RECENT MINING DEVELOPMENTS IN THE CREEDE DISTRICT, COLORADO

By Esper S. Larsen

ABSTRACT

The Creede district has produced over $43,000,000 worth of metal, mostly silver. By far the greater part of this output came from the great Amethyst vein, which lies along a major fault. Nearly all of the ore was mined from parts of the vein that were enriched by surface solutions and were above the Nelson tunnel. Production from this vein practically ceased about a decade ago.

Extensive prospecting below the Nelson tunnel exposed no ore. More recent development has opened a good ore body in the western branch of the Amethyst fault at its south end, and several small but productive veins have been worked in the hanging wall of the Amethyst vein. These veins have produced metal to the value of about $1,000,000 since 1922 and promise further production.

Another important recent discovery is the deposit on Monon Hill along the steep contact of rhyolite tuff and a rhyolite flow. This deposit has produced 756,400 ounces of silver.

Some ore has been developed in the Equity mine, which follows a reverse fault in the extreme northern part of the district.

Silver in amounts sufficient to stimulate extensive prospecting has been found in some of the flat-lying tuff beds of the area, and some of the plant remains in this tuff are rich in silver.

Some of the tuff beds of the Creede formation are partly altered to bentonite, and the Metalloid Corporation hopes to utilize this material on a large scale as a filter for oils.

INTRODUCTION

Since 1913, when the field work leading to the publication of the report by Emmons and Larsen[1] on the Creede district was completed, the district has produced over $5,000,000 worth of metals, and it is still producing. In the last eight years much of the output has come from veins that were either nonproducers or small producers before 1913. An examination of these new developments, therefore, seemed desirable, and accordingly I was detailed to the work and spent about 10 days in the district in the summer of 1927 and 3 days in August, 1928.

[1] Emmons, W. H., and Larsen, E. S., Geology and ore deposits of the Creede district, Colorado: U. S. Geol. Survey Bull. 718, 1923.

During my stay in the district I found all the mining men and the whole community most helpful and considerate. To all I wish to express my sincere thanks, and in particular to Messrs. Charles Hollister, Edward Futterer, Clarence Withrow, Durwald Withrow, W. F. Barnett, Ben A. Birdsey, A. L. Dean, W. C. Sloan, Frederick Monkemeyer, and Elwood M. Neff. Most of the maps, the data on individual mine production, and much other information were furnished by the operators.

Since 1920 the main Amethyst vein, which had been the chief producer of the district, has furnished little ore, and most of the production has come from the west branch of the Amethyst vein in the Bachelor mine, from veins in the hanging wall in the Commodore and other mines, and from an ore body along the contact between rhyolite and bedded tuff on the west slope of Monon Hill. Smaller amounts have come from the Equity mine and from other ore bodies.

In addition to the work on the veins that proved productive, a large amount of work was done below the Nelson tunnel on the Amethyst vein, but no production resulted. Extensive development work was done in the Resurrection tunnel, on the south slope of Mammoth Mountain; in the Colewood tunnel, in Nelson Gulch; in the Oxford tunnel, on the south slope of Bulldog Mountain; and elsewhere. Silver has been found to be present in appreciable amounts and over considerable areas in some of the tuff beds of the Creede formation in the ridge southwest of the Bachelor mine. Some of the tuff beds of the Creede formation are partly altered to bentonite, and attempts are being made to utilize them on a large scale for the manufacture of oil filters.

PRODUCTION

The recent production from the Creede camp has been, as in preceding years, mostly silver, with some gold, lead, and zinc and a little copper. The annual production for the last decade has been much less than in the most prosperous days of the camp and reached the low value of $117,459 in 1922; but it has since increased and in 1925 was $557,762, the highest since 1913 except in 1918, when it was $726,027. The production by years since 1920 is given in the following table. The annual production up to and including 1920 was given in Bulletin 718, pages 10 and 11.

Gold, silver, copper, lead, and zinc produced in Mineral County, Colo., 1891–1927,[a] *in terms of recovered metals*

Year	Ore (short tons)	Lode gold	Silver		Copper	
			Quantity (fine ounces)	Value	Quantity (pounds)	Value
1891–1920 [b]		$2,715,113	44,038,801	$28,704,532	268,679	$43,320
1921	7,076	3,816	192,468	192,468	1,899	245
1922	3,978	1,654	106,903	106,903	3,422	462
1923	6,462	2,394	228,867	187,671	1,088	160
1924	4,647	1,494	239,149	160,230		
1925	8,047	885	738,735	512,682		
1926	8,855	672	551,468	344,116		
1927	3,592	246	214,850	121,820		
		2,726,274	46,311,241	30,330,422	275,088	44,187

Year	Lead		Zinc		Total value
	Quantity (pounds)	Value	Quantity (pounds)	Value	
1891–1920 [b]	197,429,511	$8,723,465	27,572,407	$1,511,944	$41,698,374
1921	156,778	7,055			203,584
1922	153,455	8,440			117,459
1923	237,557	16,629	41,000	2,788	209,642
1924	191,562	15,325	41,000	2,665	179,714
1925	501,000	43,587	8,000	608	557,762
1926	354,700	28,376			373,164
1927	75,286	4,743			126,809
	199,099,849	8,847,620	27,662,407	1,518,005	43,466,508

[a] From Henderson, C. W., U. S. Geol. Survey Prof. Paper 138, p. 181, 1926, and volumes of Mineral Resources published by U. S. Geol. Survey and Bur. Mines.
[b] For annual production from the beginning, in 1891, to 1923 see Henderson, C. W., op. cit., and U. S. Geol. Survey Bull. 718, pp. 10, 11, 1923.

OUTLINE OF GEOLOGY

Only a very brief review of the areal geology will be given here. The reader is referred to Bulletin 718 for a more detailed statement.

The rocks exposed in the district are volcanic rocks of Miocene age and superficial deposits of Quaternary age. The following list of the rock formations of the Creede area includes only the major rock groups except for such subdivisions as seem necessary for an understanding of this report.

Quaternary deposits: Alluvium, terrace deposits, glacial moraines, and landslides.
Great erosion interval.
Miocene:
- Dikes of quartz latite porphyry.
- Fisher quartz latite. Flows characterized by large phenocrysts.
- Considerable erosion interval.
- Creede formation:
  - Upper member: Breccia, conglomerate, and tuff, with intercalated flows.
  - Lower member: White shaly tuffs, with some sand and breccia and some travertine.
- Considerable erosion interval.

Miocene—Continued.
- Potosi volcanic series:
  - Piedra group: Local quartz latite and hornblende andesite at the base; overlain successively by rhyolite flows and tuffs; andesite in flows and breccia; quartz latite in tuffs and flows.
  - Considerable erosion interval.
  - Alboroto group:
    - Equity quartz latite: A thick flow of fluidal biotite-quartz latite.
    - Phoenix Park quartz latite: Chiefly flows, some tuff breccia; mostly characterized by phenocrysts of plagioclase, hornblende, quartz, orthoclase, and biotite.
  - Intrusive rhyolite porphyry in dikes and sheets.
  - Campbell Mountain rhyolite: Flows of dull reddish-brown or drab mottled rhyolite.
  - Willow Creek rhyolite: Flows of purplish-drab to gray fluidal banded felsitic rhyolite.
  - Probable erosion interval.
  - Outlet Tunnel quartz latite.

The only formations that are referred to in detail in this report are the Creede formation, the Equity quartz latite, the intrusive rhyolite, the Campbell Mountain rhyolite, and the Willow Creek rhyolite.

The formations of the Creede district dip gently toward the south and are broken by a group of faults. The faults are mostly confined to an area about 5 miles east and west by 7 miles north and south. Most of the major faults strike a little west of north. Many of the faults are short, and none are over 10 miles long, yet the throw, even of the short faults, is commonly several hundred feet, and for some it is 2,000 feet. Nearly all the ore bodies are in veins along the faults, and the main Amethyst vein lies along the largest fault. The principal mineralized faults are shown by the heavy lines in Plate 26. For a more detailed map the reader is referred to Bulletin 718.

