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PRELIMINARY METALLURGICAL ASSESSMENT OF DOLLY VARDEN ORES AND REPORT ON INSPECTION OF FORMER TORBRIT SILVER MILL

FOR

DOLLY VARDEN MINES LTD.

ALICE ARM,

BRITISH COLUMBIA

WRIGHT ENGINEERS LIMITED

VANCOUVER BRITISH COLUMBIA

Project No. 373

October, 1964

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October 30, 1964

Dolly Varden Mines Ltd.,
Suite 617,
837 West Hastings Street,
Vancouver 1, B.C.

Attention: Dr. F. C. Buckland
President

Gentlemen:

Re: Our Project No. 373

We are pleased to submit herewith our preliminary metallurgical assessment of Dolly Varden Ores together with a report on our inspection of the former Torbrit Silver mill.

Yours very truly,

WRIGHT ENGINEERS LIMITED

H. M. Wright,
President

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PRELIMINARY METALLURGICAL ASSESSMENT OF ORES

INTRODUCTION

Metallurgical testwork has been carried out on ore from two different ore bodies. They are the North Star Mine and the Wolfe No. 2 ore body.

The testwork has been carried out in the Britton Research Laboratories, Vancouver, B.C. and at the Department of Mines and Technical Surveys, Mines Branch, Mineral Processing Division, Ottawa, Ontario.

North Star ore has been investigated in both laboratories, the Wolfe No. 2 ore in one only, the Mines Branch, Ottawa.

The testwork comprises flotation tests to recover the silver in a silver-lead concentrate producing a separate zinc concentrate or in a bulk concentrate containing the zinc mineral. Cyanidation tests to recover the silver in tailings have been made by the Mines Branch, Ottawa. The Mines Branch also separated the barite from the North Star ore in two of their tests.

MINERALOGICAL INVESTIGATIONS

Two samples from the Upper Kitsault Valley, Alice Arm, B.C. (North Star ore) were studied mineralogically by the Department of Mines and Technical Surveys, Mines Branch, Mineral Sciences Division, Ottawa.

1. Sample 1, nine hand specimens
2. Sample 2, a finely powdered lead-silver concentrate containing:

171.72 oz./ton	Ag
11.70%	Pb
3.20%	Zn
45.98%	$BaSO_4$

Method and Results of Investigation as presented by the Mines Branch, Ottawa

Three polished sections and two thin sections were prepared from the hand specimens (Sample 1) and the minerals were identified by means of microscopical and X-ray diffraction studies. One polished section was also prepared from the lead-silver concentrate (Sample 2) and the metallic minerals in it were identified. The non-metallic minerals, on the other hand, were identified by an X-ray diffractometer analysis of the sample.

The metallic minerals present in the ore are pyrite (FeS_2), sphalerite (ZnS), chalcopyrite ($(CuFe)S_2$), freibergite ($(Cu, Fe, Ag)_{12}Sb_4S_{13}$), galena ($PbS$), and pyrrhotite ($FeS$). The non-metallic minerals are quartz (SiO_2), calcite ($CaCO_3$), dolomite ($(CaMg(Co_3)_2$), barite ($BaSO_4$), feldspar ($(K,Na,Ca)AlSi_3O_8$) and clay ($H_4Al_2Si_2O_9$). The principal gangue minerals are quartz, calcite and dolomite, and barite occurs as small grains in the gangue.

Pyrite is the most abundant metallic mineral. It is present as angular to rounded grains disseminated in the gangue. These grains range from about 2 microns to 1 mm in size and are frequently inter-grown with sphalerite, chalcopyrite and freibergite.

SUMMARY AND RECOMMENDATIONS

Section I of this report is a preliminary assessment of the metallurgy of the ores from the North Star Mine and the Wolfe No. 2 ore bodies. Final assessment must await further test results. An acceptable flowsheet should be established before proceeding with any repairs or revisions to existing facilities.

In general, selective flotation as well as a combination of bulk flotation followed by selective flotation will give satisfactory results. Production of a bulk silver-lead and zinc concentrate will leave a sufficiently low silver content in the tailing that the need for cyanidation will be eliminated. If selective flotation, producing a silver-lead concentrate and a zinc concentrate, is finally determined for the flowsheet which will result in the highest net return, cyanidation of the tailing will be required. Selective flotation alone will leave too high a silver content in the final tailing. Some indication of the quantities of the ores to be treated from the various deposits will be necessary in order to finalize the flowsheet.

Section II consists of a report on an investigation of the existing surface facilities of the property at Alice Arm, B.C., which was formerly owned by Torbrit Silver Mines Limited.

It is recommended that after the completion of the necessary test results and the establishment of the most satisfactory flowsheet, a detailed study of mining, milling, and concentrate handling to market, be made. This should include estimates of capital and operating costs.

The economics of building a larger milling plant versus the rehabilitation of the present facilities can be investigated if the ore reserves, as determined at that time, appear to warrant it.

TERMS OF REFERENCE

The terms of reference of this report are based on discussions with Dr. F. C. Buckland in January 1963 and Dr. Buckland's letter of March 7, 1963.

Wright Engineers Limited were to report on the metallurgy of Dolly Varden ores and prepare a suitable flowsheet for operating at a rate of 300-400 TPD.

This was to have been followed by an estimate of the capital cost of rehabilitating the mill formerly operated by Torbrit Silver Mines Limited and implementing the optimum flowsheet.

