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MINERALS AND MINERAL DEPOSITS OF THE SAN JUAN  
REGION, COLORADO

This Report for the M.S. degree by

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(Washington and Jefferson College, 1934)

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A Report submitted to the Faculty of the Graduate  
School of the University of Colorado in partial fulfillment  
of the requirements for the Degree M.S.

Department of Geology

1934

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1882, there were perhaps 10,000 people. The town is connected with Denver and Pueblo by a broad-gauge branch of the Denver and Rio Grande, Eastern Railroad. Creede may be reached by automobile by turning north at Southfork from United States Highway number 160. The town is 23 miles northwest of Southfork along this road and 39 miles from Del Norte in a northwesterly direction.

(1)  
Rocks of the Region

The rocks, Creede District, Colorado

single occurrence of andesite, are all classified as rhyo-  
Location of Area

The district is located in southwestern Colorado in Mineral county. It is in close proximity to the elevated San Juan Mountains. The town of Creede is situated on Willow Creek a few miles above its junction with the Rio Grande River. The lowest part of the area is about 8,700 feet above sea level and is found downstream from Creede about a mile. The canyons above Creede, ~~as~~ <sup>though</sup> like that of Willow Creek have nearly vertical walls and are several hundred feet high. Upper parts of the streams in the region show gentler slopes as they have been modified by recent glaciation. The area is timbered and well watered like most of the other mountainous areas of the San Juan Region.

Creede at the present time (1934) is a town of about 400 population, though once in the boom days around 1892, there were perhaps 10,000 people. The town is connected with Denver and Pueblo by a broad-gauge branch of the Denver and Rio Grande, Western Railroad. Creede may be reached by automobile by turning north at Southfork from United States Highway number 160. The town is 23 miles northwest of Southfork along this road and 39 miles from Del Norte in a northwesterly direction.

(1)  
Rocks of the Region

The rocks of the region, with the exception of a single occurrence of andesite, are all classified as rhyolite. They belong to four distinct periods of eruption and are separated by very irregular erosion surfaces. The lavas and lake beds of the Creede formation form a part of the great San Juan Sequence. From plant remains found in the Creede formation and the Huerto formation to the west, all the rocks are believed to be Miocene in age. The plant remains in the lake beds are closely related to the Florissant flora, which is considered to be Miocene in age.

(2)  
Geologic Section of the Area

Structure

Hinsdale volcanic series of west not represented in this section

Quartz latite porphyry dikes (Miocene?)

Fisher quartz latite (Miocene?) 0-100 feet

Creede formation 0-2000 feet - lake beds of tuff with some flows of quartz latite in upper part (Miocene) some travertine spring deposits

Nelson Mountain quartz latite 0-350 feet

Rat Creek quartz latite 0-500 feet

Quartz latite tuff 0-500 feet

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(1) Emmons, W. H. and Larsen, E. S., The Geology and Ore Deposits of the Creede District, Colorado, U. S. Geology Survey Bulletin, 718, pp. 13-84, 1926.  
(2) Emmons, W. H. and Larsen, E. S., op. cit., (Bulletin 718) p. 13.

Andesite 0-500 feet

Intrusive andesite

Tridymite latite 0-400 feet

Windy Gulch rhyolite breccia	{ Rhyolite tuff to east 0-200 Mammoth Nitrydite 0-1000 feet
100-200 feet	
Hornblende quartz latite	{ 200 feet
200 feet	

Huerto formation - a series of andesites, flows, and tuff breccias is absent in the region

Equity quartz latite 0-1000 feet

Phoenix Park quartz latite 0-500 feet

Intrusive rhyolite

Campbell Mountain rhyolite 0-1000 feet

Willow Creek rhyolite 0-1000 feet

Outlet Tunnel quartz latite 250 - 350 feet

### Structure

The structure of the Creede Area discloses the volcanic rocks tilting gently toward the Rio Grande with a few zones of block faulting.

(3)

### Faulting

Faulting in the area is difficult to detect because of the great and varying thickness of nearly all the rock bodies, the lack of regular bedding planes and horizon markers, the common pinching out in a very few feet of some of the

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(3) Emmons, W. H. and Larsen, E. S., op. cit., (Bulletin 718) pp. 86-88.

geologic units, a lack of a regular persistent succession of rocks, marked irregularities at the bases of rock bodies, the covering of Quaternary material in critical areas, and the difficulty in distinguishing some of the rocks from each other.

The great relief, comparatively good natural exposures, and the considerable amount of prospecting in the area, make the main faults more easily detected.

The majority of the major faults are normal with strikes a little to the northwest. The Amethyst and Solomon-Ridge faults dip steeply west; the Bulldog Mountain and Alpha faults dip to the east. The Amethyst fault breaks up into a number of faults with varying strikes south of the Commodore mine. The great Equity fault strikes nearly east and dips very steeply north. This fault is the only reverse fault in the district.

Brecciation of the walls near the faults is not extensive, the walls commonly showing clear-cut and slickensided surfaces. The faults not uncommonly branch, as in the Commodore mine, where the Amethyst fault in places shows large horses of rock enclosed between two branches.

The faults die out generally along the strike. North of the Park Regent mine, the throw of the amethyst fault is believed to decrease rapidly. It is not very great south of the Equity mine.

The faulting preceded the mineralization period and is thought to have taken place in one period. The faults are not interrupted by later igneous rocks. The Amethyst fault

The Amethyst fault is known to have cut the Creede formation, the Alpha faults to have cut the Fisher quartz latite, and the intrusive quartz latite porphyry. Thus it seems likely that the major faulting occurred before the extrusion of the youngest volcanic rocks in the area. A later movement is demonstrated by some crushing and slickensiding of the vein materials in nearly all the veins. present drainage system was developed.

(4)

Mineralization Along Faults

The Bulldog Mountain fault is the only one of the five main fault systems that has not produced ore. At Sunnyside camp, ore has been produced from along the Alpha fault. The Solomon, Ridge, and Holy Moses mines are along the Solomon-Ridge fault. The Equity mine is along the Equity fault. The Amethyst vein along the Amethyst fault has produced most of the ore of the region. Most of this production has come from between the south end line of the Bachelor claim and the north end line of the Park Regent claim. An area of block faulting is found northeast of Sunnyside.

The Alpha, Equity, and Amethyst faults, and the three faults east of North Creede all have throws of over 1,000 feet. These faults show no escarpments and affect the topography in so far as they bring together rocks of different hardness. No change in the gradient of the stream is

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(4) Emmons, W. H. and Larsen, E. S., op. cit., (Bulletin 718) p. 88.

The ore minerals are sphalerite, argentiferous

noted where the extension of the Amethyst fault with a throw of nearly 1,500 feet crosses East Willow Creek. Erosion must therefore have removed 1,500 feet more of rock on the north side of the fault than on the south side of the fault. The topography must have been very much different from the present topography at the time of faulting, the faulting necessarily taking place before the present drainage system was developed.

### Ore Deposits

#### General Character

The ore deposits of the Creede district are silver-lead fissure veins in rhyolite, and fractured zones of silver ore in shattered rhyolite. Nearly all of the production has been from the silver-lead fissure veins. The veins are located along strong fault fissures and are extensive both vertically and along the strike. These veins include the Amethyst, Solomon-Holy Mases, Carsair, Mammoth, and several other smaller lodes. All the veins strike northwest and dip west or southeast.

The principal veins fill fissures along normal faults. In the hanging wall blocks at some places, there are subordinate fissures which join the principal faults at depth. Thus the hanging wall of a fault must have been shattered as it was drawn downward along the foot wall.

Some of the veins have been opened by movements since the ore was deposited; the ore itself is crossed by striated slickensided planes, with vein quartz and associated sulphides locally forming a friction breccia.

The ore minerals are sphalerite, argentiferous

galena, gold, pyrite, chal<sup>al</sup>copyrite, and their lateration products. The gangue shows quartz, much of which is ~~Amethyst~~ amethyst quartz with chl<sup>9</sup>rite, barite, and fluorite. Considerable alteration has taken place along the most productive portions of the veins, with silicification and the development of sericite and thuringite. The latter, an iron rich chlorite, locally makes up much of the gangue of the Amethyst vein. Adularia has been noted near the Amethyst vein in veinlets cutting rhyolite. Symmetrical banded crusts are common and indicate deposition in open spaces.

Enrichment is pronounced in some of the deposits, the rich secondary ores extend downward to great depths. The great relief of the area, and the open character of the veins made possible this condition.

The deposits of the Mollie S. and Monto Carlo mines are characterized by fractured zones of silver ore in rhyolite. The fractures and joint planes are filled with veinlets of malachite, chalcantinite and green chrysoprase, which locally carry very high percentages of silver. Argentite, cerargyrite, and native silver are found on the walls and in the thin narrow cracks. Minerals noted on Field Trip July 9-20, 1934.

the Amethyst mine. None was seen by the writer in the course

Quartz

Quartz is abundant throughout the deposits as a gangue mineral. A specimen of dark gray quartz containing disseminated galena, pyrite, and sphalerite was obtained from the old dump of the Humphreys Mill at North Creede. Specimens of white crystallized quartz and amethyst quartz were obtained

from

small veins in chloritic material from this same dump. Milky vein was noted on the Wilson tunnel level in the Bachelor mine, quartz was also seen by the writer on the dump. near the point where the Bachelor vein joins the Amethyst

Thuringite E. S. Larsen and W. H. Emmons at the time of their investigations in the district in 1912.

Thuringite, an iron rich chlorite, is one of the most abundant minerals in the Amethyst and Solomon Lodes.

Specimens were obtained of this material from the dump at the Humphreys Mill. This material showed veinlets of amethyst quartz, and small particles of galena and pyrite disseminated through the thuringite. Similar specimens not showing amethyst quartz were found on the dumps of the Solomon and Holy Moses mines.

Fluorite (Ca F<sub>2</sub>)

Adularia (Pure Na[Al]Si<sub>3</sub>O<sub>8</sub>)

White fluorite was seen in the material from the dump of the Holy Moses mine and also from the Solomon mine. Adularia occurs in thin veinlets with quartz and orthoclase cutting rhyolite wall rock in the Amethyst lode. A green mineral noted in material collected from the Amethyst dump by the writer was tested in the laboratory and found to be fluorite. This green fluorite is associated with galena,

Rhodochrosite (MnCO<sub>3</sub>) and amethyst quartz.

This is the first time, to the writer's knowledge, that green fluorite has been reported from this district. Rhodochrosite is found very rarely in the ore of the Amethyst mine. None was seen by the writer in the course of his investigations.

A small cluster of crystals lining a vug in the

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probably the only primary lead mineral found in the Creede

(5) Emmons, W. H. and Larsen, E. S., "The Geology and Ore Deposits of The Creede District, Colorado: United States Geology Survey, (Bulletin 718) p. 102, 1926.

(6) Emmons, W. H. and Larsen, E. S., op.cit. (Bulletin 718), p. 102.

(7) United States Geology Survey, (Bulletin 718), p. 102.

vein was noted on the Nelson tunnel level in the Bachelor mine, near the point where the Bachelor vein joins the Amethyst fault, by E. S. Larsen and W. H. Emmons at the time of their investigations in the district in 1912.

Barite ( $\text{BaSO}_4$ )

Barite occurs in considerable amounts in the outcrops of most of the lodes near Creede. It was noted by the writer at the outcrops of the Amethyst lode and also the Commodore lode in rhyolite. It was also seen in rhyolite on the ridge above the Mollie S. mine on Mammoth Mountain.

Fluorite ( $\text{Ca F}_2$ )

White fluorite was seen in the material from the dump of the Holy Moses mine and also from the Solomon mine. A green mineral noted in material collected from the Amethyst dump by the writer was tested in the laboratory and found to be fluorite. This green fluorite is associated with galena, sphalerite, chalcedony, and amethyst quartz.

This is the first time, to the writer's knowledge, that green fluorite has been reported from this district.

Galena ( $\text{PbS}$ ) is found in the sulphide ores of all the lodes. Galena is the most valuable ore of lead and probably the only primary lead mineral found in the Creede district. All the lead concentrates carry silver. In the

(7) United States Geology Survey, (Bulletin 718), p. 102.

Sphalerite (Zn S)

Lower levels of the Amethyst and Park Regent mines blocks of galena several feet square and six inches thick have been mined. Most of the galena, however, occurs as thin bands alternating with sphalerite and quartz, or as small masses disseminated in thuringite gangue. Galena alters to anglesite, cerussite, and pyromorphite. Some crystals of sphalerite from the dumps of the Holy Moses mine show a gray metallic coating. This film or layer was scraped off and tested in the laboratory. It proved to be galena.

The above description was taken from Emmons and Larsen (9) United States Geology Survey, Bulletin 718, page 102.

Galena specimens were obtained in material from the Holy Moses and Solomon dumps which show galena as small masses and crystals disseminated together with sphalerite crystals in thuringite. An ore specimen from the Commodore mine of nearly pure galena was obtained by the writer. Galena associated with amethyst quartz, sphalerite, and green chloritic material was found in materials from the dump at the Humphreys Mill.

Pyrite (Fe S<sub>2</sub>)

Pyrite is found in the sulphide ores of all the lodes. Pyrite crystallized in small pyritohedrons in a specimen of green chloritic material from on top of the ridge just above the Humphreys Mill dump. Pyritohedrons of pyrite were also seen here associated with amethyst quartz and thuringite.

Geology Survey, (Bulletin 718), p. 104.  
(9) Idem. p. 103.

Sphalerite (Zn S)

Sphalerite is one of the most abundant minerals in the unoxidized ores of the Amethyst and Solomon-Holy Moses veins, where numerous specimens of crystallized sphalerite were obtained from the dumps of these mines.

Chalcopyrite (Cu Fe S<sub>2</sub>)

Chalcopyrite in small amounts was noted in the ores of the Amethyst mine. No chalcopyrite was seen in materials from the Solomon-Holy Moses and Alpha Carsair lodes.

Gold (Au)

Gold occurs in pyrite, galena, sphalerite, and other minerals of the Creede district. The richest gold ore consists of native gold in a gangue of manganese oxide in veinlets cutting the older sulphides. Such veinlets may carry from one to two ounces to the ton while primary ore only runs .01 ounce. The gold occurring with galena is a dark yellow in color.

Native Silver (Ag)

Native silver is an abundant constituent in the Amethyst vein. In general it forms thin sheets in the siliceous sulphide ores, or is attached to fractured surfaces. In some of the cabinet specimens nests of thin closely spaced wires of native silver fill little vugs in dark quartz that is

(8) United States Geology Survey, (Bulletin 718), p. 104.  
 (9) Idem. p. 103.

stained by oxides.

Such a specimen of native silver in which the vugs are from a half to an inch wide and filled with wires of silver, was seen in the window of the barber shop in Creede. A specimen of wire silver on barite about 8 inches long and 4 inches wide was seen in the collection of Mr. Art Leonard of Creede. This specimen came from the Happy Thought mine.

(10)  
Argentite ( $Ag_2S$ )

Argentite has been noted in the Amethyst mine and in the ores of the dump of the Mollie S.

A specimen of argentite from the Paris mine was seen in Mr. Art Leonard's collection at Creede.

(11)  
Stephanite ( $5Ag_2S \cdot Sb_2S_3$ )

Stephanite is said to have been found in the ores of the Alpha-Carsair lode.

Marcasite ( $FeS_2$ )

Marcasite is developed in some of the superficial ores in some of the deposits, but it is not abundant. At the Delaware prospect near Sunnyside, masses of marcasite of considerable size were noted. At this locality the marcasite forms crusts over fragments of rhyolite and apparently belongs to a late stage of deposition.

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(10) Emmons, W. H. and Larsen, E. S., op. cit. (Bulletin 718) p. 104.

