COBALT AT THE NICKEL PLATE MINE

by

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T A B L E   O F   C O N T E N T S

LABORATORY EXAMINATION OF THE ORE

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Introduction and acknowledgment.

In 1910, Camsell (1) mentions the presence of cobalt in the ore at Hedley. In 1936, Warren and Cummings (4) published a report on the, "Mineralogy at Nickel Plate Mine", which said in part:

> "Under magnifications of 900 diameters, what are thought to be specks of this mineral, cobaltite, were seen in one place enclosing "islands" of pyrrhotite, but usually as tiny inclusions in and completely surrounded by arsenopyrite. A microchemical test betrayed the presence of cobalt and its etch reactions and physical properties are indicative of cobaltite."

This report dealt mainly with the distribution and mode of occurrence of the gold in the ore and further confirmation of the presence of cobaltite was not undertaken.

Since 1936 and under the stress of war, cobalt has become a strategic mineral. As a result of this, work was undertaken to establish the size, distribution and association of the cobalt mineral, or minerals, in the ore, which would be of practical assistance in mining and milling.

Four students, including the author, under the direction of Dr. H. V. Warren, undertook this work in the Spring of 1942. This report deals with the findings of the author with regard to the aforementioned problems.

Acknowledgment must be made to Dr. Warren, of the Department of Geology, for his enthusiastic encouragement and suggestions, and also to C. Ney and R. Thompson for advice and assistance.

Location:

The Hedley district, which is 210 miles due east of Vancouver, is situated on the Okanagan Range of southern British Columbia. The Nickel Plate mine is on Nickel Plate mountain, which is near the town of Hedley.

Hedley, on a spur of the Great Northern Railway, is situated between Keremeos 17 miles to the southeast, and Princeton 25 miles to the northwest. From the east, the locality may be reached by the Nickel Plate road which joins the Keremeos-Penticton highway. The mine is 13 miles from the road junction and 32 miles from Penticton (2).

Previous Work & History:

For detailed work on the history, development, mineralogy and geology, the reader is referred to the bibliography on page 11.

The first claims on Nickel Plate Mountain were recorded in 1894 but it was not until 1898 that ore of commercial promise was discovered. Active production started in 1904 and early in 1931 the Hedley Gold Mining Company, who were the operators at that time, were forced to end operations due to lack of ore. Exploration was carried on throughout 1933 and 1934 by the Kelowna Exploration Company and in the fall of 1934 the Nickel Plate Mine was reopened. The following table was taken from the, "Financial Post, Survey of Mines," 1941-42, and gives the reader some idea of production and recovery between 1898 and 1940.

Year	Tons	Aver. Recovery $	Total Recovery $
1898-1930	....	....	10,000,000
1935	54,032	9.14	493,990
1936	64,854	12.20	791,000
1937	77,887	13.48	1,050,000
1938	88,636	12.25	1,085,521
1939	90,204	12.65	1,141,153
1940	82,660	12.73	1,052,576

General Geology:

According to Bostock, the Hedley district lies in an area of westward dipping Triassic sedimentary rocks, which have been intruded and almost surrounded by large bodies of igneous rocks of later Mesozoic and early Tertiary age.

The igneous intrusives of this district all have a bearing on the geology of Nickel Plate mountain. They include batholiths, stocks, apophyses and sheets, and all are intrusive into the Triassic sediments after deposition had ceased. The intrusives are subdivided by Bostock as follows:

1. Gabbro-complex-sills, dykes, apophyses.
2. Granodiorite-Batholith at base of Nickel Plate Mt.
3. Granite-Batholith-contact 1½ miles north of Nickel Plate mine.

Of the phases of the diorite-gabbro complex, the later gabbro phases appear to have had the greatest mineralization associated with it. The ore deposits occur in the intruded sedimentary rocks close to the contact of the gabbro intrusive and particularly where an abundance of apophyses occur. They are found to favour beds of certain composition, particularly impure limestones. The ore deposits occur within areas in which metamorphic silicates have been developed.

In greater detail the location of the Nickel Plate ore- bodies appear to be due to permeability produced in the strata by a small fold and intrusion of sill apophyses. The mineralizing solutions seem to be independent of these sills except to their influence in guiding and localizing the mineralizing agents to favourable zones for deposition.

