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# MINES AND MINERAL RESOURCES OF
# ALPINE COUNTY, CALIFORNIA

by WILLIAM B. CLARK

With sections on the Zaca gold-silver mine and the Leviathan sulfur mine by James R. Evans

COUNTY REPORT 8

1977

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Frontispiece. Typical Alpine County scenery. View looking southeast across Twin Lakes Reservoir (Caples Lake) toward Round Top Peak. The tree-covered ridge is composed of granitic rocks, and the peaks in the background are of andesite.

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# ABSTRACT

Alpine County is in east-central California in the Sierra Nevada. The topography is characterized by high rugged peaks and ridges, deep canyons, and many lakes. Although the county is sparsely populated, it is visited by many tourists during the year. Recreation, agriculture, lumbering, and the mineral industry are the principal segments of the economy. The area was first settled during the gold-silver boom of the 1860s and early 1870s when a number of short-lived but good-sized towns and mining camps were in existence.

The region is underlain by a variety of rocks of which granitic rocks of Mesozoic age and andesitic volcanic rocks of Tertiary age are predominant. Present in smaller amounts are Mesozoic metamorphic rocks that occur as roof pendants surrounded by granitic rocks and Quaternary alluvium and glacial moraines in some of the valleys. The greatest portion of the county's mineral production has come from extensive zones of alteration and silicification in the volcanic rocks.

Sulfur, gold, silver, copper, tungsten, sand and gravel, and stone have been the most important mineral commodities; and smaller amounts of lead, mercury, selenium, and zinc also have been produced. The value of the total mineral output is unknown. The Monitor-Mogul district, where the presently active Zaca mine is located, has yielded most of the gold and silver. By-product copper, lead, and zinc are also being produced at the Zaca mine. Smaller amounts of these metals have been found in the Hope Valley, Silver King, and Silver Mountain districts.

Substantial quantities of stone and sand and gravel, most of which has been used in highway construction, have been produced at Hope Valley and near Woodfords. Tungsten was produced in the 1940s and 1950s in the Hope Valley district where scheelite is found in contact metamorphic zones between metamorphic and granitic rocks. Many years ago, dimension stone was quarried and bricks were manufactured at Silver Mountain City for use in building construction. The Monitor-Mogul district is a source of mineral specimens of interest to collectors. Other mineral commodities present in Alpine County, but which have not been produced commercially, are antimony, arsenic, barite, iron, limestone, manganese, and molybdenum.

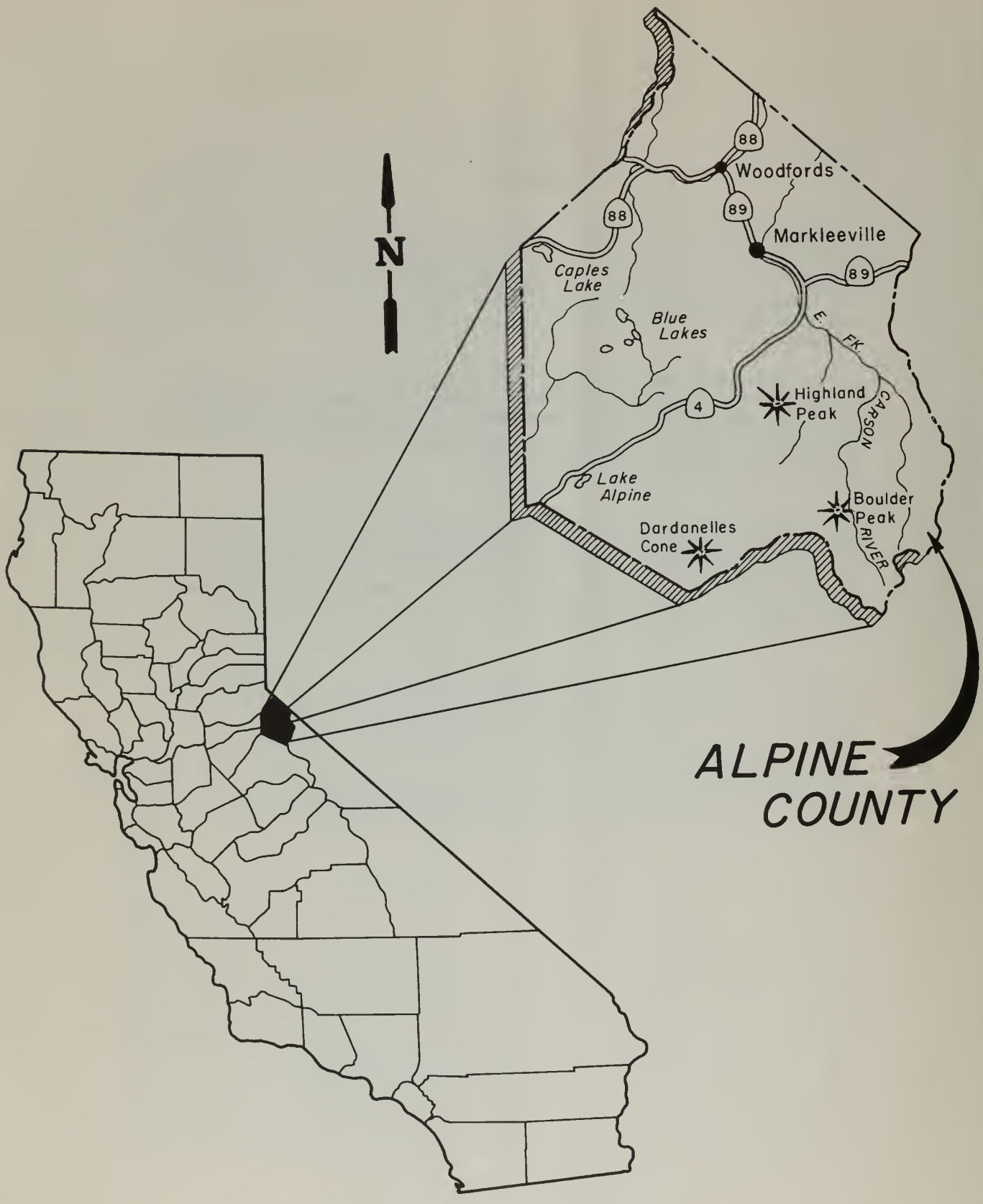


Figure 1. Index map of Alpine County.

# MINES AND MINERAL RESOURCES OF ALPINE COUNTY, CALIFORNIA

*By William B. Clark*

## Introduction

Alpine County is in east-central California and lies along the crest of the Sierra Nevada in an area of great beauty with rugged mountain or alpine scenery from which its name is derived. The county has a total area of 723 square miles or 462,720 acres. El Dorado County lies to the northwest; Amador, Calaveras, and Tuolumne Counties are west, southwest, and south; Mono County is to the east; and the State of Nevada is to the north and northeast. The population of Alpine County is small; for many years it fluctuated between 200 and 300. In 1970 it was 484. The principal settlements are Markleeville (pop. 165), which is the county seat, and Woodfords (pop. 150). Small settlements exist at the resorts of Crystal Springs, Grover Hot Springs, and Sorensons. The small agricultural communities of Fredericksburg and Paynesville are located in the northern part of the county in the Carson Valley.

Several State highways suitable for hauling ore in trucks cross the county. State Highway 89 from Lake Tahoe enters the county from the northwest via Luther Pass, crosses the county in an east-southeast direction, and continues to the east over Monitor Pass into Mono County. State Highway 88 enters Alpine County from Amador County on the southwest via Kit Carson Pass. State Highway 4 enters from Calaveras County via Ebbetts Pass. In addition, State Highway 108, the Sonora Pass road, lies just south of the southern county line. There are several good County and U. S. Forest Service roads but no railroad.

Photo 1. General view of Hope Valley looking northeast. Luther Pass is to the left, and Freel and Jobs Peaks are in the right background; these peaks are composed of granite.

Photo 2. General view looking southeast across upper Hope Valley. Pickett Peak is to the left, and Hawkins Peak is to the right. Both peaks are plugs composed of hard resistant dacite.

## Topography

Elevations in Alpine County range from 5000 to more than 11,000 feet above sea level. A number of peaks and high ridges are 10,000 or more feet in elevation. Many of these peaks and ridges make up the three major mountain systems. The principal system is the Sierra Nevada crest which extends northwesterly across the county; another extends northeastward along the Alpine-El Dorado County line; and the third extends north-northeastward along the Alpine-Mono County line. The elevation of peaks extending along the Sierran crest from southeast to northwest are as follows: Sonora Peak (11,452), Stanislaus Peak (11,220), Disaster Peak (10,047), Arnot Peak (10,036), Tryon Peak (9,920), Reynolds Peak (9,690), Round Top (10,380), Elephants Back (9,603), and Stevens Peak (10,100). Peaks that extend northeast along the Alpine-El Dorado County line are Waterhouse Peak (9,497), Thompson Peak (9,587), Freel Peak (10,881), Jobs Sister (10,823), Jobs Peak (10,633), and Monument Peak (10,085). On the Alpine-Mono line are White Mountain (11,398), Wells Peak (10,833), and Antelope Peak (10,241).

Photo 3. View looking east across Charity Valley to Markleeville Peak. The log cabin in the right foreground was erected in pioneer days. Markleeville Peak is composed of andesite.

East of the Sierran crest, the county is drained by the northeast-flowing East Carson and West Carson Rivers and their tributaries. West of the crest are the headwaters of the southwest-flowing Mokelumne and Stanislaus Rivers. Most of the streams have a steep gradient and have cut deep and steep-sided canyons that were later reshaped by glaciers. In several places, the streams flow through fairly narrow but flat valleys with high mountain walls on either side. The most extensive is the upper Carson Valley, which extends northward into Nevada where it widens perceptibly. Other valleys include Bagley, Hope, Faith, Charity, Markleeville, Diamond, and Silver King.

Alpine County contains many lakes; some are natural and some are man-made. Also, some of the natural lakes were later enlarged by dams and embankments. The most extensive body of water is Twin Lakes Reservoir, or Caples Lake, located in the northwest corner of the county. Other fairly large lakes or reservoirs are Upper and Lower Blue Lakes, Highland Lake, Twin Lake, Meadow Lake, Red Lake, Lake Alpine, Winnemucca Lake, Heenan Lake, Union Reservoir, Utica Reservoir, and Indian Creek Reservoir. A number of the lakes and reservoirs are owned or administered by the Pacific Gas and Electric Company and supply water for hydro-electric systems and irrigation districts to the west in Amador and Calaveras Counties. Indian Creek Reservoir receives treated sewage from south Lake Tahoe. The water is completely clear and clean and is potable, and the fishing is good.

Photo 4. View looking west toward Kit Carson Pass. Elephant Back Peak is in the upper center, and Red Lake is in the left foreground. Exposed in this area are volcanic rocks, some of which are iron stained.

## Economy

The economy of Alpine County is based on: various types of Federal and State programs, recreation, agriculture, the mineral industry, and lumbering. Most of the land (approximately 95 percent in 1956) belongs to the Federal Government, much of it being National Forest land. The southwest part of the county is in Stanislaus National Forest; the northwest part is in El Dorado National Forest; and the eastern half is in Toiyabe National Forest.

The California Department of Fish and Game stocks most of the streams and lakes and operates a game refuge a few miles northwest of Lake Alpine. Grover Hot Springs State Park, which was created in 1959, is administered by the California Department of Parks and Recreation. The California Department of Water Resources maintains gaging stations on all of the principal streams to measure water flow and closely studies the snowpack each winter to determine its size and moisture content. Alpine County receives a heavier snowfall than any other area in California.

Recreation has become a very important segment of the county's economy in recent years. Camping, fishing, trail riding, and hunting are the principal recreational activities. The U. S. Forest Service has built

Photo 5. Pool at Grover Hot Springs in 1960; looking north. A thin film of white calcareous tufa is shown in right foreground. *Photo courtesy of the California Department of Parks and Recreation.*

many new campgrounds in the past few years. There are a few motels and cabins at Markleeville, Woodfords, and Sorensons. The recreational potential is high because of the scenic beauty, improved roads, and the heavy snowfall coupled with a mountain terrain suitable for skiing.

Agriculture is devoted largely to the raising of beef cattle and growing hay and barley for cattle feed. There are a number of good summer pastures which include Faith, Hope, Charity, Pleasant, Bagley, and Silver King Valleys. Most of the hay and feed are grown on large farms in Carson Valley and Diamond Valley.

At various times, mining and the mineral industry have been important in the county's economy. Gold and silver were the chief attraction to the early-day pioneers. Later, some copper was produced. During the depression years of the 1930s, low mining costs coupled with a price rise stimulated gold prospecting. During World War II and the Korean War, high prices stimulated prospecting for, and mining of, tungsten. Later, the development of a large copper oxide zone at Yerington, Nevada, resulted in a demand for large amounts of sulfur for the manufacture of sulfuric acid, and the Leviathan sulfur mine was worked on a large scale from 1953 to 1962. The rise in the price of silver in the late 1960s stimulated prospecting and mining of silver-bearing ores. Highway construction has resulted in a demand for large amounts of sand, gravel, and crushed stone. Although there are no sawmills in Alpine County now, substantial amounts of timber are cut and trucked out to sawmills elsewhere.

## History

Alpine County has had a long and colorful history. The Washoe Indians occupied the area for centuries prior to the coming of the white man. The Washoes lived mainly a peaceful life, hunting and fishing and gathering pine nuts for use through the winter. Their homes, tepees made of willow poles, were temporary, as the Indians were always on the move, seeking new sources of food. The Washoes were expert at basket

weaving. They made trips in the fall to neighboring tribes in the western Sierra Nevada foothills where they traded pine nuts and obsidian, used in making arrowheads, for acorns. Some of the stones used as mortars for grinding acorns can still be seen in the county. At the present time, the Washoe Indians of Alpine County live in houses and cabins at Woodfords and in upper Carson Valley.

Probably the first white men to visit what is now Alpine County were the members of Jedediah Strong Smith's party, who crossed the Sierra Nevada going east via the Sonora Pass in 1827. In 1833 Captain Joseph Walker led a party from the Bonneville expedition up Cottonwood Canyon, past the site of Markleeville, and through Pleasant and Indian Valleys to Hermit Valley. The famous frontiersman Christopher "Kit" Carson was trapping and scouting in and about the area as early as 1839. In 1844 he accompanied Captain John C. Fremont's expedition, which traveled up the Carson River, past the site of Markleeville and Grover Hot Springs, thence over the Sierra Nevada crest, and down the American River to Sutter's Fort. A monument to the courageous scout was erected on the summit of the pass named for him. A tree which stood at the summit was inscribed with Kit Carson's name and the date 1844. This section of the tree was cut out and now is on display at Sutter's Fort in Sacramento. Also at the crest of the pass is the grave of an unknown pioneer.

In 1848 the disbanded Mormon Battalion returned to Salt Lake City via Carson Pass. At a place still known as Tragedy Springs a few miles west of the summit, they found the bodies of three men who had been slain by bandits or Indians. The names of these three men were carved into a tree, the section of which is now at Marshall State Park at Coloma.

Woodfords, the first white settlement in the area, was established as an outpost by Sam Brannan. For a time it was known as Brannan Springs and, after 1851, as Cary's Mills, for a sawmill erected in the area by John Cary. Daniel Woodford, who had arrived in the county in 1849, erected a hotel near the present California Division of Highways buildings. Later, a post office was opened there and given the name of Woodfords.

Meanwhile, gold was discovered by James Marshall at Sutter's Mill at Coloma in El Dorado County on January 24, 1848, and thousands of gold seekers arrived in the western foothills of the Sierra Nevada. Soon the prospectors were pushing eastward into the high Sierra Nevada in search of gold. In 1850 Major Ebbetts led a party of prospectors across the Sierran crest via a pass now known as Ebbetts Pass. Luther Pass was used as early as 1850 as an alternate route to Placerville and Sacramento. Another route to the western gold fields branched off the Carson Pass road at the present site of Twin Lakes and extended across the high ridges to the northwest and the South Fork of the American River. It connected with a trail that extended west along the Georgetown Divide toward Placerville and Coloma. Other trails extended to the southwest down the ridges to Jackson, Angels Camp, and San Andreas. Some of these trails became toll roads, which were maintained by local residents who were licensed by the State or Territory and later by the County. The franchises stipulated the rates to be charged for wagons, pack animals, and livestock. Some of the old toll roads were later taken over by the State highway system.

John A. Thompson, better known as "Snowshoe" Thompson, lived in Diamond Valley a few miles east of Woodfords. A native of Norway, he was an expert on skis, or snowshoes as they were then known. For 20 years (1856-1876), he carried the winter mail between Placerville and Woodfords. A monument honoring him is located in Diamond Valley near the site of his old home.

In 1861 a small herd of Bactrian camels from the Gobi Desert in China was driven over Ebbetts and Monitor Passes to Nevada. These animals caused considerable difficulty because of injuries to their hooves and because oxen, horses, and mules were terrified of them.

With the discoveries of gold and silver in the late 1850s and early 1860s, a "rush" was on to Alpine County. A number of towns sprang up, several of which grew to a considerable size. Silver Mountain City, originally known as Konigsberg, was established by Scandinavian miners in 1862. By the following year, the population of this town had grown to somewhere between 2500 and 3500. The following quote is from a description of Silver Mountain in the journal of W. H. Brewer, dated at Murphys, California, August 13, 1863: "Recent reputed discoveries of silver ore at Silver Mountain, just east of the crest, on the head-waters of the Carson River, near Ebbetts Pass have caused much excitement——Over 300 claims are being prospected. Tunnels and drifts are being run, shafts being sunk and every few minutes the booming sound of a blast comes on the ear.——Nearby everyone is, in his belief, in the incipient stages of immense wealth". By 1864 the town had a post office, telegraph office, Wells Fargo express office, two newspapers, many saloons, a school, and several hotels.

Alpine County was created in 1864 from parts of Amador, Calaveras, El Dorado, Mono, and Tuolumne Counties; and Silver Mountain City became the seat of government. However, activity in the gold-silver mines declined sharply so that the town's population shrank to 200 in 1868 and 30 in 1872. The county seat was moved to Markleeville in 1875, and by 1886 Silver Mountain City had ceased to exist. Only the ruins of the old jail and a few brick and stone foundations remain to mark the site. Some of the stone blocks from the old jail were used in the construction of the present Alpine County Courthouse and New Webster School in Markleeville. The iron jail cells were moved to Markleeville, where they may still be seen in the old jail building. The Fisk Hotel also was dismantled, moved to Markleeville, and reassembled where it stands today as the Alpine Hotel.

Figure 2. Sketch of Silver Mountain City in 1867. The Fisk Hotel, now the Alpine Hotel in Markleeville, is in right foreground. *From a photograph supplied by the Alpine Hotel.*

In 1861 Jacob Marklee built a cabin in what is now Markleeville at the site of the present Alpine County Courthouse. The town grew rapidly so that by 1864 it had a population of 2620. In that year Marklee, who derived most of his income from tolls paid by miners using the bridge he had built across Markleeville Creek, was shot to death. The town suffered a disastrous fire about 1886 and was never rebuilt in its entirety.

Meanwhile, during the early 1860s, prospecting and development work in Monitor Canyon was intensive, and the town of Monitor was settled. It was named for the *Monitor,* the famous iron-clad ship of the Civil War. The town had a population of 300 in 1872, but it declined after that. From 1898 until 1911, it was known as Loope in honor of a Dr. Loope who had an interest in mines in the district. Although there is mining activity in the district now, the town no longer exists. Silver King was a small mining town that existed for a few years near the junction of Snodgrass Canyon and the East Fork of the Carson River. By 1874, the town had been abandoned.


Photo 6. Main street of Markleeville looking northwest. The Alpine Hotel was originally located in Silver Mountain City, where it was known as the Fisk Hotel. It was moved here in 1885.

From the middle 1860s to the early 1870s, a number of other settlements existed in Alpine County. Summit City, which had a population of nearly 600 in 1864, was near the head of Summit City Creek about 3 miles south of the Carson Pass. Raymond City, northwest of Silver Mountain in Pleasant Valley, was named for R. W. Raymond of the Federal Government who made reports on the mines in the county. Other small towns included Mogul, which was north of Monitor; Centerville and Mount Bullion on the East Fork of the Carson River; Splinterville, a sawmill town near Silver King on Silver Creek; and Harmonial City, a stopping place between Hermit Valley and Summit City.

Lumbering was an important industry in Alpine County in the 1860s and 1870s, owing to a huge demand for cordwood for steam-driven mine machinery and for mine timbers both in the county and at the Comstock mines at Virginia City, Nevada, some 40 miles to the north. Lumber was also needed for the

Photo 7. Old Alpine County Jail in Markleeville. Camera facing northwest. The iron cells in this jail were brought over from Silver Mountain City in 1885.

many buildings being erected at that time, ranch structures, and for the flumes that were used to deliver cordwood to the streams. Wood "drives" down the East Carson River were common. Lumber was cut and sent to the river, where it was retained by a boom, dam, or chain. When the boom or dam was released, usually during high water in the spring, the wood was floated down to Empire, Nevada, and hauled to Virginia City. The last active sawmill in the county, which shut down in 1914, was near Pleasant Valley. The timber now being harvested in the county is trucked to sawmills elsewhere.

The demonetization of silver in 1873 put an end to the silver "boom" in the county. Thereafter, the population decreased from a high of more than 11,600 in 1864 to about 1200 in 1875, 680 in 1890, and 500 in 1910. From 1920 to 1950, it averaged less than 300. With the improvement of the roads leading into the county and the great increase in California's population and resultant recreational activities, Alpine County's population began to grow again. In the 1970 census the county's population totaled 484.

Photo 9. Kirkwood's, a historic stage stop, a few miles west of the summit of Kit Carson Pass. Camera facing west.