As of the date of this report, final metallurgy on the Wolfe No. 2 ore has not been received from the Mines Branch of the Department of Mines and Technical Surveys, Ottawa, and samples of the Dolly Varden ore body have not been examined and it has been requested that Wright Engineers Limited submit a report on the work to date.

The sphalerite, chalcopyrite and freibergite occur as irregular grains disseminated in the gangue. These grains range from about 2 to 700 microns in size and are intergrown with each other as well as with pyrite. A few of the larger sphalerite grains contain minute globules of chalcopyrite and pyrrhotite.

No galena was observed in the polished sections of the hand specimens (Sample 1), but a significant amount is present in the lead-silver concentrate (Sample 2). In addition to the galena, the lead-silver concentrate contains barite, sphalerite, freibergite, pyrite, chalcopyrite, quartz and minor amounts of feldspar and clay.

THE CHEMICAL ANALYSIS OF THE ORE

Chemical analysis of head samples from North Star ore have been carried out by Coast Eldridge Engineers and Chemists Limited, for Britton Research Laboratories and by the Department of Mines and Technical Surveys, Mines Branch, Ottawa. The results are summarized in Table 1 below.

Table 1
Chemical Analysis of a North Star Ore
Bulk Sample of January 1963

	Oz/Ton		Assay %								
						Fe		S			Acid
Investigator	Ag	Au	Pb	Zn	Cu	Sol.	Total	Sulphide	Total	$BaSO_4$	Insoluble
Coast Eldridge (J. W. Britton)	14.0	0.06	0.51	1.54	0.04	-	3.47	3.31	-	34.80	84.19
Mines Branch, Ottawa	13.51	-	0.5	1.53	0.036	3.03	-	-	8.44	35.56	83.19

Test Procedures

(a) Investigations have been made in order to determine the silver extraction of the ore in a single silver-lead concentrate as well as the zinc extraction in a zinc concentrate. Two extraction methods have been used for this purposes:

1. Direct selective flotation and
2. Bulk flotation followed by selective flotation.

(b) Testwork has been carried out in order to determine production of a Ag-Pb-Zn bulk concentrate for shipment to a smelter.

(c) Investigations were made to recover the silver in flotation tailing following the procedure 1 in (a) above and also to recover the silver from the ore by straight cyanidation.

(d) The direct selective flotation method includes the flotation of barite as a marketable product.

DIRECT SELECTIVE FLOTATION
(North Star ore sample, January 1963)

The direct selective flotation method of recovering silver-lead, zinc and barium in separate concentrates has been followed by the Mines Branch, Ottawa, in three tests designated Test No. 1, Test No. 2 and Test No. 7. Barite flotation only has been carried out in Tests No. 1 and No. 2.

In the Britton Research Laboratories, only one test (Test No. 1) was made to recover silver-lead and zinc in separate concentrates by direct selective flotation.

Liberation Grind

Tests by the Mines Branch, Ottawa, show that grinding to about 80% minus 200 mesh will be sufficient for good selectivity in flotation. This is reported in Test No. 1. The same grind was used in Test No. 7. Finer grinding to about 88% minus 200 mesh in Test No. 2 resulted in more material being floated (silver-lead rougher concentrate) with a decrease in concentrate grade. The same reagents were not used in both tests and therefore, they cannot be compared directly.

In the Britton Research Laboratories (Test No. 1), coarse grinding to about 62% minus 200 mesh did not give satisfactory results.

Flotation Results (see Table 2)

Test No. 1 and Test No. 7 give similar results. Test No. 1 shows 63.8% recovered silver in a silver-lead rougher concentrate which is 2.7% of the feed by weight and containing 332.19 oz. silver per ton. In this test, galena was floated at natural pulp pH of 8.7 using potassium ethyl Xanthate (Z-3) and cresylic acid. In Test No. 7, the use of sodium cyanide (NaCN) and zinc sulphate ($ZnSO_4$) was successful in reducing the zinc content in the concentrate. However, the sodium cyanide may have caused the depression of a large amount of silver. In Test No. 2, the ore was ground and conditioned with sodium cyanide and the galena concentrate was floated with Aerofloat 242 and cresylic acid. Because of finer grinding to 88% instead of 80% minus 200 mesh as in Test No. 1 and No. 7, more material was floated (4.5% by weight) with a reduction of the silver grade in the Ag-Pb concentrate (171.72 oz. silver per ton).

The sphalerite was floated using copper sulphate ($CuSO_4$), Aero Xanthate 301 and Dowfroth 250. A higher grade was achieved in Test No. 2 by reducing by half the cleaning time of the rougher concentrate. The grade of the zinc cleaner concentrate in Test No. 2 was 59.2% recovering 63.7% of the zinc in the ore. While the zinc recoveries in Test No. 1 and No. 7 were very much higher, the grades were below 25% zinc.

Barite was floated in Test No. 1 and No. 2 using sodium silicate (Na_2SiO_3) and Aero promotor 825 over a flotation period of about 9 minutes. One and two cleanings were made with sodium silicate. By cleaning the barite rougher concentrate twice, a product close to a marketable grade was produced.

One selective flotation test (Test No. 1) was made in the Britton Research Laboratories to recover silver-lead and zinc in separate concentrates. Owing to coarse grinding to only 62% minus 200 mesh, this test was not successful. Most of the zinc floated with the silver and lead and in effect a bulk concentrate was obtained. The results are not given in this report. No effort was made in the Britton Research Laboratories to recover Ag-Pb and Zn by the direct selective flotation method. More attention was given to sulphide bulk flotation than to finer grinding of the whole ore for selective separation into separate concentrates.

