Clear, concise, careful job.
Might have mentioned whether all Ag can be kept away from the zinc conc.
No scale to drawings.

A MINERALOGRAPHIC STUDY OF THE SILVER STANDARD MINE, HAZELTON, B. C.

A report submitted in partial fulfilment of
the requirements for Geology 409

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INTRODUCTION

The 17 polished sections examined in the preparation of this report were made in 1950 for Mr. G. A. Noel.

Location

The Silver Standard claims are located on Glen Mountain, a small, detached hill about 4 miles north of Hazelton, B. C.

History

The first claims were staked on this property in 1910. Prior to 1918, when the first mill was built, only high grade, non-milling ore was mined. Operations ceased in 1922, after which intermittent development was carried out until 1946, when Silver Standard Mines Ltd. was formed. The property has been worked almost continuously since 1946 and consists now of 15 crown-granted claims and fraction and 24 recorded claims.

The 1953 production was:

Ores treated - 21,554 tons
Product shipped - 1,631 tons Pb concentrates
2, 770 tons Zn concentrates

Gross Metal Contents (Oz.)

Au,	Ag	Cu	Pb	Zn	Cd
1,801	871,165	87,716	1,735,747	3,187,160	39,937

GENERAL GEOLOGY

Glen Mountain is composed of rocks of the Hazelton group. This group consists of massive, blocky light and dark grey, fine grained beds of calcareous sandstones, argillites and probably tuffs. These sediments are gently folded forming a low anticline with its axial plane striking north. Dips are up to 35° on the west limb. Numerous minor folds are present on both limbs of the anticline. The west limb is intruded by two small stocks of porphyritic granodiorite.

The mineralization is localized in 10 quartz veins, cutting the Hazelton rocks. These veins which are roughly parallel strike N.E. and dip S.E. 50° to 75°. The veins occur along strong fault fissures and in one case (#3 vein) extends into the granodiorite stock. The width of the veins varies from a few inches to 6 feet. The mineral content is very variable. #4 vein is the strongest on the property. Slight mineralization extends in places for as much as 3½ feet into the wall rock.

MINERALOGRAPHY

GENERAL DESCRIPTION OF THE HAND SPECIMENS

The majority of specimens exhibit a very rough banding which generally shows a somewhat folded structure on flat surfaces. The banding does not maintain a constant pattern and is therefore of little use in determining the paragenesis. In several specimens, including all those from #1 vein, no banding was apparent. Specimens from #1 vein show some effect of secondary alteration.

Minerals visible in hand specimens

Primary Minerals - Sphalerite
Galena
Chalcopyrite
Pyrrhotite
Tetrahedrite
Arsenopyrite
Pyrite

Secondary Minerals (Only from #1 vein)
- Limonite
Anglesite

Gangue Minerals - Quartz
Calcite
Siderite

Generally, the dominant metallic minerals in a specimen are galena and sphalerite. Both occur as aggregates of small crystals and as impure masses. Tetrahedrite is the dominant mineral in a few specimens from #4 vein where it exhibits a massive or fine grained texture. Pyrrhotite occurs as small, fine grained masses and as zones in the banded ore.

Chalcopyrite is occasionally massive, but generally occurs as veinlets in the other sulphides. Arsenopyrite and pyrite are less commonly observed in the hand specimens. They occur as well formed crystals disseminated throughout the ore and as brecciated masses. The quartz occurs as well crystallized disseminations through the ore and as fine grained masses. It is the dominant gangue mineral. Calcite exceeds siderite in abundance, but is relatively rare compared to quartz. Calcite occurs as dissemination through the metallic minerals and layers around massive quartz. Siderite was observed only as crystals in the ore. Anglesite forms coatings on galena, where it has been exposed to weathering. Limonite is found in pits on weathered surfaces, usually around grains of chalcopyrite.

