CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 61-52

# INVESTIGATION TO DETERMINE EXPECTED REACTION OF ORE FROM PORTAGE ISLAND IN MILL OF COPPER RAND CHIBOUGAMAU MINES LTD.

by

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MINERAL PROCESSING DIVISION

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# INVESTIGATION TO DETERMINE EXPECTED REACTION OF ORE FROM PORTAGE ISLAND IN MILL OF COPPER RAND CHIBOUGAMAU MINES LTD.

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R. W. Bruce*

## SUMMARY OF RESULTS

The Portage Island ore assayed Au - 0.213 oz/ton and Cu - 4.00%, which was considerably higher than the sample of feed to the Copper Rand mill which assayed Au - 0.047 oz/ton and Cu - 2.48%.

The investigation indicates that the proposed mixture of two parts of Copper Rand ore and one part of Portage Island ore, if treated according to the Copper Rand flowsheet, but with an added regrind circuit in the cleaning stage, would yield a copper concentrate assaying 24.0% Cu with recovery of 92.5% of the copper and 80.0% of the gold.

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## INTRODUCTION

### Location of Property

Samples were received from two properties in the Chibougamau area in northwestern Quebec, as follows:

(1) Property held by Copper Rand Chibougamau Mines Ltd., which is a copper-gold producer in the central section of the Chibougamau area;

(2) Property held by Portage Island (Chibougamau) Mines Limited, known as the No. 2 Copper Point ore-body in Roy township.

### Shipment

Two shipments of ore, submitted by Mr. D. C. McDonald, Mine Manager, Copper Rand Chibougamau Mines Ltd., were received on August 1 and 2, 1960, at the Mines Branch. The first shipment, weighing 204 lb, was diamond drill core from the Portage Island property, while the second shipment, weighing 200 lb, was taken from the mill feed of the Copper Rand mill.

### Purpose of Investigation

The purpose of the investigation as outlined by Mr. D. A. Livingstone, Metallurgical Consultant, is threefold:

(1) To determine the amenability of the Portage Island ore to the Copper Rand method of treatment and the recoveries of copper and gold anticipated thereby;

(2) To study the mineralogical characteristics of the Portage Island ore to determine the mode and occurrence of the copper and

gold, chiefly gold;

(3) To determine the alterations or additions to the Copper Rand flowsheet that may be required to attain optimum metallurgical performance when treating the Portage Island ore.

The expected plan is to treat a mixture of 2 parts of Copper Rand ore and one part of Portage Island ore in the 1600 ton Copper Rand mill.

## Sampling and Analysis

A head sample was riffled out of each of the ores and submitted for analysis. The rejects from the head samples were set aside to be used for the investigative tests.

The head samples were analysed as follows:

| | | Portage Island | Copper Rand |
|---|---|---|---|
| Au | - | 0.213 oz/ton | 0.047 oz/ton |
| Ag | - | 0.445 " | 0.215 " |
| Cu | - | 4.00 % | 2.48 % |
| Fe | - | 18.08 " | 20.91 " |
| S | - | 9.65 " | 4.18 " |

## MINERALOGICAL EXAMINATION*

A portion of the head sample from the Portage Island ore was submitted to the Mineral Sciences Division for microscopic examination and X-ray powder diffraction analysis. Five polished sections were made containing 12 pieces of ore.

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*From Internal Report MS-60-76 by W. E. White, Aug. 22, 1960.

Metallic Minerals

The metallic minerals, in order of decreasing abundance, are chalcopyrite, pyrite, pyrrhotite, sphalerite, galena and gold.

The greater part of the chalcopyrite in the polished sections occurs as small masses containing inclusions of gangue and other sulphides, (Figure 1). A minor but appreciable proportion of this mineral, however, is present as coarse to fine irregular particles and narrow veinlets in pyrrhotite, pyrite, sphalerite, and gangue (Figures 2, 3 and 4).

Pyrite occurs as coarse to fine disseminated grains in gangue and other metallic minerals. The coarser grain sizes predominate and contain a few small inclusions of gangue and sulphides, especially chalcopyrite and pyrrhotite. Some grains of pyrite are fractured and the fractures filled with chalcopyrite, pyrrhotite, and/or sphalerite, (Figures 1 and 3).

Pyrrhotite is almost as abundant as pyrite and has similar modes of occurrence to chalcopyrite and is commonly and intimately associated with it, (Figure 2). Some pyrrhotite is also scattered through gangue and other sulphides as irregular particles and narrow veinlets, (Figure 3).

Sphalerite is visible in minor amounts as coarse to fine irregular particles in gangue, chalcopyrite, pyrite, and pyrrhotite. Conversely, the sphalerite encloses particles of these minerals as well as galena. Some of the chalcopyrite inclusions grade down to very fine sizes and, in a few places, show alignment, (Figure 4).

Galena is present in comparatively small amounts as medium coarse to fine anhedral grains which are usually associated with sphalerite, (Figure 4).

