

An Investigation of  
THE RECOVERY OF COPPER  
from samples  
submitted by  
CORDILLERAN ENGINEERING LIMITED  
Progress Report No. 1

680319

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Progress Report No.1

Project No. L.R. 1174

NOTE:

This report refers to the samples as received.

The practice of this Company in issuing reports of this nature is to require the recipient not to publish the report or any part thereof without the written consent of Lakefield Research of Canada Limited.

LAKEFIELD RESEARCH OF CANADA LIMITED

Lakefield, Ontario

April 4, 1968

## I N T R O D U C T I O N

This report describes the results of mineralogical examinations and preliminary flotation tests on two samples of copper ore which were received from Cordillera Engineering Limited.

In his letter of January 8, 1968, Mr. J.W. Stollery authorized us to proceed with a preliminary testing program on these samples, as outlined in our proposal of November 24, 1967.

## S U M M A R Y

### 1. Head Analyses

#### a. Chemical Analyses

Sample No.	Type	Direct Assays, %			Calc. <sup>†</sup> % Total Cu
		Total Cu	Oxide Cu	S	
1	Sulphide Ore	0.42	0.01	1.51	0.39
2	Oxide Ore	0.48	0.28	0.90	0.44

<sup>†</sup> Calculated from average flotation test heads.

#### b. Semi-Quantitative Spectrographic Analysis

	Sample 1	Sample 2		Sample 1	Sample 2
Antimony	ND	ND	Phosphorus	ND	ND
Arsenic	ND	ND	Platinum	ND	ND
Barium	.05 %	.05 %	Rhenium	X	X
Beryllium (BeO)	ND	ND	Rhodium	ND	ND
Bismuth	ND	ND	Rubidium	X	X
Boron	ND	ND	Ruthenium	ND	ND
Cadmium	ND	ND	Silver	.1 oz/t	.1 oz/t
Cerium (CeO <sub>2</sub> )	ND	ND	Strontium	ND	ND
Caesium	X	X	Tantalum (Ta <sub>2</sub> O <sub>5</sub> )	ND	ND
Chromium	.01 %	.01 %	Tellurium	ND	ND
Cobalt	.005 %	.005 %	Thallium	ND	ND
Columbium (Cb <sub>2</sub> O <sub>5</sub> )	ND	ND	Thorium (ThO <sub>2</sub> )	ND	ND
Copper	1 %	1 %	Tin	ND	ND
Gallium	.001 %	.001 %	Titanium	1 %	1 %
Germanium	ND	ND	Tungsten	ND	ND
Gold	ND	ND	Uranium (U <sub>3</sub> O <sub>8</sub> )	ND	ND
Hafnium	ND	ND	Vanadium	.02 %	.02 %
Indium	ND	ND	Yttrium (Y <sub>2</sub> O <sub>3</sub> )	ND	ND
Iridium	ND	ND	Zinc	ND	ND
Lanthanum (La <sub>2</sub> O <sub>3</sub> )	ND	ND	Zirconium (ZrO <sub>2</sub> )	.01 %	.01 %
Lead	.1 %	.05 %	ROCK FORMING METALS		
Lithium (Li <sub>2</sub> O)	ND	ND	Aluminum (Al <sub>2</sub> O <sub>3</sub> )	30 %	30 %
Manganese	.05 %	.05 %	Calcium (CaO)	5 %	1 %
Mercury	ND	ND	Iron (Fe)	5 %	5 %
Molybdenum	.002 %	.001 %	Magnesium (MgO)	5 %	5 %
Neodymium (Nd <sub>2</sub> O <sub>3</sub> )	ND	ND	Silica (SiO <sub>2</sub> )	H	H
Nickel	.005 %	.005 %	Sodium (Na <sub>2</sub> O)	2 %	11%
Palladium	ND	ND	Potassium (K <sub>2</sub> O)	2 %	2 %



Summary - Continued

Figures are approximate:

Code

H - High  
X - Not Looked For  
ND - Elements looked for but not found

2. Mineralogy

Chalcopyrite was the only copper mineral identified in the sulphide ore. Grain size varied from less than 5 to greater than 60 microns. Free grains were smaller than 35 microns (400 mesh). In mixed grains, the chalcopyrite was mostly associated with non-metallic gangue rather than with pyrite.

The oxide sample contained malachite as well as chalcopyrite. Approximately 40 percent of the chalcopyrite and much of the pyrite was rimmed with iron oxide.

Fine veinlets, believed to contain galena and silver, were seen in both samples.

3. Flotation

A high ratio of concentration was attained with the No. 1 (sulphide) ore. Best results were achieved in test 10 in which the ore was ground to approximately 78 percent minus 200 mesh, and rougher and scavenger concentrates were recovered. The rougher concentrate was cleaned five times; cleaner tailings were combined with the scavenger

Summary - Continued

concentrate and reground to essentially 100 percent minus 270 mesh. The reground product was cleaned three times.

Predicted recoveries for various grades of concentrate were as follows:

Grade of Concentrate % Cu	% Recovery Cu
20	88.0
24	84.5
28	79.5
30	65.0

Some silver was recovered with the copper. For example, in test 8 the rougher (primary) cleaner concentrate contained 2.30 ounces of silver per ton.