AMETHYST LODE

The Amethyst lode lies along the great Amethyst fault, west of West Willow Creek. On it are located the most productive mines of the district, which are, from south to north, the Bachelor, Commodore, Del Monte, Last Chance, Amethyst, Happy Thought, and Park Regent. The lode has been extensively prospected and stoped for a length of nearly 2 miles along its strike, and the stopes extend from the surface to the Nelson tunnel, which is about 1,200 feet below the outcrop.

The vein dips about 50° W., and in most of the workings the hanging wall is the Campbell Mountain rhyolite and the footwall is the Willow Creek rhyolite. Near the surface the hanging wall is commonly one of the younger formations—the Creede formation near the south end and a formation of the Piedra group to the north.

The chief new development work on the Amethyst lode has been the search for ore below the Nelson tunnel and the development of small veins in the hanging and foot walls of the main vein. The deep development work brought no production, but the hanging-wall veins have been and are still being profitably worked and are now practically the only source of ore in the camp.

DEEP EXPLORATION

In 1917–1920 the Creede Exploration Co., a subsidiary of the American Smelting & Refining Co., carried on extensive exploration of the Amethyst vein below the Nelson tunnel level. The workings are now filled with water, and the maps and records are not accessible; hence the following statement about the deep exploration is based on information gathered from mining men who were at Creede when the exploration was being carried on.

On the Bachelor claim drifts were run on the vein for several hundred feet from the bottom of a shallow shaft below the Nelson tunnel. Toward the southeast the vein became narrower and was made up of a series of fissures filled with iron-stained gouge. In this drift the vein carried some galena and other sulphides, but much less than at the level of the Nelson tunnel.

In the Commodore mine the old shaft, which was sunk from the lowest level (No. 5) to a depth of about 375 feet, was unwatered, and drifts were run along the vein for about 1,500 feet in both directions, making a total of 3,000 feet. These drifts are about 350 feet lower than the Nelson tunnel. In them the Amethyst fault is reported to carry from 6 to 20 feet of brecciated white altered rock which contains very small quantities of sulphides and only a trace of silver.

On the Amethyst ground, about 7,500 feet from the portal of the Nelson tunnel, the company sunk a winze, inclined 70° SW., to a depth of about 120 feet and drifted north into the Happy Thought ground and south about 200 feet. In the north drift some pockets of sulphides were found, but the end of the drift is in a large crushed zone which is barren. Under the big lead stope of the Happy Thought mine the hanging wall was badly broken and made much water, which washed lead and zinc sulphides out of the fractures. In the south drift the vein is 3 to 4 feet wide and carries from 12 to 15 per cent of combined lead and zinc and a little silver. The flow of water in these two drifts was about 1,300 gallons a minute and came mostly from the north drift.

VEINS IN THE WALLS OF THE AMETHYST LODE

In the earlier report by Emmons and Larsen[2] it was stated:

> The southern part of the Amethyst fault, from the south end of the Commodore vein through the Bachelor, is exposed only here and there. Where exposed it generally carries vein matter, but no ore has been mined from it. The output of the Bachelor mine has been derived mainly from veins approximately parallel to and in the footwall of the Amethyst fault. * * * Between the Bachelor and Park Regent mines many small mineralized fractures make off from the Amethyst fault. In the Bachelor mine these are principally in the footwall; in the Commodore and Last Chance-Amethyst they are mainly in the hanging wall. Where such fractures are closely spaced large ore bodies may result. Indeed, the richest part of the Amethyst lode was in the New York-Last Chance and Delmonte section, where, owing to the presence of many closely spaced fractures in the hanging wall, the width of the lode was expanded to nearly 100 feet. The production and character of the Amethyst lode appear to justify a more thorough prospecting of its walls, especially of the hanging wall.

In May, 1922, A. L. Dean continued an old crosscut on the intermediate level of the Commodore mine, 80 feet above level 3, to the west branch of the fault and vein and opened a body of good ore. This crosscut started from the old workings of the mine, which were on the east branch of the vein. It crossed a small vein that is as much as 2 feet wide, strikes N. 20° W., and dips about 85° E. A little ore was stoped from this vein many years ago.

Later Mr. Dean ran a crosscut nearly due west from a point on level 3 of the old Commodore workings, about 280 feet south of the north end line of the Commodore mine, and at a distance of about 320 feet again struck the west branch of the Amethyst fault. This fault, called the Dean fault, has since been followed south about 260 feet and north about 450 feet to its junction with the east branch of the Amethyst fault. It strikes nearly due north and dips about 72° E. It is therefore steeper than the east branch and than the Amethyst fault north of the junction of the two branches. The east or foot wall of the fault is Willow Creek rhyolite; the west or hanging wall is Campbell Mountain rhyolite. The general relations and workings on level 3 are shown in Figure 8.

The Dean fault has therefore been explored on level 3 and above from its junction with the east branch southward for a distance of about 700 feet, and over much of this distance it has been stoped. The southern 450 feet is a continuous stope above level 3, and ore is said to continue in the south face. This stope averages 2½ feet in width and in most places extends for 100 to 125 feet above level 3 and locally goes as high as 250 feet above that level. The vein above the stopes is said to be wide, but the metal content is low (from 15 to 17 ounces of silver to the ton). The ore is said to go below level 3.

[2] Op. cit., pp. 137–138.

Above this level it carries few sulphides and little lead, but below the level both sulphides and lead increase in amount.

After Mr. Dean's discovery Clarence Withrow and the Withrow Leasing Co., who had a lease on the Commodore mine, prospected the hanging wall of the Amethyst fault and found a number of parallel veins. The workings and known veins on level 3 are shown in Figure 8, and those in the southern and most productive part of the workings of the Commodore mine on level 3 and on the intermediate level, about 75 feet higher, are shown in Figure 9. In this area, near and north of the junction of the two branches of the Amethyst fault, as many as five parallel veins have been found, and in places considerable stopes have been made on four such veins. The main Amethyst fault dips about 62° W., and the hanging-wall faults dip from nearly vertical to 70° E. These veins are best seen in the stopes above level 3 and on the intermediate level. In general, the westernmost of these veins, that farthest from the Amethyst vein, is the most continuous, and it has been followed for about 1,100 feet. Over most of this distance it carries ore and has been stoped, but for about 300 feet at the north end of the tunnel the wall rock is a soft white decomposed rhyolite and the vein is barren and not well defined.

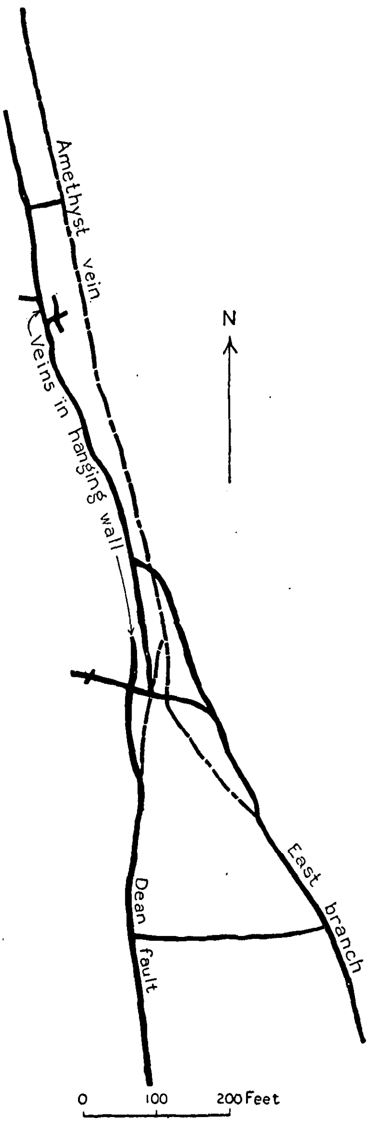


FIGURE 8.—Plan of level 3 of the Bachelor and Commodore mines, Creede district, Colorado, showing branches of Amethyst vein and veins in hanging wall