Four particles of native gold, all well under 200-Tyler mesh (74 microns) in size, were observed in pyrite, three in one grain and one in another. Both auriferous pyrite grains are in the same piece of ore. The largest particle of gold, shown in Figure 5, is the largest one seen.

Gangue Minerals

Gangue is subordinate to metallic minerals in the polished sections and consists of a coarse to fine grained assemblage of quartz, calcite and chlorite.

Conclusion

Although four grains of gold are not sufficient to adequately represent its mode of occurrence, they do prove that native gold is present and that at least some of it occurs in pyrite in fine grain sizes. Also, the fact that auriferous pyrite grains were found in only one of the twelve pieces of ore indicates that the distribution of gold is probably spotty or patchy. Because much of the chalcopyrite is so closely associated with other ore minerals, it may be difficult to obtain clean copper concentrates and good recoveries by standard methods of treatment.

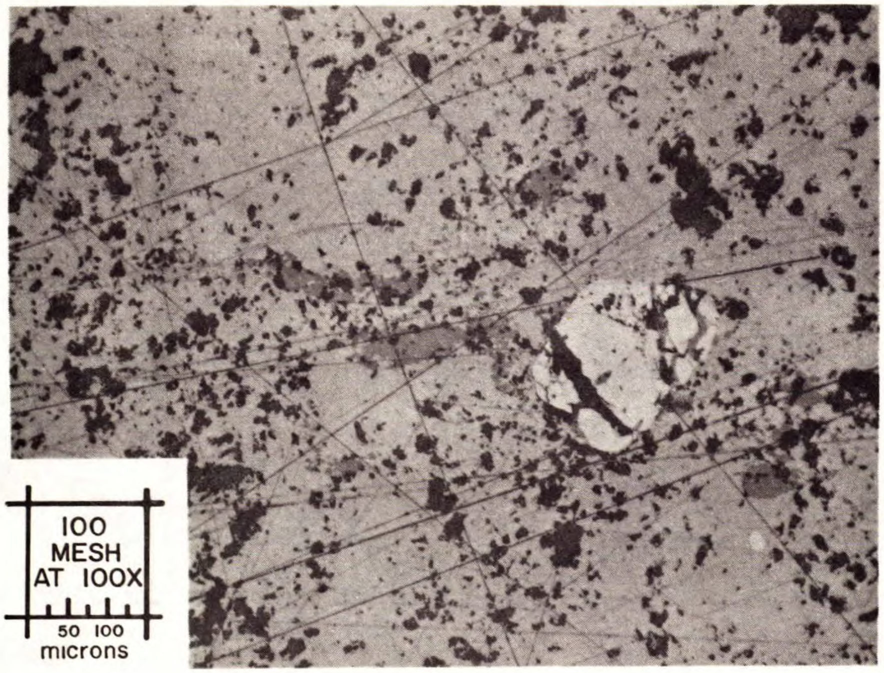


**Figure 1.** - Massive chalcopyrite (light grey) containing inclusions of pyrite (white), sphalerite (medium grey), and gangue (dark grey); note that the larger grain of pyrite is fractured and some fractures filled with sphalerite; polishing pits and scratches (black).

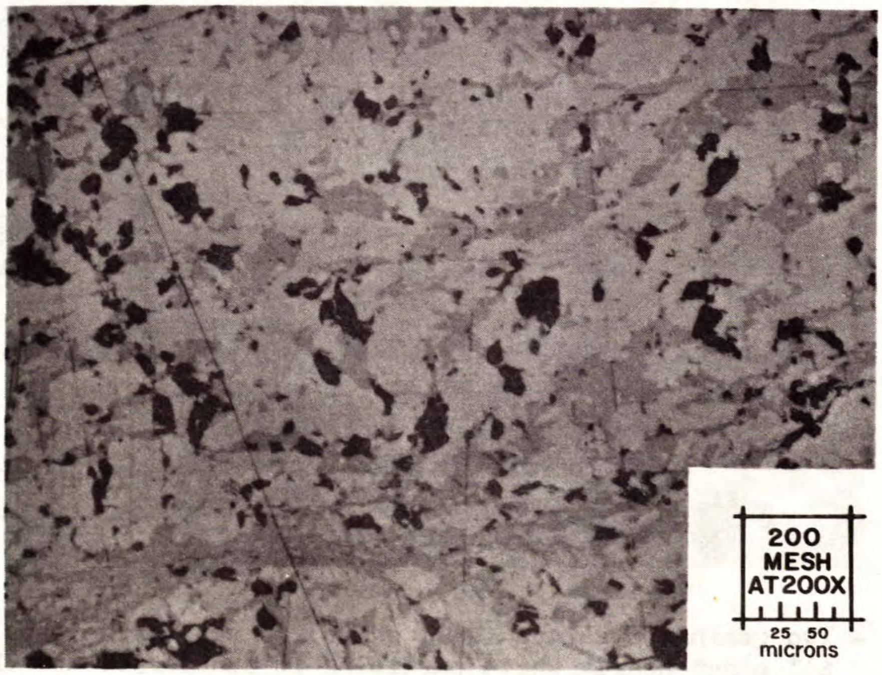


**Figure 2.** - Typical field in the polished sections which shows how massive pyrrhotite (light grey) is intergrown with ragged particles of chalcopyrite (medium grey); polishing pits and scratches (black).

