NEVADA

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January–February 1985
Volume Sixteen, Number One

NEVADA

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Wendell E. Wilson

Circulation Manager
Mary Lynn Michela

Promotions and Book Sales
Gale Thomssen

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Editing, advertising
Wendell E. Wilson
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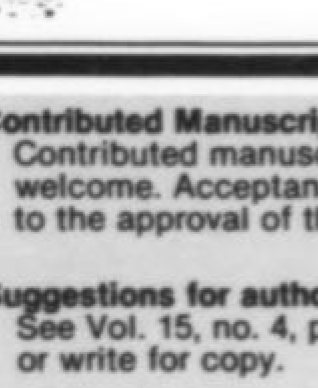


COVER: REALGAR, 8 cm tall, from the Getchell mine (see article in this issue). Barbara Cureton collection, self collected; photo by Wendell E. Wilson.

NEVADA

Nevada is a state rich in history and rich in minerals, though even by American standards its history began rather late. Aside from one Franciscan friar whose trail from Sonora to California briefly crossed the state's southern tip in 1775, no European set foot in Nevada until a group of Hudson's Bay Company trappers stumbled upon the Humboldt River in 1825. An occasional military expedition and California-bound trading party ventured through in the following years, but it wasn't until 1849 that a permanent settlement was established by a group of Mormons at Genoa, south of present-day Carson City. The following year some placer gold was found in Carson Valley, a discovery which, nine years later, led prospectors to the unsuspected and unbelievable wealth of the Comstock Lode. Ironically, the trail of placer gold they followed came not from the Comstock Lode at all but from many small gold veins riddling the hills near present-day Silver City.

At the close of the war with Mexico in 1848, Nevada became American territory; it was at that time a part of California known as Washoe country. Two years later it was included in the new Territory of Utah, and in 1861 was formally split off as Nevada Territory. The name was drawn from the Sierra Nevadas, Spanish for *snow-capped.* By this time, Virginia City, on the Comstock, was the most famous mining camp in the West. Statehood was granted in 1864 when Republicans in Congress realized a need for two more Senate votes on critical legislation. The short period, 1861–1864, during which Nevada was a territory accounts for the rarity (and high collector value) of stocks and other paper collectibles marked "N.T." or "Nevada Territory."

The Comstock became the first major silver mining camp in the United States, and it rejuvenated neighboring California, then suffering a post-gold-rush depression. Miners flocked in from California and prospected throughout Nevada and neighboring territories. Mining towns sprang up at Austin, Hamilton, Eureka and Belmont. Gold was found in Colorado in 1860, and in Idaho and Montana shortly thereafter. During the Civil War, President Lincoln remarked that the wealth from the Comstock, "made it possible for the Government to maintain sufficient credit to continue this terrible war." Additional Comstock bonanzas in the 1870s aided postwar reconstruction. The complex and fascinating history of the Comstock reads like an epic novel, only the beginning of which is recounted in Art Smith's article in this issue; see his list of references for additional reading.

The Comstock dominated the Nevada mining scene for many years, but eventually went into decline. Ever-increasing amounts of hot water, up to 77° C (170° F), were gushing into the deep workings from every crack and drill hole. Miners were reaching the limits of endurance, and could work only a few minutes at a time while being sprayed constantly with cool water pumped down from the surface. But a new mineral belt was discovered in southern Nevada around 1900, and Tonopah and Goldfield became the new headquarters. Huge copper deposits near Ely were also found around that time, and by 1907 all were serviced by the railroad.

Many other deposits have been located since the late 1800s, some of which are well known to mineral collectors. The Getchell mine, the White Caps mine near Manhattan, and the Majuba Hill mine all produced large quantities of ore and a significant number of fine mineral specimens. Other localities such as Steamboat Springs, Garnet Hill and the Julia epidote prospect near Hawthorne, while not ore producers, have yielded many fine specimens. Thirty-five new species have been described from type localities in Nevada, giving evidence that there are plenty of mineralogically unique environments in the state.

So there you have a background and an introduction to this special issue on Nevada . . . actually, at 102 pages, an issue and a half! And we have a second Nevada issue in the planning stage.

◆

The map shown here was originally prepared by Jean DeMouthe for her article on Nevada type localities, but she graciously consented to let me move it up front as an index map for the whole issue. This makes it unnecessary to run a small Nevada index map with each article.

The antique stock certificates decorating several of the articles are from the collection of Richard Thomssen. Dick was also the organizing force behind this special issue, and much credit is due for all the time and expertise he brought to bear.

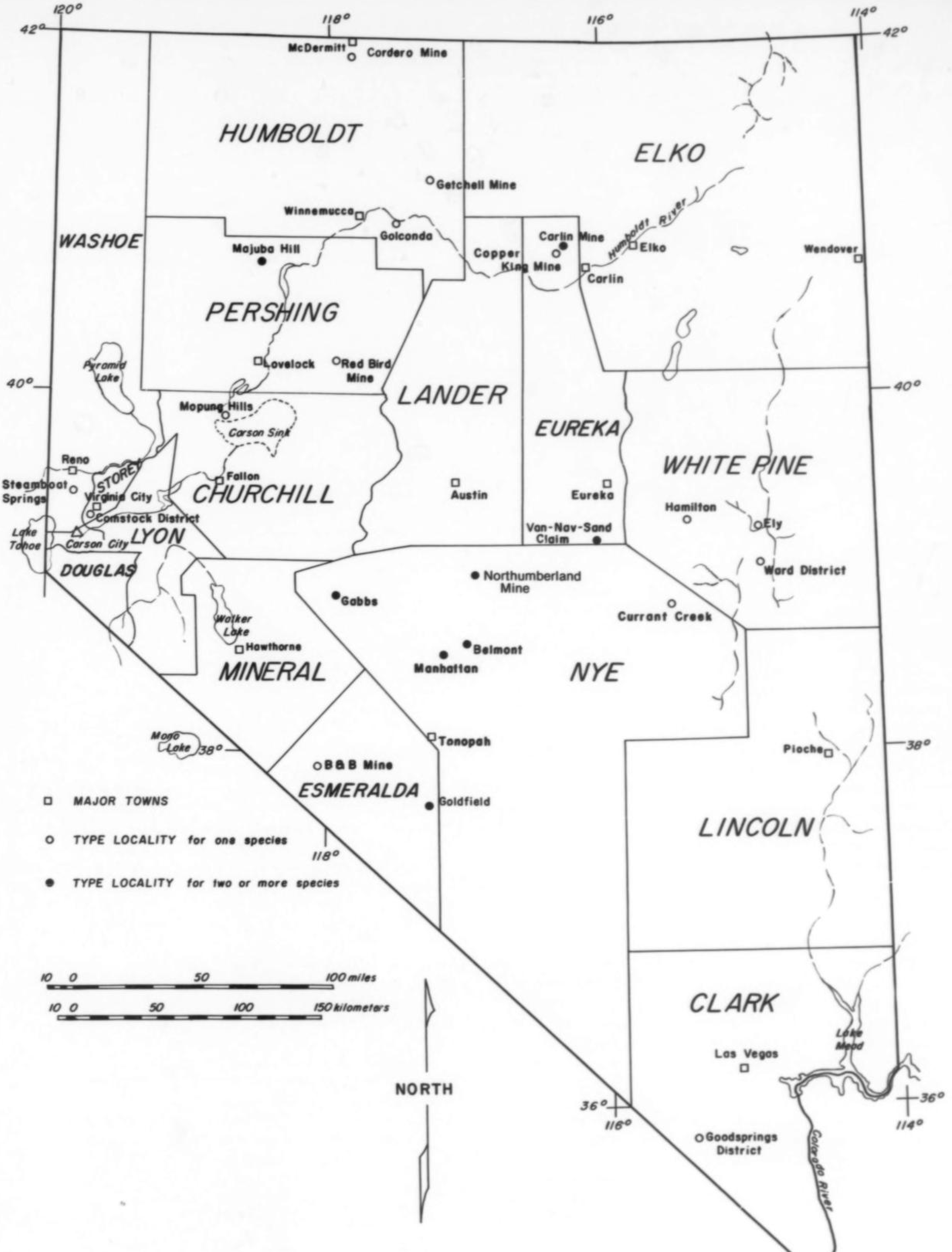
Thanks are also due the various people who loaned specimens for photography, particularly Forrest and Barbara Cureton, Carl Francis (Harvard Mineralogical Museum), Neil Prenn and Michael Smith.

To aid in preparing the annotated index of Nevada localities previously mentioned in the *Mineralogical Record,* Mike Groben kindly made available an advance copy of the Nevada section from the new cumulative index to volumes 1–14 being produced by the Friends of Mineralogy. Copies should be available by February 1, from the Mineralogical Record Book Department, at $20.00 postpaid (foreign orders add 50¢ per copy).

Our long-time benefactor, Randolph Rothschild, provided the essential support for color printing, the value of which cannot be underestimated in a journal such as ours.

And finally, like frosting on the cake, the fold-out calendar courtesy of Ken and Betty Roberts is in keeping with the Western flavor of this issue.

To all these people, and especially to the various authors, my thanks for helping to make this Nevada issue possible.


120°
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42°
42°
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116°
114°
McDermitt
Cordero Mine
HUMBOLDT
ELKO
Getchell Mine
Winnemucca
Golconda
WASHOE
Majuba Hill
Carlin Mine
Humboldt River
Elko
Copper King Mine
Carlin
Wendover
PERSHING
Pyramid Lake
Lovelock
Red Bird Mine
LANDER
Mopung Hills
Carson Sink
EUREKA
WHITE PINE
Reno
STOREY
Fallon
Steamboat Springs
Virginia City
CHURCHILL
Austin
Eureka
Hamilton
Comstock District
Van-Nav-Sand Claim
Ely
Lake Tahoe
Carson City
LYON
DOUGLAS
Northumberland Mine
Ward District
Gabbs
Currant Creek
Walker Lake
Hawthorne
Belmont
Manhattan
MINERAL
NYE
Mono Lake
Tonopah
Pioche
B&B Mine
ESMERALDA
Goldfield
□ MAJOR TOWNS
○ TYPE LOCALITY for one species
● TYPE LOCALITY for two or more species
LINCOLN
10 0 50 100 miles
10 0 50 100 150 kilometers
CLARK
Lake Mead
Las Vegas
NORTH
Goodsprings District
Colorado River

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1970–1984

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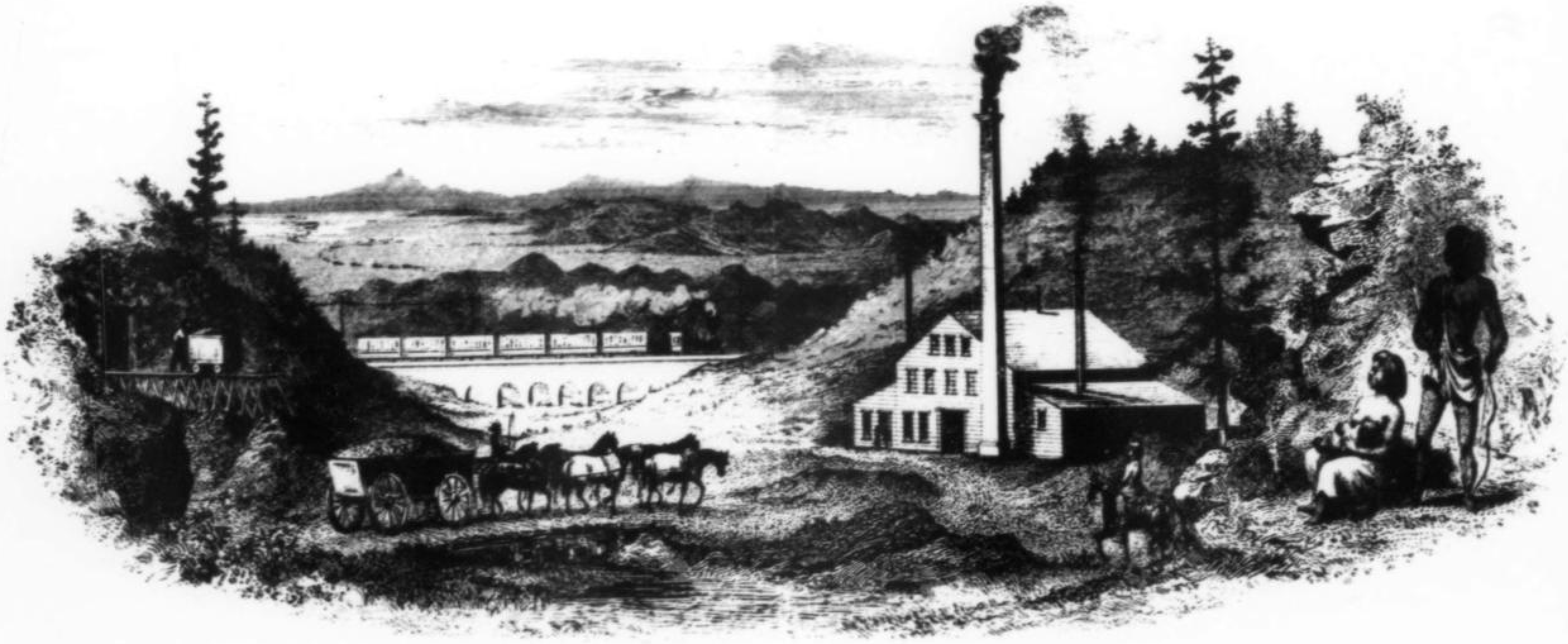


Early History of the Comstock Lode

NEVADA

Arthur E. Smith, Jr.
9118 Concho Street
Houston, Texas 77036

The Comstock Lode is among the most famous bonanzas in the long and colorful history of American mining. Since 1859 nearly $400,000,000 in gold and silver have been shipped from Virginia City. Though few fine specimens have survived, many were encountered by the miners, and tantalizing descriptions of crystal pockets were recorded by contemporary chroniclers.

The Comstock Lode story has been told and retold many times through the years. It is written in exacting detail by Grant H. Smith (1943). Contemporary accounts give less of this exactness but more of the local Western and Victorian flavor of the times in which it occurred and was written. The attempt to capture this flavor is paramount in the following account.

Dan De Quille, alias for William Wright, was on the staff of Virginia City's *Territorial Enterprise* from 1862 until its demise in 1893. His pen was very active during this time and he published numerous articles, some pamphlets and two books on the area. He was Mark Twain's supervisor during his stint with the paper. In 1889 he published a paperbound guidebook entitled, *A History of the Comstock Silver Lodes and Mines.* The following is abstracted from it:

The discovery of silver in Nevada in 1859 (then Western Utah), caused an immense excitement in California, and indeed throughout the United States. The excitement was such as had not been seen since the discovery of the gold mines of California. Permanency and ultimate value being considered, the discovery of silver undoubtedly deserves to rank in merit above the discovery of the gold mines of California, as it gives value to a much greater area of territory and furnishes employment to a much larger number of persons.

Gold was first discovered in this region in the spring of 1850. It was found in what is now known as Gold Canyon, by a company of Mormon emigrants *en route* to California. Having arrived too early to cross the Sierras, they encamped on the Carson River, where the town of Dayton now stands, to await the melting away of the snow on the mountains. To while away the time some of the men of the party tried prospecting in a large canyon that put into the river near their camp. They found gold in the first pan of gravel they washed. Looking further they soon found that certain bars and gravel banks afforded much richer pay dirt than that first tried. They were able to make from $5.00 to $8.00 a day, but left as soon as the mountains were passable, as they anticipated taking out gold by the pound on reaching California. Other emigrants who followed the Mormons did some mining in the canyon while camped on the river. All made good wages, and one or two families stopped and went regularly to work at mining. However, when the supply of water in the canyon gave out toward the end of summer, they "pulled up stakes" and crossed the mountains to California.

What was told of the mines on Gold Canyon by these emigrants induced parties of miners working in and about Placerville to visit them. During the winter and spring months, while there was water, these men were able to make from half an ounce to an ounce a day. The camp had no permanent population, however, until the winter and spring of 1852–53, when there were over 200 men at work on the bars and gravel banks along the canyon, with rockers, toms, and sluices.

As the gold found in the canyon came from quartz veins toward its head, about Silver City and Gold Hill, these early miners were even then on the track of the great Comstock Lode, but without once even suspecting the existence of such large and rich veins. The trading-post, or little hamlet near the junction of the canyon and the Carson River, which at first served as a base of supplies, was presently left far behind as the miners worked their way up the stream from bar to bar, and they founded a town of their own, on a plateau near the canyon, called Johntown. This town was situated a short distance below where Silver City now stands, and was then the "mining metropolis" of Western Utah. One dilapidated stone chimney yet stands as a monument to mark the site of this now ruined mining town.

Johntown constituted a center from which prospectors occasionally scouted forth. These prospectors had no thought of anything except placer mines – native gold in gravel deposits. In 1857 some of the Johntown miners struck paying gravel in Six-mile Canyon. This canyon is about five miles north of Gold Canyon, for the greater part of its course, but the heads of the two canyons are only about a mile apart, and both are on what is now known as the Comstock Lode. The pay found on Six-mile Canyon began only about a mile below the massive croppings that tower above the Comstock; still these early miners never once thought of going up to the head of the ravine to look for and prospect the quartz veins; all they thought of was free gold in deposits of earth and gravel.

In January, 1859, James Finney, or Fennimore, better known by his popular *soubriquet* of "Old Virginia" (he being a native of the State of Virginia), John Bishop, and a few others of the Johntown miners, struck a rich deposit of free gold in placer diggings in a little hill at the head of Gold Canyon. From this hill the town of Gold Hill derives its name. These mines were so rich that most of the Johntown people moved to them. The gold was in a deposit of decomposed quartz mingled with soil, and the miners were really delving in a part of the Comstock Lode without at first knowing that they were at work on any quartz vein. These diggings yielded gold by the pound, at times.

In the spring of 1859 several Johntowners returned to the diggings they had discovered on Six-mile Canyon two years before. With these men went Peter O'Riley and Patrick McLaughlin, but finding all the paying ground already claimed they went to the head of the canyon and began prospecting on the slope of the mountain with a rocker, leading in a small stream of water from a neighboring spring. They found but poor pay in the light top dirt they were working (for there was no washed gravel), and they had about concluded to abandon their claim when they made the grand discovery of the age. They had sunk a small pit in which to collect water for use in their rockers. It was deeper than they had yet dug. Seeing in the bottom of this hole material of a different appearance from any they had yet worked, they were tempted to try some of it in their rocker. When a bucket of this dirt was rocked out, to their great

INCORPORATED UNDER THE LAWS OF NEVADA TERRITORY.

GOLD HILL MINING DISTRICT.

No. 173

Two SHARES

The Yellow Jacket Silver Mining Company.

CAPITAL STOCK 1.200.000 DOLLARS

1200 SHARES AT $1000 EACH
One Share to the Foot.

GOLD HILL, N.T. Aug 7th 1865

This Certifies that Claus Mangels is entitled to Two (2) Shares in the Capital Stock of THE YELLOW JACKET SILVER MINING COMPANY.

Subject to assessments in the aggregate of Twenty five percent payable in instalments not exceeding Three percent in any One month.

Transferable only on the books of the Company by endorsement hereon and surrender of this Certificate.

UNITED STATES TWENTY FIVE CENTS 25 POWER OF ATTY. INTER. REVENUE

INCORPORATED February 17th 1863.

Secretary

President

Lith. Britton & Co. San Francisco

"This 'heavy black stuff,' which puzzled the two uneducated miners, was almost pure silver. They thought it some worthless base metal, and were very sorry to see it."

Stock certificates pictured are all from mines which operated on the Comstock Lode.

delight the two men saw that they had made a "strike." The whole apron of their rocker was covered with a layer of bright and glittering gold.

In that little prospect hole, silver mining in America, as now known, was born. At that moment the eyes of these two men, standing alone among the sagebrush of the rugged mountain slope, rested upon the first of many hundreds of millions in the two precious metals that have since been taken out of the Comstock Lode; for in the rocker along with the gold was a quantity of rich black sulphuret of silver. This "heavy black stuff," which not a little puzzled the two uneducated miners, was almost pure silver. They thought it was some worthless base metal and were very sorry to see it, as it clogged their rocker and interfered with the washing out of the fine gold-dust.

visitors came it was always *my* mine and *my* everything. Thus people came to talk of Comstock's mine and Comstock's vein; then it was the Comstock vein – as persons making locations asserted that they were on the same vein as Comstock, *i.e.*, the Comstock vein – and in that way the name of Comstock became fastened upon the whole lode. As the first claim was called the Ophir, that would have been a more fitting name for the whole vein than the one it now bears. For a long time Comstock no more appreciated the heavy black material that accompanied the gold, and in lumps of which much of the gold was embedded, than did O'Riley and McLaughlin. It was not until returns had been received from samples of it sent to California for assay that anyone in Nevada knew that the "heavy black stuff" was almost pure silver. With the returns of the assays came a rush from California. The assays were made at Nevada City, California, and the result so astonished the assayer that he could hardly believe his figures or his eyes. But other assays verified those first made, and the immense richness of the ore in both gold and silver could no longer be doubted. A few men were let into the secret, they let in a few more, and at once the great news spread far and wide. Soon miners, speculators, and adventurers of all kinds came over the Sierras to the silver mines in swarms. A town of tents, brush shanties, and canvas houses began to appear on the side of Mount Davidson – then known as "Sunrise Peak," as it caught the first rays of the morning sun. It was about the 1st of June when the silver was first struck, and, the weather being warm, many persons camped in the open air – cared for neither tent nor brush shanty.

SERIES B

NUMBER 1466

100 SHARES

SAN FRANCISCO, JUL 15 1908

CANCELLED AUG 28 1908

This Certifies that JAS. GARTLAND, Trustee IS ENTITLED TO ONE HUNDRED Shares in the CAPITAL STOCK OF THE

LOCATION OF MINE: STOREY CO. NEVADA

MEXICAN GOLD AND SILVER MINING COMPANY.

INCORPORATED DEC. 9th 1874.

CAPITAL 604.800 DOLLARS

201.600 SHARES $300 EACH

Transferable on the books of the Company by endorsement hereon and surrender of this Certificate.

SECRETARY

PRESIDENT.

"A gold placer, said the Mexicans, is soon worked out, but a silver mine lasts for generations and generations."

HENRY COMSTOCK. – Henry Thomas Paige Comstock, as he gave his name – has by many persons been credited with the discovery of the Comstock, but it is an honor to which he was not entitled. The credit of discovering silver in Nevada belongs to Peter O'Riley and Patrick McLaughlin. The grand discovery had been made several hours before Comstock knew of it. Toward evening on the day the "find" was made, Comstock, who had been out hunting his mustang, came to where the two men were at work. They were taking out gold by the pound and decomposed silver ore by hundreds of pounds. Comstock saw the gold and realized that a great strike had been made. He instantly determined to have a share. He at once declared that he had a claim upon the ground. He said he had located it some time before, also the water of the spring. He so blustered about his rights and so swaggered about what he could and would do that rather than have any trouble the two quiet miners agreed to take him in and give him a share of the mine.

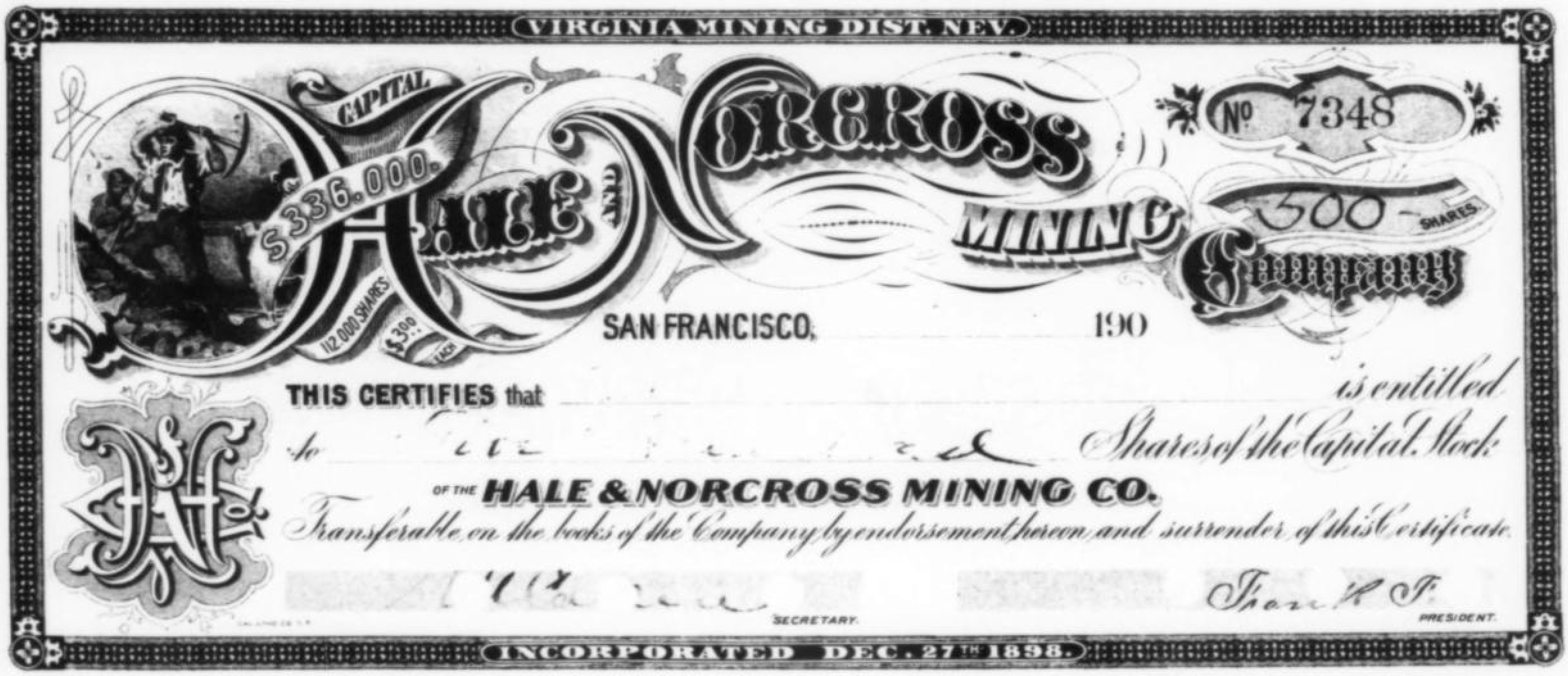
No sooner had Comstock been made a partner in the mine than he placed himself at the front in everything about it. He constituted himself superintendent, did all the talking and none of the working, and was always ready to tell strangers about the mine. When

The Fate of the Discoverers.

Although Comstock was not a discoverer, he was one of the original locators on the lode. He sold his interest for $10,000. With this he opened a store in Carson City for the sale of such goods as the trade of the country demanded; also a similar store but with a smaller stock, at Silver City. Knowing nothing of business, having no education, and being unable to keep books, he was soon "flat broke." After losing all the property he possessed in Nevada, Comstock struck out into Idaho and Montana, where he prospected for some years without success. In September, 1870, while encamped near Bozeman, Montana, *en route* to prospect in the Big Horn country, he committed suicide, blowing out his brains with his six-shooter.

Patrick McLaughlin sold his interest in the Ophir (the discovery claim) for $3,500, which sum he soon lost, and he then worked as a cook at the Green mine, in the southern part of California, for a time. He finally died while wandering from place to place and working at odd jobs, generally as a cook.

Peter O'Riley held his interest until it brought him about $50,000, a part of which he received in the shape of dividends. He erected a stone hotel on B Street, Virginia City, called the Virginia House. He then began dealing in mining stocks and soon lost everything. Under the guidance of spirits – he was a Spiritualist – he finally began running a tunnel into a bald and barren granite spur of the Sierras, near Genoa, in Douglas County, expecting to strike a richer vein than the Comstock. However, the spirits talked so much to him about caverns of gold and silver that he became insane and was sent to a private asylum at Woodbridge, California, where he soon died.



VIRGINIA MINING DIST. NEV.

CAPITAL $336.000.

112,000 SHARES $3.00 EACH

HALE AND NORCROSS MINING COMPANY

No 7348

300 SHARES.

SAN FRANCISCO, 190

THIS CERTIFIES that is entitled to Shares of the Capital Stock OF THE **HALE & NORCROSS MINING CO.** Transferable on the books of the Company by endorsement hereon and surrender of this Certificate.

SECRETARY. PRESIDENT.

INCORPORATED DEC. 27TH 1898.

"The lid, so to speak, of that wonderful ore-casket termed the Big Bonanza had been lifted off. No discovery which matches it has been made on this earth."

The men who made millions were those who came after the mines had been pretty well prospected, as Mackay, Fair, Sharon, Jones, and others.

Early Mining and Milling.

Once people became convinced of the richness, extent, and permanency of the ore deposits on the Comstock, towns were built up on the lode and at points in the valleys as if by enchantment. Machinery was brought over the Sierras under all manner of difficulties by teams, and soon mills for working the ores were built by scores. In 1859 the Americans, as a people, knew nothing about silver mining. At that time there were probably not a dozen American miners on the Pacific Coast who had ever even seen a sample of silver ore. In the California placer mines, however, were quite a number of Mexicans who had worked in silver mines in their own country. These men at once deserted their gold placers in California and came flocking over to the Sierras when the cry of "Plata! mucha plata!" was raised among them. "A gold placer," said they, "is soon worked out, but a silver mine lasts for generations and generations."

At first the word of the Mexicans was law in the new silver mines, both as regarded ore and the methods of mining and working it. Every American miner endeavored to secure a Mexican partner, or at least a Mexican foreman to take charge of his mine. Mexican methods, however, soon proved to be too slow for the Americans. Their arastras, patios, and little adobe smelting furnaces were the primitive contrivances of a non-mechanical people, and of a race of miners working as individuals, and on a very small scale at that.

The Americans at once introduced stamp mills for crushing the ore, and next introduced pans to hasten the process of amalgamation. The operation of amalgamating the crushed ore, which required days by the patio process, was reduced to hours by the use of steam-heated iron pans.

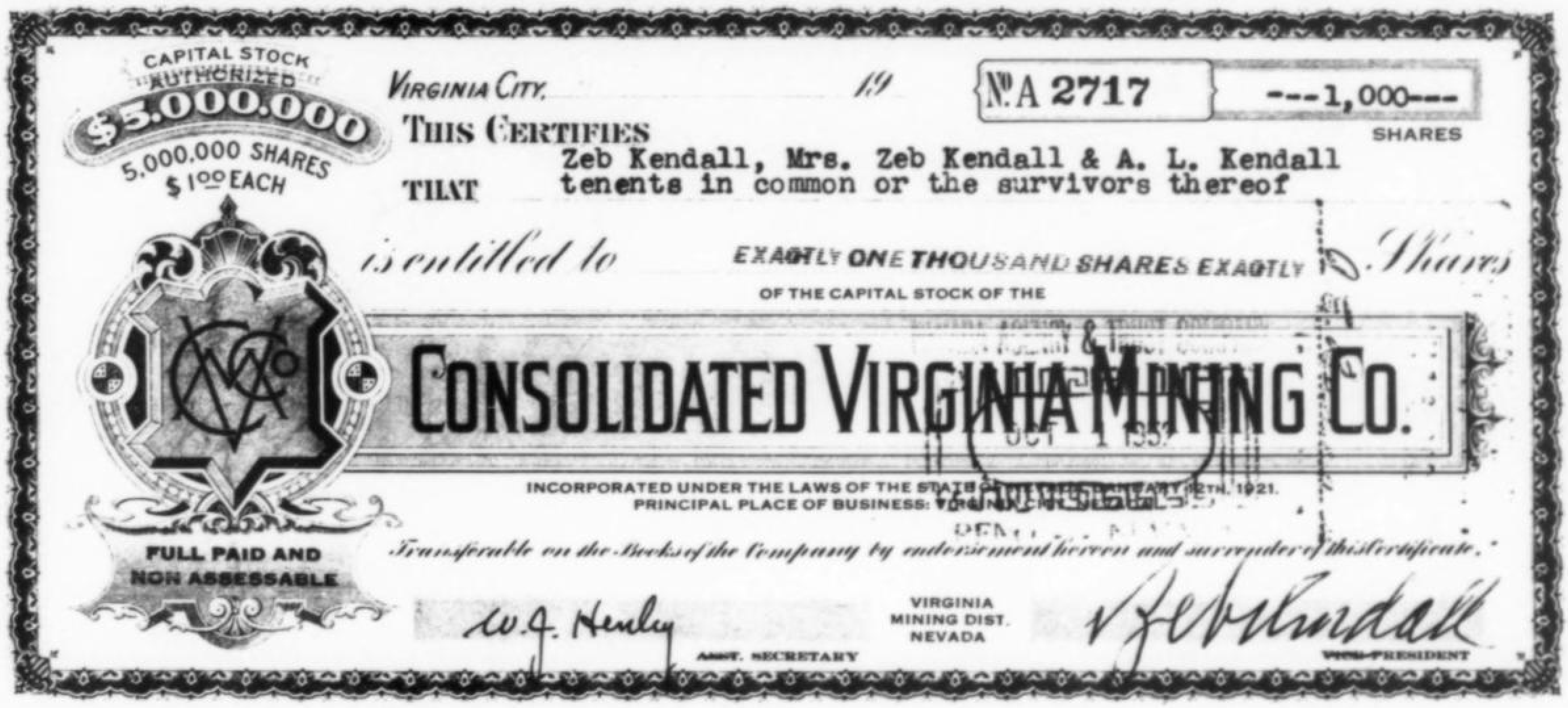
The Mexican miners were no better underground at working the vein than they were on the surface, at extracting the precious metals after the ore was mined. In the Mexican mine, where everything was managed according to their own notions – the owner being a Mexican named Gabriel Maldanado – they carried the ore out of the mine in rawhide sacks, the miners climbing to the surface by means of a series of notched poles. Their timbering was also very defective. In ore bodies so large as those of the Comstock, they did not know how to support the ground.

Among the miners working in the gold placers of California at the time of the discovery of silver on this side of the Sierras, were a few Germans who had worked in the silver mines of their "Vaterland," and among these were some half dozen who had been educated in the mining academy of Freiberg, and had received regular scientific and practical training in the art of mining. The mining and metallurgical knowledge of these men was the best then existing in any part of the world, as regarded the working of argentiferous ores. The Germans introduced the barrel process of amalgamation and the roasting of ores. While the barrel process was a great improvement on the patio, it was found not so well adapted to the rapid working of the Comstock ores as the newly invented pan process. It has also been found that the free milling ores of the lode do not require to be roasted.

Philip Deidesheimer, a German who had been appointed superintendent of the Ophir Mine, however, invented a method of timbering in "square sets," which is perfect in every respect, and which is still in use in all Comstock mines. By this method of building up squares of framed timbers an ore vein of any width may be safely worked to any height or depth; a vein 300 feet in width may as rapidly be worked as one only 10 or 20 feet wide.

Virginia City and its Surroundings.

From the tents and brush shanties set up near the Ophir Mine immediately after the discovery of silver was made, the growth of the town was rapid. The first structure worthy of the name of "house" was erected in the summer of 1859, by Lyman Jones, a pioneer miner of Gold Canyon. It was of canvas and was 18x40 feet in size. Soon several frame structures were removed from Johntown and from Dayton (then called "Chinatown") to the "new diggings" of "Ophir." Lumber from saw-mills in the foot-hills of the Sierras was then procured and a few small houses and offices erected. As there was then no wagon road up the mountain to where the city now stands it was necessary to carry lumber up to the new diggings on horses, half packing and half dragging it from the valley, where it was delivered by wagons. Very soon, however, a wagon track was made up the mountain, and building then progressed more rapidly.



CAPITAL STOCK AUTHORIZED $5.000.000

5,000,000 SHARES $1^00 EACH

VIRGINIA CITY, 19

Nº A 2717 ---1,000--- SHARES

THIS CERTIFIES THAT Zeb Kendall, Mrs. Zeb Kendall & A. L. Kendall tenents in common or the survivors thereof

is entitled to EXACTLY ONE THOUSAND SHARES EXACTLY Shares

OF THE CAPITAL STOCK OF THE

CONSOLIDATED VIRGINIA MINING CO.

INCORPORATED UNDER THE LAWS OF THE STATE OF [illegible] 12TH, 1921.
PRINCIPAL PLACE OF BUSINESS: [illegible]

Transferable on the Books of the Company by endorsement hereon and surrender of this Certificate.

FULL PAID AND NON ASSESSABLE

W. J. Henley
ASST. SECRETARY

VIRGINIA MINING DIST. NEVADA

Zeb Kendall
VICE-PRESIDENT

OCT 1 195

"The walls of the silver caverns glitter with iron and copper pyrites, regular and beautiful crystals that send out from their facets flashes of light."

At first the new mining camp had no fixed or acknowledged name. It was variously spoken of as "Ophir," "Ophir Diggings," "Pleasant Hill," and "Mount Pleasant Point," though at that time there could have been nothing very "pleasant" about the place, except the sight of the gold and silver then being dug out by the pound and by the ton almost at the surface of the ground – less than a yard below the roots of the sage-brush. Even as late as October, 1859, the place was called Ophir Diggings. About that time James Fennimore, known among the miners as "Old Virginia," was in the camp one night, having a "little run with the boys," when he fell and broke his whisky bottle against a rock. Old Virginia picked up the bottom part of the bottle, in which still remained a small quantity of the precious liquid, and, solemnly pouring it upon the ground, said, "I christen this camp Virginia!" He called upon those present to bear witness to the fact that he had duly named and christened the town in honor of himself and his native State.

Old Virginia was a favorite among the miners, and one and all declared that Virginia should be the name of the town. At first the place was called "Virginia Town," but soon the word city was tacked on to Virginia, the name by which it was christened, and Virginia City it has remained. Old Virginia had some right to name the town. He was one of the first to mine on Six-mile Canyon, working at a point now included in the eastern suburbs of the city, and he was the first man in the country to locate a quartz vein in the vicinity. This vein was a large one lying west of the Ophir, and known as the "Virginia Vein," or "Virginia Croppings." This back lead contained a vast deal of "base metal," but very little paying ore. The location was made February 22, 1858, more than a year before the discovery of silver. In July, 1861, "Old Virginia" was thrown from a "bucking" mustang, in the town of Dayton, and killed. At the time of his death he was possessed of about $3,000 in gold coin.

During the years 1860–61 the town built up very rapidly, and in 1862–63 brick and stone "fire-proof" buildings were erected in all directions, as already fires began to be of frequent occurrence. Year by year the city grew in area, population, and wealth. Building went on both summer and winter, and at times was pushed almost day and night. As the mines were opened and worked their immense richness attracted hundreds and thousands of persons from California, and all parts of the Atlantic States and Canada. Money was more plentiful and the prices paid for skilled and all other kinds of labor were far higher than anywhere else on the American continent; all articles of merchandise also brought greater prices than could anywhere else be obtained. Gold coin jingled in the pockets of all in the city – those of the drones as well as those of the workers.

After the discoveries of 1860, the development of the Comstock progressed rapidly which resulted in a boom in 1863 rapidly followed by a depression in 1864. However, mining and milling technological advances along with five shallow bonanzas, the Ophir, the Gould & Curry, the Savage, the Chollar-Potosi, the Yellow Jacket and the Gold Hill kept the yearly production at the brisk pace of from 14 to 16 million dollars. With depletion of these bonanzas and no new discoveries the yearly production dropped below 10 million dollars in 1868 and stayed there until 1871 when the discovery of a bonanza in the Crown Point brought a revival.

In 1871 a syndicate composed of Mackay, Fair, Flood and O'Brien purchased the unproductive Virginia Consolidated Mining Company. Speculative development work began in search of a possible hidden bonanza. The venture is described by Eliot Lord in his *Comstock Mining and Miners*, which was published as a United States Geological Survey Monograph in 1883:

CAPITAL 201,600 DOLLARS

201,600 SHARES $ 1.00 EACH

SERIES C

NUMBER 22453

San Francisco, 191

THIS CERTIFIES THAT

100

entitled to Shares of the

CAPITAL STOCK OF THE OPHIR SILVER MINING COMPANY.

Transferable on the books of the Company, by endorsement hereon and surrender of this Certificate.

100 SHARES

LOCATION VIRGINIA MINING DIST. NEV.

SECRETARY. PRESIDENT.

REGISTERED AND COUNTERSIGNED San Francisco APR 17 1919

INC. APRIL 30th 1860

L. LEVINSTON LITH. S.F.

"There are also found great nests of transparent and beautiful quartz crystals that are almost as brilliant as diamonds."

> Under the direction of James G. Fair a large shaft was at once projected and the work of sinking rapidly pushed. At the same time a drift from the 1,200-foot level of the Gould & Curry Mine was continued north, through the Best & Belcher, into the Consolidated Virginia section. At first the miners cut their way through barren rock; but in the Best & Belcher Mine a thin seam of ore was found, extending northward over the boundary line. This seam was traced by Mr. Fair, as the best guide through the ledge, and followed foot by foot as a thread leading to a clue. Sometimes it narrowed to a film of clay, but it was never wholly lost to the eye of the man who was seeking it as the bloodhound follows his quarry. It was traced for more than a hundred feet into the Consolidated Virginia ground, but the clue seemed as far off as ever. Others began to regard the seam as a will-o'-the-wisp and the pursuit as a wild-goose chase. More than $200,000 had been spend in the search for a bonanza, and the treasury of the Consolidated Virginia Company was nearly empty. Further assessments seemed necessary, and the available funds of the four leading stockholders were not sufficient to endure a prolonged drain. At this crisis Mr. Fair became sick and was obliged to leave the prosecution of the work to others for a month. During his absence the drift was turned toward the east and cut for many feet without success, but on his return to the mine he persisted in following the apparently endless thread. Eleven feet beyond the point where he renewed work, at a distance of 178 feet from the north boundary of the Best & Belcher Mine, a vein of ore seven feet in width, and assaying $60 to the ton, was cut in February, 1873. His judgment was justified, and the first presage of the great richness of the mine was given. Two smaller ore-bodies were found in close connection, and on the 1st day of March, 1873, the main ore-vein had widened to 12 feet, and 25 tons were taken out daily. The shaft was then 710 feet deep, and its progress was urged as rapidly as possible, for the atmosphere in the long prospecting drift was becoming unbearably foul and hot for lack of a ventilating draught, in spite of the supply of fresh air forced in constantly by powerful blowers. In October, 1873, the shaft reached the level of the drift, and the strong current which passed between the distant shafts of the Gould & Curry and Consolidated Virginia mines was welcomed as a true bonanza. In the course of a few weeks a drift ranging to the southeast cut into a rich ore-body at a point 250 feet from the shaft. Skilled miners can take out ore through a narrow drift with surprising rapidity when the work is pressed by an able superintendent. Within fourteen days a chamber was cut in the ledge from 30 to 54 feet in width and 20 feet in height, and a drift extended 140 feet through the vein. Walls, roof, and floor were still ore-surfaces, assaying from $93 to $632 per ton.
>
> The lid, so to speak, of that wonderful ore-casket, termed commonly the Big Bonanza, had been lifted off. Of its magnitude and richness all were then ignorant. No discovery which matches it has been made on this earth from the day when the first miner struck a ledge with his rude pick until the present. The plain facts are as marvellous as a Persian tale, for the young Aladdin did not see in the glittering case of the genii such fabulous riches as were lying in that dark womb of rock. The miner's pick and drill are more potent than the magician's wand. Under their resistless touch the bars of the treasure-house were broken through and its hoard revealed to

the dazzled eyes of the invaders. The wonder grew as its depths were searched out foot by foot. The bonanza was cut at a point 1,167 feet below the surface, and as the shaft went down it was pierced again at the 1,200-foot level; still the same body of ore was found, but wider and longer than above. One hundred feet deeper, and the prying pick and drill told the same story; yet another hundred feet, and the mass appeared to be still swelling. When, finally, the 1,500-foot level was reached and ore richer than any before met with was disclosed, the fancy of the coolest brains ran wild. How far this great bonanza would extend none would predict, but its expansion seemed to keep pace with the most sanguine imaginings. To explore it thoroughly was to cut it out bodily; but the systematic search through it was a continual revelation. Drifts were cut lengthwise in the mass and prolonged hundreds of feet beyond the northern boundary of the mine without passing into barren rock; crosscuts showed that its known width was from 150 to 320 feet; winzes perforated level after level as ventilating chimneys and ore-chutes, and the heart of the mass was proved to be as rich as the surface layers. The scene within this imperial treasure-chamber was a stirring sight. Cribs of timber were piled in successive stages from basement to dome four hundred feet above, and everywhere men were at work in changing shifts, descending and ascending in the crowded cages, clambering up to their assigned stopes with swinging lanterns or flickering candles, picking and drilling the crumbling ore, or pushing lines of loaded cars to the stations at the shaft. Flashes of exploding powder were blazing from the rent faces of the stopes; blasts of gas and smoke filled the connecting drifts; muffled roars echoed along the dark galleries, and at all hours a hail of rock fragments might be heard rattling on the floor of a level, and massive lumps of ore falling heavily on the slanting pile at the foot of the breast. Half-naked men could be seen rushing back through the hanging smoke to the stopes to examine the result of the blast and to shovel the fallen mass into cars or wheelbarrows. While some were shoveling ore and pushing cars, others, standing on the slippery piles, were guiding the power-drills which churned holes in the ore with incessant thumps, or cleaving the softer sulphurets with steel picks swung lightly by muscular arms.


100.000 SHARES.
CAPITAL 5 00.000 DOLLARS.
FIVE DOLLARS EACH

LOCATION
GOLD HILL MINING DIST.
STOREY CO. NEV.
SAN FRANCISCO,

No. Shares

INCORPORATED
NOV. 1904.

This Certifies, that
is entitled to Shares of the
Capital Stock of the
EXCHEQUER
Gold and Silver
MINING COMPANY
Transferable on the books of the Company by endorsement hereon and surrender of this Certificate.

SECRETARY.
PRESIDENT.

"The miners always like to find these nests of crystals, as they indicate life and strength in the vein."

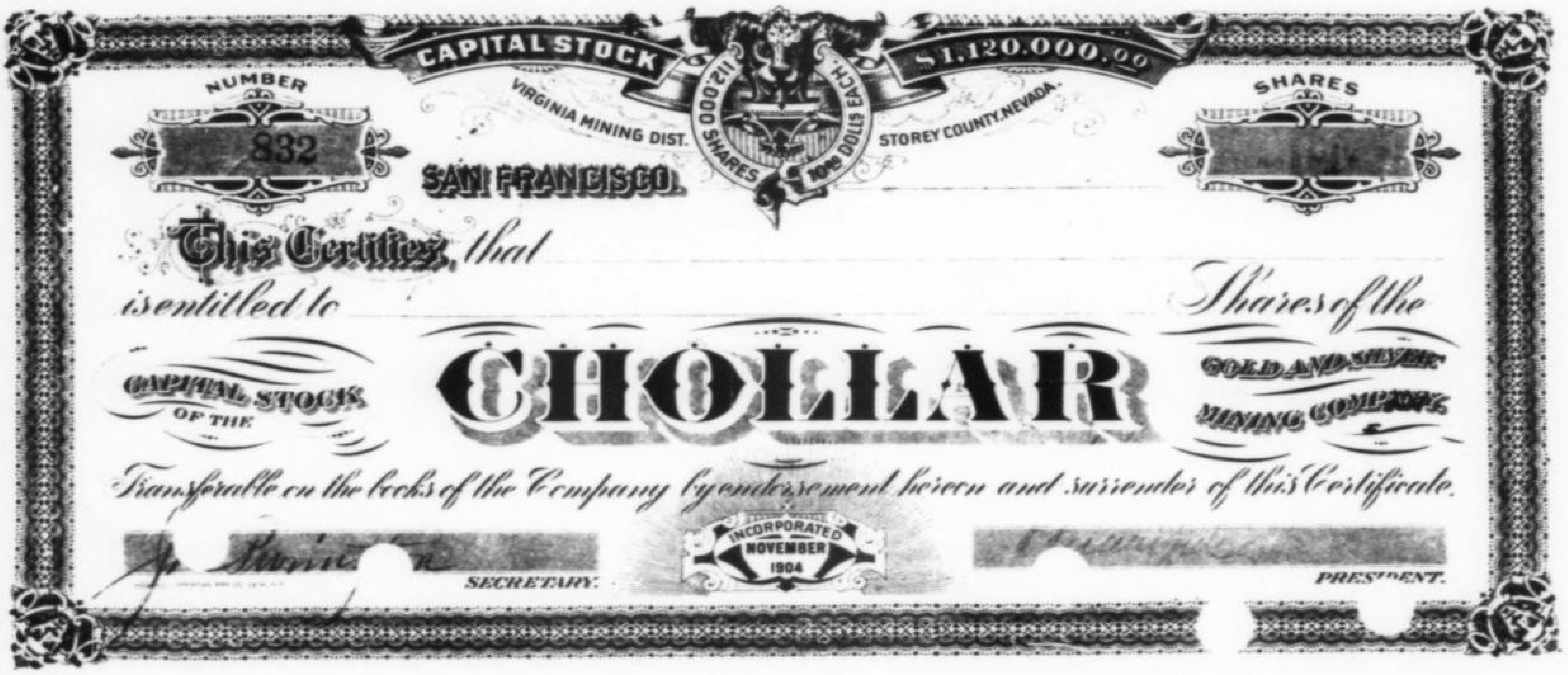
In 1874 after the ventilation drift from the California mine to the Consolidated Virginia was completed, Dan De Quille made a trip down the Consolidated Virginia shaft to view the Big Bonanza. In his book, *History of the Big Bonanza,* which was sponsored by the four Bonanza Kings, he describes the trip:

Leaving the station into which we dropped with the cage from the hoisting works, standing 1,500 feet above, we advance a few steps eastward along a broad gallery, the sides and roof of which are composed of a mass of heavy timbers and thick planks, when we reach the main north-and-south drift, which is the great highway of the mine. It is a grand gallery, nine feet in width by about the same in height, and over one thousand feet in length. It extends through the whole length of the California (600 feet) to the Ophir mine. From the Ophir to the north line of the Consolidated Virginia it was made of double height in order to carry a great volume of air; as the air, fresh and pure from the surface, is drawn down the Ophir shaft and, passing through that mine, enters the great main drift that it follows through the California and the Consolidated Virginia to the shaft of the mine last named, where it ascends and again mingles with the atmosphere of the upper world.

Crossing this thoroughfare of the 1,500-foot level and advancing a few steps farther to the eastward, we reach the vast deposit of ore known as the "Big Bonanza." Crosscuts pass through the ore east and west, and cross-drifts from north to south, cutting it into blocks from fifty to one hundred feet square, as the streets run through and divide a town into blocks. It is indeed a sort of subterranean town, and is more populous than many towns on the surface, as it numbers from 800 to 1,000 souls, and nearly all are voters.

Passing to the south end of the bonanza to the place where it was first crossed by a drift, we find it to be 148 feet in width – all a solid mass of ore of the richest description. Here a large stope is opened, and we see the miners at work in the vein, blasting and digging down the ore. They are working upward from the floor of the level, and as they progress they build up square sets of supporting timbers in the cavities or chambers cut out in extracting the ore from the bonanza. Even here, well toward its south end – as far as explored – the ore-body is by no means small, being over nine and one half rods in width! This is not a mixture of ore and worthless rock, but is a solid mass of rich silver ore, which is sent to the mills just as it is dug or blasted down – ore that will pay from $100 to $300 per ton. As thirteen cubic feet make a ton of ore, we have here for every block of ore three feet square from $200 to $600 in pure silver and gold.

We may take our stand here, where the miners are digging out the ore, and for a distance of seventy-five feet on each side of us all is ore, while we may gaze upward to nearly that height, to where the twinkling light of candles shows us miners delving up into the same great mass of wealth. On all sides of the pyramidal scaffold of timbers to its very apex, where the candles twinkle like stars in the heavens, we see the miners cutting their way into the precious ore – battering it with sledge-hammers and cutting it to pieces with their picks as though it were but common sandstone. Silver ore is not, as many may suppose, a bright and glittering mass. In color the ore runs from a bluish-gray to a deep black. The sulphuret ore (silver glance) is quite black and has but a slight metallic luster, while what is called chloride ore is a kind of steel-gray, with, in places, a pale green tinge – the green showing the presence of chloride of silver.



CAPITAL STOCK
$1,120,000.00
112,000 SHARES 10.00 DOLLS EACH.
VIRGINIA MINING DIST.
STOREY COUNTY, NEVADA.
NUMBER
832
SHARES
SAN FRANCISCO.
This Certifies, that
is entitled to
Shares of the
CAPITAL STOCK
OF THE
CHOLLAR
GOLD AND SILVER
MINING COMPANY.
Transferable on the books of the Company by endorsement hereon and surrender of this Certificate.
INCORPORATED
NOVEMBER
1904
SECRETARY.
PRES'DENT.

