

the sphalerite is both fine- and coarse-grained. Much of the sphalerite is speckled in quartz with more or less pyrite and very little galena. At the main-shaft dump considerable sphalerite and some galena ore are present. Dense pyrite masses and pyritic gray quartz gangue are common. At the dump of the middle shaft base-metal minerals are much less conspicuous, and rhodonite and rhodochrosite are present in fragments of both vein material and wall rock. The vein crops out prominently just west of the middle and the main shafts. At the former it is very irregular, stringer-like with many inclusions, and is 6-10 feet wide. At the upper shaft a small quantity of fine and coarse sphalerite intergrown with galena is on the dump. Some of the vein matter contains colloform seams of "marcasite" which Ransome⁹¹ demonstrated to be pyrite. Ransome reported that about 800 tons of gray copper and galena ore were claimed to have been taken from the vein during the development between 1874 and 1881. Output since 1900 has been small and has been mostly incorporated with that of the Frisco tunnel. The Red Cloud workings were opened up for sampling and examination by the Sunnyside Mining and Milling Co. in 1928-1930. In 1914 the Red Cloud Leasing Co. shipped to the smelter 23 tons of lead and dry siliceous ores which contained 4.80 ounces of gold, 426 ounces of silver, 117 pounds of copper, and 6,639 pounds of lead.⁹²

Other Mines

Of the scores of other small mines and prospects in the Mineral Point area it is only possible to point out or briefly mention a few. The inclusion here does not necessarily indicate an inferior vein, lode, or ore shoot.

The Oyama mine, about 1,000 feet northwest of Mineral Point, was worked through a shaft. Its dumps indicate considerable work. The vein, though poorly exposed on the flat

⁹¹Op. cit., pp. 77, 186.

⁹²Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

meadows, appears to strike about N. 35° E. and to be continuous to the north with the Pactoles vein. In 1918, 61 tons of lead ore yielding 20.88 ounces of gold, 1,329 ounces of silver, 2,152 pounds of copper, and 46,356 pounds of lead were shipped from the Pactoles mine. The Palmyra mine, located about 1,000 feet west-southwest of Mineral Point, was also worked through a shaft which is reported to be about 120 feet deep. The vein strikes about N. 55° E. and is probably almost vertical. It is continuous with the Zenobia vein to the northeast. About 400 feet southwest the Palmyra vein turns sharply to the south, a fact early recognized by the dogleg in the patented claim.

About 600 feet west of the London mine and below the road are extensive cuts on a prominent vein which is the northeast extension of the Red Cloud. The cuts are closely spaced and arranged along the vein for 200 feet or more; one small shaft (said to be 50 feet deep) has been sunk in the cuts. Although mostly on the Dewitt claim, the northeasterly excavations appear to be on the not quite contiguous Wicker claim. The vein strikes N. 58° E. and dips at the relatively low angle of 55° SE. Several good bands of sphalerite and galena are exposed in the vein which is 10 to 15 feet wide. In 1928 a small shipment made from the Dewitt workings to the Sunnyside mill assayed 0.06 ounces of gold and 13.04 ounces of silver to the ton, 0.36 percent in copper, 10.33 percent in lead, and 15.2 percent in zinc.

About 650 feet northeast of the main Red Cloud shaft and on the same vein is the Boston mine. Its altitude is 11,945 feet. It consists of a tunnel nearly 200 feet long driven S. 45° W. on the vein, which dips 70° SE. A shaft, which was evidently sunk later, is located on the dump and its collar is about five feet higher than the tunnel. The vein is a stringer lode along sheeting which has sliced the banded latites into irregular thin slabs. Sphalerite reject is common through the dump. The vein matter comprises gray and white quartz, formed during several stages and more or less

impregnated with pyrite. Rhodonite and rhodochrosite are also present.

The Rip Van Winkle mine on Mineral Point Knob south of the Bill Young mine has a 100-foot shaft on a very wide lode. The Little Maud on the south slope of Seigal Mountain is reported to have a pay streak 20 inches wide containing gray copper, brittle silver, and galena developed in a 50-foot shaft. The American claim north of the Uncompahgre Chief mine is reported to have a 38-foot shaft on a three-foot vein containing an ore streak of galena and chalcopyrite. The Port Henry prospect west of the Ben Butler mine was developed by a 40-foot shaft, and some high-grade silver ore was reported. The Blacksmith and Great American prospects north of the Ben Butler mine have good showings of base-metal ore, and it is reported that bismuth and tungsten occurred in some places on the claims.

Other prospects worthy of additional development are the Great Eastern and Boston Dip near U. S. M. M. C. west of Mineral Point; the Coronado, Bond, and Wolverine southwest of Mineral Point, and the Cacique on the multiple vein set south of the Union mine.

In 1882 Burchard⁹³ reported as follows of the Lake Park prospect which is west of Mineral Point near the Brazillian mine: "The vein is 4 to 6 feet in width, the general character of ore exposed being galena, gray copper, and a quartz-gangue matter carrying gold. An average of ten assays made in Buffalo, N. Y., from ore shipped in bulk from the different locations, gave \$380 in gold and silver per ton."

Exploration and Prospecting

The principal northeasterly vein zones of the Mineral Point area from northwest to southeast are

- (1) Lake Park, Malone, Little Chief, and Sunset vein.
- (5)

⁹³Burchard, H. C., Report of the Director of the Mint upon the production of precious metals during the calendar year 1882, p. 553, 1883.