These hanging-wall veins are nearly parallel, and they come together and branch so that in some places there are only two such veins and in others five. The veins carry from a seam to a foot or more of ore. In places the veins were so close together that the rock between the veins was broken down with ore. The westernmost vein yielded most of the ore, but the others have also been productive. All the ore came from the part of the vein above level 3, and the vein material is of lower grade on level 3 than above. The stopes extend for about 150 feet above level 3, and no ore has been found above the stopes. The ore

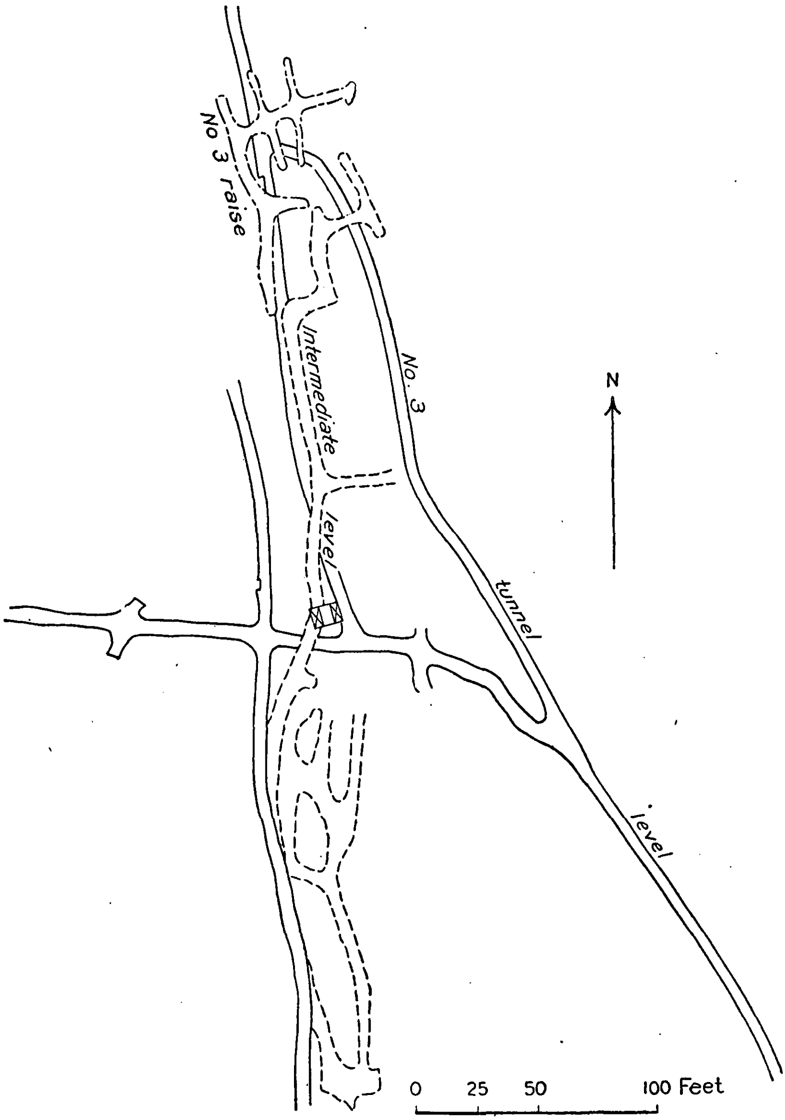


FIGURE 9.—Plan of parts of the Commodore and Bachelor mines, Creede district, showing branch of Amethyst vein and veins in hanging walls

as shipped, in carload lots, carried from 40 to 200 ounces of silver to the ton and 2½ to 3 per cent of lead.

In general, next to the productive veins, the wall rock is somewhat fractured but not much altered, while, in the northern part of the workings, ore is lacking and the wall rock is much altered.

The following data on production from the Commodore mine by the Withrow Leasing Co. from January 1, 1924, to July 14, 1927, were kindly furnished by Mr. Withrow:

Ore	dry tons	18,656
Silver (assay content)	ounces	1,440,995
Lead (wet assay content)	pounds	850,398
Gross calculated value		$935,718
Average gross value per ton		$50.154
Average silver per ton	ounces	77.23

All or nearly all of this output came from the small veins in the hanging wall of the main Amethyst fault.

Morgan & Sloan and their associates, leasing the Last Chance mine, ran a crosscut from a point on level 2 about 170 feet north of the shaft into the footwall and found a small vein at about 50 feet from the main tunnel. This vein strikes N. 70° W. and is nearly vertical, but the Amethyst vein strikes N. 10° E., and hence the footwall vein should run into the Amethyst vein at no great distance to the north. The small vein is made up of banded amethyst quartz, gray or brown quartz, gouge, a little galena, and brecciated rock. It ranges in width from 2½ feet to a few inches. It has been prospected by irregular workings that extend 25 feet below level 2 and 70 feet above and for 250 feet on that level. A few carloads of ore have been shipped. The stopes are mostly above level 2 and are from 18 inches to 2 feet across.

Farther north the Amethyst Leasing Co. has a lease on the entire Amethyst property and on that part of the Pittsburgh which is north of the south-end line of the Amethyst. This company has run a crosscut 230 feet into the hanging wall of the Amethyst vein from the outcrop of the vein, 20 feet south of No. 2 shaft. At about 145 feet from the portal it cut a small north-south vein, and at about 172 feet an 18-inch vein, striking N. 7° E. and dipping 70° E., that assayed 200 ounces of silver to the ton. At about 185 feet from the portal it cut a third vein that strikes north and is nearly vertical. This vein has been stoped for 35 feet along the vein and to a depth of 50 feet below the tunnel and 15 feet above. The stopes averaged about 3 feet, and the vein is about that width at both ends and about 2 feet at the bottom. The ore shipped and the ore exposed in the stopes are said to average about 200 ounces of silver to the ton. About 260 tons of ore of this grade had been shipped by the end of August, 1928.

The success encountered in prospecting the hanging wall has led to considerable activity.

Hollister & Futterer have a sublease on the parts of the Del Monte and New York claims that are south of the Compromise line and are starting a crosscut from the main tunnel about 20 feet south of the Morgan & Sloan ore body, to prospect the ground beyond the big cave and stope that was near the junction of the main vein and the Del Monte vein.

Herman Imperious and associates have a sublease on that part of the Amethyst mine that is north of No. 3 shaft and plan to run a crosscut on level 3 through the drainage level.

R. J. Murray and associates, who have a lease on the Happy Thought mine, are working through the Nelson tunnel on level 8 and hope to find a continuation of the old stope, which, it is reported, carried when last mined an unusually high gold content for this district.

RESURRECTION TUNNEL AND AREA SOUTHWEST OF MAMMOTH MOUNTAIN

Since the preparation of the earlier report considerable prospecting has been done on the faults on the southwest slopes of Mammoth Mountain. The main faults of the area have been considerably prospected, and the Mammoth tunnel has been extended, but according to reports no ore bodies have been found.

