent, **Si** 10 percent, **Al**- major, Na 0.015 percent (by rare alkali method), **Zn** major, **Cu** 5 percent, **Mn** 15 ppm, **B** 150 ppm, **Be** 7 ppm, **Ni** 50 ppm, **Pb** 15 ppm, **Sc** 15 ppm, **Ga** 70 ppm, **Ag** 1 ppm, all others not detected at respective limits of detection.

A refinement of unit cell parameters of the Defiance fraipontite compares very well with that of the type Belgian material: Defiance: *a* 5.331(8) Å, *b* 9.23(1) Å, *c* 7.275(6) Å, beta 104.15°; Moresnet: *a* 5.372 Å, b 9.246 Å, *c* 7.273 Å, beta 103.55° (Fransolet and Bourguignon, 1975). The refinement was done using Cu $K\alpha_1$ radiation with CaF_2 as an internal standard.

Specific gravity determined by Berman balance and Clerici-water solution refractive index determination methods yielded 3.08 g/cm^3

and 3.10 g/cm^3 respectively. A calculated density using the above chemical analysis and determined cell volume was 3.44. The discrepancy is most likely due to the fine grain size and consequently increased void space. Hardness of dense aggregates of the fraipontite is about 3.5 to 4, streak is white to pale green, not magnetic, and the mineral is not fluorescent under ultraviolet radiation. Because of the extremely fine grain size (less than 2 microns) complete optical properties could not be determined. The mean refractive index is about 1.61 and the birefringence is moderate.

Only a few pieces of light blue-green material collected proved to be pure fraipontite. Most were admixtures of sauconite, $X_{0.33}Zn_3(Si,Al)_4O_{10}(OH)_2 \cdot 4H_2O$, and fraipontite. A few specimens were composed nearly entirely of sauconite. Sauconite appears to possibly be forming from fraipontite but this is not definite, as material was not observed in place underground. In places sauconite forms stalactitic coatings in open cavities. An XRF analysis (JET) of the sauconite with some admixed (10 to 20 percent) fraipontite gave: **SiO_2** 32.8, **Al_2O_3** 10.9, **MgO** $<$ 0.1, **CaO** 1.51, **Na_2O** $<$ 0.2, K_2**O** $<$ 0.02, **TiO_2** $<$ 0.02, P_2**O_4** $<$ 0.02, **MnO** $<$ 0.02, **CuO** 4.65, **ZnO** 39.9, LOI at 900°C 13.9, **total** 103.7.

Formulation of the sauconite, assuming 20 weight percent (determined by X-ray diffraction studies) admixed fraipontite, was: $Ca_{0.18}Zn_{0.14}(Al_{0.16}Cu_{0.31}Zn_{2.53})_{3.00}(Al_{0.83}\,Si_{3.17})_{4.00}O_{10}(OH)_2 \cdot 4H_2O$ on the basis of 11 oxygen equivalents. The interlayer charge is +0.64 which is higher than that expected for a normal Na-sauconite (0.33) and may be due to vermiculite-type interlayers and/or improper assignment of the role of the exchangeable cations. Cation-exchange work was not possible on this material because of the paucity of sample.

The sauconite was examined by X-ray diffraction at 25°C as an air-dried sample prepared by the filter-membrane peel technique (Drever, 1973). This technique enhances the basal spacing reflections. Approximately 10 to 20 percent admixed fraipontite was also present. Glycolation caused some expansion from 15Å to around 16.2Å, similar to results obtained for other sauconites by Faust (1951). The fraipontite peaks showed no shift in position. Heating to 350°C for one hour caused collapse of the sauconite structure to about 9.8Å which is expected for sauconite. No (OH) interlayers were found to be present. Again there was no shift of the fraipontite lines. Intensities of diffraction peaks for both minerals were somewhat diminished. Additional heating to 550°C for one hour resulted in destruction of the fraipontite and some additional diminishing of the intensities for sauconite reflecting some loss of (OH). Examination of the position of the 060 reflection showed the sauconite to be fully trioctahedral. Destruction of the Belgian fraipontite occurred at about 425°C (Fransolet and Bourguignon, 1975). Higher temperatures of heating (600°C–1000°C) for the Belgian material resulted in formation of zincite, gahnite, and willemite as recrystallization products with increasing temperature.

