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Mineralogy of the Silver King Mine of Park City, Utah

Pierce D. Parker

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MINERALOGY OF THE SILVER KING MINE OF PARK CITY, UTAH

by

Pierce D. Parker

A Thesis
Submitted to the Department of Geology
in Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science

Montana School of Mines
Butte, Montana

May, 1951
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INERALOGY OF THE SILVER KING MINE, PARK CITY, UTAH

By

Pierce D. Parker

ABSTRACT

Quartz, pyrite, sphalerite, tetrahedrite, chalcopyrite and galena as replacement products and quartz and calcite as fissure fillings are the minerals of this suite of ores from the Silver King mine and were deposited in faults and fissures contained in the upper 900 feet of the Park City limestone. These minerals were introduced in the order shown above with the last named minerals replacing or filling the fissures of the preceding ones.

Silver, which is the most valuable product of this mine, is believed to be in close association with both the galena and tetrahedrite, although tetrahedrite is by far the most important silver mineral.

In regard to the other valuable constituents from the ore specimens, galena is important for the lead it contains, sphalerite for the zinc, and tetrahedrite for the copper.
INTRODUCTION

Except for the early work of Boutwell and Irving, little has been published on the geology of the Park City mining district. For this reason and because of the availability of a selected suite of ores from the Silver King mine of this area, this writer chose the mineralogy of the Silver King mine as a senior thesis for the department of Geology of the Montana School of Mines.

The minerals of this suite of ores were first examined megascopically, mineragraphically, and microchemically to determine their mineralogy. Next, polished mineral surfaces were examined under the microscope for paragenetic criteria as clues to mineral relationships. Lastly, although these specimens were selected from a rather restricted area of this mine, as may be seen from plates VIIIa, VIIIb, VIIc, VIIIId, and VIIle, they were nevertheless correlate with relation to their position, mineral content, and assay in an attempt to show their probate origin as well as association with valuable ore bodies.

In composing this report, the writer is especially indebted to Mr. E. O. Bracken of the Silver King Consolidated Mining Company, who provided the suite of ore samples, and supplied helpful assay maps of the Silver King mine for study and correlation. In addition, Dr. R. S. Perry and Prof. F. S. Robertson should be thanked for their assistance in preparing this report and for their encouragement in times of duress.
LOCATION AND HISTORY

The Park City district of Utah is one of the principal silver, lead, and zinc producing areas in the United States. This district, which includes the Silver King properties, lies 8000 feet above sea level on the eastern slope of the Wasatch Mountains, 25 miles south-east of Salt Lake City. (2:177)

The Park City district became important in 1872 after the discovery of the Ontario mine, and the subsequent development of rich supergene ore deposits in the area. In 1888, rich float was found along a hillside near Woodside Gulch, and led to the discovery of one of the chief ore deposits of this district. This original discovery was purchased by the Silver King Coalition Mining Company shortly thereafter, and later became the Silver King Mine. (3:228)

This mine, which is one mile southeast of Park City in Woodside Gulch, was incorporated with the Silver King Mining Company in 1892. However, in 1907 this company reincorporated and became the present Silver King Coalition Mining Company.

For more than a decade at the start of this century, the Silver King mine was one of the largest silver producers in Utah, and was largely responsible for the favorable position of that state in silver production. In relation to this production, it is said that there are over 400 miles of underground working in the Silver King
mine of which some three levels are now in operation.

PREVIOUS WORK

The first systematic geologic examination of the Park City district was under-taken in 1902 by J. D. Irving and J. M. Boutwell under the supervision of S. F. Emmons. (2:1-231) This work, which was completed in the winter of that year and was published by the U.S.G.S. in professional paper 77, is still the outstanding report on this area. This comprehensive investigation covered not only general geology, stratigraphy, structure, and mine descriptions, but also ore genesis, and mineralogy. Hence, it was of great assistance in substantiating and supplementing this thesis.

Since the time of this original geologic study, only a few specific articles have been written on the mineralogy of the Park City area. Outstanding among these is a bulletin written in 1936 by Jackson, Knaebel, and Wright (11:22) which gives some of the economic aspects of mining and milling in this area, as well as a short generalized geologic description.