(11) Idem, p. 104.

but is not abundant. It was seen at the outcrops of the  
Anglesite ( $\text{Pb SO}_4$ )  
 Amethyst vein above the Commodore mine.

Anglesite is abundant in the oxidized ore as an  
 Jarosite ( $\text{K}_2 \text{Fe}_6 (\text{OH})_{12} (\text{SO}_4)_4$ )  
 oxidation product of galena. A specimen from the Amethyst  
 dump shows galena surrounded by anglesite. A few glassy  
 crystals in cavities in galena were also noted from this dump.

Chance mine  
Cerussite ( $\text{Pb CO}_3$ )

Calcite ( $\text{Ca CO}_3$ )  
 Cerussite is developed in the oxidized ores of the  
 Amethyst, Holy Moses, and other mines in the district. A  
 specimen obtained from Happy Thought dump shows an aggregate  
 principally of white cerussite crystals. yellow crystals

of calcite, amethyst quartz, and malachite crystals,  
 in a breccia of these minerals.  
Calamine ( $\text{Zn OH})_2 \text{ Si O}_3$

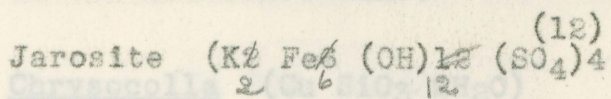
A specimen from the Happy Thought dump shows white  
 Siderite ( $\text{Fe CO}_3$ )  
 clear crystals in small radiating and spherulitic masses in a  
 breccia composed of crystals of galena, sphalerite, amethyst  
 quartz, and small yellow calcite crystals. A second specimen  
 shows similar crystals on chloritic material. Both specimens  
 were determined in the laboratory. They proved to be cala-  
 mine. Malachite was noted as a stain on rhyolite from the

Amethyst. The calamine crystals were too small to get their  
 specific gravity. The mineral has a white color, white  
 streak, vitreous luster, hardness of 4.5, and crystallizes  
 as small orthorhombic-hemimorphic crystals. zones of the

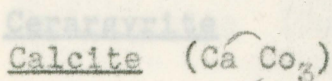
deposits. It is an alteration product of rhyolite.  
Limonite ( $2\text{Fe}_2 \text{O}_3 \cdot 3\text{H}_2\text{O}$ )

(12) Limonite is noted at the outcrops of the deposits, 3)  
 p. 105.

but is not abundant. It was seen at the outcrops of the  
 Amethyst vein above the Commodore mine.



Jarosite has been identified in oxidized material  
 taken from near the outcrop of the Amethyst lode at the Last  
 Chance mine.



It was noted by the writer on the walls of the Amethyst vein in the Commodore mine. on the sixth level of the Amethyst Mine.

Chrysocolla  $(\text{Cu SiO}_3 \cdot 2\text{H}_2\text{O})$

Chrysocolla was noted in the oxidized ores of the Mollie S. mine. seen from the dump of the old Humphreys Mill.

Cerargyrite  $(\text{Cu SO}_4 \cdot 5\text{H}_2\text{O})$

Cerargyrite has also been noted in the oxidized ores of the Mollie S. mine. Amethyst vein and was seen in a few specimens from the Amethyst dump.

Chrysoprase  $(\text{Si O}_2)$

Chrysoprase, an apple green chalcedony, is found in the ores of the Mollie S. mine. Specimens were collected from the dumps of this mine. It is also found in the ores of the Monto Carlo mines. The color is due to nickel/oxide.

Chalcedony  $(\text{Si O}_2)$

Chalcedony replaces rhyolite along the lodes. quantities in the superficial area of the Amethyst vein.

Wad

Pyromorphite  $(\text{Pb Cl}) \text{Pb}_4 (\text{PO}_4)_3$

Wad, black manganese dioxide, etc. is abundant in the oxidized ores of the Amethyst lode. A specimen of this sooty material was collected from the Humphreys Mill dump.

Goslarite  $(\text{Zn SO}_4 \cdot 7\text{H}_2\text{O})$

Goslarite occurs as masses of hairlike materials

on the walls and floors of abandoned workings. Masses of such materials were noted on the sixth level of the Amethyst Mine.

Gypsum ( $\text{Ca SO}_4 \cdot 2\text{H}_2\text{O}$ )

Gypsum of the variety selenite was noted in small amounts in a specimen from the dump of the old Humphreys Mill.

Chalcanthite ( $\text{Cu SO}_4 \cdot 5\text{H}_2\text{O}$ )

Chalcanthite is found in small quantities in the upper part of the Amethyst vein and was seen in a few specimens from the Amethyst dump.

Melanterite ( $\text{Fe SO}_4 \cdot 7\text{H}_2\text{O}$ )

Melanterite is common in the workings in the oxidized zone. A specimen was obtained but on exposure to the air it turned white.

Smithsonite ( $\text{Zn CO}_3$ )

Smithsonite was found by E. S. Larsen in small quantities in the superficial ores of the Amethyst vein.

Pyromorphite ( $\text{Pb Cl} \text{ Pb}_4 \text{ (PO}_4)_3$ )

Pyromorphite occurred in beautiful yellow and brown crystals in the upper levels of the Amethyst veins in the early days. Not much is found today. A specimen of beautiful yellow pyromorphite crystals with cerussite was seen in the

collection of Mr. Art Leonard of Creede. Small brown pyromorphite crystals on <sup>a</sup>Amethyst quartz and rhyolite were obtained from the dump at the Amethyst mine.

Hematite ( $\text{Fe}_2\text{O}_3$ )

Hematite forms oxidized material in the upper levels of many of the lodes. Specimens of thuringite altering to hematite were found on the Humphreys Mill dump at North Creede.

Manganite ( $\text{Mn}_2\text{O}_3 \cdot \text{H}_2\text{O}$ ) (?)

A specimen of a black submetallic mineral on amethyst quartz was found on the ridge above the Humphreys Mill dump. It was tested in the laboratory and proved to be manganite. (?) This specimen has a hardness of 4, a specific gravity of 4.23, a submetallic luster, an iron black color and a nearly black streak. It yields much water in the closed tube, gives a reddish-violet color to the borax bead in the oxidizing flame, and dissolves in hydrochloric acid with the evolution of chlorine gas. The mineral is infusible. No cleavage was shown, so on basis of hardness it was determined as manganite. This is the first account of this mineral being found at Creede.

Psilomelane (?) ( $\text{MnO}_2$  with  $\text{MnO}$ ,  $\text{H}_2\text{O}$ , often  $\text{BaO}$  and  $\text{K}_2\text{O}$ )

A black metallic layer, about a quarter of an inch thick, coating rhyolite on material from the dump of the

Mollie S. mine was found and tested in the mineralogy lab-

(14) Emmons, W. H. and Larsen, E. S., op. cit. (Bulletin 718)  
 oratory by the writer. It proved to be psilomelane (?).

has replaced wall rock. Some of the ore exhibits crystallized on the basis of hardness and other chemical and physical banding. Such specimens were found on the Humphreys Mill properties.

Specimen #1 shows from the outside inward from both sides of the specimen (1) thuringite; (2) white quartz on one side, amethyst quartz on the other side; (3) galena, chalcopyrite and sphalerite; and (4) a chalcocite quartz forming inter-characteristic reddish-violet color in the borax bead in the oxidizing flame. The  $HCl$  solution gives a white precipitate of

barium sulphate upon the addition of  $H_2SO_4$ . The mineral also dissolves in  $HCl$  with evolution of chlorine gas.

This is also the first account of this mineral being found in the Creede District.

#### Character of Creede Ores

The shipping ores of the Amethyst lode are highly siliceous, carrying from 65-85 %  $SiO_2$  with a few running as low as 45%  $SiO_2$ . Barite is nearly always present in shipping, or partly oxidized ore, carrying generally 10-20 % barium. Aluminum varies from 3-8%. Lime is low forming less than one percent. Sulphur runs less than 2% in most of the ore. Zinc amounts to less than 2% in the ores that are shipped. Iron and manganese amount to as much as 5% in many of the rich ores.

#### Structure and Paragenesis of The Primary Ores

The ores have been deposited in open spaces and some by replacement of wall rock. The chloritic ore in the lower levels is thought to have filled openings, but some

(14) Emmons, W. H. and Larsen, E. S., op. cit. (Bulletin 718) p. 111.

has replaced wall rock. Some of the ore exhibits crustified banding. Such specimens were found on the Humphreys Mill Dump. Specimen #1 shows from the outside inward from both sides of the specimen (1) thuringite; (2) white quartz on one side, amethyst quartz on the other side; (3) galena, chalcopyrite and sphalerite; and (4) amethyst quartz forming inter-

quartz.

Specimen #4 shows amethyst quartz on thuringite. Part of the thuringite has altered to hematite and turgite. Specimen #5 shows thuringite, galena, sphalerite, hematite, chalcopyrite, surrounded by banded quartz. Next to the banded quartz (milky quartz) and between it and the amethyst, small particles of sphalerite and green fluorite have been deposited. One specimen shows a small open vug in the amethyst on one end, and a gray chert band over the milky quartz between it and the amethyst quartz. The ores of the Mollie S. and Monto Carlo mines differ from the rest of the ores and there is no evidence of crustification. Nearly all the ore in the shattered rhyolite is cemented with carbonates and silicates of copper that carry some silver and gold.

#### Character of Solutions

The character of the solutions which deposited the primary ores is not known but the solutions probably carried alkaline chlorides, alkaline carbonates, alkaline sulphates, and sulphides with abundant silica, lead, zinc, iron and copper together with a little gold and silver. Barium was also present as a sulphate. The solutions probably carried alumina, as thuringite is present in the ores. The primary deposition was accomplished by ascending solutions.

Mines Visited in Creede Area June 10-June 20th, 1934.

## Commodore Mine

The writer visited the Commodore mine on June 12, 1934. Mr. John Weaver conducted him through the workings which are located high on the west slope of Mammoth Mountain at that time. The mine was entered on the third level, which follows the main Amethyst vein nearly north for about 1800 feet where cross-cuts have been made to intersect parallel, or nearly parallel veins. The main vein or Amethyst vein here strikes a little west of north and dips 70 to 80 degrees to the west. At the present time much of the ore is being taken from old stopes, where some ore had been left in the earlier period of mining. The new development of the ore is in parallel veins found to the west of the main vein and which dip down into it or to the east. The vein from which the ore is now being mined is about 8 inches wide with rhyolite forming both walls. The ore appears as a dark streak of sulphides carrying galena and silver in a gangue of bull quartz, amethyst quartz in places, together with fragments of rhyolite. This ore runs from 30-35 ounces of silver per ton of rock. Much gangue is necessarily included, as stringers or small veins occur on both sides of the vein and scattered throughout it. Thus it is necessary to mine the whole width of the principal vein.

In early May, 1934, two cars of ore were shipped which ran 100 ounces to the ton. An average of 5 cars of ore a month are being shipped from this mine. The mine has only been in operation about four months having been shut down for over a period of four years.

### Mollie S. and Eunice Mines

The writer spent June 13, 1934 at these mines which are located high on the west slope of Mammoth Mountain on East Willow Creek about a mile northeast of Creede.

The Mollie S. Mine is being opened up and cleaned out by two miners from Creede, one being Mr. Lee Shilling. The mine has not been in operation for 4 years. Most of the ore is in a fractured zone in rhyolite, silver-bearing minerals having been along fracture planes in the rhyolite together with green copper carbonates and silicates, and green chrysoprase. Quartz is very scarce in this deposit. Barite was observed in rhyolite from the upper prospects of this mine.

The Eunice mine is located just south of the Mollie S. A little azethyst quartz has been found in the ore zone of this vein. A specimen of breccia ore was found on the dump of this mine. It showed the characteristic development of green silver-bearing copper minerals filling the small fractures in the rhyolite. The ore minerals are the same as those found in the Mollie S. mine, being native silver, cerargyrite, lead carbonate, chrysocolla, malachite, and a little galena. The mine was not being worked at the date visited.

### Solomon, Holy Moses and Ridge Mines

The writer spent June 15 in the vicinity of these mines which are located on the west side of East Willow

Creek, about two miles north of Creede. The Solomon is the only one of these mines in which any work is being done at the present time. Mr. Hosikas and two other miners are making a crosscut in this mine in the hope of striking ore in veins to the west parallel to the main system of veins. A specimen of silver ore from the mine shows green chloritic material, galena, sphalerite, and a little white fluorite. Material from the dump shows the characteristic minerals, galena, sphalerite, and a little pyrite and chalcopryrite, in a gangue of green chlorite, talc, and quartz. No amethyst was observed, very little quartz itself being noted. The ore contains a little gold and silver.

In the Holy Moses mine barite was found in the early days. The ore in these veins is in a sheeted zone and in fissures along this zone. Rhyolite forms both walls. About 80 feet above the tunnel and 1000 feet below the surface the sulphides change abruptly to oxides. In the past, the ore here consisted of cerussite, limonite, manganese dioxide, a little galena, and sphalerite.

#### P and E and Amethyst Mines

Work in the Amethyst mine is development work on the hanging wall of the main vein. The following minerals are characteristic of the deposits of these mines:

Amethyst Specimen #1 from the Amethyst dump shows pyromorphite on rhyolite.

Specimen #2 shows brown pyromorphite crystals on

At the Park Regent mine two leasers are working chloritic material.

over the material <sup>see</sup> the dump. The material is chiefly pyrite containing gold to the <sup>value</sup> of .41 ounce to the ton. which have become stained with <sup>chlo</sup> chlorite, together with quartzite. A little galena and silver is also being handled. This

material runs \$14.20 to the ton, almost the entire value is

At the Park Regent mine two leasers are working over the material from the dump. The material is chiefly pyrite containing gold to the value of .41 ounce to the ton. A little galena and silver is also being handled. This material runs \$14.30 to the ton, <sup>and</sup> almost the entire value is in the gold content.

Big Six Mine at Sunnyside June 17

Specimens were collected from the dump of this mine.

Specimen #1 shows travertine coated with chalcedony with calcite being deposited over the chalcedony.

Specimen #2 shows travertine upon which a yellow chalcedony has been deposited. Marcasite has been deposited over the chalcedony and a few crystals of calcite on the marcasite. The calcite is unusual in that some of the crystals have taken the form of octahedrons. It seems probable to the writer that they may be pseudomorphs after fluorite.

Specimen #3 shows small clear calcite crystals living in open spaces in travertine.

Specimen #4 shows marcasite crystallized into <sup>b</sup>atryoidal masses and cylindrical shaped masses.

Specimen #5 shows selenite crystals in travertine.

Specimen #6, an ore specimen from the Carsair mine, shows principally fine grained black sulphides in quartzite. Chemical tests show that the ore carries much silver.

are lined. A specimen of octahedral galena from Monon Hill, near Sunnyside was seen in the collection of Mr. Art Leonard at Creede. This specimen is rich in silver.

Phipps' Ranch June 16

This ranch is located about 8 miles south of Creede. The morning was spent in the vicinity of the cliffs found northeast of the ranch houses. Good specimens of white, black, and greenish chalcedony were obtained from the rhyolite which forms these cliffs. Specimens of red chert were also picked up on this ranch.

A crystal of gypsum was found in the Creede formation near this ranch, also travertine containing blue chalcedony.

Aragonite Cave 8 Miles Southwest of Creede Creek directly

In the afternoon of June 16, Allan Caplan and the writer visited an old prospect which had been operated some

thirty years ago. The prospect when developed on the cut

in the travertine about 100 feet, opened up into a small

cave. The cave has long been known but not many have visited it as it is hard to find, being hidden by the timber of the mountain side.

The cave may be entered along the old prospect tunnel where after proceeding about 100 feet, a twenty foot ladder is seen leading down into the cave. Entering

the cave it is striking in that the visitor sees walls which

(15) Aurand, Harry A., Fluorspar Deposits in Colorado,

are lined with beautiful crustifications of aragonite crystals, some perfectly white and some stained yellow by iron solutions. Stalactites of calcium carbonate also hang down from the walls and ceiling. Stalagmites are not seen in the cave.