An emission spectrographic analysis (NMC) of the pale blue green sauconite gave: **Fe** 0.01 percent, **Mg** 0.03 percent, **Ca** 0.5 percent, **Si** 10 percent, **Al** 1.0 percent, **Na** not detected at 1 percent, **Mn** 15 ppm, **Ag** 1.5 ppm, **B** 10 ppm, **Ba** 3 ppm, **Cu** 5 percent, **Ni** 30 ppm, **Pb** 100 ppm, **Sc** 15 ppm, **Zn** major, and other elements not detected at the respective limits of detection.

The fraipontite described by Fransolet and Bourguignon (1975) was characterized as a Zn-berthierine (kaolin-serpentine group) while that of Dimitriadis (1977), because of a significantly higher aluminum content, was described as a variety of septechlorite. Following the nomenclature reported by Bailey (1980) the term septechlorite as adopted by Dimitriadis (1977) should be dropped. The fraipontite from Laurion, Greece, could be considered as a high-aluminum serpentine. The X-ray diffraction pattern of the cuprian fraipontite from Greece has relatively few strong reflections and few reflections overall which may be due to disordering. The Defiance-Silver Bill fraipontite is well crystallized (and well ordered?), as is the sauconite, and gives a pattern very closely matching that of the type material from Belgium.

CONCLUSIONS

Because of the similar appearance of fraipontite from the Defiance mine to chrysocolla and/or turquoise, it is suggested that perhaps fraipontite has been overlooked at other localities. Additional quantities of fraipontite and sauconite are present on the dumps of the Defiance-Silver Bill mines.

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THE HISTORICAL RECORD

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Intrepid pioneers and prospectors wandering over arid deserts and high mountains; ferocious Indians and outlaws; a vast, untamed wilderness fraught with natural perils: this was the Arizona of history, and one doesn't have to go back too far to find evidence of it. In August of 1901, W. A. Rich wrote a letter back East, telling of some of his experiences (*The Mineral Collector,* vol. 8, no. 6).

> I went out to Arizona last January to discover, if possible, the old turquoise mines and the placer gold mines which were worked by the Aztec Indians. I located the ruins all right and it would take a long letter to describe them. The works are very extensive, especially the placer mines, but have been deserted for nearly 1000 years. [Ed. note: there were never any Aztecs in Arizona.]
>
> After devoting the necessary time to the work named I determined to try and locate a copper mine of which I had been told by an old prospector. I expect to go out again for a few weeks very soon, but I dread the trip. The heat of those arid lands is terrific. The water, when you can find any, is alkaline, and one can travel days without seeing a drop, except what he carries. And the rattlesnakes, scorpions, centipedes, tarantulas, Gila monsters, and a host of poisonous insects, added to a temperature of 110 to 140 degrees in the shade, make the summer months anything but pleasant. But the nights are cool. The air is exceedingly dry and the land too.
>
> No timber of any kind, only scrub mesquite, ironwood, palo verde and cacti of all description, from the little echineses to the towering Sejolla [Saguaro] and that concentrated essence of hell called the cholla, whose millions of pricks beat the quills of a porcupine in sharpness, length, and poison. There are thousands of square miles of placer grounds, where the gold could be panned at from $2 to $50 to the yard of sand, if only water could be had, and copper everywhere.
>
> I brought home a Gila monster, 22 inches long. This fellow is alive and growing finely. Mr. Gilman Brown of West Newbury, Mass. has him and he is a black mouthed, black tongued, black hearted cuss. I think Mr. Brown is feeding him on Sunday-school children to see if he can change the exceeding wickedness of his make-up, but I fear the supply of food will fail before he is converted.
>
> Take a run out with me this month. I will guarantee you a rattlesnake six or seven feet long, plenty of jack rabbits and cotton tails, some wild pigs and antelopes, and a million, more or less, blue quail. And I will show you how to cook eggs without a fire – just put them in the sand, and the sun does the rest.