- (2) Great Eastern, Boston Dip, and Maud S. vein. (2)
- (3) Coronado, Bond, and Monette vein. (6)
- (4) Mountain Maid, Rip Van Winkle, Mastodon, Morning Star, and San Juan Chief vein. (8)
- (5) Bill Young, Davenport, Marathon vein. (8)
- (6) Cacique, Cross, Baltimore, and Elephant vein. (8)
- (7) Clara, A. W. Hafer, Del Norte, Uncompahgre Chief, American, J. H. Graham, Winnebago, and Great American vein. (8)
- (8) Vermillion, Ellen, Red Cloud, Dewitt, Wicker, and Ben Butler vein. (9)
- (9) Sewell, Big Giant, and Lucky Jack vein. (9)
- (10) Hadley, Napoleon, Denver, Twilight, and White vein.

In parentheses at the end of each are the numbers of the correlated or connected vein zones at Lake Como (see page 416). The future of mining through mine entries in the Mineral Point area is not good because of inaccessibility, the necessity of working through shafts, and the pumping of water which stands very near the surface almost everywhere. Future profitable operations on Mineral Point ores must come through large-scale operations handling low-grade as well as high-grade ores. Sporadic output will continue from high-grade pockets or small shoots. The best hope for big production is through low tunnels such as the Frisco.

The average length of lode or wide stretch on a vein is 400 to 500 feet; ore shoots are usually coincident with but smaller than these wide stretches. Even where numerous and prominent enough to be shown on the map, these wide stretches are on the average 1,000 feet apart. They are generally associated with turns in the veins, although this asso-

ciation is not nearly so obvious or clear as around Lake Como. Many of the lodes are curved, but there is no uniformity in the direction of curving. Splitting, branching, and multiplicity in general are common in the lodes, notably in the Red Cloud, Yankton, Vermillion Extension, and Rip Van Winkle. Intersections of veins are promising places for prospecting and in this respect the geologic map (plate 1) may be used as a guide.

CALIFORNIA GULCH AREA

General

Geologic mapping in California Gulch is incomplete, and only the mines and prospects of the west or northwest side of the gulch are considered in this report. Elsewhere in the area, however, there are few noteworthy veins except near Animas Forks.

California Gulch is a large singular glacial valley of smooth and gracefully curving form which although typically blunt-headed does not end in a cirque basin. A fair road usually open only a few months out of the year leads to the Mountain Queen mine at the head of the gulch.

The rocks on the west side of the gulch comprise rhyolite breccias, flows, and flow breccias of the Eureka rhyolite overlain either by andesite flows, tuffs, and breccias of the pyroxene andesite unit or by the Burns latite.

The veins in this area are mostly eastward continuations of those at Lake Como and Mineral Point, but the mammoth Mountain Queen is one, not hitherto described, that may continue southwestward to Ross Basin and appears to be connected northeastward with the Columbus vein near Animas Forks. Although the northeasterly veins are dominant, a number of easterly or northwesterly veins are present.

Frisco Tunnel

The Frisco Tunnel is located about two-thirds of a mile up California Gulch from Animas Forks. The altitude of its portal is 11,430 feet. An old mill and several dilapidated buildings still stand at the dump. The Frisco or Bagley tunnel is a crosscut 5,816 feet long projected to "get under" many of the northeasterly veins of Mineral Point, and especially those of the Red Cloud group. Drifts have been driven from it along five principal veins, listed in order from the portal to the breast as follows (see fig. 28):

- (1) Hadley "Morgan" at 2,445 feet; 710 feet of drifts.
- (2) Sewell at 4,035 feet; 100 feet of drifts.
- (3) Red Cloud at 4,500 feet; 1,100 feet of drift.
- (4) "None Such" at 5,065 feet; 650 feet of drift.
- (5) Del Norte "Dakota" at 5,800 feet; 600 feet of drift.

In all, the tunnel work aggregates about 9,000 feet and in addition a 315-foot raise connects the Red Cloud drift to the Red Cloud No. 3 level. An undetermined amount of stoping has been done from the Dakota, Red Cloud, and Morgan drifts. The Morgan, Sewell, "None Such," and about half of the Red Cloud were not accessible to this survey; the geologic mapping of the veins in these parts, quoted in figure 28, is the work of Carlton D. Hulin for the Sunnyside Mining and Milling Co.

The Hadley and Sewell veins dip northwest at the tunnel level as on the surface, and the correlation between the two exposures is reasonably simple and certain. At the tunnel level in the vicinity of the Red Cloud drift there is not

the multiplicity of veins that there is on the surface. This appears to be due to the differences in the manner of fracturing and opening up of the fractures in the rocks of the underlying Eureka rhyolite as compared to the banded Burns latite at the surface. In view of the bearing of the Red Cloud drift and the point at which the vein was encountered it seems quite probable that the vein followed in the first part is the Ellen vein, which continues into the Red Cloud vein at the surface. Branches such as the Vermillion or Franklin may escape detection where post-mineral movement resulting in gouges and slickensided walls has occurred. The "None Such" drift is labeled Vermillion drift on some of the earlier maps—a designation clearly out of line with the surface relations. An unclaimed vein mapped at the surface corresponding to the Del Norte or possibly the Waldron vein appears to be that in the Dakota drift. The Dakota vein, if present, is weak and farther to the southeast than would permit its correlation with the vein in the drift. Little or no first-hand information about the ores of the several veins of the Frisco tunnel was obtained.

Output records from the Frisco tunnel may include ore from any of the veins cut by it. Shown on page 446 is a record of output since 1900.⁹⁴

Vermillion Mine

The Vermillion mine is located about 4,200 feet southwest of the Red Cloud mine at an altitude of 12,436 feet in a high valley on the northwest side of California Gulch. Two old buildings stand by the side of the lower tunnel, a crosscut which probably extends some 300 feet to the vein. The portal is so obstructed as to make the workings inaccessible. The tunnel appears to intersect the Vermillion vein near its junction with the northwestward trending Central vein. To the east of the intersection on the Vermillion Extension No. 1 the vein at the surface is multiple and widened generally. The apparent objective of the tunnel was to ex-

⁹⁴Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

OUTPUT OF METALS FROM THE FRISCO TUNNEL

Year	Tons	Gold (ounces)		Silver (ounces)		Copper		Lead		Zinc	
		Total	Per Ton	Total	Per Ton	Pounds	Percent	Pounds	Percent	Pounds	Percent
1913	5,490	55.58 ¹	-----	8,453 ¹	-----	8,496 ¹	-----	251,470 ¹	-----	89,110 ¹	-----
1913	6 ²	0.30	.05	310	51.7	95	.8	1,886	15.7	-----	-----
1914	1,650	28.66 ³	-----	3,788 ³	-----	2,492 ³	-----	72,248 ³	-----	30,341 ³	-----
1914	20 ²	8.00	.40	812	40.6	94	.2	800	2.0	-----	-----
	7,166	92.54		13,363		11,177		326,404		119,451	

¹From 549 tons of concentrates.