The cave is quite small being about 6 feet wide and extending back about 30 feet. Specimens of aragonite and stalactites of calcium carbonate were collected at the time of the visit to the cave.

(15)  
Fluorite Deposits of Wagon Wheel Gap, Colorado

Location The vein as exposed on the steep side of the hill on Goose Creek may be traced 1/2 mile to the east where it appears to end in a small gulch or flat. It lies entirely Wagon Wheel Gap station on the Denver and Rio Grande Railroad. In the area of volcanic rocks consisting of beds of rhyolite tuff with some quartz, leucite and andesite. On top of the hill close to the vein, the rhyolite has a reddish color opposite the Mineral Hot Springs where a resort is situated because of the healing qualities of the mineral waters.

(15)  
History and Development

The vein was originally mistaken as an extension of the Amethyst vein at Creede as both of the veins strike northwest and cut through country rock of the same type, rhyolite and rhyolite tuffs. The color of the fluorite and amethyst quartz crystals is similar. The radiating fluorite crystals look much like radiating amethyst crystals and

were thus mistaken by the early locator of the mine. The fluorspar vein carries little gold or silver, so little attention was given to it prior to 1911, when the mineral was recognized by S. B. Collins, the president and general manager of the American Fluorspar Mining Company. By 1913 development had progressed to the extent that 5,000 tons were shipped to Pueblo. Since 1915, with the mine being shut down in 1914, it has been worked intermittently.

(15)

Geology

Minerals of the Deposits

Fluorite (Ca F<sub>2</sub>)

The vein as exposed on the steep side of the hill on Goose Creek may be traced 2,500 feet to the east where it appears to end in a small gulch or flat. It lies entirely in the area of tertiary volcanic rocks consisting of beds of rhyolite tuff with some quartz latite and andesite. On top of the hill close to the vein, the rhyolite has a reddish color and quartz predominates. Some white chalcedony was noted by the writer in this material. In the vicinity of the present workings andesite forms both walls of the vein.

Fluorspar Mine

The mine was visited on June 21 by the writer. Mr. Botsford the present superintendent of the mine conducted the writer through the workings. From the surface, the vein has been worked on three levels, the lowest being a little over 600 feet below level. The fluorite as observed on the upper level shows

(15) Aurand, Harry A., Fluorspar Deposits in Colorado, pp. 61-63.

the surface. The vein strikes nearly north, a little to the northwest. It dips to the south at about 80 degrees. It varies

Credite

Fluorite of a purple color and stalactitic growth was seen by the writer on the dump near the bins on the lowest level.

Marcasite ( $\text{Fe S}_2$ ) laboratory, and found to be credits. Though

Credite has been found in materials from this mine at various times, it is rare.

Marcasite was noted in specimens from the dump of the lowest level. Here it occurs as a crust on purple fluorite. The same occurrence was noted in material in place in the lowest level of the mine.

Barite ( $\text{Ba SO}_4$ ) district show that the vein being developed by

the American Fluorspar and Mining Company would, if projected, bisect a body of travertine which surrounds one of the hot springs of Goose Creek. Therefore, they consider that the connection between the hot springs and the fissure vein is very close.

Barite was observed in large crystals on the walls of the vein, up to three inches long and an inch wide, where it is open on the hill just above the lower tunnel. Numerous crystals are to be seen scattered about on this hill between the lower and upper tunnel levels. It is also observed on this hill as float with purple fluorite.

Gearsukite ( $\text{Ca F}_2 \cdot \text{Al (F OH)}_3 \cdot \text{H}_2\text{O}$ )

Mineralization Gearsukite in white ball-shaped masses was found on the dump near the very top of the hill.

(16) The writer believes that mineral deposition took place at several different periods sporadically

Covellite has been reported from the vicinity of Wagon Wheel Gap but was not seen by the writer.

(16) Economic Geology, Volume 8, 1913. pp. 235-246.

(17) Danas Textbook of Mineralogy, Fourth Edition by Ford, p. 429.

(18) Colorado Geology Survey, (Bulletin 18), 1920. p. 26.

Creedite

an eighth inch band of coarsely crystallized purple fluorite.

A specimen of small clear monoclinic crystals was found on the dump near the top of the hill. The specimen was inch thick. This second barite crystal is enclosed by a still larger barite crystal  $\frac{1}{2}$  inch thick.

Creedite has been found in materials from this mine at various times, it is rare. Section of Barite Crystal

Origin of the Deposits

near the top of the vein shows the same order of crystallization. In this specimen a layer of

Emmons and Larsen in describing the geology and hot springs of the district show that the vein being developed by the American Fluorspar and Mining Company would, if projected, bisect a body of travertine which surrounds one of the hot springs of Goose Creek. Therefore, they consider that the

A third specimen from the lower level of the mine shows that the order of crystallization has been white barite very close.

crystals, purple fluorite, and xarcesit (18)

Analyses as shown by H. A. Aurand of mineral waters of the hot springs made in 1904, do not show the presence of fluorine.

purple fluorite and white barite crystals.

Mineralization

specimen #3 shows purple fluorite, white barite crystals, purple fluorite and xarcesit in successive bands.

The writer believes that mineral deposition took place from hot waters at several different periods sporadically in one period of time. He bases his opinion on specimens collected in the field which show the relations of barite and fluorite. One large barite crystal broken across the end shows a banded growth. A small barite crystal  $\frac{1}{4}$  of an inch thick of this second crystal are sharp and distinct where in contact with the larger crystal.

an eighth inch band of coarsely crystallized purple fluorite. Over this fluorite is a second barite crystal about 1/8 of an inch thick. This second barite crystal is enclosed by a still larger barite crystal  $\frac{1}{2}$  inch thick.

#### Cross Section of Barite Crystal

A specimen from near the top of the vein shows the same order of crystallization. In this specimen a layer of small barite crystals is overlain by a band of purple fluorite, followed by two distinct and separate bands of barite crystals. This may be shown as the crystals of one layer abut against the crystal faces of the other layer.

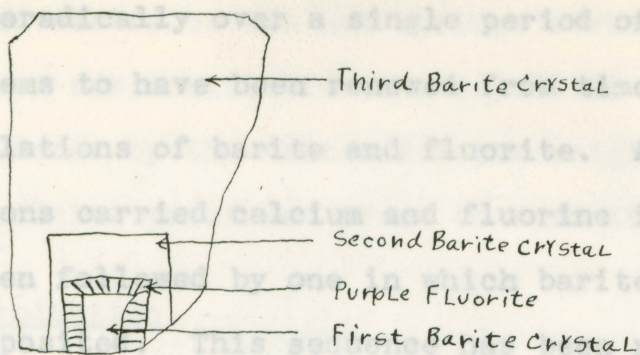
A third specimen from the lower level of the mine shows that the order of crystallization has been white barite crystals, purple fluorite, and marcasite.

Specimen #4 shows a layer of white fluorite followed successively by layers of purple fluorite, white barite crystals, purple fluorite and white barite crystals.

Specimen #5 shows purple fluorite, white barite crystals, purple fluorite and <sup>marca</sup> ~~marcasite~~ in successive bands.

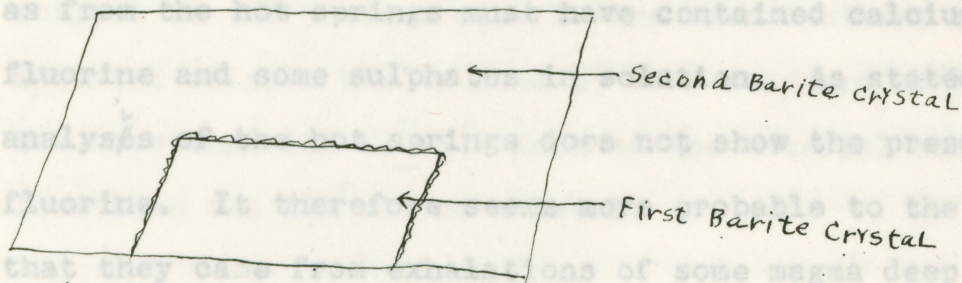
Numerous specimens of barite show that there has been at least two distinct separate crystallizations of the mineral, as often one crystal which seems on the surface to show one crystallization will, when broken, reveal a second smaller crystal enclosed within it. The crystal boundaries of this second crystal are sharp and distinct where in contact with the larger crystal.

Barite Crystal Showing Four Stages of Mineralization



Cross-section of crystal

Barite Crystal Showing Two Stages of Mineralization



Cross-section of crystal

as from the hot springs which have contained calcium, barium, fluorine and some sulphur. It is stated before an analysis of the hot springs does not show the presence of fluorine. It therefore appears to the writer that they came from solutions of some magma deep within the earth or were taken into solution in the process of their ascension. A partial analysis made of travertine found about the springs shows the presence of fluorine. It therefore seems probable that hot ascending solutions may have taken into solution both calcium and fluorine in their upward passage through the travertine, later to deposit them as fluorite. The original fluorine in the travertine may have been present from the start. The elevation of 8,000 feet is nearly at the lowest point in the region. The ore deposits are found

(19) Colorado Geology Survey, (Bulletin 18), 1920.

From a consideration of the above cited example, the writer believes the mineralization to have taken place sporadically over a single period of time. Mineralization seems to have been renewed from time to time as shown by relations of barite and fluorite. A time in which the solutions carried calcium and fluorine in solution seems to have been followed by one in which barite was the chief mineral deposited. This sequence has been repeated several times in the course of mineralization. Marcasite found chiefly in the lower workings has always been noted as the last mineral to have been deposited in these workings. The solutions coming from deep within the earth as from the hot springs must have contained calcium, barium, the fluorine and some sulphates in solution. As stated before an analysis of the hot springs does not show the presence of fluorine. It therefore seems more probable to the writer that they came from exhalations of some magma deep within the earth or were taken into solution in the process of their ascension. A partial analysis made of travertine found about the springs shows the presence of fluorine. It therefore seems probable that hot ascending solutions may have taken into solution both calcium and fluorine in their upward passage through the travertine, later to deposit them as fluorite. The original fluorine in the travertine may have been present from the West. The town at an elevation of 8,683 feet is nearly at the lowest point in the region. The ore deposits are found

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(19) Colorado Geology Survey, (Bulletin 13), 1920.

along the western shores of Lake San Cristobal for about

The hot springs are known to contain barium and some sulphates in solution. A mingling of hot ascending solutions and waters of the hot springs working together may thus have been responsible for the deposits. The above is a theory offered by the writer for the origin of the deposits though no definite proof was found to back it up.

### Production

At the present time 52 men are employed both in the mine and the mill. The mill can handle a hundred cars a day. The material is run through a grizzly and only the large barite crystals are separated and extracted. Most of the fluorite is shipped at the present time to the iron smelters at Pueblo. The material shipped has to come up to a standard of 85%  $\text{Ca F}_2$  and not more than 15%  $\text{Si O}_2$ . Much of the material shipped carries less than the 15% silica allowed.

### Lake City District, Colorado

#### Location

Lake City is located in the heart of the San Juan Mountains in the northern part of Hinsdale county. The town is situated at the junction of Lake Fork, a southern tributary of Gunnison River and Henson Creek which flows into Lake Fork from the West. The town at an elevation of 8,663 feet is nearly at the lowest point in the region. The ore deposits are found along Henson Creek to the west of the city for about ten miles, and along the western shores of Lake San Cristobal for about

three miles.

Lake City has a population of some 270 people at the present time. It may be easily reached by automobile by following Colorado State Highway number 149 south from Iola, a town located just 12 miles west of Gunnison on United States Highway number 50. A branch line of the Denver and Rio Grande Railroad from Lake Junction, 36 miles north of Lake City connects the town by rail with the main narrow gauge line.

(20)  
Topography and Drainage

The topography of the region is very rugged. The igneous rocks of the region have been eroded by the actions of streams, glaciers and atmospheric agencies into high cliffs and ridges. The average difference between the stream beds and the top of the ridges separating them is about 2,000 feet. The lowest altitude in the region is slightly over 8,000 feet while Uncompahgre Peak, about twelve miles distant, is 14,306 feet above sea level.

Drainage of the region is chiefly to the north, but in the vicinity of the town it is east by the eastward flowing Henson Creek.

(21)  
Rocks of the Region

The rocks of the region belong almost entirely to

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(20) Irving, J. D. and Bancroft, H. "Geology and Ore Deposits near Lake City, Colorado: United States Geology Survey, (Bulletin 478), 1911.

(21) United States Geology Survey, (Bulletin 478), 1911.

the great intermediate member of the Tertiary volcanic series called the Silverton Volcanic Series. The principal rocks found in this series are the Picayune Volcanic Group of augite andesite, tuffs and intrusives; the Eureka rhyolite; the Burns latite; the Pyroxene <sup>a</sup>Andesite; and the Henson tuff. The last named is the youngest in the series.

Granite is known to be one of the foundation rocks on which the Silverton Volcanic Series was deposited from a small outcrop in a bed of a south branch of Henson Creek 2 miles southwest of Capital City.

The lavas of the Potosi Series found above the Silverton Volcanic Series appear only on the high ridges of the Lake City area. These lavas are composed of light and dark, gray quartz latites.

The Hinsdale Volcanic Series overlies the Potosi flows east of Horse Park and are the youngest rocks of the region. This series belongs to a succession of rhyolite, bassalt, and intermediate rocks which form the upper parts of the divide between Lake Fork and <sup>e</sup>Cabolla Creek.

(22)

#### Faults

It is generally believed that faulting along fissures has been comparatively slight. That some movements have occurred are shown by slicken<sup>f</sup>sides, large quantities of breccia fragments, the prevalence of pinches and swells in

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(22) Irving, J. D. and Bancroft, H. op.cit. (Bulletin 478).

the veins, and the selvage clays. The displacements cannot be determined as no recognizable beds can be distinguished in this alternating complex of volcanics. Few of the lodes have been displaced by later movements.

(22)

### Mineralization

The veins of this district cut all flow rocks except the Potosi Volcanic Series even the monzonite <sup>6</sup>parphyry intrusions which are believed to be of late Eocene age. Veins are known to cut this series in the Telluride quadrangle and Silverton lodes. The mineralization therefore seems to have been of late <sup>6</sup>Miocene or early Pliocene age.

(22)

### Ore Deposits

#### General Character

The lodes of the Lake City area are fissure veins. However, they are not true fissures as in places they have largely been formed by replacement, and show all stages of transition from a simple filled fissure whose walls have been little affected by vein-forming solutions to a zone of sheeting and brecciation where most of the mass of the vein material has been produced by alteration of the enclosing rock.

The veins are known to extend vertically over a distance of 5,000 feet, as the highest point of outcrop on several veins is 12,800 feet and the deepest point reached in mining the ore is 7,900 feet and on the vein. The veins

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(22) Irving, J. D. and Bancroft, H. op. cit. (Bulletin 478).

average between 1,000 and 1,200 feet in length. They are thought to be roots of upper fissures which have been completely eroded away as extremely rich ores have been discovered in the upper workings which rapidly show impoverishment with depth. The width of the veins vary from a few inches to 20 feet, the average being about 18 inches. The veins twist and turn along the strike generally with sharp angles in a manner similar to a flash of lightning.

(22)  
Lodes

The lodes of the deposits may be divided into three groups, the tetrahedrite-rhodochrosite group, the quartz-galena-sphalerite group, and the telluride group.

The <sup>t</sup>tetrahedrite-rhodochrosite group is characteristic of the ores which consist dominantly of galena, argentiferous tetrahedrite, much sphalerite, and some pyrite in a gangue of quartz, rhodochrosite, and barite. Pyrite and chalcopyrite are subordinate in the ores. Zinc is absent in paying quantities and unless saved in the mill is objectionable. The silver value varies in proportion to the silver-bearing tetrahedrite which is present. Gold is more closely associated with pyrite than with any other mineral. Mines visited in this group were the Ocean Wave, Contention, and Ute and Ulay mines.