GENERAL GEOLOGY

The Park City district is situated in an area of Paleozoic and Mesozoic sediments which have been faulted and folded by intrusives and earth movements of Tertiary age. Although in some areas there is some question as to
the stratigraphy, the best information on the sequence of the sediments of this area is as follows: (1) the Devonian Wasatch limestone of undetermined thickness; (2) the Pennsylvanian Weber formation containing 1500 feet of quartzite; (3) the Permian Park City formation which is 590 feet thick and which contains blue limestone and shale; (4) the Woodside formation consisting of 1200 feet of red shale and sandstone of Triassic age; (5) the Thames limestone which consists of 1200 feet of calcareous sandstone and interbedded limestone also of Triassic age; and (6) the Ankarak and Nugget formations which do not appear in the Silver King area, and which overlie the sediments of the other districts with 1650 feet of red shale and sandstone from the late Triassic and early Jurassic.

The ore deposits occur chiefly in the Wasatch, Weber, and Park City formations, and to a minor extent in the Thames limestone. The sedimentary rocks were intruded as a diorite mass which gave rise to the development of typical metamorphic silicates near its contacts. This igneous body probably was the parent mass for hydrothermal solutions which deposited the ore in the sedimentary rocks.

Of great importance to the mineralization of this area is the considerable folding and faulting of the sediments. In particular, the northeast-southwest fault fractures were especially effective in providing the necessary channels for the upward passage of ore-rich
solutions. At a later period, renewed movement along these faults caused brecciation of the ore deposits. Still later, northwest-southeast faults aided the downward percolation of surface waters which caused oxidation and secondary enrichment to depths as great as 800 feet.

Two types of ore deposits, which often grade one into the other, are present in the Silver King mine, as well as in the surrounding area. The richest silver deposits in this mine occur as replacement ores which lie in the limestone above the 900-foot level, and which are largely altered to sulphates, carbonates, and oxides. These ore deposits are roughly lenticular in shape, and offshoots may extend for hundreds of feet from the parent ore body. The second type of deposit is found in fissures cutting quartzite. These fissures range in width from 3 to 8 feet, and dip at about 45 degrees. The ore of this type of deposit consists of tabular parallel sulphide bodies alternating with bodies of quartzite.

**MINERALOGY**

The samples studied in this investigation are from a vein in the upper Park City formation. The vein follows a fault with a displacement of about 1000 feet, which lies in the footwall of the Crescent fissure, a major structure of this mine. The whole general area is further cut by minor faults which are slightly mineralized.
As will be seen from the assay maps accompanying this report, the 12 specimens whose mineralogy is described below are from a restricted area between the 500- and 700-foot levels, and are largely confined to one stope. Since this is a small section of the mine, the results of this investigation may not be applicable to the whole mine, but they are diagnostic for the immediate area, which is the only one being presently operated.

**Galena**—This isometric lead sulphide (PbS) is found in large quantities in both the cleavable and granular form. The cleavable form shows cubical cleavage faces as large as one-half inch across, although the average is nearer one-eighth inch. The granular form is of the steel galena type, and the grains are discernible with the naked eye. Both these mineral forms contain small amounts of silver, some of which may be in the molecular lattice.

**Tetrahedrite**—This mineral, which is sometimes called gray copper, and which is intimately associated with galena, is a complex sulphantimonite \((\text{Cu}, \text{Fe}, \text{Zn}, \text{Ag})_{12}\text{Sb}_4\text{S}_{13}\) occurring in both a crystalline and granular form. However, the granular form far exceeds in total amount the crystalline type which is rare. The principal source of the silver from this mine is from these two types of tetrahedrite, which also appear to be the chief source of copper. The silver may be present in the molecular lattice of the tetrahedrite as a replacement of copper atoms, or as an unseen argentiferous mineral associated with the
tetrahedrite.

**Sphalerite**—Zinc sulphide, sphalerite (ZnS), occurs abundantly associated with galena and pyrite. This mineral, which is generally a deep brown, resinous, or ruby red, may likewise be associated with irregular minute grains of tetrahedrite. Although the sphalerite grains have the shape of highly irregular masses under the microscope, in some instances small resinous crystals of sphalerite occur megascopically in association with rub-red crystals of the mineral.

