NICOLA REPORT

GEOLOGY 24

- By -

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NICOLA REPORT

Introduction

The Enterprise and King William veins occur in shear-fracture zones in diabase. The veins vary in strike from north forty-five degrees west to north twenty-five degrees east, and dip usually between forty-five degrees east and vertical. The Enterprise and King William veins may turn out to be one vein when more development work is done.

Pinching and swelling of the veins is common, and varies from five inches to fifty inches. A zone of bleached and pyritized wall rock accompanies the veins to a maximum width of fifteen feet, but carries no appreciable values.

The country rock consists of altered materials of Palaeozoic or Triassic age, and may be generally classified as a diabase - porphyrite. Chloritization is extensive, and except for local shears, the rocks are massive with a green colour.

The major structure is probably a large anticline plunging to the north. In the producing area the beds are almost vertical, with a north-east strike.

Production has been intermittent throughout the life of the mine.

PROCEDURE

A number of samples were reduced to minus sixty-five mesh (-65^{M}) and divided by screening into $-65 + 100^{M}$, $-100 + 150^{M}$, $-150 + 200^{M}$, and -200^{M} products. These products were kept separate for each sample.

The constituent minerals of the samples were separated as closely as possible on a Haultain superpanner, using $-65 + 100^{M}$ first, and proceeding down to the finer sizes for each sample until enough of each mineral being separated was obtained. The amount of isolated mineral was in each case required to cover spectroscopic analysis, assay for Ag and Au, mounting and polishing for microscopic examinations, and a remaining check sample.

In superpanning, the galena, pyrite, and quartz gave apparently clean tips, and sphalerite was mixed with pyrite. Other minerals present were not observed in quantity at this time. Accordingly, each mineral was superpanned to give galena, pyrite, a mixture of pyrite and sphalerite, and quartz.

These minerals, kept separate for each sample, were analized qualitatively by spectroscopy,* assayed for Ag and Au content, and several were mounted and polished for microscopic examination.

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* emission spectrum

Polished sections prepared from each of the original uncrushed samples were obtained. These sections were examined by microscope to determine the minerals present, their relations and associations, paragenesis and grain size, and to establish additional connecting links between superpanning, spectroscope, and assay results.

Where the above facts were difficult to determine for Ag and Au, samples of the superpanned minerals high in Ag and Au were examined by microscope. Photographs were taken of this material.

A sample of the tails from the Nicola mill was assayed, and superpanned, and the mineral separated (largely pyrite) was mounted and polished for microscopic examination.

Chalcopyrite in the ore varied in grain size from large patches to minute particles, so samples sized at -150 + 200 mesh (-150 + 200^M), -200 + 325^M, and -325^M were mounted, polished and examined to determine the degree of unlocking and associations of chalcopyrite at these meshes.

<u>Samples Taken</u>

1. General mine sample.
2. Enterprise vein, 320 level, 21 stope.
3. " " " " face 16, 5, 39.
4. " " 440 " 9 stope.
5. " " 540 "
6. " " north 675 level.
7. Tailings (not a representative sample).

Assay method

	Charge	Galena	Pyrite	Tails
	Ore per	0.5 A.T.	0.5 A.T.	0.5 A.T.
Use	Sodium Carbonate	19 grams	25 grams	25 grams
	Borax-glass	0 "	5 "	5 "
	Litharge	50 "	60 "	75 "
	Niter	6.5 "	35 "	29 "
	Silica	5 "	8 "	8 "

Spectroscope Procedure

Load the plate emulsion side down.

Check -- the bar for printing the scale must be back, and the shutters closed.

Remove the diaphragm and clean the slit. Set the slit at 4 for width of line. Lift the shield to expose the plate. Set the scale at 26.

Adjust the carbons at 5½ amps., to 1½ mm. gap. Burn the carbons for 1/2 min. before taking exposure. Insert the sample in the lower carbon, adjust the gap to 1½ mm. and start the arc. Photograph for 20 seconds, diaphragm at 2. Rack two points and photograph for 30 seconds more.

Samples at 31, 41, 51, 61, at 2 on diaphragm for 20 seconds, rack to 33, 43, 53, 63, give 30 seconds more.

Tin Standard Carbon gap 2 mm., time 2 sec., diaphragm at 1. Scales at 31, 41, 51, 61. No intermediate racking.

Iron Standard Iron gap 2 mm., time 3 sec., diaphragm at 3. Scales at 33, 43, 53, 63. No intermediate racking.

Printed Scales After iron standard, same setting, time 2 sec., scales at 33, 43, 53, 63.

Make sure the bar is down before opening the scale printing aperture.