The veins of the quartz-galena-sphalerite group are characterized by dominant galena and sphalerite with subordinate chalcopyrite in a quartz gangue.

Tetrahedrite is present in many of the mines. White barite is nearly absent. Gold values are more important in this group than in the preceding group. They seem to be associated with large quantities of pyrite which are present in the ores. Copper and lead are important products while sphalerite is sufficiently abundant to yield profitable returns. Some of the veins of this group show gradations into those of the preceding group. The Ute vein shows affinities to this group in the Ute ground, but farther north in the Hidden Treasure ground it is distinctly a member of the tetrahedrite rhodochrosite group.

The telluride group contains veins in which the tellurides are disseminated through a fine-grained quartz gangue.

Subordinate minerals are galena, sphalerite, pyrite, chalcopryrite, tetrahedrite, hinsdalite, and barite. The tellurides are distinguishing features between these veins and the tetrahedrite group. Hinsdalite closely associated with the tellurides in the Golden Fleece mine make<sup>s</sup> this vein unique.

The products of the group are both gold and silver.

Minerals of the Deposit Noted June 21-25, 1934.

Minerals Formed at Moderate and Shallow Depths

TETRAHEDRITE ( $3\text{Cu}_2 \text{S} \cdot \text{Sb}_2 \cdot \text{S}_3$ )

Because of its silver content tetrahedrite is one of the most important minerals found in the Lake City district. It is present to some extent in all of the mines of the district. The silver bearing variety, freibergite, carries proportions of silver which ran in 1911 up to \$200 and \$300 per ton.

Some freibergite which is nearly pure silver reaches even 2,500 ounces to the ton. The variety rich in silver has usually a light steel-gray color and is somewhat more greasy in appearance than the nonargentiferous variety.

Bancroft and Irving in United States Geology Survey, Bulletin 478, state the tetrahedrite is invariably massive, never being found in crystals. A specimen taken from the bins of the Governor Pitkin mine located high on the mountainside nearly opposite Lake San Cr<sup>y</sup>stobal, shows small light, steel-gray colored crystals of tetrahedrite about an eighth of an inch across crystallized together with small yellow chal<sup>py</sup>rite crystals in a small vug lined with tiny quartz crystals.

### Bismuth Compounds

The complex sulphur compounds of bismuth have been reported in considerable quantities in the Monte Queen mine.

Kinsdalite ( $4PbO \cdot 3Al_2O_3 \cdot 2SO_3 \cdot P_2O_5 \cdot 6H_2O$ )

### Barite ( $Ba SO_4$ )

The mineral is abundant in the gangue of the galena-sphalerite veins, especially in those carrying tetrahedrite. These veins are developed characteristically along Henson Creek and near Lake San Cr<sup>y</sup>stobal. The barite as a rule is an interlocking network of the plates whose interstices are filled by fine grained silica or metallic minerals. Barite is very abundant in the Hidden Treasure portion of the Ute Hidden Treasure vein. United States Geology Survey. Bulletin 478, page 53.

The writer obtained specimens of barite from the

Climax mine on Henson Creek which show a nearly pure mass of white barite with small veinlets of tetrahedrite cutting it in all directions. Ore specimens taken from the bins at the Golden Fleece mine show barite associated with galena, tetrahedrite, quartz and rhodochrosite.

Rhodochrosite (Mn CO<sub>3</sub>)

Rhodochrosite occurs in many of the veins in the Lake City region. In the Hidden Treasure mine it makes up the bulk of the vein-filling in the northern end of the Hidden Treasure ground and is practically absent in the Ute end of the same vein. United States Geology Survey, Bulletin 478, pages 53-54.

Specimens of rhodochrosite were obtained from the bins of the lowest level of the Golden Fleece mine.

Hinsdalite (aPb O. 3Al<sub>2</sub>O<sub>3</sub>. 2 SO<sub>3</sub>. P<sub>2</sub>O<sub>5</sub>. 6H<sub>2</sub>O)

Hinsdalite was found in some quantity on the lowest level of the Golden Fleece mine. This mineral originally found by E. S. Larsen is described by him in the American Journal of Science, Volumes 181-182, 1911, on pages 251-252. A description of this mineral follows. "The granular hinsdalite is rather coarsely crystalline and shows a tendency to develop crystal faces. The larger imbedded crystals are rhombohedrons resembling cubes with a perfect basal cleavage truncating one corner. The crystal faces are always dull and rough. Some of the crystals are nearly transparent with a greenish tone which others have a grayish color. Chemical analyses by

W. T. Shaler show it to be a hydrous sulphate and phosphate of lead and aluminum with a little strontium replacing the lead."

Quartz (Si O<sub>2</sub>)  
Danas Text Book of Mineralogy, Fourth Edition by Ford, print of 1932, gives the formula of this mineral as  $2Pb \cdot O \cdot 3Al_2O_3 \cdot 2SO_3 \cdot P_2O_5 \cdot 6H_2O$ . It further states that the mineral is pseudorhomboidal, is found in coarse dull crystals with a greenish tone, has a perfect basal cleavage, a hardness of 4.5, a specific gravity of 4.65 and a hexagonal basal Galena (Pb S) section.

The specimens of hinsdalite collected by the writer show it to be associated pyrite, barite, and gray quartz containing disseminated tellurides and sulphides. The hinsdalite in the specimens is in coarse dull crystals with a greenish tone. the various mine dumps. A specimen of nearly pure galena was collected. A specimen of hinsdalite was given to the writer by Mr. W. C. Blair at the newspaper office in Lake City. It shows a band of hinsdalite in the specimen about half an inch wide in gray chalcedonic quartz the latter which forms the matrix of the petzite ore.

### Minerals Formed at Depths

Pyrite (Fe S<sub>2</sub>) is the most abundant mineral next to quartz. Pyrite is present in all of the lodes of the region and is by far the most widely distributed of the metal-bearing minerals. It is generally found in the lower and less valuable portions of the mines. The gold where not contained in telluride is apparently more generally contained in and associated with pyrite than with any other mineral. of galena and barite.

Specimens of pyrite crystallised in small brilliant,

octahedrons were found on the dumps of the Dawn of Hope mine.

succession of bands of galena and sphalerite alternating with  
Quartz ( $\text{Si O}_2$ )  
 quartz bands.

This mineral is formed at all depths and is common  
Chalcopyrite ( $\text{Cu Fe S}_2$ )  
 in the deposits. Large white quartz crystals which are clear  
 near their ends were obtained from a cut made in the bank of  
 the road about a half mile south of Lake City.

tetrahedrite. It is present in subordinate amounts in all  
Galena ( $\text{Pb S}$ )  
 mines.

(23)  
 Galena is absent in a few of the Lake City veins but  
 is more commonly present. It varies in amount considerably  
 in the different lodes in different portions of any one lode.

Galena is present in most of the specimens collected  
 from the various mine dumps. A specimen of nearly pure galena  
 was collected from the dump of the Gladiator mine.

In the nearly pure state galena carries not more  
 than 22 ounces of silver to the ton, but when it is intimately  
 associated and mixed with tetrahedrite the values may be much  
 higher. Tellurides are absent in all except two of the Lake

City lodes, the Gallic-Vulcan vein and the Golden Fleece mine.

Sphalerite ( $\text{Zn S}$ )

They are absent from the Nico, Telluride, and Suray districts  
 of the San Sphalerite is the most abundant mineral next to  
 pyrite that is found in the deposits. It seems to have been  
 one of the minerals of the earlier period of mineralization,  
 the amount decreasing from the lower workings to the surface.

United States Geology Survey. Bulletin 478, pages 57-58.

An ore specimen from the Hidden Treasure mine shows  
 much sphalerite with subordinate amounts of galena and barite.

Material collected from the California mine shows a succession of bands of galena and sphalerite alternating with quartz bands.

Chalcopyrite (Cu Fe S<sub>2</sub>)

Chalcopyrite is especially abundant in the veins that carry neither the tellurides nor notable quantities of tetrahedrite. It is present in subordinate amounts in all mines.

(23)

Bancroft and Irving state that the mineral is always massive and never found crystallized. The writer has collected specimens from the Governor Pitkin mine showing small crystals of chalcopyrite crystallized together with small crystals of tetrahedrite. Specimens collected from the Ocean Wave mine also show small chalcopyrite crystals deposited on quartz crystals in vugs in the ores.

(23)

Tellurides

Tellurides are absent in all except two of the Lake City lodes, the Gallic-Vulcan vein and the Golden Fleece mine. They are absent from the Rico, Telluride, and Ouray districts of the San Juan Region, and are only found as rarities in the Silverton district. The veins are consequently distinguished from the other veins of the San Juan Region. It is probable that all the varieties as calaverite, sylvanite, krennerite, petzite, and hessite are present in these veins.

Petzite is the prevalent telluride in the Golden Fleece mine.

The writer saw a piece of nearly pure petzite from the Golden Fleece mine in the collection of W. C. Blair at Lake City. The specimen was an inch square and a half inch thick. Dolomite and Calcite ( $\text{Ca Mg} (\text{CO}_3)_2$  and  $\text{Ca CO}_3$ )

Dolomite and calcite occur rarely in the Lake City veins.

A specimen of small brown calcite crystals was found on the dump of the Belle of the East mine.

Fluorite ( $\text{Ca F}_2$ )

Fluorite was quite common in the Hidden Treasure mine. A specimen shows two small, white cubes of fluorite about  $\frac{1}{4}$  of an inch square on tiny quartz crystals <sup>and</sup> was found on the dump of this mine. A second specimen from the same dump shows purple fluorite on country rock. The fluorite has taken the form as of a botryoidal crust.

Gypsum ( $\text{Ca SO}_4 \cdot 2\text{H}_2\text{O}$ )

A specimen of selenite was obtained from the dump of the Belle of the East mine. The specimen shows quartz containing small disseminated particles of pyrite and sulphides, and white quartz crystals on which the selenite has been deposited.

Selenite has not been previously reported in the

Lake City ores.

Siderite (Fe CO<sub>3</sub>)

A manganese variety of siderite was picked up from the dump of the Climax mine on Henson Creek. It was identified by the writer in the laboratory. The mineral has not been reported from Lake City previously.

Secondary Minerals

Barnite (Cu<sub>2</sub> Fe S<sub>4</sub>)

Minerals produced by oxidation are minerals such as the sulphates, chalcantite and melanterite.

Minerals formed by reprecipitation of dissolved constituents are limonite, hematite, basic ferric sulphate, pyrolusite, malachite, azurite, cerussite, and anglesite.

Minerals precipitated by the reaction of various sulphates on one another are native copper and native silver.

Secondary Sulphide Enrichment Metals

Pyrargyrite and Proustite (3Ag<sub>2</sub> S. Sb<sub>2</sub> S<sub>3</sub> and 3Ag<sub>2</sub>S. As<sub>2</sub>S<sub>3</sub>)

These two minerals occurred in large quantities in all the producing mines.

Secondary Chalcocite (Cu<sub>2</sub> S)

Gold (Au)

Chalcocite in the finely divided sooty form is a common constituent of ores high in chalcopyrite and pyrite, as in the Maro mine.

(25) United States Geology Survey, Bulletin 478, p. 64.  
(26) United States Geology Survey, Bulletin 478, p. 63.

(24) United States Geology Survey, Bulletin 478, pp. 61-63.

Covellite, (Cu S)

The mineral does not occur in quantity but is found in a number of the mines as a product of secondary enrichment, coating the surfaces of sphalerite.

A specimen showing small crystals with the form of sphalerite was found on the dump of the Silver Key mine. The sphalerite crystals have been impregnated throughout by small particles of covellite in this specimen.

Bornite (Cu<sub>5</sub> Fe S<sub>4</sub>)

Bornite has rarely been seen and then as a film on the surface of chalcopyrite which has been exposed to alteration.

Specimens showing a coating of bornite on chalcopyrite were found on the dumps of the Ocean Wave mine.

(25)

Secondary Galena

Secondary galena is uncommon as a product of secondary enrichment in the veins. In many veins containing coarse-grained sphalerite, a gray film of metallic character has been deposited in the shattered cracks in the sphalerite. This has been thought to be secondary galena.

(26)

Gold (Au)

In the Gallic-Vulcan mine crystals of sphalerite were observed coated with leaves of native gold, the latter

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{25} United States Geology Survey, Bulletin 478, p. 64.

{26} United States Geology Survey, Bulletin 478, p. 65.

mineral having apparently been reduced from solution by zinc sulphide.

Paragenesis of the Ores

In the Ute and Hidden Treasure <sup>ore</sup> ~~are~~ <sup>show a</sup> bodies, <sup>^</sup> succession of minerals <sup>ization</sup> is evident in well defined steps. After the rupture of the country rock with but little brecciation taken place, the first period of vein filling occurred depositing (1) quartz; (2) rhodochrosite, tetrahedrite and galena; and (3) quartz. A later movement shattered this material and deposited (1) quartz; (2) barite with subordinate galena; and (3) quartz. (26)

A section of a small vein collected from the California mine is shown in the diagram on the following page which shows the steps in mineralization.

- 1 Rhyolite
- 2 White Quartz
- 3 White Quartz, Galena, Black Metallic Sulphides
- 4 Galena, Black Metallic Sulphides
- 5 White Quartz, Galena, Sphalerite, Black Metallic Sulphides
- 6 Galena, Sphalerite, White Quartz

(26) United States Geology Survey, (Bulletin 478), p. 65.

Mines Visited in Lake City Area, June 21-25th, 1934

Cross-section of vein Specimen from California Mine

The mines visited during this period were the

Silver Key, Climax, Fanny Fern, Hidden Treasure, Lilly,

California, Ocean Wave, Ute and Ulay, Dawn of Hope, Gladia-

tor, East, Governor, Isel, Con-

tentive Golden Fleece.

of the specimens from these mines have been described.

specimen of ore from the Copperhead mine located near Cabin Hook, six miles above Capitol City, is rich in silver. It shows mainly mass of silver-bearing tetrahe-

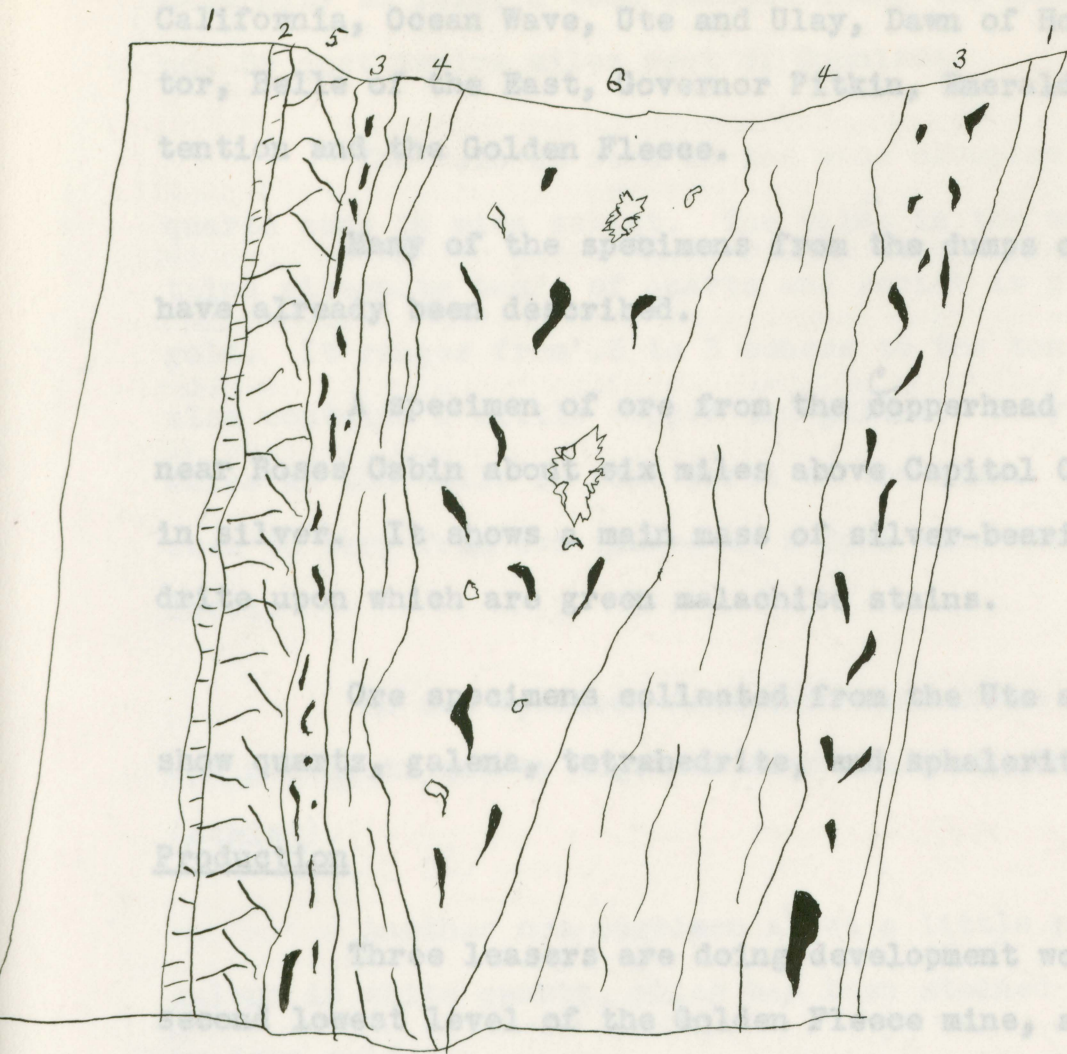
the specimens collected from the Ute and Ulay mines show galena, tetrahedrite, sphalerite.

three basins are doing development work on the level of the Golden Fleece mine, and a little

ore is being taken out.