Photo 8. The town of Monitor in 1872. Camera facing west. This is now traversed by the Monitor Pass Highway. Several mine dumps are in the background. *Photo courtesy of the Alpine Hotel.*

Table 1. Value of mineral production in Alpine County 1880-1969.

| Year | Gold | Silver | Copper | Lead | Tungsten | Miscellaneous stone | Sand and gravel | Sulfur | Miscellaneous and unapportioned and remarks | Totals | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1880 | $17,133 | $24,146 | | | | | | | | $ 41,279 | 1880 |
| 1881 | 2,000 | 2,100 | | | | | | | | 4,100 | 1881 |
| 1882 | 20,000 | 10,000 | $13,115 | | | | | | | 43,115 | 1882 |
| 1883 | 10,000 | 5,000 | | | | | | | | 15,000 | 1883 |
| 1884 | 5,000 | 4,000 | | | | | | | | 9,000 | 1884 |
| 1885 | | | | | | | | | | | 1885 |
| 1886 | | | | | | | | | | | 1886 |
| 1887 | | | | | | | | | | | 1887 |
| 1888 | | | | | | | | | | | 1888 |
| 1889 | | | | | | | | | | | 1889 |
| 1890 | | | | | | | | | | | 1890 |
| 1891 | | | | | | | | | | | 1891 |
| 1892 | | | | | | | | | | | 1892 |
| 1893 | | | | | | | | | | | 1893 |
| 1894 | | | | | | | | | | | 1894 |
| 1895 | | | | | | | | | | | 1895 |
| 1896 | 400 | | | | | | | | | 400 | 1896 |
| 1897 | | | | | | | | | | | 1897 |
| 1898 | | | | | | | | | | | 1898 |
| 1899 | | | | | | | | | | | 1899 |
| 1900 | | | | | | | | | | | 1900 |
| 1901 | 23,568 | 2,860 | 1,319 | | | | | | | 27,747 | 1901 |
| 1902 | 10,359 | 3,770 | | | | | | | | 14,129 | 1902 |
| 1903 | 2,701 | 146 | | | | | | | | 2,847 | 1903 |
| 1904 | 4,827 | 145 | | | | | | | | 4,972 | 1904 |
| 1905 | 575 | | | | | | | | | 575 | 1905 |
| 1906 | | | | | | | | | | | 1906 |
| 1907 | | | | | | | | | | | 1907 |
| 1908 | | | | | | | | | | | 1908 |
| 1909 | * | * | | | | | | | Unapportioned 1900-09 $5,465 | 5,465 | 1909 |
| 1910 | | | | | | | | | | | 1910 |
| 1911 | | | | | | | | | | | 1911 |
| 1912 | | | | | | | | | | | 1912 |
| 1913 | 537 | 4 | | | | | | | | 541 | 1913 |
| 1914 | | | | | | | | | | | 1914 |
| 1918 | | | | | | | | | | | 1918 |
| 1919 | | | | | | $ 100 | | | | 100 | 1919 |
| 1920 | 40 | 120 | | | | 780 | | | | 940 | 1920 |
| 1921 | 20 | 58 | | | | 925 | | | | 1,003 | 1921 |
| 1922 | | | | | | 2,800 | | | | 2,800 | 1922 |
| 1923 | | | | | | | | | | | 1923 |
| 1924 | | * | * | * | | * | | $2,552 | | 2,552 | 1924 |
| 1925 | * | * | | | | 520 | | | | 520 | 1925 |
| 1926 | | | | | | 450 | | | | 450 | 1926 |
| 1927 | 146 | 60 | | | | 5,100 | | | | 5,306 | 1927 |
| 1928 | 23 | 363 | * | $174 | | 2,800 | | | 5,169 includes dimension stone | 8,529 | 1928 |
| 1929 | | | 1,278 | | | 31,735 | | | | 33,013 | 1929 |
| 1930 | | | | | | 2,500 | | | | 2,500 | 1930 |
| 1931 | 16 | 13 | | | | | | | | 29 | 1931 |
| 1932 | 647 | 241 | * | * | | 1,100 | | 7 | | 1,995 | 1932 |
| 1933 | 1,651 | 1,091 | 21 | 43 | | | | 9,918 | | 12,724 | 1933 |
| 1934 | 3,726 | 2,371 | 36 | 58 | | | | 8,856 | | 15,047 | 1934 |
| 1935 | 280 | 162 | * | * | | * | | 8,999 | | 9,441 | 1935 |
| 1936 | 3,430 | 4,111 | | | | 2,000 | | | | 9,541 | 1936 |
| 1937 | 13,790 | 6,923 | 100 | 413 | | | | 1,565 | | 22,791 | 1937 |
| 1938 | 35 | 108 | | | | 10,980 | | | | 11,123 | 1938 |
| 1939 | 1,715 | 3,047 | * | * | | * | | 2,566 | | 7,328 | 1939 |
| 1940 | 15,050 | 825 | | | | * | | 2,336 | includes mercury | 18,211 | 1940 |
| 1941 | 4,760 | 231 | | | | 2,005 | | 2,500 | | 9,496 | 1941 |
| 1942 | 595 | 2 | | | | | | | | 597 | 1942 |
| 1943 | | | | | * | * | | 20,241 | | 20,241 | 1943 |
| 1944 | 525 | 477 | * | | * | | | 1,212 | | 2,214 | 1944 |
| 1945 | | | | | | 1,500 | | | | 1,500 | 1945 |
| 1946 | | | | | | 1,000 | | | | 1,000 | 1946 |
| 1947 | | | | ** | ** | | | | | ** | 1947 |
| 1948 | 280 | 2 | 1,302 | | ** | | | ** | | ** | 1948 |
| 1949 | | | | | ** | | ** | | | ** | 1949 |
| 1950 | | | | | | | ** | | | ** | 1950 |
| 1951 | | * | | | * | | * | 84,222 | | 84,222 | 1951 |
| 1952 | | | | | * | | * | 54,767 | | 54,767 | 1952 |
| 1953 | | | | | $41,408 | | ** | $ 757,740 | | ** | 1953 |
| 1954 | | | | | * | | * | 1,507,429 | 64,934 | 1,572,363 | 1954 |
| 1955 | | | | | ** | | ** | 1,671,573 | | ** | 1955 |
| 1956 | | | | | 36,990 | | ** | 1,561,595 | | ** | 1956 |
| 1957 | | ** | | | | | | 1,492,464 | | ** | 1957 |
| 1958 | | | | | | ** | ** | 1,428,852 | | ** | 1958 |
| 1959 | | | | | | ** | | 1,365,600 | | ** | 1959 |
| 1960 | † | † | † | | | | | 1,670,647 | | ** | 1960 |
| 1961 | † | † | | | | | | 1,673,609 | | ** | 1961 |
| 1962 | † | † | † | | | | ** | 1,413,223 | | ** | 1962 |
| 1963 | † | † | † | † | | | | | Includes zinc† | 130,181 | 1963 |
| 1964 | † | † | † | † | | | $34,000 | | 29,469 includes zinc† | 63,469 | 1964 |
| 1965 | † | † | † | † | | | * | | Includes zinc† | 81,251 | 1965 |
| 1966 | 10,570 | 13,100 | 181 | 378 | | * | * | | 33,335 includes sand, gravel, stone, and zinc | 57,564 | 1966 |
| 1967 | † | 5,608 | † | † | | 14,030 | * | | 59,469 includes copper, gold, lead, sand and gravel, and zinc | 79,107 | 1967 |
| 1968 | † | † | † | † | | | | | | ** | 1968 |
| 1969 | † | † | † | † | | | | | | ** | 1969 |

*Unapportioned.
**Included with production of other counties.
† See table 4 under Zaca mine in *Gold and Silver*.

## Acknowledgments

This report was originally begun in 1958 by Philip A. Lydon, geologist then in the Sacramento office of the California Division of Mines and Geology. More data were collected in the early 1960s by Edmund W. Kiessling and James R. Evans, also geologists in the Sacramento office of the Division of Mines and Geology. The articles on the Leviathan sulfur mine and the Zaca gold-silver mine in this report were written by Mr. Evans. Denton W. Carlson, geologist formerly with the Division, visited and prepared reports on the tungsten mines in the Hope Valley district in 1953 when they were active. Some information was obtained from older reports prepared by Clarence A. Logan, who for many years was District Mining Engineer in the Sacramento office of the Division.

Persons who were of assistance in the preparation of this report include Claude Lovestedt, operator of the Zaca mine; his brother Andrew Lovestedt; the late W. Chris Mann, former Alpine County Clerk; David Wood, Alpine County Assessor; Dr. Garniss Curtis, Professor of Geology, University of California at Berkeley; Carl Munck of Al Tahoe; Clyde Mailske of Jackson; A. E. Millar and H. R. Burch, Managers, Anaconda Company, Weed Heights, Nevada; and James Wilson, geologist, Anaconda Company, Reno, Nevada. The author is also grateful to the citizens of Markleeville for their help and hospitality, especially the proprietors of the motels and general stores.

Alpine County is underlain principally by volcanic and granitic rocks. The volcanic rocks are predominant in the eastern part of the county, while granitic rocks are most abundant in the west. Small pendants of metamorphic rocks occur in the northern part of the county. The valleys are underlain by alluvium. There are a few glacial moraines.

The oldest known rocks in the county are metamorphic rocks of pre-Cretaceous age. Although their exact age is unknown, some have been classified by Lindgren as possibly ranging from Triassic to Jurassic (Lindgren, 1896). Most of these rocks apparently were of sedimentary origin and were extensively metamorphosed during Late Jurassic or Early Cretaceous times, particularly near and along contacts with granitic rocks. The metamorphic rocks occur as scattered roof pendants that are usually 1 to 3 square miles in extent and are elongate in a north to northwest direction. They consist predominantly of steeply dipping, north to northwest-striking beds of micaceous schist, impure quartzite, and dark fine-grained hornfels. Present in smaller amounts are brown coarse-grained garnet-epidote tactite and crystalline limestone. These rocks are nearly always dark in color although in a few places there are light-colored banded quartzites. The typical outcrop of the metamorphic rocks is a dark brownish red as contrasted with the lighter colored enclosing granitic rocks. The economic minerals most commonly found in the metamorphic rocks are tungsten, gold, and silver, which occur in the tactite. Also, there are a few narrow gold- and silver-bearing quartz veins in the schist and quartzite.

The granitic rocks range in composition from granite to quartz diorite. The most typical rock of this group is medium- to coarse-grained biotite-hornblende granodiorite that crops out in extensive grayish-white masses. It weathers and crumbles rather easily, and the typical outcrop presents a rounded appearance with many weathered residual boulders. The rock is composed of grayish quartz, white to pink feldspar, and black biotite and hornblende. The quartz and feldspar occur in about equal amounts, while biotite and hornblende usually comprise 5 to 10 percent of the total rock. In places porphyritic textures are common, the most prominent example being in the southern part of the county near Sonora Pass where the granodiorite

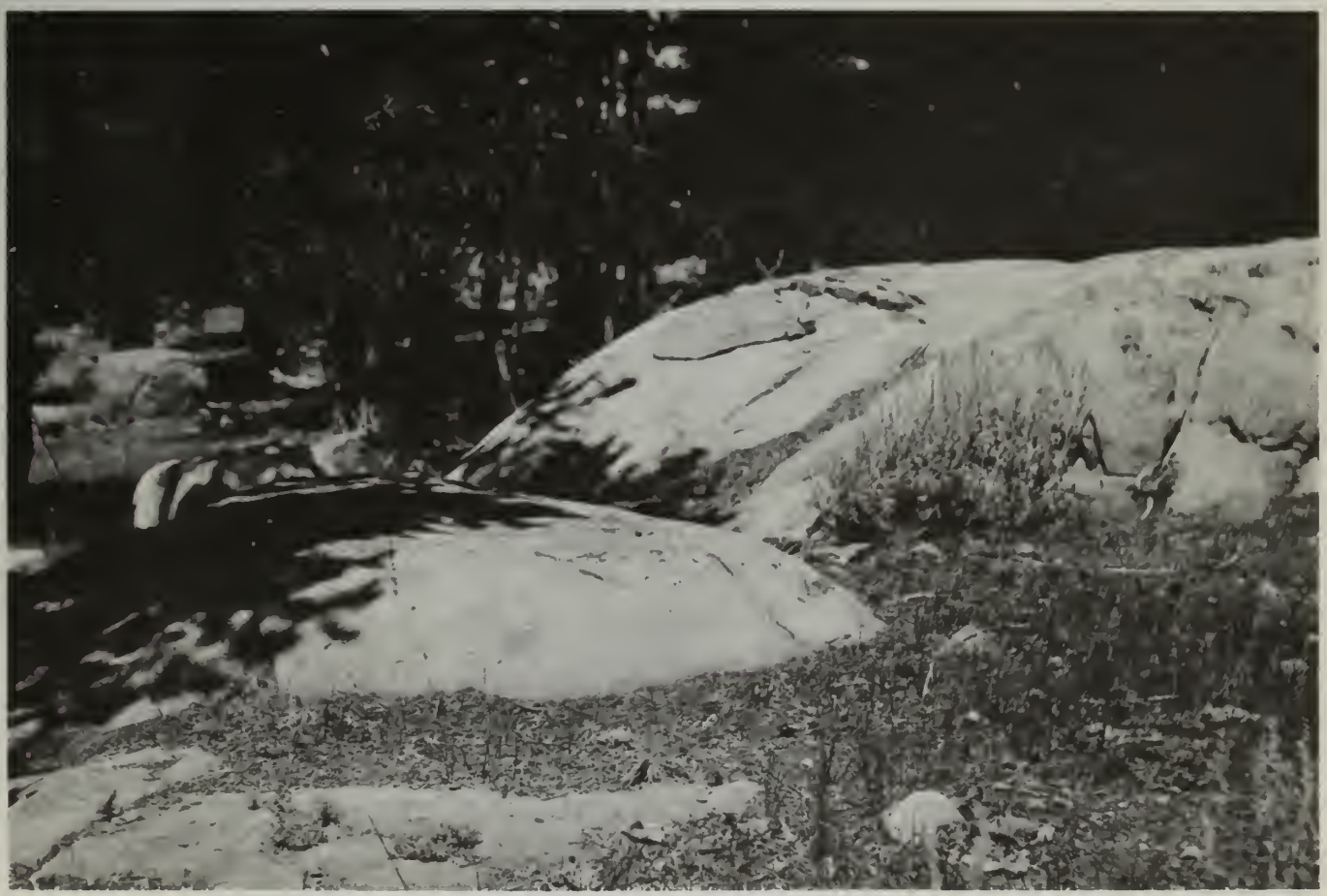

Photo 10. Granodiorite exposed near Grover Hot Springs showing typical rounded weathered surfaces. This particular outcrop was used by the Washoe Indians for grinding acorns. *Photo courtesy of the California Department of Parks and Recreation.*

contains pink orthoclase phenocrysts an inch or more in diameter.

Granite and quartz monzonite, which appear to be most abundant in the extreme northern and southern portions of the county, usually are harder, lighter in color, and less friable than the granodiorite. Some of the most rugged ridges and peaks are composed of granite. The granite consists predominantly of quartz and feldspar with small amounts of black biotite. Quartz diorite occurs in smaller amounts. It resembles granodiorite except that it contains less quartz.

There are some basic intrusive rocks, mainly diorite and gabbro. The diorite is medium- to coarse-grained, dark green, and composed of feldspar and hornblende with smaller amounts of biotite. In some places, pyroxene is abundant. The diorite occurs both in a few moderately extensive bodies and as rounded inclusions in the lighter colored, more acidic granitic rocks. Gabbro occurs in several areas in the vicinity of Twin Lakes Reservoir in the northwestern part of the county. Here, the gabbro is coarse grained, dark green, and composed of pyroxene, biotite, and some feldspar. South of Twin Lakes near Round Top Peak, various transitions between granodiorite, diorite, and gabbro are present.

In western and southern Alpine County are a number of intrusive bodies of undivided Tertiary age. These intrusive bodies are domes, plugs, sills, and dikes and are composed of dacite, rhyolite, and andesite. The rocks comprising these structures usually are quite resistant and may form rugged ridges and peaks. The most extensive Tertiary intrusives are in the southern part of the county west of Iceberg Peak and the high ridges southeast of Twin Lakes Reservoir.

Volcanic rocks cover much of the eastern portion of the county and many of the high ridges and peaks in the western and southern portions. These rocks have yielded by far the greatest amount of mineral wealth. In any future exploration program for precious and base metals and sulfur, the most logical places to explore would be the extensive alteration zones that are found in some of the volcanic rocks.

The most abundant volcanic rocks by far are andesitic breccias and tuffs of Pliocene age, which occur in beds as much as several thousand feet thick and which overlie granitic and metamorphic rocks. These breccias consist of angular andesite fragments in a matrix of finer andesitic detritus. The fragments are up to several feet in diameter. Occasional granitic boulders are present in the andesite breccias. The breccia is a rough-textured rock that is quite porous and ranges from green to dark gray. It is usually porphyritic, the most common variety containing phenocrysts of plagioclase and augite in a microcrystalline groundmass. Hornblende and hypersthene also are present. Massive andesite flows are present, especially in the vicinity of necks, domes, and plugs such as Round Top and Thimble Peaks southeast of Twin Lakes Reservoir and at Bull Run and Arnot Peaks in the southern part of the county.

Photo 11. Irregularly jointed andesite tuff breccias of Tertiary age exposed along State Highway 89, 2 miles north of Markleeville.

Photo 12. Close-up of photo 11. Andesite tuff breccia exposed in roadcut of Highway 89 north of Markleeville. This is a typical outcrop of this rock type.

A variety of other volcanic rocks occur in the county but in much less extensive deposits than the andesite. These include rhyolite and dacite tuffs and flows of Miocene age. In places, these rocks have been silicified. These rocks may have been sources of the rhyolite detritus that comprises the well-known Valley Springs Formation (Miocene) found to the west in the Sierra Nevada foothills. Also, a few small basalt flows of Pleistocene age cap several peaks in the eastern part of the county.

There are some continental deposits of Plio-Pleistocene age in the county, the most extensive being in the upper Carson Valley in the vicinity of Woodfords. In this area, they are poorly consolidated and dissected silts, sands, and gravels. There are coarse-grained terrace gravels adjacent to the Carson River.

Although much of Alpine County was shaped by glaciation during the Pleistocene Epoch, only a few glacial moraines exist, and none is very extensive. Moraines are located near Lake Alpine and Union Reservoir in the southwest part of the county, near

Grover Hot Springs, near Silver Mountain City, at the head of upper Carson Valley, and northeast of the Carson Pass. The moraines are composed of rough angular boulders of all sizes mixed with sand, gravel, and finer detritus.

Alluvium of Holocene age occupies the valleys, the most extensive deposits being in the upper Carson Valley and Hope Valley. The alluvium consists of silt, sand, and gravel in and adjacent to the present stream channels.

*Table 2. Summary of economic geology of Alpine County.*

| *Geologic age* | | | *Rock units* | *Rock types* | *Mineral deposits* |
|---|---|---|---|---|---|
| Cenozoic | Quaternary | Holocene | Alluvium | Silt, sand, gravel | Sand and gravel, placer gold |
| | | Pleistocene | Glacial moraines | Sand and gravel | Sand and gravel |
| | | Tertiary | Volcanic rocks | Andesite tuff, breccia and flows; rhyolite, dacite | Sulfur, gold, silver, copper, lead, zinc, mercury, antimony, arsenic, mineral specimens, stone |
| Mesozoic | | Cretaceous | Granitic rocks | Granite, quartz monzonite, granodiorite, quartz diorite | Stone, gold, silver |
| | | Pre-Cretaceous | Metamorphic rocks | Mica schist, quartzite, hornfels, tactite, crystalline limestone | Tungsten, gold, silver, mineral specimens, limestone |

Photo 13. The East Fork of the Carson River cutting through beds of andesite tuff breccia and massive andesite, 5 miles southeast of Markleeville. Camera facing north.

Photo 14. Coarse, loosely consolidated terrace gravels exposed in roadcut along the East Carson River. These are believed to be of Pleistocene age.

The principal mineral commodities are sulfur, gold, silver, copper, tungsten, sand and gravel, and crushed stone. In addition, small amounts of lead, mercury, selenium, and zinc have been produced. Many years ago dimension stones were quarried, and bricks were manufactured in the county. Other mineral commodities known to occur in the county are antimony, arsenic, iron, limestone, manganese, and molybdenum. Minerals of interest to collectors are numerous. The value of the total mineral output is unknown because no statistics were collected prior to 1880 and in recent years few statistics have been released. It is estimated to be about $20 million and maybe several million more. The only recent years for which statistics are available are 1954, when Alpine County's mineral output was valued at $1,572,363, and 1963, when it was $130,181.

Sulfur, gold, and silver account for most of the mineral production. More than $14.5 million worth of sulfur was produced from the Leviathan mine during the period of 1953 to 1962. The estimated value of the gold and silver output is between $3 and $5 million. In recent years, sand, gravel, and miscellaneous stone, chiefly used in road construction, have been important mineral commodities. In the early 1970s, gold and silver and small amounts of by-product copper and lead were recovered from the Zaca mine in the Monitor district. Except for the Leviathan sulfur mine and the Zaca mine, production statistics on individual mining operations have not been made available.

## Antimony

Antimony minerals occur in Alpine County, but no commercial production is on record. Enargite ($Cu_3(As,Sb)S_4$) was found in the gold and silver ores in the Monitor-Mogul district, especially at the Morning Star mine where large masses were associated with massive pyrite (see also sections on Copper and Gold-and-Silver). Small amounts of tetrahedrite ($(Cu,Fe)_{12}Sb_4S_{13}$) are found, also in the Monitor-Mogul district. Many years ago, stibnite ($Sb_2S_3$) was found associated with silver minerals at the Exchequer mine in the Silver Mountain district (Murdoch and Webb, 1956, p. 311).

## Arsenic

Arsenic is found in Alpine County, mostly as a minor constituent of gold-silver ores in the Monitor-Mogul district. Arsenopyrite (FeAsS), realgar (AsS), arsenolite ($As_2O_3$), and enargite ($Cu_3(As,Sb)S_4$) are the arsenic-bearing minerals. At one time large masses of enargite associated with massive pyrite were recovered at the Morning Star mine (see also sections on Gold-and-Silver and Copper).

## Barite

Barite ($BaSO_4$) has been found as a minor gangue mineral in the Morning Star gold-copper mine in the Monitor-Mogul district (see sections on Copper and Gold-and-Silver). Barite, a heavy white to gray mineral, is commonly known as "heavy spar".

## Ceramic Products

The principal center of brick making apparently was Silver Mountain City, where many old bricks still are lying around the ruins of the building foundations. Many also were used in the furnaces and chimney at the old ore-reduction works several miles to the east and in several powder magazines at nearby mines. The bricks range from light to dark dull red and are composed of pebbles and irregular fragments of quartz and andesite in a fine matrix. The raw material appears to have been a mixture of soil and valley alluvium from Silver Creek Valley. A few old brick structures are found elsewhere in the county, but the bricks appear to have been obtained from Silver Mountain City.

## Copper

Appreciable quantities of copper have been produced in Alpine County, but the total amount and the value of output are unknown. In the early 1970s, some copper was being recovered as a by-product of gold and silver mining at the Zaca mine in the Monitor-Mogul district (see Zaca mine under Gold and Silver). The most productive year for which statistics are available was 1882, when the output was 70,895 pounds of copper valued at $13,115. No more production was recorded until 1901 and then none until the 1920s, 1930s, and 1940s when it was intermittently produced. In 1943, 6,000 pounds valued at $1,302 were produced.

The first copper discovery in Alpine County, as well as one of the first in California, was made at Hope Valley in 1855 by a prospector known as "Uncle Billy" or "Old Billy" Rogers. This deposit, which is also known as the Altura mine, has also yielded minor amounts of gold and silver. It consists of a northwest-striking chalcopyrite-rich body in garnetiferous tactite in a contact metamorphic zone and is developed by a shaft and open cuts. Some high-grade ore was shipped out of here by ox teams in the early days. The deposit was prospected again in the 1920s and early 1930s.

The Leviathan mine, which in recent years has yielded large amounts of sulfur (see section on Sulfur), has also been a source of copper. It was discovered in

1863 by Comstock miners who were seeking a source of blue vitriol or chalcanthite ($CuSO_4 \cdot 5H_2O$) for processing silver ore at Virginia City by the Patio process. A few years later, exploration work was done at the mine for primary copper minerals, and a smelting furnace and other equipment were installed. These operations were unsuccessful, and the property was idle for many years.

The principal copper ore minerals in the county are enargite ($Cu_3(As,Sb)S_4$) and chalcopyrite ($CuFeS_2$). This is one of the few places in California where enargite has been found in quantity. Other copper-bearing minerals include tetrahedrite ($(Cu,Fe)_{12}Sb_4S_{13}$), chalcocite ($Cu_2S$), chalcanthite ($CuSO_4 \cdot 5H_2O$), famatinite ($Cu_3(Sb,As)S_4$), tenorite (CuO), and stromeyerite ($(Ag,Cu)_2S$). In the Monitor-Mogul district, these minerals are usually associated with pyrite and varying amounts of gold and silver and occur in the zones of alteration and silicification in andesite tuff breccia and related rocks. The copper minerals may occur in disseminated form in fairly extensive zones, in thin seams, veinlets, or in clots of euhedral crystals in cavities that are lined with quartz crystals. Occasionally they are found in masses. Chalcanthite is usually found as coatings in mine openings.