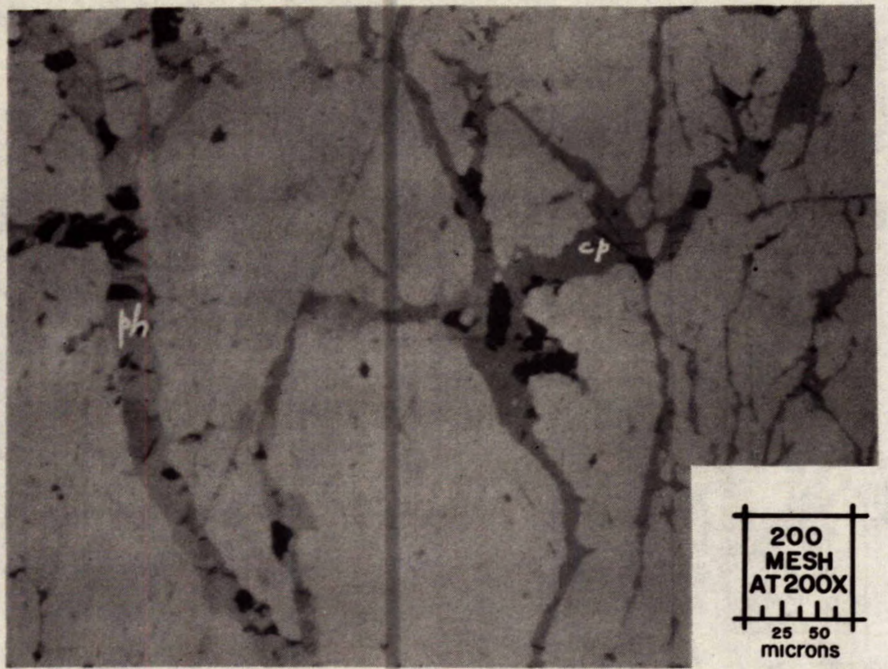


**Figure 3.** - Pyrite (greyish white) containing fracture-filled veinlets of mixed pyrrhotite (ph), somewhat darker than pyrite, and chalcopyrite (cp), slightly darker than pyrrhotite; polishing pits and scratches are black.


**Figure 4.** - Two grains of galena (ga), white, in sphalerite (sp), grey; all other nearly white particles in sphalerite are chalcopyrite; note string of tiny chalcopyrite-blebs traversing sphalerite at upper right; voids and scratches due to polishing are black.

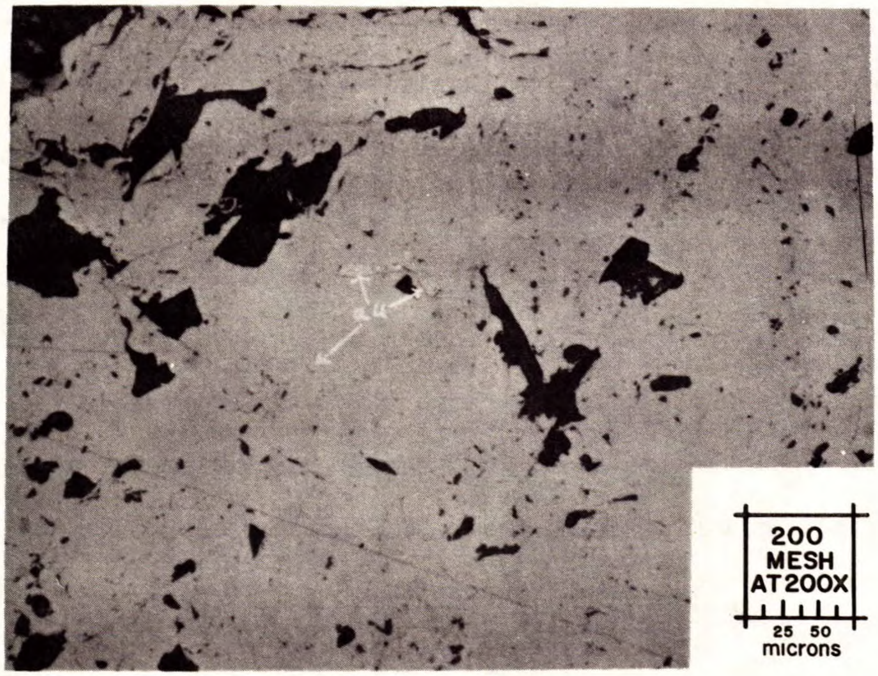


Figure 5. - Photomicrograph of polished section showing three small particles of gold (au), white, in pyrite, light grey; polishing pits and scratches are black.