A few men are also working at the Empire Chief mine six miles above Capitol City. Some ore is also

Southwestern Gunnison County, Colorado



- 1 Rhyolite
- 2 White Quartz
- 3 White Quartz, Galena, Black Metallic Sulphides
- 4 Galena, Black Metallic Sulphides
- 5 White Quartz, Galena, Sphalerite, Black Metallic Sulphides
- 6 Galena, Chalcocite, White Quartz

Mines Visited in Lake City Area, June 21-25th, 1934

The mines visited during this period were the Silver Key, Climax, Fanny Fern, Hidden Treasure, Lilly, California, Ocean Wave, Ute and Ulay, Dawn of Hope, Gladiator, Belle of the East, Governor Pitkin, Emerald Isle, Contention and the Golden Fleece.

Many of the specimens from the dumps of these mines have already been described.

A specimen of ore from the Copperhead mine located near Roses Cabin about six miles above Capitol City, is rich in silver. It shows a main mass of silver-bearing tetrahedrite upon which are green malachite stains.

Ore specimens collected from the Ute and Ulay mines show quartz, galena, tetrahedrite, and sphalerite.

Production

Three leasers are doing development work on the second lowest level of the Golden Fleece mine, and a little ore is being taken out.

A few men are also working at the Empire Chief mine located about six miles above Capitol City. Some ore is also being produced at this mine.

Economy Milling and Mining Company at Powderhorn, Southwestern Gunnison County, Colorado

The writer visited the mine on June 29, 1934. It is located about two miles north of Powderhorn, a few rods to the east of Colorado State Highway no. 149, which connects Lake City to Iola, a town located along the main U.S. Highway no. 52 just twelve miles west of Gunnison.

The vein as seen in the mine occupies a sheeted quartz zone in mica schist. The value in the ore, which contains alternate bands of quartz and schist is principally in gold. It ranges from .5 to 3 ounces to the ton. The ore also contains a little copper and galena. Gray quartzite makes up the walls in some parts of the mine. The vein was seen to vary from two inches to a foot wide along the third level.

An ore specimen from this mine shows chalcopyrite and galena in quartz together with bands of country rock (schist).

Another ore specimen shows a little pyrite and galena in white quartz, which has been stained red in places by iron oxides.

A third specimen of ore shows calcite, quartz, and country rock. Galena and pyrite are disseminated in the country rock and quartz.

### Production

Four men are working on the third level of the mine and some ore is being produced.

Good Hope and Mamouth<sup>m</sup> Chimney Mines at Vulcan, Southwestern Gunnison County, Colorado

The writer spent about six hours in the vicinity of the mines on June 30, 1934.

The wall rocks of these deposits are composed of tripoli, schists, and sericite schists. (27) Locally the schists are found beautifully veined with feldspar, chalcedonic quartz, and jasper. Occasional dark dikes of diabase come up through the schists. Granite underlies the schists in this region.

The veins in the schists are mined for gold tellurides, though formerly part of the deposit was worked entirely for sulphur. The sulphur overlies the pyrite in the mines.

Development

At the present time four men are attempting to pump the water from the Mamouth<sup>moth</sup> Chimney mine in preparation for doing some development work. Water is within 100 feet of the top of the shaft. In the lower levels of the mines, rickardite and weissite, copper tellurides, have formerly been encountered in large amounts. These levels are covered by water at the present time so no specimens of these minerals were found.

Specimens collected from the dumps are as follows:

No. 1 brown chalcedonic quartz with brownish and whitish

(27) Transactions, American Institute Mining Engineers, Vol. 26, 1896, pp. 440-449.

opa.<sup>2</sup> This material is reported to have assayed as much as 16 ounces in gold to the ton. in the district. The Devonian

No. 2. gray chalcedonic quartz. formation of limestones

No. 3. yellow sulphur and pyrite in a quartzite conglomerate. this part being composed of gray, buff or white

No. 4. garnet (almandite), and copper silicates and carbonates in schists from an outcrop just below Vulcan.

No. 5. grayish quartz showing purple splotches which are believed to carry the mineral in which most of the gold of this quartz is carried. of sandstone, shale, and thin

No. 6. massive pyrite. of a few conglomeritic sandstones

make up the Pennsylvanian series of strata of some 1400-1500 feet. The Permian is represented by 700 feet of

Location formation composed of red, sandy and limy shales

The principal mines of the district are all located within three or four miles of the town of Ouray, which is located in southwestern Ouray county. The town is located at the head of Uncompahgre valley. It is connected by a branch line with the Denver and Rio Grande Railroad at Montrose. The population is about 700 and the town is at an elevation of 7800 feet on the Uncompahgre river. U.S. Highway no. 550 extending southwards from Montrose passes through Ouray and Silverton to Durango and makes the region easily accessible by automobile. feet of a light buff or grayish

Rocks of the Region and cross-bedded sandstone. The Lower Cretaceous is represented by a formation 700 to 750 feet thick and

The rocks of the region rest upon the Algonkian

series of quartzites and slates. No Cambrian, Ordovician or Silurian rocks are present in the district. The Devonian period is represented by the Elbert formation of limestones and calcareous shales, and by the lower 68 feet of the Ouray limestone, this part being composed of gray, buff or white limestones of fine or medium grain. The Mississippian period is represented in the district by the upper 235 feet of the Ouray limestone. The Molas formation of shales and conglomerates, and the Hermosa formation overlying it and composed of <sup>al</sup> alternating beds of sandstone and shale.

sandstone member and an upper shale member. The Upper Cretaceous is represented by the Dakota sandstone, 135 to 180 feet thick and the Mancos shale 1700 feet thick.

The Eocene or earliest Tertiary is represented by the Telluride conglomerate 40-50 feet thick. This formation has been accompanied by mineral-bearing solutions and gold has been placered in places in the formation.

The San Juan tuff, the first of several series of volcanics together with the overlying Silverton Volcanic Series, is considered to be Oligocene or Miocene in age. The San Juan tuff 1800-3000 feet thick is divisible in the district into two parts, the lower Canyon Creek member 300-1200 feet in thickness of sandy tuffs, coarse agglomerate and breccia with interbedded conglomeritic beds; and the upper Sneffels member about 1500 feet thick composed of lava fragments of a uniform nature mostly of a fine-grained porphyritic lava containing numerous small phenocrysts of feldspar. Conglomerate beds are much less common in this member than in the Canyon Creek member.

The Silverton Volcanic Series is composed of a succession of flows, of tuffs, breccia with the composition of andesite, latite, and rhyolite.

The Potosi Volcanic Series of Miocene age is the youngest of the rocks of the region and it overlies the Silverton Volcanic Series. These rocks consist of massive

flows with a few thin agglomerate and tuff beds, the greater number of the rocks being of the composition of latite or quartz-latite. Rhyolites constitute a subordinate part of the series.

The greater part of this material was taken from the Colorado Scientific Proceedings, Vol. 12, No. 6, 1930, pages 156-192.

### Structure

The most striking feature structurally is the present altitude from the base of the Paleozoic upwards is their general southerly, westerly, or northerly dip away from a point in the west-central part of the San Juan Mountains.

### Intrusive Rocks

Dikes of younger intrusive rocks are few in number which cut the San Juan tuff. The Mt. Sneffels-Stony Mt. Stock is also representative of these younger intrusive rock. This rock is called gabbro-diorite by Cross. Dikes outcropping near Red Mountain and at the head of Full Moon Gulch are more alkaline and are grouped under the name of quartz-syenite porphyry by Cross and Howe. As all these intrusive rocks of the Tertiary group intrude the San Juan tuffs, and those of Stony Mt. and Mt. Sneffels intrude the lavas of the Silverton and Patosi series, they must be Miocene or later in age.

Numerous dikes and sills near Ouray of the general composition of quartz monzonite porphyry, the laccolithic bodies of Dexter Creek, Oak Creek, and Corbett Creek, and the "Blowout", Stock just north of Ouray, constitute the older intrusive type of rocks found below the San Juan tuff.

(28)  
Ore Deposits

Mineralization of Ore Deposits

Mineralization accompanied both the older and younger intrusive rocks. The conditions that favored laccolithic intrusions during the late Cretaceous and early Eocene time also favored the development of "blanket" replacement deposits. Sedimentary beds of comparatively great permeability served as channels for the lateral diversion of the ore-bearing solutions. Permeable beds overlain by impermeable shale beds were especially favorable for diverting the solutions for great distances horizontally. Blanket deposits were therefore formed in a number of beds.

The ores of the first period contain gold, silver, lead, zinc, and minor amounts of copper. Lead-zinc veins near Ouray have been with the associated replacement deposits containing high grade silver ores, the most important deposits. Gold-bearing pyritic ores which contain tellurides associated with native gold are characteristic. Low grade lead and zinc replacement deposits with much barite are particularly

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(28) Colorado Scientific Proceedings, Vol. 12, No. 6, 1930.

characteristic of this earlier period of deposition.

The deposits of the Late Tertiary period were made after a large part of the Upper Cretaceous sedimentary rocks had been removed by erosion and after a great thickness of Tertiary volcanics had been poured over the region. The late Tertiary intrusives consequently invaded a cover consisting mainly of the more rigid Paleozoic and Pre-Cambrian rocks, and a great thickness of volcanic formations. Fissures were formed which extended from great depths probably to the surface of the volcanic plateau. Thus the ore-bearing solutions deposited the metals along and in these fissures. The blanket type of deposit was not developed to any great extent in these later deposits.

The later deposits also carry gold, silver, lead, zinc, and copper. The gold in these deposits however consist of native gold in quartz veins, as contrasted with the pyritic gold deposits of the first period.

Stream deposits in which gold is associated were formed during Pleistocene and Recent time. These form the final epoch of gold concentration in the western San Juan Mountains.

#### Classification of Ore Deposits

The ore deposits of the district may be classified as fissure veins, replacement deposits in quartzite, and re-

placement deposits in limestone. East from its downward

continuation. The ore is in general barren and follows the

### Fissure Veins

The fissure veins are divisible into two groups, silver-bearing veins, and gold-bearing veins.

The silver-bearing veins are developed largely along Dexter Creek, the chief veins being the Bachelor, Wedge, and Calliope. The Newsboy and Black Girl on the east side of the Uncompahgre Valley, about four miles north of Ouray are also important.

The veins are fissures in country rock filled with high grade silver ores and the accompanying gangue minerals. They can be traced in many places from the redbeds of the Hermosa formation through greatly differing sedimentary deposits below the andesite and breccias of the San Juan. The strike of the fissures is nearly in an east-west direction, being N 83° E in the Bachelor mine. The ore is much

portion of the vein as much as 30 feet away from its downward continuation. The ore is in general unbroken and follows the shales in a thin band between the two separated portions of fissure.

The ore minerals of these veins consist of argentiferous galena, silver-bearing tetrahedrite, chalcopryrite, native silver, and ruby silver rarely found at depths very much below the surface. The gangue minerals accompanying the ore minerals are quartz, barite, rhodochrosite.

### Gold-bearing Veins

The gold-bearing veins are developed along the course of the Uncompahgre river between the mouth of Dexter Creek and Ouray. The country rocks range from the Hermosa and Cutler up through the Dakota sandstone and Mancos shale of the Cretaceous. Numerous dikes and irregular intrusions of quartz-bearing monzonite porphyry cut diagonally across the sedimentary rocks, some vertical, others with a marked dip to the south. The veins occur either wholly within the dikes or closely associated with them as highly inclined sheeted zones.

The ore consists of gold-bearing pyrite and chalcopryrite in a gangue of country rock and clay. The filling of open spaces seems to have been subordinate to the replacement of wall rock. The veins are later than the porphyry as they distinctly cut that rock. The dikes and

associated veins strike N 83° E. Nearly all of the mine workings are situated high above the bottom of the canyon. The average yield of gold is probably between two and five ounces per ton.

#### Replacement Deposits in Quartzite

These ores contain gold with very subordinate amounts of silver. They occur as irregular bodies in strata of quartzite. They have been formed by a chemical interchange of ore material for original country rock. The ores are found in a number of the Mesozoic quartzites which outcrop on both sides of Uncompahgre Canyon, being found chiefly in the Dakota sandstone.

#### Replacement Deposits in Limestone

A series of flat lying, broad ore bodies are found in beds of limestone either adjoining fissure veins or associated with numerous small vertical or nearly vertical fissures which intersect stratified rocks. Some of the deposits are fully 30 feet wide. Gold is predominant in some, silver in others. The ores are uniformly of lower grade than the quartzitic ores. The ores may be divided into baritic siliceous ores which are silver-bearing, and magnetite-pyrite ores, which are gold-bearing.

The baritic siliceous ores are lateral enrichments of silver veins or flat masses associated with small vertical fissures. The principal mines of this type are

the Newsboy, Pony Express, and the Mineral Farm mines. The ores contain silica, barite, with argentiferous tetrahedrite, and chalc<sup>c</sup>opyrite in places.

The magnetite-pyrite ores are of greater scientific interest than commercial interest. They are found only in the Bright Diamond and Iron Clad mines on the east wall of Uncompahgre Canyon, about 600 feet below the American Nettle mine. The ore occurs in a fine grained dark-blue limestone as broad flat shoots in this strata conformable to the stratification and of a uniform thickness of near six feet. It lies in close contact with the shale roof. It is an intimate mixture of a dense granular magnetite and pyrite with a little chalc<sup>c</sup>opyrite interwoven with epidote, garnet, quartz, and calcite. The ore carried in 1907, \$10 to \$14 in gold. However, it is concentrated with difficulty and in 1907 was not profitable.

Most of the material on the ore deposits was taken from the Ouray Folio, no. 153.