Farther east, on the south slope of Mammoth Mountain, these faults are prospected by a crosscut tunnel whose portal is about 1,200 feet S. 28° W. of the Eclat shaft, at an altitude of about 10,450 feet. The tunnel is being driven by Frederick Monkemeyer and associates, and I am indebted to Mr. Monkemeyer for help in the examination of the tunnel and for a map of it. A map of the workings drawn from data furnished by Mr. Monkemeyer is shown in Figure 10. The main tunnel, which is in the Willow Creek rhyolite throughout, at about 160 feet from the portal crosses a fracture that carries some quartz and at about 913 feet crosses a second fracture zone that has been followed by a drift N. 19° W. for 580 feet. This second fracture has both walls of the Willow Creek rhyolite for about 200 feet north of the main tunnel, but farther north the west or hanging wall is the Campbell Mountain rhyolite. The fracture contains a seam of gouge, and the hanging wall is good, but the footwall is more or less brecciated.

The main tunnel is being continued to prospect a quartz vein that crops out on the flat top of Mammoth Mountain about 600 feet from the breast. This vein strikes N. 60° W. and dips 35° SW. It is poorly exposed by a 20-foot shaft.

COLEWOOD TUNNEL

The Colewood tunnel is just west of Nelson Creek and about three-quarters of a mile north of its mouth. The property is owned by Elwood M. Neff and Mrs. Pearl Neff. Mr. Neff kindly accompanied me to the property and gave me free access to his maps and other information.

Some prospecting had been done in this area years ago, but the main tunnel has been driven since the preparation of the Creede report already cited. The main tunnel is about 50 feet above the bed of the creek and, as shown by the mine maps, was driven 166 feet N. 32° W. to the vein and then 909 feet N. 46° W. along the vein. The vein is on a broad zone of gouge and fractured and altered Campbell Mountain rhyolite. It dips about 70° NE.

For some distance in from the point where the crosscut strikes the vein the vein is filled with white gouge showing some limonite stains,

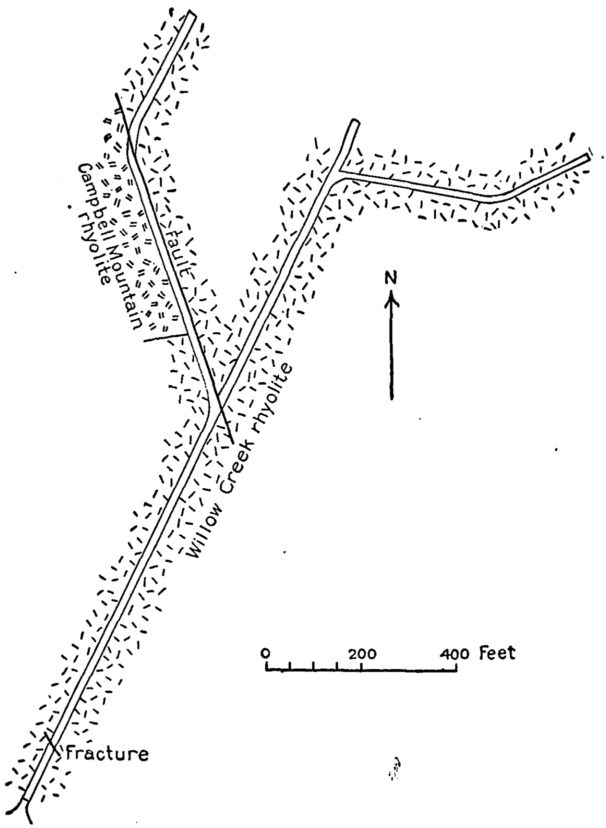


FIGURE 10.—Map of Resurrection tunnel, Creede district

but in much of the vein as exposed in the tunnel streaks of black sulphide are present in the fracture zone, and some of them extend into the hanging wall. The main streak is nearly continuous to the face and ranges in width from a few inches to a foot. This black streak is made up of brecciated, altered rhyolite cemented by galena, sphalerite, chalcopyrite, and pyrite with some anglesite.

On the outcrops above the vein and to the northwest along its strike there are a number of old shafts and prospects that show some altered and mineralized rock.

EQUITY MINE

The Equity mine is just east of West Willow Creek about 6 miles north of Creede. The old wagon road to the mine by way of Bachelor has been abandoned, and a new road has been constructed that keeps near the bed of West Willow Creek as far as Nelson Creek, follows up Nelson Creek for about three-quarters of a mile, crosses the ridge into the valley of West Willow Creek, and runs near that creek to the mine. The road is narrow and rough and has some very steep grades and some soft parts but is passable to a powerful automobile. In 1927 the property was being prospected, under bond and lease, by the North Amethyst Mining Co. under the direction of Messrs. Charles Hollister and Edward Futterer, who were of great assistance in the examination of the property and furnished maps and data on production and assay returns.

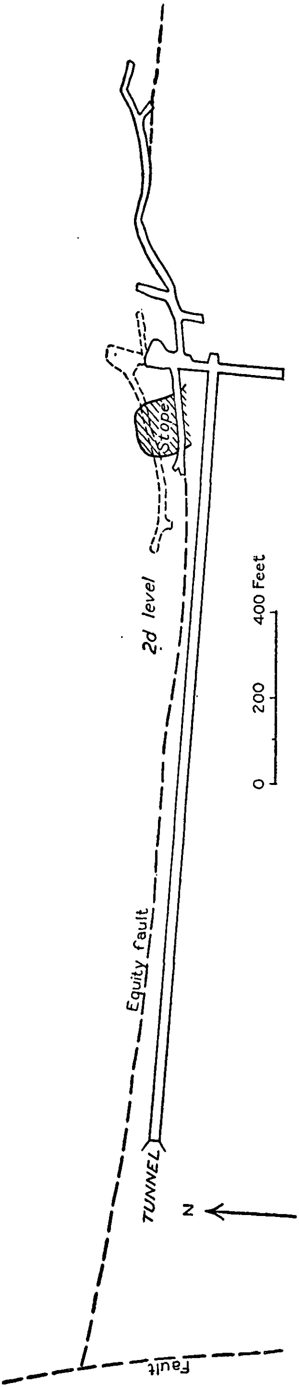


FIGURE 11.—Map of the Equity mine, Creede district

The Equity mine is on a reverse fault of great throw that strikes about east and dips steeply to the north. Its throw decreases rapidly east of the mine, and about a mile to the east both walls become latite of the Alboroto group, and the fault does not appear to extend far beyond.

West of the Equity tunnel the Equity fault ends against the branch of the Amethyst fault that continues northwestward near the line of the main fault. This branch fault has a relatively small throw south of the Equity fault, but to the north its throw is much greater. It is covered by talus and wash near the tunnel, but about 1,000 feet to the north it is exposed in several open cuts and pits on the bench east of the creek about 250 feet from the creek bed and a little west of the beginning of the steep slopes. It continues a few hundred feet east of the creek, striking a few degrees west of north, to a point about a mile north of the Equity tunnel, where it turns to nearly north and rises to the higher mountains. For about 1¼ miles north of the Equity the east or foot wall is the Willow Creek or the Campbell Mountain rhyolite and the hanging wall is the Equity quartz latite, but farther north both walls are latite, and the throw of the fault appears to be rapidly diminishing.

This fault has been prospected by pits and cuts in a number of places and commonly shows a narrow brecciated zone, with some iron oxide and altered rock but little quartz and no ore.

In 1927 plans were being made to prospect both the Equity fault and the north-south fault near their junction, but this project offered some difficulties, as the junction is near the bed of West Willow Creek and is covered with wash.

The workings of the Equity mine in July, 1927, are shown in Figures 11 and 12, which are reductions of maps kindly furnished by Mr. Futterer. These maps show that since the examination of the property in 1912[3] the main tunnel has been extended a short distance and in July, 1927, was being turned to the southeast in the hope of reaching an ore shoot that was reported in an old tunnel which was run from the outcrop of the vein, about 490 feet in altitude above the main tunnel.

