History of the Stibnite Mining Area, Valley County, Idaho

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Staff Report 00-3
April 2000

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INTRODUCTORY NOTE

This report was prepared with partial funding by the U.S. Environmental Protection Agency, Region 10, and covers developments in the Stibnite mining area through the end of 1994. This history was prepared in conjunction with work done under a cooperative agreement with the U.S. Forest Service, Region IV, to identify and describe inactive and abandoned mines in the state of Idaho. Work on the U.S. Forest Service project included preparing detailed histories of mines in Region IV that had significant recorded production. The information in this report is take from published and unpublished sources in the Idaho Geological Survey's mineral property files. Unless otherwise noted, most mine production data are drawn from the U.S. Geological Survey's (USGS) annual volumes on *Mineral Resources of the United States* (1882-1923) and the equivalent volumes produced by the U.S. Bureau of Mines (USBM)(*Mineral Resources of the United States,* 1924-1931, and *Minerals Yearbook*, 1932 to the present). Information on underground workings and mine equipment is generally from the annual reports of the Idaho Inspector of Mines (IMIR), published from 1899 to 1979. After 1974, the Mine Inspector's office was known as the Mine Safety Bureau, a section of the Idaho Department of Labor and Industrial Services. Detailed accounts of mine operations are mostly drawn from the annual reports prepared by the companies for the State Inspector of Mines; these reports were required by law, and the information contained in them formed the basis of the Mine Inspector's annual reports. Reports of recent developments are taken from the Idaho Geological Survey's (IGS) annual reports on mining and minerals in Idaho (from 1984 to present) or from similar reports produced by the Survey's predecessor, the Idaho Bureau of Mines and Geology (IBMG) from 1975 to 1984. Other published sources are referenced in the text. A complete bibliography is included at the end of the report. Where direct quotations are taken from source materials, the original spelling and grammar are preserved.

History of the Stibnite Mining Area, Valley County, Idaho

Victoria E. Mitchell[1]

Introduction

The Stibnite mining area is located in the eastern part of the Yellow Pine mining district on the East Fork of the South Fork of the Salmon River (or East Fork, for brevity). The area is in northeastern Valley County on land administered by the Payette National Forest (Figure 1). The mineralized zone is about 3½ miles long and a mile wide and roughly parallels the river north of the townsite of Stibnite (Figure 2). Various parts of the area have been worked at different times under a variety of names, including Meadow Creek Mine, Yellow Pine Mine, Stibnite Mine, West End Mine, Homestake Pit, Yellowpine Mine, Splay Pit, Midnight Pit, and Northeast Pit. Several locations are also being considered for future mining (Figure 3). Elevations range from around 6,000 feet where Sugar Creek joins the East Fork to over 8,900 feet on the tops of the surrounding ridges. Most of the mining has taken place below 7,500 feet.

The primary access to the mine is via paved road from Cascade to Landmark. From Landmark, the single-lane, unpaved Johnson Creek road runs north to Yellow Pine, and from there, the Yellow Pine-Stibnite road runs east to the mining area (Figure 4). This route crosses Big Creek (6900 feet) and Warm Lake (6300 feet) summits. Access along the South Fork of the Salmon River road is strictly controlled because of potential impact on chinook salmon spawning grounds.

[1]Idaho Geological Survey, Main Office at Moscow, University of Idaho, Moscow.

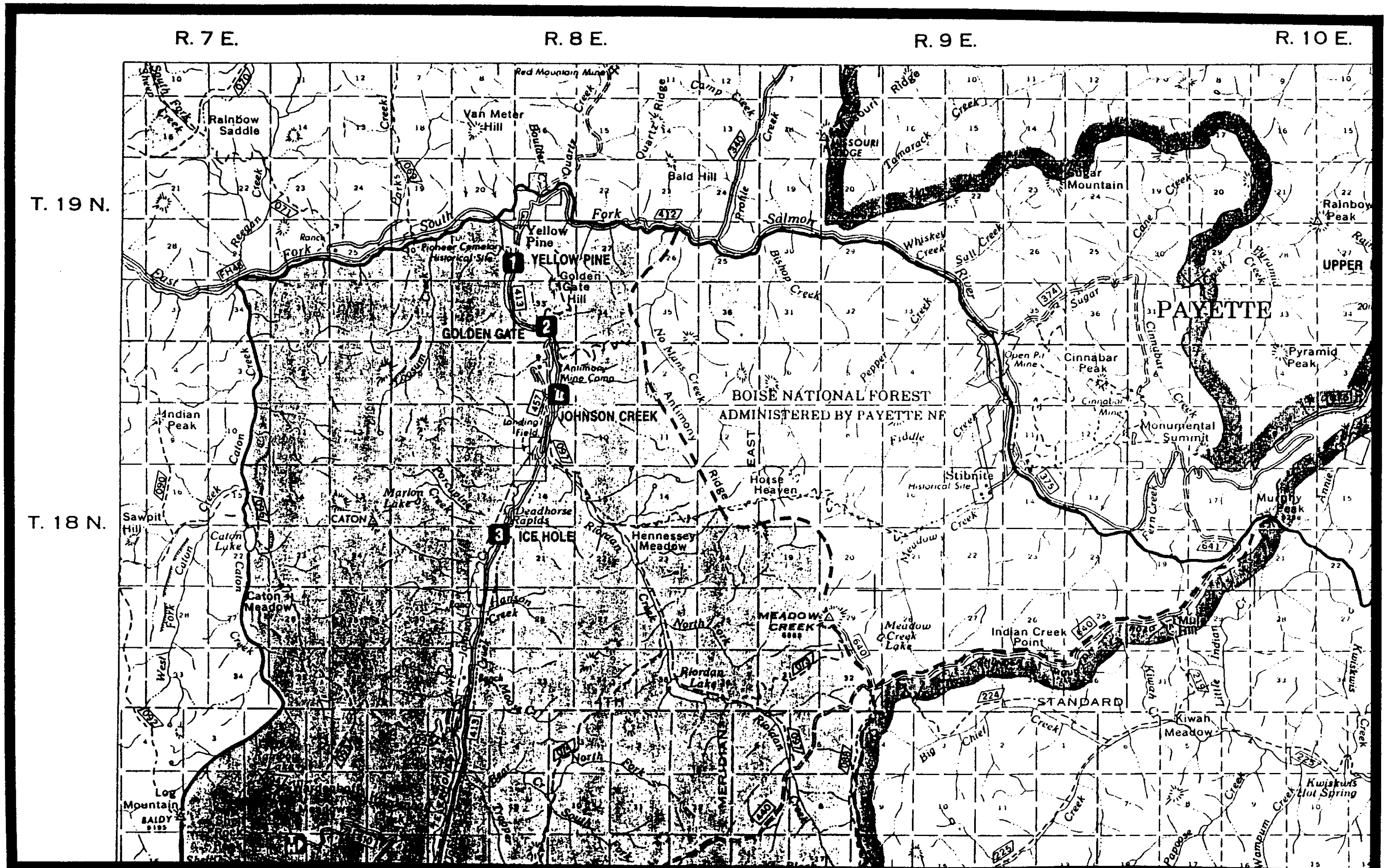


Figure 1. Location of the Stibnite mining area, Valley County, Idaho (U.S. Forest Service Boise National Forest map, scale ⅜ inch = 1 mile).

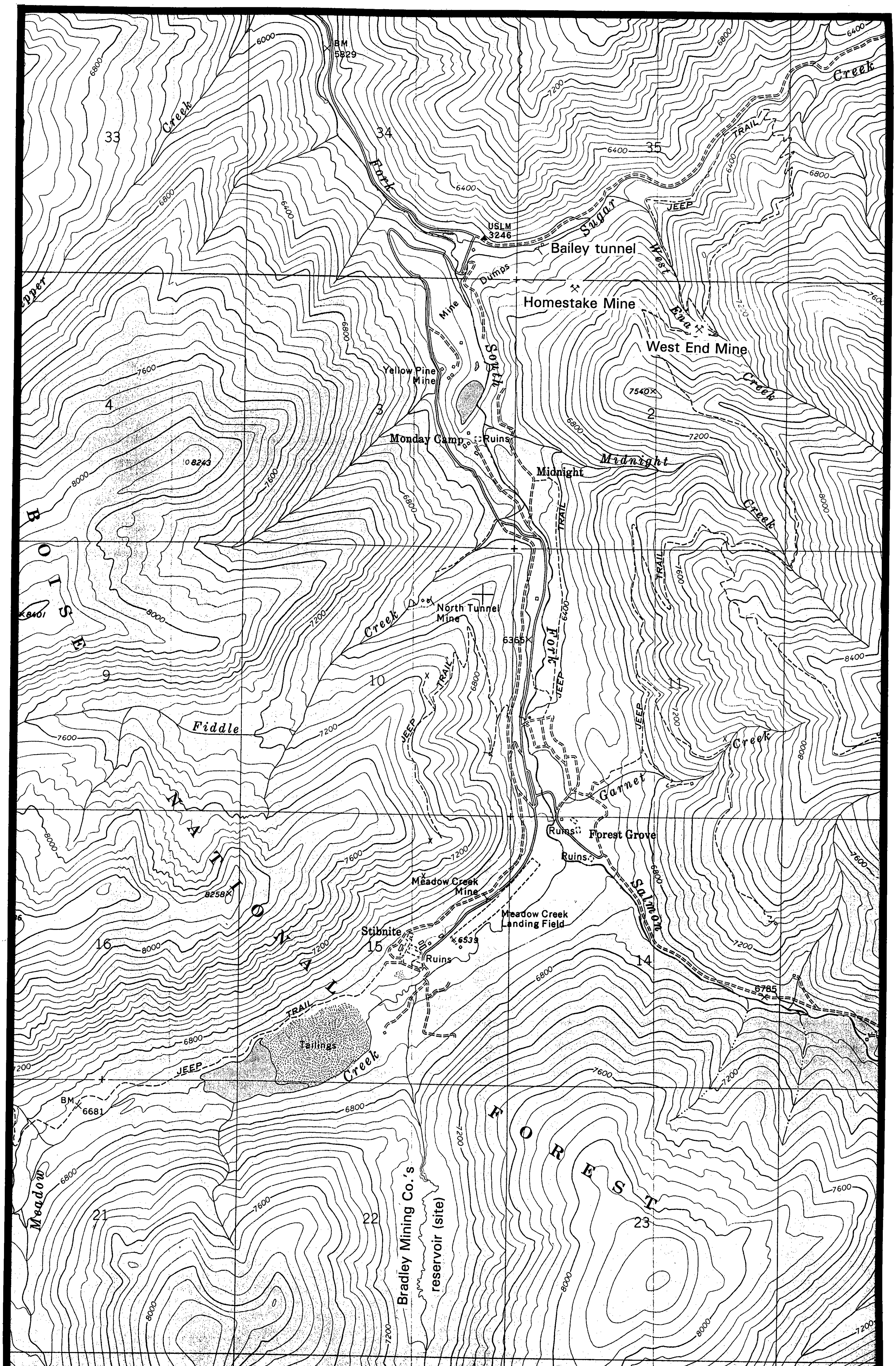


Figure 2. Topographic map of the Stibnite mining area, showing features of interest (U.S. Geological Survey Stibnite 7.5-minute topographic map).

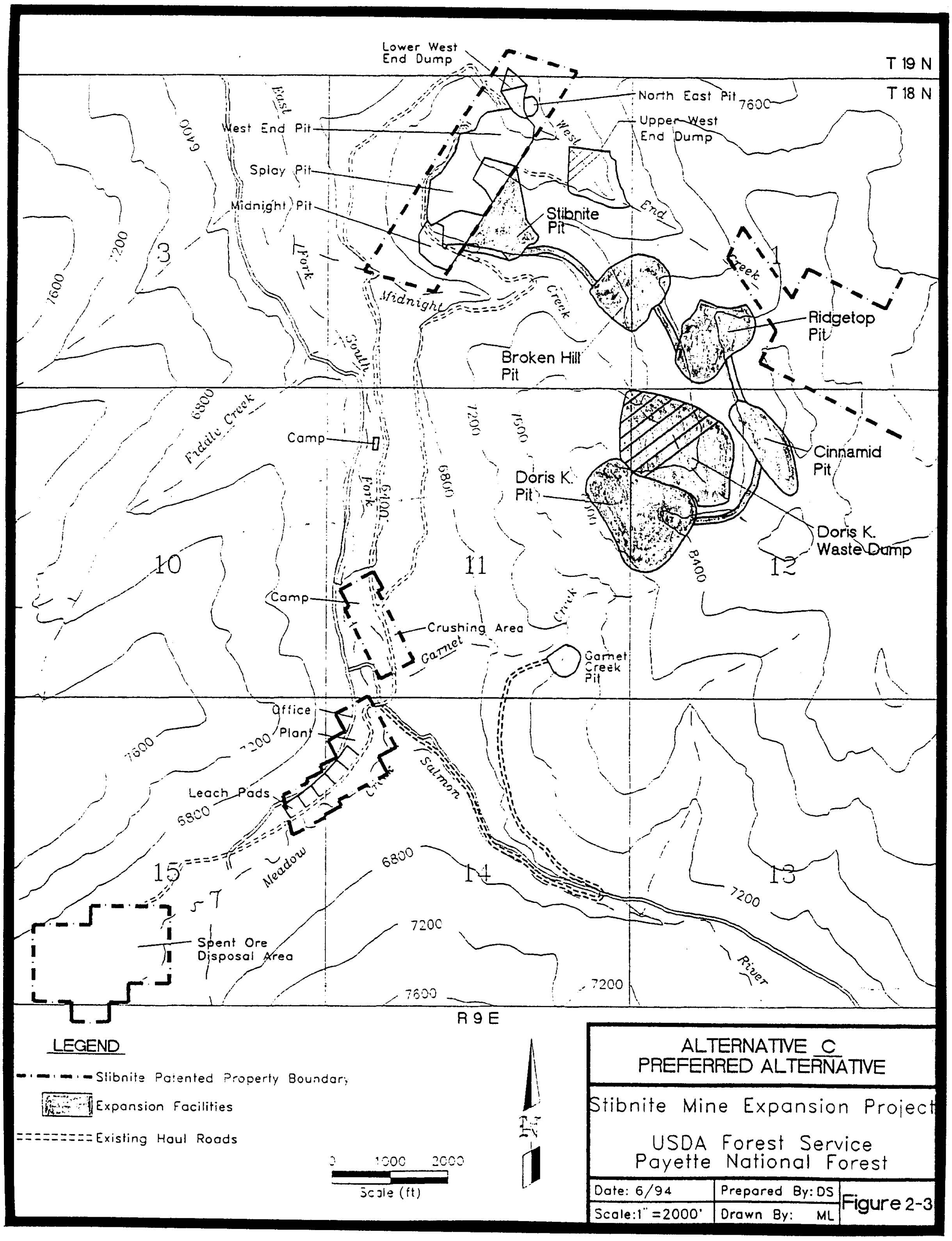


Figure 3. Map of proposed open pit operations by Stibnite Mine, Inc./Dakota Mining near Stibnite (USFS, 1994, Figure 2-3).

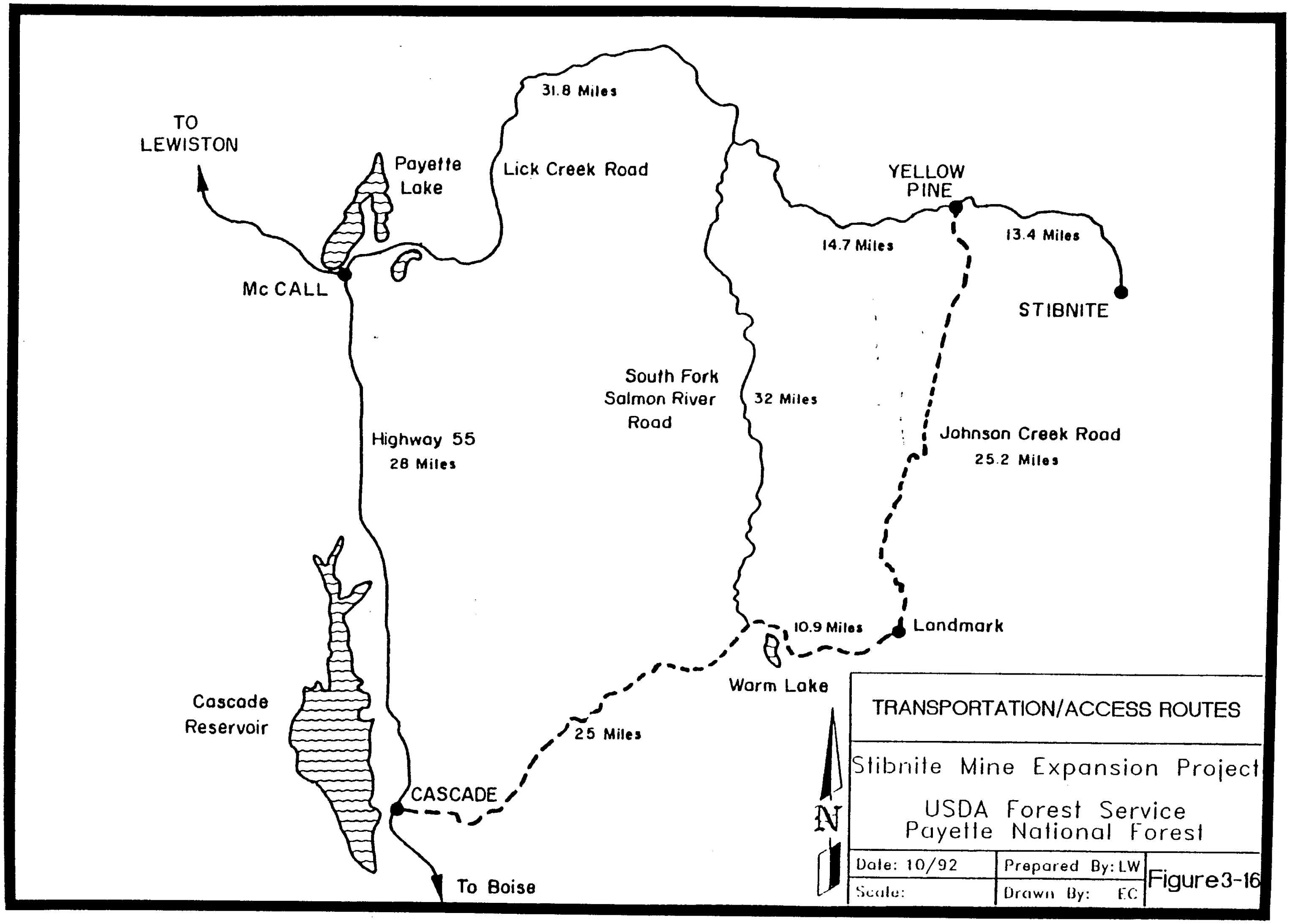


Figure 4. Access routes to the Stibnite area (USFS, 1994, Figure 3-16).

Geology

The Stibnite area is underlain by granitic rocks of the Idaho batholith and by metamorphosed sedimentary rocks that are part of a large roof pendant (Figure 5). The Idaho batholith in this area is composed of medium-grained biotite granodiorite and coarse-grained muscovite-biotite granite (Smitherman, 1985). The age and affinity of the rocks in the roof pendant are uncertain. Ross (1934, p. 942) stated that the rocks in the Yellow Pine area showed a greater lithologic similarity to the Ordovician rocks farther east than they did to any other rocks in the region. B.F. Leonard (cited in Hobbs and Cookro, 1987) assigned these rocks to the Yellowjacket and Hoodoo Formations, and the most recent geologic map of the area shows this correlation (Fisher and others, 1992). Ordovician chain corals were tentatively identified in these rocks by Lewis and Lewis (1982). Smitherman (1985) was unable to confirm the presence of fossils, but he noted that clumps of calc-silicate minerals in the metamorphosed carbonate rocks could be the "fossils" in question. Smitherman (1985) divided the roof pendant into ten map units (Figure 6).

Regionally, the rocks are folded into a large, tight, northwest-plunging, overturned syncline and have been metamorphosed to the amphibolite facies (andalusite-sillimanite isograd). Intrusion of the batholith locally altered the carbonate rocks to skarn zones (hornblende hornfels facies). The presence of a single stage of regional metamorphism and of only one fold event suggests that the rocks are most likely early Paleozoic in age (Smitherman, 1985). The older rocks are intruded by dikes of various compositions (Cooper, 1951). The dikes are associated with the Challis Volcanics (Smitherman, 1985).

The mines in the Stibnite area are low-grade disseminated gold deposits with local concentrations of antimony, silver, and tungsten (Cooper, 1951). The orebodies are located along the Meadow Creek shear zone and related structures. The Meadow Creek and West End shear zones are part of an en echelon system with a total width of 2,000 feet (Cookro, in press). The gold, antimony, and tungsten deposits formed from hydrothermal fluids which rose through the shear zone (Cookro and others, 1987). All three types of deposits may be cogenetic (Lewis, 1984), although Gammons (1988) believes there were two pulses of mineralization. The deposits are localized by changes in the strike or dip of the main fault zone, which strikes north-south, and by the intersection of subsidiary northeast-trending faults with the main fault zone (Cooper, 1951). Breccia zones at the base of thrust sheets cap the Yellow Pine and West End deposits (Cookro, in press).

Mineralization occurred in several pulses, accompanied by hydrothermal alteration of the wall rocks. Pyrite, arsenopyrite, and gold were deposited first (White, 1940), accompanied by sodium- and potassium-metasomatism and sericitization of the wall rocks. The gold values are carried by the pyrite and arsenopyrite; no separate gold minerals are present (Lewis, 1984). Considerable

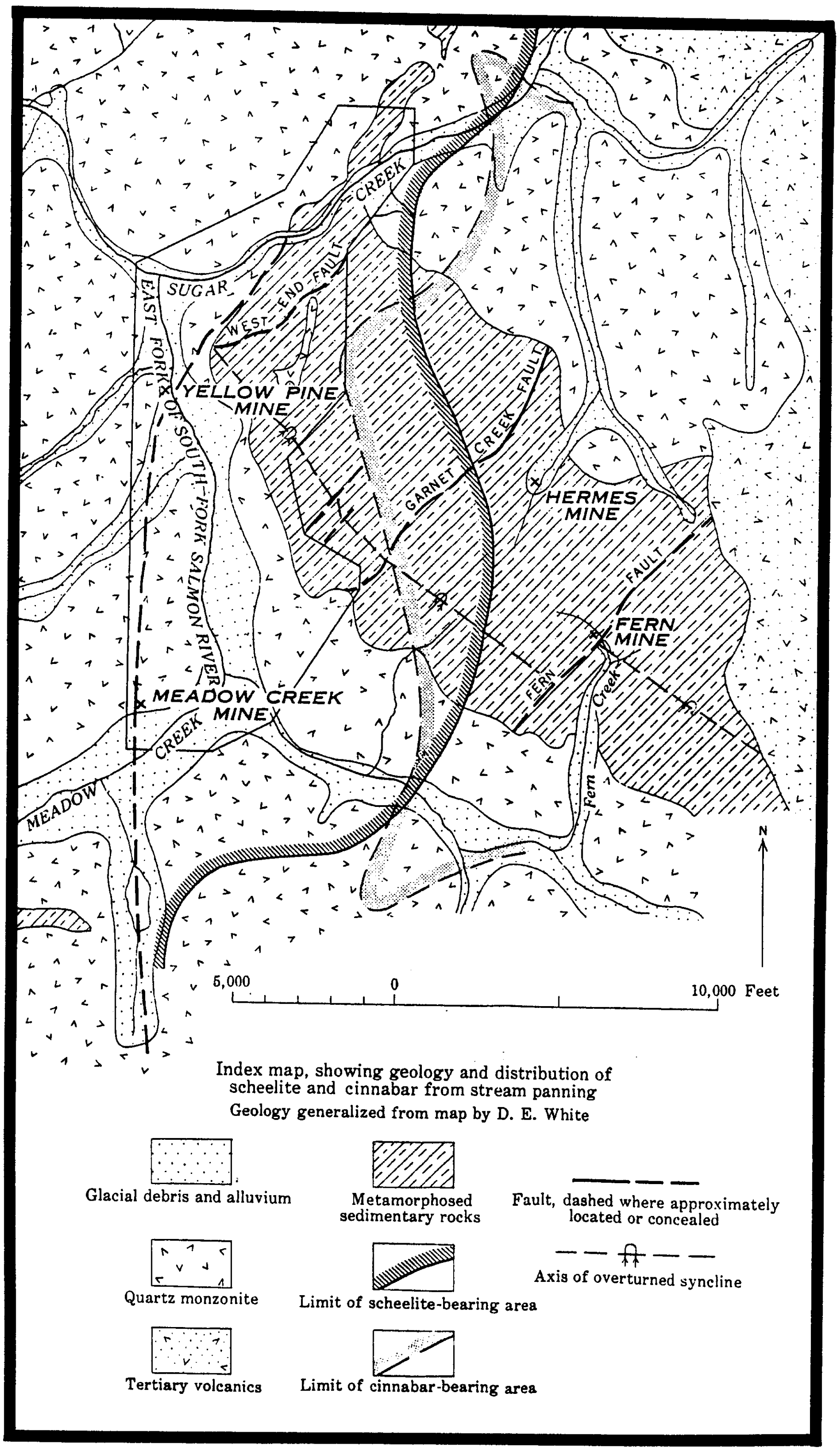


Figure 5. Generalized geologic map of the Stibnite area. Note the lines which delineate the scheelite (tungsten)- and cinnabar (mercury)-bearing rocks (Cooper, 1951, Plate 38, index map).

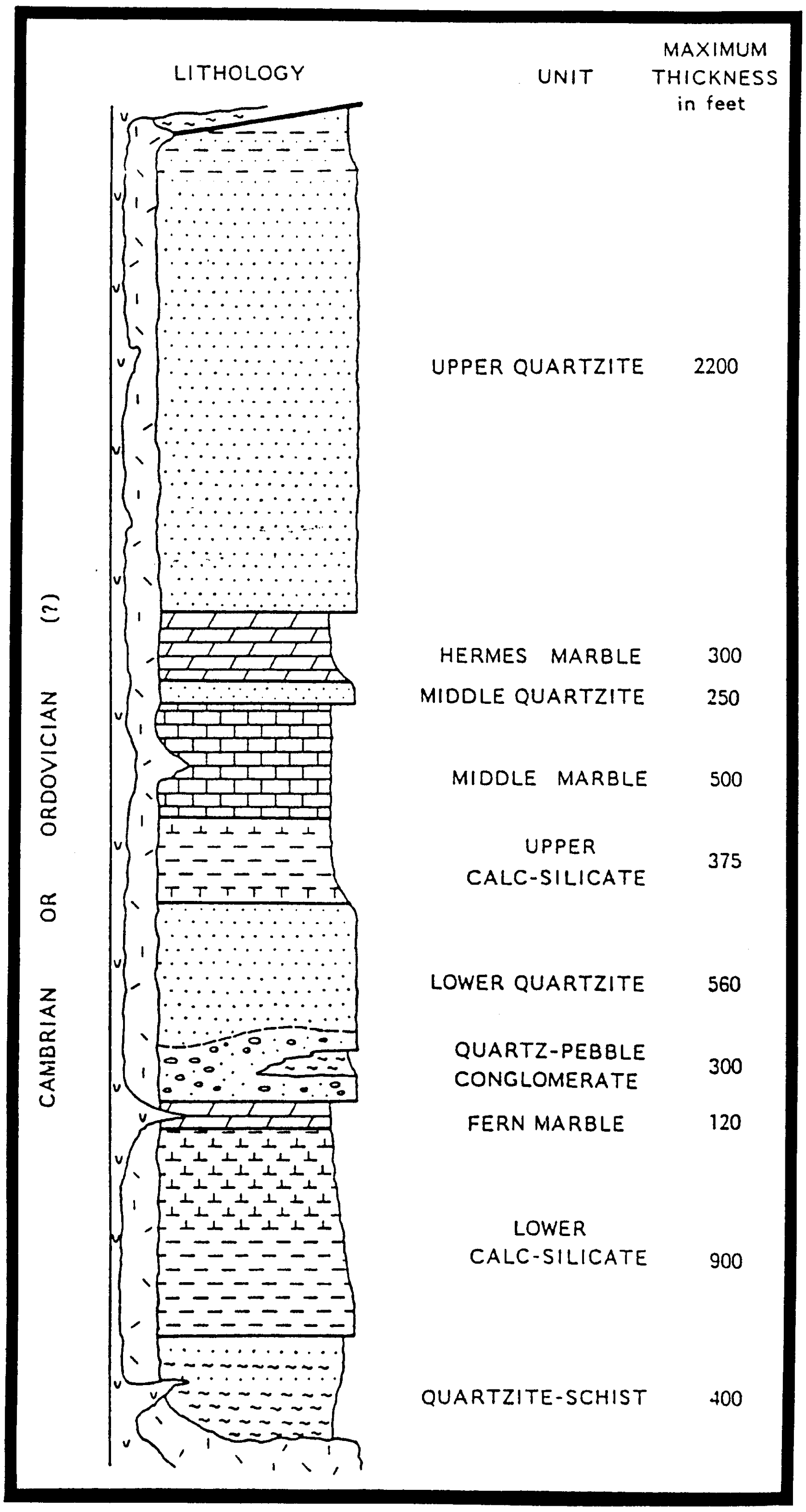


Figure 6. Stratigraphic column of the rocks in the Stibnite roof pendant (Smitherman, 1985, Figure 4).

movement along the Meadow Creek shear zone is believed to have taken place between the deposition of the gold and the later phases of mineralization (White, 1940).

Fine-grained tungsten minerals, dominantly scheelite, formed after the gold. The scheelite occurs as disseminated grains in the gold ore, embedded in stibnite, as branching veinlets and stringers 1 to 5 millimeters thick, and as cemented breccia with scheelite in both the groundmass and the breccia clasts (Cooper, 1951). Field relationships, textural evidence, and mineral associations suggest that the deposits formed under low temperature and low pressure (epithermal) conditions (Cookro and Petersen, 1984; Cookro and Silberman, 1986).

Antimony-silver mineralization overlaps the late phase of tungsten crystallization (Lewis, 1984). Stibnite occurs as disseminations, microveinlets, stockworks, massive lenses, small quartz-stibnite veins that fill fissures, and euhedral crystals coating late fractures (Cooper, 1951). Silicification overlapped the end of the stibnite crystallization. Sericitization, accompanied by mercury mineralization, was the final ore-forming event in the area (Lewis, 1984); the Hermes and Fern Mines to the east (shown on Figure 5) represent this phase of the ore-forming process. The deposits are zoned vertically with respect to the paleosurface. The mercury deposits formed at or near to the surface, and the scheelite and stibnite at somewhat lower levels (Cookro, in press).

The deposits are Late Cretaceous (L.W. Snee, quoted in Cookro, 1989) or earliest Eocene (K-Ar age of about 57 m.y. on adularia associated with the gold mineralization; Lewis, 1984). Gammons (1988) obtained a date of 78.4 to 71.3 Ma ($^{40}Ar/^{39}Ar$ method) on sericite related to the gold mineralization and assigned an age of 67-69 Ma to the antimony-silver-tungsten-mercury deposits, based on evidence from the surrounding area.

Meadow Creek Mine

The mineral deposits in the Stibnite area were discovered around 1900 during the Thunder Mountain gold rush. Development was slow because of the remoteness of the area (Wells, 1983). The first work at the Meadow Creek Mine was in 1902, when J.C. McFarnahan filed for water rights on Meadow Creek; the water was to be used for milling at the Meadow Creek Mine. However, the stamp mills used around the turn of the century could not handle the complex gold and antimony ore, so little happened at that time (Oberbillig, 1976). Albert Hennessy staked the Meadow Creek Group near Stibnite (Figure 7) in 1914 (Schrader and Ross, 1926). (Table 1 lists the individuals and companies operating at this property.) Hennessy had studied the gold prospect at Meadow Creek a decade earlier, but did not stake the claims until the demand for metals during World War I stimulated interest in the antimony and

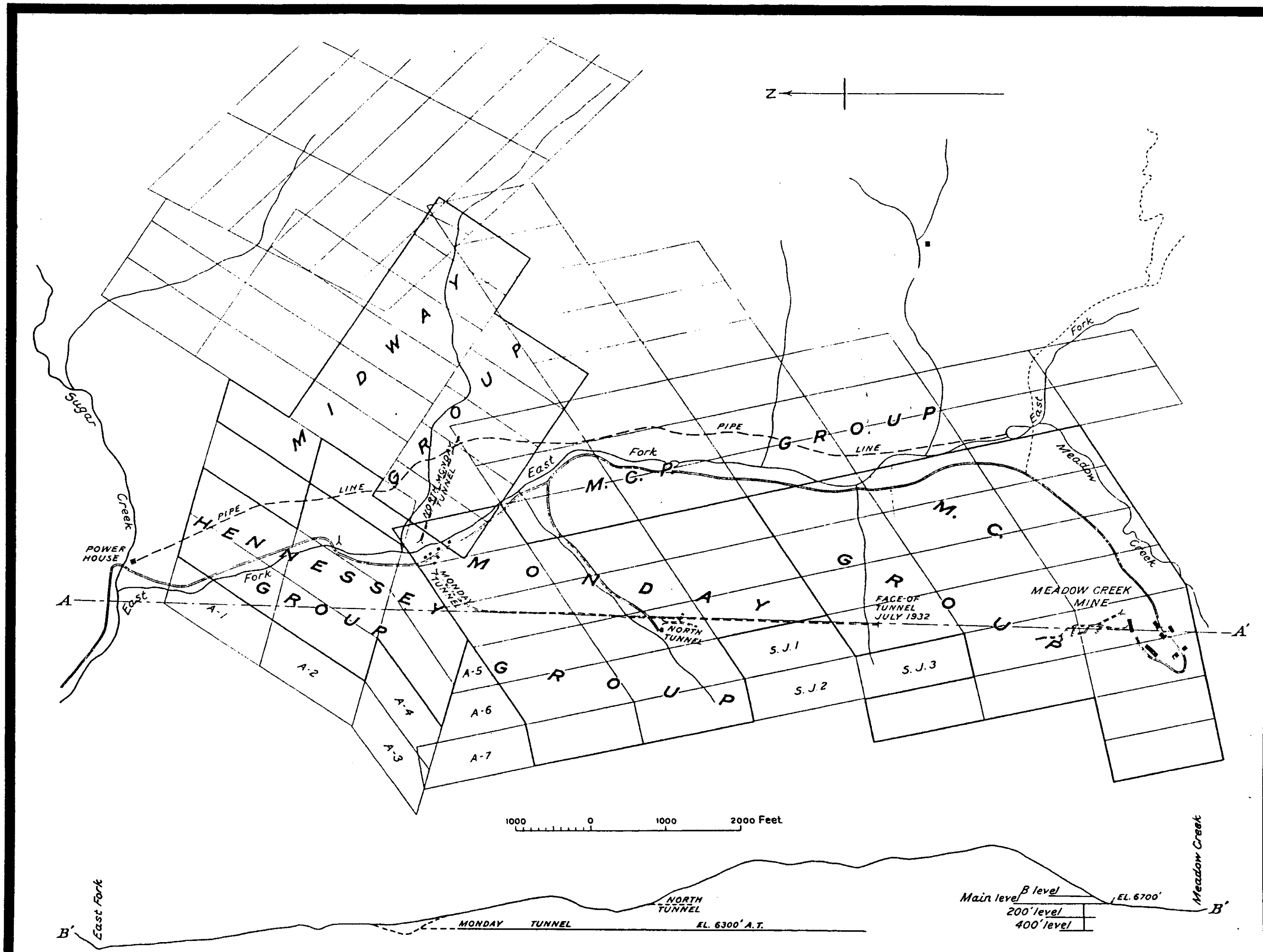


Fig. 7. Map of area along East Fork between Meadow Creek and Sugar Creek, showing claims held by Yellow Pine Company and location of chief developments.

Figure 7. Claim map along the East Fork between Meadow Creek and Sugar Creek. "M.C. Group" is Meadow Creek Group; "M.C.P. Group" is Meadow Creek Pipeline Group; "Midway Group" should probably be Midnight Group (Currier, 1935, Figure 7).

Table 1. Companies and individuals operating at the Meadow Creek Mine.

Company Name	Officer	Date Incorporated	Charter Forfeited	Year(s) at Mine
Albert Hennessy	---	---	---	1914-
Meadow Creek Silver Mines Co.	Albert Hennessy, President	June 17, 1919	1921	1919-1921
United Mercury Mines	J.J. Oberbillig, President	Jan. 22, 1921; reinstated Dec. 20, 1929	1929; Nov. 30, 1963	1921-1942(?)
Homestake Mining Co.	[1]	California: Nov. 5, 1877	[1]	option: 1925-1926(?)
Yellow Pine Syndicate	Fred W. Bradley, President	---	---	1927-1928
Yellow Pine Co.	Fred W. Bradley, President	filed in Idaho: May 25, 1928	taken over by Bradley M. Co.; Nov. 30, 1942	1928-1938
Bradley Mining Co.	Worthen Bradley, President	July 28, 1938	active: 1981	1938-[2]
Ranchers Exploration and Development Corp.	[1]	[1]	merged with Hecla Mining Co.: 1984	1970-1984
Hecla Mining Co.	Arthur Brown, Chairman, President, and CEO	Oct. 14, 1891	active	1891-[3]

[1]Information not available in Idaho Geological Survey's files.

[2]The Bradley family were the owners of record for the patented claims as of 1979 (Bailey, 1979). In 1981 (the last year for which the Idaho Geological Surveys's files contain information) the Bradley Mining Co. was still in existence, although "nonproductive."

[3]Company is still involved with the mine.

mercury mines of the Yellow Pine district. He also staked a number of other claims in the Yellow Pine area (Oberbillig, 1976). The 1918 IMIR described one of Hennessy's discoveries, possibly either the Hard Climb or the Midnight claim (p. 97):

> Along this Western margin of the sedimentaries, . . . on the East fork slope, but well within a magnesium limestone horizon, showing a conspicuous development of fiberous

> metamorphic minerals, another Hennessy group of claims exhibited some remarkably interesting deposits of rich antimony ore with several big surface cut exposures, disclosing deposits in apparently nearly vertical veins varying from clean, high grade stibnite mineral containing fifty to sixty per cent antimony to brecciated quartz veins five to fifteen feet thick of good concentrating antimony mineral that, from surface appearances, indicated average values of five to twenty-five per cent antimony. Two of these larger quartz breccia veins were closely paralleled by big porphyry dikes.

In 1919, Hennessy and two partners formed the Meadow Creek Silver Mines Company to work the Meadow Creek Group. Hennessy's partners were J.L. Niday, a Boise lawyer, and J.J. Oberbillig, a Boise assayer and mining engineer (Oberbillig, 1976). The 1919 IMIR described the property as follows (p. 132):

> [O]n Meadow Creek the Meadow Creek Silver Mines Company is a new corporation designed for the further development of some bold zonal mineral croppings on a steep mountain side that vary from 20 to 50 feet in width and are said to carry average values of 17 ounces silver and several dollars gold associated with disseminated antimony sulphide that, it is believed will afford a high grade concentrate that, with proper wagon road facilities, will justify shipping to outside markets. This property is admirably situated for adit tunnel development which can be started on the new ore course and gain depth rapidly as it progresses and with plenty of water power and timber in the nearby tributaries presents the possibilities of a good producer of relatively rich silver bearing concentrates. No mercury has been found in this deposit so far. It is situated a little west of the main quicksilver bearing section and on the trail towards the Yellow Pine postoffice and the Yellow Pine Antimony Mines near the stage route from Cascade.

Meadow Creek Silver Mines Company did 100 feet of development work on the property in 1920 and planned to develop enough ore to design a mill for treating it. (Table 2 lists development work, men employed, and operating companies at the mine, by year.) In spite of high hopes, Meadow Creek Silver Mines did little more than assessment on the property, according to Oberbillig (1976).

United Mercury Mines Company (UMM) was organized in January 1921 for the purpose of consolidating most of the mining properties in the "Yellow Pine cinnabar belt" (Figure 5). By the end of the year, UMM had acquired the Meadow Creek Mine, most of the mercury claims to the east of Stibnite (including the Hermes Mine on Cinnabar Creek), and some of the gold-antimony prospects south of Yellow Pine (Figure 8). The company's balance sheet valued the Meadow Creek Group at $100,000. According to Oberbillig (1976), UMM paid Hennessy in stock, and he lived off the sale of the stock for the next two years.

Between 1921 and 1922, UMM more than doubled the number of claims that the company controlled and did substantial development work (most of which was probably performed on its mercury properties, collectively referred to as the Cinnabar Group). The company continued development work in 1923 and 1924 on the Cinnabar Group and also on the Meadow Creek Group. F.C. Schrader visited the Yellow Pine antimony deposits in 1923 and C.P. Ross examined the nearby mercury deposits in

Table 2. Development work, number of men employed, and operating companies at the Meadow Creek Mine, by year.

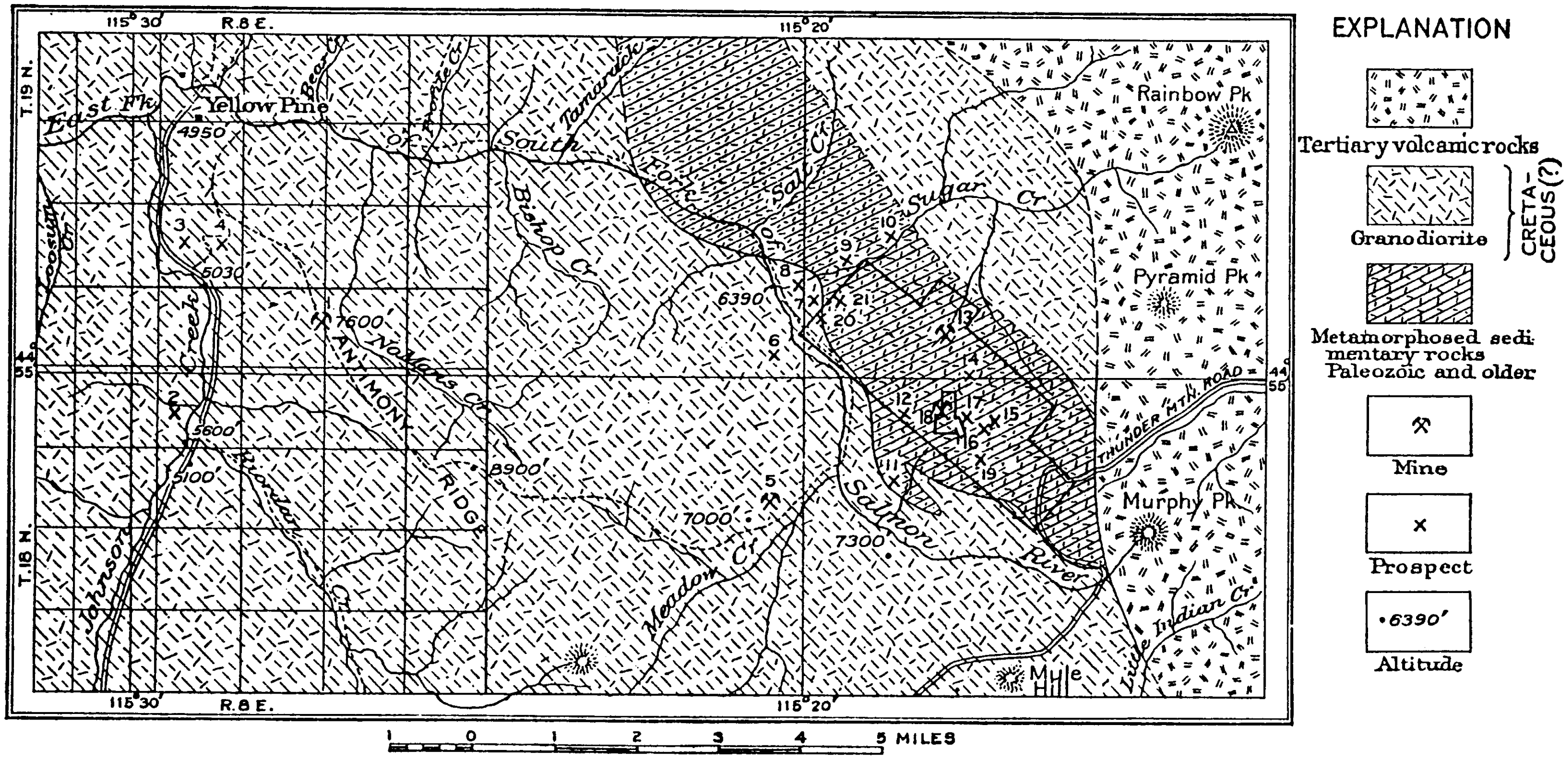
Year	No. of Men employed	Tunnels (feet)	Sinking (feet)	Cross-cutting (feet)	Drifting (feet)	Raising (feet)	Operator
1920	2 (part time)	100[1]	---	---	---	---	Meadow Creek Silver Mines Co.
1924	---	546[2]	---	---	---	---	United Mercury Mines Co.
1928	80	2,000	---	---	---	---	Yellow Pine Co.
1929	80	2,720[3,4]	---	---	---	---	Yellow Pine Co.
1930	55	1,590	---	---	920	530	Yellow Pine Co.
1931	80	3,234	240	240	---	---	Yellow Pine Co.
1933	33	308	---	119	348	---	Yellow Pine Co.
1934	46	---	---	329	1,826	322	Yellow Pine Co.
1935	53	347	---	507	1,311	---	Yellow Pine Co.
1936	48	---	---	274	532	802	Yellow Pine Co.

[1]Type of work was not specified.
[2]Figure taken from Mining Truth (1925). The work apparently included tunneling and crosscutting.
[3]Type of work was not specified, but most of it was probably tunnelling and cross-cutting.
[4]Development work for the year also included 1,600 feet of diamond drilling.

1924. They described the mine as follows (Schrader and Ross, 1926, p. 154-156):

> The Meadow Creek mine (No. 5, fig. 6 [Figure 8])[2], owned by the United Mercury Mines Co., is on Meadow Creek about three-quarters of a mile above its mouth and 100 feet above the creek, in the steep mountain side that bounds the relatively open flat-floored valley on the northwest side. The deposit was discovered about 1900 by Albert Hennessy, who in 1919 sold it to the present owners. Nearly all the development work has been done by this company since 1920. The property comprises a group of 17 claims, known as the Meadow Creek group, and the camp, consisting chiefly of two cabins and a corral.
>
> The country rock is the granodiorite of this region. It is medium grained and fresh and is intruded by finer-grained alaskite and lamprophyric dike rocks. The deposits seem to be genetically connected with the alaskite, locally called porphyry, which is flesh-colored and slightly porphyritic and contains or is associated with stibnite and pyrite. In a part of the deep workings a dike of the lamprophyric rock 5 feet wide is said by Mr. Ross

[2]See Figure 2 for location on topographic base.



Antimony:		Quicksilver:		Miscellaneous:
1. Babbitt Metal mine.	8. No Name ledge.	13. Hermes mine.	18. Fern mine.	5. Meadow Creek gold mine.
2. Silver Cliff lode.	9. Bonanza ledge.	14. Silver Bow lode.	19. Mountain Chief ledge.	10. Kennedy "mica ledge."
3. Golden Gate vein.	11. Doris K. prospect.	15. Vermilion lode.	20. Midnight ledge.	
4. Copper King vein.	12. Doris K. No. 3 prospect.	16. White metal ledge.	21. Hard Climb ledge.	
6, 7. Hennessy lode.		17. Buckbed lode.		

Figure 8. Geologic sketch map showing approximate locations of mines and prospects. Larger outline indicates UMM's holdings in the early 1920s (Schrader and Ross, 1926, Figure 6).

to form the hanging wall. The dike contains sparsely disseminated pyrite and has been somewhat altered by mineralizing solutions, but so far as known none of it has been converted into ore.

The deposits occur in a poorly defined shear zone or lode about 500 feet wide in which the rock is more or less altered and mineralized. The lode for the most part strikes about N. 12° W. and dips steeply toward the west, but in the workings at about 600 feet in from the portal it gradually curves to the right. Where it crops out several hundred feet above and about a quarter of a mile distant from the mine the lode is much softer than the inclosing country rock and has been eroded down into a shallow gully or ravine. According to Mr. Ross, the outcrops consist chiefly of mineralized granodiorite exposed over a considerable area, with gash veins of stibnite present in places.

The lode consists mainly of crushed silicified and mineralized granodiorite, alaskite, and quartz forming the gangue, in which are variously distributed the dark sulphide ore minerals, principally antimonial silver and gold, argentite (?)[3], tetrahedrite (?)[3], and the antimony minerals, chiefly stibnite. Some of the alaskite has much stibnite so evenly distributed through it as to suggest that the stibnite is primary in the rock. Some of the ore seems to be almost pure stibnite. In places there occurs also some pyrite. The stibnite is mostly of sub-medium grain, but scattered through it are also slender bladelike crystals nearly three-quarters of an inch in length.

The deposit is opened by an adit tunnel and drift which in 1924 was about 800 feet in length and 500 feet vertically below the surface at the face. The last 400 feet was said to be mostly in good ore. During 1924, it is reported, considerable crosscutting was done.[4]

At the time of visit about 400 tons of ore derived from development work and said to average about $10 to the ton lay on the dump. In December, 1924, the company reported that it had just struck and was driving on a 5-foot ore shoot that runs $20 in gold to the ton and, by estimate, about 35 per cent of antimony.

The silver-bearing minerals other than stibnite were not determined in this work. From casual inspection tetrahedrite and argentite seem to be present. Tests made by the company are said to show that the ore contains 12 to 15 per cent of antimony. Specimens several inches in diameter collected by the writer are chiefly stibnite. In the deeper part of the workings arsenic is thought by the owners to be present in the ore, but a test made in this work of a specimen of the ore having on the joint and fracture surfaces a thin reddish coating or film, thought to be realgar, failed to indicate the presence of arsenic. The reddish film resembles cinnabar but no decisive result was obtained.

According to Oberbillig (1976, p. 9), "In the years of 1921-1925, Fred Franz, George Brewer, and George Kennedy worked at Meadow Creek and drove hundreds of feet of tunnel into the Meadow Creek ore body, opening up half a million tons of antimony-silver-gold ore." However, the development work also proved that it would

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[3]Through the use of the electron microprobe, Lewis (1984) identified miargyrite as the silver-bearing mineral. He was unable to identify any silver-bearing sulfosalts by reflected light microscopy.

[4]The January 16, 1925, issue of *Mining Truth* reported that the company had completed 546 feet of tunnel and crosscut work, all of which was in ore. The "unusually fine body of ore" was found 800 feet from the mouth of the tunnel and over 500 feet below the surface. The company planned to continue development work throughout the winter.

require many millions of dollars to bring the mines into operation. The company could not raise that much money through stock sales, so it was decided to sell the properties to a large mining company (Campbell, 1932).

At this time, access to the area was difficult. According to Schrader and Ross (1926, p. 137-139):

> The Yellow Pine district (fig. 5)[5] is about 100 miles northeast of Boise, near the center of Valley County, in the midst of the little-developed mountainous region of central Idaho. Yellow Pine, a small settlement and post office in the northwestern part of the district, is most conveniently reached from Cascade, a thriving lumber town on the Long Valley branch of the Oregon Short Line, by the automobile road recently completed by the United States Forest Service. The distance is about 65 miles. Yellow Pine is a little over 20 miles west of the site of the old town of Roosevelt, the former center of the Thunder Mountain gold-mining district. From the vicinity of Yellow Pine several trails lead eastward to the mines and prospects shown in Figure 6 [Figure 8]. The shortest trail to the quicksilver deposits leaves the road near the Johnson Creek ranger station, about 4 miles south of Yellow Pine, crosses the high mountains to Meadow Creek, and is about 16 miles long. The old Thunder Mountain road passes within 2 miles of the camp of the United Mercury Mines Co. and is connected with it by a trail. Machinery and supplies for this and other properties in the district have been brought in over this road, but it is reported to be in poor repair and to have such steep grades as to be an impracticable route for regular traffic. A more suitable route would probably be up the East Fork from Yellow Pine along one of the present trails. Such a road would have about the same grade as the stream, approximately 3 per cent most of the way, but would be expensive to construct because of the large amount of excavation in solid rock that would be necessary.

During 1925 the company did 215 feet of development work on the orebody (Schrader and Ross, 1926). Lawrence Wright, mining geologist for the Homestake Mining Co. (Lead, South Dakota), examined the property during the year (Oberbillig, 1976). Homestake optioned the mine at a price of one million dollars (Campbell, 1931a). A small shipment of ore was sent out for testing (IMIR). The company seriously considered purchasing the mine, but Homestake's metallurgists rejected the deal because they were unable to treat the complex gold-antimony ore (Hart, 1979; Oberbillig, 1976).

The company continued development work during 1926. Two cars of silver ore, which contained a little gold, were shipped. At the end of the year, the company reported the tunnel at the Meadow Creek Mine was 1,700 feet long.

On May 17, 1927, F.W. Bradley[6] optioned the Meadow Creek and Cinnabar groups for $1.5 million (Oberbillig, 1976). Bradley's company was known as the

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[5]Figure omitted.

[6]Bradley, a San Francisco mining engineer, was the president of Bunker Hill & Sullivan Mining & Concentrating Co. He also had a large interest in Alaska's Juneau gold mines and had been the managing engineer of the Alaska-Treadwell Mine (Oberbillig, 1976).

Yellow Pine Syndicate. The new company began an active development program. In addition, it enlarged and improved the mine camp at the Meadow Creek Mine and also built a new camp (the North camp) on Fiddle Creek. The North camp was 14,000 feet north of the old camp and 500 feet lower in elevation. The vein, which was about 40 feet wide, had been traced for this distance along the surface, and the North tunnel was started to prove the vein at the that point. Improvements to the camp included stringing a telephone line between Johnson Creek and Meadow Creek (Campbell, 1931a).

Construction on a 12-mile highway from Yellow Pine to Meadow Creek along the East Fork[7] was started in 1928. Part of this work was done by the Forest Service (with half the funding provided by the Yellow Pine Mining Co.), and a connection to the Forest Service road was built independently by the company. According to Campbell (1932), "The entire distance involved the heaviest kind of mountain construction, as much of it passed through a precipitous box canyon. This work was maintained throughout the winter of 1928 and completed early in 1929, thus making it possible to replace pack strings and saddle horses with motor trucks and automobiles."

