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GEOLOGY 9

Investigations into Mineral Occurences in the Nickel Plate Ore

April 1942.

R. Haywood-Farmer

ACKNOWLEDGEMENTS

The author wishes to acknowledge the able assistance and timely hints and suggestions given by Dr. H.V.Warren in connection with this work. My thanks are also due to Dr. Warren for his work on duplicate sections and for his help in the photography.

The author would also like to acknowledge the assistance of the Messrs. R. Thompson and C. Ney for their help in the laboratory.

R.H.F.

University of British Columbia April, 1942.

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Introduction

Object of Investigation

The work was done in an effort to identify the cobalt bearing minerals, and to find the relationship between the cobalt minerals and the other metallic minerals present. The association of the gold in the ore was considered in view of future mineral dressing work for the recovery of cobalt and gold. It was hoped, that by microscopic work an answer could be obtained as to the possibility of making a high grade cobalt concentrate.

At present, no recovery of cobalt is made from the ore. The concentrator heads run about 0.4 ounces in gold and about 0.05% cobalt. The ore, after mining is ground in a stamp mill and cyanided. The cyanide tails are floated to recover a sulphide concentrate containing about 1.0 ounces of gold. This concentrated is shipped to the smelter where payment is made only for the gold. The cobalt is lost in the slag.

The Samples Used

The tests were made on representative samples from each of the ore bodies shown in figure 4. These samples were taken by the Kelowna Exploration Company's Engineer from the middle of each ore body shown on the diagram. Each of these samples was one piece of rock weighing about two pounds.

The following samples were tested:

Section 49----------Middle Red
Section 48----------Middle Upper Purple
Section 62----------Middle Yellow
Section 11.6----------Middle Orange

Sections for observation were cut from the samples with a diamond saw. The sections were mounted in dammar gum and hand polished.

