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MINES BRANCH INVESTIGATION REPORT 62-39

INVESTIGATION OF GOLD RECOVERY FROM MILL PRODUCTS, FROM MADSEN RED LAKE GOLD MINES LIMITED, MADSEN, ONTARIO

by

G. I. MATHIEU

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The Madsen mill feed assayed 0.23 oz Au/ton. The gold was associated mostly with sulphide minerals. The material also contained a small amount of pyrrhotite which could be removed by magnetic separation with gold losses of less than 1% (Tests 2 to 4).

Cyanidation tests with or without other treatments were carried out on the mill feed. Table 1 summarizes the procedures and the results of these tests.

TABLE 1

Procedures and Results of Tests 5 to 7

Test	Procedure	Overall Recovery % Au
5	Magnetic separation, cyanidation	92.6
6	Selective regrinding, cyanidation	91.8
7	Cyanidation	91.3
7B	Cyanidation, flotation, regrinding, cyanidation	92.2

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The mill tailing, marked primary DorrClones overflow, assayed 0.011 oz Au/ton of which only 48% was associated with sulphide minerals (Test 9). No further investigation was made on this sample.

The mill tailing, marked secondary Dorr lones underflow, assayed 0.043 oz Au/ton of which 61% was associated with sulphide minerals (Test 11). Bulk sulphide concentrates, containing from 12.2% to 56.4% of the gold, were floated from the underflow (Tests 12 to 20). Straight cyanidation of the flotation concentrates resulted in overall gold recoveries varying from 29.4% to 34.4%. Roasting and cyanidation of the flotation concentrate resulted in overall gold recovery of 46.1%.

Flotation of a calcite concentrate resulted in no significant gold concentration. Attempts to separate pyrite from arsenopyrite were also unsuccessful.

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INTRODUCTION

Shipments

Two shipments of material were submitted by Madsen Red Lake Gold Mines Limited, Madsen, Ontario.

The first shipment was received wet in four drums, on October 17, 1961. Two of these drums contained material representing the feed to "A" Unit primary thickener and the other two representing the feed to "B" primary thickener. The material contained in the four drums was dried without heating and mixed to produce a 187 lb sample representing the Madsen mill feed.

The second shipment was received wet in four drums on December 28, 1961. Two of these drums contained a sample representing the finer portion of the mill tailings, namely, primary DorrClones overflow. The other two contained a sample representing the coarser portion of the mill tailings, namely, secondary DorrClones underflow product. The two samples were dried to give --

(1) A 81 lb sample of the Tailing O'flow;
(2) A 113 lb sample of the Tailing U'flow.

Instructions

Mr. A. A. McCloskey, P. Eng., Madsen Red Lake Gold Mines Limited, Suite 1109, 55 Yonge Street, Toronto 1, Ontario, requested this investigation. He suggested that the following tests might result in an increase in the gold recovery from the Madsen mill feed --

(1) Removal of pyrrhotite by magnetic separation prior to cyanidation;
(2) Flotation of the gold-bearing minerals, regrinding of the flotation concentrate and cyanidation of the flotation concentrate and tailing combined. This procedure is referred to as selective regrinding in this report;
(3) Cyanidation of the mill feed, flotation of the cyanide residue, regrinding and cyanidation of the flotation concentrate.

After consultation with Mr. McCloskey, it was decided that no concentration tests would be done on the primary DorrClones overflow due to its low gold content.

Concerning the secondary DorrClones underflow (Tailing O'flow), Mr. McCloskey suggested that the gold might be recovered by flotation of the gold-bearing minerals and recyanidation. He also wished to know if a

separation of pyrite from arsenopyrite could be realized by cleaning with sodium permanganate to depress the arsenopyrite during flotation.

Location of Property

Madsen Red Lake Gold Mines Limited is a gold producer operating a mine in the Red Lake district, near Madsen, Ontario.

Sampling and Analysis

A 4 lb head sample was riffled out by conventional methods from each sample submitted, and sent for chemical analysis. The determinations obtained are shown in Table 2.