Other work during 1928 included expanding the Meadow Creek camp (Figures 9 and 10) and installing a large amount of new equipment. Moving the heavy machinery to the mine was difficult. According to Campbell (1931a, p. 17):

> Geologic reports published from 1918 to 1927 describe the old road which the state constructed into Thunder Mountain during the boom as "abominable," "atrocious excuse," "terrific grades." Nevertheless, over this road, in the summer of 1928, two large boilers, steam engines, a complete sawmill, a compressor and other mining equipment were transported to the head of South Meadow Creek and thence down the steep mountain side to the mine, a distance of four miles. Over much of the last four miles it was necessary to let the equipment down by means of snubbing blocks and tackle.

Yellow Pine Mining Co.'s activities for 1928 were described in great detail in a series of letters written by J.J. Oberbillig to the stockholders of the United Mercury Mines Co. On June 4, 1928, he wrote:

> The work of development has been carried on continuously from the time Mr. Bradley has taken over the properties, with an average force of thirty men on the payroll, completing more than 1,500 feet of tunnel work. The improvements and developments as directed are being done on the basis of sound engineering in a first class manner, and since the signing of the option Mr. Bradley has fully complied with all the terms of the

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[7]From Yellow Pine Post Office, the road went south along Johnson Creek to Landmark, over Warm Lake Summit (7300 feet) to Warm Lake and Knox, then over Big Creek Summit (6900 feet) to Cascade. This route was 90 miles long and, in places, had grades of up to 15 percent. The shorter route down the East Fork and over Lick Creek Summit to McCall was not completed until after World War II (*Spokesman Review*, January 6, 1946).

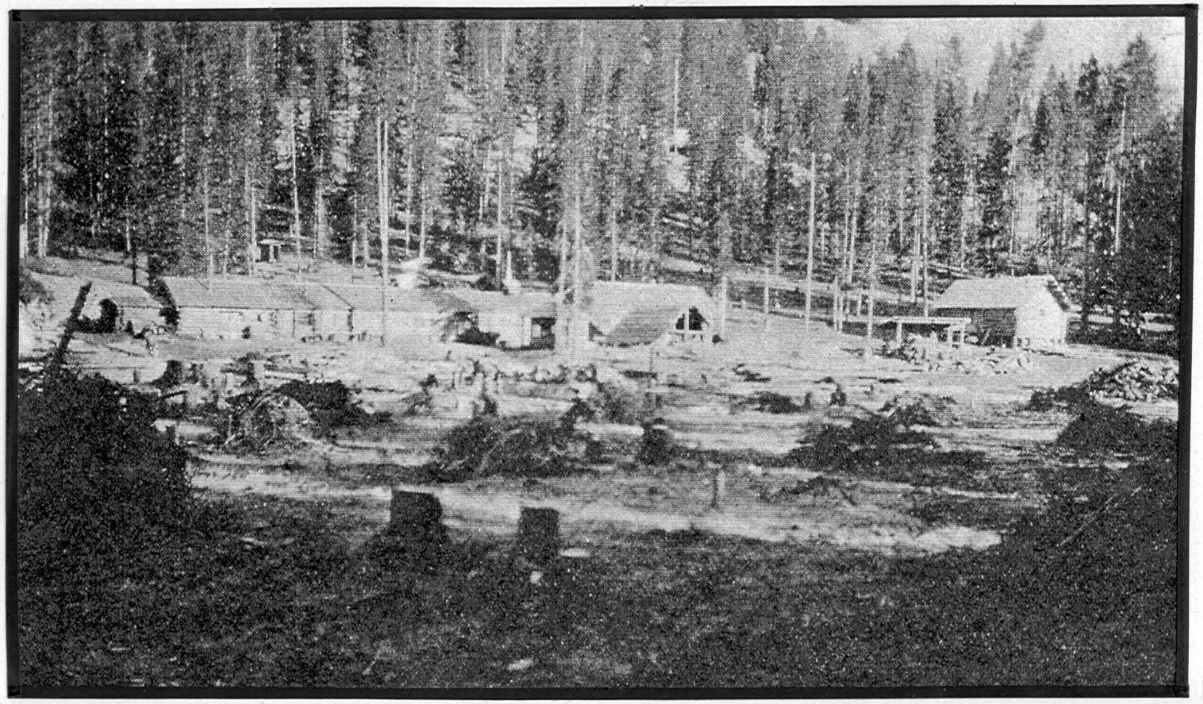

Figure 9. Yellow Pine Co.'s Meadow Creek camp in 1928. The work of expanding the camp has just started, as indicted by the stumps and recently cut trees in the foreground (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 34).

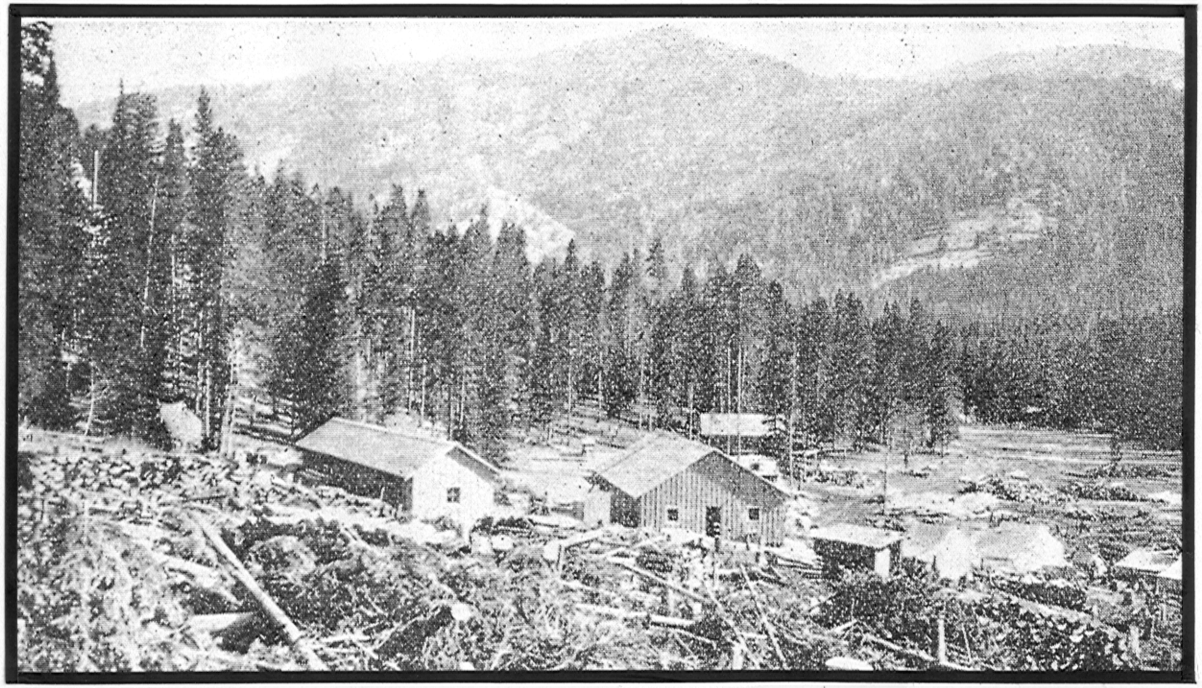

Figure 10. Yellow Pine Co.'s Meadow Creek camp in 1928. View is almost directly east along Meadow Creek. The clearing on the right side of the picture is the Meadow Creek landing strip (Campbell, Stewart, 1929, Thirtieth Annual Report of the Mining Industry of Idaho for 1928, p. 240).

contract. The splendid progress thus far made at the mines has been accomplished by reason of the fact that Mr. Bradley has expended for developments and improvements nearly twice the amount agreed upon[8]. The new developments disclose a very large tonnage of ore at both Cinnabar and Meadow Creek mines.

On October 5, 1928, Oberbillig wrote:

Since my last letter to the Stockholders, dated June 4th, 1928, the work of general development and improvements made by the Yellow Pine Company at the mines, necessary to bring the mines nearer to a productive basis, has been carried on continually with a force ranging all the way from 110 to 145 men. During the past week I have made an inspection of all these operations which are being carried on by the new owners, therefore, in this letter it is my intention to carefully embody my views of the operations thus far accomplished this season, for the purpose of informing the stockholders in a general way of the progress made by the Yellow Pine Company, and to assure you that all of the developments and improvements as directed are done in a first class manner. Trusting also that you will note from this letter, that from the different points of operation there is a great distance to be covered, and at present these points of operation can only be reached by foot or on horseback, and the necessary food supplies and mine equipment to carry on the operations must be taken to these different points for the present by packhorse, and the distance to be covered in this manner from Yellow Pine to the various camps ranges all the way from 12 to 18 miles.

The contract for the packing and freighting of the supplies and mine machinery was given to the firm known as Stonebreakers Bros., which is one of the largest packing and freight carriers in the state. The food supplies and all things that can be carried by pack horse are moved over the trail and all of the heavy mine machinery was trucked over the steep grades of the Thunder Mountain road on trucks especially made for this purpose, and before reaching the mines these loads had to be transferred on drag skids and hauled down the mountain with horses a distance of three miles. With this method of pack horse and trucking, over 500 tons of freight has been taken to the mines thus far this season. To overcome this great difficulty, which is the greatest handicap to the successful operation of these mines, the Yellow Pine Company has and is putting forth every effort to complete the road from Yellow Pine to the mines. During the early spring months, the Yellow Pine Company negotiated with the Government Forest officers for the purpose of cooperating, which resulted in the plan of building the first four and one-half miles of road from Yellow Pine to Profile Creek up the east fork of the south fork of the Salmon River on a 50-50 basis. For this part of the road the Company advanced $17,500.00, and the work of constructing the road for this distance is being done by the officers of the Payette National Forest Reserve. This part of the road consists of heavy construction. For a distance of nearly two miles the road passes through a box canyon, and in several places in order to build the road bed it was necessary to cut through solid rock. For this remarkable piece of road work, built on a good standard grade, the Forest Officials are entitled to great credit from an economical standpoint as well as good road building. This four and one-half miles of road, when completed, becomes part of the chain of public highways and will stand as a public benefit as long as roads are maintained and used for public transit. For that reason I maintain that there is due to Mr. F. W. Bradley a very great credit for the advancement of this large sum of money for the construction of this

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[8]Expenditures from January 1928 to November 30, 1928, totalled $269,661.87.

part of the road. The distance from the mouth of Profile Creek to the mines is a little over 10 miles.

The Yellow Pine Company is pushing the road work from the mines, and has already constructed over four miles of the main highway from Meadow Creek to Yellow Pine. Besides this amount of road work, the Company has finished and put in good condition nearly two miles of good road around the mines.

Judging from the progress thus far made in the way of road building, by November 1st there will not be more than five miles of unfinished road left out of the entire 15 miles. It is clear to be seen that the Yellow Pine Company will put forth every effort to work as late as the snow conditions of this section will permit, and to start early in the spring, so that by July 1st of next year the entire road may be finished. This section of the country that the road passes over is very rough, with steep mountain sides, and in building such a road heavy rock work is encountered.

AT MEADOW CREEK. About six weeks ago the Company had completed the installation of the saw mill, which has a capacity to cut 25,000 board feet of lumber per day. Since its erection and completion the mill has been in continuous operation cutting lumber for immediate and future use, and since lumber has become available in this manner, all of the camp buildings have been remodeled, a large new storehouse was built, and a fine large cellar, 34 feet wide by 40 feet in length. These buildings contain sufficient room to store at least 200 tons of supplies. At Meadow Creek Mine the Company is installing a large air and power drill compressor. This installation is expected to be in operation within the next three weeks. From then on the work of mine development will be carried on with air drills. At this point of operation the company has started a new, large working tunnel, which is to connect with the former Meadow Creek tunnel. This new tunnel has already been driven over a distance of 140 ft., following along the strike of the ore body. Within the next 50 feet this new tunnel will cut into the south drift of the old Meadow Creek tunnel. The north and south drifts of the Meadow Creek workings have opened the ore body along its strike over a distance of 700 feet. At this camp the company has contracted the cutting of over 700 cords of wood for use at the compressor and sawmill, also has logs cut and stacked at the sawmill containing 500,000 board feet of lumber.

In addition to all these developments and improvements at Meadow Creek proper the Company has cleared off a space of land about 400 feet wide by about 4,000 feet long, for the purpose of having in readiness a landing field for airplane use if necessary.

NORTH TUNNEL, at Meadow Creek, which is located by road a distance of two and one-half miles north from Meadow Creek proper: At this camp, the Company is driving a tunnel south, following along the strike of the ore body. At this point of operation, since my last report to the Stockholders, the new owners have driven over 300 feet of new tunnel and cross-section work. The camp buildings were remodeled, and the mine was supplied sufficiently with food supplies, timber and wood to carry on the work of development through the winter months. In addition to this work the Company has built a fairly good road from the Meadow Creek highway to the north tunnel, which covers a distance of nearly three-fourths mile. . . .

During the later part of the summer Mr. C. G. Dennis of San Francisco, California, who is the Manager of the Yellow Pine Company, determined that the power which could be developed around the mines was inadequate to carry out the plans and purposes of the future. He therefore directed that the company have more power resources, which resulted in the location of a splendid power site below Yellow Pine, at a short distance below the forks of both streams, the south fork of the east fork of the Salmon River and Johnson Creek. These streams are both large and flow sufficient water

> to generate several thousand horsepower. . . .
>
> Before concluding this letter, I also wish to inform the Stockholders that all of the new locations which have connected the Cinnabar and Meadow Creek Mines into one group, and all that portion of the new power site and locations was done in the name of the United Mercury Mines Company as the holder of the property, which in turn is deeded to the Yellow Pine Company and the deeds placed in escrow.

On December 21, 1928, Oberbillig described the activities for the last three months of the year:

> At Meadow Creek proper the company has erected additional living quarters; the new buildings consist of a large modern bunk house and 4 neatly built cottages, a machine shop and the completion of the compressor building. A complete laboratory and assay outfit has recently been installed, and since the installation of the compressor and the use of air drills the work of tunnel development is showing great speed over the former method of hand drilling.
>
> The Company is still at work on the road. No doubt they are very anxious to get the road work over with and should weather conditions permit it is not at all unlikely to expect that this work will be carried on through the entire winter; the completion of the unfinished part of the road will mark the end of that very difficult problem, of moving freight, machinery and supplies to the miner. . . .
>
> The ores at Meadow Creek presented a very difficult metallurgical problem, and the solving of a process to successfully treat these ores on a commercial basis was left up to Mr. Bradley and his able staff; through his efforts a successful process has been accomplished.

Also in 1928, the Yellow Pine Company chose a site near the mouth of Midnight Creek to drive two long tunnels (Campbell, 1932). These tunnels were the Monday tunnel, which headed southwest and south in the Meadow Creek fault zone, and the Cinnabar tunnel, which was driven southeast to intersect the company's mercury deposits from below. Buildings for the Monday camp were constructed.

The company completed nearly 2,500 feet of drifting and 1,600 feet of diamond drilling during 1929. Most of the development at the Meadow Creek tunnel consisted of diamond drilling. A number of new buildings were constructed at the Meadow Creek camp, and a steam-driven compressor and "complete mining equipment" were installed in the mine. A large "modern" boarding and bunkhouse was constructed at the Monday camp (Figure 11). Work was started on the Monday tunnel, and a gas-driven compressor and complete mining equipment were installed at the tunnel. The Monday tunnel was 8,000 feet north of the Meadow Creek tunnel and 450 feet lower in elevation. In addition, work was started on the Cinnabar tunnel. The highway was completed during the first part of the year. Other improvements listed by the company included the installation of phone lines and the construction of a warehouse and a stable.

Active development work continued in 1930. The company did 2,682 feet of work on the Monday and Cinnabar tunnels and completed 865 feet of drifts,

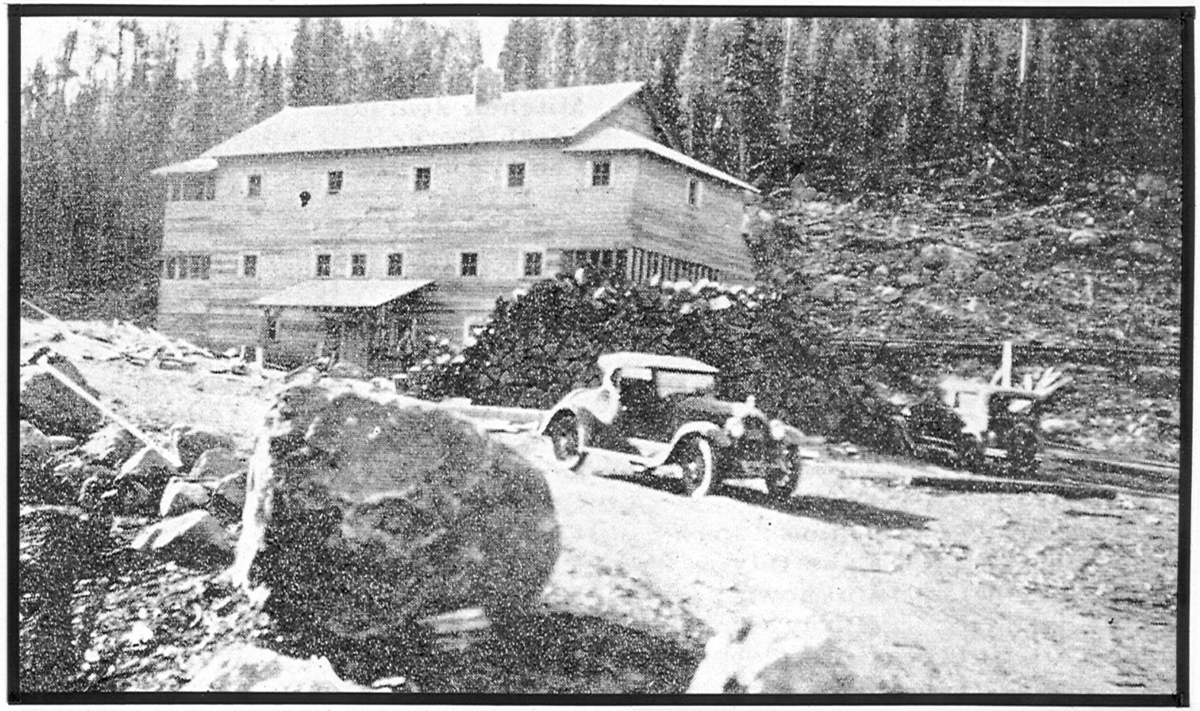

Figure 11. Boarding house at the Monday camp in 1929 (Campbell, Stewart, 1930, Thirty-first Annual Report of the Mining Industry of Idaho for the Year 1929, p. 269).

crosscuts, raises, and shaft work in the Meadow Creek workings. The Meadow Creek Mine contained over 4,500 feet of workings, and the Meadow Creek tunnel was over 3,000 feet long. Two inclined raises extended from it and connected to three intermediate levels. The Meadow Creek "B" tunnel was 410 feet long. Extensive additions were made to the camps and to the company's mine plants and equipment. According to the 1930 IMIR (p. 278):

> The expenditure made by this company for power plant construction and installation, for new mining equipment, erection of new buildings, road construction, and mine development work was the largest in southern Idaho during 1930. The Monday tunnel camp was selected as the principal base of operations and was established as a post office with the name of Stibnite[9], having a mail service three times a week. The Monday and Cinnabar tunnels, on each side of Meadow Creek, are at the same elevation and the portals are connected with a long trestle [Figure 12], thus making all equipment and camp facilities accessible to both tunnels. The Cinnabar tunnel is projected to develop the gold and mercury deposits of the Cinnabar group. Its total length when completed will be about 10,000 ft., and it will intersect the ore zones approximately 1,600 ft. below the upper levels. The Monday tunnel, which is practically a drift on the Meadow Creek vein, has a projected length of 8,000 ft. and a depth of 410 ft. below the Meadow Creek tunnel. In the Meadow Creek tunnel there is approximately 4,500 ft. of crosscuts, drifts, and raises that open the ore bodies 400 ft. below the surface. New buildings erected in Stibnite were: assay office, post office, machine shop and compressor house, change house, large barn, warehouse, woodsheds, oil house, meat house, large cellar, large bunkhouse. New equipment installed: Two large electrically driven compressors, electrically driven ventilator blower, steel sharpener, oil furnaces, lathes and machine tools, storage battery locomotive haulage, and complete mining equipment. At the Meadow Creek camp a new slaughter house, corrals, an additional residence and a warehouse were erected. The compressor was converted to electrically driven. An electrically driven hoist, complete equipment for shaft sinking and for fire protection were added. A new 525-kw. hydroelectric power plant was installed on Meadow Creek[10]. The generator is driven by a Pelton water wheel operating under a 520-ft. head. The water is delivered through an 11,000-ft, 28-inch, redwood-stave pipe [Figure 13] and a 1620 ft., 24-inch steel penstock. Construction work was started on the 1st of June, and the plant was completed and in operation on the 1st of November. This work involved also the clearing of a right-of-way for the pipe line and transmission lines through heavy forest for a width of 200 ft. Mine development work was maintained throughout the year in the Meadow Creek tunnel and in extending Monday and Cinnabar tunnels. A station and skip pockets were cut in Meadow Creek tunnel, hoist and sinking equipment were installed therein, and all arrangements were completed for sinking a 410-ft. vertical shaft on the ore. When completed, Monday tunnel will connect with this shaft.

The South Meadow Creek hydroelectric power plant was driven by a Pelton water

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[9]Currier (1935) refers to the Monday camp as "Stibnite Camp." However, later references show the town of Stibnite at the location of the Meadow Creek camp.

[10]The Meadow Creek power plant was actually near the confluence of Sugar Creek and the East Fork (Figure 7).

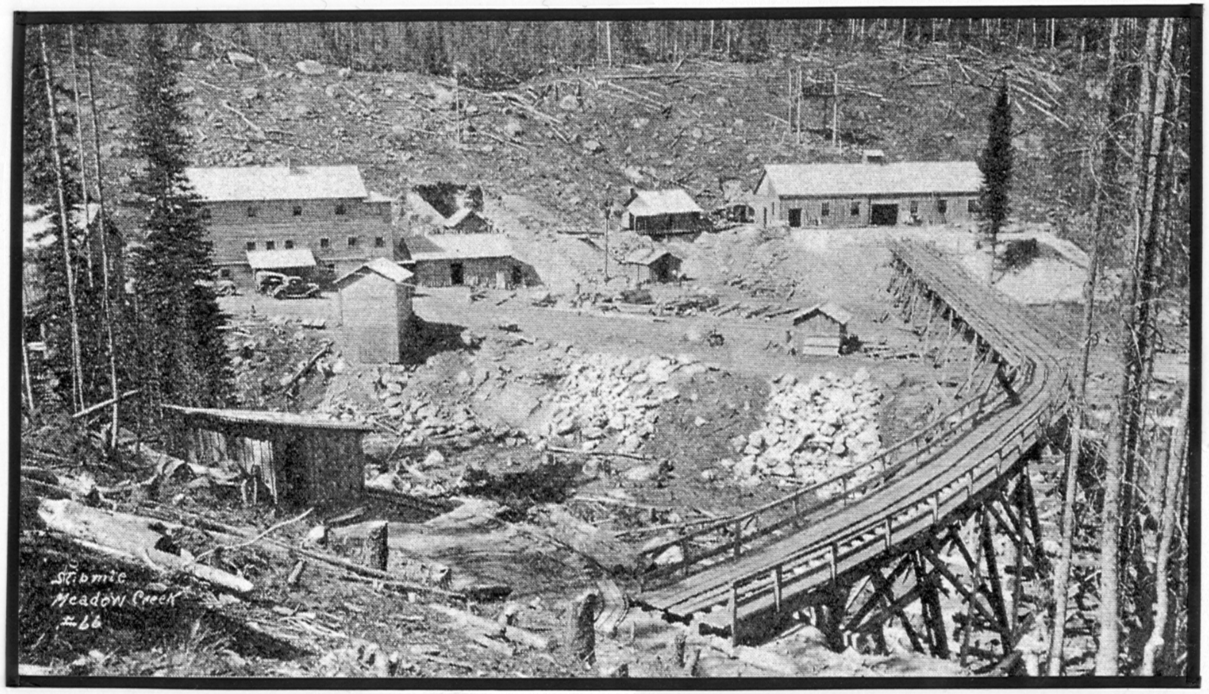

Figure 12. Partial view of Yellow Pine Co.'s Monday camp, showing the trestle connecting the Monday and Cinnabar tunnels (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 37).

Figure 13. Pipeline for the Yellow Pine Co.'s Meadow Creek power plant (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 38).

wheel under a 422-foot head and could generate 75 kilowatts. Five miles of transmission lines were used to distribute power to the company's operations. Figure 14 gives the locations of the power plants and pipe lines; Figure 15 shows the relative elevations of the various features.

The other important development during 1930 was the advent of mail service by air. (Figure 16 shows the landing field.) According to Campbell (1931a, p. 17):

> In November, 1930, George Stonebreaker, who holds the government mail contract, replaced dog team mail delivery [Figure 17], requiring three days from Cascade, with airplane service, requiring less than an hour. Passengers and light supplies are transported and a regular schedule is maintained from November to June [Figure 18[11]].

The company did 8,000 feet of development during 1931, mostly on the Monday and Cinnabar tunnels. By the spring, the company had blocked out sufficient ore in the Meadow Creek vein to sustain operations at the rate of 2,500 tons per day (tpd) and to justify construction of a mill to process this ore. According to Campbell (1932, p. 37), "The metallurgical treatment of the ore had been solved by Mr. Bradley and his staff, and, as the milling methods involved some new procedure, Mr. Bradley displayed his usual caution by deciding to construct a pilot or experimental mill of 150 tons capacity, in order that all tests should be proved in practice before building such a large mill." According to Bradley (1942), the flotation process for the mill was developed at the Berkeley Laboratory in Berkeley, California. The 1931 IMIR described the year's activities as follows (p. 30-31):

> Early in the year the Yellow Pine Co. decided that sufficient ore had been developed to warrant the construction of a 150-ton pilot mill. In order that operations in advancing the Monday tunnel would not be interrupted, and as there was a large tonnage available above the level of Meadow Creek tunnel, this camp was selected as the location for the mill. Plans were then made for the year, and a large sum[12] was appropriated to carry them out. By the close of the year the expenditures in new mine work and construction had exceeded those of any other company in the State. The work was carried on by approximately 200 men, divided into 10 crews, under the supervision of Geo. W. Worthington, mine superintendent. Besides directing all of the work successfully and expeditiously, he established a new tunnel-driving record for the United States, by advancing the Monday tunnel 663.6 feet during the month of August[13]. Construction of the mill was started in June; the building was erected, equipment

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[11]Until 1941, the road from Stibnite to Cascade was closed six months out of the year; snowshoes, dog sleds, or ski-equipped planes were the only way in or out. This particular photograph was probably taken in the winter of 1932, when an oil storage tank at the mill ruptured and 12,000 gallons of fuel oil had to be flown in (Bailey, 1978).

[12]Elsewhere, Campbell (1931b, 1932) stated that $450,000 was the amount allocated for the year's work.

[13]During May, June, July, and August, 1,964 feet of work was done on the tunnel, for an average of 491 feet per month. This work was done by three shifts of six men. The muck was handled by hand and trammed by an electric storage battery locomotive. The tunnel was in granite; its dimensions were 6 by 8 feet where no timber was needed and 7 by 9 feet where support was required. By the end of August, the tunnel was 4,820 feet long (Campbell, 1932).

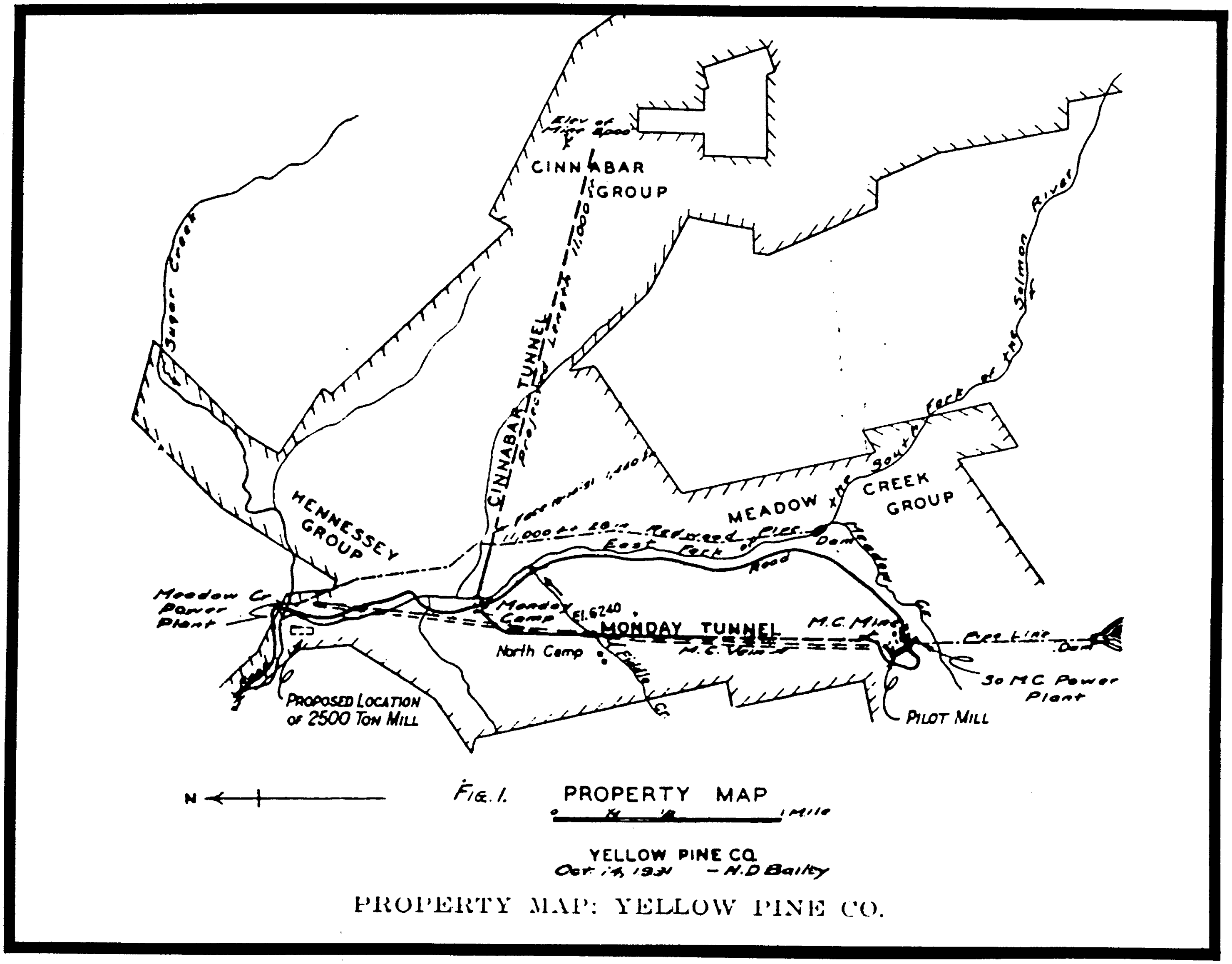
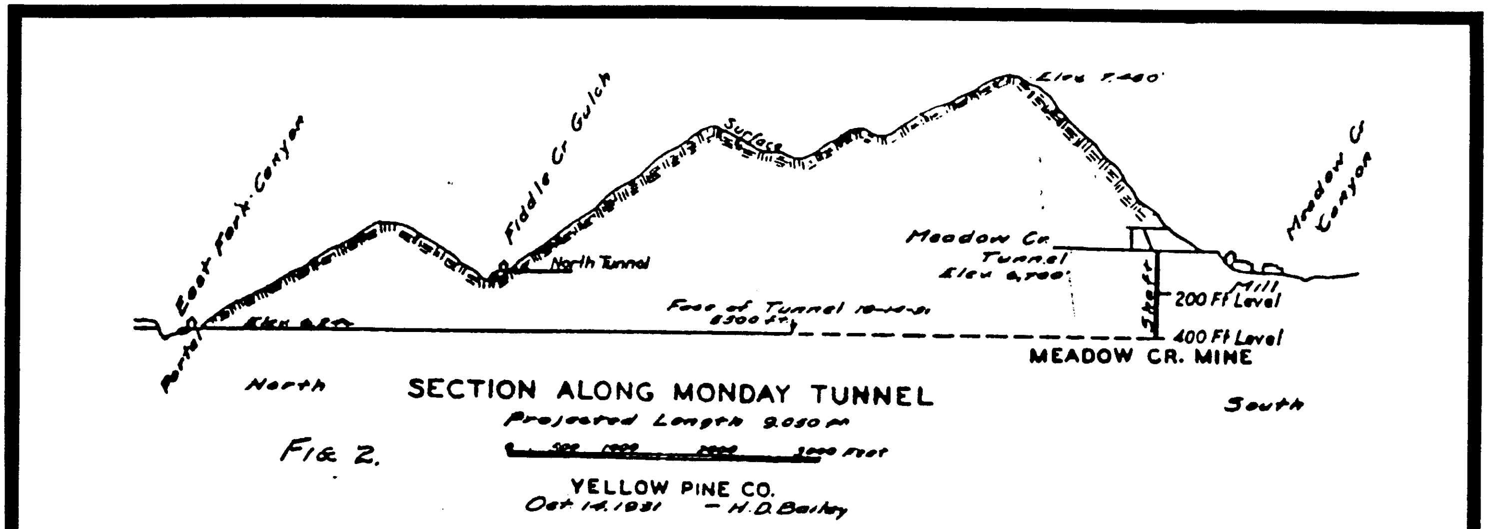


Figure 14. Property map of the Yellow Pine Co. in 1931, showing locations of the pipelines and power plants (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 36).



SECTION ALONG MONDAY TUNNEL

Figure 15. Cross-section of the Yellow Pine Co. property in 1931, along the line of the Monday tunnel as shown in Figure 14 (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 36).

Figure 16. Landing field at Meadow Creek camp in 1930 or 1931 (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 39).

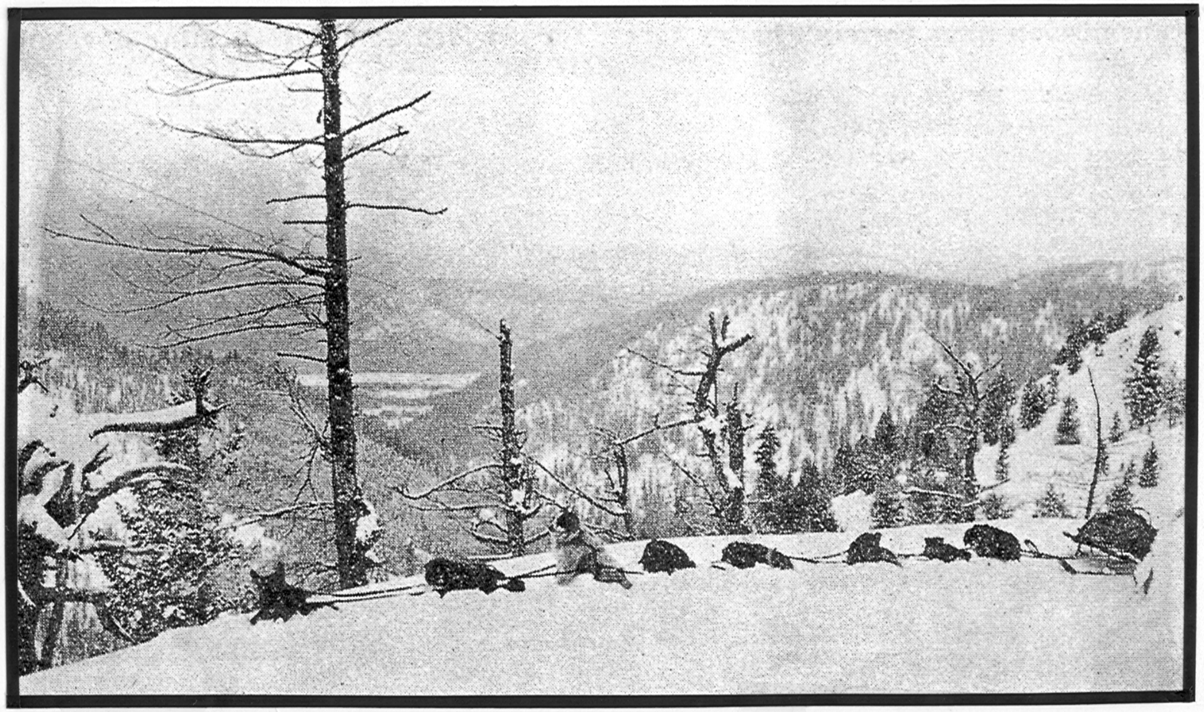


Figure 17. Dog sled on the route to Stibnite. This was the standard method of winter transportation prior to the establishment of regular air service (Campbell, Stewart, 1931, Thirty-second Annual Report of the Mining Industry of Idaho for 1930, p. 270).

Figure 18. Unloading fuel oil at the Stibnite airstrip (probably in 1932), with the Meadow Creek mill in the background (Simons, W.H., 1935, Thirty-sixth Annual Report of the Mining Industry of Idaho for the Year 1934, p. 267).

completely installed, and the mill was ready to start at the close of the year. In addition to the mill building, a new cook house, bunk house, and store building were constructed, and the company assisted the employees in building 13 residences. The mine work was divided into four separate operations: crosscutting and drifting on the 200 and 400 foot levels in the shaft in Meadow Creek tunnel; advancing Monday tunnel, Cinnabar tunnel, and Antimony tunnel[14]. The other principal activities included: moving the South Meadow Creek power plant into the mill building, reconstructing the pipe line and constructing a 40-foot earth-filled dam at the intake; covering the 11,000-foot redwood pipe of Meadow Creek power plant to prevent freezing[15], 4,000 feet being buried and 7,000 feet being boxed, then filled with sawdust and covered; logging and sawing of more than 1,000,000 feet of lumber and cutting and delivering to the yards 80,000 feet of mine timber. The company assisted in constructing 4 miles of road down the river from Yellow Pine for the development of the proposed site of a large hydroelectric power plant[16] and in establishing a public school, which is conducted in the original Meadow Creek camp building.

Campbell (1931b, p. 9) described the Meadow Creek ore and how it was processed in the new mill:

The Meadow Creek vein has been opened by three major entries—Meadow Creek, Monday and North tunnels, between which it has a known length of more than 2½ miles. So far four ore bodies have been determined and the ore in Meadow Creek tunnel has been proved to a vertical depth of 800 feet by mine entries and to a greater depth by diamond drill holes.

The vein is a wide shear zone in which the granite is altered and mineralized. Where opened in the Meadow Creek tunnel a diabase dike, about six feet wide, occupies the center of the vein and the mineralization graduates from solid ore adjacent to the dike, on each side, to a fine dissemination at a distance. The ore shoots vary from 20 to 60 feet in width; no walls are apparent and assaying is necessary to determine ore from altered rock to ascertain the width of the ore shoots.

The ore consists of stibnite (antimony sulphide), yellow pyrite and a black pyrite (iron sulphides) in a matrix or gangue of quartz and unreplaced country rock.[17] The distribution of the sulphide minerals in the gangue varies from pure massive stibnite to finely disseminated particles.

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[14]At the Babbitt Metal Mine on Johnson Creek, south of Yellow Pine (Figure 7).

[15]During the first winter the pipeline was in use, the water froze inside the pipe, diminishing the flow of water. Eventually, the system had to be shut down until the weather warmed up in the spring (Bailey, 1978).

[16]The company owned the 30 claims of Yellow Pine Country Placer group, which was located on the river below Yellow Pine. While the claims were being held for placer gold, they also covered the site of the proposed 8,000-horsepower hydroelectric plant (Campbell, 1932).

[17]In a different version of this article (Campbell, 1932), the description of the ore read: "The ore consists of stibnite (antimony sulphide), arsenopyrite (iron-arsenic sulphide) and pyrite (iron sulphide) in a matrix or gangue of quartz and unreplaced country rock. . . .

The stibnite contains a small silver content; the pyrite is barren; and the arsenopyrite carries the principal gold and silver values; also an unidentified silver mineral may be present."

> In places the stibnite is free from the pyrites and again all three are so intimately mixed that each mineral can not be distinguished by the naked eye.
>
> The stibnite contains a small silver content, the yellow pyrite is barren and the black pyrite carries the principal gold and silver values; also an unidentified silver mineral may be present.[17]
>
> The ore is delivered from the mine into a crude ore bin, thence through a coarse crusher and onto a conveyor belt, which discharges on an impact screen. The oversize from the screen goes to a Symons cone crusher; it then joins the undersize and goes to the fine ore bin from which it is fed into a Hardinge ball mill operating in closed circuit with a Dorr classifier. The overflow from the classifier is then conditioned and goes to the antimony rougher flotation circuit, a six-cell Kraut flotation machine. This machine makes two products, an antimony concentrate and a tailing which contains the iron, gold and silver. Pending completion of the electrolytic antimony plant, now under construction, the antimony concentrate will be stored or, possibly, shipped to a smelter.
>
> The tailing from the antimony flotation cells goes to the iron rougher flotation circuit, an eight-cell Kraut flotation machine, which makes an iron concentrate and a tailing. The tailing goes to waste and the concentrate to a two-cell flotation machine for further concentration or cleaning. The product from this machine is then filtered and sent to the cyanide plant.
>
> On reaching the cyanide plant the iron concentrate is first roasted in a Nichols-Herreshoff roaster, which converts it from an iron sulphide into an iron oxide thus liberating the gold and silver. The discharge from the roaster passes into the cyanide circuit, which consists of an intricate system of tanks, agitators, filters, pumps and clarifiers, and thence into the precipitation tanks which remove the gold and silver. The precipitate is then melted and the bullion shipped to the mint.

The ore was ground to minus 100 mesh before it was sent through the flotation cells. To produce the stibnite concentrates, the following reagents were used (Bradley, 1942, p. 6):

Reagent	Pounds per ton
Copper sulfate	1.21
Soda ash	0.03
Caustic soda	1.37
Chlorine	0.82
Cresylic acid	0.30

The resulting concentrate contained 0.77 ounce per ton (opt) of gold, 10.51 opt of silver, and 48.6 percent antimony. Marketing the stibnite product was difficult because there were few antimony smelting plants in the United States. (The Texas Mining & Smelting Co.'s plant in Laredo, Texas, which began operations in December 1930, processed mainly Mexican ore. Other processing facilities did not start operations until the late 1930s.) Foreign buyers did not want the concentrates because of the silver, gold, and arsenic (up to 1 percent) contained in the concentrates. Most of the Meadow Creek Mine's concentrates were sold to the United States Smelting Co. plant at Midvale, Utah. This plant used the Betts process, an

electrolytic process for refining base-metal bullion that required the ore to contain at least 1 percent antimony (Bradley, 1942).

The reagents used to produce the gold-iron concentrate were (Bradley, 1942, p. 6):

Reagent	Pounds per ton
Xanthate	0.006
Pine oil	0.056
No. 301	0.170

During the first year, this produced a gold concentrate that contained 2.75 opt of gold, 3.37 opt of silver, and 4.14 percent antimony. The final tailings contained 0.05 opt of gold, 0.09 opt of silver, and 20 percent antimony (Bradley, 1942).

Figure 19 shows the Meadow Creek camp late in 1931, after the mill and its associated buildings had been constructed. Over $1.3 million dollars was spent between 1927 and 1931 to develop the Meadow Creek Mine (Campbell, 1932). In 1934, the company estimated the replacement cost of the mill and its equipment at $94,000.

The mill began operations on January 3, 1932, and ran throughout the year. (Table 3 shows production and Table 4 lists cost data). The USBM credited the mine with producing 858 tons of ore[18] containing 48.47 percent antimony. This made the mine by far the largest producer of antimony in the United States for 1932. No primary antimony had been mined in the country in the previous three years, although annual U.S. consumption of the metal was roughly equal to the world's yearly production. Most of the antimony used in the country came from imports, was produced as a byproduct from lead ores, or was recovered from old scrap and alloys. Antimony was used to make storage-battery plates, bearings, type metal, solder, paint, ammunition, and rubber goods.

Additional flotation cells were added to the mill in May, increasing its capacity to 200[19] tpd. However, the company discovered that it could not recover the gold from the concentrates by cyanidation, and the process was discontinued. The failure was attributed to the presence of too much antimony in the gold concentrates (Bradley, 1942). A large tonnage of high-grade antimony concentrate and of gold-iron concentrate was produced and shipped to the smelter. In October, all operations at the mine were reduced to a single shift per day. (The price of gold was fixed at $20.67 per ounce, but the prices for most other metals hit all-time record lows in 1932 at the bottom of the Great Depression. Antimony prices (Figure 20) followed the same

[18] Both the quantity and the antimony content of this material suggest that the Bureau was actually discussing the *concentrates*, not the ore, shipped by the Yellow Pine Co.

[19] Company reports give the capacity of the mill as 175 tpd, but most published references put the figure at 200 tpd.

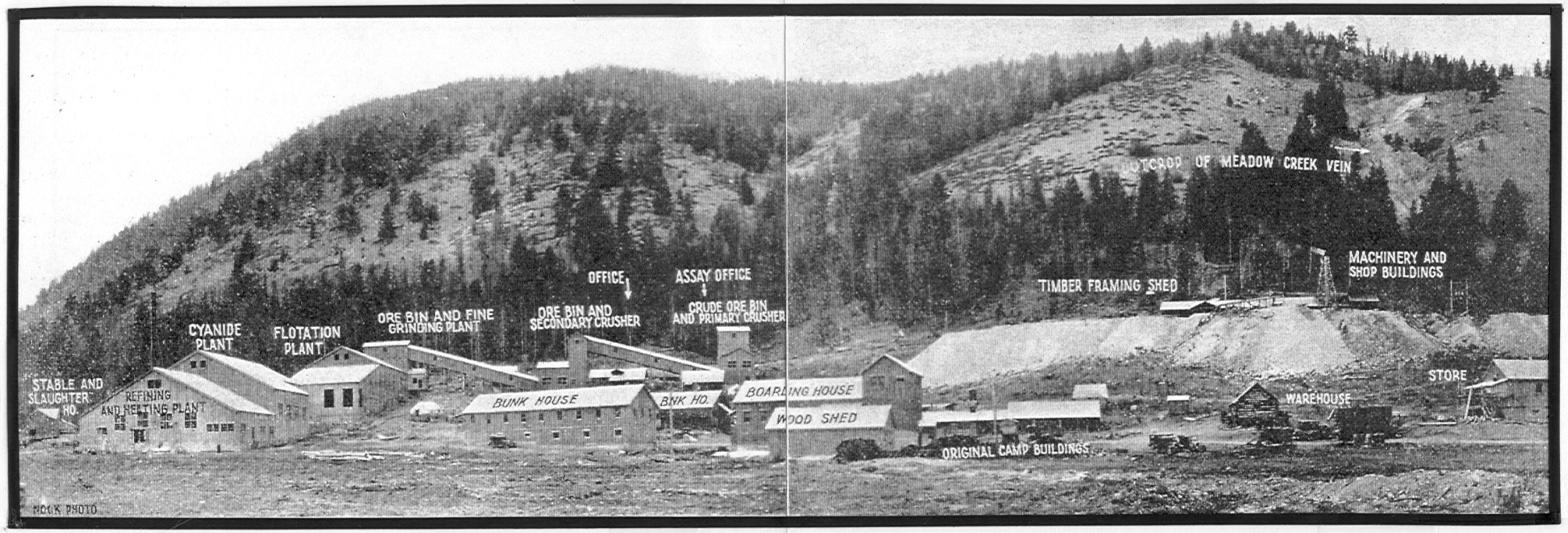

Figure 19. Yellow Pine Co.'s Meadow Creek camp in 1931. Except for the original camp buildings, all the structures identified in this photograph were built in 1928 or later (Campbell, Stewart, 1932, Thirty-third Annual Report of the Mining Industry of Idaho for 1931, p. 32-33).

Table 3. Production from the Meadow Creek Mine (Cole and Bailey, 1948, p. 4).

Year	Ore mined, tons	Concen-trates, tons	Metal content of concentrates		
			Antimony, tons	Gold, ounces	Silver, ounces
1932	34,366	3,242	489	6,915.76	18,488
1933	45,710	3,534	588	10,411.85	29,817
1934	54,000	3,735	404	10,491.36	25,384
1935	50,965	3,602	550	8,373.38	25,217
1936	43,324	3,787	729	7,797.96	32,615
1937	39,521	3,246	755	5,514.00	36,572
Total[1]	267,886	21,146	3,515	49,504.31	168,093

[1]The 1938 production from the Meadow Creek Mine (5 months) is included with that from the East and West Quarries (Table 7).

Table 4. Economic cost data per ton for operation of the Meadow Creek mill, 1932-1940 (Bradley, 1942, p. 12).

Year	Heads	Net smelter returns	Economic recovery, percent	Milling labor	Total milling	Total operating costs	Tons milled
1932	$5.27	$3.05	57.9	$0.59	$1.284	$5.89	34,366
1933	6.76	5.39	79.7	.295	.913	4.33	45,710
1934	8.01	6.29	78.5	.262	.886	4.84	54,000
1935	7.35	5.10	69.4	.277	.867	4.77	50,965
1936	7.26	5.89	81.1	.318	.967	5.11	43,355
1937	5.52	5.40	97.8	.341	.984	5.18	40,330
1938	4.29	3.36	78.3	.315	.937	3.88	35,880
1939	5.06	3.18	62.9	.324	.864	2.90	56,074
1940	4.94	2.71	54.9	.274	.785	2.00	132,297

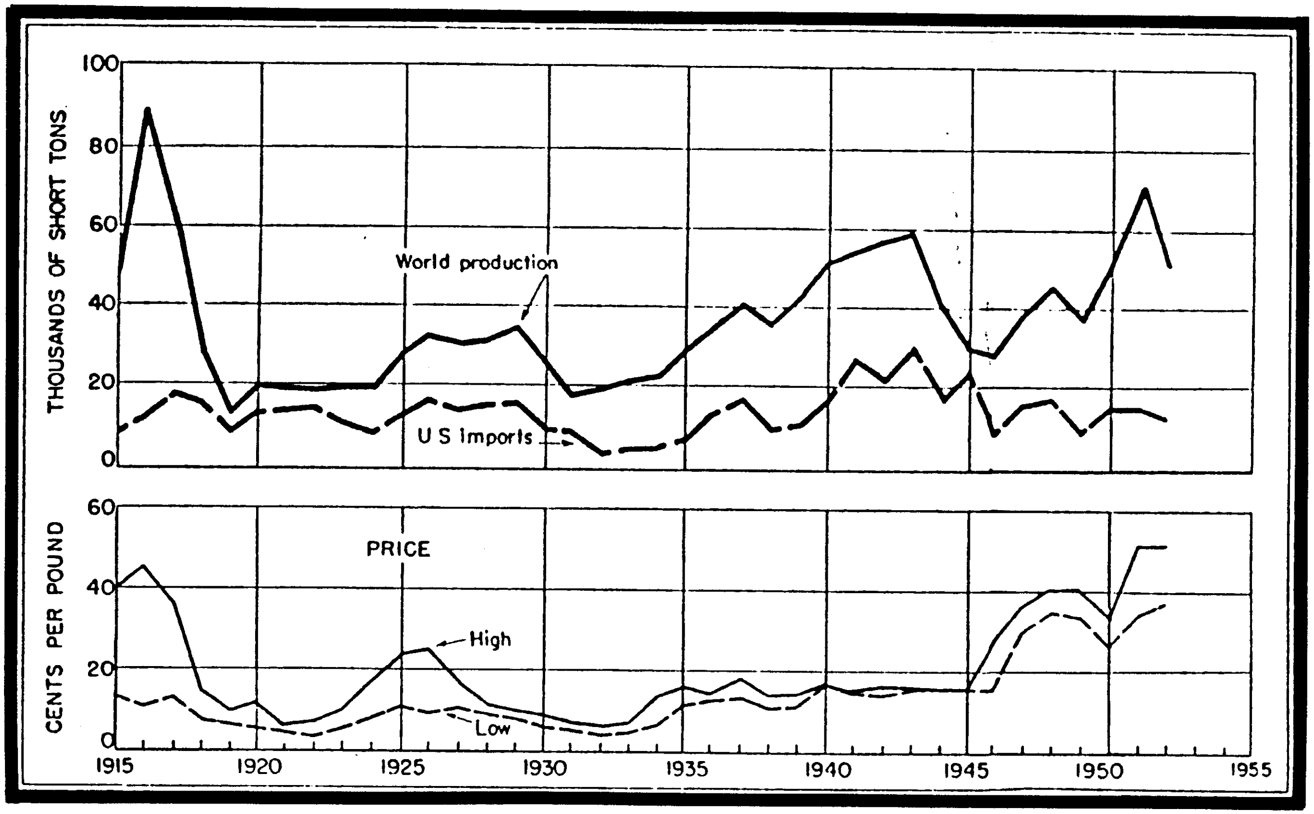

Figure 20. Trends in the New York price, world production, and United States imports of antimony, 1915-1952 (U.S. Bureau of Mines Yearbook, 1952 (Antimony chapter), p. 150).

downward trend as the other metals, falling to a low that has not been reached since[20].) No work was done on the Cinnabar or Monday tunnels during the year; the company focused its efforts on extracting ore from the upper levels of the Meadow Creek tunnel. By the end of the year, the mine was the third largest gold producer in Idaho.

Currier visited the mine in 1932. At that time, the Meadow Creek Mine had two tunnels on the main level, which was 100 feet above Meadow Creek, and an adit on the B level, 100 feet above the main level. The adit on the main level had been driven about 1,175 feet north along the vein, and numerous crosscuts and drifts extended in both directions from it (Figures 21, 22, and 23). A winze from the main level reached levels 200 and 400 feet below the main level. Most of the recent development had been on the lower levels, but comparatively little stoping had been done. The Monday tunnel had been driven southward for about 6,200 feet along the Meadow Creek vein (Figure 15), and the North tunnel also entered the vein but was not very long (Currier, 1935).

The mine was the second largest gold producer in Idaho in 1933, and a considerable amount of silver was also produced. The company reported the "Milling methods were perfected" (IMIR, 1933). According to Hart (1979), the company decided it was more economical to ship the gold concentrates to the Salt Lake City smelters for processing than it was to operate the cyanide circuit in their mill. The Meadow Creek Mine was the only mine in the country that produced antimony during the year. The mine shipped 1,133 tons of concentrates, which contained 587 tons of antimony. The company operated continuously during 1933, employing about 65 men (half of them in the mine and half in the mill or in support jobs). All work in the mine was confined to the upper levels. In May, the company showed its first profits after an expenditure of more than $1.5 million on the property. Plans were made to double the capacity of the mill in the spring, but the expansion was postponed.

