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THE MINERALOGY OF THE ST. PAUL CLAIMS,

OSOYOOS DISTRICT, B.C.

ACKNOWLEDGEMENTS

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THE ST. PAUL GROUP.(1)

The St. Paul group of claims is on Monashee Mountain (5800 feet), Vernon mining division, Osoyoos district, B.C. It is accessible from the Vernon-Edgewood highway. A branch road, one mile long, leaves the highway 42 miles east of Vernon. It is another 2½ miles by trail to the lower claims on which is located an old camp and 2-stamp mill belonging to the company. It is a short, steep climb from here to the St. Paul mine workings on Toughnut claim.

The St. Paul has had a varied career over 40 years prior to 1930 with alternating periods of development and idleness. Several hundred tons of ore have been shipped to Trail smelter. In 1927, 11 tons of ore from the Toughnut claim were shipped and ran: gold, 0.50 ounce; silver, 147.9 ounces; lead, 12.4%; zinc, 1.2%; antimony, 17%; sulphur, 17.4%; silica, 25.4%; iron, 13.2%; lime, 0.7%, and had a gross value of $1,074.64. Development work consists (1930) of adits up to 300 feet long, a couple of winzes and some open cuts.

GENERAL GEOLOGY.

The rocks in the vicinity are largely greenish volcanics (andesitic) and intercalated sediments (argillaceous and limestone types). The mine workings have exposed an intrus-

(1) St. Paul Group of Mineral Claims, Osoyoos District, B.C., by C.E. Cairnes, G.S.C. Summ. Rep. 1930, Part A.

ive body of diorite (medium-grained, nearly equigranular dark grey rock, carrying disseminated pyrite). The mineralization of the mine is related to this intrusive.

MINERALOGY.

To give a picture of the vein mineralization, the following is extracted from Cairnes' report:

"The gangue of the veins in most of the showings at the St. Paul mine is largely quartz. With it is associated a varying proportion of sulphide minerals occuring as disseminations or as streaks, bunches, or small kidneys of nearly solid mineral. The sulphides are principally arsenopyrite, antimonial sulphides, pyrite, and pyrrhotite in about this order of abundance. Very small amounts of galena, sphalerite, and copper pyrites are present and native silver occurs in microscopic specks. The sulphides of the creek showing are chiefly arsenopyrite and pyrite and the proportion of quartz is smaller than elsewhere. Samples from all the various vein exposures are reported to have carried $2 to $10 in gold a ton. No free gold has been observed. Silver values vary with the amount of antimonial sulphides present. At least three such sulphides are present. The most abundant of these carries lead and resembles jamesonite in its physical and microchemical properties. Intimately intergrown with it is another with very similar properties and which, probably, is stibnite. The third is tetrahedrite (grey copper) and occurs in very minor amounts and mostly in microscopic particles. The sulph-antimonides occur in various ways : as streaks or irregularly lying bands in the quartz and varying from less than an inch to several inches in thickness; as bunches or small kidneys lying either in quartz or in masses of other sulphides; intimately associated with other minerals, chiefly arsenopyrite; and as crystals disseminated through the quartz. They occur massive or finely granular or in masses with a coarsely fibrous and bladed structure.

"Arsenopyrite is abundant. It occurs in small, well-formed crystals scattered through the quartz and in crystalline masses or aggregates intimately associated with the other sulphides. Pyrite is much less plentiful. A little pyrrhotite is also present. Galena and sphalerite are even less conspicuous. The gold values appear to be associated with the arsenical and iron sulphides or at any rate seem to be quite independent of the amount of antimony sulphides present."

The following table by Cairnes is reproduced to give an idea of the mineral proportions of the high-grade ore. The calculations are based on the analysis of the 11 tons of ore shipped to Trail in 1927.

	Per cent
Arsenopyrite..........................	28.2
Pyrite (and pyrrhotite).............	6.9
Jamesonite............................	26.7
Stibnite..............................	11.4
Quartz................................	25.4
Other minerals........................	1.4
	100.0

A 1945 paper by Dr. H.V. Warren and R.M. Thompson (2) verifies Dr. Cairnes' identification of jamesonite in this ore. The methods used were X-ray powder photography, spectrographic analysis and chemical analysis.