The major problem in flotation was in separating the chalcopryrite from siliceous gangue, which appeared to be readily activated by xanthate. The problem was partially overcome by using a minimum amount of ethyl xanthate, by the use of lime and sodium silicate, and by repeated cleanings. Nevertheless, close to 15 percent of the copper reported in the cleaner tailings (test 10). Further testwork should be carried out to determine whether a significant portion of the copper in the cleaner tailings could be recovered without diluting the concentrate.

\*

Summary - Continued

Only two tests were done on the oxide ore due to the limited quantity available. Poor results were obtained. In test 7, 33.1 percent of the total copper was recovered in a concentrate which assayed 8.40 percent copper. Undoubtedly the grade of concentrate could be improved by further testing if more material had been available. Significant improvement in recovery by flotation may not be possible due to the large percentage of oxide copper in this ore.

4. Reagents

Reagents used in test 10 were as follows:

<u>Reagent</u>	<u>Amount lbs/ton</u>
Lime - $\text{Ca}(\text{OH})_2$	1.35
Ethyl Xanthate (Z-4)	0.14
Netso Granular - $\text{Na}_2\text{SiO}_3 \cdot 5\text{H}_2\text{O}$	0.50
Methyl Isobutyl Carbinol (MIBC)	0.06

(reagents used for second scavenger concentrate not included)



Summary - Continued

5. Power Consumption

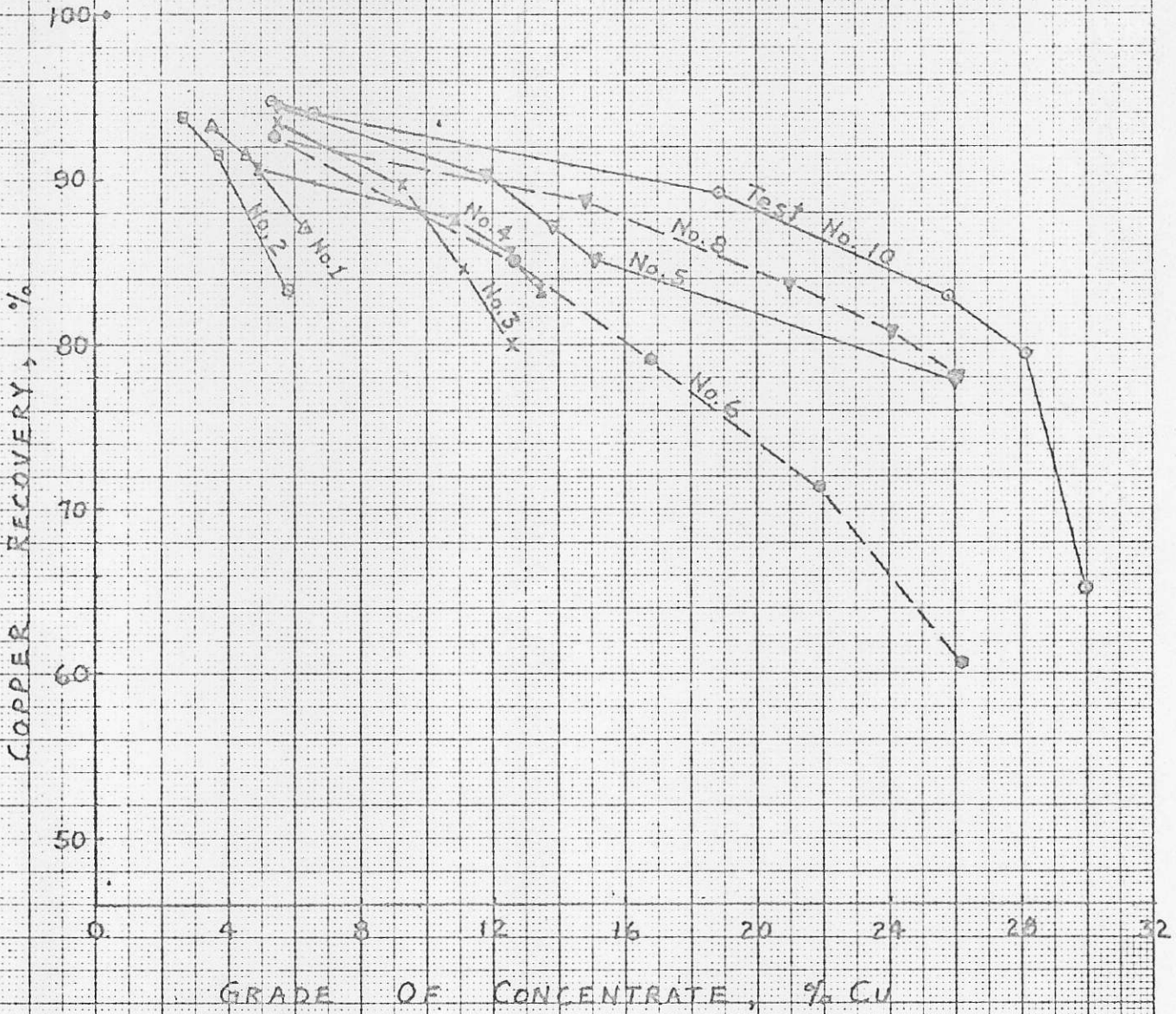
The calculated net power expended in grinding the minus 10 mesh roll-crushed sulphide ore to 78 percent minus 200 mesh was 6.2 kilowatt-hours per ton (test 10). The power expended in regrinding the scavenger concentrate was not determined; however, this was very small because less than 5 percent of the rougher flotation feed was reground.

LAKEFIELD RESEARCH OF CANADA LIMITED



A.G. Scobie, P. Eng.