The price of gold was raised to $35 per ounce by the Gold Reserve Act of January 31, 1934, and henceforth, the U.S. Treasury valued all gold (old and new) at that price. Antimony prices recovered quickly from their low in 1932; in 1934, the average price per pound was 8.92 cents. Toward the end of the year, prices rose in response to strict control by the Chinese government of antimony exports from the country, which was the world's largest antimony producer.

In 1934, the Meadow Creek Mine was again the second largest gold producer in Idaho, the only antimony producer in the United States, and the largest operation in

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[20]The antimony market was notoriously volatile in the early part of the twentieth century, and the average prices in 1921 (4.96 cents per pound) and 1922 (5.47 cents per pound) were lower than the 1932 price (5.59 cents per pound). These are the New York prices for Chinese antimony, compiled by the USBM from *Engineering and Mining Journal*; the average price for domestic antimony in 1932, as compiled by the USBM from the *American Metal Market*, was 5.62 cents per pound.

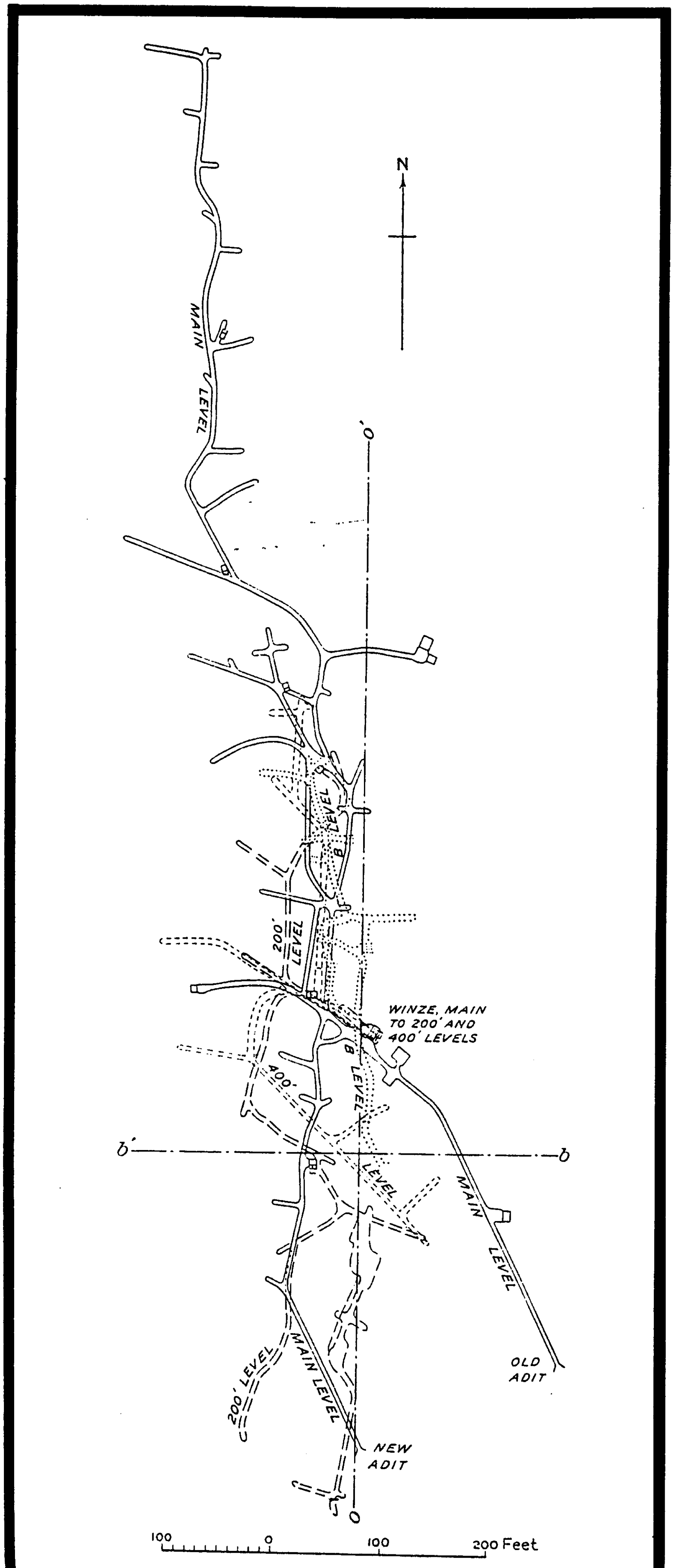

Figure 21. Map of the levels at the Meadow Creek Mine (Currier, 1943, Figure 4).

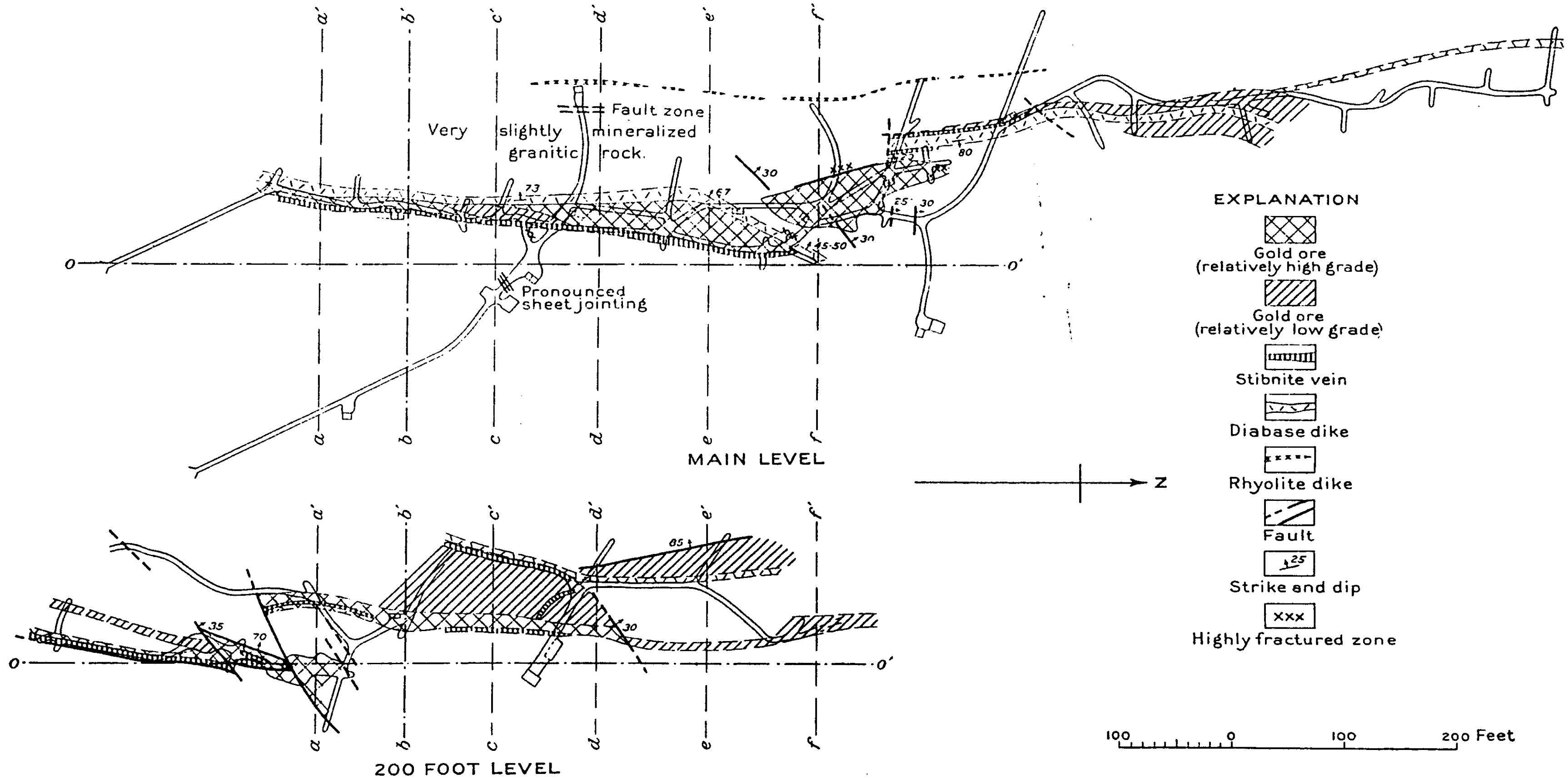

Fig. 5. Map of main and 200-foot levels of Meadow Creek mine, showing ore bodies, dikes, and faults. Data in part from level maps by H. D. Bailey

Figure 22. Map of the main and the 200-foot levels of the Meadow Creek Mine, showing the orebodies, dikes, and faults (Currier, 1935, Figure 5.)

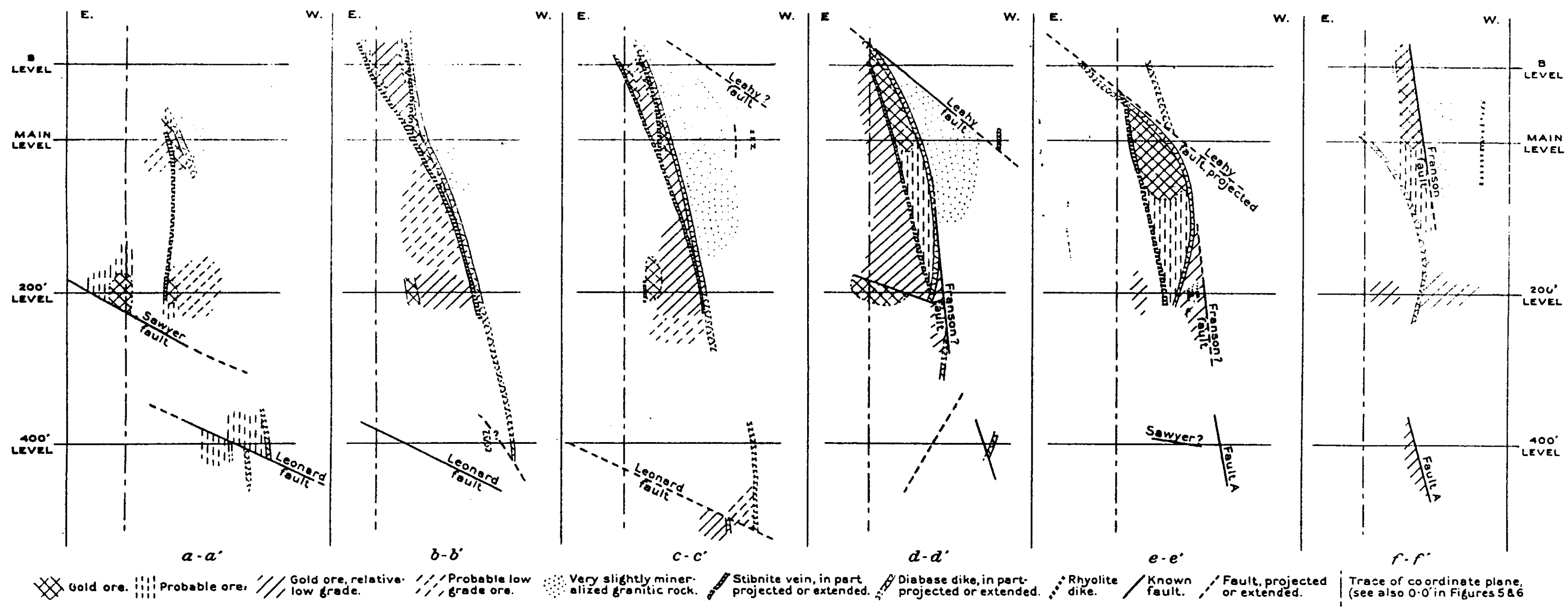

Fig. 6. Interpretative cross sections in part of Meadow Creek mine along lines indicated in Figure 5.

Figure 23. Interpretive cross-sections of part of the Meadow Creek Mine, along the lines shown in Figure 22 (Currier, 1935, Figure 6).

Valley County. Production was about the same as the previous year. The mine produced 54,000 tons of gold-antimony ore and marketed more than 3,700 tons of concentrates, mostly at Midvale, Utah. The mine's 897 tons of antimony concentrate contained 404 tons of antimony. All the ore came from the upper levels of the mine. Total development was 20,674 feet of workings. This included 448 feet of shafts, 1,145 feet of raises, 11,589 feet of tunnels, 2,969 feet of crosscuts, and 5,523 feet of drifts. The company did 3,195 feet of development during the year.

The company treated over 50,000 tons of gold-antimony ore by flotation in 1935. Even so, gold production from the district (which essentially was the Meadow Creek Mine) decreased from 10,491 ounces in 1934 to about 8,380 ounces in 1935. The mine was still the largest operation in Valley County and second largest gold producer in the state. It also produced most of the antimony ore mined in the country[21], but the output was the smallest since 1932. The company did 2,165 feet of development during the year.

By 1936, there were several significant changes in the strategic position of the U.S. with respect to antimony. In 1929, 70 percent of the antimony imported into the country came from China; by 1936, 90 percent of the imports came from Mexico and South America. During the same period, an increase in smelting capacity allowed a shift in the type of material imported. About 70 percent of the imports in 1929 were antimony metal, while 76 percent of the imports in 1936 were ore. Prices continued to move upward, spurred by high demand in both Europe and the United States. One of the reasons for this was the need for automobile batteries that could produce more power. Increasing the antimony content of the lead in the battery plates from 6-9 percent to 12 percent allowed the plates to be made thinner.

The Meadow Creek Mine operated continuously in 1936. It was the largest producer of gold in Idaho and by far the largest producer of antimony in the country. (The mine produced 729 tons of antimony concentrate; three other mines produced a combined total of 26 tons.) In spite of this, the amount of ore mined and the amount of gold produced were less than the previous year. The concentrates were still shipped to a smelter in Utah. The company did 1,608 feet of development during the year.

The company operated the mine and the flotation mill throughout 1937. Meadow Creek remained the largest mine in the county, although the production again declined. It produced 754 tons of antimony concentrate, which was over half the country's primary antimony production; however, eight other mines also produced antimony ore during the year. The apparent consumption of antimony in the U.S. nearly equaled the 1929 level of consumption. Prices continued to rise, in part because of increased demand[22] and in part because of disruptions in shipments from

---

[21]In most years, more antimony was obtained as a byproduct of lead mining than was produced from primary antimonial ores.

[22]Some consumers bought heavily to protect themselves against possible shortages.

China. In the early part of the year, Chinese producers refused to sell their output to the government-run monopoly, and in August, the Japanese invasion again interrupted Chinese exports.

The Meadow Creek Mine was closed in June 1938, but the mill operated for the entire year. (Ore for the second half of the year came from the Hennessy Group, or Yellow Pine Mine.) Production from the Meadow Creek Mine for the year equaled about 8,000 tons of ore. The mine was closed because both the main vein, which contained the higher grade ore, and the West orebody, which was of lower grade, pinched out against the Meadow Creek fault slightly above the 422-foot level (Figure 24). The main vein was 1,000 feet long at the level of the main (haulage) adit, but it was stoped for only half of that length. The stopes were supported by square sets and then backfilled. A 460-foot shaft had been sunk to the east of the vein, and levels were driven from the shaft at 100, 200, 300, and 422 feet below the main adit (Mining World, 1940).

About the closure of the Meadow Creek Mine, J.J. Oberbillig wrote in a letter to the stockholders of United Mercury Mines dated December 5, 1939:

> Antimony is the most persistent mineral of this section and these large ore bodies containing the antimony are readily traceable along the lines of surface oxidation of the contained minerals of this area. The ore deposit of the Meadow Creek Mine area has been extensively developed and in those workings the ore shoots are huge bodies containing high values in antimony. This richly disseminated antimony, particularly of the Meadow Creek ore shoot, presents a very difficult metallurgical problem, and too often high-grade antimony in the ore interfered with the treatment of recovering the gold and silver to such an extent that mining operations at various points in the mine were prohibitive.
>
> On several occasions I have received letters from stockholders who desire to learn the reasons why the mining operation of the ore from the Meadow Creek deposit was abandoned. The answer to that is that the excess antimony per cent of the ore makes it impossible to recover a sufficient amount of gold and silver values to make the operations profitable at that mine and due to that fact that operations from that ore body were transferred to the East Fork Group[23], where the antimony content is slight compared to that of the Meadow Creek Mine.
>
> As I have often stated in my previous letters with reference to these antimony gold ore deposits which crop to the surface in large, massive shoots in this great mineralized area, where as a matter of fact each of these ore deposits require different processes to recover the values, I can give two reasons why the company abandoned its operations at the Meadow Creek Mine to operate the East Fork Group:
>
> FIRST: The recovery of the values from the East Fork Group is a much simpler problem, especially to recover the gold and silver values where the existence of antimony is comparatively slight.
>
> SECOND: The great, massive ore deposit of the East Fork Group has already been proven to be approximately 300 feet wide and has been definitely proven over a distance of approximately 2,000 feet along its northeast and southwest strikes. I estimate from the present developments that there is more than 5,000,000 tons of ore fairly well

[23]The West Quarry of the Hennessy Group (Yellow Pine Mine).

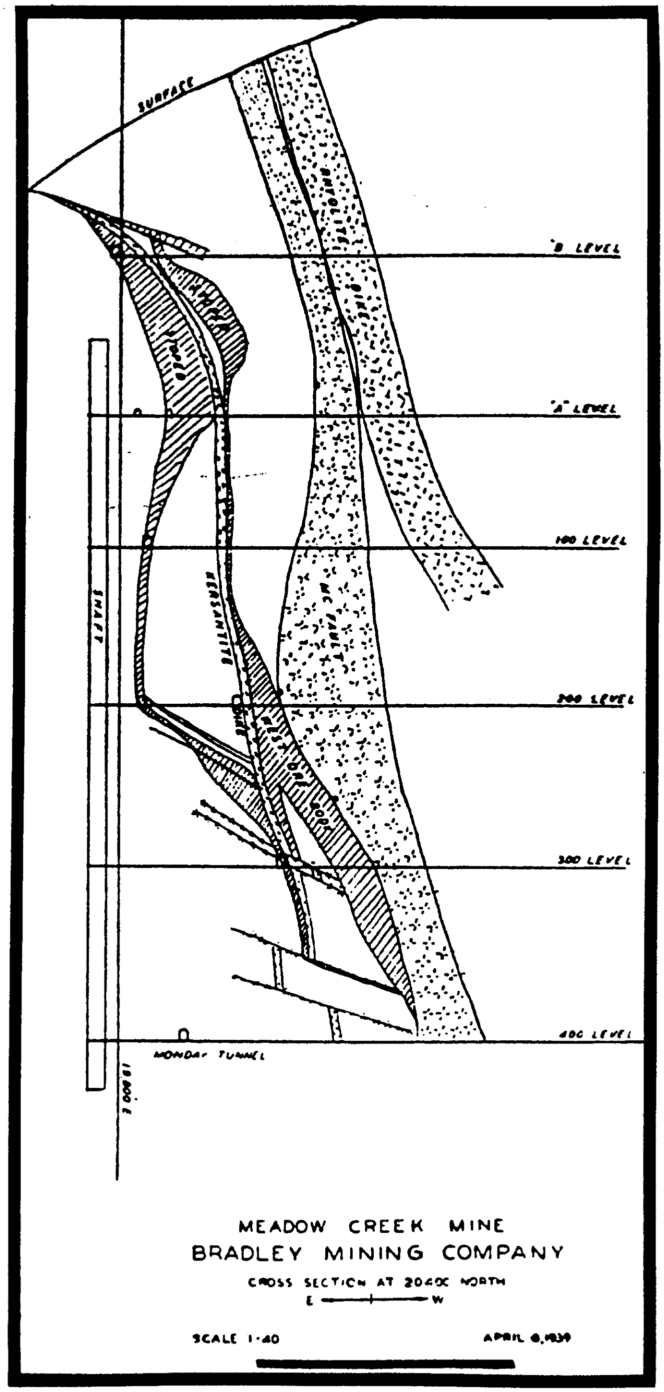

Figure 24. Cross-section of the Meadow Creek Mine (Mining World, 1940, p. 7).

proven to work on. This vast tonnage of ore containing values as a whole which predominate in gold and silver are comparatively good if not better than those of the Meadow Creek ore shoot.

In the period between 1932 and June 1938, the Meadow Creek Mine produced 275,654 tons of ore (Mining World, 1940). This ore yielded $1,547,000 in gold, $116,000 in silver, and $215,000 in antimony (White, 1940). Profit was less than 80 cents per ton (Bailey, 1979), meaning that the entire venture (including development costs) had about broken even (Hart, 1979). On August 1, 1938, Bradley Mining Company took over control of the property from the Yellow Pine Company. In 1943, after tungsten was discovered at the Yellow Pine Mine, the Meadow Creek workings were dewatered. Only small bodies of tungsten were found and the workings were badly caved, so the mine was abandoned (Cookro, in press).

According to the U.S. Bureau of Mines records, the Meadow Creek Mine produced 303,853 tons of ore between 1926 and 1938. This material yielded 53,035 ounces of gold, 186,451 ounces of silver, 19,818 pounds of copper and 8,099 of lead. Antimony production is not reported with the other metals.

Yellow Pine Mine (Hennessy Group)

The Yellow Pine Mine is about 2½ miles north of the Meadow Creek Mine and is on the Hennessy Group of claims (Figure 7). The mine is north of Midnight Creek and south of the confluence of Sugar Creek and the East Fork (Figures 1 and 2). The geology of the deposit was described by Bradley and others (1943, p. 60-61):

> [T]he prevailing rock is quartz monzonite shown in the accompanying table[24] [Figure 25]. Typically, this is a medium-grained rock with a somewhat gneissoid, granitic texture consisting of about 25 percent quartz, 60 feldspar, 10 biotite, and 5 chlorite, muscovite, and other minerals. The aplite, pegmatite, and alaskite of the third group[25] essentially consist of quartz and feldspar, and are distinguished from each other by grain size. The dacite is a greenish gray rock with large phenocrysts of white or yellowish feldspar, green muscovite, and glossy quartz, and with smaller phenocrysts of black biotite, all in a dense ground mass. Lamprophyre dikes are grayish green. The principal minerals are feldspar, biotite, olivine, apatite, and magnetite.
>
> Quartzite and dolomite predominate among the metamorphosed sediments. The former is a coarse-grained, white rock usually containing little or no mica. The dolomite is crystalline and light gray, white, or buff. Near the contact with the quartz monzonite, typical contact metamorphic minerals have developed. The glacial deposits (Pleistocene) are as much as 150 ft. thick in places and cover nearly all of the orebody of the mine.

[24]Shown as the legend for Figure 25.

[25]Number refers to rock key for Figure 25.

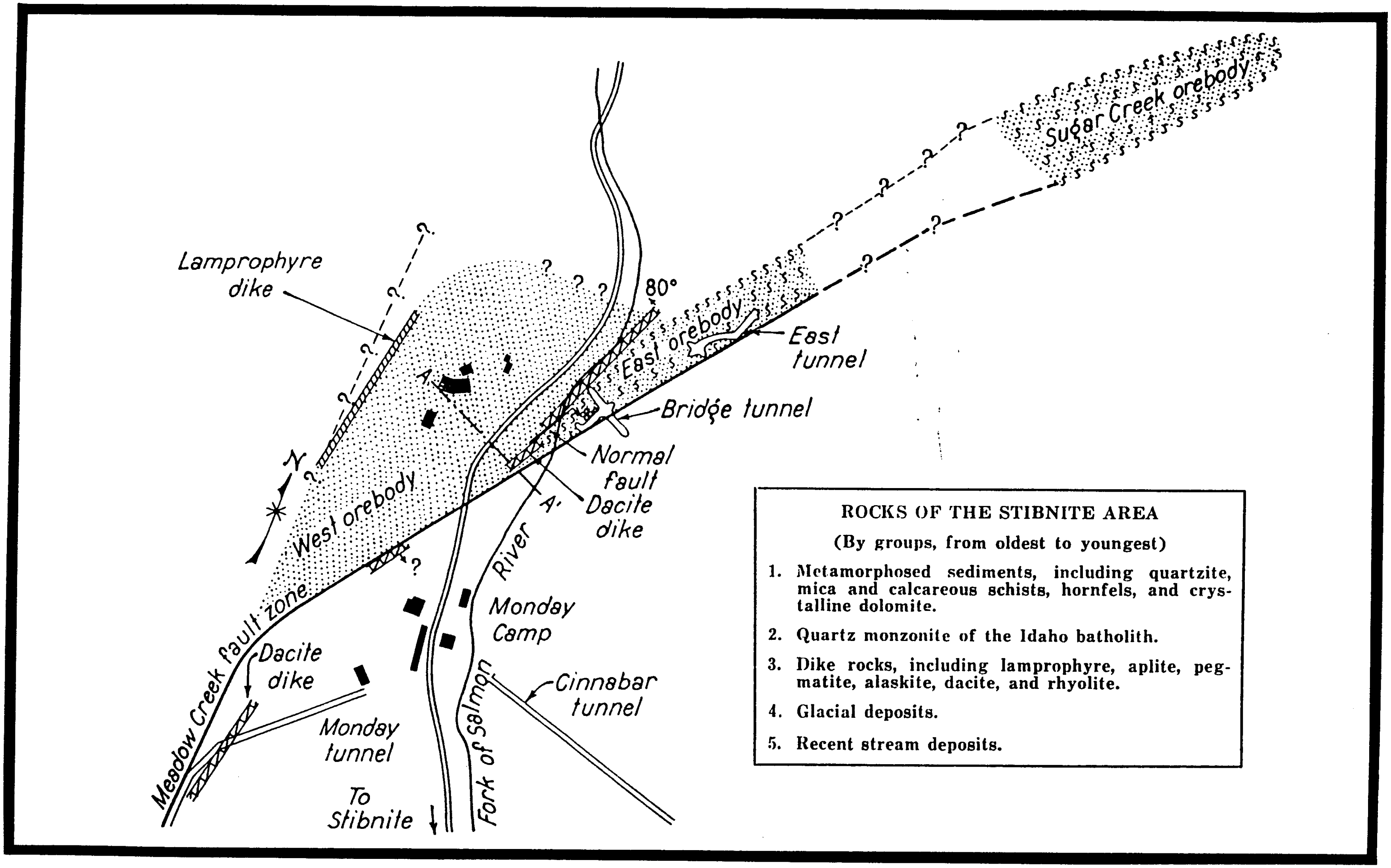

Figure 25. Sketch map of the geology around the East and West orebodies of the Yellow Pine Mine (Bradley and others, 1943, as reproduced in Campbell, Arthur, 1944, Forty-fifth Annual Report of the Mining Industry of Idaho for the Year 1943, p. 50).

They are made up of coarse material, with some boulders measuring several feet in diameter. The recent stream gravels are negligible in bulk.

The country rock, quartz monzonite, is traversed by numerous fracture zones, most of which trend north to northeast and dip east and west. Principal zones explored so far are the Meadow Creek fault, the Yellow Pine shear, and the Northeast system.

The Meadow Creek fault is exposed at several places in the Meadow Creek mine and in the Monday tunnel, driven along the fault in hope of finding other orebodies similar to the Meadow Creek deposit. The fault strikes due north to a point west of Monday Camp (see accompanying surface plan [Figure 25]), beyond which its course is not fully known. From this point it appears to swing abruptly northeast, striking N. 25 to 30 deg. E. and forming the eastern boundary of the Yellow Pine shear zone. The minimum width of the fault zone, as exposed, is 100 ft. Maximum width has not been determined, but probably is several hundred feet. Dip is near vertical.

The Yellow Pine shear zone containing the orebodies of the Yellow Pine mine is in the form of a "V." Its western limit, or left side of the "V," is marked by a lamprophyre dike which strikes N. 10 deg. E. and dips 60 deg. E. The eastern limit, or right side of the "V," is the Meadow Creek fault, striking here about N. 27 deg. E. Dimensions of the shear zone are not known, but just north of the shaft[26] the "V" is about 900 ft. wide. Several fracture systems are present, but it is difficult to distinguish a dominating pattern from surface exposures. Underground, however, a set of fractures trending N. 45 to 70 deg. E. is outstanding and will be discussed later. Both shearing and brecciation are pronounced throughout the Yellow Pine zone. Some of the shears have gouge and some have not. Uncemented fault breccia is abundant along some of the post-scheelite shears, whereas in other parts the breccia has been cemented. The shear zone probably is related to the Meadow Creek fault, and is in a "horsetailing" or "offshoot" relation to it at the bend in the fault line.

A system of conjugate fractures within the shear zone is genetically related to the Meadow Creek fault. The fractures strike N. 45 to 80 deg. E., dip northwest and southeast, and are well exposed in the underground workings. Some of the fractures are tight fissures that are not persistent and have no gouge. Others, such as *A* and *B* fractures, shown in the vertical section taken along line A-A′ of the plan [Figure 26], exhibit heavy gouge and "fluccan,[27]" and are relatively persistent. *A* fracture, along which most of the ore in the mine is localized, strikes N. 75 to 85 deg. E. and dips 50 to 80 deg. N. It is exposed 170 ft. along the strike and 100 ft. along the dip. At its eastern end, it splits into several branches trending in northeasterly directions, and eventually disappears or merges with other nearly parallel fractures. The western end of *A* fracture has not been reached. Where it appears in the face of one of the drifts it gives no indication of "dying out." Followed upward along the dip from the main level, the *A* fracture flattens toward the southeast and splits into several minor fractures. It is characteristic of these northeast fractures to flatten when followed upward along the dip. The *A* fracture has not yet been found in the workings on the No. 3 level. *B*, *C*, and *D* fractures have been exposed for various distances from 100 to 200 ft. along the strike and 50 to 300 ft. along the dip. Slickensided stibnite on surfaces of some of these fractures indicates that at least the latest movement has been post-mineral.

The Hennessy fault (seen in the vertical section [Figure 26]) is a part of the Yellow Pine shear zone. It strikes N. 15 to 27 deg. E. and dips nearly vertical. It contains

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[26]The shaft is located near the northeast end of the section line (marked "A") on Figure 25.

[27]The scaly, intimately sliced rock shavings of the shear zones [footnote in original document].

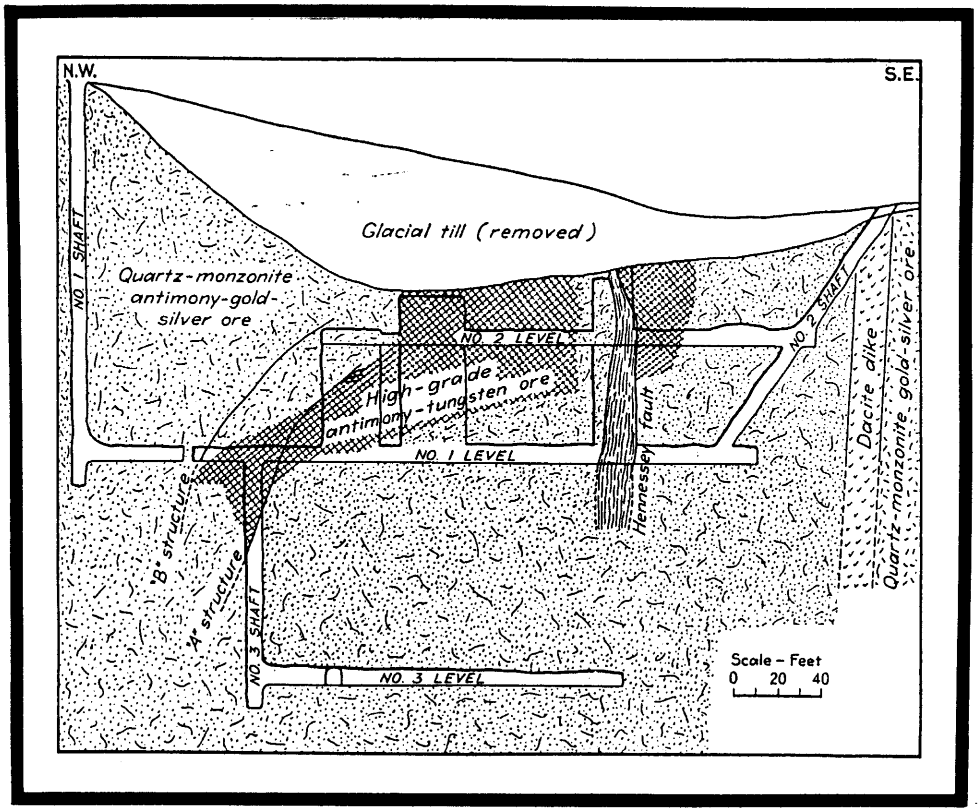

Figure 26. Cross-section through the orebody at the Yellow Pine Mine, showing the underground workings and their relationship to the ore. Section is through line A-A′ in Figure 25 (Bradley and others, 1943, p. 61).

> gouge, breccia, and "fluccan," and varies in width from 1 to 15 ft. Some of the breccia fragments have been well rounded by movement. The latest movement was normal and post-scheelite. What effect the fault had in displacing the tungsten orebody is not yet clear, however.

Figure 27 is a geologic map of the deposit and Plate 1 shows the orebodies at the bedrock surface.

In 1923, Albert Hennessy located the Hennessy 1-3 claims (Oberbillig, 1976). On February 7, 1924, Hennessy and J.L. Niday organized the Great Northern Mines Company (see Table 5 for individuals and companies operating at the mine). The company stated it was looking for gold, silver, and lead on the property.

Niday put $800 into the bank in the name of the corporation and was credited with another $200 for the expenses incurred while incorporating the company. In return, he received half the stock in the company. However, Hennessy apparently thought that Niday was going to contribute more money. When he did not, Hennessy located several additional claims (some by himself, some with his friend, Fred Franz), but did not deed these claims to the company. The dispute between Hennessy and Niday over the later claims ended in court. The Idaho Supreme Court ordered Hennessy to turn over all the claims to the company, for which he was to receive $50,001 in stock and Niday $49,999 (Oberbillig, 1976).

Hennessy and Niday had been doing minimal work on the claims. In 1926, there were two short tunnels on the property, totalling about 110 feet, and some surface work. Hennessy did a small amount of development work in 1927, but his 1928 report to the Idaho Inspector of Mines said that little was going to be done except assessment work until the lawsuit was settled. However, the same report stated that the property was under lease to the Yellow Pine Company. According to Oberbillig (1976), F.W. Bradley optioned the property for $500,000, half of which was to be paid out of net proceeds. Schrader and Ross described the prospect in 1923 or 1924 (1926, p. 152):

> The Hennessy antimony lode (Nos. 6 and 7, fig. 6 [Figure 8]), owned by Albert Hennessy, is on East Fork about three-quarters of a mile above the mouth of Sugar Creek. It seems to trend across East Fork and to have an extent of nearly a mile. Where exposed by outcrops and a few small pits on the southwest side of East Fork, the lode shows a width of about 200 feet. It strikes northeast and is cut by a zone of close sheeting. It consists chiefly of silicified granodiorite, some lighter-colored and more siliceous rock, and quartz, in all of which occur irregular masses and tabular bodies of stibnite or dark antimony ore, some of which yield slabs 3 to 4 inches in diameter by an inch in thickness. . . . Specimens of the ore are reported to have assayed about $100 in gold and $20 in silver to the ton. However, as the specimens came from croppings or from near the surface, the high gold content probably represents concentration by oxidation and can not be expected to continue in depth.
>
> On the northeast side of East Fork what seems to be the continuation of the lode is exposed by outcrops and shallow openings about 300 feet above the stream. Here the showings indicate a lode width of at least 100 feet and seem more promising for stibnite

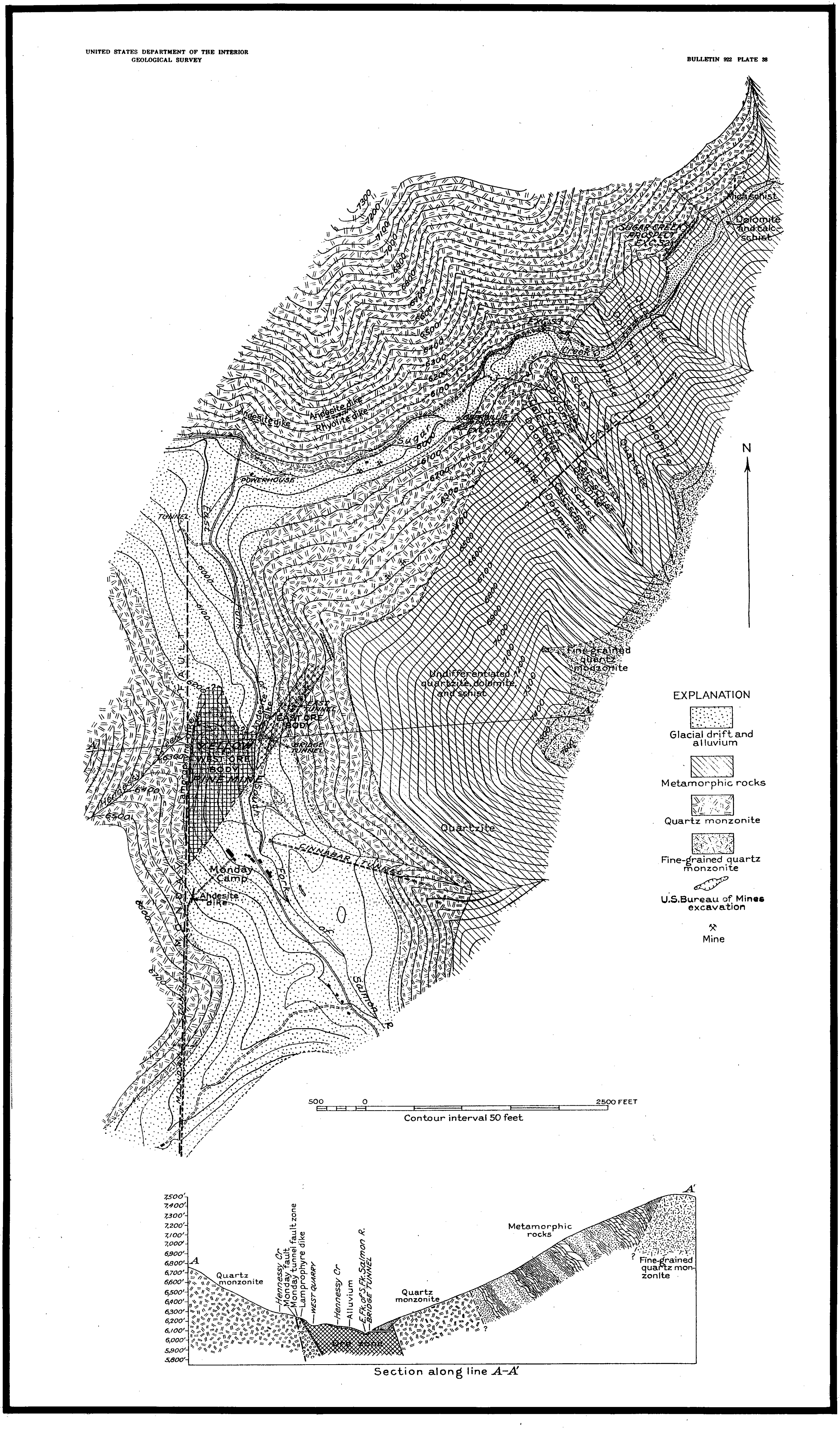

Figure 27. Geologic map and structure section of the Yellow Pine Mine area (White, 1940, Plate 38).

Table 5. Companies operating at the Yellow Pine Mine and associated deposits.

Company Name	Officer	Date Incorporated	Charter Forfeited	Year(s) at Mine
Albert Hennessy	---	---	---	1923-1933
J.L. Niday	---	---	---	1923-1933
Fred Franz	---	---	---	1924(?)-1928(?)
Great Northern Mines Company	Albert Hennessy, President	Feb. 7, 1924; reinstated: June 26, 1925; March 20, 1930	1924; 1929; 1934	1924-1933
Yellow Pine Company	Fred W. Bradley, President	filed in Idaho: May 25, 1928	taken over by Bradley; Nov. 30, 1942	1928-1931
United Mercury Mines Co.	J.J. Oberbillig, President	January 20, 1921; reinstated: Dec.20, 1929	1929; Nov. 30, 1963	1933-1942
Yellow Pine Co.	Fred W. Bradley, President	filed in Idaho: May 25, 1928	taken over by Bradley; Nov. 30, 1942	1933-1938
Bradley Mining Co.	Worthen Bradley, President	July 28, 1938	active: 1981	1938-[1]
Ranchers Exploration and Development Co.	[2]	[2]	merged with Hecla: 1984	1970-1984
American Independent Mines and Minerals Co.	[2]	[2]	[2]	exploration: 1982
Hecla Mining Co.	Arthur Brown, Chairman, CEO, and President	October 14, 1891	active	1984-[3]
American Barrick Resources Corporation	[2]	[2]	[2]	1992

[1]The Bradley family were the owners of record for the patented claims as of 1979 (Bailey, 1979), and the Bradley Mining Co. was still in existence on the last date for which the IGS's files contain information.

[2]Information not available in the Idaho Geological Survey's files.

[3]Company is still involved with the mine.

than those on the south side of the stream. The stibnite is more coarsely crystalline and striated. Granodiorite is present, and heavy quartzite talus indicates the probable presence of quartzite near by up the mountain side.

By the end of 1928, there were three tunnels on the property, with a combined length of 190 feet. Yellow Pine Company constructed its road across the property, and clearings for the pipeline and the transmission lines for Yellow Pine's hydroelectric plant also ran across Great Northern's claims. According to Oberbillig (1976), Hennessy and Niday received $5,000 in cash for easements for the road, pipeline, and transmission lines. By 1930, Yellow Pine Co. had begun work on five tunnels and had carried out extensive diamond drilling projects from some of them. Yellow Pine Co.'s agreement with Great Northern called for the expenditure of at least $10,000 on or for the benefit of the property. However, after the flurry of activity in 1929 or 1930, little additional work seems to have been done. Yellow Pine Co. relinquished its option in July 1932.

J.J. Oberbillig[28] purchased the Great Northern claims in 1933 for $15,000 ($7,500 for Hennessy and $7,500 for Niday; Oberbillig, 1976). The claims were immediately re-optioned to the Yellow Pine Co. (Lorain, 1945). Early in 1937, a leak in the redwood pipeline supplying water to Yellow Pine Co.'s hydroelectric plant washed the dirt off the hillside and exposed the ore zone on what would be the east side of the Yellow Pine pit (Oberbillig, 1976). Diamond drilling from short tunnels on the east and west sides of the ore zone during the latter part of 1937 indicated the value of the orebodies (Bradley, 1942). Mining from the West Quarry (Figure 25) began on September 1, 1937 (White, 1940). Soon the company was producing 500 tpd from this property (Oberbillig, 1976). (See Tables 6 and 7 for production from this area.) The orebodies on the Hennessy claims were larger, but of lower grade, than those at the Meadow Creek Mine. However, because they could be worked by surface methods, the Hennessy orebodies were much more economical to mine (Bradley, 1942).

During 1938, the Yellow Pine Company discontinued underground operations at the Meadow Creek Mine. From early July on, all production came from the West Quarry (Lorain, 1945). The combined output of antimony concentrate for the two mines was 379 tons, which was almost 60 percent of the primary antimony produced in the country during the year. On August 1, Bradley Mining Co. took over all operations. While the West Quarry was being mined, a diamond drilling program was carried out on the East orebody. When the drilling showed higher gold values in the East orebody, a 200-foot crosscut tunnel and 400 feet of new drifts confirmed the results (Bradley, 1941). A decline in antimony prices, coupled with an apparent decrease in consumption[29], now made the East orebody more profitable.

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[28]Oberbillig purchased the claims for the United Mercury Mines Co. (Lorain, 1945).

[29]Consumers were drawing on stocks accumulated the previous year.

Table 6. Production from the West Quarry (White, 1940, p. 251).

Year	Ore milled (tons)	Antimony in concentrates (approximate)[1]
1937	4,193	35
1938	27,872	233
1939	20,505	171
Total	52,570	439

[1]These numbers are based on an estimate of 1.08 percent metallic antimony in the ore and a recovery of 77.2 percent.

Table 7. Production from the East and West Quarries (Call and Bailey, 1948, p. 4).

Year	Ore mined (tons)	Concen-trates (tons)	Metal content of concentrates		
			Antimony (tons)	Gold (ounces)	Silver (ounces)
1938[1]	38,880	2,200	379	3,529.00	17,687
1939	56,074	2,677	228	5,810.00	14,844
1940	132,297	4,521	18	12,401.00	15,825
1941	80,658[2]	3,323	13	8,280.00	9,994
Total	304,909	12,721	638	30,020.00	58,350

[1]Includes about 5 months production from Meadow Creek Mine.
[2]Amount of ore produced before the start of tungsten mining.

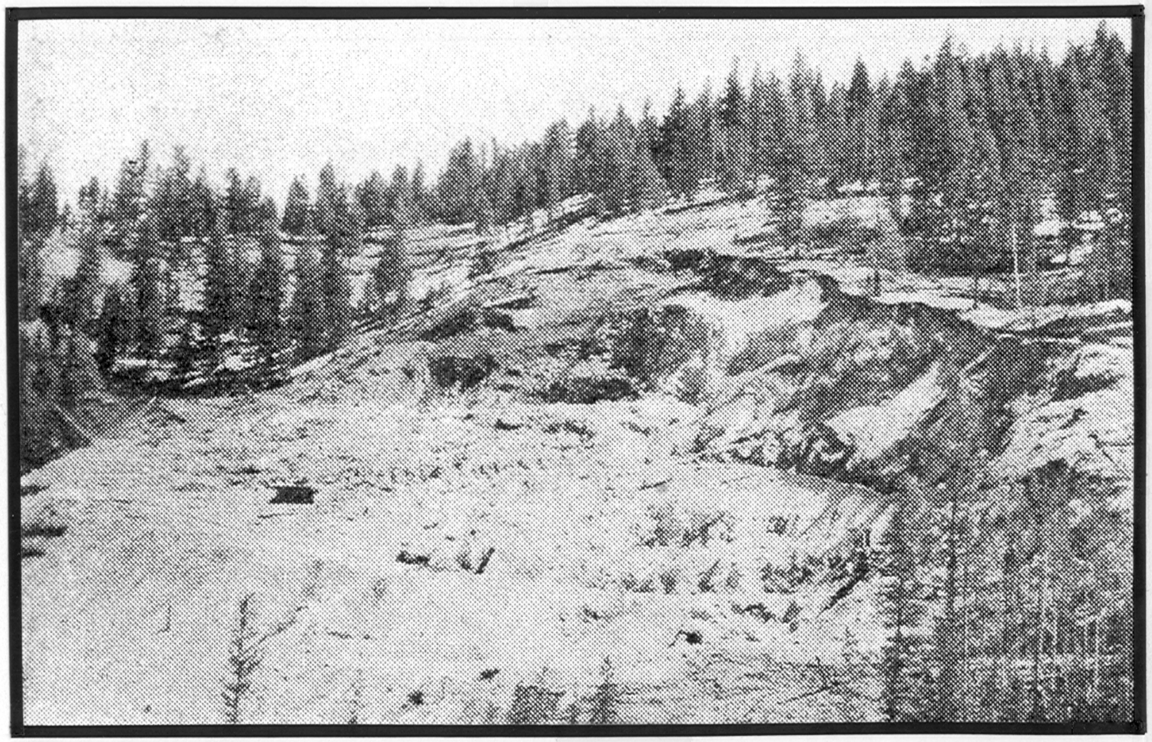

Figure 28. East Pit, probably late in the summer of 1939. This picture was taken just before a blast was set off in the lower center. Note the area stripped of overburden in the upper center (Mining World, 1940, page 2).

In July 1939, operations were shifted to the East Quarry (Figure 28) on the opposite side of the river. (See Table 7 for production from the East Quarry.) This ore contained more gold and almost no antimony (White, 1940). The mine plan used 40-foot benches after 2 to 20 feet of soil and slide rock were stripped from the hillside. In addition, 10 to 30 feet of oxidized ore was removed and stored in dumps for possible future treatment (Mining World, 1940). Production from the Hennessy claims again placed the Bradley operation among the top gold producers in the state. The ore was trucked to the 200-tpd Meadow Creek mill, which operated continuously throughout the year and treated 56,074 tons of gold-antimony ore by flotation. This was a substantial increase over the previous year's production; however, antimony production declined substantially. The concentrates were shipped to a smelter in Midvale, Utah. The replacement cost of this mill (buildings and equipment) was $208,696.68, according to the company. Late in the year, Bradley enlarged the mill's capacity. (According to White (1940), it was increased from 150 tpd to 400 tpd, and it could be further increased to 500 tpd with little difficulty.) In addition to the surface mining, Bradley did 787 feet of underground development work (Table 8).

On June 7, 1939, in anticipation of World War II, President Roosevelt signed the Strategic Materials Act. This bill authorized $100 million to be spent over the next four years for the purchase of stockpiles of mineral commodities that the Army and Navy Munitions Board had classified as strategic. (In June 1940, the Metals Reserve Company was created to purchase strategic and critical materials for the government.) Antimony and tungsten were both designated as strategic commodities, but antimony was not given a high priority for stockpile purchases. In addition, the bill also authorized the expenditure of $500,000 annually for the next four years to investigate domestic resources of strategic minerals. Also of importance to the mine was the development by the U.S. Bureau of Mines of an electrolytic method that improved the recovery of antimony from antimony-gold ores like those in the Yellow Pine district. The outbreak of war in Europe and expanding industrial output in the U.S. increased the demand for antimony at the same time that the Japanese occupation of China curtailed exports from that country. Despite this, the average price of antimony showed little change from the previous year, and U.S. production of primary antimony ore declined during 1939.

Late in the summer, both the U.S. Geological Survey and the U.S. Bureau of Mines began separate projects to investigate the antimony deposits in the Yellow Pine district. D.E. White of the USGS spent six weeks during August and September mapping the surface geology of the Yellow Pine area as part of the Survey's Strategic Minerals Program. After examining a number of antimony prospects in the district, the Bureau of Mines started a four- or five-month diamond-drilling program at the mine in November. White (1940) described what was known about the Yellow Pine orebodies at the time of his visit (p. 269-271):

> Most antimony deposits are groups of small, lenticular, high-grade veins, in which it is impossible to block out large tonnages, of known tenor, ahead of actual

Table 8. Development work, number of men employed, and operating companies at the Yellow Pine Mine, by year.

Year	No. of Men Employed	Tunnels (feet)	Sinking (feet)	Cross-cutting (feet)	Drifting (feet)	Raising (feet)	Diamond Drilling (feet)	Operator
1939	19	372	---	43	297	75	---	Bradley Mining Co.
1940	38	---	---	---	---	---	4,500	Bradley Mining Co.
1941	20	---	180	---	---	---	3,000	Bradley Mining Co.
1942	250	1,150	103	---	1,700	---	12,700	Bradley Mining Co.
1943	530/175[1]	2,876	---	---	570	---	16,164	Bradley Mining Co.
1944	250/50[1]	---	70	---	627	---	9,210	Bradley Mining Co.
1945	200	---	---	---	---	---	10,215	Bradley Mining Co.
1946	200	---	---	---	---	---	5,063	Bradley Mining Co.
1947	200	---	---	---	---	---	1,947	Bradley Mining Co.
1948	200	---	---	---	200	---	5,403	Bradley Mining Co.
1949	250	---	---	---	---	---	1,495	Bradley Mining Co.

[1]The first number is the average number of men employed by the company; the second number is contract workers who were also working at the mine.

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mining. The West ore body of the Yellow Pine mine, on the other hand, is very large, and its percentage of antimony, though low, is relatively uniform. Because of these characteristics, it constitutes the largest dependable reserve of antimony in the United States.

The limits of the West ore body have not been determined, except on the west side. A block having a triangular horizontal cross section with sides of 650, 600, and 800 feet has been explored by diamond drilling (see pl. 39 [Figure 29]), and most or all of it consists of possible ore; but much more diamond drilling must be done to determine the exact boundaries of the ore body. Possibilities for continuance at depth are yet unknown, though good ore has been found in one hole as deep as about 250 feet below creek level.

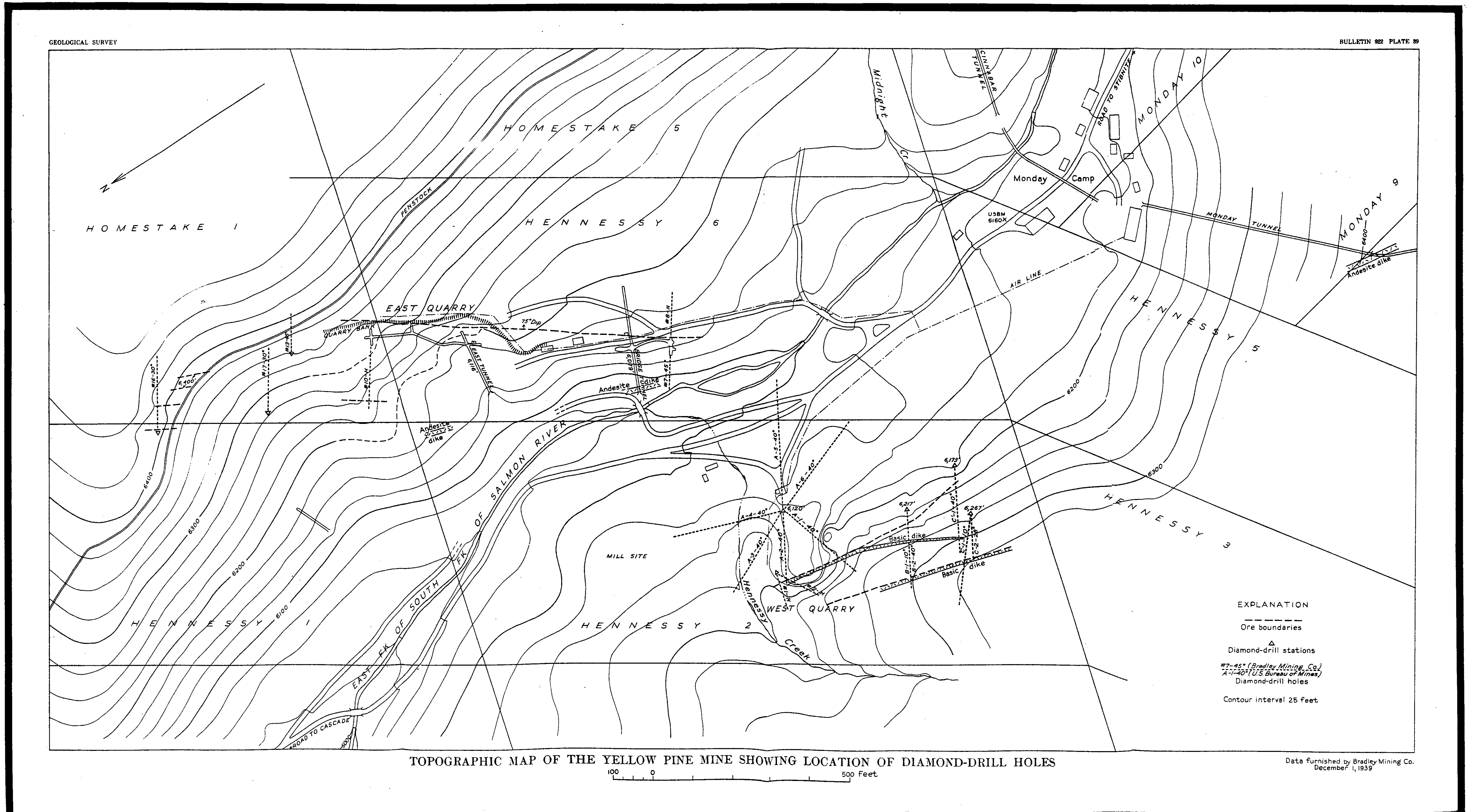

Figure 29. Topographic map of the Yellow Pine Mine, showing the locations of the diamond-drill holes through December 1, 1939 (White, 1940, Plate 39).