The specimens used in the work of the present writer were collected at the mine by Dr. Warren. They were selected for their high jamesonite content and therefore are not truly representative of the ore throughout the mine.

Five polished sections were prepared and examined in detail. Several others were prepared but revealed nothing new and were therefore not studied further. Sec. No. 3 is 94% arsenopyrite; No. 4 is 90% jamesonite-plagionite (?)-tetrahedrite; No. 5 is 84% quartz, veined by sulphides and Nos. 1 and 2 have more equally distributed mineralization and were not found so interesting for the study of age relations.

The minerals noted in this work are as follows: jamesonite, arsenopyrite, quartz, pyrite, carbonate, an unknown, tentatively identified as plagionite, tetrahedrite, chalcopyrite and pyrrhotite. The most plentiful minerals are plac-

(2) Mineralogical Notes, University of Toronto Studies, Geological Series, No. 49, page 82, 1945.

ed first on the list.

Jamesonite:

In hand specimens, jamesonite, if not contaminated with other minerals, shows its characteristic long prismatic, fibrous habit and the perfect, basal, cross-cleavage. In the polished section, the cleavage was not observed. In appearance and color, jamesonite is similar to galena but the triangular cleavage-pits of galena are lacking. It has strong anisotropism; its polarization colors are blue, brown and grey. KOH tarnishes a blue-purple iridescent color. Microchemistry shows Cu, Fe and Sb. Plate 3 illustrates its appearance under microscope.

Arsenopyrite:

In hand specimens, arsenopyrite is fine-grained and dense. In a polished section it is disseminated in small amounts through all the sections observed as well-formed small, idiomorphic grains (Plates 2 and 5) but in some places it is concentrated and makes up over 90% of the mineral present. In the section with high arsenopyrite content, the arsenopyrite is fractured and brecciated to a high degree, the cracks running across grains as well as separating the grains (Plate 1). In this section, jamesonite (with associated plagionite (?) and quartz fill the fissures in the arsenopyrite.

Quartz:

The quartz is dense, white and glassy. Like arsenopyrite, it is found disseminated in all sections and also occurs in larger, glassy bodies separated from other minerals, though usually containing isolated, idiomorphic, small grains of arsenopyrite and pyrite. Very irregular, rounded particles of jamesonite are seen similarly scattered in the glassy quartz, and are suggestive of replacement. (Plate 2).

Pyrite:

Pyrite is in much smaller quantity than arsenopyrite but seems to be associated with it inasmuch as the larger amounts of pyrite are found in the presence of arsenopyrite. The pyrite grains are well developed, showing cubes and triangular and diamond-shaped grains. (Plate 2).

Carbonate:

This mineral is seen in hand specimens as a coating on the surface and less frequently as veinlets cutting the sulphides. Imperfect rhombohedral cleavage can be seen and the mineral effervesces strongly with cold HCl. The color is white.

Plagionite (?):

An unknown mineral which is intimately intergrown with jamesonite and thought by Cairnes to be stibnite, has been tentatively identified as plagionite (Pb Sb S). KOH tarnishes a brownish-grey in contrast to the iridescent tarnish assumed by the jamesonite surrounding each grain. Microchemical analysis gave Pb and Sb but no Fe or Cu. It has much the same anisotropism as jamesonite, giving blue, brown and grey polarization colors. Although difficult to distinguish from jamesonite in polished section it is slightly lighter in color and a little softer. A powder has been sent away for an X-ray powder photograph to confirm this identification.

Tetrahedrite and Chalcopyrite:

Tetrahedrite occurs in very small amounts as small, irregularly rounded grains in the jamesonite and intimately associated with it as was plagionite (?). It is a grey color, slightly darker than jamesonite and occurs most commonly in the neighbourhood of arsenopyrite grains. Small chalcopyrite blebs from ex-solution are nearly always seen in the tetrahedrite. Other chalcopyrite (very small grains) is frequently seen just outside the tetrahedrite in the jamesonite and, no doubt, is related to the tetrahedrite. (Plate 3).