²Ore smelted.

³From 165 tons of concentrates.

plore the vein either beneath that wide part or beneath the ore shoots that were actually mined in the upper tunnel.

The ore on the dump is quite siliceous. Kaolin, sericite, and much altered rock are present in the vein matter. Sphalerite, galena, and chalcopyrite were found in small pieces on the dump.

Ore in the upper workings must have been encouraging, for a crosscut was driven much lower in the gulch at an altitude of 11,869 feet. This tunnel was not entered, but for it to have reached the Vermillion vein would have required 1,700-1,800 feet of crosscutting. It would cut the Two Micks vein, however, about 800 feet from its portal, and, judging from the size and nature of material on the dump, it must have extended at least that far. At one time the Vermillion equipment included a small mill located below the lower tunnel in the bottom of the gulch.

In 1910 the Vermillion company milled 2,763 tons of ore which made 435 tons of concentrates containing 27 ounces of gold, 5,250 ounces of silver, 1,998 pounds of copper, 217,500 pounds of lead, and 201,873 pounds of zinc.⁹⁵ Since it is uncertain whether the lower tunnel extends all the way to the Vermillion vein, all or part of this output may have come from the Two Micks vein. The zinc derived from the Vermillion ore since 1900 amounts to 30 percent of the total of the districts.

Mountain Queen Mine

The Mountain Queen mine is located at the head of California Gulch at an altitude of 12,791 feet. The mine was the only active one in this area during 1941 and 1942. The upper workings, where the mining was being done in 1942, consisted of a 70-foot shaft, about 65 feet of northeast drifts, and 135 feet of southwest drifts. In addition to these workings there is a crosscut tunnel reported to be some three or four hundred feet long located near the bottom of the gulch

⁹⁵Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

at an altitude of 12,353 feet. A cabin and a combination hoist house and shop stand at the shaft.

The lode strikes generally about N. 30°-35° E. at the shaft and dips 75° SE. Immediately north of the shaft the lode turns sharply eastward and continues with a dip of 75° S. to the bottom of the gulch, a distance of about 1,000 feet. Thereafter the vein assumes its normal northeasterly course. At the shaft and along the easterly course the lode is 50 to 150 feet wide. Although in most places this width consists of vein matter, there are horses of altered country rock in the vein between the principal ribs of dense quartz.

The shaft is located near the middle of the lode and neither wall had been prospected from the shaft. Along the northeast drift the ore made better on the northeasterly courses than on the northerly ones, but drifting was stopped at an easterly break because the ore became poorer. On the southwest drift considerable high-grade lead ore had been recently mined and a vein 1 to 1½ feet wide was being worked in 1942. The ore shoots along the drifts strike N. 40°-50° E. and dip 75°-80° E. In general the ore is highly broken and consists of much gouge with vuggy quartz and galena. Some sphalerite and very little chalcopyrite are present. Some of the galena contained a little tetrahedrite. In general the lead content of the shipping ore is about twice that of the zinc, and the silver content ranges from about one-half to one ounce for each percent of lead.

The property, owned by the Eureka Mining and Milling Co. of Denver, was being operated by the Mountain Queen Lease.

In 1875 the mine supplied ore from a five-foot shoot in which there was a 24-inch streak of galena ore that assayed 75 percent in lead and 32 ounces in silver. Ransome⁹⁶ reported as follows: "It is one of the oldest workings in the district (Placer Gulch and Treasure Mountain), and in 1877 shipped 370 tons of ore to Lake City. This ore was carried

⁹⁶Op. cit., p. 184.

by pack animals to Rose's Cabin (on Henson Creek, a distance of about eight miles) at \$3 per ton, and is said to have contained 30 ounces of silver and 64 percent of lead. The mine was most active from 1878 to 1880, and during one of these years is reported to have shipped \$60,000 worth of ore."

Since 1900 the Mountain Queen mine has accounted for about 31 percent of the lead produced in all the districts. The record of output is given on page 450.⁹⁷

Other Mines

The Burrows prospect is located about 1,900 feet west of the Vermillion tunnel at an altitude of 12,085 feet. In 1942 it was developed only by small cuts. The lode is 20 to 30 feet wide, strikes about N. 45° E., and dips 70° NW. The cuts have exposed an ore shoot of white quartz thickly speckled with coarse galena and sphalerite. The ore shoot ranges from six inches to six feet in width and is continuous for more than 100 feet along the lode. This is one of the better showings of base-metal ore in the area.

Other noteworthy veins or lodes of the area are the Indian Chief, Little Ida, Two Micks, and an unnamed lode 500-750 feet north of the Mountain Queen mine.

Exploration and Prospecting

The mines and deposits of the California Gulch area are generally more accessible than those of the Lake Como or Mineral Point areas. Operations have an advantage over those at Mineral Point because of a better mode of entry. Large backs of ore may be developed by relatively short tunnels.

The Sewell-Burrows lode, one of the most promising to extend from Lake Como to Mineral Point, is well developed and fairly accessible in outcrop and by short drifts or cross-cuts.