## DETAILS OF INVESTIGATION

The two ores under investigation were tested with the flowsheet of the Copper Rand concentrator in mind. The feed at Copper Rand is subjected to single-stage, closed-circuit grinding to 65% minus 200 M, followed by 7 minutes conditioning and flotation in 2 parallel banks of cells. A high grade concentrate is removed as a finished product from the first three cells, while the remaining rougher concentrate is subjected to two or three stages of cleaning to yield another finished product.

The investigation was carried out in three series of tests. Tests performed on Portage Island ore are designated by the prefix P, those performed on Copper Rand ore by the prefix C, and those performed on the mixture by the prefix M.

Tests Nos. P-1 to P-4 (Grinding, Amalgamation, and Cyanidation Tests)

Three 2000 g batches of Portage Island ore were ground to determine the time required to grind the ore to 65% -200 M, and at the same time to determine the per cent free milling gold, at the various grinds, by amalgamation. 500 g of the amalgam tailings were then cyanided for 48 hr to determine the maximum possible recovery of the gold. Following this a 1000 g sample was ground for 18 minutes and treated similarly to the three 2000 g batches.

Results of Tests Nos. P-1 to P-4

Screen Test

| Test No. | P-1 | P-2 | P-3 | P-4 |
|---|---|---|---|---|
| Grinding Time (min) | 20 | 25 | 30 | 18 |
| +48 M | 0.3 | 0.3 | 0.3 | |
| -48 +65 M | 0.9 | 0.4 | 0.4 | 1.0 |
| -65+100 M | 4.4 | 2.5 | 1.8 | 4.0 |
| -100+150 M | 9.7 | 6.9 | 5.7 | 8.5 |
| -150+200 M | 14.8 | 14.1 | 11.3 | 11.4 |
| -200 M | 69.9 | 75.8 | 80.5 | 75.1 |

Amalgamation Test

| | P-1 | P-2 | P-3 | P-4 |
|---|---|---|---|---|
| Head Au, oz/ton | .22 | .22 | .22 | .22 |
| Amalgamation Tailing Au, oz/ton | .15 | .09 | .07 | .07 |
| Hg Analysis (by difference) | .07 | .13 | .15 | .15 |
| Recovery, Au % | 31.8 | 59.1 | 68.2 | 68.2 |

Cyanidation Test

| | P-1 | P-2 | P-3 | P-4 |
|---|---|---|---|---|
| Head Au, oz/ton | .22 | .22 | .22 | .22 |
| Amalgamation Tailing Au, oz/ton | .15 | .09 | .07 | .07 |
| Cyanide Residue Au, oz/ton | .015 | .015 | .015 | .015 |
| Solution Analysis (calcd by diff.) | .135 | .075 | .055 | .055 |
| Recovery, Au, % | 61.4 | 34.1 | 25.0 | 25.0 |

**Test No. P-5**

This was a standard flotation test duplicating the Copper Rand flotation conditions. 2000 g of ore was ground for 20 minutes to 68.8% -200 M.

Reagents and Conditions

| Operation | Reagents - lb/ton | | Time min | pH Pulp |
|---|---|---|---|---|
| Grind | CaO | - 1.5 | 20 | |
| | NaCN | - 0.02 | | |
| | Z-200 | - 0.03 | | |
| Conditioning | Dowfroth 250 | - 0.015 | 10 | 10.4 |
| | Z-200 | - 0.03 | | |
| Rougher flotation | | | 1-2 | |
| Conditioning | Z-6 | - 0.05 | | |
| 2nd rougher flot | | | 1 | |
| " " " | Dowfroth 250 | - 0.015 | 1½ | |
| " " " | " 250 | - 0.010 | 2½ | |
| 2nd rougher conc (cleaned twice) | CaO to pH of 11 - | | | 10.9 |

Results of Test No. P-5

| Product | Wt, % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Cu rougher conc | 4.4 | 1.51 | 27.64 | 27.7 | 31.1 |
| Cu recleaner conc | 6.4 | 1.08 | 26.62 | 28.9 | 43.6 |
| Combined conc (calcd) | 10.8 | 1.25 | 27.0 | 56.6 | 74.7 |
| 2nd cleaner tail | 4.6 | 0.75 | 13.00 | 14.4 | 15.3 |
| 1st " " | 5.2 | 0.42 | 4.90 | 9.1 | 6.5 |
| Rougher " | 79.4 | 0.06 | 0.17 | 19.9 | 3.5 |
| Feed (calcd) | 100.0 | 0.47 | 3.91 | 100.0 | 100.0 |

Test No. P-6

This test was similar to Test No. P-5 except that grinding time was reduced to 15 minutes, obtaining a product 61.2% -200 M.

Results of Test No. P-6

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Cu rougher conc | 6.9 | 1.19 | 26.00 | 35.9 | 46.0 |
| Cu recleaner conc | 7.9 | 0.91 | 19.60 | 31.5 | 39.7 |
| Combined conc (calcd) | 14.8 | 1.11 | 24.0 | 67.4 | 85.7 |
| 2nd cleaner tail | 4.7 | 0.63 | 6.60 | 13.0 | 8.0 |
| 1st cleaner tail | 4.2 | 0.34 | 2.73 | 6.3 | 3.0 |
| Rougher tail | 76.3 | 0.04 | 0.17 | 13.3 | 3.3 |
| Feed (calcd) | 100.0 | 0.23 | 3.90 | 100.0 | 100.0 |

Test No. P-7

This test was similar to both Tests Nos. P-5 and P-6 except that the ore was ground for 18 minutes to 64.2% -200 M.