"Here are frequently found deposits of stephanite in the form of crystals, and nests of pure silver in the shape of flattened wires."

Throughout the mass of the ore in very many places, however, the walls of the silver caverns glitter as though studded with diamonds. But it is not silver that glitters. It is the iron and copper pyrites that are everywhere mingled with the ore, which in many places are found in the form of regular and beautiful crystsls that send out from their facets flashes of light that almost rival the fire and splendor of precious stones. There are also often found in the mass of the ore great nests of transparent and beautiful quartz crystals that are almost as brilliant as diamonds. Many of these crystals are three or four inches in length. Some of the nests of crystals are of a light-blue color, and then they may be classed among the precious stones, as they are amethysts. Some of these are almost as handsome as the precious amethyst. The miners always like to find these nests of crystals, as they indicate life and strength in the vein.

On the 1,500-foot level the bonanza extends into the Consolidated Virginia ground over three hundred feet. How much farther it may extend in that direction on the levels below remains to be ascertained.

Two hundred feet north of the bonanza we have been examining (the stope at crosscut No. 3), another stope has been raised (on crosscut No. 1) toward the 1,400-foot level, and here large quantities of rich ore are being extracted. Crosscut No. 2, about halfway between the two stopes mentioned, shows the bonanza to be three hundred feet in width, all of this great distance being a mass of rich ore, and ore that can be sent to the mills without assorting. Think of a mass of silver ore over eighteen rods in width! In many places a vein of ore three feet in thickness is considered large, and in California veins of gold-bearing quartz that are only from one to six inches in thickness are profitably worked. Compared with such deposits, the bonanza is not a vein at all, but a field, a district of ore!

In this broadest part of the bonanza we find at work a great number of miners, but they are so distributed that we see but a few in any one spot. They work on separate floors, and floor above floor they are digging down the ore. The pyramids of timbers rise to the height of fifty or seventy-five feet, and, as all the heated air of the level ascends to the highest point, it is very hot where the upper gangs of men are at work. In addition to the natural heat of the mine, coming from the heated rock and hot water, the flame of the hundreds of candles and lamps does much to heat the limited atmosphere of the level.

In the center of this part of the bonanza we have on each side of us a width of over nine rods of silver ore that will mill from $100 to $250, and in many parts of which ore is found that assays $500 or $600. Not only have we this mass of ore on all sides of us, but it also extends to a great height above. On the 1,400-, 1,300-, 1,200-, and the 1,167-foot levels men are at work as we see them here. From the level last named, when the ore was first found, in 1873, they have followed it up to the 1,000-foot level and even above. Fifty feet below the level on which we stand, or on the 1,550-foot level, a long drift has been run through rich ore toward the Ophir mine, and from this drift a number of crosscuts have been run into the bonanza. On this 1,550-foot level a winze has been sunk to a depth of over two hundred feet, all the way in excellent ore. This shows the bonanza to extend at least to a depth of over 1,750 feet. Near the stope on crosscut No. 1, about the California line, is seen some of the richest ore found in the great bonanza. At this point comes in what is called a "horse," which is a huge mass of propylite (generally spoken of as porphyry in the mines), which tumbled into the vein from the upper or hanging wall at the time of the formation of the fissure. This "horse" crowds the ore into a smaller space, and the ore-body is here only about twelve rods in width, but the greater part of it is immensely rich, such as will yield from $300 to $600 per ton.

Here are frequently found deposits of stephanite, or silver in the form of crystals. This is almost pure silver. In the places where the stephanite occurs, there are frequently found nests of pure, malleable silver in the shape of flattened wires that look as though they had been pulled in two and, in springing back after breaking, had coiled up against the pieces of ore on which they are found. Some of these wires have the luster of metallic silver, but the greater part are blackened as though by the fumes of sulphur. Some of the smaller and finer wires on being unrolled and straightened out are found to be a foot or more in length, and often have several branches, when they somewhat resemble sea-moss or some similar vegetable production. The old Mexican mine was particularly rich in specimens of this kind. In that mine they were found in a kind of yellow clay in the crevices occurring in the mass of the ore.

CAPITAL STOCK $1.120.000

NUMBER 10888

SAN FRANCISCO, 19

MAR 14 1917

This Certifies that [illegible]

IS ENTITLED TO

One Hundred - Shares of the Capital Stock of the

SAVAGE GOLD & SILVER MINING COMPANY.

10 DOLLARS EACH

-100- SHARES

Transferable on the books of the Company by endorsement hereon and surrender of this Certificate.

SECRETARY. INCORPORATED IN CALIFORNIA NOV. 1904 PRESIDENT.

REGISTERED AND COUNTERSIGNED

DEC 29 '14

COMPANY

San Fra.

1000 SHARES

"A chamber about ten feet square was opened; the roof was filled with stephanite in the form of crystals. Many magnificent specimens for cabinets were taken from this chamber."

Free gold, in glittering spangles, is also very frequently found in the places where the rich deposits of black sulphuret of silver and native silver occur. A large percentage of the value of the ores of all the mines on the Comstock is in gold. In many instances the bullion extracted is fifty per cent gold. In that part of the bonanza through which passes the line between the California and the Consolidated Virginia companies it is an easy matter to find ore that assays from $1,000 to $5,000 or $10,000 per ton, but this is, of course, only in places where the strength of the vein appears to have concentrated.

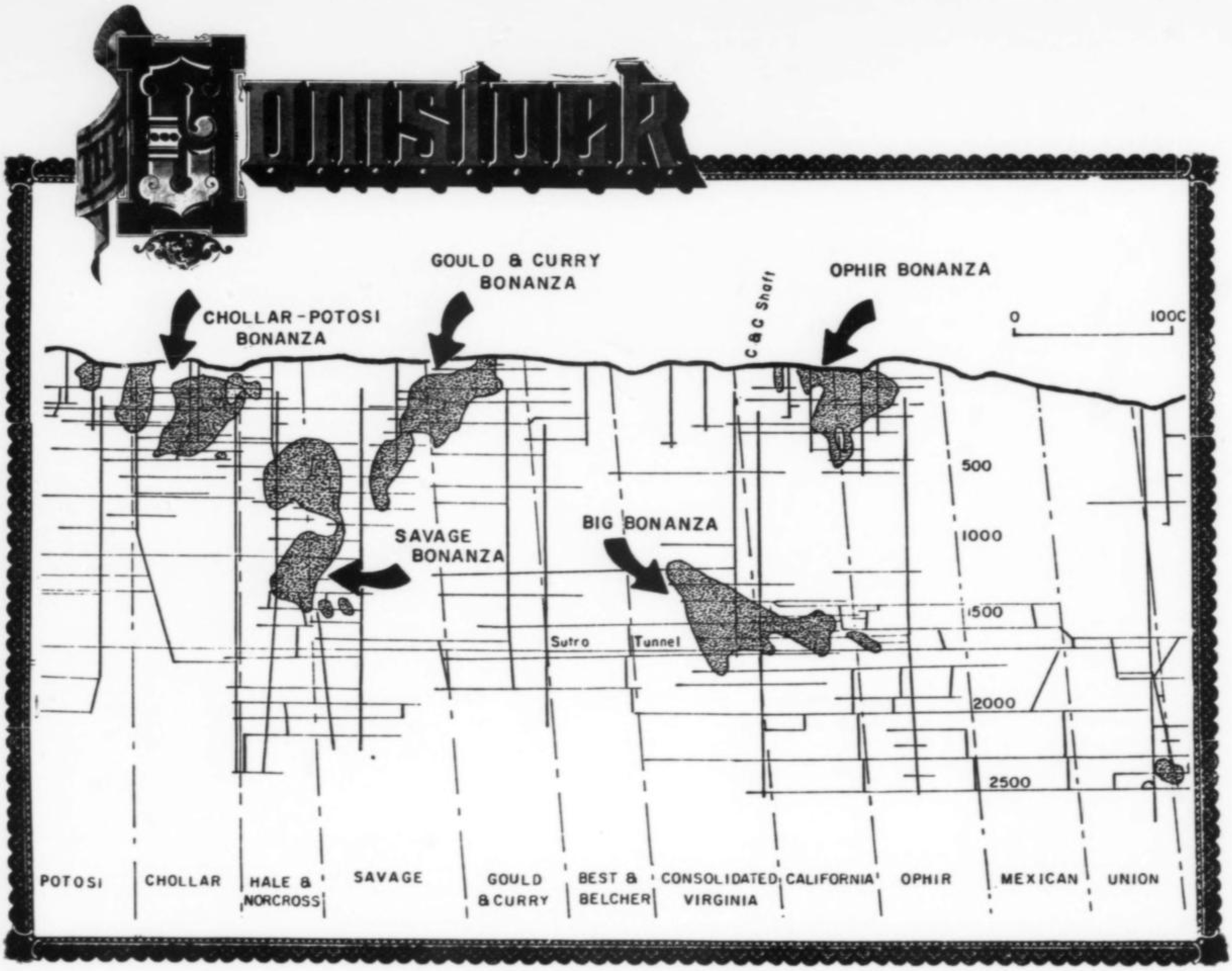
At the time that the first crosscut (No. 1) was run through this part of the bonanza, at a point about fourteen feet south of the California line, a chamber about ten feet square was opened (at a point marked "winze down to 1550" on the map), the walls of which were a solid mass of black sulphuret ore flecked with native silver, while the roof was filled with stephanite, or silver in the form of crystals. This was one of the richest spots found in that part of the bonanza, and the masses of ore taken out were almost pure silver. Many magnificent specimens for cabinets were taken from this chamber and parts of the mine adjoining, some of them little else but stephanite and wires of native silver. The whole crosscut through this part of the mine showed an average assay of $600 per ton. Bottom, top, sides were all the same. Look where you might, you saw but a solid mass of black sulphuret ore mingled with the pale-green ore containing chloride of silver.

Two mining superintendents were one day discussing the bonanza, when one of them said to his brother silver-hunter: "Supposing the Almighty to have given you full power and authority to make such a body of ore as you pleased, could you have made a better one than this?"

"I don't know that I could," said the other, "but I should have made it still bigger."

"Well," said the first speaker, "you have more cheek than any man I ever saw!"

Mineral specimens from the Comstock are very scarce today, even in museums. In 1913 when Edson Bastin went to Virginia City to procure some material for a microscopic study of the ores, specimens from the shallow workings and bonanza ore specimens were difficult to obtain (Bastin, 1923). No doubt there are several reasons for this scarcity of specimens. The isolated location of the Comstock in the early days, the lack of appreciation of specimen material by the mostly uneducated people working the mines, lack of a tradition for specimen collecting and selling, the devastating fires, particularly the one in October of 1875 when much of the town was destroyed, and the fact that attractive specimens in the Comstock mines were probably not abundant. The bonanza ores



Longitudinal projection of deposits in the Comstock Lode, showing the various claims (Becker, 1882).

were usually dull black mixtures of acanthite, polybasite, stephanite and tarnished silver that were only rarely well crystallized. It was certainly not something that a miner would want decorating his hearth. And even in the case of attractive specimens, most material that he highgraded was probably turned into bullion as soon as he needed money.

The mining of the Big Bonanza took almost 6 years and with its depletion in 1878, Virginia City saw the last of its glory days fade away. A total of about 105 million dollars was produced with most of the profits going into the pockets of the four Bonanza Kings. After 1878, the annual production of the Comstock was generally far under 10 million dollars. Though many have searched no new bonanzas have been found that would crown any new Bonanza Kings on the Comstock Lode.

Table 1. **Minerals reported from the Comstock Lode.**

Anglesite
Acanthite
Calcite
Cerargyrite
Chalcocite
Chalcopyrite
Chlorite group
Covellite
Epidote
Epsomite
Galena
Gold
Gypsum
Kaolinite
Pearceite
Polybasite
Pyrargyrite
Pyrite
Quartz
Silver
Stephanite
Sternbergite
Sphalerite
Uytenbogaardtite
Wulfenite (?)

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the Getchell Mine
Humboldt County
NEVADA

Craig S. Stolburg
3231 Woodmont Drive
San Jose, California 95118

Gail E. Dunning
773 Durshire Way
Sunnyvale, California 94087

The Getchell mine, located in north-central Nevada, has for many years been the world's leading producer of fine crystallized realgar. In addition, crystals of orpiment and rare sulfosalts including galkhaite, laffittite and getchellite (type locality) occur in the arsenic orebody.

INTRODUCTION

The Getchell gold mine is located approximately 42 km north of Golconda, Humboldt County, Nevada. The mine is situated on the eastern flank of the Osgood Mountains along the Getchell fault and is within the Potosi mining district. Gold bullion was produced intermittently between 1938 and 1967. This deposit is one of several disseminated-type gold deposits in the western United States, including Carlin, Cortez, Gold Acres, Jerrett Canyon and Mercur, in addition to numerous smaller deposits (Roberts *et al.,* 1971).

HISTORY

The history of the Potosi mining district dates back before 1918 when considerable mining activity centered around the tungsten deposits in the area. Hotz and Willden (1964) have summarized the mining history of the Getchell mine.

The deposit was discovered in the fall of 1934 by two prospectors, Ed Knight and Emmett Chase, who believed they had discovered a large low grade gold deposit. Within a year they had sold their mine to Nobel Getchell and his partner, George Wingfield. The mine was named after Nobel Getchell and, after just five years of production, it had achieved the distinction of being the largest gold producer in Nevada. It was not until 1954 that production of by-product gold from the Ruth mine at Ely, Nevada, exceeded Getchell's output.

The Getchell mine had the good fortune of mining an arsenic-bearing orebody at the beginning of World War II, when the federal government closed all non-essential gold mines. Due to the need for this strategic metal, Getchell was permitted to mine gold along with the arsenic. Production continued until 1951 when the easily mined gold ores were exhausted and mining of tungsten ore started along the major fault zone.

The production of tungsten ceased in 1957, when additional reserves of gold ore were discovered. The Getchell mine produced gold until 1968, when it became unprofitable to continue operations, and the mine closed. Since then, many mining companies have explored the possibility of reopening the mine for gold but, to date, none have found adequate reserves to warrant renewed mining operations.

GEOLOGY

The geology of the Getchell mine and surrounding Osgood Mountains has been mapped and studied by a number of authors including Hobbs (1948), Hotz and Willden (1964), Silberman and McKee (1971), Erickson and Marsh (1974), Joralemon (1951), Berger and Taylor (1974) and Berger (1980).

The rocks in the vicinity of the Getchell mine are lower Paleozoic sediments which have been intruded by a granodiorite stock of Cretaceous age. The oldest rocks consist of Middle and Upper Cambrian carbonaceous shale and thin-bedded limestone called the

Preble formation. This formation is unconformably overlain by a sequence of intercalated dolomitic limestone and chert, shale, siltstone and mafic volcanic rocks assigned to the Comus formation of Early and Middle Ordovician age. The Getchell fault system, a connecting group of high-angle, dip-slip faults, cuts the thrust faults along the eastern margin of the Osgood Mountains. Berger and Taylor (1974) have re-evaluated field evidence and concluded that the displacement of the fault has been predominantly vertical, and that the fault system controlled the emplacement of the granodiorite stock and related dikes. The fault system has remained active right up to the present, as shown by displacement of Quaternary (?) alluvium in the mine area.

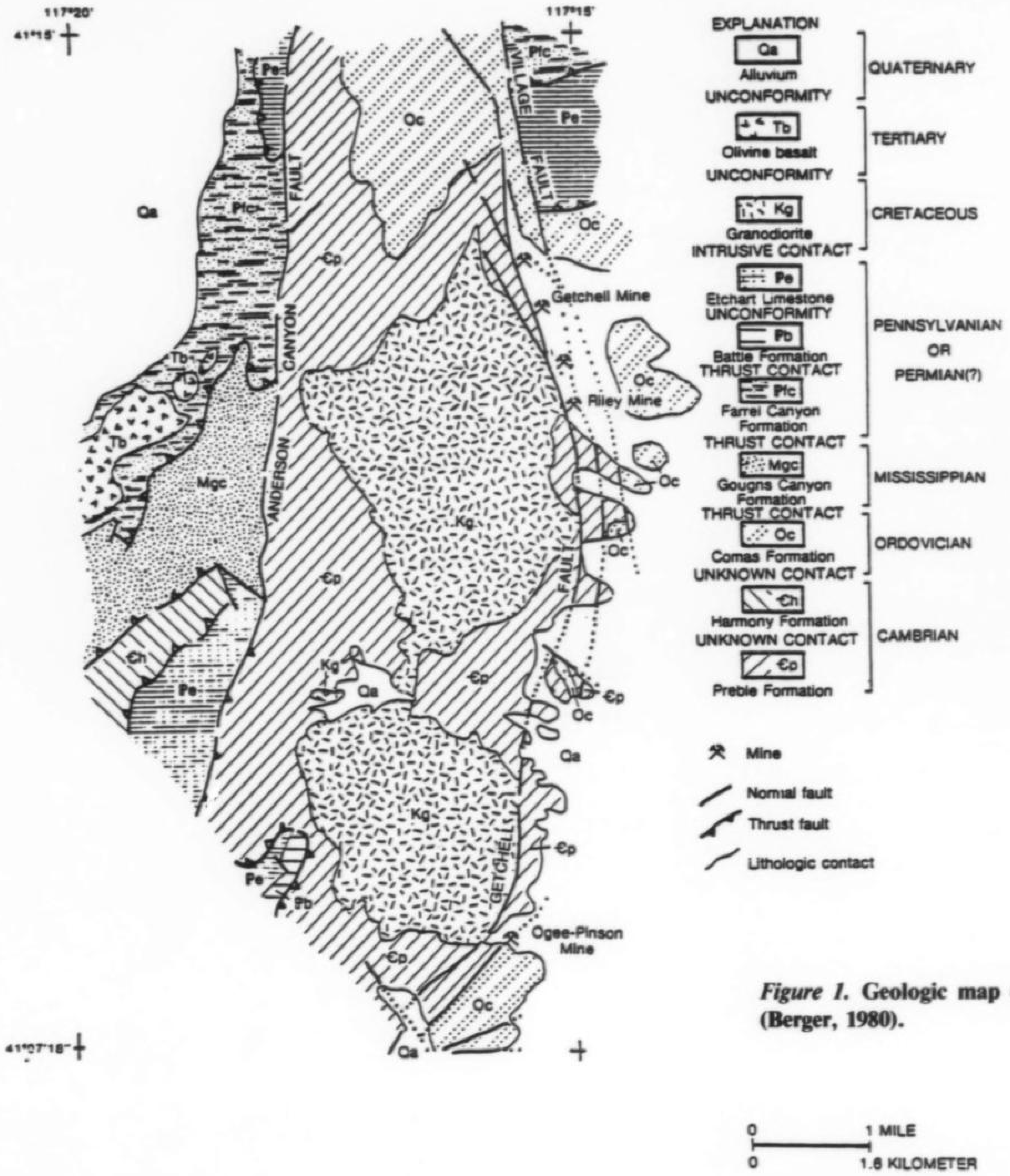

Figure 1. **Geologic map of the Getchell mine (Berger, 1980).**

Gold mineralization was controlled by three segments of the Getchell fault system which provided channels for the ascending epithermal solutions and resulted in silicification of the Preble formation limestone and carbonaceous shale beds.

MINERALOGY

Aside from the rock-forming minerals, the mineralogy of the Getchell mine is dominated by massive arsenic sulfide mineralization containing minor amounts of mercury, silver, antimony, zinc, copper, cesium, thallium and gold. Except for gold, these elements have combined with either arsenic or sulfur to form a number of sulfide and sulfarsenide minerals which have resulted from late-stage hydrothermal activity along the Getchell fault. Berger (1980) suggests that this hydrothermal activity has altered the limestone by decarbonatization accompanied by silicification. Early low-temperature hydrothermal action, which preceded the sulfide mineralization, deposited gold, the principal ore mineral, along the fault zone and replaced the limestone with quartz.

The minor ore minerals include cinnabar, stibnite, chalcopyrite and sphalerite. Molybdenite and scheelite are unrelated to the sulfide mineralization but are more closely associated with the granodiorite rocks adjacent to the fault zone, especially in the South pit. Realgar and orpiment constitute the major arsenic sulfide minerals, which resulted from late-stage hydrothermal activity along the fault zone and rock fractures. The rare sulfosalts getchellite, galkhaite and laffittite occur in minor amount in the sulfide orebody and are usually found as small, granular crystals associated with realgar and orpiment.

In addition to quartz and calcite, the gangue minerals include marcasite, pyrite, arsenopyrite, magnetite, barite, fluorite and chabazite. Secondary minerals resulting from local weathering of

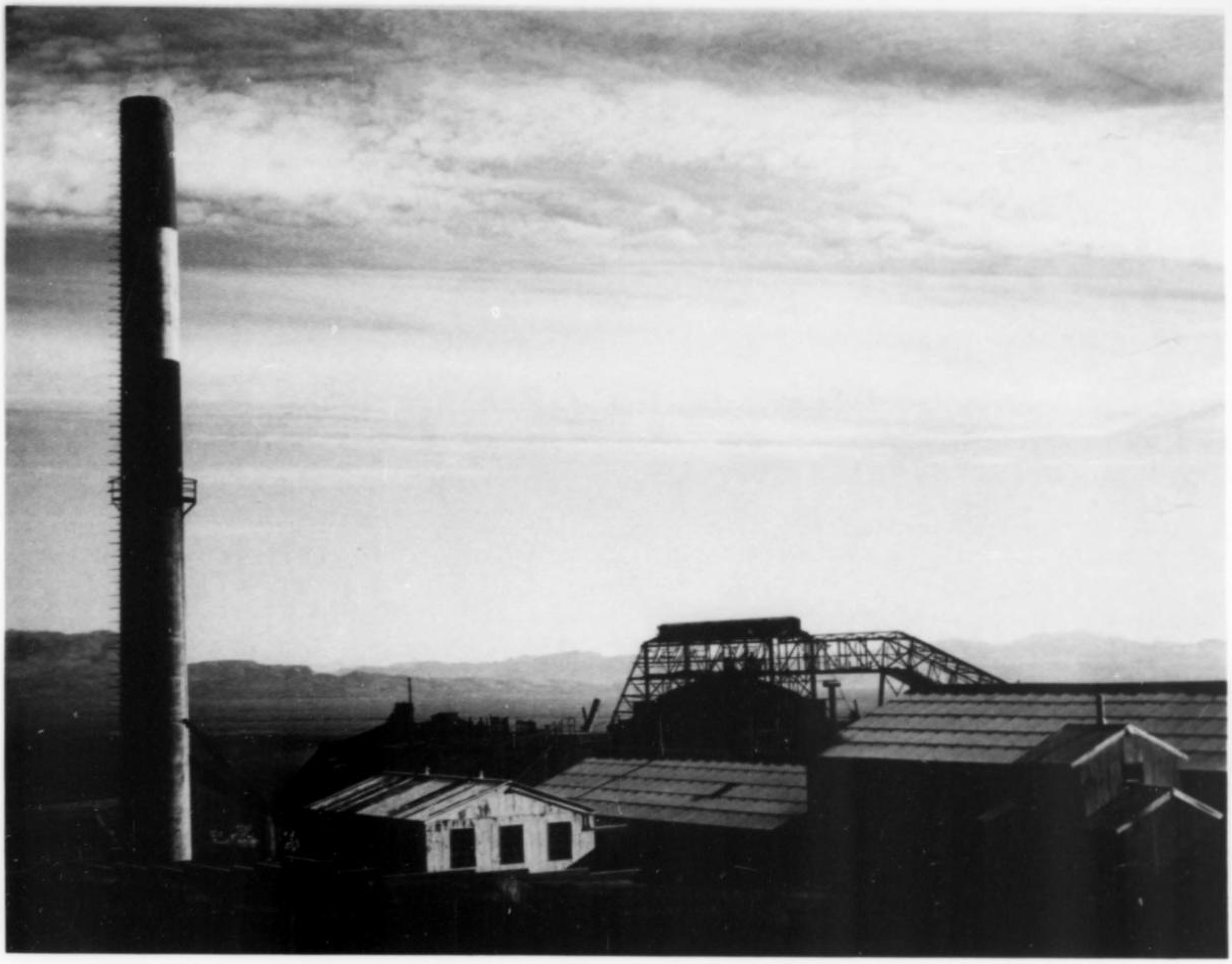

Figure 2. **Getchell mine in 1975; Stolburg photo.**

the ore minerals include gypsum, picropharmacolite and ilsemannite.

Cinnabar HgS

High mercury concentrations in the gold ore have been attributed to cinnabar in association with stibnite. The South pit ores show about five times the mercury concentration as do the ores of the North pit. Cinnabar occurs in very minor amounts in the Getchell orebody and it is usually found as very small (less than 1 mm), dark red, pseudocubic rhombohedral crystals associated with quartz, realgar and stibnite. The crystals are single or complex intergrowths attached to either quartz or realgar crystals. Most crystals are quite complex and twinned. Pyrite crystals and grains are in intimate association with cinnabar and are usually found nucleated on the faces of cinnabar crystals.

Fluorite CaF_2

Fluorite is one of the common accessory minerals found in the Getchell deposit. It typically occurs as simple cubes, often showing color zoning from clear to violet, in the carbonaceous quartz rock associated with orpiment and realgar. Late-stage calcite has covered much of the fluorite; this can be removed by mild acid etching. In the North pit area fluorite is associated with stibnite, orpiment, realgar and galkhaite. Crystals up to 1 cm on an edge are common.

Galkhaite $(Cs,Tl)(Hg,Cu,Zn)_6(As,Sb)_4S_{12}$

The rare sulfosalt galkhaite was first described by Gruzdev *et al.* (1972) from the Gal-Khaya deposit, Yakutia, and the Khaidaikan deposit, Kirgizia, U.S.S.R., as idiomorphic crystals up to 1 cm, crystal aggregates, and granular aggregates in mercury deposits (see also Jungles, 1974). Associated minerals in the Soviet deposits include pyrite, stibnite, cinnabar, metacinnabar, aktashite, wakabayashilite, orpiment, realgar, getchellite, calcite, fluorite and quartz. It has been replaced in many places by cinnabar and metacinnabar.

Galkhaite has since been discovered at the Getchell mine by Botinelly *et al.* (1973) and at the Carlin, Nevada, gold deposits by Dickson and Radtke (1978). A recent re-examination of galkhaite from Getchell by Chen and Szymanski (1981) has shown that cesium is an important element in the structure; cesium is rarely associated with thallium.

At Getchell, galkhaite is principally found on the dark gray, limy, carbonaceous quartz rocks in the North pit area. Here it is associated with pyrite, fluorite, realgar, stibnite and orpiment. Galkhaite occurs as simple cubes or as multiple intergrowths of cubes and is steel-gray to brownish black with a metallic luster. The color is probably due to included or surficial graphite. Where the crystals have been protected by calcite they are brilliantly deep red in color with deep red internal reflections. All crystals show the

Figure 3. **Realgar from the Getchell mine. The crystal at upper left measures 1.4 cm. Barbara Cureton collection.**

Figure 4. **Realgar from the Getchell mine, showing crystals to 1.4 cm which have been partially freed from enclosing calcite. Barbara Cureton collection.**

common *a*{100} form. However, the forms *d*{110} and *o*{111} occur occasionally.

In the South pit galkhaite typically occurs in association with getchellite and cinnabar. The crystals are usually black, intergrown, simple cubes in cavities of massive getchellite, with realgar and orpiment.

Getchellite $AsSbS_3$

Getchellite was first described by Weissberg (1965) as a new mineral from the Getchell mine; it is intimately associated with abundant orpiment and realgar and lesser amounts of quartz, stibnite, cinnabar, galkhaite and laffittite. Other occurrences of getchellite include the Carlin, Nevada, gold deposit (Radtke *et al.*, 1977), the Zarehchauran orpiment mine in northeastern Iran (Bariand *et al.*, 1965, 1968) and the Gal-Khaya deposit, U.S.S.R. (Gruzdev *et al.*, 1972).

At Getchell, getchellite was first discovered in the arsenic sulfide ores of the South pit extension where it has formed thin lenses and pods in the massive orpiment-realgar arsenic ore along the fault zone. Weissberg (1965) suggests that getchellite was one of the first hydrothermal minerals deposited after quartz.

Getchellite occurs both as anhedral grains molded by realgar and

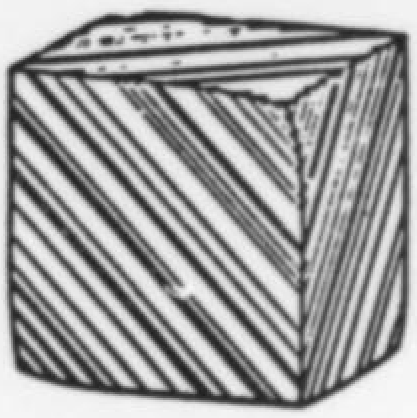

Figure 5. **Crystal sketch of galkhaite (Jungles, 1974).**

Figure 6. **Deep red galkhaite crystals to 2 mm from the Getchell mine. Barbara Cureton collection.**

orpiment and as rare euhedral crystals included in orpiment (Weissberg, 1965). Free-standing crystals are very rare and occasionally have been found in small cavities in the massive material. Both stibnite and galkhaite crystals have been observed partially filling small cavities in massive getchellite.

Aside from its darker red color and orange-red streak, getchellite closely resembles orpiment in physical properties. Crystals of both getchellite and orpiment are commonly bent or otherwise deformed by movements subsequent to ore deposition. Masses of getchellite up to 5 cm or larger are not uncommon in the veins. These masses, when broken, reveal the mineral's perfect basal cleavage and these multiple basal cleavages, surrounded by yellow orpiment, make very attractive specimens.

Gold Au

In the orebody gold occurs as micron to submicron-sized particles closely associated with carbonaceous quartz and shales, within the sulfide minerals, and as fine particles within and between

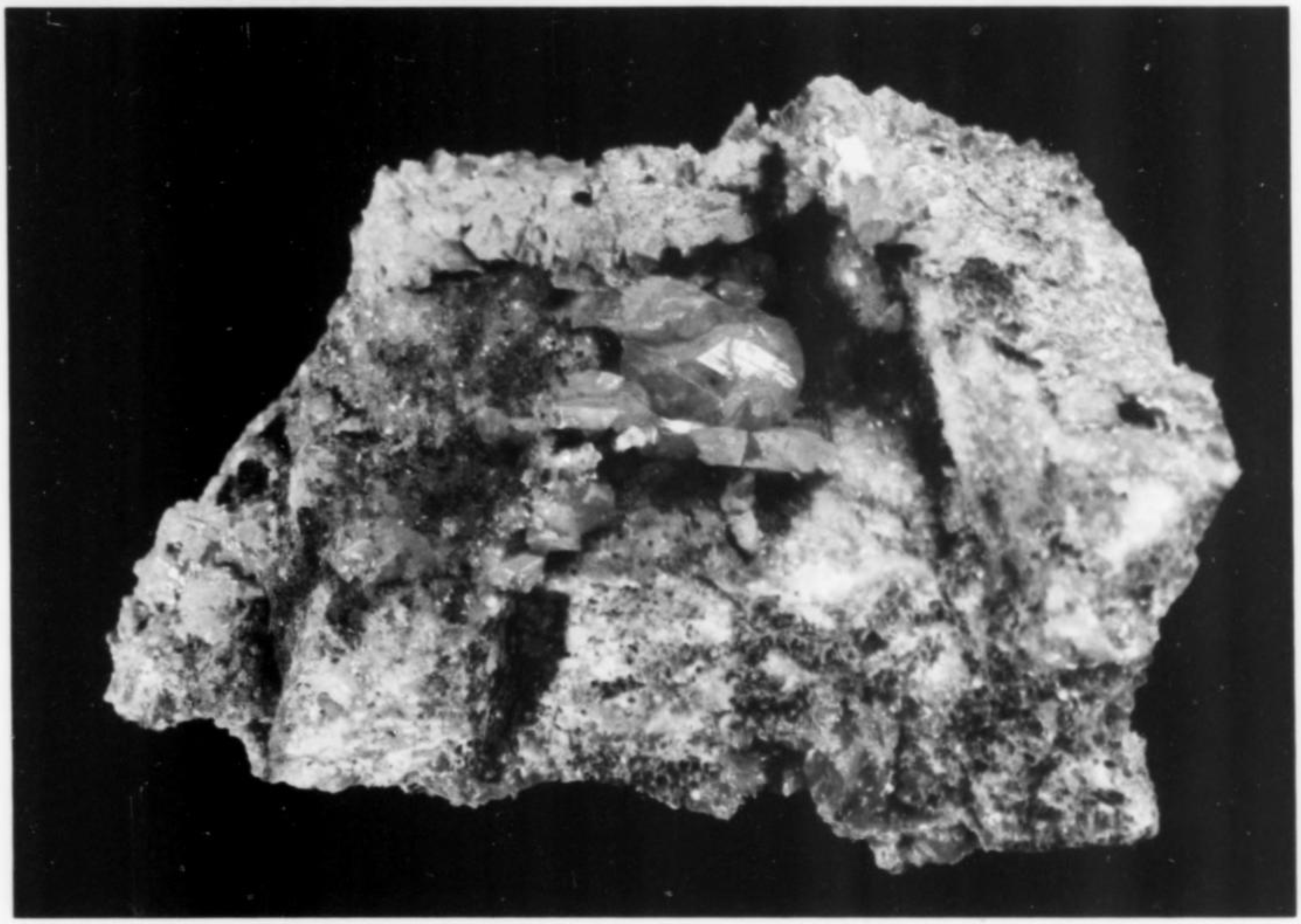

Figure 7. **Orpiment crystals, 1.2 cm crystal on a 5.0 x 6.3 cm matrix; Stolburg specimen.**

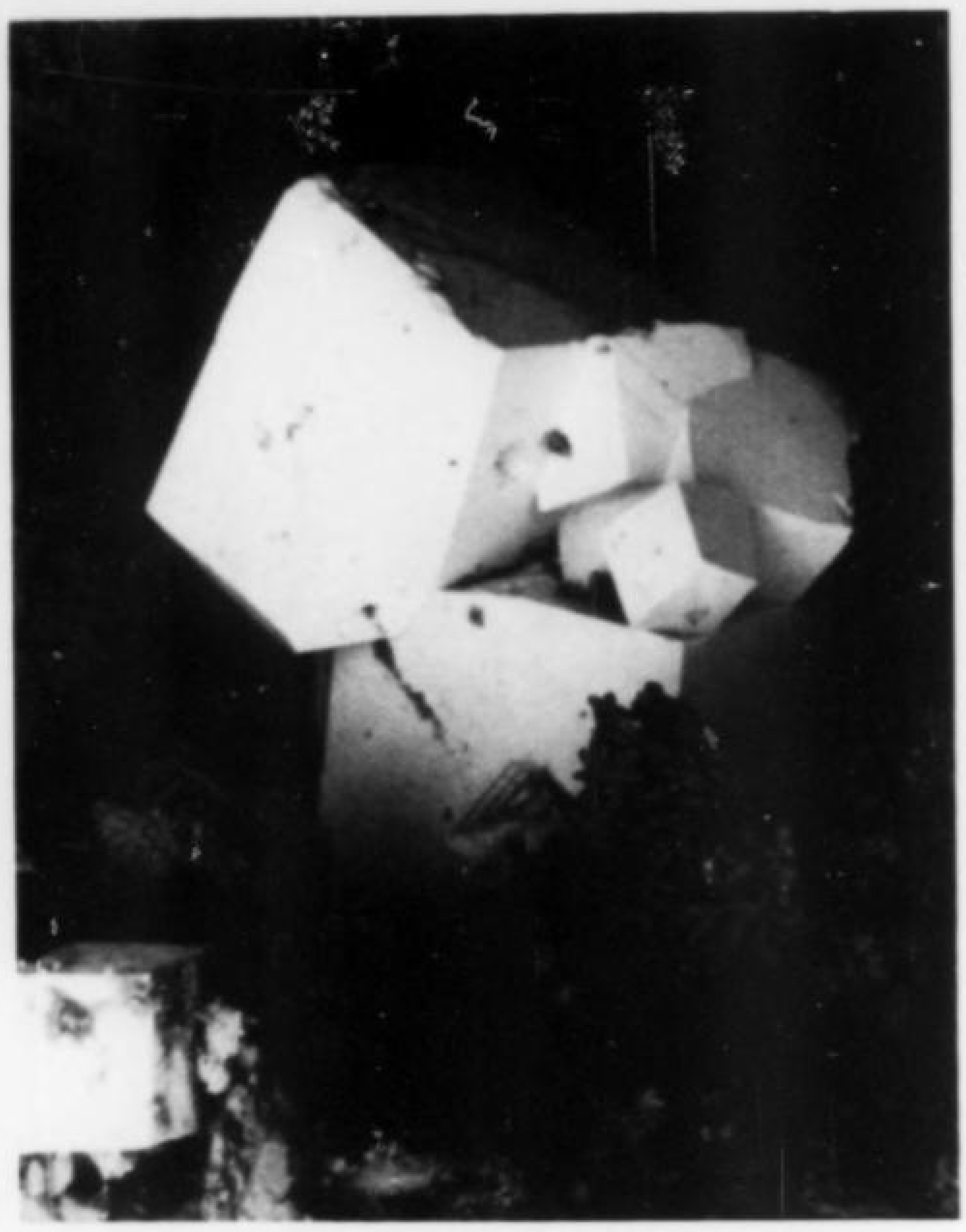

Figure 8. **Intergrown galkhaite crystals, 0.4 mm across, showing diagonal striations normal to {111} on {100}; Dunning SEM photo and specimen.**

quartz and clay grains. Although it is the principal ore mineral of the mine, no specimen quality samples of gold have been found. It is only by examining polished sections of ore that gold can be seen, although some isolated grains have been reported visible under low magnification.

Graphite C

Graphite, amorphous carbon and organic complexes occur in the silicified zones of the orebody and account for the dark gray color of the ore. The graphite is very fine grained and occasionally coats crystals of the ore minerals.

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum occurs as delicate radiating groups of clear acicular crystals in cavities and along fracture planes of the gray carbonaceous quartz-realgar ore of the North pit. The crystals show striations and typical terminations.

Ilsemannite $Mo_3O_8 \cdot nH_2O$ (?)

Local groundwater alteration of molybdenite in the North pit area has resulted in dark blue coatings of ilsemannite along fractures in the gray carbonaceous shales.

Laffittite $AgHgAsS_3$

The rare sulfosalt laffittite was first described from the Jas Roux mine, Hautes Alpes, France, by Johan *et al.* (1974). At this mine it occurs as small grains up to 0.2 mm associated with smithite, stibnite, pierrotite, realgar, sphalerite, pyrite and two thallium antimony minerals in dolomitic rocks. Laffittite has also been identified from the mines at Iquique, Chile.

Recently Nakai and Appleman (1983) discovered laffittite on a Smithsonian Institution specimen (#134796) labeled getchellite from the Getchell mine, Humboldt County, Nevada. In this specimen laffittite occurs as anhedral grains about 1 mm in maximum length which are generally surrounded by either getchellite or orpiment. This discovery prompted a thorough examination of the authors' getchellite-containing specimens. Laffittite was subsequently found in about 75% of the hand specimens examined.

Figure 9. **Deep red, transparent crystals of laffittite, 0.2 x 0.6 mm, embedded in quartz with orpiment. Visible faces show fine striations. Dunning SEM photo and specimen.**

Laffittite is most easily recognized when it occurs in massive, fine grained orpiment rather than in the darker red getchellite or realgar. Although very rare, monoclinic crystals of laffittite do occur in specimens containing veins of crystallized quartz and orpiment. Single or multiple contact crystals have formed in quartz cavities associated with acicular realgar crystals and foliated masses of orpiment. Laffittite crystals are deep red in color, resembling cinnabar, although slightly darker than getchellite. The developed faces are very brilliant and are striated. Both the crystals and anhedral grains show no cleavage when broken. They also are quite brittle, which accounts for the rarity of visible crystals when the rock is broken. Occasionally, small imperfect crystals are found in massive orpiment and, after weathering of the orpiment, stand out in relief.

The original description of getchellite by Weissberg (1965) makes no reference to material which might be ascribed to laffittite. The only dark red mineral that he refers to is cinnabar. Considering the abundance of laffittite in some samples of getchellite-orpiment-realgar ore, together with its physical and chemical properties, it is surprising that it was not recognized earlier.

Molybdenite MoS_2
Scheelite $CaWO_4$

Disseminated molybdenite together with scheelite can be found in the granodiorite stock adjacent to skarn along the west vein and granodiorite dikes in the east wall of the South pit (Berger, 1980).

Orpiment As_2S_3

Orpiment and realgar are the two most abundant arsenic sulfide minerals at Getchell. The major portion of orpiment occurs as veins of foliated, columnar or fibrous masses in the South pit extension, although it is distributed throughout the three main areas of mining. Where space permitted, crystals of orpiment formed in cavities along the quartz-rich fracture fillings. The crystals are generally small (1 cm or less), bright yellow-orange in color, and occur both as single and multiple intergrowths. The smaller crystals have a golden yellow color but, as the crystals become larger, the color deepens to a golden brown. The crystals are generally distorted, probably by remobilization of the ore following sulfide formation.

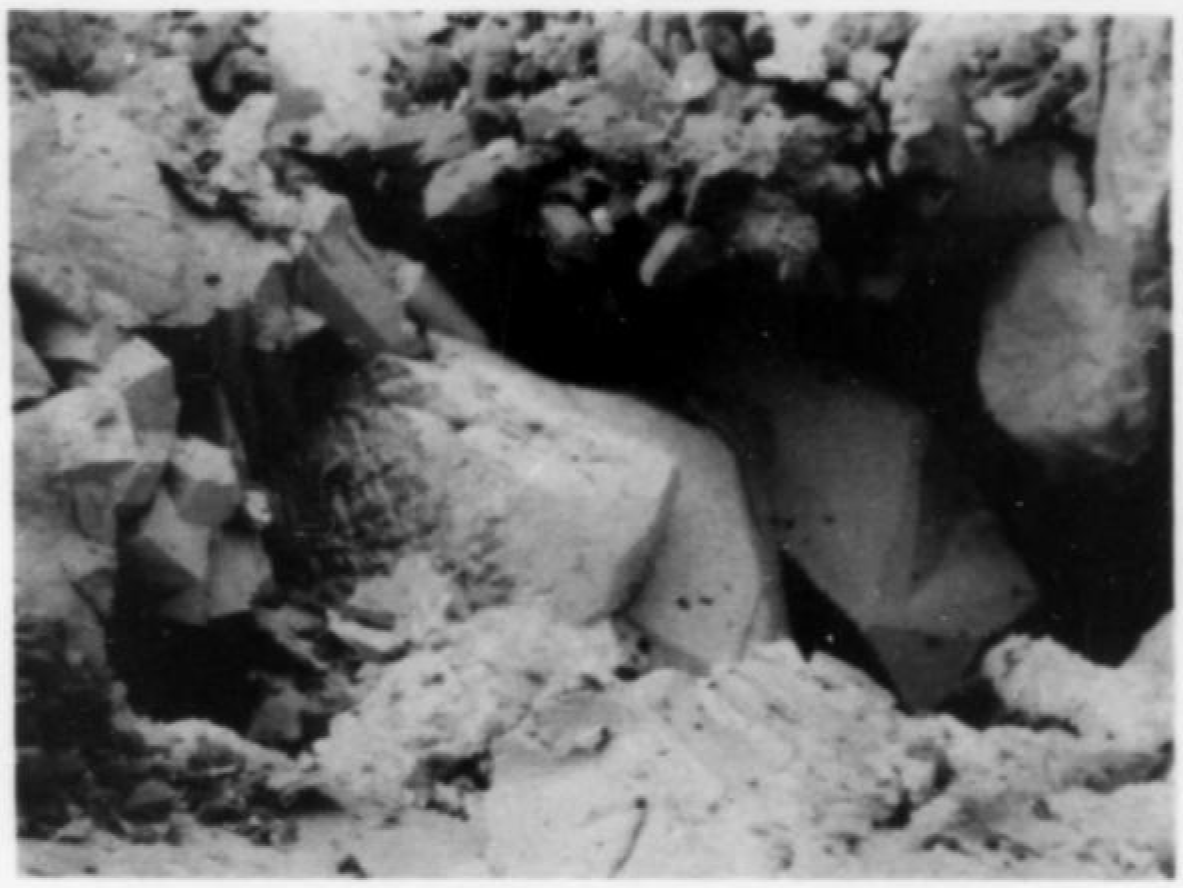

Figure 10. **Euhedral crystals of getchellite in cavity, 0.2 x 0.5 mm, with black cubes of galkhaite at left center; Dunning SEM photo and specimen.**

Figure 11. **Dark red, pseudocubic rhombohedral cinnabar crystal, 0.2 mm wide, on quartz; Dunning SEM photo, R. W. Thomssen specimen.**

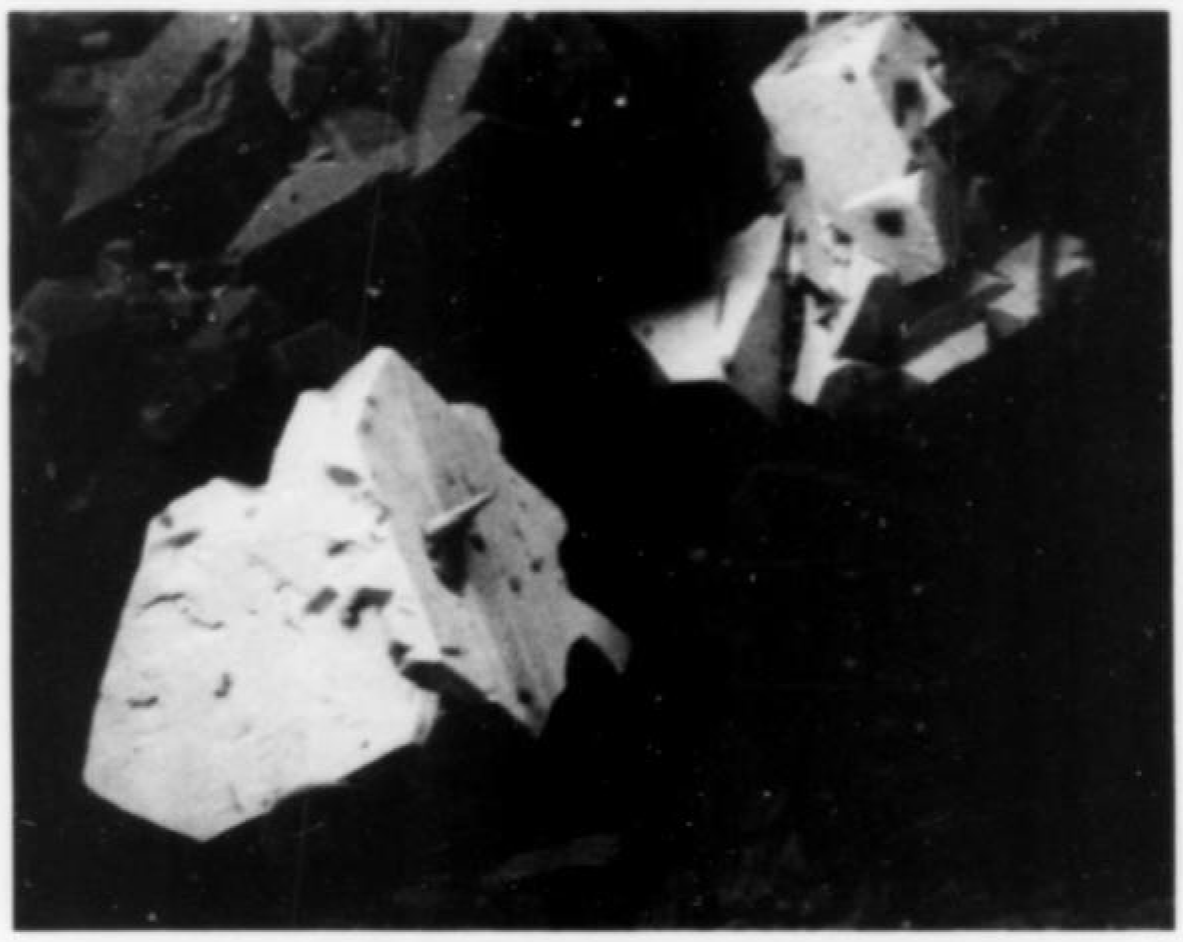

Figure 12. **Dark red, intergrown, rhombohedral crystals of cinnabar, 0.5 mm wide, and intergrown galkhaite cubes on quartz; Dunning SEM photo, R. W. Thomssen specimen.**

Figure 13. **Radiating groups of blue-black stibnite crystals, 0.2 mm long, on red realgar; Dunning SEM photo, R. W. Thomssen specimen.**

Figure 14. **Bright red realgar crystal, 0.1 x 0.3 mm, containing radiating groups of stibnite and 0.1 mm rhombohedral cinnabar crystals; Dunning SEM photo, R. W. Thomssen specimen.**

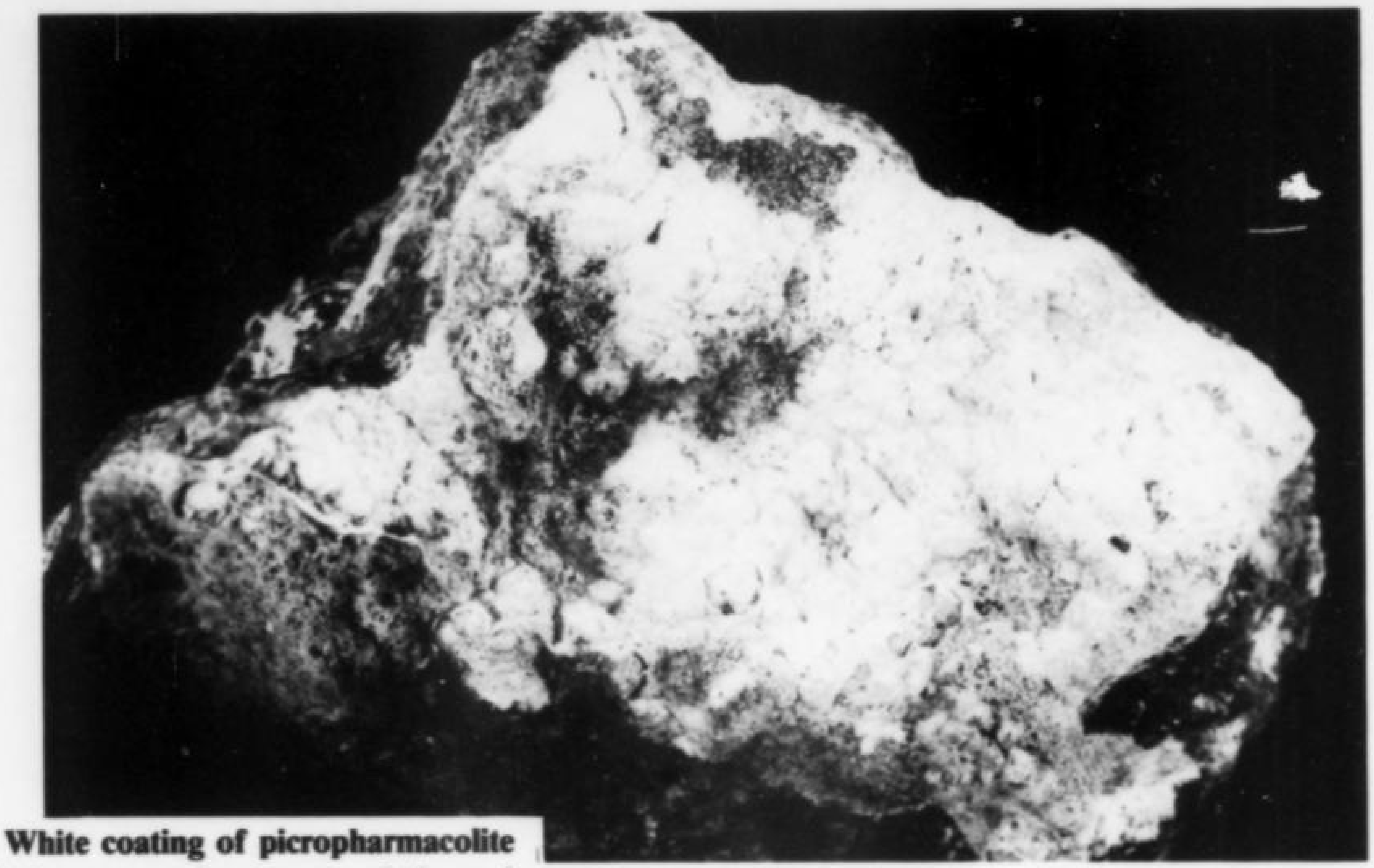

Figure 15. **White coating of picropharmacolite covering dark gray carbonaceous shale and massive realgar specimen, 6 x 8 cm; Dunning SEM photo and specimen.**

Picropharmacolite $H_2Ca_4Mg(AsO_4)_4 \cdot 11H_2O$

Picropharmacolite occurs at the west end of the North pit as coatings along fracture surfaces in the realgar-rich carbonaceous shales and quartz. It generally forms dense white coatings less than 2 mm thick, or thicker botryoidal coatings showing a resemblance to cauliflower. Under the scanning electron microscope these coatings are seen to be composed of minute bladed crystals less than 0.2 x 9 microns in size. The massive material generally shows a radiating to foliated appearance. Oxidation of both realgar and orpiment under acidic conditions has resulted in the formation of picropharmacolite. In addition, a number of unidentified calcium arsenates have been discovered in the partially oxidized realgar-orpiment veins. Owing to the complex nature of these secondary minerals and their dehydration products, further description will be delayed until their identification can be completed.