⁹⁷Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

OUTPUT OF METALS FROM THE MOUNTAIN QUEEN MINE

Year	Tons	Gold (ounces)		Silver (ounces)		Copper		Lead		Zinc	
		Total	Per Ton	Total	Per Ton	Pounds	Percent	Pounds	Percent	Pounds	Percent
1901	95	3.80	.04	2,403	25.3	-----	-----	-----	-----	-----	-----
1902	22	-----	-----	294	13.7	-----	-----	19,800	45.1	-----	-----
1918	32	0.90	.03	747	23.3	602	.9	13,427	21.0	-----	-----
1924	49	0.81	.02	1,020	20.8	-----	-----	-----	-----	-----	-----
1926	67	0.70	.01	1,294	19.3	865	.6	47,209	35.2	-----	-----
1926	179 ¹	2.47 ¹	.01	3,313 ¹	18.5	3,067 ¹	.9	94,172 ¹	25.7	51,570 ¹	14.4
1940	711	16.29	.02	8,013	11.5	3,535	.2	137,483	9.7	61,151	4.3
1941	8	-----	-----	214	26.8	129	.8	9,130	56.8	2,456	15.3
1941	284 ²	7.19 ²	.03	2,365 ²	8.3	1,403 ²	.2	45,710 ²	8.0	20,162 ²	3.5
	1,447	32.16		19,663		9,601		366,931		135,339	

¹From mill heads, 117 tons concentrated.

²From mill heads, 24 tons concentrated.

The Mountain Queen lode offers good opportunities for the mining of base-metal ores; exploration through the lower tunnel may yield abundant mill-grade ore.

In the Frisco tunnel the Sewell vein has been only very little explored and the surface mapping suggests better possibilities for ore to the south on the Yankton claim and to the north on the Sewell claim. There is no reason to believe that extension of the crosscut tunnel would open up veins or ore shoots better than or as good as those already cut.

Exploration of the Belcher and Silver Chord ore shoots can be made advantageously from a drift and crosscut respectively.

In general the possibilities for productive mining from California Gulch in the near future are brighter than for either Upper Poughkeepsie Gulch or Mineral Point.

ENGINEER MOUNTAIN AREA

General

The Engineer Mountain area is bounded on the south by the Uncompahgre River and extends as far as Henson Creek, about a mile northeast of Engineer Mountain. Although embracing only about one and one-half square miles, it includes mines in Ouray, San Juan, and Hinsdale counties around the headwaters of the Uncompahgre, Animas, and Lake Fork rivers. The high central part on Engineer Mountain is made more accessible by the Lake City road which crosses from Mineral Point over Engineer Pass at an altitude of 12,750 feet.

The rocks of the lower and eastern parts are andesite with local interbedded tuffs or breccias. The lower andesites, usually below 12,400 feet in altitude, are those of Mineral Point which are designated as belonging to the Burns latite. The upper andesites belong to the pyroxene andesite unit. Engineer Mountain is capped by Henson tuff and rhyolite of the Potosi volcanic series (see pl. 2, sec. F-F'). Banded rhyolite and pitchstone dikes are intrusive into the

volcanic rocks locally and sills of quartz latite porphyry are emplaced high in the series—for example, the sill that caps Engineer Mountain. The volcanic rocks dip generally about 15° NW. A landslide occupies a large area on the south side of Engineer Mountain.

The fissure veins strike generally northeast, but range between north-northeast and east-northeast. They dip 70° to 90° SE. The veins are less well exposed and show less splitting, branching, or multiplicity than those of Mineral Point. The Polar Star, Palmetto, and Frank Hough are the principal mines of the area.

Frank Hough Mine

The Frank Hough mine is located at the head of Palmetto Gulch in an open basin northeast of Engineer Mountain. The altitude at the shaft is 12,740 feet. The workings are inaccessible but they are said to consist of a 425-foot shaft with drifts 50, 80, 140, and 200 feet below the collar. A drift adit at an altitude of 12,660 feet was at one time driven along the vein as far as the shaft, a distance of about 290 feet. In 1882 a road was built up Palmetto Gulch to the mine; in 1942 this road was repaired and extended southward onto Engineer Mountain and eastward along the ridge to connect with the Lake City road at Engineer Pass.

The rock adjoining the vein is thin-bedded, water-laid Henson tuff. The strike of the vein is about N. 30° E. The dip, however, is not definitely known. Ransome⁹⁸ reported J. S. Hough as saying it was 45° W., a direction and an amount not compatible with the surface course of the vein or with the usual attitudes in this area. It is possible, however, that the ore shoot may have had this attitude locally in the vein, or that it conformed locally to the tuff beds whose dip had been steepened along the fissure. Burchard⁹⁹ reported that the 50-foot level exposed "12 feet of solid ore"; the 80-foot level exposed "17 feet"; the 140-foot level,

⁹⁸Op. cit., p. 190.

⁹⁹Burchard, H. C., Report of the Director of the Mint upon the production of precious metals during the calendar year 1882, p. 477, 1883.

"25 feet"; and the 200-foot level had "been run for 57 feet in a solid ore body." Burchard also states that the prospectors at the time worked on the theory that the Frank Hough body was "a layer in a horizontal direction." The course of the vein southward across Engineer Mountain is not at all certain. The course northward is poorly exposed, but it probably swings more northward through the Lilly claim and into the rhyolite of the Potosi volcanic series on American Flats. The ore body seems to have been irregular and commonly to have been impregnated in the walls. Burchard¹⁰⁰ described the deposit in 1882 as follows: "It is no fissure vein, but one of those large and irregular bodies of copper ore such as are known to exist at Fahlun (Falun) in Sweden and other parts of the Old World, where they have been worked with profit for many centuries. The ore is a copper ore, composed of a thorough mixture of gray copper, copper pyrites, and iron pyrites. Occasionally some galena is found within this copper matrix. The ore occurs in solid, large and irregular bodies, often separated and intersected by small and large talcose and chloritic fissures, traversing in every direction."