Results of Test No. P-7

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Cu rougher conc | 6.6 | 1.18 | 27.14 | 36.4 | 44.4 |
| Cu recleaner conc | 7.3 | 0.82 | 22.81 | 28.0 | 41.0 |
| Combined conc (calcd) | 13.9 | .99 | 24.78 | 64.4 | 85.4 |
| 2nd cleaner tail | 4.7 | 0.78 | 7.74 | 17.2 | 9.0 |
| 1st " " | 4.5 | 0.36 | 2.99 | 7.6 | 3.3 |
| Rougher " | 76.9 | 0.03 | 0.12 | 10.8 | 2.3 |
| Feed (calcd) | 100.0 | 0.22 | 4.03 | 100.0 | 100.0 |

Test No. C-1

This test was conducted for the purpose of comparing the Copper Rand ore to the Portage Island ore. 2000 g of Copper Rand ore was ground for 18 minutes to 74.3 -200 M and floated under conditions similar to those in Test No. P-5.

Results of Test No. C-1

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Cu rougher conc | 4.3 | 0.243 | 28.28 | 34.8 | 52.2 |
| Cu recleaner conc | 3.7 | 0.223 | 21.05 | 27.5 | 33.4 |
| Combined conc (calcd) | 8.0 | 0.235 | 24.9 | 62.3 | 85.6 |
| 2nd cleaner tail | 1.6 | 0.311 | 8.46 | 16.6 | 5.8 |
| 1st " " | 1.9 | 0.103 | 5.37 | 6.6 | 4.4 |
| Rougher tailing | 88.5 | 0.005 | 0.11 | 14.5 | 4.2 |
| Feed (calcd) | 100.0 | 0.03 | 2.33 | 100.0 | 100.0 |

Test No. M-1

A composite sample of Portage Island ore and Copper Rand ore was prepared by mixing 40 lb of -10 M Copper Rand ore with 20 lb of -10 M Portage Island ore. The assay of this mixture, to be known as the Copper Rand composite mixture, was calculated to be as follows:

Au - 0.10 oz/ton
Ag - 0.29 "
Cu - 2.99 %
Fe - 19.97 %
S - 6.00 %

Two thousand grams of the composite mixture was ground for 18 min to 70.7% -200 M, and floated with conditions similar to those of Test No. P-5.

Results of Test No. M-1

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Cu rougher conc | 5.8 | 0.605 | 26.06 | 37.7 | 53.5 |
| Cu recleaner conc | 4.4 | 0.715 | 22.89 | 33.8 | 35.6 |
| Combined conc (calcd) | 10.2 | 0.654 | 24.70 | 71.5 | 89.1 |
| 2nd cleaner tail | 1.3 | 0.45 | 6.64 | 6.3 | 3.0 |
| 1st cleaner tail | 2.7 | 0.26 | 2.81 | 7.5 | 2.7 |
| Rougher tail | 85.8 | 0.016 | 0.17 | 14.7 | 5.2 |
| Feed (calcd) | 100.0 | 0.093 | 2.83 | 100.0 | 100.0 |

Test No. P-8

The purpose of this test was to determine the effect of regrinding the second rougher concentrate before the two cleaning operations. 2000 g of the Portage Island ore was ground 18 minutes to 64.0% -200 M. Two rougher concentrates were floated in conditions similar to those in Test No. P-5. The second rougher concentrate was then reground for 12 minutes and cleaned at a pH of 11.5.

Results of Test No. P-8

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Cu rougher conc | 3.7 | 1.85 | 27.18 | 33.3 | 25.4 |
| Cu recleaner conc | 7.0 | 0.815 | 27.18 | 27.7 | 48.1 |
| Combined conc (calcd) | 10.7 | 1.17 | 27.2 | 61.0 | 73.5 |
| 2nd cleaner tail | 3.2 | 0.68 | 14.77 | 10.6 | 12.0 |
| 1st " " | 6.1 | 0.335 | 5.21 | 9.9 | 8.0 |
| Rougher tail | 80.0 | 0.0475 | 0.32 | 18.5 | 6.5 |
| Feed (calcd) | 100.0 | 0.206 | 3.96 | 100.0 | 100.0 |

Test No. P-9

This test was similar to Test No. P-8 except that the second copper rougher concentrate was reground with 0.5 lb/ton of lime for 12 minutes, and a finished copper concentrate was skimmed from the reground rougher concentrate in the first minute. The third concentrate was then floated and cleaned twice at a pH of 11.0.