Pyrrhotite:

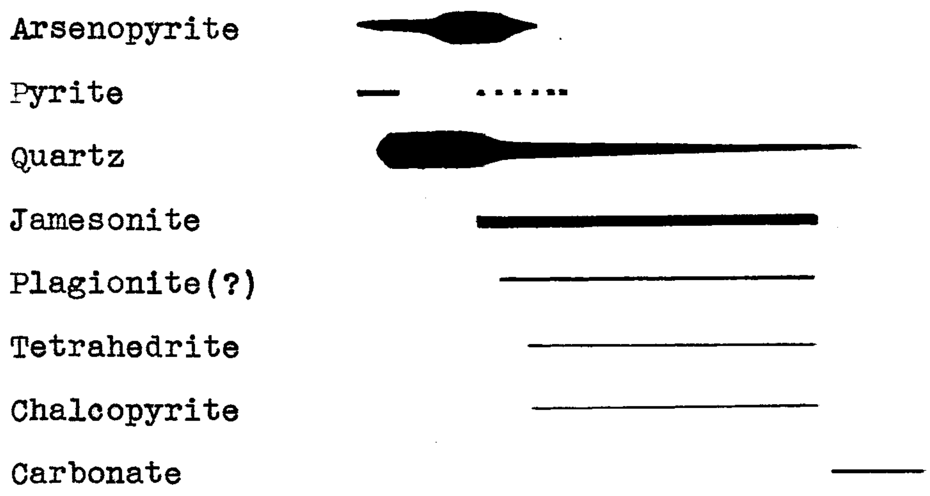
Only 2 small grains of pyrrhotite were found. These were on a contact between tetrahedrite and jamesonite. (Plate 3).

The other minerals mentioned by Cairnes (i.e. galena, sphalerite, native silver) were not found.

Tabulation of Etch Tests

Mineral	HNO_3	HCl	KCN	$FeCl_3$	KOH	$HgCl_2$
Jamesonite	Tarnished dark brownish-grey with effervescence	Neg.	Neg	Neg	Tarnished iridescent	Neg
Plagionite(?)	Tarnished dark brown with effervescence	Neg.	Neg	Neg	Tarnished brownish-grey	Neg
Tetrahedrite	Neg.	Neg.	Neg	Neg	Neg	Neg

PARAGENESIS OF VEIN MINERALS.



Arsenopyrite is considered early because in Sec. 3, arsenopyrite, forming 94% of the secion, is replaced by jamesonite and has fractures filled by jamesonite and quartz. (Figure 1). This deduction is supported by geochemical evidence that arsenopyrite is a high temperature mineral in comparison with the other minerals present.

The deposition of pyrite overlaps that of arsenopyrite (partly simultaneous and partly later). This conclusion is drawn because of the lack of any evidence to show conclusively that pyrite is earlier or later than arsenopyrite. Since most of the pyrite is found in the vicinity of arsenopyrite grains of similar size and with a similar degree of characteristic grain-shape development, it seems to be associated with arsenopyrite and may be assumed largely contemporaneous. This close age association of arsenopyrite and pyrite is commonly found in other typical ores.

Quartz appears to have a long drawn-out period of deposition or else has come out of solution in several different stages. It clearly antedates arsenopyrite and pyrite in Sec. 5, in which these minerals veined the quartz (Plate 2 illustrates this). But in Plate 1, quartz has filled fractures and cavities in arsenopyrite and in this section is younger than arsenopyrite. It was decided that the quartz had come down in successive periods of deposition or in one prolonged period rather than that the arsenopyrite and pyrite had done so because it appears in the literature (3) that this is a common behavior for quartz and not so much for arsenopyrite.

It was decided that jamesonite overlaps arsenopyrite and pyrite to some extent to explain the inclusions of jamesonite commonly seen in arsenopyrite and pyrite. These inclusions may be replacement bodies of jamesonite but owing to the general weakness of evidence proving that jamesonite replaces arsenopyrite and pyrite, it is a good plan to consider that some jamesonite came down before all the arsenopyrite and pyrite had precipitated and was thereby enclosed in these two minerals. For the most part, jamesonite is later than pyrite, arsenopyrite and the majority of the quartz as shown by the fracture filling and replacement in Plates 1, 2 and 4.