The best estimate of the grade of the West ore body is supplied by records of the Bradley Mining Co.'s flotation plant for the two periods June to November 1938 and May to July 1939, when ore from only the West quarry was milled. The mill heads for those months consisted of 30,540 tons of dry ore, which assayed 1.08 percent of antimony. The recovery of antimony in the concentrates, by the flotation methods now used, averaged 77.2 percent, so that 0.835 percent of the mill heads was recovered as metallic antimony. Nearly all of this ore was quarried near the center of the shear zone. Diamond drilling indicates that the northwest part of the zone will assay nearly 1.5 percent of antimony and that a quantity of ore from 5 to 10 feet thick adjacent to the lamprophyre dike bounding the ore body to the west will assay nearly 5 percent of antimony. But because of uncertainties concerning the exact grade, particularly at depth, the above production figures are considered the best available estimate of the grade of the deposit as a whole.

The East ore body is at least 800 feet in length and averages probably about 170 feet in width, but the ore is so poor in antimony that it should not be considered in any estimate of dependable antimony reserves. . . .

The Monday tunnel entered an ore body of unknown extent directly under Fiddle Creek. For a length of 240 feet beyond this point assays averaged 1.1 percent of antimony and about $0.75 in gold per ton. Fifty feet of this length averaged 1.6 percent of antimony and another 40 feet averaged 2.35 percent. The relation of this ore body to the fault zone is not yet known, but it is of prime importance. If the ore body is wholly within the main fault zone the tonnage is probably small, but if it lies at the junction of a northeast-trending shear zone with the main fault it may be comparable in size to the West ore body. This ore body was inaccessible in 1939 because the tunnel was badly caved in the fault zone.

Although the Monday tunnel was driven in glacial material for the first 600 feet of its length, bedrock was exposed on the floor 370 feet from the portal. Diamond-drill holes driven northeastward and southwestward from this point were in ore for about 50 feet on each side of the tunnel. The ore is said to assay from $2 to $3 per ton in gold and from 1 to 2 percent of antimony. The orientation of the ore body and its relation to the main ore bodies of the Yellow Pine mine is not known.

About the economics of the deposits, White stated (1940, p. 271):

At normal prices none of the antimony deposits of the district are rich enough in antimony to be profitably mined for that mineral alone. The Yellow Pine ore bodies are minable at the present time only because of their gold content. Under present conditions the ores are submarginal in respect to the antimony content. Any estimate of reserves must take into account not only the estimates of tonnage and grade given but the factor of price, which must depend on future conditions not now predictable.

He continued with a detailed analysis of the then-current economics of the deposit (White, 1940, p. 273-275):

Until July 1939 most of the ore milled at the Yellow Pine mine had come from the West quarry. During the months of June to November 1938 and May to July 1939, while the ore was coming entirely from this source, the mill heads, weighing 30,540 tons, averaged $4.07 in gold, 21.61 pounds (1.08 percent) of antimony, and 0.51 ounce of silver per ton. The respective mill recoveries were 79.2 percent, 77.2 percent, and about 80 percent. The value of the metals recovered per ton of ore totalled $4.15, of which

> $3.22 was in gold, $0.63 in antimony, and $0.30 in silver. The net value of the ore at the mill, after subtracting charges for smelter treatment, freight, and hauling, was $2.78 per ton.
>
> During August 1939 the company shifted operations to the East quarry, where the ore contains considerably more gold but less antimony and silver per ton than in the West quarry. The mill heads for the months from October 1939 to February 1940 totalled 41,135 tons. They averaged $5.47 in gold and about 0.25 ounce of silver per ton but contained only a negligible amount of antimony. Only $3.60 in gold, or 65.8 percent of the mill heads, was recovered during this period, as compared with 79.1-percent recovery from the West ore. No difference between the ores of the two quarries that would seem to account for this difference in gold recoveries has yet been found. The net value of the ore at the mill was $2.77 per ton, or almost the same as the ore of the West quarry. The difference in the values of the concentrates and of the ratios of concentration of the two ores have been considered in arriving at the net values.
>
> The Bradley Mining Co. may shift operations temporarily back to the West quarry at any time, because with present recoveries the net values of the two ores are almost identical, and by milling ore from the West quarry the higher-grade ore of the East quarry may be saved until a more efficient metallurgical treatment for it has been put in operation. Experimental cyaniding of the flotation tailings has given good results, and the company plans to build a cyanide plant which, with the flotation plant, is expected to recover from 85 to 90 percent of the gold content of the mill heads.
>
> By thus revising the metallurgical treatment, the relative net values of the ores will be changed considerably. If 90 percent of the gold and 85 percent of the antimony is recovered, the net value at the mill of the gold from the East quarry will be $4.09 and that of the gold-silver-antimony ore from the West quarry $3.22 per ton, with antimony at its present price. Recovery of 85 percent of the antimony is not too much to expect, for that recovery was exceeded during the month of June 1938.

White concluded that the price paid by the smelters for the antimony in Bradley's concentrates would have to almost double[30] to make the West Quarry ore as profitable as that from the East Quarry, once the metallurgical difficulties with the East Quarry ore were solved. He also suggested that a stable (for several years) price of 10 cents a pound for antimony in concentrates, or 15 cents a pound for metallic antimony, would be needed to justify expanding the mine and mill substantially. Bradley Mining Co. apparently felt it could afford to construct an antimony smelter if the average open-market price of antimony remained at 12 cents a pound for several years (White, 1940).

The U.S. Bureau of Mines started its field work at the Yellow Pine Mine on August 23, 1939. Initial work involved surface trenching on an antimony prospect on Sugar Creek about 1¼ miles above its confluence with the East Fork (Figure 30; the location is marked "Antimony Prospect.") Additional trenching in a southwest direction uncovered the gossan above the Homestake gold deposit (Plate 1 and Figure 30).

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[30]The contract price paid to Bradley Mining Co. by the smelters for antimony in concentrates in 1939 was 3.75 cents per pound. A price increase to about 7 cents per pound was suggested.

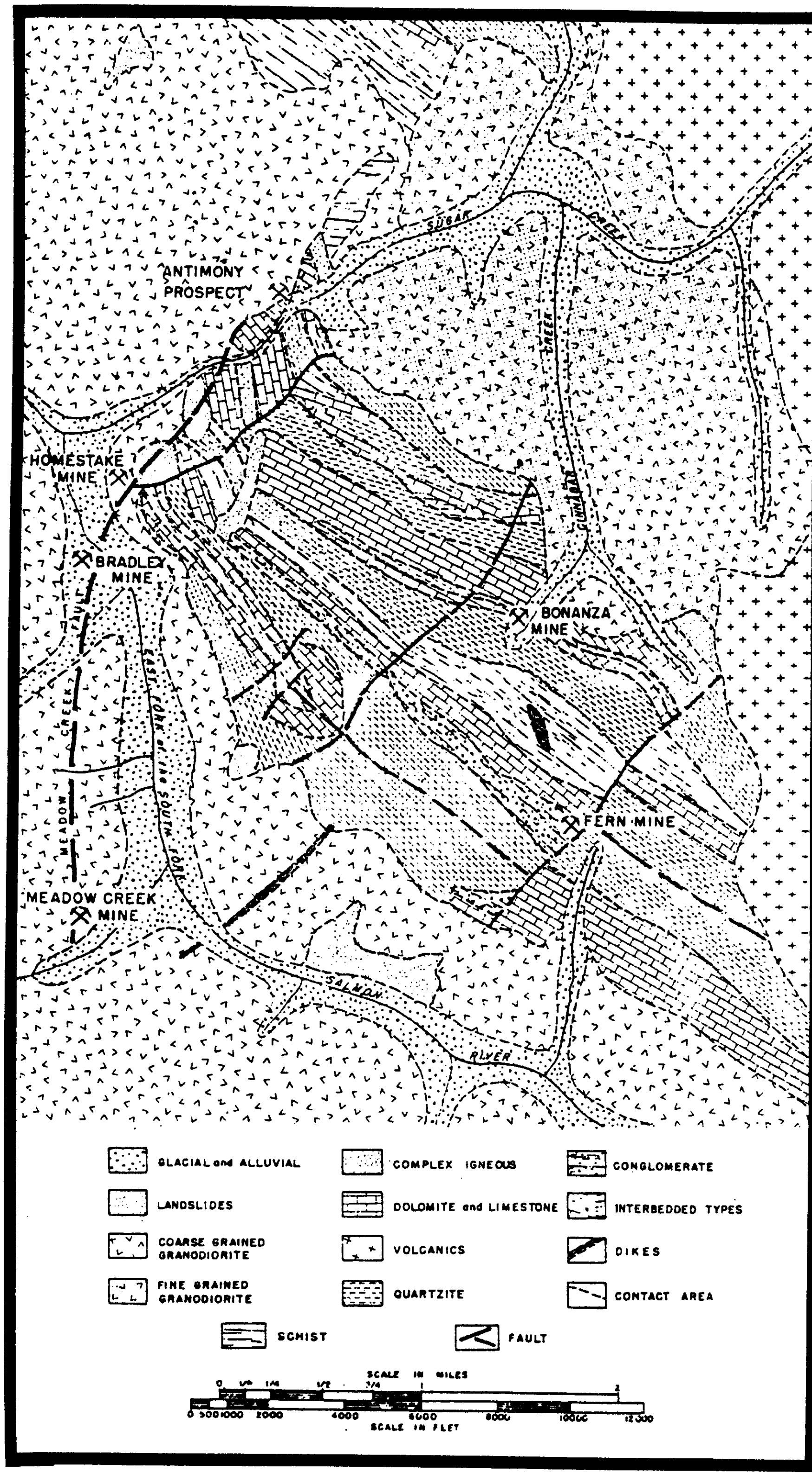

Figure 30. Geologic sketch map of the Yellow Pine Mine and vicinity, showing locations of the major mines in the area (Lorain, 1945, Figure 1).

On November 3, 1939, diamond drilling was started in the West Quarry. (Figure 31 shows the holes drilled and the boundaries of the orebodies). Eleven holes were drilled between then and February 28, 1940, when the drilling project was suspended due to lack of funds. Holes 10 and 11 located "exceptionally good" antimony ore under the floor of the valley (Lorain, 1945).

During 1940, Bradley treated 132,297 tons of ore containing stibnite, pyrite, and arsenopyrite in the 400-ton flotation plant. This was over twice the amount of ore produced in the previous year; however, antimony production was "negligible," according to the USBM. Bradley employed an average of 52 men at the Yellow Pine Mine and mill (Figures 32 and 33), which was the largest mining operation in the county. The company enlarged its mill building and ore bin during the year. Equipment added to the mill included an 8′x48″[31] Hardinge ball mill, a 3′x8′[32] tube mill, eight Denver Sub-A flotation cells, and a 175-horsepower diesel plant. A Bucyrus Erie 20-B shovel, a Caterpillar D7 tractor, and a Gardner Denver D-99 drill were purchased for the mine. The company also made plans to double the capacity of the 720-acre-foot reservoir that powered the South Meadow Creek hydroelectric plant. According to Mining World (1940), mining costs totalled about 35 cents a ton, while it cost 25 cents a ton to truck the ore from the quarry to the mill.

The U.S. government's strategic minerals investigations of the mine continued during 1940[33]. Preliminary results were released in USGS Bulletin 922-I (White, 1940). During the summer, White mapped the regional geology around the mine, logged the drill cores from the previous winter's drilling program, and collected additional specimens (Cooper, 1951). On July 17, the U.S. Bureau of Mines began a systematic drilling program to delineate the size and shape of the antimony orebody beneath the East Fork. This work involved an additional 13,000 feet of diamond drilling (Lorain, 1945). Total work done by the Bureau at the Yellow Pine Mine included (Lorain, 1945, p. 13):

Diamond-drill holes, number	52
Diamond-drill holes, linear feet	16,039
Diamond drill sample intervals	2,863
Diamond-drill sample assays	17,500
Trenching, hand, linear feet	853
Trenching, bulldozer, linear feet	1,587
Cubic yards moved in trenching	15,621
Linear feet of tunnel driven	135
Linear feet of road built	5,300
Channel samples cut, number	114
Channel samples cut, linear feet	946
Assays on channel samples, number	342

[31] The diameter (in feet) and the length (in inches) of the cylinder in the mill.

[32] The diameter and length of the of the cylinder in the mill.

[33] The government also purchased metallic antimony for its stockpile. However, domestic antimony was purchased from the Texas Mining & Smelting Co.'s smelter in Laredo, Texas, and so did not directly affect the Yellow Pine Mine.

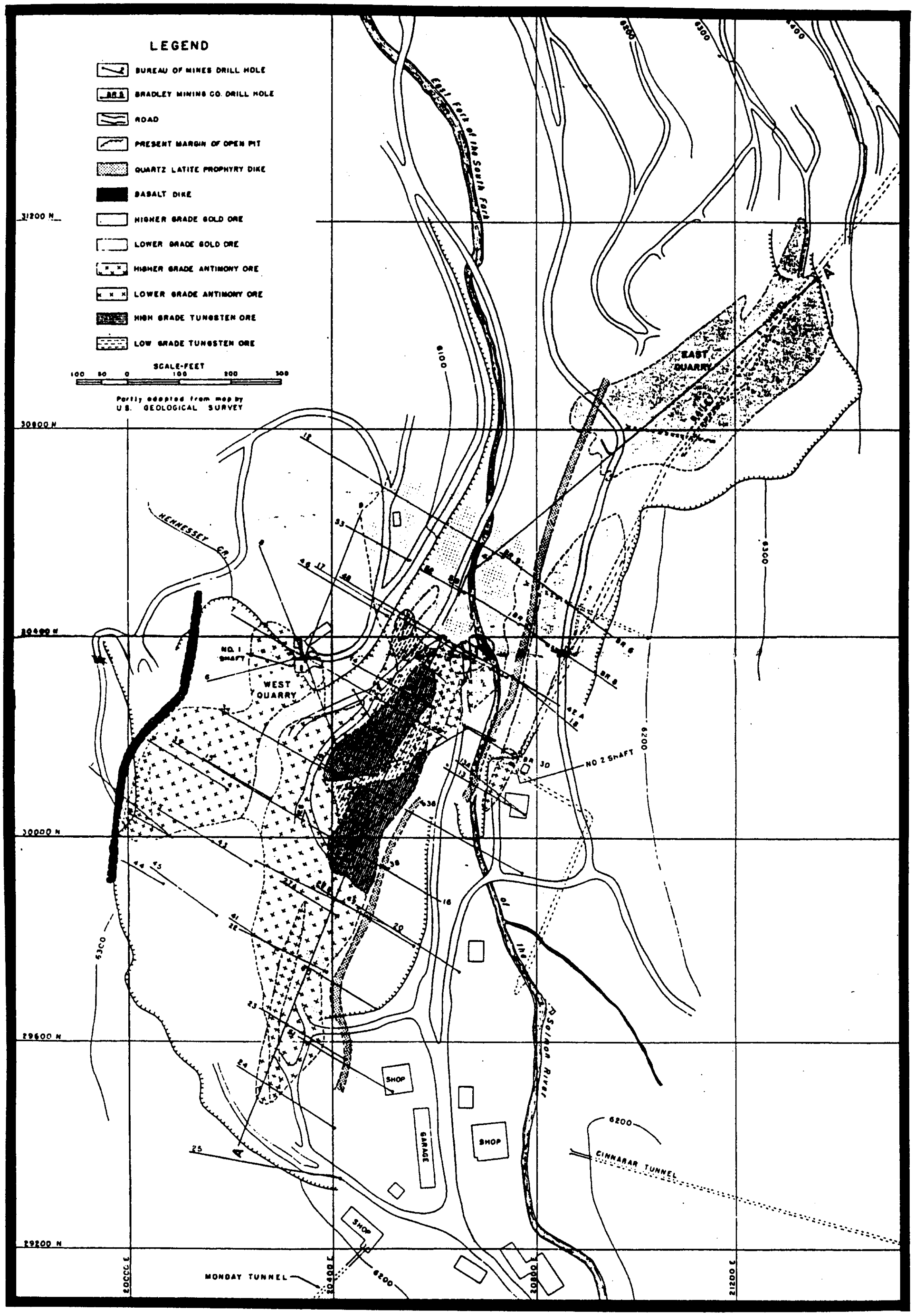

Figure 31. Geology of the Yellow Pine Mine, showing position of diamond-drill holes (Lorain, 1945, Figure 2).

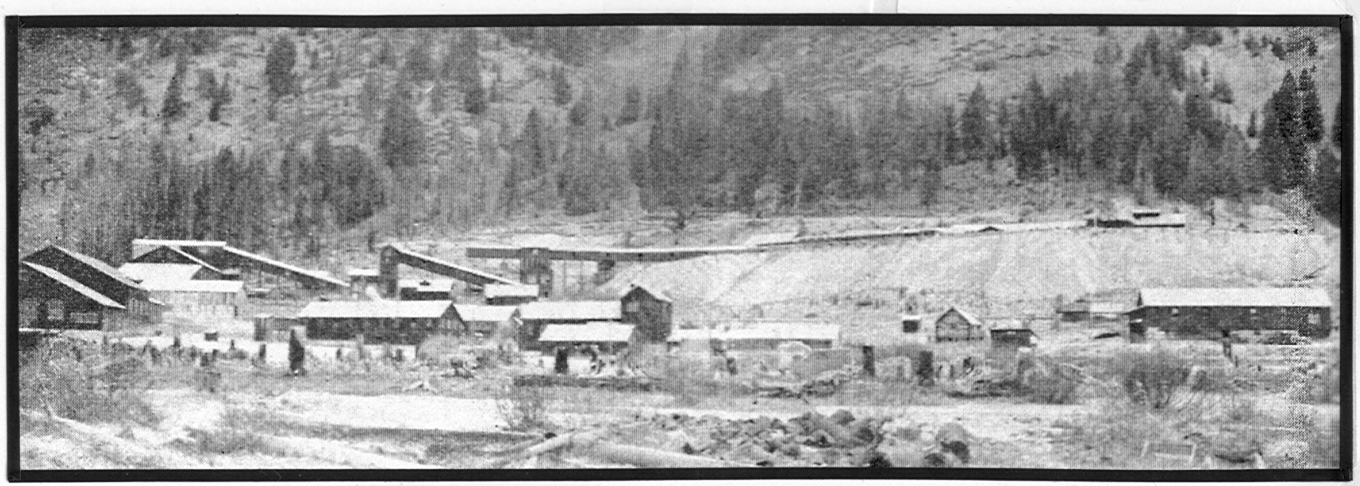

Figure 32. Panorama of the Bradley Mining Co.'s Meadow Creek camp, probably in 1939. The dark colored building on the far right is the town store. Behind it is the dump for the Meadow Creek Mine. The covered tramway on the dump leads to the building that houses the jaw crusher. From there, an elevator goes to the building for the Symons cone crusher, and the elevator to the left of that leads to the main mill building. The dark building at the left of the picture (in front of the mill) is the pilot cyanide-roaster plant. The buildings in the foreground are (left to right) the bunkhouse, the boarding house, and the office. See Figure 19 for comparison (Mining World, 1940, p. 2).

Figure 33. Stibnite in 1940, with the main building for the Meadow Creek mill in the center back (Idaho Historical Society photograph).

The cost of the Bureau of Mines drilling program was $52,225.55 (Cole and Bailey, 1948). As a result of this work, the USBM made the following estimates of the gold-silver-antimony reserves at the Yellow Pine Mine (Lorain, 1945, p. 15):

		Average assay			Metal content		
Ore class	Tons	Sb, percent	Au, oz.	Ag, oz.	Antimony, tons	Gold, oz.	Silver, oz.
A[1]	495,900	3.80	0.08	1.09	19,000	39,500	542,500
B[2]	1,593,900	1.31	.08	.65	21,000	126,400	1,040,600
C[3]	551,600	.28	.12	.37	1,500	66,900	204,200
	2,641,000	1.56	.008	.676	41,500	232,800	1,787,300

[1]Class A ore = Sb over 2 percent.
[2]Class B ore = Sb 1 percent to 2 percent.
[3]Class C ore = Sb less than 1 percent, Au over 0.10 oz.

While most of this ore was subeconomic at normal prices, the USBM believed that about 300,000 tons might be commercial ore if the proper milling equipment was used.

Mining World described the mill and its operation (1940, p. 4-5):

> The present mill feed averages about $5.25 per ton and the returns from the smelter on this mill input average approximately $3.00 per ton of ore milled. Thus, the economic recovery is slightly less than 60 per cent.
>
> It is expected that cyanidation of the flotation tails, which are presently running $1.80 per ton, will substantially increase the economic recovery.
>
> The mill at present has capacity for 400 tons daily, but improvements are under consideration which should increase capacity to 500 tons or over. This gain will be made largely by increasing the speed of the ball mills by 25 per cent.
>
> The general scheme of milling can be followed closely by reference to the accompanying flow sheet [Figure 34]. The ore as received permits hand sorting of a small amount of waste. The fine milling itself follows standard practice of crushing, ball milling and classifying, followed by flotation of the values in a sulphide concentration.
>
> Trucks from the pit dump into a 500-ton receiving bin, used as a stock pile. From this bin the ore is discharged through a Link-Belt pan feeder onto a 30-in. picking belt. Milling ore is discharged from this conveyor into a 150-ton bin, from which it is drawn by means of another pan feeder onto a grizzly the oversize from which is crushed in a 14 by 24-in.[34] Blake jaw crusher. Crusher discharge and grizzly undersize is taken by an 18-in. conveyor to a 3 by 6-ft. Link-Belt screen fitted with ½-in. mesh. Screen oversize goes to a 3-ft.[35] Symons crusher, open circuit. The total ore stream is discharged onto a 20-in. conveyor and taken over a Merrick weightometer to the 500-ton ore bin.
>
> The fine grinding plant consists of two Hardinge ball mills, 8 ft. by 36 in. and 8 ft. by 48-in., each served by a Dorr duplex heavy duty classifier 6 by 25 ft.[36] [Figure 35].

[34]The gape, or maximum working cross-section, of the jaw crusher, in inches.

[35]The maximum diameter of the gyrating conical head in the cone crusher.

[36]The width and the length, in feet, of the tank of the two-rake (duplex) classifier.

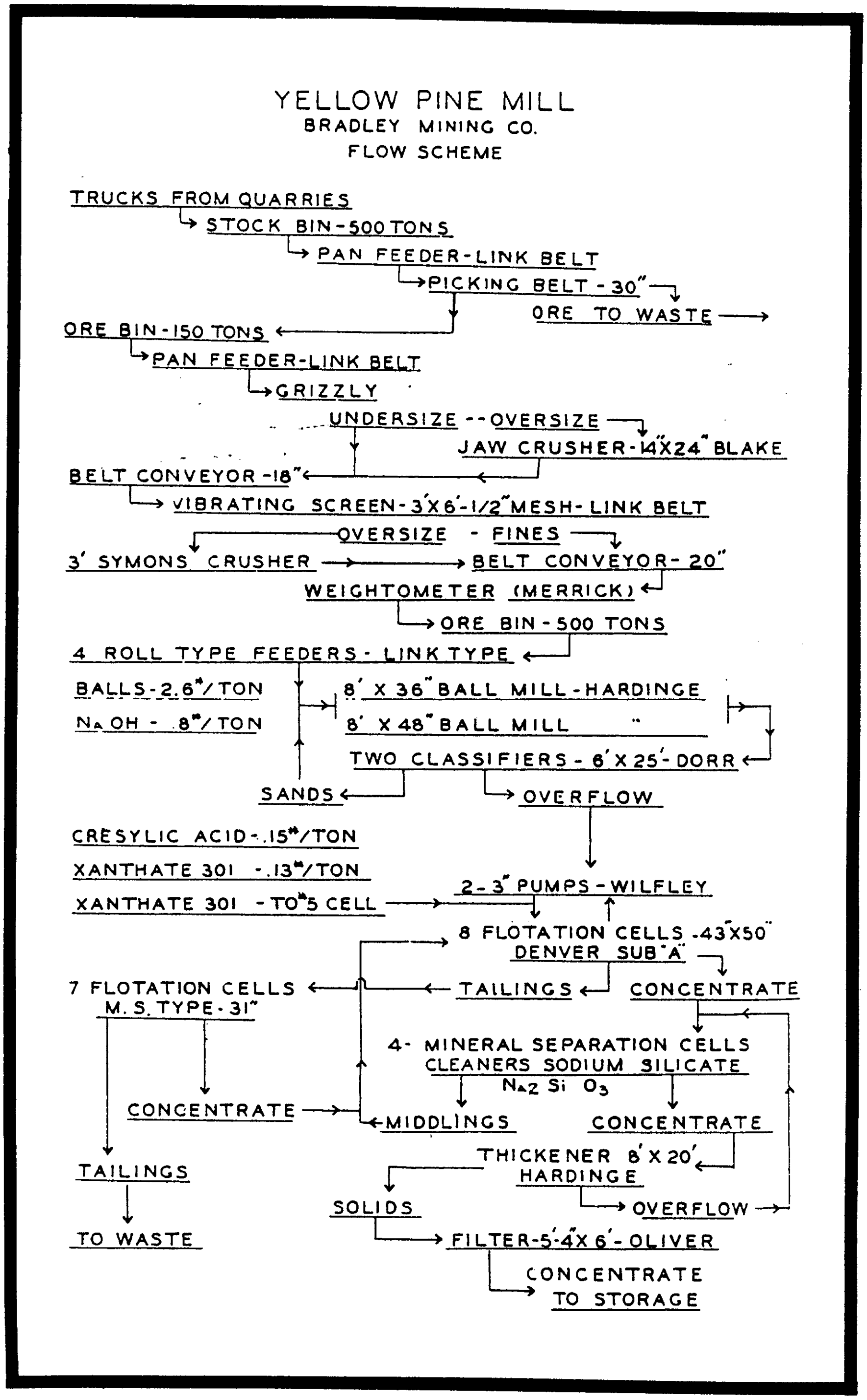

Figure 34. Flow chart for Bradley Mining Co.'s mill in 1940 (Mining World, 1940, p. 6).

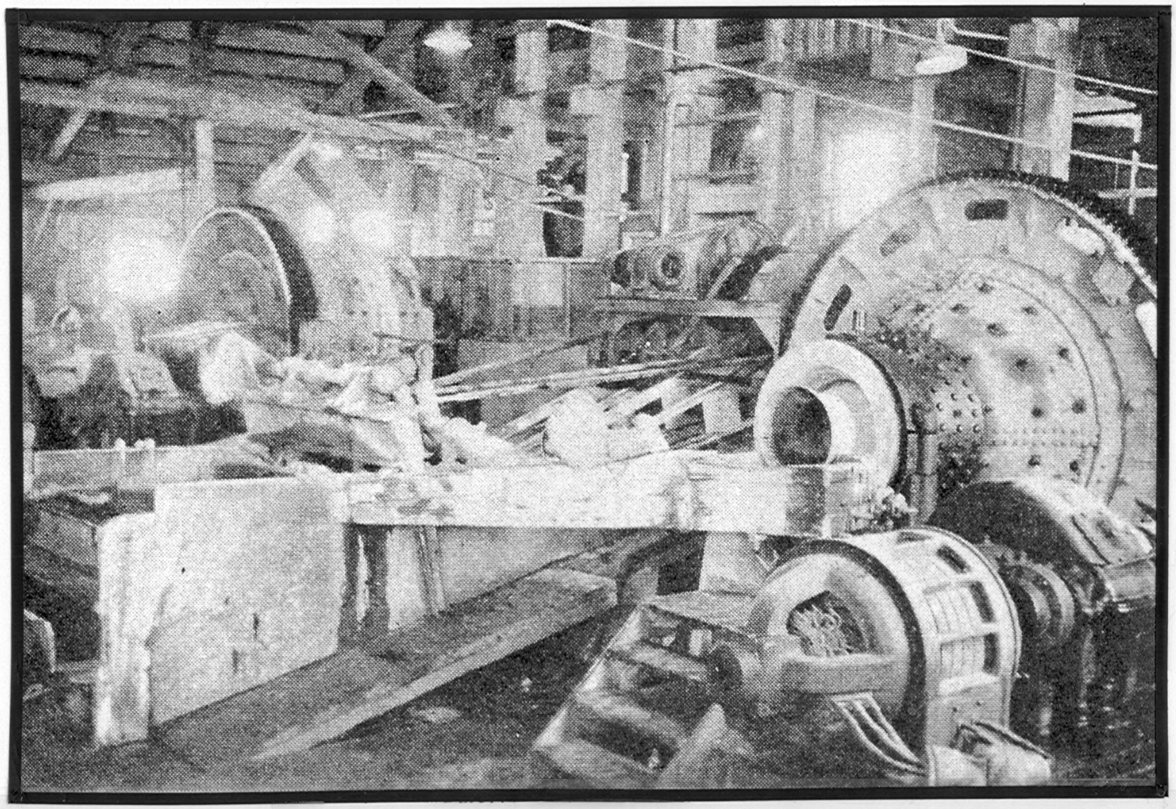

Figure 35. Hardinge ball mills in the Bradley Mining Co. mill. The unit on the left is 8 feet by 48 inches and is driven by a 200-horsepower motor, while the unit on the right is 8 feet by 36 inches and is driven by a 150-horsepower motor. The two ball mill are separated by a 6 foot by 25 foot Dorr classifier (Mining World, 1940, p. 5).

Caustic soda is added to the grinding circuit at the rate of 0.8 lbs. per ton of ore to aid in the fineness of grinding as well as in the control of the pH. There seems to be no necessity for finer than a minus 65-mesh classified grind, as flotation tails have not been improved thereby.

Classifier overflows are sent to one circuit of eight 48 by 50-in.[37] Denver Equipment Co. Sub-A cells [Figure 36] and to one circuit of seven Minerals Separation cells, functioning as roughers and scavengers in series. Concentrate from the rougher cells goes to four 31-in.[38] Minerals Separation cells used as cleaners.

Frother is 0.15 lbs. of cresylic acid, and collector is 0.13 lbs. of xanthate 301. Some sodium silicate is used in the cleaners, from which the middlings return to the rougher feed. Cleaner concentrates are thickened in an 8 by 20-ft.[39] Hardinge thickener and filtered in a 5 ft. 4 in. by 6-ft.[40] Oliver filter, the water from which returns to the rougher circuit.

Concentrates, which are shipped to the smelter, usually contain about 20 per cent insoluble. This insoluble seems to contain some metallic gold, as well as considerable amounts of slime too difficult to depress by the reagents. In fact, the principal metallurgical difficulties are associated with the presence of an unusual amount of slime. Some of this is primary and carries values which are difficult to recover, but which cannot be wasted.

At present a pilot cyanide plant of about 25 tons capacity is operating on the flotation tailings. It is hoped that the results of this pilot plant operation may justify the construction of a commercial plant to take the entire tails from the flotation mill. Some problems connected with the troublesome colloidal slime remain to be entirely cleared up, but the results to date encourage hope for an ultimate recovery of 90 per cent of the values by a combined process.

Cyanide alone has not proved sufficient to recover the entire value from the heads, owing probably to the deleterious effect of the stibnite present, and also to the difficulty of obtaining the solution of the large proportion of the gold associated with the arsenopyrite.

The tailings were impounded behind a large dike in Meadow Creek during most of the year. However, during the winter, in order to prevent the movement of the tailings across the snow-covered landing field, the tailings were dumped directly into the creek (Bradley, 1942).

The Yellow Pine Mine operated throughout 1941 and produced 80,658 tons of ore. It was one of the largest gold producers in the state, even though production was less than in the previous year. (Figure 37 shows blasting being done in the East Pit during the summer.) The mine was also the largest producer of primary antimony in the country. The company noted that the equipment had been removed from the Meadow Creek Mine and the mine had been allowed to fill with water.

The major event at the mine during 1941 was the discovery of tungsten in the ore. In January, while examining thin sections from the drill cores from the U.S. Bureau of Mines project, D.E. White identified scheelite in one of the slides. The discovery was reported to the Bradley Mining Co., and the company switched its exploration efforts to delineate the tungsten orebody (Cooper, 1951). All the drill cores were lamped with ultraviolet light to determine the extent of the scheelite occurrence. A vertical shaft, called

---

[37]The dimensions of the flotation cells, in inches.

[38]The Minerals Separation flotation machines had square cells.

[39]The depth and diameter, in feet, of the tank for the thickener.

[40]The diameter of the fliter's rotating drum and the length of the working face.

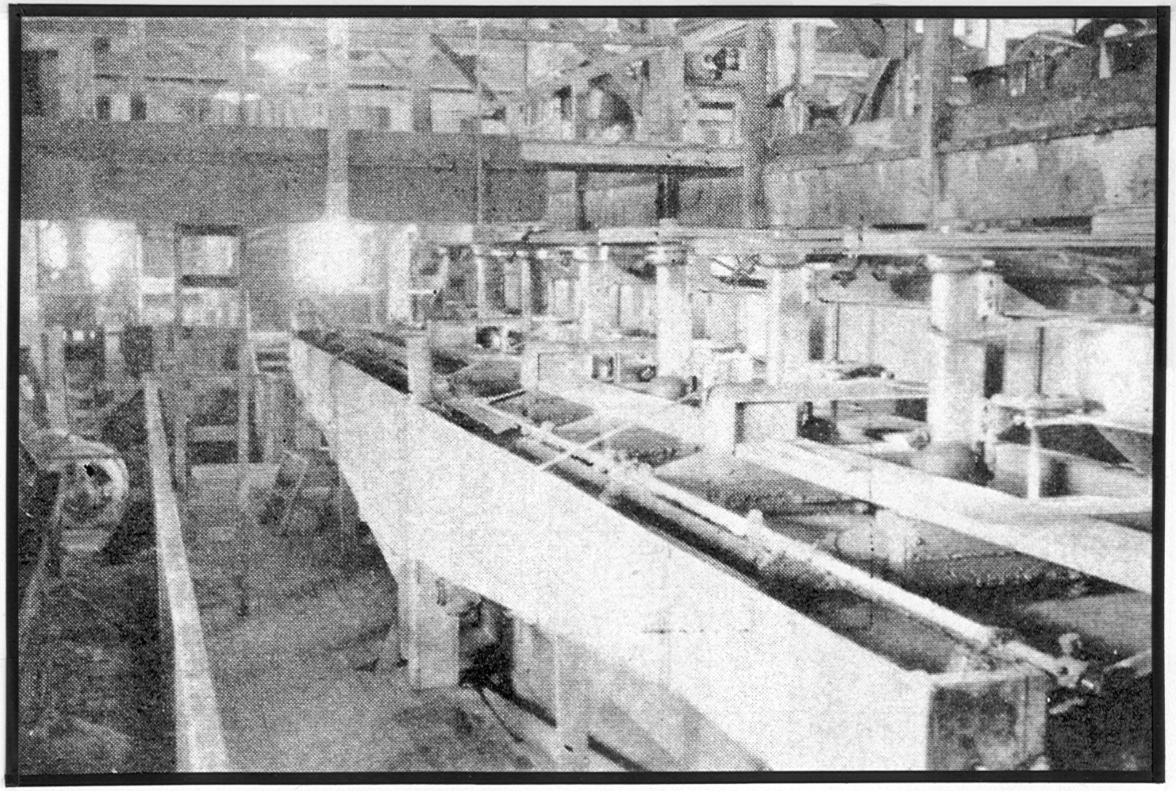

Figure 36. Bank of eight Denver Equipment Co. Sub-A flotation cells in the Bradley Mining Co. mill. The cells are 43 inches by 50 inches (Mining World, 1940, p. 5).

Figure 37. Blasting in the East Pit during the summer of 1941 (Bradley, 1941, p. 17).

the Tungsten Shaft, was started in April (Figure 38) near the northern edge of the West Quarry (Bradley and others, 1943). The shaft went down 175 feet, and a crosscut was driven from it to the ore (Call and Bailey, 1948). The shaft and crosscut were apparently intended to get under the orebody, but instead found an extension of the high grade ore zone (Edgar and Smith, 1942). A level 100 feet lower found antimony ore but no tungsten (Bailey, 1979). (Figure 39 shows a cross section through the orebody.) According to the company, the hoist and other equipment removed from the Meadow Creek Mine were used for this work. The first tungsten ore was mined in August (Cooper, 1951), and by the end of the year, all mining had been shifted to the tungsten-antimony-gold orebody (Call and Bailey, 1948). The mill was rearranged to produce tungsten concentrate (Figure 40), a process that involved a certain amount of experimentation. Its operation was described by Call and Bailey[41] (1948, p. 18-20):

> Grinding
>
> The ore was ground in four Hardinge ball mills and one Marcy ball mill. . . .
>
> The pulp density was maintained at 70 to 72 percent solids in the ball mills and 38 percent solids at the classifier overflow. The combined output of the five grinding circuits was approximately 750 tons per 24 hours at a screen size of 96 percent minus 60-mesh.
>
> Flotation
>
> The flotation circuit consisted of one long series of cells, with a capacity of 750 tons of ore in 24 hours.
>
> Four separate concentrates were floated in the following order: Iron sulfides (containing most of the gold), antimony sulfide (containing most of the antimony and silver), high-grade scheelite, and low-grade scheelite. Because of marketing conditions, the antimony content of the iron sulfide concentrate was held at 20 percent.
>
> The value of the tungsten in the ore exceeded by many times the value of the combined gold, silver, and antimony. Therefore, emphasis was placed on recovery of tungsten in a high-grade concentrate. A typical analysis of the mill heads was: Tungsten trioxide, 1.50 percent; antimony, 3.2 percent; gold, 0.06 ounce per ton; and silver, 1.50 ounces per ton.
>
> Iron Sulfide (Gold) Circuit
>
> The classifier overflow was pumped to a common head box that discharged to the head of a series of four 48-inch Denver cells. Head samples were taken from the head box discharge by a Geary-Jennings automatic sampler. Reagents added to the iron sulfide circuit were:

Place added	Reagent, pound per ton of ore
Ball mills	0.07 pound Xanthate 301
.30 pound Caustic soda	
Headbox	.12 pound B-23

[41]Although Call and Bailey (1948) present this description of the mill as representing its operation throughout the period when tungsten being mined (1941-1945), other sources (USBM Yearbook) report that tabling the low-grade concentrates was discontinued in 1942 and that the flotation process was modified at the same time. However, some of the equipment listed in this description (such as the Marcy ball mill, which was purchased in late 1943 or early 1944) was added after the processing method was changed.

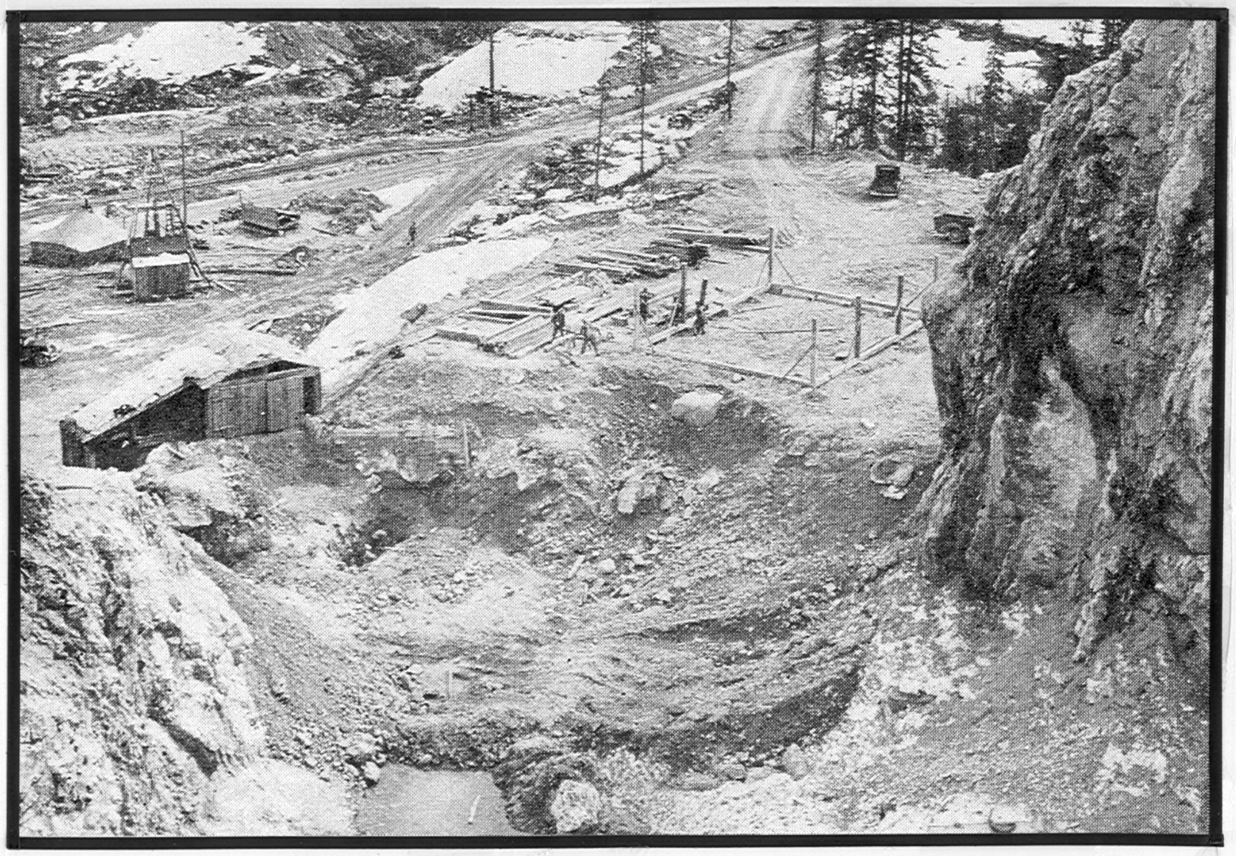

Figure 38. Starting the Tungsten Shaft on April 1, 1940 (Bradley, 1941, p. 17).

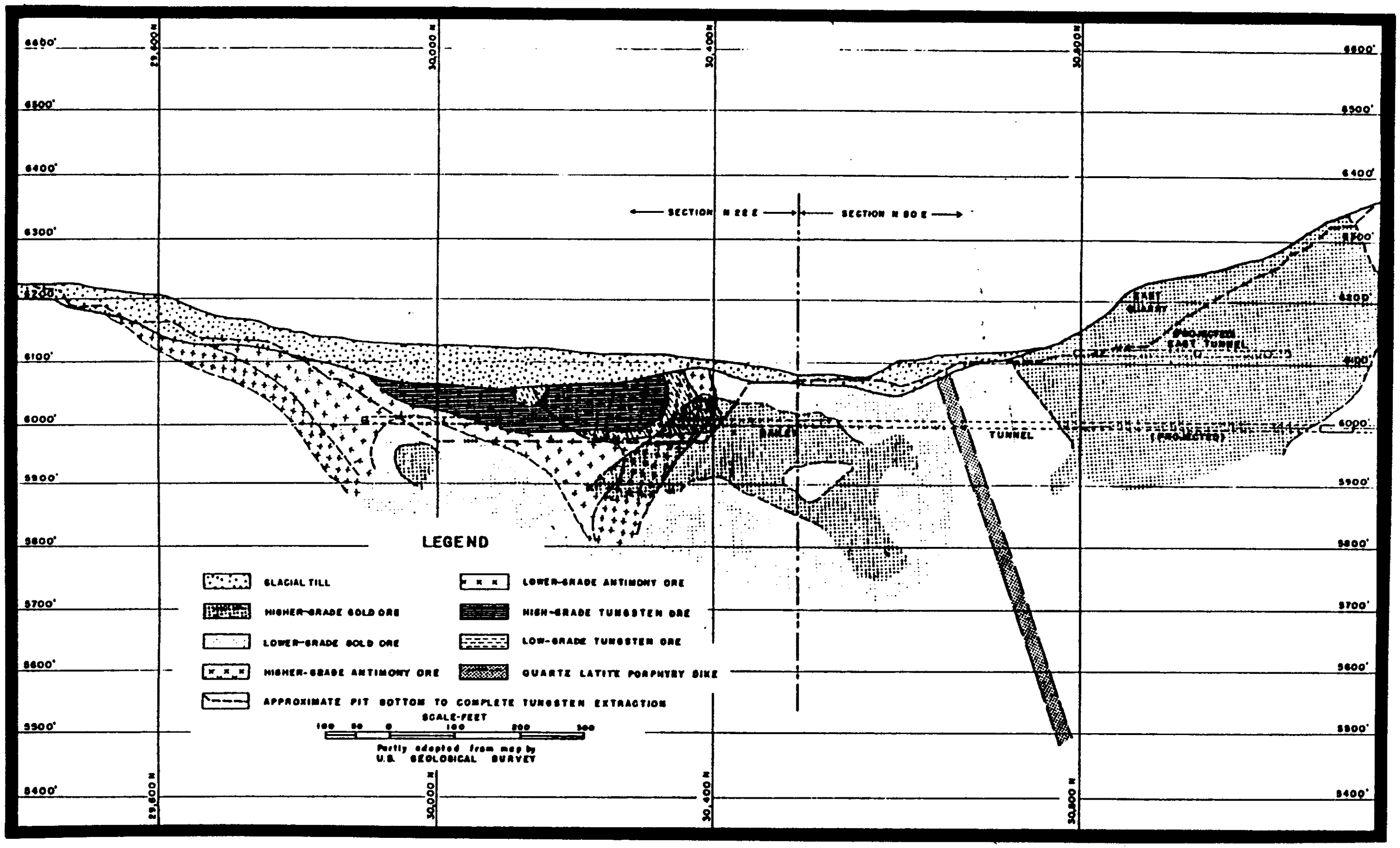

Figure 39. Cross-section of the Yellow Pine Mine, showing the orebodies. The section is along line A-A′ in Figure 31 (Lorain, 1945, Figure 3).

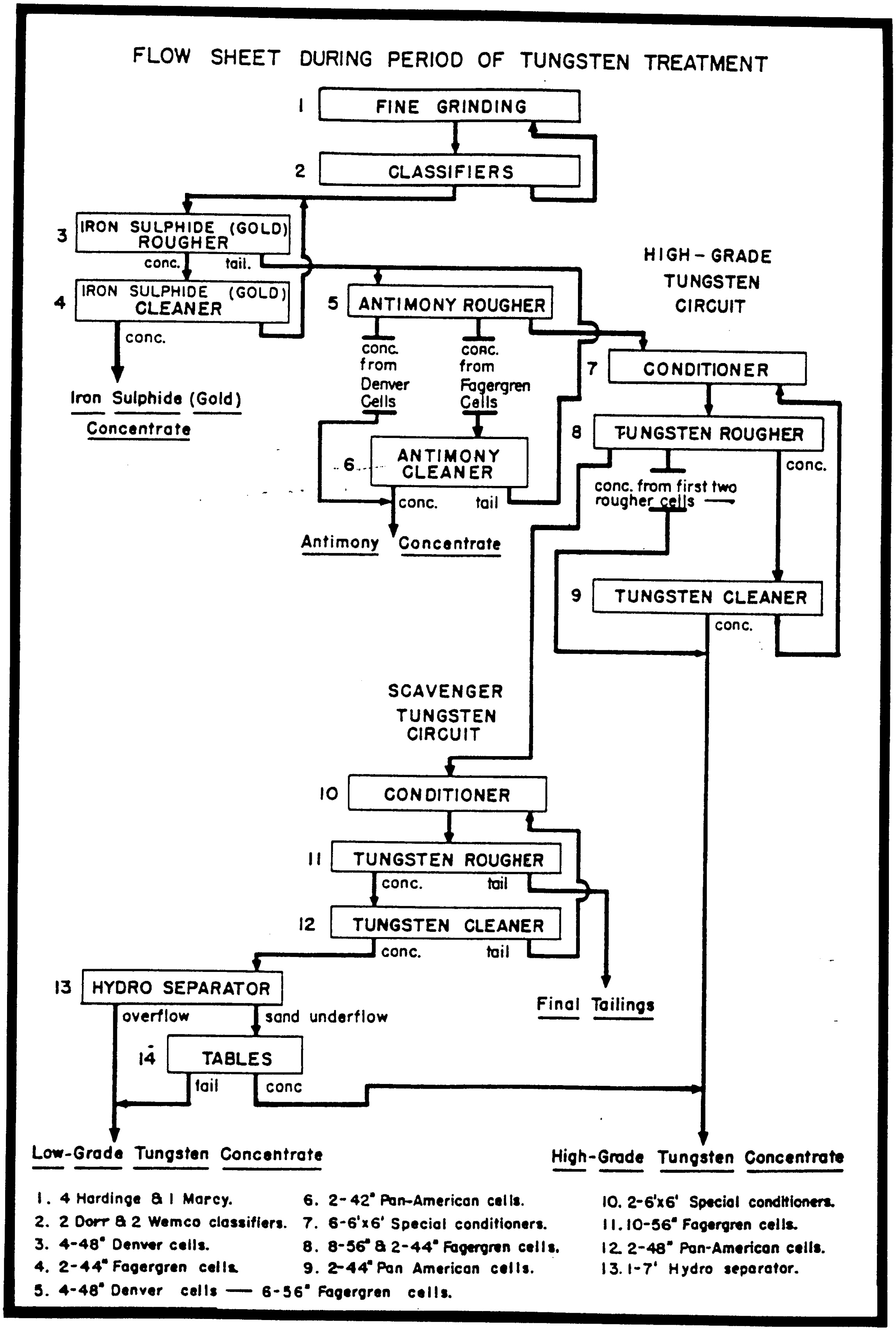

Figure 40. Flow sheet for the Bradley Mining Co.'s mill, probably during 1941 (Cole and Bailey, 1948, Figure 7).

The concentrates from the four Denver cells were treated in two 44-inch Fagergren cleaner cells. The mineral content of the concentrates from the cleaner cells averaged: Gold, 1.36 ounces per ton; silver, 8.66 ounces per ton; and antimony, 20 percent. The cleaner-cell tailings were returned to the head of the circuit. The antimony content of the iron sulfide concentrates was controlled by the quantity of caustic soda used. Only 54 percent of the gold was recovered in the iron sulfide concentrate. In addition, the iron concentrate contained 14 percent of the total antimony and 12 percent of the total silver.

Antimony Sulfide Circuit

The tailings from the iron sulfide circuit went to a series of four 48-inch Denver cells followed by six 56-inch Fagergren rougher cells. Concentrates from the Denver cells went directly to the antimony thickener. The concentrates from the Fagergren cells were treated in two 48-inch Pan-American cleaner cells. The cleaner-cell tailings were returned to the head of the antimony sulfide circuit; the cleaner-cell concentrates went to the antimony concentrate thickener. The reagents added for the antimony sulfide float were:

Place added	Reagent, pound per ton of ore
Head of circuit and to . .	0.91 pound lead acetate
3rd Fagergren cell	.03 pound Xanthate
. . . .	.06 pound B-23

The antimony sulfide concentrates contained an average of: Antimony, 51 percent; gold, 0.20 ounce per ton; silver, 18.0 ounces per ton; and tungsten trioxide, 0.5 percent. The antimony sulfide circuit recovered an average of 64 percent of the antimony, 51 percent of the silver, 13 percent of the gold, and 1.3 percent of the tungsten trioxide.

High-Grade Tungsten Circuit

The tailings from the antimony circuit went to six 6-foot by 6-foot conditioning tanks. The conditioning time was approximately 15 minutes. The following reagents were added:

Place added	Pounds per ton of ore
1st conditioner	1.0 pound caustic soda
do.	.2 pound quebracho
do	.35 pound sodium silicate
do	2.7 pound soda ash
Head pump	.60 pound Keminol
7th cell	.20 pound Keminol
5th conditioner	1.00 pound oleic acid
7th cell	.10 pound oleic acid

The high-grade tungsten circuit comprised eight 56-inch and two 44-inch Fagergren rougher cells. The concentrates from the first two rougher cells went directly to the concentrate thickener. The concentrates from the last eight rougher cells were treated in two 48-inch Pan-American cleaner cells. The tailings from the Pan-American cells were returned to the head of the tungsten circuit. Fifty percent of the tungsten content of the mill heads was recovered in this circuit, and the concentrates averaged 50 percent tungsten trioxide. Impurities in the tungsten concentrate included 0.50 percent phosphorus, 0.15 percent arsenic, and 0.20 percent sulfur.

Low-Grade Tungsten Circuit

The tailings from the high-grade tungsten circuit discharged into two 6- by 6-foot conditioners, where 0.67 pound per ton of Perkins pine fatty acid oil was added. The pulp

from the conditioners was fed to 10 56-inch Fagergren rougher cells. The tailings from these cells constituted the final tailings for the entire circuit. The concentrates from the rougher cells were treated in two 48-inch Pan-American cleaner cells. The cleaner-cell tailings were returned to the conditioners. The cleaner-cell concentrates averaged approximately 15 percent tungsten trioxide. The tungsten recovery in this circuit was 35 to 40 percent of the tungsten trioxide content of the mill heads. The concentrates from the Pan-American cleaner cells were treated in a 7-foot[42] hydroseparator, to which was added 7 pounds of sodium silicate for each ton of concentrate. The sand underflow from the hydroseparator went to two concentrating tables. The concentrates from the tables contained 60 to 65 percent of the tungsten content of the table feed; they assayed 45 to 55 percent tungsten trioxide. The hydroseparator overflow and the table tailings were combined in a low-grade tungsten product which averaged approximately 7 percent tungsten trioxide.