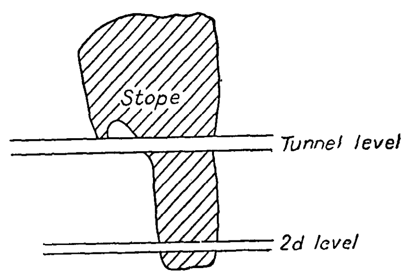


FIGURE 12.—Stope of the Equity mine, Creede district

The chief new work is represented by the stope from the north drift west of the second sharp turn in the main tunnel and by the work on the lower (second) level. These lower workings were filled with water at the time of my visit.

The stope shown in Figure 12 is reported to have extended about 160 feet, measured along the incline, above the main tunnel, and about 40 feet below the second level, which is 100 feet, measured along the incline, below the main tunnel. The stope was 140 feet long above the main tunnel and about 60 feet long below it. The width ranged from 1½ to 5 feet and is said to have averaged about 3 feet. Assays across the stoped ore are reported to have shown, for silver, 6.3 to 154.3 ounces to the ton, mostly between 20 and 90 ounces, average about 42 ounces; for gold, 0.06 to 1.61 ounces, average about 0.28 ounce. There is about 1 ounce of gold to 100 ounces of silver in the high-grade ore and somewhat less in the low-grade ore. The ore shipped averaged about 3 per cent iron oxide, 87 per

[3] U. S. Geol. Survey Bull. 718, p. 170, 1923.

cent insoluble matter, 1½ per cent zinc, 0.5 per cent lead, and a trace of copper. The ore is reported to continue below the stope, and plans had been made to develop it by an inclined shaft along the vein.

Another small stope, about 40 feet east of the main stope, is about 30 feet long and extends for about 20 feet above the main tunnel.

In the mine workings the Campbell Mountain rhyolite of the footwall is only slightly fractured, but the Willow Creek rhyolite of the hanging wall is much fractured for several feet from the vein and is greatly silicified. The fragments are cemented by quartz with some sulphides, in places forming a breccia of altered rhyolite fragments in white quartz with some galena, sphalerite, and ruby silver. Some fractures with gouge show coatings of pyrite. Open cavities are not uncommon.

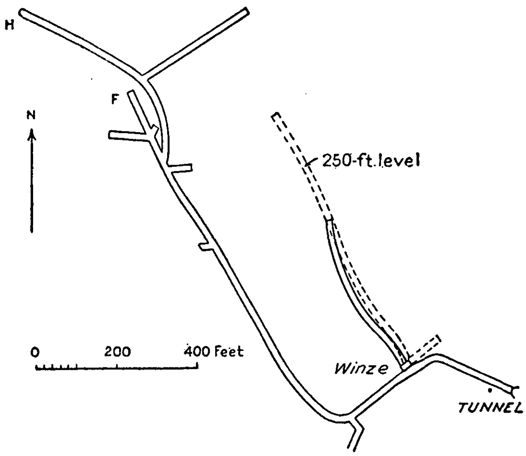


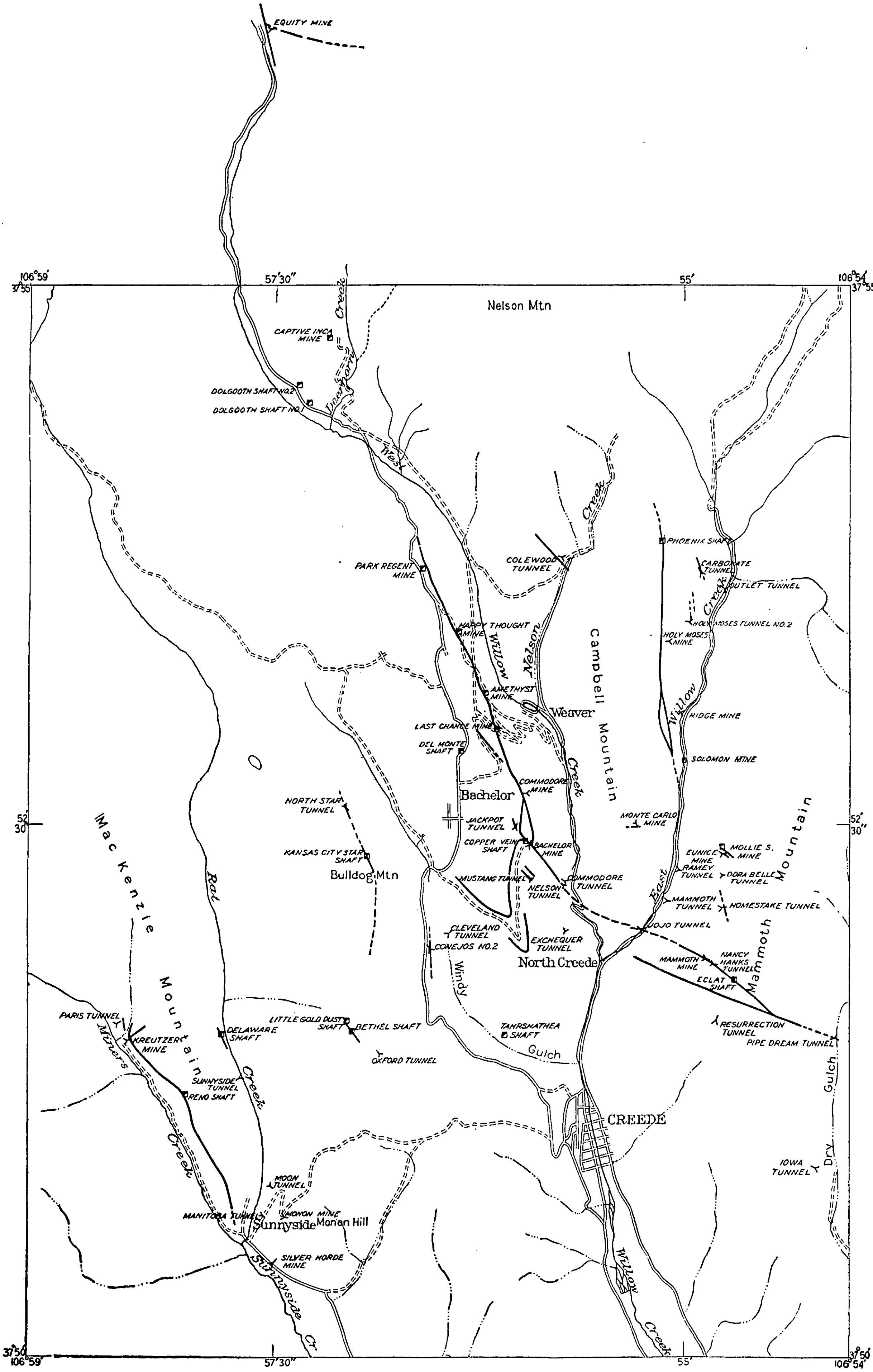
FIGURE 13.—Map of the Oxford tunnel, Creede district

In August, 1928, the company was erecting a mill to treat the ore. The total production of the mine to August, 1927, is reported as $91,000 gross with silver at 56 cents an ounce.

BETHEL OR OXFORD TUNNEL

Considerable new work has been done on the Bethel claim and Oxford tunnel, partly on the tunnel level and partly on a level 250 feet below it. The development is shown by Figure 13, which is taken from maps kindly furnished by Mr. Elwood Neff. In this area the Creede formation overlies an irregular southward-sloping surface of the Campbell Mountain rhyolite, which is cut by several bodies of intrusive rhyolite. The tunnel appears to run about parallel to the two main intrusive bodies, and the main workings are between them. The tunnel starts in the Creede formation and for the first few hundred feet runs near its base and is partly in the Campbell Mountain rhyolite and partly in the Creede formation, and much of the tunnel shows the contact. Beyond that the main rock is the Campbell Mountain rhyolite, but intrusive rhyolite comes in and out of all the workings again and again, and some of the tunnels follow the contact of the two rhyolites.