Although the dump material consists mostly of fines, small pieces of tetrahedrite ore can be found. Some of the lower-grade material is a granular and finely vuggy quartz with grains or patches of chalcopyrite, pyrite, and tetrahedrite. Polished sections of these pieces show patches of coarse sphalerite and pyrite grains replaced by tetrahedrite in which is more or less finely intergrown chalcopyrite. Hessite (Ag_2Te) is present in some pieces. It is associated with both tetrahedrite and sphalerite in a way which obscures its age relations with either. Ransome¹⁰¹ made the following observation: "Judging from specimens collected on the dump, the ore of the Frank Hough consists chiefly of chalcocite, often intimately intergrown with quartz, associated with a little chalcopyrite. There is possibly some tetra-

¹⁰⁰Op. cit., p. 477.

¹⁰¹Op. cit., p. 190.

hedrite present with the chalcocite." No chalcocite was present in any of the polished sections. If chalcocite is present, whether it is supergene or hypogene is not established. Some of the sulfide pieces contain a little galena. The Frank Hough deposit is one of the few mines in the districts in which the copper content of the ore has consistently exceeded that of lead or zinc.

The Frank Hough mine was discovered in 1881, but most of the early workings were driven during 1882. The lower drift exposed nearly 60 feet of solid ore and some of the ore shipped contained from 50 to 60 ounces of silver to the ton and 25 to 27 percent copper. During 1908-1911 shipments totaling 2,800 tons of ore averaged 0.15 ounces of gold and 37 ounces of silver to the ton, 24 percent copper, and 3.5 percent lead. Output from 1908 to 1920 amounted to about \$300,000. Ransome¹⁰² reported that in all the mine supplied about 2,000 tons of high-grade copper and silver ore up to 1900. The Frank Hough is the most productive mine in any of the districts described in this report; its total output is valued at nearly \$600,000.

The record of output since 1900 is given on page 455.¹⁰³

About 84 percent of the copper credited to the districts described in this report from 1900 to 1941 came from the Frank Hough mine.

Palmetto Mine

The Palmetto mine is located on Palmetto Gulch at an altitude of 12,190 feet. It was originally worked near the surface in a small shaft and a tunnel. About 1880 a vertical, three-compartment shaft was sunk about 75 feet east of the vein in the hanging wall. The shaft is reported to have been 400 or 500 feet deep. The vein near the workings strikes about N. 23° E. and dips 75° E. It is a continuation of the Polar Star vein. The country rock consists of a dense andesite and an amygdaloidal gray andesite.

¹⁰²Op. cit., p. 190.

¹⁰³Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

OUTPUT OF METALS FROM THE FRANK HOUGH MINE

Year	Tons	Gold (ounces)		Silver (ounces)		Copper		Lead	
		Total	Per Ton	Total	Per Ton	Pounds	Percent	Pounds	Percent
1908	344	34.60	.10	12,923	37.5	186,774	27.1	30,507	4.4
1909	1,370	185.00	.14	49,640	36.2	708,514	24.8	88,598	3.2
1910	1,055	219.00	.22	38,657	36.6	553,514	26.3	97,961	4.6
1911	31	6.01	.19	1,144	36.9	12,000	19.4	-----	-----
1912	20	3.77	.19	1,008	50.4	8,771	21.9	-----	-----
1913	127	25.58	.20	6,770	53.2	71,920	28.3	6,198	2.4
1914	65	4.65	.07	1,236	19.0	19,830	15.3	-----	-----
1916	26	1.44	.06	204	7.9	3,852	7.4	1,691	3.3
1917	23	1.44	.06	291	12.6	3,678	8.0	570	1.2
1918	18	1.30	.07	298	16.6	3,253	9.0	950	2.6
1920	2 ¹	0.40	.20	53	26.5	718	17.9	259	6.5
	3,081	483.19		112,224		1,572,824		226,734	

¹Ore shipped from the dump.

Ore near the surface was reported to derive most of its value from argentite and ruby silver, as were the ores of the Polar Star mine. Several carloads of this rich ore worth as much as \$500 per ton were shipped about 1878. The ore from the deep shaft was pyritic and low-grade but was treated by chlorination in a 15-stamp mill located on Henson Creek about a mile below the mine. In 1882 five levels were being worked from the shaft. The mine has been idle since 1891. In 1881¹⁰⁴ the mine had a 15-stamp mill capable of handling 25 tons per day; 400 tons of ore yielding \$28,000 were milled. In 1882 an additional 400 tons were milled yielding \$18,480.

Wyoming Mine

The Wyoming mine is located about 700 feet north of the Hinsdale county line and midway between Engineer Mountain and Engineer Pass. The altitude at the shaft and No. 1 tunnel is 12,714. The mine was called the Mohawk in the Silverton folio and this name also appears on the recently issued topographic base map. The name Mohawk, however, is not recognized by those who worked the mine as far back as the early 1900's.

The principal workings consist of what are termed the No. 1 and No. 2 levels. The No. 1 level is a tunnel some 580 feet long. A shaft 25 feet east of the tunnel portal is 120 feet deep. The portal of the No. 2 level is about 350 feet down the creek at an altitude of about 12,655 feet. It is reported to have connected with an old inclined shaft on the vein which is now filled or caved. None of the workings were accessible during the present survey.

The vein strikes about N. 25° E. and dips 80°-85° E. Along the length of the claim the vein has several short sharp turns eastward; one of them occurs between the lower and upper tunnels. The No. 1 or upper tunnel was driven during the summers of 1904-1907. Its portal and its

¹⁰⁴Burchard, H. C., Report of the Director of the Mint upon the production of the precious metals during the calendar year 1881, p. 402, 1882.

first 125-150 feet were in slide rock. Because of this and the low slope along the course of the tunnel, backs of ore averaged only about 35 feet along most of the drift; nevertheless, the vein has been stoped for a length of about 250 feet.