The above-described treatment resulted in a 70- to 72-percent recovery of the tungsten content of the mill heads in a high-grade (50 percent tungsten trioxide) concentrate and an additional recovery of 10 to 20 percent in a low-grade concentrate.

The low-grade tungsten product was shipped for further treatment to the plant of Metals Reserve Co., Salt Lake City, Utah; to the plant of the United States Vanadium Corp., near Bishop, Calif.; and to the plant of the Bradley Mining Co., Boise, Idaho.

In the last five months of 1941, the Yellow Pine Mine produced 14,498 short tons of ore averaging 2.4 percent WO_3. (See Table 9 for production from the tungsten orebody.) This ore yielded 1,111 tons of concentrates containing 25.45 percent WO_3. The mine was the largest producer of tungsten[43] in Idaho for the year. During 1941, the government made substantial purchases of tungsten for its stockpile and entered into three-year contracts with Bolivian and Argentinean producers to make large purchases of tungsten at a guaranteed price of $21 per short-ton unit[44]. Contracts were also made with three of the largest domestic producers and were being negotiated with other producers for a guaranteed price of $24 per unit. Tungsten was used to make steel alloys for cutting tools (which were made of an alloy containing 18 percent tungsten, 4 percent chromium, and 1 percent vanadium), magnets, valves and valve seats, armor-piercing projectiles, and erosion-resistant gun liners; for making tungsten carbide cutting tools; and in lamp and radio-tube filaments, X-ray targets, and electrical contact points.

Antimony prices remained at 14 cents per pound during 1941. On August 21, a price increase of half a cent per pound was posted, but the Office of Price Administration and Civilian Supply requested that the 14-cent price be maintained.

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[42]The diameter of the tank in the hydroseparator.

[43]Yellow Pine's tungsten guaranteed that keeping the mine in production would be a high priority of the U.S. Government throughout World War II. According to Clark (1951), at least one supply-services general credited Yellow Pine's tungsten with shortening the war by a year and saving a million lives.

[44]A unit is 1 percent of a ton of tungsten trioxide (WO_3). A short-ton unit is 20 pounds of WO_3 or 15.86 pounds of tungsten (W).

Table 9. Production from the tungsten ore body at the Yellow Pine Mine (Cole and Bailey, 1948, p. 4).

Year	Ore mined, tons	Concen-trates, tons	Metal content of concentrates			
			WO_3 units	Antimony, tons	Gold, ounces	Silver, ounces
1941[1]	14,498	2,466	27,921	367	2,055	8,987
1942	69,861	15,210	181,230	2,801	2,714	85,161
1943	178,747	22,787	303,502	2,734	4,529	109,307
1944	211,382[2]	13,438	233,664	2,031	6,110	74,498
1945	109,796	7,590	85,512	2,895	6,505	87,815
Total	611,284	61,491	831,829	10,828	21,913	365,768

[1]Production started in August 1941.
[2]Includes 966 tons of tailings, which were reprocessed.

Antimony was in comparatively short supply during most of the year, but the Office of Production Management did not invoke any production priorities.

In 1942, the Yellow Pine Mine[45] produced 96,861 tons of ore, which contained an average of 0.039 opt of gold, 1.41 opt of silver, 4.79 percent antimony, and 2.59 percent tungsten. The 400-tpd mill yielded 2,294 tons of high-grade tungsten concentrate, 6,887 tons of low-grade tungsten concentrate, 7,564 tons of gold-silver-antimony concentrate, and 816 tons of gold-antimony-iron concentrate. Most of the low-grade concentrate was shipped to Salt Lake City for further treatment. The mine was the principal producer of antimony in the country; it shipped 5,950 tons of antimony concentrates, which contained 2,597 tons of antimony. This exceeded the entire output of the United States in any previous year (the record was 2,100 tons of antimony, produced in 1915). The mine was also the largest producing tungsten mine in Idaho and the second-largest producer of high-grade tungsten ore in the country[46]. Four-fifths of the ore was mined from the underground workings.

[45]The section of the mine from which the tungsten was produced was sometimes referred to as the Idaho Tungsten Mine.

[46]When both the high- and low-grade concentrates are considered, the mine was the largest tungsten producer in the country. However, the low-grade concentrates were shipped to the Metals Reserve Co.'s re-treatment plant, which did not begin operation until April 1943. Thus, the USBM did not consider the low-grade concentrates in figuring the total production for 1942.

The price of antimony remained at 14 cents per pound for the first part of the year, but the Office of Price Administration adjusted it upward in March (to 15.955 cents) and again in April (to 16.013 cents per pound) to reflect an increase in freight costs. The price was again raised at the end of December to cover an excise tax on transportation. On March 30, the War Production Board issued General Preference Order M-112 (effective May 1), which strictly controlled deliveries of all forms of antimony (ore, concentrates, and alloys). These controls were later relaxed for deliveries of less than 50 tons of antimony. The USBM noted that a growing use for antimony oxide was the treatment of canvas and other textiles to prevent rotting and fire.

The Metals Reserve Co. continued to buy tungsten at a price of $24 a unit for the government stockpiles during most of the year. The price was raised to $30 a unit in mid-November. Labor shortages at some tungsten mines were alleviated when the Army furloughed soldiers to work in the mines. Bailey (1978) noted that the men sent to the Yellow Pine Mine were coal miners and that they did not adapt easily to the different style of mining.

Development work continued on the Yellow Pine tungsten orebody. The core drilling and underground exploration showed that it was suitable for open-pit mining. Underground mining continued until the open pit was ready for operation[47] (Cole and Bailey, 1948). About 1 million cubic yards of glacial material had to be removed from above the orebody (Bradley and others, 1943). Part of this waste was dumped on both sides of the East Fork downstream from the pit, and the remainder was dumped on the south side of Sugar Creek (Cole and Bailey, 1948).

In addition, the water from the East Fork, which at flood stage had a flow of more than 300 cubic feet per second, had to be diverted. This was accomplished by driving a 3,500-foot drainage tunnel (Bailey, 1943). Another 500 feet of raises connected the tunnel with the surface. The Bailey tunnel ran from the East Fork, upstream of the open pit, to Sugar Creek (Figure 2 and Plate 1). (Figure 41 shows the diversion dam and the Bailey tunnel in relationship to the orebody; Figure 42 shows the outlet of the tunnel.) The tunnel was driven by crews working from each end. Tunnelling costs totaled $33.18 per foot, of which $22.27 was for labor and $10.91 was for supplies (Cole and Bailey, 1948). The finished tunnel measured 7 by 9 feet and took about five months to complete (Bailey, 1942). Raised sills above a 2-foot-deep ditch allowed for the installation of permanent track (Cole and Bailey, 1948). The upper section of the tunnel was used for development work ten months out of the

[47]The decision to operate the mine by underground methods rather than wait until more economic surface methods could be used was dictated by need to produce tungsten as fast as possible for the war effort. The underground workings were extremely wet because the mine was under the river, and the timbers used to support the workings gave the miners problems later when they had to be removed from the open pit (Bailey, 1978).

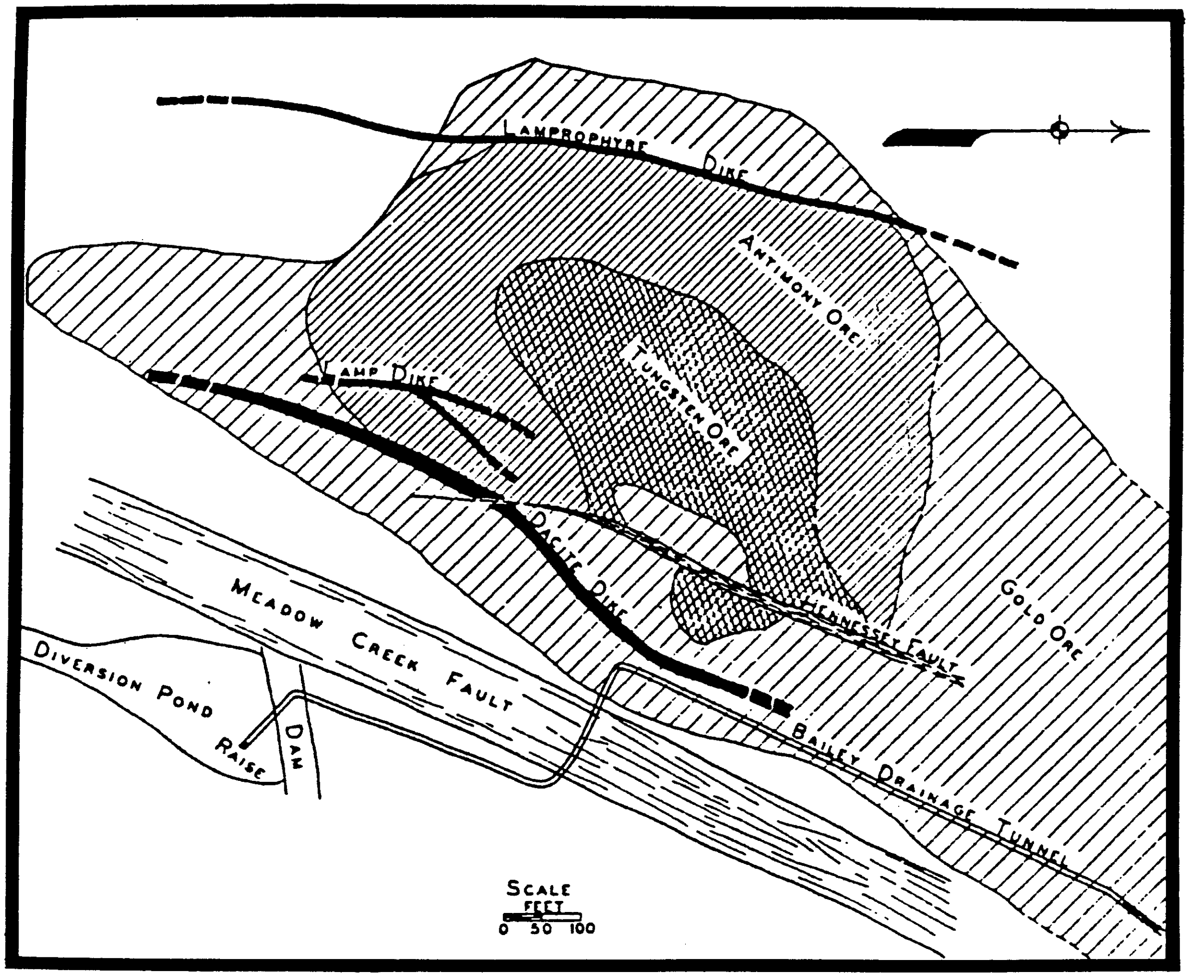

Figure 41. Sketch of the diversion pond and the Bailey tunnel, showing the locations relative to the orebodies (Bailey, 1943, p. 7191).

Figure 42. Outlet of the Bailey tunnel on Sugar Creek in 1994 (photograph by Virginia S. Gillerman, Idaho Geological Survey).

year (Bailey, 1943). Bradley and others (1943, p. 64-65) described the combined open-pit and underground mining operation:

> Mining operations are carried on simultaneously underground and on the surface. Some 800 tons of ore is mined daily, with 300 tons coming from underground workings and 500 tons from a pit. About 1,000,000 cu.yd. of glacial till was removed from the top of the orebody before open-pit mining started. Five shovels were used—namely, a B-E[48] 44-B, 2-cu.yd. unit; B-E 20-B, ¾ cu.yd.; Lima 6-ELH, 1¾ cu.yd.; Northwest 20, ¾ cu.yd., and a Northwest 20, ⅝ cu.yd. Additional pit equipment included three International TD-18's; a Cletrac DD; Cletrac FD; two Caterpillar RD7's; with two RD6's and one RD8. Haulage of waste to the dumps was done by 25 Cummins diesel trucks and 25 gasoline trucks.
>
> The pit proper is worked in level benches 30 ft. wide with 30-ft. faces [Figure 43 and 44]. Ultimate over-all slope (top to bottom) will be 45 deg. The access road starts at the south end and spirals downward on a 6 percent grade to the bottom. Ore is mined selectively. All benches are lamped with fluorescent lights, and tungsten-bearing areas are marked and blasted separately from areas barren of scheelite. After each blast, the broken ore again is lamped before haulage to mill or stockpiles.
>
> One G-D[49] D99 and four I-R[50] X71 wagon drills are used for drilling the benches. Eighteen-foot to 24-ft. horizontal holes are drilled with 1¼-in. round steel and Timken bits. The bits vary from 2⅞ in. to start the hole down to 2 in. to finish it. Large boulders are blockholed in the pit with I-R C49 jackhammers using 1-in. hexagonal steel with forged-on bits. The highly sheared nature of the ground makes it unnecessary to drill vertical holes, except when a new bench level is established. Horizontal holes are loaded with Gelex No. 2, and vertical holes with duPont "Red Cross" No. 4 free-running powder. Compressed air for the drills is furnished by two 500-cu.ft. I-R compressors; a 315-cu.ft. I-R compressor, and a 360-cu.ft. G-D compressor, all portable. The shovels used in stripping serve also for loading broken ore and waste into trucks, and the trucks and tractors are employed in current mining work. About 300 g.p.m. of water from drainage constantly enters the pit. The water is bypassed through the mine and pumped up one of the old stopes.
>
> Cost of breaking in the open pit and loading into trucks is 28c. per ton, which includes 10c. per ton for stripping.
>
> The underground workings are distributed over three levels, and consist of a 175-ft. vertical shaft, a 165-ft. inclined shaft, a 103-ft. vertical winze, 4,000 ft. of drifts and crosscuts, and several raises and stopes[51]. I-R DA30 and DA35 machines are used in crosscutting and drifting. Fifteen to twenty holes, using a V-cut, are drilled in establishing lateral workings with a 6x8-ft. cross-section. Broken ore on the lower two levels is loaded with Eimco Model 12B loaders, and I-R Model 4NNOJ slushers are used in the drifts and crosscuts on the upper level. The ore on the upper level either is scraped into transfer raises or loaded directly into 18-cu.ft. end-dump cars by using a slusher and ramp. In the lateral headings about 6 tons per man-shift is produced at a cost of $2.78 per

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[48]Bucyrus-Erie.

[49]Gardner-Denver.

[50]Ingersoll-Rand.

[51]The underground workings were destroyed by subsequent work in the open pit (Cole and Bailey, 1948).

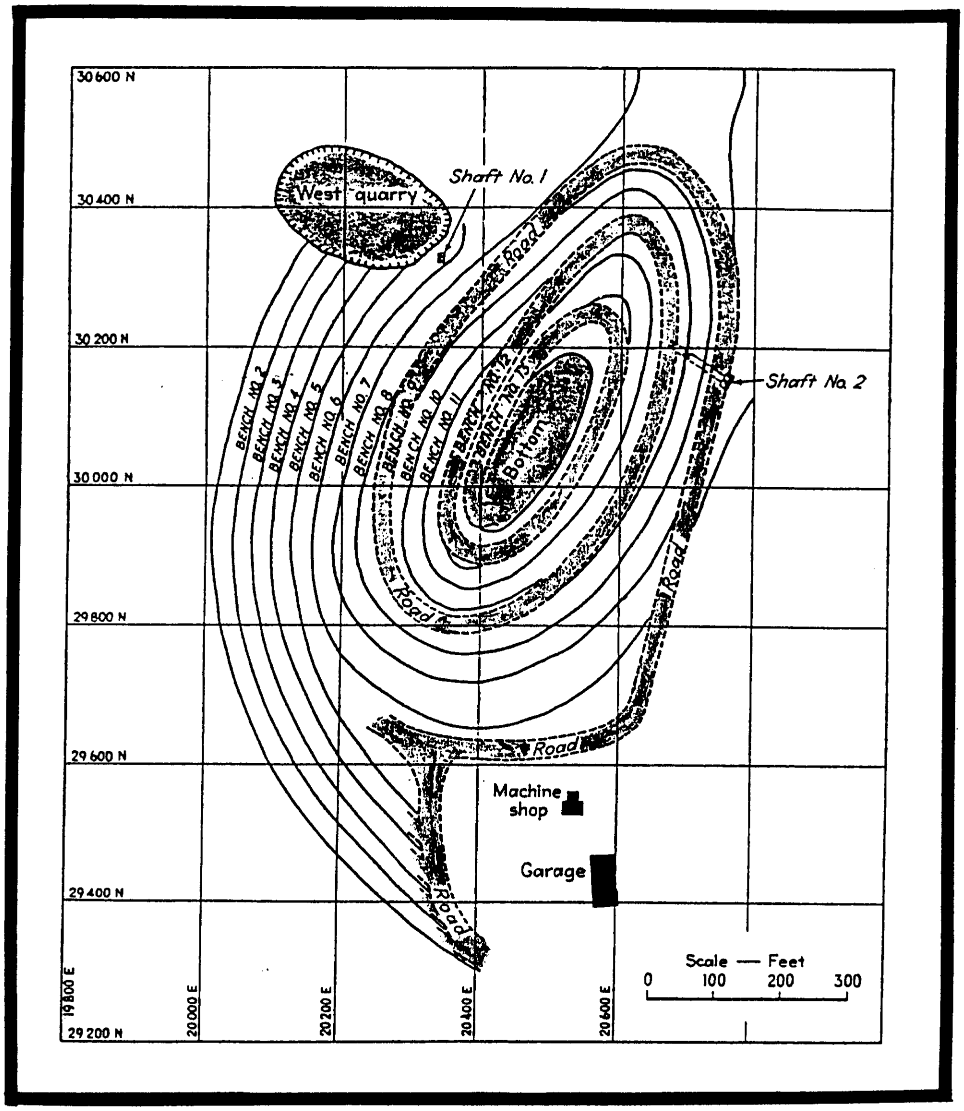

Figure 43. Plan of the proposed layout for the Yellow Pine Pit (1942), showing benches and roads. The benches were 30 feet wide and 30 feet high, with a final slope of 45 degrees. The spiral road had a 6 percent grade (Bradley and others, 1943, p. 62).

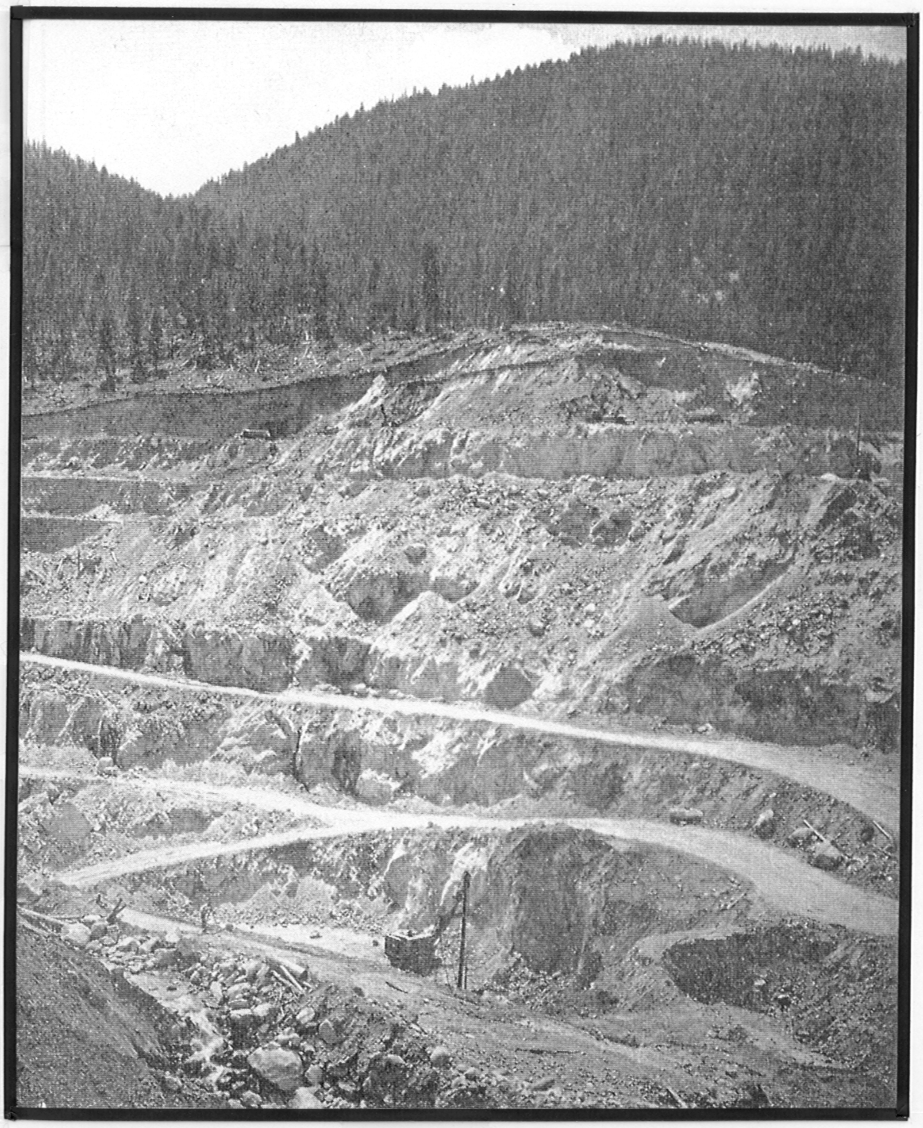

Figure 44. The west side of the Yellow Pine Pit, probably in 1942 (Bailey, 1943, p. 7191).

ton. The drifting crew consists of a miner and helper on one shift, and a loader for half of the next shift. Drilling in the square-set stopes is done with I-R R58 stopers, with the stope crew comprising a miner and a helper on each shift. The two do all the mining, mucking, timbering, and filling in the stope.

The orebody is divided into vertical blocks 15 ft. square and extending from the middle level to the surface [Figure 45]. In starting a new stope, a vertical, two-compartment raise is driven from the middle level to the upper level or to the surface. When the raise is completed, operations shift to the first floor, and the block is mined out in a series of horizontal slices. Stope sets measure 5 x 5 ft. x 7 ft. 9 in. They are made from local Engelman spruce. The sill floor posts are 9 ft. long over all, stope posts 7½ ft., caps 5 ft., and girts 4 ft. 8 in. A worked-out stope is filled with glacial till, which is either brought down the waste compartment of No. 2 shaft to the upper level and hand-trammed to the stopes, or dumped directly into the stopes from the surface. The stopes are filled only to the upper level. Stope production per man-shift amounts to 6.75 tons at a cost of $1.75 per ton. A bonus system was established recently based on payment by the company for all tonnage produced by the mine over a certain amount. The first month after installation of the system, the output per man-shift increased 22 percent at a cost increase per ton of 8.7 percent. The over-all tonnage per man-shift, including maintenance men, is about 5, and the over-all cost per ton of ore mined $2.25.

Bradley and others (1943, p. 62-63) described the ore:

The typical ore is a breccia of angular fragments of scheelite and mineralized quartz-monzonite cemented by a matrix of fine-grained stibnite. Commonly, scheelite fragments include angular fragments of quartz monzonite. Veinlets of stibnite indiscriminately crosscut the scheelite and quartz monzonite. In color, the scheelite is cream to straw-colored, the quartz monzonite fragments are white to light gray, and the stibnite is metallic dark gray. The main body of tungsten ore contains 2 to 4 percent tungstic oxide (WO_3), about 5 percent antimony, 0.08 oz. gold, and 1.25 oz. silver. Currently, some 250,000 tons of 2 to 4 percent tungsten ore and 500,000 tons of 0.7 percent tungsten ore are blocked out, and prospects for developing an even greater tonnage are excellent. . . .

The early sulphites—pyrite and arsenopyrite—are thoroughly disseminated in microscopic grains throughout the quartz monzonite of the shear zone. They selectively replace biotite and sericitized plagioclase to a limited extent. The abundance of the early sulphides within the Yellow Pine mine is related to the degree of shearing. Although all gold apparently is inclosed in the early sulphides, no coincident distribution of sulphides and gold is observable. There are masses of high-grade gold ore and masses nearly barren of gold, independent of the amount of sulphides present.

The scheelite ore occurs in several ways—namely in mineralized breccia zones where gold ore fragments are imbedded in a scheelite matrix; in inclusion breccia zones, where scheelite fragments are imbedded in a matrix of fine or coarse-grained stibnite; in nearly pure stringers that occupy dilatant partings in the host rocks; and in haphazard disseminations in the country rock. The best grade of ore comes from the inclusion breccias of scheelite fragments in stibnite. In every case, high-grade scheelite ore is found to accompany high-grade stibnite ore.

Milling practices for treating the gold-silver-antimony-tungsten ore were changed again in 1942. The mill switched from bulk sulfide flotation to selective

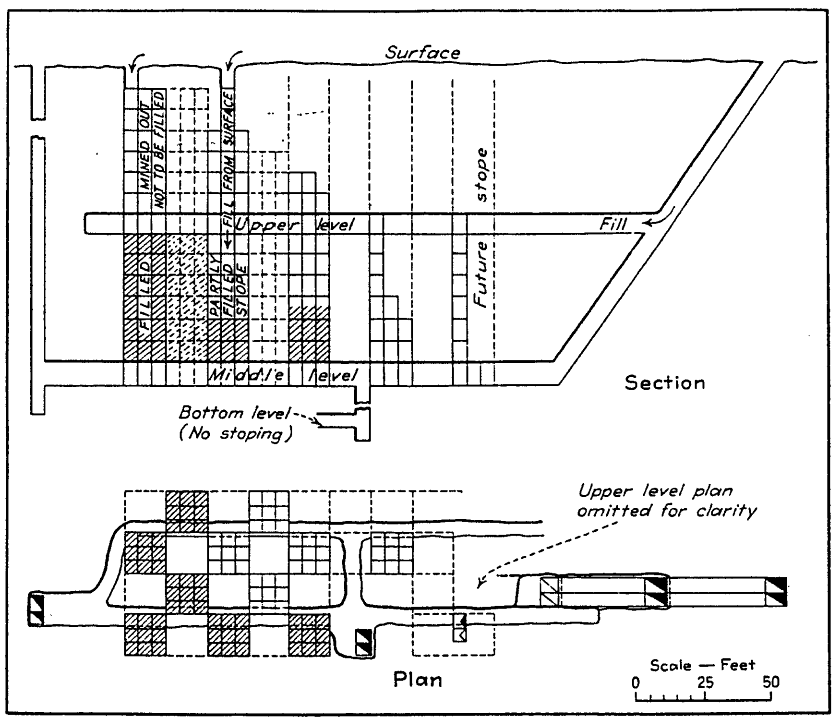

Figure 45. Cross-section and plan of underground operations at the Yellow Pine Mine. The ore was divided into 15- by 15-foot blocks, which were mined out and filled from the bottom up (Bradley and others, 1943, p. 63).

flotation to separate the antimony minerals from the pyrite and arsenopyrite, and improved flotation techniques replaced tabling of the low-grade tungsten concentrates. In addition, two more ball mills, several flotation cells, and auxiliary equipment were added to the mill. Bradley and others (1943, p. 65-66) described the milling operation, including some of the controls for the flotation process:

> History of the metallurgy at the Yellow Pine mine has been extremely varied. The objective, in most cases, on its original basis, was the separation of stibnite from the arsenopyrite and pyrite containing gold. At various times different methods were used. The flowsheet of the original plant was based on laboratory work done at Berkeley by Dr. L. H. Duschak. It involved use of clorox to depress gold while floating stibnite. In 1934, Fred Brinker discovered the applicability to the local ores of the process now known by his name, which is still used with variations. It is based on grinding in a strongly alkaline circuit with sodium hydroxide to depress the stibnite, simultaneously adding copper sulphate to activate the pyrite and arsenopyrite. Adding these reagents together in the ball mill formed the so-called blue gel, which may or may not have had anything to do with the separation. At any rate it is still used fundamentally. After floating the pyrite and arsenopyrite, lead acetate was used to reactivate the stibnite possibly by coating the surface with lead sulphide. Addition of large amounts of copper sulphate produces the same effect but not as efficiently as does the lead acetate.
>
> As to the present metallurgy, the pit ore varies in size up to pieces 3 ft. in longest dimension. It is hauled to the mill in 10-ton trucks and dumped onto a stockpile, from which point it is bulldozed into the crusher hopper by a small tractor [Figure 46]. This gives easy access to a large supply. From the hopper the ore is fed by a 48-in. apron feeder over a steel grizzly. Oversize of this goes to a 24x36-in. Blake-type crusher to be reduced to about 3½ in., the undersize joining the crusher product, which is sent to a No. 37 Kennedy crusher. This unit reduces it to about 1½ in. and delivers it to 3x6-ft. vibrating screens. Oversize goes to two 3-ft. Symons standard cone crushers and undersize to fine-ore bins. These bins have 1,900 tons' live capacity. The ore is discharged on to conveyor belts feeding four Hardinge ball mills, two 8 ft. by 48 in., one 8 ft. by 36 in., and one 7 ft. by 36 in. The rate of feed for the two largest units is 9½ to 10 tons per hour, for the 8 ft. by 36 in. mill 8½ tons, and for the smallest 7½ tons per hour.
>
> Sodium hydroxide, copper sulphate, and reagent No. 301 are added to the ball-mill feed [Figure 47]. Consumption per ton of ore treated is 1 lb., 0.3 lb., and 0.05 lb. respectively. The caustic serves a dual purpose: (1) it depresses stibnite, as mentioned; (2) it has a dispersing action on the pulp, thereby producing a finer ball-mill discharge and avoiding the possibility of sanding the classifiers.
>
> There are two Dorr duplex classifiers and two Wemco screw classifiers, all in closed circuit with the ball mills. The return load in the grinding circuit is about 500 percent of the original feed. The water used in the circuit is that employed for cooling in the diesel power plant. Classifier overflow temperature is about 50 deg. C. Use of hot water has been found to reduce reagent consumption considerably. Classifier overflow usually runs between 10 to 15 percent plus 100 mesh, the material of this size appearing to be mostly quartz grains from the granite. This product is pumped into a mixing tank and distributed as desired to either of two separate flotation circuits.
>
> First in the flotation line-up is the gold circuit consisting of eight 43-in. Denver cells. Save for the frother, which is duPont B-23 alcohol (0.07 lb. per ton), no additional reagents are added to this circuit. The rougher gold froth goes to two cleaners, to which

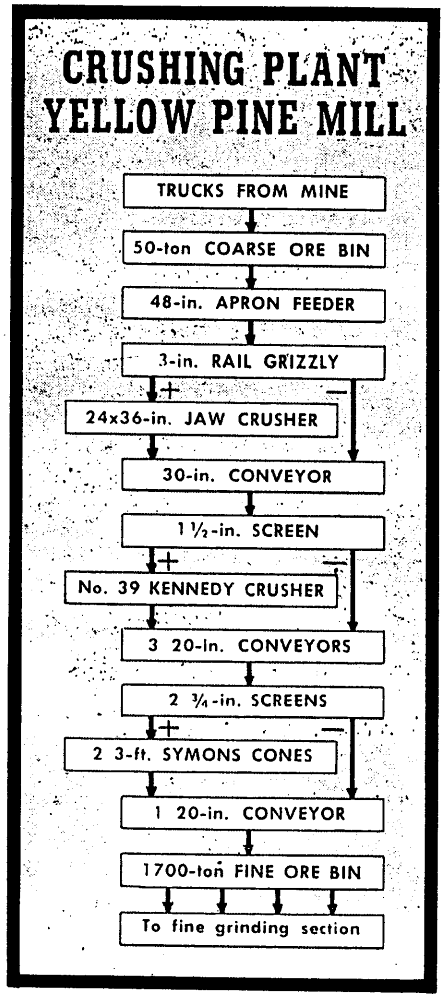

Figure 46. Flow chart for the crushing plant at the Yellow Pine mill. The use of a number of short stages was intended to minimize the slimes and aid in scheelite flotation (Bradley and others, 1943, p. 64).

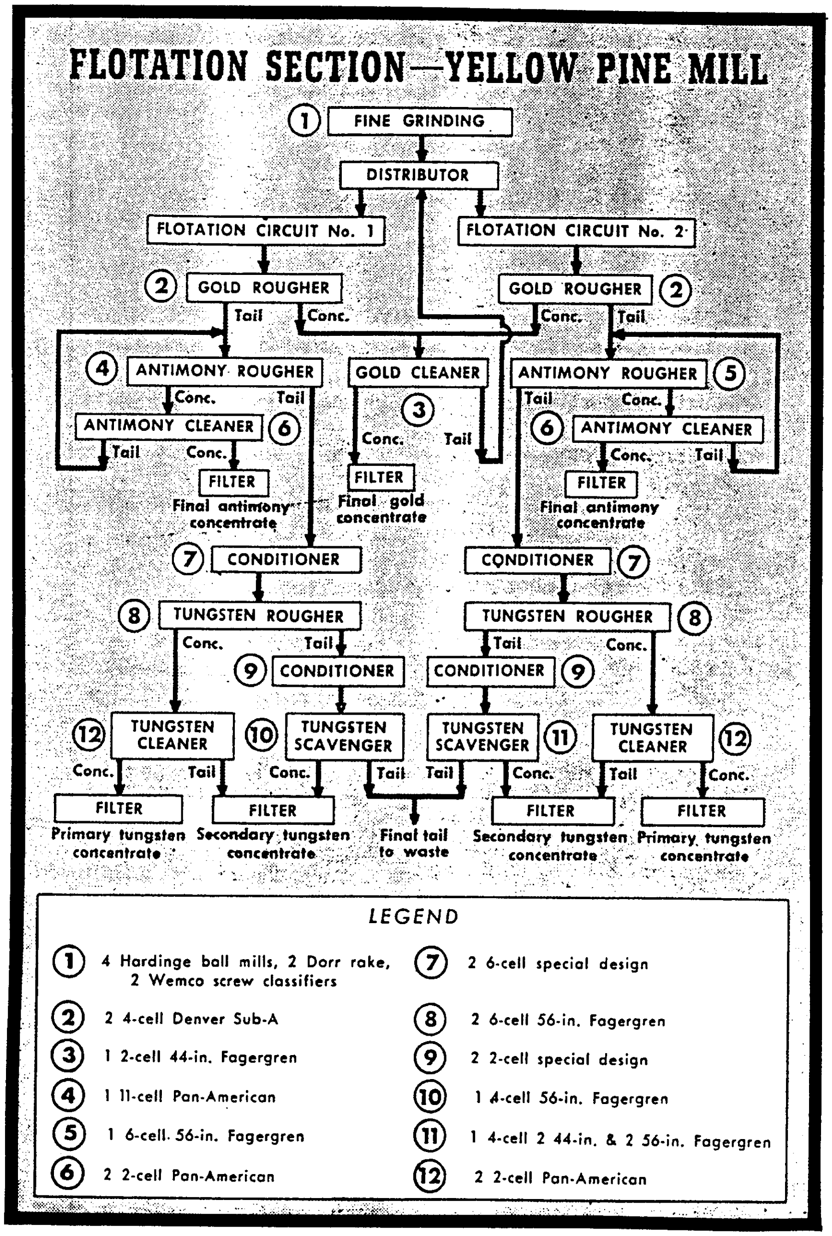

Figure 47. Flow chart of the flotation section of the Yellow Pine mill, showing how the gold, antimony, and tungsten concentrates were produced (Bradley and others, 1943, p. 65).

sodium hydroxide may or may not be added to depress the stibnite, depending in the grade of gold concentrate desired. The cleaner tails return to the head of the gold circuit. Amount of gold concentrate recovered is about 1 ton per 100 tons of feed. The amount of gold contained varies from 1.5 to 2.5 oz. per ton, the insoluble usually being up to 5 percent. The amount of silver in the concentrate depends entirely on the quantity of antimony, but in general is not more than 10 oz. per ton. Flotation time is 6 to 7 min.

Stibnite and Scheelite Floated

Gold tailings are pumped directly into the antimony circuit, which consists of nine 90-cu. ft. Pan-American flotation machines. Lead acetate is added at the head of the circuit, the amount depending on the amount of stibnite to be floated. The theory is that in an alkaline circuit a soluble antimony surface will be replaced by a relatively insoluble coating of galena. This reaction is easily seen and is one of the best examples imaginable of the effect of a surface coating. There can be little doubt as to what is taking place when one sees the reaction; nevertheless, there is some controversy about this. Similarly, though to a lesser extent, with copper sulphate.

Reagents used in the antimony circuit include reagent No. 301 (0.15 lb. per ton), and B-23 for the frother. The first four cells produce concentrates which run about 5 percent more in antimony than the cleaner concentrate from the remaining cells. The main operating factor in this circuit is to control the amount of lead acetate used, this varying proportionately to the amount of antimony floated. Likewise, more frother must be added. The cleaner tails return to the head of the antimony circuit. Flotation time is 20 to 25 min., and the amount of concentrate produced is about 7 tons per 100 tons of mill feed. Finished concentrate runs 50 to 55 percent antimony, 15 to 20 oz. silver, and 0.15 to 0.20 oz. gold.

Scheelite flotation is done in a very alkaline circuit. The pH after conditioning will run between 10 and 10.5. Conditioning for the scheelite circuit is done in a bank of 12 rectangular wood tanks made very much like flotation cells, with a sand bleeder on the bottom to effect complete circulation. Into the first two cells of the conditioner are added the reagents for controlling the alkalinity as well as those for depressing undesirable constituents. Soda ash and caustic, added in amounts of 5 lb. and 2 lb. per ton respectively, belong to the first category; the depressants used per ton are: quebracho, 0.15 lb.; and sodium silicate, 1 lb. The conditioning continues 5 to 7 min. To the third conditioner cell is added oleic acid at about 0.75 lb. per ton, and either Kemenol or Aerosol OT in the amount of 0.2 lb. per ton. After conditioning for another 12 min., the pulp is pumped to the first scheelite rougher. The scheelite circuit comprises a series of twelve 56-in. Fagergren flotation machines. Every other cell receives a small amount of Kemenol or Aerosol to maintain the froth. The froth from the first two cells will generally run upwards of 50 percent WO_3, and it is planned to send it direct to the concentrate thickener. However, at the moment the froth from all roughers goes to four Pan-American cleaners. In most cases, the grade of the scheelite concentrate can be readily maintained at any desired point by the judicious use of reagents, the main controlling factor being the amount of oleic acid used. The greater part of the scheelite in this concentrate is minus 200 mesh. Recovery in the first concentrate consists of most of the freed scheelite, and about 70 percent of the total WO_3 is contained in it.

A problem is thus presented in recovering the remaining scheelite. It is solved as follows: The tailings from No. 1 scheelite circuit go to a bank of two conditioners to which is added 1.5 lb. per ton of Perkins pine fatty acid oil. The conditioning time is 7 min. From the conditioners the pulp goes to a bank of eight Fagergren cells used as

scavengers. In the scavenger concentrate there are some large grains of free scheelite. However, most of the WO_3 in this product, which runs about 10 percent WO_3, is a middling. This product joins the cleaner tails, and the resulting low-grade concentrate, containing 20 to 25 percent of the total WO_3 recovered, is shipped for refining to the U. S. Vanadium Co., agents for Metals Reserve Co., in Salt Lake City.

Summing up the operation as a whole, we may say that there are two factors which control the whole flotation circuit—namely, alkalinity and a thoroughly dispersed pulp. Credit for the successful flotation of the scheelite in this ore must be given to L. H. Lange, of the Galigher Co., of Salt Lake City, Utah.

Figures 48 and 49 show the Meadow Creek mill in 1942 or early 1943.

Also in 1942, United Mercury Mines deeded the Meadow Creek and Yellow Pine properties to Bradley Mining Co. "on the terms of a perpetual gross royalty throughout the life of the property" (1942 IMIR). The option price for the property was $900,000. Bradley was also leasing the Midnight Group[52] of sixty claims from UMM.

The Yellow Pine open pit was operated continuously during 1943. The mine produced 178,747 tons of ore, which contained about 0.04 opt of gold, 1.16 opt of silver, 2.43[53] percent antimony, and 2.08 percent tungsten. About three-fifths of the ore came from open-pit operations. The property was the largest producer of antimony and tungsten in the country in 1943 and was the third largest producer of gold in Idaho[54]. The capacity of the mill was increased early in the year[55]. The company produced 3,382 tons of high-grade tungsten concentrate (47.60 percent WO_3), 12,940 tons of low-grade concentrate (11.57 percent WO_3), 8,027 tons of antimony-silver-gold concentrate, and 1,902 tons of gold-silver-antimony-iron concentrate. The low-grade tungsten concentrate was re-treated in Salt Lake City and yielded 1,847 tons of concentrate averaging 65 percent WO_3. The 9,930 tons of antimony concentrate contained 4,341 tons of antimony metal. The antimony concentrate averaged 50 percent antimony, 4.5 opt of silver, and 0.057 opt of gold.

[52]The exact location of this group is not certain, but it appears to have been near the drainage of Midnight Creek (Figure 2). It may include the claims labeled "Midway Group" in Figure 7, particularly since UMM did not include in the company's list of property even a single claim with the name "Midway".

[53]Calculated from published tonnages.

[54]Idaho's output of recoverable gold in 1943 was nearly 68 percent less than in 1942. This decrease was caused by War Production Board Limitation Order L-208, which closed all the gold mines in the country in October 1942. The Talache Mine (gold-silver-tungsten), the Triumph mine (lead-zinc-silver-gold), and the Yellow Pine Mine produced 81 percent of Idaho's gold output in 1943.

[55]According to the 1942 USBM Yearbook, the capacity of the mill was increased to 800 tpd early in 1943. However, the 1943 Yearbook rated the mill at 600 tpd, suggesting that the "800" may have been a mistake in reporting or a typographical error. Company reports place the capacity of the mill at 700 tpd during the first half of 1943.

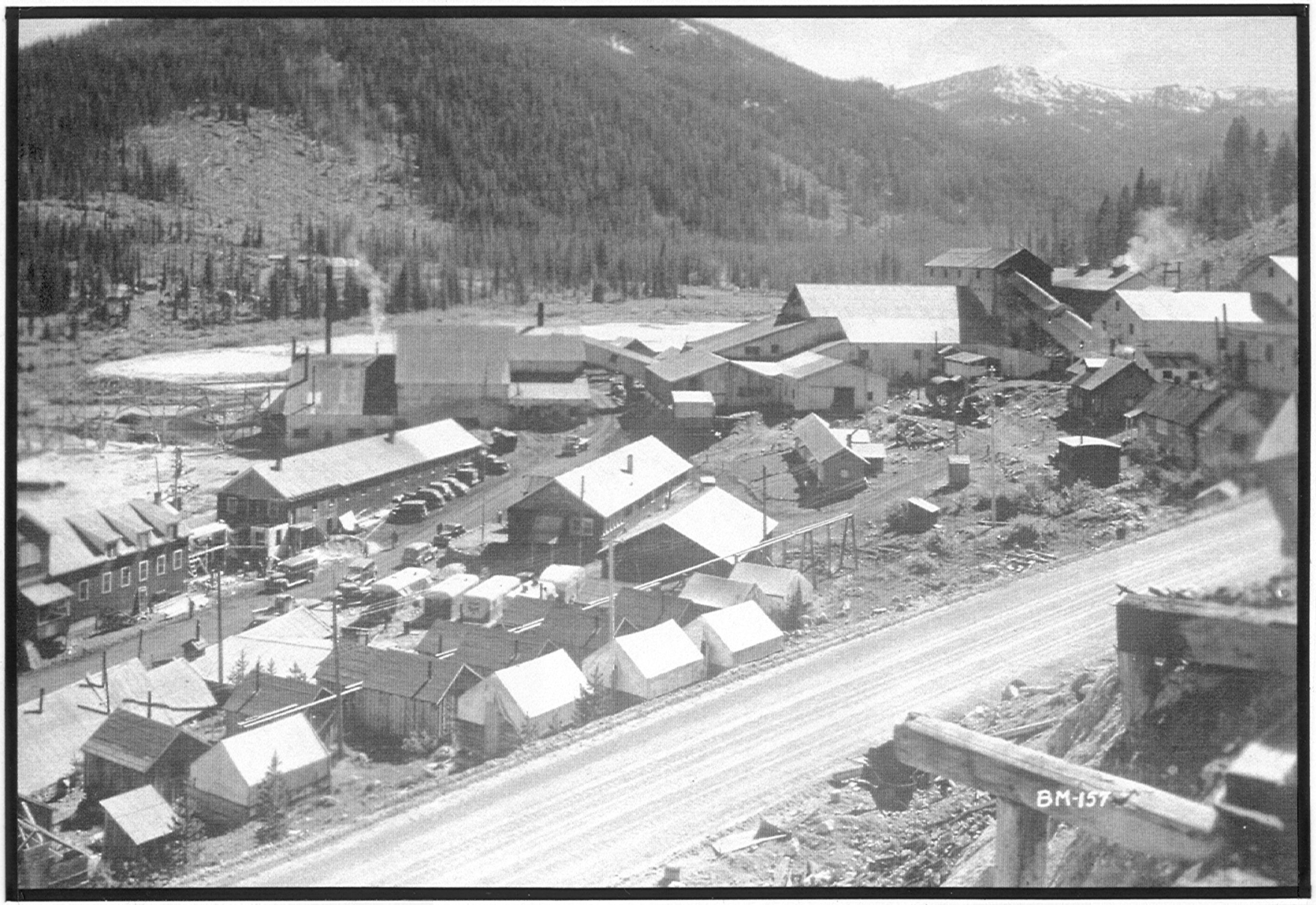

Figure 48. Stibnite in 1942. The large building in the left center of the photograph is the main mill, and the white area in the background behind the buildings is the tailings pond (Idaho Historical Society photograph).

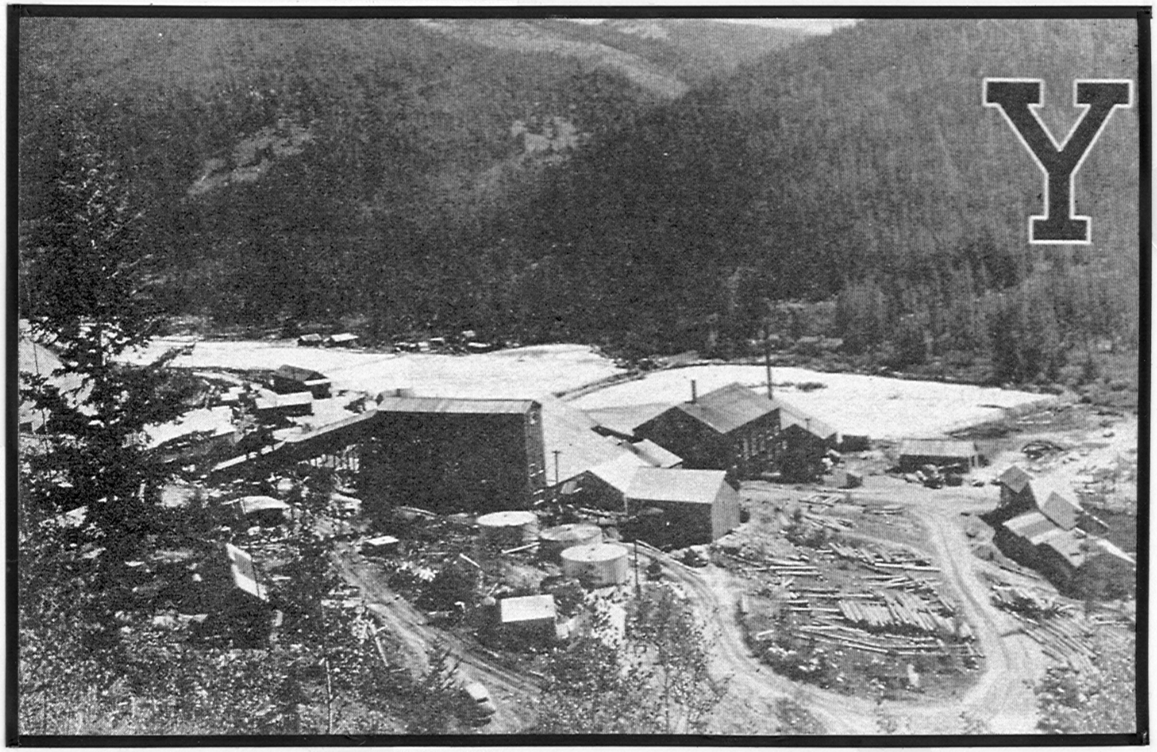

Figure 49. The Bradley Mining Co.'s mill and surface plant at Stibnite, with the tailings pond in the background (Bradley and others, 1943, p. 60).

A major event at the mine was the completion of the Bailey drainage tunnel on March 16, 1943. The two crews digging from each end met with a "perfect" connection (Hart, 1979). Between the spring of 1941 and early 1943, Bradley's payroll had grown from 100 to 650 men, and the population of Stibnite had grown from 400 to 1,500, which included the wives and children of the men. Many houses, a new and bigger school, and a hospital were constructed (Bradley and others, 1943). Power requirements for the mill made it necessary to supplement the company's hydroelectric plants with twelve diesel electric generators. In spite of this, the company still did not have enough power available. During 1943, Idaho Power Company ran a 106-mile power line, which carried 66,000 volts of electricity, to Stibnite. (The installation was scheduled for completion by November (Bailey, 1943), but was probably finished behind schedule, since Bailey (1978) said that it was completed in 1944. The project had a high priority because of the importance of Yellow Pine's tungsten and antimony for national defense (Clark, 1951).) When it was finished, Idaho Power's transmission line replaced fifteen diesel generators and three hydroelectric plants (Bailey, 1979) and saved 1.2 million gallons of fuel oil a year. With sufficient power now available, the company made plans to increase the size of its mill to 1,000 tpd. On June 1, 1943, Cooper (1951) estimated that the indicated reserves of the Yellow Pine Mine were 12 million tons of ore. Of this, 40,000 tons of metallic antimony was in ore that averaged more than 1 percent antimony; about half of that was in ore that ran more than 4 percent antimony. An additional 20,000 to 25,000 tons of antimony was estimated to be present in ore that averaged 0.25 to 1 percent antimony. Much of this ore contained 0.06 opt of gold. The mine also had an estimated 140,000 ounces of recoverable gold in antimonial ores that averaged more than 1 percent antimony, nearly 600,000 ounces of gold in indicated ore averaging between 0.1 and 0.2 ounce per ton of gold, and nearly 400,000 ounces of gold in ore averaging 0.05 to 0.1 opt of gold. The inferred reserves were estimated at 4 million tons of ore containing 5,000 to 8,000 tons of recoverable antimony and 390,00 ounces of recoverable gold. However, some of these reserves were mined after the reserve estimate were made (Cooper, 1951).

On February 1, 1943, antimony was reclassified from Group II to Group III of the Materials Substitutions and Supply List of strategic minerals[56]. The metal remained under government control during the year, but supplies increased due to imports from Bolivia and Mexico. Prices were lowered in June (from 16.05 cents per pound to 15.84 cents), reflecting a reduction in freight costs that was passed on to consumers. The U.S. production of antimony in 1943 was almost double that of the

[56]Group I was critical minerals of which supplies were inadequate to meet the existing demand; Group II was essential minerals of which the supplies were equal to the current demand; and Group III contained materials which were available in significant quantities and which were recommended as substitutes for critical materials.

previous year, and the Yellow Pine Mine accounted for 77 percent of the total production.

Tungsten prices remained stable during the year, with the Metals Reserve Co.'s buying price from "eligible" domestic producers remaining at $30 a unit. The average price for high-grade domestic concentrates was $25.07 a unit. In spite of record consumption, tungsten supplies greatly exceeded requirements in 1943, and the War Production Board discontinued allocation of tungsten ore and concentrates, and some tungsten products, at the end of the year. Acute labor shortages affected many mining regions, and the army again furloughed soldiers with mining experience to work as miners.

During 1944, the Yellow Pine Mine was again the leading producer of tungsten and antimony in the country and the largest producer of gold in Idaho. The mine produced 211,382 tons of gold-silver-iron-antimony-tungsten ore from its open pit mine. The ore averaged 1.42 percent WO_3 and yielded 3,573[57] tons of high-grade tungsten concentrate, 8,807[57] tons of low-grade tungsten concentrate, 6,975 tons of antimony-silver-gold concentrate, and 4,103 tons of gold-silver-antimony-iron concentrate. The low-grade tungsten concentrate was shipped to the re-treatment plant at Salt Lake City, to the United States Vanadium Corporation's plant near Bishop, California, or to the Bradley Mining Co.'s purification plant at Boise. The low-grade concentrate shipped to Salt Lake City yielded 588 tons of high-grade concentrate averaging 67.5 percent WO_3. The mine produced 91 percent of the antimony mined in the country during the year.

The capacity of the Yellow Pine mill was increased to 800[58] tpd during the year. During the spring, Bradley Mining Co. remodeled an old building in Boise and installed a leaching plant for purifying the low-grade concentrates from Stibnite. The leaching plant used muriatic acid to eliminate the apatite and calcite in the concentrates and caustic soda to remove the antimony. This treatment produced a product containing 70 percent WO_3, which was sold directly to steel plants.

The price of antimony remained stable at 15.84 cents per pound. Antimony was free of allocation control throughout 1944. However, by the end of the year decreased supplies (domestic production declined 20 percent and multiple factors caused a reduction in imports), coupled with increasing demand by the military for fire-retardant paints and flame-proof fabrics, pointed to the need to return to strict controls. Tungsten also remained free of allocation controls in 1944. Supplies greatly exceeded demand, with the result that the Metals Reduction Co. discontinued its premium price for domestic tungsten and suspended operation of the re-treatment

[57]The tungsten chapter of the 1944 Yearbook reported that the mine produced 3,428 tons of high-grade concentrate (53.60 percent WO_3) and 7,782 tons of low-grade concentrate (8.40 percent WO_3).

[58]According to the company, the capacity of the mine and mill was 1,200 tpd, and total capacity for four of the five ball mills was 700 tpd.

plant in Salt Lake City. Prices for domestic tungsten ore and concentrates trended downward during the year, with the average price being $23.36 per unit.

During 1945, Bradley Mining Co. produced gold-tungsten-antimony ore from the Yellow Pine Mine from January to July. During the next four months, the company treated tungsten tailings in its 800[59]-tpd flotation plant, but in December it resumed milling ore. During the year, the mill treated 109,796 tons of ore, which averaged 0.424 percent WO_3, and 47,359 tons of old tailings, averaging 0.755 percent WO_3. This material yielded 5,098 tons of low-grade tungsten concentrate, 138 tons of high-grade tungsten concentrate[60], 2,500 tons of antimony-silver-gold concentrate, and 2,308 tons of gold-silver-antimony-iron concentrate. The reduced output during 1945 was in part attributable to the lower grade of the ore. However, most mining areas showed decreases in production due to an acute labor shortage. Despite this, the mine was one of the largest producers of gold in Idaho, yielded most of the antimony mined in the United States, and was a major producer of tungsten.