Manager.



Grade-Recovery Curves - SULPHIDE ORE

CC & S  
MICROGRAPH

10 X 10 TO THE CM  
G8-14

## MINERALOGY

### Introduction

Two samples labelled "Sulphide Head Sample" and "Oxide Head Sample" respectively were received for microscopic examination. The samples consisted of minus 10 mesh material.

Polished grain mounts representative of each sample were prepared for microscopic examination. The purpose of the examination was

1. Identification of the copper minerals.
2. Determination of the ore mineral grain size.
3. Determination of ore mineral association with respect to grain size.

### Copper Mineralization

The only copper minerals identified were chalcopyrite and malachite. Fine veinlets and stringers of a mineral galena were also present. The chalcopyrite exhibited two distinctly different colours, a difference which showed up distinctly in adjoining grains of the copper sulphide. Pyrite was also present in both samples.

### Sulphide Ore

Chalcopyrite was the only copper mineral identified with certainty in this sample. It was present as grains ranging in size from smaller than 5 microns to more than 60 microns. The average grain size was estimated to be between 25 and 35 microns. Approximately 30 percent of the chalcopyrite appeared to be free, and such grains were smaller than 35 microns. Chalcopyrite coarser than 35 microns was associated with either non-metallic gangue or pyrite in mixed grains. Distribution of copper sulphide in this association was approximately 80 percent or more with non-metallic gangue and 20 percent or less with pyrite.



Mineralogy - Continued

Veinlets or seams of a mineral resembling galena were present. These veins were too narrow for any physical tests under the microscope. Silver was believed to be present in these veinlets.

Oxide Ore

Chalcopyrite and malachite were the only two copper minerals identified. Cuprite may have been present. The ratio of chalcopyrite to malachite was estimated to be 4:1. The malachite grain sizes ranged from smaller than 5 to 40 microns and the chalcopyrite grain sizes ranged from smaller than 5 to greater than 100 microns. The average grain size for 60 percent of the chalcopyrite was estimated to be 30 to 35 microns. Approximately 40 percent of the copper sulphide and much of the pyrite was rimmed with iron oxide. The oxide rims varied in thickness from submicron to 10 microns.

Veinlets of galena or galena plus silver, were present in the coarser grains.

SAMPLE PREPARATION

Seventy pounds of sample No. 1 and fifteen pounds of sample No. 2 were received on January 18, 1968. These were assigned Lakefield reference No. 6818389.

The samples had been originally crushed to approximately 1/8 inch. Fifty pounds of the No. 1 sample and all the No. 2 sample was reduced by roll crushing to pass a 10 mesh screen. It then was mixed and riffled into 1000 gram charges for testing and analysis.

Approximately eighteen pounds of the No. 1 sample remained after these tests. All the No. 2 sample was used.



DETAILS OF TESTS

Test Nos. 1 and 2

Purpose: Preliminary tests on the No. 1 sample to determine the liberation size.

Procedure: Grind and float a series of copper rougher concentrates.

Feed: Two 1000-gram charges of minus 10 mesh sample No. 1.

Grinds: 10 and 20 minutes at 50 percent solids in the ball mill (28 pounds steel) for tests 1 and 2 respectively.

Conditions:

Stage	Reagents Added, pounds per ton			Time, minutes		pH
	Na <sub>2</sub> CO <sub>3</sub>	Z-6 *	MIBC **	Cond.	Froth	
Conditioning	1.0	-	-	3	-	8.2
Cu Concentrate 1	-	0.05	0.05	2	3	-
Cu Concentrate 2	-	0.05	0.02	1	3	-
Cu Concentrate 3	-	0.05	0.02	1	3	-

\* Potassium amyl xanthate  
 \*\* Methyl isobutyl carbinol

Stage                      Rougher Flotation  
 Flotation Cell            1000 gram D-1  
 Speed: r.p.m.            1700  
 % Solids                    16

Metallurgical Results - Test No. 1

Products	Weight %	Assays, % Cu	% Distribution Cu
Cu Concentrate 1	5.47	6.30	87.08
Cu Concentrate 2	2.51	0.70	4.45
Cu Concentrate 3	2.66	0.25	1.69
Flotation Tailing	89.36	0.03	6.78
Head (calculated)	100.00	0.40	100.00

Calculated Grades and Recoveries

Concentrates 1 + 2	7.98	4.54	91.53
Concentrates 1 to 3	10.64	3.47	93.22

Test Nos. 1 and 2 - Continued

Metallurgical Results - Test No. 2

Products	Weight %	Assays, % Cu	% Distribution Cu
Cu Concentrate 1	5.90	5.78	83.27
Cu Concentrate 2	4.77	0.71	8.28
Cu Concentrate 3	4.35	0.21	2.22
Flotation Tailing	84.98	0.03	6.23
Head (calculated)	100.00	0.41	100.00

Calculated Grades and Recoveries

Concentrates 1 + 2	10.17	3.69	91.55
Concentrates 1 to 3	14.52	2.64	93.77

Comments: Rougher recoveries were about equal in tests No. 1 and 2, indicating that a primary grind to approximately 78 percent may be satisfactory. Rougher concentrates were very low in grade.