Results of Test No. P-9

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| 1st Cu conc | 5.8 | 1.54 | 28.00 | 41.2 | 41.3 |
| 2nd Cu conc | 3.5 | 0.87 | 24.73 | 14.1 | 22.0 |
| Cu recleaner conc | 2.5 | 0.92 | 25.15 | 10.6 | 16.0 |
| Combined conc (calcd) | 11.8 | 1.21 | 26.4 | 65.9 | 79.3 |
| 2nd Cu recl tail | 3.9 | 0.67 | 12.31 | 12.0 | 12.2 |
| 1st Cu cl tail | 6.2 | 0.30 | 2.76 | 8.6 | 4.3 |
| Rougher tail | 78.1 | 0.375 | 0.21 | 13.5 | 4.2 |
| Feed (calcd) | 100.0 | 0.217 | 3.93 | 100.0 | 100.0 |

Test No. M-2

Two thousand grams of the composite mixture was ground for 18 minutes to 68.6% -200 M and was floated under the following conditions:

Reagents and Conditions

| Operation | Reagents - lb/ton | | Time (min) | Pulp pH |
|---|---|---|---|---|
| Grind | CaO - | 1.5 | 18 | |
| | NaCN - | 0.02 | | |
| | Z-200 - | 0.03 | | |
| Conditioning | Dowfroth 250 - | 0.009 | 10 | 10.5 |
| | Z-200 - | 0.03 | | |
| Flotation (finished conc) | | | 1 | |
| Conditioning | Z-6 - | 0.05 | 3 | |
| | Dowfroth 250 - | 0.021 | | |
| Rougher flotation | | | 2 | |
| " " | Dowfroth 250 - | 0.009 | 3 | |
| Regrind rougher conc | CaO - | 0.5 | 12 | |
| Flotation (2nd Cu conc) | | | 1 | |
| Flotation (3rd Cu conc) | | | 3 | |
| Reclean 3rd Cu conc | CaO to pH of 11 | | | 11.0 |

The tailings from the 3rd Cu concentrate flotation and from the recleaning flotation were combined and sized in a screen test.

Screen Test on Combined Tailings

| Sized Fraction | Wt., % |
|---|---|
| +100 M | 0.2 |
| -100+150 M | 0.3 |
| -150+200 M | 1.2 |
| -200 M | 98.3 |

Results of Test No. M-2

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| 1st Cu conc | 6.6 | 0.61 | 26.12 | 50.4 | 61.5 |
| 2nd Cu conc | 2.0 | 0.61 | 24.94 | 15.3 | 17.8 |
| Cu cl conc | 0.8 | 0.64 | 26.46 | 6.4 | 7.5 |
| Combined conc (calcd) | 9.4 | 0.61 | 25.9 | 72.1 | 86.8 |
| Cleaner tail (comb) | 4.6 | 0.185 | 4.50 | 10.6 | 7.4 |
| Rougher tail | 86.0 | 0.016 | 0.19 | 17.3 | 5.8 |
| Feed (calcd) | 100.0 | 0.079 | 2.80 | 100.0 | 100.0 |

Test No. M-3

This test was similar to Test No. M-2 except that the initial grinding time was reduced to 16 minutes, obtaining a product of 68.5% -200 M.

Results of Test No. M-3

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| 1st Cu conc | 7.1 | 0.55 | 26.36 | 51.0 | 64.2 |
| 2nd Cu conc | 2.0 | 0.605 | 21.87 | 15.8 | 15.0 |
| Cu recleaner conc | 0.8 | 0.584 | 26.12 | 6.1 | 7.2 |
| Combined conc (calcd) | 9.9 | 0.57 | 25.4 | 72.9 | 86.4 |
| Combined cleaner tail | 4.8 | 0.15 | 4.55 | 9.4 | 7.5 |
| Rougher tail | 85.3 | 0.016 | 0.21 | 17.7 | 6.1 |
| Feed (calcd) | 100.0 | 0.077 | 2.92 | 100.0 | 100.0 |

Test No. M-4

This test was a five-stage, locked-cycle test, designed to simulate a plant operation with a recycling of the cleaner tailing from the second rougher concentrate. Each cycle involved the grinding of 2000 g of the composite sample for 16 minutes to 68% -200 M, and the addition of the cleaner tailing from the previous cycle to the ground ore.

The conditions of operation in each cycle were as follows:

| Operation | Reagents and Conditions: Reagents - lb/ton | | Time min | pH Pulp |
|---|---|---|---|---|
| Grind | CaO | - 1.5 | 16 | |
| | NaCN | - 0.02 | | |
| | Z-200 | - 0.03 | | |
| Conditioning | Z-200 | - 0.03 | 10 | 10.6 |
| | Dowfroth 250 | - 0.015 | | |
| Flotation (1st Cu conc) | | | 1 | |
| Conditioning | Z-6 | - 0.05 | 3 | |
| | Dowfroth 250 | - 0.015 | | |
| Flotation (2nd rougher conc) | Dowfroth 250 | - 0.009 | 2 | |
| Clean and reclean (2nd rough conc) | CaO to pH of 11 | | | 11.0 |