The vein is reported to be about three or four feet wide, with an ore shoot at the hanging wall which averages about one foot in width. In 1906 a shipment of 55 tons averaged 1.07 ounces of gold and 218 ounces of silver to the ton and 10 percent of lead. In 1916 a shipment of one ton of high-grade ore contained 5.1 ounces of gold and 357 ounces of silver.

In the early days the best shipping ore from the stopes of this tunnel are reported to have contained 2.5 ounces of gold and 180 ounces of silver to the ton, 18 percent of lead, and 12 percent of zinc, the last being mostly removed by sorting. Copper was present only in traces and bismuth, although not paid for, often assayed 1-1.5 percent. Some of the ore contained fine-grained secondary sulfur termed "black sulfurettes"; small shipments of this material are said to have contained from 1.5 to 2.5 ounces of gold and 180 to 250 ounces of silver to the ton. A narrow streak of gray porous quartz containing fine wire silver was sometimes found at the hanging wall, separated from the main shoot of shipping ore by a half inch or so of "talc" slip.

The shaft at the No. 1 tunnel was sunk between 1907 and 1909. It cut the vein at a depth of 110 feet; at the 120-foot level drifts were driven about 105 feet north and 175 feet south, but no stoping was ever done. The ore shoot is reported to have been from one to three feet wide.

The No. 2 tunnel is reported to have been driven between 1910 and 1914; the lead and zinc ore then piled on the dump was shipped during World War I. The ore shipped contained 10 percent of lead, 12 to 15 percent of zinc, and a small quantity of bismuth.

The vein continues northeastward on the Emperor Wilhelm claim and on the south side of Engineer ridge on the John J. Croke claim.

About 1927 plans were projected for a low crosscut tunnel, the portal of which was to have been north of Engineer Pass in Red Cloud Gulch. The tunnel would have been more than 1,300 feet below the Wyoming shaft and would have required some 3,600 feet of crosscutting to reach the Wyoming vein.

The output since 1900 is as follows:¹⁰⁵

Year	Tons	Gold (ounces)		Silver (ounces)		Lead	
		Total	Per Ton	Total	Per Ton	Pounds	Percent
1901	8	8.25	1.10	1,380	183.6	-----	-----
1902	16	21.56	1.35	1,920	12.0	4,800	15.0
1905	56	61.00	1.09	12,040	215.0	11,950	11.7
1906	55	59.00	1.04	12,039	218.3	11,947	10.9
1916	1	5.15	5.15	357	357.0	64	3.2
1917	7	12.24	1.75	865	123.5	176	1.3
1920	9	2.60	.29	384	42.6	799	4.4
	152	169.80		28,985		29,736	

Engineer Mine

The Engineer mine is located about 800 feet southeast of the Wyoming mine. The workings consist of a shaft on the ridge crest and two tunnels on the north side. The altitude at the shaft is 12,930 feet. The first tunnel is only 40 feet below the ridge crest and is connected with the shaft. The altitude of the lower tunnel is about 12,800 feet. None of the workings is accessible. The vein strikes about N. 40° E. and is nearly vertical. At the shaft the vein is about four feet wide, but the ore streaks range from one to ten inches wide. The ore is siliceous and pieces on the dump are composed of granular and finely vuggy quartz commonly honey-combed with a sphalerite-leached boxwork. Pyrite, galena, and sphalerite grains are disseminated in some of the quartz. This porous ore with black coatings, seams, and in-

¹⁰⁵Henderson, C. W., U. S. Bureau of Mines, Records of the Mineral Production and Economics Division, Denver, Colorado.

crustations of sulfur filling the openings was of high grade. Ruby silver was also present in the ore.

The reported value of the mine's output mostly during the nineties is about \$50,000. Two carloads of ore are said to have been sorted and shipped from the dumps during World War I.

The Engineer vein is probably continuous through the Black Silver and Eastern Star claims to the Humboldt vein near the south base of Engineer Mountain.

Polar Star Mine

The Polar Star mine is located on the south side of Engineer Mountain in Ouray county. The workings, including those of the Polar Star Extension on the north side of the ridge, consist of four or five tunnels on each side. None of these was accessible, and because of the extensive reworking of the dumps some of the old portals could not be exactly located. The altitudes of what are termed the No. 4 levels on the south and north sides respectively are 12,805 feet and 12,896 feet. Below the No. 4 level on the south side a crosscut at an altitude of 12,781 feet has been driven to the vein but no work thereon was ever done. There are probably nearly 2,000 feet of drifts on all the levels. The No. 4 level south is 450 feet long and the No. 4 level north is over 400 feet long.

The vein strikes about N. 27° E. and dips about 75° E. The average width of the vein is about three feet and that of the ore shoot from one to three feet. At the discovery workings near the top of the ridge there is very little coarse quartz of the usual type. Instead, the quartz is granular and finely vuggy. Much of the andesite wall rock is impregnated with quartz and pyrite, and the mass is highly sericitized and kaolinized. Silver in the rich ore near the surface is said to have been in the form of ruby silver and argentite, which were chiefly in pockets or bunches in the vein. At the dumps of the lower workings the vein matter is of the usual type,

being composed mainly of coarse white quartz with pyrite, some galena, sphalerite, and chalcopyrite.

On the No. 3 level south a branch tunnel driven 30 to 40 feet eastward cuts a parallel vein along which there has been about 20 feet of drifting. The vein is said to be about three to four feet wide, containing some lead and zinc ore.