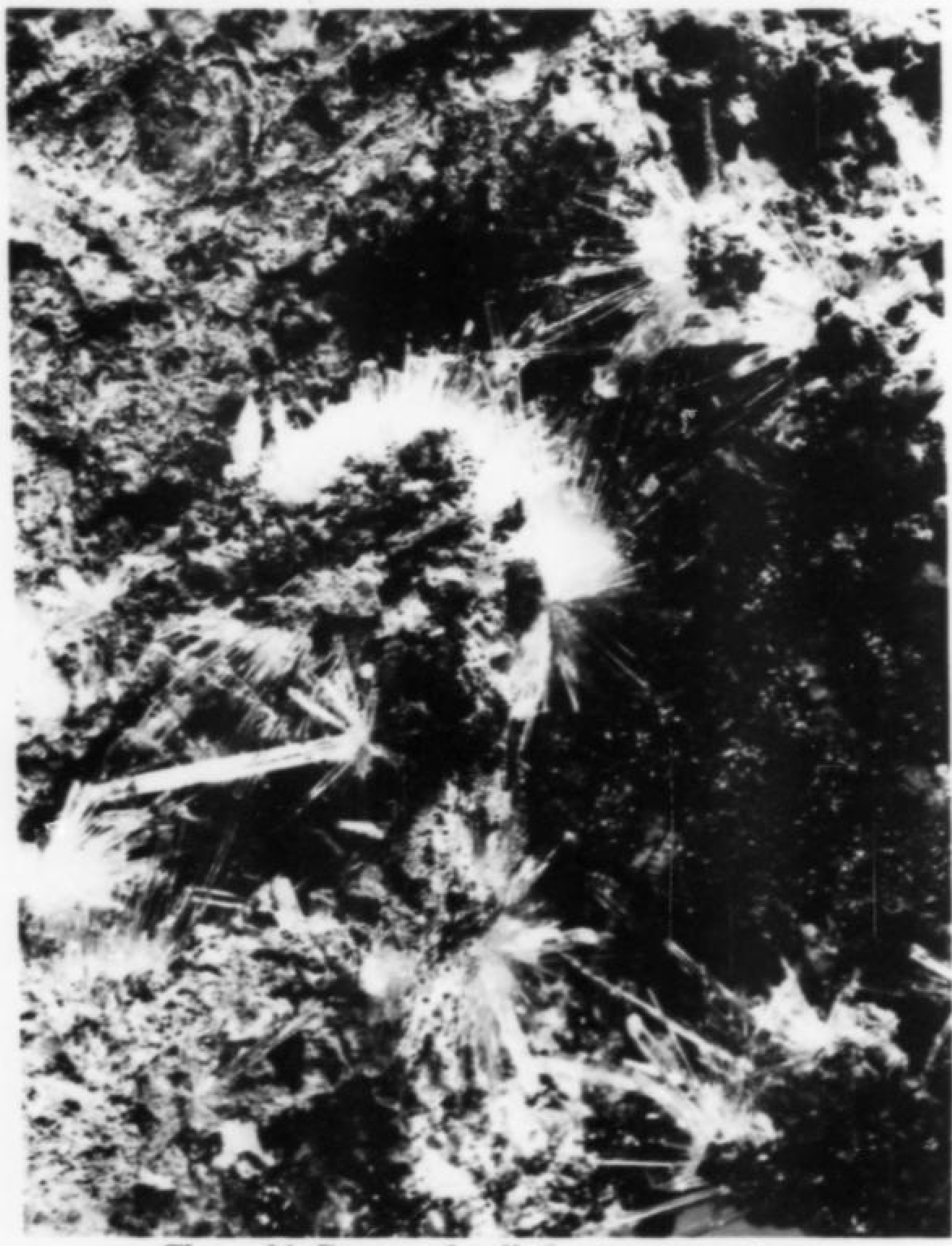

Figure 16. **Groups of radiating transparent gypsum crystals on carbonaceous shale with realgar and orpiment. Specimen 4 x 6 cm; Dunning photo and specimen.**

Realgar AsS

Realgar is one of the more spectacular sulfide minerals at Getchell. It was deposited, along with orpiment, as a late-stage product of local hydrothermal activity following the gold and quartz mineralization along veins and fractures of the Getchell fault system. In rocks with abundant carbonaceous material realgar and orpiment are found surrounded by dense mattes of late-stage remobilized carbon (Berger, 1980).

The Getchell mine has been known for many years for its realgar crystal groups. Especially attractive groups of divergent crystals surrounded by calcite and attached to dark gray carbonaceous quartz have been recovered from the mine. After etching to remove most of the calcite, stout prismatic red crystals, commonly 10 cm or longer, form a colorful contrast against the white calcite and dark gray matrix rock.

In addition to the large, stout, elongated crystals, short stubby crystals less than 5 mm in length have been found in cavities in the quartz-calcite host rock. These crystals are deep red, transparent, and typically show contact twinning on (100).

Along the facture faces in the North pit area realgar can also occur as thin vein fillings of needle-like crystals less than 1 mm long, with typical terminations. These drusy coatings of crystals give a deep red brilliance in sunlight and under a microscope show a radiating habit similar to gypsum.

ACKNOWLEDGMENTS

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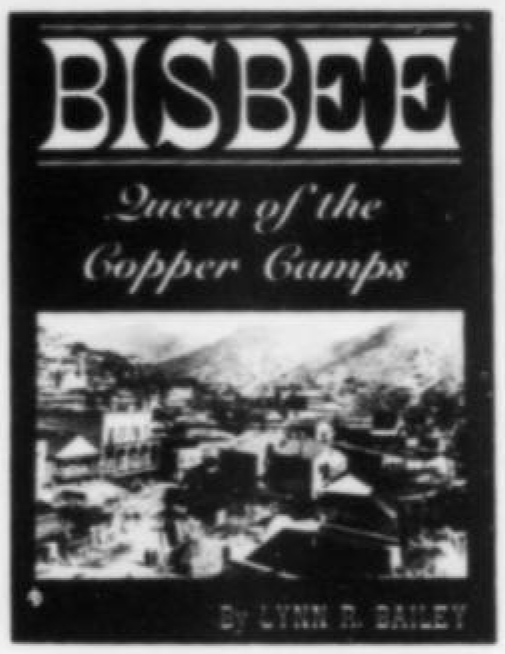

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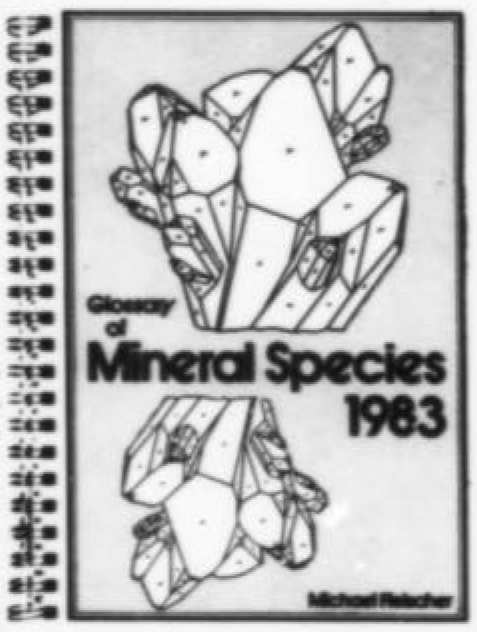

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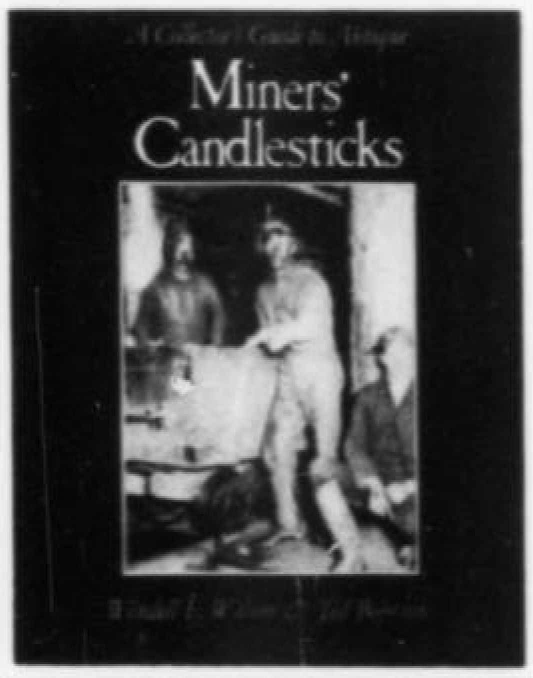

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LOCATION

The Steamboat Springs district is located in Washoe County, Nevada, about 17 km (10 miles) south of Reno near U.S. Highway 395 in sections 28 and 33, T18N, R20E (Steamboat 7½-minute quadrangle). The springs occur on the west slope of a narrow north-south valley at the northwest base of Mount Davidson, just 10 km from the famous Comstock Lode. Mine workings lie about 2 km west of the active springs.

HISTORY

The hot springs were first discovered by Felix Monet in 1860, and were mentioned by J. Ross Browne (1866, 1867). A health resort sprung up on the site, with access provided by the Virginia and Truckee Railroad, completed in 1872. Comstock miners and their families were fond of picnic outings to Steamboat via the train, and Steamboat Station became a favorite stop for locals and visiting tourists and dignitaries (McDonald, 1982).

A short distance to the west of the active springs area is an inactive zone rich in sulfur and cinnabar. This deposit, generally known as the Mercury mine, was discovered by Thomas Wheeler in 1875 and subsequently sold to P. A. Humbert in 1877. The Nevada Quicksilver Mining Company commenced mining that same year (Thompson and West, 1881). Cinnabar and sulfur were mined for a short time via several adits driven into the hillside at various levels, and a furnace was constructed for reducing the cinnabar to mercury (LeConte, 1883). Total production is unknown, but mining ceased before 1883, and by 1887 most of the workings had become inaccessible (Becker, 1888).

Active prospecting for mineable concentrations of sulfur continued for a short while. Day (1887) commented:

> The mineral is found lying under four or five feet of soil, and when first exposed is so hot that it can scarcely be held in the hand. Unless [sulfur is] found in larger masses these deposits are not likely to be of much commercial value.

Geologists visited the site repeatedly, fascinated by what appeared to be sulfides forming directly from a hot water solution. The notion of hydrothermal deposition was still being questioned, and Becker (1888) wrote:

> Here, if anywhere, the question of the mode of genesis of cinnabar deposits can be settled.

Studies subsequently showed that not only cinnabar but also pyrite, stibnite and a new mineral Becker named metastibnite were precipitating from the springs. The complex equilibria were finally explained in detail by Learned *et al.* (1974).

Nothing is known of mining activity from the late 1870s until 1929, when the Steamboat Springs Mining Company tried unsuccessfully to obtain mercury by a flotation process. In 1930 the property was leased to Balfour and Company of Liverpool, England; an open cut known as the silica pit was excavated in a futile search for cinnabar and as a source of silica for glassmaking (Schoen *et al.*, 1974). The property was leased again in 1938 by John Keeler, George Blackmore and associates, who planned to install a rotary furnace but never did. Two years later the property was leased to

Figure 1. **Sulfur crystal group 10 cm across, with individual crystals to 1.5 cm, from near the Silica pit, Steamboat Springs. Barbara Cureton collection.**

W. D. Swallow who planned to recover mercury by using sodium sulfate in a vibratory precipitation process, but most likely never did (Bailey and Phoenix, 1944).

Exploration for mercury was carried out again in 1965, by the Texierra Mining Corporation of Dallas, Texas, in a joint venture with Old West Corporation of Reno, Nevada. Approximately "25,000 tons of cinnabar-bearing rock assaying between 3 to 4 pounds of mercury per ton" were delineated (Bonham, 1969).

The earliest reference in the collector literature appears to be Berkholz (1957), who commented mainly on the salmon-red, cinnabar-impregnated opalite sinter, some of which is suitable for cutting and polishing. She did note, however, that several sulfur outcrops could be readily seen in the canyon and should be searched for specimens.

The area was visited in 1972 by Michael, David and Forrest Cureton, commercial mineral collectors. At a site just uphill from the Silica pit the Curetons excavated along fissures into the hillside and removed large quantities of fine sulfur crystals. Shortly thereafter the same site was mined for sulfur specimens by Tom Palmer, another commercial collector, and Michael Cureton continued to return to the site occasionally until around 1978. Between them, Palmer and the Curetons estimate that they removed approximately 2000 flats* of crystallized sulfur specimens. Many of Cureton's specimens were later sold through mineral dealers Walter Miller and Chris Galas.

According to Forrest Cureton, large quantities of sulfur crystals probably remain, but heavy equipment would be necessary to uncover them. Collecting conditions are made uncomfortable by the continual seepage of hot sulfuric acid and acidic vapor from the fissures.

GEOLOGY

The Steamboat Springs hot springs system has had the longest and most complex geologic history of any active geothermal area in the world (White, 1980). Thermal waters reach the surface by way of fissures which are similar to and approximately parallel to those of the nearby Comstock Lode (Becker, 1888). A bedrock of late Cretaceous granodiorite is capped by Tertiary volcanic rocks and Quaternary basalt flows and gravel and, in places, extensive siliceous sinter terraces built up by precipitation from overflowing springs. The mine is located at the granodiorite/basalt unconformity (Lincoln, 1923; White, 1955). Approximately 50 hot springs occur along a line about 2 km long, most vents having created a gently sloping sinter mound around the opening (LeConte, 1883). Thermal waters and gases discharge through surrounding rock as well, over an area of about 5 km^2 (White, 1980).

The Steamboat Springs thermal area lies within a northeast-southwest trending zone containing four rhyolite domes—the Steamboat Hills rhyolite (Bonham, 1969). These domes range in age from 1.2 to 3.0 million years and correlate with early hot springs activity. Vertical uplift under Sinter Hill was most likely

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*The "flat" is the standard measure of specimen volume used in the mineral collecting business. Originally made from the bottoms of cardboard beer shipping cases and called "beer flats," the flat is now manufactured in a slightly larger and stronger version specifically for mineral dealers, though production is erratic. Measurements are approximately 8 cm deep, 25–40 cm wide, and 40–50 cm long. The authors *do not* know of a current source for custom-made flats . . . interested readers should consult a mineral dealer for further information.

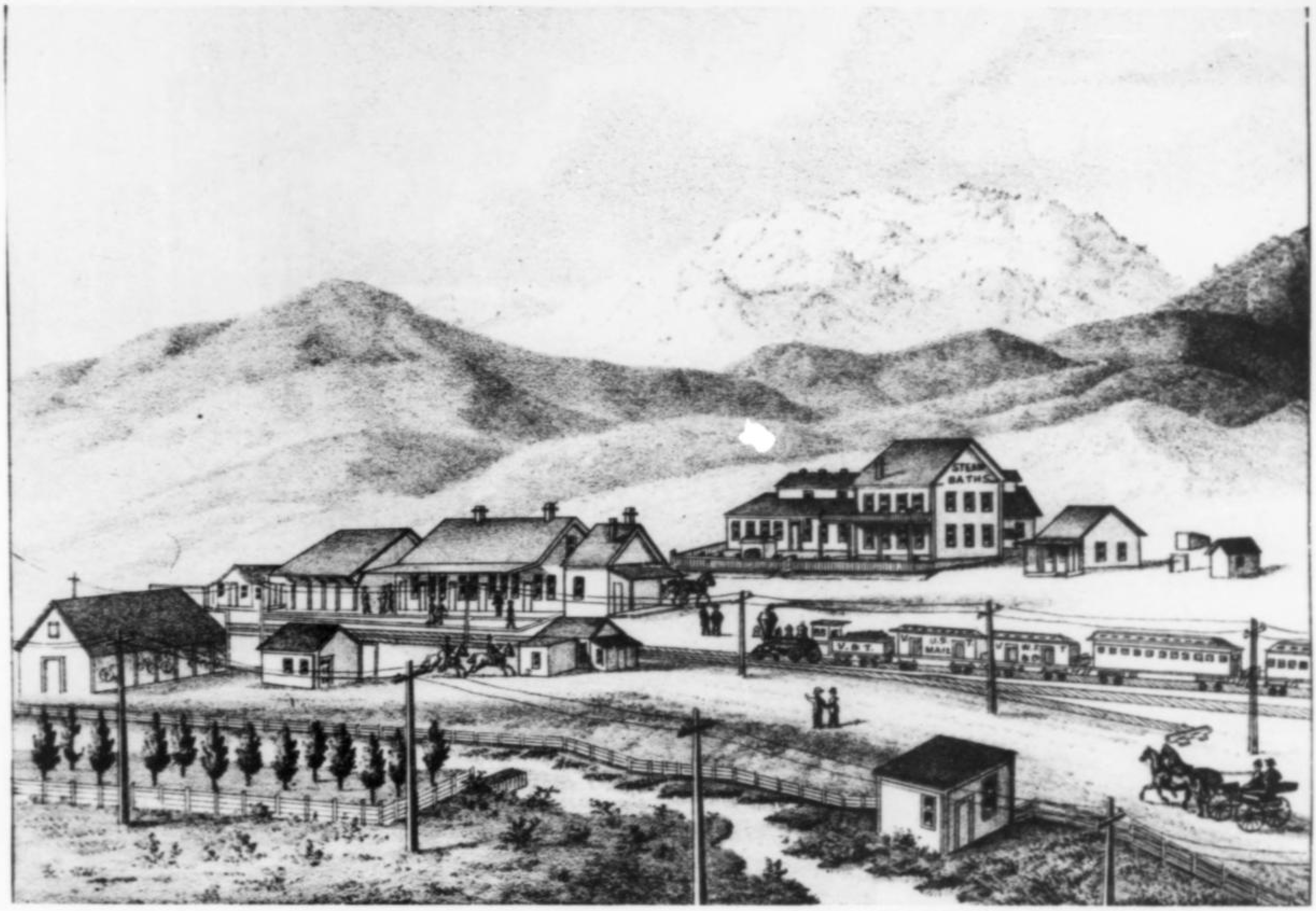

Figure 2. **Spa facilities at Steamboat Springs, 1879–1880 (courtesy Nevada Historical Society).**

caused by a shallow intrusion related to the rhyolite domes (White, 1980). White (1974) and Silberman *et al.* (1979), through isotopic analyses, demonstrated that thermal springs originated and deposited sinter in the area about 3 million years ago, prior to the extrusion of basaltic andesite (2.5 m.y.) from a vent near the crest of Steamboat Hills 2.5 km southwest of the Main Terrace. White (1980) estimated that between 100 and 3000 cubic kilometers of magma must have been solidifying at depth in order to power the Steamboat thermal system throughout its intermittent 3-million-year history.

All wallrock in the thermal area has been altered. Near-surface acid bleaching is the most obvious visible effect on the granodiorite and basalt, extending to a depth of 30 meters or more. Below this

Figure 3. **Sulfur crystals to 1.3 cm from near the Silica pit, Steamboat Springs. Barbara Cureton collection.**

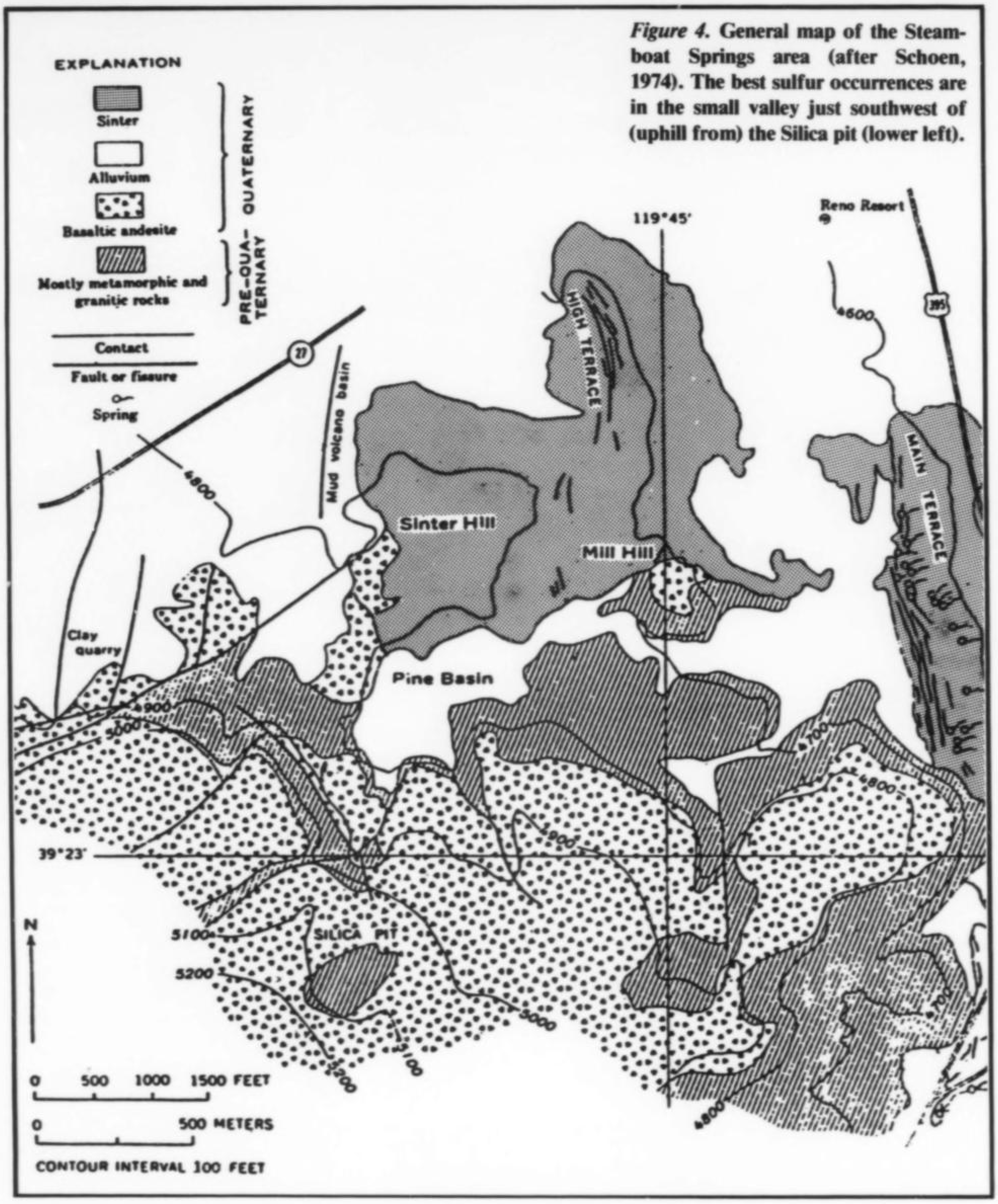

Figure 4. **General map of the Steamboat Springs area (after Schoen, 1974). The best sulfur occurrences are in the small valley just southwest of (uphill from) the Silica pit (lower left).**

zone hydrothermal alteration is limited to the rocks adjacent to channelways for migrating thermal waters, where a type of propylitic alteration is prevalent (Bonham, 1969).

Water in the system has been determined to be virtually entirely meteoric (White, 1957a, 1957b). Carbon isotope ratios suggest that descending meteoric water spends between 30,000 and 300,000 years underground before resurfacing at Steamboat Springs (Craig, 1962). Although much precipitation directly from heated water occurs, White *et al.* (1971) have concluded that overall the hydrothermal system is vapor-dominated. Vapor is generated by boiling water at the water table and moves upward, condensing in cooler rock or escaping at the surface. Oxidation of associated gaseous H_2S yields elemental sulfur and also (with a bacterial assist) sulfuric acid which retards the formation of calcite in the upper zones and which gives rise to an advanced argillic alteration suite (Schoen *et al.*, 1974). The high acidity of the waters was first noticed by Brannock *et al.* (1948) "when parts of the authors' clothing disintegrated."

The water table is at or close to the surface in the eastern area where active springs are found, but is as much as 40 m below the surface in the western area where the sulfur and cinnabar mine is located (White, 1955). Although no active springs currently exist in the mine area, steam and other gases are venting there, and deposition from vapor (particularly sulfur mineralization) is probably still in progress beneath the surface.

Exploratory drilling by the U.S. Geological Survey penetrated to a depth of about 55 meters, where water temperatures reached 172° C (96° C being the boiling point on the surface at that elevation). Obviously such temperatures suggest practical uses, and as early as 1916 efforts were being made to pipe hot water to Reno for heating purposes. The first well specifically for geothermal use was drilled in 1920, and a well in search of steam for generating electricity was drilled in 1950. More wells were drilled in the 1960s, the deepest reaching 558 meters and 186° C. Then in 1979 a well was drilled to 930 meters, where a temperature of about 230° C was encountered (White, 1980).

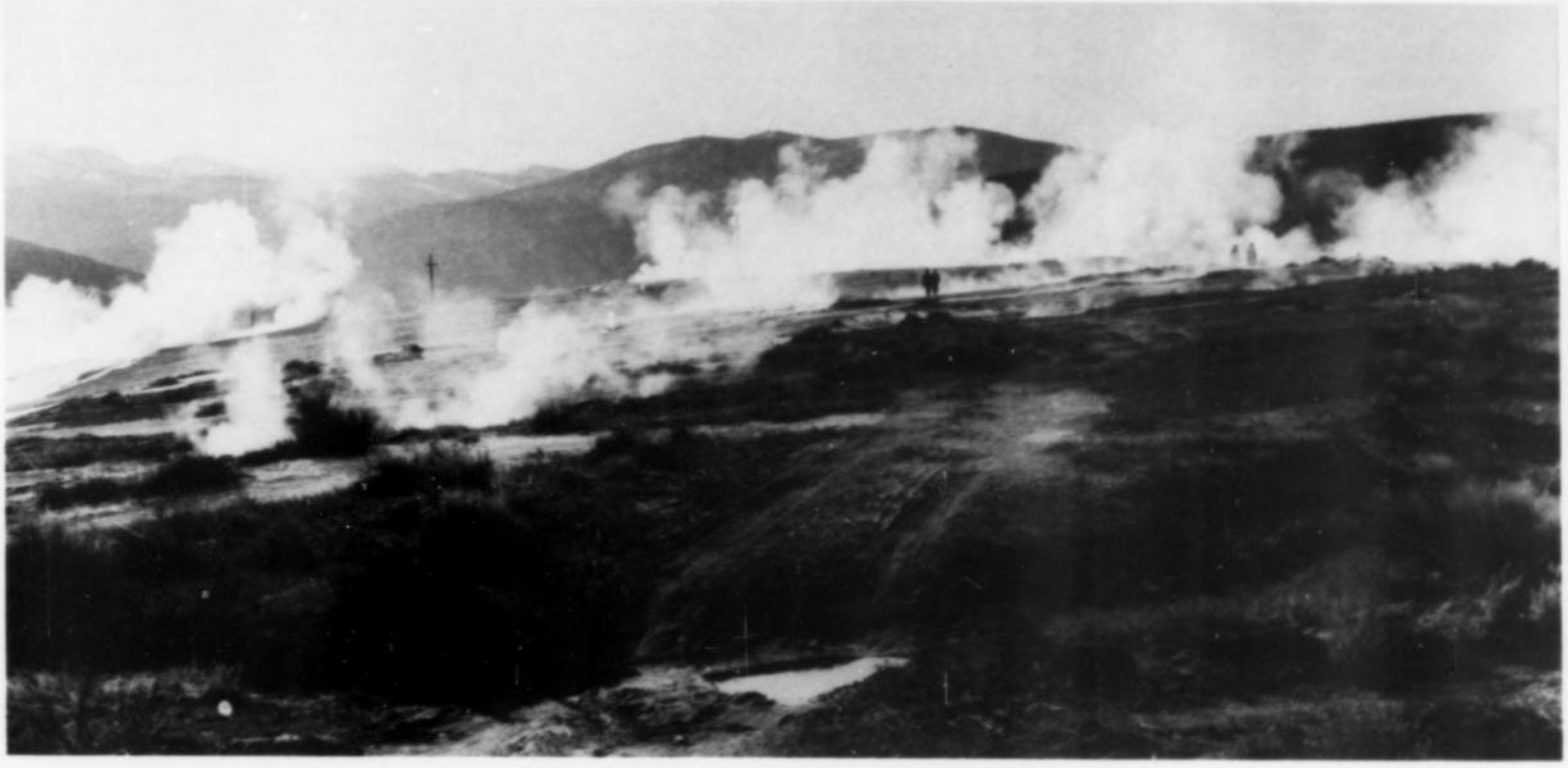

Figure 5. **Steam erupting from the many hot springs vents on the Main Terrace, 1942 (courtesy Nevada Historical Society).**

By the time these thermal waters have reached the surface they have cooled to 80–95° C (Lindgren, 1906; Gianella, 1939; Sigvaldason and White, 1962). The waters are heavily mineralized, having a high content of NaCl and SiO_2, and also carrying antimony, arsenic and mercury (Becker, 1888; Jones, 1914). Iron, lead, copper, gold, thallium, boron, germanium and silver (including visible pyrargyrite crystals) have been reported as well (White, 1980). Carbon dioxide, hydrogen, hydrogen sulfide, nitrogen, oxygen and argon gases have been measured (Sigvaldason and White, 1962; Brannock *et al.*, 1948). Precipitation, primarily of siliceous sinter, is so heavy that vents appear to have commonly sealed themselves off, new ones breaking through elsewhere along the fissures. The flow through pipes installed to convey mineral waters to the spa facilities are said to have become restricted within a week due to deposition inside the pipes (Gianella, 1939).

Siliceous sinter deposits surrounding the springs reach a maximum depth of about 30 meters, and calcite deposition occurs only below 50 meters (Schoen *et al.*, 1974).

Observers as early as Laur (1863) noted that sulfide precipitates forming at Steamboat Springs appear identical to true fissure veins. Drilling has revealed veins and alteration assemblages indistinguishable from those at many other ore deposits, although ore grade at Steamboat Springs is too low to be economical (White, 1955). The deposit is now viewed as a present-day equivalent of Tertiary geothermal systems responsible for gold-silver deposits throughout the Great Basin (White, 1980).

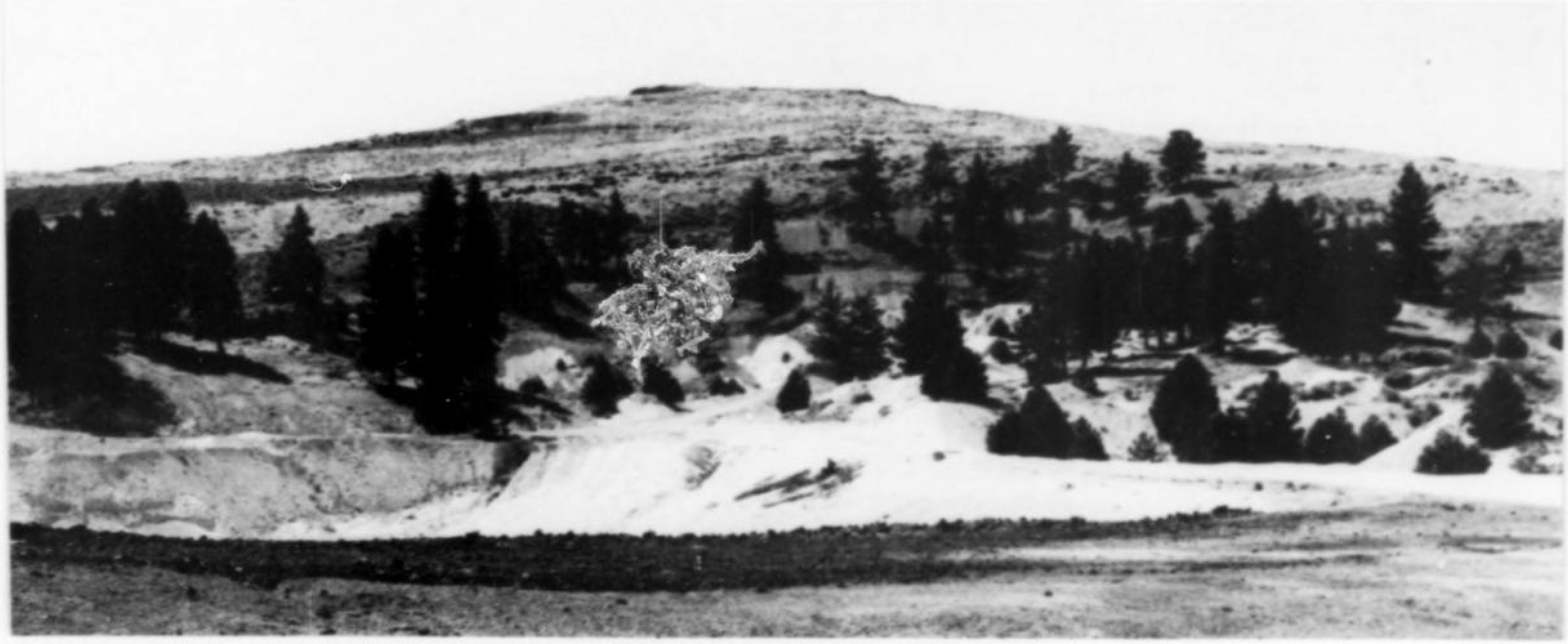

Figure 6. **Silica pit (foreground) and the small, tree-lined valley leading uphill from it where the best sulfur outcrops are found. Photo (1984) by R. W. Thomssen.**

Figure 7. **Some of the sulfur diggings just uphill from the Silica pit. Photo (1984) by R. W. Thomssen.**

MINERALS

Minerals identified at Steamboat Springs include the following:

- alunite
- alunogen*
- arsenopyrite
- bonattite*
- calcite
- chalcopyrite
- cinnabar
- jarosite*
- mercury
- metacinnabar*
- metastibnite
- opal
- pyrargyrite
- pyrite
- quartz
- siderotil*
- stibnite
- sulfur

Clays, chlorites and feldspars are also common. Of all the species, only sulfur has been found as display-quality specimens. Most occur merely as smears or microcrystals unsuitable even for micromounting.

Cinnabar HgS

Fine-grained cinnabar occurs as streaks, veins and disseminations in siliceous sinter and in decomposed basalt and granodiorite. Small amounts of mercury have been measured in the spring waters. The most dramatic demonstration was made by White (1955); he observed tiny crystals of cinnabar to have precipitated on test specimens suspended in thermal wells. No cinnabar has been found deeper than about 10 m below the surface. Brannock *et al.* (1948) noticed that brass parts of a thermometer assembly, when lowered into a well, became coated with mercury within 5 minutes, before having been lowered as far as the water level.

Metastibnite Sb_2S

Metastibnite is the amorphous dimorph of stibnite. It is red in color, prominently marking much of the siliceous deposits at Steamboat Springs, where it was first found and named (Becker, 1888). A second U.S. occurrence was found in California recently (Brookins, 1970).

Stibnite Sb_2S_3

Clark (1911) noted that stibnite is soluble in water heated to 80° C, particularly if sodium sulfide is present, which it is at Steamboat Springs. Minute, acicular crystals of stibnite to about 1 mm in singles and rosettes have been found to compose up to 4% of spring mud by weight; the mineral was also observed floating as a thin scum on the surface of spring waters. Brannock *et al.* (1948) commented that the mud is as rich in antimony as mine-run ore in most of the antimony mines in the U.S. and Mexico.

Stibnite crystals also occur in cavities in sinter, in some areas associated with pyrite, chalcopyrite, arsenopyrite and cinnabar (Lawrence, 1963). Stibnite is prominent in cavities and veinlets but decreases rapidly with depth, becoming insignificant at around 30 m (White, 1955).

Sulfur S

Free sulfur occurs at many of the springs and also in the area of the mine where it forms irregular concentrations (LeCónte, 1883; Becker, 1888). Superb crystal crusts and single crystals to 7 cm have been collected in large quantities. Crystals are typically acute bipyramids with hopper faces, although some crystals are more equant and less hoppered. Slabs of fissure walls to more than 50 kg have been collected which are completely covered on the fissure face by large, attractive sulfur crystals. Crystal-lined fissure vugs to more than a meter in length have been found. Some sulfur crystals have a pleasant pink tinge due to inclusions of a red mineral, most likely cinnabar.

Others

As mentioned above, most other species occur as smears, stains, powders and crusts of unprepossessing appearance. Forrest

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*X-ray identified by S. A. Williams (F. Cureton, personal communication).

Cureton (personal communication) reports pale blue bonattite in small, botryoidal crusts; black massive metacinnabar; and whitish, glassy crystals of alunogen to 2 mm.

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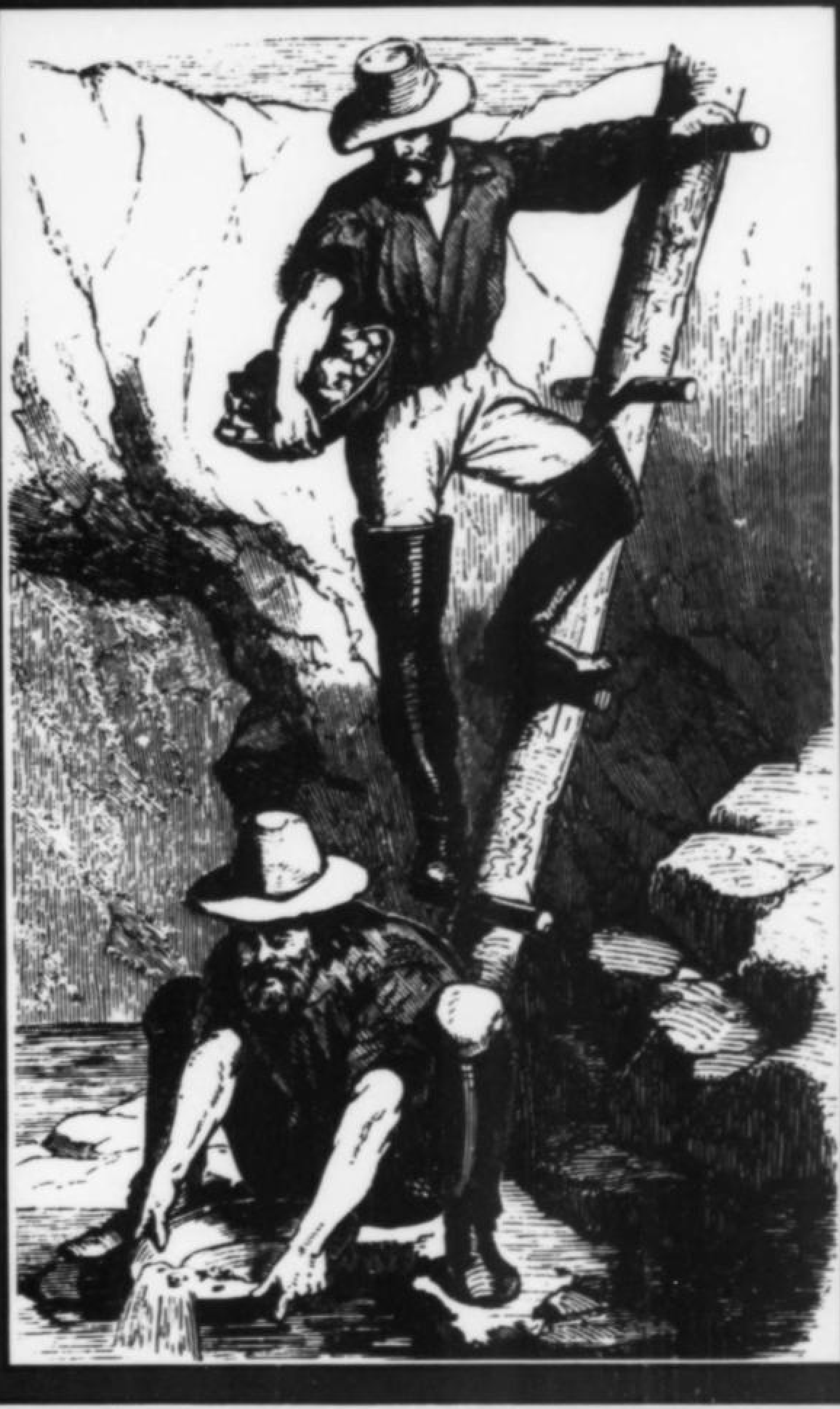

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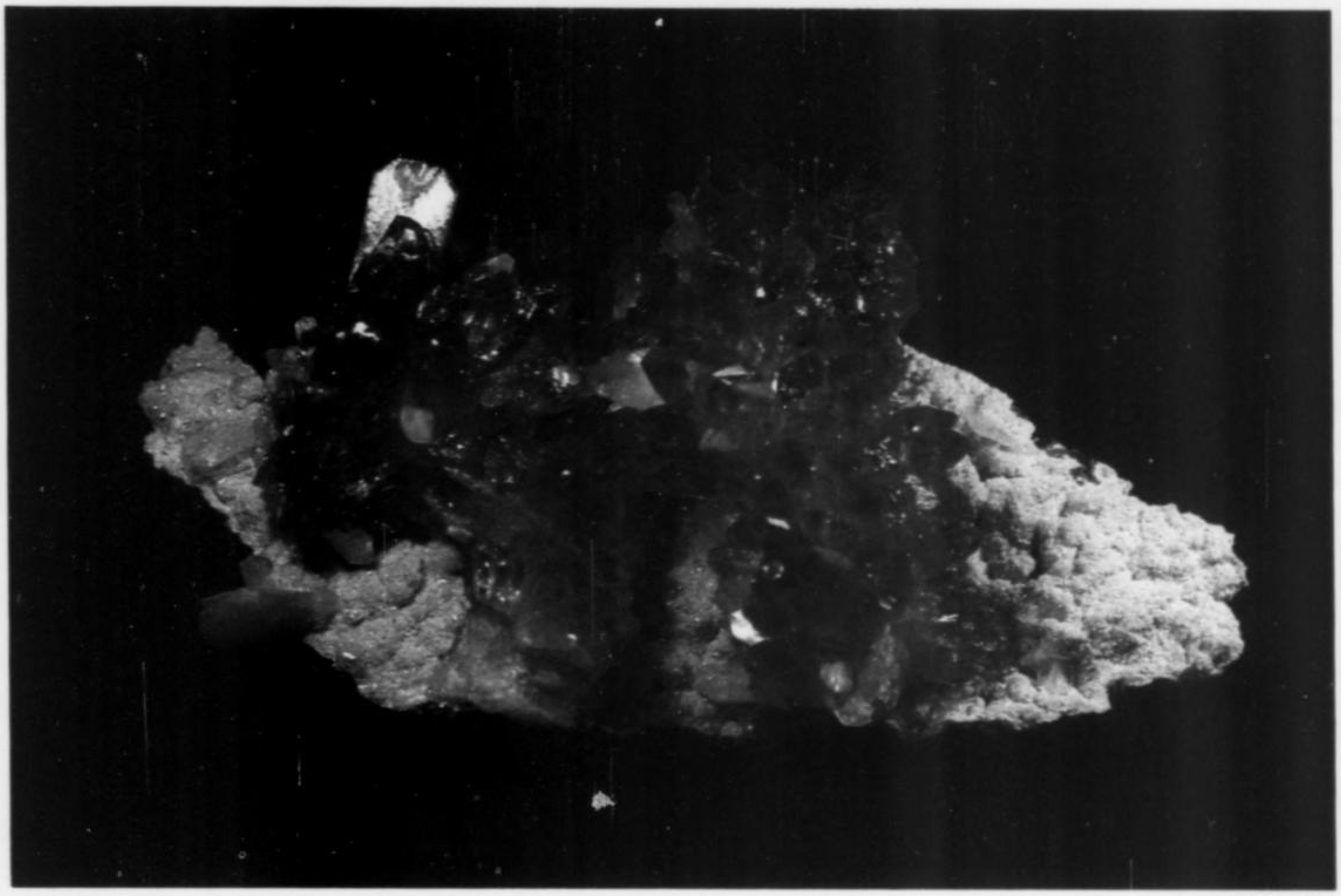

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Neil Prenn
394 Fricke Court, Rt. 1
Gardnerville, Nevada 89410

The Northumberland mine is the highest-elevation operating open-pit mine in Nevada. Well crystallized barite from this deposit has been known to collectors for many years. The locality has also produced the first examples of twinning in pharmacosiderite.

INTRODUCTION

The Northumberland mine is located in the Northumberland mining district of the northern Toquima Range. The Toquima Range overlooks Big Smoky and Monitor Valleys. The district is in the Toiyabe National Forest and has produced gold, silver, barite and turquoise. Barite is mined along East and West Northumberland Canyons; the Northumberland mine is located where both canyons meet at the crest of the range. The district is about 130 km (80 miles) northeast of Tonopah and about 81 km (50 miles) south of Austin, Nevada.

HISTORY

Production from the Northumberland district began in 1866 with silver ores shipped from the Northumberland and the Lady Cummings mines. In October of 1866 the *Reese River Reveille* stated, "In Northumberland District, forty distinct ledges have been discovered and located, which are generally of large size and better defined than those of any other district in the region." The Detroit, Blue Bell (reportedly with 1200 meters of workings according to Kral, 1951), and the Monitor became the principle mines of the district. Considerable money was expended by Quintero Mining Company to erect a 10-stamp mill located at a spring in West Northumberland Canyon. Raymond (1869) noted that the mill closed soon after construction on account of "financial embarrassments." Northumberland proved to be a large "vein" but the ore was low-grade. Production of the initial camp was only about 20 tons.

A very short-lived town, Learnville, was started in 1868, however production was then even lower than at the time of the initial camp (Paher, 1970). In 1879, a town called Bartlett was formed when the Quintero Mining Company apparently resumed mining activity, and again was only short lived, ceasing operation in 1881 (Thompson and West, 1881). There was sporadic activity in the district in 1891; recorded production between 1866–1891 is reported by Kleinhampl and Ziony (1980) to have been 564 tons of silver ores; however, they state that actual production may have been greater than recorded. Silver was mined intermittently between 1908 and 1917 when a new mill was constructed; however, the amount of production is unknown (Lincoln, 1923).

Gold production from the district probably did not occur until the late 1930s; however, gold was known to occur in the district. Low grade ore was discovered in 1936. The Northumberland Mining Company acquired the property in 1938 and began production in 1939 (Kral, 1951). A 300-ton-per-day mill was moved from Weepah, Nevada, to Northumberland and three small open pits were operated by the Weepah Mining Company. The ores mined were mainly composed of jasperoid and were very hard. The mill could not treat 300 tons per day of Northumberland ore without

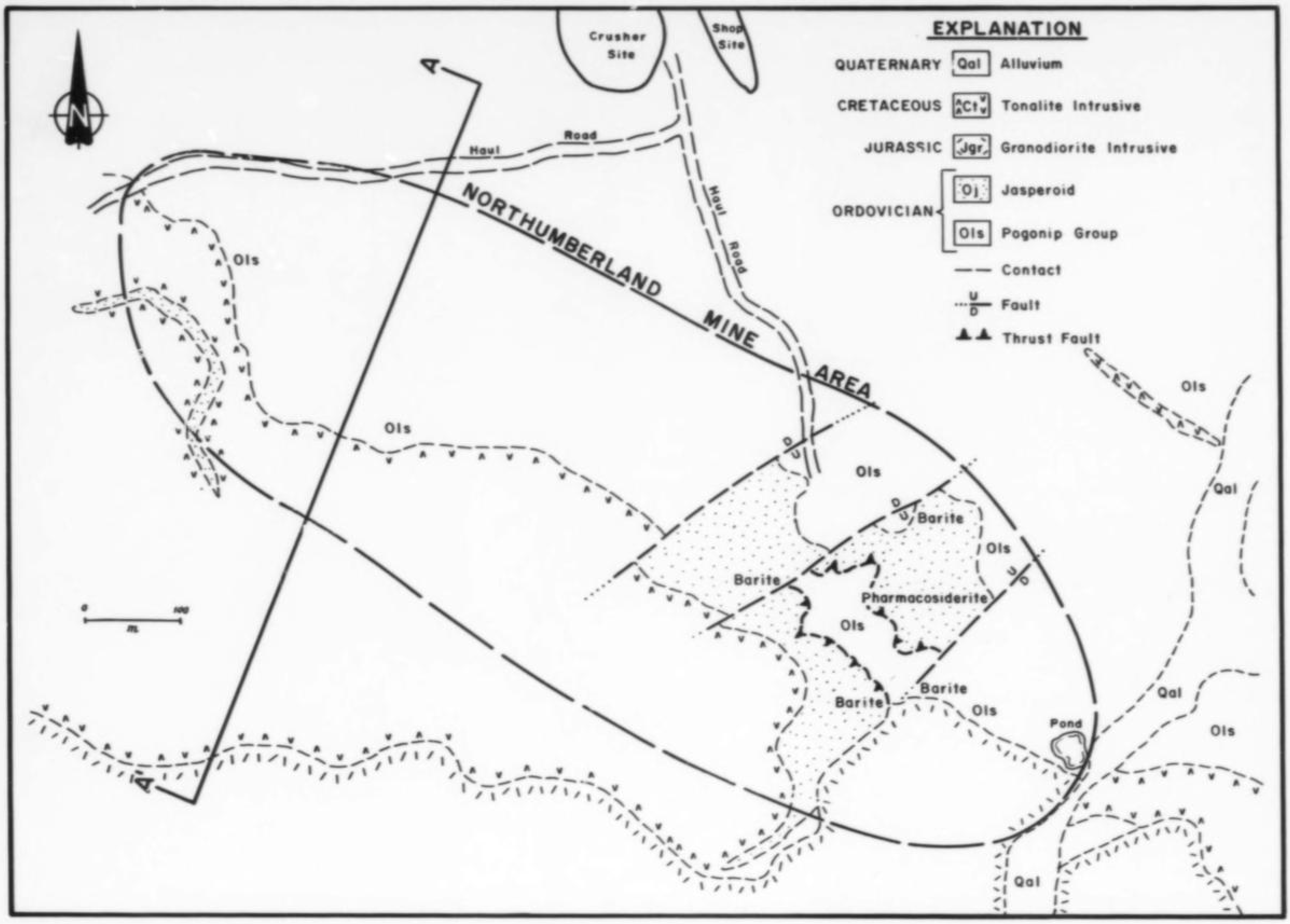

Figure 1. **Geologic map (after Chapman, 1982).**

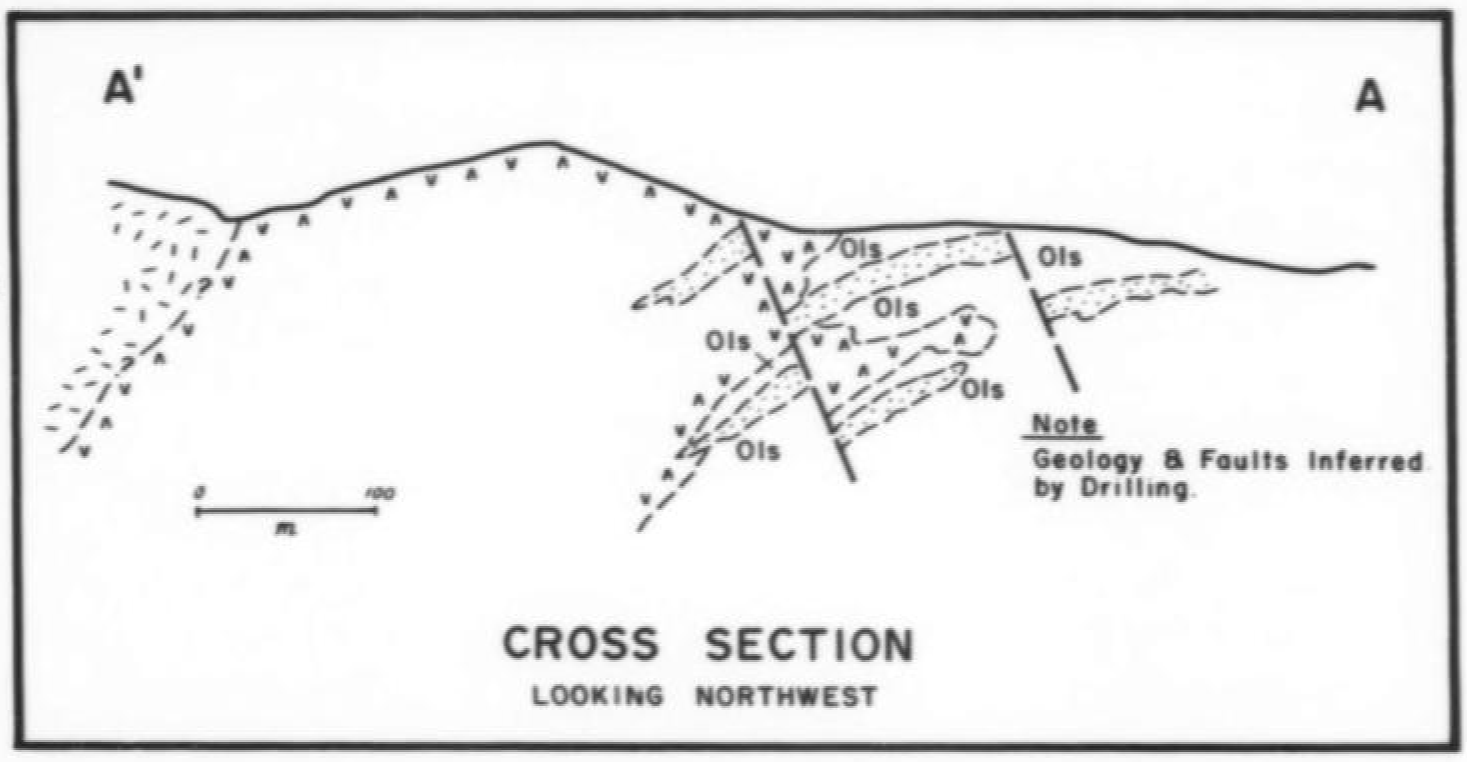

Figure 2. **Cross-section from Figure 1.**

additional grinding machines. Ore in the lowest elevation pit was refractory and gold recovery was only 60–65% compared to 85–90% normal recovery. The operation continued until late 1942 when War Production Board Order L-208 shut down most gold mines. Kleinhampl and Ziony (1980) state total production for the period 1939–1942 was 200,284 tons averaging $5.20 per ton or a total value of production of $1.15 million.

