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Mineralogical notes on the Silverton quadrangle, Colorado

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than 800 feet long. The strike of the vein is N. 5° - 10° W.

Ransome (1901, p. 198) described the deposit as follows: "The lode is a sheeted zone 20 feet or more in width. The ore is chiefly bornite and tetrahedrite, carrying silver and chalcopyrite, and occurs in bunches along some one of the fissures. It is found in quartz, which is largely silicified San Juan breccia. It contains from 20-30 percent copper and sometimes as much as 300 ounces of silver per ton. The best ore is said to occur in solid quartz. There has been considerable post-mineral movement along the lode, resulting in soft gouge, and where the disturbance is pronounced it is regarded as unfavorable for ore. The ore usually occurs near the west (called the foot) wall, but it is far from continuous. The country rock on both sides of the lode is traversed by numerous parallel fissures, along which there has frequently been some late movement, as attested by the presence of wet clay gouge." Over 2,200 feet of drifting has been done along the vein. Most of the veins bottom at the Precambrian surface. The Silver Link mine is one of the oldest in the district, the tunnel work and much of the drifting having been done in the early eighties.

According to the Mint reports, ore worth about $50,000 was shipped from the Silver Link mine from 1888 to 1891. The mine was idle from 1893 to 1899 and then was reopened and operated for several years. In 1902 shipments of 70 tons of ore grossed 12.0 ounces of gold, 1,685 ounces of silver, and about 44,084 pounds of copper.

Sutton Mine

The Sutton mine is on the west side of Uncompahgre Canyon at an altitude of 10,595 feet. The mine is reached by road and trail from the old Mineral Farm mine south of Ouray. The mine workings consist of four levels, with the principal workings along the No. 4 level, where a 925-foot crosscut known as the Barber tunnel cuts the vein. An aerial tramway 2,700 feet long leads from the Barber tunnel to a 100-ton mill located at Bear Creek Falls.

The Sutton vein dips roughly 70° SE., strikes about N. 40° E. on the No. 1 level, and about N. 30° E. on the No. 4 level. In the few places where the vein was observed it is highly siliceous with a low sulfide content that appeared to be principally pyrite. Mill returns, however, indicate that the ore contained some galena and copper sulfide. The Sutton vein bottoms at the Precambrian quartzite, at an altitude of about 9,700 feet. Near the base of the San Juan tuff about 200 feet of drifts has been driven along the vein and its short branches. The vein here strikes N. 25° - 35° E., dips 75° S., and is a few inches to four feet wide.

In 1917 eight tons of ore shipped to the smelter grossed 0.42 ounce of gold, 404 ounces of silver, and 352 pounds of copper. In 1925, 36 tons of lead ore were milled and yielded 7.46 ounces of gold and 626 ounces of silver.

MINERALOGICAL NOTES ON THE SILVERTON QUADRANGLE, COLORADO

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INTRODUCTION

During the long history of mining in the districts of the Silverton quadrangle, considerable amounts of gold, silver, copper, lead, and zinc have been produced. The ores mined were primarily composed of the more common minerals of these metals. In some deposits, however, especially some of the silver-rich ones, a few rather exceptional, even unique, mineral species have been found. Locally some of these are important ore minerals, as well as potential sources of metals not previously sought, such as bismuth and tungsten. Several of these minerals were first described from this area, and at least one has never been reported from any other locality. This paper provides a brief description of the minerals which are characteristic of the ores of the Silverton quadrangle.

The deposits are generally grouped into three structural and genetic classes as follows: (1) fissure and cavity fillings, (2) breccia-chimneys, and (3) replacement deposits. Although largely distinct, the classes may be mixed within a single deposit. The three classes are mineralogically similar, varying more in texture and bulk composition than in mineral species present. On the other hand, the mineralogical composition may vary considerably from one deposit to another and from one part of the quadrangle to another. Gold mineralization, and to a lesser extent silver, tends to be separated from the base-metal ores, especially lead and zinc, whereas copper ores frequently contain considerable amounts of silver.

Although Ransome (1901) has suggested that the minerals in some of the richer ores were supergene, it has

been demonstrated by Bastin (1923) and others that most of the sulfides and sulfosalts are hypogene. The brittle silvers, polybasite and stephanite, are generally considered to be hypogene, although the lateness of their formation makes it difficult to demonstrate this fact in many cases, and the possibility that they may be supergene in part must be considered. Argentite is usually supergene, and native silver is considered to be always supergene. There is some evidence to indicate gold enrichment in some of the ores. Oxidized ores are rather uncommon, with small amounts of copper and lead sulfates and carbonates appearing near the surface. The silver chloride, ceragyrite, is mentioned by Ransome (1901) but the occurrence has not been verified. Anglesite was of importance in the upper part of a few deposits. The lack of much oxidized ores is explained by the very rapid rate of erosion in this area of high relief.