DESCRIPTION OF MINERALS
AS SEEN UNDER THE REFLECTING MICROSCOPE

Galena

Galena forms large, well crystallized masses containing inclusions of all of the other minerals. Where it is in contact with masses of sphalerite the two exhibit a strongly developed emulsion texture. This texture is also present where the galena forms irregular veinlets through the sphalerite. Tetrahedrite, polybasite and bournonite occur as small inclusions in the galena and commonly the grains send small projections into the galena. Chalopyrite and pyrrhotite occur less frequently and are found only very close to the contacts with sphalerite and the tetrahedrite. Covellite and a dark grey non-metallic mineral (probably anglesite) replace galena to a very minor extent along cleavage planes in sections from #1 vein. Pyrite and arsenopyrite occur in galena as complete or fractured and partially replaced crystals with fracture fillings of galena. Galena also occurs as small inclusions in sphalerite, pyrite, tetrahedrite and bournonite.

Sphalerite

Sphalerite is the most abundant mineral in the majority of specimens studied. It appears as irregularly shaped masses and often contains very numerous blebs of chalcopyrite forming a pseudo-eutectoid texture. Chalcopyrite also occurs as stringers in the sphalerite and as more massive inclusions of galena, which it has apparently replaced, and contains a major proportion of the observed polybasite. In section 1A, #1 vein, masses of tetrahedrite contain very numerous inclusions of chalcopyrite, sphalerite and fragments of arsenopyrite and pyrite. The adjacent galena is practically devoid of inclusions. In the same section, bournonite appears consistently as a rim around the tetrahedrite grains. Tetrahedrite is very commonly formed at boundaries between sphalerite and galena.

Chalcopyrite

Chalcopyrite, which was probably deposited in 2 phases, is contained almost exclusively in sphalerite, tetrahedrite and bournonite, but also occurs as inclusions in galena, pyrite, arsenopyrite and quartz. The relationships of chalcopyrite to the other minerals are:

sphalerite - exsolution texture (pseudo-eutectoid)

galena - replaces chalcopyrite

tetrahedrite- somewhat smooth boundaries in come cases, probably indicating exsolution. In other cases chalcopyrite fingers project into the tetrahedrite, possibly indicating that the chalcopyrite is replacing the tetrahedrite;

bournonite - fractures in bournonite are cut by chalcopyrite indicating that chalcopyrite is later

polybasite - seems to cut chalcopyrite in some cases, but at other times is cut by chalcopyrite.

pyrite and arsenopyrite - contain small blebs of chalcopyrite grains at the sphalerite boundaries. Sphalerite also contains inclusions of pyrite, galena, tetrahedrite, pyrrhotite and arsenopyrite and occurs as inclusions in these minerals. The boundary relationships between sphalerite and the other minerals are:

pyrite and arsenopyrite	- sphalerite fills fractures in both. There sometimes appears to be fracture fillings of pyrite in sphalerite.
galena	- boundaries show emulsion texture.
chalcopyrite	- pseudo-eutectoid or exsolution texture. Occasionally the small blebs of chalcopyrite are lined up in a particular direction.
tetrahedrite	- small sphalerite grains in tetrahedrite are rounded; in larger grains the contact is usually concave towards the sphalerite.
pyrrhotite	- occurs as veinlets in sphalerite exhibiting almost an emulsion texture in places.

<u>Tetrahedrite</u>

Tetrahedrite is mouse-grey in colour, isotropic and shows little relief against galena. It is generally inert to all etch reagents, but the argentiferous variety (freibergite) quickly etches irridescent with HNO_3. Both varieties are common in this ore.

In sections from #6 vein tetrahedrite occurs only as inclusions in galena and sphalerite. In #1 and #4 veins it occurs as large masses, sometimes constituting the major component of the specimens. It usually contains small

Pyrrhotite

Pyrrhotite is readily recognized by its distinctive pink hue, anistropism and hardness. It occurs in two ways in this ore, first by exsolution from pyrite and by replacement of (or exsolution from)sphalerite . It occurs as extremely irregularly shaped grains which form vein-like bodies in sphalerite & galena. It also exhibits emulsion texture with galena or sphalerite. Pyrrhotite is found in tetrahedrite, quartz and pyrite as small single grains.