But, with all the hazards and pitfalls in this hostile country, there were great fortunes to be made by those who dared. From the August, 1895, issue of *The Mineral Collector* (vol. 2, no. 6) comes this inspiring story:

> Hackberry, Arizona, June 24. – From Peach Springs comes the story of the finding of a nugget, or boulder, rather, of pure silver, such as there has been no record of in the history of mining in the West. The boulder weighed about half a ton, and its value is anywhere from $8,000 to $10,000. It was found by William Tucker and John Doyle, both old prospectors, and they have kept the facts to themselves heretofore because of the chance that there was more silver where this lump came from, and they desired to get the best location for themselves before letting the rest of the world into the secret.

Not all of Arizona's wealth was just waiting to be found by the persistent prospector, however. Some of those riches had to be torn from the grip of Mother Earth, and only remarkable ingenuity could have led to some of the methods that were used. The following article published in 1896 speaks for itself.

Arizona Mining Ants

"It's as monotonous as herding sheep, and that's saying a good deal. However, I sold out at a profit of 100 percent, and I'm going to devote the future to some other occupation."

That is how J. W. Blundon, formerly of Winslow, A. T., summed up his experience as the owner of a lot of red-ant colonies, and the utilization of the little fellows as jewel miners in the petrified region of Arizona.

"The termite miners are vicious little red fellows. I purchased a half interest in sixty colonies shortly after I reached Winslow. A colony means an uncertain number of ants. They swarm and live in factions, and are subject to the most stringent rules. When you buy a colony you may get a thousand or a billion ants; it all depends upon the disposition of the termite-ruler.

"The ants are natural-born miners as well as fighters. They will attack a man in a holy minute, and if he does not retreat they will swarm over him from head to foot, and literally pinch him to death.

"In the Winslow country, the land is of peculiar formation. The ground is filled with natural jewels, such as garnets, opals, quartz crystals, fake diamonds, rubies, and a lot of other stones that look mighty fine when they are polished and put in a ring. Water is scarce in those parts and there is no talking about ground sluicing or rigging a hydraulic on the land.

"Now, about the ants. You have to take a water cart and wear high gum boots. Then you must have good broad wooden shovels. All of a sudden you go to your colony, scoop up the ants with the wooden shovel, dump them in the carts, and then you start for the jewel mines. The ants won't go away. Of course, you may loose one or two from the cart, but they are death on swarming, and I never knew one of them to touch a horse. In fact they are not curious when they are being taken out to work.

"When we reach the place where the ants are to work we take our shovels and dump them out without ceremony. The ants begin to burrow at once. First they strike the fine hot sand of the desert. This the ants deposit in a ring which is remarkable for its symmetry. Then comes the coarse gravel, and it is deposited in a circle outside the sand.

"When the gravel and coarse sand layers are complete, we begin to look out for the jewels. Suddenly a cardinal-hued termite miner will come up with something in his claws. He will pass beyond the sand and gravel layers and start new strata on the outer edge. This fellow will be followed by his thousand or more mates, and when the sun goes down they will have made a new home, besides doing duty for their owners.

"You can't imagine a more monotonous existence," concluded

ON THE ROAD.

Mr. Blundon. "You buy your ants, take them to the petrified region, dump them out, and there you are. You never hear a sound. Day after day you go about the hills and pick up the brilliants, the garnets, and the rubies, as well as other mineral creations of the strange land of Arizona. When it's all over you will have cleared up about $10 a day, provided you can sell your rough gems in San Francisco or St. Louis."