For more detailed information, the flotation results in the direct selective flotation tests have been summarized in Table 2 with additional indications about reagent consumption and test conditions.

Table 2
Direct Selective Flotation
Metallurgical Results (North Star Ore)

Product	Test No.	Weight %	Oz/Ton Ag	Assay % Pb	Assay % Zn	Assay % $BaSO_4$	Recovery % Ag	Recovery % Pb	Recovery % Zn	Recovery % $BaSO_4$
1. Ag-Pb Rougher Conc.	1	2.7	332.19	17.76	7.10	30.30	63.8	85.3	12.6	2.3
	2	4.5	171.72	11.70	3.20	45.98	58.4	89.8	9.7	6.0
	7	2.6	301.25	14.20	4.50	-	62.9	85.6	7.7	-
2. Zn Cleaner Conc.	1	5.2	37.93	0.60	24.70	2.64	14.0	5.5	84.6	0.4
	2	1.6	35.76	0.11	59.20	0.80	4.3	0.3	63.7	0.1
	7	6.0	35.01	0.35	22.33	-	16.5	5.0	88.2	-
3. Zn Recleaner Conc.	7	3.6	28.76	0.21	31.54	-	8.1	1.8	74.8	-
4. Barite Cleaner Conc.	1	34.2	1.18	0.01	0.033	91.80	2.9	0.6	0.7	89.2
	2	30.6	0.803	0.014	0.049	91.88	1.8	0.8	8.6	77.3
5. Barite Recleaner Conc.	2	27.8	0.60	0.01	0.045	93.56	1.2	0.5	8.4	71.5
6. Zn Cleaner Tails	1	2.9	21.32	0.53	0.40	33.06	4.4	2.7	0.8	0.2
	2	6.9	43.82	0.34	3.52	17.44	22.8	4.0	16.3	3.3
	7	2.1	17.18	0.31	1.41	-	2.8	1.5	1.9	-
7. Zn Recleaner Tails	7	2.4	44.38	0.57	8.53	-	8.4	3.2	13.4	-
8. Barite Cleaner Tails	1	9.3	6.18	0.11	0.063	23.32	4.1	1.8	0.4	6.2
	2	9.4	4.54	0.10	0.090	41.48	3.2	1.6	0.6	10.7
9. Barite Recleaner Tails	2	2.8	2.82	0.053	0.086	75.22	0.6	0.3	0.2	5.8
10. Flotation Tailings B	1	45.7	3.31	0.051	0.028	1.34	10.8	4.1	0.9	1.7
	2	47.0	2.66	0.044	0.085	2.08	9.5	3.5	1.1	2.6
11. Flotation Tailings A	1	89.2	2.79	0.041	0.034	38.27	17.8	6.5	2.0	97.1
	2	87.0	2.10	0.039	0.073	37.92	14.5	5.9	10.3	90.6
	7	89.3	2.57	0.039	0.036	-	17.8	7.9	2.2	-

Note: Test 1 and 2 include Barite flotation
10. Flotation tailings B have been obtained after Barite flotation
11. Flotation tailings A exclude Barite flotation
Flotation tests carried out at the Mines Branch, Ottawa

ADDENDUM TO TABLE 2

Reagent Consumption and Test Conditions

Test No. 1

Grinding without reagents to 80.3% minus 200 mesh.
Natural pulp pH = 8.7
Silver-lead rougher flotation with Potassium Ethyl Xanthate (Z-3) and Cresylic Acid, flotation time 3 minutes. No cleaning.
Sphalerite rougher flotation using copper sulphate, Aero Xanthate 301 and Dowfroth 250, flotation time 6 minutes.
Zinc rougher concentrate cleaning without additional reagents 3 minutes.
Barite rougher flotation with Sodium Silicate (2 lb./ton) and Aero Promotor 825 (2 lb./ton), flotation time 9 minutes.
Barite rougher concentrate cleaning once with Sodium Silicate (1.0 lb./ton).

Test No. 2

Grinding with Sodium Cyanide (0.1 lb./ton) to 88.3% minus 200 mesh, pH 8.8.
Conditioning with Sodium Cyanide (0.1 lb./ton).
Silver-lead rougher flotation with Aerofloat 242 (0.04 lb./ton) and Cresylic Acid (0.02 lb./ton). No cleaning.
Sphalerite rougher flotation made in the same manner as in Test No. 1.
Sphalerite rougher concentrate cleaning for 1.5 minutes without additional reagents.
Barite rougher flotation was made in the same manner as in Test No. 1.
Barite rougher concentrate cleaning twice, using 1.0 lb./ton Sodium Silicate in each cleaning stage.

Test No. 7

This test was carried out in a similar way to Test No. 1 with the difference that 0.1 lb./ton of Sodium Cyanide and 0.3 lb./ton of Zinc Sulphate was used in silver-lead rougher flotation.

BULK FLOTATION FOLLOWED BY SELECTIVE FLOTATION

(North Star ore sample, January 1963)

Two tests, Test No. 4 and Test No. 5, were carried out in the Britton Research Laboratories, Vancouver, by Mr. J. W. Britton, P. Eng., to produce separate silver-lead and zinc concentrates by bulk flotation followed by selective flotation.

In Test No. 4, the ore was ground to 70% minus 200 mesh without further regrinding of the bulk concentrate for treatment by selective flotation, whereas in Test No. 5, the bulk concentrate was reground to about 78% minus 200 mesh. Test No. 5 was appreciably better with regard to the silver assay and to the recovery obtained in the silver-lead concentrate.