Pyrite

Pyrite usually occurs as broken and largely replaced crystals. It contains fracture fillings of galena, sphalerite, chalcopyrite and pyrrhotite and may contain some exsolved pyrrhotite. It also appears as fracture fillings in sphalerite which indicates another phase of pyrite deposition. First phase pyrite is seen to replace first phase quartz.

Arsenopyrite

Arsenopyrite is recognized by its poor polish, white colour, hardness, crystal form and its effervescence with HNO_3. It seems to be just slightly later in the sequence than first phase pyrite since it sometimes cuts pyrite structures. It often occurs as euhedral rhombic crystals but usually it is broken and replaced by tetrahedrite, galena and sphalerite. In places it seems to localize the precipitation of tetrahedrite.

Bournonite

This mineral is lighter in colour than tetrahedrite and has a slightly greenish tint against galena. It has two cleavages, is negative to all etch reagents except HNO_3 and is moderately anistropie.

Bournonite occurs in galena as small semi-angular grains, but the main occurence is as rims around masses of tetrahedrite, where it often exhibits a 'granular' texture with chalcopyrite and sphalerite. In the latter case it is being replaced by chalcopyrite which is seen to cut fractures in the bouronite. The small amount of sphalerite present here is probably exsolved from the chalcopyrite.

Polybasite

This mineral has a strong bluish-green tint against tetrahedrite and galena and is anistropic. Its most common occurence is in tetrahedrite where the grains have an extremely irregular, angular outline. Polybasite contains no inclusions except for a very small amount of chalcopyrite which sometimes seems to replace it.

SECONDARY MINERALS (Occur only in sections from #1 vein)

Covellite

Covellite replaces galena along cleavage fractures especially along contacts with bournonite and occurs as small blebs in galena, tetrahedrite and bournonite. It occurs in very insignificant amounts and then only in weathered specimens.

Limonite

Limonite appears dark grey, very soft and has a red streak. It is associated with chalcopyrite and probably with siderite. This also occurs in very insignificant amounts.

Unknown Mineral (Probably Anglesite)

This mineral occurs along contacts of galena with bournonite and in cleavage fractures of galena. It is soft, dark grey and apparently anisotropic.

GANGUE MINERALS

Quartz

There appears to be two phases of quartz crystalization. The first deposited quartz contains fracture fillings of galena, sphalerite, tetrahedrite, chalcopyrite, pyrrhotite, arsenopyrite and pyrite. It also contains inclusions of these minerals.

A later phase of quartz deposition is indicated by the fact that occasionally quartz crystals seem to cut across otherwise continuous structures of galena and sphalerite.

Quartz usually occurs as fairly large crystals or masses but occasional small fragments are found disseminated in the ore minerals.

Calcite

Calcite is less abundant in the specimens than is quartz, but in proportion it is more frequently and widely distributed through the ore minerals. It contains fracture fillings of galena, but its relationships to the older minerals are not indicated. It is often found as semi-rounded inclusions in the metallic minerals.

Siderite

Siderite occurs in small quantities. Its relationships with other minerals are undetermined, although it sometimes seems to be closely associated with calcite. It can be identified by its cleavage, dark colour and by the fact that it turns green with HNO_3.

PARAGENESIS

Quartz was the first mineral deposited in the sequence. This is demonstrated where quartz crystals are replaced by pyrite which is definitely earlier in the sequence than the other metallic minerals, with the possible exception of arsenopyrite. Calcite was probably second in the sequence since it is often found in a position between quartz and the ore minerals and often seems to be replaced by the metallic minerals. The position of siderite in the sequence is not clear, but there is some indication that it was contemporaneous with the calcite. This phase of mineralization was followed by fracturing.

The first phase of metallic mineralization consisted of pyrite, with exsolved pyrrhotite, and arsenopyrite deposition. Arsenopyrite is seen occasionally to project into pyrite fragments, thereby indicating that pyrite may be slightly earlier in the sequence. A second period of fracturing followed this phase.

The next phase of deposition formed sphalerite with exsolved chalcopyrite and pyrrhotite which may have been exsolved or otherwise simultaneously deposited. More fracturing occured at this stage.