LABORATORY EXAMINATION OF THE ORE

Introduction:

A cross section of the Nickel Plate ore body is shown in fig.1. The main ore bodies are called, upper purple, lower purple, red, orange and yellow. Samples were taken from upper, middle and lower sections of each of these ore bodies and the author studied the samples of the red and orange ore bodies.

Mineralogy:

The following minerals have been determined by the author.

Gold	Calcite
Arsenopyrite	Silicates
Pyrite	
Chalcopyrite	
Pyrrhotite	
Sphalerite	
Loellingite-Safflorite	
Cobaltite?	

Table I shows the relative abundance of the metallic minerals in the polished sections of the two ore bodies studied by the author.

Table I.

Sample.	Assay.								
	Gold	Cobalt	Arsenopyrite	Pyrite	Pyrrhotite	Chalcopyrite	Sphalerite	Lollingite Safflorite	Cobalt-ite
Upper Red	2.00	0.38%	90%	--	trace	--	--	10%	?
Middle Red	0.60	0.14	60	5	15%	5	15%	trace	-
Lower Red	0.27	0.19	90	--	trace	trace	5	trace	-
Upper Orange	2.70	0.19	99	--	trace	--	trace	trace	-
Middle Orange	0.76	0.33	96	--	trace	--	--	4	-
Lower Orange	0.04	0.22	95	--	1	--	4	trace	-

TABLE SHOWS RELATION BETWEEN METALLIC MINERALS IN RED AND ORANGE ORE BODIES

Summary and Conclusions:

Cobaltite is known to exist in the Nickel Plate ore but its presence was not established, with possible exception of the upper-red section, in the suite studied by the author.

Lollingite-Safflorite is known to be present in the ore. The crystals of this mineral vary in size from about 5 microns to .2 millimeters and appear in greatest abundance in the upper-red and middle-orange sections. In all cases noted the cobalt minerals seem to be connected with and concentrated in and around arsenopyrite.

The following table, given by Dr. Warren, gives analyses for cobalt, arsenic, iron and sulphur.

ASSAY LOCATION	COBALT	ARSENIC	IRON	SULPHUR	AS/S Ratio
Top Red 25.	0.38%	8.3%	7.7%	3.6%	3.20
Middle Red49.	0.14	12.7	20.0	10.7	1.19
Bottom Red89.	0.19	15.5	13.0	6.0	2.58
Top Orange 51.	0.19	22.6	15.4	7.5	3.02
Mid.Orange 11.6.	0.33	8.5	10.9	3.1	3.77
Bot.Orange 15.3.	0.22	13.1	11.1	5.8	2.26

Arsenopyrite with composition FeAsS, (As-46%, S-19.7, Fe-34.3%) has an arsenic: sulphur ratio of 2.33. It is noted that in the above table arsenic: sulphur ratios are in places above 2.33. The extra arsenic may therefore be Lollingite (FeAs) and Safflorite ($CaAs_2$). On this basis the analyses above and the estimates based on experimental data, (Table I, p.5) check roughly. It is also interesting to note that microchemical tests given in Table III give distinct cobalt reactions for the top red and middle orange which correspond to the cobalt assay above.

Examination for Cobalt Minerals:

The most abundant metallic mineral is arsenopyrite, (see table I.) The problem appeared to be the separation of arsenopyrite from a group of minerals which are also hard and white. Table II gives a series of etch tests for microscopic examination of minerals of this group.

Table II #

Mineral	Comp.	Conc. HNO_3	Dil. HNO_3	Pot. Perm.	$FeCl_3$ Sat.	A.R. FeAsS.	A.R. (CoNi)AsS.
Arsenopyrite	FeAsS	+	+	-	-	-	-
Chloanthite	$NiAs_2$	+	+	-	+	+	+
Cobaltite	CoAsS	-	-	-	-	-	-
Gersdorffite	NiAsS	+	+	+	-	-	-
Loellingite	$FeAs_2$	+	+	-	+	-	-
Rammelsbergite	$NiAs_2$	+	+	-	+	+	-
Safflorite	$CoAs_2$	+	+	-	-	-	+
Skutterudite	$CoAs_3$	+	-	-	-	-	-
Smaltite	$CoAs_2$	+	+	-	-	-	+

Cobaltite:

Cobaltite was shown to be in the Nickel Plate ore by A. Allen in 1941. For this reason it was the first cobalt mineral tested for by the author.