Controls on antimony use were reimposed early in 1945. An amendment to War Production Board General Preference Order M-112, which again put strict allotment controls on antimony, went into effect on February 10. Any company possessing or using more than 2,240 pounds of antimony had to make monthly reports on its activities to the government. On March 14, General Preference Order M-122 was amended to extend controls to possessors or users of 224 pounds of antimony. These controls remained in effect for the rest of the year, and the ceiling price for antimony also remained at 15.84 cents per pound.

Domestic tungsten production, which had started to decline in May 1944, continued its downward trend through April 1945. In May, the Office of Metals Reserve (successor to the Reserve Metals Co.) reopened the Salt Lake City plant. The War Production Board issued an order on May 18 which limited purchases of high-tungsten tool steel. However, following the end of the fighting in Europe, tungsten supplies were again adequate to fill all needs, and the War Production Board revoked its order on July 3. Tungsten prices remained stable throughout the year, averaging $23.21 per unit of WO_3.

The known tungsten ore at the Yellow Pine Mine was virtually exhausted by the end of the year. (Figures 50 and 51 show the pit at the end of tungsten mining.) Between August 1941 and December 1945, the mine produced 611,284 tons of ore

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[59]The company stated that the capacity of the mill was 1,000 tpd.

[60]According to the tungsten chapter in the 1945 USBM Yearbook, the mill treated 109,796 tons of ore (0.424 percent WO_3), 45,359 tons of tailings (0.755 percent WO_3), and 3,290 tons of low-grade concentrate (6.322 percent WO_3). This material yielded 176 tons of high-grade concentrate (58.97 percent WO_3) and 5,551 tons of low-grade concentrate (9.97 percent WO_3). With additional treatment, the low-grade concentrate yielded an additional 768 tons of high-grade concentrate (68.5 percent WO_3).

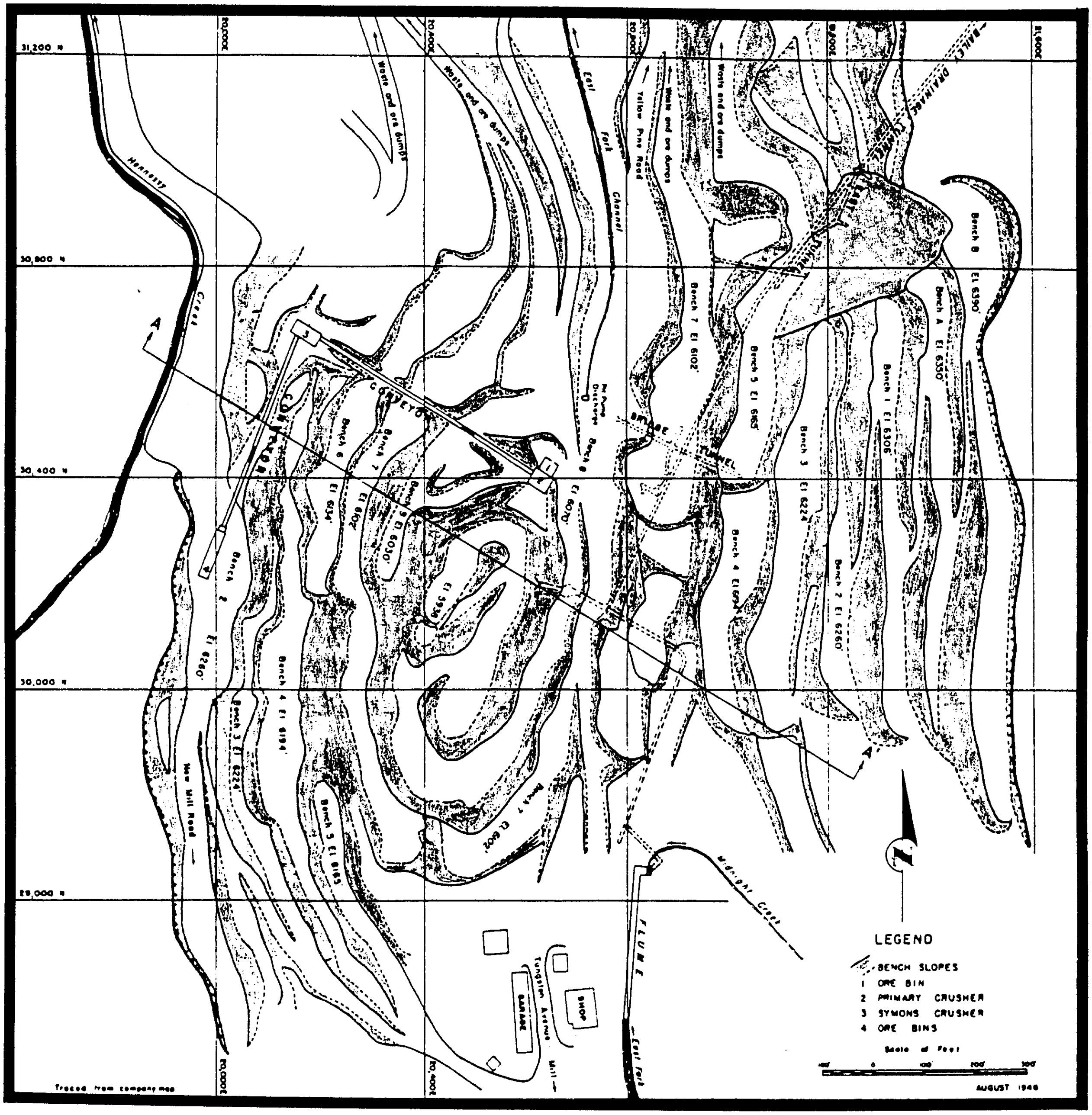

Figure 50. Plan of the open-pit workings at the Yellow Pine Mine in August 1946 (Cole and Bailey, 1948, Figure 4).

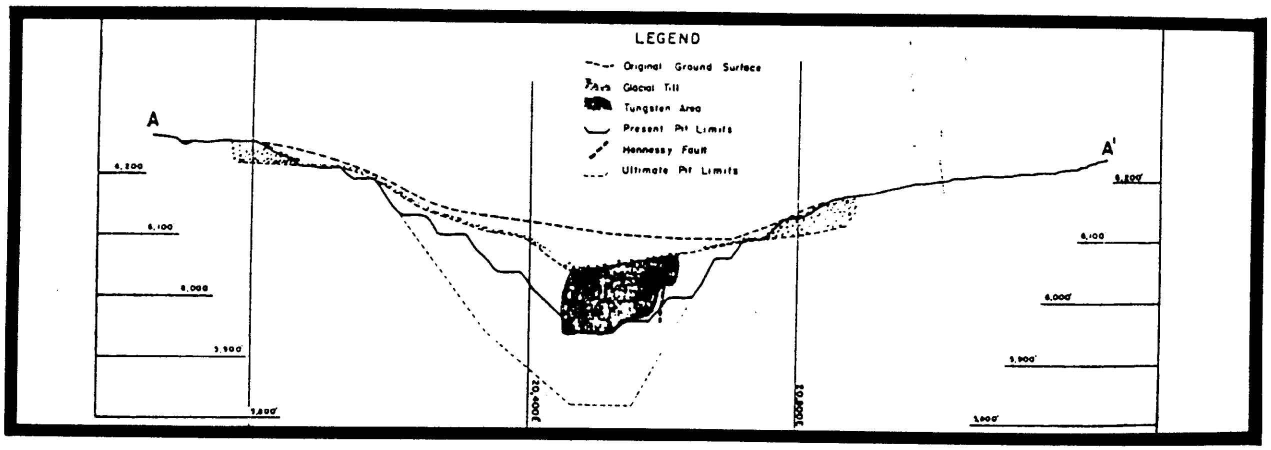

Figure 51. Longitudinal section through the Yellow Pine open pit in August 1946. The section is along line A-A′ in Figure 50 (Cole and Bailey, 1948, Figure 5).

averaging 1.645 percent WO_3. This ore yielded 10,373 tons of high-grade concentrate, which contained 503,915 units of WO_3, and 29,889 tons of low-grade concentrate, which contained 322,055 units of WO_3 (USBM). More tungsten came from Yellow Pine than from any other mine in the United States. At the close of tungsten mining, an estimated 2 million tons of ore was left in the pit. This ore contained 25,000 tons of antimony, 180,000 ounces of gold, and 1.4 million ounces of silver. Much of this ore was broken during the course of the tungsten mining and placed in stockpiles for later processing. Additional bodies of gold ore were also known to exist (Lorain, 1945).

During the early summer of 1945, Bradley installed a crushing plant in the open pit. Initially, the ore went through a 36x48 jaw crusher and then was carried by a 500-foot conveyor to a 5½-foot Symons cone crusher. From there, another 500-foot conveyor transported the ore to storage bins (Figure 52). From the bins, plans originally called for having the ore pumped 13,000 feet and up 360 feet to the mill; however, this idea was abandoned (Bailey, 1979). Later in the year, most of the grinding equipment, including an 8x6 Marcy ball mill and three 8x48 Hardinge ball mills, was moved from the mill to the new crushing plant, and a 9½x12 Marcy rod mill was added. The remodeling of the crusher and the mill was not completed until the following year (Huttl, 1952), and even then, it took until March 1947 to work out all the start-up problems (Bailey, 1979).

In 1945, the population of Stibnite was almost 600 (Bailey, 1979). The town had 160 homes (Hart, 1979), with over a hundred of them being relatively new. There was a four-room school house, a service station, a hospital with surgical facilities, and a general store. The large recreation hall had a bowling alley, a restaurant, and an auditorium that was used for weekly movies and for dances about once a month (Bailey, 1979). Most of the construction, both in the town and of the mine buildings, was done by Hubert Martin of Martin Construction Company. A great deal of the wartime construction was done with green lumber, and the buildings were put up on frozen ground. Few houses ever had concrete foundations, and most required blocking and leveling each spring (Hart, 1979).

The mill operated intermittently during 1946. Unlike most mining areas, Yellow Pine seemed relatively undisturbed by the labor shortage that was affecting the rest of Idaho; the number of men employed at the mine remained the same as the previous year. In addition to operating the mine, Bradley was also exploring for additional tungsten deposits. The mill treated 147,505 tons of ore, which contained an average of 0.10 opt of gold, 0.58 opt of silver, and 1.38 percent antimony. This material yielded 1,353 tons of gold concentrate and 5,488 tons of gold-antimony concentrate. Some of this ore was material that had been stockpiled during World War II (Bailey, 1979). In addition, 5,014 tons of old tungsten tailings were treated to produce 72 tons of tungsten concentrate. The mine was by far the largest producer of gold in Idaho, as well as the largest antimony producer in the country. The mill was

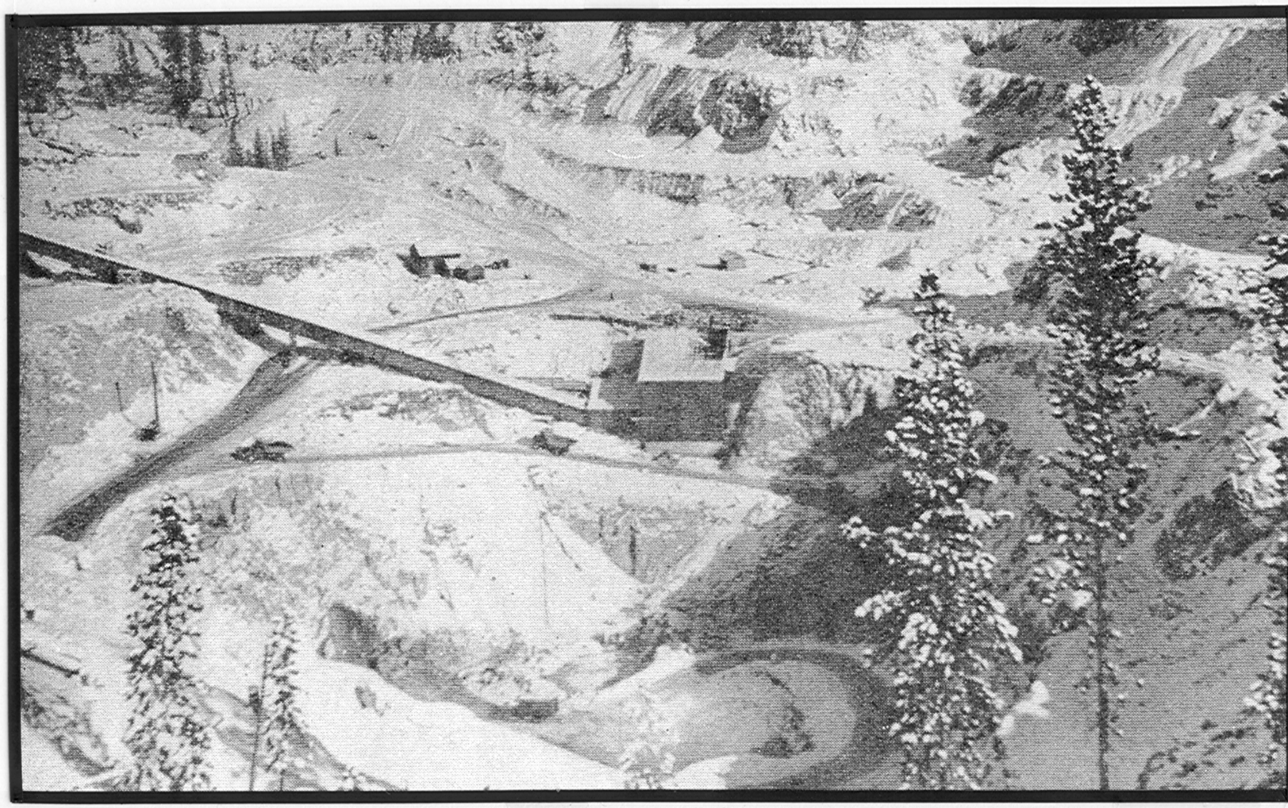

Figure 52. Yellow Pine Pit, with the new crushing plant and the conveyor, in 1946 or 1947 (McDowell, G.A., 1948, 49th Annual Report of the Mining Industry of the State of Idaho for the Year 1947, p. 61).

modernized and converted from tungsten processing to gold-silver-antimony milling. As a result, a completely new flow sheet was used when milling operations started in May. When a rod mill was added in October, mill capacity increased from 800 to 1,800 tpd[61]. Other additions to the mill expanded its capacity to 2,400[62] tpd by the end of the year. The 1946 IMIR (p. 130) contained the following article about the tailings pond at Stibnite:

> The Bradley Mining Company, at Stibnite, Idaho, employs 300 men and supports a community of over 700 people in the open pit mining and milling of gold, antimony and tungsten ores from its Meadow Creek mine, located on a tributary of the east fork of the south fork of the Salmon river in Valley county. This is the largest operation of its kind in the state.
>
> The operation involves the purification of the treatment water used in the milling operation. The company has been ponding mill slimes in an effort to prevent unnecessary sedimentation and turbidity of the stream into which the water is discharged, but the operation had reach[ed] a point in volume whereby the present ponding is ineffective. Consequently, the company is building a new settling basin which includes the construction of a reservoir nearly a mile in length and approximately 1400 feet across at the widest point. The storage capacity of this huge settling tank will be about 12 million tons of mill tails.
>
> It is necessary to dig a mile of canal to divert the water of Meadow creek around the settling basin and to construct a secondary settling basin to complete clarification of the mill waters before discharge into the stream.

On November 9, the Office of Price Administration finally lifted the ceiling of 15.84 cents per pound on antimony. Prices immediately jumped to 23.50 cents per pound, and rose again to 28.25 cents per pound in December. Other wartime restrictions on antimony remained in place throughout 1946. Also during the year, Bradley dismantled and sold its tungsten purification plant in Boise.

Bradley operated the open-pit mine and the mill continuously in 1947. During the year, the mill treated 584,483 tons of ore (four times the amount of ore mined the previous year) containing 0.076 opt of gold, 0.555 opt of silver, 1.146 percent antimony, and some iron. The mine produced more than 94 percent of the lode gold mined in Idaho during the year. The Yellow Pine Mine also produced 97 percent of the antimony mined in the United States in 1947[63]. During the early part of the year, the company produced a high-grade antimony concentrate that was low in gold and

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[61]This numbers are from the U.S. Bureau of Mines. Company reports state that the mill capacity increased from 1,000 tpd to 2,000 tpd, and that the rod mill was purchased before May 1946.

[62]Bradley Mining Co. reports gave the capacity as 2,500 tpd.

[63]This information is from the Antimony chapter of the 1947 USBM Yearbook. An article from the Idaho Daily Statesman (quoted in the 1947 IMIR) listed the Sunshine Mining Company and the Mineral Point Mine in Shoshone County. The Idaho chapter of the 1947 Yearbook reports antimony production from the Mineral Point Mine, but not from the Sunshine.

silver and a low-grade antimony concentrate that was high in gold and silver. Later in the year, the company switched to producing three concentrates: a high-grade antimony concentrate, a medium-grade antimony concentrate, and a gold concentrate that contained as little antimony as possible.

The average price of antimony rose to 33.45 cents per pound, almost double the 1946 average price. Antimony remained under government allocation control, according to the provisions of War Production Board General Preference Order M-122, throughout 1947. However, in early September the order was modified to dispense with the requirement to apply for permission to ship antimony, and purchasers were no longer required to name their suppliers. All other restrictions remained in effect.

The mine operated all year during 1948. The mill treated 655,682 tons of ore containing 0.075 opt of gold, 0.485 opt of silver, and 1.211 percent antimony. The antimony concentrate and gold concentrate together contained 27,158 ounces of gold, 236,031 ounces of silver, and 12,678,776 pounds of antimony. Forty-six percent of the gold produced in the state (and 97 percent of the lode gold) came from the mine, again making it the largest gold producer in Idaho. The company also produced 93 percent of the antimony mined in the country during 1947. The mine produced 6,004 tons of antimony, which was contained in high-, medium-, and low-grade concentrates; the antimony was not recovered from the gold concentrate. In May, the company began construction of an antimony smelter at Stibnite (Figure 53). This construction required building new housing for the construction crews and additional employees (Hart, 1979). A news article from the *Kellogg News Wardner* describing the project was reprinted in the 1948 IMIR (p. 42):

> Details of the new million dollar antimony-gold smelter to be built at Stibnite, Idaho, have been released by officials of the Bradley Mining company.
>
> Western Knapp Engineering company of San Francisco will build the smelter. This firm is also rebuilding the Bradley company's Ima mine concentrator which was destroyed by fire in 1947.
>
> The smelter is being designed with sufficient capacity so that it may treat on a custom basis antimony ores or concentrates produced in the northwest.
>
> The principal units involved in the smelter and the general flow scheme are as follows:
>
> Twenty-two-foot multiple hearth roasters will be used in calcining the concentrates. The oxide from the roasting operation will be cooled and collected in bag house units and returned along with the oxides from the electric furnace, which has been similarly cooled and collected, to the reduction furnace with the calcine. A 2,000 kva Pittsburgh electromelt reduction furnace will be used for reduction of the calcine. Slag from this furnace will be granulated and then pumped to storage sites. The crude antimony bullion from the reduction furnace containing the gold and silver will be sent to two refining furnaces for arsenic and iron removal.
>
> The refined antimony bullion still containing the gold and silver will be transferred to two butane-fired converters where the antimony will be blown by air, thereby producing antimony oxide to be collected in the bag houses. The precious metals

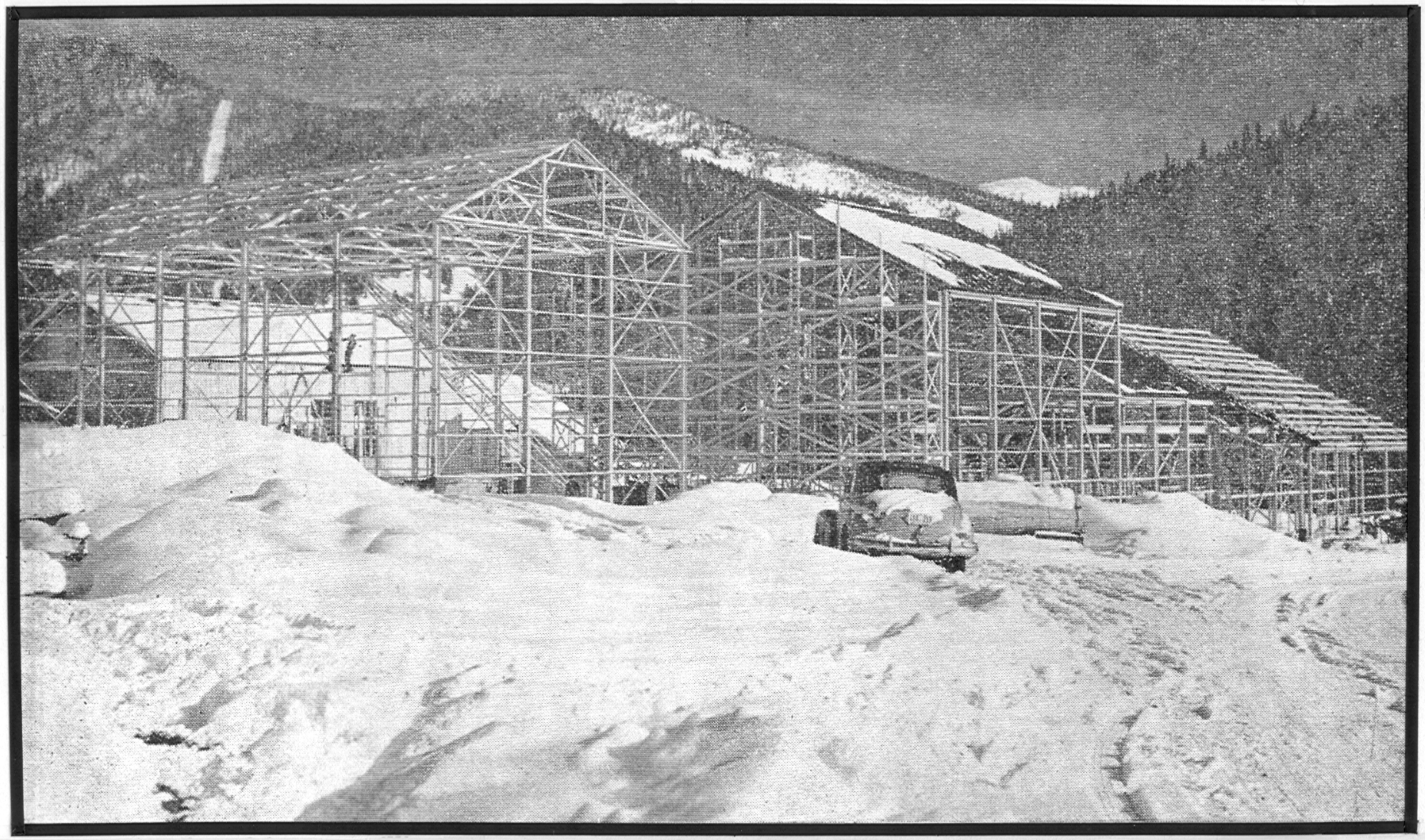


Figure 53. Initial stages of construction of the Bradley Mining Co.'s Yellow Pine antimony smelter during the winter of 1948-1949 (McDowell, G.A., 1949, 50th Annual Report of the Mining Industry of the State of Idaho for the Year 1948, p. 43).

(gold and silver) remaining in the converters as a residue will be further refined to gold and silver bullion. The antimony oxide will be sold as such or reduced back to pure antimony metal and sold as metal, depending upon the market demand for such products.

The foregoing smelter scheme is the only one of its type in the world and is an improvement over smelting practice that has been employed by other smelters on the Yellow Pine concentrates, particular in the recovery of gold and silver. In addition to being a progressive metallurgical step, the smelter will upgrade a large tonnage of otherwise non-commercial ore at the Yellow Pine mine and in addition it should stimulate antimony mining development in that district and in the northwest.

Worthen Bradley, president of Bradley Mining company said:

"We are taking this step because of our belief in the future of antimony as an industrial metal, and because of our faith in the mining area tributary to Stibnite. It is expected that the smelter will have an annual production of 5,000 to 6,000 tons of antimony."

Huttl (1952, p. 74) expanded on Bradley's reasons for constructing the smelter:

Principal factors which influenced Bradley's decision to build a smelter were these:

1) There was a limited market for antimony concentrates even during periods of high metal prices.

2) Existing smelters had difficulty in recovering Yellow Pine's metal values from the complex concentrates.

3) Transportation of concentrates was very costly.

Antimony prices continued to rise during 1948, although not as rapidly as in the preceding two years. The average price for the year was 36.67 cents per pound. The government allocation of antimony under War Production Board General Preference Order M-112 continued throughout the year, although minor changes were made in the export regulations. In December, the order was revised by the Department of Commerce and redesignated Allocation Order M-112. It was finally revoked on March 25, 1949.

Bradley Mining Co. operated its Yellow Pine Mine and 2,000-tpd flotation mill throughout 1949. The mill treated 610,988 tons of ore, which contained 0.112 opt of gold, 0.209 opt of silver, and 0.344 percent antimony. The ore yielded 4,558 tons of antimony concentrate and 20,404 tons of gold concentrate; together these contained 53,576 ounces of gold, 92,439 ounces of silver, and 3,163,735 pounds of antimony. The gold production was nearly double that of 1948 because the gold content of the ore was higher, but the silver and antimony production was much less. The mine produced 69 percent of Idaho's total gold output (and 98 percent of the lode gold). Although still the principal antimony producer in the country, Bradley quit mining ore on April 1. In part, this was because the crushing plant at the mine burned down in March; the mill was kept operating on stockpiled ore while the crushing plant was rebuilt (Bailey, 1979). A recession and resistance to high antimony prices caused antimony prices to drop sharply toward the end of the year, although the average price for 1949 was still 38.73 cents per pound.

Despite heavy snowfall and snow slides that closed the roads into the area in February (Bailey, 1979), Bradley finished construction on its smelter in July 1949 (Figures 54 and 55). The construction cost was approximately $2.5 million (Mining World, 1951). The roasting units were started on July 18 and the electric furnace on August 1. At first, the furnace and accessory equipment did not work well and had to be rebuilt (Bailey, 1979). The difficulties caused by arsenic in the ore were not finally solved until 1951 (Huttl, 1952).

About the construction of the smelter, Mining World (1951, p. 31) noted:

> In the construction of the new smelter, these important jobs are worthy of special note:
>
> Western-Knapp Engineering Division of Western Machinery Company, San Francisco, California, was general contractor and prepared general- and detail-design plans for that phase of the work. Wemco, Western's parent company, furnished large items of equipment, including the seven cupel-type reverberatory furnaces.
>
> Pacific Foundry Company, Ltd., Oakland, California, supplied the two large roaster units.
>
> Independent Iron Works, Oakland, California, fabricated the all-steel smelter, roaster, and baghouse buildings, and the outside reagent-storage bins.
>
> Pittsburgh Lectromelt Furnace Corporation, Pittsburgh, Pennsylvania, supplied the 2,000-kva electric reduction furnace.

The mine and mill operated all year in 1950. The mine produced 620,800 tons of ore. The antimony and gold concentrates obtained from the ore contained 48,472 ounces of gold, 137,073 ounces of silver, and 5,926,279 pounds of antimony. Tungsten was produced primarily by reprocessing tailings, although some scheelite was recovered from the antimony-gold ore. The Yellow Pine Mine accounted for 61 percent of the gold and 98 percent of the lode gold produced in Idaho during 1950. The mine was also the principal producer of antimony in the U.S. The smelter was run intermittently during the year while the metallurgical problems were worked out. Plant additions and improvements were expected to raise the smelter's 1951 output to over 3,500 tons of antimony oxide. Antimony prices continued to fall during 1950, with the average for the year being 29.41 cents per pound.

The company mined 620,733 tons of gold-antimony ore in 1951. From this ore, the mill produced 14,394 tons of gold concentrate containing 19,605 ounces of gold and 141,044 ounces of silver. This was 60 percent less gold and 3 percent more silver than in the previous year. In spite of this, the Yellow Pine Mine produced 44 percent of the total gold mined in Idaho during 1951 and was the largest gold mine in the state. The mine was the largest antimony producer in the country. The mill's 8,120 tons of antimony concentrate contained 2,851 tons of antimony. The company attributed the decline in metals production to conditions in the pit that made it difficult to mine the ore in an economic manner; this resulted in wide variations in the mill feed and poor recovery of the metals.

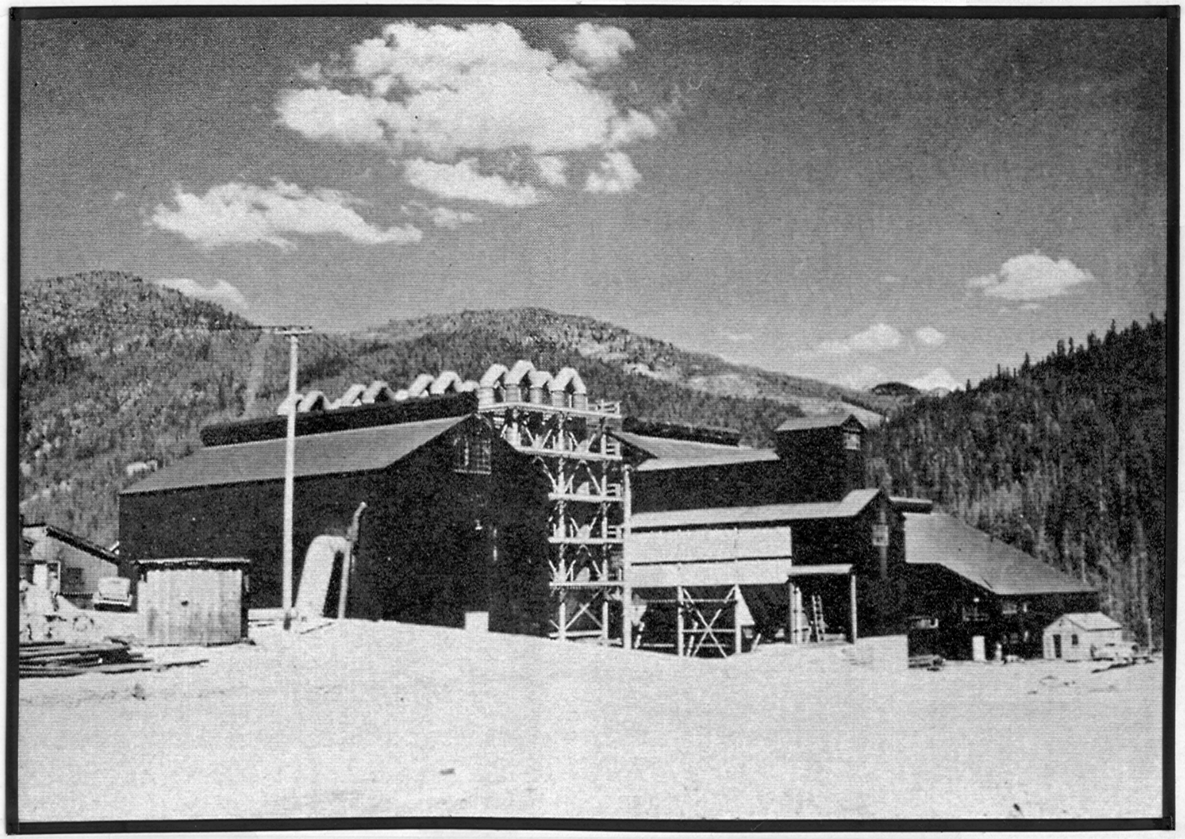


Figure 54. The Yellow Pine antimony smelter, probably in 1949 or 1950. From left to right are the bag house, cooling towers, reagent storage bins, and the main smelter building. The small building to the right is the superintendent's office (Mining World, 1951, p. 30).

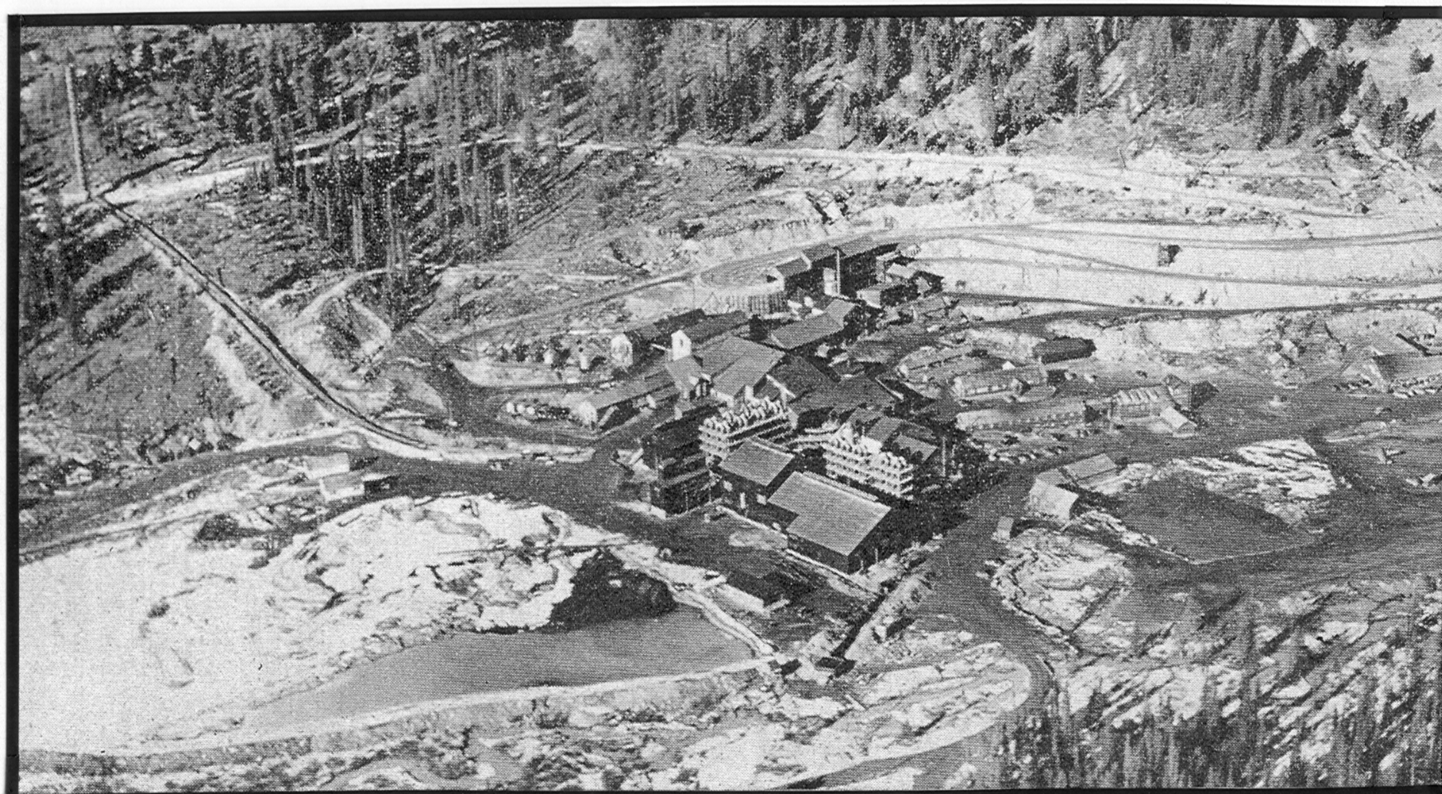


Figure 55. Overview of the Yellow Pine antimony smelter, with the mill behind it and the Meadow Creek dump in the background on the right. Note the size of the tailings area to the left and the meandering course of Meadow Creek in the extreme foreground (McDowell, G.A., 1953, 54th Annual Report, Mining Industry of Idaho for 1952, p. 145).

With the start of the Korean War and the accompanying $50 per unit price support for tungsten, Bradley increased its efforts to locate more tungsten ore (Bailey, 1979). The crusher in the pit was moved, allowing the company to mine the remnant of the tungsten orebody that was beneath it (Mining World, 1951). During 1951 Bradley set up a 1,000-yards-per-day placer plant (Figure 56) to recover tungsten from the glacial till near the mouth of the Yellow Pine pit (Huttl, 1952). The operation was described by Huttl (1952, p. 72-73):

> Placer tungsten ore occurs in an old river bed about 20-ft. thick. It is mined by shovel and trucked to a stockpile near the new gravity plant. A dragline removes ore from the stockpile at the rate of 1,000 tons a day, and feeds it onto a 4-in. steel grizzly over a 30-ton storage bin. Oversize goes to waste. Undersize falls into the bin and is fed by a pan feeder to a 30-in. conveyor belt which delivers it to two 3x14-ft. washing trommels.
>
> Trommel oversize (minus-4-in., plus-⅜-in.) goes to a picking belt which passes through a darkroom. There, under two 10-in. ultraviolet lights, workmen select a product containing about 30% WO_3, and sack it for sale. Rock remaining on the belt goes to waste.
>
> Undersize from the trommels (minus-⅜-in.) goes to four 42x42-in. Pan-American rougher jigs in series. They make three products—a high-grade bed concentrate, a hutch concentrate, and a tailing.
>
> Rougher-jig bed concentrates, assaying about 60%-plus WO_3, go to the magnetic separator and sacking plant at the concentrator.
>
> Rougher hutch concentrates are retreated in a 12x18-in. Denver duplex cleaner jig operating in closed circuit with the roughers. The product from the first hutch of the cleaner jig, assaying 8-16% WO_3, is stored in barrels pending magnetic separation.
>
> Product of the cleaner jig's second hutch goes to a 4x8-ft. concentrating table, which produces a high-grade concentrate of 15-25% WO_3, and a low-grade concentrate of 3-6% WO_3.
>
> Tailing from the rougher jigs passes over a ⅛-in. screen and the undersize then goes to four 2x12-ft. corduroy tables which produce an 11% concentrate. Screen oversize and table tailing go to waste.
>
> The magnetic separator produces several high-grade concentrates for shipment and sale: Rougher jig-bed concentrates are upgraded from 60% WO_3 to 70%. The high-grade table concentrate goes from 15-25% to about 50%. And the product from the first hutch of the cleaner jig, from 8-16% to 45%.
>
> The lower grade products are shipped to a chemical processing plant in California.

In 1951 government controls were again imposed on antimony. National Production Authority Order M-39 (effective February 16) limited consumers to 60-day inventories of antimony and materials containing antimony. Also, anyone who handled[64] 2,000 pounds of antimony, either as metal or contained in other products,

---

[64]The order covered anyone who, in the words of the USBM, "produced, consumed, imported, shipped, or received" 2,000 (or more) pounds of antimony; reports were also required of anyone who had that much antimony "in his possession or under his control."

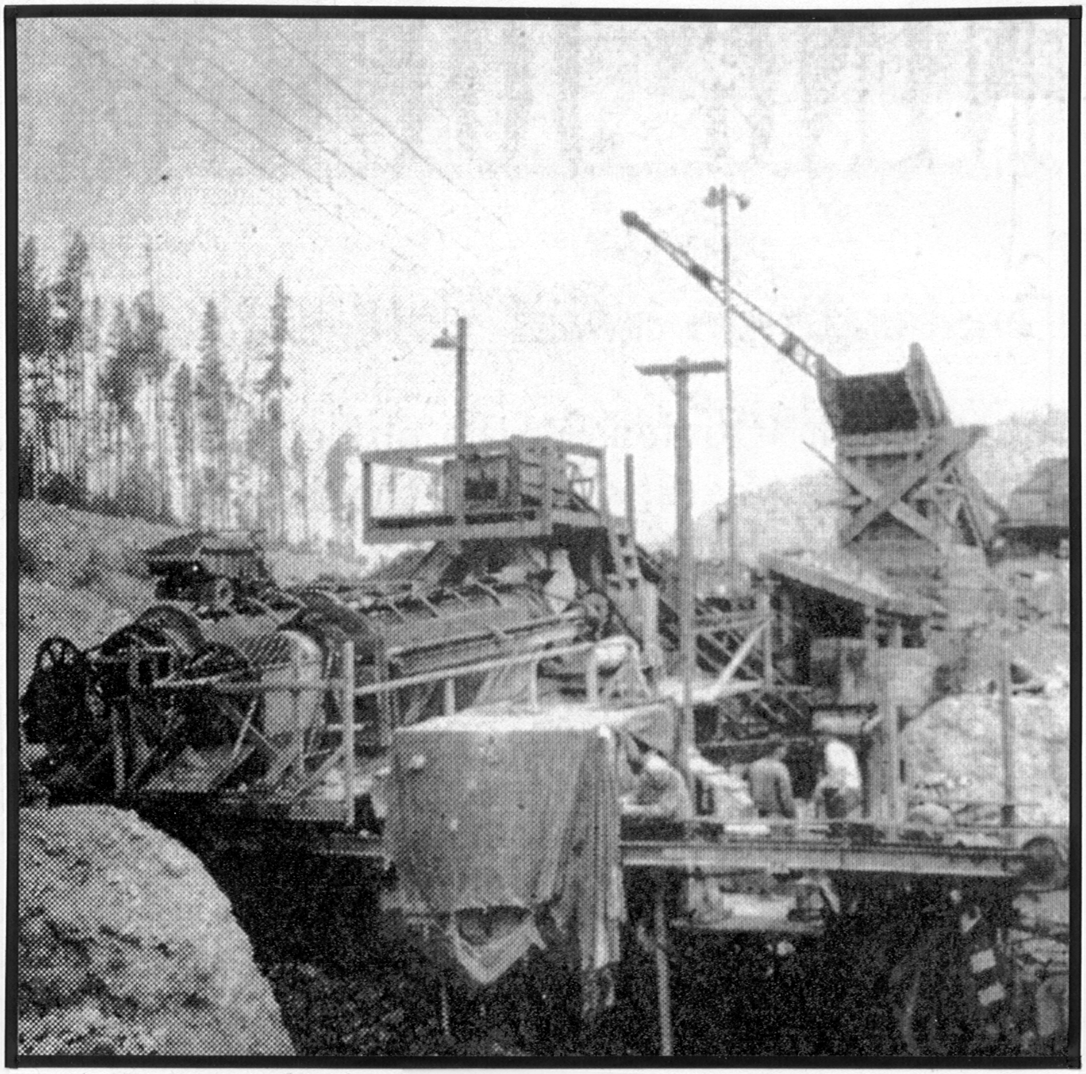


Figure 56. Tungsten placer operation near the mouth of the Yellow Pine Pit in 1951 (Huttl, 1952, p. 72).

was required to file monthly reports with the government. Prices ranged between 32 and 50 cents a pound during the year, with the average being 44.17 cents per pound. On November 21, the Office of Price Stabilization placed a ceiling on antimony prices. The ceiling prices for antimony metal ranged between 49.5 and 50.5 cents per pound, depending on the grade, and the ceiling price for antimony oxide (the principal product of the Yellow Pine Smelter) was 48 cents per pound. On December 13, the sale of domestic antimony ore and concentrates was exempted from price control.

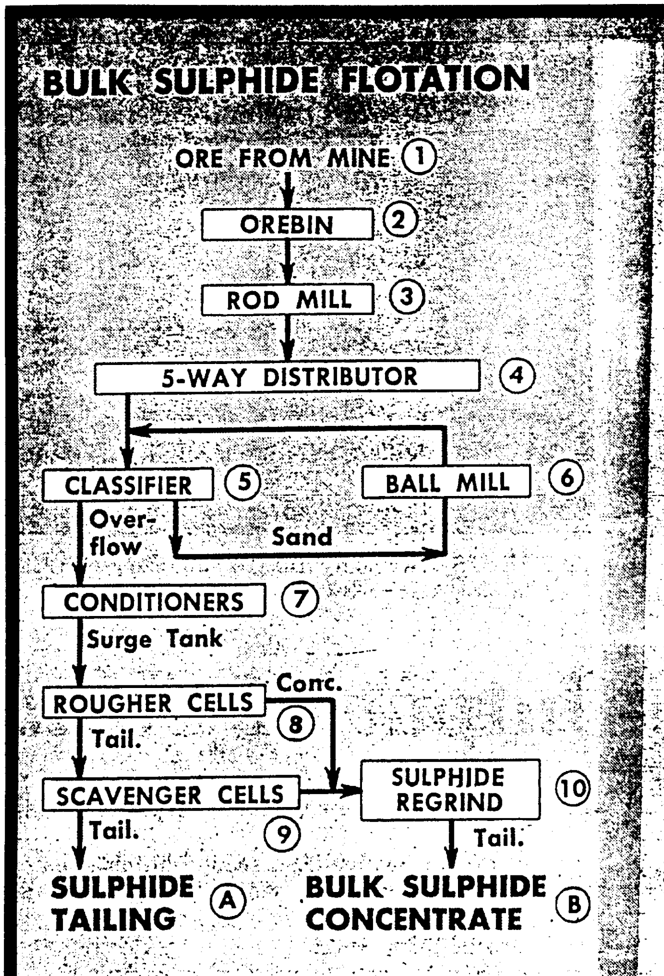
Huttl (1952, p. 74) described the operation of the mill and smelter:

> Since milling operations started in 1931 (at 150 tons daily) the plant has changed several times. A few of the influencing factors were change from underground to open pit mining, discovery of tungsten ore, and changing demand for gold, antimony, and tungsten.
>
> In the past, successful flotation of Yellow Pine ores was complicated by varying degrees of oxidation. As the pit became deeper, the ore became less oxidized and easier to treat. Recoveries improved.
>
> The present 2,400-ton concentrator is the result of a remodeling job completed in 1946. [Figures 57, 58, and 59 show the flow sheets for the mill.]
>
> Bulk-sulphide flotation is rather difficult because a compromise pH range must be used. Pyrite and arsenopyrite float best at a pH of 9.5, and stibnite at 6.8. A compromise of 8.4 gives good recovery of both in a bulk concentrate.

The mill produced about 900 tons of gold concentrate and 1,100 tons of antimony concentrate each month. On average, the gold concentrate contained 2.5 opt of gold, 3 opt of silver, 4 percent antimony, 9 percent arsenic, and 35 percent sulphur. The antimony concentrate averaged 0.6 opt of gold, 17 opt of silver, 46 percent antimony, 1.8 percent arsenic, and 22 percent sulphur (Mining World, 1951).

Huttl (1952, p. 74-77) described the operation of the smelter as follows:

> Briefly, the smelter operation starts with antimony and gold concentrates from the mill [Figure 60].
>
> Roasting oxidizes the concentrates and reduces sulphur and arsenic content.
>
> Blending prepares the charge for the electric furnace.
>
> Electric smelting reduces antimony, copper, lead, gold, and silver to metals.
>
> Refining removes the iron and arsenic.
>
> Converting oxidizes the refined antimony, producing two products: Antimony oxide and a residue which contains the other base and precious metals.
>
> ROASTING
>
> **Gold concentrate** is fed to an eight-hearth 21½-ft. Herreshoff roaster at a rate of 1.3 tons per hour. Because it is self-roasting, the only fire is a small oil burner on hearth 8. Temperatures range from 700 deg. F. on hearth 1, to 1,350 deg. F. on hearth 7. Highly acid gas comes from hearths 1 to 4 at 750 deg. F., passes through a hot cyclone, then to pipe cooling towers 75-ft. high, and is filtered in a Nor-Blo automatic baghouse.



LEGEND

BULK SULPHIDE FLOTATION

1. About 2,500 daily tons ore from mine crusher plant; minus 1½-in.; 1.0% antimony; 0.08 oz. gold; 1 oz. silver; up to 0.20% tungstic oxide.
2. 3,000-ton truck bin.
3. 9½ x 12′ Marcy rod mill. Product: 96% minus 10 mesh. Rod consumption: 1.25 lb. per ton.
4. 5-way distributor.

5&6. Five ball mill-classifier circuits. Product: 97% minus 48 mesh. Ball consumption: 1.85 lb. per ton.
8′ x 6′ Marcy — 72″ screw
8′ x 48″ Hardinge — 60″ screw
8′ x 48″ Hardinge — 60″ screw
8′ x 48″ Hardinge — 60″ screw
8′ x 36″ Hardinge — 72″ Dorr Duplex

7. Three 8 x 8′ conditioners.
8. Two parallel banks rougher flot. cells.
First bank: 2 @ 48″ Agitair, then 8 @ 56″ Fagergren.
Second bank: 2 @ 48″Agitair, then 12 @ 56″ Fagergren.
9. Scavenger flotation: 2 @ 48″ Agitair, then 12 @ 56″ Fagergren.
10. Sulphide regrind circuit. Product: minus 200 mesh
5 x 8″ ball mill — 72″ Dorr Duplex

REAGENT FEED: 0.7 lb. soda ash and 0.5 lb. caustic soda for pH control; 0.20 to 0.25 lb. Z-11 as collector; 0.4 to 0.75 lb. lead acetate to activate stibnite; 0.25 to 0.4 lb. copper sulphate to activate pyrite and arsenopyrite.

pH: 8.4

Figure 57. Flow sheet for the bulk flotation circuit at the Yellow Pine mill in 1951. Processing of the tailings from this circuit (marked "A") is shown in Figure 58; processing of the bulk sulfide concentrate (marked "B") is shown on Figure 59 (Huttl, 1952, p. 74).

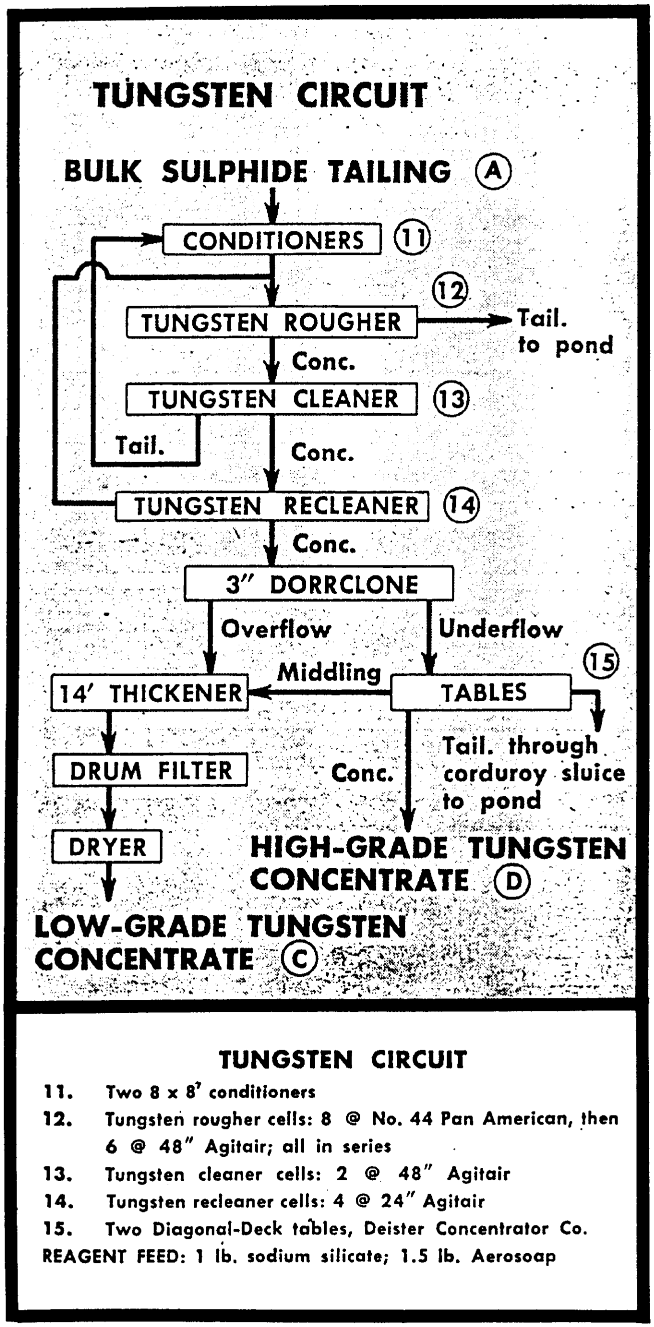
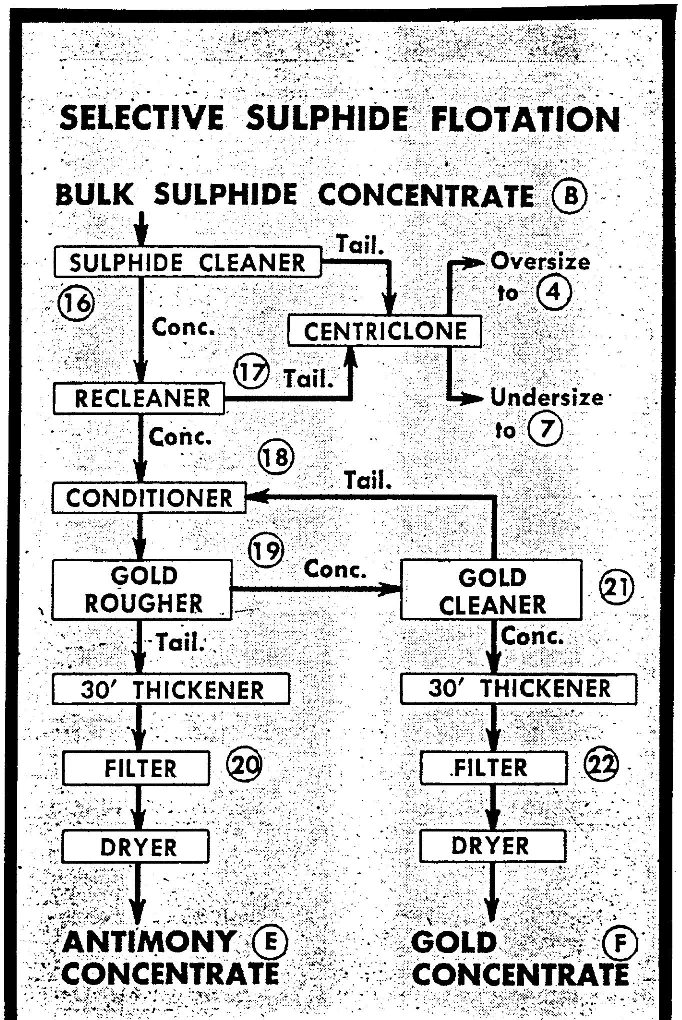


Figure 58. Flow sheet for the tungsten flotation circuit of the Yellow Pine mill in 1951 (Huttl, 1952, p. 75).



