LEVIATHAN MINE

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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

CALIFORNIA DIVISION OF MINES AND GEOLOGY
1416 Ninth Street, Room 1341
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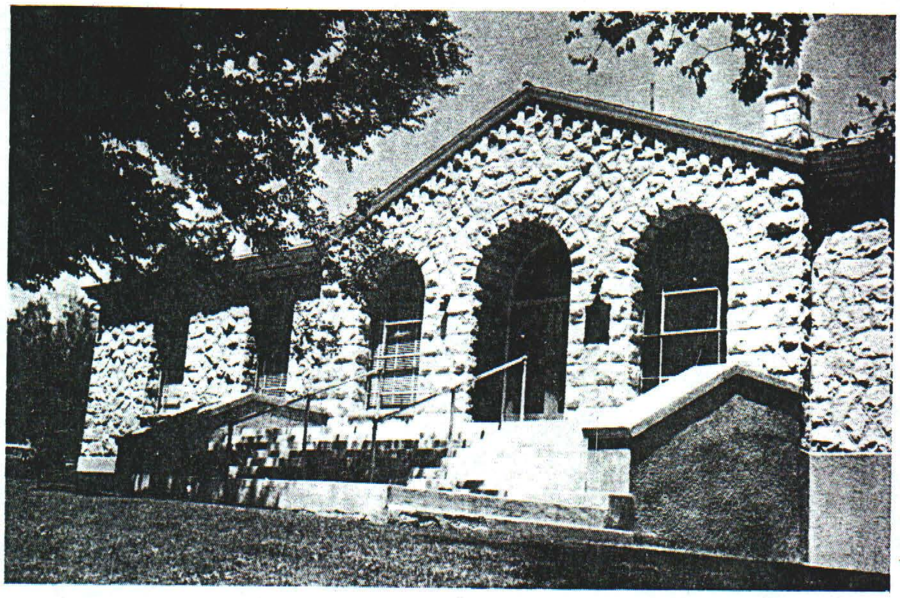

Photo 33. Alpine County Courthouse in Markleeville. This building was constructed in 1928 of blocks of rhyolite tuff that were obtained from Silver Mountain City. Camera facing east.

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 ($CuSO_4 \bullet 5H_2O$) 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.

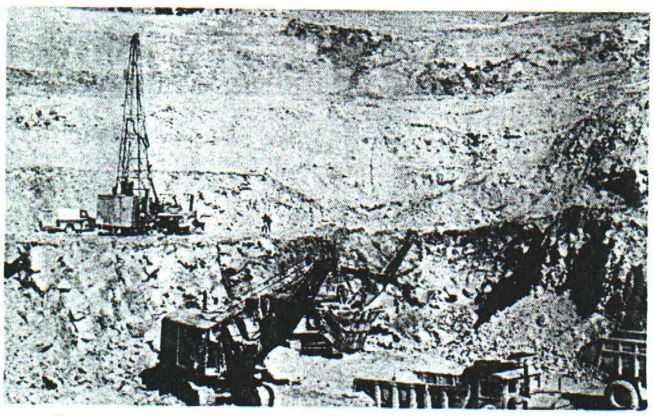

Photo 34. Mining operations at the Leviathan sulfur mine in 1962 showing rotary drill, power shovel, trucks, and benches. *Photo by Edmund W. Kiessling.*

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.

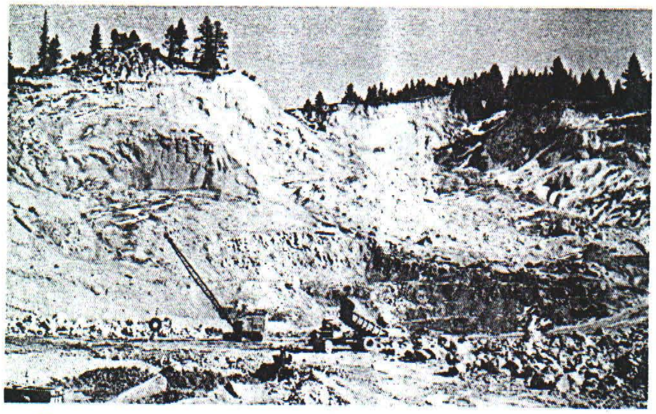

Photo 35. Mining operations at the Leviathan sulfur mine in 1962 showing drop ball used for secondary breaking of large fragments. Camera facing east. *Photo by Edmund W. Kiessling.*

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 ($CuS0_4 \bullet 5H_20$); iron-chalcanthite ($Fe0 \bullet Cu0 \bullet 2S0_3 \bullet 10H_20$); halotrichite ($FeS0_4 \bullet Al_2(S0_4)_3 \bullet 22H_20$); melanterite ($FeS0_4 \bullet 7H_20$); romerite ($FeS0_4Fe_2(S0_4)_3 \bullet 14H_20$). 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.