Screen Analyses of Flotation Feed

Mesh Size (Tyler)	Test No. 1			Test No. 2		
	% Retained Ind.	% Retained Cum.	% Passing Cum.	% Retained Ind.	% Retained Cum.	% Passing Cum.
+ 48	0.4	0.4	99.6	-	-	-
65	1.4	1.8	98.2	0.1	0.1	99.9
100	4.0	5.8	94.2	0.6	0.7	99.3
150	6.8	12.6	87.4	2.4	3.1	96.9
200	8.9	21.5	78.5	4.8	7.9	92.1
270	8.9	30.4	69.6	6.5	14.4	85.6
325	10.3	40.7	59.3	10.3	24.7	75.3
- 325	59.3	100.0	-	75.3	100.0	-
Total	100.0	-	-	100.0	-	-

Calc. Net Power Expended in Grinding - Test No. 1 = 6.2 kwh/ton  
 Test No. 2 = 12.4 kwh/ton

Test No. 3

Purpose: To investigate the effect of cleaning the combined rougher concentrates.

Procedure: Grind, float a rougher concentrate and clean the concentrate three times.

Feed: 2000 grams of minus 10 mesh sample No. 1.

Grind: 20 minutes at 60 percent solids in the ball mill.

Conditions:

Stage	Reagents Added, lbs/ton			Time, minutes			pH
	Na <sub>2</sub> CO <sub>3</sub>	Z-6	MIBC	Grind	Cond.	Froth	
Grind	1.0	-	-	20	-	-	-
Rougher Float (1)	-	0.05	0.05	-	2	3	8.3
Rougher Float (2)	-	0.05	0.01	-	1	3	-
Rougher Float (3)	-	0.05	0.01	-	1	3	-
1st Cleaning (1)	-	-	-	-	1	2	-
(2)	-	-	0.01	-	1	2	-
2nd Cleaning	-	-	0.01	-	1	3	-
3rd Cleaning	-	-	0.01	-	1	2	-

Stage	Flotation	Cleaning
Flotation Cell	1000 gram D-1	250 gram D-1
Speed: r.p.m.	1700	1000
% Solids	33	

Test No. 3 - Continued

Metallurgical Results

Products	Weight %	Assays, % Cu	% Distribution Cu
Cu Cleaner Concentrate	2.55	12.58	80.00
3rd Cleaner Tailing	0.50	3.68	4.59
2nd Cleaner Tailing	0.82	2.54	5.19
1st Cleaner Tailing	2.98	0.50	3.71
Rougher Tailing	93.15	0.028	6.51
Head (calculated)	100.00	0.40	100.00

Calculated Grades and Recoveries

Conc. after 2 Cleanings	3.05	11.12	84.59
Conc. after 1 Cleaning	3.87	9.30	89.78
Rougher Concentrate	6.85	5.47	93.49

Comments: Grade of concentrate was improved considerably by cleaning, but was still well below normal commercial grade.



Test No. 4

Purpose: To repeat test No. 3, but regrind the rougher concentrate before cleaning.

Procedure: Grind, float a rougher concentrate, regrind the concentrate and clean three times.

Feed: 2000 grams of minus 10 mesh sample No. 1.

Grind: 20 minutes at 60 percent solids in the ball mill.

Conditions:

Stage	Reagents Added, lbs/ton			Time, minutes			pH
	Na <sub>2</sub> CO <sub>3</sub>	Z-6	MIBC	Grind	Cond.	Froth	
Grind	1.0	-	-	20	-	-	-
Rougher Float (1)	-	0.05	0.05	-	2	3	8.3
Rougher Float (2)	-	0.05	0.01	-	1	3	-
Rougher Float (3)	-	0.05	0.01	-	1	3	-
Ro. Conc. Regrind	-	-	-	10	-	-	-
1st Cleaning (1)	-	0.01	0.02	-	1	2	-
(2)	-	0.01	-	-	1	2	-
2nd Cleaning	-	-	0.01	-	1	3	-
3rd Cleaning	-	-	0.01	-	1	2	-

Stage  
Equipment  
Speed: r.p.m.  
% Solids

Roughing  
1000 gram D-1  
1700  
33

Concentrate Regrind  
Pebble Mill  
(10 lbs. pebbles)

Stage  
Flotation Cell  
Speed: r.p.m.

1st Cleaning  
500 gram D-1  
1300

2nd and 3rd Cleanings  
250 gram D-1  
1000



Test No. 4 - Continued

Metallurgical Results

Products	Weight %	Assays, % Cu	% Distribution Cu
Cu Cleaner Concentrate	2.46	13.46	83.19
3rd Cleaner Tailing	0.24	3.84	2.31
2nd Cleaner Tailing	0.52	1.65	2.16
1st Cleaner Tailing	4.18	0.29	3.04
Rougher Tailing	92.60	0.04	9.30
Head (calculated)	100.00	0.40	100.00

Calculated Grades and Recoveries

Conc. after 2 Cleanings	2.70	12.60	85.50
Conc. after 1 Cleaning	3.22	10.84	87.66
Rougher Concentrate	7.40	4.88	90.70

Comments: A modest improvement was attained by regrinding. Binocular examination of Flotation products revealed that the concentrates contained a considerable amount of siliceous material which was mostly free, or almost free, of sulphides.

Test No. 5

**Purpose:** To investigate the effect of using a more selective collector and of splitting the float into a rougher and scavenger circuit, cleaning each separately. Lime was substituted for soda ash and the pH was raised.

**Procedure:** Grind, float a rougher and a scavenger concentrate. Clean the rougher concentrate three times, combine the cleaner tailings with the scavenger concentrate and clean three times.