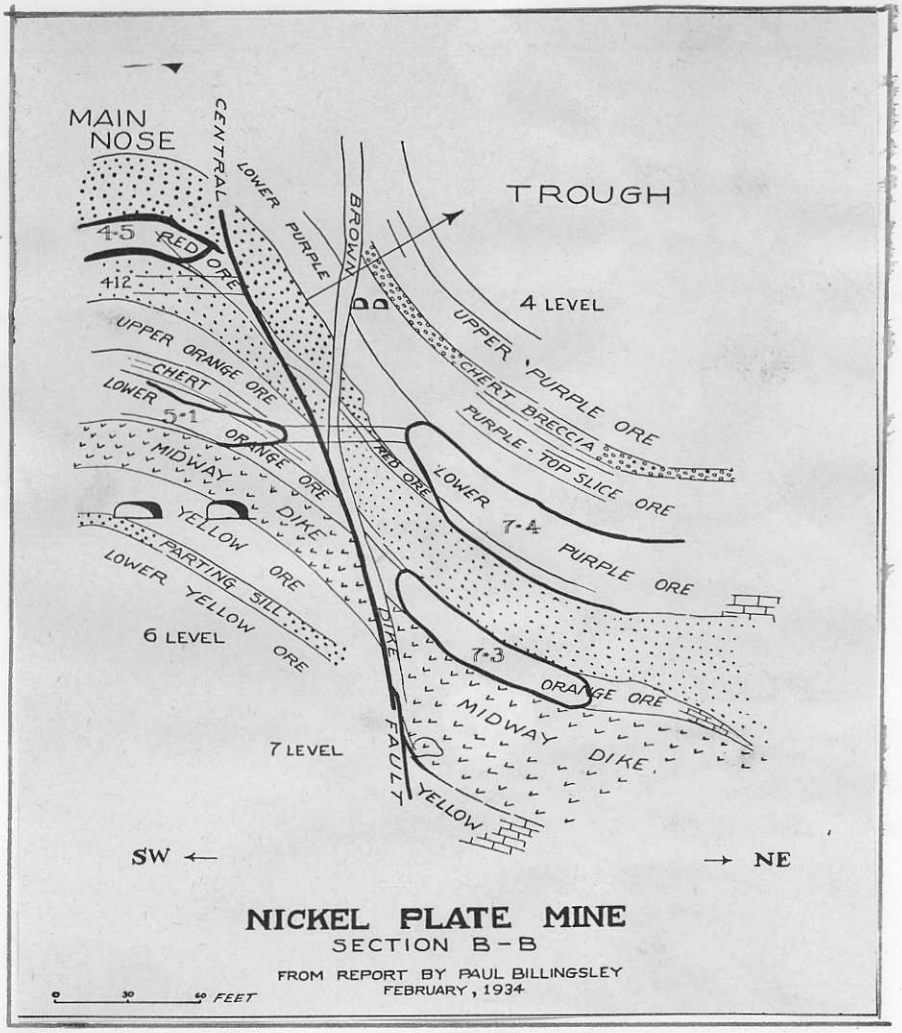


Fig. No 4

Section Showing the Ore Bodies of
The NICKEL PLATE MINE

(From arreport by Paul Billingsly, 1934.)

Summary of Conclusions

The only cobalt mineral present in these samples is safflorite-loellengite occuring as minute inclusions in the arsenopyrite. These inclusions were not found larger than 90 microns and were generally about 10 microns in size.

The orange ore body is the richest in cobalt. It appears that the safflorite-loellengite will not be freed from the arseno-pyrite by commercial grinding. However grinding will free some of this mineral.

The gold is generally in the arsenopyrite but is also in gangue and in chalcopyrite. Gold as large as 20 microns was present.

Preliminary Observations

Assaying

The samples from the mine were resampled for assaying. Gold assays were run with the assistance of the Department of Metallurgy. Cobalt, sulphur, iron and arsenic assays were run by the Department of Mines at Victoria.

Microscopic Identification of Common Minerals

The common metallic minerals were identified in the specimens by etch tests and by micro-chemical tests. Used the procedure as laid down in "Microscopic Determination of Ore Minerals" by Short, for this work. Made an estimation of the percentage of each of these metallics in the section. The table following gives the list of the minerals found and their quantity.

Description of Section Ore Body	No.	Arseno pyrite	pyrihotite	pyrite	marcasite	chalcopyrite
Middle Low Purple	64	60%	none	none	none	trace
Middle Upper Purple	48	10%	5%	trace	none	trace
Middle Red	49	30%	10%	5%	5%	2%
Middle Orange	11.6	10%	none	none	none	none
Middle Yellow	62	85%	1%	1%	trace	trace

After identifying these common metallic minerals a detailed microscopic study was made in an effort to locate the cobalt bearing minerals, and to find the distribution of the gold.

Cobalt Identification

As the ore heads in the Nickel Plate Mine run only about .05% cobalt, only minute amounts of the cobalt mineral could be present. The possibility of the presence of the following cobalt minerals was considered: Cobaltite, Danite, Loellengite-Safflorite, and Smaltite.

These minerals, along with certain nickel minerals can only be distinguished from each other, and from arsenopyrite, by special etch tests. These minerals all appear the same under the microscope. Since no nickel has been found by assay tests on the ore, it was concluded that there were no nickel minerals present. The problem was then, to locate and identify minerals similar in appearance and in most properties to arsenopyrite. A search was made by examining each of the sulphide minerals and by examining the gangue.

Search in the Pyrrhotite

In previous work, by this department on Nickel Plate ore, some cobaltite had been found as small white mineral inclusions in the pyrrhotite. In all the sections observed by this author, no inclusions of any kind could be found in the pyrrhotite.

Cholcopyrite, Pyrite and Marcasite

No evidence of any cobalt bearing minderal could be found associated with the chalcopyrite, pyrite, and marcasite.

Search in the Gangue

No cobalt bearing minerals could be found in the gangue but possibly some small crystals of metallic minerals in the gangue that were assumed to be arsenopyrite, could have been a cobalt mineral (not all the small crystals of arsenopyrite were confirmed with etch tests).

Search in Arsenopyrite

In all the sections, except the middle red, small white mineral inclusions were found surrounded by arsenopyrite. Photo No. 3 shows the occurrence of these inclusions. These inclusions were suspected to be the cobalt mineral, or minerals present.

