GEOLOGY 9

A Microscopic Analysis of Ore from The Waterloo Silver Mine Lightning Peak Area southern B.C.

by

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Introduction:

The ore examined was supplied by the Geology Department. Information concerning the history and geology of the mine was obtained from a 1930 Geological Survey of Canada Report, and from numerous Annual Reports of the Minister of Mines, B.C. These reports occur intermittently from 1904 to 1936 with the 1919, 1927, and 1930 reports being of particular importance. All other information was derived from a megascopic and microscopic examination of the ore by the author with particular emphasis being laid on the latter by the use of polishing, etching and microchemical methods.

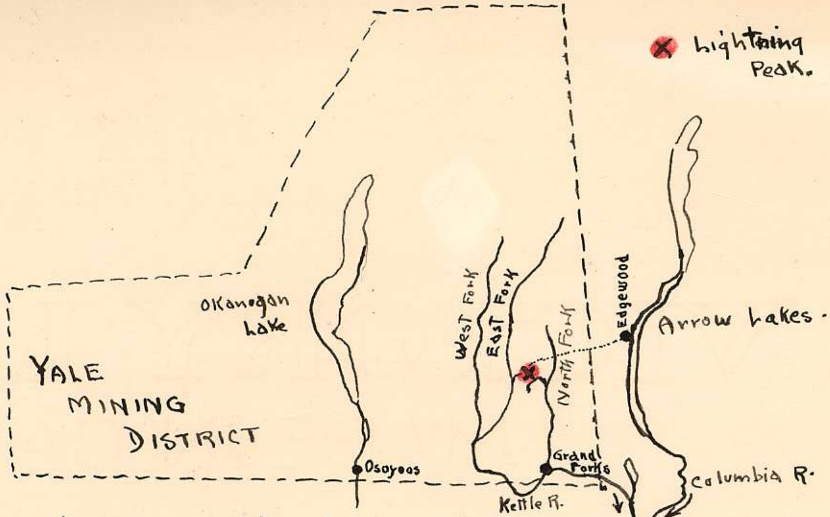
Location of Mine:

The original Waterloo Mine (now known as Waterloo No. 3, one of a consolidated group of Waterloo mines) lies at the western extremity of a group of claims comprising the Lightning Peak Area. This area extends in a band running in a N. W. W. direction between the East and North forks of the Kettle river, and lies just north of Lightning Peak from which it takes its name. It lies at the headwaters of Kendell and Granby creeks tributary to the East and North forks respectively, with the Waterloo adjacent to Rendell creek. Since the boundary line between Greenwood and Grand Forks Mining Divisions passes through Lightning Peak the area is divided between the two with the Waterloo well inside the Greenwood Division. These divsions are part of the larger Yale Mining District covering most of the southern interior of British Columbia. The mine lies at the terminus of a skid road built in to the area along the old Galloping Mountain trail from Edgewood about twenty-five miles N. E. E., on the shores of the Lower Arrow Lake.

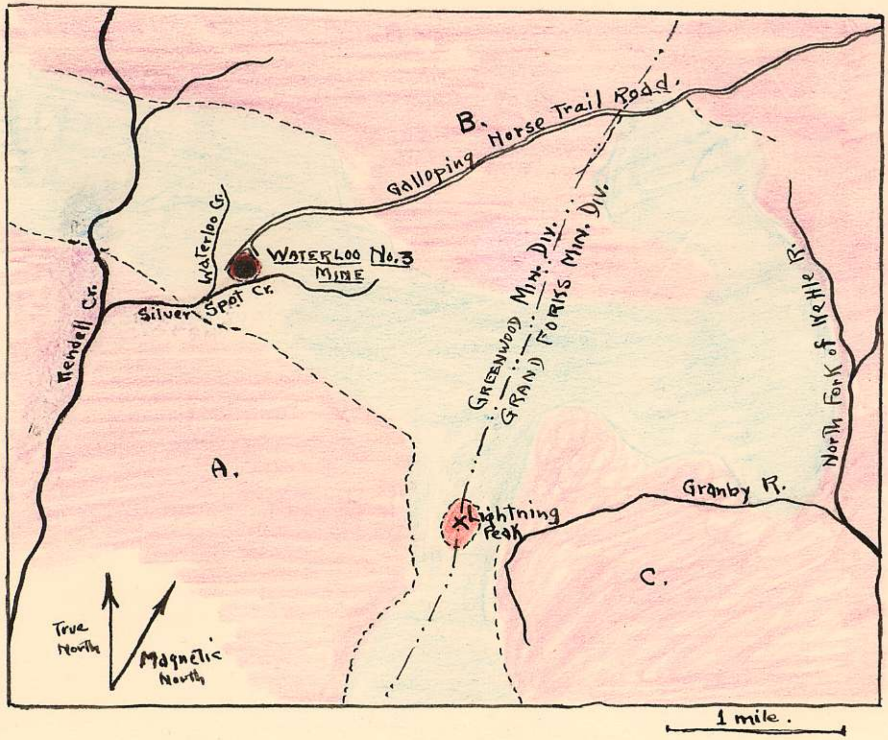
History of the Mine:

The Waterloo claim was staked out in 1903 by Adam Scaia. It was sold

General Location Of Mine



Particular Location Of Mine.