Plagionite(?), tetrahedrite and chalcopyrite entirely overlap each other and the jamesonite as there is complete lack of any evidence of age disparity between these minerals. In the polished section which consists of 90% jamesonite, plagionite(?) and tetrahedrite, these minerals are very in-

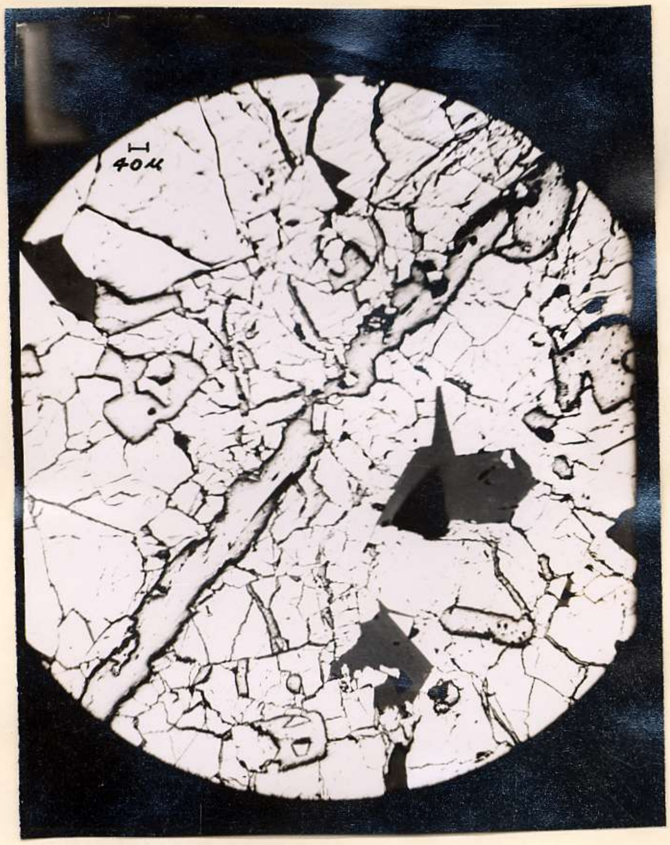
(3) Criteria of Age Relations, Ec. Geology, Vol. 26, no. 6.

timately related and intergrown. They might be considered to have "mutual boundaries". There is nothing to show that any one of them is of a different age - there is no fracture filling and no replacement. As they all have similar chemical constituents, an assumption of their contemporaneity is logical. The chalcopyrite is in the tetrahedrite as ex-solution blebs and also occurs in the jamesonite, closely associated with the tetrahedrite grains. Therefore, it is of the same age as jamesonite.

The presence of arsenopyrite, pyrite and quartz grains in the jamesonite section indicate that some deposition of these minerals was still going on at the time the jamesonite group was crystallizing.

The carbonate was seen in hand specimen veining the sulphides and in polished section at a contact between quartz and sulphides. Therefore it was the last mineral to be deposited.

The paragenesis may be summarized as follows: (1) Arsenopyrite and pyrite are early in the crystallization schedule, (2) quartz is continuous but is concentrated at the beginning, (3) the remaining minerals with the exception of the carbonate form a group, the minerals of which were deposited together in the last stage of crystallization. The above minerals, judging from their composition and a lack of evidence to the contrary in this ore, are primary in origin and of medium temperature. The carbonate may be a Pb carbonate and, if so, may be a secondary mineral formed by oxidation of jamesonite. It did not appear to be related to jamesonite in such a way as to indicate replacement of jamesonite. Therefore, if it is secondary , it was deposited from solution as a fracture filling, with no obvious reaction of the descending solution.with jamesonite. The carbonate may however be a primary mineral, the last one to be deposited by the ascending solutions.



Sec. No. 3

H=11.8, V=55.9

X 60

Plate 1

Background mineral (white) is arsenopyrite, highly fractured and brecciated. Quartz (dark grey or black) fills large angular cavities in arsenopyrite and also fills some of the small fissures. Jamesonite (grey) fills the majority of the small fractures and some of the large cavities. There is some evidence of jamesonite replacing arsenopyrite in the rounded or "bitten-into" appearance of the arsenopyrite host at the contacts with jamesonite. Many of the smaller filled fractures show good matching of their sides.

In the upper left-hand quadrant, quartz and arsenopyrite are jointly occupying a large cavity in the arsenopyrite. This is a common feature of this section. It suggests partial replacement of quartz by the jamesonite.