SELECTIVE SULPHIDE FLOTATION

16. Sulphide cleaner: 4 No. 24 "Sub-A"
17. Sulphide recleaner: 4 No. 24 "Sub-A"
18. Two 8 x 8′ conditioners
19. Gold rougher: 5 @ No. 44 Pan American
20. 5 x 8′ drum filter.
21. Gold cleaner: 4 @ No. 44 Pan American
22. 5 x 6′ drum filter.

REAGENTS: copper sulphate, caustic soda

ANTIMONY CONCENTRATE	GOLD CONCENTRATE
900 tons per month	1,100 tons per month
Gold, 2.50 oz.	Gold, 0.60 oz.
Silver, 3.0 oz.	Silver, 17.0 oz.
Antimony, 4%	Antimony, 46%
Arsenic, 9%	Arsenic, 1.8%
Sulphur, 35%	Sulphur, 22%

Figure 59. Selective sulfide flotation circuit at the Yellow Pine mill in 1951. The final products of this circuit are the gold and antimony concentrates (Huttl, 1952, p. 75).

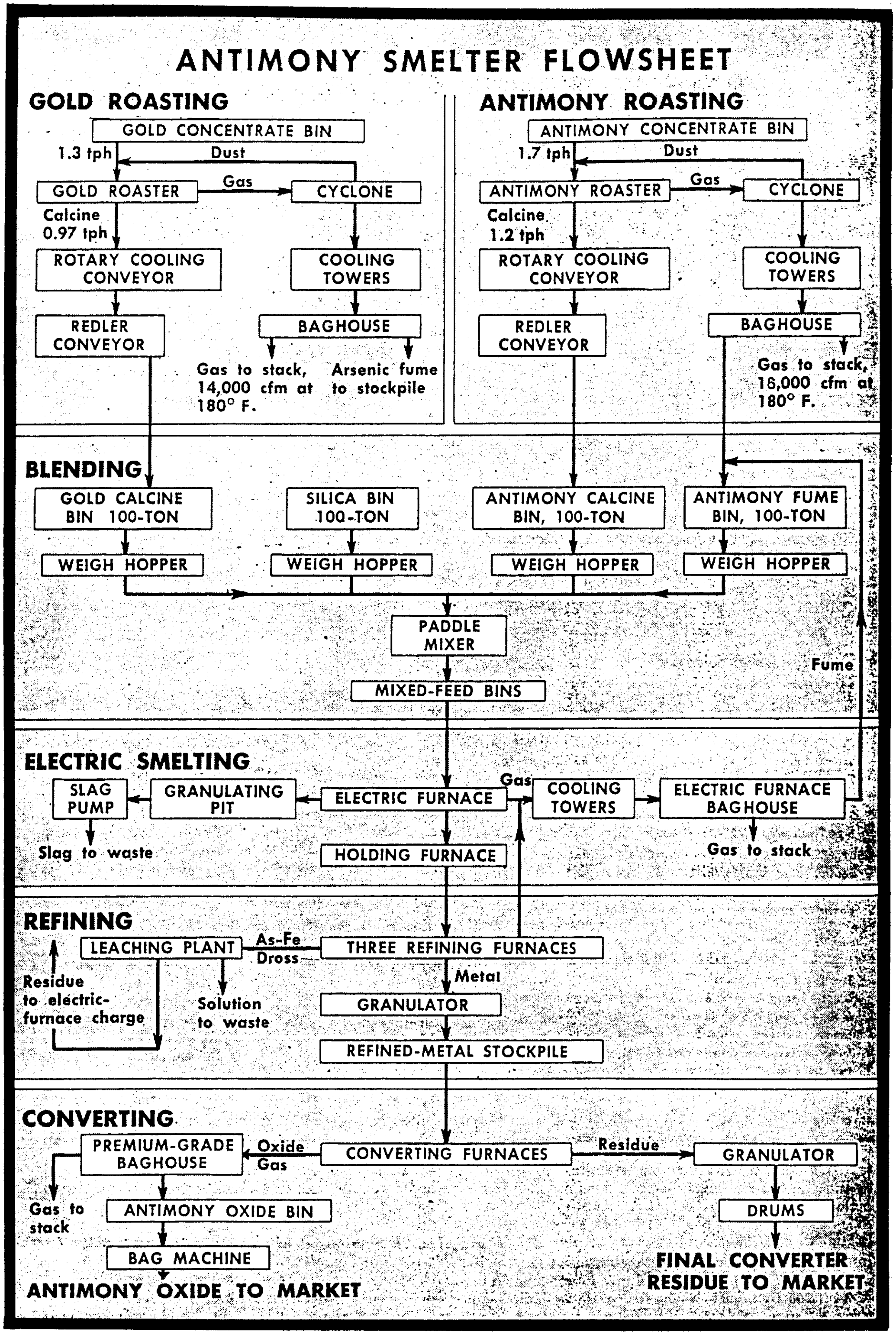


Figure 60. Flow sheet for the Yellow Pine antimony smelter in 1951 (Huttl, 1952, p. 76).

Calcine from the roaster goes by rotary cooling conveyor and bucket elevator to storage bins in the smelter building.

Antimony concentrate is fed to a 10-hearth by 21½-ft. Herreshoff roaster at the rate of 1.7 tons per hour. A burner is operated on hearth 10. To avoid fusion, the temperature on the first five hearths must be held below 780 deg. F. In succeeding hearths, temperature rises to a maximum of about 1,020 deg. F. About 75% of the contained antimony remains in the calcine and the remainder fumes off. Gas escapes from hearths 1 to 5.

BLENDING

In the smelter building proper, overhead steel bins contain gold calcine (1.5% sulphur), antimony calcine, (antimony, mostly as Sb_2O_4, with 2% sulphur), antimony fume (Sb_2O_3), coal, silica, soda ash, and secondaries. Each bin is connected to individual weigh hoppers by screw conveyors. Weigh hoppers discharge into a batch type paddle mixer which is capable of mixing 12 tons of charge per hour. Each blended charge is elevated and discharged into an 80-ton bin near the electric furnace.

ELECTRIC SMELTING

When the smelter was first broken in, the metallurgy department ran head-on into a major difficulty. The trouble involved iron: Slag from the furnace had to be held at 6 to 7% antimony in order to keep iron in the bullion at about 6 to 7%. And not only was 6 to 7% iron in the bullion considered too high for efficient refining, but also the loss of antimony in the slag was too high.

Solution by R. J. McRae and Harold E. Lee came during a period of testing from April 1 to June 1, 1951. They found the trouble was high arsenic content of the charge which somehow caused selective reduction of iron. The arsenic came into the charge in the antimony fume portion.

Their solution involved 1) smelting the high arsenic portion of the charge with a deficiency of coal or reducing agent, and thus allowing a low iron fall to the antimony but a rather high antimony content of the slag; and 2) smelting, in the next step, a charge made up only of antimony calcine and gold calcine low in arsenic; sufficient coal is added to reduce the contained antimony was well as that held in the slag of the first charge.

This new system might be described as a continuous batch smelting, as opposed to continuous feeding of the charge to the electric furnace.

Original Furnace Charge

Product	% of Total	% Arsenic	% Antimony
Gold Calcine	15	0.5	3.0
Antimony Calcine	45	1.5	45
Antimony Fume	30	20	60
Secondaries	10	. . . .	. . . .

Current practice is to charge the electric furnace after a slag tap with 30 tons of under-reduced charge; this is high in arsenic content, and is made up of gold calcine, antimony calcine, and antimony fume. This is followed by 10 tons of over-reduced charge; it has a low arsenic content, and is made up of gold calcine, antimony calcine, and excess coal (no antimony fume). Then the charge is melted, and slag is tapped.

Metal taps are made as needed, about every 6 hours. Slag is tapped at the rate of about 1 ton per minute into a granulating pit, and then is pumped to the disposal area;

temperature ranges from 2,180 to 2,250 deg. F. Metal temperatures range from 1,700 to 1,800 deg. F.

Under the new system, the smelting rate is as high as under continuous feed, the furnace metal fall has increased from 52 to 71%, antimony in the final slag has dropped from 7 to 2%, and iron in the final furnace metal from 7 to 3%. In the under-reduced cycle, metal assays 1% iron, and slag 12% antimony.

The Lectromelt furnace [Figure 61] was designed for a maximum input of 2,000 kva and operates at a 0.97 power factor. Its three 24-in. electrodes are in a straight line, spaced 48 in. between centers; phase voltage can be varied between 80 and 130 v. Power input is adjusted to about 360 to 380 kw per ton of charge.

The furnace hearth is 7 ft. 3 in. by 17 ft. A 9-in. invert holds about 12 tons of metal. The invert and side and end walls up to the slag line are lined with magnesite brick.

REFINING

Purpose of refining the bullion is to remove iron to the limit of 0.05% and arsenic to 0.10%. Used for refining are three 5 x 7-ft. oil-fired reverberatory furnaces [Figure 62] each of which holds 9 tons of metal.

In refining, the metal is brought up to 1,600 deg. F., 400 lb. of caustic flake is added, and the bath is air lanced until the caustic sets into a pasty dross. An operator, using a wooden hoe, skims off the dross through the working door. This cycle is repeated until the metal assays less than 0.10% arsenic, at which time the iron is down to less than 0.05%.

It takes about 16 hours to refine 8 tons of metal; and it requires about 3½ lb. of caustic for each 1 lb. of metal refined.

The dross contains about 18% antimony, 14% arsenic, and 17% iron. It is water leached. The residue, containing about 85% of the antimony and only 7% of the arsenic, is returned to the electric furnace.

Refined metal is granulated and, ready for converting, sent to the stockpile.

CONVERTING

Converter Products

	Refined Metal (Feed)	Primary Residue (Inter)	Final Residue (Product)	Ratio Product to Feed
Gold	5. oz.	52. oz	250. oz.	50
Silver	50. oz.	500. oz	2,500. oz.	50
Copper	0.6%	4.%	20.%	33
Lead	. . . .	1.5%	6.%	. . . .
Antimony	98.5%	88.%	68.%	0.69

The table above tells the story of converting. Antimony metal is burned off, oxidized to Sb_2O_3, and leaves gold, silver, copper, lead, and a remainder of antimony in a primary residue. The residue in turn is saved, and reburned until it is about 50 times as rich in gold and silver as the original refined metal.

Two identical oil-fired furnaces of local design are used for converting. On each, four stainless-steel tuyeres project into the sidewalls.

Granulated metal, charged continuously through the arch of the furnace, maintains the metal bath at 10-in. of depth. Capacity of each is determined by the volume of low-pressure air supplied to the tuyeres; under normal conditions, each will make up to about 12 tons of oxide per day.

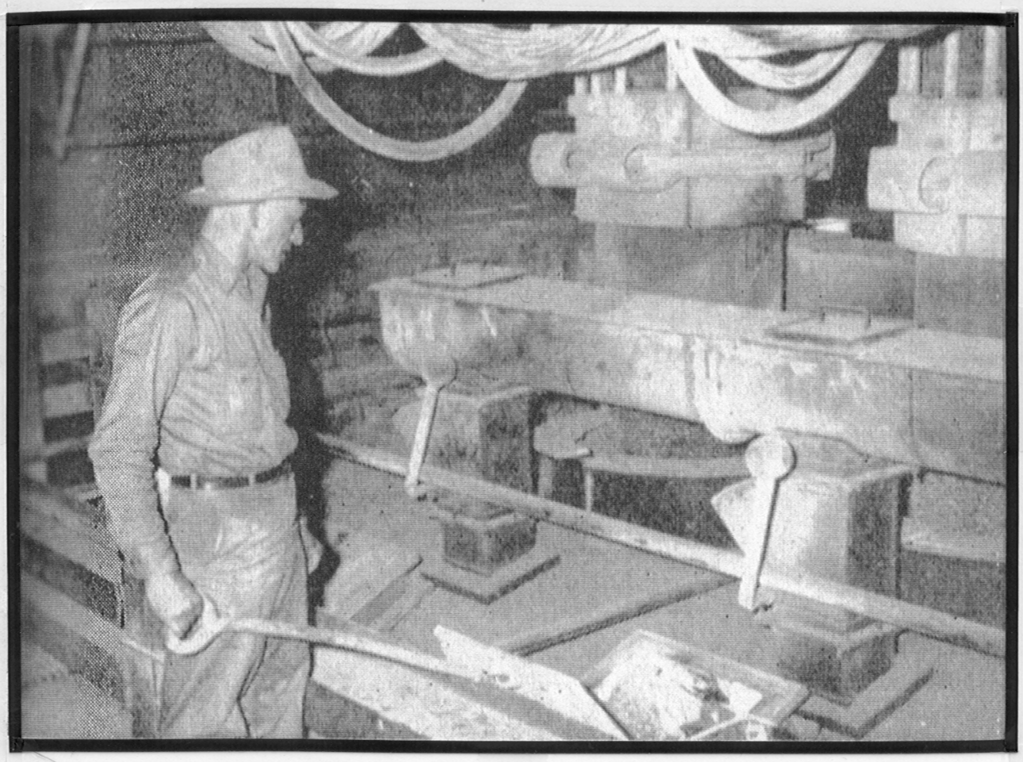


Figure 61. Smelter superintendent opening an inspection port on the Lectromelt furnace to inspect the charge. The screw conveyor which feeds the furnace is between the superintendent and the electrodes (Mining World, 1951, p. 31).

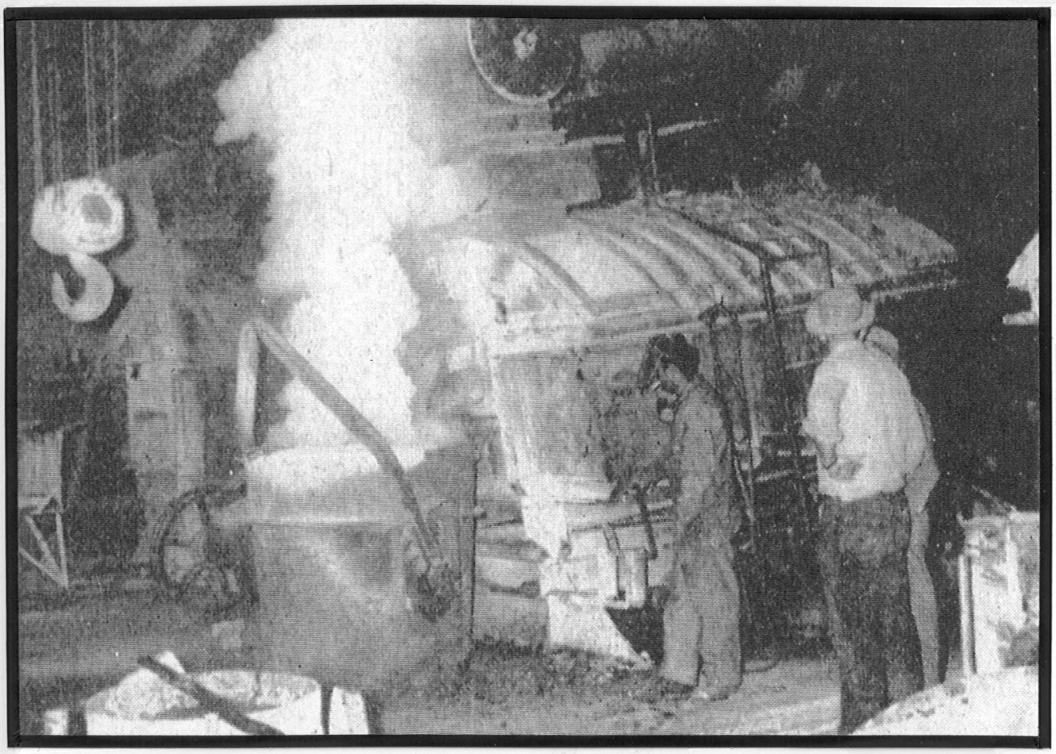


Figure 62. Refinery operator tilts a refining furnace to tap a ladle of molten antimony (Mining World, 1951, p. 31).

> Gas leaves through an outlet in the center of the arch. Four adjustable openings in the escape flue provide for bleeding in quench air. The gas is first quenched at the furnace throat to about 750 deg. F., and is then quenched to 220 deg. F. before entering the premium oxide baghouse. Collected premium oxide is bagged in valve-type paper bags by a St. Regis bagging machine. Each unit of 20 bags, after being checked for color, and after testing of each 5-ton sublot for color, tinting-strength and impurities, is ready for sale.
>
> Primary converter residue, in the amount of 10% of the day's metal feed, is withdrawn every 24 hours. About every two weeks, it is burned down into final residue—until the oxide turns a yellow color. This oxide goes to the metal-grade baghouse. The final residue is granulated and barreled for shipment to the United States Smelting, Refining and Mining Co.
>
> Since all current smelter production is saleable as oxide, reduction of oxide to metal is done only on the off-color oxide. It is done about once each month in a furnace identical to the refiners. The charge consists of oxide mixed with 3% soda ash and 10% coal. Reduced metal is granulated in 8-ton batches, and is ready for sale as metal.
>
> Though the smelter has reached its capacity of 6,000 tons of antimony a year, a number of changes are under way which will increase recovery and production. Under construction is an addition to recover antimony and gold from the gold roaster fume; calcium arsenate will be a byproduct.

The main product of the smelter was Elk Brand pigment-grade antimony oxide. Mining World (1951) noted that "Average Elk Brand Antimony Oxide is superior in color to any other brands of oxide that Bradley has been able to secure for comparison."

The high point of Stibnite's fame, according to Bailey (1979), was an article on the town and its people in the *Saturday Evening Post*. Titled "Want to Get Away From It All?", the story (Clark, 1951) described life in the isolated mining community [Figure 63] and sketched the history of the mine.

The price of antimony fell sharply in early 1952. At the same time, demand dropped and available supplies of (cheaper) imported antimony increased. The average price for the year was 44.02 cents per pound, but the January price was 51.85 cents per pound. By December, the price had fallen to 36.17 cents per pound. Effective May 15, the National Production Authority order restricting consumption and stocks of antimony was revoked, but the requirement for monthly reports was retained.

In response to the falling antimony prices, operations at the Yellow Pine open pit were suspended in June. The 2,200-tpd flotation mill operated until July 31, and the antimony smelter was closed in the middle of August. The company did not announce any plans to resume production. Before the closure, the mill processed 310,201 tons of ore and 3,622 tons of waste materials from the metallurgical operations. The concentrates contained gold, silver, antimony, and tungsten. The company recovered 4,000 short tons of antimony concentrate, which contained 1,900 tons of antimony. This was 86 percent of the domestic antimony production. The mine was also the largest producer of gold in Idaho for the year.

In 1952, the Yellow Pine Mine again was the recipient of a government-sponsored exploration program. The Defense Production Act of 1950 included

provisions for assisting companies to locate new reserves of strategic and critical minerals. Companies whose exploration projects met the criteria set by the government received loans to cover a fixed proportion of the costs of the project (typically 50 to 75 percent). If ore was discovered, the company was required to repay the government out of the proceeds; when no ore was discovered, the government loans were forgiven. In late 1951, the Defense Minerals Exploration Administration (DMEA) was established to continue the mineral exploration programs that were already in place under the authority of the Defense Production Act. Under the DMEA program, antimony mines were eligible for assistance amounting to 75 percent of the project costs. On November 25, 1952, Bradley Mining Co. was awarded DMEA Contract E453 for $53,000 to explore for antimony at the Yellow Pine Mine. The company held a second DMEA contract (E173), also to explore for antimony at Yellow Pine. This contract was for $175,368, but the date of the award is not known for certain. It is believed that this contract is the one that later USBM Yearbooks show as being awarded on February 27, 1953, because the amounts are identical. However, this does not explain why the 1952 USBM Yearbook listed the contract as active in that year.

In late 1951 or early 1952, the Yellow Pine Pit was more than 450 feet deep. The benches were generally 40 feet high, although some were 80 feet high near the outside of the pit and some were less than 40 feet where the orebody was narrow. The projected final size of the pit was 1,500 by 2,500 feet. Ore was being mined at the rate of 2,500 tpd, and stripping was proceeding well in advance of mining. The final ore-to-waste ratio was estimated to be 1:1½. Both spiral and switchback patterns were used for the roads in the pit, and the average haul to the crusher was about 0.5 mile. The main haulage road to the crusher had a grade of 7 percent. Most grades in the pit were under 8 percent, but a few short stretches were up to 12 percent (Huttl, 1952).

The following was written to applaud the construction of the smelter, but it could equally have been Yellow Pine's epitaph (Mining World, 1951, p. 34):

> The metal-mining industry is the very basis of our machine-power-atomic age; without metals, we would be reduced from a first-rate industrial power to groups of itinerant herdsmen. And so it is a sad fact that many of our political and economic leaders have not realized that the metal-mining industry lives by the future—that today's production is the result of work done during the last 5, 10, or 20 years.
>
> Yellow Pine is today an integrated chain of operations which processes ore into final metal and oxide products for consumption by industry. Today, the new smelter, the last link in the completed chain of production, is not only a plant which illustrates modern, mechanized, material handling[65]. It is a plant and a part of an operation which should be studied by economists and politicians. They should study it to see what factors,

[65] i.e., the plant was highly mechanized and employed the latest methods for handling materials. The comma after "mechanized" should have been omitted.

what natural encouragements and foresight, caused the plant to be in operation today when its product is needed, rather than tomorrow when its products may have arrived "too late."

The mine, mill, and smelter remained closed throughout 1953, even though company officials announced plans to reopen the smelter at the end of the year or early in 1954 to process imported antimony ore. (Company officials blamed the shutdown on an excess of imported antimony.) Exploration work under the company's DMEA contracts continued.

The mine was idle in 1954, except for exploration and development on the DMEA projects. The mill was used to process 12,000 tons of tungsten ore from Bradley's open-pit operation at the Springfield Mine. The ore averaged about 0.25 percent WO_3.

Work was finished during 1955 on both of Bradley's DMEA contracts. The larger contract was amended to a total cost of $203,836, an increase of $28,468. Government participation was still 75 percent. USGS files indicate that ore was discovered by this work. However, since Bradley never reopened the mine, the discovery was somewhat academic.

Also during 1955, Bradley used the magnetic separators at Stibnite to process tungsten concentrate from the Springfield Mine. This produced 2,159 units of WO_3 in high-grade concentrate and a small tonnage of lower quality material. In October, Bradley purchased a trial shipment of 53 tons of cathode antimony metal from Sunshine Mining Co.'s electrolytic plant. The material contained over 95 percent antimony, with arsenic making up most of the remainder. Plans called for additional quantities of antimony to be shipped to the Yellow Pine smelter if the plant was able to remove the arsenic from the initial shipment.

In June 1956, Bradley entered into an agreement with Sunshine to purchase that company's accumulated stockpile of cathode antimony metal, which totalled about 2,000 tons. By the end of the year, 3,519,031 pounds of cathode metal containing 3,343,079 pounds of antimony had been shipped to the smelter at Stibnite. After refining, the antimony was sold to the U.S. government under a purchase contract. Also in June, Bradley announced that the crushing and concentrating plants at Stibnite were to be dismantled and sold.

During 1957, Bradley completed its processing of the cathode antimony purchased from Sunshine. After this work was completed, Bradley dismantled the smelter and removed it from the site[66]. Hart (1979) stated that the smelter was shipped to Kellogg in 1958. Also between 1950 and 1964, all but five of the houses at Stibnite were moved to other Idaho towns, including Yellow Pine, McCall, Cascade, Riggins, New Meadows, and others (Hart, 1979). When the salvage of the smelter

[66]Sunshine was building its own facilities for refining the cathode antimony produced by its electrolytic plant. Hence, the company had no need to continue using the Stibnite smelter.

was completed, the property was placed on a caretaker basis. The 1958 USBM Yearbook described Stibnite as "a modern-day ghost town." (See Figures 64, 65, and 66.) By 1960, the company was no longer maintaining a caretaker at the mine. For the next decade, the property remained idle.

According to U.S. Bureau of Mines records, the Yellow Pine Mine produced 4,344,459 tons of ore and reprocessed 74,570 tons of old tailings between 1939 and 1952. This material yielded 256,443 ounces of gold, 1,497,223 ounces of silver, 25,514 pounds of copper, and 7,211 pounds of lead. In addition, the property produced 59,341,502 pounds of antimony and 844,779 units of tungsten. These last two metals are classed as strategic materials and Yellow Pine's production of both was critical to the United States during World War II.

In 1965, the dam to Bradley's reservoir on the East Fork of Meadow Creek[67] failed. The water scoured the stream channel to a depth of 100 feet in the area below the dam and deposited a debris flow where the East Fork joins Meadow Creek (Figure 67). Because of the steep grade of the East Fork, vegetation was still reestablishing itself thirty years later on the steeper slopes and on the side gullies cut into the silts deposited in the reservoir (USFS, 1994).

In 1968, the U.S. Bureau of Mines began a reappraisal of the potential for gold-silver-antimony deposits in the Stibnite area. A reconnaissance geochemical survey that sampled conifer-needle humus (Banister, 1970) outlined several areas containing anomalous gold and antimony (Figure 68). The areas on Garnet Creek and West End Creek were later acquired by Canadian Superior (see below).

This area was visited by an Idaho Geological Survey geologist in the summer of 1994 as part of a program to inspect abandoned and inactive mine lands. Figures 69, 70, and 71 show the remains of the Yellow Pine Pit at the time of the visit, while Figure 72 shows how it looked a decade earlier.

Modern Operations — Overview

A major chapter in the history of the Stibnite area closed with the Bradley smelter. There was little work on the East Fork of the South Fork of the Salmon River until the 1970s. After the U.S. Bureau of Mines developed the heap leach method for extracting gold from very low grade deposits using cyanide and open-pit mining methods, every area in Idaho (and the rest of the country) that had produced gold in the past was re-examined. Reconnaissance geochemical studies by the U.S. Geological Survey and the U.S. Bureau of Mines (which included both investigations in the Stibnite area and tests of new methods for geochemical exploration) further stimulated interest in locating low-grade gold deposits.

[67]This creek was called "Blowout Creek" in the most recent environmental impact statement (USFS, 1994).

Figure 64. Ruins of the Yellow Pine smelter and mill in 1982 (photograph by Earl H. Bennett, Idaho Geological Survey).

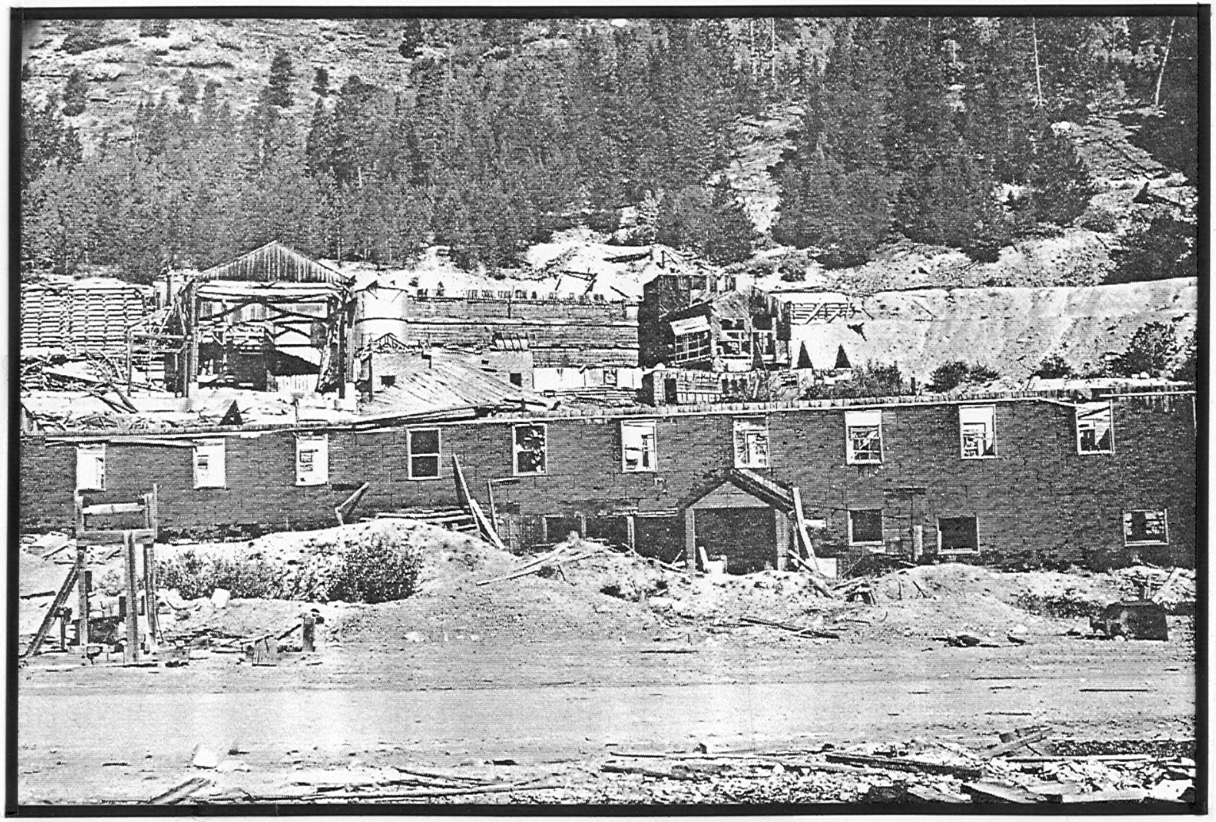
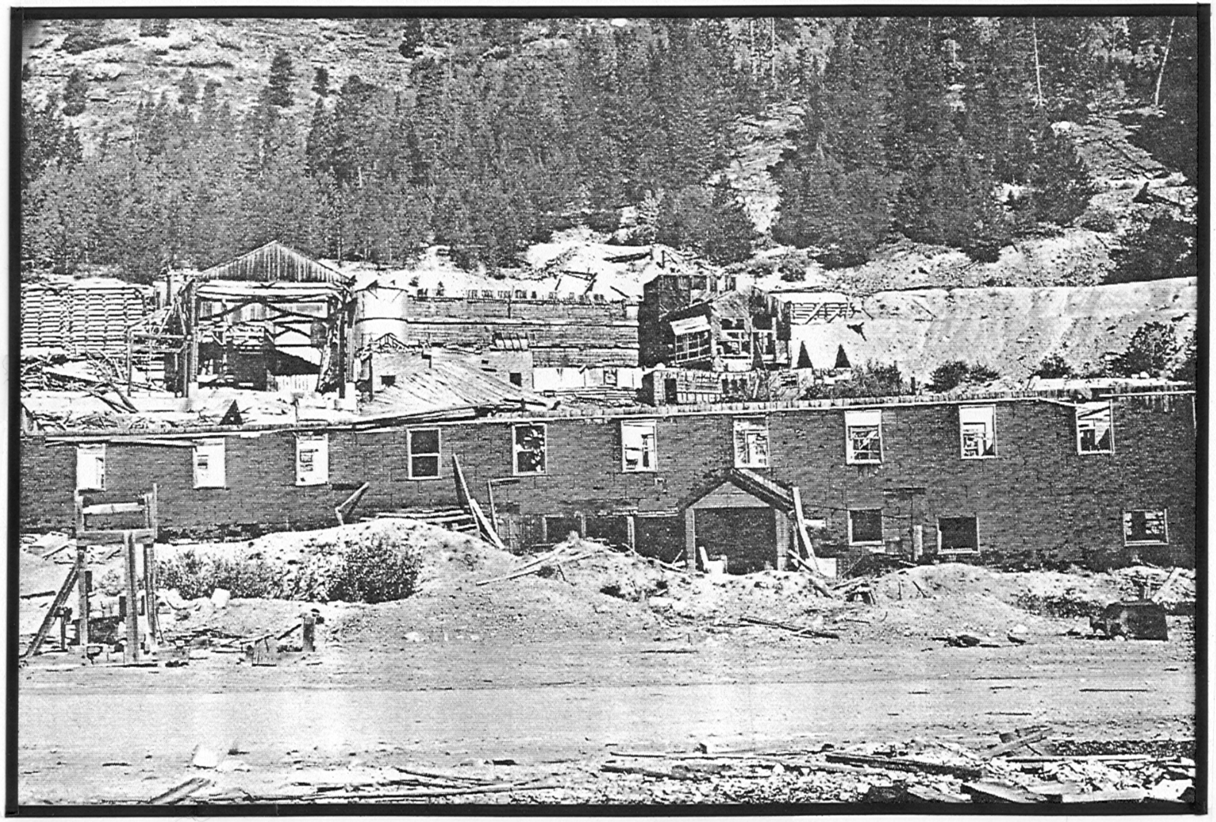


Figure 65. Ruins of the bunkhouse and various mill buildings at Stibnite (Hart, 1979, Figure 2-6).



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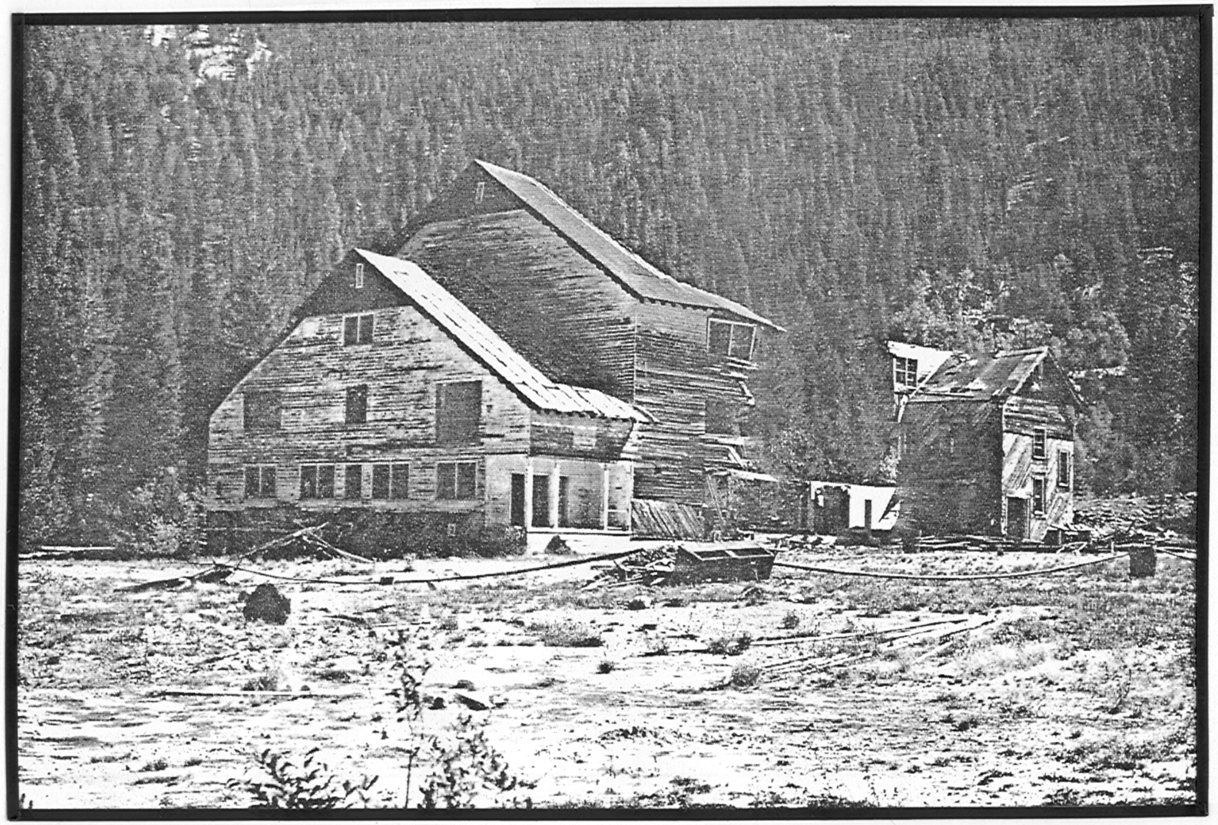


Figure 66. Ruins of the Recreation Hall (popularly known as the "Wreck), partially destroyed for salvage (Hart, 1979, Figure 2-7).

Figure 67. The debris from the blowout of the Bradley Mining Co.'s reservoir on the East Fork of Meadow Creek is visible among the trees on the left side of the photograph. The steep, bare hillside in the far upper left is part of the scar from the blowout. The channel lined with riprap in the center of the picture is the latest effort to divert Meadow Creek around the tailings area (photograph by Virginia S. Gillerman, Idaho Geological Survey).

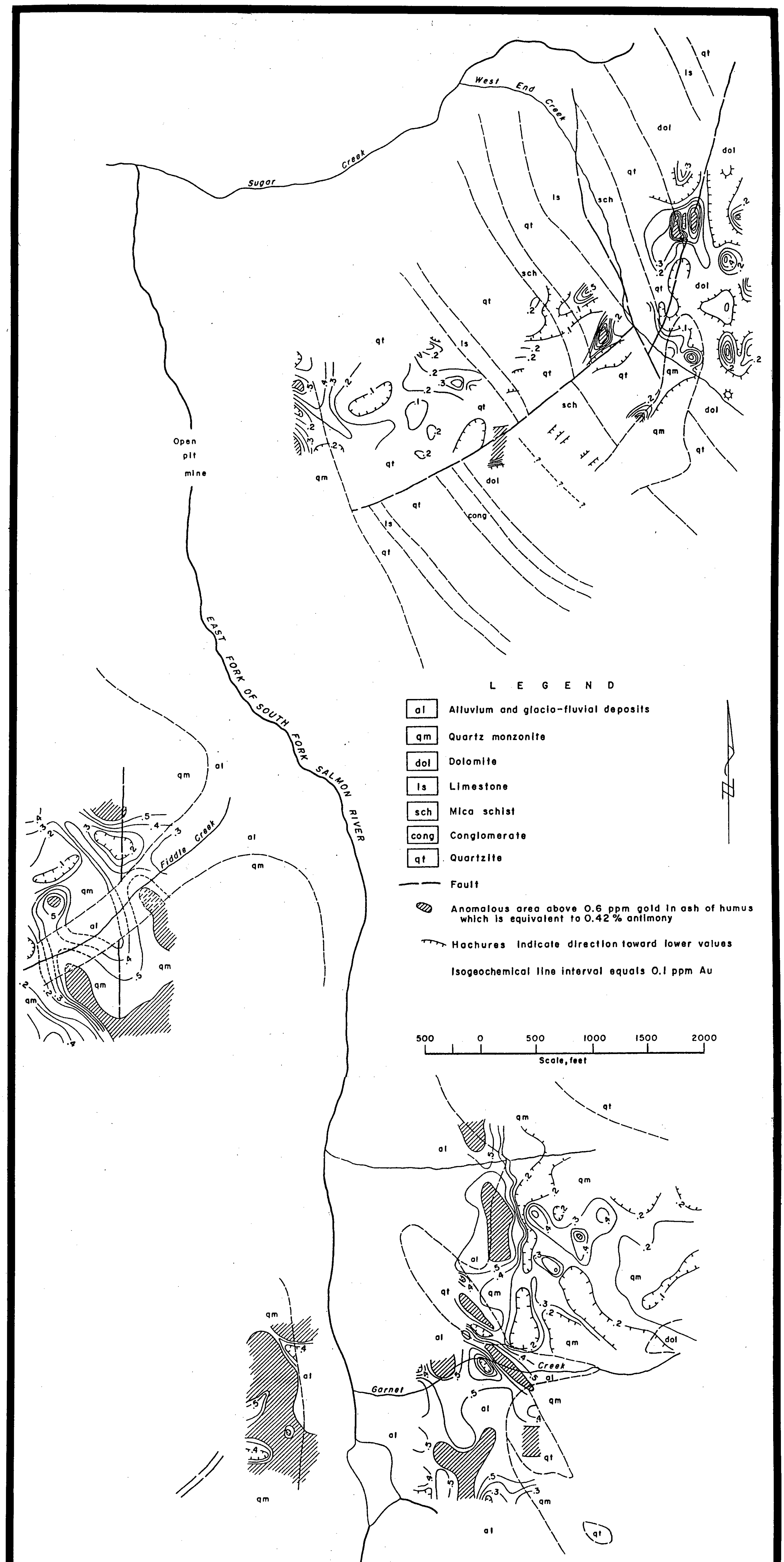


Figure 68. Gold and antimony anomalies outlined by reconnaissance geochemical sampling of humus by the U.S. Bureau of Mines (Banister, 1970, Figure 2).

Figure 69. Ruins of Monday camp on the south rim of the Yellow Pine Pit. The East Fork of the South Fork of the Salmon is visible to the south behind the camp and to the left where it is descending into the open pit (photograph by Earl H. Bennett, Idaho Geological Survey).

Figure 70. Sheared rock on the west side of the Yellow Pine Pit. The light-colored boulders on the opposite side of the pond are where the East Fork enters the pit. The ruins of Monday camp are barely visible against the trees on the left side of the picture (photograph by Earl H. Bennett, Idaho Geological Survey).

Figure 71. The pond in the bottom of the Yellow Pine Pit, looking toward the east. The debris fan on the right of the picture is where the East Fork enters the pit; the outlet is at the left center (photograph by Earl H. Bennett, Idaho Geological Survey).

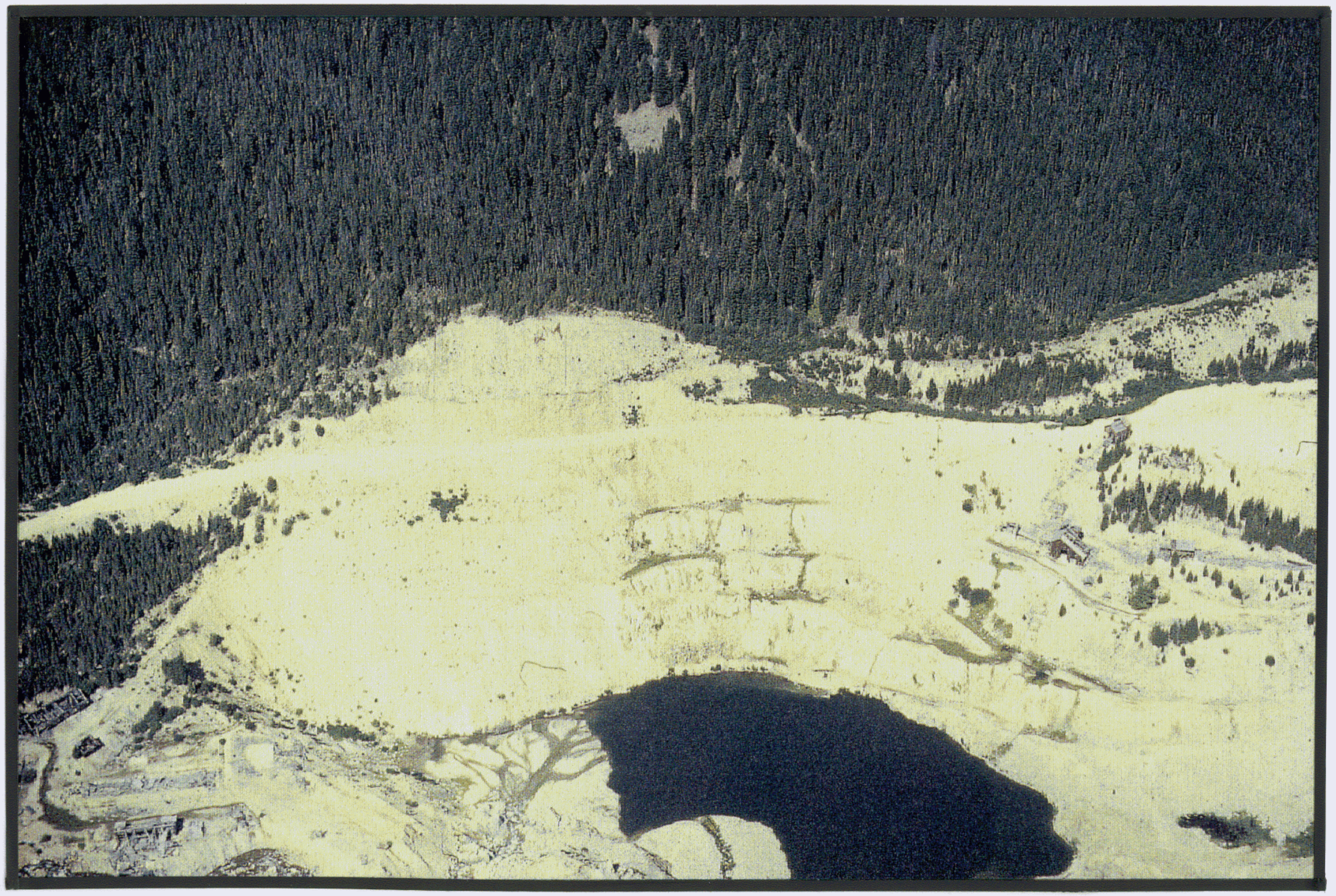


Figure 72. Yellow Pine Pit in 1983. Notice the "delta fan" of material washed into the pond by the river. The ruins of Monday camp are in the lower left corner; the buildings in the right center are probably the remains of the post-World War II crushing plant (photograph by Earl H. Bennett, Idaho Geological Survey).

A further boost to the start-up of new mining projects came when the Canadian government allowed the use of "flow through shares" for financing risky exploration and development projects. This freed traditional sources of capital for both large and small Canadian mining companies, and they poured south in search of gold in the United States. One of the areas that was rediscovered was the Stibnite area. In 1970 Ranchers Exploration and Development Corp. (now Hecla Mining Co.) leased the block of patented claims beneath the old Yellow Pine and Meadow Creek mines. Since 1974, Canadian Superior Mining (and its successors) have controlled the claim block to the east of, and surrounding, the Ranchers/Hecla holdings.

Ranchers Exploration and Development Corporation/ Hecla Mining Company Operations

During its strategic minerals investigations in 1939, the U.S. Bureau of Mines discovered the Homestake orebody (Figure 2; Plate 1). The deposit was explored by a dozen diamond drill holes at that time, and the ore was said to resemble that in Bradley's East Quarry (Cooper, 1951). The Homestake deposit occurs entirely within strongly sheared and faulted quartz monzonite adjacent to the Meadow Creek fault zone (Hecla Mining Co. fact sheet, 1990).

In 1970, the property was leased by Ranchers Exploration and Development Corporation from the Bradley Mining Co. Ranchers' holdings covered most of the areas that had been mined by Bradley Mining Co. (Figure 73). Exploration drilling for antimony was conducted, and the deposit was said to be one of the largest in the world. Plans were made to put the property into production, but nothing came of them.

American Independent Mines and Minerals Co. conducted exploration and development for Ranchers at the Yellow Pine Mine in 1982. In 1984, Ranchers merged with Hecla Mining Co. The Yellow Pine claim block was one of the properties Hecla inherited in the merger. During the year, Hecla renegotiated the lease with the owners, obtaining a reduction in royalties, and began to evaluate the deposit. By 1985, Hecla had developed reserves of about 900,000 tons of oxidized ore containing 0.10 opt gold. The following year, the company decreased the estimated reserves to 800,000 tons of ore and conducted a feasibility study for a modest heap-leach operation.

Development work continued in 1987. Hecla negotiated a contract with Pioneer Metals to use Pioneer's leach plant at Stibnite on a fixed-fee basis. The arrangement called for Pioneer to process 400,000 tons of ore per year, from which Hecla expected to obtain about 25,000 ounces of gold annually. The mine was to employ about 35 people. Hecla also conducted a feasibility study on the economics of mining a large body of gold-bearing sulfide ore. The refractory orebody contained

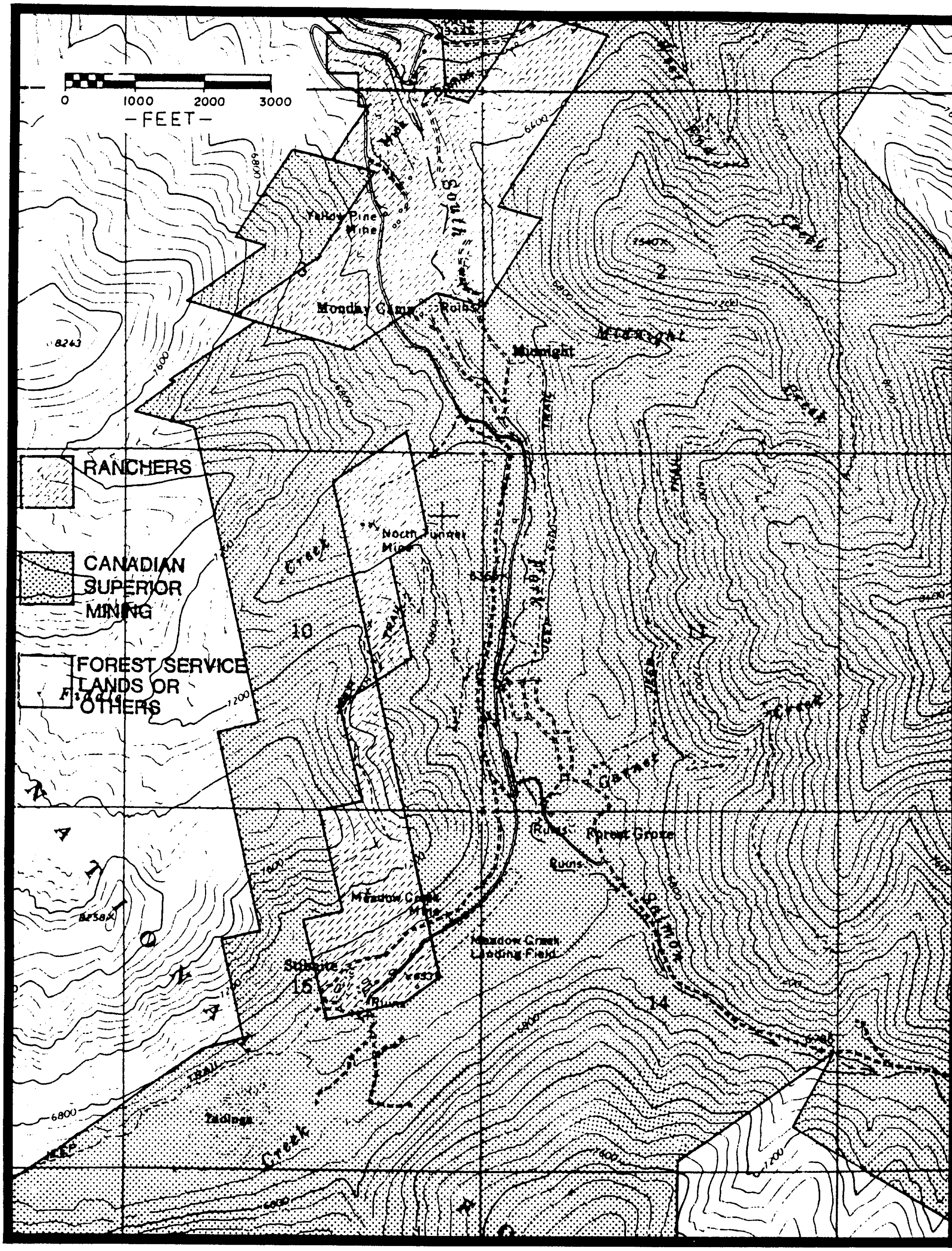


Figure 73. Claim blocks in the Stibnite area in 1980 (USFS, 1980, Figure 2-9).

between 15 and 20 million tons of ore averaging around 0.10 opt of gold, but was not amenable to heap leaching.

The Yellow Pine Mine was the third largest gold producer in Idaho in 1988. A gold pour on July 29 marked the official start of production. The cost of starting the operation was $700,000. The mine produced 20,701 ounces of gold and 6,802 ounces of silver from 278,193 tons of ore. This was less than 75 percent of the planned tonnage, but the ore grade and recovery were better than expected. The 1988 production was lower than anticipated because a disagreement with Pioneer over leach-pad usage. This caused a suspension of production for six weeks in August and September. The mine only operated from about April to November because of the harsh winters at its high elevation (6,500 feet). Argee Corporation was the mining contractor for Hecla.

At the end of the 1988 production season, Hecla had a reserve of 1.1 million tons of oxide ore with an average grade of 0.078 opt gold. In addition, Hecla was investigating building a mill to process 15-20 million tons of refractory (arsenical) gold-bearing sulfide ore. An agreement was signed with Artech Recovery Systems to conduct a pilot test of its low-temperature-Cashman chemical process to recover the gold and other metals from the sulfide ores. Tests were conducted in August and September to see if Hecla could use the process.

In 1989, Pioneer Metals canceled the toll-leaching contract with Hecla. Pioneer needed all its leach pads to process its own ore because of an increase in the company's reserves. Hecla received approval to build a heap-leach plant in the Stibnite area. (Figure 74 shows the new leach pad.) Construction of the $4.5-million facility was completed (Figure 75 shows a schematic diagram of the processing plant), and 93,000 tons of ore was stockpiled during the summer. The ore mined from the Homestake Pit was stacked on the leach pad in continuous lifts. Plans called for the final heap to be about 120 feet high and to cover about 12 acres. The mine had reserves of about 1.1 million tons of oxide ore, which contained about 80,000 ounces of extractable gold. The projected life of the mine was two years. The operation employed about 100 people, including 30 Hecla employees and 70 who worked for the mining contractor.