The Mineral Collector
vol. 3, no. 2, April 1896

But what of all the fabulous sources of fine minerals that we have come to associate with Arizona? Many superb specimens came out in the 1800's before the advent of modern mining methods. Maynard Bixby must have had the same question in mind when he undertook a journey to Globe, Arizona, in 1897 and, according to him, just barely survived to tell about it:

Arizona is not a particularly pleasant region to travel through, even the best of it, and the journey to Globe from the railroad is exceedingly tiresome, not more or less interesting from the fact that the stage-road passes through the San Carlos Indian reservation, where the Government has corralled the villainous Apaches.

In answer to my inquiry as to Geronimo, the terminus of the railroad, whence stages leave for Globe, I was informed that there were about a hundred men in the town, half of whom had killed a man each. This was not reassuring, but I thought it might be another to add to my list of experiences.

In Geronimo everything was serene, it was said, because the town had lately taken on virtuous airs, and numbers of undesirable denizens had been forced to take hasty leave. Beds were scarce and of divers character, but 'grub' and 'firewater' were said to be abundant, quality not considered. The floor was occupied, but I managed to get a spring affair, probably spring of '65, where sleep failed to woo me to any great extent.

About 2 a.m. the driver of the stage entered, and announced that passengers for Globe would have to 'dig out,' whereat there arose considerable shuffling of boots and clatter of luggage, and after the usual Arizona breakfast, a sleepy party was bundled into the old thorough brace 'mud-wagon,' and we were off for Globe.

We soon began to pass Apache bucks and squaws on ponies, and driving wagons loaded with wood, and sometimes the whole family, going to San Carlos to draw rations, as it happened to be slaughtering day at the Post, when fresh beef is distributed. I was told that the blood from the abbatoir was considered a choice beverage by the Apache squaws.

We were constantly passing long trains of freight wagons, and to their cutting up the road was due the appetizing jolting we had been enduring, so that it was a welcome event when we pulled up at the Post and alighted for dinner.

A miner's 'grub' would be angels' food compared to the stuff set before us by the Chinaman who executed the eatables, and vigorous kicks were in order, but we had to take the dose or nothing, for the four bits damage done our purses and vastly more to our outraged gastronomy. San Carlos Agency is pleasantly situated at a fertile bend of the Gila, and some land appeared to be under cultivation by the Indians. The murderous band once led by Geronimo, is among the savages watched by the few regulars at the post, and very few travelers take the road unarmed.

The road from San Carlos is a weary uphill grind for twenty miles or so, and one becomes so tired and sleepy, that neither the geology nor the giant cactus seem to stimulate interest. The hills are almost bare of trees, and water is a rarity, until we near the mining camp. A stream of uncertain size occasionally flows by the town, which at first sight appears to be somewhat more endurable than some of the other copper mining camps in Arizona.

Mexicans, freighters, miners, and the omnipresent saloon seem to hold the principal street, while the mines and works are from one to eight miles away.

The mines belonging to the Old Dominion Co., as well as two or three others in the district, were working, but very little in the way of cabinet minerals was to be had anywhere. A few local collections contained an occasional fine specimen, and these were the only sources of supply.

Of all the magnificent velvet malachite found in former years, not a single fine piece remains in the camp. Fine octahedral cuprite crystals on copper were formerly obtained, but now only from some of the collections.

The beautiful quartz on chrysocolla is now found only in the collections of the town. A late find was a very few octahedrons of copper in groups, and occasionally very perfect single crystals.

Chalcotrichite occurs rarely at the Old Dominion Mine, generally coating or enclosed in calcite, and probably less than a dozen specimens have been found. A few specimens of calcite have been collected very rich in native silver, usually crystallized in beautiful and delicate feathery forms.

Several other copper mines are being opened, and possibly some of the former beautiful minerals may again appear.

At Richmond Basin, about 20 miles distant, rare specimens of crystallized silver in rolled nuggets have been found loose in the soil. I obtained one weighing several pounds, and a larger piece weighing about 30 lbs. was taken out several years ago. Placer silver is more abundant at this camp than at any place I have known, and in fact these nuggets are the largest and rarest of this metal in the United States.

Fluorite occurs here in large purple crystals, on the dump of one of the prospects. In all, Globe is an exceedingly poor place, at present, for the mineral collector.