The largest source of copper in the county apparently has been the Morning Star gold-silver-copper mine, in the north end of the Monitor-Mogul district (see also section on Gold-and-Silver). This mine was opened in 1863 when an adit was driven southward from the north side of the hill. At a distance of 775 feet from the portal, a large mass of pure enargite mixed with pyrite was encountered. This mass was 10 to 15 feet thick and 20 to 30 feet long (Eakle, 1919, p. 14). Some of this ore was shipped all the way to Swansea, Wales, for smelting. Operations continued intermittently for many years. By-product copper has been recovered in other mines in the Monitor-Mogul district.

## Gold and Silver

Gold and silver are the best-known mineral commodities of Alpine County and were the chief attractions to the early-day prospectors and settlers. Although California's gold rush began soon after James Marshall's historic discovery at Sutter's Mill at Coloma on the American River in January 1848, it was more than 10 years before there was much prospecting in what is now Alpine County. One of the earliest precious metal discoveries here was reported in the August 24, 1857, issue of the Sacramento *Union*. This article stated: "A ledge containing silver ore was discovered near the East Fork of the Carson River in the summer of 1857, but no systematic attempt was ever made to develop it, though it was vaguely reported to be very rich, and few prospectors had the curiosity to inspect it". The Comstock silver rush began in nearby Virginia City in 1857, which stimulated prospecting throughout eastern California. Discoveries were soon made in the Monitor-Mogul, Silver Mountain, Silver King, and other districts; and Alpine County's gold-silver "boom" was on.

The value of the total production of gold and silver in the county is unknown, but most estimates have placed it as being somewhere between $3 and $5 million with gold and silver being in about equal amounts in value. Production statistics were not collected prior to 1880, and those collected since that date do not appear to be complete. The county's total recorded output from 1880 to 1948 amounted to $143,769 worth of gold and $72,198 worth of silver. Complete figures since 1948 are not available.

During the "boom" of the 1860s and 1870s, high-grade ore and concentrates were shipped to smelters and reduction works in various parts of the western United States; some high-grade copper-gold-silver ore was shipped all the way to Swansea, Wales, for treatment (see also section on Copper). Most of these plants have long since been dismantled, and their records lost. Impure gold and silver bullion from Alpine County was shipped to the United States Mints at Carson City, Denver, and San Francisco. Most gold and silver has come from the Monitor-Mogul district. The Silver Mountain district has yielded some values, but the Hope Valley and Silver King districts have yielded only small amounts. Also, there has been some production from a few scattered mines and prospects such as the Lost Cabin mine.

During the gold-silver "boom", the county was divided into a number of well-defined mining districts (see figure 1); however, most of the claims yielded no values. Many long adits were driven in barren or nearly barren rock and then abandoned. Great difficulty was encountered in treating the complex sulfide or "rebellious" ores during the early days, and vast sums were spent on large but unsuccessful mills and reduction works. The ruins of one of these old reduction works are visible from Ebbetts Pass Highway a few miles east of the site of Silver Mountain City.

In the early 1970s, the principal gold and silver mining operation in Alpine County was the Zaca mine in the Monitor-Mogul district. Several nearby properties were explored or developed in conjunction with the Zaca mine, and the output from small amounts of ore that were mined and milled in these operations are part of the Zaca mine totals shown in table 4. There has been minor exploration and development work at several other gold-silver mines in the Monitor-Mogul district in the 1960s and 1970s but hardly any production. These properties include the famous Morning Star mine and the Alpine, Dixon, Orion, Georgiana, and B. and J. mines. Minor work was done also at the I.X.L., Exchequer, and Raymond Meadows Creek mines in the Silver Mountain district and at a few other scattered properties such as the Lost Cabin mine. During the early 1950s, possibly a minor output of by-product gold and silver was made from tungsten-gold mines in the Hope Valley district (see also section on Tungsten).

In addition to regular or intermittent gold and silver mining on a commercial scale, prospecting and locating of gold and silver claims is active, and the gold and silver claims located in Alpine County probably number in the thousands. A search of old records

reveals that in 1863 more than 300 claims were being prospected and developed in the Silver Mountain district alone. A moderate number of mines and prospects, including virtually all of any importance, have been described in the publications of the Division of Mines and Geology and its predecessor, the California State Mining Bureau (see Bibliography). Some of the mines are also described in other publications or periodicals such as the *Mining and Scientific Press* and the old U. S. Government reports on the mineral resources of the states and territories west of the Rocky Mountains.

The tabulated list of gold and silver mines that accompanies this report is for those whose locations are definitely known. Data on most of these mines have been supplemented by field examination. A complete list of all of the gold and silver mining claims located in the county does not exist and to compile one would be impracticable because of vague descriptions and locations, duplicate names (there are any number of "Alpine" mines or claims), overlapping or conflicting claims, and almost complete obliteration of any evidence of location and mining work. A partial list of claims that existed in 1864 at the height of the gold-silver "boom" is shown in table 3.

## MONITOR-MOGUL DISTRICT

Although classified by some as two separate mining districts, Monitor and Mogul actually comprise a single area of metal mineralization that has been the chief source of gold and silver in Alpine County, as well as much of the copper and most of the lead and zinc. Mercury was produced in the area; and antimony, arsenic, manganese, and tungsten are known to occur here. Monitor and Mogul also have long been favorite places for the collecting of mineral specimens.

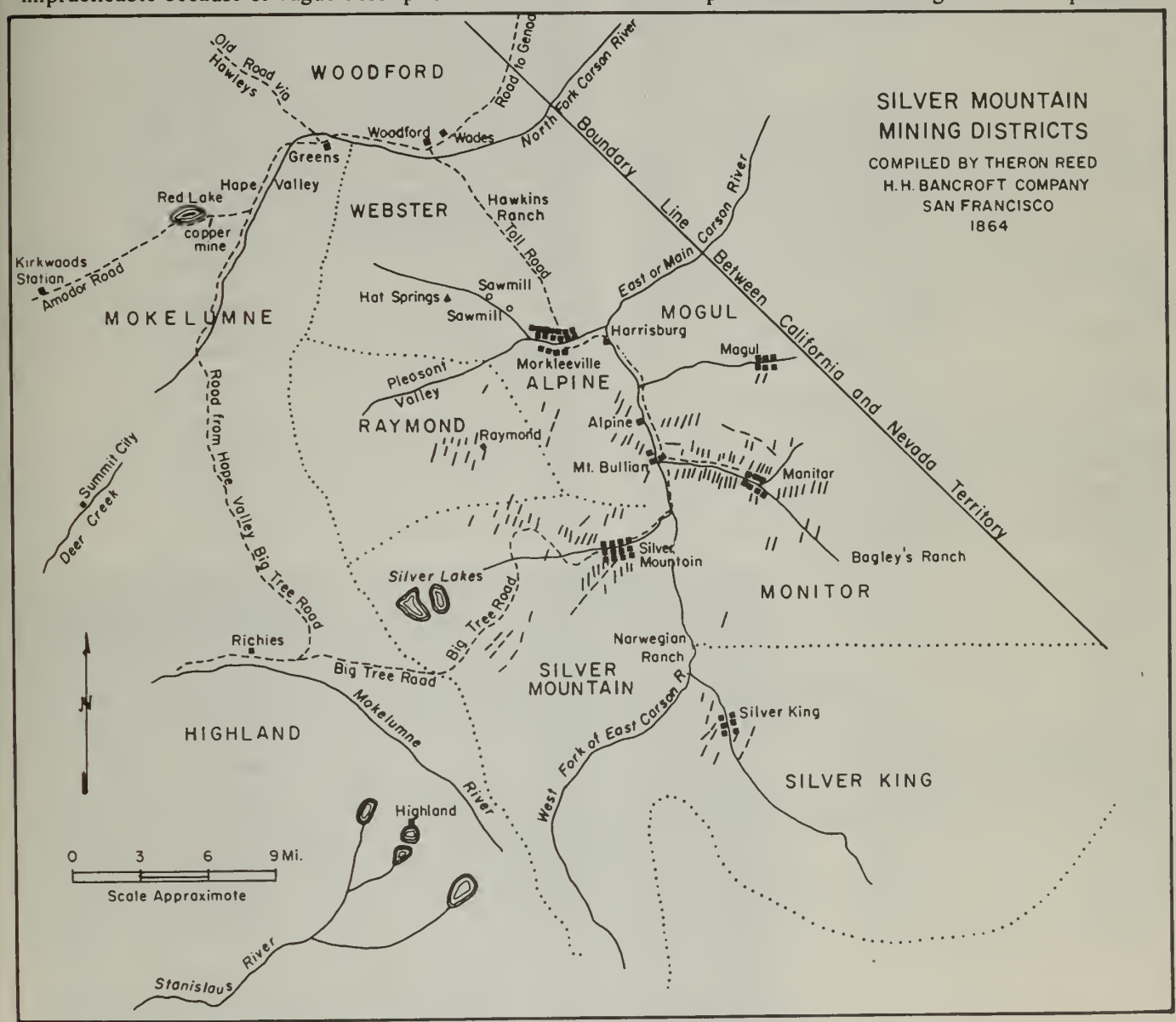


Figure 3. Copy of old map of Alpine County showing the mining districts. The short lines are mining claims. See table 3 for list of claims in these districts. *From Alpine County 1864-1964, p. 42.*

*Table 3. List of mining claims by district in Alpine County in 1864. From Alpine County 1864-1964, p. 42. Also see figure 1.*

| ALPINE DISTRICT |
|---|
| Anchor of Hope |
| Black Hawk |
| Buckeye |
| Comstock |
| Constitution |
| Dubuque |
| Eastern Slope |
| Elgin |
| Galena |
| Good Hope |
| Highland Mary |
| Iron Duke |
| Medina |
| Metropolitan |
| Monitor |
| Mt. Bullion |
| Mt. Bullion T. & M. Co. |
| Santa Eulalia |
| Snell |
| Sonoma |
| St. Mark |
| Union |
| Victoria |
| Washington |

| MOGUL DISTRICT |
|---|
| Buffalo |
| Eagle |
| Great Mogul |
| Henry Clay |
| Morning Star |
| Saugatuck |
| Village Bird |

| MONITOR DISTRICT |
|---|
| Abe Lincoln |
| Alert |
| Alta California |
| American |
| Anthony Wayne |
| Atlantic |
| Caledonia |
| Central |
| Chapin Co. |
| Chicago |
| Congress |
| Constitution |
| Constitution No. 2 |
| Cosmopolitan |
| Detroit |
| Dictator |
| Flora Temple |
| Florence |
| Forest Queen |
| Foundling |
| F. Jones |
| Garrison |
| Gladiator |
| Glasgow |
| Gosky |
| Hercules |
| Hercules Co. |
| Helvetia |
| Indian Chief |
| Jones Co. |
| Kate Kearney |
| Last Chance |
| Lexington |
| Manchester |
| Marion Co. |
| Matagorda |
| Michigan |
| Michigan T. & M. Co. |
| Mineral Point |
| Monitor |
| Monitor Con. T. & M. Co. |
| Monster |
| Morning Star |
| Mountain |
| Mountain Express |
| Mt. Mahogany |
| Neosha |
| Nevada |
| New York |
| Ninekeequa |
| Oconto |
| Ohio |
| Otto |
| Placerville |
| Rhode Island |
| Senate |
| Star of the West |
| Star of the West No. 2 |
| Sunshine |
| Triumph |
| Washington |
| Washington Co. |
| Weneolen |
| White Swan |
| Wide West |
| Wild Yankee |
| Worden Co. |
| Union |
| Young Monster |

| RAYMOND DISTRICT |
|---|
| Avalanche |
| Butcher Boy |
| California |
| Franklin |
| General Grant |
| Great Eastern |
| Gregory |
| Niagara |
| Pittsburgh |
| Pride of the Mountains |
| Prospect |
| Red, White, and Blue |
| Sacramento |
| Sheba |
| St. Lawrence |
| Twin Lodes |
| Wyoming |

| SILVER KING DISTRICT |
|---|
| Carson Co. |
| Chapelle |
| Chapelle Ex. 8 |
| Cleopatra |
| Excelsior |
| General Grant |
| Golden Era |
| Golden Key |
| Mt. President |
| Osceola |
| Sedonia |
| Silver King |
| Silver Queen |
| Taggard |
| Washington |

| SILVER MOUNTAIN DISTRICT |
|---|
| Almanza |
| American Eagle |
| Apollo |
| Astor |
| Baltimore |
| Bamboo Chief |
| Bear Track |
| Big America |
| Big Tree |
| Blue Lead |
| Bonanza |
| Buckeye |
| Bull Dog |
| Buster |
| Cambridge |
| Casteel |
| Cataract |
| Cayuga |
| Centaur |
| Chrysopolis |
| Clifton |
| Coast Range |
| Cooper |
| Creek |
| Crescent |
| Crinoline |
| Crystal 1 & 2 |
| Diamond |
| Dictator |
| Dora |
| Eagan |
| El Dorado |
| Emma Frances |
| Essex |
| Eugenia |
| Eureka |
| Golden State |
| Hancock |
| Hooper |
| Illinois |
| Inca Chief |
| I.X.L. |
| Jefferson |
| Jones |
| Knox |
| Lady Franklin |
| Lady Washington |
| Leviathan |
| Lincoln |
| Lucky Star |
| Magna Charta |
| Mammoth |
| Metropolitan |
| Metropolitan Co. |
| McGregor |
| Morning Star |
| Mountain |
| Mountain Oak |
| Napa |
| Neplus Ultea |
| Nightingale |
| Noble |
| Nonpareil |
| North America |
| Onodaga |
| Orient |
| Owasco |
| Pearl |
| Pennsylvania |
| Pioneer of the Mts. |
| Platina |
| Poplar |
| Revenue |
| Ruby |
| Rhodes |
| Sacramento |
| Scandinavian |
| Seventy Six |
| Sierra Nevada |
| Silver Brick |
| Silver Creek |
| Silver Prize |
| St. Charles |
| St. George |
| Star of Hope |
| Tip Top |
| Treat |
| Twin |
| Uncle Sam |
| Union |
| Virginia |
| Washington |
| Willow |
| Wisconsin |
| Young America |

The most important mines in the district are the Zaca, Morning Star, Alpine, Curtz, Orion, Georgiana, and Globe.

This district contains extensive zones of highly altered and silicified volcanic rocks (see figure 4), and it is in these zones of alteration that the various metals are found. The area is underlain by dark gray to green andesitic tuff breccia, lapilli tuff, flows, and agglomerate. In a number of areas, these volcanic rocks have been intensely altered and silicified. The altered and silicified rocks are striking in appearance—being colored various shades of white, yellow, red, and reddish brown—and stand out predominantly from the unaltered gray and green enclosing rocks. The altered zones at Colorado Hill are especially striking, and the hill can be observed for many miles from any direction (see photo 15).

The altered rocks range from those that are extremely hard and highly silicified to those that are much softer and contain appreciable amounts of kaolin. Some of these rocks are composed of alternating bands of white and gray chert and kaolinized material in which relict crystals of feldspar are visible. Some altered rocks contain ribbons of chert with quartzitic breccia. Flow-banding structures can be seen in some of the altered rocks. Others consist of lapilli-tuff with white fragments in a light gray matrix. Many of these rocks contain quartz seams and veins and many small cavities lined with euhedral crystals of glassy, white and gray quartz. Many of the altered rocks are stained various shades of yellow, red, and reddish brown. This staining is a result of the oxidation of the sulfide minerals and is especially prominent along seams, fracture planes, and in some of the cavities.

The gold and silver nearly always occur with various sulfide minerals. Only small amounts of free gold and silver have been found in the district. Pyrite is the most abundant ore mineral, but others that are common in places are chalcopyrite, enargite, sphalerite, galena, argentite, tetrahedrite, and arsenopyrite. Other minerals that have been found at Monitor and Mogul include barite, famatinite, pyrargyrite, cinnabar, chalcocite, realgar, stephanite, arsenopyrite, stromeyerite, rhodochrosite, tenorite, polybasite, hubnerite, and wolframite (see also sections on Arsenic, Copper, Mercury, and Tungsten).

The ore minerals occur in disseminated form, in small bunches or clots of crystals, in veins and seams, in small cavities associated with quartz crystals, and occasionally in large tabular masses such as the body of enargite and pyrite found many years ago at the Morning Star mine. The ore mineral grains range from those that are extremely small to those that may be several millimeters in diameter and commonly are well-formed crystals. The ore bodies often are in soft clay-rich pockets or soft friable cores of small anticlinal structures. Many of the ore bodies appear to occur in flexures. Because of the complexity of the sulfide ores in the district, it is necessary to concentrate them by selective flotation.

### Alpine mine

The Alpine mine is on the west flank of Colorado Hill in NW1/4 sec. 31, T. 10 N., R. 21 E., M.D.M. The property consists of a number of claims including the Happy Thought, Lewis, and Markleeville. Some are owned by William Hubbard *et al.* and are leased to Claude Lovestedt, who has been prospecting and developing this area in conjunction with his operations at the Zaca mine to the southeast. A large number of "Alpine" prospects and claims were located in the county, but this appears to be the only significant gold-silver mine of that name.

The Alpine mine was first worked in the early 1860s and for some years following. Around 1900 it came under control of the Curtz Consolidated Mining Company of Oakland. At that time the mine was believed to be rich in free gold, and a water-powered 20-stamp mill was erected by the East Fork of the Carson River about three-quarters of a mile to the west.

Photo 15. The crest of Colorado Hill, Monitor district, as viewed from the south. Much of the hill is composed of altered and silicified andesite. Mogul Peak and the Curtz mine are in the right background.

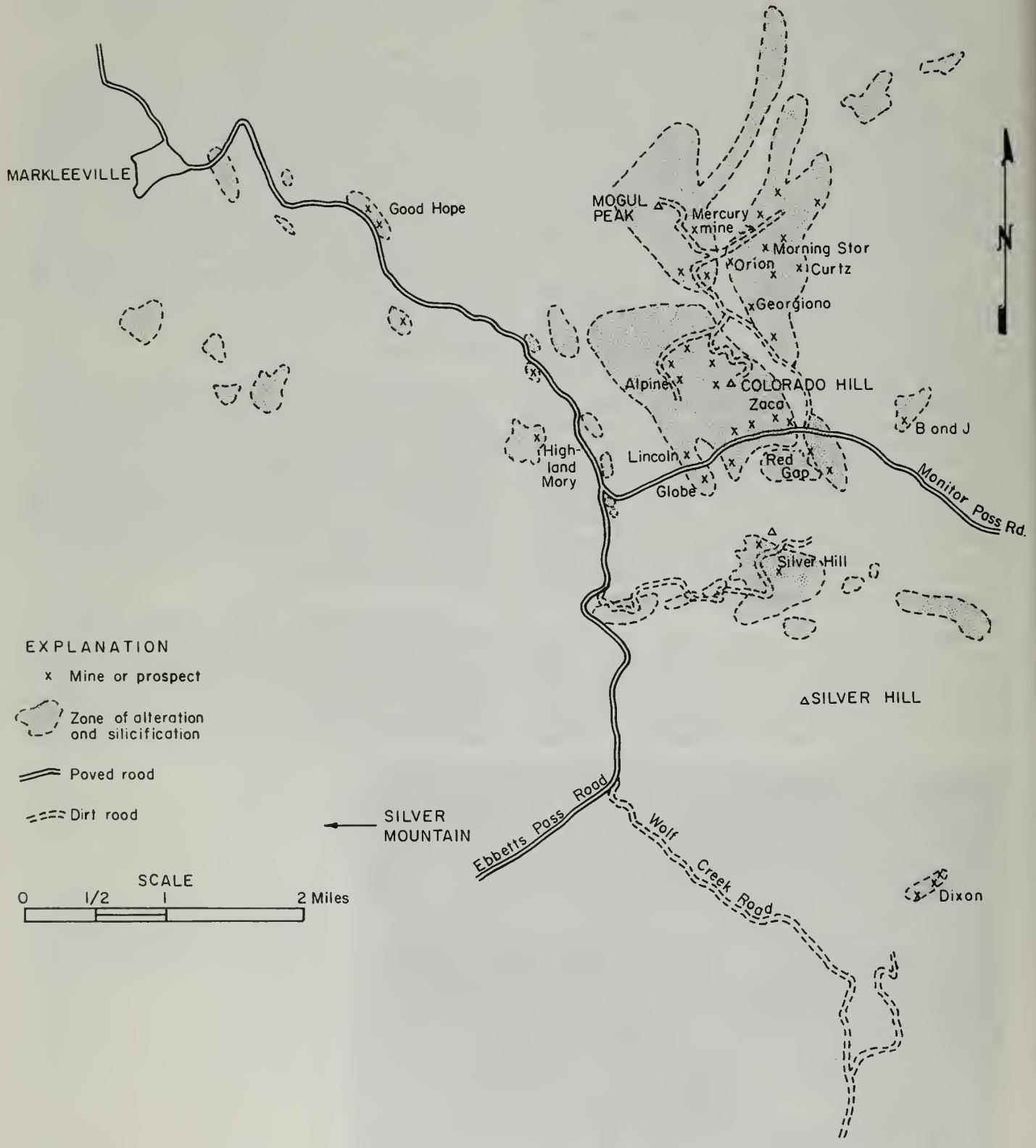


Figure 4. Map of the Monitor-Mogul district showing locations of mines and zones of alteration and silicification.

The mine was connected to the mill by an aerial tramway. Very little ore was milled, and for some years the mill was used as a power house. In the early 1930s, the Alpine Consolidated Mining Company controlled the mine and did some prospecting work. Recent work on the property has consisted of developing a large open cut with an east face up to 50 feet high. The value of the total output of the claims in this group is unknown, but older reports have estimated it to be at least $378,000 (Logan, 1923, p. 359). The recent output of this mine, if any, is combined with the figures for the Zaca mine (see table 4).

The deposits at the Alpine mine are located along the west margin of the main zone of silicification and alteration of the Monitor portion of the district, where a series of roughly parallel northwest-striking gold- and silver-bearing veins and seams occupy shear zones. Some of the veins consist of numerous stringers of silicified breccia. The veins usually range in thickness from 1 to 6 feet. One ore body was reported to have had a stoping length of 60 feet (Logan, 1923, p. 359). Although some free gold may occur at this mine, most of the values apparently were in fine-grained disseminated pyrite. In addition to the open cut, the mine is developed by a number of east-trending crosscut adits, some of which are partly open. The lowest adit is more than 1000 feet long; the others are shorter. The old mill is nearly destroyed, but portions of the aerial tramway remain.

### B. and J. mine

This is a prospect in the eastern part of the Monitor-Mogul district in SW¼ sec. 33, T. 10 N., R. 21 E., M.D.M. In the early 1960s, it was owned and operated by Hindmen Industries, Inc., Van Nuys, California. In 1961 about 50 tons of ore were mined here and concentrated at the Zaca mill. The ore is silicified breccia containing abundant pyrite and smaller amounts of galena and chalcopyrite. The mine is developed by a 35-foot adit; several buildings and an ore bin remain on the property.

### Colorado Hill

Open pit mining was done at the top of Colorado Hill in the late 1960s and early 1970s. This operation was conducted by Claude Lovestedt in conjunction with his operations at the Zaca mine in Monitor Canyon just to the south. The production from this mine is included in the production figures given for the Zaca mine in table 4. There are a number of open cuts up to 20 feet deep and 100 feet or more long. The rock was blasted and delivered by loader over a grizzly into a loading pocket and then trucked down to the Zaca mill. Much of the silicified and altered rock exposed at the top of Colorado Hill contains some gold, silver, and base-metal values.