**Feed:** Two 2000-gram samples of minus 10 mesh sample No. 1.

**Grind:** Each 2000 grams ground for 40 minutes at 60 percent solids in the ball mill.

**Conditions:**

Stage	Reagents Added, lbs/ton			Time, minutes			pH
	Ca(OH) <sub>2</sub>	Z-4A	MIBC	Grind	Cond.	Froth	
Grind	1.0	-	-	80	-	-	-
Rougher Float (1)	-	0.02	0.05	-	2	2	9.7
(2)	-	0.02	-	-	1	2	-
Scavenger Float (1)	-	0.05	0.01	-	1	3	-
(2)	-	0.05	0.01	-	1	3	-
1st Ro. Cleaning	0.05	-	-	-	2	2	10.5
2nd Ro. Cleaning	0.05	-	-	-	2	1½	10.9
3rd Ro. Cleaning	-	-	0.005	-	1	1	-
1st Scav. Cleaning (1)	0.10	-	-	-	2	2	10.7
(2)	-	0.01	0.005	-	1	2	-
2nd Scav. Cleaning	0.05	-	-	-	2	2	11.0
3rd Scav. Cleaning	-	-	-	-	1	1½	-

Stage	Roughing	Rougher Cleaning
Flotation Cell	2000 gram D-2	250 gram D-1
Speed: r.p.m.	1100	950
% Solids	30	

Stage	1st Scav. Cleaning	2nd + 3rd Scav. Cl.
Flotation Cell	500 gram D-1	250 gram D-1
Speed: r.p.m.	1200	950

\* Sodium Ethyl Xanthate

Test No. 5 - Continued

Metallurgical Results

Products	Weight %	Assays, % Cu	% Distribution Cu
1. Rougher Cleaner Conc.	1.16	26.00	77.90
2. Scavenger Cleaner Conc.	1.02	2.77	7.31
3. 3rd Scav. Cleaner Tail.	0.26	2.98	1.99
4. 2nd Scav. Cleaner Tail.	0.52	2.38	3.20
5. 1st Scav. Cleaner Tail.	3.66	0.43	4.05
6. Rougher Tailing	93.38	0.023	5.55
Head (calculated)	100.00	0.39	100.00

Calculated Grades and Recoveries

Products 1 + 2	2.18	15.13	85.21
Products 1 to 3	2.44	13.84	87.20
Products 1 to 4	2.96	11.82	90.40
Products 1 to 5	6.62	5.52	94.45

Comments: A marked improvement in selectivity was achieved when the rougher concentrate was cleaned. Cleaning was relatively ineffective on the scavenger products after the first stage.

Test No. 6

Purpose: To repeat test No. 5, except combine the rougher and scavenger concentrates and regrind before cleaning. A slime depressant also to be used.

Procedure: Grind, float a rougher concentrate, regrind the concentrate and clean three times.

Feed: Two 2000-gram samples of minus 10 mesh sample No. 1.

Grind: Two 40-minute grinds at 60 percent solids in the ball mill.

Conditions:

Stage	Reagents Added, lbs/ton				Time, minutes			PH
	Ca(OH) <sub>2</sub>	R-620 *	Z-4	MIBC	Grind	Cond.	Froth	
Grind	1.0	-	-	-	40	-	-	-
Rougher Float (1)	-	0.20	0.02	0.03	-	2	2	9.8
(2)	-	-	0.02	-	-	1	2	-
(3)	-	-	0.05	-	-	1	3	-
(4)	-	-	0.05	0.01	-	1	3	-
Conc. Regrind	-	-	-	-	15	-	-	-
1st Cleaning (1)	0.1	-	-	-	-	3	2	9.9
(2)	-	-	0.005	0.005	-	1	2	-
2nd Cleaning	-	-	-	-	-	1	3	9.5
3rd Cleaning	0.05	-	-	-	-	2	2½	9.6
4th Cleaning	-	0.05	-	-	-	5	2	9.0

\* Cyanamid Reagent 620



Test No. 6 - Continued

Metallurgical Results

Products	Weight %	Assays, % Cu	% Distribution Cu
Cleaner Concentrate	0.88	26.19	60.69
4th Cleaner Tailing	0.36	11.27	10.69
3rd Cleaner Tailing	0.55	5.33	7.72
2nd Cleaner Tailing	0.76	2.96	5.92
1st Cleaner Tailing	3.97	0.73	7.61
Rougher Tailing	93.48	0.03	7.37
Head (calculated)	100.00	0.38	100.00

Calculated Grades and Recoveries

Conc. after 3 Cleanings	1.24	21.86	71.38
Conc. after 2 Cleanings	1.79	16.78	79.10
Conc. after 1 Cleaning	2.55	12.66	85.02
Rougher Concentrate	6.52	5.40	92.63

Comments: Regrinding of the total concentrate appeared to be detrimental. Reagent 620 did not appear to depress the gangue to any extent.



Test No. 7

**Purpose:** To investigate the possible grade and recovery of copper from the oxide ore sample.

**Procedure:** Grind and float the sulphide copper in a rougher concentrate, clean the concentrate twice. Combine the rougher and cleaner tailings and attempt to float the oxide copper in a scavenger concentrate by sulphidizing. Clean the scavenger concentrate three times.