The lower level was inaccessible. The upper level shows a few slips with gouge, notably the one followed by the winze and those



MAP OF CREEDE DISTRICT, COLORADO, SHOWING PRINCIPAL MINES AND PROSPECTS AND MINERALIZED FAULTS AND VEINS followed by drifts F and H. However, no ore was found and no indication of much mineralization.

MONON HILL AREA

One of the most interesting and important of the new developments at Creede is the production of silver from deposits along the contact of the Willow Creek rhyolite and the Creede formation, in the Monon and Manitoba mines, on the west slope of Monon Hill.

About 1915 or 1916 Samuel Magnusson, working the Monon mine on a lease, found the large ore body that yielded nearly all of the metal of the Monon and Manitoba mines. He produced some silver and then turned his lease over to A. B. Collins and H. R. Wheeler, and under their lease most of the production of the Monon was made. Some silver was produced later from the Monon and some from the Manitoba. The total yield of this deposit was 21,833 tons, carrying 21 ounces of gold, 756,400 ounces of silver, and 345,000 pounds of lead.

The geology of the Monon Hill area is shown in Figure 14, modified from the geologic map of the Creede district. Monon Hill is underlain by travertine of the Creede formation, and this body extends to the east, south, and southwest and is the largest and thickest mass of travertine in the district. The travertine is a hot-spring deposit and was formed partly at the surface and partly in the channels through which the water moved toward the surface. The slopes west and northwest of Monon Hill are underlain by well-bedded tuff and gravel of the Creede formation. The hill to the northeast of Monon Hill is underlain by the Campbell Mountain rhyolite.

The map and field study show that the Willow Creek and Campbell Mountain rhyolites and some younger rocks (Piedra) formed a mountainous surface, about as rugged as the present mountains of the area, at the time the Creede beds were deposited, and that these beds filled in the gulches and canyons of that surface. The area occupied by the Creede formation west and north of Monon Hill was formerly a small gulch, and the ryholite northeast of Monon Hill formed the crest of the ridge east of the gulch. The travertine was deposited on the southern nose and east slope of the rhyolite ridge. The slopes of this ridge were steeper than the present slopes to the east, south, and west.

No known faults were found in the prospected area, but faults are shown within a thousand feet to the west and within half a mile to the north and northeast. From the fault to the west—the Alpha-Corsair fault—considerable silver ore has been produced.

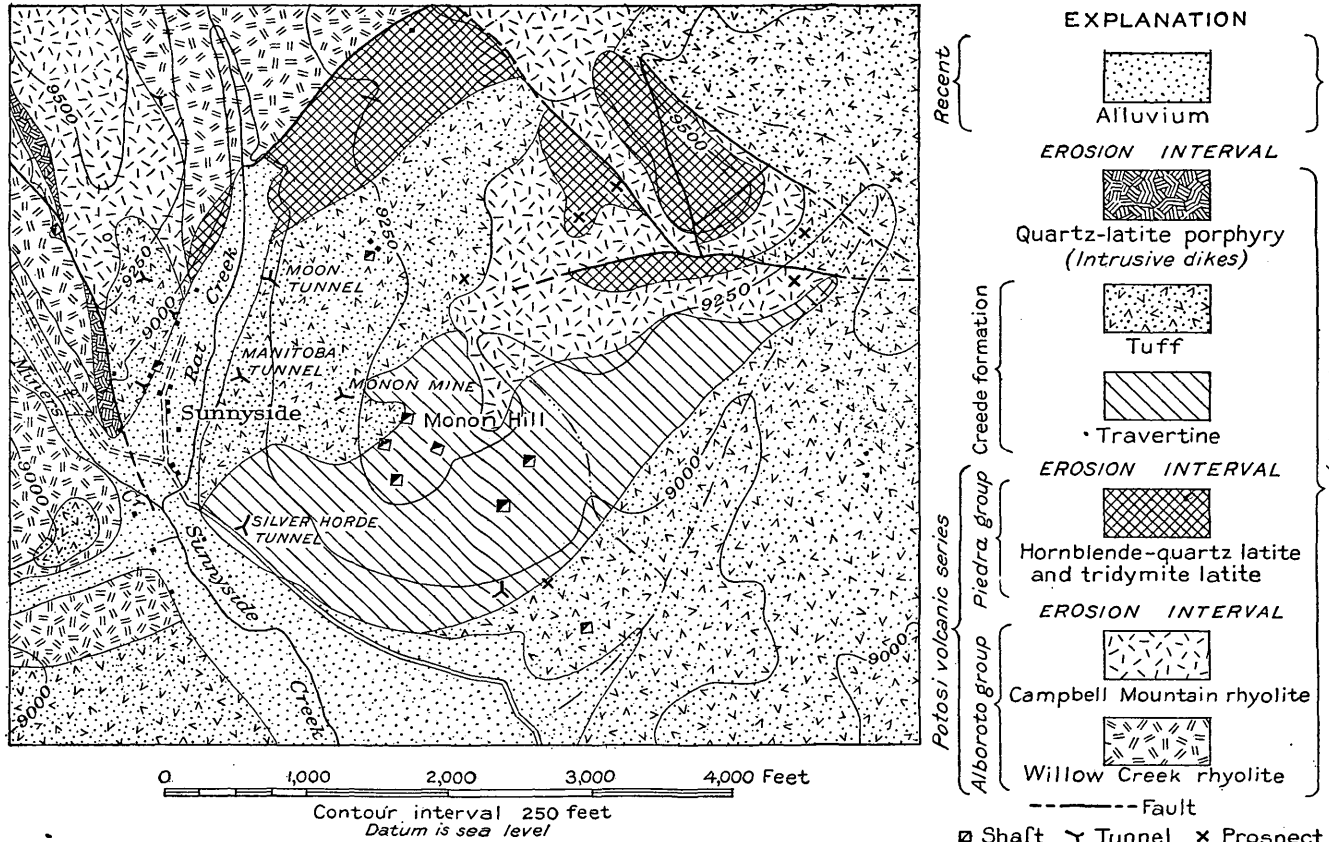


FIGURE 14.—Geologic map of the Monon Hill area, Creede district

The relations deduced from the map and field study are confirmed by the mine workings, which are shown in plan in Figure 15 and in cross section in Figure 16, both compiled from the mine maps. The ore, main drifts, and stopes lie along the contact between the rhyolite and the overlying Creede tuff beds.

The Creede formation in the workings is well bedded, and some beds are made up of fine material, some of sandy material, some of breccia, and some of conglomerate. In part the beds are altered to soft bentonitelike material; in part they are silicified and hard.

In the Silver Horde workings there is considerable travertine. The beds are nearly flat at a distance from the contact, but about 50 feet from the contact they turn up and dip at about 20° to 30° or even more to the west, away from the rhyolite, but less steeply than the rhyolite-tuff contact. The beds maintain their character, are well bedded and in part fine textured, and contain no large amount of the underlying rhyolite up to the rhyolite contact and hence do not represent talus or fan or other rapidly accumulated material at the base of the steep slopes of rhyolite.

The contact of the Creede formation and the rhyolites in most places dips at about 40°, though locally it is much flatter. Along the strike, as followed by the tunnels, the contact is rather irregular in detail in both directions, much like the slope of a steep hillside, and in the Silver Horde workings it appears to be very irregular. It is clearly the original contact of deposition of the Creede beds on a steep slope of rhyolite, somewhat modified, as shown by the steep dip of the Creede beds near the contact. This turning up of the soft, younger bedded rocks may be largely attributed to settling due to compacting and shrinkage on alteration of the Creede beds, but it is probably due in part to a moderate forcing up of the hard rhyolite mass through the soft Creede beds. As shown in the cross section (fig. 16) the contact dips regularly from the lower tunnel nearly to the upper tunnel, but just under the upper tunnel it must flatten or probably turn down into a gulch that existed to the east when the Creede beds were deposited. The ore lies along the contact between the rhyolite and tuff or in the tuff beds very near the contact.