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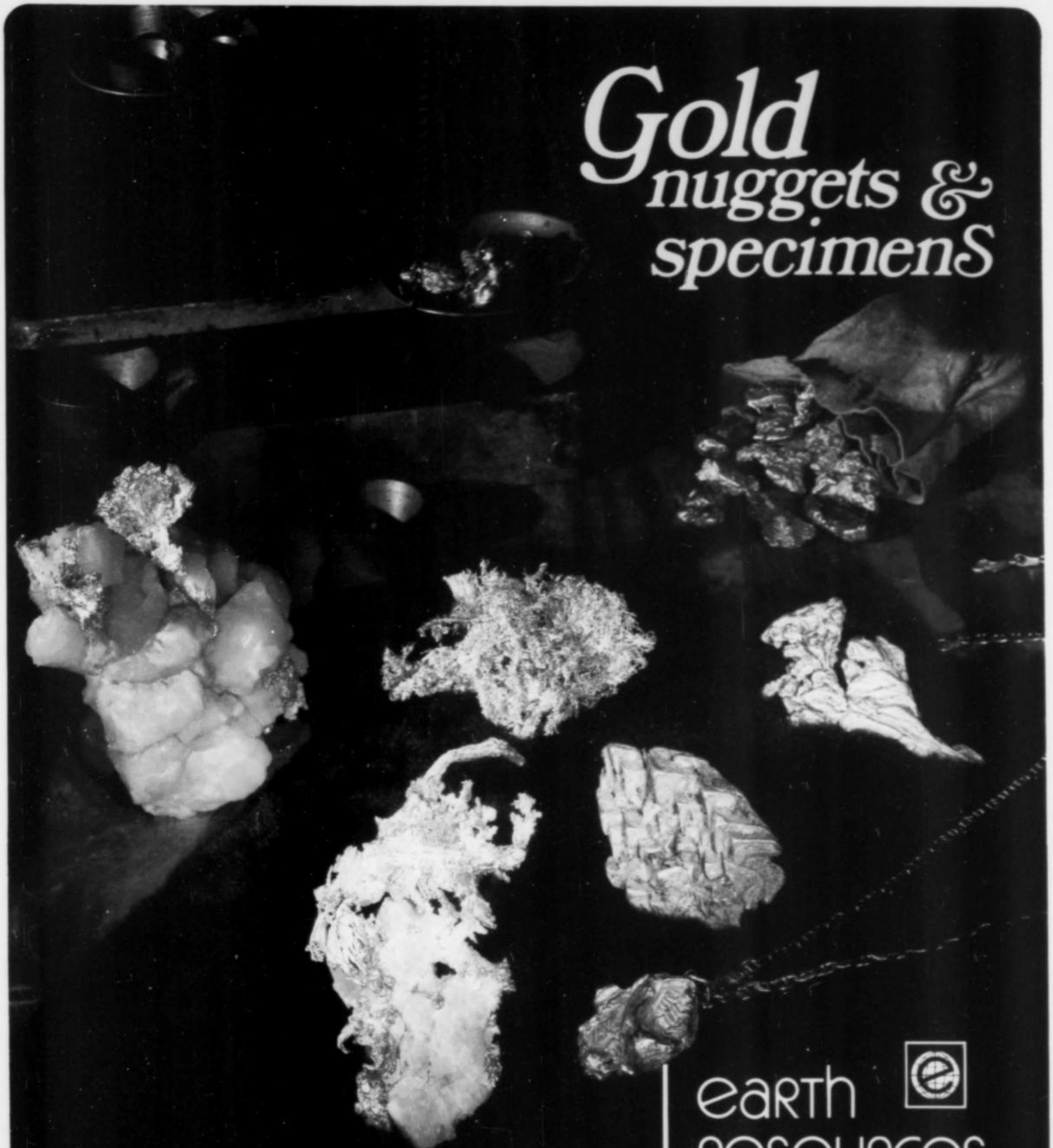
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