### Curtz mine

The Curtz mine is at the top of Morning Star Hill about half a mile southeast of the Morning Star mine in the Mogul portion of the district, sec. 29, T. 10 N., R. 20 E., M.D.M. Several times in the past, this mine and the nearby Georgiana mine were considered part of the Morning Star mine. It was at the crest of this hill in the area of this mine that iron-stained jasper was discovered in 1863. This discovery led to the driving of the Morning Star adit from the northwest and the development of the famous and rich body of massive enargite in that mine.

The Curtz mine and others in the district were controlled for many years by the Curtz Consolidated Mining Company. These mines, as well as some to the south in the Monitor area, came under the control of the Alpine Consolidated Mining Company in the 1930s. Some work was done at the Curtz mine in the 1960s; a sign posted on the property in 1969 stated that it was the "Ardis" mine. An open cut approximately 100 feet long, 20 feet deep, and 15 feet wide was made with a bulldozer northwest of the old caved 300-foot shaft, but production, if any, from this operation is unknown.

The deposit is a southeast continuation of the Morning Star ore zone. The zone of mineralization strikes approximately N15°W, and here it is as much as 30 feet wide. The silicified material ranges from a soft bleached kaolinite-rich rock to a hard grayish silicified breccia, some of which has an andesitic matrix. As at the Morning Star mine, the gold-, silver-, and copper-bearing rock contains disseminated or massive pyrite and varying amounts of chalcopyrite, galena, enargite, sphalerite, and arsenopyrite.

### Dixon (Boulder Hill, Wolf Creek) mine

This mine, known by several names, is in NW¼ sec. 21, T. 9 N., R. 21 E., M.D.M., about 15 miles southeast of Markleeville and half a mile east of the junction of Wolf Creek and the East Fork of the Carson River. It is accessible by a trail that extends half a mile up a narrow canyon northeast of the mine camp, which is by the river. The property has been owned by

Photo 16. Adit, timbers, and buildings at the lower workings of the Dixon gold-silver mine, looking north. *Photo by Edmund W. Kiessling.*

the Dixon brothers of Markleeville for many years. Although no production of gold and silver is known, a considerable amount of prospecting and development work was done. During the 1950s and 1960s, the mine was worked intermittently.

The deposit consists of several parallel west-northwest striking veins of silicified breccia that dip steeply to the north in country rock of andesite tuff breccia. The veins range from 2 to 5 feet in thickness and contain fine-grained pyrite and smaller amounts of chalcopyrite and chalcocite. The lithic fragments in the vein are often weathered, with some clayey material developed. Some of the breccia contains fragments of jasper. No free gold occurs; all of the gold and silver values are in the sulfides.

The mine is developed by a lower or main adit that crosscuts 85 feet north to the vein zone and a caved adit about a quarter of a mile up the canyon to the northeast. Some equipment and several small buildings were on the property in 1966, and the adit was open.

### Georgiana mine

The Georgiana, or Georgia, mine is just east of Forest City Flat in SW1/4 sec. 29, T. 9 N., R. 21 E., M.D.M. It is about a third of a mile southwest of the Curtz mine. At one time this mine was owned by the Curtz Consolidated Mining Company and was operated in conjunction with the Morning Star and Curtz mines. The Georgiana mine apparently was developed in the hope of encountering the southward extension of the Morning Star-Curtz ore zone. The value of the production from this mine is unknown.

The property is developed by a northeast-trending adit about 2000 feet long. A large dump contains pyritic silicified tailings typical of the rocks of this district. About 1914, a plant was erected on the property, which contained a 100-ton Huntington mill, concentrators, and slimers (Eakle, 1919, p. 22). This plant has since been removed, but several buildings were on the property in 1969, and the adit was open.

Photo 17. Georgiana gold-silver mine; camera facing east. The portal of the main adit is shown.

### Globe mine

The Globe mine is on the south side of Monitor Canyon in S1/2 sec. 31, T. 10 N., R. 21 E., and N1/2 sec. 6, T. 9 N., R. 21 E., M.D.M. It was first worked in 1862 when a pocket containing $3000 worth of gold and silver was discovered near Monitor Creek. The mine was active until the early 1870s. In 1918 it was reopened and some crosscutting and drifting was done, but apparently there was little or no production. The mine may have been prospected during the 1930s.

The deposit is in a 200- to 300-foot-wide zone, or belt, of alteration and silicification that extends along the west side of the Monitor district. The Lincoln mine, across the canyon to the northwest, is located in this zone. The mineralized deposit consists of a north-striking vein of silicified breccia that contains varying amounts of pyrite, chalcopyrite, chalcocite, and enargite. The vein is 5 feet or more thick. The property was developed by a 1000-foot south-southeast-trending adit, from which crosscuts extend westward to the vein. A winze and an unknown amount of drifting complete the workings. The adit was caved in 1969.

### Lincoln mine

This mine is on the north side of Monitor Canyon about half a mile west of the Zaca mine in SW1/4 sec. 31, T. 10 N., R. 21 E., M.D.M. The property has been idle for many years. The mine is in a 100- to 200-foot-wide zone of alteration and silicification west of the zone that contains the Zaca mine to the east. However, the zone containing the Lincoln mine is the same one that contains the Globe mine just to the southeast. As yet, detailed studies have not been made to determine the extent of these zones in this portion of the Monitor district.

The deposit is a north-striking vein of silicified breccia that occupies a shear zone. There are about 2000 feet of underground workings. The main adit extends 400 feet to the northwest from which a crosscut extends westward to the vein. The workings were inaccessible in 1969.

### Morning Star mine

This famous gold-silver-copper mine is located in the northeast portion of the district in W1/2 sec. 29, T. 9 N., R. 21 E., M.D.M. It and several adjoining properties were owned by T. E. Woods *et al.* of Oakland, California, in the 1960s.

Work began on this property in 1863. An adit was driven south-southwest from the north side of the hill along a zone of sulfide mineralization. A large body of enargite mixed with pyrite was encountered 775 feet from the adit portal. This mass ranged in thickness from 10 to 15 feet and was 20 to 30 feet long. Considerable difficulty was encountered in treating this rich but complex sulfide ore, and some was shipped all the way to Swansea, Wales, for smelting. Work continued at the mine fairly steadily until 1904, the last

year for which large-scale activity was reported (U. S. Bureau of Mines records).

Some work was done at the mine again in the 1920s and 1930s, and minor exploration work was reported in 1951-52 and 1957. In 1962 the Boyles Drilling Company of Salt Lake City diamond-drilled about a third of a mile east of the mine. A 200-foot hole inclined 45° to the west was sunk to explore for additional ore. The results of this program are unknown.

For many years this and other mines in the Mogul portion of the district were owned and operated by the Curtz Consolidated Mining Company. The Georgiana and the Curtz for a time were operated in conjunction with the Morning Star, their workings having been driven in hopes of developing additional ore bodies in the same zone as the Morning Star. This concern also built a 35-stamp mill on the East Carson River, but apparently very little, if any, ore was treated in it. The mill later was used as a power house (Eakle, 1919, p. 20). The value of the total production of the mine has been estimated to be about $600,000 (Logan, 1921, p. 403). The relative proportions of gold, silver, and copper in this figure are unknown. However, it is believed that the total values of gold and silver probably exceed that of the copper.

The ore deposits at this mine are located along the east side of the major zone of alteration and silicification of the Monitor-Mogul district (see figure 4). They are associated with a major shear zone that has a southwest trend and contains the Curtz and Georgiana mines to the southwest. This shear zone, or belt, then appears to curve to the southeast and may include the new prospects now (1969) under development on the south side of Monitor Canyon near the Zaca mill.

The ore in this mine resembles that of other mines in the district, except that enargite is more abundant. The mine dump, which is fairly extensive in size, consists chiefly of white silicified rock that contains fairly abundant and usually fine- to medium-grained disseminated pyrite, chalcopyrite, and enargite. The silicified zone at the top of the hill south of the mine stands out prominently from the surrounding unaltered andesite. In places the silicified rock is stained by iron oxide.

Photo 18. Morning Star gold-silver-copper mine, Mogul district, as viewed from the northwest. Enargite is common at this mine.

The mine is developed by a south-southeast-trending main adit that is about 1200 feet long. It is also known as the 148-foot level. A 480-foot shaft is connected with the main adit 922 feet in from the portal. In addition to the adit level, there are levels at 220, 280, and 480 feet. Crosscuts extend to the ore zone, where stoped areas and several winzes are located. The main adit and shaft were open, and several buildings, a ramp, and ore bins were on the property in 1971.

### Orion mine

The Orion mine is a quarter mile west of the Morning Star mine in the Mogul portion of the district. It is in E1/4 sec. 30, T. 10 N., R. 21 E., M.D.M. Like the Morning Star, it at one time was owned and operated by the Curtz Consolidated Mining Company. Apparently very little work has been done on the property for many years, although there were signs in the 1960s that attempts were being made to reopen the lower adit.

The deposit is in the west portion of the same wide zone of altered and silicified volcanic rock that contains the Morning Star, Curtz, and Georgiana mines. The gold, silver, and copper values appear to be in a north-northwest-striking vein-like zone which contains abundant sulfide minerals. The mineralized vein is probably associated with a shear zone. The mine dump contains bleached silicified rock with fine-grained pyrite, chalcopyrite, arsenopyrite, enargite, and galena. The mine is developed by two southeast-trending drift adits and a 100-foot shaft near the top of the hill. The lower adit is 300 feet long, and the upper adit is 200 feet long. All workings were inaccessible in 1969.

### Red Gap mine

This property is in S1/2 sec. 32, T. 10 N., R. 21 E., M.D.M., on the south side of Monitor Canyon by the Zaca mill. Gold, silver, copper, and lead values were discovered around 1963 by Claude Lovestedt, and for several years he operated this mine in conjunction with the nearby Zaca mine. Several open cuts were made on the hill, and a U.S. Government loan was obtained to do additional exploration work. A southwest-trending crosscut adit was begun from just east of the mill (see photo 20). In August 1965, the adit was about 150 feet long.

This deposit appears to be in the southeast extension of the same zone of alteration and silicification that contains the Morning Star and Curtz mines some 2 miles to the north-northeast (see figure 4). This is a major zone of shearing and silicification that extends along the east side of the Monitor-Mogul district, but much more detailed geological work needs to be done to determine the major structures here and their relationships to metal mineralization. The ore is highly altered, much of it being soft and clayey. It contains disseminated pyrite, chalcopyrite, galena, and in places chalcocite.

### Silver Hill prospects

Some prospects about a mile south of Monitor Canyon on the north flank of Silver Hill were prospected and developed on a small scale during the 1960s. They are located in sec. 5, T. 9 N., R. 21 E., M.D.M. Several moderate-sized zones of alteration and silicification in andesite tuff breccia occur which, in places, contain disseminated pyrite and minor amounts of other sulfides. One of these prospects is developed by a 50-foot northwest-trending adit, while others are developed by pits and open cuts. They are accessible by a steep dirt road that extends east from Ebbetts Pass highway about a mile south of its junction with Monitor Pass highway.

### Zaca (Advance, Colorado, Tarshish) mine, by James R. Evans

*History.* This famous and productive mine was one of the first to be located in Alpine County. It is a consolidation of two adjacent mines once known as the Advance and the Colorado. L. L. Hawkins, rancher and mining engineer, claimed to have made the discovery of silver ore along Monitor Creek on Colorado Hill at or very near the site of the present mine workings in 1857. The discovery was originally known as the Tarshish mine. By 1866 the mine was purchased (from Hawkins?) by the Schenectady Gold and Silver Mining Company, New York. At that time an indefinite amount of tunnel work was done. In 1867 news of a rich strike at the Tarshish mine was recorded by the *Silver Mountain Bulletin* (April 1867):

> "We saw a piece of the ore, of about a pound in weight, on Thursday evening, which was nearly all a mass of antimonal silver. We understand that an assay by Mr. Graff, gave $150 in gold, and over $800 in silver to the ton."

Unfortunately, high-grade ore like this came only in local areas, and the owners also had trouble in milling and processing the complex sulfide ore. These very high assays, however, kept alive hope of finding another bonanza such as that at the Comstock Lode near Virginia City, Nevada. In fact, another strike of rich ore in the late summer of 1870 by the Schenectady Company prompted the following statement from the *Alpine Miner* (September 1870):

> "Well the county is safe now without a doubt, for this soft ore, without further reduction works than a simple system of concentration, is convertible into sack sulphurets worth 75 cents to $1 per pound. Above, below, and on all sides the Tarshish is proving to be a great and continuous mine, and anybody who doubts the future prosperty of Monitor would see cause to doubt that of the United States of America."

Monitor was a mining town established in 1863 in Monitor Canyon just east of the discovery at the Tarshish mine. It was named in honor of the famous ironclad ship of the Civil War. Monitor thrived because of British investors who controlled many of the mines in Alpine County until about 1880.

A 20-stamp mill and chlorination processing plant, which cost an estimated $70,000, was built in 1871 or 1872 by the Schenectady Company at Monitor. Apparently the Washoe process was used for silver recovery, but unfortunately, less than half of the assay value of the ore was recovered. This inefficient process plus the additional panic created when the United States discontinued coinage of silver dollars and demonetized silver resulted in a mine shut-down by the end of 1873. In November 1876 the Tarshish or Schenectady mill was sold by the sheriff on a judgment for B. E. Hunter of Monitor for $6,544 plus costs (*Alpine Chronicle,* November 1876).

Logan (1921, p. 402) reported that Peter Curtz opened the mine in 1879 and operated it for one year. Chlorination processes were used on the ore, and bullion recovered was 91 to 95 percent of the assay value of the concentrates. Concentrates ranged in value from $20 to $900 a ton and averaged $585, of which 38 to 43 percent was gold and the remainder silver. Ore, however, averaged only $12 a ton.

The record of mine activity from 1876 to 1920 is sketchy. It was reported inactive in 1888 (Irelan, p. 38) and 1914 (Eakle, 1919, p. 23 and 25), but some "recent" mining activity was reported by Eakle. Logan (1921, p. 401) writes that Mr. DuBoise held a lease and option on the property about 1912, and took out several thousand dollars worth of ore from the DuBoise stope in the Advance tunnel in one year. High-grade ore was shipped to an unnamed refinery, and low-grade was processed at the Colorado mill (same as the Schenectady mill?). The ore occurred in bunches and was associated with pink and black manganese minerals. A. M. Dahl, J. H. Pearson, and A. L. Stewart of Markleeville and G. P. Merrill of Woodfords were the owners in 1920. They "ran" a 40-foot raise on a 1-inch stringer of sulfide ore adjacent to the DuBoise stope. Small shipments were made in the summers of 1920 and 1921 and are reported in table 4. The mill was removed in 1921.

The name "Zaca" may have been taken from the large yacht *Zaca* that belonged to Templeton Crocker, a noted San Francisco financier, who apparently had an interest in the mine during the 1930s (Francis Frederick, personal communication, 1965).

Continuous production was reported from the mine from 1931 to 1941 although ownership is not known. By 1960, the Siskon Corporation, Box 889, Reno, Nevada, owned the property and had leased it to the present (1973) operator Claude Lovestedt, who began exploration and development work.

Under option, the W. S. Moore Company of Reno, Nevada, trenched and drilled a few hundred feet on the top of Colorado Hill over the underground workings in 1963 and 1964. They hoped to block out sufficient ore of mining grade to develop the area by open cut and bench quarry methods but have since removed all equipment. Underground mining continued in the Colorado tunnel under the direction of Claude Lovestedt. From 1962 to 1966, high-grade silver-gold ore assaying from about $40 to as much as $300 per ton was

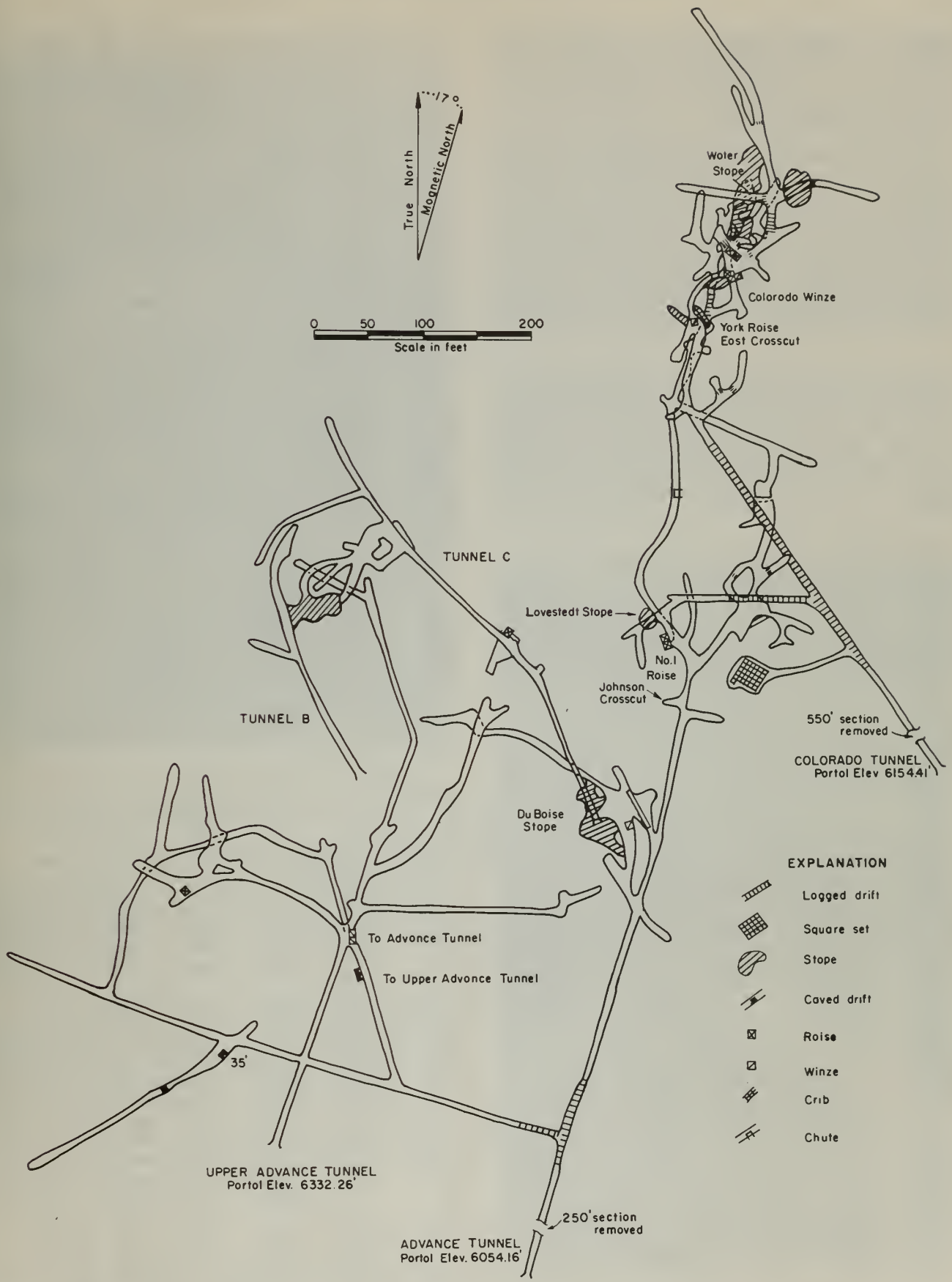


Figure 5. Composite level map of the Zaca gold-silver mine. *After Evans, 1966.*

mined from overhand stopes in the tunnel, sacked, and shipped to the American Smelting and Refining Company's smelter at Selby, California. Assays from drill cores adjacent to the stopes showed values that ranged from $0.10 to $100 a ton.

From 1967 through 1969, on an intermittent basis, Bruce Wachter, a graduate student at Stanford University, worked in the Monitor district. His dissertation—Rapid fresh and altered rock-analysis for exploration reconnaissance: Infrared absorption applications in the Monitor district, California—was completed in 1971. Part of his study was a cooperative venture with the U.S. Bureau of Mines. The Bureau drilled one 500-foot core hole (inclined 40° N 30°W) by the portal of the Lower Advance tunnel.

From 1970 through 1972, the Parnasse Company, Scottsdale, Arizona, did extensive exploration work around the Zaca mine area. Five vertical core holes were drilled, four just over 2,000 feet and one about 1,600 feet. Surface geochemical sampling was done prior to drilling. The Parnasse Company has since removed all equipment and released all interest in the property.

Tunnels B and C and an extension of the Upper Advance tunnel were done from 1968 to 1973 by Claude Lovestedt. In October of 1973, a drift was being driven in a southwest direction off the main workings of the C tunnel about 190 feet from the portal. The drift is on a sheared mineralized zone about 12 feet thick that dips about 75° to the southeast.

*Geology and Mineralogy.* The Colorado Hill area is composed of dark gray to green andesitic flows, tuff breccia, volcanic breccia, lapilli-tuff, and agglomerate of Late Tertiary age, which are intruded by light colored and prominently flow banded rhyolite wall rocks that have been intensely altered and silicified. Outcrops of rhyolite are striking in appearance and locally mineralized. Lindgren (1911, p. 191) described them as: "white, yellow, and red outcrops consisting of jaspery and chalcedonic rocks as well as kaolin. In places the rocks are rich in sulphides, principally pyrite, but also argentite, and various rich silver antimonites. Zinc-blende, chalcopyrite, pyrargyrite, enargite, and galena also occur. No well defined veins could be seen."

Eakle (1919, p. 9-14) also discussed the vividly colored mineralized rocks and noted several other minerals in the Monitor-Mogul area not mentioned by Lindgren: gold, polybasite, stephanite, stromeyerite, and tetrahedrite. He mentioned the occurrence of rhodochrosite as a gangue mineral, typically with silver-rich minerals, and that it weathered readily to form black stains on outcrops. Eakle also noted the absence of definite veins and walls within the mineralized rocks.

Gianella (1938, p. 341, 345-347) described minute acicular crystals of hübnerite (MnO, 23.6%; FeO, 2.38%; $WO_3$, 73.97%) in specimens from the Zaca mine. It was found encrusting ore minerals, drusy quartz crystals, and on quartz crystals filling vugs. Mill superintendent (1937) O. J. Benstron felt that hub-

*Table 4. Production of the Zaca mine from 1920 to 1968*.*

| Year | Crude ore (tons) | Recoverable metals | | | | | Concentrates (tons) | Concentrates produced | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Gold (oz) | Silver (oz) | Copper (lbs) | Lead (lbs) | Zinc (lbs) | | Gold (oz) | Silver (oz) | Copper (lbs) | Lead (lbs) | Zinc (lbs) |
| 1920 | 1 | 2 | 109 | | | | | | | | | |
| 1921 | 1 | 1 | 58 | | | | | | | | | |
| 1931 | 1 | 1 | 44 | | | | | | | | | |
| 1932 | 26 | 2 | 92 | | | | 6 | 9 | 684 | 55 | 140 | |
| 1933 | 1,400 | | | | | | 7 | 65 | 3,118 | 404 | 1,230 | |
| 1934 | 142 | 1 | 125 | | 115 | | 10 | 35 | 3,362 | 261 | 598 | |
| 1935 | 4 | 8 | 226 | 42 | 219 | | | | | | | |
| 1936 | 250 | | | | | | 15 | 98 | 5,308 | | 2,236 | |
| 1937 | 2,500 | | | | | | 84 | 393 | 8,950 | 1,182 | 6,992 | |
| 1938 | 1 | 1 | 167 | | | | | | | | | |
| 1939 | 510 | | | | | | 17 | 37 | 4,141 | | 1,102 | |
| 1940 | 3,364 | | | | | | 21 | 409 | 1,054 | 116 | 596 | |
| 1941 | 423 | | | | | | 5 | 127 | 322 | | | |
| 1944 | 9 | 15 | 671 | 26 | | | | | | | | |
| 1960 | 152 | 47 | 2,176 | | | | 3 | 31 | 1,006 | 45 | 247 | 267 |
| 1961 | 100 | | | | | | 0.1 | 10 | 56 | | | |
| 1962 | 1,800 | | | | | | 60 | 434 | 15,851 | 946 | 4,834 | 5,566 |
| 1963 | 2,500 | | | | | | 93 | 709 | 24,864 | 1,152 | 6,685 | 7,907 |
| 1964 | 535 | 297 | 10,559 | 261 | 1,518 | 2,363 | 25 | 58 | 2,148 | 50 | 382 | 523 |
| 1965 | 2,700 | | | | | | 71 | 634 | 19,815 | 786 | 3,968 | 5,021 |
| 1966 | 2,500 | | | | | | 52 | 302 | 10,131 | 539 | 2,622 | 4,339 |
| 1967 | 1,600 | | | | | | 22 | 87 | 3,618 | 267 | 1,541 | 1,584 |
| 1968 | 3,040 | | | | | | 30 | 145 | 21,666 | 314 | 1,620 | 1,502 |
| Totals | 23,559 | 375 | 14,127 | 329 | 1,852 | 2,363 | 496.1 | 3,583 | 126,092 | 6,117 | 34,793 | 26,709 |

*From U.S. Bureau of Mines records and published with permission of the mine owner.