Tests to Identify Cobalt Minerals

The microscopic analysis was carried out by the method outlined by Ellis Thompson in his report called "Quantitative and Qualitative Determination of Ores from Cobalt Ontario."

The following table from Thompson's report was used for the etch reactions of the different cobalt minerals.

Mineral	Formula	REAGENTS						
		Con. HNO_3	1-1 HNO_3	3-10 HNO_3	Pot. Mang.	$FeCl_3$ (sat)	Aqua Regia & Fe AsS	Aqua Rega & CoN_2 AsS
Arsenopyrite	Fe AsS	D gray	Ird.dk.bn	—	—	—	—	—
Loellingite	Fe As_2	Gy. Diff	Gry diff	—	—	ft.bn.	—	—
Safflorite	$CoAs_2$	Dk gray	Dk gray	Ft bn remains	—	—	—	—
Smaltite	$CoAs_2$	Dk gray	Lt. bn.	—	—	—	—	Ft. bn. or neg.
Cobaltite	CoAsS	neg.	—	—	—	—	—	—

The reagents were made up and used as outlined by Thompson.

Results of Etch Tests and Microchemical Tests

Section 64--The Middle Lower Purple

A large number of small white mineral inclusions were found here in the arsenopyrite. Only certain grains of the arsenopyrite contained these inclusions

Etch Reactions--3-10 Nitric--Faint Brown
A.R. & Co Ni AsS--Faint Brown
$FeCl_3$ --Faint Brown
Con HNO_3--Positive
1-1 HNO_3--Positive

The mineral shows the reactions for both safflorite and loellengite

and is probably a member of the safflorite Loellengite series. The minerals appeared to be anisptropic, but because of their small size, this point could not be confirmed definitely.

Microchemical

An attempt was made to drill out these inclusions and test for cobalt microchemically. Although several tests were made, using both cessium chloride and ammonium mercuric-thio-cyanide methods no positive cobalt tests were obtained.

Section 48--Middle Upper Purple

Inclusions, similar in size and occurrence to those in section 64, were found. Only about one quarter as many inclusions were found as in section 64. Etch tests were similar to those with section 64. Again no positive cobalt microchemical tests were obtained.

Section 62--Middle Yellow

The number and size of inclusions were about the same as in section 48. Microchemical tests were negative for cobalt.

Section 49--Middle Red

No inclusions were found in this section.

Section 11.6--Middle Orange

Several large inclusions and at leat 25 smaller ones were found in the arsenopyrite. All these inclusions were found in a single grain of arsenopyrite. The other grains of arsenopyrite in the section were examined with great care but no inclusions could be found.

Etch Reactions: 3-10 Nitric--Neg.
1-1 Nitric--Positive remains
$FeCl_3$ --Brown, remains
A.R. 4 Ni Co AsS--Negative.

The particles appeared to be anisotropic. The etch reactions indicate the presence of Loellengite and are probably a member of the Safflorite-Loellingite series.

Inclusions were drilled out and positive cobalt tests using Cessium chloride were obtained. The amount of cobalt indicated by the microchemical test was very small.

Size of Cobalt Inclusions

Some of the inclusions in the sections were measured with a magnification of 382 diameters.

Section 62
The smallest measured----------4 microns
The largest measured----------10 microns
The average size is about----------8 microns

Section 64
The size of the inclusions varied from 5 to 10 microns.