**Chalcopyrite**—This sulphide of copper and iron (CuFeS₂) was not observed megascopically in the mineral specimens, but was recognized microscopically in blebs and veinlets, chiefly in the sphalerite and to a minor amount in the tetrahedrite. These blebs are quite irregular in outline and do not appear in all the sphalerite and tetrahedrite of the specimens.

**Pyrite**—Iron sulphide, pyrite (FeS₂), occurs mostly in a granular-massive form, but it is also present as small crystals intergrown with the other sulphides. This mineral, which is only a relatively minor constituent of the ores, appears under the microscope as both single euhedral crystals and severely masticated masses of crystals.

**Quartz**—Quartz (SiO₂) is not abundant in the ore specimens. Although this mineral does occasionally occur in crystals up to three inches in length, it generally appears as a massive gangue associated with the sulphide
minerals and calcite.

Calcite—Although economically unimportant, calcite (CaCO₃) is the chief gangue constituent of the ores, and under the microscope is abundant in association with the other minerals present. Much of the mineralization gives carbonate tests probably caused by calcite.

Silver Minerals—No silver minerals were found in the course of this examination. However, both galena and tetrahedrite appeared chemically to contain this metal. Therefore, the writer has assumed that the silver occurs either in the crystal lattice of the minerals or as an argentiferous mineral associated with the minerals mentioned above.

PARAGENESIS

The following discussion is based on the examination of 12 polished sections taken from the areas shown on the accompanying mine sketches. The mineralogy together with the assay reports, give a picture of the history of mineralization. The paragenetic relations are summarized below.

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Calcite
Prior to discussing the paragenetic relationships of the ore minerals, mention should be made of the criteria that were used in determining age diversity or similarity. Of the criteria mentioned by W. H. Newhouse (7:147-161) in the book by Fairbanks, the following are applicable to this examination.

1. Euhedral crystals of the guest mineral as advance "islands" in the host mineral.

2. Cusps or incipient veinlets of replacing mineral in the host.

3. Veinlets of guest mineral transgressing between two different host minerals.

4. Veinlets cutting across grains of host mineral.

5. Irregularity of veinlet walls.

6. Termination of veinlets at grain boundaries.

7. Residual remnants left by the host mineral in the guest.

8. "Ghost" crystal forms which have been replaced by one or more guest minerals.

9. Preferred orientation of mineral blebs in the host minerals.

10. Veinlets with regular walls following crystal borders and originating in a parent mineral mass.

The first eight criteria are distinctive of replacement, whereas the last two are distinctive of exsolution and fissure filling respectively. The replacement criteria are given a primary place because the overwhelming evidence points toward this type of mineralization, and
A. Galena entering between tetrahedrite and sphalerite

B. Galena cutting across a sphalerite grain

C. Galena replacing pyrite

D. Galena replacing sphalerite

Photomicrographs of Ores from the Silver King Mine
A. Calcite filling fissures in sphalerite

B. Calcite filling fissures in galena

C. Calcite filling fissures in galena

D. Calcite filling fissures in pyrite

Photomicrographs of Ores from the Silver King Mine
A. "Ghost" crystal of quartz partially replaced by pyrite and sphalerite

B. Pyrite replacing quartz

C. Ragged pyrite crystal in quartz

D. Pyrite replacing quartz

Photomicrographs of Ores from the Silver King Mine
A. Galenal replacing pyrite

B. Unoriented blebs of chalcopyrite in sphalerite

C. Oriented blebs of chalcopyrite in sphalerite

D. Sphalerite and tetrahedrite of contemporaneous origin

Photomicrographs of Ores from the Silver King Mine
because the important ore minerals have been implanted in this manner, as is brought out in the following discussion.

**Introduction of Quartz:** The fissures and faults of this area were first occupied by quartz under low pressure since "comb crystals" are observable in some specimens.

**Introduction of Pyrite:** Pyrite was introduced after the first quartz; however, it formed euhedral grains in the early quartz indicating the contemporaneous nature in some instances of these two minerals. The evidence for the later deposition of the pyrite is given by criteria 1, 2, and 8 of the preceding page.