Barite production in the district did not begin until 1964. Barite has been mined from both East and West Northumberland Canyons (Kleinhampl and Ziony, 1980). All Minerals, Inc. and Standard Slag Company currently operate mines intermittently on these deposits. Crystallized mineral specimens are apparently uncommon at the barite operations.

The Northumberland district was again idle between 1942 and 1979; however, many companies investigated and drilled the area. Idaho Mining Company acquired the property in 1971 and entered into a joint venture in 1974 with Cyprus Mines Corporation. Exploration continued and a decision to put the property in production was reached in 1978–79 with Cyprus Mines acquiring Idaho Mining Company's remaining interest. Development costs totaled approximately $17 million by the time the property was placed into operation in 1982.

Northumberland ore is currently being mined at a rate of approximately 750,000 tons per year. The ore is crushed, agglomerated, and transported 16 km to the leach pads. Agglomeration is a process that bonds fine grained clay particles into larger particles to improve leach solution percolation. The Northumberland open pit is located at approximately the 2600 meter elevation. The operation has about 115 employees and, since it is currently active, is closed to mineral collecting. One of us (NP) managed the Northumberland mine during the period of September, 1981, through December, 1983.

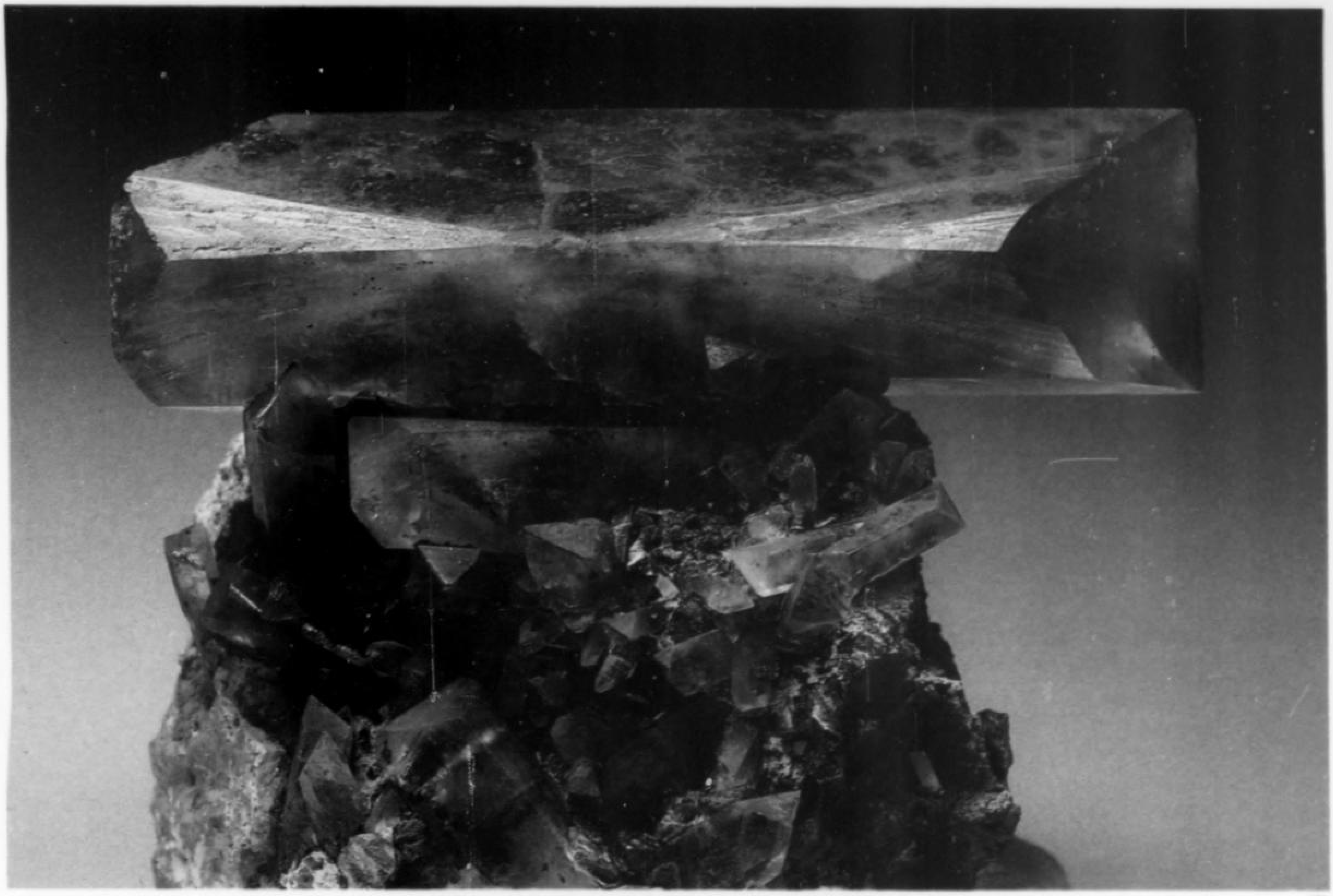

Figure 3. **Barite crystal, 10 cm across, from the Northumberland mine. Neil Prenn collection.**

GEOLOGY and MINERALIZATION

Most of the geology presented here has been condensed from a Northumberland mine handout prepared by Peter Chapman (1982) and from discussions with Jack Motter (1983). The geology of the Toquima Range in the vicinity of the Northumberland mine consists primarily of lower and middle Paleozoic carbonate and clastic rocks. Tertiary rocks, primarily ash flow tuffs and shallow intrusive bodies, are locally found intruding and covering the Paleozoic sediments. The tuffs appear related to a volcanic eruptive event which occurred 33 million years ago at the Northumberland volcanic center and caldera located 6.5 km to the west. The Tertiary rhyolitic intrusives found in the mine appear to be related to this event but remain undated.

Gold mineralization at the mine is primarily located in Ordovician sediments on the northern margin of a granitic stock dated at about 154 million years old (Chapman, 1982). The interior portion of the stock is a medium grained granodiorite. Numerous dikes and sills of younger tonalite (quartz porphyry) are found intruding the sediments in the area of the present mining operations. The altered portion of the tonalite has been dated by the U.S.G.S. at approximately 84.6 million years according to Chapman (1982). Both silver and gold mineralization are present within the tonalite as well as in the adjacent rocks.

Two distinct periods of mineralization have been recognized at Northumberland. The first period is responsible for the emplacement of quartz-silver veins as well as selective silicification of the sediments. Superimposed over the high-grade silver veins and silicified zones is a later stage of broader alteration associated with the disseminated gold mineralization. While much of the alteration responsible for the emplacement of the silver mineralization is masked by the later gold-related alteration, the former appears directly related to stages of the tonalite intrusion.

The alteration related to the gold mineralization at Northumberland is typical of the Carlin-type epizonal alteration, and shows evidence of vertical controlling structures, as well as stratiform control along selective horizons in the sediments. One of the most prominent features of alteration is the outward mobilization of calcite (decarbonitization) followed by replacement with silica and pyrite in the sediments. Barite and pharmacosiderite found in the oxidized portions of the main orebody (generally near high-angle structures) are believed to be closely related to the source structures channeling the mineralization. Locally, the limestones are dolomitic and this dolomitization appears to be related to the gold mineralization. While the micron-sized gold particles of the deposit have yet to be studied by electron microscope techniques, it is believed that the gold is intimately associated with the fine grained pyrite and within iron oxides in the jasperoid (silicified) rocks.

MINERALS

The minerals found at Northumberland are generally microscopic or submicroscopic with the notable exception of barite. The following list of minerals is probably not complete, as the study of minerals at Northumberland has thus far included only a small portion of the deposit. The minerals of most interest are barite and pharmacosiderite.

Barite $BaSO_4$

Barite is common in the eastern flank of the deposit. Crystals in excess of 12 cm have been found lining pockets in jasperoid. Pockets up to 2.5 meters in length and 2 meters wide have been

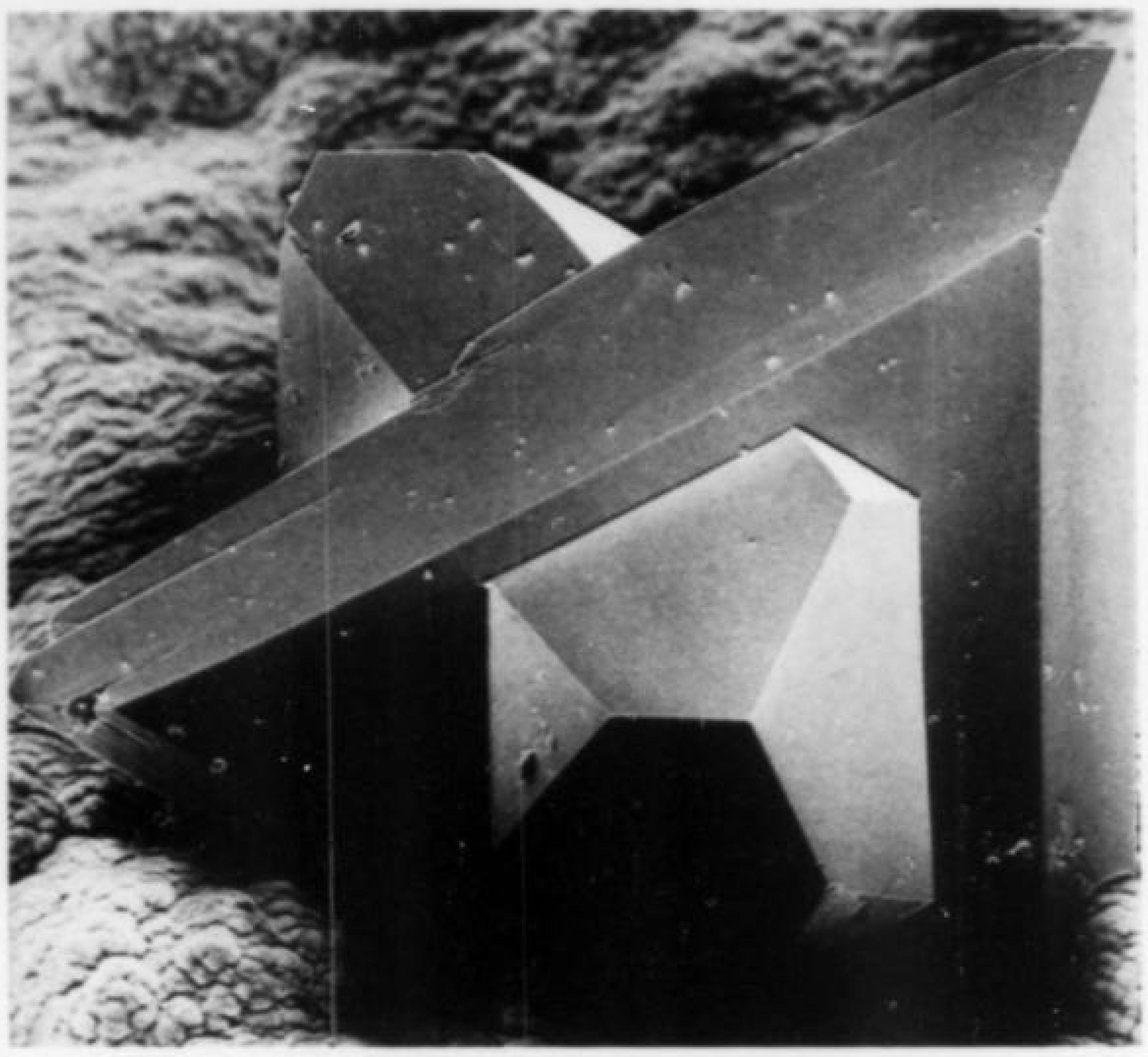

Figure 4. **SEM photo of a pharmacosiderite penetration twin about 0.3 mm across. The crystals consist of a tetrahedron with cube modifications.**

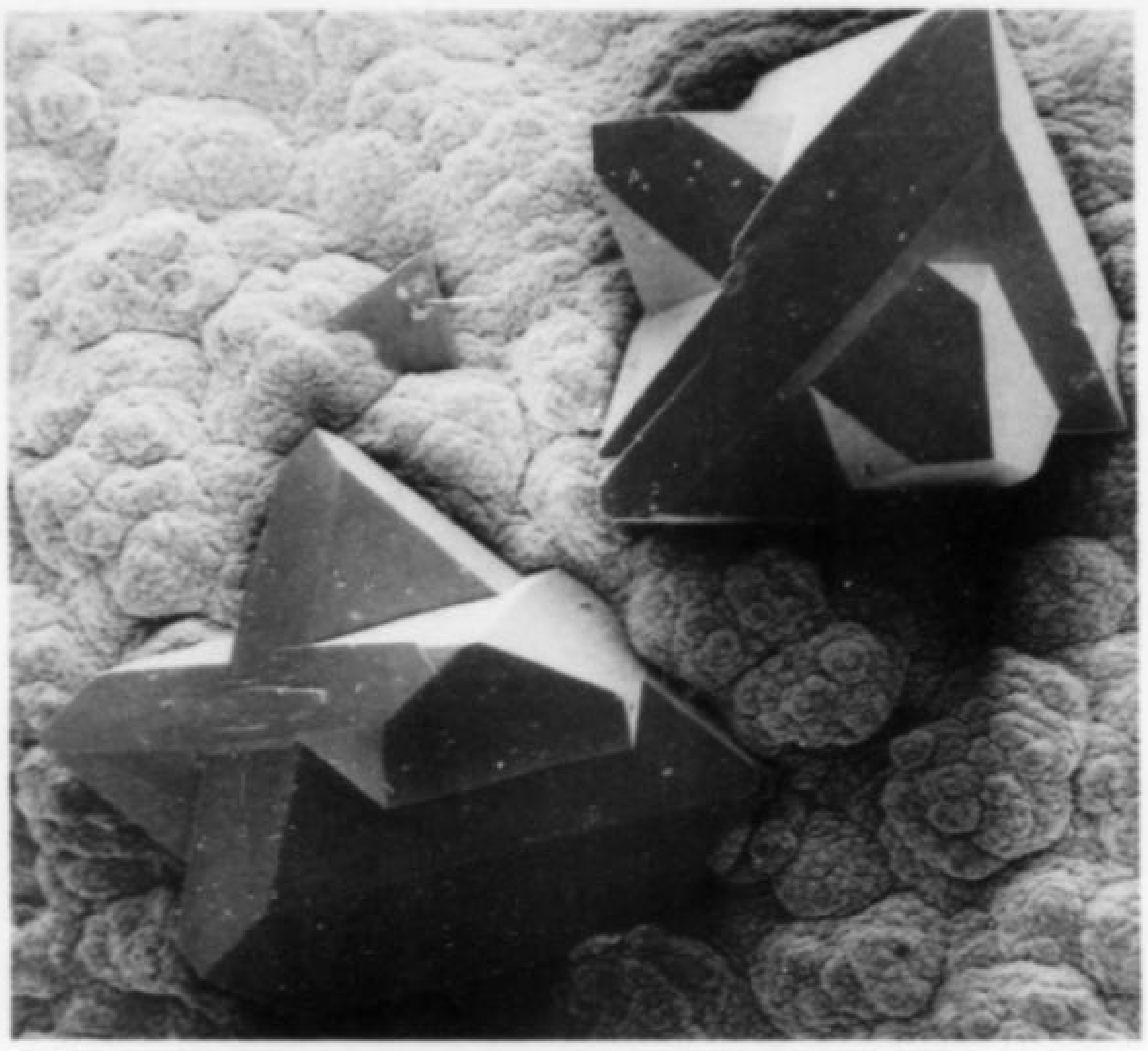

Figure 5. **SEM photo of pharmacosiderite penetration twins.**

found. Barite in these pockets is commonly etched. The crystals formerly lining the upper portions of the pocket are usually found in a rubble at the bottom of the pocket. The pockets appear to be larger and more common in the northeast area of the pit. The barite crystals are generally elongated along the *b*-axis [010] and occasionally show phantom inclusions of limonite. The most common colors are greenish brown, golden brown, gray-blue and colorless. It also occurs in small, massive, white veinlets in a silicified breccia.

Pharmacosiderite $KFe_4^{+3}(AsO_4)_3(OH)_4 \cdot 6\text{–}7H_2O$

Pharmacosiderite has been found in the northeast portion of the deposit. It occurs as well-formed cubes, tetrahedrons and tetrahedron twins up to 0.3 mm on jasperoid. The crystals vary in color from emerald to olive-green, though some cubes are honey-brown. The twin tetrahedrons and tetrahedrons have only been found in one small area in the northeast portion of the pit; however, the occurrence of cubes is common. The twins are penetration twins with (100) as the twin plane.

Other minerals occurring at Northumberland are:

Aragonite $CaCO_3$

Aragonite occurs filling fractures and as radiating aggregates up to 1.2 cm. It is a common mineral in several nearby limestone caves.

Arsenopyrite FeAsS

The rhyolite dikes in the Northumberland deposit generally contain blebs and crystals of arsenopyrite, usually less than 0.5 cm. Pharmacosiderite is one of the alteration products of arsenopyrite.

Azurite $Cu_3(CO_3)_2(OH)_2$

Azurite has been found coating fractures with malachite in one small vein in the southwestern portion of the deposit.

Calcite $CaCO_3$

Calcite commonly occurs as fracture fillings. Occasionally the fractures are wide enough for 2-cm, water-clear crystals to develop. Calcite has been found in the shales and limestones of the deposit.

Chlorargyrite AgCL

Chlorargyrite was noted by Raymond (1869).

Fluorapatite $Ca_5(PO_4)_3F$

Fluorapatite occurs as minute white balls on limonite-stained jasperoid.

Freibergite $(Ag,Cu,Fe)_{12}(Sb,As)_4S_{13}$

Freibergite is the predominant silver mineral of the district. It occurs in massive form in shales, limestones and jasperoid.

Gold Au

Gold occurs as submicroscopic grains in the jasperoid, limestone and shales.

Gypsum $CaSO_4 \cdot 2H_2O$

Gypsum has been found as fibrous aggregates and crystals up to 5 mm.

Jarosite $KFe_3^{+3}(SO_4)_2(OH)_6$

Jarosite is a common oxidation product in the deposit. It is found as minute crystals or crusts and coatings along fractures.

Malachite $Cu_2(CO_3)(OH)_2$

Malachite was found in one small vein as a coating in fractures associated with azurite.

Opal $SiO_2 \cdot nH_2O$

Opal occurs in altered rhyolite dikes pseudomorphous after clay minerals. The opal is highly fractured and is generally green to blue.

Pitticite $Fe_2^{+3}AsO_4SO_4OH \cdot nH_2O$ (approximate)

Pitticite is found as black waxy masses resembling opal. Pitticite is an inadequately described mineral (Roberts, 1974).

Proustite/Pyrargyrite Ag_3AsS_3/Ag_3SbS_3

Raymond (1869) describes ruby silver ores from the Northumberland district.

Pyrite FeS_2

Pyrite occurs as small crystals and blebs in rhyolite dikes, shale and jasperoid.

Quartz SiO_2

Quartz occurs commonly, generally in druses lining small cavities. The jasperoid rock type is a silicified limestone.

Scorodite $FeAsO_4 \cdot 2H_2O$

Scorodite occurs as crusts of sugary crystals associated with pharmacosiderite on jasperoid.

Strengite $Fe^{+3}PO_4 \cdot 2H_2O$

Strengite has been identified by microprobe analysis as white crusts associated with pharmacosiderite on jasperoid.

CHEMISTRY

Microprobe analyses of brown and greenish cubes of pharmacosiderite associated with scorodite and fluorapatite indicate a barium-rich variety but not enough barium to constitute the analogous species barium-pharmacosiderite. The cubes of pharmacosiderite have approximately 20–30% of their potassium replaced by barium, while the tetrahedrons have about 10% of the potassium replaced by barium (microprobe analyses by William Wise). No attempt has been made to determine why the cubes have a greater substitution of barium for potassium. Both cubes and tetrahedrons have been found in approximately the same areas. Microprobe analyses of pharmacosiderite tetrahedrons reflect the substitution of minor amounts of sodium for potassium, aluminum for ferric iron, and phosphorus for arsenic. White crusts associated with pharmacosiderite were identified by microprobe analysis as strengite. Shown in Figure 6 is a diagram indicating the composition of Northumberland strengite as compared to mansfieldite, scorodite and variscite.

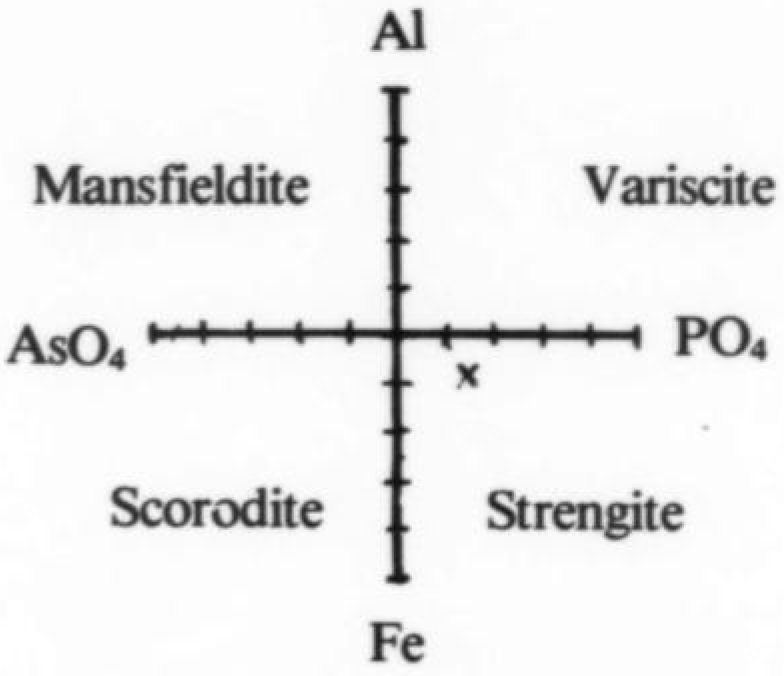

Figure 6. **Northumberland mine strengite composition plotted (x) with respect to the isomorphous series leading to scorodite and variscite.**

TWINNING IN PHARMACOSIDERITE

Penetration twins of tetrahedral pharmacosiderite crystals were found associated with strengite and "pitticite" and single tetrahedrons of pharmacosiderite. The crystals are all modified by *a* (cube) faces. Figure 5, a SEM photograph, shows the *a* faces modifying the tetrahedron. Twinning has not previously been described for pharmacosiderite. Some cubic crystals were found in the same general area as the tetrahedrons and twin tetrahedrons.

ACKNOWLEDGMENTS

Our thanks to William S. Wise, University of California, Santa Barbara, for microprobe analyses of strengite, scorodite, fluorapatite, pharmacosiderite, and pitticite; also for the SEM photograph of twinned pharmacosiderite. W. W. Crook, Mobil Oil Corporation, performed the X-ray diffraction work on the pharmacosiderite and jarosite. Bruce Runner, Delhi, California, brought the pharmacosiderite crystals to our attention, and aided in identification of other species. Pete Chapman, Carson City, Nevada, prepared the geologic handout used at the Northumberland mine which was condensed for use here, including the geologic map. Jack Motter, Reno, Nevada, aided in the geologic description. Wendell E. Wilson provided the barite photograph.

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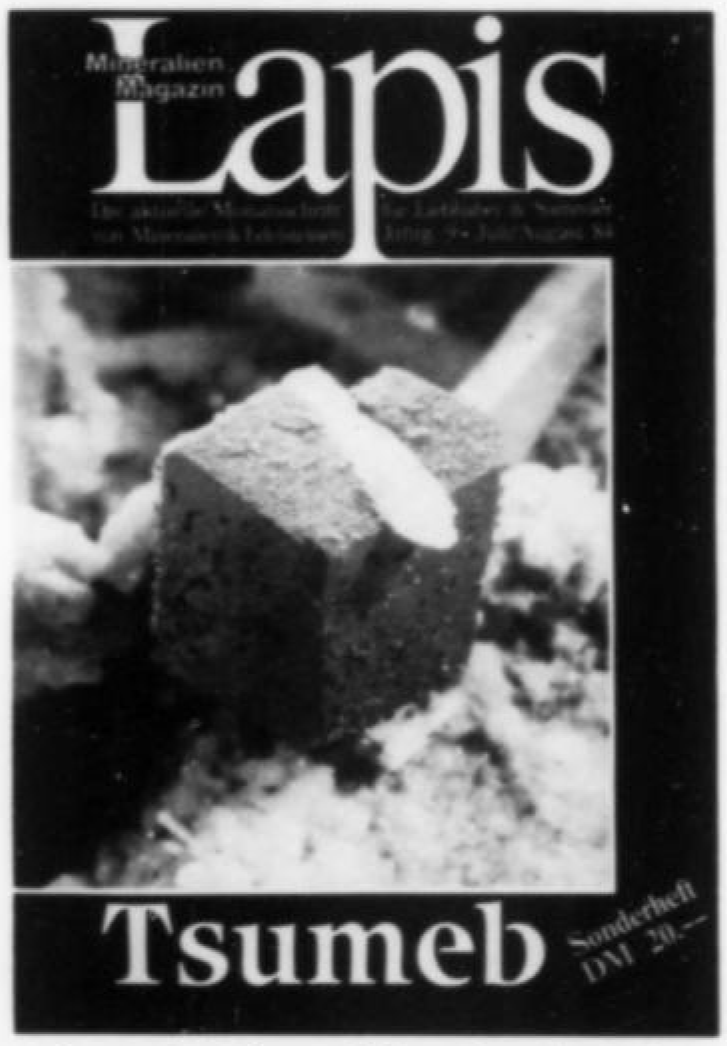

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Type Localities in NEVADA

Jean F. DeMouthe
Geology Department
California Academy of Sciences
San Francisco, California 94118

The state of Nevada is best known for its large, economically important deposits of precious and base metals. It has also, however, been the source of many rare minerals. A total of 35 new species have been discovered and named from Nevada, 26 of which are still valid.

INTRODUCTION

When a new mineral species is described, the specimen or specimens that are used for the definitive analyses are called *types*. There are different classifications of types, depending on the number of specimens designated and the relationships of the material in question to the original specimens and locality. A system of seven mineralogical type categories was established by Embrey and Hey (1970). These categories are:

Holotype: a single specimen selected by the author as the type of a species, or the only known specimen.

Cotypes: specimens other than the holotype used in making the original description, preferably from the same locality.

Metatype: a specimen compared with the holotype by the author and determined to be co-specific with it.

Ideotype: a metatype from a different locality.

Plesiotype: a specimen used for subsequent or additional descriptive work.

Neotype: a plesiotype selected to replace a holotype that has been lost or destroyed.

Topotype: a specimen from the original locality that corresponds to the original description.

Most mineral museum curators only concern themselves with holotypes and cotypes. The original described specimens usually come from one location, which is called the *type locality*.

Table 1 is a list of all minerals described from localities in Nevada, in order of publication date. Synonomy is given for those species that are no longer valid. The references for each species, both initial and supplementary, are included as part of the species descriptions.

The distribution of type localities in Nevada is illustrated on the index map shown at the beginning of this issue. Some mines or districts have produced a number of new species. For example, five new minerals have been named from the Carlin mine in Eureka County.

Three of the minerals that were first described from Nevada have multiple type localities. This means that the specimens used for the definitive analyses on which the species description is based came from several different places. In the case of schuetteite, for instance, type specimens came from Nevada, California and Texas.

AURORITE

Original Composition: $(Mn,Ag,Ca)Mn_3O_7 \cdot 3H_2O$
Status: valid
Type Locality: Aurora mine, Treasure Hill, Hamilton, White Pine County

Aurorite was first found as microscopic grains and veins in black calcite, associated with other silver-bearing manganese oxides. It is the silver analogue of chalcophanite. The host rocks are Paleozoic carbonates.

The name is taken from the mine and the nearby town, which were called Aurora after the ancient Roman goddess of the dawn.

Reference: RADTKE, A. S., TAYLOR, C. M., and HEWETT, D. F. (1967) Aurorite, argentian todorokite and hydrous silver-bearing manganese oxide. *Economic Geology*, **62**, 186–206.

Table 1. **Minerals first described from Nevada**

date	species	county	status
1867	Stetefeldtite	Nye	valid
1888	Metastibnite	Washoe	valid
1901	Esmeraldaite	Esmeralda	= Goethite + water
1909	Goldfieldite	Esmeralda	valid
1911	Belmontite	Nye	= Barysilite ?
1915	Vegasite	Clark	= Plumbojarosite ?
1916	Trainite	Nye	= Vashegyite + Laubanite ?
1925	Benjaminite	Nye	valid
1940	Clinobarrandite	Nye	= Phosphosiderite
1944	Mackayite	Esmeralda	valid
	Blakeite	Esmeralda	= Goethite + Tellurite
1953	Huntite	Nye	valid
	Callaghanite	Nye	valid
	Faustite	Eureka	valid
1959	Schuetteite*	Esmeralda	valid
1960	Metaschoderite	Eureka	valid
	Schoderite	Eureka	valid
1965	Getchellite	Humboldt	valid
1967	Aurorite	White Pine	valid
1969	Dadsonite*	Pershing	valid
1972	Elyite	White Pine	valid
1973	Heyite	White Pine	valid
1974	Corderoite	Humboldt	valid
	Frankdicksonite	Eureka	valid
1975	Carlinite	Eureka	valid
1977	Christite	Eureka	valid
1978	Parnauite	Pershing	valid
	Weissbergite	Eureka	valid
	Goudeyite	Pershing	valid
	Uytenbogaardtite*	Storey	valid
1979	Cuproartinite	Nye	= Nakauriite
	Cuprohydromagnesite	Nye	= Nakauriite
	Curetonite	Humboldt	valid
	Ellisite	Eureka	valid
1985	Mopungite	Churchill	valid

*Species with multiple type localities.

BELMONTITE

Original Composition: silicate of lead

Status: = barysilite (?)

Type Locality: Belmont, Nye County

The type material was associated with stetefeldtite and was donated to the Royal Natural History Museum of Vienna by Kustel in 1873. The original description is merely of a yellow silicate of lead, with no composition given. The locality information is also vague.

The species was named for the town and mining district. The name Belmont is from the French word *beaumont,* meaning "beautiful mountain," which is a reference to the town's location at the foot of the Toquima Range.

Reference: KUSTEL, G., and KOECHLIN, R. (1911) *Mineralogisches Taschenbuch der Wiener Mineralogischen Gesellschaft.* p. 16.

BENJAMINITE

Original Composition: $Pb_2(Ag,Cu)_2Bi_4S_9$

Revised Composition: $(Ag,Cu)_3(Bi,Pb)_7S_{12}$

Status: valid

Type Locality: Outlaw mine, near Round Mountain, Manhattan district, Nye County

The Outlaw mine is located about 19 km (12 miles) north of Manhattan at the head of Mariposa Canyon. The mine was run by the Aikinite Mining Company, which had gone out of business before the original publication of the species in 1925.

Benjaminite occurs, in the original deposit, as irregular masses up to 5 cm long in fractures in milky quartz. It is the predominant sulfide present, with accessory chalcopyrite, pyrite, molybdenite and covellite. The quartz veins also contain fluorite and muscovite.

Type specimens were collected by H. G. Clinton of Manhattan, Nevada, and were donated by him to the U.S. Geological Survey and later to the U.S. National Museum (#95058). Nuffield (1953) used the original type material and a specimen from the collection at the Harvard Mineralogical Museum (#85749).

The species is named for Dr. Marcus Benjamin of the U.S. National Museum.

References: SHANNON, E. V. (1925) Benjaminite, a new sulfosalt mineral of the Klaprothite group. *Proceedings of the U.S. National Museum,* **65**, article 24, 1–9.

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MAKOVICKY, E., and MUMME, W. G. (1979) The crystal structure of Benjaminite. *Canadian Mineralogist,* **17**, 607–618.

BLAKEITE

Original Composition: $Fe_2(TeO_3)_3$

Status: = mixture of goethite + tellurite

Type Localities: two locations at Goldfield, Esmeralda County:

1. McGinnity shaft (90 foot level), between the Jumbo and Clermont mines.
2. Sheets-Ish lease, Mohawk mine.

Blakeite was originally described as dark brown microcrystalline crusts on emmonsite crystals. Type material was deposited at Harvard and possibly at the American Museum in New York.

Blakeite has been proven to be a mixture of goethite and tellurite, based on a reexamination of the type material at Harvard by S. A. Williams (personal communication, 1984). The discreditation of the species is currently before the I.M.A. Commission.

Blakeite is named for William Phipps Blake (1826–1910), a pioneer geologist and mineralogist in the American West.

Reference: FRONDEL, C., and POUGH, F. H. (1944) Two new tellurites of iron: mackayite and blakeite. *American Mineralogist,* **29**, 211–225.

CALLAGHANITE

Original Composition: $Cu_4Mg_4Ca(OH)_{14}(CO_3)_2 \cdot 2H_2O$

Revised Composition: $Cu_2Mg_2(CO_3)(OH)_6 \cdot 2H_2O$

Status: valid

Type Locality: working pits (in 1952), Gabbs Refractories Inc., Gabbs, Nye County.

Callaghanite occurs as small blue crystal grains in veinlets and crusts, and disseminated in magnesite and dolomite beds. The original observation of the mineral in place was made by Conrad Martin of Reno, Nevada. There is no mention of type specimens in the original manuscript, but material may have been deposited at the Rice Institute, Houston, Texas, or at Indiana University at Bloomington.

The mineral is named for Dr. Eugene Callaghan, Director of the New Mexico Bureau of Mines and Minerals, in recognition of his work on magnesite deposits.

References: BECK, C. W., and BURNS, J. H. (1953) Callaghanite, a new mineral. *Programs and Abstracts, Mineral-*

ogical Society of America, p. 10 *also* in *American Mineralogist,* **39**, 316 (1954).

BECK, C. W., and BURNS, J. H. (1954) Callaghanite, a new mineral. *American Mineralogist,* **39**, 630–635.

CARLINITE

Original Composition: Tl_2S

Status: valid

Type Locality: bench 6440, approximate elevation 6,445 feet, at mine coordinates 23,050N, 19,900E, in the East pit, Carlin mine, Eureka County

Carlinite occurs as scattered gray grains that are less than 0.5 mm in length in sheared carbonaceous limestone. It appears to be closely associated with fine-grained quartz and hydrocarbon compounds.

Type specimens were deposited at the U.S. National Museum and at the Department of Geology, Stanford University.

The mineral was named for the type locality, which, in turn, is named for the town that bears the name of William Passmore Carlin, an officer in the Union Army.

Reference: RADTKE, A. S., and DICKSON, F. W. (1975) Carlinite, Tl_2S a new mineral from Nevada. *American Mineralogist,* **60**, 559–565.

CHRISTITE

Original Composition: $TlHgAsS_3$

Status: valid

Type Localities: two localities in the Carlin mine, Eureka County:

1. near the bottom of oxidized section, east ore zone, between benches 6,400 and 6,420, near mine coordinates 22,800N, 19,750E;
2. on benches 6,340 and 6,360, between coordinates 23,100N, 20,300E and 23,500N, 20,700E.

Christite occurs as subhedral grains less than 1 mm in length with lorandite, realgar and orpiment in barite veins and with realgar, lorandite and getchellite in carbonaceous silty dolomite. The type localities are shown on Radtke's (1973) map of the Carlin deposit. The mineral was named in honor of Dr. Charles L. Christ of the U.S. Geological Survey, in recognition of his contributions to geochemistry, crystallography and mineralogy. Type specimens were deposited at Stanford University and at the U.S. National Museum.

Reference: RADTKE, A. S., DICKSON, F. W., SLACK, J. F., and BROWN, K. L. (1977) Christite, a new thallium mineral from the Carlin gold deposit, Nevada. *American Mineralogist,* **62**, 421–425.

CLINOBARRANDITE

Original Composition: $(Al,Fe)PO_4 \cdot 2H_2O$

Status: = Phosphosiderite

Type Locality: Manhattan, Nye County

A specimen of barrandite from the U.S. National Museum (#94669) was analyzed by McConnell (1940) in the course of his work on the variscite group. The specimen was found to be an intimate mixture of two minerals. The author identified clinobarrandite as the monoclinic dimorph of barrandite. McConnell's paper does not give a description of the locality or host rock, but Shannon (1923) describes the barrandite at Manhattan as occurring in a limestone/rhyolite contact with vashegyite and variscite. The specimens used by Shannon at the U.S. National Museum were probably the same ones in which McConnell later found clinobarrandite.

Clinobarrandite is listed by Roberts, Rapp and Weber (1974) as a variety of metastrengite and by Fleischer (1983) as aluminian phosphosiderite (phosphosiderite being the preferred synonym for metastrengite).

References: SHANNON, E. V. (1923) Barrandite from Manhattan, Nevada. *American Mineralogist,* **8**, 182–184.

McCONNELL, D. (1940) Clinobarrandite and the isodimorphous series, variscite-metavariscite. *American Mineralogist,* **25**, 719–725.

CORDEROITE

Original Composition: $Hg_3S_2Cl_2$

Status: valid

Type Locality: Cordero mine, Opalite mining district, Humboldt County

Corderoite was first found in specimens of mercury ore collected by Eugene Foord in February 1973 from playa sediments of Upper Miocene age near the Cordero mercury mine. Corderoite is found in intimate association with cinnabar, of which it is a replacement. Type material was deposited in the mineral collection at Stanford University, at the U.S. National Museum and with the San Francisco office of Placer Amex, Inc.

Reference: FOORD, E. E., BERENDSEN, P., and STOREY, L. O. (1974) Corderoite, first natural occurrence of α–$Hg_3S_2Cl_2$, from the Cordero mercury deposit, Humboldt County, Nevada. *American Mineralogist,* **59**, 652–655.

CUPROARTINITE

Original Composition: $(Cu,Mg)_2(CO_3)(OH)_2 \cdot 3H_2O$

Status: = Nakauriite

Type Locality: unnamed brucite pit (abandoned), Basic Refractories mine, near Gabbs, Nye County

(see explanation under Cuprohydromagnesite)

CUPROHYDROMAGNESITE

Original Composition: $(Cu,Mg)_5(CO_3)_4(OH)_2 \cdot 4H_2O$

Status: = Nakauriite

Type Locality: unnamed brucite pit (abandoned), Basic Refractories mine, near Gabbs, Nye County

Cuprohydromagnesite was found with cuproartinite in a mineralized contact zone between primary copper sulfides and magnesite-brucite-serpentine rock. They were named for their compositions and their relationships to artinite and hydromagnesite. Type material of both was deposited at the U.S. National Museum (#144188) and at the Carnegie Museum of Natural History.

Peacor *et al.* (1982) discredited both of these species. They determined that these minerals are both identical with nakauriite. Examination of the type specimens at the U.S. National Museum did not reveal the presence of eihter mineral as described in the original reference.

References: OSWALD, S. G., and CROOK, W. W. III (1979) Cuprohydromagnesite and cuproartinite, two new minerals from Gabbs, Nevada. *American Mineralogist,* **64**, 886–889.

PEACOR, D. R., SIMMONS, W. B., JR., ESSENE, E. J., and HEINRICK, E. W. (1982) New data on and discreditation of "texasite", "albrittonite", "cuproartinite", "cuprohydromagnesite", and "yttromicrolite", with corrected data on nickelbischofite, rowlandite and yttrocrasite. *American Mineralogist,* **67**, 156–169.

CURETONITE

Original Composition: $Ba_4Al_3Ti(PO_4)_4(O,OH)_6$

Status: valid

Type Locality: "barite prospect," sec. 12, T37N, R41E, near Golconda, Humboldt County

Curetonite occurs in veins of barite and adularia that cut through massive barite. Crystals are found on vein walls or as inclusions in adularia crystals. Type specimens have been deposited at the British Museum of Natural History and the U.S. National Museum.

Curetonite is named for Michael Cureton and Forrest Cureton, II, of Tucson, Arizona, who first discovered it.

Reference: WILLIAMS, S. A. (1979) Curetonite, a new phoshate from Nevada. *Mineralogical Record,* **10**, 219–221.

DADSONITE

Original Composition: $Pb_{11}Sb_{12}S_{29}$

Revised Composition: $Pb_{21}Sb_{23}S_{55}Cl$

Status: valid

Type Localities: 1. NEVADA: Red Bird mercury mine, Pershing County

2. CANADA: surface trench, Brock zone, Giant property, Yellowknife, N.W.T.
3. CANADA: lot 12, concession XIV, Huntingdon Township, Madoc, Ontario
4. GERMANY: Wolfsberg

This mineral was first described without a name (mineral Q) from the Yellowknife Bay area, Northwest Territory (Coleman, 1953), and as mineral "QM" from Madoc, Ontario, and Pershing County, Nevada (Jambor, 1967, pt. 2). The Madoc locality is described in the first part of Jambor's 1967 paper on lead sulfantimonides.

Specimens used in the definitive analyses described by Jambor (1969) were from Pershing County, Nevada, and Wolfsberg, Germany. That author also refers to crystallographic data obtained on the Yellowknife material by Coleman (1953). A new unit cell and form were proposed by Cervelle *et al.* (1979), based on dadsonite from Saint-Pons, near Barcelonnette, Alpes de Haute Provence, France. At the Nevada locality, dadsonite occurs as minute gray fibers with robinsonite in light-colored gangue. There are types in the collection of the U.S. National Museum, and the Wolfsberg specimen used by Jambor (1969) was provided by W. Pinch of Rochester, New York.

Dadsonite is named for Alexander S. Dadson (1906–1958) in recognition of his contributions to the development of the gold deposits of the Yellowknife area.

References: COLEMAN, L. C. (1953) Minerals of the Yellowknife Bay Area, Northwest Territory. *American Mineralogist,* **38**, 506–527.

JAMBOR, J. L. (1967) New lead sulfantimonides from Madoc, Ontario. *Canadian Mineralogist,* **9**, 7–24, 91–213.

JAMBOR, J. L. (1969) Dadsonite (minerals Q and QM), a new lead sulphantimonide. *Mineralogical Magazine,* **37**, #288, 437–441.

CERVELLE, B. D., CESBRON, F. P., SICHÈRE, M. C., and DIETRICH, J. (1979) La chalcostibite et la dadsonite de Saint-Pons, Alpes de Haute Provence, France. *Canadian Mineralogist,* **17**, 601–605.

ELLISITE

Original Composition: Tl_3AsS_3

Status: valid

Type Localities: two locations in the Carlin mine, Eureka County

1. southwest end of the east ore zone, near mine coordinates 22,900N, 19,800E, on benches 6,380 to 6,400; and
2. central part of eastern ore zone, coordinates 23,100N, 20,300E to 23,500N, 20,700E between benches 6,340 and 6,350.

Ellisite occurs as minute, dark gray grains in an argillaceous carbonaceous dolomite of the Roberts Mountains formation. It is associated with lorandite, getchellite, christite and realgar. Type specimens were reportedly deposited in the Epithermal Minerals Collection, Department of Geology at Stanford University.

The mineral is named for Dr. A. J. Ellis of the Chemistry Division, D.S.I.R., New Zealand, in honor of his contributions to hydrothermal geochemistry.

Reference: DICKSON, F. W., RADTKE, A. S., and PETERSON, J. A. (1979) Ellisite, Tl_3AsS_3, a new mineral from the Carlin gold deposit, Nevada, and associated sulfide and sulfosalt minerals. *American Mineralogist,* **64**, 701–707.

ELYITE

Original Composition: $Pb_4Cu(SO_4)(OH)_8$

Status: valid

Type Locality: Caroline tunnel, Ward district, White Pine County

Elyite was first collected in 1964 from the Caroline tunnel, which has since been destroyed by open pit operations. The mineral occurred as very small violet crystals in earthy brown cavity-fillings in sulfide masses. Type material was deposited at the British Museum of Natural History.

Elyite was named for John H. Ely, a frontiersman, adventurer and founder of one of Nevada's earliest mining companies.

Reference: WILLIAMS, S. A. (1972) Elyite, basic lead-copper sulfate, a new mineral from Nevada. *American Mineralogist,* **57**, 364–367.

ESMERALDITE

Original Composition: $Fe_2O_3\cdot4H_2O$

Status: = goethite with absorbed water

Type Locality: Esmeralda County

The type specimens were sent to Dr. Schaller at the University of California at Berkeley by the collector, W. H. Shockley. The original reference lists the locality merely as "Esmeralda County, Nevada."

The mineral is described as a siliceous limonite with "considerable impurities." Palache *et al.* (1944) list it as a mixture that is predominantly hydrous iron oxide. Strunz (1970) shows esmeraldite to be goethite with absorbed water.

Reference: EAKLE, A. S. (1901) Esmeraldite, a new hydrous sesquioxide of iron from Esmeralda County, Nevada. *University of California Publications in Geology,* **2**, #10, 320–322.

FAUSTITE

Original Composition: $(Zn_{0.8}Cu_{0.2})Al_6(PO_4)_4(OH)_8\cdot5H_2O$

Revised Composition: $(Zn,Cu)Al_6(PO_4)_4(OH)_8\cdot4H_2O$

Status: valid

Type Locality: main level, Copper King mine, Maggie Creek district, Eureka County

The Maggie Creek district, which is also known as the Schroeder or Susie Creek district, is located in the Tuscarora Mountains, about 16 km (10 miles) northwest of Carlin.

Faustite occurs as thin apple-green veins or nodules in mottled green montmorillonitic clay. The country rock consists of altered fine-grained Paleozoic sediments. Faustite is a member of the turquoise group and closely resembles turquoise in hand specimen.

Faustite is named for Dr. George Tobias Faust of the U.S. Geological Survey. Type specimens were collected by Paul Proctor in about 1952 and were deposited at the U.S. National Museum.

Reference: ERD, R. C., FOSTER, M. D., and PROCTOR, P. D. (1953) Faustite, a new mineral, the zinc analogue of turquoise. *American Mineralogist,* **38**, 964–972.

FRANKDICKSONITE

Original Composition: BaF_2

Status: valid

Type Localities: two localities in the Carlin mine, Eureka County:

1. on the 6,420 bench of the east pit, at elevation 6,425 feet, mine coordinates 23,050N, 20,100E; and
2. on the 6,320 bench of the east pit, approximate elevation 6,325 feet, mine coordinates 23,800N, 20,750E.

Frankdicksonite occurs as very small, euhedral, translucent, isometric crystals in quartz veins in silicified carbonaceous limestone. No other minerals were found in direct association with frankdicksonite, but similar quartz veins 5 meters higher in the section contain traces of pyrite and gold. The two type localities are shown on the geologic map of this deposit by Radtke (1973). Type specimens were deposited at Stanford University and at the U.S. National Museum.

It was named for Dr. Frank W. Dickson of the Department of Geology, Stanford University, in recognition of his work in the geochemistry and geology of low temperature ore deposits.

Reference: RADTKE, A. S., and BROWN, G. E. (1974) Frankdicksonite, BaF_2, a new mineral from Nevada. *American Mineralogist,* **59**, 885–888.

GETCHELLITE

Original Composition: $AsSbS_3$

Status: valid

Type Locality: west side of the south pit extension, Getchell mine, Humboldt County

This mineral occurs as dark orange-red micaceous crystals and grains in intimate association with realgar and orpiment in a mineralized shear zone in fine grained Paleozoic sediments. Type specimens were collected by B. G. Weissberg in August 1962. The author does not state whether types have been deposited at any institutions in this country, but the U.S. National Museum has types of this species in their collection.

Getchellite was named after the mine, which was named for Noble H. Getchell, a Nevada mining pioneer.

Reference: WEISSBERG, B. G. (1965) Getchellite, $AsSbS_3$, a new mineral from Humboldt County, Nevada. *American Mineralogist,* **50**, 1817–1826.

GOLDFIELDITE

Original Composition: $Cu_6Sb_2(S,Te)_9$ (?)

Revised Composition: $Cu_{12}(Sb,As)_4(Te,S)_{13}$

Status: valid

Type Locality: Mohawk Combination lease, Goldfield, Esmeralda County

Specimens of what probably was goldfieldite were described by Sharwood (1907), but the name was first applied by Ransome (1909). There has been dispute as to the validity of the species, and it was described as a tellurium-rich variety of famatinite or enargite (Sharwood, 1911), as a mixture (Witt, 1917), and as a tellurian tetrahedrite (Thompson, 1946). Tolman and Ambrose (1934) support it as a valid species, and it is listed as such by Fleischer (1983), who puts it in the tetrahedrite group.

References: SHARWOOD, W. J. (1907) Gold Tellurides. *Mining and Scientific Press,* **94**, 731–732.

RANSOME, F. L. (1909) Geology and ore deposits of Goldfield, Nevada. U.S. Geological Survey Professional Paper 66, 116–117.

RANSOME, F. L. (1910) Geology of the Goldfield District. *Economic Geology,* **5**, 453–454.

SHARWOOD, W. J. (1911) Tellurium-bearing gold ores. *Economic Geology,* **6**, 32.

SHANNON, E. V. (1917) Famatinite from Goldfield, Nevada. *American Journal of Science,* **XLIV**, fourth series, 469.

TOLMAN, C. F., and AMBROSE, J. W. (1934) The rich ores of Goldfield, Nevada. *Economic Geology,* **29**, 270–276.

THOMPSON, R. M. (1946) Goldfieldite = tellurian tetrahedrite. *University of Toronto Studies,* Geologic Series, #50, 77–78.

GOUDEYITE

Original Composition: $Cu_6Al(AsO_4)_3(OH)_6 \cdot 3H_2O$

Revised Composition: $(Al,Y)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

Status: valid

Type Locality: 30 meters (100 feet) north of the entrance to the Copper stope, Middle adit, Majuba Hill mine, Pershing County

This mineral occurs as very fine, yellow-green, acicular crystals in tufted groups or compact masses. Chemically, it is in the mixite group, and is the aluminum analog of agardite. Both goudeyite and parnauite are found alone, but near other secondary copper minerals in a mineralized fault zone in rhyolitic country rock. Type specimens were deposited at the U.S. National Museum.