On the No. 4 level south the tunnel penetrates andesite for 160 feet before entering the vein, and from there it follows the vein except for short stretches of hard material which was avoided by diverting the tunnel into the wall. The ore on the No. 4 level is said to have differed from that on the levels above as it contained no rich silver and gold shoots; however, assay tabulations that I have inspected do not indicate that the silver or gold contents on the No. 3 level were better than those on the No. 4 level. It has been pointed out that neither of the No. 4 levels have been extended under the ridge where the high-grade ore was obtained at the surface. The No. 4 level of the Polar Star Extension is said to contain a narrow streak of copper ore which has a high silver content.

The position of the No. 4 level tunnel on the Polar Star when compared with that on the Polar Star Extension suggests that the two may be on different veins or that there may be a jog or offset in the vein somewhere between the ends of the two drifts. Projection of the south No. 4 level to the north side of the ridge would bring it too far east of the north No. 4 level, even though allowances were made for the differences in altitude of the two levels.

George A. Collins in a private report (1920) states that earlier records show that 146 cars or 1,672 tons of sorted ore were shipped to the Durango smelter between June 25, 1880, and July 12, 1892. The average of these shipments was 0.12 ounces in gold and 72 ounces in silver, worth in all about \$125,000. Collins estimated the total output to be at least \$250,000. In 1940, 896 tons of dump ore hauled to the Shenandoah-Dives mill yielded 37 tons of concentrates

which contained 9.00 ounces of gold, 8,268 ounces of silver, 1,212 pounds of lead and 2,044 pounds of zinc.¹⁰⁶

Mammoth Mine

The Mammoth mine is located at the base of Engineer Mountain near the Mineral Point road. The workings consist of three tunnels. The lower, main tunnel, at an altitude of 12,072 feet is 580 feet long. The portal of the main tunnel is on the Wair claim about 75 feet beyond the south end line of the Mammoth claim. The middle tunnel, 84 feet above and at an altitude of 12,156 feet, is 233 feet long. The upper tunnel, 129 feet above the middle tunnel and at an altitude of 12,285 feet, is 235 feet long. Some work on the lower tunnel was done during 1940 (see fig. 29).

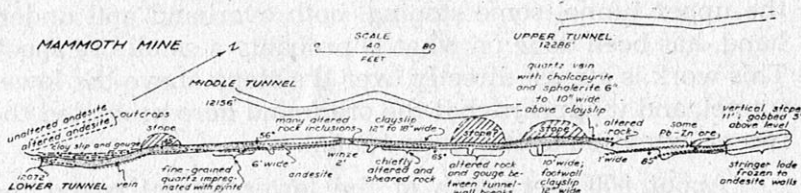


Figure 29. Plan of the Mammoth mine.

The vein strikes N. 25° E. The dip in the lower tunnel ranges from 45°-85° SE. with the higher dips toward the breast of the tunnel. The lode along the surface ranges from 5 to 15 feet in width.

The tunnels on the vein seldom explored both walls. The lower tunnel is driven on or near the hanging wall of the vein. The part of the vein followed in the tunnel has a well marked "footwall" break usually heavily coated with a gouge clay slip. Some stretches contain much altered rock as inclusions in the zone. Three shoots have apparently been stopped, the first about 80 feet and the others 300 to 400 feet from the portal. The second and largest opening is about 40 feet long and 50 feet high, but as no ore shows in its back

¹⁰⁶Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

and both walls are strongly marked with clay gouge this may be a cave. Ten feet beyond this opening is a stope some 50 feet in length and about ten feet wide. The footwall is overlain by about 12 inches of sticky clay and above this is a quartz vein 6 to 10 inches wide speckled with grains of chalcopyrite and sphalerite. Beyond this stope the vein consists of sheeted andesite containing stringers of white and gray quartz impregnated with pyrite and base-metal sulfides for the full width of the tunnel. Many small and large inclusions occur in the lode and most of these are impregnated with pyrite. The vein is very dense and no well-defined walls are exposed.

The middle tunnel begins on the vein but crosses into the hanging wall for most of its length. At the entrance to the upper tunnel some stoping, both overhand and underhand, has been done on what is probably a small ore shoot. This work is almost directly over the stope above the lower tunnel, and it appears that the ore found here prompted the recent extension of the lower tunnel.

About 800 feet north of the lower tunnel portal the main Mammoth vein apparently ends; about 150 feet to the east another vein begins which when followed northward connects with the Polar Star vein. Exposures are so lacking that it is not possible to determine whether this apparent offset is caused by a fault or whether the two veins bear an en echelon relation to each other.

The Mammoth lower tunnel offers the best approach for further development and mining of the Mammoth-Polar Star vein zone. However, the ore showings and assays are not very encouraging. George A. Collins in a private report (1920) states that between September 2, 1891 and November 29, 1892 lessees mined 275 tons of ore averaging 1.46 ounces of gold and 111 ounces of silver to the ton, and that the net smelter returns were \$28,226.61. The Mint reports for 1891-1892 record an output valued at \$25,655. Collins estimated a total value of \$50,000. Other smaller shipments

of ore were made to the Crooke smelter in 1881 and to Durango in 1894. In 1902,¹⁰⁷ 110 tons shipped contained 114.5 ounces of gold, and 3,045 ounces of silver.

Syracuse Pride Mine

The Syracuse Pride is located on the Lake City road near the side road to the Polar Star mine. It was operated from two tunnels, but the portals have been caved for many years. The altitude at the lower tunnel is about 12,506 feet. The vein, which strikes nearly north is reported to be four or five feet wide. The workings are said to aggregate about 800 feet with many short finger-like stopes from the levels. The ore contains sphalerite, galena, pyrite, and quartz. Vugs in the quartz occasionally contain rhodochrosite crystals. Many andesite fragments are incorporated in the vein.