The silver-lead rougher concentrate of Test No. 4 assayed 151.8 oz. silver per ton with a recovery of 65.4%, while in Test No. 5, the silver assay was 185.0 oz. per ton with a recovery of 76.6%. The increase of silver grades after one cleaning were 236.3 and 294.1 oz. per ton respectively with recoveries of 58.1% and 70.1%.

The complete results and procedure of Test No. 5 are shown in Table 3. A high percentage of sphalerite floated with the silver and lead and more cyanide will be necessary to overcome this drawback.

From Test No. 5, a graphical representation has been developed which shows the relationship of recovered silver to the silver grade in the silver-lead concentrates. The broken line curves show lead and zinc in the product. See drawing 373-1-1.

Table 3
Bulk Flotation Followed by Selective Flotation
Metallurgical Results (North Star Ore)

	Product	Weight %	Oz/Ton Ag	Assay % Pb	Assay % Zn	Recovery % Ag	Recovery % Pb	Recovery % Zn
1	Bulk Conc. plus Scav. Conc.	15.53	76.3	2.43	9.14	89.54	97.80	99.41
2	Bulk Conc.	14.46	81.0	2.60	9.81	88.49	97.58	99.33
3	Ag-Pb Rougher Conc.	5.48	185.0	6.56	12.14	76.56	93.40	46.60
4	Ag-Pb Cleaner Conc.	3.18	294.1	10.85	16.64	70.65	89.58	32.61
5	Zn Rougher Conc.	2.45	24.8	0.20	30.46	4.58	1.30	52.27
6	Ag-Pb 2nd Cleaner Conc.	2.34	373.2	14.56	17.07	65.96	88.47	27.98
7	Zn Conc.	1.51	19.5	0.17	47.36	2.22	0.67	50.09
8	2nd Zn Conc. plus Zn Cl. Tails	0.94 (0.55+0.39)	33.3	0.26	3.31	2.36	0.63	2.18
9	1st Ag-Pb Cleaner Tails	2.30	34.0	0.64	8.68	5.91	3.82	4.63
10	2nd Ag-Pb Cleaner Tails	0.84	73.9	0.51	7.88	4.69	1.11	13.99
11	Selective Flot. Tails	6.53	14.9	0.17	0.10	7.35	2.88	0.46
12	Bulk Tailing (before Scav.)	85.54	1.78	0.01	0.01	11.51	2.42	0.67
13	Bulk Tailing	84.47	1.64	0.01	0.01	10.46	2.20	0.59
14	Head (calc.)	100.00	13.2	0.39	1.43	100.00	100.00	100.00
15	Head (assay)	100.00	14.0	0.51	1.54	100.00	100.00	100.00

Note: 6 to 13 Test Results
1 to 5 Calculated Results
Flotation tests carried out in Britton Research Laboratories.

Addendum to Table 3

Reagent Consumption and Test Conditions

Reagents etc. (1)	Grind	Bulk Conc. Regrind	Bulk Flotation		Silver-Lead			Zn		Total
			Roughing	Scavenging	Rougher Flotation	1st Cleaning	2nd Cleaning	Roughing	Cleaning (2)	
Pine Oil	0.024	-	-	-	-	-	0.024	0.024	-	0.072
Xanthate Z11	-	-	0.25	-	-	-	0.02	-	-	0.27
Dowfroth 250	-	-	0.15	-	-	-	0.01	0.10	0.02	0.28
Copper sulphate	-	-	0.20	-	-	-	-	0.50	-	0.70
Sodium carbonate	-	2.0	-	-	-	-	-	-	-	2.0
Sodium Cyanide	-	0.2	-	-	-	-	0.02	-	-	0.22
Calcium hydroxide	-	-	-	-	-	-	0.25	1.0	0.25	1.50
Z 200 (Dow)	-	-	-	-	-	-	-	0.069	-	0.069
Aerofloat 31	-	-	-	0.058	-	-	-	-	-	0.058
Cell used (Denver)	-	-	1000g.	1000g.	1000g.	1000g.	500g.	1000g.	500g.	-
pH	-	-	8.4-8.0	8.0	9.6-9.4	9.3-8.8	10.4-9.6	10.5-10.1	10.6-9.2	-
Temperature °C	-	-	22	24	21	18	20	20	20	-
Frothing time - min.	-	-	20	4	6	5	4	5	5	-
" speed - R.P.M.	-	-	1200-1800	1600	1500	1500	1500	1800	1500	-
Pulp density - % solids	70	50 (approx.)	27	-	-	-	-	-	-	-
Grind % -200 mesh (approx.)	70	-	-	-	-	-	-	-	-	-

Note: (1) All reagents are expressed in pounds per ton of original ore.
(2) First concentrate only.

BULK FLOTATION

Preliminary investigations to produce a bulk concentrate from North Star ore for shipment to a smelter were made by the Britton Research Laboratories in Tests 2 and 3. Test results, test conditions and reagent consumption as presented in Progress Report No. 1 by Mr. Britton are given on page 1-9, Table 4.

The ore for Test 2 is ground to 70% minus 200 mesh whilst finer grinding to 85% minus 200 mesh has been chosen in Test 3.

The silver recoveries in Test 2 and Test 3 were 89.22% and 90.36% respectively in concentrates assaying 76.5 and 82.5 oz. silver per ton. The weight of the bulk concentrate of Test 2 was 16% and of Test 3, 14.98% of the head. The bulk concentrates have not been assayed for lead and zinc, but lead and zinc recoveries can be assumed in the range of 97 to 98%.