GANGUE MINERALS

Gangue minerals include the nonmetallic minerals which make up the matrix of the ore, or are intimately associated with it. Quartz, barite, calcite, and clay minerals are common and very usual gangue minerals. Rhodochrosite and rhodonite, manganese carbonate and silicate respectively, are abundant though somewhat more unusual gangue minerals. Fluorite is locally important but not very widespread. Chlorite as minute green flakes in and with quartz is regarded as indicative of good gold ores. Dolomite occurs as a very minor constituent with rhodochrosite and rhodonite. Zunyite, a rare aluminum silicate, forms a part of the gangue at one locality. It is included here as gangue only because of its lack of economic value, and not because it is in any sense ordinary. Following is a description of the less familiar gangue minerals.

Rhodochrosite $MnCO_3$ – This mineral occurs as coarse-grained masses with good rhombohedral cleavage or as small rhombohedral crystals in vugs in the massive material. Except for its color and somewhat higher specific gravity (about 3.8) it closely resembles coarse-grained calcite or dolomite marble. The color is usually some shade of pink, the lighter colors usually indicative of some substitution of calcium for manganese. The introduction of considerable iron carbonate generally results in a brownish-pink color. At the Grizzly Bear mine, on Bear Creek at the northern boundary of the quadrangle, it occurs as beautiful, translucent, rose-red rhombohedrons. Rhodochrosite, often with rhodonite, is one of the more abundant gangue minerals in this area. It is probably exceeded in importance as a gangue only by quartz and barite in that order. Typical rhodochrosite gangue was very common in the Titusville lode, about two miles west of Silverton.

Rhodonite $MnSiO_3$ – This manganese silicate is similar in color to rhodochrosite, but may be readily distinguished from it by its lack of rhombohedral cleavage, its greater hardness (about 6 as opposed to 3.5), and its failure to react with hydrochloric acid. Calcium is present in all samples of this mineral and probably is an essential constituent. It crystallizes in the triclinic system, but no single crystals of any size are known in this area. It typically occurs as tough masses of very fine-grained to cryptocrystalline intergrowths of fibrous crystals. It is invariably associated with rhodochrosite (Ransome 1901), and together with it makes up the "pink spar" of the miners. It is an abundant gangue mineral, especially in the deposits of the northeastern part of the quadrangle and in the deposits of the Treasure Mountain area. At the surface, rhodonite weathers to form a black manganese oxide coating.

Clay minerals – White, powdery to massive clay minerals are widespread as gangue in the Silverton quadrangle. The only clay mineral listed by Ransome (1901) is kaolinite. In view of the lack of detailed knowledge of the clay minerals at the time of his report, it might be supposed that other clay minerals, such as montmorillonite, might be included under his kaolinite.

Zunyite $Al_{13}Si_5O_{20}(CH)_{18}Cl$ – This mineral is named for the Zuni mine on Anvil Mountain about two miles northeast of Silverton. It is from this locality that it was first described (Hillebrand, 1885). It has since been found at several other prospects on Anvil Mountain, and has been reported from Red Mountain to the north and from Postmasburg, South Africa. Zunyite is isometric, colorless, has a specific gravity of 2.8, and a hardness of 7. It occurs at the Zuni mine as brilliant tetrahedral crystals up to 5 mm in diameter, embedded in massive blue-grey guitermanite (see below) or, where the latter is oxidized, in anglesite. Although the mineral is of no economic value and extremely rare, it has received considerable attention from mineralogists and crystallographers. Of the host of silicate minerals known, few are isometric. An investigation of the crystal structure of zunyite (Pauling, 1933) showed it to have very complex and unique structure. The isometric cell is built up of a unit of twelve octahedrally-coordinated aluminums, a unit of five tetrahedrally-coordinated silicons, and a unit of a single tetrahedrally-coordinated aluminum. The formula here given varies

slightly from that given by Hillebrand (1885) and is based on the structural scheme.