Photo 19. Colorado adit at the Zaca gold-silver mine, Monitor district, as viewed from the south. The crest of Colorado Hill is to the left. Altered silicified volcanic breccia is to the left, and unaltered rock is on the right.

nerite was an indicator of high-grade ore and at times was so abundant as to form a brownish band on the concentrating table. Quartz and rhodochrosite were described as gangue minerals by Gianella (1938, p. 342-343). Locally, the rhodochrosite contained cavities lined with clear quartz crystals.

Three main rock types are exposed in the immediate area of the Zaca mine: dark gray finely porphyritic andesitic basalt, white and yellow to reddish-brown rhyolite locally showing abundant thin ribbons of gray quartz and some blocks of whitish-gray lapilli-tuff breccia, which apparently have been caught up in the rhyolite during its intrusion. The intrusive contact between andesitic basalt and rhyolite is well exposed at the portal of the Colorado adit and in parts of the Colorado, Advance, and Upper Advance adits. Locally, contacts between these rocks are sheared.

Colorado Hill is largely covered with talus and slope wash, but on the south slope prominent "ribs" of rhyolite and rhyolite-breccia are exposed and are readily visible from the Monitor Pass road. "Ribs" trend north and are as much as 50 feet in outcrop width, a few tens of feet in maximum height, and from a few to several hundred feet long.

Bright colors of the silicified rocks are a result of oxidation of sulfide grains and the formation of sulfuric acid. The acid has attacked the rock, leaving iron and manganese stains along seams and fracture planes. Cube- and prismatic-shaped cavities that contained pyrite and other sulfide minerals are common, and some are partially filled with a residue of hydrous iron oxide. In places, as much as 50 percent of the rhyolite is composed of gray quartz bands ranging in thickness from a fraction of an inch to as much as 1 inch and occasionally more. Material between the bands of gray chert is white and locally shows phenocrysts of sanidine (?) locally altered to clay.

Rhyolite in the underground workings is gray to white and contains fresh disseminated sulfide minerals. Locally, areas are strongly mineralized with pyrite, silver-rich tetrahedrite, galena, and polybasite with minor free gold and silver. Argentite, chalcopyrite, arsenopyrite, sphalerite, and enargite may be present. Mineralized areas occur in soft clay pockets a few inches to several feet in longest dimension parallel to and

Photo 20. View of Zaca mine, Monitor district, looking east showing mine yard and Monitor Pass highway. Mill is in upper center.

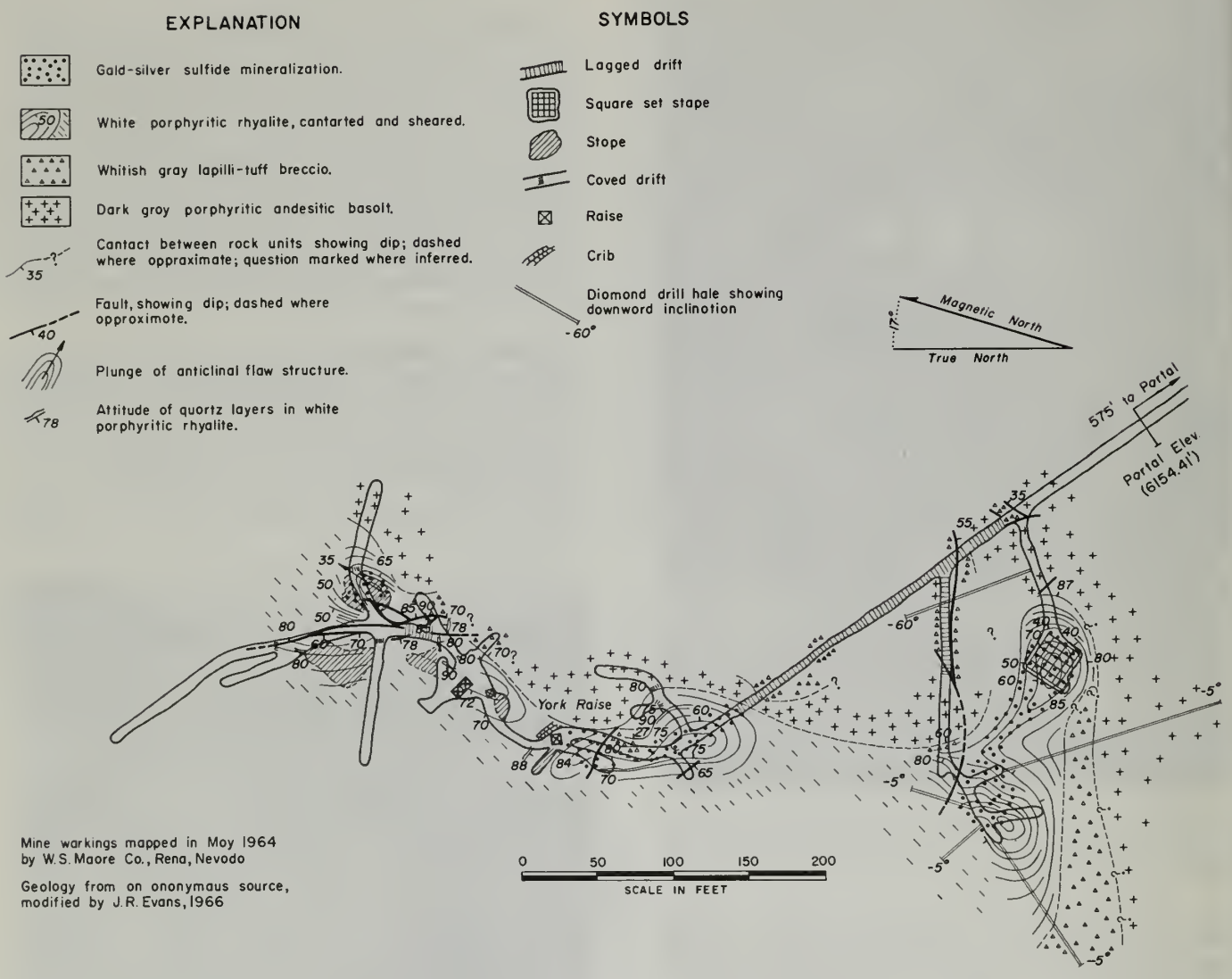


Figure 6. Geologic sketch map of part of the Colorado tunnel, Zaca mine.

crosscutting quartz banded zones and in soft friable cores of anticlinal structures. Since 1960, the bulk of high-grade ore has come from the cores of these anticlinal structures, and lower grade ore from the flanks. Many cavities occur in the rhyolite and are filled with gray euhedral quartz crystals as much as three-quarters of an inch long. Most crystals, however, are much smaller. Crystals of rhodochrosite, hübnerite, pyrite, and silver-bearing sulfide minerals have been deposited upon the vuggy quartz, testifying to the late stage development of mineralization.

*Mining Operations and Water Use.* Ore is trammed from the workings to surge piles near the portals of each tunnel and transported by a 10-ton truck to the mill on the south side of Monitor Creek adjacent to the Monitor Pass highway. The mill flow-sheet is shown in figure 7. Concentrate from the complex ore is shipped after milling to the American Smelting and Refining Company smelter at East Helena, Montana.

Waste discharge requirements for the Zaca mining and milling operation were adopted by the Lahontan Regional Water Quality Control Board in 1962 and revised in 1968. After the valuable metals have been recovered in the mill, a slurry of ground rock and water is discharged into two ponds operated in a series for the settling of waste solids. The water from the second or lower pond filters slowly into the ground. No water is discharged into Monitor Creek.

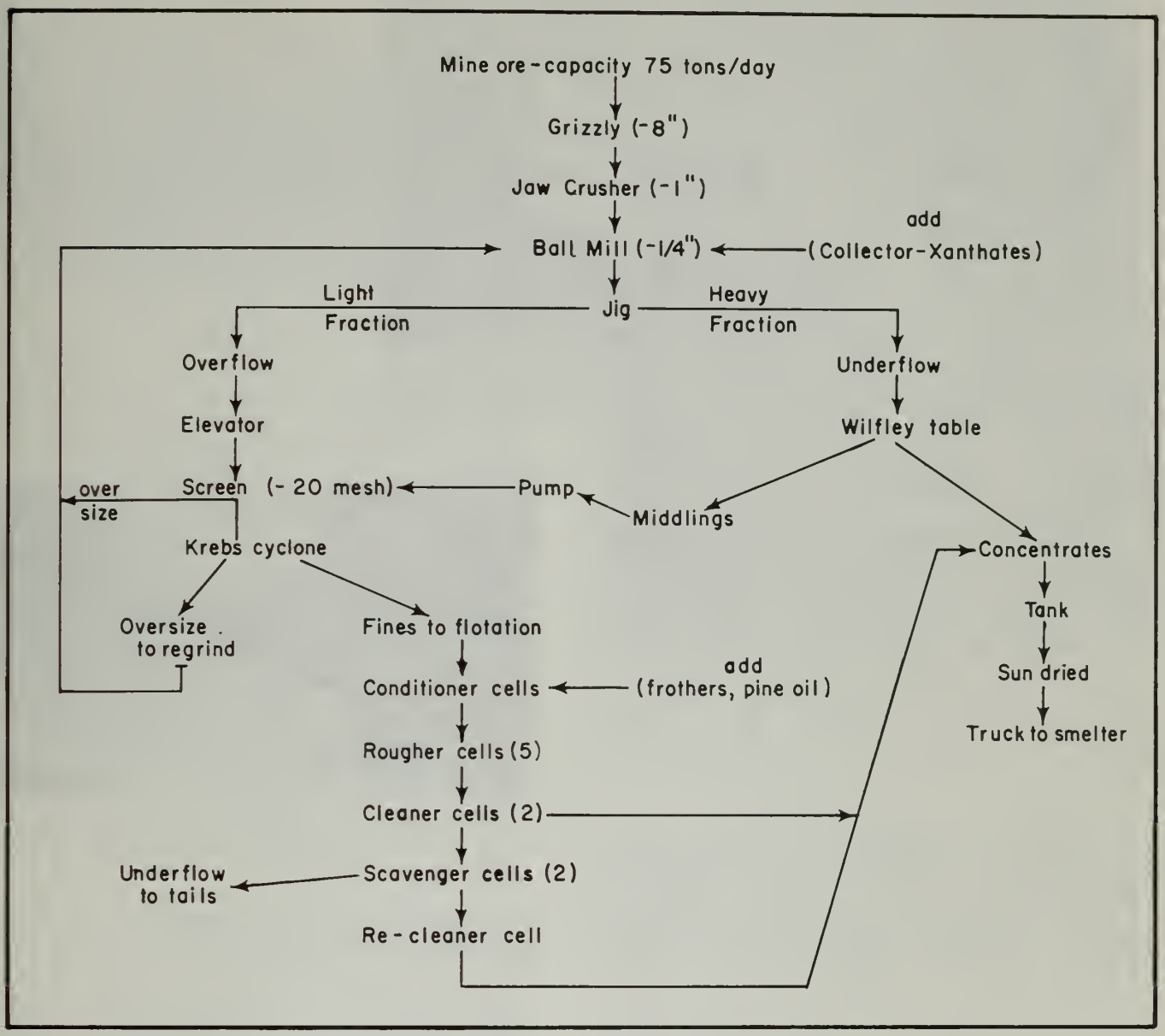


Figure 7. Flow sheet of the Zaca mill.

Photo 21. Mill at the Zaca gold-silver mine, Monitor district. Dump at left is from the south-trending adit of the Red Gap mine. Camera facing southeast.

## SILVER KING DISTRICT

The Silver King district is in the southeastern part of the county near the confluence of Silver King and Snodgrass Creeks. It is accessible by a trail that extends south from Silver King Valley and another that extends northwest down Snodgrass Creek from the Coleville pack station. The area was prospected for gold and silver during the "boom" of the 1860s, and there may have been a minor output of these metals. A small settlement existed here for a few years. The area has been prospected in recent years, including small-scale prospecting for tungsten at the Snodgrass Creek prospect (see section on Tungsten).

A few narrow pyrite and galena-bearing quartz veins and bodies of schist occur which, in places, contain small amounts of gold and silver. The veins and schist bodies are part of a roof pendant of metamorphic rocks that is enclosed by granite and granodiorite. The area of mineralization extends eastward into Mono County. Several small prospects are developed by short adits and shallow open cuts.

## SILVER MOUNTAIN DISTRICT

The Silver Mountain district is in south-central Alpine County about 10 miles south of Markleeville by road. The area is crossed by the Ebbetts Pass Highway. Extensive prospecting and development work was done in the district during the "boom" of the 1860s and early 1870s, and Silver Mountain City was the largest town in the county (see section on History). A very large number of mining claims was located in those times (see table 3 and figure 3). Huge sums were spent in driving long tunnels and in erecting elaborate but largely unsuccessful reduction works and mills. Several mines were controlled by the Isabella, or Isabel, Mining Company of London, England; Lewis ("Lord") Chalmers was resident manager. The company failed after sustaining huge losses. Chalmers' old mansion stands today and is a private home.

Photo 22. Ruins of chimney at old smelter several miles east of site of Silver Mountain City. The Chalmers mansion is just to the left, and the remains of the furnaces are on the extreme left under the trees.

The value of the total output of the mines in this district is unknown, but it is doubtful if it exceeds $300,000. The principal sources of gold and silver were the Exchequer, I.X.L., and Pennsylvania mines. Only small-scale prospecting has been done in recent years—largely in the vicinity of Raymond Meadows to the west and in I.X.L., Exchequer, and Lady Franklin mines in Scandinavian Canyon north of the site of the old town.

The gold- and silver-bearing deposits occur both in silicified zones in altered volcanic rocks and in quartz veins or veins of silicified breccia in granitic rocks or in volcanic rocks. Those that occur in granitic rocks are in the western portion of the district. In the silicified zones in volcanic rocks, the gold and silver are associated with disseminated pyrite and smaller amounts of other sulfide minerals. In addition, small amounts of pyrargyrite, argentite, and other silver-bearing

Photo 23. Zone of alteration and silicification in volcanic rocks in the Silver Mountain district looking northeast. Ruins of old jail at site of Silver Mountain City are in the right foreground.

minerals are present. In the quartz veins the gold and silver are associated with pyrite and chalcopyrite. Some of the silicified and altered zones in the volcanic rocks are extensive (see photo 23), but as yet no systematic studies have been made to determine their size and distribution and the distribution of minerals of value. Silver Mountain Peak is partly composed of silicified volcanic rock.

### Exchequer mine

The Exchequer mine is at the head of I.X.L., or Scandinavian, Canyon and is just northwest of the I.X.L. mine. The property consists of four claims: the Acacia, Buckeye, Exchequer, and Saugatuck located in secs. 8, 9, and 16, T. 9 N., R. 20 E., M.D.M. The claims were located during the "boom" of the early 1860s. Some production was recorded from high-grade ore that was processed elsewhere.

Later, the claims came under the control of the Isabella Mining Company of London, England. Vast amounts of money were spent. Some reports indicate as much as $500,000 was spent on the mine, mill, and surface plant. Some ore was treated at a 16-stamp mill and roasting furnace located to the south by Silver Creek, but the recoveries were small. Some prospecting work was done in the mine in 1967-70 by Carl Munck.

Three roughly parallel north-northwest-striking ledges or veins of silicified breccia exist in altered volcanic rocks. The veins have nearly vertical dips and an average thickness of 5 feet. In places, varying amounts of gold- and silver-bearing sulfides are found. As in other mines in the district, the complex sulfide or "rebellious" ores were extremely difficult to concentrate. The mine is developed by several drift adits, including one 810 feet long on the Buckeye vein, and a 200-foot shaft.

### Isabella mine

The Isabella mine is in sec. 22, T. 9 N., R. 20 E., M.D.M., about a mile northeast of the site of Silver Mountain City. The property was developed on a major scale in the early 1870s by the Isabel or Isabella Mining Company of London, England. The Isabella "tunnel" or adit was driven 4400 feet northwest into the mountain with the hope of encountering a mineralized zone that crops out above. The adit was wide and double tracked. The company went bankrupt, and nothing has been done since. The extensive dumps that remain consist chiefly of unaltered grayish-green andesite porphyry. Minor amounts of pyrite-bearing rock are present. Some dump material has been used as road sub-base. The adit was open in 1971; foundations of buildings can still be seen, as well as an old brick-powder magazine and the ruins of a reduction works and smelter just to the east.

Photo 24. Isabella mine showing the adit portal and overgrown dump. Camera facing north. Most of the rock here is unaltered andesite.

### I.X.L.

One of the better-known mines of the Silver Mountain district, the I.X.L. is in secs. 16 and 21, T. 9 N., R. 20 E., M.D.M. Located in I.X.L. or Scandinavian Canyon about 2 miles north of the town site of Silver Mountain, it is accessible by a steep road. The property consists of five claims including the Ophir Lode and a mill site by Silver Creek in sec. 22, T. 9 N., R. 20 E.

The mine was originally worked in 1861, and shortly afterward a high-grade ore body that yielded $50,000 to $60,000 worth of gold and silver was discovered. Later, this property and the adjoining Exchequer mine came under the control of the Isabel or Isabella Mining Company. A 20-stamp mill was installed in 1876 but was never used; the ore taken from the mine was treated at the Exchequer mill. The mine was idle for many years thereafter. Some mining led to small production in the late 1930s. The mine was prospected in 1970-71 by Carl Munck of Al Tahoe.

The deposit consists of a north-striking vein of silicified breccia a few feet thick. It contains pyrite and a variety of sulfide and silver-bearing minerals including pyrite, galena, chalcopyrite, argentite, proustite, pyrargyrite, and stibnite. Although reported assays were high, mill recoveries were very low because of the great difficulty in treating the complex ores. The ore

Photo 25. I.X.L. mine, Silver Mountain district, showing dumps and stacked mine timbers. The adit portal is behind the bushes on the lower right. Camera facing west.

bodies were small and erratically distributed; much of the vein material that was stoped was barren or nearly so. The mine is developed by a 2000-foot north-trending main drift adit, from which a 400-foot winze has been sunk. In addition, there is an upper adit that is 500 feet long. The adits were open in 1971.

### Raymond Meadows Creek mine

This mine, which probably has had other names, is just north of the Ebbetts Pass Highway by Raymond Meadows Creek and about 3 miles southwest of the site of Silver Mountain City. It is in W1/2 sec. 32, T. 9 N., R. 20 E., M.D.M. Although the mine was idle at the time of several visits (1966 and 1969), it apparently is intermittently worked.

A quartz vein strikes approximately N 45°W with a nearly vertical dip. The vein is irregular and consists of glassy and white to gray quartz and cemented siliceous breccia. Pyrite is abundant in places, and many crystal-lined open cavities are found. The vein has an average thickness of 5 feet. Country rock is granodiorite, but dark-green diorite and gneissic rock occur in the area. The mine is developed by an open southeast-trending drift adit and several open cuts on the hill above to the southeast. The adit was open in 1969. Several buildings stand on the property including a small sawmill.

Photo 26. Raymond Meadows Creek mine, Silver Mountain district. Camera facing southeast. The rocks in the area are mainly granodiorite.

A small prospect was seen about a quarter of a mile to the south by the Ebbetts Pass Highway where a pyritic, flat-dipping quartz vein penetrates exfoliated granodiorite. It is developed by a 10-foot adit.

## OTHER GOLD- AND SILVER-BEARING AREAS

Gold and silver are found in a number of other scattered areas in the county. Small amounts were recovered from several of the mines in the Hope Valley tungsten district (see also section on Tungsten). Probably the best-known and most productive mine outside any of the recognized mining districts in the county is the Lost Cabin mine.

Several limonite-rich zones in the western part of the county locally contain traces of gold and silver. The limonite is derived from the weathering and leaching of pyrite and other sulfides that are disseminated in schist, granitic rocks, and volcanic rocks. Some of these zones were prospected on a small scale at various times in the past. One such zone is on the north side of Red Lake and another is north of Upper Blue Lake.

### Lost Cabin mine

The Lost Cabin mine is about a mile south of the Carson Pass Highway (State Highway 88) on the ridge west of Woods Lake. It also has been known as the Woods Lake mine. The mine is in W1/2 sec. 28, T. 10 N., R. 18 E., M.D.M. It is accessible by a steep dirt road that branches off from the Woods Lake road half a mile north of the lake. From 1932 to 1962, the property was leased and operated by Clyde Mailske of Jackson, California. The mine is believed to have been first worked during the 1860s and 1870s. Moderate activity was reported again during the 1920s and 1930s with some recorded production of gold, silver, copper, and lead (see table 5). It has been intermittently prospected and developed since but with apparently little or no production.

*Table 5. Production of Lost Cabin mine*.*

| *Year* | *Ore* | *Gold* | *Silver* | *Copper* | *Lead* |
|---|---|---|---|---|---|
| 1932 | 8 tons | 20 oz. | 78 oz. | 126 lbs. | 771 lbs. |
| 1934 | 30 tons | 42 oz. | 128 oz. | 381 lbs. | 934 lbs. |
| 1936 | 150 tons | 48 oz. | 55 oz. | 143 lbs. | 1,125 lbs. |
| 1936 concentrates | 4 tons | 14 oz. | 83 oz. | 206 lbs. | 571 lbs. |
| 1939 | 4 tons | 8 oz. | 31 oz. | 61 lbs. | 431 lbs. |
| Totals | 196 tons | 132 oz. | 375 oz. | 917 lbs. | 3,832 lbs. |

*From U. S. Bureau of Mines records; published with permission of Clyde Mailske, operator.

Two parallel west-striking quartz veins a few feet apart dip vertically. A third vein is flat-dipping. The ore contains abundant sulfides including pyrite, chalcopyrite, and galena. Considerable fault gouge is associated with the veins. Country rock in the immediate vicinity of the mine ranges from medium-grained quartz diorite to hard, fine-grained diorite. Coarse-grained quartz diorite crops out to the north.

The mine is developed by a 700-foot southwest-trending adit, some drifts, and a shallow winze near the adit portal. The flat vein also is developed by an adit. The workings were partially accessible in 1965. A 25-ton mill is equipped with an ore bin, crusher, ball mill, and flotation cells. Several other buildings were still on the property in 1965.

Photo 27. Buildings at Lost Cabin gold-silver mine. Camera facing southwest.