This contact must turn to the east within 1,000 feet south of the southern stopes and must then swing around under the present hill and turn to the northeast. This southern part of the contact is probably between rhyolite and travertine. Travertine is exposed in the Silver Horde tunnel near and for about 90 feet beyond the turn that is about 600 feet from the portal.

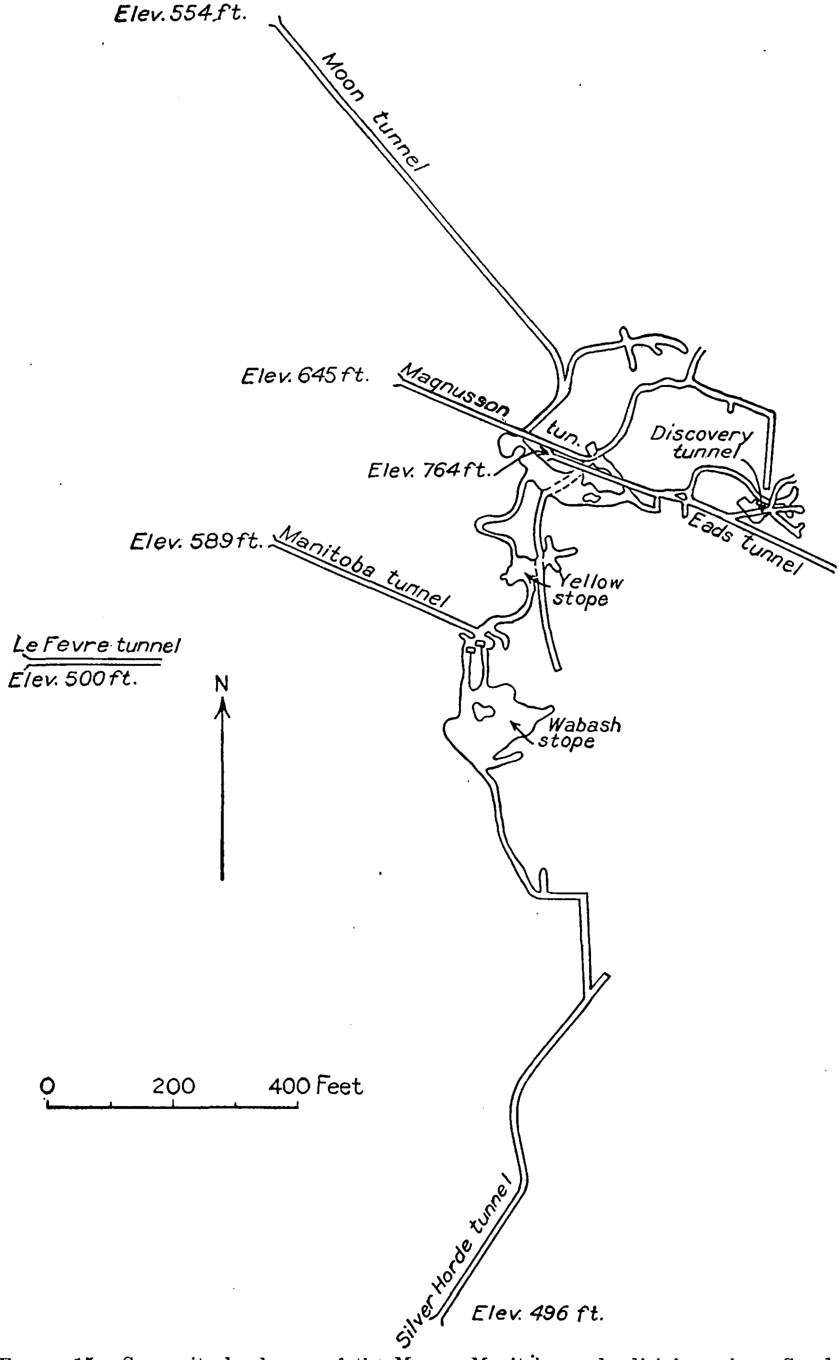


FIGURE 15.—Composite level map of the Monon, Manitoba, and adjoining mines, Creede district

BEDDED DEPOSITS SOUTHWEST OF THE COMMODORE MINE

It has long been known that the upper member of the Creede formation was somewhat mineralized in the area about Windy Gulch and to the east as far as the Commodore mine, but a few years ago much excitement was caused at Creede by the discovery by Frederick Monkemeyer that some parts of these tuff beds gave good assays for silver. A number of tunnels were run in the tuff beds, and about 10 carloads of carefully selected ore was shipped to the smelters. This ore is said to have run from 12 to 30 ounces of silver to the ton, averaging about 17 ounces, and one car carried 2½ per cent of lead.

Mr. Ben A. Birdsey kindly accompanied me to the prospects and furnished me with information in regard to ore shipments and values.

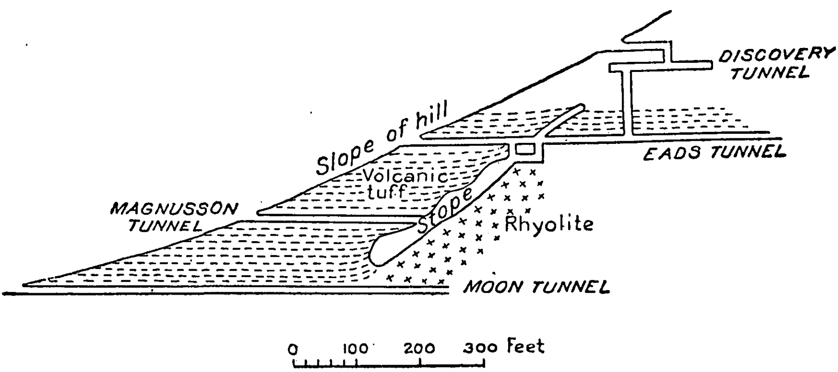


FIGURE 16.—Cross section along the vein of the Monon mine, Creede district

These so-called " flat veins " are really beds of tuff that have been mineralized. The chief mineralized bed is about 160 feet above Commodore No. 3 tunnel and extends around the hill, about on the level, nearly to Windy Gulch. The mineralization occurred chiefly in sandy to flinty textured tuff beds, which are underlain by conglomerate and overlain by sand and conglomerate. It is reported that cut samples from the beds for a thickness of 10 feet average from less than 10 to 20 ounces of silver to the ton. The beds contain some black carbonized fragments of wood, and these are especially rich in silver, running as high as 3,000 ounces to the ton. One tree trunk weighing a little less than a ton returned 80 ounces of silver.

Other beds in the Creede formation no doubt carry some silver, and one a little above the main bed and another a little below it have been prospected but show less silver than the main bed.

The origin of the silver in these tuff beds offers an interesting problem, but sufficient data for a definite solution are not available. The tuffs of this area are well bedded and are made up mainly of rhyolitic and latitic material. They are considerably indurated, and the fragments are somewhat altered. The cement consists of iron oxide, iron silicate, some silica, and locally barite, jarosite, and other minerals. The beds that were most mineralized are those of finer texture and therefore probably less porous. It seems probable that the mineral solutions rising along fault fractures permeated the tuff beds and found some beds, possibly because of their high content in organic matter, more favorable for mineralization than others. Clearly the organic matter served as a precipitant for the silver.

BENTONITE BEDS

A nonmetallic mineral that may prove of value is the bentonite recently discovered in the Creede district by Ben A. Birdsey and now being developed by the Metalloid Corporation. The bentonite occurs in the lower member of the Creede formation and represents more or less altered beds of rhyolitic tuff. One body of bentonite is prospected by a pit and short tunnel just southwest of the southwest corner of the cemetery. Where opened this bed is nearly 20 feet thick and has a 1-inch layer of silica and some lenses of less altered rock. The extent along the beds is uncertain. The beds strike N. 20° W. and dip 40° W., but this is a local dip, and the beds probably flatten at no great distance from the prospect, as the normal dip of this area is a few degrees to the south. The bentonite bed lies between beds of less altered sandy tuff.