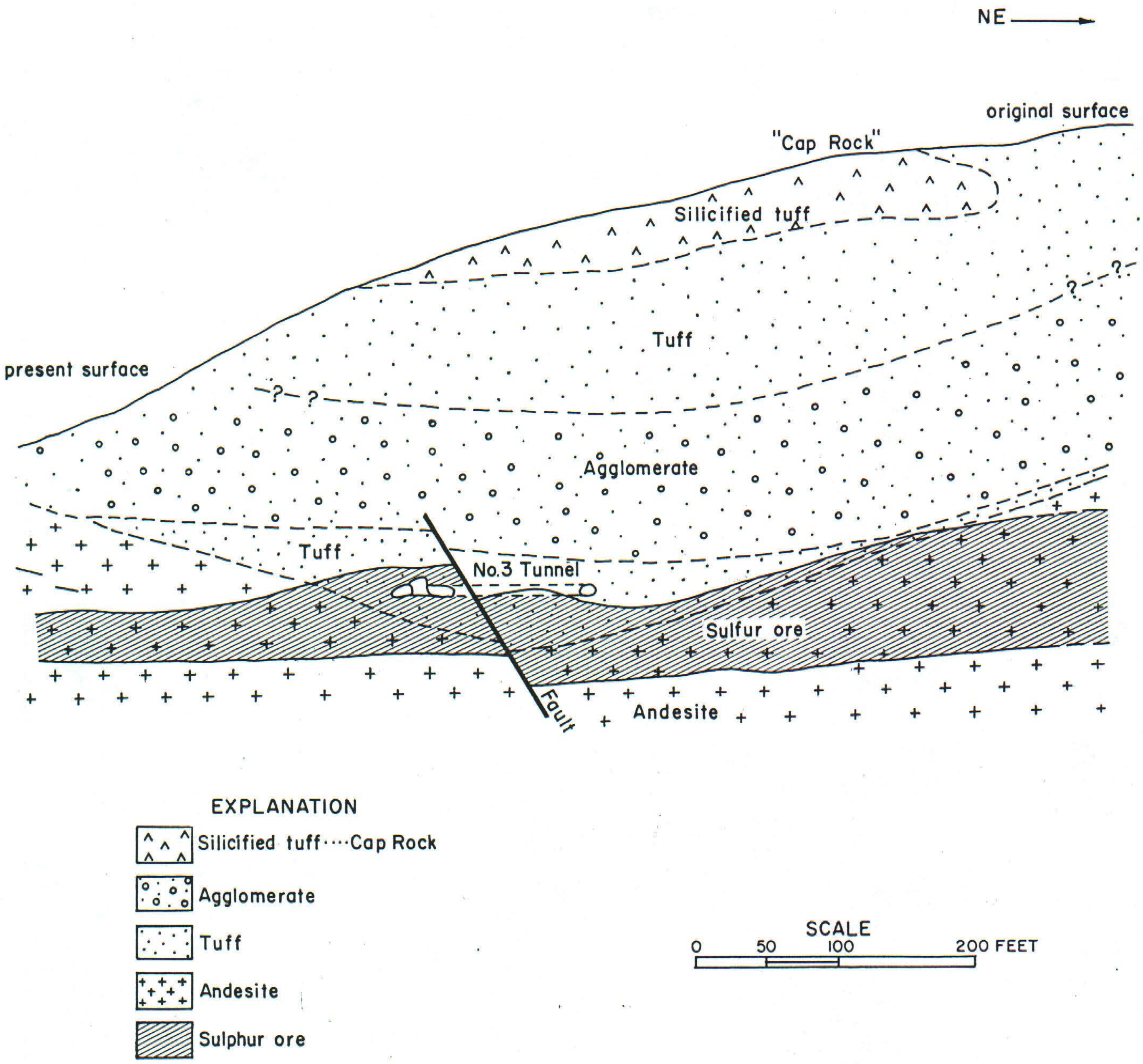

Figure 8. Restored geologic cross-section of the Leviathan sulfur mine prior to open-pit mining. *Courtesy of The Anaconda Company. Modified after Evans, 1966.*

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).

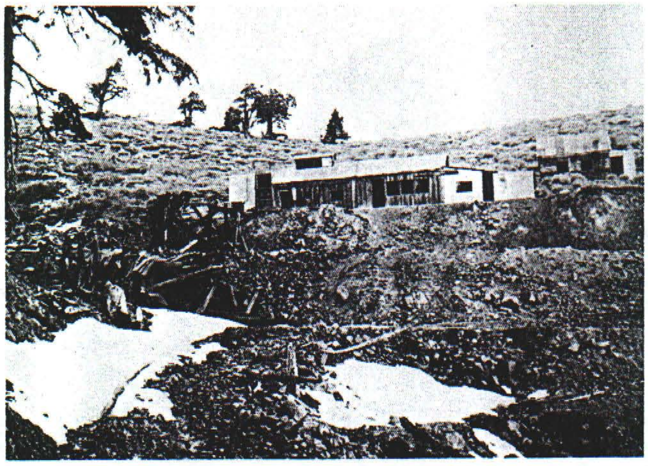

Photo 36. Surface plant at the Alpine tungsten mine in 1962. Camera facing west. *Photo by Edmund W. Kiessling.*

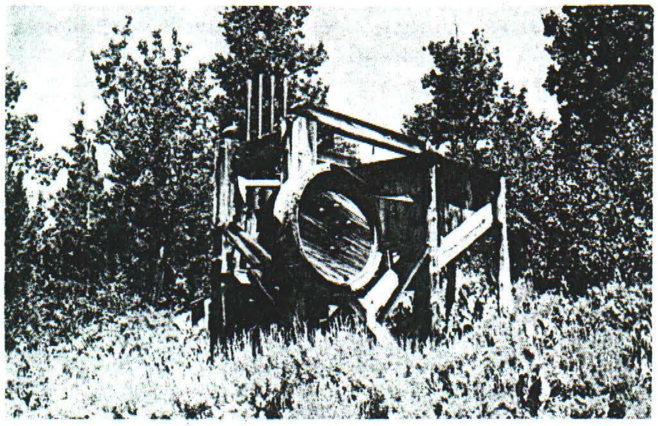

Photo 38. Four-stamp mill at the Cal-Pine tungsten-gold mine. Camera facing northeast. This old mill was originally installed here many years ago.

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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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
56	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 39:488-489; 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 31:488-489; 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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