The combined Cu cleaner tailing was filtered and added to the 2000 g batch of freshly ground ore of the second cycle. This mixture was then treated in conditions similar to those of the first cycle. The variation in pH in each cycle was as follows:

| Cycle No. | 1st Conditioning pH | Cleaning pH |
|---|---|---|
| 2 | 11.0 | 11.2 |
| 3 | 10.1 | 11.0 |
| 4 | 10.8 | 10.9 |
| 5 | 10.9 | 11.0 |

Results of Test No. M-4

| Cycle No. | Product | Wt gm | Wt % | Assays oz/ton Au | Assays % Cu | Distn % Au | Distn % Cu |
|---|---|---|---|---|---|---|---|
| 1 | 1st Cu conc | 111.3 | 1.1 | | 28.87 | | 11.1 |
| 2 | 1st Cu conc | 138.4 | 1.4 | | 25.40 | | 12.4 |
| 3 | 1st Cu conc | 127.1 | 1.3 | | 27.37 | | 12.4 |
| 4 | 1st Cu conc | 124.3 | 1.2 | | 26.57 | | 11.1 |
| 5 | 1st Cu conc | 144.3 | 1.4 | | 25.86 | | 12.6 |
| | 1st Cu conc (calcd) | 645.4 | 6.4 | | 26.51 | | 59.6 |
| Composite 1st Cu conc (assay) | | | | 0.61 | 26.42 | 43.8 | |
| 1 | Cu clean conc | 102.0 | 1.0 | | 17.27 | | 6.0 |
| 2 | Cu clean conc | 106.2 | 1.1 | | 16.66 | | 6.4 |
| 3 | Cu clean conc | 110.5 | 1.1 | | 15.79 | | 6.1 |
| 4 | Cu clean conc | 129.5 | 1.3 | | 15.33 | | 6.9 |
| 5 | Cu clean conc | 110.4 | 1.1 | | 15.53 | | 6.0 |
| | Cu clean conc (calcd) | 558.6 | 5.6 | | 16.11 | | 31.4 |
| Composite Cu cl conc (assay) | | | | 0.555 | 16.10 | 34.9 | |
| Combined Cu conc (calcd) | | 1204.0 | 12.0 | 0.58 | 21.75 | 78.7 | 91.0 |
| 5 | Cu clean tail | 30.3 | 0.3 | 0.37 | 5.75 | 1.1 | 0.6 |
| 1 | Rougher tail | 1755.0 | 17.6 | | 0.32 | | 2.0 |
| 2 | Rougher tail | 1755.0 | 17.6 | | 0.24 | | 1.5 |
| 3 | Rougher tail | 1763.0 | 17.6 | | 0.28 | | 1.7 |
| 4 | Rougher tail | 1747.0 | 17.5 | | 0.28 | | 1.7 |
| 5 | Rougher tail | 1741.0 | 17.4 | | 0.25 | | 1.5 |
| | Rougher tail (calcd) | 8761.0 | 87.7 | | 0.27 | | 8.4 |
| Comp. rougher tail (assay) | | | | 0.02 | 0.23 | 20.2 | |
| | Feed (calcd) | 9995.3 | 100.0 | 0.089 | 2.87 | 100.0 | 100.0 |

Test No. M-5

This test was a locked cycle test similar to Test No. M-4 except that in each cycle, the 2nd copper rougher concentrate was reground for 12 minutes with lime before floating a copper recleaner concentrate. The pH variations in each cycle were as follows:

| Cycle No. | 1st Conditioning pH | Cleaning pH |
|---|---|---|
| 1 | 11.2 | 11.3 |
| 2 | 11.2 | 11.3 |
| 3 | 11.3 | 11.4 |
| 4 | 10.8 | 11.0 |
| 5 | 11.1 | 11.0 |

The results of Test No. M-5 are shown on page 20.

Summary of Results of Tests Nos. M-4 and M-5

In order that the results of the two locked-cycle tests might be more easily compared, the following table of results was condensed from these two tests:

| Product | Wt % | Assays | | Distn % | |
|---|---|---|---|---|---|
| | | oz/ton Au | % Cu | Au | Cu |
| Test No. M-4 | | | | | |
| Combined Cu conc | 12.0 | 0.58 | 21.8 | 78.7 | 91.0 |
| Cu cl tail | 0.3 | 0.37 | 5.8 | 1.1 | 0.6 |
| Rougher flot tail | 87.7 | 0.02 | 0.27 | 20.2 | 8.4 |
| Test No. M-5 | | | | | |
| Combined Cu conc | 11.3 | 0.64 | 24.0 | 80.0 | 92.5 |
| Cu cl tailing | 0.6 | 0.24 | 8.0 | 1.1 | 1.6 |
| Rougher flot tail | 88.1 | 0.02 | 0.19 | 18.9 | 5.9 |
| Feed (calcd) | 100.0 | 0.09 | 2.90 | 100.0 | 100.0 |