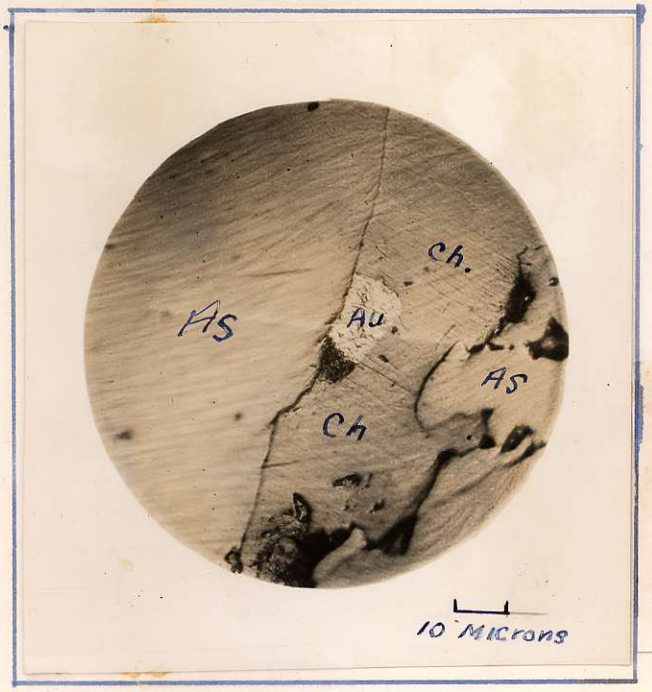
Section 48
The size was much the same as in section 64.

Section 11.6
The largest size was----------90 by 29 microns
The smallest size was----------8 microns
There were 5 over 30 microns
The average size from 25 inclusions counted is about 20 microns.

Relationship Between the Minerals

The chief metallic mineral in all sections is arsenopyrite. Pyrrhotite occurs in minor amounts in all sections except the middle lower purple, and the middle orange. Pyrite, Marcasite and Chalcopyrite are lesser metallic minerals present. Section 49, middle red, has large amounts of both pyrite and marcasite. The marcasite gives the coloform structure shown in photo No. 2. There is a trace of marcasite in the middle yellow.

In studying the ore, it is apparent that the arsenopyrite has replaced the silicious gangue rock. The pyrite, marcasite, chalcopyrite,



325 Mesh
675 X

NICKEL PLATE (Photo no. 1)
Section 49 -- Middle Red.

GOLD in CHACOPYRITE

(Magnification 675 X)

Gold ----------Au.
Chalcopyrite--Ch.
Arsenopyrite--As.

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NICKEL PLATE (Photo no. 2)
Section 49---Middle Red.
Coloform Structure in Pyrite & Marcasite

(Magnification 170 x)

Pyrite - Marcasite-------Py.

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325 Mesh
1160 X

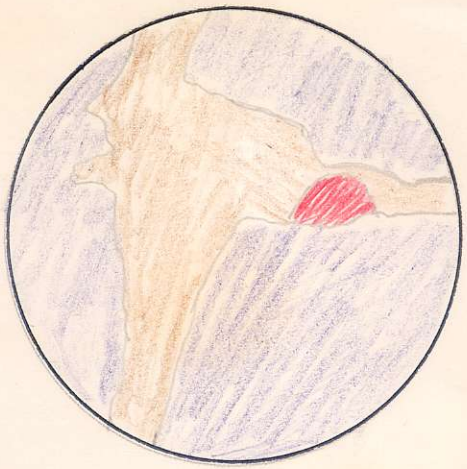
NICKEL PLATE (Photo no. 3)
Section 64 ---Middle Lower Purple

GOLD and SAFFLORITE- LOELLINGITE INCLUSIONS

(Magnification 1160X.)

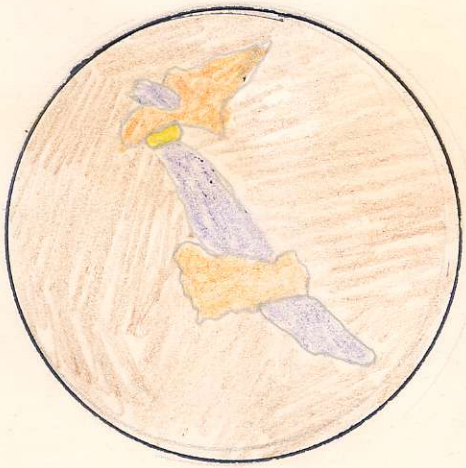
Gold ----------Au.
Arsenopyrite ----------As.
Safflorite-Loellingite-S.L.

R H-F.