Production resumed in the Homestake Pit in 1990. The plant processed over 900,000 tons of ore, and an estimated 57,747 ounces of gold was produced during the year (Figure 76). About 5,000 tpd of ore, which averaged 0.08 opt gold, was mined from the Homestake open pit. The orebody was mined on 20-foot benches. Seven 35-ton trucks hauled the ore to an agglomerator, and the agglomerated ore was then piled on the leach pad. The mine employed 94 people and had a payroll of $340,000. Reclamation of the Homestake Pit proceeded in concert with mining operations. Fifteen acres was revegetated in 1989 and another 30 acres was reseeded in 1990. The mine's reserves included 15,000 ounces of gold in oxide ore and a substantial amount of sulfide ore. Hecla did considerable testing of the sulfide ore during the

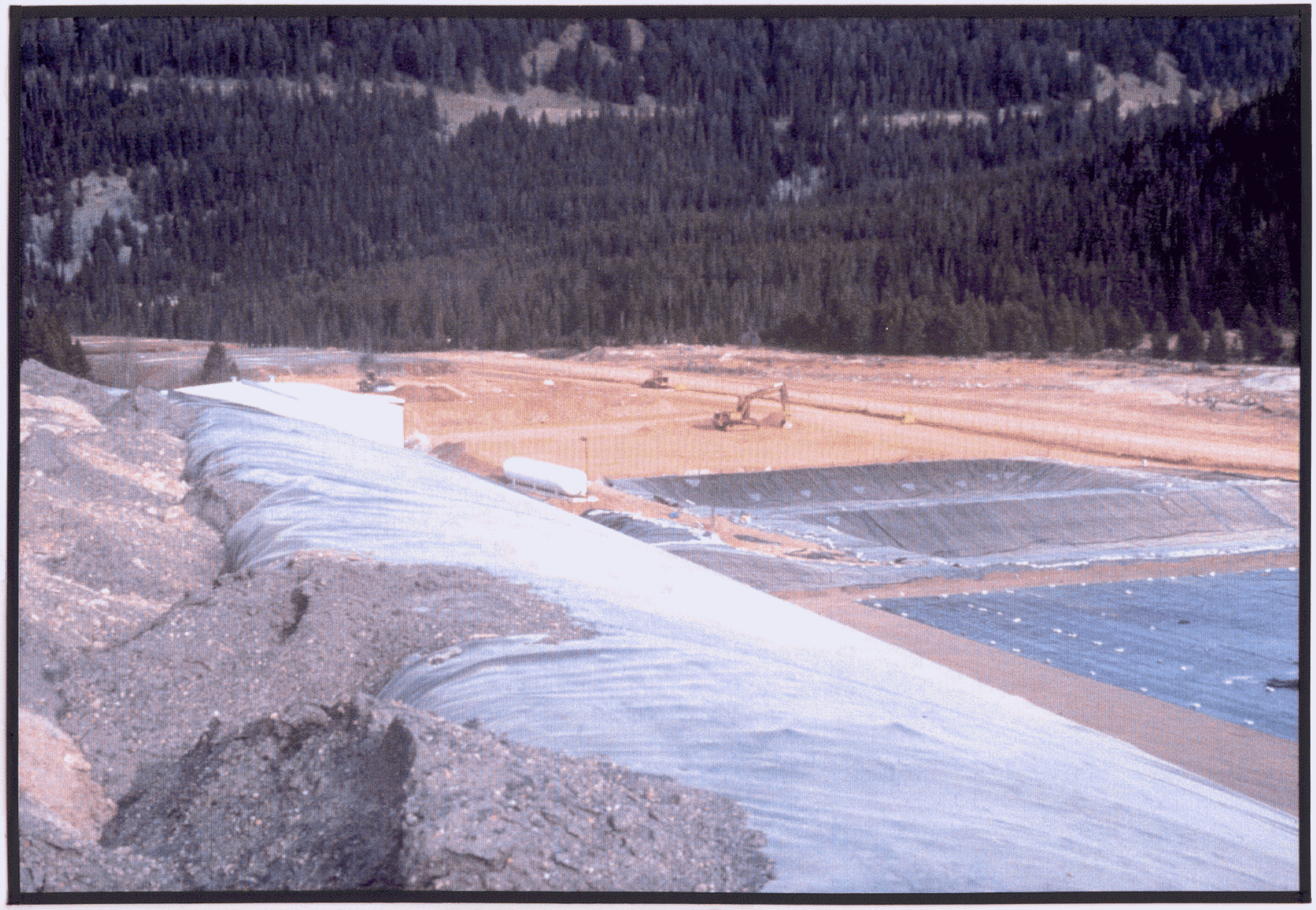
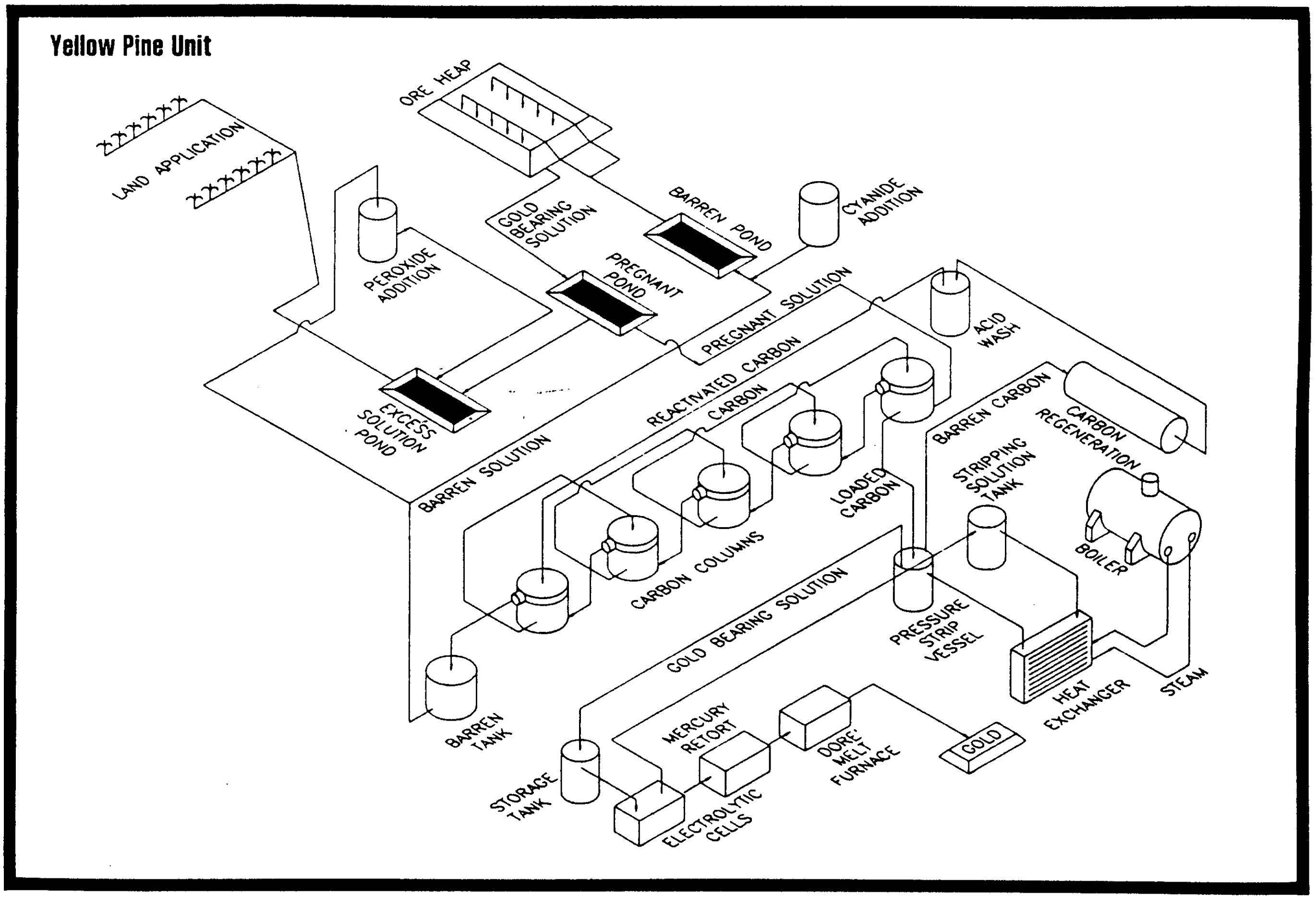


Figure 74. Construction of Hecla's leach pad at Stibnite (Idaho Geological Survey photograph).



Facts & Figures

•Initial Gold Recovery Rate: 80%

•Mining Volume: 7,000 tons/ per working day

•Homestake Pit Size: 30 acres

•Heap Size: 12 acres

•Employees: 35 Hecla employees, 60 contractor employees

•Mine Equipment Includes: 6.5-yard hydraulic front shovel, 35-ton haul trucks, 7-yard front-end loaders, D8L dozers, Ingersoll Rand ECM-350 blasthole drills, water truck, grader, jaw crusher, cone crusher, 20-yard belly dump trucks, 30-ton crane

•1991 Oxide Reserves: 250,000 tons at .04 ounce of gold per ton

1990 Production Figures

Yellow Pine Unit	1990
Tons of ore milled	982,240
Gold recovered grade (oz./ton)	0.06
Gold produced (oz.)	57,747

Figure 75. Schematic diagram of Hecla's processing plant (Hecla Mining Co. Yellow Pine Unit fact sheet).

Figure 76. Pouring molten gold into a mold at Hecla's Yellow Pine plant (Hecla Mining Co. 1990 Annual Report).

year, looking for ways to process the refractory material. Between Hecla and Pioneer Metals, the Stibnite area was the sixth largest gold-producing district in the state.

During 1991, Hecla finished mining the low-grade oxide ore in the Homestake Pit and processed about 200,000 tons of 0.05 opt gold oxide ore stockpiled from the old Bradley operations. The company produced about 17,542 ounces of gold during the year. Recontouring and other reclamation efforts were nearly completed at the Homestake Pit (Figure 77). A tree spade was used to transplant mature trees in the reclaimed area, and an additional 12,000 new seedlings were also scheduled for planting. Hecla received the state's "Award for Excellence in Operation of a Large Mine" for this reclamation work. Metallurgical studies were continued on the sulfide orebody under the old Bradley Pit.

Hecla finished leaching at Yellow Pine in 1992 and started reclamation work at the plant site. About 2,000 ounces of gold was produced as part of the cleanup effort. The mine yielded close to 100,000 ounces of gold between 1989 and 1992, with a 25 percent return on investment for the company. The plant was dismantled, and the roads, ponds, and leach pad were reclaimed. (Figure 78 shows the reclaimed leach pad.) Hecla used an experimental process that was developed by Pintail Systems, Inc., to neutralize and detoxify the leached ore. A cyanide-eating bacteria, which was grown in the lab and freeze-dried for transport, was cultured on-site in the heaps. Tests showed the bacteria were working well and removing the cyanide. An added advantage was that the nutrients added to the heaps for the bacteria aided the reclamation effort. The new process was monitored through the spring of 1993. For pioneering the innovative bio-neutralization process, Hecla received the Pacific Northwest Pollution Control Association's 1992 Industrial Pollution Control Award for Idaho. A drought retarded the growth of grass planted in the Homestake Pit, but lodgepole pine seedlings did well. The gold recovery plant was recycled. Twenty semitrailer loads were needed to ship it to Hecla's new gold mine in Mexico.

In June 1992, Hecla and American Barrick Resources Corporation started a major exploration program at the Yellow Pine Mine. The target for the joint venture was the extensive sulfide gold resource (2-4 million ounces) at the property. As noted, Hecla had mined only the oxide ore at Yellow Pine because the sulfides require a different treatment. Barrick had considerable experience with sulfide gold ore. The two companies drilled 14 core and 3 reverse circulation holes, which totalled over 10,000 feet. After evaluating the exploration effort, American Barrick withdrew from the joint venture.

Hecla received an award for Excellence in Annual Operations of Large Hard Rock Mines from Governor Cecil Andrus and the Idaho Land Commissioners in August 1993. The award was for reclamation at the Yellow Pine Mine.

Figure 77. Reclaimed site of Hecla's Homestake Pit (photograph by Earl H. Bennett, Idaho Geological Survey).

Figure 78. Hecla's continuous-lift leach pad at Stibnite. The pad has been terraced, planted, and reclaimed. The cyanide was neutralized by cyanide-eating bacteria (photograph by Earl H. Bennett, Idaho Geological Survey).

Canadian Superior Mining (U.S.), Ltd./ Pioneer Metals Corp./Stibnite Mines, Inc., Operations

Several open-pit mines have been operated, or are being considered, along the eastern side of the valley of the East Fork of the South Fork of the Salmon River. Most of these areas are on land that was originally part of United Mercury Mines Cinnabar claim group; some of the claims were probably staked in UMM's name by Yellow Pine Co. or Bradley Mining Co. when those companies were actively working to link the Cinnabar, Meadow Creek, and Hennessy claim groups into one unit (Figures 2, 3, 7, 8, and 73). (Table 10 shows the various companies that have operated on these properties.) Little progress was made at any of these claims until relatively recently. The Doris K. Group was worked between about 1918 and 1925 (1919 IMIR; Schrader and Ross, 1926), but the workings were inaccessible ten years later (Currier, 1935). The property was originally held by the Doris K. Mining Co., but was acquired by United Mercury Mines, probably in 1922 (Schrader and Ross, 1926). The Midnight "ledge" was known in the early 1920s (Schrader and Ross, 1926). The West End deposits were discovered by Bradley Mining Company in 1943, and work at that time showed that the oxidized ore could readily be treated with cyanide (Cooper, 1951). The U.S. Geological Survey conducted a geochemical sampling program in West End Creek in 1972 which outlined a gold and silver anomaly in West End Creek (Leonard, 1973).

Between 1962 and 1965, Antimony Gold Ores Co. strip-mined antimony ore from various properties in Valley County. One of the properties was in the Garnet Creek area. The company shipped concentrates (produced in a 50-tpd mill near Yellow Pine) in 1962 and 1963. Work in 1964 consisted of mining and stockpiling ore at the mill. Some of the ore was milled in 1965, but the concentrates were not shipped.

In 1974, Canadian Superior Mining (U.S.), Ltd., began exploring the Stibnite area. Also, a joint venture between El Paso Mining and Milling Company and Louisiana Land and Exploration Company explored near Stibnite in 1974 and 1975. The work consisted of geological, geophysical, and geochemical investigations, and included some diamond drilling. Canadian Superior purchased the property controlled by the joint venture in 1975 (USFS, 1994).

Canadian Superior continued to evaluate the gold potential of the Stibnite area in 1976 and 1977. In 1978, the company started a pilot plant near Stibnite to recover gold from a cyanide heap leach operation. The plant produced a gold-silver bar weighing 60 ounces. Construction and operation of this plant was described by the USFS (1980, p. 2):

> During the 1978 and 1979 seasons, CSM [Canadian Superior Mining] also constructed and operated a pilot level mining operation [Figure 79] and cyanide heap leaching plant. The pilot operation consisted of mining three 500-ton lots of ore. The ore

Table 10. Companies operating at the Cinnabar Group and other claims adjacent to the Yellow Pine and Meadow Creek Mines.

Company Name	Officer	Date Incorporated	Charter Forfeited	Year(s) at Mine
J.J. Oberbillig	---	---	---	1918-1921[1]
Doris K. Mining Co.	1	1	1	1918(?)-1922(?)
United Mercury Mines	J.J. Oberbillig, President	Jan. 22, 1921; reinstated: Dec. 20, 1929	1929; Nov. 30, 1963	1921-1993[2]
Yellow Pine Syndicate	Fred W. Bradley, President	---	---	1927-1928
Yellow Pine Co.	Fred W. Bradley, President	filed in Idaho: May 25, 1928	taken over by Bradley; Nov. 30, 1942	1928-1938
Bradley Mining Co.	Worthen Bradley, President	June 28, 1938	active: 1981	1938-1942(?)
Bonanza Mines, Inc. (55%)	S.R. Smith, President	filed in Idaho: Oct. 2, 1941	Nov. 30, 1949	1942-1949
Antimony Gold Ores, Inc.	Ernest Oberbillig, President	Feb. 11, 1935	active: 1981	1962-1965
Myown Mines Co.	Don D. Oberbillig, President	Oct. 23, 1941	active: 1981	uncertain
J.J. Oberbillig Estate	---	---	---	1958-[2]
Electronic Metals, Inc.	Lesley Oberbillig, President	Feb. 20, 1964		1971-1972
Canadian Superior Mining (U.S.), Ltd.	1	Dec. 8, 1975	taken over by Superior Oil	1974-1979
El Paso Mining and Milling Co./ Louisiana Land and Exploration Co. joint venture	1	1	1	exploration: 1974-1975
Superior Oil Co./ Superior Mining Co.	1	Feb. 18, 1968	bought by Mobil Corp.	1979-1984
TRV Minerals (25%)	1	1	1	1982(?)- (?)
Mobil Corp.	1	1	active	1984-1986
Pioneer Metals Corp. (50%; operator)	Robert D. Willis, President, CEO and director	1	1	1986-1991
Mining Finance Corp. of Toronto, Canada (50%); Barrier Reef, Inc./ MinVen Gold Corp.	1	1	1	1986- (?)

Table 10 (continued). Companies operating at the Cinnabar Group and other claims adjacent to the Yellow Pine and Meadow Creek Mines.

Company Name	Officer	Date Incorporated	Charter Forfeited	Year(s) at Mine
Pegasus Gold, Inc.	John M. Wilson, President and CEO	August 20, 1984	active	1988-1991
MinVen Gold Corp. (100%)	[1]	[1]	name changed to Dakota Mining	1991-1993
Stibnite Mine, Inc.	subsidiary of MinVen/Dakota	[1]	active	1992-
Dakota Mining	[1]	1993	active	1993-

[1]This information is not available in the IGS's files.
[2]Some of the claims in this block are still owned by the J.J. Oberbillig estate and/or by Oberbillig's heirs.

> was processed at the leaching facility located north of the existing tailing pile in an area known as Adkin's Flat. The operation involved a specially designed impervious asphalt pad [Figure 80], and a total containment non discharge leaching process utilizing a dilute sodium cyanide solution to dissolve gold and silver from the ore pile. The gold- and silver-laden solution was then passed through activated carbon columns which absorbed the precious metals [Figure 81]. The columns were taken to a commercial laboratory for final processing. At the end of each operating season, the piles were washed and neutralized, and the remaining solution treated to convert the sodium cyanide to carbon dioxide and water.

During 1979, Canadian Superior conducted further exploration and continued work on its cyanide heap-leach facility. The company worked to acquire the necessary permits for operating small open pits in the West End and Garnet Creek areas. This included doing feasibility studies and extensive environmental testing throughout the Stibnite area. During the year Superior Oil Company of Houston, Texas, the parent company of Canadian Superior, tendered an offer for the 4.6 million outstanding shares of Canadian Superior.

Superior did no further testing of its proposed heap leach operation in 1980. The U.S. Forest Service and an independent consultant prepared the draft Environmental Impact Statement, which was scheduled to be released in December. The company estimated that it had spent over $2.3 million on geologic mapping, sampling, diamond and rotary drilling, metallurgical testing, and construction of the pilot plant.

The Environmental Impact Statement for Canadian Superior's cyanide heap-leach gold operation was completed early in 1982, and the company started

Figure 79. West End Pit in 1982 (photograph by Earl H. Bennett, Idaho Geological Survey).

Figure 80. Canadian Superior's pilot leach pad at Stibnite in 1979 (photograph by Earl H. Bennett, Idaho Geological Survey).

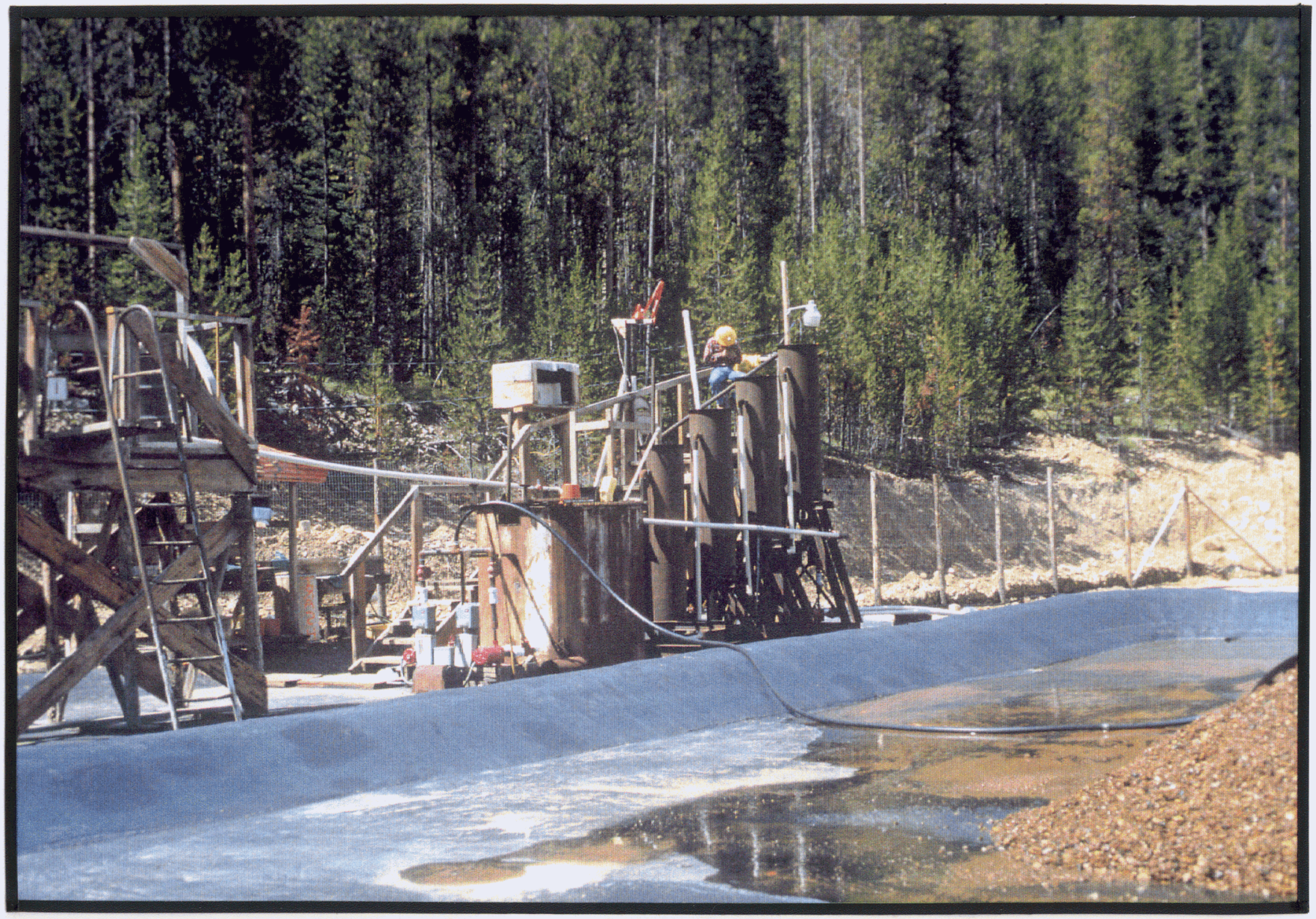


Figure 81. Canadian Superior's pilot recovery plant at Stibnite. The black cylindrical objects are the activated carbon columns (photograph by Earl H. Bennett, Idaho Geological Survey).

construction on its production pads. The five leach pads were 250 feet wide by 325 feet long and were designed to hold 25,000 to 30,000 tons of ore per pad. Plans called for six large trucks to haul 2,000 to 3,000 tpd of ore from the West End Pit to the leach pad site. The company hoped it would be able to recover 1 ounce of gold for every 10 to 20 tons of ore. The facility was 90 percent complete by the end of the year. Sixty people were employed during construction, and the company needed a similar number of people to operate the mine. The life span of the mine was projected at seven to ten years, with operations being carried out for only six months of each year because of severe winter conditions. Preproduction costs for the new mine were estimated at $10 million.

The five leach pads were completed during 1982. (Figure 82 shows an overview of the leach pads and the plant.) The company leached 200,000 tons of ore, producing more than 1,000 ounces of gold. The operating season was short due to construction and start-up efforts. About 2,000-3,000 tpd of oxidized ore was removed from the West End Pit. The ore was hauled to a crusher, reduced to minus 1.25 inch, and placed on the leach pads. Activated charcoal in closed columns was used to reclaim the gold from the pregnant cyanide leach solution. (Figure 83 shows the flow chart for processing the ore.) Reserves were estimated at 2.5 million tons of ore averaging 0.085 opt of gold.

The main contractor for the mining operations was Western Construction of Boise. Superior attributed the smooth construction and start-up to Western's excellent efforts. Western employed 80 people at the site, and Superior had about 20 more. A major part of Superior's environmental planning involved reclaiming the tailings pile left from previous operations. The 77-acre dump contained about 4.2 million tons of finely ground waste left from the Bradley operations (USFS, 1994). The pile was approximately 1,200 to 1,500 feet wide, 2,200 feet long, and up to 50 feet thick. The material was highly susceptible to liquefaction (USFS, 1980). In addition, Meadow Creek meandered through the tailings, and the extremely fine-grained material was easily eroded. An estimated 10,000 tons had been removed by Meadow Creek (Klahr, 1987). Between 1982 and 1994, 6,050,000 tons of crushed, spent ore were placed on top of the Bradley tailings (Figure 84 and 85). In addition, Meadow Creek was rerouted around the tailings pile (Figure 67), and a retention berm, or keyway, was built to prevent the tailings from being carried downstream (USFS, 1994).

Superior's West End Mine completed its first year of full production in 1983 and was the largest gold producer in Idaho. The company mined 480,000 tons of ore, yielding 29,000 ounces of gold. The mine operated from May to November, when it shut down for the winter. The mining contractor was Western Construction of Boise. About 100 people were employed in the mining operation and an additional 45 men at the mill. Reserves were estimated at 1.8 million tons of ore, averaging 0.085 opt gold.

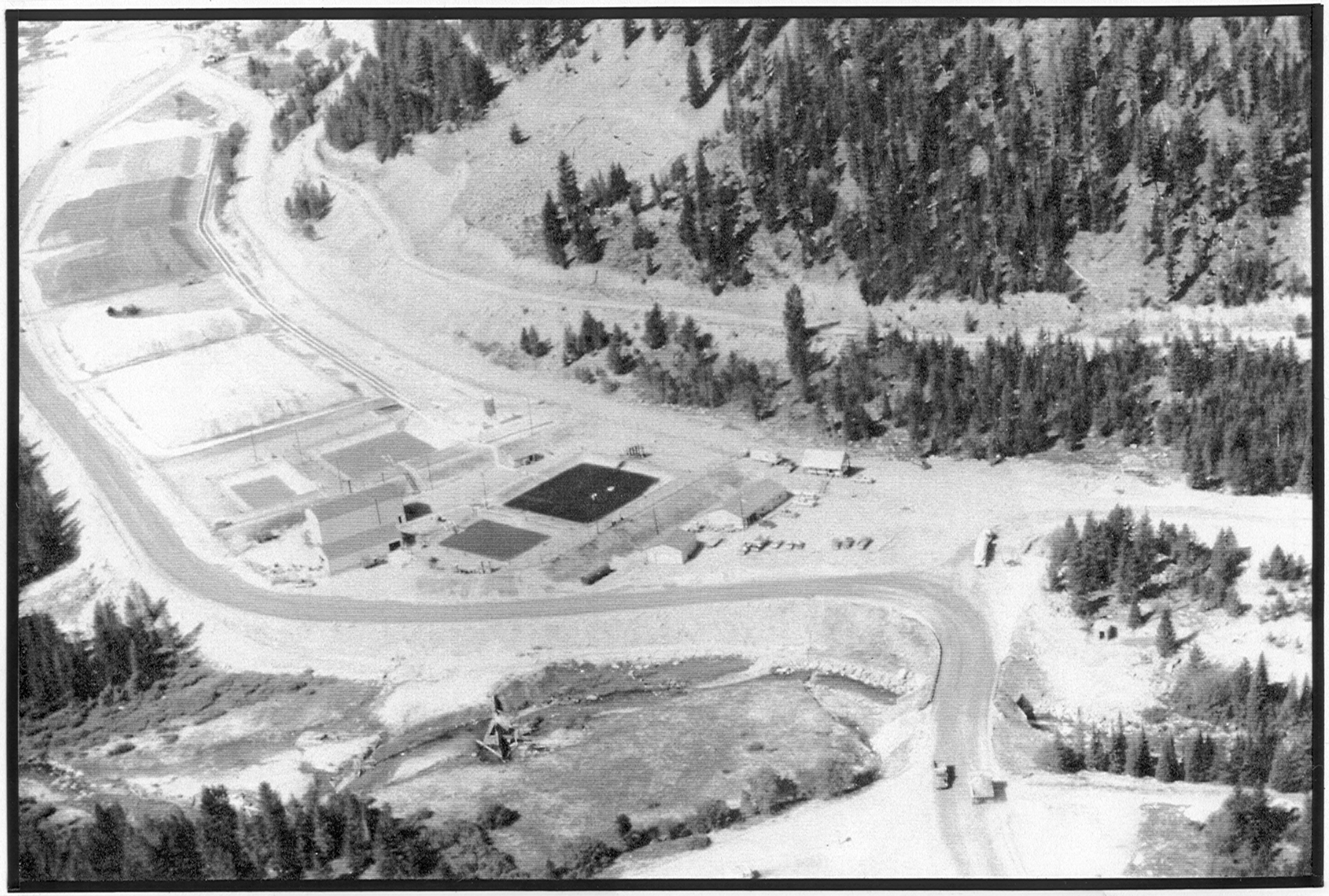


Figure 82. Aerial view of the five leach pads and the processing plant at Stibnite in 1984 or 1985 (photograph by Earl H. Bennett, Idaho Geological Survey).

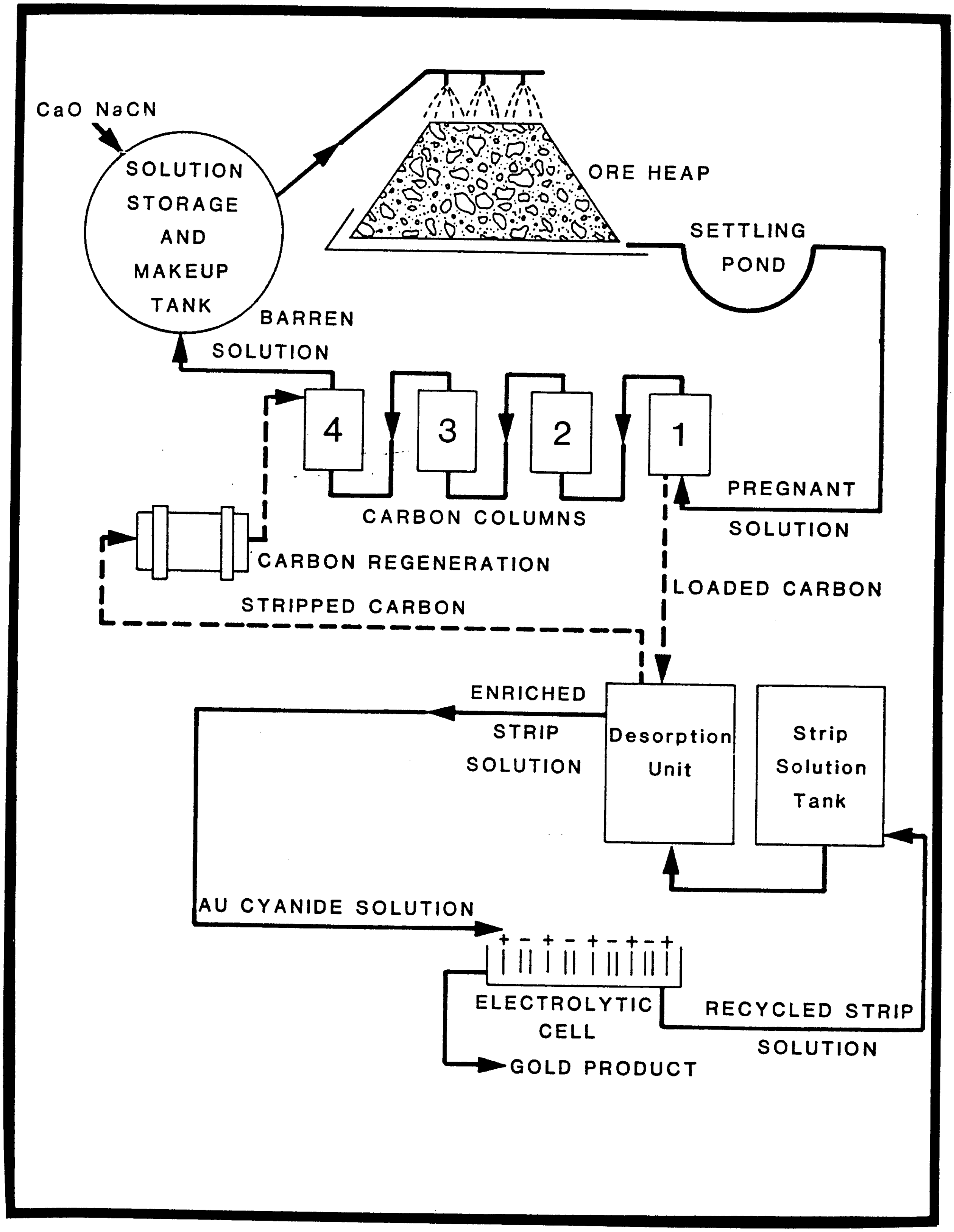


Figure 83. Schematic diagram of the cyanide leaching process at Superior's Stibnite plant (USFS, 1980, Figure 4-2).

Figure 84. Waste rock piled on top of old tailings at Stibnite. The gray material near the water is fine-grained tailings left from the Bradley operation (photograph by Virginia S. Gillerman, Idaho Geological Survey).

Figure 85. Looking across the waste rock from the Pioneer Metals-Hecla operations at Stibnite. This material has been placed across the fine-grained tailings left from previous operations (photograph by Earl H. Bennett, Idaho Geological Survey).

The West End Mine was again the state's largest gold producer in 1984, even though production was down from the 1983 level. The mine functioned normally during the season and closed for the winter in November. In July, Mobil Oil bought Superior Oil for $5.7 billion (including a $423.7 million stock purchase on June 21, the largest single trade in the history of the New York Stock Exchange). Rumors were widespread that Mobil wanted to sell Superior's mining operations, and TRV Minerals announced that it was interested in buying the Stibnite operation. In November, Mobil announced that the mine might close in 2½ years, five years earlier than expected, due to the low price of gold and the resulting decrease in estimated reserves.

The West End Mine did not operate in 1985, and the heap leach plant treated previously mined ore. Mobil Corp. decided to sell the mine, and at the end of the year, was negotiating with TRV Minerals.

In the spring of 1986, Pioneer Metals Corporation purchased the Stibnite heap-leach gold mine from Mobil Corporation for $2.95 million. The Mining Finance Corporation provided two-thirds of the capital needed for the purchase and was a 50 percent partner in the deal. TRV Minerals, owner of 25 percent of the West End Pit, owned 18 percent of Pioneer's stock. Pioneer resumed mining in June, with a division of Peter Kiewit and Sons as contractor. The first two bars of gold were poured on July 14; one contained 250 ounces of gold and the other 400 ounces (Mining Magazine, 1986). The cycle of loading, leaching, neutralizing, and unloading each leach pad took about fifty days. (Figure 86 shows one of the leach pads in operation.) The heap leach operation produced 30,400 ounces of gold and 15,000 ounces of silver from 510,000 tons of ore during the year. Production costs were about $235 per ounce of gold, and mine costs were approximately 12 percent below projections. Eighteen reverse circulation holes were drilled in the Garnet Creek and South West Extension areas. Reserves in the Garnet Creek area numbered 290,000 tons averaging 0.4 opt of recoverable gold (Mining World, 1986). Pioneer patented a number of mining claims in the spent ore disposal area, at the West End Pit, and under the processing plant and housing areas. The company's Plan of Operations was amended to expand the West End Pit (USFS, 1994). (Figure 87 shows the West End Pit in 1986.)

Pioneer Metals' Stibnite Mine was again Idaho's leading gold producer in 1987. The company mined 8,000 tpd averaging 0.05 opt gold from the West End deposit. The operation produced about 36,500 ounces of gold and 22,400 ounces of silver from oxidized ore during the year. (Figure 88 shows Pioneer's mill.) The mining contractor, Gilbert Construction Company, employed about 70 people at the mine; Pioneer had 20 employees. Production from the West End Pit ended in 1987, and future production was planned from the Garnet Creek and Southwest Extension orebodies. Total production from the West End Pit was approximately 128,500 ounces of gold and 67,400 ounces of silver. Drilling during the year (Figure 89) confirmed

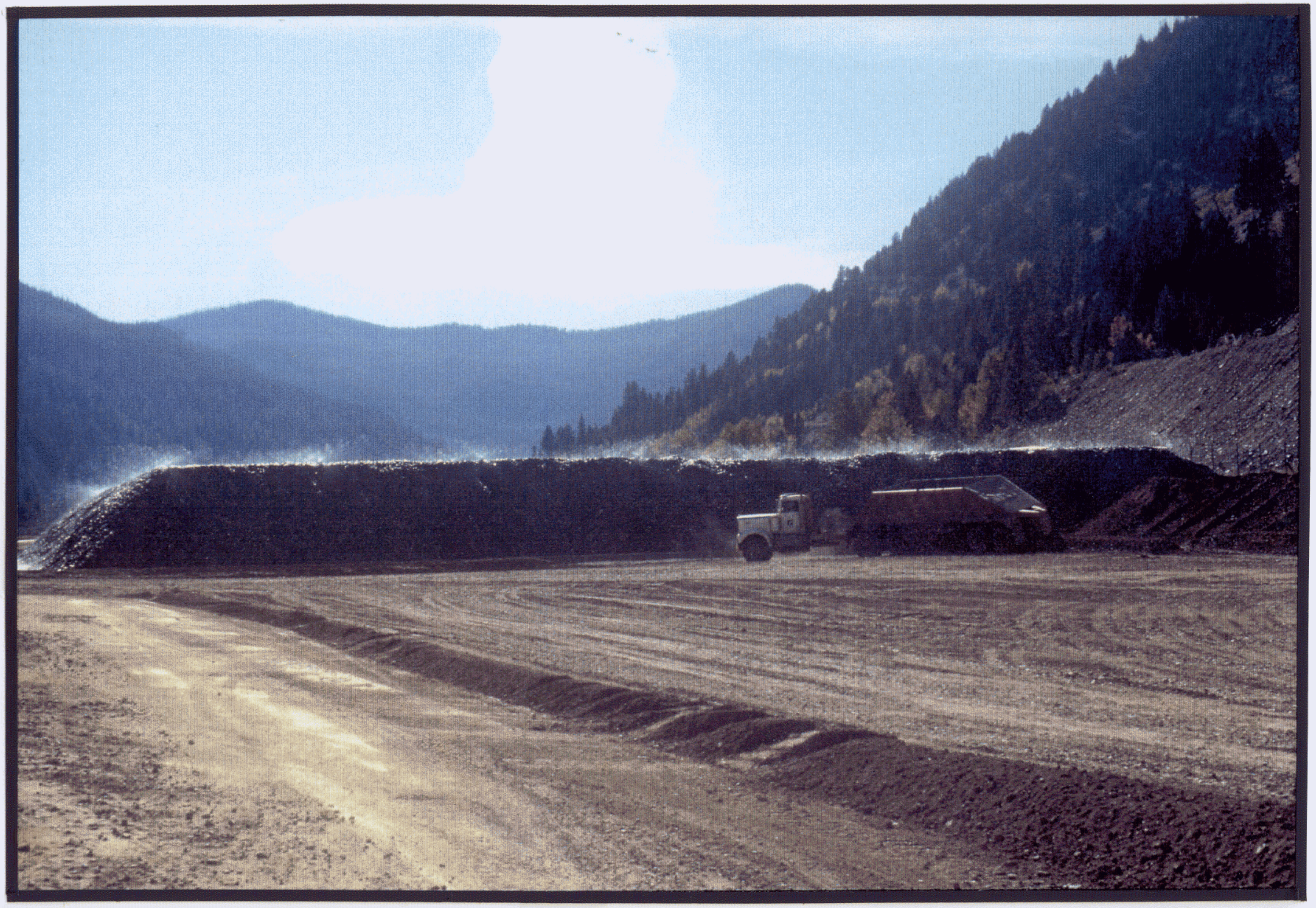


Figure 86. Leach pad in operation at Pioneer's Stibnite plant in 1987 (photograph by Earl H. Bennett, Idaho Geological Survey).

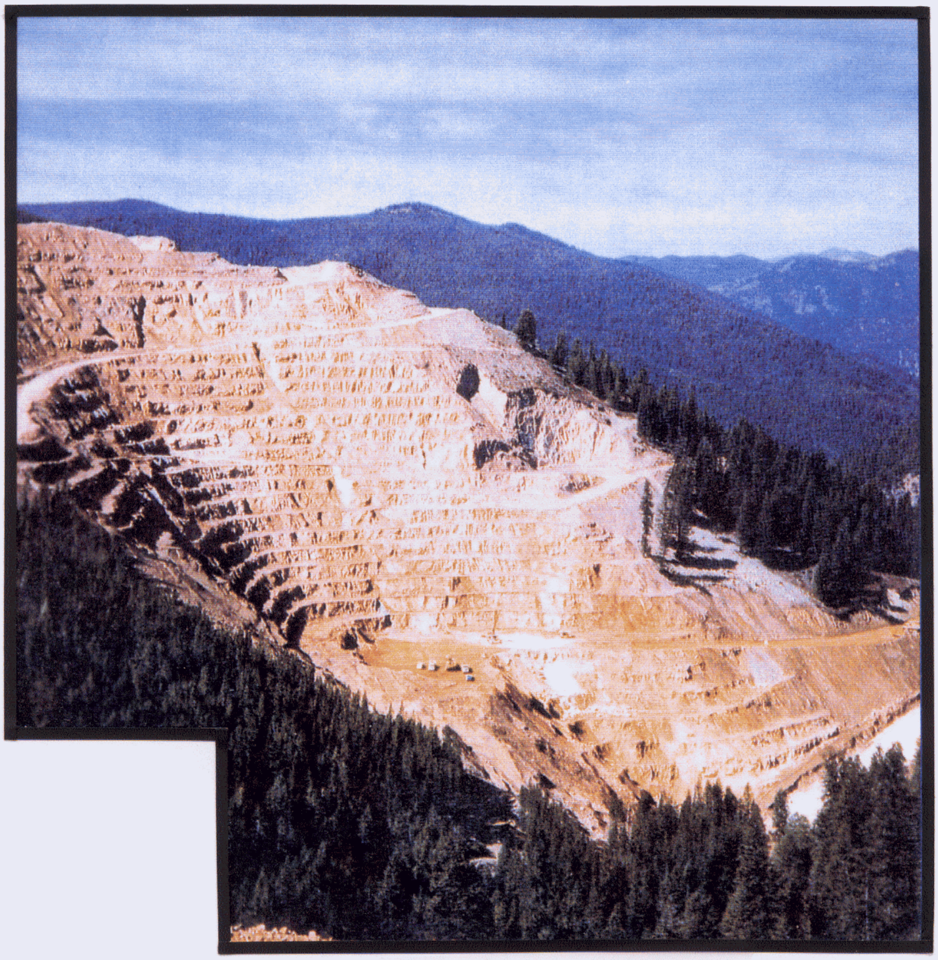


Figure 87. West End Pit in 1986 (Pioneer Metals Corporation 1986 Annual Report).

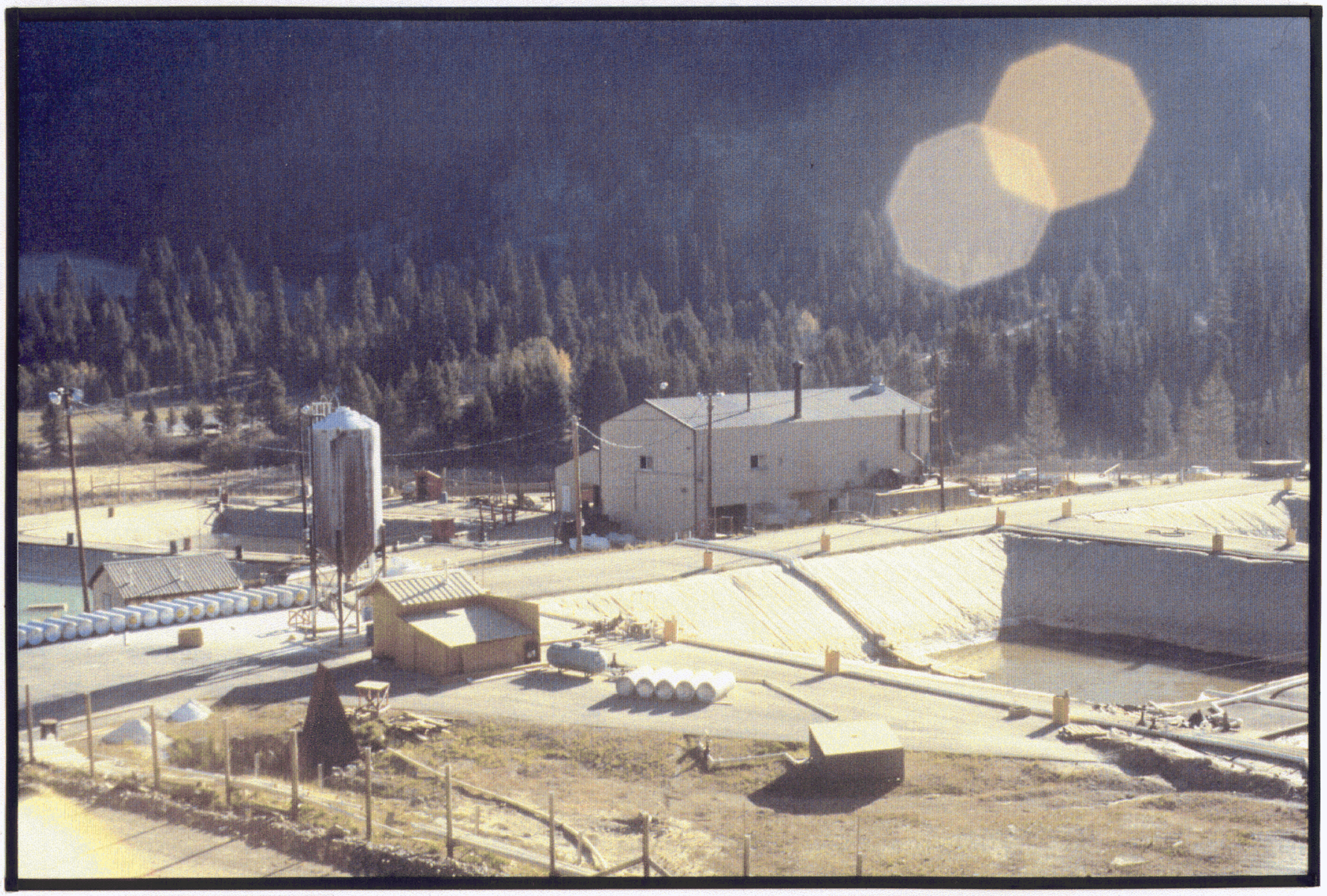


Figure 88. Pioneer's processing plant at Stibnite in 1987 (photograph by Earl H. Bennett, Idaho Geological Survey).

Figure 89. Drill in the West End Pit in 1987 (photograph by Earl H. Bennett, Idaho Geological Survey).

that there were additional reserves of minable oxide ore adjacent to the existing workings. Pioneer also evaluated the sulfide ore beneath the oxide orebodies. About 30,000 tons of sulfide material, which contained about 0.1 opt of gold, was stockpiled and sampled for metallurgical testing.

In 1988, Pioneer mined ore from a new pit above the West End Mine. The company also had about 3 million tons of reserves in several small deposits, giving it about four more years of operation. In addition, Pioneer Metals reached an agreement with Hecla Mining Company to process 400,000 tons of ore a year from Hecla's Homestake orebody for a fixed fee. The first gold from the Hecla project was poured in June. Argee Corporation was the mining contractor for Pioneer. Production in 1988 was down significantly from 1987 levels. A disagreement with Hecla over leach-pad usage resulted in 45 days being lost from the limited operating season. Pioneer did process 241,576 tons of its own ore, which contained 0.031 opt gold. The ore yielded 5,516 ounces of gold and 4,884 ounces of silver. A 47-hole drilling program increased oxidized ore reserves from 800,000 tons (with a grade of 0.052 opt gold) to 3,175,000 tons (with a grade of 0.04 opt gold). This insured operation at 1988 levels for another four years. The total resource at the mine was estimated to be 11,200,000 tons of ore containing 0.037 opt gold.

Pioneer processed about 880,000 tons of ore averaging 0.037 opt gold during the 1989 season. Work at the Stibnite operation started in May. The mining contractor changed when D.H. Blattner and Sons of Avon, Minnesota, outbid Gilbert Western Construction for the contract. During the year, in addition to processing its own ore, Pioneer leached ore from Hecla's Homestake Pit. Pegasus Gold increased its holdings of Pioneer stock to almost 8 percent and held warrants which, if exercised, would increase Pegasus' interest to 20 percent.

In 1990, Pioneer produced about 30,000 ounces of gold and made plans to open a new pit on Forest Service land in 1991. The Splay Pit was mined out during the year. Pioneer canceled its toll-leaching contract with Hecla, citing the increase in its reserves as reason for needing all its leach pads for its own ore. However, the year's events were dominated by environmental and legal difficulties. In April, the Idaho Department of Health and Welfare reported low levels of cyanide in Meadow Creek. The cyanide was supposedly coming from leached ore that had not been fully neutralized. Pioneer faced up to $30,000 in fines and penalties for the cyanide leak. A diesel fuel leak at the site was included in the citation.

In financial matters, Pegasus Gold Corporation sued Pioneer for failing to meet interest payments on a $12 million loan. In 1988 Pegasus bought $12 million in Pioneer debentures that were convertible to common stock. In addition, the Stibnite property was offered as collateral for the loan. Pioneer defaulted on interest payments in the fall of 1989. Pegasus wrote off $3.7 million on the investment in 1989 and another $1 million in 1990. Also, Pegasus sued Pioneer and announced plans to take over the Stibnite property. In August, the Supreme Court of British Columbia ruled in Pegasus' favor. This ruling placed Pioneer one step closer to bankruptcy.

Pegasus Gold assumed ownership of the Stibnite Mine in 1991 as a result of the settlement of its lawsuit with Pioneer Metals. In the middle of the year, MinVen Gold Corporation purchased the mine from Pegasus for $6.5 million. MinVen operated the property with 30 employees at the site, while the mining contractor, D.H. Blattner, employed an additional 70-80 workers. MinVen mined the West End Pit, which had almost a million tons of 0.039 opt gold in calc-silicates and fractured metasediments along a jog in the West End fault. The ore was mined on 20-foot benches, and the crushed ore was placed on the five onload/offload leach pads. (Figure 90 shows the crushing plant.) The gold was stripped from the pregnant solution in a carbon circuit and sent through an electrowinning cell before firing. The resulting doré bullion (mixed gold and silver) contained about 30 percent silver. Approximately 27,000 ounces of gold was produced in 1991. Reserves totalled 2.6 million tons of 0.043 opt gold in oxide ore in the Midnight, Northeast, Stibnite, and Garnet Creek pits. This ore could be mined with a 2.5 to 1 strip ratio and was expected to last for two to three years at 1991 production rates. Exploration work, including soil and rock sampling, geophysics, and drilling, was conducted throughout the year. Total production since leaching began in 1982 was approximately 150,000 ounces of gold. MinVen spent almost $10 million at the mine during 1991. The company corrected the problems that had led to the minor diesel and cyanide spills at the site in 1990.

During 1992, the mine was operated by Stibnite Mine, Inc., a subsidiary of MinVen Gold Corporation. About 950,000 tons of ore was mined during the May-to-November season and yielded 31,549 ounces of gold. The West End Pit was almost exhausted, and mining activity shifted to two new pits, the Midnight Pit at the south end of the West End Pit and the Northeast Pit. Additional reserves of oxide ore were present in the West End Pit, but they were economically marginal at 1992 gold prices. The company reclaimed the Upper West End dump during the year. Figure 91 shows a pile of waste rock being used to fill part of the pit.

Stibnite also announced plans for expanding operations in April 1992. The company applied to the Payette National Forest for permits to open five new sites: the Stibnite, Broken Hill, Ridge Top, Cinnamid, and Doris K pits (Figure 3). The new deposits covered 265 acres, mostly on federal land. The deposits contained an estimated 15.2 million tons of ore, which could extend the mine's life by 15 years. Plans called for mining at a rate of 990,000 tons a year and processing the ore at the existing heap-leach facility. The preliminary Environmental Impact Statement was completed late in 1994 (USFS, 1994).

Stibnite produced just under 1,000 ounces of gold in 1993, with half of it coming from the cleanup of ore mined in 1992. Minimal mining was started in August at the West End Pit, which was the only deposit that the company had a permit to operate. About 1½ million tons of rock were moved, but only 100,000 tons of that was ore. The reason for the poor performance was new Forest Service

Figure 90. Pioneer's crushing plant at Stibnite (photograph by Earl H. Bennett, Idaho Geological Survey).

Figure 91. Waste rock used to backfill the West End Pit. This is part of the general reclamation plan for the mine (photograph by Earl H. Bennett, Idaho Geological Survey).

regulations that limited transport of hazardous materials over the Johnson Creek road. (Petroleum products and explosives are classified as hazardous materials in this context.) Only four trucks carrying these materials were allowed to use the road each week, and each vehicle could not exceed 25,000 pounds gross weight. This severely curtailed bringing supplies to the mining operation. The restriction was supposed to be in effect only until a biological assessment of the risks to the chinook salmon was completed. The study was needed after the salmon was listed as a threatened species in 1992.

Stibnite was cited by the Idaho Department of Health and Welfare Division of Environmental Quality (DEQ) for hazardous waste and water quality violations at the mine during 1993. The company agreed to pay a $3,800 fine for failure to determine if chemicals from the mine's lab and the lead containers used in the plant were hazardous materials. The water quality violations involved a diesel fuel leak and problems with diesel and nitrate contamination of the ground water. The company disputed some of these violations, for which the maximum fines totalled $43,000. In resolving this issue, DEQ required remediation of the spills and stipulated a number of modifications to the Stibnite operation. In particular, Stibnite was required to apply for a permit to process ore using cyanide; this had not been required before because the mine went into operation before Idaho's present law governing the use of cyanide in mining operations was passed in 1988.

Also in 1993, MinVen (Stibnite Mine's parent company) eliminated its debt and obtained capital from an $11 million private stock placement. With its restructuring complete, MinVen changed its name to Dakota Mining.

No work was done at the mine in 1994. Stibnite submitted its application for a cyanidation permit to DEQ in early April, and public hearings were held on the application. However, the major obstacle to 1994 operations was the failure of the National Marine Fisheries Service to decide on two permits that had been applied for in August 1993. These were a commercial road permit to transport equipment and supplies to the mine and a permit to operate the Garnet Creek Mine. The National Marine Fisheries Service, which had to approve the permits because of the possible impact of Stibnite's activities on the endangered chinook salmon, repeatedly requested supplemental information on the permit applications. However, the National Marine Fisheries Service had made no decision on the applications by the time the company announced in September that it would not operate at all during the year. In May, the Idaho Conservation League, the Concerned Citizens for Responsible Mining, and the Mineral Policy Institute threatened to sue Stibnite over compliance with the Clean Water Act and the Endangered Species Act. A company spokesmen responded by stating that Stibnite was in compliance with both laws.

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Plate 1. Geologic map showing orebodies at the bedrock surface of the Yellow Pine Mine and the Sugar Creek area (Cooper, 1951, Plate 39).