Other Mines

The Sunset mine is located about 3,500 feet southwest of Engineer Mountain. The workings consist of two upper tunnels at altitudes of 12,155 feet and 12,275 feet together with many prospects and a lower tunnel at an altitude of 11,690 feet. The vein followed in the upper tunnel strikes about N. 50° E., but the lower tunnel, which is nearly 1,000 feet long, appears to have followed a nearly north-trending vein for about 750 feet and then to have followed the north-easterly vein of the upper tunnel; however, the exposures are poor. Ransome¹⁰⁸ describes another vein with a N. 25° W. strike and a dip of 75°-80° SW. This vein is four or five feet wide; it consists of "gouge, crushed decomposed rock, and bunches of quartz and ore," the latter composed chiefly of tetrahedrite and pyrite in a gangue of quartz and some kaolin. Most of the mining at the Sunset mine was done before 1900. On record¹⁰⁹ is a shipment made in 1917 of 4 tons containing 0.04 ounce of gold, 19 ounces of silver, 454 pounds of copper, and 325 pounds of lead.

¹⁰⁷Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

¹⁰⁸Op. cit., p. 189.

¹⁰⁹Henderson, C. W., U. S. Bur. of Mines, Records of the Mineral Production and Economics Division, Denver, Colo.

On the north side of Engineer Mountain the Miners Bank and First National Bank claims, both on the Polar Star-Palmetto vein, have been extensively prospected, and it is possible that some small quantities of ore were shipped from them in the early days. North of the Wyoming mine on the Emperor Wilhelm claim there are several small cuts and short tunnels. The vein is remarkably jogged and has sharp walls. Considerable zinc and lead ore is stacked on one of the dumps. In 1913 a shipment of 4 tons yielded 0.46 ounce of gold, 206 ounces of silver, 18 pounds of copper, and 640 pounds of lead.

The Annie Wood vein east of the Polar Star was at one time rather extensively mined and some bunches of good ore were found. The Geo. M. Tibbitts vein is a northward continuation of the Annie Wood. It has been explored through a short tunnel located at an altitude of 12,385 feet, about 1,500 feet north of the Wyoming mine. It is one of the more persistent fissures of the Engineer Mountain district. The Eastern Star mine is located about 600 feet east of the Mammoth vein at an altitude of about 12,275 feet. A short tunnel has been driven along a prominent vein which strikes about N. 55° E. and dips 75° SE. Some base-metal sulfides show in the ore on the dump. This is the vein that probably connects with the San Juan Chief vein.

Adjoining the Engineer claim on the south is the Black Silver; their common endline is almost on the divide of Engineer Mountain. The Black Silver had some very rich silver ore similar to that of the Engineer mine. The Hoffman claim adjoins the Engineer claim on the north. During 1913-1914, 16 tons of ore were shipped from small open cuts on the Hoffman claim and yielded 0.57 ounce of gold and 282 ounces of silver.

Many prospects have been opened on Seigal Mountain. Some of the more important of them are the Blacksmith, Little Maud, F. L. Seigal, Early, and several on unpatented claims in the small high valley about a thousand feet west of the peak.

Exploration and Prospecting

The Engineer Mountain area has been rather thoroughly prospected at the surface largely as the result of interest stimulated by the discovery of the bonanza ores of the Polar Star and Frank Hough mines. In comparison with the number and extent of the veins, the amount of underground exploration is moderate, and there is still much ground to be developed. Elaborate plans have been made at one time or another for large-scale exploration and mining. The projected tunnel to crosscut to the Wyoming vein has already been described (see page 458). The Frank Hough tunnel located near the Mineral Point road on the south side of the mountain was even started (see pl. 1). The output records of the Frank Hough from 1908 to 1920 seem to indicate that the richer copper ores are exhausted. The area is remote and generally out of reach of available low tunnels. The principal future of deposits in this area depends on the mining of mill-grade ore through such tunnels as the Mammoth. The Mammoth and the deeper Palmetto workings have shown that low- or mill-grade ore is likely to be dominant in veins of this area. The ground between the Humboldt and Engineer mines is deserving of exploration, which could be done from the Eastern Star or a still lower portal on the vein. From such a portal or in a relatively short crosscut from the Mammoth tunnel the Annie Wood and John J. Croke veins should receive further attention. Farther east the Blacksmith, F. L. Seigal, and New Chicago veins have attractive exposures and showings of base-metal ore at least locally.

FUTURE OF THE DISTRICTS AS A WHOLE

One of the most important conclusions of this survey is that by and large the ore of these districts is mill-grade and that high-grade ore shoots are generally small or merely in bunches. The aggregate reserves of low-grade silver-gold ore and base-metal ores with valuable silver and gold contents are enormous, and many of the low-grade ore bodies

seem large enough to be profitably mined by large-scale low-cost methods.

If this fact were more widely known and understood much of the disappointment that has accompanied ventures in these districts might have been avoided. Many deposits are either ruined or made more expensive to mine later by poorly planned and incomplete mining. The early bonanza ores of mines like the Old Lout, Ben Butler, and Polar Star have been the cause of "setting the sights too high" during later operations. The early bonanza ores were in no small way the unwitting cause of building mills before developing mines. I do not mean to say that there is no good ore left, for the very distribution of mines and ore bodies in the districts proves that there is. It will do no harm to reiterate that the high-grade or shipping ore is the exception rather than the rule; nevertheless, the exceptionally high-grade ore bodies that are likely to be found will probably have to be blended with the average mill ore to make mining profitable. If this condition is recognized and mining practices are followed that are compatible with the general grade and mode of occurrence of the ore, the region may in the future enjoy a long term of productive activity.

The evidence seems to be clear that the ores are dominantly hypogene. Although there may be some downward decrease in silver content due to hypogene zoning, the production records do not bear this out very markedly. There is no uniform, abrupt, or sharply defined horizon below which the veins may be decidedly lower in silver or gold content. Output records, furthermore, do not show a greater base-metal content at lower altitudes in the veins. In general, therefore, the evidence tends to encourage exploration for metals of all sorts at any altitude above the top of the pre-Cambrian basement rocks.