## Results of Test No. M-5

| Cycle No. | Product | Wt gm | Wt % | Assays oz/ton Au | Assays % Cu | Distn, % Au | Distn, % Cu |
|---|---|---|---|---|---|---|---|
| 1 | 1st Cu conc | 148.0 | 1.5 | | 27.18 | | 13.9 |
| 2 | 1st Cu conc | 150.8 | 1.5 | | 25.29 | | 12.9 |
| 3 | 1st Cu conc | 146.4 | 1.5 | | 24.32 | | 12.5 |
| 4 | 1st Cu conc | 164.0 | 1.6 | | 25.86 | | 14.1 |
| 5 | 1st Cu conc | 166.2 | 1.7 | | 25.34 | | 14.7 |
| | 1st Cu conc (calcd) | 775.4 | 7.8 | | 25.7 | | 68.1 |
| Composite 1st Cu conc (assay) | | | | 0.63 | 25.35 | 54.4 | |
| 1 | Cu cl conc | 65.9 | 0.7 | | 19.06 | | 4.5 |
| 2 | Cu cl conc | 72.0 | 0.7 | | 22.34 | | 5.4 |
| 3 | Cu cl conc | 91.0 | 0.9 | | 21.36 | | 6.6 |
| 4 | Cu cl conc | 65.1 | 0.6 | | 18.65 | | 3.8 |
| 5 | Cu cl conc | 60.4 | 0.6 | | 20.03 | | 4.1 |
| | Cu cl conc (calcd) | 354.4 | 3.5 | | 20.1 | | 24.4 |
| Composite Cu cl conc (assay) | | | | 0.67 | 20.50 | 25.6 | |
| | Combined Cu conc (calcd) | 1129.8 | 11.3 | 0.64 | 24.0 | 80.0 | 92.5 |
| 5 | Cu cl tail | 60.2 | 0.6 | 0.235 | 8.02 | 1.1 | 1.6 |
| 1 | Rougher tail | 1718.0 | 17.2 | | 0.18 | | 1.1 |
| 2 | Rougher tail | 1788.0 | 17.9 | | 0.24 | | 1.5 |
| 3 | Rougher tail | 1758.0 | 17.6 | | 0.18 | | 1.1 |
| 4 | Rougher tail | 1756.0 | 17.5 | | 0.17 | | 1.0 |
| 5 | Rougher tail | 1792.0 | 17.9 | | 0.19 | | 1.2 |
| | Rougher tail (calcd ) | 8812.0 | 88.1 | | 0.19 | | 5.9 |
| Comp. rougher tail (assay) | | | | 0.019 | 0.19 | 18.9 | |
| | Feed (calcd) | 10002.0 | 100.0 | 0.090 | 2.93 | 100.0 | 100.0 |

## CONCLUSIONS

The copper mineral, chalcopyrite, in the Portage Island ore occurs mainly as small masses, containing inclusions of gangue and other sulphides. The investigation showed that these masses of chalcopyrite can be freed for flotation by grinding to 65% minus 200 M. The gold in this ore seems to be closely associated with the pyrite and occurs as native gold of particle size less than 200 M. Grinding the ore to 65% minus 200 M results in the complete liberation of about 32% of the gold, while grinding to 80.5% minus 200 M results in the liberation of 68%.

The grinding tests did not indicate that prolonged grinding would liberate the chalcopyrite entrapped in the pyrite as veinlets. Grinding to 65% minus 200 M seems to result in the optimum liberation of values. Since Portage Island ore requires a longer grinding period than the Copper Rand ore to achieve the same degree of fineness, the grinding of the composite mixture might reduce milling capacity slightly and tend to produce a composite flotation feed that resembles the Copper Rand ore in the finer fractions and the Portage Island ore in the coarser fractions. As most of the copper is liberated in the Portage Island ore by grinding to 65% minus 200 M, it is to be expected that the recovery of copper from the mixture will remain high. Similarly, the recovery of gold from the mixture can be expected to drop, because of the reduced liberation of the gold in the higher grade ore.

The regrinding of the second rougher concentrate before the cleaning stages was investigated. Preliminary tests on the

Portage Island ore indicated that the regrinding will produce a higher overall grade of concentrate from this ore. The locked-cycle tests on the composite mixture, of two parts Copper Rand ore and one part Portage Island ore, resulted in an appreciable increase in both grade and recovery of copper when regrinding the second rougher concentrate. The grade of the final concentrate was increased from 21.8% to 24.0% copper. The overall recovery was increased from 91.0% to 92.5% for copper and from 78.7% to 80.0% for gold (Tests Nos. M-4 and M-5).

The higher gold content of the composite mixture over that of the Copper Rand ore will result in an increase in the gold content of the flotation tailing. The cyanidation tests indicate that the gold loss in the tailing is recoverable. Should the proportion of Portage Island ore be increased at some time in the future, it might be advisable to consider the cyanidation of the flotation tailing for maximum gold recovery.

The two ores under investigation were fairly similar in their physical nature and reacted favourably individually and as a mixture to the flotation conditions and reagents of the Copper Rand mill. The only alteration to the Copper Rand mill which would seem to be advisable would be the inclusion of a regrind circuit for the second copper rougher concentrate before cleaning.

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