From table II it is seen that cobaltite is negative to all tests, Arsenopyrite is only positive to nitric acid. Consequently, by applying nitric acid (conc.) to an arsenopyrite crystal the part or parts that did not etch would presumably be cobaltite.

#Thompson, Ellis, "A Qualitative and Quantitative Determination of the Ores of Cobalt, Ontario." Economic Geology, Vol. 25, No.5, August, 1930.

Some twenty tests of this type were tried and no cobaltite was found in any of the sections.

For these tests the usual minute for etching was found to be too long. The acid ate too deeply into the arsenopyrite causing a thick precipitate to form on the surface of the section, which, it was thought, would mask any small unetched crystals of cobaltite. Ten to fifteen seconds were found to be ample time for etching the arsenopyrite.

With magnification of over 1000 diameters, one small (app. 7 microns) crystal, with the characteristic outline of cobaltite, was found in the upper-red section completely surrounded by arsenopyrite. It was then thought that cobaltite may exist in small crystals disseminated in the arsenopyrite but too small to see by the etching described above and under magnification of 250 diameters.

A series of microchemical tests were made on the arsenopyrite crystals with results given in table III. These tests confirmed the presence of cobalt in the arsenopyrite and suggested either that cobaltite was disseminated in small crystals through the arsenopyrite (especially upper-red and middle-orange sections) or the presence of another cobalt mineral.

TABLE III #

MICROCHEMICAL TESTS

Section	Test	Results
Upper Red	1	Abundant cobalt crystals
	2	"
	3	"
	4	"
Middle Red	1	Trace
	2	Small amount
	3	Trace
Bottom Red	1	Trace - One small blue crystal
	2	Trace - Several blue crystals
	3	Nil
	4	Trace?
Top Orange	1	Nil
	2	Trace?
	3	Trace?
	4	Nil
Middle Orange	1	Cobalt
	2	"
	3	"
Lower Orange	1	Trace
	2	Nil
	3	Trace
	4	Nil

Short, M.N.; "Microscopic Determination of Ore Minerals," U.S.G.S., Bulletin #914 p.p. 195-6.(Cesium Chloride Test).

Lollingite-Safflorite:

A mineral with positive reactions to saturated ferric chloride; aqua regia and FeAsS; aqua regia and (Co,Ni)AsS; and nitric acid, was believed to be lollingite-safflorite. Lollingite, $FeAs_2$, and safflorite, $CoAs_2$, are thought to mix in all proportions. They appear in the ore as small disseminations (app. 8 microns) in the arsenopyrite, or as segregations (up to 0.2 m.m.) in the arsenopyrite, in the gangue or on the border of the arsenopyrite and gangue; see plate 1. The small disseminations may have been deposited contemporaneously with the arsenopyrite and concentrated, possibly by exsolution. The larger crystals seem to have been deposited later than the arsenopyrite, see fig. 2.

Gold:

Gold was found in and completely surrounded by arsenopyrite, on the border of arsenopyrite and gangue and in the gangue, see plate 2. The gold in the arsenopyrite was probably deposited contemporaneously with that mineral. The gold in the gangue occurs, in all cases noted, on the border of calcite and a silicate. It has been suggested that the gold was deposited from a colloidal condition when the calcite crystallized. This seems doubtful because the calcite present is either an original mineral replaced by silicates and metallic minerals or as secondary calcite deposited by supergene processes. Therefore the gold is either supergene or deposited by the silicates.

In the sections studied no gold was found over 20 microns in size and the average size was much smaller. Assays for the different sections are given in Table I.

Paragenesis:

The first minerals to replace the limestone were the silicates (with gold?). The silicates were followed by arsenopyrite, gold and lollingite-safflorite, which appear to have been deposited contemporaneously. Later lollingite-safflorite was seen cutting the arsenopyrite (fig.2.). Chalcopyrite was noted filling a fracture in an arsenopyrite crystal (fig.3.) and in one section the chalcopyrite was cut by pyrrhotite (fig. 4.). The relationship between these minerals and the sphalerite and pyrite was not determined.

Order of Deposition

Silicates (gold?).........

Arsenopyrite. ....

Gold. ....

Lollingite-Safflorite..................

Chalcopyrite. ....

Pyrrhotite. ....

Bibliography:

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2. Bostock, H.S.; G.S.C., Summ. Rept., 1929. Part A, p.p. 198-252.

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