ORE MINERALS

Under this heading are included all the metallic minerals and all minerals containing metals of economic value. Gold is present as the native metal, although small amounts of unidentified gold tellurides have been detected. Some silver is also present in the native state. The ores consist in large part of the common sulfides of lead, zinc, and copper, the last two frequently containing considerable amounts of silver. Tetrahedrite is an abundant and important sulfosalt mineral, and locally several other sulfosalts are of importance. These include enargite, the ruby and brittle silvers, aikinite, bournonite, zinkenite, guitermanite and several sulfobismuthates. Hematite and hubnerite are not uncommon oxygen-bearing minerals in the primary ores. Anglesite and several other oxidation products are present in small amount as mentioned above.

The native elements – Native gold is the only important gold mineral in the area. When visible it forms thin arborescent sheets in quartz and often with rhodonite. Most of the rich gold shoots are highly siliceous and are separated from the base-metal ores. *Native silver* in the form of thin wires was mined long ago in the upper workings of many of the deposits. It is considered to be entirely of supergene origin. *Native copper* is a very minor mineral in this area.

Pyrite FeS – This mineral is very widespread and usually of no economic value. It usually occurs as small crystals of several isometric forms, radially fibrous, or massive. It often impregnates large rock masses, such as at Red Mountain. In a few deposits it contains considerable gold and is mined for that metal.

Galena PbS – Galena is present in almost every deposit of the area, although the amount present may vary considerably. It is perhaps the most widespread and abundant, if not the most valuable, ore mineral in the area. It presents the usual blue-gray metallic appearance and high density, and varies from coarse cleavable masses to fine granular masses. The latter is often , though not invariably, rich in silver.

Sphalerite ZnS – According to Ransome (1901), sphalerite was not mined in this area during the earlier days, although it is an abundant and widespread mineral. It is found in tetrahedral crystals or cleavable masses and varies from light yellow, through brown, to nearly black in color. The lighter colored varieties contain little iron and are commonly associated with native gold. Some deep-yellow to orange varieties which may contain some cadmium have been reported, but no analyses are available.

The copper sulfides – Chalcopyrite $CuFeS_2$, *bornite* Cu_5FeS_4 , and *chalcocite* Cu_2S are widespread throughout the area. They present no unusual appearance but often contain considerable silver. This is especially true of chalcopyrite and bornite. Bornite was an important copper-silver ore in many of the mines of the Red Mountain area. Chalcopyrite was important in the Red Mountain area and the Titusville mine, southwest of Silverton.

Stromeyerite CuAgS – Except for a somewhat higher specific gravity (about 6.2), this mineral is very similar to chalcocite. It was erroneously believed that a continuous series exists between chalcocite and stromeyerite, but this is not the case, and so-called argentian chalcocite is probably a mixture of these two minerals. A small lot of such ore from Yankee Girl mine in the Red Mountain district contained over 5,000 ounces of silver per ton, and one from the Guston mine in the same area contained 15,000 ounces per ton, almost pure stromeyerite.

Tetrahedrite $(Cu,Fe,Zn,Ag)_{12}(Sb,As)_4S_{13}$ – Isometric, in tetrahedral crystals, but usually massive. Usually steel-grey with a metallic luster; hardness 3–4; Sp. G. 4.8-5.1, increasing with increase in antimony content. Antimony predominates in most of the samples from this area, but in a few cases arsenic predominates and the mineral should properly be called *tennantite*. The relative amounts of the metals present is quite variable. Copper is always present in significant amount, and silver may be present up to 19 percent (*freibergite*), though it is usually forms no more than a few percent. Tetrahedrite rivals galena in abundance and importance (Ransome, 1901), and forms much of the copper and silver ore of the area. It is found in most of the lodes of Picayune, California, and Poughkeepsie Gulch and in the Red Mountain ores. Freibergite is reported from the King Solomon mine about three miles west of Silverton.

Polybasite $(Ag,Cu)_{16}Sb_2S_{11}$ and *stephanite* Ag_5SbS_4 – These two minerals are commonly known as "brittle silver". Both are present as minor ore minerals in several districts. Polybasite may be the more common of the two, and was important in some mines of the Red

Mountain district, where it was occasionally found in well-formed pseudohexagonal tabular crystals. Polybasite is actually monoclinic and stephanite is orthorhombic. Both are black, have a Sp. G. of about 6.2, and a hardness of 2-3.

Pyargyrite and *proustite* $Ag_3(Sb,As)S_3$ – This pair of minerals, commonly called "ruby silver", were found in some of the upper parts of silver-rich deposits, expecially in the Red Mountain area. They were never important ore minerals. The arsenical end member seems to have been more common. Both are characterized by their deep ruby-red color, which blackens rapidly on exposure to direct sunlight or ultra-violet.