**Feed:** Two 2000-gram charges of minus 10 mesh sample No. 2.

**Grind:** Each 2000 gram charge ground for 40 minutes at 60 percent solids in the ball mill.

**Conditions:**

Stage	Reagents Added, lbs/ton					Time, minutes			pH
	Ca(OH) <sub>2</sub>	Z-4	MIBC	NaHS	Z-6	Grind	Cond.	Froth	
Roughing (1)	-	0.02	0.03	-	-	-	2	2	7.6
Roughing (2)	-	0.02	-	-	-	-	1	2	-
1st Ro. Cleaning	0.10	-	-	-	-	-	3	2	10.1
2nd Ro. Cleaning	0.05	-	-	-	-	-	3	1½	10.2
Scav. Conditioning	-	-	-	0.2	-	-	4	-	8.2
Scav. Conc. 1	-	-	0.02	-	0.025	-	1	3	-
Scav. Conc. 2	-	-	0.01	-	0.025	-	1	3	-
Scav. Conc. 3	-	-	-	0.2	0.05	-	4	4	-
1st Scav. Cleaning	-	0.01	0.01	0.1	-	-	4	5	9.0
2nd Scav. Cleaning	0.05	-	-	-	-	-	3	3	9.5
3rd Scav. Cleaning	0.05	-	-	-	-	-	3	2	9.9

Stage	Roughing + Scav.	Cleanings
Flotation Cell	2000 gram D-2	250 gram D-1
Speed: r.p.m.	1100	950
% Solids	30	

Test No. 7 - Continued

Metallurgical Results

Products	Weight %	Assays, %		% Distribution	
		Cu	Oxide Cu	Cu	Oxide Cu
1. Rougher Cleaner Conc.	0.84	7.29	-	14.12	-
2. Scav. Cleaner Conc.	0.78	9.56	-	17.21	-
3. 3rd Scav. Cl. Tailing	0.09	8.69	-	1.80	-
4. 2nd Scav. Cl. Tailing	0.35	3.67	-	2.95	-
5. 1st Scav. Cl. Tailing	3.96	1.30	-	11.88	-
6. Final Tailing	93.98	0.24	0.17	52.04	57.1
Head (calculated)	100.00	0.43	0.28	100.00	-

Calculated Grades and Recoveries

Products 1 + 2	1.62	8.38	-	31.33	-
Products 1 to 3	1.71	8.40	-	33.13	-
Products 1 to 4	2.06	7.59	-	36.08	-
Products 1 to 5	6.02	3.45	-	47.96	-

Comments: Recovery and selectivity were poor. Much malachite was observed in the tailing. Attempts to sulphidize and float it were not successful. Much iron oxide was evident.

Screen Analysis on Flotation Tailing

Mesh Size (Tyler)	% Retained		% Passing Cumulative
	Individual	Cumulative	
+ 100	0.2	0.2	99.8
150	1.3	1.5	98.5
200	4.3	5.8	94.2
270	5.8	11.6	88.4
325	5.0	16.6	83.4
- 325	83.4	100.0	-
Total	100.0	-	-

Test No. 8

**Purpose:** To repeat test No. 5, but regrind the scavenger products before cleaning, reduce the amount of xanthate used in the rougher flotation and to test sodium silicate as a gangue depressant.

**Procedure:** Grind, float a rougher concentrate and a scavenger concentrate. Clean the rougher concentrate three times. Combine the cleaner tailings with this scavenger concentrate, regrind and clean three times.

**Feed:** Two 2000-gram charges of minus 10 mesh sample No. 1.

**Grind:** Each 2000 gram charge ground for 40 minutes at 60 percent solids in the ball mill.

**Conditions:**

Stage	Reagents Added, lbs/ton				Time, minutes			pH
	Ca(OH) <sub>2</sub>	Z-4	MIBC	Metso Gran. †	Grind	Cond.	Froth	
Grind	1.0	-	-	-	80	-	-	-
Rougher Float (1)	-	0.02	0.03	-	-	2	2	9.7
(2)	-	0.02	0.01	-	-	1	2	-
Scavenger Float (1)	-	0.04	0.005	-	-	1	3	-
(2)	-	0.04	0.005	-	-	1	3	-
1st Ro. Cleaning	0.05	-	-	-	-	2	2	10.4
2nd Ro. Cleaning	0.05	-	-	-	-	2	1½	10.7
3rd Ro. Cleaning	-	-	0.005	-	-	1	1	-
Scavenger Regrind	0.25	0.01	-	0.05	15	-	-	-
1st Scav. Cl. (1)	-	-	0.005	-	-	1	2	10.9
(2)	-	0.01	0.005	-	-	1	2	-
2nd Scav. Cleaning	-	-	-	0.05	-	3	2	10.4
3rd Scav. Cleaning	0.05	-	-	-	-	2	1	10.7

† Metso Granular - Na<sub>2</sub>SiO<sub>3</sub> · 5H<sub>2</sub>O

Stage	Ro. and Scav.	Ro. Cleaning.	Scav. Regrind
Equipment	2000 g D-2	250 g D-1	Pebble Mill
Speed: r.p.m.	1100	950	(10 lbs. pebbles)
% Solids	30		

Stage	1st Scav. Cl.	2nd & 3rd Scav. Cl.
Flotation Cell	500 g D-1	250 g D-1
Speed: r.p.m.	1250	950