Silver grades, corresponding recoveries and bulk weights as shown in drawing 373-1-2 indicate the advantage of finer grinding. Better liberation of the minerals with higher concentrate grades can be expected from closed circuit grinding in mill operation. The economic shipping grade of the concentrate will be dependent on the freight and smelter charges. As seen from graph 2, a 120 oz. silver per ton concentrate weighing 10% of the ore will contain about 86% of the silver. This product may be economical and corresponds to the preliminary assumption made in the test work.

Table 4
Bulk Flotation
Test Results - Reagent Consumption and Test Conditions

#	Product	Weight % Test 2	Weight % Test 3	Ag Assay oz/ton Test 2	Ag Assay oz/ton Test 3	Ag Distribution % Test 2	Ag Distribution % Test 3
1	1st Concentrate	9.77	8.77	114.3	131.1	81.42	84.11
2	2nd Concentrate	1.85	1.71	30.5	25.0	4.11	3.12
3	3rd Concentrate	1.41	1.57	17.4	13.1	1.79	1.51
4	4th Concentrate	1.81	1.79	8.8	7.1	1.16	0.93
5	5th Concentrate	1.16	1.14	8.7	8.3	0.74	0.69
6	Tailing	84.00	85.02	1.76	1.55	10.78	9.64
	Head (calc.)	100.00	100.00	13.7	13.7	100.00	100.00

Cumulative Results

Product	Weight % Test 2	Weight % Test 3	Conc. assay Ag oz/ton Test 2	Conc. assay Ag oz/ton Test 3	Ag recovery % Test 2	Ag recovery % Test 3	Tailing assay Ag oz/ton Test 2	Tailing assay Ag oz/ton Test 3
Conc. 1	9.77	8.77	114.3	131.1	81.42	84.11	2.82	2.38
Conc. 1 + 2	11.62	10.48	101.0	113.8	85.53	87.23	2.24	1.95
Conc. 1 to 3	13.03	12.05	91.9	100.7	87.32	88.74	2.00	1.75
Conc. 1 to 4	14.84	13.84	81.8	88.6	88.48	89.67	1.85	1.64
Conc. 1 to 5	16.00	14.98	76.5	82.5	89.22	90.36	1.76	1.55

Reagent Consumptions and Test Conditions

Reagents, etc.	Grinding Mill	1st conc.	2nd conc.	3rd conc.	4th conc.	5th conc.	Total
Pine oil	0.024						0.024
Xanthate Z9	-	0.05	0.05	0.05	0.05	0.05	0.25
Dowfroth 250	-	0.03	0.03	0.03	0.03	0.03	0.15
Copper Sulphate	-	-	-	-	0.25	-	0.25
pH (Test 2	-	8.3	-	8.2	-	7.6	-
pH (Test 3	-	8.3	-	8.3	-	7.8	-
Temp °C (Test 2	-	18	-	21	-	22	-
Temp °C (Test 3	-	20	-	22	-	24	-
Frothing time - Min.	-	5	5	5	5	5	25
speed R.P.M.	-	1500-1600	1500-1600	1500-1600	1500-1600	1500-1600	-
Pulp density % solids	70	27	-	-	-	-	-

All reagent consumptions are expressed in pounds per ton of original ore.

Grind (approx.) - Test 2 70% - 200 mesh Test 3 85% - 200 mesh

Four bulk rougher flotation tests (Test No. 22 to 26) with Wolfe No. 2 ore ground to various fineness were carried out by the Mines Branch, Ottawa.

The Wolfe No. 2 ore sample with about 26 oz. silver per ton of ore is more suitable for flotation than the North Star ore.

When the ore was ground to about 85% minus 200 mesh and using lime, Potassium Amyl Xanthate (Z-6) and Pine oil, 97% of the silver was recovered in a rougher concentrate containing more than 170 oz. silver per ton (Test No. 23). Upgrading to about 420 oz. silver per ton with 88% recovery was possible in two cleaning stages without addition of reagents. A concentration ratio of 18.5 was achieved. Results and test conditions are shown in Tables 5 and 6.

Table 5
Bulk Roughing on the Wolfe No. 2 Ore at Different Grinds

Test No.	Grind % -200 mesh	CaO	Na_2CO_3	Z-6	Pine Oil	pH	Frothing Time, Min.	Weight %	Oz/ton Ag	Recovery % Ag
22	84.8	-	2.0	0.15	0.06	9.0	9	16.7	151.88	97.8
23	84.8	0.7	-	0.15	0.06	9.0	9	14.6	171.44	97.0
24	65.2	0.7	-	0.2	0.08	8.9	9	14.1	175.12	96.5
25	52.2	0.7	-	0.2	0.08	8.9	8	13.4	185.32	95.9

Table 6
Cleaning of the Bulk Rougher Concentrate No. 23

Product	Weight %	Oz/ton Ag	Recovery % Ag
Bulk Concentrate	5.4	421.70	88.3
2nd Cleaner Tails	4.2	38.34	6.2
1st Cleaner Tails	5.0	12.96	2.5
Flotation Tails	85.4	0.91	3.0
Head (calc.)	100.0	25.81	100.0

Note:
Lime was added to maintain pH = 10.0 in both cleaner stages. No additional reagents were added during the cleaning operation.