Galena and possibly a second generation of pyrite were next in the sequence. Both form veinlets in sphalerite. A second phase of quartz deposition may also have occured here. Simultaneous depostion of tetrahedrite and bournonite succeeded galena with possibly some overlapping. These relationships are inferred mainly from the contact characteristics of these minerals.

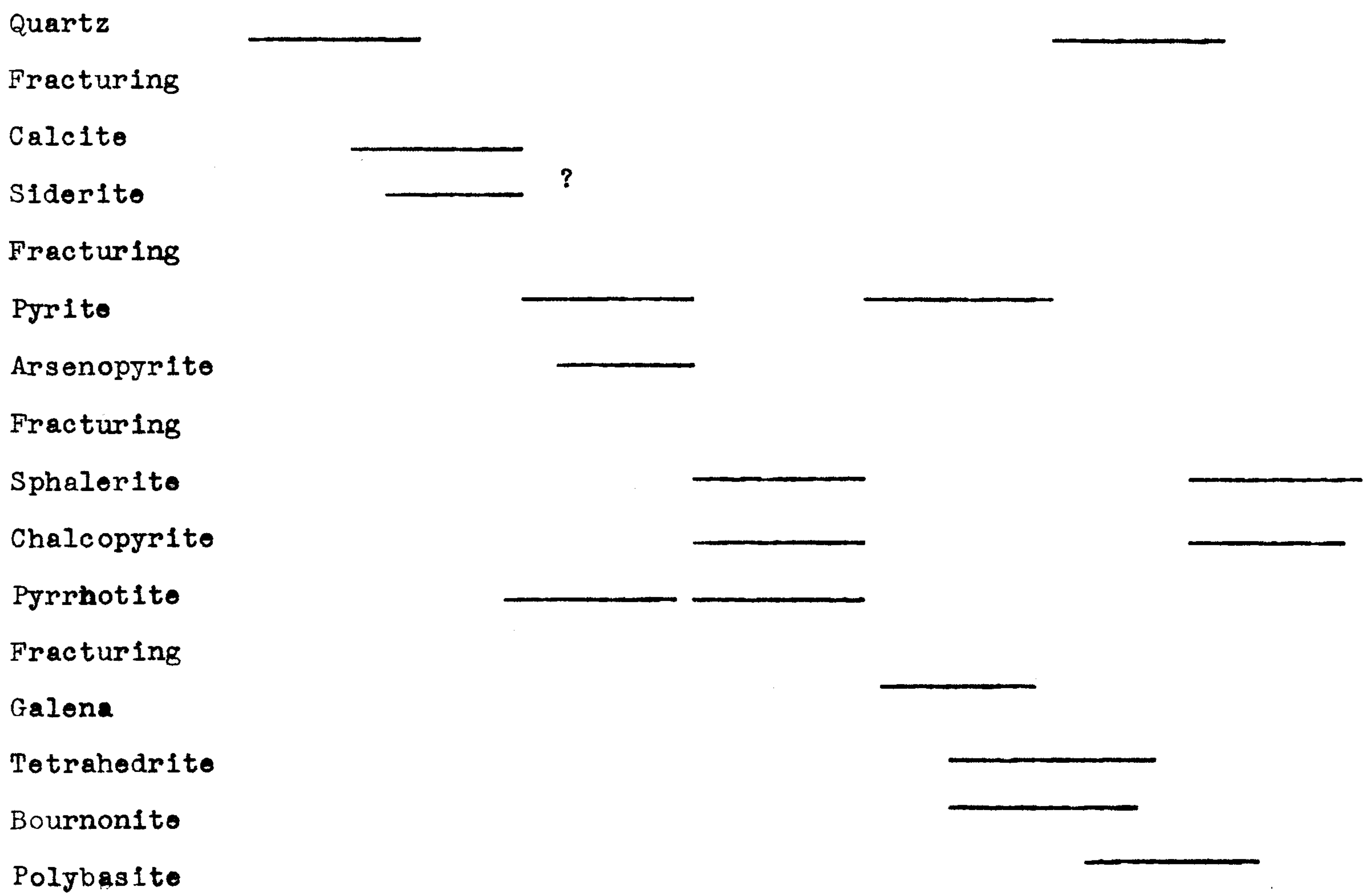
Polybasite seems to be later than the tetrahedrite judging from the angularity of the grains. It is almost certainly not older than tetrahedrite and therefore must be classed as contemporaneous or more probably as later than tetrahedrite. The last primary metallic mineral deposited seems to be chalcopyrite which is seen to cut tetrahedrite, bournonite and polybasite structures.