Minerals of the Deposits Noted in the Field, July 2-6, 1934

Quartz ( $\text{SiO}_2$ ). Quartz is abundant in the ores of the district. Specimens were collected from the lower dump of the Camp Bird mill. Quartz is present as a gangue mineral in most of the ore.

Calcite. Calcite was noted on the dump of the Camp Bird mill.

Rhodo-chrosite ( $MnCo_3$ ). Rhodo-chrosite associated with galena, quartz, sphalerite, and rhodonite was observed in material from the dump of the Revenue mine.

Rhodonite ( $MnSiO_3$ ). Rhodonite was found in small amounts on the dump of the upper workings of the Camp Bird mine and also from the Revenue mine.

Chalcopyrite ( $CuFe_2S_4$ ). Chalcopyrite was noted in fair amount in the ore from the upper level of the Camp Bird mine. It occurs in many of the other mines of the district in small amounts.

Sphalerite ( $ZnS$ ). Sphalerite is found in a great many of the ores. Here it is closely associated with galena.

Galena. Galena was noted in the ores from the Camp Bird, Revenue, Pony Express, U.S., Yellow Rose, Torpedo Eclipse mines as making up much of the ore material.

Tetrahedrite ( $3Cu_2S.Sb_2S_3$ ). Tetrahedrite of the argentiferous variety occurs in some of the ores.

Fluorite ( $CaF_2$ ). Green fluorite was noted in quantity on the third level of the Camp Bird mine. Specimens were obtained near the bottom of the vein on this level. Massive green fluorite was also collected from the dump of the Torpedo Eclipse mine.

Siderite ( $FeCO_3$ ). Siderite was noted filling small solution cavities in silica, in material from the

lower dumps of the Camp Bird mine near the mill.

Pyrite ( $\text{FeS}_2$ ). Pyrite is found in a number of the ores of the district. Pyrite in country rock associated with amethyst quartz was picked up on the upper dumps of the Camp Bird mine.

Amethyst Quartz ( $\text{SiO}_2$ ). A little amethyst quartz was noted on the dumps of the upper workings of the Camp Bird mine.

Specularite ( $\text{Fe}_2\text{O}_3$ ). Specularite is found in the lower levels of the Camp Bird mine in large amounts.

Malachite ( $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ ). Malachite was noted in the ores from the U.S. and Revenue mines.

Wad (manganese dioxide, etc.). Wad was noted in material from the Revenue mine.

#### Mines Visited, July 2-6, 1934

Only one mine was entered by the writer during this time, the Camp Bird Mine. Specimens were collected from the dumps of the Revenue, Atlas, Yellow Rose, U.S., Torpedo Eclipse, and Pony Express mines. Most of the specimens have already been described.

Ore from the U.S. mine shows galena associated with sphalerite and chalcopyrite. Copper carbonates appear in this ore in places.

Ore from the Revenue mine shows galena, sphalerite, chalcopyrite, rhodochrosite, and quartz.

Ore from the Pony Express mine is composed of argentiferous galena with much barite and a little quartz and calcite.

#### Camp Bird Mine Near Ouray

The mine is located about six miles southwest of the town of Ouray high up in the mountains.

The geologic formations are here composed chiefly of a series of sedimentaries, alternating shales, sandstones, and quartzite, with minor layers of limestone. A conglomerate is found at the top of this series. On top of the sedimentaries is found a thick series of andesite flows and breccias of the San Juan formation. This is the ore-bearing formation in the mine. Above the San Juan is a series of several alternating bands or layers of rhyolite and andesite. Rhyolite forms the topmost formation at this locality.

The mine was entered on the third level. After going back into the mountain about  $1\frac{1}{2}$  miles on this level, the writer was lowered in a bucket to the fifth level. The vein on this level strikes nearly east and west and dips to the south at about 75 degrees. Mr. Woods, the present manager of the mine, stated that so far whenever the vein changes in strike to the NW-SE a few degrees, greater values

have been encountered. The vein as seen in the stopes on the fifth level averaged about eight feet and extended over 340 feet. The material of the vein was here composed of country rock with quartz, carrying gold to the value of .2 to .5 of an ounce to the ton. The vein also carries minor amounts of galena, pyrite, sphalerite, and chalcopyrite. The andesite in many places is really an andesitic breccia in which pieces of andesite of a different color are found in the main andesite mass. The andesite forms both walls on the fifth level.

In the upper levels hematite and rhodochrosite are characteristic. Hematite of the variety specularite persists down to 600 feet from the surface. Gold has been the principal value here with only minor amounts of the other metals being present. Bodies of galena and sphalerite are rare on these levels. Lower down rhodonite, the silicate of manganese, was found abundantly on some of the levels. More sphalerite and galena are found in the lower levels. In general, the gold content decreases with depth while the silver content increases.

Fluorite was seen on the footwall of the third level. Mr. Woods, already mentioned before, stated that it was followed as an indication of good mineralization.

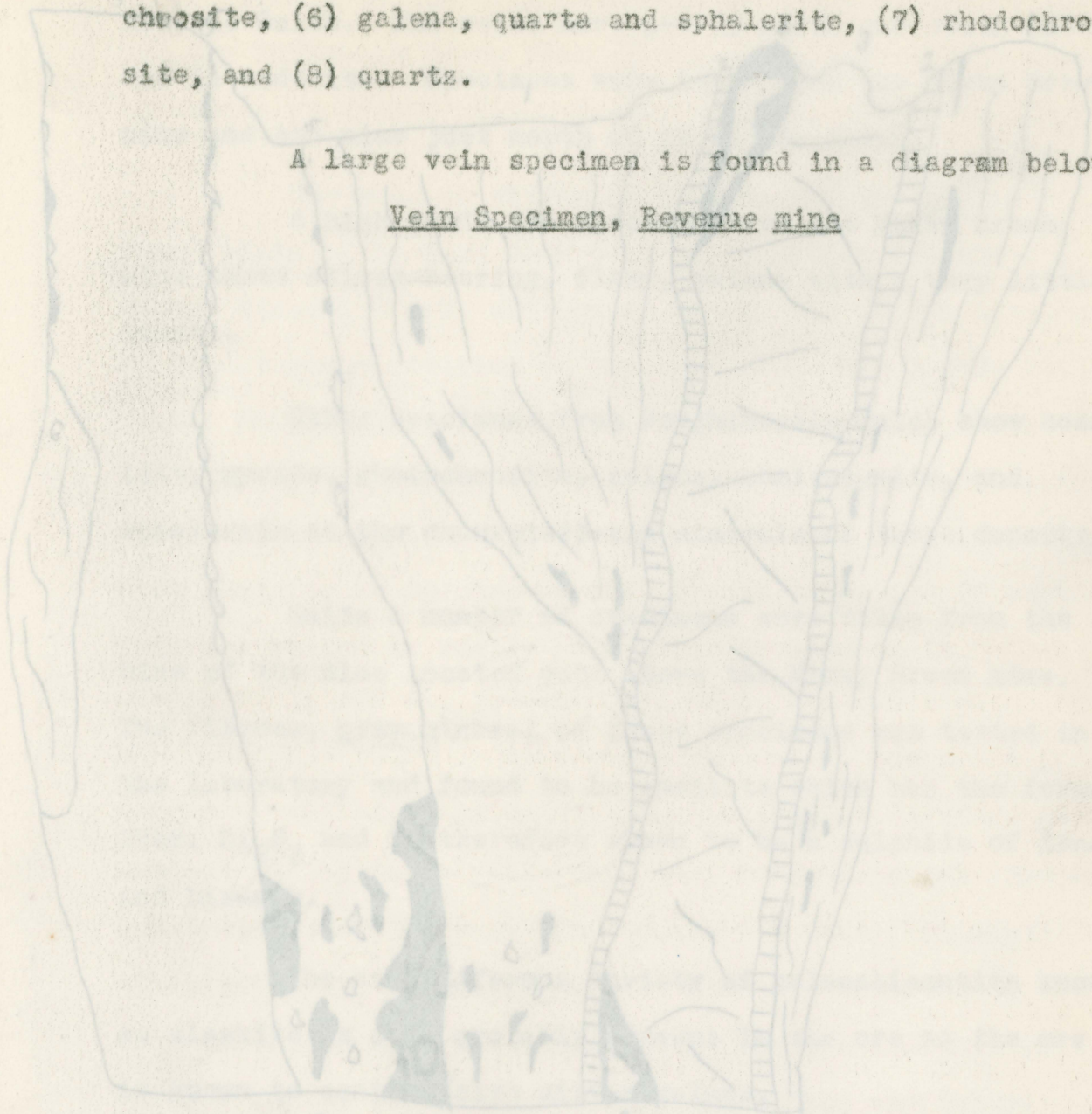
#### Paragenesis of the Ores

A specimen from the Revenue mine shows that the

Succession of minerals has been (1) dark sulphides and galena, (2) rhodochrosite, (3) quartz, (4) dark sulphides, (5) rhodochrosite, (6) galena, quartz and sphalerite, (7) rhodochrosite, and (8) quartz.

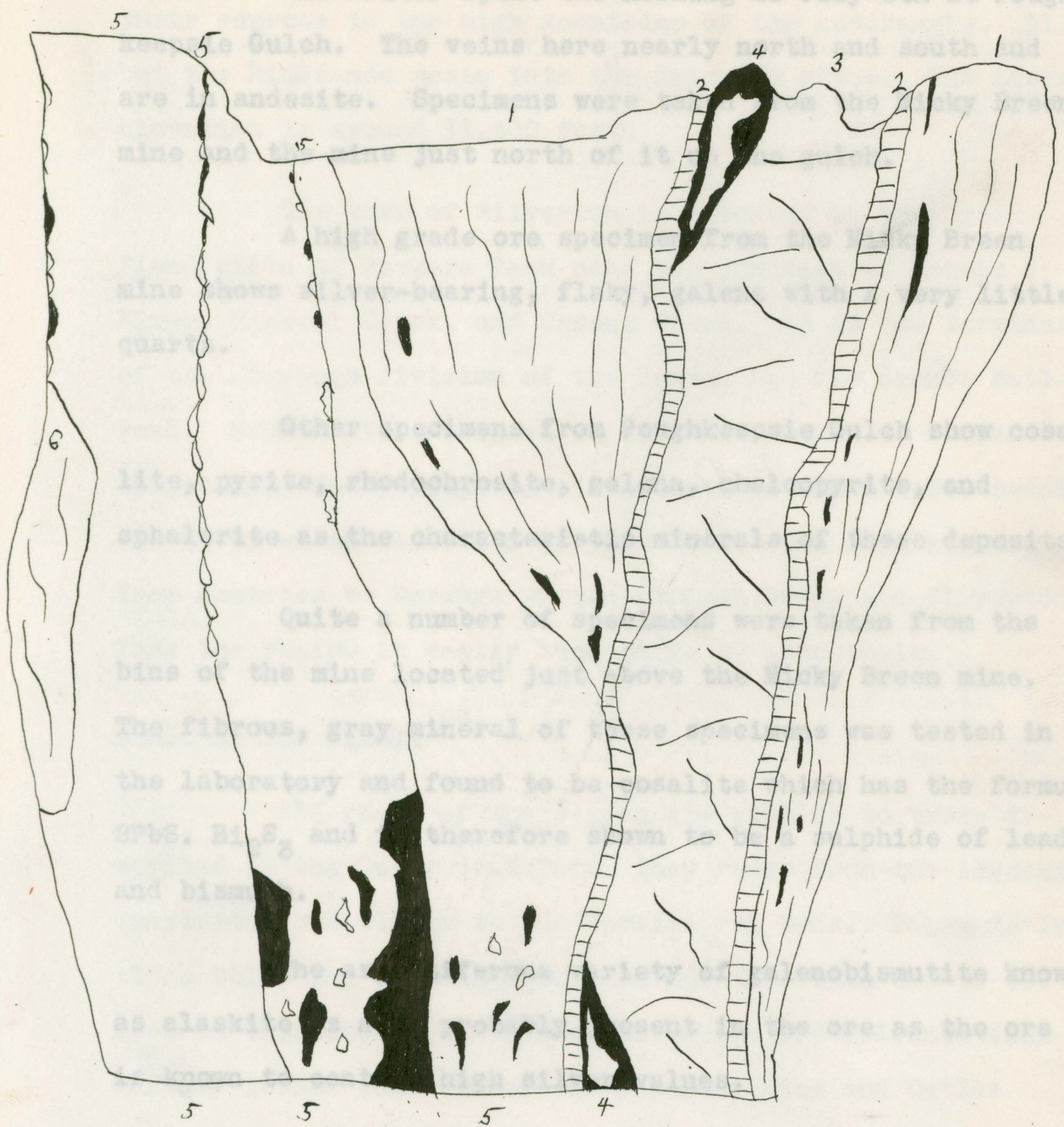
A large vein specimen is found in a diagram below.

Vein Specimen, Revenue mine



- 1 Rhyolite  
2 Colorless  
3 Rhodochrosite  
4 Galena, black sulphides, quartz  
5 Quartz, galena, sphalerite  
6 Country rock
1. Country rock and black sulphides  
2. Quartz band of colorless quartz  
3. Rhodochrosite  
4. Galena, black sulphides, quartz  
5. Quartz, galena, sphalerite  
6. Country rock
5. Rhodochrosite, Galena, Sphalerite  
6. Rhyolite

Mines in Poughkeepsie Gulch, Four Miles South of Ouray  
Cross-section of vein specimen, Revenue Mine, Ouray



- 1 Rhyolite, Black Metallic Sulphides
- 2 Colorless Quartz
- 3 Rhodochrosite
- 4 Galena, Quartz
- 5 Quartz, Galena, Sphalerite
- 6 Rhyolite

Silverton District, Colorado

The district is located in southwestern Colorado

in San Juan country. Parts of it are included in

Mines in Poughkeepsie Gulch, Four Miles South of Ouray

The writer spent the morning of July 6th at Poughkeepsie Gulch. The veins here nearly north and south and are in andesite. Specimens were taken from the Micky Breen mine and the mine just north of it up the gulch.

A high grade ore specimen from the Micky Breen mine shows silver-bearing, flaky, galena with a very little quartz.

Other specimens from Poughkeepsie Gulch show cosalite, pyrite, rhodochrosite, galena, chalcopyrite, and sphalerite as the characteristic minerals of these deposits.

Quite a number of specimens were taken from the bins of the mine located just above the Micky Breen mine. The fibrous, gray mineral of these specimens was tested in the laboratory and found to be cosalite which has the formula,  $2PbS \cdot Bi_2S_3$  and is therefore shown to be a sulphide of lead and bismuth.

The argentiferous variety of galenobismutite known

Hinsdale, Ouray, and San Miguel counties. The Lake Fork, Gunnison, Animas, Uncompahgre and Rio Grande rivers have their sources in the high mountains of the quadrangle. All but the Rio Grande drain into the Colorado river. The average elevation is around 11,500 feet.

The town of Silverton is situated on the broad flood plain of Barkers Park near the junction of Animas River, Mineral Creek, and Cement Creek. It is the terminus of the Durango division of the Denver and Rio Grande Railroad. Branch lines connect it with Red Mountain, Eureka and Gladstone. The population of the town is about 1,300 people and it is at an elevation of 9302 feet. The main highway from Montrose to Durango passes through Ouray and Silverton. Thus the region is easily accessible by automobile.

### Rocks of the Region <sup>(29)</sup>

The rocks of the region are similar to those described in the Ouray district. They range from the Algonkian quartzites and slates to the Permian red beds. Paleozoic formations below the Carboniferous are not more than 400 to 600 feet in thickness. The remainder of the pre-volcanic sedimentary series consists of the Hermosa, Rico and Cutler formations. The Tertiary lavas of the region are underlain by the San Juan tuffs and an older conglomerate, the Telluride conglomerate.

(29) U.S. Geological Atlas, Silverton Folio, No. 120, 1905.