SILVER EXTRACTION BY CYANIDATION

Straight Cyanidation

Two tests were made at the Mines Branch, Ottawa, to compare the silver extraction by cyanidation in the North Star, and Wolfe No. 2 ores. The North Star sample assayed 13.61 and the Wolfe No. 2 sample 24.01 oz. silver per ton. 73.3% of the silver was recovered from the North Star ore which was ground to 88.3% minus 200 mesh, whilst only 36.5% of the silver was recovered from Wolfe No. 2 ore which was ground to 84.8% minus 200 mesh. These results are shown in Table 7.

Very fine grinding will be necessary for higher silver recoveries by straight cyanidation. No more testwork was made in this field.

Table 7
Straight Cyanidation on the North Star Ore and Wolfe No. 2 Ore

			Ag oz/ton		Recovery %
Test No.	Ore	Grind % -200 mesh	Feed	Cyanide Residue	Ag
A	North Star	88.3	13.61	3.63	73.3
B	Wolfe No. 2	84.8	24.01	15.24	36.5

Cyanidation Tests on Flotation Tailings

A series of cyanidation tests on flotation tailings from the various tests were carried out by the Mines Branch, Ottawa.

The flotation tailings all from the North Star ore sample assayed from 2.04 to 2.67 oz. silver per ton. The dilution in agitation was 2:1, except in Test 9K in which the dilution was 5:1. The solution strength was maintained at 1.0 lb. NaCN/ton and 1.0 lb. CaO/ton in Test 3 to 8 and 0.5 lb. NaCN/ton and 0.5 lb. CaO/ton in the remainder.

The best result of these series was achieved in Test 9H with 48 hours agitation recovering only 70.6% of the silver in the tailings. The cyanide consumption was 1.12 lb. per ton of ore and the lime consumption 2 lb. per ton of ore. These results indicate that very fine grinding of the flotation tailing will be necessary for a greater efficiency in silver extraction.

The complete testwork of cyanidation on flotation tailings is shown in Table 8.

Table 8
Cyanidation Tests on Flotation Tailings

Test No.	Grind % -200 mesh	Cyanidation Time Hours	Reagent Consumption lbs./ton ore NaCN	CaO	Ag oz/ton Head	Residue	Recovery % Ag
3	64.1	24	0.34	1.20	2.59	1.85	28.6
4	64.1	48	0.53	1.28	2.59	1.41	45.6
5	64.1	72	0.44	1.36	2.59	1.24	52.1
6	82.2	48	0.77	1.31	2.59	0.93	64.1
7	80.3	24	0.28	0.96	2.67	1.29	51.7
8	80.3	48	0.44	1.04	2.67	1.12	58.0
9A	69.7	48	0.64	1.48	2.04	1.04	49.0
9B	69.7	24 FR 24*	1.20	2.24	2.04	1.03	49.5
9C	93.2	48	1.00	1.40	2.04	0.88	56.9
9D	93.2	24 FR 24*	1.16	2.84	2.04	0.765	62.5
9E	93.2	48	0.96	1.80	2.04	0.74	63.7
9F	93.2	24 FR 24*	1.84	2.60	2.04	0.63	69.1
9G	93.2	24 FR 24FR24*	2.48	3.24	2.04	0.55	73.0
9H	98.0	48	1.12	2.00	2.04	0.60	70.6
9K	98.0	24 FR 24*	4.56	5.04	2.04	0.40	80.4

Note: Tests 3 to 8 - Dilution in agitator: 2:1
Solution strength: 1.0 lb. NaCN/ton and 1.0 lb. CaO/ton
Tests 9A to 9H - Dilution in agitator: 2:1
Solution strength: 0.5 lb. NaCN/ton and 0.5 lb. CaO/ton
Test 9K - Dilution in agitator: 5:1
Solution strength: 0.5 lb. NaCN/ton and 0.5 lb. CaO/ton

* 24 Hr cyanidation followed by filtering and re-pulping in fresh solution.

SUMMARY AND CONCLUSIONS

Three flotation methods were used in the metallurgical testwork to recover the silver-lead and zinc minerals from samples of the North Star and Wolfe No. 2 ore deposits of Dolly Varden Mines Limited:

(a) Bulk flotation to produce a silver-lead-zinc bulk concentrate for shipment to a smelter.
(b) Bulk flotation followed by selective flotation with or without regrinding of the bulk concentrate to produce a silver-lead and zinc concentrate.
(c) Direct selective flotation to produce a silver-lead and zinc concentrate.

Several cyanidation tests were carried out to recover additional silver from bulk tailing (primary tailing).

The North Star ore sample assayed 14.0 oz. silver whilst the Wolfe No. 2 ore sample was higher in silver containing about 26 oz. silver per ton of ore.

The testwork shows that grinding from 78% to 85% minus 200 mesh or finer is necessary for mineral liberation.

After grinding the North Star ore sample to 85% minus 200 mesh, 90.36% of the silver recovered in a bulk concentrate of 14.98% by weight of the feed containing 82.5 oz. silver per ton. Lead and zinc recoveries can be assumed of from 97 to 98%. The relationship of recovered silver to silver grade and fineness of grinding of the bulk concentrate is shown graphically in drawing 373-1-2. A concentrate assaying 120 oz. Ag per ton and being 10% by weight of the head will contain about 86% of the silver in the ore. Higher concentrate grades may be achieved in practise from closed circuit grinding and continuous mill operation.

The Wolfe No. 2 ore sample is more suitable for flotation. This ore ground to the same fineness (85% minus 200 mesh) gave a bulk concentrate of 14.6% by weight of the head assaying 171.44 oz. silver per ton at 97% recovery. By twice cleaning, upgrading to 420 oz. Ag per ton, an 88% silver recovery was possible. The Mines Branch, Ottawa, reported in a letter dated September 28, 1964 that a high grade final bulk concentrate assaying 754.0 oz. silver per ton at 84% recovery has been achieved after four cleanings. No other details are available at present.