Other beds of bentonite have been discovered along the southern borders of the low hills between Sunnyside and Willow Creeks and just north of the automobile road.

Tuff beds of the kind that might yield bentonite are common in the lower part of the Creede formation, and bentonite may be found in any part of that formation. The Creede formation underlies the low hills about the Rio Grande Valley from a point below Wagonwheel Gap to the mouth of Trout Creek at Antelope Park.

The continuity of the bentonite beds is uncertain until more work has been done. The alteration of the tuff may have affected certain beds over large areas, but it seems more probable that the alteration was somewhat erratic and that the degree of alteration will be found to change along the strike.

Thin sections of specimens of the bentonite from the pit by the cemetery show a few crystals of biotite and feldspar and abundant remnants of volcanic glass in a matrix of the secondary clay mineral montmorillonite. The proportion of unaltered volcanic glass varies somewhat from place to place. The alteration of the volcanic glass is less complete than in most bentonites of other localities.

The Creede bentonite is said to be more coherent and firm than most bentonites and hence to make superior filters, especially for clarifying vegetable oils. This character is probably due to the presence of the feldspar crystals and especially the remnants of volcanic glass, which give more body to the material and prevent the clay minerals from packing too closely.

CONCLUSIONS

As measured by value 70 per cent of the metal recovered from ores produced in the Creede district has been in silver, 20 per cent in lead, 6 per cent in gold, and 4 per cent in zinc. In the last 10 years silver has formed about 90 per cent of the value, and in the last seven years an even larger part. To judge from the past production and the present development, the future of the camp as a producer of metal would seem to depend chiefly on the continued output of silver. A study of the silver production therefore seems desirable.

By far the greater part of the silver came from the Amethyst vein between the Bachelor and Amethyst mines. About $700,000 was produced from the Monon and Manitoba deposit, about $600,000 from the Alpha-Corsair vein, and smaller amounts from other veins. Nearly all of the silver produced came from the upper workings, chiefly above water level, and in most of the mines the ore was of low grade in the lower workings and became too poor to work in depth. All the great bonanzas of the early days came from the upper levels, and in spite of extensive explorations no body of workable ore has been found in the Amethyst vein below the Nelson tunnel level.

These facts, together with the character of the ore itself, show that the silver ore at Creede was first deposited in veins along faults as a rather low-grade ore, and that much later ordinary surface waters moving downward dissolved silver from the upper parts of the vein, carried it down, and deposited it in the lower parts, chiefly near the level of ground water. A generalized picture of the course of events leading to the formation of the bonanzas should aid in understanding the deposits.

After all the volcanic bedrock formations of the area had been laid down, great earthquake rifts or faults were formed, the greatest of which was the Amethyst fault, which was several miles long. The numerous associated faults to the north, south, and east of the Amethyst and all the other faults of the area represent associated breaks. The area about Creede was thus broken into a number of great block mountains. The block east of the Amethyst fault was raised about 1,000 feet relative to that on the west. The wedge in which the Eclat shaft was sunk, on the southwest slope of Mammoth Mountain, was lowered with relation to the blocks both to the north and to the south. The block north of the Equity fault was raised about 1,200 feet above the block south of that fault and an even greater amount above the block west of West Willow Creek. The displacement along the Amethyst or any of the other faults did not occur at one time but is the aggregate result of many small movements, distributed over a long period.

After the movement along the faults was nearly completed mineralized solutions from below, moving through the openings along the faults, deposited the primary ore. At that time the surface of the ground was very different from the present surface, and many hundreds of feet of rock then present has since been removed.

Weathering, stream erosion, and all the surface agencies of disintegration acted on the old surface much as they do at present. Surface solutions percolated down along the veins, slowly oxidized the sulphide minerals, and carried the silver and other metals down and redeposited them at or near the level of ground water, thus impoverishing the vein near the surface and enriching it at moderate depths. At the same time the streams were slowly wearing down the mountains and carrying the waste away. These two processes, the erosion of the mountain mass and the leaching and redeposition of the silver, went on together until hundreds of feet of the mountains and the veins had been removed and the silver of these hundreds of feet concentrated at moderate depths. This concentration gave rise to the great bonanzas of the Amethyst vein which were mined in the early days.

These processes have been active to the present time, but there have been changes in the conditions. One important change occurred just before the earlier glaciation. At that time the land surface was much less mountainous than at present, the streams occupied broad valleys with relatively gentle slopes, and the surrounding hills and mountains were smoother and less steep than at present. Large remnants of this old surface, somewhat modified and deeply dissected by the present canyons, are preserved and can be seen near Bachelor and to the north. The basin of Windy Gulch above the Bachelor road crossing shows this old surface, little modified, and the canyon of the gulch below the road crossing has been recently cut below this old surface. Dry Gulch, on the east border of the area shown on the Creede special map published by the United States Geological Survey, is another good illustration, with a steep, rugged canyon in its lower part giving place abruptly and with marked contrast at an altitude of about 10,500 feet to a broad valley and rolling hills.

The development of these broad valleys took a very long time, and in the later stages the rate at which the rock surface was worn down was very slow. Leaching of the upper part of the vein by surface waters went on at about a normal rate, however, and hence veins immediately under this surface were greatly impoverished and much silver was deposited near the ground-water level of that time, forming the great bonanzas of those veins.

At a later time the mountains were raised and tilted toward the Rio Grande, and the streams rapidly cut the deep canyons that we now see. This lowered the level of ground water, and the leaching of that part of the vein below the former ground-water level began, but time enough has not yet elapsed to make this leaching very effective, though much of the silver taken from the lower levels of the mines was formed in this way.

In the main Amethyst vein most of the large bodies of rich ore in the upper workings were formed by downward-moving solutions at the time the upland valleys were being sculptured and were near or above the ground-water level of that time. The ore of the lower workings was probably formed by the enrichment of primary vein filling by descending surface waters while the present canyons were being eroded. This ore was mostly of lower grade than that of the upper workings.

The ore mined at present comes mostly from small veins in the hanging wall of the Amethyst vein and from the upper levels. This ore has no doubt been enriched by descending solutions, and it seems probable that in these small veins only enriched ore can be mined profitably. The enrichment of these small veins should extend to about the same depth as that of the main vein,[4] although it would be affected by the tightness of the vein material and adjoining wall rock. The main ore body would probably be at approximately the same vertical positions in the main vein and in veins in the hanging wall.

Most of the production from the hanging-wall veins has come from those near the southern part of the main vein, but ore is being mined from such fractures in the Last Chance and Amethyst mines, though little prospecting has been done in this northern part of the vein. It is possible that the numerous hanging-wall fractures in the Commodore mine may be connected with the wedgelike branch in the Amethyst vein. The ground to the west and south of the west branch of the Amethyst fault would also be favorable for fractures. The fractures so far opened have been in the upper workings of the mines, but there appears to be no reason why similar mineralized fractures may not be found at greater depth, though below the zone of enrichment the ore would probably be of low grade. Some of these fractures may die out before reaching the surface.

In the Monon and Manitoba vein the ore was nearly all above water level and was clearly enriched by descending surface waters.

[4] See U. S. Geol. Survey Bull. 718, fig. 15, p. 127, 1923.

In the lowest workings sulphides were more abundant, and the ore was of lower grade.

In the Equity mine the ore has come from below water level in a glaciated canyon, shows no evidence of oxidation, and has probably not been much enriched by surface solutions. On the upper slopes of the relatively gentle hill east of the mine this vein may have ore that was enriched, as this hill is part of an old, rather mature topography, and any ore bodies under its gentle slopes would have been enriched by surface solutions.