- - - - - definite boundaries

Tertiary -olivene basalt

Mesozoic and Paleozoic sediments and volcanics (met.)

Mesozoic Intrusives (Nelson Batholith)

A. granodiorite
B. porphyritic granite
C. pink granite.

almost immediately to George Mcleod who took out a little high grade ore and within a year turned it over to G. A. Rendell of Trail. He remained sole owner until 1927 then joining up with Dr. C. M. Kingston of Grand Forks. During this period development progressed slowly with loads increasing from a fraction of a ton to as much as twenty tons. Transportation by pack-horses and winter raw-hiding along the Galloping Mountain trail were the only methods of removing the ore. The long awaited tractor road built in along this trail and completed in 1929 helped to lower the high transportation costs. In this same year Kendell and Kingston collaborated with several others to form the Waterloo consolidated Mines Limited. Two new tunnels, the"Intermediate" and No. 3, opened up at this time below the first two tunnels only confirmed the steadily decreasing, though still payable nature of the ore values. In 1930 the growing loss of interest in silver was accompanied by a growing desire to explore the north to south striking quartz veins for gold. The search for gold began in earnest in 1932 when an anticipated drop in base metal values occurred. No. 4 tunnel, already begun, was pushed ahead speedily to intersect quartz veins thought to lie ahead. Although gold values remained relatively low, the Waterloo was nevertheless established in 1933 as the Waterloo Gold Mines Limited with headquarters in Penticton, and financed by Col. Victor Spencer of Vancouver. Since then a certain amount of further development has been carried on continuously in these old tunnels as well as in the newer Waterloo properties lying to east and west. But, since no mention of the Waterloo occurs later than 1936 in the Reports, and since the author has been unable to obtain any other knowledge of further activity it is to be presumed that the mine has become either totally or partially closed down since that date. This mine primarily a silver producer, should not be confused with the Waterloo Gold Mine, of the McKinney Camp group, just west of the Cariboo Gold Quartz.

Prior to 1931 a total aggregate of 150 tons of ore had been shipped with silver values ranging between 250 and 700 ounces to the ton and averaging from 300 to 350 ounces. Some of the records given are:

	Au.	Ag. (oz.)	Pb (%)	Zn (%)
1904:	$10	669	45	not given
1917:	trace	521	12	17
1918:	.02 oz.	763	4	9
1919:	trace	528	53	11
	nil	293	5	8
1926:	trace	250	$5^1/2$	9
1929:	$7 to 9	472	not given	not given

(the general analysis also shows about 36 % SiO_2, 15 % CaO, 5 % S, 4 % Fe)

Topography of Lightning Peak Area:

This area lies in the low Monashee mountains in the heart of the Columbia System. For miles around the country is gently rolling and generally covered with soil, making the prospector's job a difficult one. The development of the Lightning Peak group has been greatly retarded by a heavy overburden of gravel and loam covering all but the two extreme ends where lie the greatest producing mines, the Waterloo and the Lightning Peak camps.

The elevation of these mountains ranges generally around 5000 feet with the country taking on almost the aspect of a plateau region at this point where the eastern mountain systerns blend into the Interior Plateau of B.C. Major river valleys cut in deeply, however, as low as the 1000 foot level and a few summits rise above the general level. Lightning Peak is one of these, having an elevation of 7035 feet.

General Geology of Lightning Peak Area:

The rock formations of this area are of four types: Tertiary basalt, late minor intrusives, batholitic intrusives probably late Jurassic in age and pre-batholitic rocks of early Mesozoic and late Paleozoic age. The earliest formation, consisting of highly metomorphosed sediments and volcanics extends in a belt about a mile long and four miles wide, in a general east to west direction across the area. The intruding batholith is exposed over most of the remaining area and shows three distinct phases: a conspicuous porphyritic granite in the north (probably an extremity of the Nelson complex further east), a grano-diorite complex of a gray to greenish colour in the south-west part of the area and a pink granite exposed in the south-east corner and along the Galloping Mountain road. Among the later minor intrusives, dykes of an acidic nature are predominant and are of three types: pegmatites, granitic porphyries and quartz porphyries, the porphyry dykes being of interest because of their relation to the north to south striking gold-quartz veins. The only remmant of Tertiary basalt in this area occurs as a cap, 200 feet thick on the top of cone-shaped Lightning Peak, believed itself to be of volcanic origin.