RESULTS

Spectroscope

* = lines weak

Plates		Ag	Au	Bi	Cd	Cu	Fe	Pb	Sb	Sn	Zn	Te
7-28												
Sphalerite and pyrite	320	"*	"*		"	"	"	"			"	
pyrite	"	"	"			"	"	"			"	
galena	"	"	"		"*		"	"			"*	
quartz							"			"*		
7-29												
Galena	440	"			"*	"	"	"	"		"*	
"	540	"	"		"*	"	"	"	"		"*	
"	675	"	"*		"*	"	"	"	"		"*	"*
Quartz	440						"					
7-30												
Pyrite	440	"	"		"*	"*	"				"	
"	540	"	"		"*	"*	"				"	
"	675	"	"		"*	"*	"	"*			"	
Quartz	540						"				"*	
7-31												
Sphalerite and pyrite	440	"	"*		"	"*	"				"	
" " "	540	"*			"		"				"	
" " "	675	"	"*		"		"			"*	"	
quartz	675						"*			"*		

Assay

Galena

	Au (oz./ton)	Ag (oz./ton)
General sample	9.27	131.97
320 level 21 stope	0.65	21.25
440 " 9 "	1.15	9.45
540 "	9.97	75.57
675 "	1.00	255.80

Pyrite

General sample	0.95	66.72
320 level 21 stope	1.13	10.20
440 " 9 "	0.80	4.44
540 "	1.15	8.25
675 "	0.67	148.40

Tailings	0.76	15.44

Microscope

Pyrite

The pyrite is highly fractured, rounded, sometimes veined by chalcopyrite and often bounded by it. Galena was also observed veining pyrite. Native gold is carried in the pyrite as exposed particles and veinlets in the fractured areas. See plate 5.

Chalcopyrite

Chalcopyrite is present as large and small smooth boundaried inclusions in sphalerite and galena. There are large fields of chalcopyrite around and between pyrite grains, with chalcopyrite veins in pyrite.

Galena

There are small amounts of galena between pyrite boundaries, and some galena was seen veining pyrite. Galena is more closely associated with sphalerite than with pyrite, as large areas or small islands in a sphalerite field. The galena contains large and small smooth boundaried inclusions of chalcopyrite, and also native gold, and much tetrahedrite. See plates 1, 2, 3 and 4.

Sphalerite

Sphalerite is mostly in large fields, closely associated with galena. The sphalerite contains many large and small smooth boundaried inclusions of chalcopyrite, and occasionally small, rough boundaried pyrite islands. Sphalerite was seen veining pyrite in several places.

Tetrahedrite

The 675 level specimen contains the largest amount of tetrahedrite, associated with galena and having smooth boundaries at contact. There is some tetrahedrite with chalcopyrite, again with smooth boundaries at contact. Tetrahedrite was seen veining pyrite along with galena.

In plate 1, tetrahedrite (dark grey) is shown associated with chalcopyrite (orange) in a piece of galena (pale blue). The yellow particle in the field is pyrite. The photograph was taken from 675 level superpanned galena.

Native Gold

Native gold was observed in both galena and pyrite, and also several free particles were found. The gold appears to be simultaneous with galena. See plates 2, 3 and 4. Gold occurs in fractured pyrite as tiny veinlets or irregular patches. See plate 5.

In plates 1, 2, 3 and 4, the material used for mounting and polishing was superpanned galena.

In plate 2, (540 level) the gold shows as a round white spot just above the centre of the field. In plate 3 there are two spots of gold (deep yellow) in galena (pale blue), one showing just below a particle of chalcopyrite (orange), and one near the top of the field. The pale yellow is pyrite. Between the pyrite and chalcopyrite is sphalerite, which did not show well because of the length of printing exposure necessary to show the gold. In plate 4 (675 level) there are four particles of gold in the single piece of galena near the centre of the field.

Plate 5 is of superpanned pyrite from the 540 level, and shows gold (white) in fractured pyrite (light grey), with two pieces of sphalerite attached (dark grey). Small black inclusions of chalcopyrite in sphalerite are barely visible.