## FUTURE EXPLORATION

The logical places for an exploration program for gold and silver deposits are the extensive zones of altered and silicified volcanic rocks in the Monitor-Mogul district. In 1970, with greatly increased demands for silver, copper, lead, zinc, and mercury, it appeared that some sort of systematic exploration could be done in this district for additional reserves of these metals.

The mineralization zones at Monitor and Mogul occupy much of a 2-by-4-mile area (see figure 4) in which literally millions of tons of metal-bearing rock exist. However, only a careful and detailed exploration program can determine whether or not a large low-cost mining operation can be initiated. Such an exploration program should include detailed geologic mapping with special attention being paid to geologic structures and their relationships to ore deposition. Geochemical studies, systematic sampling, and mining and metallurgical studies also are necessary. The complex nature of the sulfide-rich ores in this district will require pilot-plant study to determine the best method of ore concentration. The rugged topography and stream courses must be considered in determining the most suitable location for open pits and waste disposal areas to prevent pollution.

Other areas offering possible exploration targets are in the Silver Mountain district. Although the mines here were far less productive than the mines at Monitor-Mogul, several extensive zones of altered and silicified volcanic rocks are present. No silicified or altered zones of silicified rock have been encountered in the Silver King and Hope Valley districts.

## Iron

Small amounts of iron are found in Alpine County. Hematite ($Fe_2O_3$), a reddish-brown mineral, occurs in the Hope Valley district in tactite rock associated with tungsten and pyrite. Limonite ($Fe_2O_3 \cdot nH_2O$), which ranges from yellowish to reddish brown, occurs as stains or in cavities and veinlets in the Monitor-Mogul district. It has developed from the oxidation of the sulfide minerals.

## Lead

Some lead concentrate has been produced in Alpine County, most of it having been recovered as a by-product of gold and silver mining in the Monitor-Mogul district. At the present time (1971) it is being produced at the Zaca gold-silver mine in this district (see also section on Gold and Silver).

Galena (PbS) is the only ore mineral of lead that has been found thus far in the county. This mineral occurs as fine- to medium-grained cubic lead-gray crystals in the zones of alteration and silicification in Tertiary volcanic rocks. It occurs either in disseminated form in these rocks or in thin veins or as clots of crystals in small quartz-lined cavities. The galena is commonly associated with pyrite, enargite, chalcopyrite, sphalerite, and other sulfides. It nearly always contains silver and is usually a good indicator of values in the ore deposits in the Monitor-Mogul district.

Galena also is a minor constituent in the ores in the Silver Mountain, Silver King, and Hope Valley districts, although there has been no recorded production. Some galena has been produced as a by-product from the Lost Cabin gold-silver mine, which is in the northwestern part of the county.

## Limestone

Several deposits of crystalline limestone are known in Alpine County. Three deposits are shown on the Walker Lake sheet of the State Geologic Map (Koenig, 1963). Two are located east of the Burnside Lake Road, and the third is just east of the Carson Pass highway near Red Lake Creek. Little is known of the extent or purity of these deposits. On the Walker Lake geologic map sheet, they are shown as lenticular marble bodies interbedded with schist and quartzite. Only a detailed study that should include geologic mapping and systematic sampling would determine the economic potential of these deposits.

At Grover Hot Springs a considerable amount of calcareous travertine has been deposited. In an early report on the mines of Alpine County, a large limestone deposit of high quality in Hot Springs Valley was mentioned (Irelan, 1888, p. 39), but this probably refers to the calcareous tufa at Grover Hot Springs.

Photo 28. Grover Hot Springs showing deposition of white calcareous tufa. Camera facing south.

## Manganese

Small amounts of manganese have been found in Alpine County, but there has been no production. Rhodochrosite ($MnCO_3$) has been found as a minor constituent of the ores in the Zaca and several other mines in the Monitor-Mogul district. It occurs as small pink or gray crystals in altered and silicified zones in volcanic rocks. After being exposed to air, the rhodochrosite commonly is altered to dark-brown manganese oxide.

## Mercury

Some mercury was produced in Alpine County in 1940 from the Mogul Peak mine. This mine is located in sec. 30, T. 10 N., R. 21 E., M.D.M., just southeast of Mogul Peak in the north end of the Monitor-Mogul mining district. The deposit was discovered in 1939 after cinnabar-rich float was found in Mogul Canyon the previous year (Ransome and Kellogg, 1939). The mine is owned by R. W. Brune of Reno and leased by Claude Lovestedt, who also has been operating the Zaca gold-silver mine to the south. In the late 1960s, intermittent development and exploration work was done.

Cinnabar (HgS) occurs as finely disseminated red crystals in a zone of silicification and oxidation in andesite. The rock containing the cinnabar ranges from white to brick red and consists predominantly of silicified breccia that is cut by small quartz veinlets. The mineralized zone strikes to the northeast and appears to be several hundred feet wide. The mine is developed by two northeast-trending adits. The upper or main adit drifts along the mineralized zone for about 100 feet, where a 200-foot crosscut extends to the northwest. Some small areas were stoped at the junction of the adit and the crosscut. The lower adit, which is 500 feet down the hill to the southeast, is about 100 feet long. There is an open cut near the portal of this adit. The remains of an old mill including a small brick furnace are still on the property near the lower adit.

Photo 29. Mogul Peak mercury mine adit portal. Camera facing northeast. The rocks are altered silicified breccia. *Photo by Fenelon F. Davis.*

Photo 30. Remains of old mill and furnace at the Mogul Peak mercury mine. Camera facing south. The bricks used in this furnace may have come from Silver Mountain City.

Several mercury prospects are developed by shallow open cuts about a mile to the east of this mine. Traces of cinnabar have been found in several other localities in the Monitor-Mogul district and at the Leviathan sulfur mine to the east.

## Mineral Specimens

A variety of mineral specimens of interest to collectors has been found in Alpine County. The area with the greatest variety and the greatest abundance is the Monitor-Mogul district; but specimen material has been found also in the Silver Mountain, Hope Valley, and Leviathan districts.

The Monitor-Mogul district is best known for the considerable variety of sulfide minerals. These minerals occur either as disseminated individual crystals in zones of alteration or in small clots of crystals, thin seams, veinlets, and in crystal-lined cavities. Occasionally large masses of sulfides occur such as the well-known body of enargite and pyrite found at the Morning Star mine. Pyrite is the most abundant sulfide; but appreciable amounts of chalcopyrite, enargite and galena are present; and smaller amounts of tetrahedrite, realgar, arsenopyrite, chalcocite, sphalerite, argentite, famatinite, polybasite, pyrargyrite, stephanite, and stromeyerite have been found. These minerals quite commonly occur in well-formed crystals, especially in cavities which may be several inches in diameter and usually are lined with a mixture of euhedral quartz and sulfide crystals.

Several interesting minerals have been found at the Leviathan sulfur mine. The native sulfur occurs as coarse shiny yellow crystals. Substantial amounts of "blue vitriol" or chalcanthite were found in the old workings. Brown crystals and masses of romerite, stalactites of melanterite, and thin seams of halotrichite also have been found at the Leviathan mine.

Several minerals occur in contact metamorphic deposits in the Hope Valley district. These include garnet, epidote, pyrite, chalcopyrite, and scheelite. Lazulite was found in bands with andalusite and rutile in garnetiferous quartzite, 10 miles south-southwest of Markleeville (Murdoch and Webb, 1956, p. 204). The exact location of this occurrence is unknown, but it is believed to be somewhere in the contact metamorphic zone that extends in a southerly direction through this district.

Sulfide minerals usually disseminated in alteration zones in andesite also are found in the Silver Mountain district.

## Molybdenum

Some molybdenum minerals have been found in the county, although there has been no recorded production. Around 1930 some molybdenum claims collectively known as the Libby group were located just south of the intersection of the Ebbetts Pass Highway and the Highland Lake road (Logan, 1931, p. 491). Molybdenum minerals also have been found near the east side of Winnemucca Lake, which is just south of Carson Pass. Here, molybdenite ($MoS_2$), in fine- to medium-sized, flat, metallic silver-colored crystals, is disseminated in granitic rocks.

## Radioactive Minerals

Although radioactive minerals have not been found thus far (1972), uranium and possibly other radioactive elements have been found in several adjacent areas in rocks similar to those in Alpine County.

The Carrigan mine, the largest source of uranium ore in California, is about 6 miles south of Alpine County in eastern Tuolumne County near Sonora Pass. The ore occurs in several near-horizontal lenticular beds of black shale up to 3 feet thick. The ore mineral is a black amorphous uranium oxide. The shale is interbedded with various types of andesite, including breccias and agglomerates, similar to those occurring in Alpine County. The mine was worked in the middle 1960s. In the middle 1950s, a number of uranium claims were located in the southeast corner of El Dorado County. This activity apparently was centered in the High Meadows area 3 miles north of Freel and Jobs Sister Peaks on the Alpine-El Dorado County line. This area is underlain by granitic rocks.

## Rock Products

### SAND AND GRAVEL

In recent years the production of sand and gravel has been a significant part of the mineral industry in Alpine County; but production statistics are not available. The largest use of these materials has been in the reconstruction of the State highway system and in building County and U. S. Forest Service roads. Smaller amounts have been used in building construction. In addition, moderate amounts of sand and gravel have been trucked north to the Lake Tahoe area in El Dorado County for use in concrete aggregate.

The principal source of sand and gravel has been the flood plain of the West Fork of the Carson River in Hope Valley. In this valley, which is up to half a mile wide, the gravel-bearing deposit is 20 feet or more deep and at least 500 acres in extent. Most of the production has been from the southern or upper end of the valley. The gravels contain sub-rounded to sub-angular pebbles of various metamorphic rocks and smaller amounts of andesite and granitic rocks. The metamorphic rocks are estimated to constitute about 70 percent of the total, the andesite about 25 percent, and granitic rocks the remainder. Most of the fragments are 6 inches or less in diameter. Sand-sized weathered material extends to 10 feet, and there is about 3 feet of overburden.

There were two operations active in 1956, both in Hope Valley. They were the Tahoe Western Concrete Company and Sutherland Company. In both operations the sand and gravel were excavated by bulldozers. At the Tahoe Western plant, the material was sent through a portable crushing, washing, and sizing plant. The various sizes went to overhead loading hoppers or were yard stockpiled. Much of the finished product was trucked 16 miles north to a concrete batch plant at Tahoe Valley. Considerable amounts were used in the

Photo 31. Sand and gravel plant of Tahoe Western Ready-Mix Company at Hope Valley. Camera facing east. *Photo by Edmund W. Kiessling.*

runways at the Tahoe Valley airport. At the Sutherland Company plant, pit-run material was screened. Oversize was stockpiled, while the undersize, which was used as sub-base, was trucked to the various construction projects in the county.

Another source of sand and gravel has been in the vicinity of Woodfords where there are flood plain and river gravels in the upper Carson Valley. At one time the Alpine County Road Department operated sand pits here. Other alluvial deposits that may eventually be of economic interest are in Charity, Pleasant, and Bear Valleys. Coarse sand derived from decomposed granodiorite is obtained from a quarry by State Highway 88 a few miles west of Woodfords (see also section on Stone). A bulldozer and a payloader are used to excavate and load the sand into dump trucks.

## STONE

This commodity includes crushed and broken stone and dimension stone. Crushed and broken stone is stone where the shape is not specified and which has uses such as in aggregate, road ballast, and riprap. Dimension stone is quarried and shaped for specific uses such as building stone and monumental stone. In all of the above uses, the stone is required to be hard, dense, durable, and fresh and can be broken easily to the specified shapes and sizes or shaped and cut with relative ease.

Both granitic and volcanic rocks have been quarried for the above uses. In recent years substantial amounts of crushed and broken stone have been used in rebuilding the State highways and in the construction of County and U.S. Forest Service roads. Several quarries in granodiorite are located on State Highway 88 west of Woodfords and on the Grover Hot Springs-Markleeville road.

The largest rock quarry in the county is located on the high bluff on the west side of the East Fork of the Carson River about 2 miles south of the junction of the Ebbetts Pass highway and the Wolf Creek road. Stone from this quarry has been used as highway sub-base and riprap. The stone is a fresh gray-colored, tough, irregularly jointed andesite porphyry that contains plagioclase and hornblende phenocrysts in a dense microcrystalline groundmass. In 1965, the quarry dimensions were 300-by-300 feet with a west face nearly 200 feet high. The stone was blasted from the face and shipped out by dump truck. Some of it was screened in the quarry.

During the gold and silver "boom" of the 1860s and 1870s, when numerous structures were being erected in the county, several quarries were opened for the production of dimension stone. The principal one was located near Silver Mountain City. A light cream-colored massive rhyolite tuff was quarried here that was used in the construction of several local buildings. The jail at this town, the ruins of which are by the Ebbetts Pass Highway, was constructed of this rock. The Alpine County Courthouse and the New Webster School in Markleeville were constructed partly of stone blocks obtained from the ruins at Silver Mountain. The numerous old foundations at the site of Silver Mountain City are composed of large well-fitted but irregularly shaped blocks of rhyolite and andesite. All appear to have been obtained locally.

Photo 32. Wolf Creek rock quarry. Camera facing west. The rock is irregularly jointed andesite porphyry. The quarry face is nearly 200 feet high.

Photo 33. Alpine County Courthouse in Markleeville. This building was constructed in 1928 of blocks of rhyolite tuff that were obtained from Silver Mountain City. Camera facing east.

## Selenium

Small amounts of selenium have been recovered as a by-product of sulfur mining at the Leviathan mine by the Anaconda Company. All of it was recovered from the residues in the sulfuric acid plant at Weed Heights, Nevada. Selenium is a member of the sulfur family, which it resembles in various forms as an element and in its compounds.

## Sulfur

Sulfur has been the most important mineral commodity in Alpine County in value of total output. All production has come from the Leviathan mine.

### Leviathan mine, by James R. Evans

*History.* The Leviathan mine is located in secs. 15 and 22, T. 10 N., R. 21 E., M.D.M., 10 miles east of Markleeville and 2 miles north of the Monitor Pass Highway. About 500,000 long tons* of sulfur valued at $14½ million have been produced from this mine (table 5). Nearly all the production came in the period 1953 to 1962 when the mine was owned and operated by the Anaconda Company, 25 Broadway, New York, New York, and Weed Heights, Nevada.

Discovery of the mine came in 1863 by Comstock Lode miners and prospectors who apparently were seeking a source of blue vitriol or chalcanthite ($CuSO_4 \cdot 5H_2O$) for processing silver sulfide ore by the Patio process at Virginia City, Nevada. At that time, an adit was driven about 400 feet into silicified and mineralized rock in search for a concentration of chalcanthite. The chalcanthite occurred, however, only as coatings, seams, and cavity fillings.

By 1869 the miners had given up any idea of extracting chalcanthite but had become interested in the showings of primary copper minerals. A copper smelting furnace and other mine machinery were shipped in from Reno, Nevada, by San Francisco investors who hoped to attract English capital to Alpine County. They were successful, as Edward Dorsett of London gained control of the mine (Alpine *Chronicle,* October 1869). By 1870 two adits were driven and 500(?) tons of 30-50 (?) percent copper ore were extracted (Alpine *Chronicle,* July 1870). In 1872 the mine was leased to Captain Bennett, and reports were still glowing about high-grade copper ore (Alpine *Chronicle,* March 1872). A significant point here is the first printed note about the mine "bottoming" in sulfur. In July 1872 the sulfur deposit was described as immense (Alpine *Chronicle*). Edward Dorsett died in late 1872 or early 1873, and information about mine ownership and operation is lacking until about 1900. At this time the mine was owned by D. Bari of Silver Creek, Alpine County, but reported idle in 1905 (Aubury, 1905). Exploration work consisted of the 400-foot adit driven through a ledge 250 feet below the outcrop, and a 700-foot adit 200 feet below the upper adit. The adits were connected by a winze.

Apparently the mine was idle until 1931 when it was optioned from Mr. Brune, Markleeville, to Western Clay and Metals Co., Los Angeles. The "old" workings were reopened by five miners (Logan, 1931, p. 491). In 1935 the mine was leased to Texas Gulf Sulfur Co. and then subleased to the Calpine Corp., Los Angeles. An experimental plant was erected for recovery of sulfur by steam liquation, and about 5000 long tons of sulfur were produced from underground workings. The main adit was at the top of the sulfur body and 3000 feet long. Several drifts, raises, and stopes explored the orebody. Underground mining was extremely hazardous because of the highly combustible nature of the sulfur. In 1941, Calpine Corp. gave up its sublease, and in 1945 Siskon Mining Corp. (subsidiary of Texas Gulf Sulfur Co.) acquired the mine.

* A long ton = 2240 pounds avoir.

*Table 6. Sulfur production from the Leviathan Mine (Courtesy of Anaconda Company).*

| *Year* | *Crude ore (long tons)** | *Sulfur content (long tons)** | *Estimated value* |
|---|---|---|---|
| 1953 | 151,549 | 37,887 | 757,740 |
| 1954 | 185,085 | 53,175 | 1,507,429 |
| 1955 | 196,541 | 58,962 | 1,671,573 |
| 1956 | 183,717 | 55,115 | 1,561,595 |
| 1957 | 168,925 | 48,144 | 1,492,464 |
| 1958 | 148,016 | 46,092 | 1,428,852 |
| 1959 | 141,513 | 42,637 | 1,365,600 |
| 1960 | 173,124 | 44,320 | 1,670,647 |
| 1961 | 173,431 | 39,889 | 1,673,609 |
| 1962 | 146,448 | 39,395 | 1,413,223 |
| Totals | 1,668,349 | 465,616 | $14,542,732 |

*2240 lb.

The Anaconda Company purchased the property in 1951 with the intent to develop an open pit mine. The company needed sulfur to manufacture sulfuric acid for leaching secondary or oxide copper ore at its newly opened Weed Heights mine near Yerington, Nevada. Stripping of overburden was done in 1952 and early 1953 by the Isabel Construction Co., Reno, Nevada. Open pit mining of the sulfur ore was begun in July 1953 and continued until 1962. Sulfur ore was trucked 60 miles to Weed Heights in 17 (23-cubic yard) belly dump trucks. Hauling was done under contract by Wells Cargo Co., Reno, Nevada.

The mine was closed in 1962 for several reasons. Ore away from the existing open pit is under an increasingly thick overburden, and mining costs were certain to rise. Also, the walls of the existing pit were caving and needed shaving to shallower slopes. To add to these problems, the mine at Weed Heights had been worked down into primary sulfide ore (chalcopyrite), which does not require acid leaching. Even with these problems, if a nearby demand for sulfur could have been found, the mine might have been kept in operation. In January 1963 the property was sold to W. Chris Mann, County Clerk, Markleeville, Alpine County. No production was reported from 1963 to 1971. The mine is accessible by a wide dirt road that extends west from U. S. Highway 395, 12 miles south of Gardnerville, Nevada, and then south up Leviathan Creek to the mine. Another dirt road extends 3 miles north to the mine from the Monitor Pass Highway.

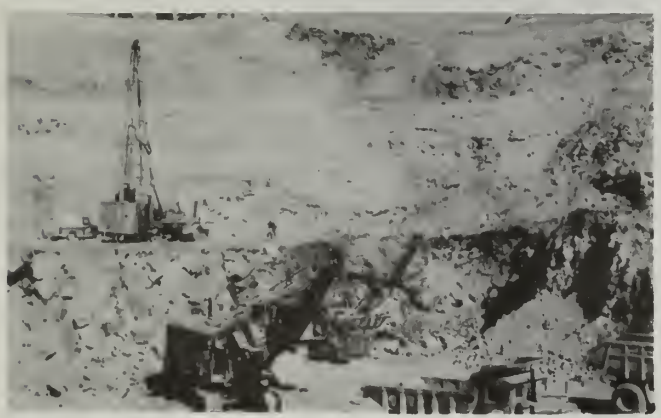

Photo 34. Mining operations at the Leviathan sulfur mine in 1962 showing rotary drill, power shovel, trucks, and benches. *Photo by Edmund W. Kiessling.*

*Geology and Mineralogy.* The sulfur ore body occurs as a faulted, flat northwest-trending elliptical lens about 90 feet in maximum thickness and at least 2400 feet long. As reported in the History section, sulfur does not outcrop at the surface but was first discovered through underground mining at about 200 to 300 feet below the ground surface, while prospecting for chalcanthite.

Sulfur has impregnated the lower part of a lake-deposited(?) tuff bed and part of the underlying andesite(?). The tuff is white to yellowish brown and locally bedded. Tuff visible in the walls of the present pit is mostly white and massive. Locally it is replaced by highly irregularly shaped areas of gray opaline material several feet in length. Part of the tuff contains fine-grained crystals of kaolinized feldspar. These crystals are more obvious in the gray replacement areas as relicts. Possibly the andesite(?) is completely opalized tuff. It is remarkably similar to those areas in the white tuff.

Photo 35. Mining operations at the Leviathan sulfur mine in 1962 showing drop ball used for secondary breaking of large fragments. Camera facing east. *Photo by Edmund W. Kiessling.*

Tuff is very porous and provides an excellent sponge for mineralization. In this unit most sulfur was distributed uniformly, although it locally occurred in clots and veins. The sulfur usually is coarsely crystalline and glossy. Sulfur in the andesite(?) or opalized tuff is less uniformly distributed. Mineralized rock exposed in the west wall of the main pit is broken, and bright yellow sulfur fills fracture planes rather than pores as in the tuff. Marcasite, pyrite, and chalcopyrite occur in discontinuous bunches mostly along the upper and lower margins of the sulfur ore body but also in small quantities throughout the body.

Mineralized tuff contains as much as 70 percent sulfur but averages about 35 percent. Mineralized andesite has a wide variability in sulfur content but averages about 25 percent. Thick masses or veins of pure sulfur occur in both rocks but only rarely. Contacts between mineralized tuff and nonmineralized tuff are quite sharp, whereas contacts in the andesite are gradational over 10 to 15 feet.

Several veins of pure sulfur 1 to 2 feet thick were noted in the lower underground workings by Anaconda Company geologists. The veins cut tuff.

An agglomerate unit about 120 feet in maximum thickness overlies the tuff. Clasts are rounded to angular fragments of brown, gray, and black largely porphyritic volcanic rocks. The clasts are poorly sorted and range roughly from 1 foot to a fraction of an inch in longest dimension. They are set in a gray tuffaceous sandstone matrix. This unit greatly resembles typical rocks of the Mehrten Formation (Pliocene) of the western Sierra Nevada foothills. Overlying the agglomerate is an unmineralized white tuff about a hundred feet in maximum thickness. It thins rapidly and pinches out (figure 8). Prior to pit development, a silicified "cap rock" rested on the tuff. It was as much as 160 feet thick but thinned markedly away from the center of the ore body.

The chemical data were supplied by The Anaconda Company. A typical analysis of a sample from a truckload lot of mineralized tuff is: insoluble (mostly $SiO_2$), 49 percent; iron, 6 percent; sulfur, 33 percent; soluble salts, 12 percent; and traces of $Al_2O_3$, MgO, and CaO.

The following is suggested as the possible origin for deposition of the sulfur.

1. After faulting and the development of channelways, the tuff was altered by ascending silica-rich solutions in part derived from an underground source, presumably an unexposed magma. The part, if any, which heated ground water may have played in mineralization is not known.

2. Contemporaneously, and closely following silicification, iron-copper-bearing and hydrogen sulfide-charged fluids were channeled through fractures such as those once exposed in the underground workings.