Mineralization of the Area:

Mineralization occurred almost entirely within the highly metamorphosed rocks intruded by the batholith, all claims of this area lying along this belt. There are two main types of depostion; an east to west trending system of shear zones and a north to south trending system of low-grade, gold-quartz fissure veins. The shear zones vary from several inches to six feet in width and can be traced for hundreds of feet in many cases. They are partly filled with broken and crushed wall rock partly with vein matter and the whole is cemented with a gangue of quartz (largely calcite in the western limestone areas like Waterloo). As a rule the smaller zones have the grestest concentrations of metals and therefore show the highest values. Waterloo, producing from one of the largest shear zones is not only an exception to this rule but actually the greatest silver producer in the area. At the Waterloo where the rock involved is largely limestone (in comparison to the schists predominant in the eastern part of area), replacement by mineralizing solutions has been a significant factor, elsewhere unimportant. Ore minerals are largely concentrated in shoots up to a foot or two wide and fifty feet or more long, these containing galena, sphalerite, pyrite, chalcopyrite and high grade silver minerals such as ruby silver, argentite, native silver etc.

The north to south striking veins, ignored at first were later found to return fair values in gold and silver, as much as $30 in gold and 250 ounces in silver to the ton. The gold values are beleived related to the pyrite and chalcopyrite content, hence their greater importance in these veins. The plentiful and coarsely crystalline pyrite in them is incontrast to the sparse and finely-divided pyrite of the shear zones. Moreover, the quartz veins tend to carry considerable tetrahedrite in contrast to the conspicuous ruby and native silvers of the shear zones. Actually the two systems yield very similar ore suites but the proportions of the minerals vary widely indicating either different conditons or different periods of deposition. Little is known about the quartz veins except where values increase with depth. The relationship between thetwo systems is rather obscure. Intersections apparently occur only rarely and are hidden from exposure by the oversoil. Indications are, however, that the quartz veins were formed first since at least one example is given of these veins being intercepted and displaced by a major shear zone. The peculiar affinity shown between the quartz veins and porphyry dykes is another point of interest, more easily explained. A great number of the quartz veins are found lying along the flanks of these dykes but the relationship is beleived to be structural, not genetic. Inclusion of porphyry remmants in the quartz veins indicates their later origin and suggests that the veins merely found their easiest mode of intrusion along these weaker planes.

Geology of the Waterloo Mine:

Production comes almost entirely from one of the larger shear zones which is phenomenally persistent and rich in silver, and also carries lesser amounts of gold, This zone averages about four feet in width and contains the Waterloo ore vein which measures about four to eight inches in width and has been known to yield assay values as high as 5000 ounces of silver to the ton from special locations. The rest of the shear zone is low grade yielding only about four ounces silver and about three to four percent of lead and zinc each. The shear zone cuts largely through crystalline limestone this being a distinctive feature of the mine. It is also known, however, to cut through small bands of shaly sediments, and in the lower workings particularly, it encounters remmants, of a highly altered greenish schist, part of a large mass lying further west again. Moreover, contact with the intruding batholith is never very far away. Tongues of granodiorite are found intruding at No. 2. level near the surface with the tunnel cutting through a sectiontwenty-five feet in diameter. Several large acid dykes are known to suffer displacement, usually not greater than 35 feet, along the main shear zone. In the vicinity of the lower workings tongues of granite appear frequently altering the lime to a dark grey colour and a texture approaching almost that of marble in some cases. The granite mass seems to have intruded from the west and shows an east to west strike with a dip of 55° to the north. The main contact, exposed from one to two thousand feet south of the mine workings, is remarkably even and comparatively straight as compared with the irregular contacts underlying the Waterloo property.