**Introduction of Sphalerite:** After the pyrite and quartz were deposited, sphalerite replaced these minerals. The relative age of the minerals was determined by the incipient cusps and veinlets, and by the sphalerite surrounding the pyrite. The sphalerite has abundant inclusions of chalcopyrite some of which have a definite orientation indicating the probability of exsolution. More often, however, the blebs and inclusions are scattered and seem to outline invisible grain boundaries.

**Introduction of Tetrahedrite:** This mineral occurs only rarely in the polished surfaces of the specimens which makes criteria identification difficult. Nevertheless, the tetrahedrite appears to replace all the preceding minerals on the basis of incipient veinlets and a long stringer cutting through a grain of sphalerite. Inclusions of chalcopyrite are not uncommon in this mineral as unoriented blebs and stringers.
Introduction of Chalcopyrite:—Most of the blebs of chalcopyrite in the tetrahedrite and sphalerite are interpreted as replacement features, although there is some indication of exsolution. These blebs and the longer stringers of chalcopyrite probably can be attributed to deposition along submicroscopic openings in the host minerals. An interesting feature of this replacement is the termination of the long stringers of chalcopyrite at the tetrahedrite and sphalerite boundaries, so that none of the chalcopyrite appears in the galena grains.

Introduction of Galena:—As indicated by criteria 2, 3, 4, and 5, and because of the termination of chalcopyrite stringers at the galena boundaries, galena follows chalcopyrite, sphalerite, and tetrahedrite in order of introduction. Galena is the most plentiful sulphide mineral, and shows conspicuous replacement relations with the earlier hypogene mineralization.

Introduction of Late Quartz and Calcite:—Because of the evenness of the veinlet walls these two minerals have been determined to be late fissure fillings. The quartz and calcite were deposited along cracks, crystal boundaries, and in fissures; and in hand specimens, show typical late secondary deposition. As the minerals do not occur associated together to any significant extent, their age relations are uncertain.
MINE LEVEL MAPS
SHOWING
ORE DISTRIBUTION

(From E. O. Bracken of the Silver King Mining Company)
STOPE ABOVE 600' LEVEL

600' LEVEL

AG - 157.2 OZ.
Pb - 22.8 %
Zn - 18.6 %
Cu - 6.2 %

(HIGH TETRAHEDRITE)
479  STOPE RAISE — BETWEEN 600' & 700' LEVEL

(HIGH TETRAHEDRITE)

AG - 176.4 oz.
Pb - 24.5 %
Zn - 14.8 %
Cu - 8.0 %

AG - 8.6 oz.
Pb - 10.6 %
Cu - .2 %
Zn - 27.0 %

AG - 7.0 oz.
Pb - 4.8 %
Cu - .7 %
Zn - 19.2 %

AG - 33.6 oz.
Pb - 10.2 %
Zn - 9.8 %
Cu - 2.6 %

PLANE FOR HORIZ. SECTIONS AT RIGHT

700' LEVEL

MONTANA SCHOOL OF MINES LIBRARY
BUTTE

AG - 13.0 oz.
Pb - 23.2 %
Zn - 24.2 %
Cu - 0 %

700' LEVEL
SUMMARY

Although lead, zinc, and copper are recovered in important amounts, the ore of the Silver King mine is important principally for its silver content. These ores were deposited along faults or fissures cutting the upper 900 feet of the Park City limestone, and are of the replacement and fissure-filling types.

The minerals which were found in this suite of specimens are quartz, pyrite, sphalerite, tetrahedrite, chalcopyrite, galena, and calcite. In addition, silver was found as a metal constituent of these minerals.

Since silver is the most valuable mineral in this mine, it was the chief subject of this examination with the following conclusions.

1. The silver appears to be associated with the tetrahedrite in large amounts, although some is also associated with the galena.

2. The silver may be associated with these minerals as an atomic replacement in the molecular lattice, as a submicroscopic exsolution product, or as unidentifiable mineral grains.

In conclusion, this writer would like to point out that these conclusions are verified by E. O. Bracken in the accompanying assay maps, which show the increase of silver as the copper increases.
BIBLIOGRAPHY