Using bulk flotation followed by selective flotation of the reground bulk concentrate to 78% minus 200 mesh, 76.6% of the silver in ore was recovered in a silver-lead concentrate of 5.48% by weight of the head and assaying 185.0 oz. silver per ton. In one cleaning, this product was upgraded to 294.1 oz. Ag per ton at 70.65% recovery. A half of the zinc in ore was recovered in a zinc concentrate of 47.36% zinc, whilst about 46% of the zinc remained in the silver-lead rougher concentrate which was reduced by cleaning to about 32% of the zinc.

More than 12% less silver was recovered at a higher grade using the direct selective flotation method. The silver-lead rougher concentrate of 2.7% by weight of the feed assayed 332.19 oz. silver per ton at 63.8% recovery. The once cleaned zinc concentrate contains about 59% zinc at 64% recovery, only about 12% of the zinc remained in the silver-lead rougher concentrate. These results will be improved in continuous mill operation.

The flotation testwork on North Star ore indicates, that in both methods, the direct selective flotation or the bulk flotation followed by selective flotation with regrinding the bulk concentrate, good silver-lead and zinc concentrates can be produced. Direct selective separation is simpler and the capital cost is lower with somewhat better zinc metallurgy. On the other hand, regrinding of the bulk concentrate in the first method will decrease the grinding cost appreciably.

A total cell volume of 620 cu. ft. is necessary for a 300 short tons a day mill capacity in the direct selective flotation method. Of this, 240 cu. ft. is for Ag-Pb roughing, 320 cu. ft. (max.) for zinc roughing and 60 cu.ft. for zinc cleaning.

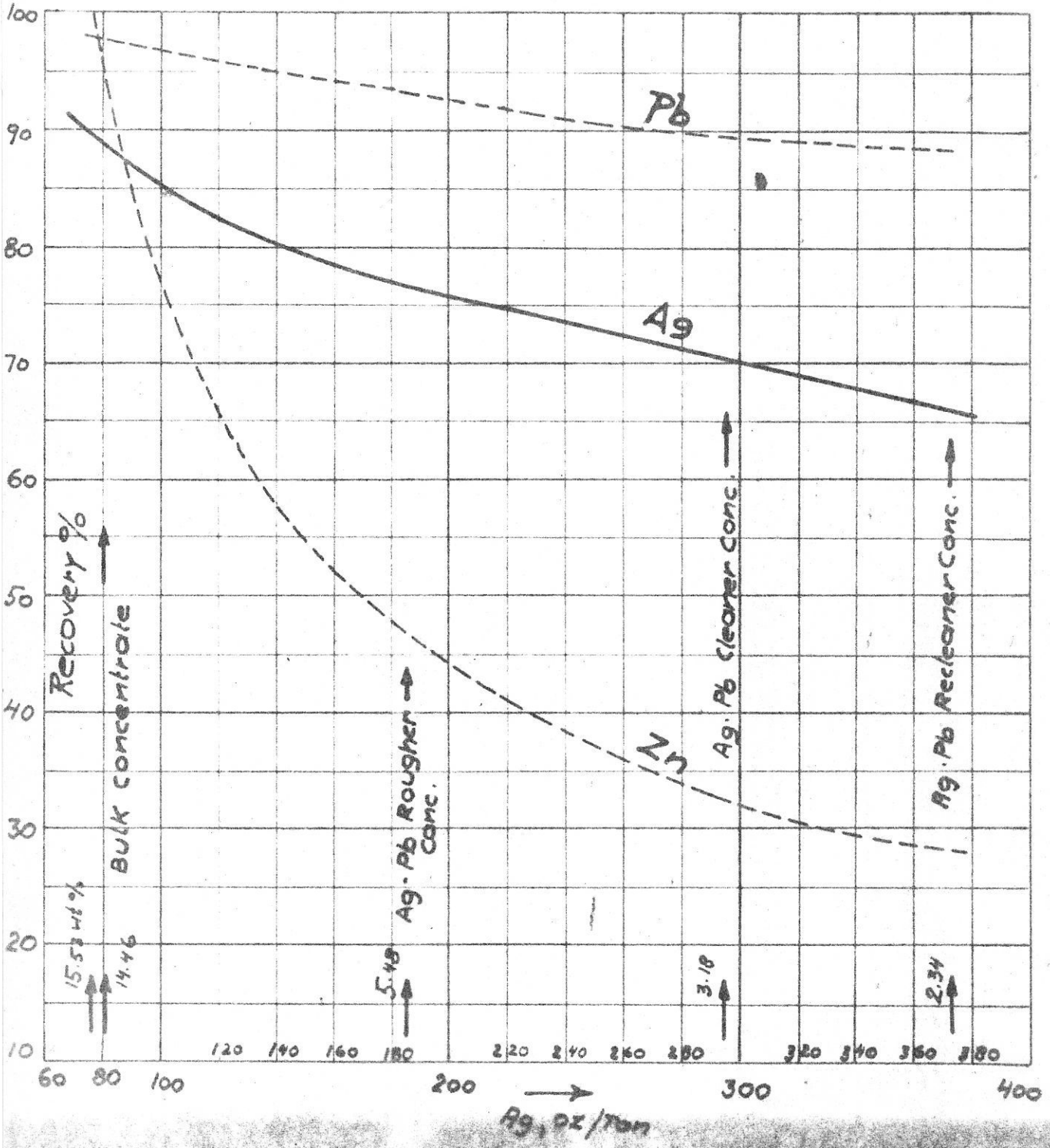
Using bulk flotation followed by selective flotation, a total cell volume of 780 cu. ft. must be installed. This is an increase of 26%. Of this, 560 cu. ft. is for bulk flotation and about 110 cu. ft. for each of the silver-lead and the zinc sections.