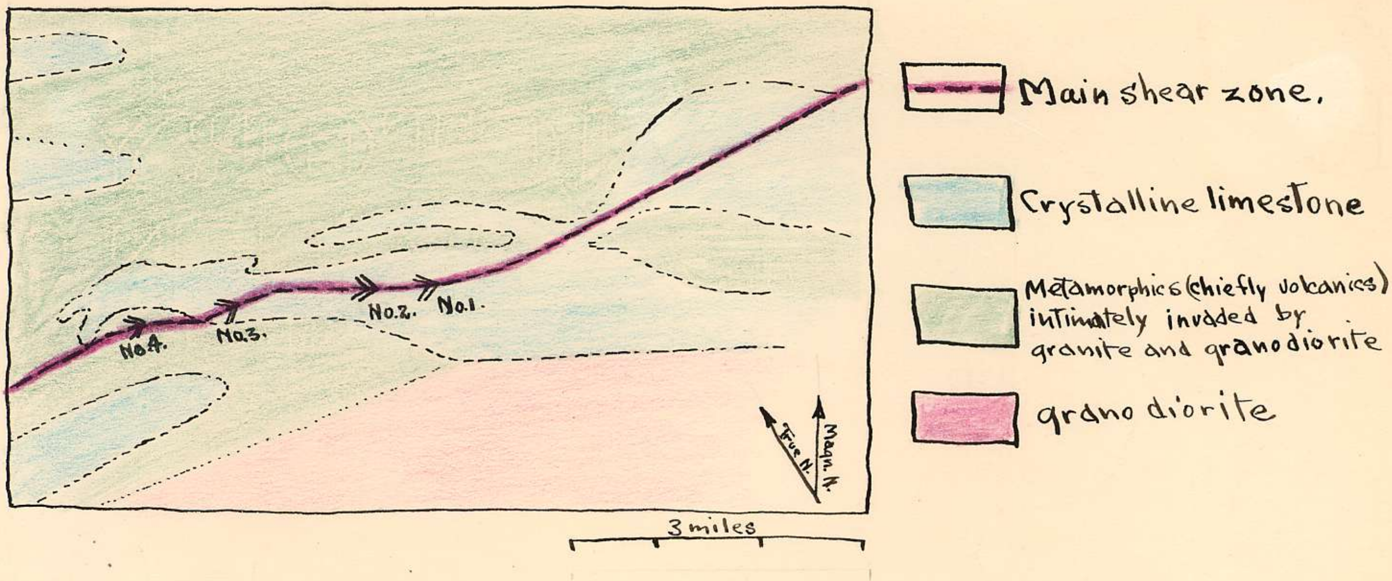
General Layout of the Mine:

The workings include four main adits which occur progressively, following the shear zone, down a west-facing slope inclined at about a 25° angle. There is a distance of four hundred feet and a difference in elevation of somewhat over one hundred feet between the two extreme adits, No. 1. near the t op and No. 4 near the bottom of the slope. The surface of the hill is quite flat-topped, sloping gently upwards from a about twenty feet above No. 1 tunnel. Here the old original open-cut workings occur and the shear has been followed and investigated to a point several hundred feet east of the most easterly tunnel face, this being No. 2. All tunnels have reached a length of from five and a half, to six thousnad feet. Generally speaking it can be said that Nos. 1, 2,and 4 carried the highest grade ores with "Intermediate" and No. 3 tunnels carrying the lowest grades. Accross the ravine at the foot of the slope, the shear zone continues, with still payable though unspectacular values, it is beleived; over a ridge and down another slope to Waterloo creek. This extra two hundred foot drop along the shear zone has never been developed.

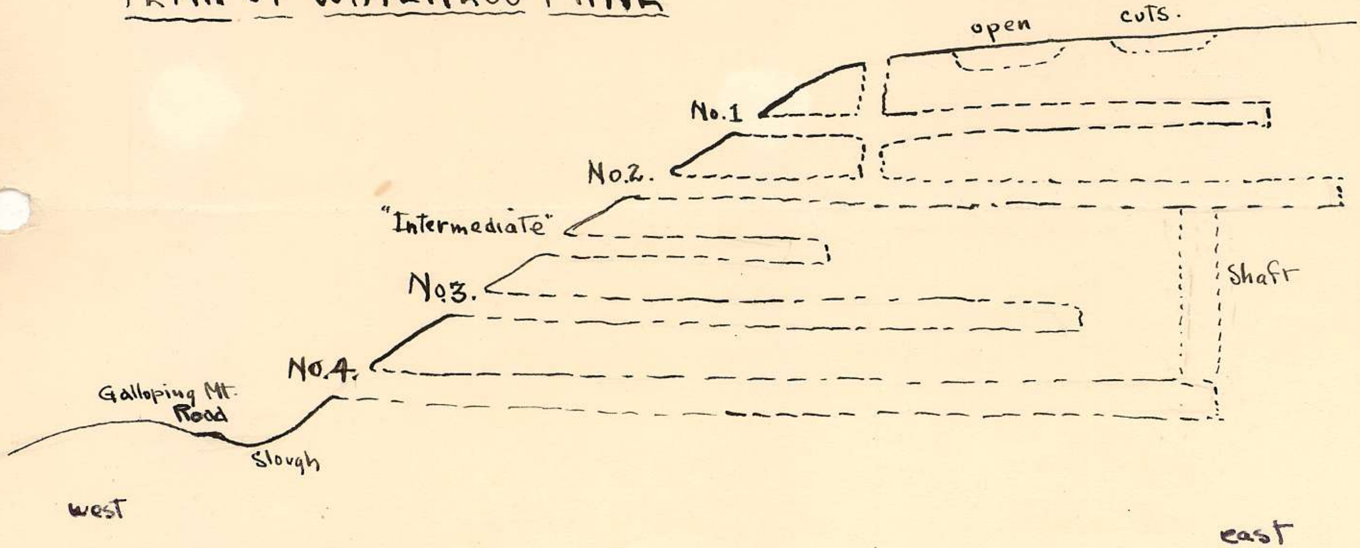
Mineralization of the Mine:

The minerals reported from the Waterloo mone include galena, sphalerite, pyrite and marcasite, chalcopyrite, tetrahedrite, native silver, argentite and several ruby silver minerals. These are beleived to be the antimonial types pyargyrite, polyargyrite and stephanite, although proustite is mentioned in one report strangely enough a two inch junk of native arsenic embedded in coarse calcite is reported

Geology Of Waterloo Mine



Plan Of Waterloo Mine



from an upper level location. No argentite, marcasite, stephanite, polyargyrite or proustite were indentified as such in the ore of the author although argentite was suspedted in several instances.

Surface workings rich in argentite and ruby silver brought phenomenal silver values and an acknowledgeable ammount of gold. The almost equally high grade ores of No. 2 and No. 4 tunnels and the slight falling off at values in between them may be accounted for by the proximity of intrusive tongues at these levels. At No. 2 level the ore occurs in lenticular bodies with a general rake to the east, as well as in shoot-like forms. Smaller segregations of almost pure galena, sphalerite and pyargyrite (see polished section No. 1) and occasionlly native silver occur a few inches apart and about half an inch in diameter. Tetrahedrite first appears at the No. 3 level and is beleived to represent a new level of ore deposition. Since all the polished sections except No.1, already mentioned, reveal varying ammounts of tetrahedrite it is indicated that they ore supplied to author came from the lower and more recent workings of the mine. Since all these are high grade ore samples, excepting No. 6, perhaps, which appears to have originated from a north striking quartz vein anyhow then it would seem likely that some at least came from the rich No. 4 level. Since schists replace the limestone to a considerable extent along the western part of the tunnel and since no schists were observed in the ore by the author, it is further speculated that the eastern and latest workings of this tunnel might be the source of origin. The last recorded activity of the mine seemed to be mention of a shaft being driven up from No. 4 to meet No. 2 tunnel.

Megascopic descriptions of ore::

1st Sample:: consisting of small granular fragments and several larger segregations of almost pure pyargyrite. The latter were nearly an inch long and showed small amounts of associated galena on the surface. Poor cleavage, clear multiple twinning lines and particularly the red streak indicated pyargyrite although the presence of tetrahedrite intimately mixed with the ruby silver was also suspected. It was definitely proven to be pyargyrite by a specific gravity test which gave a reading of 5.82; 5.85 being the correct value for pure pyargyrite and about 4.1 for telrahedrite.

2nd Sample:: consisting of several small pieces of sphalerite ore richly and uniformly mineralized, probably originating from one of the larger veins. Sphalerite accompanied by some galena comprised nearly ninety percent of the ore with small amounts of quartz and soft calcite scattered throughout.

3rd Sample:: consisting of altered limestone impregnated by sulphides comprising thirty to forty percent of the ore. Of these, half at least was sphalerite, galena about five to ten percent, ruby silver about fifteen, chalcopyrite aboutfive and just a trace of pyrite.

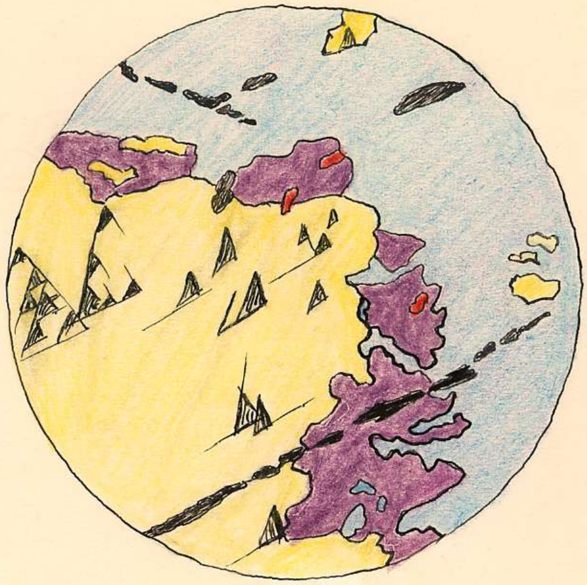
4th Sample:: another impregnated limestone differing from No. 3 in several respects, however, The metallic content scarcely amounted to fifteen percent but was much richer than the other since it consisted almost entirely of ruby silver and another soft creamy-silver coloured ore, probably native silver. Traces of chalcopyrite and bornite occurred along the larger fracture veins with a few small pyrite cubes occurring in limestone near the largest veins. The silver minerals were, of coarse, also concentrated in the small fracture veins but occurred scattered through the limestone in a fine, almost invisible hair-like state. The limestone was altered strongly to a poor grade of marble with much of it a dark gray due to impurities.