Sec. No. 5

H=7.0, V=49.2

X 55

Plate 2

Background mineral is quartz (dark grey) with arsenopyrite (A) and pyrite (Py). The arsenopyrite and pyrite were probably deposited from solution at the same time as the surrounding quartz.

Jamesonite (J) occurs along contact of two different grains of quartz and along contact between different kinds of minerals. Its appearance and that of the host mineral suggest that replacement of quartz, arsenopyrite and pyrite was a factor in the formation of these jamesonite grains.

There is a small grain of arsenopyrite included in the large pyrite grain near the bottom of the photograph.

Sec. No. 4

H=26.9, V=52.1

X 61

Plate 3

Tetrahedrite in jamesonite background. The white crescent at the top is unetched jamesonite, the black portion of the photograph is jamesonite etched with KOH. The white body in the center is the tetrahedrite, unaffected by the KOH. The other small white grains are arsenopyrite.

The black grains in the tetrahedrite are ex-solved chalcopyrite blebs; there are also some larger chalcopyrite grains, not clear in the photograph, between the tetrahedrite and jamesonite.

The only occurrence of pyrrhotite noticed in this work is visible as two whiter grains just outside the tetrahedrite at the bottom.

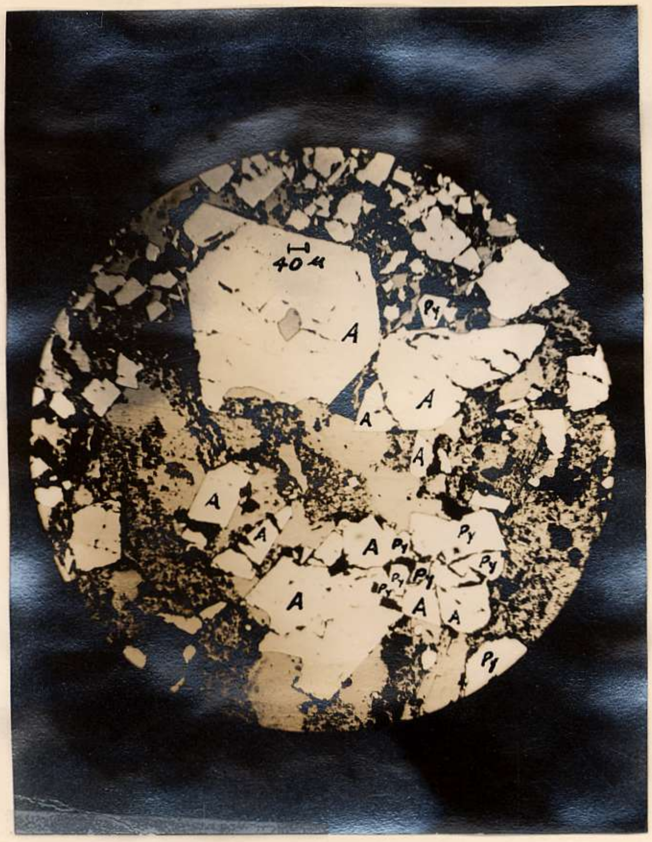
Sec. No. 5

H=22.0, V=49.3

X 55

Plate 4

A fractured and corroded grain of arsenopyrite (white) in a sea of quartz (black). The fractures in the arsenopyrite are filled largely by jamesonite but quartz fills the larger fractures. The rounded grains inside the arsenopyrite are jamesonite (grey). They suggest replacement of the arsenopyrite by jamesonite. The white grains scattered in the quartz are arsenopyrite and pyrite. There are 3 small inclusions of pyrite in arsenopyrite indicated by arrows.



Sec. No. 1

H=10.8, V=53.1

X 50

Plate 5

Arsenopyrite and pyrite grains in matrix of jamesonite (grey). The jamesonite "bites-into" the arsenopyrite in places but this alone is not decisive evidence of replacement. In this particular section, arsenopyrite, pyrite and jamesonite were probably deposited from solution at the same time. The triangular inclusion of jamesonite in the large arsenopyrite grain may be due to crystallization of arsenopyrite around a previously formed grain of jamesonite.

The black portion of the photograph is not quartz, but is rough-surfaced jamesonite.

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(3) Criteria of Age Relations, Economic Geology, Vol. 26, No. 6, by

(4) Microscopic Determination of the Ore Minerals, by M.N. Short. U.S. Geological Survey Bulletin 914.