Enargite Cu_3AsS_4 – Orthorhombic, in prismatic crystals or massive; black with one perfect cleavage and very brittle; Sp. G., 4.4; hardness 3. Enargite is frequent in the ores of the Red Mountain Range, and formed the major ore mineral at the National Belle mine, where it was sometimes found in clusters of prismatic crystals. At the Zuni mine, enargite ore contained as much as 200 ounces of silver per ton; the National Belle ore was probably of much lower grade.

Bournonite $PbCuSbS_3$ – This mineral was found as black, vertically striated prisms with zunyite and guitermanite at the Zuni mine.

Zinkenite $Pb_6Sb_{14}S_{27}$ – An arsenian variety of this mineral was found at the Brobdignag claim about three miles northeast of Silverton. It is massive, steel-grey, and has a hardness of 3 and Sp. G of 5.8.

Aikinite $PbCuBiS_3$ – This mineral is described from the Dunmore mine (Kelley, 1946; Kelley & Silver, 1946) where it forms an important part of the ore in the copper shoot within a hematite breccia-chimney. The aikinite from this locality contains a significant amount of silver. The mineral is massive, blackish-grey; has a hardness of 2.5 and a Sp. G. of 7.1. It is associated with chalcopyrite and tetrahedrite in barite gangue.

Guitermanite $Pb_{10}As_6S_{19}$ – This mineral was first described (Hillebrand, 1885) from the Zuni mine where it is associated with zunyite. It is named for Frank Guiterman, metallurigist and chemist of Denver, Colorado. It has never been found at any other locality. The mineral is massive, bluish-grey in color, and contains numerous small crystals of zunyite embedded in it. It is brittle, has a hardness of 3 and Sp. G. slightly under 6. Several later workers have found guitermanite to be identical with jordanite ($Pb_{14}As_7S_{24}$), and another found it to correspond to baumhauerite ($Pb_4As_6S_{13}$). The only conclusion to be drawn from these observations is that this material may be a mixture of several known species, or that it is a distinct but rather impure species.

Lead sulfobismuthates – Bismuth-bearing sulfosalts are frequent consituents of the ores of the northeastern part of the quadrangle, and this area may be regarded as a bismuth province (Kelley, 1946). Some sulfobismuthates have also been found in the ores of the Red Mountain area. In addition to aikinite described above, Ransome (1901) lists the following: *galenobismuthite*, $PbBi_2S_4$; *cosalite*, $Pb_2Bi_2S_5$; *kobellite*, $Pb_2(Bi,Sb)_2S_5$; *beegerite*, $Pb_6Bi_2S_9$; *alaskaite*, $Pb(Ag,Cu)_2Bi_4S_8$; and possibly others. An examination of the composition of these minerals immediately reveals the difficulties which might be encountered in their identification. None are found in individual crystals, and all are very similar in appearance. At the time of Ransome's report the only reliable method of identification was quantitative chemical analysis, and this fails where impurities may be present. With the exception of aikinite and galenobismuthite, all of these minerals require further study to establish their validity. Alaskaite was first found (Koenig, 1881) at the Alaska mine in Poughkeepsie Gulch. It has since been found at the nearby Saxon mine and at one locality in Bolivia. The mineral is massive, light lead-grey, has a hardness of 2 and a Sp. G. of 6.8. At the Alaska mine it is found associated with pyrite, tetrahedrite, and cosalite in weathered-looking masses with some clay.

Hübernite $MnWO_4$ – This tungstate of manganese forms a complete isomorphous series with iron tungstate, the term wolframite being applied to members of intermediate composition. Most of the samples from this area contain no more than five percent by weight of FeO, and so may be properly classed as hübernite. It is monoclinic, and commonly forms bladed crystals with one pronounced cleavage. It has a hardness of 4 and the Sp. G. is about 7.2, increasing slightly with increase in iron content. Hübernite is reddish brown in color, and usually slightly translucent, so that deep-reddish internal reflections are not uncommon. The color becomes darker and finally black in the iron-rich varieties. Hübernite has been found at quite a few deposits in the Silverton quadrangle, some of the more notable ones being the Adams lode and the Dunmore mine in the Poughkeepsie Gulch area, and at several localities in the vicinity of Silverton. It usually occurs as clusters of bladed crystals embedded in quartz and occasionally associated with fluorite.