Test No. 8 - Continued

Metallurgical Results

Products	Weight %	Assays, %				% Dist. Cu
		Cu	Mo	Pb	Ag*	
1. Rougher Cl. Conc.	1.15	26.12	0.15	0.02	2.30	78.11
2. Scav. Cleaner Conc.	0.14	7.18	-	-	-	2.63
3. 3rd Scav. Cl. Tail.	0.24	4.69	-	-	-	2.94
4. 2nd Scav. Cl. Tail.	0.78	2.51	-	-	-	5.10
5. 1st Scav. Cl. Tail.	4.35	0.35	-	-	-	3.95
6. Flotation Tailing	93.34	0.03	-	-	-	7.27
Head (calculated)	100.00	0.39	-	-	-	100.00

Calculated Grades and Recoveries

Products 1 + 2	1.29	24.07	-	-	-	80.74
Products 1 to 3	1.53	21.03	-	-	-	83.68
Products 1 to 4	2.31	14.78	-	-	-	88.78
Products 1 to 5	6.66	5.35	-	-	-	92.73

Comments:           Some improvement was evident in the scavenger flotation although the grade of scavenger concentrate was still low.



Test No. 9

Purpose: To investigate the effect of desliming prior to flotation on the oxide ore sample No. 2.

Procedure: Grind, dilute to 8 litres, condition with dispersant, allow to settle for 10 minutes and siphon off slimes. Transfer sands to flotation cell and float a rougher concentrate, and clean the concentrate once.

Feed: 2170 grams of minus 10 mesh sample No. 2.

Grind: 43½ minutes at 60 percent solids in the ball mill.

Conditions:

Stage	Reagents Added, pounds per ton							Time, minutes			pH
	Ca(OH) <sub>2</sub>	Metso Gran.	Z-6	NaHS	MIBC	STPA	Z-4	Grind	Cond.	Froth	
Grind	0.5	0.5	-	-	-	-	-	43½	-	-	-
Deslime	-	-	-	-	-	3.0	-	-	-	-	8.4
Ro. Float (1)	-	-	0.04	-	0.05	-	-	-	1	3	8.2
(2)	-	-	0.04	0.5	0.02	-	-	-	4	3	-
(3)	-	-	0.04	0.3	0.01	-	-	-	4	2	-
1st Cleaning	0.1	0.1	-	-	-	-	-	-	2	-	9.8
1st Cleaning (1)	-	-	-	0.1	-	-	-	-	2	2	-
(2)	-	-	-	0.1	.005	-	-	-	2	2	-
(3)	-	-	-	0.1	.005	-	-	-	2	2	-
2nd Cleaning (1)	-	-	-	0.1	0.01	-	0.02	-	2	-	9.4
	0.25	-	-	-	-	-	0.02	-	2	-	11.3

Note: No concentrate was taken from the second cleaning.  
Excess hydrosulphide appeared to depress all minerals.

Stage	Roughing	Cleaning
Flotation Cell	1000 gram D-1	250 gram D-1
Speed: r.p.m.	1800	1000

\* Sodium tripolyphosphate

Test No. 9 - Continued

Metallurgical Results

Products	Weight %	Assays, % Cu	% Distribution Cu
Cleaner Concentrate	1.03	3.97	9.14
Cleaner Tailing	2.25	4.12	20.72
Slimes	22.72	0.73	37.08
Rougher Tailing	74.00	0.20	33.06
Head (calculated)	100.00	0.45	100.00

Calculated Grades and Recoveries

Rougher Concentrate	3.28	4.07	29.86
Tailing + Slimes	96.72	0.32	70.14

Comments: Heavy losses of copper occurred in the slimes and in the flotation. The copper was evidently overground. Extensive testing would probably be required to make a satisfactory concentrate with reasonable recovery.

Test No. 10

**Purpose:** To repeat test No. 8 on sample No. 1, but with a coarser primary grind, more cleaning stages and with more sodium silicate.

**Procedure:** Grind, float a rougher concentrate and two scavenger concentrates. Clean the rougher concentrates five times, combine the cleaner tailings with scavenger concentrate 1, regrind and clean three times. Reserve scavenger concentrate 2 for assay only.

**Feed:** Two 2000-gram charges of minus 10 mesh sample No. 1.

**Grind:** Each 2000 gram charge ground for 20 minutes at 60 percent solids in the ball mill.

**Conditions:**

Stage	Reagents Added, lbs/ton					Time, minutes			pH
	Ca(OH) <sub>2</sub>	Z-4	MIBC	Z-6	Metso Gran.	Grind	Cond.	Froth	
Grind	1.0	-	-	-	-	40	-	-	-
Ro. Float (1)	-	0.02	0.03	-	-	-	2	2	10.0
(2)	-	0.02	-	-	-	-	1	2	-
Scav. Conc. 1	-	0.04	0.01	-	-	-	1	3	-
	-	0.04	0.01	-	-	-	1	3	-
Scav. Conc. 2	-	-	0.01	0.04	-	-	1	3	-
1st Ro. Cleaning	0.05	-	-	-	-	-	2	2	10.5
2nd Ro. Cleaning	0.05	-	-	-	-	-	2	1½	10.7
3rd Ro. Cleaning	-	-	-	-	0.10	-	2	1	9.8
4th Ro. Cleaning	-	-	-	-	0.10	-	2	1	-
5th Ro. Cleaning	-	-	-	-	-	-	1	1	7.0
Scav. Regrind	0.25	0.01	-	-	0.20	15	-	-	-
1st Scav. Cl. (1)	-	-	0.005	-	-	-	1	2	10.6
(2)	-	0.01	0.005	-	-	-	1	2	-
2nd Scav. Cl.	-	-	-	-	0.10	-	-	2	10.0
3rd Scav. Cl.	-	-	-	-	-	-	-	-	9.6

**Note:** 3rd Ro. Cl. Conc. contained much silica with minor gangue attachments. Tailing very high in gangue.

Stage	Ro. + Scavenger	Cleanings
Flotation Cell	2000 gram D-2	250 gram D-1
Speed: r.p.m.	1100	950
% Solids	30	

LAKEFIELD RESEARCH OF CANADA LIMITED  
LAKEFIELD, ONTARIO  
CANADA

Certificate of Analysis

Date: December 9, 1968

Received: \_\_\_\_\_

From: Cordilleran Engineering Ltd.  
400 - 837 West Hastings Street  
Vancouver 1, B.C.