The San Juan series of tuffs and the Silverton Volcanic Series with the overlying Potosi Volcanic series is similar to that described in the Lake City district and includes the Pécayune Group of and<sup>u</sup>gite and<sup>n</sup>desite, tuffs, and intrusives; the Eureka rhyolite, the Burns latite; and the Pyroxene andesite.

#### Ore Deposits

Intrusions of various kinds of igneous rocks took place in the bodies of rocks now exposed and doubtless lavas piled up above the Potosi rhyolite.

The above material was derived from the Silverton Folio.

#### Faulting

Extensive fissuring occurred in the Silverton area sometime later than the period of volcanic eruptions. The faults of the region are not all simple fissures, but are complex and are fault zones mostly. Faulting has taken place in a great many directions without reference to system. The faults as a rule exhibit a curving course and vary in dip from 45 degrees to nearly vertical. The displacements along the faults range from more than 1000 feet on down.

#### Mineralization

At a later period after the close of the faulting, ore-bearing solutions emanated from magmas and penetrated into the rocks filling the fissures with quartz and the

economic metallic minerals. In many places the country rock has been replaced by metallic and gangue minerals. The andesites and latites have been extensively attacked by the solutions yielding epidote, serpentine, bastite, chlorite, calcite, quartz, and other minerals. This condition is not confined to the immediate vicinity of the fissures.

### Ore Deposits

The ores are found filling fissures or in zones of closely spaced fissures. Country rock has been impregnated and replaced in places. The fissures occur in all rocks from the pre-Cambrian schist to the latest monzonitic intrusions which cut the Tertiary volcanic series. The greater number of fractures are found in the San Juan tuff and the Silverton Volcanic series. The fissures and ore deposits are thus Tertiary or later in age.

### Minerals Found in the Deposits, July 7-10, 1934

#### Gangue Minerals

Quartz ( $\text{SiO}_2$ ). Quartz is the commonest of the gangue minerals in the lodes, as vein quartz and crystallised in cavities or as druses in open spaces in the veins.

Ore specimens from the Mayflower mine show principally quartz, galena and chalc<sup>c</sup>opyrite.

Barite ( $\text{BaSO}_4$ ). Barite was noted in the ores from the Little Dora mine associated with galena, chalc<sup>c</sup>o-

pyrite, and manganese oxide (wad). It is not nearly as an important gangue mineral as quartz. It is also found in the other mines of the district.

Calcite ( $\text{CaCO}_3$ ). Calcite was noted in materials from the Camp Bird mine. It is less abundant than barite in the deposits.

Dalmanite.  $\text{Ca.Mg}(\text{CO}_3)_2$ . The mineral is not abundant but occurs as a microscopic constituent with rhodonite and rhodochrosite.

Rhodochrosite ( $\text{MnCO}_3$ ). Rhodochrosite was noted in small amounts in the ore of the Camp Bird mine. It was also noted in small amounts at the Sunnyside mine at Eureka. Here it occurs very subordinately in quartz with rhodonite.

Kaolinite (30). As a soft white powder kaolinite occurs with the gold quartz of the Tomboy and Camp Bird mines. As an original constituent accompanying the ores, it is abundant in the stock deposits of the Red Mountain District. In the Zuni mine or Anvil Mountain, the compact variety is abundant.

Fluorite ( $\text{CaF}_2$ ). Fluorite of the green variety occurs in the Camp Bird mine. It is also found in material from the Micky Breen mine in Poughkeepsie Gulch.

A specimen of green fluorite with hubnerite was

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(30) Silverton Folio, No. 120, p. 29.

obtained from the Little Dora mine.

Rhodonite ( $MnSiO_3$ ). A little rhodonite was noted in the ores from the Camp Bird mine. It is especially abundant in the Sunnyside lode at Eureka where a number of specimens were collected.

Zunyite<sup>(30)</sup> ( $Al(OH, F, Cl)_2$ )<sub>6</sub>  $Al_2Si_3O_{12}$ . Zunyite, a basic orthosilicate of aluminum, occurs only in the Zuni and one or two adjacent prospects on Anvil Mountain.

#### Ore Minerals

Pyrite ( $FeS_2$ ). Pyrite is common in all of the ores of the district. Crystallised as cubes it was seen in the ore from the North Star Tunnel. Here it is associated with galena and quartz.

Tetrahedrite ( $3Cu_2S \cdot Sb_2S_3$ ). Tetrahedrite because of its silver content rivals galena in the district.

A specimen from the Little Dora mine shows galena, tetrahedrite and quartz.

In the Micky Breen mine, in Poughkeepsie Gulch, it forms the principal part of the ore body.

Enargite<sup>(31)</sup> ( $3Cu_2S \cdot As_2S_5$ ). The mineral has been found in the ores of the Red Mountain range. It formed the principal ore of the National Belle mine. It was also

30. Silverton Folio, No. 120, p. 29.

31. Ibid.

abundant in the Zuni mine where it is said to have carried over 200 ounces of silver per ton.

Chalcocite ( $\text{Cu}_2\text{S}$ ). Chalcocite has been found on the dump of the Frank Hugh mine.

Stromeyerite ( $\text{Ag}_2\text{S} \cdot \text{Cu}_2\text{S}$ ). Stromeyerite has been reported to have formerly been an abundant ore in the Yankee Girl mine. Here it has been reported to have contained as much as 5,300 ounces of silver to the ton.

Chalcopyrite ( $\text{CuFeS}_2$ ). Chalcopyrite is common throughout the deposits of the region and is sometimes auriferous.

It was noted in large amounts in the ore in Mayflower mine associated with galena and quartz.

Galena ( $\text{PbS}$ ). The mineral occurs in nearly every deposit in the district.

It was noted in large amounts in the ores from the North Star, Mickey Breen, Mayflower, Little Dora, and Sunnyside mines.

Sphalerite ( $\text{ZnS}$ ). Sphalerite is a very common mineral in the region always found accompanying galena.

Bournonite<sup>n</sup> (32) ( $2\text{PbS} \cdot \text{Cu}_2\text{S}$ ). This mineral has been found in the Zuni mine in small vertically striated prisms, with pyrite and zunyite.

Zinkenite<sup>(33)</sup> ( $\text{PbS} \cdot \text{Sb}_2\text{S}_3$ ). Zinkenite occurs sparingly with barite in the Broldignag claim.

Gutermanite<sup>(33)</sup> ( $3\text{PbS} \cdot \text{As}_2\text{S}_3$ ). The mineral occurs only in the Zuni and adjacent claims.

Stibnite<sup>(33)</sup> ( $\text{Sb}_2\text{S}_3$ ). A single specimen of this mineral was found in the North Star mine on Sultan mountain.

Polybasite<sup>(33)</sup> ( $9\text{Ag}_2\text{S} \cdot \text{Sb}_2\text{S}_3$ ). Polybasite was present in the upper workings of the Yankee Girl mine.

Proustite<sup>(33)</sup> ( $3\text{Ag}_2\text{S} \cdot \text{As}_2\text{S}_3$ ). Ruby silver is known to have occurred in the Yankee Girl mine. It also occurred in the Ridgeway, Red, Cloud, Polar Star, Mammoth, Annie Wood, Palmetto, and Wheel of Fortune mines.

Bismuthite<sup>(33)</sup> ( $\text{Bi}_2\text{S}_3$ ). Bismuthite occurs with specularite and quartz at the Neigold claim on Galena mountain.

Argentite<sup>(33)</sup> ( $\text{Ag}_2\text{S}$ ). Argentite is not abundant in the Silverton district. It was distinctly recognized only at the Ridgeway mine.

Molybdenite ( $\text{MoS}_2$ ). This mineral occurs at the Sunnyside Extension mine where it has been mistaken for graphite.

Hematite<sup>(33)</sup> ( $\text{Fe}_2\text{O}_3$ ). The variety specularite is found frequently in small amounts in the Lodes, as at the Crown Point, Little Giant and Neigold mines.

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(33) Ibid., p. 30.

Galenobismutite<sup>(34)</sup> ( $\text{PbS} \cdot \text{Bi}_2\text{S}_3$ ). The variety alaskaite which is silver-bearing is abundant in the Alaska claim at Poughkeepsie Gulch.

Cosalite<sup>(34)</sup> ( $4\text{bS} \cdot \text{Bi}_2\text{S}_3$ ). Cosalite occurs in the Yankee Girl mine.

Kobellite<sup>(34)</sup> ( $2\text{PbS} (\text{BiSb})_2\text{S}_3$ ). Kobellite has been described and analyzed from the Silver Belle mine by Keller.

Beegerite<sup>(34)</sup> ( $6\text{PbS} \cdot \text{Bi}_2\text{S}_3$ ). Beegerite has been identified from Poughkeepsie Gulch by Koenig.

Tellurides. Tellurides are very scarce in the district, being noted in very small amounts from the Camp Bird mine, Barstow mine, Silver Ledge mine, and the Magnet Mine.

Gold<sup>(34)</sup> Au

Free gold forms aborescent sheets in quartz and rhodonite in the Golden Fleece vein. It has been found scattered through masses of spongy quartz in the Sunnyside Extension Mine. It is intimately associated with quartz, rhodonite, fluorite, yellow sphalerite, and galena being found embedded in the latter. It is found with pyrite and quartz in the Tomboy mine. At the Camp Bird mine it has been found enclosed as small particles with galena, sphalerite, pyrite, chalcopryrite, traces of some telluride, and

(34) Ibid., pp. 30-31.

in fluorite and quartz.

Silver <sup>(35)</sup> Ag. Native silver is rarely seen in the present ores. It was formerly found in the Pride of the West, Aspen, Ben Franklin, and Sunnyside Extension mines.

Copper <sup>(35)</sup> Cu. Native copper occurs as irregular plates and branding forms. It has been found in small amounts in the Royal Tiger, Tom Moore, and Sunnyside Extension mines.

Hubnerite (FeMn) WO<sub>4</sub>. Hubnerite is widely distributed in the Silverton district.

A specimen from the North Star mine shows brown, bladed prisms of hubnerite in quartz together with pyrite.

A specimen from the Little Dora mine shows brown crystals of hubnerite with green fluorite.

Products of Superficial Decomposition.

Small amounts of azurite, malachite, cerussite, manganese dioxide, and anglesite can be found in the out-croppings of most of the lodes.

Telluride District, Colorado

Location

The district is located in <sup>A</sup>Southwestern Colorado. It lies on the western edge of the great elevated San Juan mountain area, wholly to the west of the Continental Divide.

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(35) Ibid., pp. 30-31.

The quadrangle is drained by the San Miguel and Dolores rivers. Small branches of the Uncompahgre and Animas rivers rise in the eastern part. Most of the district lies in San Miguel county but smaller areas of Dolores, San Juan, and Ouray counties are in the district. The town is connected by means of the Rio Grande Southern Railroad with the main lines of the state.

At an elevation of 8,500 feet and a population of 500, the town may be reached by automobile by turning west at Ridgeway on state highway no. 64, which branches off 24 miles south of Montrose from U.S. Highway No. 550, State Highway No. 64 runs from Ridgeway to Placerville, whence state highway No. 108 may be followed south to Telluride.

### Rocks of the Region

The sedimentary rocks of the region range from the Algonkian quartzites up through the Dolores, LaPlata, McElmo, Dakota, Mancos, and the San Miguel or Telluride Conglomerate. This coarse conglomerate of the Eocene period rests with a marked unconformity on the underlying Mesozoic formations. The conglomerate is made up of granites, gneisses, greenish schists of several varieties, white, gray and bluish quartzite, limestone, red sandstone and porphyritic gneissous rock.

The Tertiary gneissous rocks are represented in the district by the San Juan tuff, an intermediate series of

andesite tuffs, agglomerates, rhyolites, etc., similar to the Silverton Volcanic Series; and the Pátosi rhyolite series.

Intrusive rocks in the quadrangle are diorite-monzonite, gabbrodiorite, diorite porphyry, granite porphyry. These rocks occur principally as stocks and sheets. The dike rocks are pyroxene andesite, plagioclase basalt, <sup>u</sup>augite minette, vogesite, and augite camptonite.

### Faulting

Faulting along fissures on a large and perceptible <sup>OK</sup> scale ~~have~~ <sup>has</sup> rarely been observed in the deposits.

### Ore Deposits

The ore deposits of the district are mainly in filled fissures and fissure zones. Five main systems of fissuring have occurred in the region. The first with a strike of N 87° W is especially well developed in the Mount Wilson area and to the eastward. The N 38° E system has also obtained marked development in the same area. Here the fissures dip to the west up to near the Special Session mine and from there dip steeply east. The fissures of the N 53° - 63° E system are especially prominent in the Mount Wilson area and dip steeply north or stand vertical. In the north part of the quadrangle fissures of the N 17° W - N 2° E system are common. A fifth system, the N 25° - 51° W dips to the southwest almost without exception. They

are found principally in the north eastern part of the quadrangle.

The fissures penetrate all the rocks exposed in the region and are later than the extr<sup>u</sup>sion of rhyolite, and later than the dioritic stocks.

### Veins.

The lodes of the veins may be considered to be narrow zones of closely spaced mineralized fissures. In going from the San Juan formation into the Telluride Conglomerate below, as in the Smuggler mine, the veins do not appear to become narrower, but they assume an irregularly broken and brecciated structure. In general, veins in the Mancos and McElmo are wide while those in the Dolores are narrow. The Smuggler vein extends over two miles in length showing the unusual extent of some of the veins of the district.

### Minerals of the Deposits

Primary minerals in the deposits in which gold and silver are associated are galena, silver-bearing tetrahedrite, polybasite, proustite, pyrargyrite, and stephanite.

Metallic gangue minerals are pyrite, chalcopyrite, sphalerite, mispikel, magnetite, stibnite, and native copper.

The nonmetallic gangue minerals are quartz, cal-

cite, siderite, rhodochrosite, dolomite, fluorite, barite, sericite, biotite, chlorite, amphibole, apatite, garnet, orthoclase, picotite, and kaolinite.

Secondary minerals are chalcantite, malachite, azurite, cerussite, anglesite, and limonite.

Mines Visited, July 12-13, 1934

The Japan, Tomboy, and Smuggler mines were visited, none of which <sup>is</sup> are being worked except the Smuggler where four leasers are doing development work.

Specimens of malachite and azurite were seen from the Japan mine; also quartz, and purple fluorite; quartz, galena, and ruby silver; and quartz, galena, sphalerite, chalcopyrite, tetrahedrite, and native silver.

Ore in the Tomboy and Smuggler mines is found chiefly in andesite and andesite breccia. The vein runs NW-SE and to the north it swings around more to the south-east. The ore has averaged about .5 of an ounce in gold. Gold and silver are the economic minerals.

A specimen was seen in the collection of one of the miners in Telluride of native gold in quartz from the Tomboy mine.

Specimens seen on the dumps of these two mines are as follows:

No. 1. An ore specimen showing galena, pyrite, sphalerite and quartz.

No. 2. Calcite crystals.

No. 3. Galena, quartz, sphalerite, pyrite, rhodonite, and rhodochrosite.

No. 4. Chalcantite on quartz with hematite.

No. 5. Yellow, iron stained, quartz crystals.

No. 6. Rhodonite, galena, quartz, chalcopyrite.

No. 7. Small cubes of pyrite on andesite rock.

No. 8. Ruby silver. This specimen was given to the writer by Mr. Fife, the assayer, at Telluride.

#### Ophir, Colorado

On July 14, 1934, the writer stopped at the mine alongside of the road at this town.

Specimens collected from the dumps of the mine are as follows:

No. 1. Country rock containing disseminated pyrite, capped by small clear quartz crystals on which light brown ankerite crystals had been deposited.

No. 2. Siderite with a little quartz.

No. 3. An ore specimen containing galena, sphalerite, tetrahedrite, siderite, quartz, and barite.