The last event was the formation of the secondary minerals, covellite, limonite, anglesite and probably another dark grey mineral.

TYPE OF DEPOSIT

This deposit was probably formed at temperatures which approached the lower limit of those typical of mesothermal deposits. Deposition was probably by both open space (fissure) filling and by replacement.

GRAPHIC REPRESENTATION OF PARAGENESIS



GRAIN SIZES

Sphalerite, galena, tetrahedrite, and the gangue minerals range in size from sub-microscopic to massive.

Pyrite and arsenopyrite crystals range in size up to 2,000 microns.

Bournonite - up to 1500 microns

Chalcopyrite - up to 1000 microns

Polybasite - 50 to 400 microns, usually about 200

Covellite - average about 65 microns

Gangue Minerals

Percentage of Sections (average).

Quartz > 18%

Calcite < 5%

Siderite < 1%

Metallic Minerals

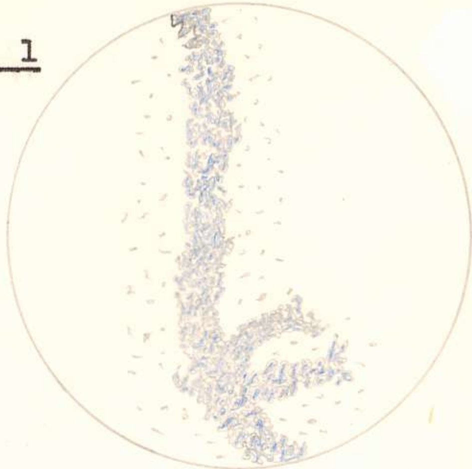
Percentage of Metallic Minerals (Average)

Sphalerite	$>$ 40%	
Galena	$>$ 20%	
Tetrahedrite	$>$ 10%	
Arsenopyrite	$<$ 10%	Arranged in decreasing
Pyrite	$<$ 10%	order of abundance.
Chalcopyrite	$<$ 10%	
Pyrrhotite	$<$ 5%	
Bournonite	$<$ 5%	
Polybasite	$<$ 1%	

Secondary minerals $<$ 1%

PLATE 1

Fig. 1

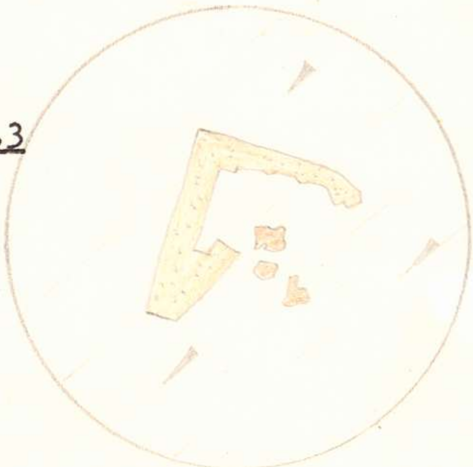


Veinlet showing early stage of replacement of sphalerite (white) by galena (blue).

Fig. 2

Pyrite (mottled) replacing quartz (grey) and being replaced by sphalerite (blue) and chalcopyrite (yellow). The chalcopyrite has been exsolved from the sphalerite and has migrated to the grain boundaries. The pyrrhotite (brown) probably exsolved from the pyrite.

Fig.3



Pyrite (yellow) being replaced by galena (white).

BIBLIOGRAPHY

Short, M.N., "Microscopic Determination of the Ore Minerals".

Edwards, A.B., "Textures of the Ore Minerals".

British Columbia, Report of the Minister of Mines
1911 - 1922; 1946

Geological Survey of Canada Memoir 223, pp. 28 - 35,
Paper 44-24.