5th Sample:: derived from a rich sphalerite vein. The ore consisted of about thirty percent sphalerite, twenty percent pyargyrite, five to fifteen percent galena, small amounts of chalcopyrite, pyrite etc. The calcite gangue amounted to about thirty or forty percent with only a trace of quartz occurring in the ore. The calcite appeared to be of two types:: a pure white, crystalline calcite and a dull compact, impure calcite.

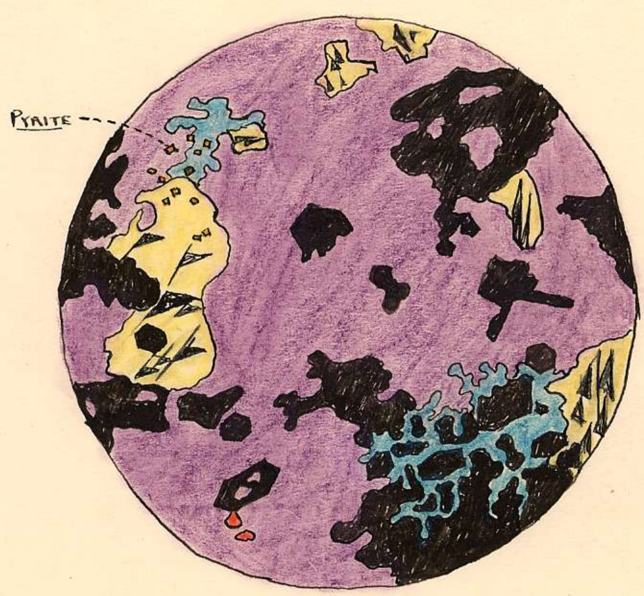
6th Sample: a pyrite-galena ore, consisting nearly half of coarsely crystallized pyrite, this fact alone suggesting that it may have come form the north-to south striking-quartz veins There is actually less than fifteen percent quartz present and more than this amount of calcite but this condition might still occur in these veins in such a lime-rich area. There is about twenty percent galena present, only about five percent sphalerite and a trace of chalcopyrite. This ore shows no definite boundaries or vein walls but appears to be ~~arranged ore~~ derived from a large loosely-arranged ore body.

Polished Sections of Waterloo Silver Ore

No. 1.



No. 2.



Key

- Galena
- Chalcopyrite
- Pyrite
- ~~Tetrahedrite (mixed with Ruby Silver)~~
- Sphalerite
- ~~Bornite~~
- Ruby Silver (Pyargyrite)
- Gangue (Quartz)

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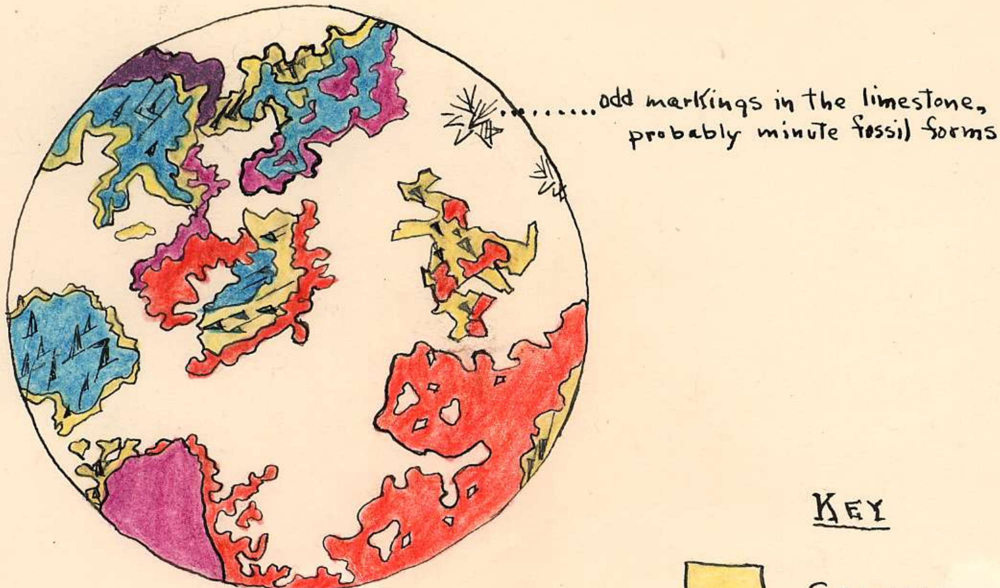
Polished Sections of Waterloo Silver Ore.