It is named for Hatfield Goudey, a mining geologist and mineral collector and dealer of San Mateo, California, who has contributed substantially to understanding the mineralogy of the Majuba Hill deposit.

Reference: WISE, W. S. (1978) Parnauite and goudeyite, two new copper arsenate minerals from the Majuba Hill mine, Pershing County, Nevada. *American Mineralogist,* **63**, 704–708.

HEYITE

Original Composition: $Pb_5Fe_2(VO_4)_2O_4$

Status: valid

Type Locality: Betty Jo Claim, 13 km (8 miles) southeast of Ely, White Pine County

Heyite occurs as a yellow-orange coating on and replacement of wulfenite in fractured quartz in a silicified Paleozoic limestone. Physically, it closely resembles descloizite, and it is chemically similar to brackebuschite.

It was named for Dr. Max H. Hey (1904–1984), British mineralogist and chemist. Type material was deposited at the British Museum of Natural History and the U.S. National Museum.

Reference: WILLIAMS, S. A. (1973) Heyite, $Pb_5Fe_2(VO_4)_2O_4$, a new mineral from Nevada. *Mineralogical Magazine,* **39**, 65–68.

HUNTITE

Original Composition: $Mg_3Ca(CO_3)_4$

Status: valid

Type Locality: Ala-Mar deposit, section 34, T12N, R59E, Currant Creek, Nye County

Huntite found at the Currant Creek magnesite deposit occurs as white masses in vugs and fractures. Crystals are microscopic. The original specimens were found in material collected by C. J. Vitaliano and E. Callaghan. More specimens were collected in 1944 by George Faust and E. Callaghan.

Although the initial analysis was done on huntite from the Ala-Mar deposit, the mineral has been found in other parts of the Currant Creek magnesite deposits. Since its discovery, huntite has also been identified in carbonate deposits in New Mexico, California, Europe, Australia and the Middle East.

It was named for Professor Walter F. Hunt (1882–1975) of the U.S. Geological Survey, the University of Michigan, and former editor of the *American Mineralogist.*

Reference: FAUST, G. T. (1953) Huntite, $Mg_3Ca(CO_3)_4$, a new mineral. *American Mineralogist,* **38**, 4–24.

MACKAYITE

Original Composition: $Fe_2(TeO_3)_3 \cdot nH_2O$

Revised Composition: $Fe^{+3}Te_2O_5(OH)$

Status: valid

Type Localities: two locations at Goldfield, Esmeralda County:

1. McGinnity shaft (90 foot level), between the Jumbo and Clermont mines; and
2. Sheets-Ish lease, Mohawk mine

Mackayite occurs as light to brownish green crystals in crusts or lining vugs and seams in silicified volcanic rocks. Type material was collected by C. D. Woodhouse of Santa Barbara, California. It may be assumed that type material was deposited at Harvard and possibly at the American Museum in New York.

It was named for John W. Mackay (1831–1902), an Irish-American mine owner who, having amassed a fortune on the Comstock Lode, endowed the Mackay School of Mines at the University of Nevada, Reno.

References: FRONDEL, C., and POUGH, F. H. (1944) Two new tellurites of iron: mackayite and blakeite. *American Mineralogist,* **29**, 211–225.

GAINES, R. V. (1965) Nuevos datos sobre mackayita. *Boletin Soc. Geologico de Mexico,* **28**, 75–82.

PERTLIK, F. (1968) Formel und Struktur von Mackayite: *Anz. Oesterr. Akad. Wiss.:* Math-naturuv. K., **165**, 332–333.

METASCHODERITE

Original Composition: $(Al_2O_3)_2(V_2O_5)(P_2O_5) \cdot 12H_2O$

Revised Composition: $Al_2(PO_4)(VO_4) \cdot 6H_2O$

Status: valid

Type Locality: bulldozer cut, approximately 4.6 meters below surface, Van-Nav-Sand claim, section 34, T16N, R52E, Eureka County

Schoderite dehydrates to become metaschoderite in a dry atmosphere. Both hydration states are monoclinic, but have distinctly different X-ray patterns and optical properties.

References: HAUSEN, D. M. (1960) Schoderite, a new phosphovanadate mineral from Nevada [abs.]. *Bulletin of the Geological Society of America,* **71**, #12, part 2, 1883.

HAUSEN, D. M. (1962) Schoderite, a new phosphovanadate mineral from Nevada. *American Mineralogist,* **47**, 637–648.

METASTIBNITE

Original Composition: Sb_2S_3

Status: valid

Type Locality: Steamboat Springs, Washoe County

Originally metastibnite was found as a red stain on siliceous sinter "near the railroad" at Steamboat Springs. It is dimorphous with stibnite and has been identified in deposits in California and Bolivia.

The name was initially proposed by Becker to Hunt (1888), for use in his work on mineralogical systematics, where the name and formula are included as a footnote, attributed to Becker. Becker (1888) used the name himself later that year, with a more complete description of the locality.

References: BECKER, G. F., *in* HUNT, T. S. (1888) The classification and nomenclature of metalline minerals. *Proceedings of the American Philosophical Society,* **25**, 170–180.

BECKER, G. F. (1888b) Ores at Steamboat Springs; *in* Quicksilver Deposits of the Pacific Slope: *U.S. Geological Survey Monograph* **13**, p. 343 and 389.

BROOKINS, D. G. (1970) Metastibnite from the Geysers, Sonoma County, California. *American Mineralogist,* **55**, 2103–2104.

MOPUNGITE

Original Composition: $NaSb(OH)_6$

Status: valid

Type Locality: Mopung Hills, Churchill County

This species is described in this issue.

PARNAUITE

Original Composition: $Cu_9(AsO_4)_2(SO_4)(OH)_{10} \cdot 7H_2O$

Status: valid

Type Locality: walls and ceiling of crosscut 212 near the Copper stope, Middle adit, Majuba Hill mine, Pershing County

Parnauite occurs as light blue to blue-green rosettes or fans, which combine to form crusts or scales on fracture surfaces. Chemically, it is very similar to tyrolite. The differences are a replacement of the sulfate radical for carbonate, and a lack of calcium in parnauite.

Type specimens were deposited at the University of California at Santa Barbara (#8090) and at the U.S. National Museum.

Reference: WISE, W. S. (1978) Parnauite and goudeyite, two new copper arsenate minerals from the Majuba Hill mine, Pershing County, Nevada. *American Mineralogist,* **63**, 704–708.

SCHODERITE

Original Composition: $(Al_2O_3)_2(V_2O_5)(P_2O_5) \cdot 16H_2O$

Revised Composition: $Al_2(PO_4)(VO_4) \cdot 8H_2O$

Status: valid

Type Locality: bulldozer cut, approximately 4.6 meters below surface, Van-Nav-San claim group, Section 34, T16N, R52E, Eureka County

The type locality is in the Fish Creek Range, approximately 48 km (30 miles) south of Eureka, where schoderite is associated with vashegyite and wavellite in Lower Paleozoic phosphatic cherts. It occurs as yellow-orange microcrystalline coatings in fractures. Type specimens were deposited at the U.S. National Museum.

It is named for William P. Schoder, a research chemist with Union Carbide Nuclear Company, in recognition of his work on the metallurgy of vanadium.

References: HAUSEN, D. M. (1960) Schoderite, a new phosphovanadate mineral from Nevada [abs.]. *Bulletin of the Geological Society of America,* **71**, #2, part 2, 1883.

HAUSEN, D. M. (1962) Schoderite, a new phosphovanadate mineral from Nevada. *American Mineralogist,* **47**, 637–648.

(continued on page 55)


ESTABLISE
ROBER
PREMIUM
CRYSTALS
TWAIN HA


SHED IN 1978.
RTS
MINERALS
SUPERLATIVE
MINERALS
ARTE, CALIF.


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JANUARY

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FEB

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JULY

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OCTOBER

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ROBERTS MINERALS, P.O. BOX

PHOTOGRAPHY AND DES

985

FEBRUARY

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MARCH

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MAY

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JUNE

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23_{30}	24	25	26	27	28	29

AUGUST

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SEPTEMBER

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NOVEMBER

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DECEMBER

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29	30	31				

BOX 1267, TWAIN HARTE, CA 95383
ND DESIGN BY WENDELL E. WILSON

SCHUETTEITE

Original Composition: $HgSO_4 \cdot 2H_2O$

Revised Composition: $Hg_3(SO_4)O_2$

Status: valid

Type Localities: NEVADA: steep northeast wall of glory hole, B & B mine, Esmeralda County

CALIFORNIA: burnt ore dump, Oceanic mine, San Luis Obispo County

TEXAS: Chisos furnace, Terlingua district, Brewster County

The Texan material was used in the initial X-ray analysis, so the furnace must be considered one of the type localities, even though it is not a natural occurrence.

Schuetteite is found as a thin yellow crust on cinnabar ore that has been exposed at or near the surface. The original reference mentions a number of localities at which this mineral has been found, but only specimens from the three localities listed above were used in the definitive analysis. Type specimens are in the collection of the U.S. National Museum.

The mineral is named for Curt N. Schuette, a mining geologist who specialized in mercury deposits.

Reference: BAILEY, E. H., HILDEBRAND, F. A., CHRIST, C. L., and FAHEY, J. J. (1959) Schuetteite, a new supergene mercury mineral. *American Mineralogist*, **44**, 1026–1038.

STETEFELDITE

Original Composition:

Revised Composition: $Ag_2Sb_2(O,OH)_7$

Status: valid

Type Locality: Belmont, Nye County

Further analysis of the type material showed it to be the silver analogue of bindheimite (Mason and Vitaliano, 1953) and a member of the stibiconite group (Fleischer, 1983). Mason and Vitaliano (1953) refer to specimens at the U.S. National Museum (#104763) and at Harvard University (#80285). Their calculations of the refractive index of stetefeldite are based on the U.S. National Museum specimen.

Stetefeldite was named for Carl August Stetefeldt (1838–1896), a German-American mining engineer.

References: RIOTTE, E. N. (1867) Stetefeldit, eine neues mineral von Nevada. *Berg- und Huttenmannische Zeitung*, Freiburg, Leipzig, **26**, 253.

MASON, B., and VITALIANO, C. J. (1953) The mineralogy of the antimony oxides and antimonates. *Mineralogical Magazine*, **30**, 100–112.

TRAINITE

Original Composition: "impure banded variscite"

Status: = intergrowth of vashegyite and a hydrated Ca-Al silicate (Laubanite?)

Type Locality: near Manhattan, Nye County

This species was never recognized by anyone except mineral dealers and, possibly, by Mr. Train. The first mention of the name in print is as part of a list in Schaller (1918), where he designates it as "impure banded variscite."

The probable holotype was submitted to the U.S. National Museum (#92909) for identification by Percy Train of Manhattan, Nevada, after whom it was subsequently named. During initial analysis, it was compared with a specimen labeled "vashegyite" in the Roebling collection, with which it was later found to be identical. A specimen named trainite and described on the accompanying dealer's label as aluminum phosphosilicate was acquired by the British Museum in 1913.

References: WHERRY, E. T. (1916) A peculiar intergrowth of phosphate and silicate minerals. *Journal of the Washington Academy of Sciences*, **VI**, #5, 105–108.

SCHALLER, W. T. (1918, for 1917) Gems and precious stones. *U.S. Geological Survey, Mineral Resources of the U.S., part II (non-metals), 163.*

UYTENBOGAARDTITE

Original Composition: Ag_3AuS_2

Status: valid

Type Localities: NEVADA: Comstock Lode, Storey County

U.S.S.R.: Smeinogorski (Schlangenberg), Altai

INDONESIA: Tambang Sawah, Benkoelen district, Sumatra

Chemical work was done on specimens from all three localities, while X-ray diffraction data were obtained only on material from Nevada and the U.S.S.R. The Comstock specimens were found to contain up to 4% copper by weight and traces of selenium and tellurium, which were lacking in specimens from the other localities.

Uytenbogaardtite occurs as tiny brownish-gray metallic grains with acanthite, electrum and quartz in low-temperature gold-silver deposits. In the Comstock Lode, the host rocks are hydrothermally-altered Tertiary volcanics.

Type specimens have been deposited at the Free University, Amsterdam; the University of Amsterdam; and the U.S. National Museum. The name is in honor of Professor Willem Uytenbogaardt of the Technical University, Delft, the Netherlands, former chairman (1962–1970) of the I.M.A. Commission on Ore Microscopy.

Reference: BARTON, M. D., KIEFT, C., BURKE, E. A. J., and OEN, I. S. (1978) Uytenbogaardtite, a new silver-gold sulfide. *Canadian Mineralogist*, **16**, 651–657.

VEGASITE

Original Composition: $PbO(Fe_2O_3)_3(SO_3)_3 \cdot 6H_2O$

Status: = plumbojarosite (?)

Type Locality: Rosella prospect, "several hundred feet" north of the Boss mine, Goodsprings district, Clark County

Vegasite was described as a straw-colored mineral that occurs as relatively pure microcrystalline ocherous masses up to several centimeters across in carbonaceous dolomite. In the initial analysis, it was found to be similar to plumbojarosite in all but specific gravity, indices of refraction and molecular ratios. Fleischer (1983) lists it as a questionable equivalent of plumbojarosite. There are type specimens at the U.S. National Museum.

It was named for Las Vegas, which is the largest town in Clark County.

Reference: KNOPF, A. (1915) Plumbojarosite and other basic lead-ferric sulphates from the Yellow Pine District, Nevada. *Journal of the Washington Academy of Sciences*, **V**, #14, 497–503.

WEISSBERGITE

Original Composition: $TlSbS_2$

Status: valid

Type Localities: two locations in the east ore zone of the Carlin mine, Eureka County:

1. bench 6,450, mine coordinates 23,000N, 19,800E; and
2. bench 6,350, mine coordinates 23,850N, 22,700E.

Weissbergite occurs as gray metallic grains, less than 0.5 mm in length, with quartz and stibnite in silicified carbonate rocks. The type localities are shown on the map of this deposit by Radtke (1973). Type specimens were deposited at the Department of Geology, Stanford University and at the U.S. National Museum.

The mineral was named for Dr. Byron G. Weissberg of the Chemistry Division, D.S.I.R., New Zealand, because of his work on the geochemistry of epithermal hydrothermal processes.

Reference: DICKSON, F. W., and RADTKE, A. S. (1978) Weissbergite, $TlSbS_2$, a new mineral from the Carlin gold deposit, Nevada. *American Mineralogist,* **63**, 720–724.

CONCLUSION

Nevada has proved to be a rich source of new and rare minerals. The recent increase in exploration, particularly for finely disseminated gold deposits of the Carlin type, combined with the study of existing material will undoubtedly reveal more hitherto unknown species from the diverse and fascinating Silver State.

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the Majuba Hill Mine
Pershing County

NEVADA

Martin Jensen
P.O. Box 545
Crystal Bay, Nevada 89402

The Majuba Hill mine, in northwest Nevada, is a locality well-known among collectors for its superb arthurite, chalcophyllite, clinoclase, pharmacosiderite and olivenite specimens. Although many fine pieces were collected during the 1940s and 1950s when the mine was active, the locality is still productive and outstanding specimens continue to be discovered in the old workings.

INTRODUCTION

Majuba Hill, in the Antelope (Majuba, Cedar) mining district, is located in the central portion of northwest Nevada approximately 160 airline km northeast of Reno, and is readily accessible via 29 km (18 miles) of good gravel road from the small town of Imlay. Topographically, the hill is about 5 km across and is surrounded by a circular drainage pattern. It can be easily distinguished on the skyline by its jagged profile in relation to the neighboring peaks of the Antelope Range. The summit of the hill is at an altitude of 2117 meters, with the local relief amounting to no more than 520 meters.

The climate is characteristic of a desert environment, with warm summers and relatively cool winters. The annual temperature range is about 35° C and the state flower, the desert sagebrush, dominates the area.

Most publications and maps refer to Majuba Hill as "Majuba Mountain," however, either term may be used. The name Majuba Hill comes from a South African battle site of the Boer War and presumably dates from about 1900, the time of that battle (MacKenzie and Bookstrom, 1976).

Minerals of particular interest include arthurite, chalcophyllite, clinoclase, olivenite, pharmacosiderite, scorodite, spangolite and strashimirite, all of which occur in fine, crystallized specimens.

HISTORY and PRODUCTION

Activity at Majuba Hill began in 1907 when A. J. McCauly of Imlay located the Majuba copper mine. It was leased in 1914 to the Mason Valley Mines Company (Matson, 1948), which did some development work on the property and shipped 4000 tons of ore that contained 12% copper during the First World War. In 1917, the Mason Valley company discovered the tin deposit underground during a search for copper ore (Smith and Gianella, 1942). The mine then remained idle until 1941 when Freeport Sulfur Company obtained an option and conducted a rather extensive core drilling program to explore the tin-bearing zone. The property was then acquired by E. J. Myler under a bond and lease arrangement with H. Reber, who owned the mine (Trites and Thurston, 1958). Myler then assigned a lease to J. O. Greenan and G. W. Kerr, both of Reno, who reactivated the mine and shipped ores of both copper and tin during the period between October of 1942 and May of 1945 (MacKenzie and Bookstrom, 1976). At that time, the property was returned to E. J. Myler, who worked it on a small scale for copper ore from May, 1945, to May, 1949. Since then, the property has been leased and explored by several smaller companies and only minor underground mining and development work has been done.

Figure 1. **View looking up Majuba Hill to the northeast.**

Gulf Chemical currently possesses the lease on the Majuba Hill properties and permitted mineral collecting until just recently (June, 1982). The gate on the main road is now locked, as is the wooden door to the portal of the middle adit. The caretaker, Dick Bailey, who resides with his family in Majuba Canyon below the mine, is always very cordial and friendly, but he cannot give out the keys to the locks as before.

As of February, 1982, the Bureau of Land Management listed three patented claims in the Antelope mining district: the Majuba Hill, Majuba Hill No. 1, and Majuba Hill No. 3, all under survey number 4610.

MINE DEVELOPMENT

The Majuba Hill mine is developed by three main levels, the Lower, Middle and Upper adits, all of which were accessible as of July, 1982. The Lower and Middle adits are reached by traveling along an unimproved gravel road which climbs 150 meters in a horizontal distance of 1600 meters via a series of five switchbacks. The road is passable with a little oil pan–scraping to an ordinary automobile; if possible, it is preferable to utilize a high ground-clearance vehicle to avoid the rocky obstacles. (Of course, with enough determination, a small, two-wheel-drive vehicle can make it up the hill, even in deep snow. J. F. Leising, personal communication, 1983.)

The Lower adit is at an altitude of 1780 meters, about 2.5 km from the caretaker's cabins, and consists of a very long, straight, northerly-trending drift more than 600 meters in length. The objective of this drift was to intercept the orebodies at a depth some 140 meters below the main working level, the Middle adit. Sadly, the entire length of the workings penetrated no ore and were, for the most part, completely barren. A minor crosscut to the west was driven at a point about 550 meters from the portal, but explores only barren ground. As of July, 1982, the Lower adit had caved at around 460 meters from the portal in the vicinity of the Majuba fault.

The Middle adit, at an elevation of about 1910 meters, was the main working level for the deposit during operation and consists of a haulage level, the Copper stope, Tin stope, 153 stope, Myler stope, and several smaller exploratory workings. During early collecting in the 1940s and 1950s many of the finer specimens recovered from the locality were collected from the large dump outside of the portal. There was also an aerial tramway which delivered ore from the Middle adit to a mill set up in Majuba Canyon below, and many fine specimens also occurred along this tram route (J. L. Parnau, personal communication, 1982).

The Middle adit trends northwesterly and access to the main Copper stope is gained by taking the first drift to the left off of the main haulage level at a point 180 meters from the portal. Access to this stope is becoming increasingly difficult due to a small cave-in which threatens to block off this drift. The Copper stope itself is above the main level and, upon entering, one is truly amazed at the size of this huge underground excavation. The exact dimensions have not been determined, but a typical electric miner's lamp will not shine to the back of it. Because the stope dips at about 45° to the southwest, a large rope is present to aid accessibility.

The Tin stope is reached by continuing along the main haulage level in a northwesterly direction to a point 260 meters from the

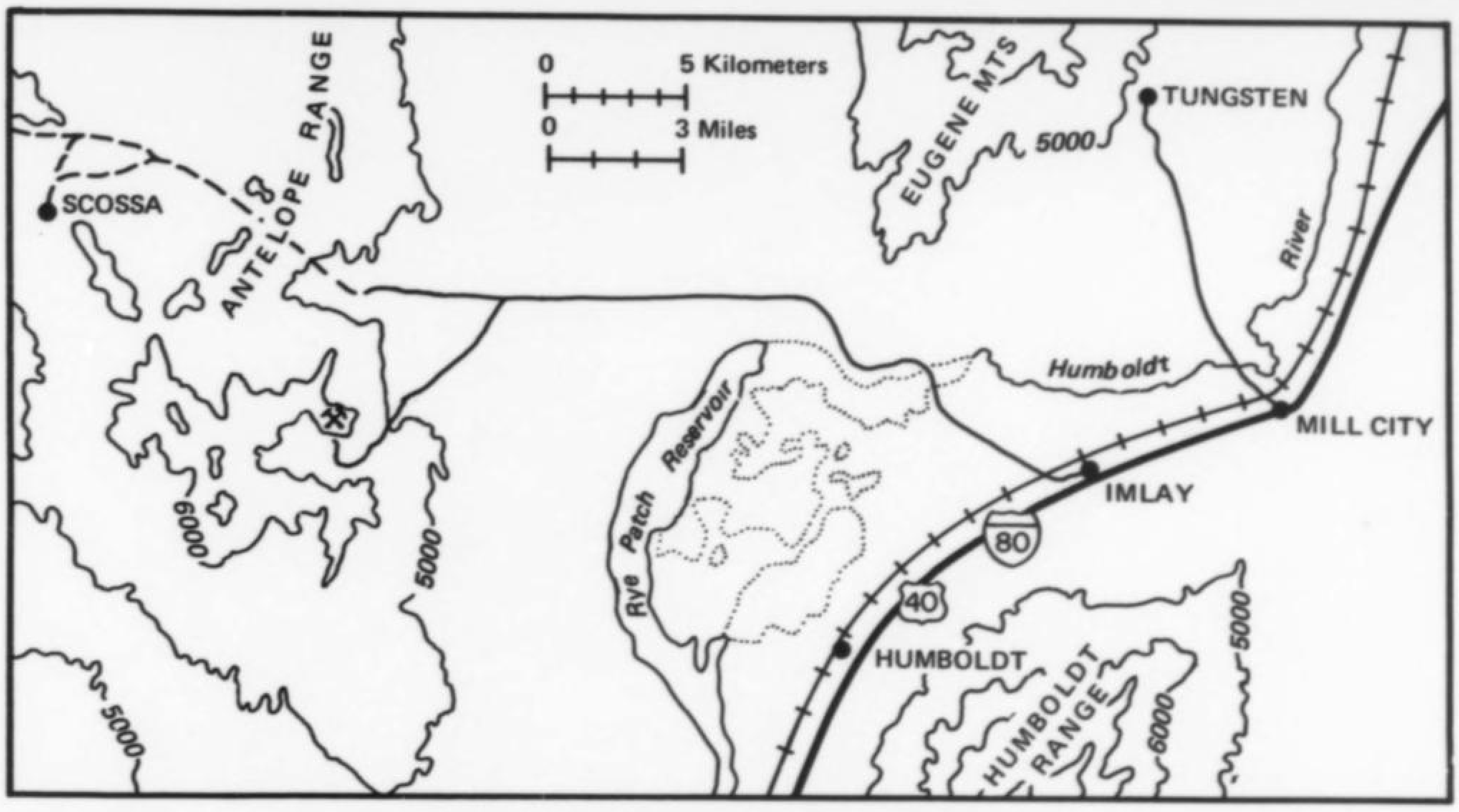


Figure 2. **Location map (from MacKenzie and Bookstrom, 1976).**

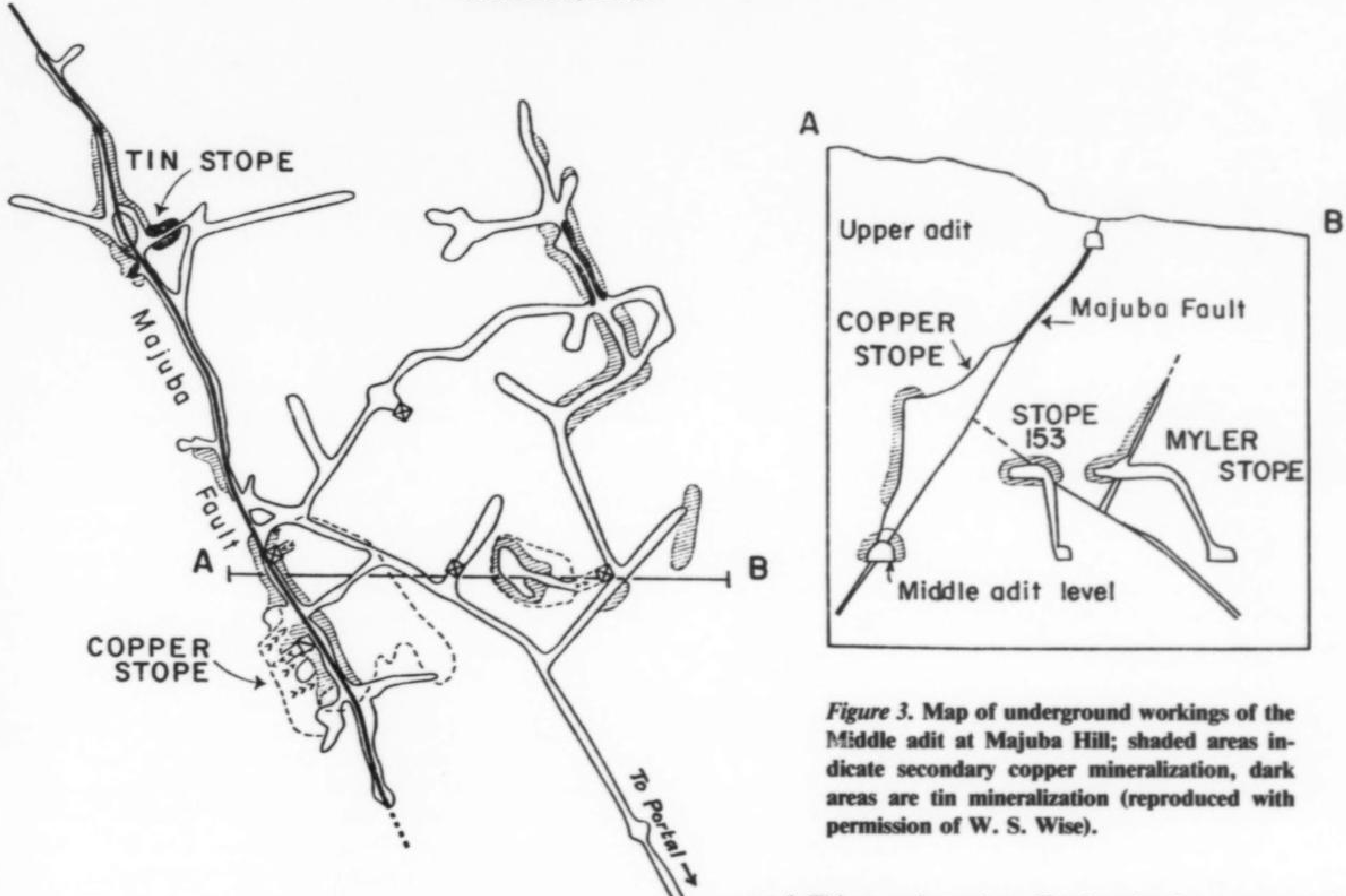


Figure 3. **Map of underground workings of the Middle adit at Majuba Hill; shaded areas indicate secondary copper mineralization, dark areas are tin mineralization (reproduced with permission of W. S. Wise).**

portal. This stope is much smaller than the Copper stope and is irregularly shaped due to the very localized nature of the pods of cassiterite that were found there.

Timbering was present in both the Copper and Tin stopes as recently as about 1975, which aided immensely in gaining access to minerals that occurred at the backs of these stopes; unfortunately, however, the timber has since been taken away.

The 153 and Myler stopes, about 50 meters above the main level, are accessible via vertical raises and manways with ladders. Bad ground and loose rock are abundant, especially in the Myler stope and one must move very deftly to avoid accidents.

Figure 4. **View to the north of the Middle adit at Majuba Hill about 1955 (photo by R. W. Thomssen).**

Figure 5. **Entrance to the Majuba Hill mine (Middle adit) in 1982. All exposed rocks are iron-stained intrusive rhyolites.**

The Upper adit is situated at an elevation of 1975 meters and is rather inconspicuous. Finding this adit is quite difficult today, but the location is only of limited interest to the mineral collector. Fresh air, however, is constantly supplied to the Copper stope through a badly caved area at the end of this adit and so for this reason, the adit is important.

GEOLOGY

The geology of Majuba Hill is fascinating although exceedingly complex. Geological cross-sections, upon first glance, seem unlikely due to the variety of intrusions and their cross-cutting relationships. But, after a few moments of contemplation, one begins to understand the time-frame of events which must have occurred.

Majuba Hill is the surface expression of a subvolcanic complex of rhyolitic porphyries and breccias intruded during mid-Tertiary time into a series of steeply-dipping, northeast-trending Triassic argillites (MacKenzie and Bookstrom, 1976). The northeast grain of the argillites imposd a northeast elongation on the intrusives of the complex and on the complex as a whole. In vertical section, the intrusive is fan-shaped, the magmas having been introduced through a narrow conduit and spreading laterally to the presently observed site not far beneath the present surface.

With decreasing age, the intrusives of the complex progress from large, elongated masses of weakly porphyritic rock to distinct dikes and sills of strongly porphyritic rock. The oldest breccias formed large, irregular masses; breccias of intermediate age formed dikes, sills and pipes, some of which contain abundant tourmaline (schorl); the youngest breccias are pebble dikes and pods (MacKenzie and Bookstrom, 1976).

In general, the textural and lithologic character of the intrusive rocks exposed at Majuba Hill varies from a fine grained, light colored, quartz porphyry to a porphyritic rhyolite containing inclu-

sions and breccia fragments derived from earlier intrusions. Quartz-tourmaline veinlets, tourmaline schlieren, and tourmaline pseudomorphs after feldspar are locally quite abundant.

Northeast- and northwest-trending, steeply dipping faults are the most common type of structural feature at Majuba Hill. One major fault, the Majuba fault, is partially responsible for the localization of the ore minerals. In the vicinity of the Copper stope, the intersection of the Majuba fault with a large breccia pipe served as a prime depositional site for mineralization. Hydrothermal, mineral-bearing fluids migrating upward along the conduit from a granitic (?) source at depth encountered this favorable location and were localized and precipitated to form the orebodies. More recent oxidation and minor supergene enrichment has been responsible for further concentration of the ore.

MINERALOGY

Fine mineral specimens have been found in both the Copper and Tin stopes of the middle adit, as well as in a small stope in the lower adit. Even after more than 30 years of lying essentially idle, the mine still yields good specimens of almost all of the 52 different minerals that are known to occur at the mine. It is easy to miss several of the individual localities upon the first visit because many of the minerals are small in size and relatively local in occurrence. Upon subsequent visits, though, one finds that the mine is virtually loaded with minerals.

As of July, 1982, all of the localities mentioned below were still accessible and productive and would yield fine mineral specimens.

***Figure 6.* Ore chutes along the main haulage level below the Copper stope. Abundant chalcanthite is exposed in the winze below the level.**

***Figure 7.* Entering into the bottom of the Copper stope with J. F. Leising, 1982.**

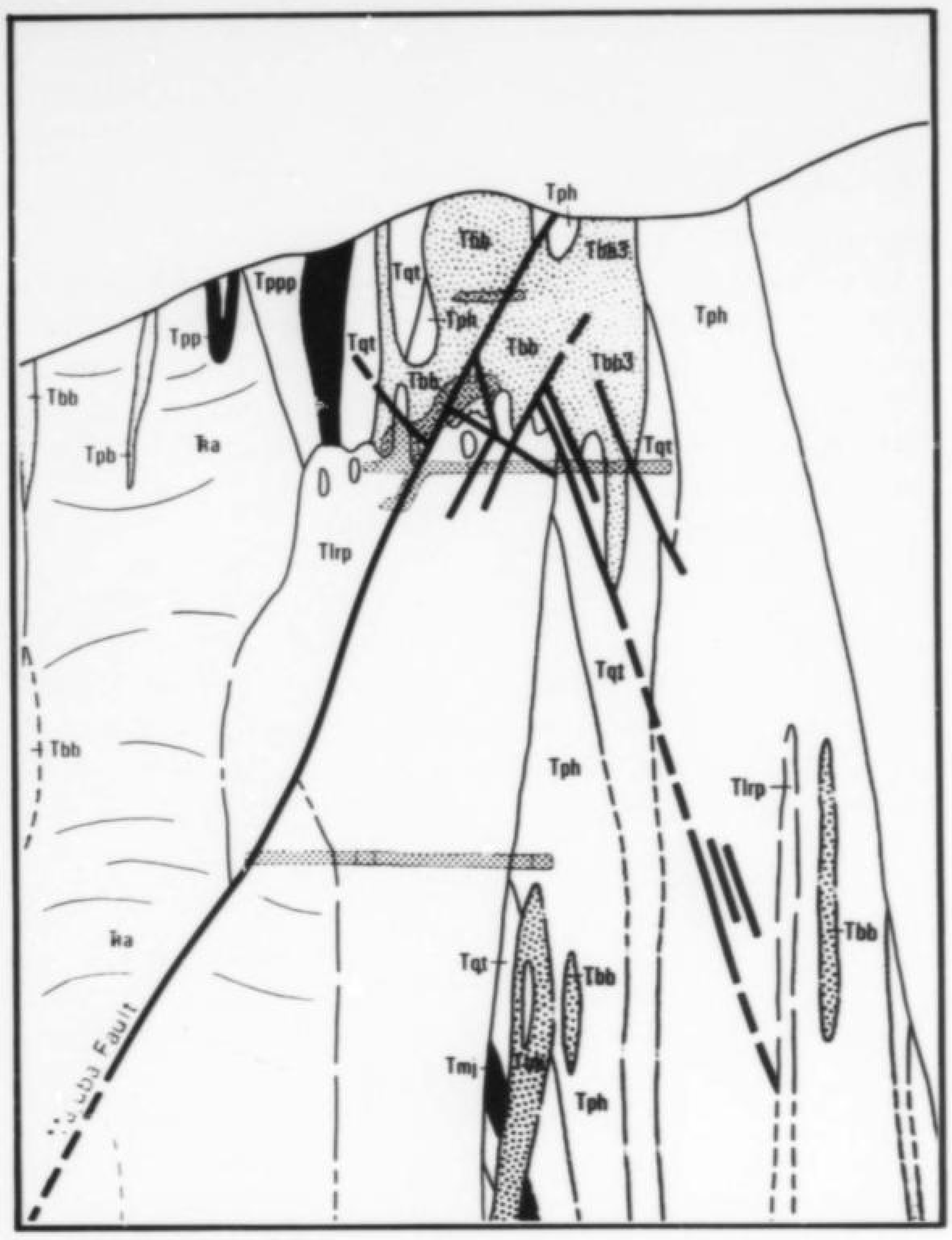


Figure 8. **Geologic cross-section of Majuba Hill, from the southwest to the northeast, showing the varied cross-cutting relationships of the intrusive rhyolites (from MacKenzie and Bookstrom, 1976).**

Primary Minerals

In general, the primary minerals form massive and unappealing blebs, pods and veinlets throughout the altered rhyolite porphyry; in places, however, secondary minerals have formed within the centers of pods of the primary species and, in these cases, very attractive specimens result.

Anatase TiO_2

According to W. S. Wise (personal communication, 1983), anatase occurs at Majuba Hill only rarely, as disseminated grains distributed throughout altered rhyolite.

Arsenopyrite $FeAsS$

Arsenopyrite associated with pyrrhotite has been described from many Majuba rocks, as very fine grained, intergrown aggregates and veinlets, and as a minor constituent of chalcocite-rich pods in the Copper stope. It also occurs commonly in zones along the Majuba fault (W. S. Wise, personal communication, 1983). In general, it seems reasonable to assume that the arsenic in the many secondary arsenates was provided primarily by the arsenopyrite.

Bornite Cu_5FeS_4

W. S. Wise (personal communication, 1983) also notes the occurrence of bornite at Majuba Hill, as a rare associate with chalcopyrite in the ore-bearing zones.

Brookite TiO_2

A single crystal of brookite perched on a schorl needle has been identified by W. S. Wise (personal communication, 1983).

Cassiterite SnO_2

Geochemical surveys indicate the presence of considerable tin throughout the mine workings, but only one small area, the Tin stope, has produced any ore. Here, cassiterite occurred as irregularly shaped aggregates up to 20 x 60 cm (Smith and Gianella, 1942), intimately intergrown with a gangue of quartz, sericite, tourmaline and fluorite. Porous specimens of tin ore consist of euhedral and highly lustrous cassiterite crystals to about 2 mm resting on quartz crystals and tourmaline prisms. During mining operations, drusy crusts to 30 x 30 mm of cassiterite crystals were common (J. L. Parnau, personal communication, 1982). Today, however, cassiterite seems to be virtually absent from the Tin stope.

Chalcopyrite $CuFeS_2$

Low-grade copper mineralization at Majuba Hill is commonly represented by veinlets of chalcopyrite with pyrite, or as veinlets of very fine grained aggregates associated with arsenopyrite, bornite and pyrrhotite. Disseminated grains with pyrite and tourmaline also occur within the rhyolite porphyries.

Enargite Cu_3AsS_4

Enargite is present as a minor constituent within pods of secondary chalcocite and chalcopyrite which occur in the Copper stope.

Molybdenite MoS_2

Molybdenite occurs chiefly within strongly silicified rocks associated with quartz and tourmaline and was most prevalent in samples taken from deep drill holes.

Pyrrhotite $Fe_{1-x}S$

Pyrrhotite commonly occurs associated with arsenopyrite and primary copper sulfides, as minute grains and masses.

Pyrite FeS_2

Pyrite, as disseminated grains and crystals, is present nearly everywhere in the Majuba rocks. According to MacKenzie and Bookstrom (1976), however, there appears to be a noticeable lack of any abundant or massive pyrite mineralization.

Secondary Minerals

Where the primary ores have been oxidized, open spaces have formed and the secondary copper and iron arsenate species occur in abundance. Along joint and fracture surfaces, good crystals are also commonly plentiful.

Oxidation of the ores in the Majuba Hill complex extends from the surface down to a depth of 60 to 90 meters, and to 310 meters along larger faults and broken zones.

Arthurite $CuFe_2(AsO_4,PO_4,SO_4)_2(O,OH)_2 \cdot 4H_2O$

Originally described as a new species in 1964 from the Hingston Down Consols mine in Cornwall, England (David and Hey, 1964), arthurite remains a relatively rare mineral. Only thin crusts are known from the type locality and the Potrerillos locality in Chile. At Majuba Hill, however, beautiful, apple-green, well-formed crystals of arthurite are common. Formless crusts occur as well, but the crystals are easily the finest in the world. Crystals of arthurite are monoclinic and occur as elongated prisms up to 1 mm in length; the more common size is about 0.5 mm. Although most specimens are generally small (thumbnail), they can be outstandingly esthetic.

In the bottom portion of the Copper stope, the altered rhyolite locally contains abundant pods and blebs of black chalcocite, and it is here that the best arthurite is found. Some pods may be completely massive and solid, but most are extremely vuggy, with cavities ranging from 2 to 40 mm in diameter. It is in these pockets that groups of radiating arthurite crystals occur, commonly associated with emerald-green pharmacosiderite cubes and sky-blue scorodite crystals.

In June of 1982, during one of the author's last collecting trips to Majuba Hill, a superb find of arthurite was made in one of the large pillars at the bottom of the Copper stope. Only a thin lens of chalcocite was exposed at first, containing tiny vugs of poor arthurite and scorodite. Further picking resulted in a sudden shower of some very fine but small "floater" groups of arthurite and scorodite crystals grown on adularia crystals. Soon, a lenticular cavity developed and it was then possible to look inside and see that it opened up into a space about the size of the palm of one's hand. It was a beautiful sight, with bunches of lustrous, deep, yellow-green arthurite crystals and blue scorodite crystals attached to drusy adularia crystals sparkling in the light of the miner's lamp. The presence of large fractures in the surrounding altered rhyolite made removal quite safe and simple and numerous fine specimens were quickly collected, including one large cabinet piece with a surface about 8 x 8 cm completely covered with crystals.

Arthurite also occurs quite abundantly as yellow-green fibrous crystals less than 0.5 mm in length associated with green pharmacosiderite crystals in cavities in the rhyolite, without any recognizable sulfide minerals. Because these fibrous crystals coat clays and chalcanthite, they are assumed to be a more recent growth than the larger and more euhedral crystals found within the chalcocite pods. Areas of crystal coverage may be as large as 5 x 5 cm when the underlying matrix is removed intact.

Along fractures in the rhyolite porphyry, balls of radiating arthurite crystals associated with tiny pharmacosiderite crystals and clusters of blue-gray scorodite crystals are locally common. The typical occurrence here, however, is for only thin, non-crystalline crusts and patches.

Azurite $Cu_3(CO_3)_2(OH)_2$

Azurite at Majuba Hill forms azure-blue crystals typical of this species, but is rarely of interest to the collector because of the small crystal size. Single crystals or groups of crystals never exceed 1 cm in size, the more common size being about 2 mm. Three distinct localities are known, all in the Middle adit. Below the Copper stope, the mineral occurs with chalcophyllite and a host of other uncommon copper arsenate species. Above the Tin stope, a rather thick, brecciated zone contains abundant azurite associated with malachite and iron oxides. Access to this area is highly dangerous, though, and definitely not worth the risk. In the northeast portion of the mine, azurite and malachite occur sporadically along a narrow fracture zone.

Brochantite $Cu_4(SO_4)(OH)_6$

Dark, forest-green, subhedral crystal groups and druses of brochantite associated with malachite and parnauite occur below the Copper stope in an area which contains numerous uncommon copper arsenate minerals. This is the same locality for the chalcophyllite, cyanotrichite, spangolite and parnauite. It is a vuggy and favorable environment for crystal development. Brochantite crystals from this zone do not exceed 1 mm, are commonly rounded in aspect and not lustrous.

Fine, deep-green crystals of brochantite have been reported from the back of the Copper stope; however, since the timbering was removed, verification of this occurrence has not been possible.

Chalcanthite $CuSO_4 \cdot 5H_2O$

Certain mineralogy texts, such as Sinkankas (1964), describe large masses of chalcanthite fibers from near Imlay, Nevada; the locality is actually Majuba Hill. Large groups of attractive blue, translucent fibers to more than 3 cm in diameter have formed after mining and are present in abundance in the winze below the Copper stope. Here, the rock is extremely altered and fragmented and the chalcanthite literally cements the rock together. No actual crystals have yet been found at this locality.

The former caretaker, E. F. Strode, once told of very bad air down in this winze, and he was correct. As one attempts to descend the ladder into the winze, a sour, musty taste is quickly felt in the mouth, even after only a few moments of exposure.

Chalcocite Cu_2S

In the main Copper stope, chalcocite-rich pods of from 2.5 to 25 cm are included within altered rhyolite porphyry and, during mining, constituted the chief ore mineral. The pods have formed as an alteration of chalcopyrite and contain centers of pyrite, chalcopyrite and minor enargite surrounded by digenite and chalcocite (MacKenzie and Bookstrom, 1976).

Chalcomenite $CuSeO_3 \cdot 2H_2O$

W. S. Wise (personal communication, 1983) reports the occurrence of chalcomenite from Majuba Hill. Only one specimen is known (J. L. Parnau collection), consisting of chalcomenite blebs on a largely limonitic mass with quartz phenocrysts and sprays of schorl in the rockier parts of the matrix. This piece was collected from the Middle adit dump by J. L. Parnau.

Chalcophyllite $Cu_{18}Al_2(AsO_4)_3(SO_4)_3(OH)_{27} \cdot 33H_2O$

Superb, blue-green, lustrous, hexagonal plates of chalcophyllite to 3 mm occur abundantly below the Copper stope in small vugs in heavily altered and iron-stained rhyolite. Individuals are characteristically six-sided, flattened on {0001}, and highly lustrous. Azurite, brochantite and/or spangolite are commonly directly associated with chalcophyllite. Crystals may occur as single plates or as masses of intergrown individuals, but areas with crystal coverage rarely exceed 2 x 2 cm. Better crystals occur at several mines in Cornwall and in Chile, but the specimens from Majuba are certainly some of the finest from North America.

In vugs the chalcophyllite forms free-standing and, for the most part, transparent crystals. Along fractures, however, the mineral may be abundant, but only as translucent green and incomplete crystals. The variation in transparency is due to the progression of the dehydration process. Because the mineral contains so many water molecules, the structure is easily altered when the water is removed. Thus, with the loss of water, there is an accompanying loss in transparency. A few specimens have been observed to dehydrate after removal and change from transparent green to translucent unattractive crystals. The suggestion is, therefore, to keep specimens away from direct sunlight and heat.

Chenevixite $Cu_2Fe_2(AsO_4)_2(OH)_4 \cdot H_2O$

Olive-green to brown, dusty coatings of chenevixite to less than 0.1 mm in thickness occur on breccia fragments in many areas near the middle and bottom of the Copper stope. Surfaces to 4 x 4 cm completely covered with the mineral are not uncommon. In the middle of the Copper stope, fibrous, dark-green olivenite and tiny, yellowish, translucent pharmacosiderite crystals are locally associated with the chenevixite.

Tiny plates of green metazeunerite are liberally sprinkled on chenevixite coatings from the bottom of the Copper stope. Although unspectacular, chenevixite is interesting as an unusual species.

Chlorargyrite AgCl

A brown waxy mineral has been noted as an alteration of native silver collected from the dump of the Middle adit (R. W. Thomssen specimen) and is tentatively identified as chlorargyrite. It occurs as minute blebs less than 0.5 mm across and is very rare for the locality.

Chrysocolla $(Cu,Al)_2H_2Si_2O_5(OH)_4 \cdot nH_2O$

Chrysocolla is locally abundant at many localities throughout the Middle adit as greenish blue coatings and stains on altered rhyolite.

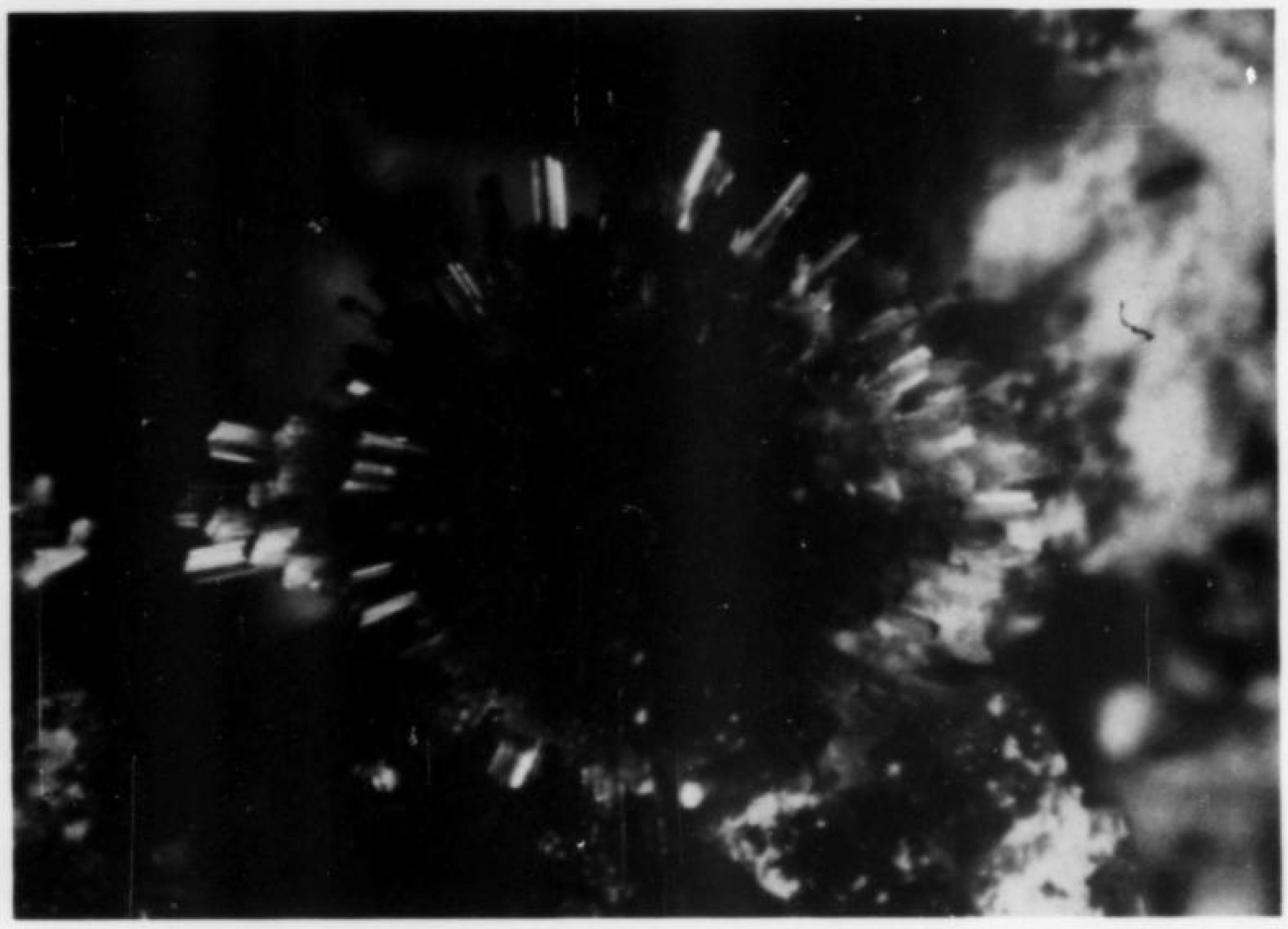
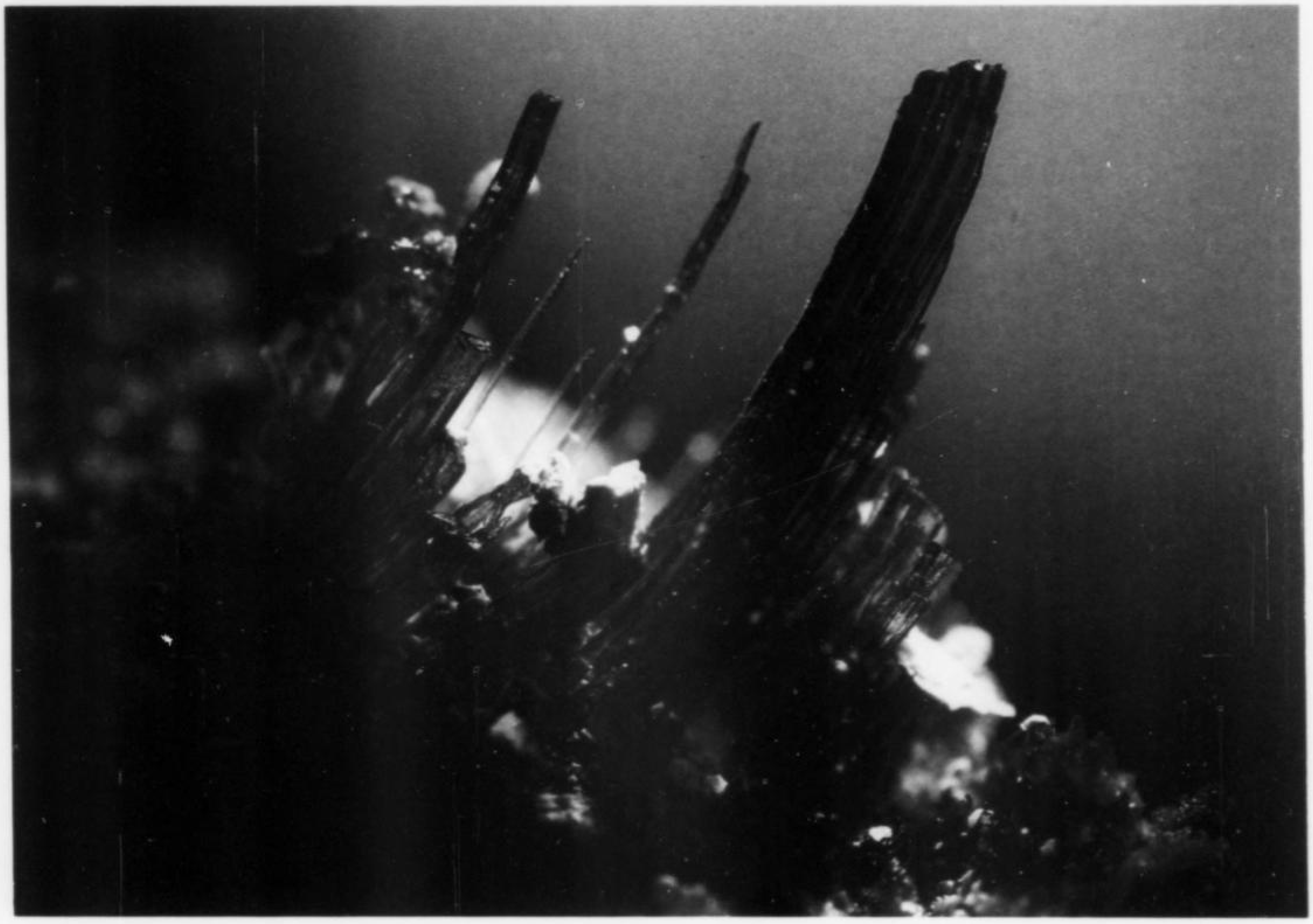


Figure 9. **Radiating group of apple-green arthurite crytals, 2 mm across, associated with green pharmacosiderite cubes, from the Copper stope.**

Figure 10. **Chalcanthite growths to 1 cm, from a winze below the Copper stope. Eric Offermann specimen and photo.**



Clinoclase $Cu_3(AsO_4)(OH)_3$

Majuba Hill is perhaps best known among collectors for its breathtaking clinoclase specimens. Over the years, many museum-quality specimens have been recovered from the mine (and the dump). Surprisingly, many of the best pieces continue to reside in private collections. Rumors have been heard in the Reno area of a specimen about 20 x 20 cm in size completely coated with a dense mat of lustrous crystals; whether or not the piece actually exists has not been confirmed. Although mines at Tintic, Utah, and at Tavistock and Cornwall, England, have also produced fine clinoclase, the specimens from Majuba Hill easily rank as some of the world's finest.