No. 4. An ore specimen showing galena, enargite, quartz, pyrite, and small, orange colored ankerite crystals in cavities in quartz.

No. 5. Barite, siderite, quartz, and galena.

No. 6. Barite, siderite, tetrahedrite, chalcopyrite, and bornite.

No. 7. Malachite stain on quartz, also chalcopyrite and galena.

No. 8. Quartz crystals, barite, hematite, and a few specks of bornite.

No. 9. Pyrite, some of it crystallised in cubes, and flaky hematite.

### Rico District, Colorado

#### Location

The Rico district is located in southwestern Colorado about 50 miles west of the Continental Divide. It is in a zone bordering the San Juan Mountains, almost at the head of the Dolores River. The quadrangle extends from southeastern Dolores county into northeastern Montezuma county. The Dolores Plateau makes up the western half of quadrangle. The Rico Mountains are found in the northeastern part of the heart of which the town of Rico is located. The Dolores River, in its passage through the Dolores Valley, has carved its way through the heart of the Rico Mountains.

The town of Rico is on the Dolores River in the center of the mining district and is at an elevation of 8,900 feet. The Rio Grande Southern Railroad crosses the quadrangle along the course of the Dolores River and connects Rico with the outside. The population of the town is about 500.

Rico may be reached by automobile by traveling north on state highway No. 10 for fifteen miles from the town of Cortez to Dolores. At Dolores, State Highway no. 145 follows the course of the Dolores river to Rico. From the north it may be reached from Montrose by traveling south on U.S. Highway no. 550 to Ridgeway, then southwards on Colorado State Highway no. 62 to Placerville where state highway no. 145 intersects with it and may be followed south to Rico.

### Rocks of the Region

The rocks of the Rico Mountains consist of the Uncompahgre formation of quartzites and schists of Algonkian age; the Ignacio quartzite of Cambrian age; the Ouray <sup>e</sup> Limestone of Devonian and Mississippian ages; the Molas and Her-<sup>ies</sup> mosa formations of Pennsylvanian age composed of thin reddish calcareous or sandy beds and limestones, shales, and sandstones respectively; the Rico formation of Permian age composed of sandstones and conglomerates with intercalated shales and thin fossiliferous limestones; the Cutler formation also of Permian age of alternating sandstones, sandy and calcareous shales, grits, and conglomerates with occasional impure limestones and marls; the Dolores formation of Triassic age composed of alternating sandstones, sandy shales, and limestone conglomerates; the LaPlata sandstone of Jurassic age; the McElmo also of Jurassic age composed largely of shales; and the Dakota and Mancos of Cretaceous

age. faults vary from clean cut fissures to zones of breccia-

tion many feet in width. The upthrow of the faults is on the inside or towards the center of the dome. The Telescope valley alluvium, torrential fans, and calcareous tuffs.

Igneous rocks are represented principally in the center of the Rico Mountains. Intrusive sheets and dikes of hornblende-monzonite-porphry, two dikes of pyroxene-monzonite-porphry, a large stock of monzonite west of Rico, the Calico Peak <sup>L.C.</sup> Porphyry, and basic dike rocks are characteristically developed in the area.

South Park, Silver Creek, Deadroad, and Spruce Gulch faults, Structure

The structure of the mining district shows a domal uplift with the mountains forming a circle of peaks. The sedimentaries are found dipping away on all sides from the outsides of this circle of mountains. Igneous rocks make up the greater part of the center of the dome. Few are found near the borders of the sedimentaries. The igneous rocks have in part at least been responsible for the domal uplift.

### Faulting

At the time of the formation of the dome, faulting and fissuring are thought to have been accompanying processes. The faults and fissure have since filled, in late Tertiary time, with vein matter, partly ore-bearing and partly barren.

The faults vary from clean cut fissures to zones of brecciation many feet in width. The upthrow of the faults is on the inside or towards the center of the dome. The Telescope Mt. fault shows amounts of dislocations up to nearly 2,000 feet, the throw being to the north or outer side of the dome. Thus it is the most important exception to the rule. Other important faults are the Blackhawk striking NW with a dislocation of 800 feet on the SW or inner side of the dome, the Nellie Bly, an important east<sup>^</sup>west fault with an upthrow of 75 feet to the south, the Last Chance fault, nearly parallel to the Nellie Bly with a throw of over 1000 feet, the Smelter, South Park, Silver Creek, Deadwood, and Spruce Gulch faults, and many minor ones.

### Ore Deposits

The ores occupy fissures while structural faults are barren. The deposits take the form of lode fissures, blanket veins, and replacements in limestone. The blanket veins often lie parallel to the sheets of intruded rocks or below impervious shales. The greater part of the production has come from the blankets. The deposits have a characteristically very limited vertical range.

The chief blanket is the so-called New Hill or Enterprise "contact". It is for the most part an unconsolidated breccia occurring nearly midway between the top and bottom of the series of sandstones, shales, and limestones make up the lower division of the Pennsylvanian, Hermosa

formation. The blanket rests everywhere upon a bed of limestone known as, "the short lime", here called the blanket limestone. This bed varies from a few inches to about two feet thick. The blanket resting on this bed varies from two to twenty feet with about an average thickness of six feet. The blanket is overlain by an impervious black, fissile shale which keeps out the abundant surface waters. The breccia forms generally only the upper part of the blanket, with the lower part a gray, soft, silty material. In some places, bodies of gypsum occur above the blanket in space usually filled by it.

#### Minerals of the Deposits

Pyrite ( $\text{FeS}_2$ ). Pyrite associated with quartz, chalcopyrite, sphalerite, and galena constitutes the practically worthless filling in most of the lodes. It is found in large blanket-like masses free from gangue in C.H.C. Hill.

Galena ( $\text{PbS}$ ). Galena occurs abundantly in the Enterprise blanket and in most of the bodies of the unoxidised ore. It always carries silver, but is not rich un-

chalcopyrite, rhodochrosite, and quartz. It occurs both in the northwesterly lodes and in the blankets.

Chalcopyrite ( $\text{CuFeS}_2$ ). Chalcopyrite is nearly always present together with galena and sphalerite in the workable ores, but it is not abundant in the district. In the Blackhawk replacement bodies associated with pyrite, fluorite, some galena and sphalerite, it formed some of the best ore.

Tetrahedrite ( $3\text{Cu}_2\text{S} \cdot \text{Sb}_2\text{S}_3$ ). Tetrahedrite, silver-bearing, occurs in the rich ores of the Enterprise and Rico-Aspen mines. It is here associated with sphalerite, polybasite, galena, rhodochrosite and quartz.

Enargite. ( $3\text{Cu}_2\text{S} \cdot \text{As}_2\text{S}_3$ ). Enargite occurred at the head of Horse Creek in the Johnny Bull mine.

Specularite ( $\text{Fe}_2\text{O}_3$ ). Specularite is found abundantly in several of the mines and prospects in metamorphosed Devonian beds. It is closely associated with chlorite, epidote, garnet, wollastonite, galena, sphalerite, and chalcopyrite.

Magnetite ( $\text{Fe}_3\text{O}_4$ ). Magnetite occurs massive with a little chalcopyrite, replacing limestone on the north side of Darling Ridge and near the head of Sulphur Creek. Here it has been mined for fluxing purposes.

Argentite, polybasite and proustite occur in the rich blanket and lode ores of Newman Hill.

Silver (Ag). Native silver has been reported in the Enterprise and Puzzle mines.

Gold (Au). Free gold has rarely been detected in the Rico ores. Some however has been said to have occurred in the Enterprise mine associated with galena and chalcopryrite. Imbedded in rhodochrosite, it has been reported from the same mine.

Copper (Cu). Native copper occurs as small crystalline sheets or skins in the country rock of the California prospect near Iron Draw.

Quartz ( $\text{SiO}_2$ ). Quartz is the most common gangue mineral in the fillings in the lode fissures.

Rhodochrosite ( $\text{MnCO}_3$ ). Rhodochrosite is present in the Enterprise blanket and in the upper richer portions of the northeasterly lodes of Newman Hill.

Calcite ( $\text{CaCO}_3$ ). Calcite is abundant only in the veins of Nigger Baby Hill. Here it takes the place of quartz as the principal gangue mineral.

Fluorite ( $\text{CaF}_2$ ). Fluorite is not common in the deposits, but it is found abundantly in the displacement ore bodies of the Blackhawk mine, also in the Fortune and Duncan prospect north of Silver Creek.

Gypsum ( $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ). Gypsum occurs as a gangue mineral only in the ores which have replaced massive gypsum

in Newman Hill., Mancos, Colorado, July 17, 1934

Barite ( $\text{BaSO}_4$ ). Barite occurs on a claim adjoining the Aztec mine, but has not been found in the gangue of any workable ore body.

Chlorite. Chlorite occurs abundantly as a gangue for sphalerite, chalcopyrite and specularite in the Atlantic Cable and other prospects in the Devonian limestone.

Garnet, epidote, pyroxene, and wollastonite are contact metamorphic minerals occurring in altered Devonian limestone of the Atlantic Cable and adjoining claims.

Kaolinite and Sericite. ( $\text{H}_4\text{Al}_2\text{Si}_2\text{O}_9$  and  $\text{H}_2\text{KAl}_3(\text{SiO}_4)_3$ ). Some kaolinite has been found associated with the ore in the Johnny Bull mine. Sericite is found in connection with the C.H.C. blanket.

Specimens Collected, July 15-16, 1934

- No. 1. Quartz, sphalerite on sandstone.
- No. 2. Black and green chalcedony.
- No. 3. Black and green chalcedony and quartz.
- No. 4. Sphalerite and quartz on sandstone, pyrite on sphalerite in small combinations of cubes and pyritohedrons.
- No. 5. Small yellow quartz crystals on sandstone.
- No. 6. Rhodochrosite, galena, quartz, sphalerite, and tetrahedrite.

Mancos, Colorado. July 17, 1934

The writer did not visit Starr's Red Arrow mine which is located eight miles north of Mancos, but obtained the following information concerning the mine from Mr. Brown, a part-owner of the mine.

The ore is contained in a fault-fissure vein in the LaPlata sandstone. The vein averages five feet in width and dips to the south at about 60 degrees.

The ore is composed chiefly of a sandstone breccia with barite and gold as the cementing materials. Malachite and azurite are also noted in the ore and also galena and other sulphides at times.

Specimens were seen from the mine which ran eleven ounces in gold, none of the gold being visible in the barite and sandstone breccia.

A nugget of gold, two inches long by one inch wide, was shown to the writer by Mr. Brown. It was almost pure gold, but a little sandstone was attached to it.

Other specimens seen in the newspaper office in Mancos show flakes of native gold plastered on small fractures and fracture planes in the sandstone.

A rich silver ore specimen was given to the writer by Mr. Clay Williams of Mancos. This specimen from the Rose mine in Silver Gulch located along the West Fork of the

Dolores River between seven and ten miles south of Dunton shows polybasite, rhodonite, and quartz.

Dike-like forms of this so-called South Mountain latite have been found in the Summitville District, Colorado among other

#### Location

Summitville is located in the extreme southwestern corner of Rio Grande county. It is situated at the north foot of South Mountain nearly at the head of Wightman's Fork, a branch of the Alamosa River. It is at an elevation of approximately 11,300 feet. A country road leads in a northeasterly direction to Del Norte, twenty-eight miles distant. From Del Norte southwest, the first twelve miles of this road are in good condition, but the remainder of the road, owing to neglect, is nearly impassible. The nearest railroad to Summitville is at Del Norte.

#### Rocks of the District

The principal rocks in the immediate vicinity of Summitville are the quartz-biotite latite which makes up most of South Mountain and in which the mines are located, and the underlying Summitville <sup>u</sup>angite-andesite. These rocks belong to the <sup>o</sup>Edwards Volcanic series of flows. Most of the

ranging in length up to two inches.

Dike-like forms of this so-called South Mountain latite have been found in several localities cutting other formations. They probably represent fissures through which the latite magma flowed up to the surface.

Dikes of augite-andesite are also found in the South Mountain area.

Both of the dike-like masses probably form the feeders to the greater part of these two lava flows.

### Ore Deposits

The mines of the district are located on a series of parallel running veins that have a general northwest and southeast strike. The veins consist of altered quartz-latite which has been replaced by the ore and gangue minerals. In the process of replacement, the phenocrysts of glassy andesine have been dissolved out completely and have left absolutely sharp casts of their original forms. The casts occur in a groundmass of quartz, which has replaced the latite. Ore-bearing solutions deposited the minerals in these casts and in the quartzitic ground mass.

### Minerals of the Deposits

Enargite ( $3\text{Cu}_2\text{S} \cdot \text{As}_2\text{S}_3$ ). Enargite occurs as crystals in feldspar cavities, also as solid masses fre-

quently associated with barite and always with pyrite. It also has been observed intimately intergrown with massive pyrite tennantite on the Chandler vein.

Tennantite ( $3\text{Cu}_2\text{S} \cdot \text{Sb}_2\text{S}_3$ , with arsenic replacing the antimony). Massive tennantite occurs on the Chandler level.

Covellite ( $\text{CuS}$ ). Covellite occurs on both the Chandler and Golconda levels being found on the first named level in masses three to six inches thick.

Barite ( $\text{BaSO}_4$ ). Barite is noted as an occasional gangue mineral in the Golconda vein.

Gold ( $\text{Au}$ ). Gold in the free state associated with limonite or limonite mixed with clay is found in the Golconda vein in a belt varying from 50-300 feet in depth, and in a lower sulphide belt. It occurs in the crystallised form as a lining in the feldspar casts.

Pyrite ( $\text{FeS}_2$ ). Pyrite occurs as small crystals in feldspar cavities and in the quartz gangue.

Chalcopyrite ( $\text{CuFeS}_2$ ). Chalcopyrite is infrequently observed in the ores.

Sphalerite ( $\text{ZnS}$ ). Sphalerite occurs sporadically in the Golconda vein.

Silver ( $\text{Ag}$ ). Silver values have been found in pyrite. The value of silver in this camp is not great.

Values are also probably found in galena.

Kaolin or Sericite. ( $H_4Al_2Si_2O_9$  and  $H_2KAl_3(SiO_4)_3$ ).

These two minerals have been formed by alteration of the feldspar crystals. This condition is very pronounced in the Winchester tunnel near the portal.

Specimens Collected from Dumps Near Reynolds Tunnel.

No. 1. Quartz-latite showing glassy phenocrysts of andesine and phenocrysts of orthoclase.

No. 2. Vein rock of quartzose character showing covellite crystals.

No. 3. Covellite crystals and kaolinite in quartzose rock containing disseminated particles of pyrite.

No. 4. A piece of iron pipe from the old air line, about 140 feet in on the tunnel, which has been completely replaced by native copper.

No. 5. Covellite crystals in cavities in siliceous rock which is impregnated with small particles of pyrite and chalcopyrite. The green stain of malachite is present in a few places on this specimen.

No. 6. Covellite crystals in a mass two inches long, an inch wide and a half inch thick.

No. 7. Siliceous rock containing disseminated pyrite particles with black metallic sulphides.

No. 8. Quartzite impregnated with pyrite particles, covellite coated with chalcocite in solution cavities lined with quartz crystals, enargite in a small mass filling

a cast of andesine.

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Thirty men were working at Summitville at the time visited by the writer on July 18, 1934. They were employed cleaning out the old caved-in Reynolds tunnel. They had progressed inwards about 140 feet from the mouth of the tunnel. Much water was observed rushing out of the old air line and oozing out of the material blocking the tunnel at this place. A new tramway is being installed which will be a mile long. This will carry four ten ton cars, and will be electrically operated. The operating company plans to connect the Little Annie and Little Ida and other stopes with the main Reynolds tunnel, which will be used to transport ore from the workings to the new mill which is being put in.

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