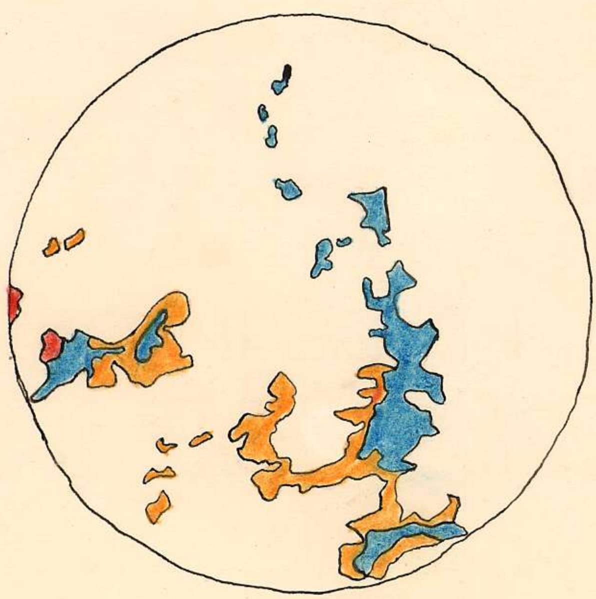
No. 3.



Key

- Galena
- Chalcopyrite
- Tetrahedrite
- Sphalerite
- Ruby Silver
- Native Silver
- Gangue (Calcite)

No. 4.



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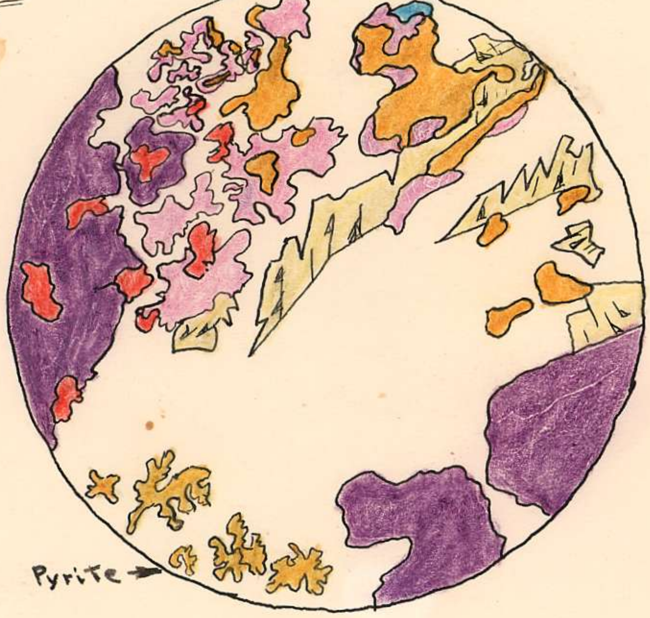
POLISHED SECTIONS OF WATERLOO SILVER ORE.

No. 5.



KEY

- NATIVE SILVER
- RUBY SILVER.
- TETRAHEDRITE
- GALENA
- SPHALERITE
- CHALCOPYRITE.
- PYRITE
- QUARTZ
- CALCITE

No. 6.

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* *

Insertion: at end of Micrographic Description, Section 1.

Identity of the so-called sphalerite was later found to be doubtful since no internal reflections could be obtained under the arc light.

The points in favour of, and against Sphalerite and other suspected minerals are as follows:

Sphalerite:

- microchemical (Zn test), etching (all negative), hardness, associations etc all good.
- colour too bronzy and metallic, no internal reflections of yellow and brown.

Pyrrhotite:

- colour, hardness, etching (all neg.) all good.
- Zn, not Fe, obtained in microchemical; improbable association (not recorded at the Waterloo either)

Argentite: very unlikely unless occurring in a mixture.

- association is really only good point.
- etching wrong, too hard, colour too bronzy.

~~body~~.

Note: all values given in this section are merely estimations on the part of the author since no actual assays of the ore could be made.

Microscopic descriptions and parageneses:

Section I.

Sphalerite was discovered under the microscope occurring sporadically along the galena-ruby silver contacts. It was derermined by a positive microchemical test for zinc, by a negative reaction to all the etching reagents, and by its comparative hardness and colour, the latter being rather deceptive since the dull gray takes on a bronzy hue beside the blueish gray of the ruby silver.* A good antimony and a fair silver microchemical test was obtained for the pyargyrite and the internal reflections of red were visible even without the arc light.

The sphalerite appeared to be more closely associated with the ruby silver than with the galena, since small amounts occur through the pyargyrite but not through the galena. Actually however, most of the sphalerite occurs along the galena contact and the two are shown to be contemporaneous by small segregations of chalcopyrite deposited at the same time, in both these sulphides. There is no chalcopyrite in the ruby silver which occurred later in origin from warm ascending solutions. The quartz is later still, probably of secondary origin from supergene solution coming in along slight fracture lines.

Section II.

In this section the filagree-like impregnations of ruby silver were the only source of difficulty. They were identified easily by observing the red streak and internal refection under the arc light.