In fact, upon receiving specimens from Majuba Hill, Palache and Berry (1946) performed a complete revision of the crystallographic elements, forms and setting of the species because of the perfection of the Nevada crystals. Up until that time, only curved crystals had been found and it was possible to make only approximate goniometric measurements. Figure 13 shows the original crystal drawing presented by Palache and Berry (1946) of Majuba Hill clinoclase. Although clinoclase crystals from Majuba are not

Figure 11. **Chalcophyllite rosettes to 6 mm across. J. L. Parnau specimen; W. S. Wise photo.**

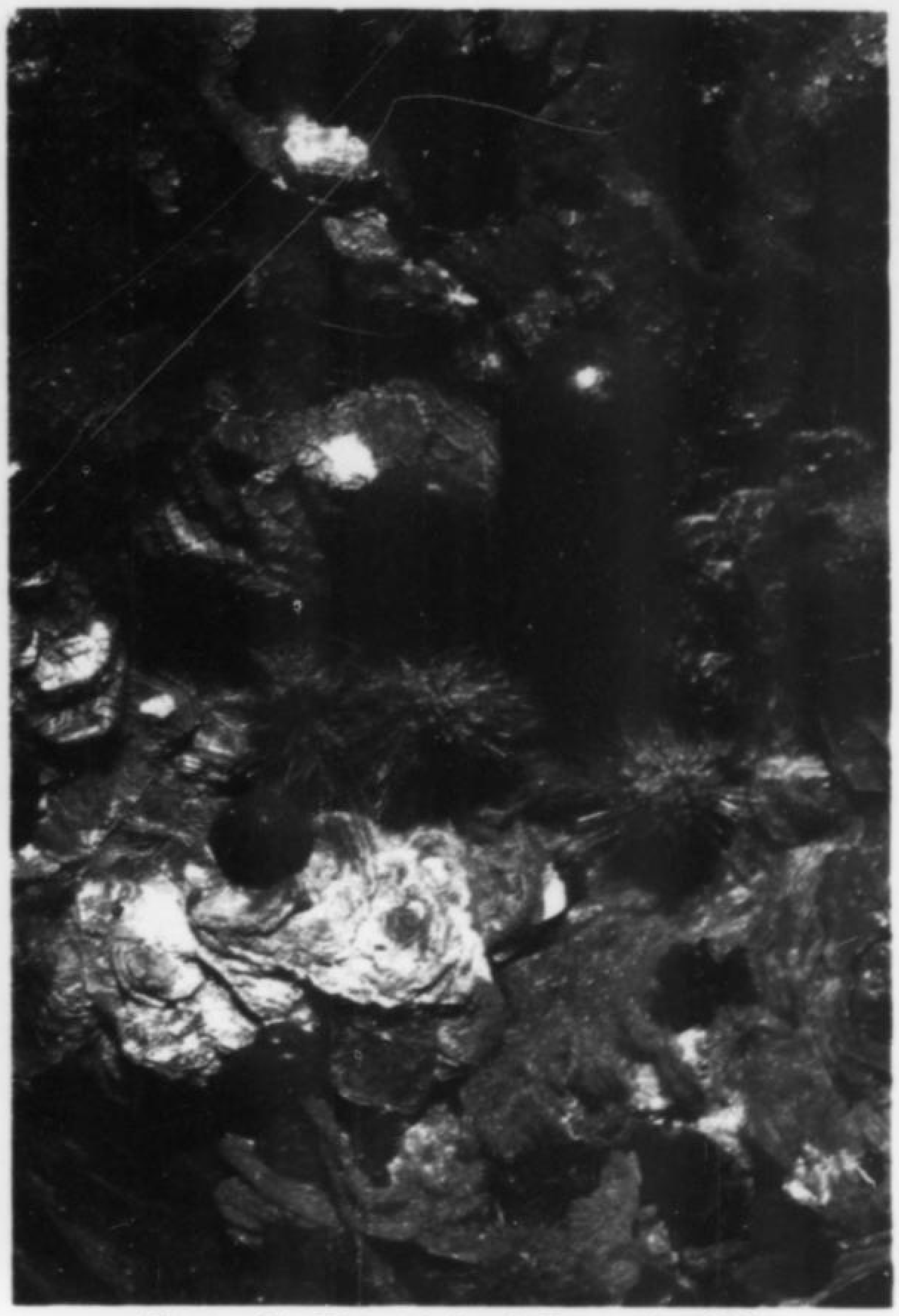


Figure 12. **Platy chalcophyllite, spheroidal brochantite to 2 mm and acicular tufts of cyanotrichite. J. L. Parnau specimens; W. S. Wise photo.**

the largest in the world (Palache and Berry, 1946, note spherical aggregates of radiating crystals to 3 cm from the Bullion Beck mine at Tintic, Utah), they are definitely the best-formed and are highly prized.

The mineral is without doubt an intrinsically attractive species and, at Majuba Hill, fine crystals occur in abundance. The more one looks, the more clinoclase there seems to be. The finest crystals by far are found in the Tin stope at the top of a badly abused and decaying ladder. Here, elongated, lustrous, perfectly formed, prismatic, deep-blue single crystals to 2 mm and groups of radiating crystals to 5 mm occur sprinkled upon fracture surfaces and filling interstices between breccia fragments. Yellowish iron oxides and brick-red clay layers commonly coat the fracture surfaces and provide very pleasing backgrounds for the clinoclase crystals. Rarely, large vugs between breccia fragments may be discovered, up to 1 x 5 x 8 cm in size (J. F. Leising, personal communication, 1981), completely filled with radiating clinoclase crystals. These are very spectacular specimens. Light green olivenite needles to 2 mm and coatings of cornubite and cornwallite are commonly associated with the clinoclase.

In the Copper stope, two individual localities are known which are still productive. At each, however, the clinoclase crystals are not nearly as well-formed as those found in the Tin stope. They are larger, up to 6 mm, but form aggregates of sub-parallel, twisted crystals.

The first locality is about halfway up the stope at the base of a small pillar of brecciated and altered rhyolite. Most of the breccia fragments are small in size and are coated with a thin, spotty veneer of chrysocolla and clinoclase crystal aggregates.

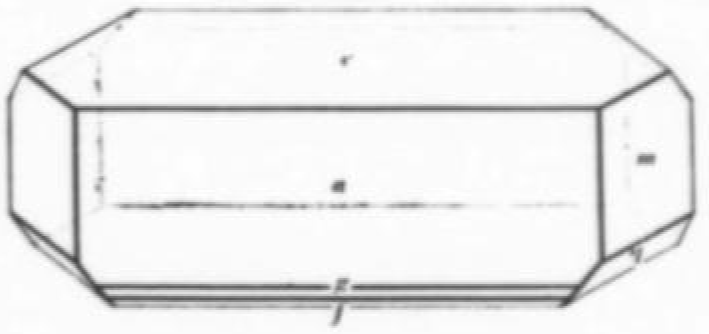


Figure 13. **Clinoclase crystal from Majuba Hill. Forms: $c\{001\}$, $a\{100\}$, $m\{110\}$, $f\{\bar{3}02\}$, $g\{\bar{2}01\}$, $q\{\bar{1}11\}$ (Palache and Berry, 1946).**

At the top of the Copper stope, small vugs from 2 to 80 mm in diameter occur within a hard, altered, iron-stained, massive rhyolite. Clinoclase aggregates resting on a blackish background are found in these vugs. Attempting to dissolve away the iron oxides with acid is an exercise in futility because the clinoclase is attacked and removed much faster.

Clinoclase also occurs as much smaller yet well-formed crystals in the Myler stope. Surfaces of whitish rhyolite fragments are irregularly coated with minute, dark blue aggregates of clinoclase crystals to 1 mm.

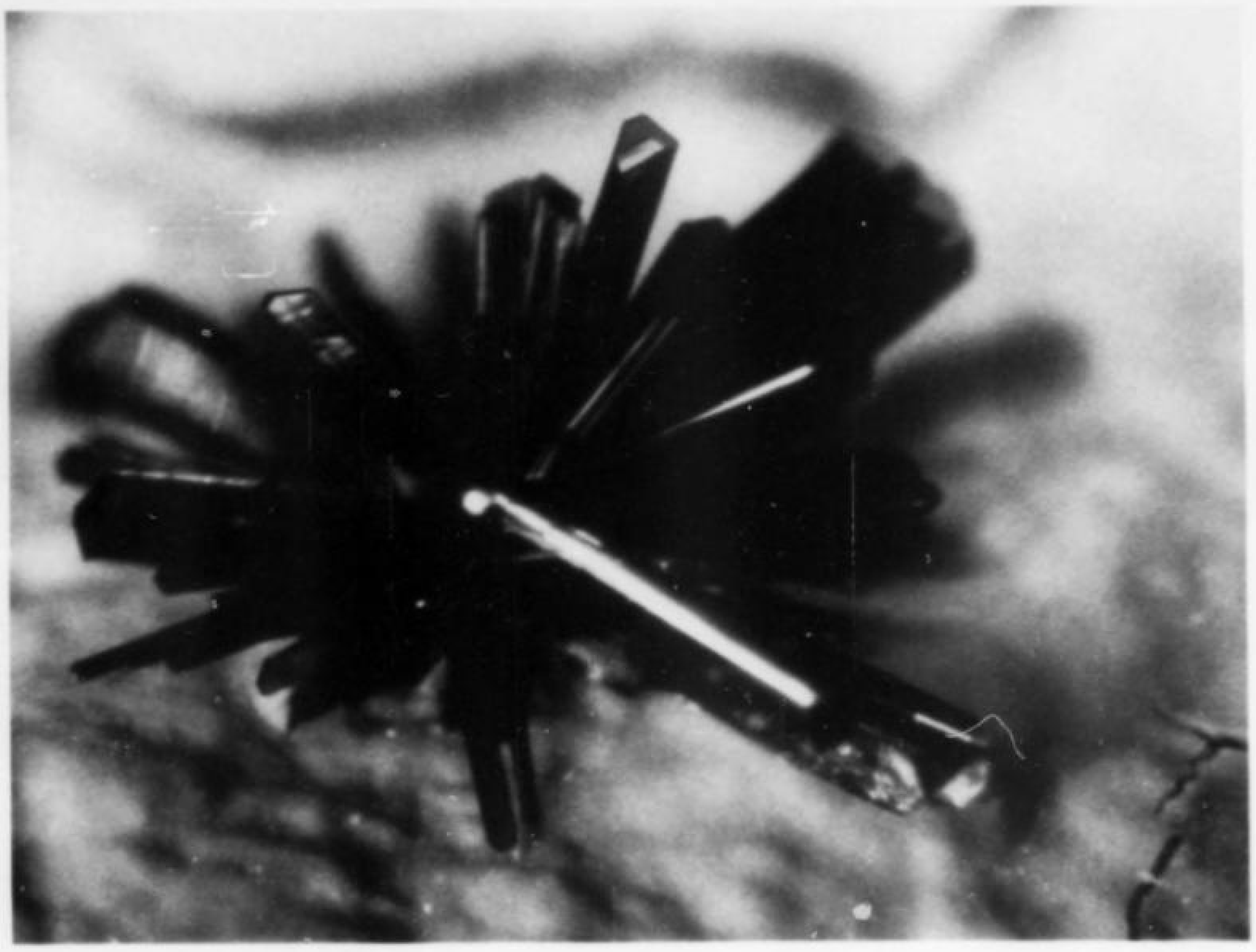


Figure 14. **Cluster of clinoclase crystals 1.5 mm across resting upon brick-red clay matrix, from the Tin stope.**

Copper Cu

According to W. S. Wise (personal communication, 1983), native copper occurs very rarely associated with cuprite on the dump of the Upper adit.

Cornubite $Cu_5(AsO_4)_2(OH)_4$

Cornubite forms light, grass-green, non-crystalline, botryoidal crusts either directly on altered rhyolite fragments or as balls and crusts resting on darker green cornwallite. The mineral has also been noted by W. S. Wise (personal communication, 1983) as coatings on clinoclase and as a pseudomorph after parnauite. The occurrence is restricted to the Copper and Tin stopes where it is associated with clinoclase, olivenite and cornwallite.

Cornwallite $Cu_5(AsO_4)_2(OH)_4 \cdot H_2O$

Cornwallite, like cornubite, forms botryoidal crusts occurring directly on altered rhyolite within the Copper and Tin stope. It is distinguished from cornubite primarily by its darker olive to forest-green color. When the two are found together, the distinction can be made quite easily; the light green cornubite is paragenetically later than and occurs upon the cornwallite.

Covellite CuS

Tiny balls of indigo-blue plates of covellite are noted as occurring in the ore zones by W. S. Wise (personal communication, 1983).

Cuprite Cu_2O

Cuprite occurs as isolated subhedral grains to 4 cm wholly enclosed within altered rhyolite, associated with chalcocite, chrysocolla and malachite (R. W. Thomssen, personal communication, 1983). A few crystals have been found, but Majuba cuprite is generally massive and unattractive. At one time, the mineral was so abundant that it constituted a significant portion of the copper ore mined. Now, though cuprite is abundant only in the breccia exposed in the Myler stope (Trites and Thurston, 1958). Small masses and veinlets up to 10 cm in length are still exposed in places in the Copper stope.

Cyanotrichite $Cu_4Al_2(SO_4)(OH)_{12} \cdot 2H_2O$

Velvety coatings of acicular, sky-blue crystals of cyanotrichite less than 1 mm in length are surprisingly scarce at Majuba Hill. Very few specimens have been noted and areas of crystal coverage are generally small. The occurrence apparently is in the large pillar at the bottom of the Copper stope, where brochantite, chalcophyllite, malachite and parnauite are found.

Digenite Cu_9S_5

Digenite has been reported as occurring within pods of chalcocite, chalcopyrite, enargite and pyrite. Both digenite and chalcocite are of supergene origin and have partially replaced the earlier phases.

Epsomite $MgSO_4 \cdot 7H_2O$

White epsomite fibers as a post-mining efflorescent mineral are common throughout the workings of the Majuba Hill mine. Following the activities of mining, "hairs" to 1 cm could be found dangling from fault surfaces and coating recently brecciated rocks. Chalcanthite and gypsum are commonly closely associated.

Goudeyite $(Al,Y)Cu_6(AsO_4)_3(OH)_6 \cdot 3H_2O$

Majuba Hill is the type locality for the mineral goudeyite, which was first described from the Copper stope by Wise (1978). The species is named for Hatfield Goudey, who collected often at the locality during the 1940s and 1950s and brought many Majuba minerals to the attention of the mineralogical world. The mineral is hexagonal and is closely related to both agardite and mixite.

Although the species is essentially massive (crystals are never larger than 0.5 mm in length), it is desirable because of its rarity.

At Majuba Hill, goudeyite occurs as pale to dark yellow-green patches with a peculiar greasy luster, varying in size from 5 to 40 mm in diameter. It irregularly coats fracture surfaces of iron-stained and altered rhyolite and is commonly associated with white kaolinite. The occurrence at the bottom of the Copper stope was believed by many to be exhausted, but this is not the case and large specimens can still be easily collected.

Gypsum $CaSO_4 \cdot 2H_2O$

As with chalcanthite and epsomite, gypsum has also formed subsequent to the activities of mining and is present as whitish lumpy crusts in areas where abundant oxidation is occurring.

Jarosite $KFe_3(SO_4)_2(OH)_6$

Jarosite from Majuba Hill has been identified by W. S. Wise (personal communication, 1983) as occurring in minute quantities in the upper levels of the mine.

Kaolinite $Al_2Si_2O_5(OH)_4$

Kaolinite has formed primarily as the result of hydrothermal and secondary alteration of feldspar and the rhyolite along the Majuba fault. In fact, the only constituent to evade alteration here is quartz, which remains as glassy phenocrysts enclosed within a whitish, fine grained matrix consisting mostly of kaolinite. White clays are also rather common as coatings on pharmacosiderite and scorodite crystals from the bottom of the Copper stope; the clays are easily removed by a quick rinse in water.

Limonite (hydrous iron oxides, mostly goethite)

In areas with strong sulfide mineralization which has been exposed to surface weathering effects, dark brownish orange crusts, coatings and boxworks of limonite have formed.

Malachite $Cu_2(CO_3)(OH)_2$

Malachite at Majuba Hill is a species of little interest to the collector because it occurs only as thin crusts and stains in altered rhyolite. It is extremely common as green stains along bedding planes of the argillites exposed in the Lower adit, and as greenish, botryoidal coatings associated with azurite in the Middle adit. Lustrous, botryoidal crusts of radiating, light green fibers to 3 mm are typically found in both the Copper and Tin stopes. Below the Copper stope it may be confused with parnauite, which it closely resembles. The surfaces of crusts of parnauite are commonly rough and hummocky, however, whereas the malachite botryoids are smooth and lustrous.

Metatorbernite $Cu(UO_2)_2(PO_4)_2{\cdot}8H_2O$

Torbernite crystals, which are locally present along the ribs and in a small stope of the lower adit, may rarely be altered to the dehydrated form metatorbernite. Instead of being lustrous and transparent, metatorbernite crystals are only translucent and a pale grass-green color.

Metazeunerite $Cu(UO_2)_2(AsO_4)_2{\cdot}8H_2O$

As with the metatorbernite mentioned above, metazeunerite appears to form as a result of dehydration of the parent mineral zeunerite. At the bottom of the Copper stope, where the zeunerite crystals occur, metazeunerite is also locally present. In general, specimens which have been exposed to air circulating through the mine are more apt to be the dehydrated species metazeunerite and may be recognized by their lack of transparency and somewhat dull luster.

Mixite $BiCu_6(AsO_4)_3(OH)_6{\cdot}3H_2O$

Mixite from Majuba Hill is rare and occurs only in the Tin stope (W. S. Wise, personal communication, 1983) as extremely minute, blue fibers associated with olivenite crystals on drusy quartz. The only way to reliably identify the mineral is to obtain a positive chemical test for bismuth.

Olivenite $Cu_2(AsO_4)(OH)$

Excellent, well-formed crystals of olivenite, characteristically elongated on [100], occur at several locations in the Middle adit. Some specimens easily rank among North America's finest. Very large crystals have been found in the past; according to J. L. Parnau (personal communication, 1981), the well-known geologist V. P. Gianella, who did some of the early work at Majuba Hill, had in his possession a group of three parallel crystals, one to about 2.5 cm, but lying flat on matrix.

Within the Middle adit, olivenite is quite abundant and occurs in a wide variety of habits. The finest crystals are found at the top of the Copper stope, where individuals of amazing perfection reach lengths of up to 1 cm. At this locality, open spaces between iron oxide-coated rhyolite breccia fragments are commonly quite large, allowing the development of abundant, well-formed olivenite crystals and groups. Their color is a deep, blackish olive-green, most crystals being quite lustrous and perfectly transparent. Thumbnail to cabinet-size specimens may still be obtained, although one must work rock at the back (ceiling) with the resultant downpouring of rock fragments into one's face. As the larger crystal groups are commonly poorly attached, it can be very distressing to see these fall to the floor as the removal process progresses.

Figure 15. **Divergent spray of very large, olive-green, transparent crystals of olivenite from the top of the Copper stope; width of view is 6 mm.**

Another interesting locality, also at the top of the Copper stope, consists of bleached and altered fault gouge in which olivenite rarely occurs. The discovery of this locality began with two blackish spots seen high up on the wall. A brief moment of searching turned up an old ladder nearby which was quickly dragged over and propped up. By standing on the top rung of the aging ladder with my face flat against the wall, I could look up and see that the black spots were really solid masses of olivenite crystals. With the combination of gad and fingernails and considerable determination, I dug at the surrounding rock. My reward was the sudden release of the olivenites plus abundant waste directly into my face and from there down to the floor. Surprisingly, the olivenites survived and later proved to be very fine specimens. The pieces are composed of masses to 3 cm of well-formed, radiating crystals in sphere-like aggregates. Individual crystals reached lengths of up to 7 mm and are a deep olive-green color.

The white fibrous variety of olivenite, leucochalcite, also occurs at the top of the Copper stope, mostly in piles of old muck. Whitish, feathery masses up to several cm in length occur as coatings on tight joint surfaces.

At a point about halfway up the Copper stope, fibrous, gray-green olivenite, trending towards leucochalcite, occurs between small breccia fragments associated with crusts of chenevixite.

In the Tin stope olivenite crystals are much more abundant than many people currently believe. In addition to the association of small, light green, needle-like crystals to 3 mm with clinoclase, cornubite and cornwallite, olivenite also occurs somewhere at the back of the stope, as crude crystals to 12 mm lying flat on matrix. Blocks which have fallen from the back may contain some of these larger crystals and should be carefully checked.

Also, along the ribs of a small drift which leads away from the Tin stope, J. C. Rota (personal communication) discovered rather abundant olivenite crystals lining fractures between breccia fragments. These crystals are no longer than 4 mm, but are lustrous and well-formed. Where the fracture surfaces are coated with yellow-brown iron-rich clays, the contrast between the green-black

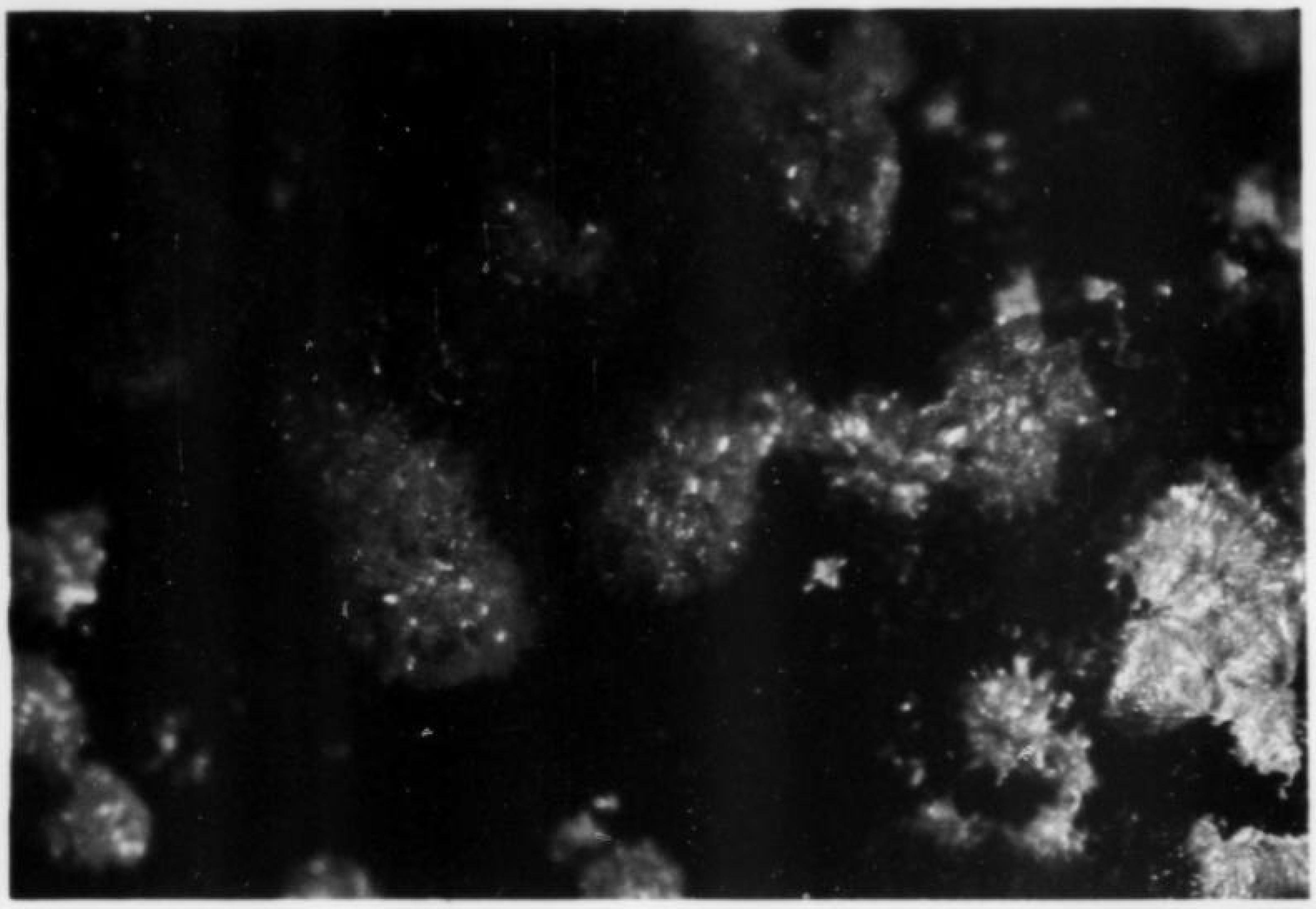


***Figure 16.* Dark green cornwallite on pale green strashimirite from the top of the Copper stope. W. S. Wise specimen and photo.**

***Figure 17.* Tapered spangolite crystals about 1 mm long from below the Copper stope. J. L. Parnau specimen; W. S. Wise photo.**

olivenites and the matrix surface is quite pleasing.

An unusual and scientifically interesting occurrence of olivenite crystals replaced by chalcocite and later coated by tiny pharmacosiderite crystals has been discovered at the bottom of the Copper stope. Small vugs to 3 cm in diameter are completely filled with loose, thumbnail-size specimens consisting of rather abundant, radiating crystals to 2 mm of chalcocite pseudomorphs after olivenite. Although only a few specimens have been found, more vugs undoubtedly do exist in the same general area.

According to R. W. Thomssen (personal communication, 1983), excellent, large olivenite crystals have also been found at the winze leading down from the Upper adit into the top of the Copper stope.

Parnauite $Cu_9(AsO_4)_2(SO_4)(OH)_{10}\cdot 7H_2O$

Parnauite is a mineral species initially found at Majuba Hill and was described by Wise (1978). Prior to this date, the mineral had been called "tyrolite" by most collectors; most specimens so labeled are probably parnauite. Named for John L. Parnau, the mineral occurs as variably colored crusts of microcrystals to no more than 1 mm in thickness. It was originally discovered below the Copper stope as green crusts and vug fillings and is still present there as coverings to more than 4 x 4 cm.

Identifying the mineral can be quite difficult because it occurs in such a wide variety of colors, from silvery white to blue-green, with every variation in between. Malachite is about the only other mineral with which it can be confused, but parnauite commonly exhibits a distinct silky luster and characteristically forms platy orthorhombic crystals. Under the magnification of a hand lens, the thin, lath-shaped crystals with square ends typical only of parnauite can be seen. At the locality below the Copper stope, the typical associates include brochantite, chalcophyllite, goudeyite, malachite and spangolite.

Pharmacosiderite $KFe_4(AsO_4)_3(OH)_4\cdot 6\text{–}7H_2O$

The occurrence of pharmacosiderite is restricted to the Copper stope where it is found in moderate abundance at two localities. The finest specimens are found at the bottom of the stope, within altered pods to 8 cm in diameter of primary and secondary copper sulfides. The interiors of the pods are characteristically vuggy and contain lustrous little pharmacosiderite crystals. Scorodite and arthurite are common associates.

Individual pharmacosiderite crystals are simple, diagonally striated cubes up to 3 mm, with the average being about 1 mm. They are a transparent, deep-green color. When the crystals are viewed in natural light (outdoors), they are much more colorful because the green is more pronounced than when viewed under artificial light. Trying to capture the beautiful green color on film has been an elusive goal; for some reason, the color always comes out a drab, green-brown. A light blue wratten filter helps to correct the problem.

The second locality, at the top of the Copper stope, is purported to rarely produce pharmacosiderite crystals to the huge size of almost 2 cm. If true, these would be extremely unusual and desirable. The only crystals now present in this area, however, are minute and occur only as druses liberally coating large surfaces of breccia fragments. The crystals are light green-brown in color but, due to their small size, are of little interest to the collector.

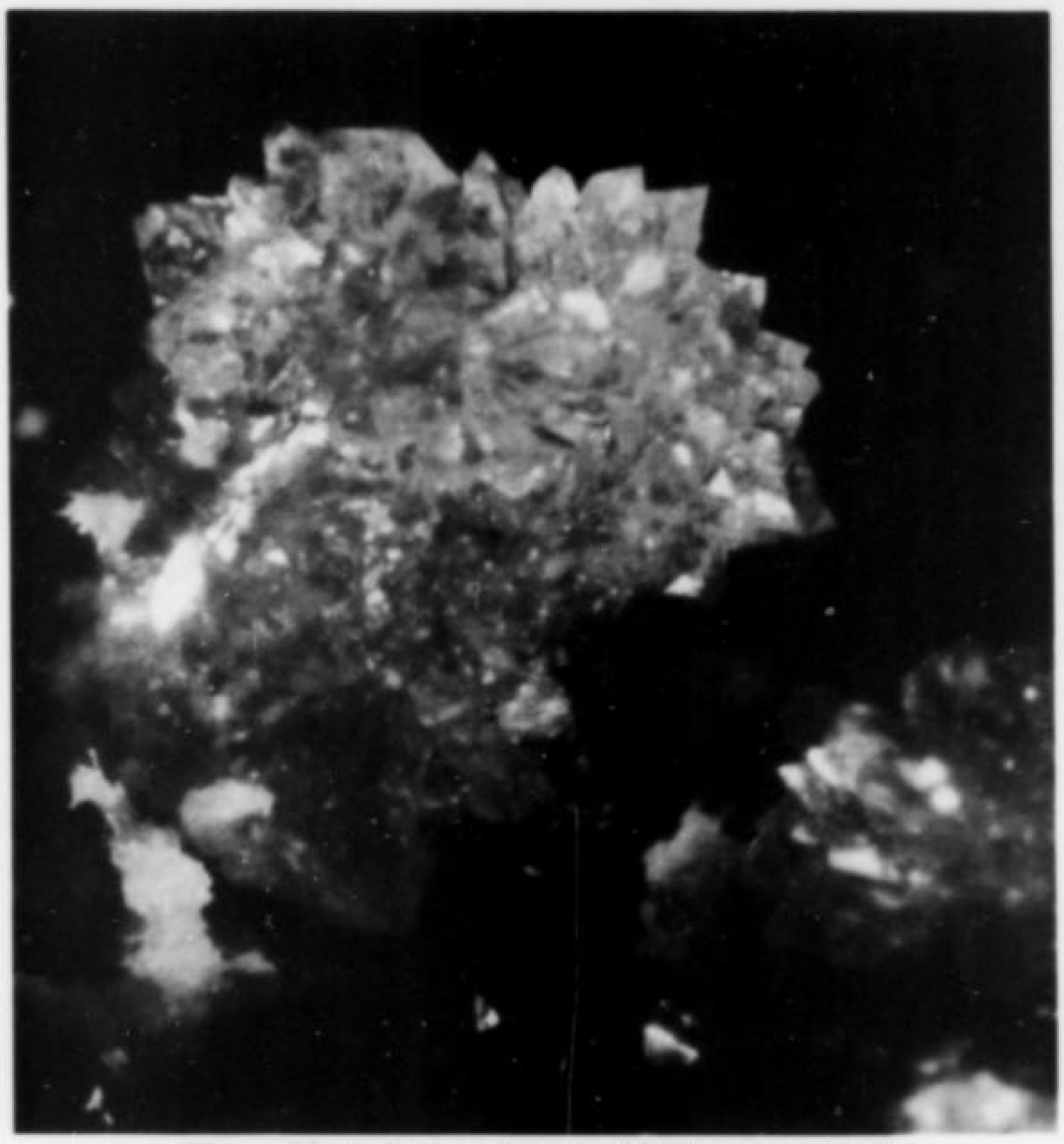


Figure 18. **A 2 mm cluster of lustrous scorodite crystals associated with minor arthurite and pharmacosiderite from the bottom of the Copper stope.**

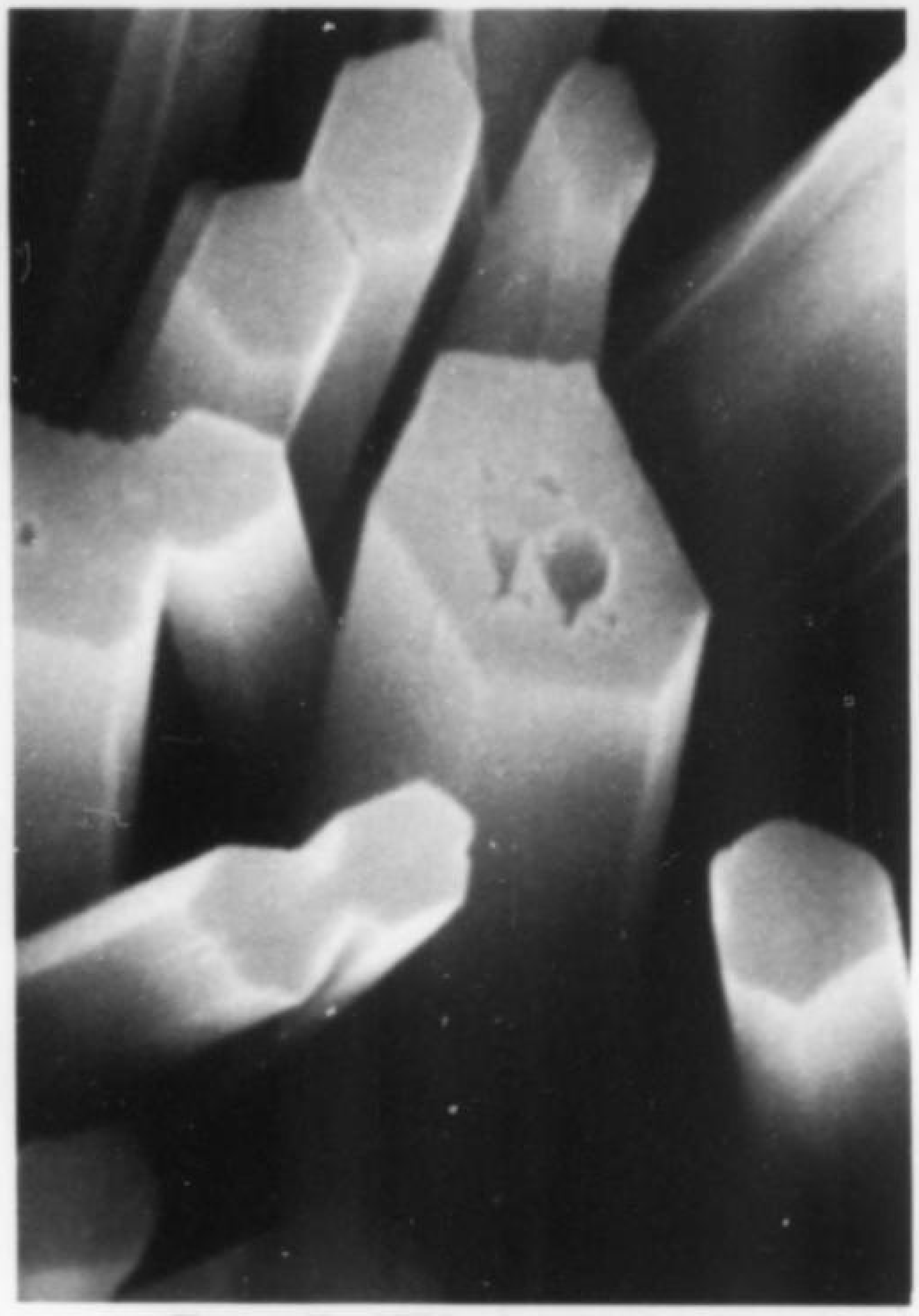


Figure 19. **SEM photograph of parnauite crystals to 2 μm in diameter. B. Runner photo.**

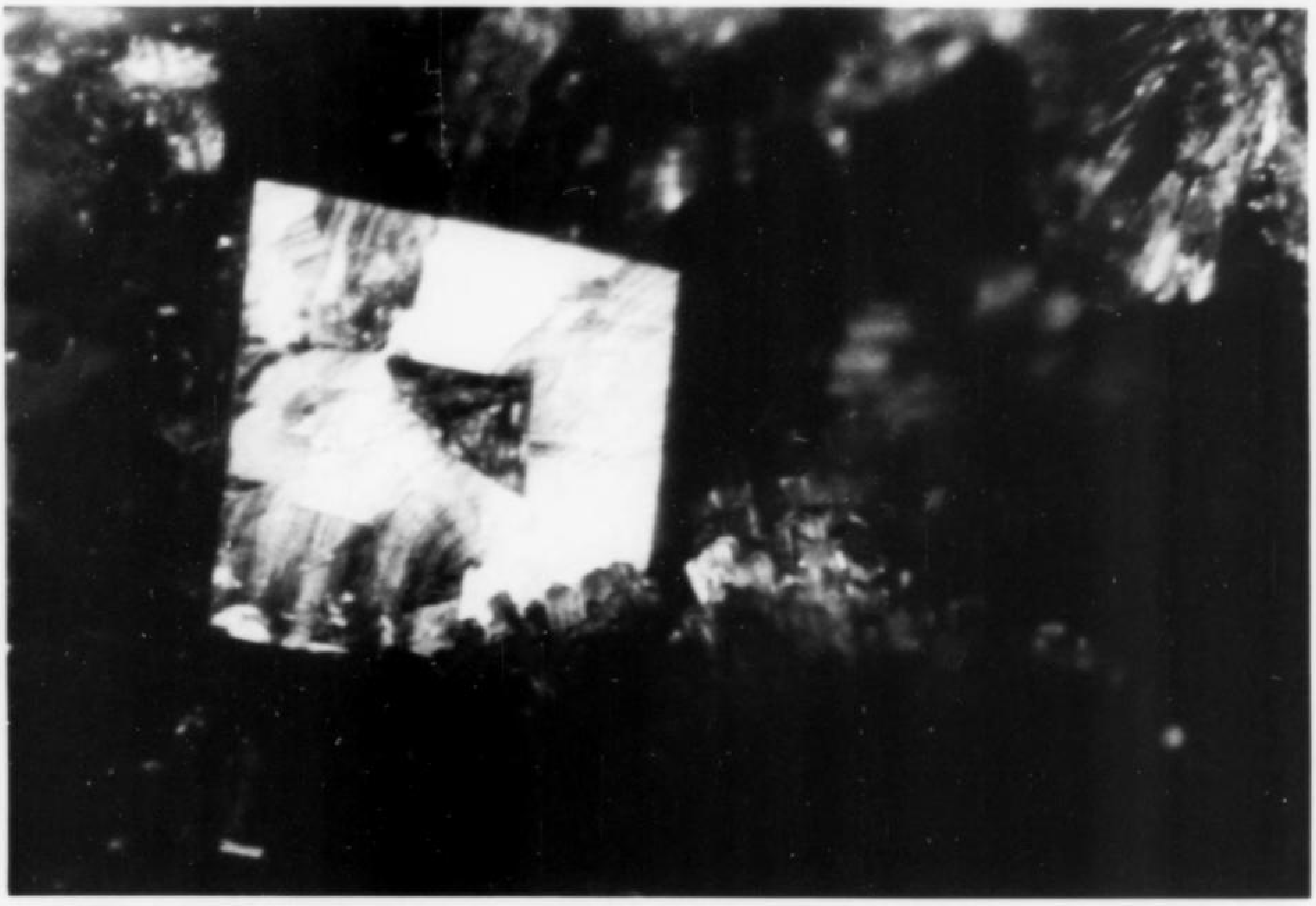


Figure 20. **Lustrous, deep green pharmacosiderite cube, 1 mm on edge, with a smaller interpenetrant crystal; the pharmacosiderite is associated with sprays of arthurite and is from the bottom of the Copper stope.**

Scorodite $Fe(AsO_4)\cdot 2H_2O$

Fine, sky-blue crystals of scorodite to 2 mm occur along with green pharmacosiderite cubes and arthurite prisms in crystal-lined pockets in chalcocite at the bottom of the Copper stope. Scorodite individuals are found rarely as elongated, well-formed orthorhombic prisms, up to 3 mm in length. Clusters of pyramidal crystals are more common, being quite lustrous and sharp. The scorodite from Majuba Hill is easily some of the best from the western United States.

In some cases, scorodite may be the only mineral within the altered chalcocite pods. Whatever the occurrence, identification should not be difficult because the mineral cannot be confused with any of the other species found in this part of the mine.

Silver Ag

From drill-hole data and assay reports, silver has been noted at Majuba Hill in amounts up to 10 ounces per ton. A single sample (R. W. Thomssen specimen) discovered on the dump of the Middle adit consists of a large sheet of native silver about 1 mm thick and associated with chlorargyrite, chalcocite and later metazeunerite crystals. When found, this sheet actually held two separate rhyolite fragments together such that one would dangle from the other. In general, however, the mineral occurs as very minute grains and blebs within brecciated rhyolite.

Spangolite $Cu_6Al(SO_4)(OH)_{12}Cl \cdot 3H_2O$

Spangolite is not abundant at Majuba Hill. Initially, one may have trouble differentiating spangolite from chalcophyllite. The two minerals definitely occur in different habits, though, and the distinction can be made quickly and easily. The spangolite crystals are always small, seldom larger than 1 mm, and are more blue-green than chalcophyllite. Further, the spangolite forms stubby hexagonal prisms terminated by the pinacoid or pyramid, whereas chalcophyllite occurs typically in more flattened, thin hexagonal plates.

Spangolite crystals occur either as druses in small vugs within iron-stained rhyolite or as isolated singles with brochantite, azurite and chalcophyllite crystals. For the most part, the crystals are lustrous and transparent. In some instances, though, dehydration appears to be responsible for a cloudiness and lightening of color, especially in direct association with chalcophyllite.

The occurrence seems to be restricted to the area below the Copper stope, where chalcophyllite, brochantite and parnauite are present. Single crystals or tiny vugs may be easy to locate, but the larger pockets (to 1 x 1 cm) are very uncommon.

Strashimirite $Cu_8(AsO_4)_4(OH)_4 \cdot 5H_2O$

Coatings and thick crusts of felted, acicular crystals of strashimirite occur rather abundantly at the top of the Copper stope. The mineral was first found in Bulgaria in 1968 as fibrous aggregates in spherulites to 0.5 mm. The specimens from Majuba Hill are easily the finest in the world; crystals are typically a pale green color and may exceed 2 mm in length. Along iron-stained joint and fracture surfaces in the rhyolite, areas to 5 x 5 cm may be found completely coated with free-standing strashimirite needles (J. L. Parnau specimen). Olivenite is a common associate, as either bundles of hair-like, olive-green crystals, whitish *leucochalcite* fibers, or as large, somewhat dull singles lying flat on matrix.

Distinguishing between strashimirite and the fibrous variety of olivenite, *leucochalcite,* may at first be difficult. Identification is actually quite simple, however, in that strashimirite occurs only as pale green, distinct crystalline needles. *Leucochacite,* on the other hand, forms distorted and twisted mats of fibers varying in color from snow-white to olive-green.

Torbernite $Cu(UO_2)_2(PO_4)_2 \cdot 8\text{–}12H_2O$

Stories of torbernite crystals to 5 cm (2 inches) from the lower adit have been heard and, surprisingly, they could be true. As recently as June, 1982, exceptional crystals, some to 1.5 cm (D. Bailey specimen), were collected from a caved area in the lower adit. Further questioning with the caretaker revealed that there had recently been a cave-in in the lower adit exposing a small stope and that these green crystals were all over the place. It was noted, however, that access to the stope was extremely dangerous because you had to crawl through a very narrow opening. We decided to give it a try anyway; the temptation of large torbernite crystals was just too difficult to resist. As we neared the caved area, the air became much warmer and humid and even the rock itself was soft and crumbly because of extensive fault motion along the nearby Majuba fault. The opening into the stope was small, but not terribly risky, so up we went. Fractures had been recently exposed in which irregular coatings of lustrous, deep green torbernite crystals sparkled in the light of our lamps. It was relatively easy going at first, simply prying out the specimens; but it eventually became increasingly difficult to remove pieces and so we left (with our flats of specimens and a healthy dose of radon).

When first collected, the crystals are completely transparent, lustrous, and a deep grass-green color. In this state, they are still torbernite. Upon exposure to dry air and sunlight, however, they slowly alter and dehydrate, becoming translucent and converting to the species metatorbernite. Exposure to light seems to be the most destructive factor in causing the loss of transparency; if specimens are kept in darkness as much as possible, they seem to retain their clarity and luster. Spraying with clear sealers does not prevent the alteration.

Figure 21. **SEM photograph of leafy strashimirite; the view is 20 μm across. B. Runner photo.**

At the locality in the lower adit the small stope along the Majuba fault explores the contact between porphyritic rhyolite and argillite. The zone is brecciated and wet, and it is here that green crystals of torbernite are found. Surfaces to 20 x 20 cm totally covered with green crystals to 5 mm are not uncommon.

Even the porphyritic rhyolite from this locality is attractive, the matrix being a clean white color with black pseudomorphs of tourmaline after feldspar distributed evenly throughout the groundmass. Specimens of green torbernite on fresh fracture surfaces are unique and highly prized.

Tyrolite $CaCu_5(AsO_4)_2(CO_3)(OH)_4 \cdot 6H_2O$

Before the identity of parnauite was recognized, most specimens consisting of green, orthorhombic, lath-like crystals were assumed to be tyrolite. Following the work of Wise (1978), however, the problem was resolved and today, it is known that most specimens considered to be tyrolite are actually parnauite. Tyrolite does actually occur in the mine (W. S. Wise, personal communication, 1983), but only rarely and a chemical test would be needed to confirm the identification of specimens.

Zeunerite $Cu(UO_2)_2(AsO_4)_2 \cdot 10\text{–}16H_2O$

Zeunerite was once extremely plentiful at Majuba Hill, according to persons who collected at the locality before 1975. The occurrence at the bottom of the Copper stope is virtually cleaned out today, although it is still possible to obtain a few small crystals with a moderate amount of work. Typical crystals are a light grass-green color, with individual thin, square plates to about 2 mm. Groups of crystals to 15 mm on an edge have been found, but only rarely.

The fact that zeunerite is an arsenate and therefore would be more likely to occur with other arsenates, serves to distinguish it from torbernite. Also, zeunerite crystals commonly exhibit the form {110}, whereas torbernites are simple tetragonal plates. These two features aid greatly in the distinction between zeunerite and torbernite, the two often being confused with one another.

Unconfirmed Minerals

Considerable controversy has arisen regarding the validity of three minerals described from Majuba Hill. Cornetite and libethenite are listed by MacKenzie and Bookstrom (1976) from Majuba Hill, but their existence remains to be proven. Rosasite was identified by an X-ray powder study done by Frondel in 1949, but there is difficulty in accepting this information.

Gangue Minerals

Fluorite CaF_2

As is quite typical of tourmaline and tin-bearing ore deposits, fluorite is locally quite abundant at Majuba Hill. Very crude, cubic crystals to 2 mm have been found, but the more common habit is small to large masses of purple, intergrown crystals. At the back of the Myler stope, fluorite is abundant and occurs within heavily altered and copper-stained rhyolite and fault gouge as conspicuous purple pods to more than 10 cm in length.

Orthoclase (var. adularia) $KAlSi_3O_8$

Grayish white adularia crystals of rhombohedral aspect to 4 mm have been found rarely in small pockets within the rhyolite exposed in the Copper stope. The pockets are commonly lined with smoky quartz crystals to 5 mm, with the adularia resting on the quartz. In two cases noted so far, large pods of chalcocite have been discovered close to these adularia-quartz vugs; the pleasing result was that deep green pharmacosiderite cubes, arthurite crystals and scorodite crystals had formed on the adularia and quartz.

Quartz SiO_2

Quartz is a widespread constituent of the rhyolites at Majuba Hill and commonly occurs as phenocrysts of β quartz crystals (cloudy gray, doubly terminated crystals without prism faces) up to 5 mm in size. These are, of course, α quartz now, the transition occurring at 573° C.

In addition to the occurrences within the rhyolites, quartz is also present as highly lustrous and well-formed smoky crystals within vugs distributed randomly throughout the mine. In the Tin stope, there seems to be a high proportion of quartz-lined pockets and, in places, the crystals are so abundant that the walls tend to glitter from the thousands of tiny crystal reflections.

In the Copper stope, smoky quartz crystals to 1 cm have been found containing inclusions of schorl needles. These crystals are also commonly left-handed and may rarely be overgrown by pharmacosiderite or arthurite crystals.

Schorl (tourmaline) $NaFe_3Al_6(BO_3)_3Si_6O_{18}(OH)_4$

Black tourmaline is locally very abundant at Majuba Hill, occurring typically as needle-like prisms up to a maximum of 5 mm in length. Tourmalinization has been widespread and is most easily recognized by the replacement of feldspar phenocrysts within the rhyolite porphyries. In the Tin stope, masses of interlocking black schorl crystals larger than a man's fist occur by the ton. Clear quartz crystals are found locally among the schorl needles.

Sericite $KAl_2(Si_3Al)O_{10}(OH)_2$

According to W. S. Wise (personal communication, 1983), sericite is a very common mineral at Majuba Hill, having formed during the initial alteration of the porphyritic rhyolitic intrusions and breccias.

CONCLUSION

When I first became interested in collecting at Majuba Hill many years ago, no really useful references could be found to aid in the identification, location or nomenclature of the minerals that occur there. Most of the literature, in its limited descriptions of the mineralogy, is not useful for those who wish to collect and identify specimens.

As noted before, all of the underground workings at Majuba Hill are accessible and relatively safe. Certain areas are somewhat dangerous and are best avoided. Specimens of almost all of the above-mentioned minerals are still present within the mine workings, but due to the temporary closure of the property to mineral collectors, will have to remain in place until the situation once again becomes favorable.

The Majuba Hill mine is one of those localities that one just has to keep going back to; you simply cannot collect it out in five trips, or even ten. I would always leave saying that there was no reason to return but, upon a subsequent trip, would discover something new and even more spectacular than anything found on previous trips.

ACKNOWLEDGMENTS

I am grateful to former caretaker E. F. Strode and his family for many happy hours of bad-air stories and reminiscences about Majuba's past. Discussion and editorial assistance from R. W. Thomssen and W. S. Wise was of significant help, and their interest is very greatly appreciated. D. D. Carda and G. A. Stone aided in the scanning electron microscope work, while P. Bjork provided photographic equipment for the photomicrography of specimens. Special appreciation is due J. F. Leising, J. C. Rota and W. W. Parks, III, for participating with the author on many enjoyable and rewarding collecting trips to Majuba Hill. Also, the many fine minerals collected from Majuba Hill by H. Goudey and J. L. Parnau are certainly noteworthy and, if it were not for these two collectors, the importance of Majuba Hill would probably have gone unrecognized. R. Ross gave partial financial support.