3. Hydrogen sulfide gas was oxidized with deposition of sulfur and formation of water.

4. Tuff served as a sponge for fluids which spread laterally through the porous and permeable material.

5. Deposition of sulfur in the pores eventually caused the tuff to seal and resulted in more lateral and downward spreading of mineral-charged fluids. No widespread mineralization is known below the zone shown in figure 8. Deep drilling could prove otherwise. The last phase of sulfur deposition consisted of fracture filling in the andesite(?) and filling of the channels with sulfur.

6. Significance of silicified "cap rock" which was removed during pit development is undetermined but probably is related to the period of silicification. Many other silicified outcrops where sulfur is not known are found in the area.

7. Time of deposition was probably in the middle to late Tertiary period.

8. Oxidation of copper and iron sulfides produced the following sulfate minerals: chalcanthite ($CuSO_4 \cdot 5H_2O$); iron-chalcanthite ($FeO \cdot CuO \cdot 2SO_3 \cdot 10H_2O$); halotrichite ($FeSO_4 \cdot Al_2(SO_4)_3 \cdot 22H_2O$); melanterite ($FeSO_4 \cdot 7H_2O$); romerite ($FeSO_4Fe_2(SO_4)_3 \cdot 14H_2O$). Gary (1939) identified all these minerals in the underground workings. Some or perhaps all of these minerals are forming on the pit floor where ground or surface water is impounded.

*Mining Operations.* A maximum of 350 feet of overburden was stripped from the orebody by the Isabel Construction Co. Thirty-five-foot benches were maintained in stripping and 15-foot benches used for mining the ore body. In 1970 the pit was roughly 2000 feet long, 1000 feet wide, and 400 feet deep. The total waste-to-ore ratio was generally about 11:1, although locally it was only 4:1. Primary blasting of the orebody was done in the 1960s with Dupont gelatin. Prior to this time, a special blasting compound was used. It was composed of 80 pounds of ammonium nitrate, 1 gallon of molasses, and 1 gallon of water. This seemingly odd mixture served well, as it did not ignite the highly combustible sulfur.

Blasted ore was loaded by a power shovel into Euclid trucks for a half mile haul to the crushing plant west of the pit area. Ore was dumped over a 21-inch grizzly with automatic oversize reject. Oversize was broken by a 2300-pound drop ball for return to the grizzly. Material from the grizzly went to a 5-inch jaw crusher (300 tons/hr) and then to four 100-cubic yard storage bins by conveyor belt. Overflow from the bins was stockpiled in the yard. From the storage bins, ore was trucked 60 miles to Weed Heights by Wells Cargo Co. belly-dump trucks. At Weed Heights it was crushed to -3 inches by jaw crusher and -1 inch by a Nordberg short-head crusher and pulverized in four rod mills. Fines were roasted at 1100-1250°F to produce $SO_2$ which was cooled in a water-spray chamber and then passed through a series of cyclone precipitators to remove dust. The gas was then scrubbed in a Peabody scrubber, passed through Cotrell mist precipitators, and sent to a contact sulfuric acid plant. A minor amount of selenium was recovered during treatment of the sulfur. Sulfuric acid was piped from the plant to copper ore treatment vats.

When active, the mine was operated for about six months out of the year, roughly May through October, because of the rigorous winter conditions associated with elevations above 7000 feet.

A significant problem connected with this mine is the northward flow of Leviathan Creek through the mine dumps and spoil area. Also, there is seepage from the partly caved tunnel which contains toxic material, and direct precipitation percolates through the dump and spoil area carrying dissolved waste products into the creek. According to studies made in 1970 by the State Water Resources Control Board, the condition of the waters in Leviathan Creek is such that beneficial uses are precluded.

When the mine was active, a settling pond was made to impound water north of the dump. Moistened lime was sprayed over the pond to neutralize the acid water. Iron was precipitated out, dredged, and stockpiled. Also, an earthen dam was built upstream from the dump and a quarter-mile pipeline connected the dam with the area downstream from the dumps. Overflow from the dam that went through the dumps in winter did not cause any problems because the large volume of water diluted the contaminating agents. However, the dam was subsequently washed away, and the pipeline was destroyed by corrosion.

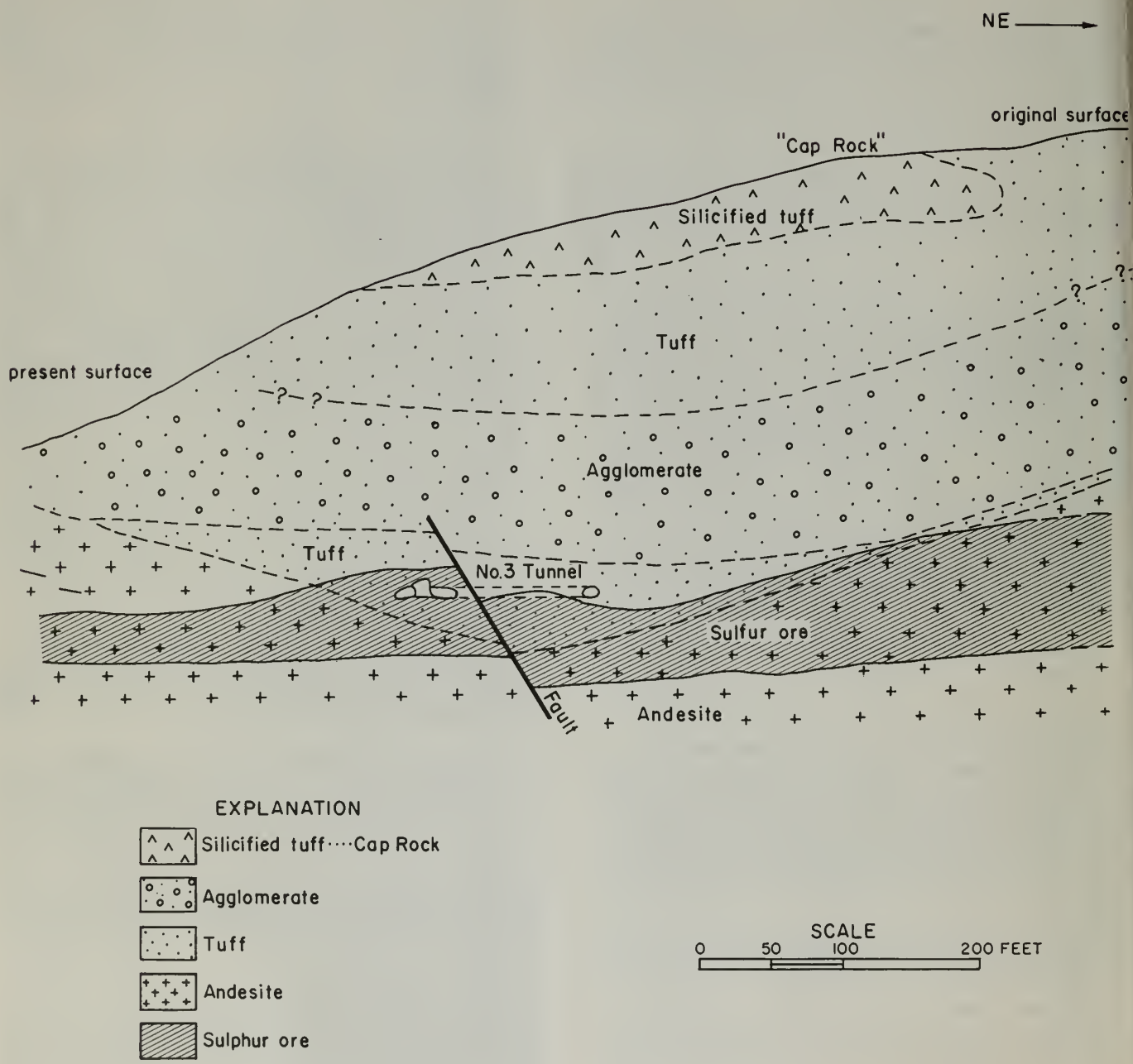


Figure 8. Restored geologic cross-section of the Leviathan sulfur mine prior to open-pit mining. *Courtesy of The Anaconda Company. Modified after Evans, 1966.*

The State Water Resources Control Board adopted a water quality control plan for the Bryant Creek Basin in January 1971 (A.L. Franks, personal communication, and State Water Resources Control Board, 1971). Leviathan Creek joins Mountaineer Creek about 3 miles north of the mine, and the two form Bryant Creek. Bryant Creek flows north and northwest into Nevada and finally empties into the East Carson River.

The following outlines the program recommended by the Board in 1971.

A. Statement of Problem

At present the stream waters are unusable. Seepage from the tailings pile contributes an estimated 58 percent of the total pollution; direct runoff from the dump and spoil areas, 21 percent; tunnel seepage, 19 percent; and surface drainage from the open pit, 2 percent.

B. Possible Corrective Measures

These include (1) diverting the creek around the overburden with the construction of a flume, pipeline, and ditch; (2) blocking the pit and tunnel exits and using the pit as an evaporation pond; (3) grading and compacting the dump and spoil areas so surface waters would flow rapidly over them and through the area; and (4) collection of all waste-bearing streams followed by treatment or transport to other areas for disposal and evaporation. Relative costs of these methods had not been determined, and no funds were available for the corrective steps as of 1971.

## Tungsten

Moderate amounts of tungsten ore have been produced in Alpine County. The years for which production was recorded were 1943 and 1948 to 1956. Unfortunately, detailed statistics for most of those years are unavailable. In 1953 the county was credited with an output of 662 units* of tungsten concentrates valued at $41,408, and in 1956 the output was 661 units valued at $36,990. Virtually all of the tungsten ore was recovered from the Hope Valley district where the Alpine and Burnside mines were the principal producers. Minor amounts of tungsten minerals also occur in the Monitor and Silver King districts. In 1971, there was practically no prospecting for or mining of tungsten minerals.

Scheelite ($CaWO_4$) is the principal tungsten ore mineral found in Alpine County. Scheelite most commonly occurs as small to medium-sized grains that are disseminated in garnetiferous tactite rock. Occasionally large well-formed crystals are present. Sometimes pyrite, chalcopyrite, and small gold-bearing veins are present. The tactite bodies are usually tabular or vein-like and are interbedded with quartzite, schist, and other metamorphic rocks in roof pendants that are surrounded by granitic rocks. Some scheelite also is found in quartzite or in quartz veins.

*1 unit = 20 pounds avoir.

At Hope Valley two roof pendants are surrounded by granodiorite. The pendant on the west side of the district is about 2 miles long, trends in a north to northeasterly direction, and is on the high ridge just west of the Kit Carson Pass highway. The Alhambra and Alpine mines are located in this pendant. The eastern pendant in this district is on the east side of the Burnside Lake road. It is about 3 miles long, trends in a northwesterly direction, and contains the Burnside and Cal-Pine mines.

Minor amounts of scheelite have been found in narrow gold-quartz veins and small tactite bodies in the Silver King district, but apparently there has been no commercial tungsten ore production here. Small amounts of hübnerite ($(Fe,Mn)WO_4$), a brownish-black mineral, have been found in the Zaca gold-silver mine in the Monitor district (Gianella, 1938) (see also section on Gold and Silver).

### Alpine mine

This mine is in NW1/4 sec. 11, T. 10 N., R. 18 E., M.D.M., on a high ridge 1 mile west of State Highway 88. It is accessible by a steep dirt road. It was owned by the Stuart Estate, Mill Valley, California, in 1971.

The Alpine mine has been the principal source of tungsten ore in the county. It was opened around 1943 and worked almost continuously until 1956. In the early 1950s the operator was Donald Burgner of Reno, Nevada; the last operators were Claude and Andrew Lovestedt of Minden, Nevada.

The deposit consists of scheelite-bearing tactite that occurs in a contact zone between granitic rock on the west and a roof pendant of schist and hornfels on the east. The scheelite is disseminated in the tactite and is associated with hematite. Much of the production came from a tabular-shaped ore shoot with a stoping length of 60 feet and a pitch length of more than 100 feet. It pitched steeply to the north. The ore averaged 0.6 percent $WO_3$, but in places the deposit yielded ore that was considerably higher than 1 percent $WO_3$ (Denton W. Carlson, field notes, 1953).

Photo 36. Surface plant at the Alpine tungsten mine in 1962. Camera facing west. *Photo by Edmund W. Kiessling.*

The mine is developed by two west-trending crosscut adits several hundred feet long and about 100 feet apart, vertically. The upper or main adit was partly caved in 1969. A west-dipping winze connects the two levels and extends downward another 50 feet to the 150-foot level. An 85-foot air raise extends to the surface from the main level. Approximately 1000 feet of drifts were run. The ore body was stoped from the adit level to the 150-foot level. Square-set stopes with waste fill were employed. Several buildings were on the property in 1971. In the last operation, the ore was trucked to a mill in the Pine Nut Mountains east of Gardnerville, Nevada. After crushing and screening, the coarse ore was hand sorted and the waste discarded, while the rich fines were concentrated.

### Alhambra mine

The Alhambra mine is located in W1/2 sec. 11, T. 10 N., R. 18 E., M.D.M., half a mile south of the Alpine tungsten mine and about half a mile north of Crater Lake.

This property was first worked for gold many years ago. It was active in the early 1930s (Logan, 1931, p. 488-489) and again in the early 1950s when it was prospected for tungsten. This and the adjoining Alpine mine are located in a contact zone between metamorphosed sediments on the west and granitic rocks on the east. The metamorphic rocks consist predominantly of mica schist and quartzite while the granitic rocks are principally coarse-grained granodiorite.

The zone of mineralization contains quartz stringers with abundant pyrite, galena, chalcopyrite, and sphalerite and small bodies of fine-grained tactite with disseminated scheelite. The ore zone strikes north-northeast. The mine is developed by two open southwest-trending adits about 100 feet long and about 100 feet apart vertically. The workings were accessible in 1969.

### Burnside (Calpine, Longshot) mine

This mine is in SE1/2 sec. 9, T. 10 N., R. 19 E., M.D.M., 6 miles west-northwest of Markleeville and half a mile east of the Burnside Lake road. The owner is Stuart Merrill, Markleeville (1969).

This property was worked for tungsten in the early 1950s. It was originally a gold prospect.

Scheelite occurs disseminated as fine grains in a veinlike body of fine-grained iron-stained tactite. The tactite body strikes nearly due north and is as much as 12 feet wide. It occupies a contact zone with granodiorite on the west and schist and quartzite on the east. Limy quartzite is to the southeast, and some pyroxenite occurs in the area. Pyrite and hematite are abundant in some places in the deposit. Ore shipped to Nevada for milling in 1953 was reported to have averaged 0.9 percent $WO_3$ (Denton W. Carlson, field notes, 1953).

The property is developed by three open pits along the contact zone. The pits are 20 to 30 feet wide, up to 30 feet deep, and about 100 feet long. A short adit extends southward under the north pit where a loading ramp was installed. The best exposed material at the property appears to be in the most southerly pit.

### Cal-Pine mine

The Cal-Pine tungsten-gold mine is located in the Hope Valley district in NW1/4 sec. 9, T. 10 N., R. 19 E., M.D.M. The owner is Carl C. Munck of Al Tahoe (1971). The mine is approximately 1 mile northwest of the Burnside tungsten mine, and both were incorrectly interchanged on the U.S. Geological Survey Markleeville 15-minute quadrangle topographic map of 1956.

Photo 37. View of Burnside tungsten mine showing the north pit and adit portal. Camera facing south.

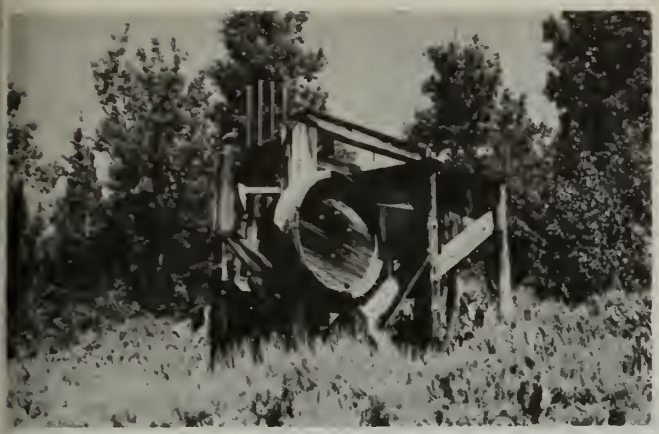

Photo 38. Four-stamp mill at the Cal-Pine tungsten-gold mine. Camera facing northeast. This old mill was originally installed here many years ago.

The mine was first worked for gold many years ago; the ore was treated in a 4-stamp mill. The mine was prospected for tungsten in the 1940s and early 1950s, but was idle in 1969. The deposit is in a belt of tungsten and gold mineralization that extends southeast to the Burnside mine. Disseminated, fine-grained scheelite with varying amounts of pyrite and hematite occurs in iron-stained garnet-tactite. The tactite body strikes northwest and is up to 20 feet wide. The tactite is in a zone of contact metamorphism with granodiorite lying to the west and schist and quartzite to the east. In addition, there are several narrow northwest-striking quartz veins that contain pyrite. The mine is developed by several open cuts, the largest of which is about 50 feet long and up to 20 feet deep. The old 4-stamp mill was still on the property in 1969.

### Snodgrass Creek prospect

This prospect is in the Silver King district on the north side of Snodgrass Creek in SW1/4 sec. 21, T. 8 N., R. 22 E., M.D.M. It was prospected in 1960 and 1961 by Everett McDonald and Cecil Murphy, but apparently there was no production. An east-striking iron-stained quartz vein contains small amounts of pyrite, galena, and scheelite. The vein is in granite near a contact with metamorphic rocks. The deposit is developed by several open cuts up to 10 feet in depth.

## Zinc

Some zinc concentrate has been produced in Alpine County. Virtually all of it was recovered as a by-product of gold, silver, and copper mining in the Monitor-Mogul district (see also sections on Gold-and-Silver and Copper). At the present time (1971) a zinc concentrate is being produced at the Zaca gold-silver mine in this district. Since 1960 this mine has yielded a total of 26,186 pounds of zinc (see table 4).

Sphalerite (ZnS) is the principal zinc ore mineral in the county, but minor amounts of smithsonite ($ZnCO_3$) also have been found. In the Monitor-Mogul district, sphalerite occurs as fine- to medium-grained dark brown crystals in the altered and silicified zones in Tertiary volcanic rocks. It usually is closely associated with galena, pyrite, and chalcopyrite and occurs either in disseminated form or in thin bands or in clots of well-formed crystals in quartz-lined cavities. Traces of zinc minerals occur in the Silver King and Silver Mountain districts.

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# *Tabulated List of Mines and Mineral Deposits of Alpine County*

Following is a tabulation of mines and mineral deposits arranged in alphabetical order by commodity and by name of mine or deposit. The numbers in the left-hand column refer to numbers on the map of Alpine County showing the locations of mines and mineral deposits (plate 1).

Under *Location* are section, township, and range numbers. All townships are north of and ranges are east of the Mount Diablo Base and Meridian. The name of the mine or mineral deposit is that which has been most commonly used. Following in parentheses are other names, if any, of the property. Most of the mines in the county have had several names. A considerable number of "Alpine" mines and claims exist as well as several Dixons, Morning Stars, Unions, and Washingtons. The names of mine owners shown in this list are only those that were made readily available to the author; no detailed search was made of county and U.S. Government property records.

Under *Geology,* brief descriptions of the geology and nature of the ore deposit are given on some of the mines and deposits of lesser importance. Under *Remarks and References* other data are given such as the dates the mine was worked, extent of development work, etc. The names and numbers in parentheses refer to the accompanying bibliography. The first number after the author's name is the year of publication and is separated from the page reference by a colon. References are separated from each other by semicolons. In the case of several authors, only the senior, or first one, is shown here. "MSP" followed by a date, colon, and number refers to the *Mining and Scientific Press,* the month, day, year of issue, and the page. If the word "herein" is shown, the mine or mineral deposit is described in the text of this report.

## COPPER — ALPINE COUNTY

| MAP NO | NAME OF CLAIM, MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 1 | Alpine Fairview (Fairview) | Secs. 1 and 2, T. 11 N., R. 20 E. | | A 10- to 15-foot copper-bearing vein strikes northwest. Sulfides and oxides present. | On high ridge west of Carson Valley. Active 1901, 1912, and early 1920's with small production. Developed by 165-foot adit. (Logan 21:402-403; 23:361-362; Eric 48:212) |
| | Altura | | | | See Uncle Billy Rogers. |
| 2 | Drumlummon | Sec. 2, T. 10 N., R. 18 E. | | Massive chalcopyrite and pyrite contain some gold. | Copper-gold prospect at Hope Valley; active early 1930's. (Logan 31:490; Eric 48:213) |
| | Fairview | | | | See Alpine Fairview. |
| | Globe | | | | Gold-silver mine in Monitor-Mogul district that has yielded some copper. See Gold-and-Silver. (Eric 48:213) |
| | Stella | Sec. 29?, T. 10 N., R. 21 E. | | | May be part of Curtz gold mine. Active 1884 when some cement copper produced. (Aubury 05:199; 08:246; Eric 48:213) |
| 3 | Uncle Billy Rogers (Altura) | Sec. 18, T. 10 N., R. 19 E. | | | (Irelan 88:37; Aubury 05:199; 08:246; Logan 23:361; Eric 48:213; herein) |

## GOLD AND SILVER — ALPINE COUNTY

| MAP NO. | NAME OF CLAIM MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| | Acacia | Sec. 16, T. 9 N., R. 20 E. | | | See Exchequer. |
| | Advance | | | | See Zaca. (Irelan 88:38) |
| | Alhambra Mining Corporation | | | | Prospected for gold and silver in the Hope Valley district in the early 1930's. See also Alhambra mine under Tungsten (Logan 31:488-489) |
| 4 | Alpine | Sec. 31, T. 10 N., R. 21 E. | Wm. Hubbard et al.; leased to Claude Lovestedt Box 265 Minden, Nevada | | (Eakle 19:21; Logan 21:401; 23:359; herein) |
| | Alpine Consolidated Mining Company | | | | Concern that worked the Morning Star and Curtz mines in the Monitor-Mogul district in the early 1930's. (Logan 31:489) |
| | Altura | | | | See Uncle Billy Rogers under Copper. |
| | Ardis | | | | See Curtz. |
| 5 | B. and J. | Sec. 33, T. 10 N., R. 21 E. | Hindman Ind., Inc. 14434 Hamlin St. Van Nuys | | Herein. |
| 6 | Balaklava | Sec. 22, T. 9 N., R. 20 E. | | A 2-foot vein in andesite contains pyrite and other sulfides. | Active in 1860's when a 100-foot adit was driven. (MSP 4/28/66:262) |
| | Black Jack | Sec. 29, T. 10 N., R. 21 E. | | Clayey seam in altered volcanic rock contains galena. | Prospect in Monitor-Mogul district; long idle. (Logan 21:404; Goodwin 57:413) |
| | Boulder Hill | | | | See Dixon. |
| | Buckeye | | | | See Exchequer. |
| 7 | Bueno | Sec. 21, T. 9 N., R. 20 E. | | North-striking vein in andesite. | In Silver Mountain district; prospected many years ago. |
| | Burnside | | | | Tungsten mine in the Hope Valley district that has yielded small amounts of gold. See Tungsten. |
| | Cal-Pine | | | | Tungsten-gold mine in Hope Valley. See Tungsten. |
| | Colorado | | | | Part of the Zaca mine. (Irelan 88:37-38; Crawford 96:65; Eakle 19:23-25; Logan 21:401-402; 23:360; 31:490) |
| 8 | Colorado Hill | Sec. 31, T. 10 N., R. 21 E. | Siskon Corporation P.O. Box 889, Reno, Nevada; leased to Claude Lovestedt Box 265 Minden, Nevada | | Herein. |