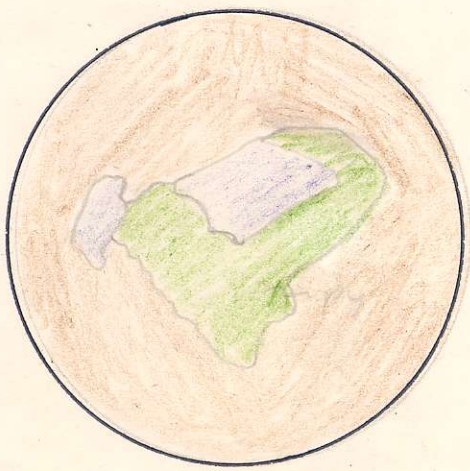
Gold
Arsenopyrite
Carbonate Gangue

Fig 2



arsenopyrite
Pyrrhotite
Chalcopyrite
Gangue.

Fig 1



arsenopyrite
Pyrite
Gangue

Fig 3

and pyrrhotite appear to have come in later than the arsenopyrite. Grains of arsenopyrite are cut by the other sulphides as shown in figure No. 1 and No. 2. Photo No. 1 definitely shows chalcopyrite cutting arsenopyrite.

No evidence was found to establish in what order the pyrite, chalcopyrite, and the pyrrhotite came in. It is probable that these sulphides were deposited at very nearly the same period.

The arsenopyrite has been cut by stringers of carbonate gangue mineral as shown in figure No. 2.

The safflorite-Loellingite occurs in small inclusions in the arsenopyrite as illustrated by photo No. 3.

The Gold is found principally in the arsenopyrite (photo No. 3) In section 49 of the Red ore body, gold was found in chalcopyrite. (photo No. 1). No gold was found in the arsenopyrite in section 49. In section 62 gold was found in the carbonate gangue (see figure 2) in a fissure in the arsenopyrite. Gold was also seen in the arsenopyrite in this section. It was common to find gold near to, or in direct contact with safflorite-Loellingite inclusions (photo No. 3). It is unlikely that a great deal of the gold is associated with Safflorite-Loellingite since the sections with the high cobalt assays do not usually have a high gold assay (e.g. section 64).

Comparison of Assays with Estimated Values

To compare the amount of visible Safflorite-Loellingite in the sections used the following system. Section 11.6 had the most Safflorite-Loellingite, so called it 100; section 49 had no visible Safflorite-Loellingite to called amount 0.

The amount of the inclusions were estimated and given a number between 0 and 100 to represent their value. The table No. 1 shows the assays, the visible estimates for the minerals; and the cobalt-arsenic ratio.

Section	Assays					Estimationof visible Minerals Present						Co/As Ratio
	Au	Co	S	As	Fe	Arseno-pyrite	Pyrrh-tite	Chalco pyrite	Pyrite& Marcasite	Saffl.-Loell.	Gold	
	oz	%	%	%	%							
48	.32	.31%	6.2	12.2	14.9	10%	5%	trace	trace	25	25	25
64	.07	32%	3.4	8.9%	14%	60%	nil	trace	nil	50	25	36
49	.60	.14%	10.7	12.2	20.0	30%	10%	5%	10%	0	25	11
11.6	.76	.33%	3.1	8.5%	10.9	10%-	nil	nil	nil	100	100	3#
62	.64	.23	10.0	11.7	16.5	85%	1%	trace	1%	25	50	19.7

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ASSAY VALUES and MICROSCOPIC ESTIMATIONS

table No. 1

The sections with a high arsenic-cobalt ratio had the greatest amount of Safflorite-Loellingite present in them.

In sections 64, and 11.6 there is more arsenic present than could be combined as arsenopyrite, considering the low sulphur assay. This excess in arsenic would confirm the presence of Loellingite with a formula of $FeAs_2$ plus cobalt. It is significant that these two sections are the highest in cobalt by the assays.

Conclusions.

The only cobalt bearing minerals in these sections is loellengite-safflorite, occuring as minute inclusions in the arsenopyrite. These inclusions were not found larger than 90 microns and were generally about 10 microns. The cobalt bearing mineral could not be definitely identified as loellengite or safflorite . Most inclusions showed positive etch tests for both minerals. Loellengite ($FeAs_2$) and safflorite ($CoAs_2$) form isomorphous series so the mineral tested is apparently a member of it. (loellengite carrying cobalt).