It will require 560 cu. ft. for production of a bulk concentrate comprising the silver-lead and zinc minerals from the North Star ore, whilst 400 cu. ft. will be sufficient for the Wolfe No. 2 ore which is much easier to float. Of this, 320 cu. ft. is for roughing and 80 cu. ft. for cleaning in two stages.

Cyanidation tests on flotation tailings from the North Star ore indicate that very fine grinding will be necessary. Only 70.6% of the silver was recovered from flotation tailing ground to 98% minus 200 mesh by cyanidation with reasonable cyanide consumption (North Star ore, Test 9H).

High losses occur in the total tailing using selective flotation. The best operating technique will depend on the proportion of the ores to be treated from the various deposits, freight and smelter charges for the concentrates, the unit cost of cyanidation of the silver remaining in the tailing, fineness of grinding and reagent consumption.

The development work on Wolfe No. 2 ore is continuing. A composite sample of probable mill feed will be necessary before finalizing the mill flowsheet.



SILVER-LEAD AND ZINC RECOVERIES IN CONCENTRATES OF NORTH STAR ORE RELATIVE TO THEIR SILVER CONTENTS.

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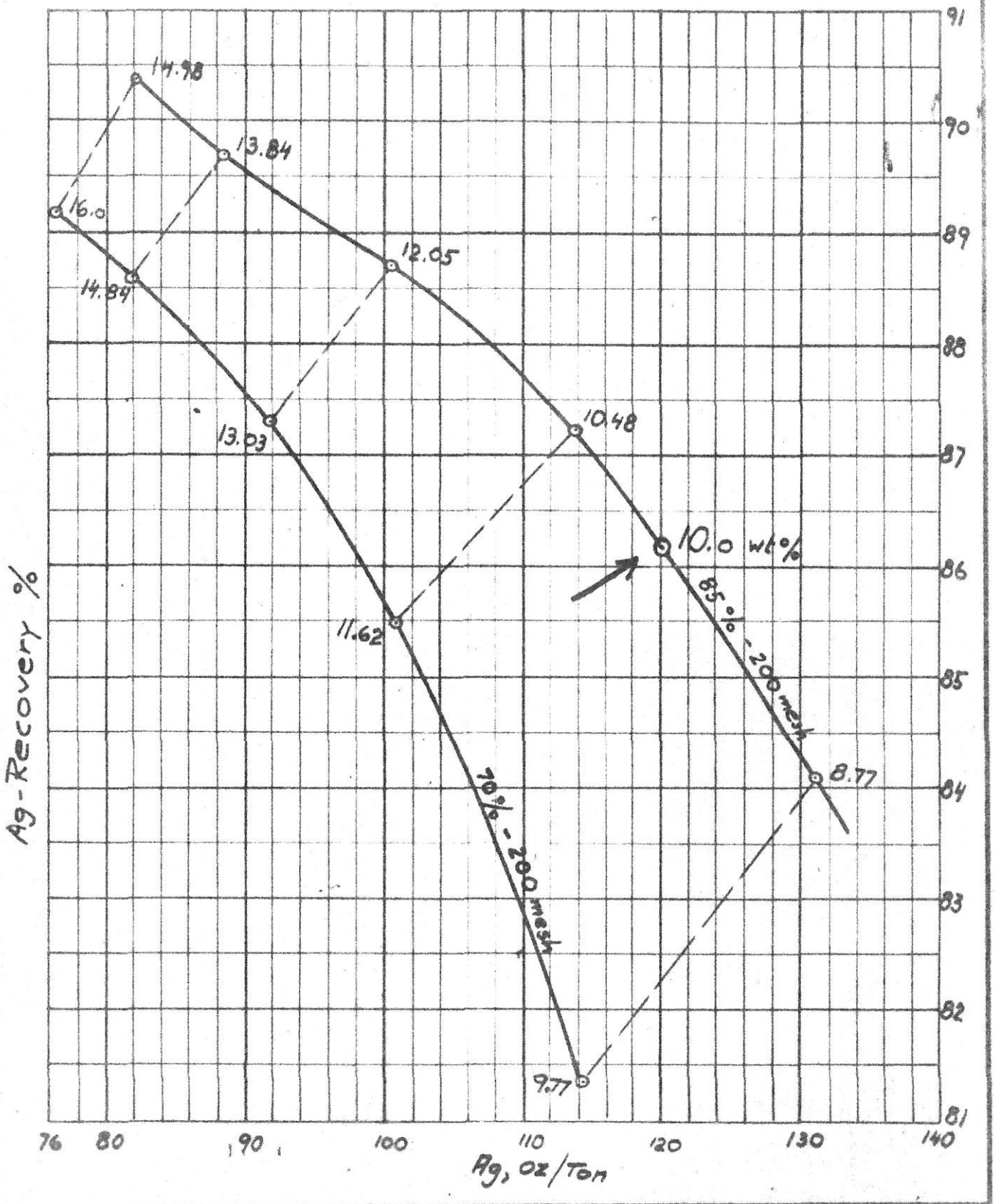

BULK FLOTATION
NORTH STAR ORE

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