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Mopungite
a new mineral from
NEVADA

S. A. Williams
Globo de Plomo Enterprises
P.O. Box 872
Douglas, Arizona 85607

ABSTRACT

Mopungite occurs in the Mopung Hills, Nevada, and is named for the locality. It occurs on oxidized stibnite with selenium, sulfur, and various Sb-oxides. The specific gravity is 3.21; luster is resinous to dull; colorless to white; H = 3, $n_\epsilon = 1.605$, $n_\omega = 1.614$.

The strongest powder lines are 4.581(10), 3.985(8), 1.205(7), 1.629(5), 1.325(5), 1.265(5), 1.192(5), 3.925(4). The space group is $P4_2/n$ with $a = 7.994$, $c = 7.859$Å (tetragonal). Mopungite is a member of the stottite group.

Chemical analysis of synthetic material and of an impure natural sample leads to the formula $NaSb(OH)_6$.

OCCURRENCE

Mopungite was discovered at the Green Prospect in the Mopung Hills, Churchill County, Nevada. The name is for the locality; mineral and name have been approved by the Commission on New Minerals and Mineral Names, IMA. The prospect is described by Lawrence (1963) as an antimony occurrence with unusual amounts of selenium, and we visited it originally because of its unusual chemistry.

At the prospect there are numerous small workings exposing loose boulders and fragments of vein matter embedded in debris representing the former shoreline of Lake Lahontan. The quartz-fluorite-stibnite vein matter was evidently weathered out and submerged in brackish water for a considerable time. Mopungite occurs as an oxidation product of stibnite; it encrusts other minerals such as stibiconite, senarmontite, romeite and tripuhyite which form pseudomorphs after stibnite crystals. Pseudomorphs of stibnite crystals up to 15 cm in length were found.

Mopungite was found in abundance only in a small hand-sorted pile of ore left by the original prospectors. With the exception of stibiconite, most of the other minerals found with mopungite were found nowhere else at the prospect. A determined search of other prospect pits and dumps revealed only stibnite and pyrite with abundant jarosite.

Well-crystallized native selenium occurs with mopungite. Native sulfur is locally abundant as granular masses in the gangue, and it ranges in color from pale yellow to rich carmine-red with increasing selenium content.

Mopungite typically occurs as small pseudocubic crystals 0.2–0.3 mm on an edge. They thickly encrust fractures which riddle the earlier Sb-oxide assemblage. The ultimate result is a breccia of Sb-oxides cemented by spongy mopungite crusts. The ore appears to have shrunk as though dessicated.

PHYSICAL PROPERTIES

Mopungite crystals are colorless and clear to milky white with a bright glassy luster. Only once were milky white acicular crystals found. The crystals are pseudocubic and show the forms {001}, {110} and {101}, but no measurable crystals were seen. The crystal faces are invariably frosted or dull and have a curious wrinkled texture. No cleavage was observed, even in thin section.

Crystals are uniaxial (–) and show no zoning or optical abnormalities. The indices of refraction (white light) are $n_\epsilon = 1.605$, $n_\omega = 1.614$.

The specific gravity was estimated using Clerici solution using measured standards and found to be 3.21. The calculated density is 3.264 g/cm^3. The Mohs hardness is 3. No fluorescence is observable in shortwave or longwave ultraviolet light.

CRYSTALLOGRAPHY

Mopungite provides a crisp, clear X-ray powder diffraction pattern obtained using CrKα radiation; an indexed pattern is presented in Table 1. These photographs were used to refine cell dimensions obtained from Weissenberg single-crystal films, yielding a = 7.994Å, $c = 7.859$Å.

Rotation and Weissenberg photographs based on c-axis rotation of a single crystal establish the space group as $P4_2/n$ (also given by Strunz, 1970, for the synthetic salt).

Table 1. **X-ray powder diffraction data for mopungite, 114 mm camera, CrKα radiation.**

$I_{obs.}$	$d_{obs.}$	$d_{calc.}$	hkl
10	4.581	4.589	111
8	3.985	3.997	200
4	3.925	3.930	002
2	2.826	2.826	220
4	2.801	2.802	202
1	2.525	2.523	301
1	2.490	2.490	103
4	2.406	2.406	311
2	2.380	2.377	113
3	2.296	2.294	222
2	1.999	1.998	400
1	1.968	1.965	004
1	1.835	1.832	331
2	1.822	1.819	313
4	1.789		
4	1.784		
2	1.767		
5	1.629		
3	1.616		
3	1.540		
1	1.532		
2	1.518		
1	1.415		
2	1.404		
4	1.353		
4	1.347		
4	1.338		
3	1.332		
5	1.325		
5	1.265		
3	1.248		
3	1.217		
1	1.210		
7	1.205		
5	1.192		

Table 2. **Chemical analyses of mopungite and synthetic $NaSb(OH)_6$**

	natural		synthetic	
	1	2	3	4
Na_2O	11.2%	12.8%	12.94%	12.67%
Sb_2O_5	57.2	65.2	65.90	65.10
H_2O	(19.3)	22.0	21.0	21.8
insol.	11.1			
	98.8%	100.0%	99.84%	99.57%

1) (natural material) Na and Sb by analysis in aqueous solution using energy-dispersive X-ray fluorescence based on 243 μg. The H_2O was calculated based on the average ratios found in columns 2 and 3. Insol. is native sulfur.

2) Recalculation of 1) to 100% after subtracting insoluble native sulfur residue.

3, 4) (synthetic material) Na and Sb done by XES as above on 495 and 872 μg; H_2O by TGA on 6.70 and 5.35 mg respectively.

CHEMISTRY

The synthetic compound has been known for a surprisingly long time and has been well studied. Probably the first chemist to produce $NaSb(OH)_6$ was Terreil (1866). The recipe given by Cormimboeuf (1892) was used with good effect to produce considerable quantities of pure $NaSb(OH)_6$ which were used in this study. Although there is no particular scarcity of natural mopungite, difficulty was encountered in separating pure material for analysis. The synthetic salt was examined by optical and X-ray diffraction means (including single-crystal study) to insure that it is identical to natural mopungite. Some work was performed on mopungite as well, and results of the analyses are presented in Table 2. Note the close similarity in composition between natural and synthetic material.

Mopungite is soluble in hot water but is not visibly affected by cold water. It dissolves readily in cold dilute tartaric acid and is decomposed by hydrochloric and nitric acid.

Mopungite is a member of the stottite group.

SPECIMENS

A dozen or so pieces were found at the locality and they comprise some tens of milligrams of mineral. Type material will be provided to the British Museum (Natural History).

ACKNOWLEDGMENTS

I am grateful to my wife Betty for field assistance, and to Marjorie Duggan for preparing synthetic material. Fabien Cesbron reviewed the X-ray data at my request.

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the Julie Claim
Mineral County
NEVADA

Michael R. Smith and **Julia A. Benham**
14 Andes Lane
Yerington, Nevada 89447

Late in 1981 a series of skarn pockets was opened up near Hawthorne, Nevada, and a new locality for world-class epidote was discovered. Fine crystals to 15 cm were removed.

INTRODUCTION

In late 1981 a series of pockets filled with epidote and quartz crystals were collected near Hawthorne in Mineral County, Nevada. The locality is in the Pamlico mining district, NW¼ Sec. 9, T7N, R32E, about 16 km (10 miles) east of Hawthorne. The occurrence has apparently been known to a few local prospectors for quite some time, but the epidote remained uncollected except for a few crystals found in alluvium.

All of the mineralized zone in the vicinity is currently held under mining claims (The Julie and Green Jug claims, etc.) and no collecting is allowed. The locality was independently discovered by one of the authors (MRS) in the summer of 1980 while doing exploration.

In the fall of 1981 the authors and Dick and Helen Jones visited the locality several times. Many fine specimens were then collected from about a dozen pockets. All of the pockets located at or near the surface have been collected and further collecting will require much greater expenditures of time, effort and money.

GEOLOGICAL SETTING

Regional Geology

The epidote occurrence is situated near the junction of two provinces, the Basin and Range and the Sierra Nevada. This area is also approximately coincident with the Walker Lane, a regional zone trending N20°W characterized by right-lateral strike-slip faulting. Sediments in the area range from late Permian to Jurassic. The Triassic and Jurassic sediments are of marine origin, having been deposited in a back-arc basin called the Luning Embayment. They are composed of clean to dirty carbonates, very fine to coarse grained clastic rocks of largely volcanic origin, and volcanic flows. The marine sediments are locally intruded by dikes, sills and stocks of granitic rocks, which are about 90 million years old (Evernden and Kistler, 1970). Along the intrusive-carbonate contacts skarns formed locally, hosting the epidote occurrence. Tertiary volcanic rocks, ranging from basalt to rhyolite, and sediments locally cover the older rocks. Structure in the area is complex due to the overlap of Basin and Range faulting and Walker Lane strike-slip faulting, as well as suspected Jurassic thrust faulting related to the Nevadan Orogeny.

Local Geology

As illustrated in Figure 4, a highly irregular exoskarn body consisting of massive grossular-andradite garnet (*grandite*) or diopside (*salite*) occurs along the contact between marbleized limestone and quartz monzonite. Pods of unreplaced marble, dipping steeply to the northwest, are locally isolated in the exoskarn bodies. Some of the quartz monzonite adjacent to the exoskarn is altered to endoskarn composed of scapolite, clinopyroxene, epidote, actinolite, quartz and pyrite. There is an irregular alteration zoning from scapolite endoskarn,, to salite exoskarn, to grandite exoskarn, to calcite marble. All of the epidote found to date occurs near endoskarn-exoskarn contacts. However, other areas of similar occurrence have failed to produce epidote specimens.

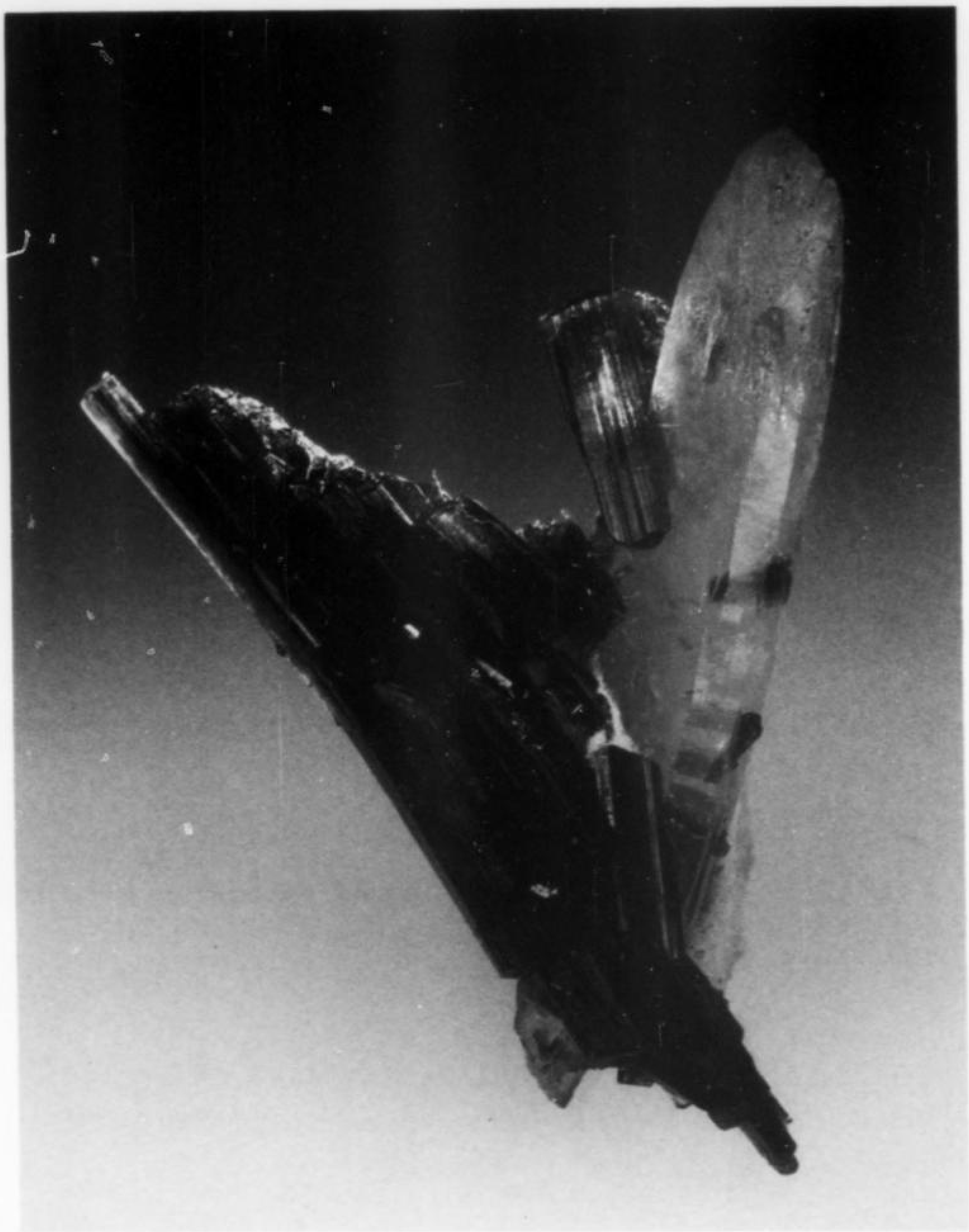


Figure 1. **Epidote crystals to 2.5 cm, with quartz crystal, from the Julie claim. Michael Smith collection.**

The paragenesis of the skarns is summarized in Figure 7. The various skarn types formed in two overlapping, mineralogically distinct episodes. The earlier episode formed anhydrous exoskarn consisting dominantly of grandite and salite. These anhydrous skarns formed at relatively high temperatures, probably shortly after intrusion and quenching of the quartz monzonite. As temperatures lowered and H_2O activity increased, hydrous skarn (composed of epidote, quartz, titanite, pyrite and actinolite) began to replace grandite exoskarn. During this phase, the epidote crystals formed. Endoskarn formation was probably contemporaneous with the formation of hydrous retrograde skarn, as suggested by the endoskarn's hydrous mineralogy. Actinolite pseudomorphs after epidote indicate that hydrothermal activity continued after the formation of epidote.

Pockets of epidote, quartz and other minerals formed along fractures in grandite exoskarn. Many of the pockets are lenticular, and where they intersect a pipe-like pocket formed. The pockets measure from a few centimeters in largest dimension to pipe-like pockets 1.5 meters long and 0.5 meters across. All of the large pockets found to date have been within about three meters of endoskarn. Figure 5 diagrammatically shows the occurrence of epidote pockets. The best strategy for finding pockets is to follow epidote-coated fractures in grandite exoskarn and hope the fracture opens up into a pocket.

MINERALOGY

The following species have been identified by inspection only; subsequent analyses may modify these identifications.

Actinolite $Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$

Actinolite is fairly common in the area. Deep green actinolite is common on fracture surfaces in salite skarn. One felted pseudomorph of actinolite after epidote was found, and byssolite is locally present as inclusions in quartz.

Axinite group

Small tan to brown axinite crystals are locally present on the base of rare epidote and quartz matrix specimens, where the specimen was "peeled" from the altered grandite skarn. They have typical axinite morphology, and are unspectacular.

Diopside $CaMgSi_2O_6$

Massive, gray-green diopside, variety *salite,* is very common in the area, forming outcrops of exoskarn. No euhedral crystals have been found. Broken salite exoskarn fragments locally show typical clinopyroxene cleavage.

Epidote $Ca_2(Al,Fe)_3(SiO_4)_3(OH)$

Of the mineral specimens to be found at the locality, epidote is the most outstanding. It occurs in altered grandite exoskarn and rarely in endoskarn. When initially dug out, the epidote crystals

Figure 2. **Epidote crystals to 4.2 cm from the Julie claim. Michael Smith collection.**

Figure 3. **Epidote crystal group 14.6 cm long, collected by Dick Jones in 1981.**

(and all other crystals) are covered with caliche and a silica and zeolite coating. This coating can be removed with HCl and HF, respectively, resulting in lustrous, deep green crystals with appealing internal reflections of lighter green. Late-growth crystals up to 3 mm long, usually perched on larger epidote or quartz crystals, are transparent and similar in color to Knappenwand, Austria, epidote. The epidote crystals are usually deeply striated.

The largest epidote found to date is about 15 cm long. Epidotes less than about 6 cm long typically occur as simply twinned crystals, while larger crystals are composed of multiple twins that are slightly divergent (Wilson, 1982). End sections of simply twinned crystals are occasionally butterfly shaped. The end sections of single crystals range from equidimensional to elongate. The length/width ratio of single crystals ranged from about one to five.

Many detached crystals were found but one termination typically consists of a healed break, generally being as brilliant as free-grown terminations. The healed terminations are often quite complex, appearing as a flat surface studded with triangular facets. Apparently the pockets came under stress during the formation of epidote, resulting in broken epidote and quartz crystals which healed as crystallization continued. The crystal terminations are generally not quite as lustrous as the prism faces. Interpenetrating epidote crystals were found only rarely.

Good matrix specimens larger than thumbnail size are quite rare; only a few miniatures were found. Several dozen thumbnails of quartz and epidote were found, and on a few of these thumbnails both species are doubly terminated. Most of the specimens are single crystals, most of which have only one termination, with the other end being an unhealed recent break. About *90%* of the total crystals found are broken off at both ends. When found, the

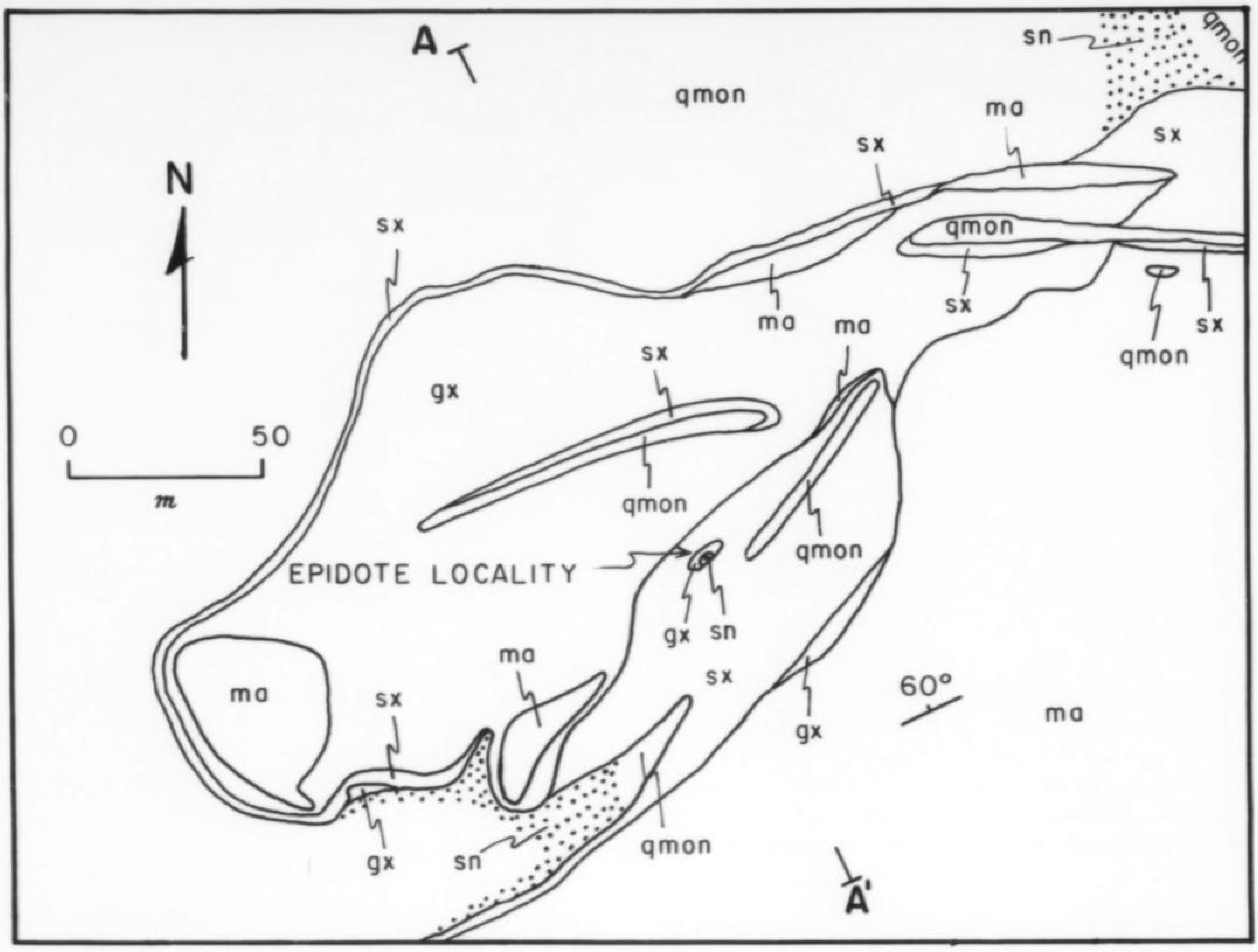
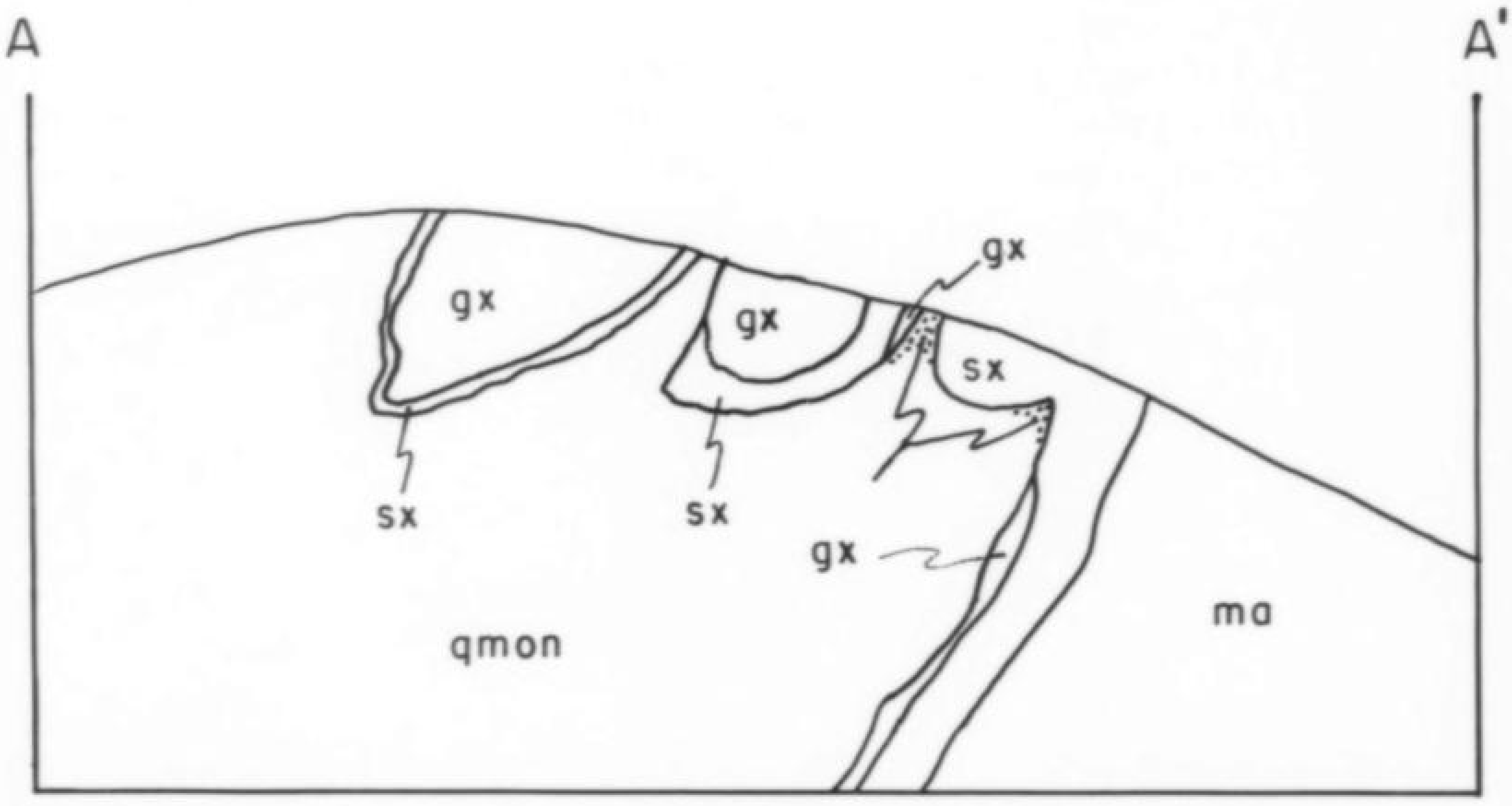


Figure 4. **Geologic map of the area surrounding the epidote skarn; qmon = quartz monzonite, sn = scapolite endoskarn, sx = salite exoskarn, gx = grandite exoskarn, ma = marble. The cross-section A–A′ is shown at right.**



pockets weren't open but were packed with loose crystals in a matrix of zeolite, silica and caliche.

Grandite $Ca_3Al_2(SiO_4)_3Ca_3Fe_2(SiO_4)_3$
(Grossular-Andradite series)

Grandite is very common in the area, comprising large outcrops of exoskarn. In one area (northeast corner of Fig. 4) grandite and scapolite have replaced intrusive rocks forming endoskarn. The grandite crystals are generally of poor quality in the immediate area of the epidote occurrence. This is apparently because epidote, quartz and calcite formed at the expense of grandite; any crystals which weren't entirely replaced are highly corroded. The grandite crystals reach 2 cm across and are commonly growth zoned. Away from the epidote occurrence nice uncorroded crystals can be found, but many skarns in the western U.S. produce far better grandite specimens, *e.g.*, Stanley Butte, Arizona.

Limonite

Limonite pseudomorphs after pyrite are fairly common, being intimately associated with epidote and quartz. Pyrite seems to have been the last hypogene mineral to form, generally occurring toward the center of the epidote pockets. Relict striations can be seen on the bronze-colored limonite pseudomorphs, and on many specimens the cube face is curved. When collecting, the presence of earthy limonite mixed with decomposed epidote and quartz sometimes portends the discovery of good epidote crystals.

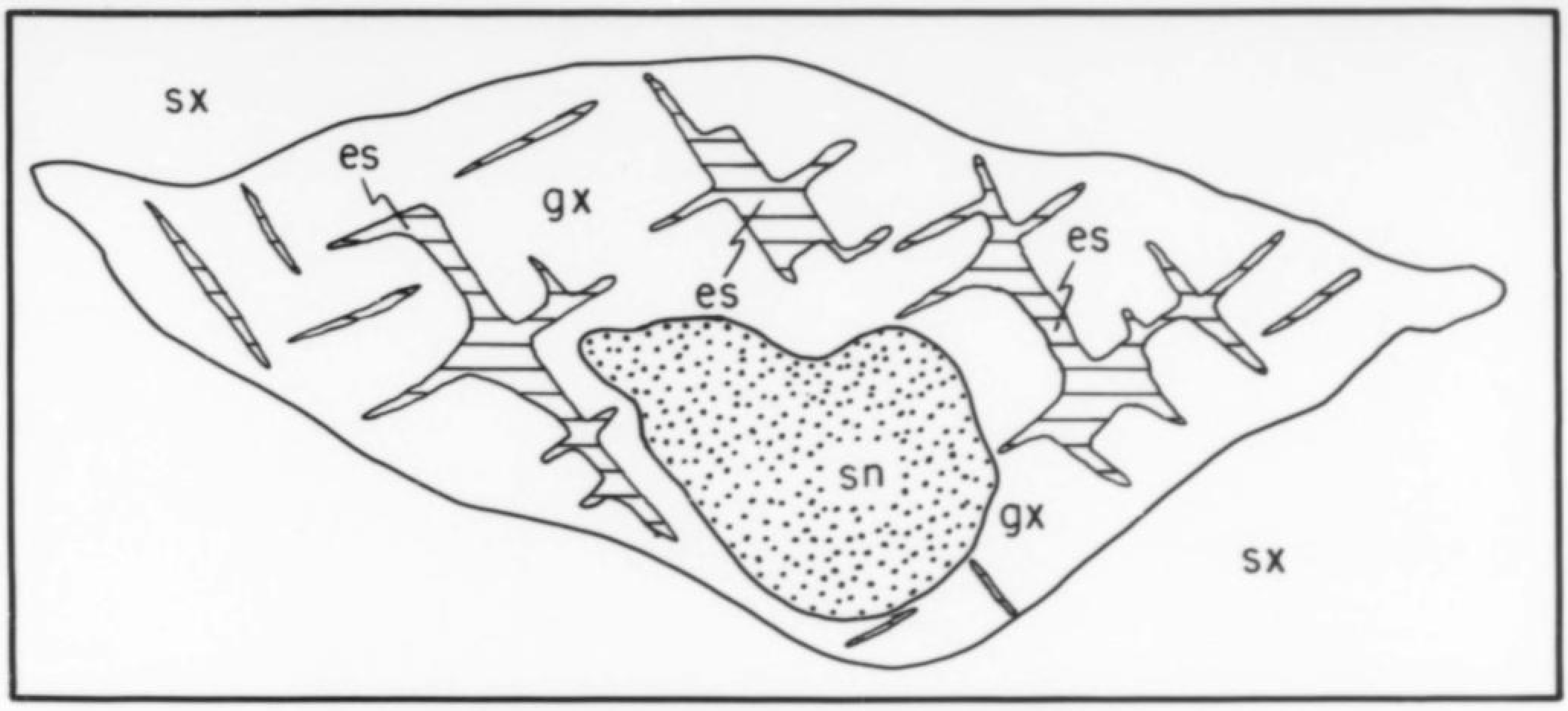


Figure 5. **Sketch illustrating the distribution of epidote skarn areas (es) with relation to grandite skarn and scapolite skarn.**

Quartz SiO_2

Quartz crystals were also found in abundance, intimately associated with epidote, but they are not particularly attractive. The crystals are clear and colorless except for one smoky crystal, and range up to 4 cm long. The one smoky crystal suggests the presence of some radioactive mineral, but none was observed. The quartz crystals come in three morphological types, listed in order of decreasing abundance:

1. crystals with parallel and roughly equal-sized prism faces
2. spear-shaped crystals with equal-sized prism faces which converge toward the termination
3. flattened crystals with parallel prism faces.

The larger the crystal the greater the propensity for being spear-shaped. A few crystals were found with hair-like inclusions of green byssolite. No crystals twinned on the Japan law were found.

Scapolite group

Milky white scapolite replaces plagioclase in endoskarn, along with clinopyroxene, grandite and epidote. The scapolite forms columnar crystals that locally form radiating masses. Only one specimen of scapolite crystals in a vug was found, but the crystals are dull and not well formed.

Titanite $CaTiSiO_5$

Honey-yellow titanite crystals are rarely found perched upon epidote or quartz. The titanites reach 1.5 mm in greatest dimension, and occur as flattened wedges. They are very brilliant.

Zeolite group (?)

As mentioned earlier, a zeolite (?) occurs as a coating on epidote and quartz. It is milky white and earthy to massive with a conchoidal fracture. This mineral partially decomposes in diluted HF, such that it can be "flaked" from epidote crystals.

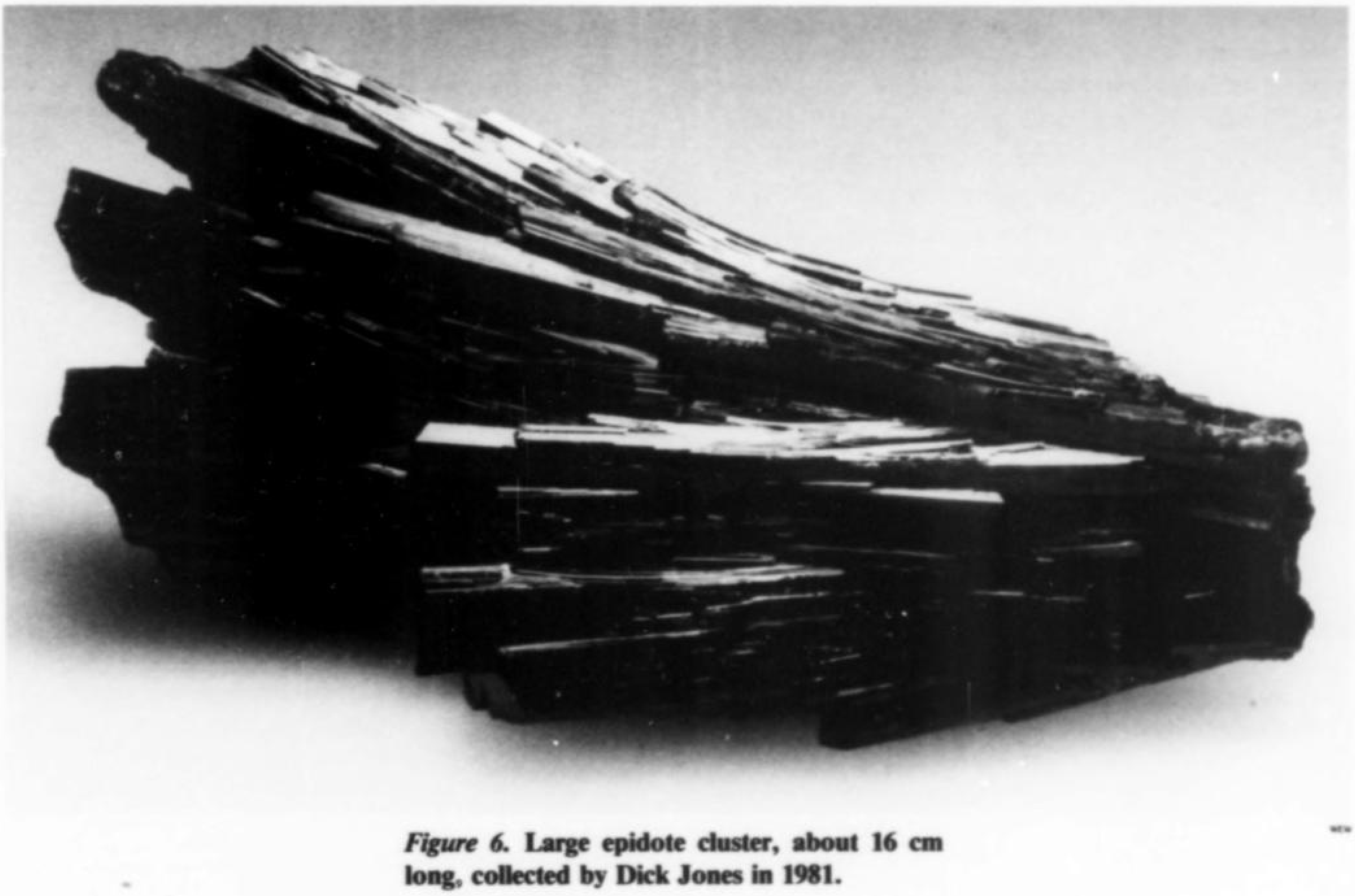
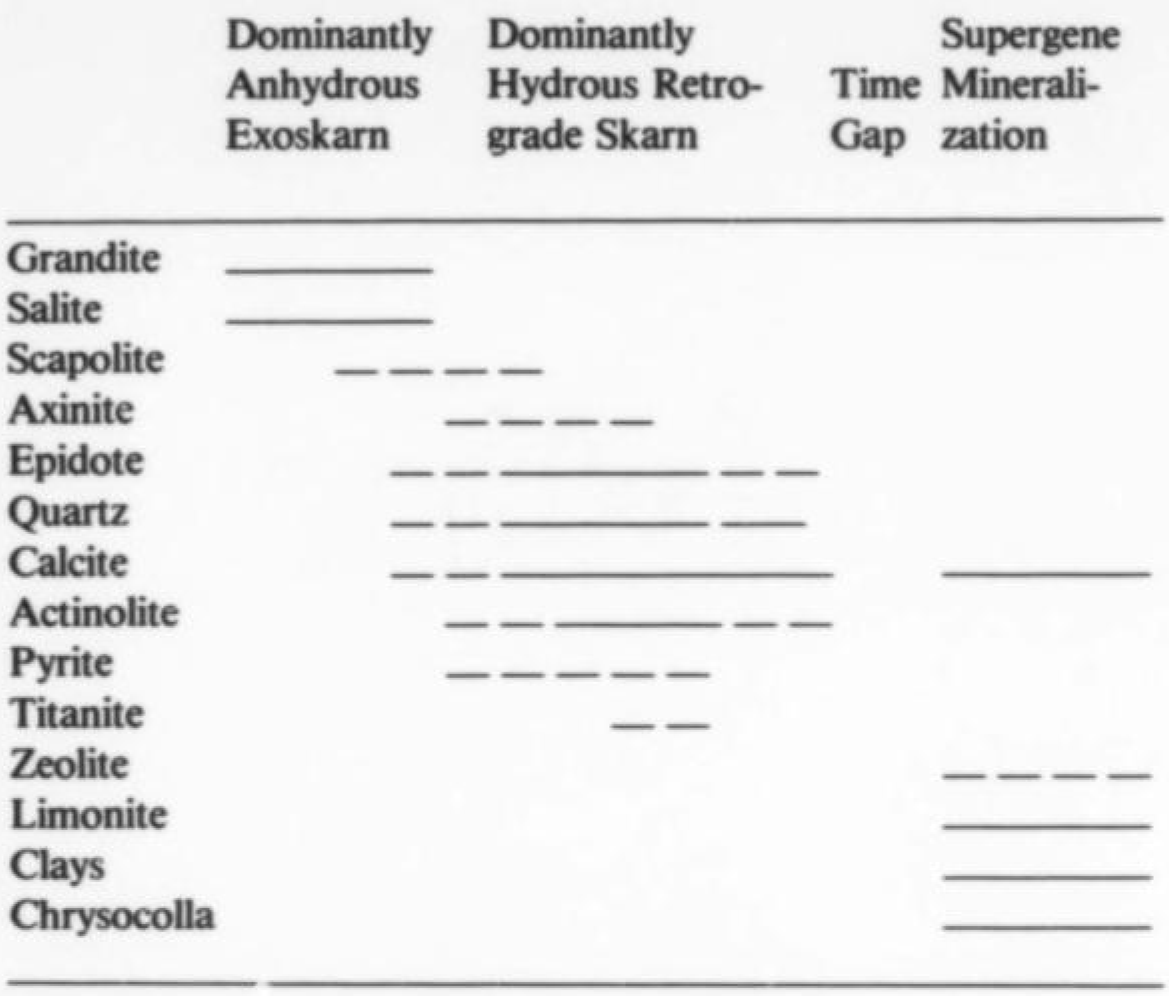


Figure 6. **Large epidote cluster, about 16 cm long, collected by Dick Jones in 1981.**

Figure 7. **Paragenesis of skarns at the Julie claim**



Other Minerals

Calcite is ubiquitous, occurring as marble, in caliche, and as an alteration product of grandite. Chrysocolla is locally present, especially in salite skarn, but no primary copper sulfides were observed. Clays were quite common, occurring with caliche.

CONCLUSIONS

The occurrence of epidote at the Julie Claim is rather restricted, both geologically and in terms of collectible specimens. The epidote occurs only near endoskarn contacts with grandite exoskarn. The area of the locality which produces epidote crystals measures only about 2 by 7 meters. Most of this zone, down to about 1 meter deep, has been exhausted, and fewer pockets were found at depth. It is therefore unlikely that large numbers of fine specimens will be found here in the future.

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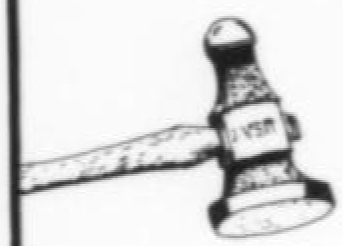
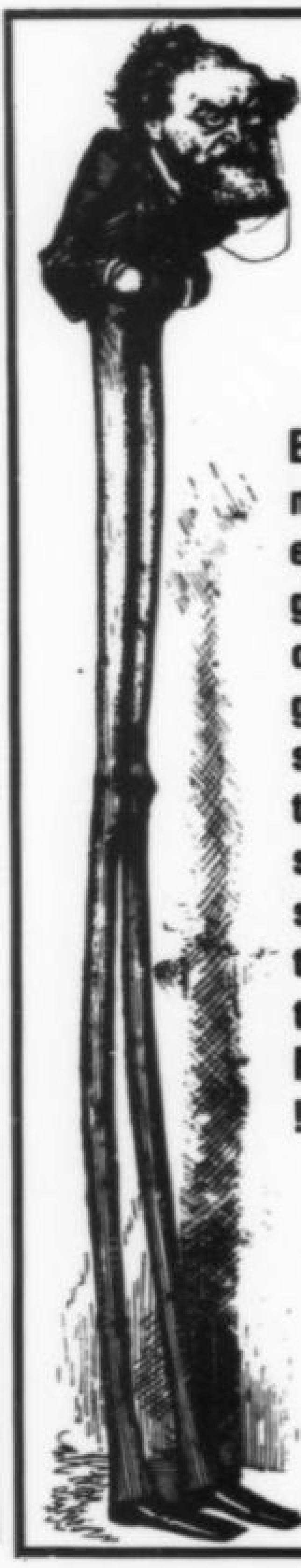




the White Caps Mine

Manhattan

NEVADA

Ronald B. Gibbs
P.O. Box 448
Tyrone, New Mexico 88065

The White Caps mine is famous among mineral collectors as the source of North America's best stibnite crystals, and also the world's best wakabayashilite. Fine specimens of realgar, orpiment and arsenolite have also been found.

INTRODUCTION

The White Caps mine is well known as the source of North America's finest stibnite specimens. The mine was developed for gold, but produced arsenic and antimony as well as specimens of realgar, orpiment and the world's best wakabayashilite. A disastrous fire ended the mine's sporadic production, but also produced fine arsenolite crystals in the main shaft.

The White Caps mine is situated 2.4 kilometers (1.5 miles) east of the town of Manhattan, Nye County, at an elevation of 2285 meters. Manhattan is in the southern end of the Toquima Range, about 80 road kilometers (50 miles) northeast of Tonopah.

HISTORY

Mining in nearby areas began about 1865. The first activity at Manhattan took place around 1866, but that small venture was abandoned by 1869. Activity was renewed around the turn of the century and rich gold ore was discovered in 1905. When John C. Humphrey found "specimen ore" only 100 meters from the well-traveled road to Belmont, the rush began. All the best ground had been staked by the end of 1905, some more than once, and the town had established itself with a population of several hundred people. In January of 1906 the area became popular with speculators and promoters and Manhattan became a boom town of 4000 in only a few weeks.

The White Caps vein had been located during the rush and was being explored by an inclined shaft in 1906. Before the boom camp had established running water, it sported a steam-powered electric plant. The cost of electricity was $2.50 per month for each 16-candlepower lamp. Miners earned $5.00 a day and a shovel cost $1.50 (Rice, 1906). The disastrous San Francisco earthquake and fire in 1906 dried up many of the investors' assets and the boom at Manhattan subsided.

Placer mining became an important industry that grew steadily in the early years of the camp. Miners turned their attention to the gravels in Manhattan Gulch as the lode mines expired. Lode mining sporadically improved following the bust.

By 1912 many of the surrounding lode mines had played out but a rich strike had been made at the White Caps. This strike prompted the building of a 75-ton-per-day cyanide plant. The incline had reached the 46-meter level. Although a sufficient quantity of oxidized ore had been blocked out for the new mill, the ore below the 46-meter level was found to be sulfides. The oxidized ore gave a 90% gold recovery, but the best that could be produced from the sulfide ore with the conventional cyanide plant was a 50% recovery. The mill was shut down after depletion of the oxide ores. Some higher grade ore was shipped out for processing, but most ore was too low in grade to be shipped.

In 1915 the White Caps Mining Company was formed and issued 2,000,000 shares of stock with a value of 10¢ per share. The new

company began extensive underground development and initiated experiments to discover a practical way to treat the sulfide ores. After extensive testing it was found that roasting within a specific temperature range would satisfactorily prepare the ore for a normal cyanide recovery plant. It was expected that this method would yield a recovery of 90%.

By 1917 a new vertical shaft had been sunk to the 130 meter level and the new mill was completed. This new mill featured a new cyanide plant and a 7-meter-diameter seven-hearth Wedge mechanical roasting furnace with automatic temperature control. The ore was to be roasted at not more than 566° C for one hour and then agitated in a neutral cyanide solution for one hour. The mill operated until 1921, but apparently gave unsatisfactory results. Contamination by antimony and arsenic may have been responsible for erratic results. Large lenses of stibnite and realgar were avoided whenever encountered.

The mill was reopened in 1922, but closed again in 1923. Since 1920, sporadic shipments of realgar and stibnite were made for their arsenic and antimony contents. No significant gold mining has taken place since 1920.

Over the years, the White Caps mine has been operated by many leasees. The last leasee to operate the mine had a significant impact on its future. Around 1958, as the story goes, two men were faced with a frozen water pipe at the collar of the main shaft. A blowtorch was procured to thaw the stubborn pipe. Since the project looked like it would take a long time the men propped the blowtorch in a position that kept it trained on the pipe, and went elsewhere in search of coffee. Upon their return they discovered the headframe in flames. The fire spread to the mill and down the shaft. The result was the complete destruction of the mill, the headframe and all shaft timbers down to the 94-meter level (P. Chapman, personal communication).

Although leased many times since the fire, the mine has not produced any additional ore. Throughout its life the White Caps produced over $2,700,000 in gold. With gold prices having risen in recent years, the mine has become an exploration target for various companies, and is under lease today as the search for an orebody continues. Mineral collectors visiting the locality have thus far not been turned away.

GEOLOGY

The majority of the mines in the Manhattan district are developed in metamorphosed Cambrian marine sediments which include mica schists, quartzites and marbles. The deformation of these sediments was followed by several volcanic and plutonic events which were occasionally accompanied by gold mineralization. Mineralization in the Manhattan district has been dated at 16 million years ago, and may be related to small nearby rhyolitic intrusions (Shawe, 1981).

The White Caps mine is one of several in the district in which ore mineralization has replaced marble. The marble is replaced by coarse, crystalline calcite, dark gold-bearing quartz, and accompanying sulfides. Faulting, jointing and bedding control the location of mineralization in the limestone. There were at least two episodes of mineralization (Ferguson, 1921) and two major sets of faults. The earlier faults had a east-northeast strike with steep dips but minor displacements. The first pulse of mineralization followed these faults, as well as bedding planes, and formed orebodies at their intersections. This pulse consisted primarily of coarse calcite and dark quartz. The second pulse of mineralization was similar to the first but included realgar, orpiment and cinnabar as well. This last major pulse occurred before and during movement on the second set of faults. These faults have northeast strikes and flatter dips to the southeast but exhibit much greater displacements. They include the East fault, the White Caps fault and the West fault. The last movement on these faults is younger than the ore.

The mineralizing fluids commonly followed the footwall of the limestone as well as faults and joints. As the fluids advanced they replaced the limestone with a coarse, white, crystalline calcite, most of which was subsequently replaced with dark gold-bearing quartz. Orebodies commonly have a cap of coarse, white calcite as a remnant of the first phase of replacement, hence the name White Caps.

Figure 1. **Panorama (this page and opposite page) showing the abandoned workings of the White Caps mine in 1984. R. Gibbs photo.**

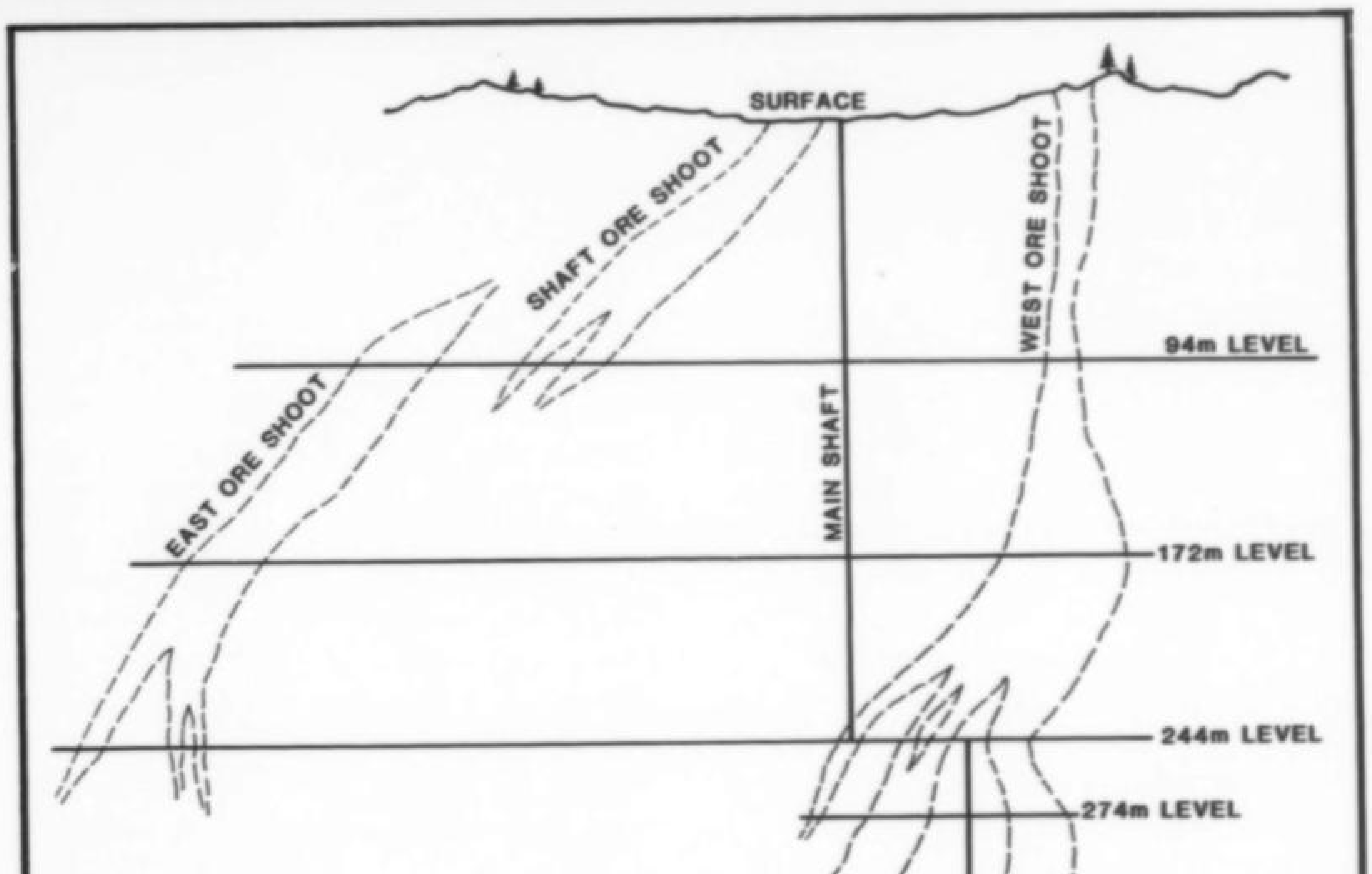


Figure 2. **Idealized cross-section through the White Caps mine along the White Caps limestone, looking south (after Ferguson, 1924).**

Dark quartz formed the bulk of the gold ore mined. It was commonly so dense that it resembled black jasper. The color and gold content is due to minute inclusions of pyrite, stibnite, arsenopyrite and carbonaceous matter. The exact manner in which the gold occurs is unknown and has been the subject of much speculation. Studies on White Caps ore at the Mackay School of Mines in 1917 (Palmer, 1919) concluded that the gold occurs as extremely minute particles of native metal and is coated with a black mineral, possibly stibnite. The replacement of calcite with quartz resulted in a volume loss which created numerous druse-lined cavities. These cavities were then filled with stibnite, realgar and orpiment.