As the particles are so small, only part of the loellengite - safflorite would be freed by commercial grinding. Loellengite-safflorite is very difficult to float . If an arsenopyrite concentrate were made by floatation most of the loellengite-safflorite that had been freed by grinding would remain in the tails.

The gold is generally in the arsenopyrite but is also along the arsenopyrite -gangue contacts. There is evidence of gold in the chalcopyrite of the red ore body. Although gold does appear

appear in contact with loellengite-safflorite, the assays show that there is no relation between cobalt and gold.

The orange ore body is the richest in cobalt, and also the richest in gold.

The lower purple ore body is rich in cobalt but lowest in gold.

Note:

The average cobalt assays of the samples used is 0.26%. The concentrater heads at theNickel Plate run only 0.05% cobalt. It is apparent that these samples do not represent the ore heads but only high suphide portions of the ore.

Hedley Golds.

			% Arsenopyrite.		oz Au/ton	Co
Top	v. Purple.	A8N	50	(15)	.32	.10
Middle.	"	48	20	(28)	.47	.31
Bottom.	"	68S	15	(15)	.07	.13
Top	Lav. Purple	A7	5	(5)	.07	.26
Middle	"	64	10	(21)	.07	.32
Bottom	"	15.4	20	(46)	.16	.41
Top	Red	25	5	(19)	2.00	.38
Middle	"	49	10	(30)	.60	.14
Bottom	"	89	10	(31)	.27	.19
Top	Orange	51	50	(51%)	2.70	.19
Middle	"	11.6	15	(20)	.76	.33
Bottom	"	15.3	20	(30)	.04	.22
Top	yellow.	22	Small	(6)	.07	.25
middle		62	20	(27)	.64	.23
Bottom		12.2	5	(3)( )	1.10	.15
		N450A	25	(26)	.80	.49
		S450A.	25.	(31)	2.30	.46

OFFICE OF THE CHIEF ANALYST AND ASSAYER

THE GOVERNMENT OF
THE PROVINCE OF BRITISH COLUMBIA

Folio No. 108

DEPARTMENT OF MINES

VICTORIA

Sample received from Dr. H. V. Warren,

Address Dept. Geology & Geography,

University of B. C., Vancouver, B. C.

Certificate No.	DESCRIPTION OF SAMPLE.	GOLD. Oz. per Ton.	SILVER. Oz. per Ton.	COPPER. %	LEAD. %	ZINC. %	
		Cobalt	Arsenic		Iron	Sulphur	
11489 B	Mark # A7	0.26	2.3		7.1	2.6	
11490 B	" #A8N	0.10	6.4		10.7	5.4	
11491 B	" #12.2	0.15	1.3		12.1	6.7	
11492 B	" #15.3	0.22	13.1		11.1	5.8	
11493 B	" #15.4	0.41	20.0		14.8	7.4	
11494 B	" #22	0.29	7.0		11.1	6.2	
11495 B	" #25	0.38	8.3		7.7	2.6	
11496 B	" #48	0.31	12.2		14.9	6.2	
11497 B	" #49	0.14	12.7		20.0	10.7	

Date April 4, 1942.

G. Cam. Browne. Camp

Chief Analyst and Assayer.

1M-1041-4616

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		Cobalt	Arsenic		Iron	Sulphur		
11498 B	Mark #51	0.19	22.6		15.4	7.5		
114 99 B	" #62	0.23	11.4		16.5	10.0		
11500 B	" #64	0.32	8.9		14.0	3.4		
11501 B	" #68-S	0.13	6.5		15.6	5.1		
11502 B	" #89	0.19	15.5		13.0	6.0		
11503 B	" #116	0.33	8.5		10.9	3.1		
11504 B	" N450A	0.49	11.0		17.3	5.6		
11505 B	" S450A	0.46	15.6		15.8	6.1		

Date April 4, 1942.

G. Cave. Brown. Cave.

Chief Analyst and Assayer.

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