Our Reference No. L.R. No. 1174-10

Invoice No. 8044

Samples submitted to us show results as follows:

<u>Test No.10</u>	<u>Products 1 - 4</u>	<u>% MoS<sub>2</sub></u>	<u>Au oz/ton</u>	<u>Ag oz/ton</u>
	Rougher Cleaner Concentrate	0.012	0.020	2.48
	Scavenger Cleaner Conc.	0.058	0.050	3.90
	Scavenger Cleaner Tail (3)	0.15	0.05	2.04
	Scavenger Cleaner Tail (2)	0.09	0.060	0.90

To: Mr. A.F. Reeve (2)

SIGNED \_\_\_\_\_



A.G. Scobie, <sup>MANAGER</sup> P. Eng.



Test No. 10 - Continued

Metallurgical Results

Products	Weight %	Assays, % Cu	105W			% Distribution Cu
			PA	PA	PA	
1. Rougher Cleaner Conc.	0.79	29.85	0.1	0.2	2.5	65.26
2. Scav. Cleaner Conc.	0.23	22.30	0.6	0.5	3.9	14.20
3. 3rd Scav. Cl. Tailing	0.14	8.88	15.5	2.0	0.4	3.43
4. 2nd Scav. Cl. Tailing	0.55	4.14	0.7	0.6	0.9	6.31
5. 1st Scav. Cl. Tailing	3.45	0.51				4.87
6. Scav. Concentrate 2	1.27	0.21				0.75
7. Flotation Tailing	93.57	0.02				5.18
Head (calculated)	100.00	0.36				100.00

Calculated Grades and Recoveries

X Products 1 + 2	1.02	28.15	79.46
Products 1 to 3	1.16	25.82	82.89
Products 1 to 4	1.71	18.85	89.20
Products 1 to 5	5.16	6.59	94.07
Products 1 to 6	6.43	5.33	94.82

Comments: Recovery in the rougher (primary) cleaner concentrate was quite high, despite the coarser primary grind. An even coarser primary grind may be feasible. Sodium silicate appeared to be helpful in depressing gangue.

Screen Analysis - 1st Scav. Cl. Tail.

Mesh Size (Tyler)	% Retained		% Passing Cumulative
	Individual	Cumulative	
+ 150	0.1	0.1	99.9
200	0.3	0.4	99.6
270	0.5	0.9	99.1
325	2.1	3.0	97.0
- 325	97.0	100.0	-
Total	100.0	-	-

Investigation by: I.C. Edwards, P. Eng.  
 R.W. Deane  
 C.W. Payne

Lakefield Research of Canada Limited  
 Lakefield, Ontario  
 April 4, 1968 / tmg

3.

LAKEFIELD RESEARCH OF CANADA LIMITED  
LAKEFIELD, ONTARIO  
CANADA

P.O. BOX 430

PHONE 652-3341

April 4, 1968.

Mr. J.W. Stollery, P. Eng.,  
Vice-President,  
Cordilleran Engineering Limited,  
400-837 West Hastings Street,  
VANCOUVER 1, British Columbia.


Dear Mr. Stollery:

We are pleased to enclose six copies of our Progress Report No. 1 on an Investigation of the Recovery of Copper from samples of Sulphide and of Oxide Ore, submitted by you on behalf of Cordilleran Engineering Limited. Additional copies of the report will be supplied if needed.

These preliminary tests indicate that the sulphide ore is quite amenable to concentration, and that a concentrate assaying 25.82 percent Cu with a recovery of 83 percent of the copper may be obtained with a reasonably simple flowsheet and with a ratio of concentration of 86:1. Further work may show that appreciable additional recovery could be realized from the cleaner tailing. The oxide copper ore did not respond well to flotation and further testing would be required to improve grade and recovery indications.

We would be interested in your comments on these tests, and we will retain all test batches and products and will not proceed with further tests until we hear whether you wish to continue with additional work at this time.

Yours very truly,  
LAKEFIELD RESEARCH OF CANADA LIMITED



A.G. Scobie, P. Eng.,  
Manager.

AGS:tmg

Encl.



April 10, 1968

Composition of Samples Taken from Hail Copper Deposit  
for Lakeland Metallurgical Test

Method of Sampling

Crushed assay rejects were sampled. The rejects are stored in 15# bags each representing 10 feet of drill core or surface channel samples.

The metallurgical samples were taken by scooping an equal measure of rock from each bag.

Sample #1 - 75 pounds of drill core.

Source -	Drill hole #1	110' to 250'
"	" #1	280' to 356'
"	" #5	22' to 90'
"	" #6	40' to 170'
"	" #3	140' to 280'

Sample #2 - Surface material channel samples

Source - Cut #S-2 - 0' to 110'