The pyrite apparently crystallezed out of solution early and in a finely-divided state. The quartz, sphalerite, galena and chalcopyrite were deposited later from hydrothermal solutions and were practically contemporaneous with each other. The quartz crystals, surrounded by sphalerite, show corroded surfaces and are also observed with inclusions of this same mineral; these conditions indicating the simultaneous deposition of these minerals. The galena appears to be a trifle later in origin and the pyargyrite again comes in much later from warm hypogene solutions.

Section III

Tetrahedrite was observed the first time in this section. It resembled sphalerite and has a similar mottled surface and negative etch reactions but is a lighter gray in colour and has a metallic-coloured streak. It is also harder than stibnite which it ressembles in colour. Impregnation and replacement of the limestone reached an advanced stage in this ore, Assimilation of the limestone was observed in the enclosure of small calcite rhombs in the intruding chalcopyrite. The chalcopyrite, galena, sphalerite and tetrahedrite were all deposited simultaneously from hot hydrothermal solution.

The invaded limestone suffered considerable alteration and re-crystallization at this time. The galena and chalcopyrite were distinctly contemporaneous, in this case, with the sphalerite slightly earlier and the tetrahedrite slightly later. The ruby silver was again late in origin, replacing galena for the most part, also replacing some tetrahedrite and small amounts of the other sulphides. It appeared to be almost secondary in nature although no native silver was observed in the ore sample. Fine markings seen in the limestone were believed inherent in nature probably originating from minute calcareous fossil forms.

Section IV

Native silver was identified for the first time in this section, its softness, sectility and positive microchemical test for silver being distinguishing features. Its colour is important, of course, distinguishing it from argentite, but is somewhat deceptive being a creamy yellow beside the bluish-gray pyargyrite.

Apparently this sample of altered limestone was practically untouched by hydrothermal action since only a trace of chalcopyrite occurred to represent this stage. Intrusion was not as great as in the third Sample, although metamorphism of the limestone was probably greater. The intrusive solutions were warm and late in origin depositing almost pure pyargyrite. Some native silver may have been deposited at this time as a primary mineral but most of it probably originated later, as a secondary mineral, from the oxidation of the ruby silver.

Section V.

The sphalerite, galena, tetrahedrite and chalcopyrite again occurred contemporaneously in this section. Moreover the calcite the calcite appeared to have been deposited from solution as gangue at this same time. A little pyargyrite was deposited later from the cooling solutions. The pyrite and the native silver are a little more difficult to place but are late and probably secondary, in origin, perhaps depositing from cold, iron and silver bearing, supergene solutions.* The pyrite occurred spreading through the calcite in fine, dendritic patterns. The silver occurred largely replacing tetrahedrite and some galena, this ~~indict~~ indicating a possible derivation from, at any rate, an a association with the silver content carried by these minerals However since segregations of silver occur free in the calcite it can only be explained as a secondary deposit from supergene solutions unless the possibility of it occurring as an original primary constitnent of the ore nagma is considered.

Section VI

In this section early quartz and pyrite crystallized out simultaneously in a coarse, interlocking state: this in itself being an indication of relatively poor silver values to come. Although considerable galena and tetrahedrite were produced

* correction: pyrite deposited from late hypogene solution, not from supergene solution.

by later hydrothermal action none of the richer late-forming silver minerals occurred. A little chalcopyrite was deposited contemporaneously with the others namely galena sphalerite and tetrahedrite. Of these tetrahedrite was probably the last to come down and characteristically form a coating around the chalcopyrite.

General paragenesis:

The minerals identified by the author were:

Galena

Sphalerite

Tetrahedrite

Pyrite

Chalcopyrite

Native Silver (Pyargyrite)

Quartz

Calcite

The stages of deposition represented by these minerals are:

I. Primary deposition from hypogene solution:

A. Early hydrothermal action, depositing

1. early quartz.

2. early pyrite.

B. Middle hydrothermal action, depositing

3. calcite (?)

4. sphalerite

5. galena

6. chalcopyrite

7. tetrahedrite

C. Late hydrothermal action, depositing.

8. ruby silver

9. late pyrite

II <u>Secondary deposition, from supergene solution.</u>

10. late quartz

11. native silver

12. bornite.

<u>Conclusions:</u>

Because of its phenomenally rich silver ores, the Waterloo was considered "an attractive property" for many years, in spite of the heavy losses caused by its iin accessibility. Closing down of operations within recent years in probably due to a number of reasons; perhaps to temparary exhaustion of high-grade ore and lack of funds to open up new workings, persisting transportation difficulties gerneral hard times etc. It is more than likely, however, that high-grade ores have become permanently exhausted, since the reserves of ore known to exist further west are beleived to be of a poorer grade. With war-time demand for base-metals again arising however, these ores may become once more payable and cause renewed activity at the mine. Unfortunately lead assays run much higher in the ores from eastern members of the Lightning Peak group.

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