Rickardite

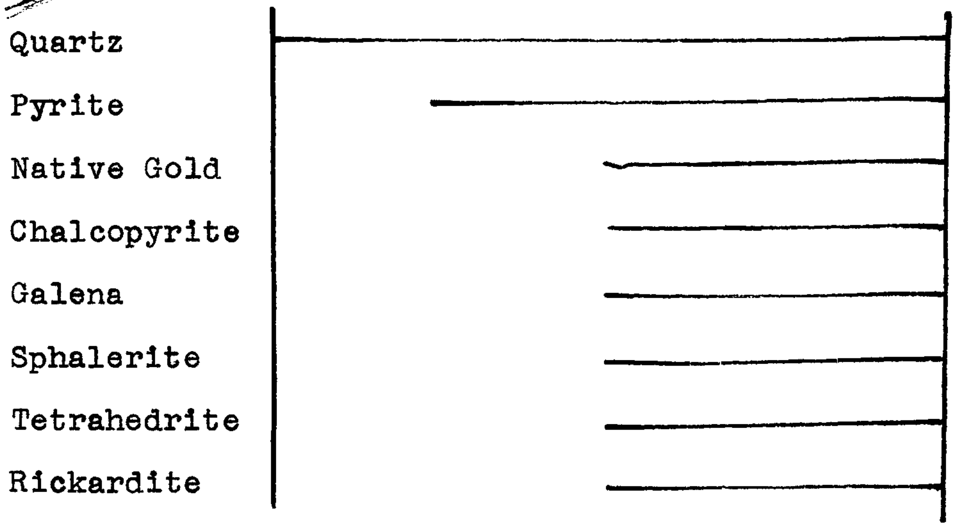
A very small group of purplish colored mineral inclusions was observed in the tailings pyrite. The purple mineral is strongly anisotropic, giving a reddish orange interference color and four extinctions per revolution. The particles were only about two microns in diameter, and were therefore too small for hardness or etch tests. Fortunately this mineral was associated with chalcopyrite, so that its hardness could be placed by visual comparison as approximately that of chalcopyrite - (3.5 - 4).

The telluride "rickardite" (Cu_3Te_2) has all of the above mentioned characteristics. Also copper is present in the ore, and tellurium was reported in the spectroscopic analysis, so that the presence of rickardite is not unlikely.

(Cu_3Se_2) is the only alternative mineral that could be found, but no selenium was found in the spectroscope, therefore the mineral was classed as rickardite.

This is of interest here because it indicates the possibility of gold being carried to a small extent in tellurides.

Paragenisis



Grain Size

Grinding to -200^M would successfully unlock all the minerals observed, excepting chalcopyrite and gold.

Most of the gold particles observed and photographed were about four microns in diameter, or about 3200 mesh.

The chalcopyrite observed ranged in size from large patches to inclusions in sphalerite too small to measure.

To determine the degree of unlocking of chalcopyrite, samples of $-150 + 200^M$, $-200 + 325^M$ and -325^M were mounted, polished, and examined with the following results:

$-150 + 200^M$

Chalcopyrite particles counted = 303, of

which 65 were locked with ZnS
16 " " " FeS_2
28 " " " PbS
13 " " " SiO_2

If all the chalcopyrite were removed in a single concentrate at this mesh, it would contain as impurity approximately -

11.4% of ZnS
3.4% " FeS_2
12.0% " PbS
1.4% " SiO_2 by weight, and the total

percent of undesirable impurity (ZnS + FeS_2) would be 14.8.

$-200+325^M$					
	chalcopyrite particles counted	locked with			
		ZnS	FeS_2	PbS	SiO_2
particles counted	311	50	3	10	2
percent of impurity by weight		8.5	0.6	4.2	0.2
percent of undesirable impurity		9.1	(= ZnS + FeS_2)		

-325^M

	chalcopyrite particles counted	locked with			
		ZnS	FeS_2	PbS	SiO_2
particles counted	339	16	1	3	1
percent of impurity by weight		2.5	0.2	1.1	0.1
percent of undesirable impurity		2.7	(= ZnS + FeS_2)		

For purposes of smelting, a chalcopyrite concentrate should not contain ZnS or FeS_2.

Out of the total number of chalcopyrite particles counted, at

$-150+200^M$

21.4% is locked with ZnS
5.3% " " " FeS_2
9.2% " " " PbS
4.3% " " " SiO_2
or 26.7% " " " ZnS + FeS_2.

For the releasing of 95% of the Chalcopyrite a 100% - 325^M grind is necessary. Of course the mesh to which the ore is ground must be determined by a balance between grinding costs and the value of additional Chalcopyrite released by further grinding.

OBSERVATIONS

The Sb that shows with galena in spectroscopy, shown by microscope observations to be in tetrahedrite, is there for either or both of two reasons:

(a) The microscope shows galena and tetrahedrite to be closely associated, therefore there would be unlocked particles.

(b) The tip removing on the superpanner was done before tetrahedrite was known to be present, and because of the similarity in color it would be picked up with galena and excluded from the pyrite. This would be especially true of the lighter colored argentiferous tetrahedrite.

It cannot be assumed that all the tetrahedrite existed in the galena tip as unlocked particles because many of the tetrahedrite particles observed under the microscope were large. Therefore there must have been enough free tetrahedrite to show Sb in a spectroscope, and all of this migrated on the superpanner to the heavy side of the pyrite tip and was picked up with the galena. This would indicate a specific gravity definitely exceeding that of pyrite, showing replacement of Cu by a heavier element. The high Ag values in the galena assays make it very likely that Ag is accounting for the high specific gravity of the tetrahedrite.