MINERALOGY

The White Caps mine is best known as the premier locality in North America for stibnite. Many museums have excellent specimens collected during the mine's heyday. Palache and Modell

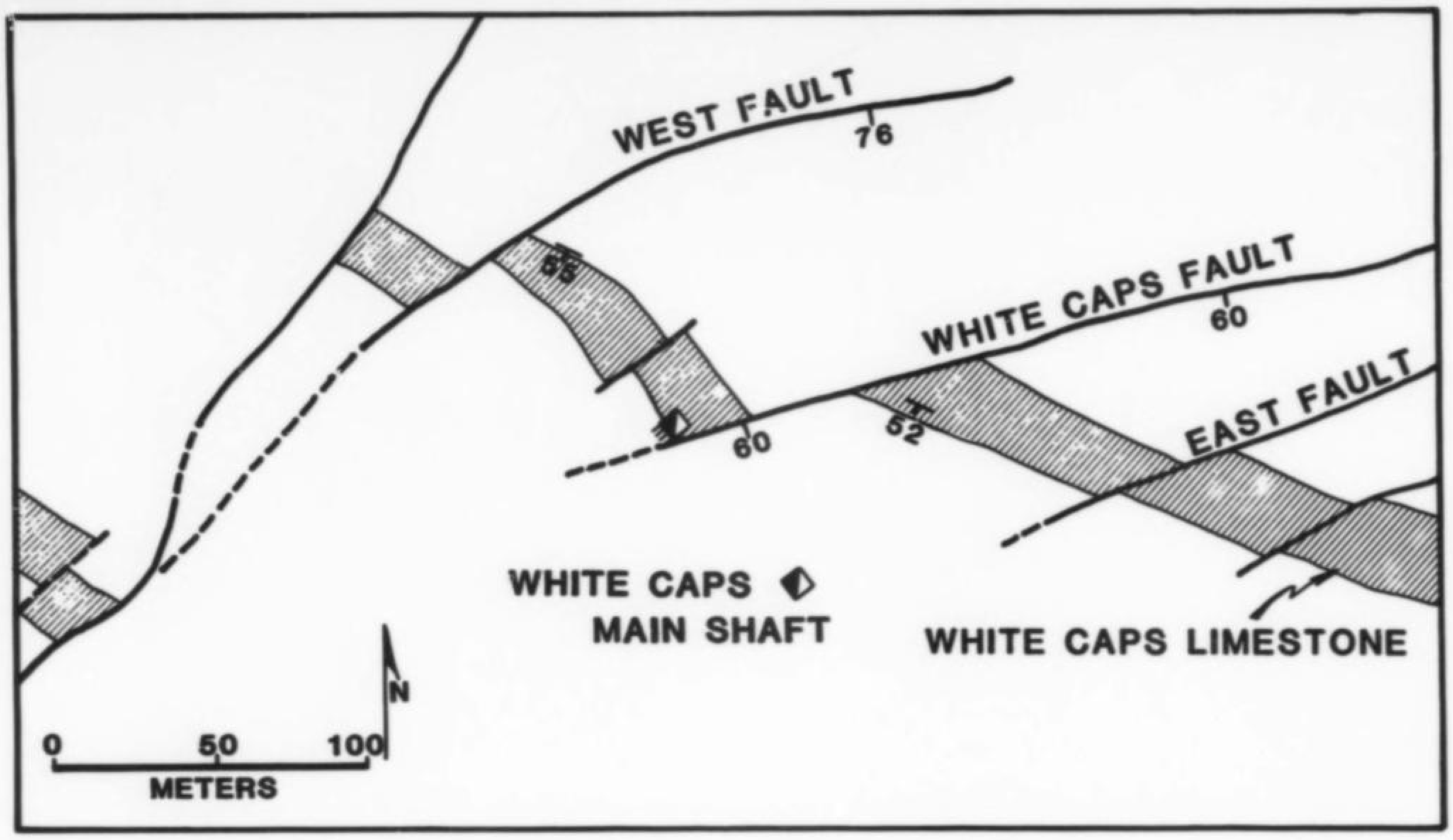


***Figure 3.* Generalized surface geology of the White Caps mine (after Ferguson, 1924).**

(1930) claim that the best White Caps stibnite crystals compare favorably with specimens from the mines at Felsobanya, Romania. The late H. G. Clinton, a Nevada mineral dealer, collected and sold many specimens during the 1920s and 1930s, and the mine has remained a favorite among Nevada collectors for years.

A list of reported species is presented (Table 1) but only the species which have collector significance will be discussed in detail.

Stibnite Sb_2S_3

Stibnite is one of the major minerals present in the ore zone, but has only occasionally constituted ore itself (when rich and abundant enough to ship for its antimony content). Stibnite is found primarily in the western part of the mine as brilliant radiating crystals in vugs in quartz ore and as radiating crystal groups and masses up to 35 cm in diameter replacing limestone and calcite. Many of the crystal groups have a dull gray color in contrast to the brilliant metallic luster of the better specimens. Occasionally the crystals take on a beautiful iridescent color. Also, it is not uncommon to find white translucent rhombs of calcite perched on and almost obscuring brilliant stibnite crystals. Rarely the mineral is found as delicate acicular crystals, commonly curved, in calcite vugs. Associations include realgar and cinnabar. Oxidation of stibnite has resulted in a variety of antimony oxides.

The most unusual occurrence of stibnite in the mine consists of brilliant crystals up to 1.3 cm long with rounded or melted edges that were recovered from deep in the shaft after the fire (S. A. Williams, personal communication). These crystals were apparently formed during the fire, presumably in a zone of reducing conditions below where the arsenolite formed under oxidizing conditions.

Palache and Modell (1930) studied the crystallography of White Caps stibnite and identified several new forms. Two new pyramids, {673} and {425}, and a new orthodome, {503}, were established. The combination of forms present on White Caps specimens was found to be strikingly similar to those from Ichinokawa, Japan.

***Figure 4.* Stibnite crystals, the largest about 1 x 6 cm, with calcite from the White Caps mine. Barbara Cureton collection.**

Wakabayashilite $(As,Sb)_{11}S_{18}$

Wakabayashilite was described by A. S. Kato *et al.* (1970) from the Nishinomaki mine in the Gumma Prefecture of Japan. A sec-

Figure 5. **Wakabayashilite crystals to 2 cm, on calcite, from the White Caps mine. This specimen was sold in 1927 by H. G. Clinton for $10. Cureton Mineral Company specimen.**

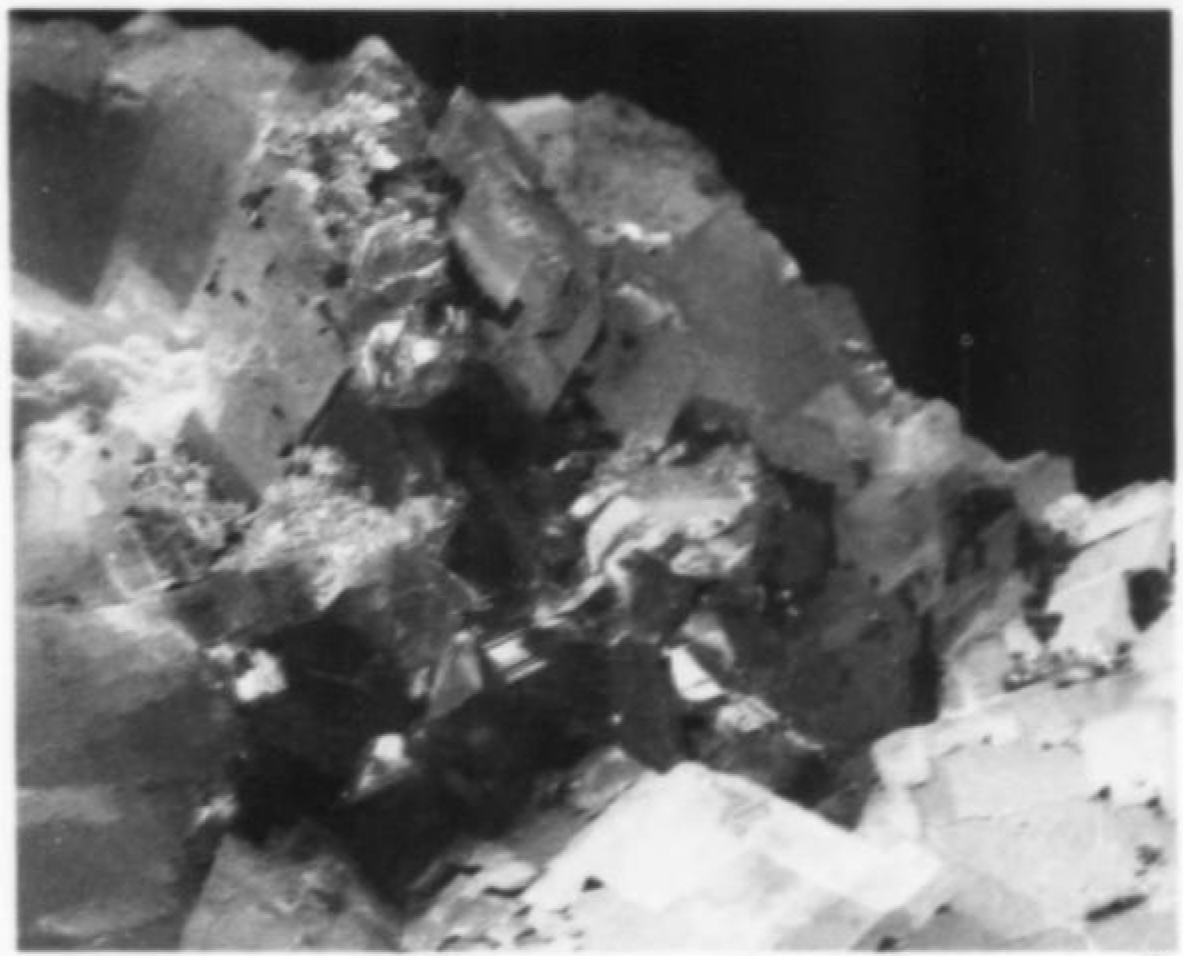


Figure 6. **Orpiment crystals on calcite from the 400-foot level of the White Caps mine. Harvard specimen no. 91980. The view is about 3 cm across.**

ond occurrence was found on U.S. National Museum specimens from the White Caps mine. The mineral has been noted from the mine since at least as early as 1921 although it was thought to be orpiment at the time. Ferguson (1921) mentions "hair-like crystals of . . . orpiment which are sometimes found." Many specimens of acicular "orpiment," also called "hair orpiment," were collected and sold before its true identity was determined. Wakabayashilite from the White Caps mine is the best in the world. It typically forms beautiful acicular masses of flexible golden to lemon-yellow crystals up to 2 cm in length, on or imbedded in calcite and associated with orpiment and realgar.

Realgar AsS, **Orpiment** As_2S_3

Realgar is widespread but is most abundant in the East orebody. It is usually found as massive replacements of calcite and in quartz vugs but small euhedral crystals are sometimes found. Ferguson (1924) noted a few specimens of realgar occurring as small "radiating rods, replacing stibnite."

The realgar is gold-bearing but is not nearly as rich as the dark quartz ore. Small shipments were made for its arsenic content which also yielded a modest gold return. The White Caps mine was, at one time, the best realgar locality in the West. Many pounds of specimens were collected and sold by dealers around the country. Jack Parnau (personal communication) described the dumps in 1949 as looking "as red as a tomato patch"! Today the red color is nearly gone and Getchell, Nevada, has replaced White Caps as a locality for realgar. (See the article on Getchell elsewhere in this issue.)

Orpiment is present as a replacement of realgar. Nearly always massive, it is usually associated with realgar and wakabayashilite, but is rarely found as isolated crystals in calcite vugs. Palache and Modell (1930) measured several White Caps crystals and found seven new forms, adding significantly to the known crystallography of orpiment.

Arsenolite As_2O_3

Although H. G. Clinton offered arsenolite for sale in the 1930s, the best specimens resulted from the fire which ended the mine's productive life. Arsenolite occurs as octahedrons, sometimes skeletal, ranging in size from minute to crystals over 2 cm across. The crystals are commonly clear but are in some cases colored yellowish or reddish by included minerals. Collectors have found nice euhedral crystals on charred mine timbers and on the walls of the vertical shaft. Arsenolite is dimorphous and Clinton also sold its counterpart, claudetite, presumably of non-fire origin.

Other Minerals

Although the White Caps mine was a gold mine, no free gold has

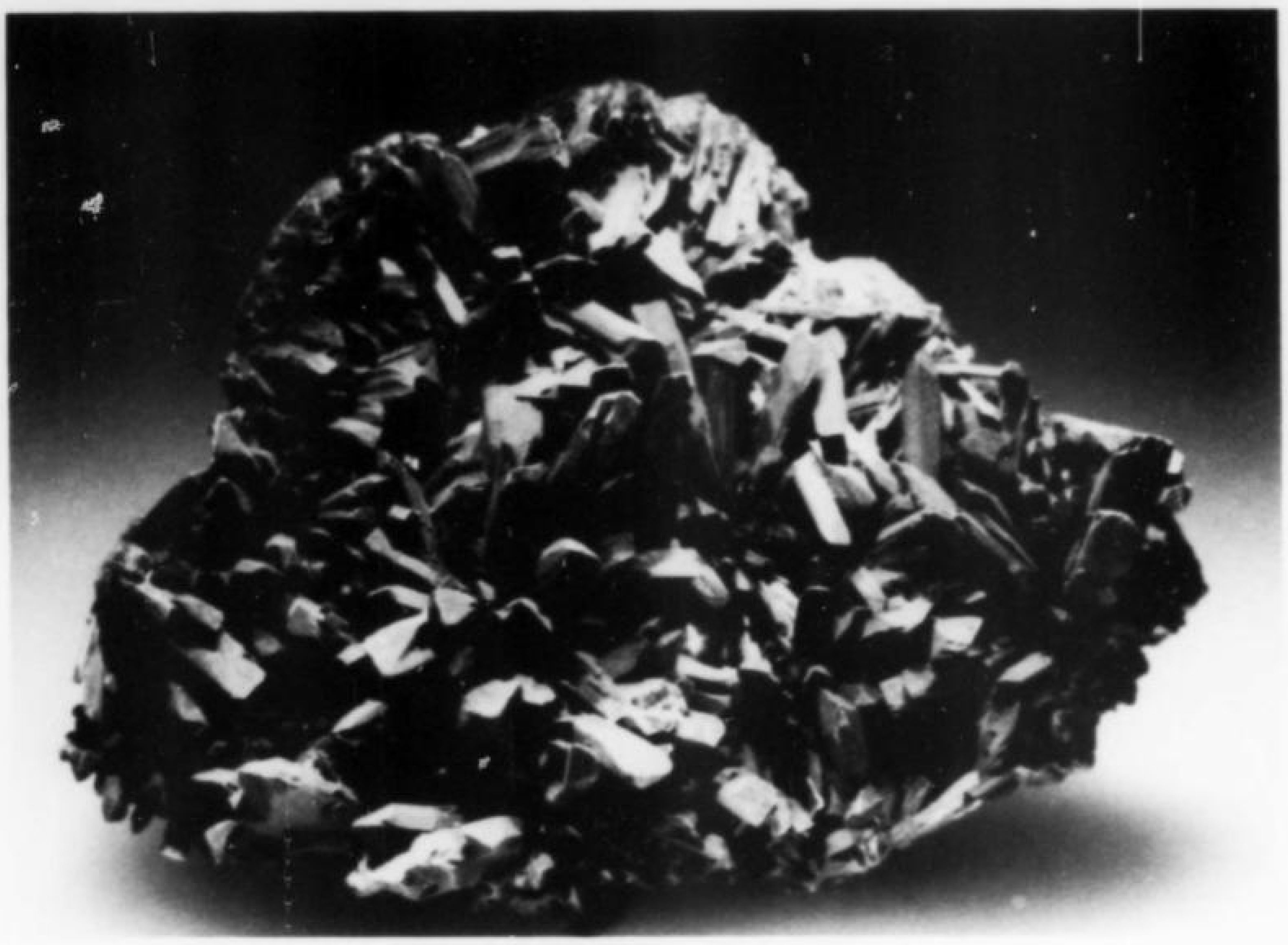


Figure 7. **Stibnite crystals to 2 cm, possibly of mine fire origin. California Academy of Science collection. R. Gibbs photo.**

Figure 8. **Colorless arsenolite crystals to 2.5 mm on a 6-cm matrix, from the White Caps mine. Jim McGlasson specimen.**

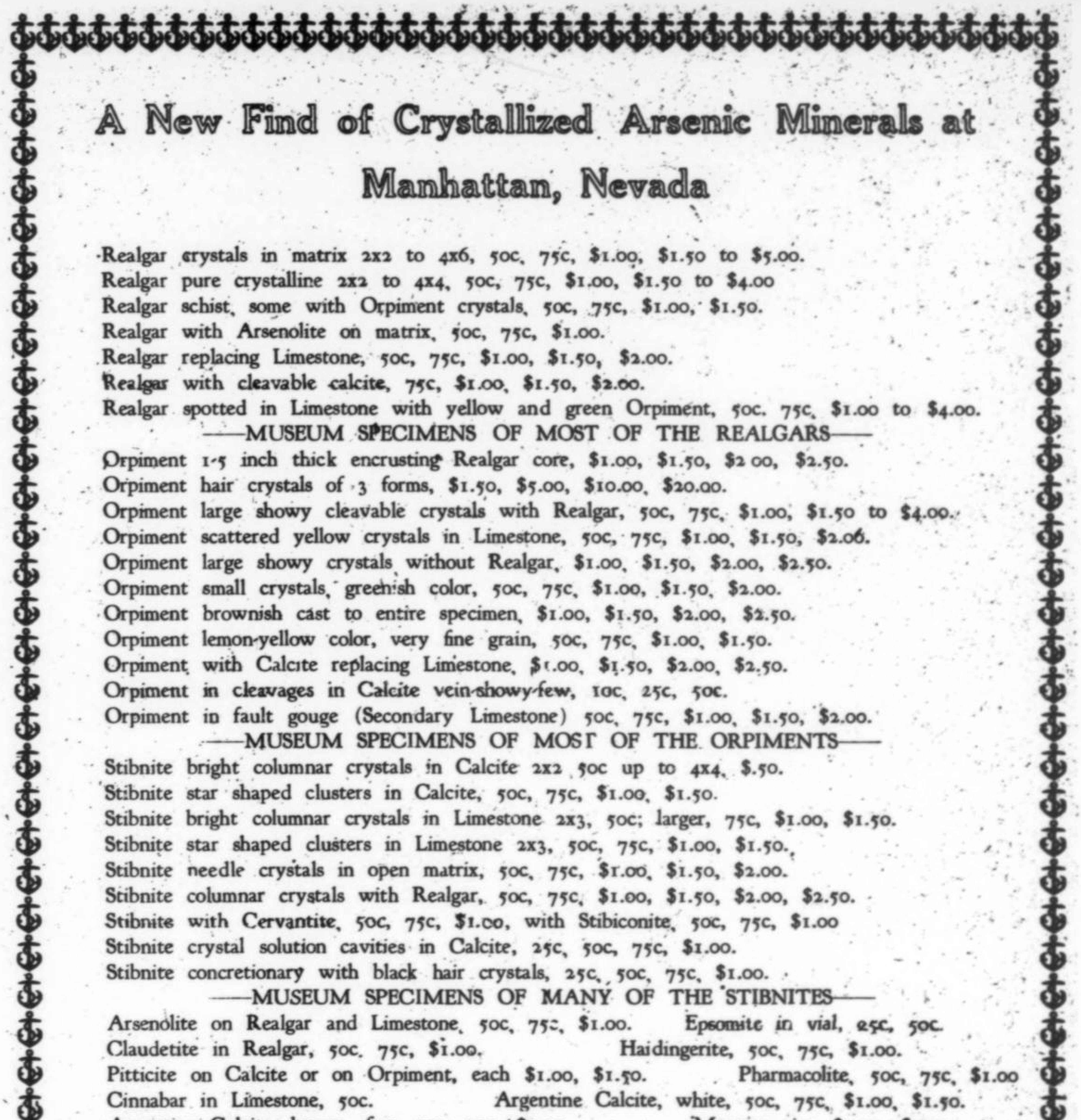
Table 1. **Minerals reported from the White Caps mine**

Sulfides and Ore Minerals	
Stibnite	Sb_2S_3
Realgar	AsS
Orpiment	As_2S_3
Cinnabar	HgS
Wakabayashilite	$(As,Sb)_{11}S_{18}$
Pyrite	FeS_2
Arsenopyrite	FeAsS
Gold	Au
Silver	Ag
Gangue Minerals	
Quartz	SiO_2
Calcite	$CaCO_3$
Dolomite	$CaMg(CO_3)_2$
Fluorite	CaF_2
Muscovite	$KAl_2(Si_3Al)O_{10}(OH,F)_2$
Barite	$BaSO_4$
Disseminated carbonaceous matter	
Secondary Minerals	
Haidingerite	$CaHAsO_4 \cdot H_2O$
Pharmacolite	$CaHAsO_4 \cdot 2H_2O$
Roesslerite	$MgHAsO_4 \cdot 7H_2O$
Arsenolite	As_2O_3
Claudetite	As_2O_3
Pitticite	hydrous ferric arsenate-sulfate
Cervantite	$Sb^{+3}Sb^{+5}O_4$
Stibiconite	$Sb^{+3}(Sb^{+5})_2O_6(OH)$
Azurite	$Cu_3(CO_3)_2(OH)_2$
Epsomite	$MgSO_4 \cdot 7H_2O$
Valentinite	Sb_2O_3
Senarmontite (?)	Sb_2O_3
Kermesite	Sb_2S_2O
Gypsum	$CaSO_4 \cdot 2H_2O$
Sulfur	S
Melanterite	$Fe^{+2}SO_4 \cdot 7H_2O$
Unknown #1	$AsSbO_3$

been positively identified. It occurs in the dark quartz and in realgar but sparingly elsewhere, presumably as minute specks of free gold. Silver is equally elusive. Its presence was noted only in assays where it maintains a 17:1, gold:silver ratio (Ferguson, 1921).

Many secondary minerals have been reported, some of which are post-mining. Foshag and Clinton (1927) reported that haidingerite was well developed on broken rock in a small low-grade stope on the 274 meter level. They also reported an interesting occurrence of pitticite in the old workings. Pitticite was found oozing out of joints and fractures forming crusts as much as 1.3 cm thick on the limestone walls and floor of the drift. Melanterite and epsomite are associated with the pitticite. Melanterite formed long, slender, green stalactites and epsomite formed a carpet of white needles, up to 5 cm long, on the floor of the drift.

Ed McDole collected at the White Caps mine in 1964. He collected from the fire zone in the shaft and one of his specimens contained some small, hexagonal, clear, glassy plates of $AsSbO_3$, a new mineral as yet undescribed (S. A. Williams, personal communication). The supply of the new mineral was not sufficient for a complete description of the species.



A New Find of Crystallized Arsenic Minerals at Manhattan, Nevada

Realgar crystals in matrix 2x2 to 4x6, 50c, 75c, $1.00, $1.50 to $5.00.
Realgar pure crystalline 2x2 to 4x4, 50c, 75c, $1.00, $1.50 to $4.00
Realgar schist, some with Orpiment crystals, 50c, 75c, $1.00, $1.50.
Realgar with Arsenolite on matrix, 50c, 75c, $1.00.
Realgar replacing Limestone, 50c, 75c, $1.00, $1.50, $2.00.
Realgar with cleavable calcite, 75c, $1.00, $1.50, $2.00.
Realgar spotted in Limestone with yellow and green Orpiment, 50c. 75c, $1.00 to $4.00.

—MUSEUM SPECIMENS OF MOST OF THE REALGARS—

Orpiment 1-5 inch thick encrusting Realgar core, $1.00, $1.50, $2 00, $2.50.
Orpiment hair crystals of 3 forms, $1.50, $5.00, $10.00, $20.00.
Orpiment large showy cleavable crystals with Realgar, 50c, 75c, $1.00, $1.50 to $4.00.
Orpiment scattered yellow crystals in Limestone, 50c, 75c, $1.00, $1.50, $2.06.
Orpiment large showy crystals without Realgar, $1.00, $1.50, $2.00, $2.50.
Orpiment small crystals, greenish color, 50c, 75c, $1.00, $1.50, $2.00.
Orpiment brownish cast to entire specimen, $1.00, $1.50, $2.00, $2.50.
Orpiment lemon-yellow color, very fine grain, 50c, 75c, $1.00, $1.50.
Orpiment with Calcite replacing Limestone, $1.00, $1.50, $2.00, $2.50.
Orpiment in cleavages in Calcite vein-showy-few, 10c, 25c, 50c.
Orpiment in fault gouge (Secondary Limestone) 50c, 75c, $1.00, $1.50, $2.00.

—MUSEUM SPECIMENS OF MOST OF THE ORPIMENTS—

Stibnite bright columnar crystals in Calcite 2x2 50c up to 4x4, $.50.
Stibnite star shaped clusters in Calcite, 50c, 75c, $1.00, $1.50.
Stibnite bright columnar crystals in Limestone 2x3, 50c; larger, 75c, $1.00, $1.50.
Stibnite star shaped clusters in Limestone 2x3, 50c, 75c, $1.00, $1.50.
Stibnite needle crystals in open matrix, 50c, 75c, $1.00, $1.50, $2.00.
Stibnite columnar crystals with Realgar, 50c, 75c, $1.00, $1.50, $2.00, $2.50.
Stibnite with Cervantite, 50c, 75c, $1.00, with Stibiconite, 50c, 75c, $1.00
Stibnite crystal solution cavities in Calcite, 25c, 50c, 75c, $1.00.
Stibnite concretionary with black hair crystals, 25c, 50c, 75c, $1.00.

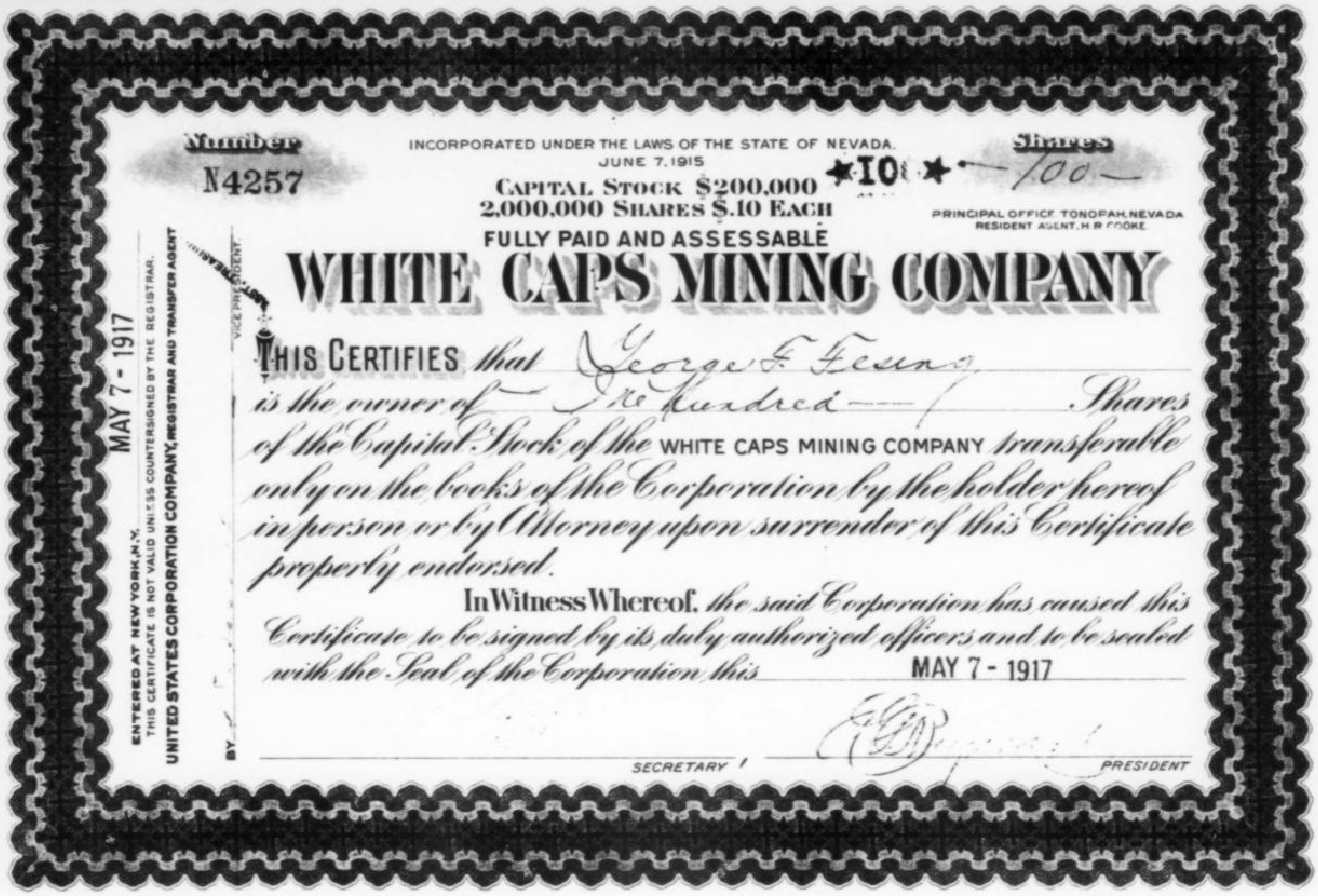
—MUSEUM SPECIMENS OF MANY OF THE STIBNITES—

Arsenolite on Realgar and Limestone, 50c, 75c, $1.00. Epsomite in vial, 25c, 50c.
Claudetite in Realgar, 50c. 75c, $1.00. Haidingerite, 50c, 75c, $1.00.
Pitticite on Calcite or on Orpiment, each $1.00, $1.50. Pharmacolite, 50c, 75c, $1.00
Cinnabar in Limestone, 50c. Argentine Calcite, white, 50c, 75c, $1.00, $1.50.
Argentine Calcite, brown, fine, 50c, 75c, $1.00. Museum size, $4.00, $5.00.
Cleavable Calcite, white or brown mottled, 50c, 75c, $1.00, $1.50.

Exhibition sizes of Orpiment-Realgars are 15, 20, 30, 40, and 50 lbs. each. All of the above minerals are out of the White Caps Gold Mine. Suites of ores, minerals, and enclosing rocks, made up from mines of Gold, Silver, Electrum, etc., in Sedimentaries and Volcanics. Also Metasomatic Replacements, Banded Crustification and Vein Phenomena. Minerals sent on approval. Postage extra or F. O. B. Tonopah—Freight or Express. List of Gold Specimens and Micro-mounts on cork sent if wanted.

H. G. Clinton, ***Manhattan, Nevada, U.S.A.***

Figure 9. **Early advertisement (1920s or 1930s) from H. G. Clinton listing White Caps mine specimens. "Orpiment hair crystals" were described in 1970 as a new mineral, wakabayashilite.**



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RESIDENT AGENT, H. R. COOKE

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MAY 7 - 1917

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UNITED STATES CORPORATION COMPANY, REGISTRAR AND TRANSFER AGENT

BY

VICE PRESIDENT.

ACKNOWLEDGMENTS

The author is indebted to those who shared their knowledge of the White Caps mine, especially James Firby and Steve Pullman at the Mackay School of Mines Museum, and Jean DeMouthe at the California Academy of Sciences, who allowed me to photograph and examine their respective institution collections. Peter Chapman provided useful information as well.

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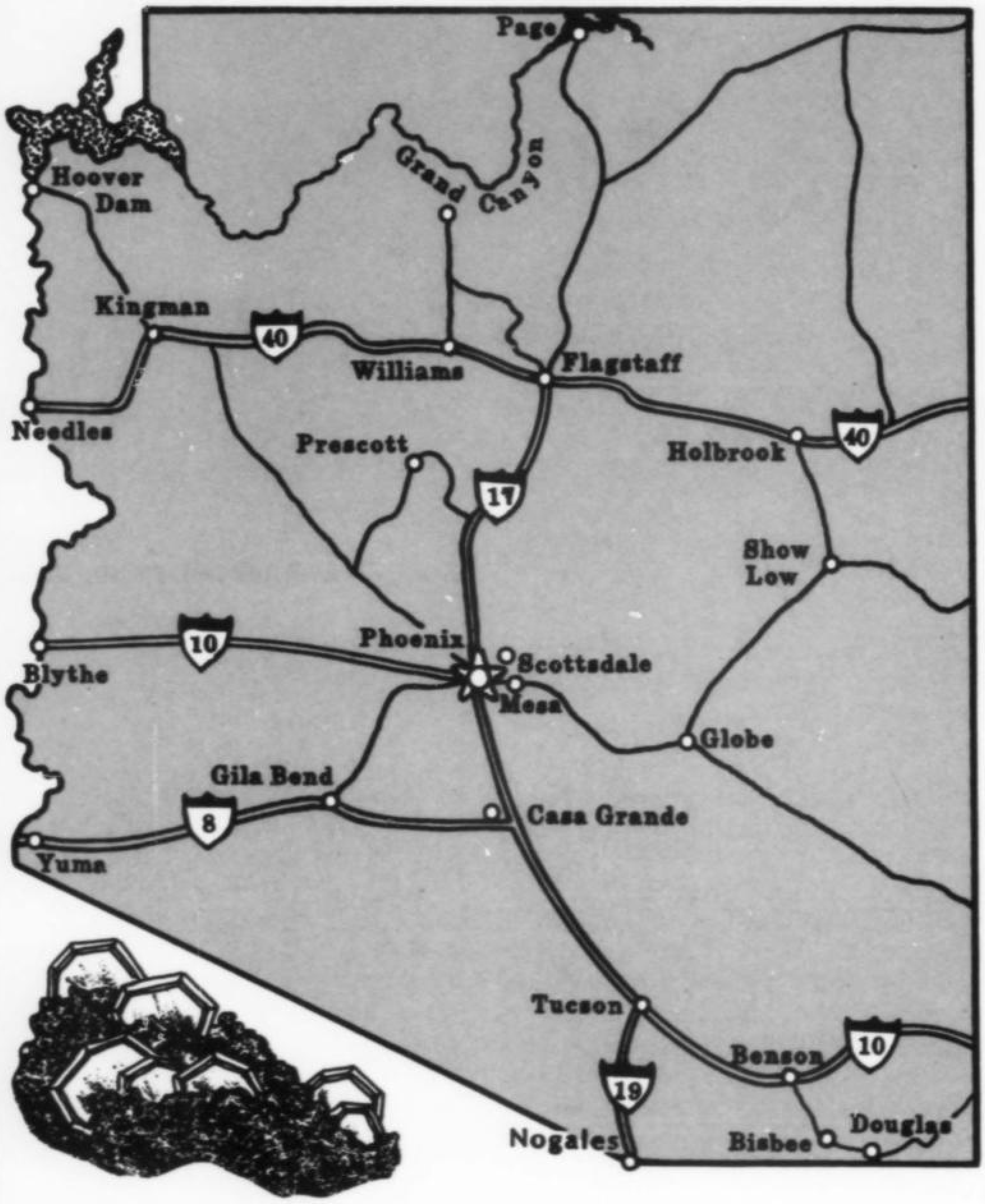

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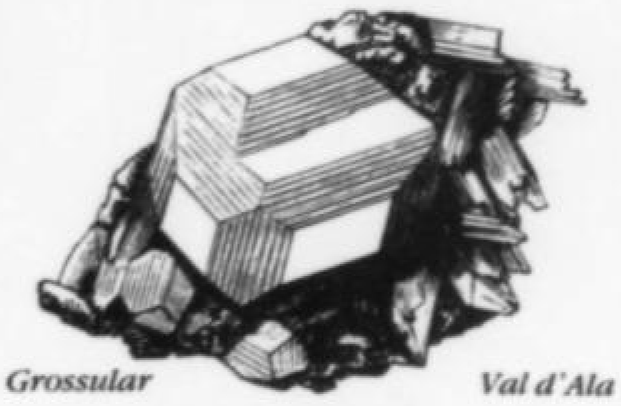

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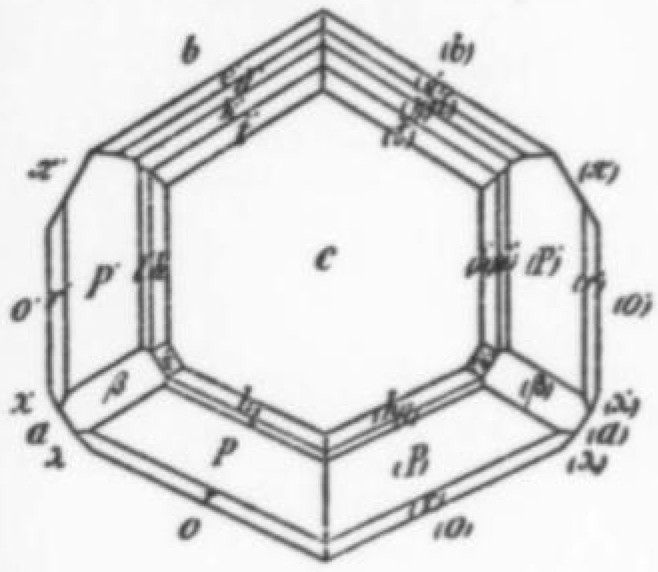

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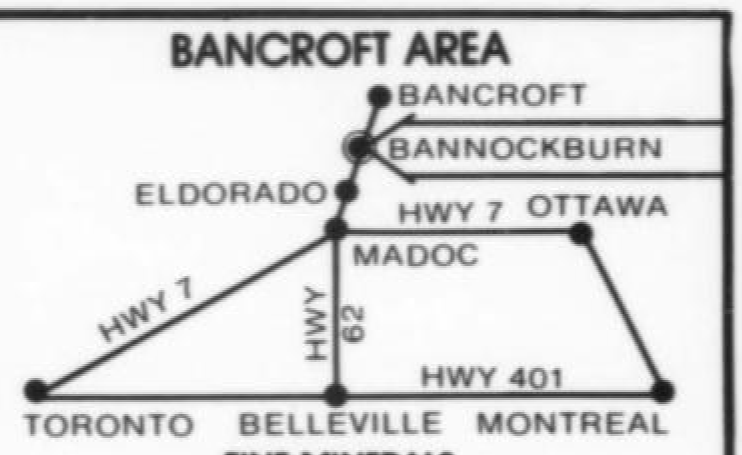
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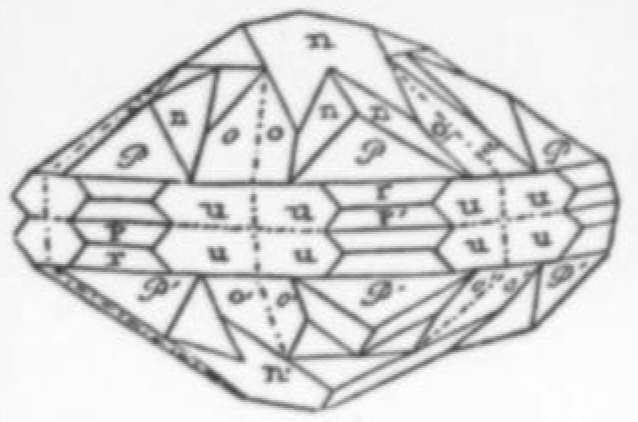
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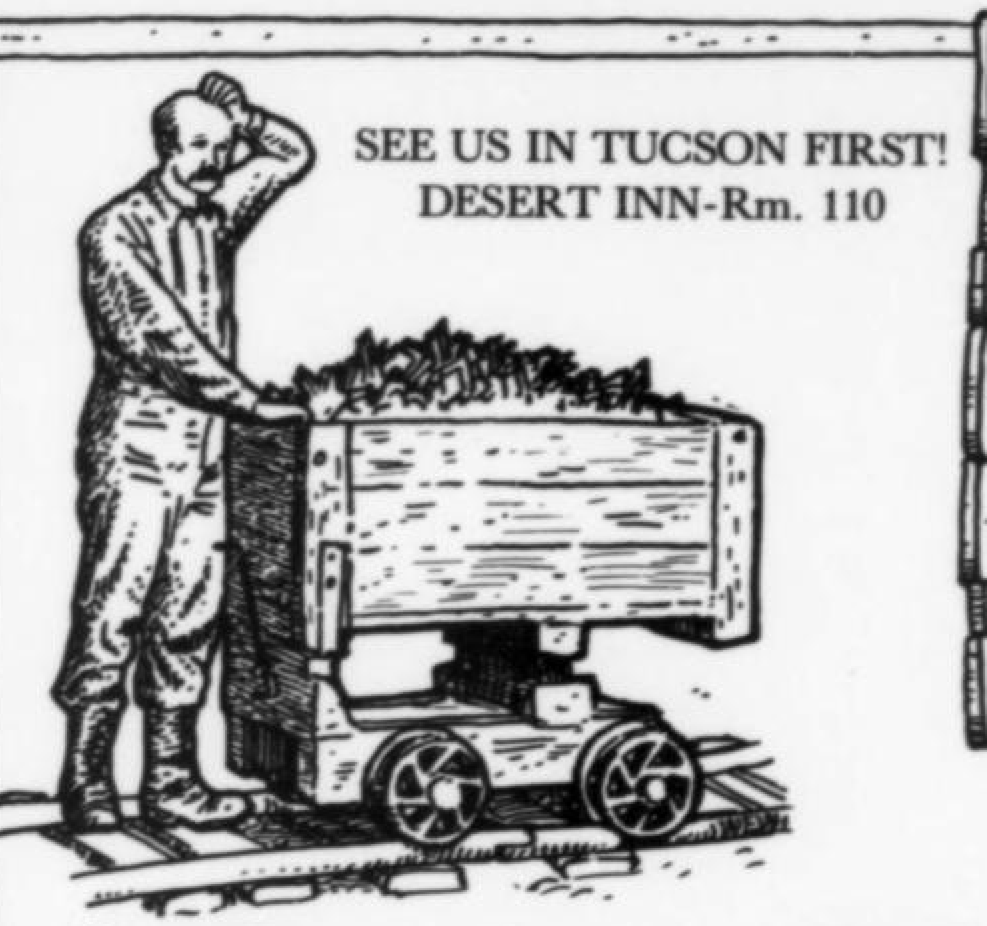

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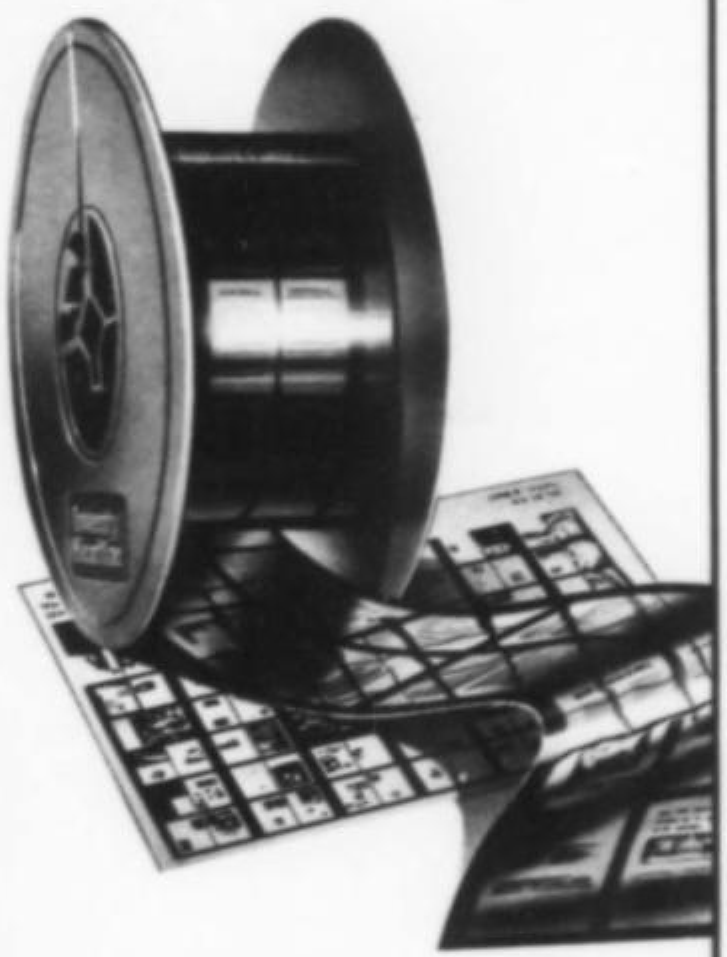

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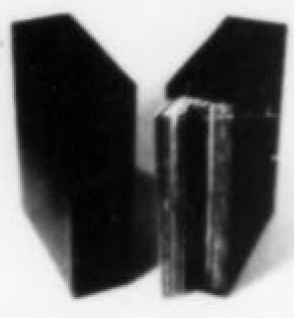
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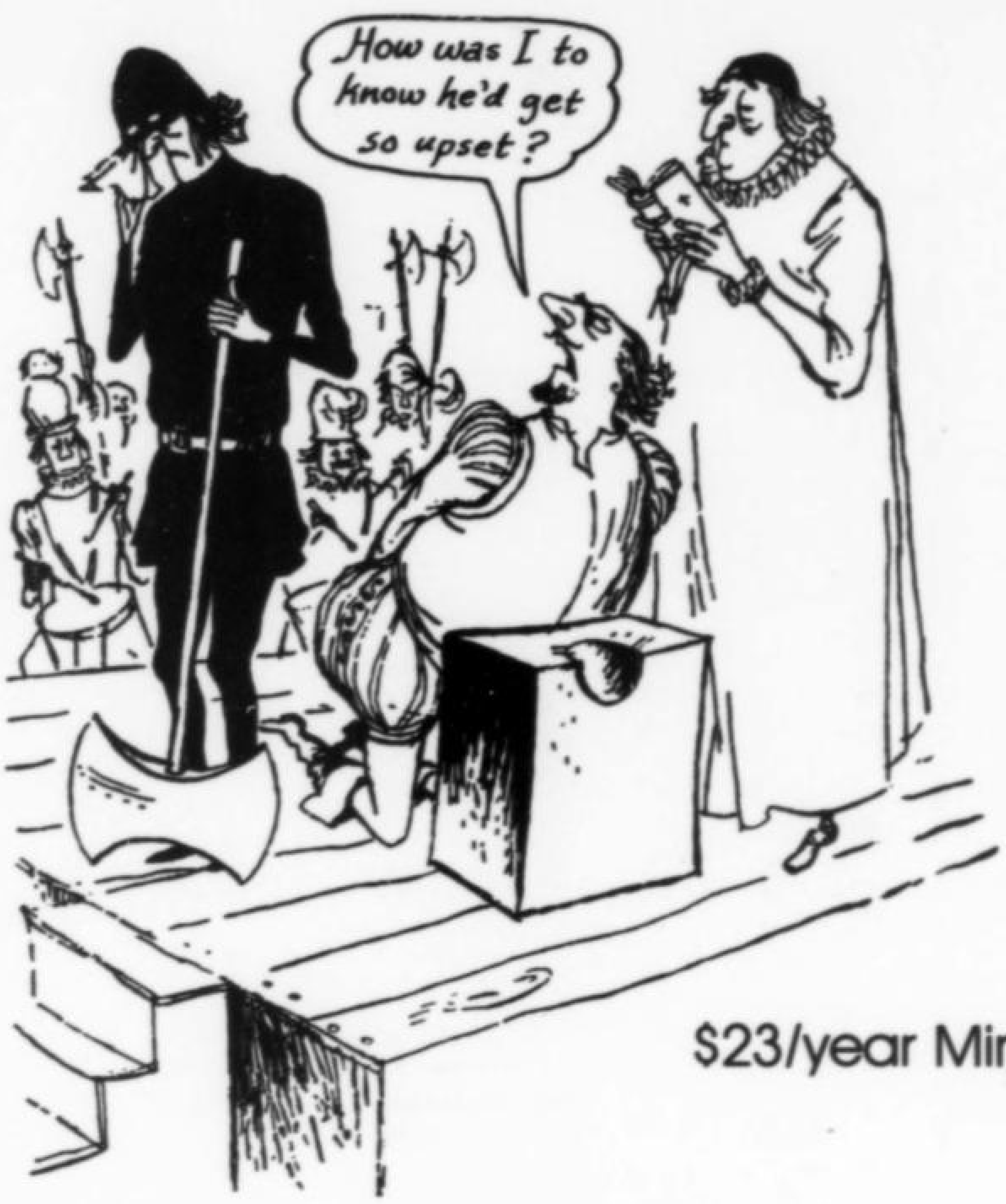
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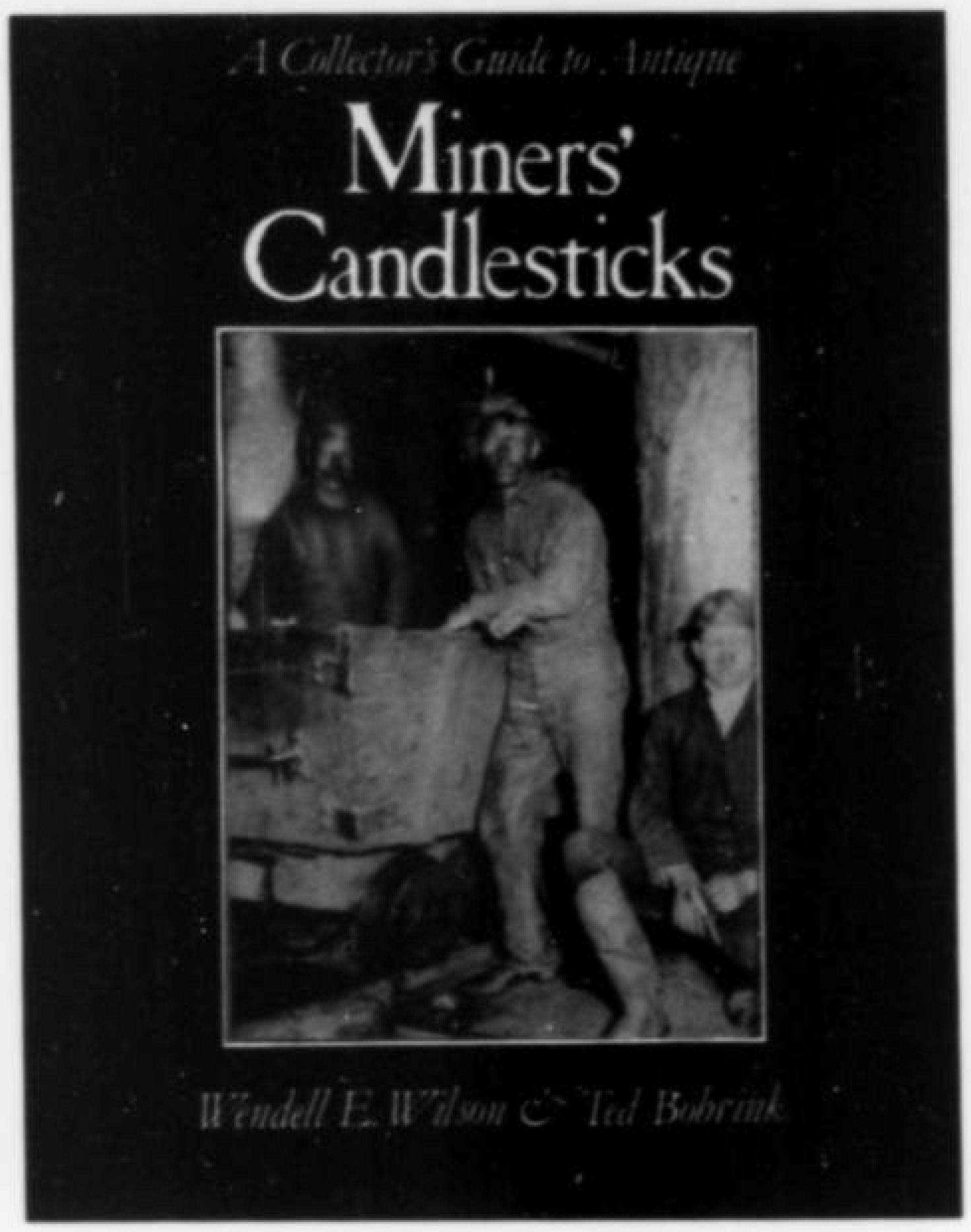

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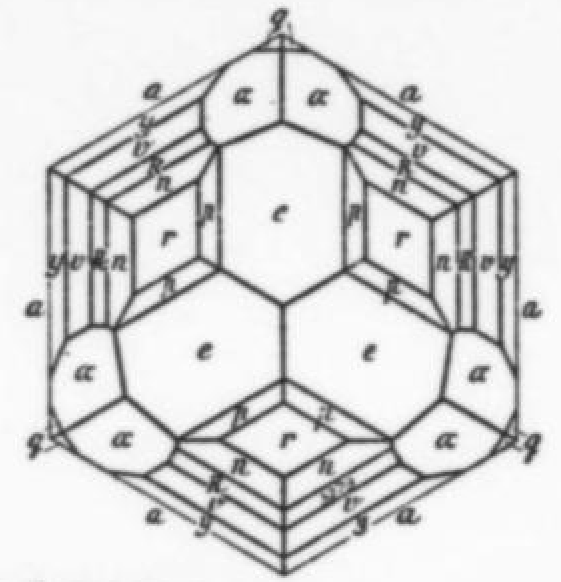

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