GOLD AND SILVER—Continued ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| | Colossus Mining Company | | | | Concern that prospected in the Monitor-Mogul district in the early 1930's. (Logan 31:490) |
| | Crothers | | | | In Monitor-Mogul district; worked many years ago. May be part of Zaca mine. |
| 9 | Curtz | Sec. 29, T. 10 N., R. 21 E. | | | (Eakle 19:14-23; Logan 21:403; herein) |
| | Curtz Consolidated Mining Company | | | | Company that at one time controlled mines in the Monitor-Mogul district. See also Alpine, Georgiana, and Morning Star mines. (Eakle 19:14-23; Logan 21:403-404) |
| 10 | Dixon (Boulder Hill Wolf Creek) | Sec. 21, T. 9 N., R. 21 E. | Dixon Brothers, Markleeville, California | | (Logan 21:402; 23:361; 31:489; herein) |
| 11 | Dixon Brothers prospect | Sec. 20, T. 8 N., R. 22 E. | Dixon Brothers, Markleeville, California | Narrow quartz vein in schist contains traces of gold and silver. | Small prospect in Silver King district. |
| | Drumlummon | | | | See Copper. |
| | Duke of Wellington | | | | Part of the Highland Mary group. |
| 12 | Esmeralda | Sec. 6, T. 9 N., R. 21 E. | | Northeast-striking vein in altered volcanic rock. | In Monitor-Mogul district, just east of Globe mine. Long idle. |
| 13 | Exchequer (Acacia, Buckeye, Saugatuck) | Secs. 8, 9, and 16, T. 9 N., R. 20 E. | | | (MSP 3/31/66:198; 9/29/77:204; Irelan 88:39; Eakle 19:26; Logan 23:360-361; herein) |
| | Flint | | | | See Lincoln. |
| 14 | Fremont | Sec. 30, T. 10 N., R. 21 E. | Stanley Brackett Richmond, California | Silicified zone in altered andesite. | Intermittently prospected. Developed by adit and shallow shaft. |
| | Garfield | | | | See Washington. |
| 15 | Georgiana | Sec. 29, T. 10 N., R. 21 E. | | | (Eakle 19:22; herein) |
| 16 | Globe (Hercules, Laura Karner) | Sec. 31, T. 10 N., R. 21 E., and sec. 6, T. 9 N., R. 21 E. | A. F. Brune Markleeville, California | | (MSP 1/14/71:20; Raymond 72; Eakle 19:18, 2S; Logan 21:404; Eric 48:213; herein) |
| 17 | Good Hope | Sec. 26, T. 10 N., R. 20 E. | | Silicified zone in altered andesite. | On west side of Monitor-Mogul district. Active 1860's and 1870's; prospected in early 1930's. Developed by +600-foot adit. (Raymond 74; Logan 31:490-491) |
| | Hercules | | | | Part of the Globe mine. |
| | Hercules Consolidated Mining Company | | | | Owned and operated the Advance and Colorado mines in the early 1900's. These mines now are part of the Zaca mine, which see. (Eakle 19:23-24) |
| 18 | Highland Mary et al. | Secs. 1 and 2, T. 9 N., R. 20 E. | | Altered and silicified zone in andesite. | West of Monitor-Mogul district. A series of parallel claims that were prospected many years ago. |
| 19 | Imperial Group | Secs. 5 and 6, T. 9 N., R. 21 E., and sec. 1, T. 9 N., R. 20 E. | | Several vein-like bodies in altered volcanic rocks strike north-northeast and contain varying amounts of gold and silver. | In southwest part of the Monitor-Mogul district. Group consists of 16 nearly parallel claims mostly in section 6. |
| 20 | Isabella | Sec. 22, T. 9 N., R. 20 E. | | | (Eakle 19:26; herein) |
| 21 | I.X.L. | Secs. 16 and 21, T. 9 N., R. 20 E. | Arnot Estate San Francisco, Calif. | | (MSP 6/24/6S:38; Browne 68:170; MSP 9/29/77:204; Irelan 88:38-39; Eakle 19:26; Logan 21:400; 23:361; herein) |
| | Joe Larson | T. 10 N., R. 21 E. | | Vein in altered volcanic rock. | In Lexington Canyon east of Monitor. Active 1928 when small shipment of gold-silver-lead ore made. (Goodwin S7:413) |
| 22 | Lady Franklin | Sec. 16, T. 9 N., R. 20 E. | | | In Silver Mountain district. Active in 1860's when 200-foot shaft was sunk. (Irelan 88:39) |
| | Last Resort | | | Silicified zone in altered volcanic rock. | Near Lincoln mine in Monitor-Mogul district. Prospected in 1880's when +500-foot adit driven. (Irelan 88:38) |
| | Laura Karner | | | | Part of the Globe mine. |
| 23 | Lincoln (Flint) | Sec. 31, T. 10 N., R. 21 E., and sec. 6, T. 9 N., R. 21 E. | | | (Irelan 88:38; Eakle 19:18, 2S; herein) |

GOLD AND SILVER—Continued ALPINE COUNTY

| MAP NO | NAME OF CLAIM, MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 24 | Lost Cabin (Woods Lake) | Sec. 28, T. 10 N., R. 18 E. | Clyde Mailske Jackson, California | | (Lindgren 96:8; Logan 21:402; 23:361; Eric 48:213; Goodwin 57:413; herein) |
| | Mammoth | T. 9 N., R. 20 E. | | Thin quartz seam. | In Silver Mountain district; active in 1860's when 100-foot adit driven. (Irelan 88:39) |
| | Manchester | Sec. 6, T. 9 N., R. 21 E. | | Northeast-striking vein in altered andesite. | In Monitor-Mogul district west of the Globe mine. Active in the 1860's (MSP 10/15/64:246) |
| | Marion | | | Altered volcanic rock. | In Monitor-Mogul district. Active prior to and during 1880's. Developed by 550-foot adit. (Irelan 88:38) |
| | Merrimac | Sec. 6, T. 9 N., R. 21 E. | | Northeast-striking vein in altered volcanic rock. | In the Monitor-Mogul district south of Lincoln mine. Active 1860's when developed by 75-foot adit. (MSP 10/26/67:262) |
| 25 | Morning Star | Sec. 29, T. 10 N., R. 21 E. | T.E. Woods et al. Oakland, California | | (Browne 68:170; Raymond 72:53; 73:95; 73a:15; Aubury 05:199; 08:246; Eakle 19:14-23; Logan 21:403; 23:362; 31:489; Eric 48:213; Goodwin 57:414; herein) See also chapter on Copper. |
| 26 | Mountain Gold and Silver | Secs. 27, 28, and 33, T. 9 N., R. 20 E. | | Northeast-striking vein in volcanic rock. | In Silver Mountain district; active in 1860's when 1200-foot adit was driven. (MSP 5/5/66:278; 7/6/67:6) |
| | O'Byrne | | | | In Monitor-Mogul district; active many years ago. Developed by adit and shaft. (Irelan 88:38) |
| 27 | Orion | Sec. 30, T. 10 N., R. 21 E. | | | (Eakle 19:21-22; herein) |
| 28 | Pennsylvania | Sec. 20, T. 9 N., R. 20 E. | | A 3- to 8-foot vein of silicified breccia in granitic rock strikes north. Varying amounts of sulfides present. | In Silver Mountain district in Pennsylvania Canyon. Active 1860's and 1870's with some production. Developed by lower 900- and upper 300-foot adits and shaft. (MSP 5/12/66: 294; 2/22/73: 116; Irelan 88:39; Eakle 19:26) |
| | Polaris group | | | | Organization which at one time controlled claims in Monitor-Mogul district. (Irelan 88:38; Crawford 94:373) |
| 29 | Raymond Meadows Creek | Sec. 32, T. 9 N., R. 20 E. | | | Herein. |
| 30 | Red Gap | Sec. 32, T. 10 N., R. 21 E. and sec. 5, T. 9 N., R. 21 E. | Claude Lovestedt Box 265 Minden, Nevada | | Herein. |
| | Saugatuck et al. | Sec. 16, T. 9 N., R. 20 E. | | | See Exchequer. |
| 31 | Silver Cloud | Sec. 8, T. 9 N., R. 20 E. | | | In Silver Mountain district; prospected in 1860's and 1870's. |
| 32 | Silver Hill | Sec. 5, T. 9 N., R. 21 E. | | | Herein. |
| 33 | Silver King | Sec. 24, T. 8 N., R. 21 E. | | Narrow quartz veins in schist contain traces of gold and silver. | In Silver King district. Prospected many years ago. |
| | Silver Mountain | T. 9 N., R. 20 E. | | Narrow quartz vein. | In Silver Mountain district; active around 1864 when 1800- and 300-foot adits driven. (Irelan 88:39) |
| 34 | St. Helena | Sec. 9, T. 9 N., R. 20 E. | | Vein in volcanic rock. | In Silver Mountain district; prospected in 1860's when 100-foot shaft sunk. (MSP 1/27/66:51) |
| | Tarshish | | | | See Zaca. |
| 35 | Washington (Garfield) | Sec. 26, T. 9 N., R. 20 E. (approx.) | | A 1- to 4-foot vein in altered volcanic rock has yielded minor amounts of gold and silver. | In Silver Mountain district; active 1860 and early 1870 when ore treated in 10-stamp mill. Developed by several adits and drifts. (MSP 9/1/66:134; 2/22/73: 116; Irelan 88:39) |
| 36 | Winchester | Sec. 6, T. 9 N., R. 21 E. | | Northeast-striking vein in altered andesite. | In Monitor-Mogul district. Active in 1860's when worked through adit. (MSP 6/16/66:374) |
| | Wolf Creek | | | | See Dixon. |
| | Woods Lake | | | | See Lost Cabin. |
| 37 | Zaca | Sec. 31, T. 10 N., R. 21 E. | Siskon Corp. Box 889 Reno, Nevada; leased to Claude Lovestedt Box 265 Minden, Nevada | | (Raymond 74:54, 57-58; Irelan 88:38; Eakle 19:25; Gianella 38; Tucker and Sampson 41:565; Goodwin 57:414; Evans 66:69-76; herein) |

## LIMESTONE — ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 38 | Grover Hot Springs | Sec. 24, T. 10 N., R. 19 E. | State of California Department of Parks and Recreation 1416-9th St. Sacramento, Calif. | | (Waring 15:131; herein) |
| 39 | Hope Valley No. 1 | Secs. 4 and S, T. 10 N., R. 19 E. | | Lenticular limestone body in schist and quartzite. | Near Hope Valley. Size of deposit is unknown. (Koenig 63) |
| 40 | Hope Valley No. 2 | Sec. 1S, T. 10 N., R. 19 E. | | Lenticular limestone body in schist and quartzite. | Near Burnside Lake. Size of deposit is unknown. (Koenig 63) |
| 41 | Hope Valley No. 3 | Sec. 13, T. 10 N., R. 18 E. | | Lenticular limestone body in schist quartzite. | In Hope Valley. Size of deposit unknown. (Koenig 63) |

## MERCURY — ALPINE COUNTY

| MAP NO | NAME OF CLAIM. MINE OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 42 | Mogul Peak | Sec. 30, T. 10 N., R. 21 E. | R.W. Brune Reno, Nevada | | (Ransome and Kellogg 39:371; herein) |

## MOLYBDENUM — ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 43 | Libby | Sec. 13, T. 8 N., R. 19 E. | | | (Logan 31:491; herein) |
| 44 | Winnemucca Lake | Sec. 34, T. 10 N., R. 18 E. | Judge Jones Pine Grove, Calif. (19S2) | | Herein. |

## ROCK PRODUCTS — ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE. OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 4S | Alpine County pit No. 1 | Sec. 36, T. 11 N., R. 19 E. | | Coarse alluvial sand deposited by Carson River. | One mile east of Woodfords. Used as source of sub-base by Alpine County Road Department. Pit is about 3 acres in size and up to 2S feet deep. |
| 46 | Alpine County pit No. 2 | Sec. 35, T. 11 N., R. 19 E. | | Coarse sand derived from weathering of granodiorite. | At Woodfords. Intermittently used as source of fill by Alpine County Road Department. |
| 47 | East Carson River | Sec. 36, T. 10 N., R. 20 E. | | Gravel bar by river. | Near junction of East Carson River and Monitor Creek. Sand and gravel produced in early 1950's for use in construction of Monitor Pass Highway. |
| 48 | Hot Springs Valley quarries | Sec. 19, T. 10 N., R. 20 E. | State of California | Weathered granodiorite. | Two small quarries 1 mile east of Grover Hot Springs were used as sub-base source for roads in area. |
| 49 | Kit Carson quarry | Sec. 31, T. 11 N., R. 19 E. | | Weathered coarse-grained granodiorite. | Just east of Kit Carson Campground. Worked around 1960 when used as source of sub-base for reconstruction of State Highway 88. Quarry is 100 feet long and 2S feet deep. |
| | Nevada Lumber Company pit | | | | See Tahoe Western. |
| S0 | Silver Mountain quarry | Sec. 22, T. 9 N., R. 20 E. | | Welded rhyolite tuff. | Worked in 1860's and 1870's. Source of stone for buildings and foundations at Silver Mountain City. |
| 51 | Sutherland pit | Sec. 36, T. 11 N., R. 18 E. | Sutherland Sand and Gravel Co. Auburn, California | Sub-rounded pebbles and cobbles in flood plain of West Carson River. | Worked late 19S0's and 1960's. Developed by several borrow pits up to 20 feet deep. Material was screened and used as road subbase. |

## ROCK PRODUCTS—Continued — ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 52 | Tahoe Western pit | Sec. 6, T. 10 N., R. 18 E. | Tahoe Western Concrete Co. Tahoe Valley, Calif. | Sub-rounded pebbles and cobbles principally of metamorphic rocks in flood plain of West Carson River. | Active in 1960's. Developed by pit up to 20 feet deep. Material excavated with bulldozer and sent through 100-ton-per-hour portable washing and sizing plant. At one time pit was worked by Nevada Lumber Company. |
| 53 | Twin Lakes quarry | Sec. 18, T. 10 N., R. 18 E. | | Granodiorite overlain by andesite porphyry. | Just north of Twin Lakes Reservoir. Used as source of riprap. |
| 54 | Wolf Creek quarry | Sec. 19, T. 9 N., R. 21 E. | | Irregularly jointed gray andesite porphyry. | Recently used as highway sub-base and riprap source. Quarry dimensions are 300 by 300 feet with west face up to 200 feet high. |
| 55 | Woodfords quarry | Sec. 34, T. 11 N., R. 19 E. | | Weathered coarse-grained granodiorite. | Just west of Woodfords. Active early 1960's; source of sub-base for reconstruction of State Highways 88 and 89. Quarry is 150 feet long, 50 feet wide, and has north face up to 100 feet high. |

## SULFUR — ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| S6 | Leviathan | Secs. 15 and 22, T. 10 N., R. 21 E. | Undetermined 1976. | | (Irelan 88:38; Aubury 05:199; 08:246; Logan 31:491; Gary 39:4B8-489; Eric 48: 213; Norman 51:310; Lydon 57:613-614; Evans 66:63-68; herein) |

## TUNGSTEN — ALPINE COUNTY

| MAP NO | NAME OF CLAIM MINE, OR GROUP | LOCATION | OWNER (NAME AND ADDRESS) | GEOLOGY | REMARKS AND REFERENCES |
|---|---|---|---|---|---|
| 57 | Alhambra | Sec. 11, T. 10 N., R. 18 E. | Alhambra Mining Corporation, Gardnerville, Nevada | | (Logan 31:488-4B9; herein) |
| 58 | Alpine | Sec. 11, T. 10 N., R. 18 E. | Stuart Estate Mill Valley, Calif. | | (Norman 49:33; 51:310; herein) |
| 59 | Burnside (Calpine, Longshot | Sec. 9, T. 10 N. R. 19 E. | Stuart Merrill Markleeville, Calif. | | Herein. |
| | Calpine | | | | See Burnside. |
| 60 | Cal-Pine | Sec. 9, T. 10 N., R. 19 E. | Carl C. Munck P.O. Box 203 Al Tahoe, Calif. | | Herein. |
| | Longshot | | | | See Burnside. |
| 61 | Snodgrass Creek | Sec. 21, T. 8 N., R. 22 E. | | | Herein. |
| | Wolframite | T. 10 N., R. 18 E. | F.W. Kuechler Minden, Nevada (1941) | Several scheelite-bearing veins crop out near Carson Pass Road at Hope Valley. | (Tucker and Sampson 41:565) |
| | Zaca | Sec. 31, T. 10 N., R. 21 E., and secs. 5 and 6, T. 9 N., R. 21 E. | Siskon Corporation P.O. Box 889 Reno, Nevada | | Gold-silver mine that contains minor amounts of tungsten. (Gianella 38; Partridge 41:264; Tucker and Sampson 41:565; herein under Gold and Silver) |

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CALIFORNIA DIVISION OF MINES AND GEOLOGY
THOMAS E. GAY JR., STATE GEOLOGIST

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF CONSERVATION

COUNTY REPORT 8
PLATE 1

AVR 9556

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# GEOLOGIC MAP OF ALPINE COUNTY, CALIFORNIA

## SHOWING MINES AND MINERAL DEPOSITS

COMPILED BY WILLIAM B. CLARK

Geology adapted from Geologic Map of California, Olaf P. Jenkins Edition Sacramento Sheet (compiled by R. G. Strand and J. B. Koenig, 1965) and Walker Lake Sheet (compiled by J. B. Koenig, 1963)

SCALE 1:125,000

CONTOUR INTERVAL 250 FEET

LOCATION MAP

SYMBOLS

Contact

Fault
(dashed where approximately located; dotted where concealed)

● 24
Mines and Mineral Deposits

## EXPLANATION

| | | | |
|---|---|---|---|
| CENOZOIC | QUATERNARY | Holocene | Qal — Alluvium. Stream and river alluvium, glacial outwash |
| | | Pleistocene | Qg — Glacial deposits. Glacial moraines and till |
| | | | Qb — Basalt. Basalt flows |
| | | | QPc — Continental deposits. Dissected fanglomerates, terrace gravels |
| | TERTIARY | Pliocene | Pv — Volcanic rocks. Chiefly andesitic breccia, tuffs, and flows. |
| | | Miocene | Mv — Volcanic rocks. Chiefly rhyolite and dacite tuffs. |
| | | Undivided | Ti — Intrusives. Rhyolite, dacite, and andesite domes, plugs, sills, and dikes. |
| MESOZOIC | PRE-CRETACEOUS | | g — Granitic rocks. Granite, quartz monzonite, granodiorite, and quartz diorite. |
| | | | bi — Basic intrusives. Gabbro and diorite |
| PALEOZOIC | | | m — Metamorphic rocks. Schist, quartzite, hornfels, and tactite. |
| | | | ls — Limestone. Crystalline limestone. |

## MINES AND MINERAL DEPOSITS SHOWN ON MAP

| Map No. | Name of property | Location* Sec. | T. | R. |
|---|---|---|---|---|
| *COPPER* | | | | |
| 1. | Alpine Fairview | 2 | 11N. | 20E. |
| 2. | Drumlummon | 2 | 10 | 18 |
| 3. | Uncle Billy Rogers | 18 | 10 | 19 |
| *GOLD AND SILVER* | | | | |
| 4. | Alpine | 31 | 10 | 21 |
| 5. | B. and J. | 33 | 10 | 21 |
| 6. | Balaklava | 22 | 9 | 20 |
| 7. | Bueno | 21 | 9 | 20 |
| 8. | Colorado Hill | 31 | 10 | 21 |
| 9. | Curtz | 29 | 10 | 21 |
| 10. | Dixon | 21 | 9 | 21 |
| 11. | Dixon Brothers | 20 | 8 | 22 |
| 12. | Esmeralda | 6 | 9 | 21 |
| 13. | Exchequer | 9, 16 | 9 | 20 |
| 14. | Fremont | 30 | 10 | 21 |
| 15. | Georgiana | 29 | 10 | 21 |
| 16. | Globe | 6 | 9 | 21 |
| 17. | Good Hope | 26 | 10 | 20 |
| 18. | Highland Mary | 1, 2 | 9 | 20 |
| 19. | Imperial group | 6 | 9 | 21 |
| 20. | Isabella | 22 | 9 | 20 |
| 21. | I.X.L. | 16, 21 | 9 | 20 |
| 22. | Lady Franklin | 16 | 9 | 20 |
| 23. | Lincoln | 31 | 10 | 21 |
| 24. | Lost Cabin | 28 | 10 | 18 |
| 25. | Morning Star | 29 | 10 | 21. |
| 26. | Mountain Gold and Silver | 28 | 9 | 20 |
| 27. | Orion | 30 | 10 | 21 |
| 28. | Pennsylvania | 20 | 9 | 20 |
| 29. | Raymond Meadows Creek | 32 | 9 | 20 |
| 30. | Red Cap | 5 | 9 | 21 |
| 31. | Silver Cloud | 8 | 9 | 20 |
| 32. | Silver Hill | 5 | 9 | 21 |
| 33. | Silver King | 24 | 8 | 21 |
| 34. | St. Helena | 9 | 9 | 20 |
| 35. | Washington | 26 | 9 | 20 |
| 36. | Winchester | 6 | 9 | 21 |
| 37. | Zaca | 31 | 10 | 21 |
| *LIMESTONE* | | | | |
| 38. | Grover's Hot Springs | 24 | 10 | 19 |
| 39. | Hope Valley No. 1 | 4, 5 | 10 | 19 |
| 40. | Hope Valley No. 2 | 15 | 10 | 19 |
| 41. | Hope Valley No. 3 | 13 | 10 | 18 |
| *MERCURY* | | | | |
| 42. | Mogul Peak | 30 | 10 | 21 |
| *MOLYBDENUM* | | | | |
| 43. | Libby | 13 | 8 | 19 |
| 44. | Winnemucca Lake | 34 | 10 | 18 |
| *ROCK PRODUCTS* | | | | |
| 45. | Alpine County No. 1 | 36 | 11 | 19 |
| 46. | Alpine County No. 2 | 35 | 11 | 19 |
| 47. | East Carson | 36 | 10 | 20 |
| 48. | Hot Springs Valley | 19 | 10 | 20 |
| 49. | Kit Carson | 31 | 11 | 19 |
| 50. | Silver Mountain | 22 | 9 | 20 |
| 51. | Sutherland | 36 | 11 | 18 |
| 52. | Tahoe Western | 6 | 10 | 18 |
| 53. | Twin Lakes | 18 | 10 | 18 |
| 54. | Wolf Creek | 19 | 9 | 21 |
| 55. | Woodfords | 34 | 11 | 19 |
| *SULFUR* | | | | |
| 56. | Leviathan | 15, 22 | 10 | 21 |
| *TUNGSTEN* | | | | |
| 57. | Alhambra | 11 | 10 | 18 |
| 58. | Alpine | 11 | 10 | 18 |
| 59. | Burnside | 9 | 10 | 19 |
| 60. | Cal-Pine | 9 | 10 | 19 |
| 61. | Sandgrass Creek | 21 | 8 | 22 |

* Mount Diablo Base and Meridian

SECTIONIZED TOWNSHIP

| | | | | | |
|---|---|---|---|---|---|
| 6 | 5 | 4 | 3 | 2 | 1 |
| 7 | 8 | 9 | 10 | 11 | 12 |
| 18 | 17 | 16 | 15 | 14 | 13 |
| 19 | 20 | 21 | 22 | 23 | 24 |
| 30 | 29 | 28 | 27 | 26 | 25 |
| 31 | 32 | 33 | 34 | 35 | 36 |

TOPOGRAPHIC BASE BY U.S.G.S.
This map is an enlargement of a 1:250,000-scale published map