Cu shows without Sb in all the spectroscope plates for pyrite, and besides tetrahedrite the only Cu mineral observed in the ore in an amount worth considering is chalcopyrite. Therefore it can be assumed that Cu shows in the spectroscope plates for pyrite because of chalcopyrite either as unlocked particles or as free particles included as salting in the pyrite superpanner tip. The microscope shows both, with the percentage of unlocked chalcopyrite in pyrite very low in the sample used for spectroscopy, and a large amount of free chalcopyrite present.

Cu shows without Sb in two of the pyrite-sphalerite spectroscope plates, and by the reasoning used above, indicates chalcopyrite. The microscope shows many very small particles of chalcopyrite in sphalerite, and few in pyrite. Therefore the Cu probably shows in the spectroscopic analysis of pyrite and sphalerite because of unlocked particles of chalcopyrite in sphalerite.

The average Ag assay of galena is over twice that of pyrite. The spectroscope shows all galena samples but one to carry Sb, reasoned above to be present as tetrahedrite. No Sb shows in pyrite spectroscope plates. The microscope shows tetrahedrite to be associated with galena and to be most abundant in the 675 level, which has the highest Ag assay. Therefore superpanner, assay, spectroscope and misroscope combine to indicate tetrahedrite as the most important Ag carrier in the ore.

The highest Ag content, in the 675 level galena and pyrite samples, is checked by strong Ag lines on the photographic plates for these samples.

The highest Au content, in the 540 level galena and pyrite samples, is checked by Au lines showing on the plates for these samples.

Low assay values could not be checked except by quantitative spectroscopy.

Cd lines only show on the plates when Zn also shows, therefore it is likely that any Cd present is carried by sphalerite, a likely association to begin with.

CONCLUSIONS

Occurrence of Silver

The high Ag bearing mineral in the ore is tetrahedrite of the argentiferous variety known as friebergite, containing 3 to 30% Ag. This conclusion is supported by the absence of native silver or any silver sulphides in isolated mineral form, the presence of Sb as well as Cu wherever high Ag is proved by assay, and by the high specific gravity of the tetrahedrite. The fact that tetrahedrite came out on the superpanner on the galena side of the pyrite tip indicates a specific gravity at least slightly higher than that of the pyrite present. This necessitates almost the maximum amount of Ag to be carried by the tetrahedrite.

Ag is carried by all the sulphides in the ore. Because sphalerite was not separated from pyrite it was not possible in the scope of the tests applied to deterine the amount of Ag or Au in the sphalerite alone.

Occurrence of Gold

Gold is present as tiny particles (4 microns) in galena, and as small patches and veinlets in pyrite. There is some indication of tellurides, but only one possible telluride was observed in microscopic examination.

Grinding

Grinding to release the Au particles would be impossible or impracticable (3200 mesh).

As nearly to - 325^M as is financially feasible is recommended for the release of chalcopyrite.

Method of treatment

Grinding to release the Au particles is out of the question, and cyanidation is impossible when much of the Au is included as in plate 4. Therefore it would be necessary to remove the Au present in the galena at the smelter from a galena concentrate, which would also carry a large portion of the Ag.

The Au observed in pyrite (plate 5) is just as small as that in galena, but is amenable to cyanidation.

The high Ag and Au assays for pyrite show that pyrite should not be rejected as tailings without previous treatment, but an assay of the tailings shows that this was being done.

In view of the above observations, probably the best method of treating this ore would be to grind to as much finer than - 200^M as the additional chalcopyrite recovery would warrant, depending upon grinding costs, then to float a Pb concentrate containing most of the Au and Ag. This would be followed by a chalcopyrite float, then a Zn float carrying most of the unlocked chalcopyrite, some Cd, Au, and Ag. The tails from flotation, consisting mainly of pyrite and quartz, could be cyanided, then rejected.

Plate 1

Plate 2

Plate 3

Plate 4

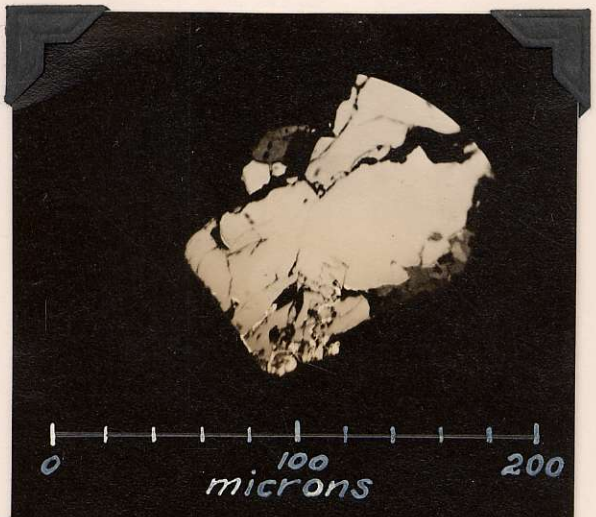


Plate 5