TABLE 2

Chemical Analysis

Element	Mill Feed	Tailing O'flow	Tailing U'flow
Gold (Au) oz/ton	0.229	0.011	0.043
Silver (Ag) "	0.065	0.065	0.035
Iron (total Fe) "	8.73	8.08	8.51
Iron (soluble Fe) "	6.60	6.57	6.89
Arsenic (As) "	0.28	0.26	0.47
Antimony (Sb) "	n.d.*	n.d.	n.d.
Nickel (Ni) "	0.010	0.010	0.010
Copper (Cu) "	0.015	0.014	0.014
Sulphur (S) "	1.67	1.24	2.76
Insoluble "	67.15	63.3	71.8
Calcium oxide (CaO) "	-	-	1.85

* none detected

A second head sample was cut from the mill feed and divided into two portions for spectrographic analysis and mineralogical examination.

The spectrographic analysis detected the following elements listed in Table 3, in their approximate decreasing order of abundance:

TABLE 3

Semi-Quantitative Spectrographic Analysis*

I	-	Si, Fe, Ca
II	-	Al, Mg, Na
III	-	As, Ti, Mn
IV	-	Cu, Ni, Ba, V, Cr

MINERALOGICAL EXAMINATION**

A 50 g head sample from the Madsen mill feed was submitted to the Mineralogy Section of the Mineral Sciences Division to determine the association of the minerals in the sample.

A -100 +200m fraction of the head sample was separated into fractions by means of heavy liquids and the mineralogy of each fraction was determined by means of microscopical and X-ray diffraction studies. The combined results are listed in Table 4.

TABLE 4

Mineralogy of the Head Sample

Mineral	Weight %
Quartz	35
Biotite	40
Pyroxene	10
Chlorite	5
Calcite	5
Epidote and garnet	4
Pyrrhotite, pyrite, arsenopyrite, ilmenite magnetite and chalcopyrite	1
Total -	100

*From Internal Report MS-61-547, by E. Kranck, Analytical Chemistry Subdivision, Mineral Sciences Division, Mines Branch, November 10, 1961.

**From Internal Report MS-61-586, by W. Petruk, Mineralogy Section, Mineral Sciences Division, Mines Branch, November 21, 1961.

DETAILS OF INVESTIGATION

Mill Feed

Test 1

A screen and infrasizer analysis was done on a 500 g sample of the mill feed. Table 5 shows the results of this test with the gold values in each fraction also shown in dollars based on gold at $35.00 per oz.

TABLE 5

Results of Test 1

Size	Weight %	Assays		Distribution	
		oz Au/ton	$/ton	%	$
+100m	1.5	0.125	4.38	0.8	0.06
-100+150m	5.3	0.145	5.08	3.4	0.27
-150+200m	11.4	0.147	5.15	7.4	0.59
-200+325m	17.8	0.210	7.35	16.5	1.31
-325m + 20 microns	32.1	0.375	13.13	53.3	4.22
-20 +10 microns	14.1	0.165	5.78	10.3	0.81
-10 microns	17.8	0.105	3.68	8.3	0.65
Feed (calcd)	100.0	0.226	7.91	100.0	7.91

Test 2

A 5,000 g sample was fed to a Jones magnetic separator set at 0 amp to concentrate the pyrrhotite. The magnetic concentrate was ground for 10 min to 88% -325m and cleaned on the same machine set at 0 amp. The results of this test are summarized in Table 6.

TABLE 6

Results of Test 2

Product	Weight %	Assays		Distribution %	
		oz/ton Au	% Fe	Au	Fe
Pyrrhotite cl conc	0.9	0.205	58.0	0.8	7.6
Pyrrhotite cl tail	3.0	0.330	13.0	4.4	5.7
Tailing	96.1	0.223	6.21	94.8	86.7
Feed (calcd)	100.0	0.226	6.88	100.0	100.0

Test 3

A 5,000 g sample was fed to a three-drum Jeffrey magnetic separator set at 2.2, 1.2, 0.7 amp respectively. The middling products were added to the concentrate. Table 7 shows the results obtained in Test 3.

TABLE 7

Results of Test 3

Product	Weight %	Assays		Distribution %	
		oz/ton Au	% Fe	Au	Fe
Pyrrhotite conc	1.0	0.100	53.2	0.5	8.1
Tailing	99.0	0.210	6.06	99.5	91.9
Feed (calcd)	100.0	0.209	6.53	100.0	100.0

Test 4

A 15,000 g sample was fed to a Crockett magnetic separator. The concentrate produced was ground for 10 min to 87% -325m and cleaned on the same machine. The results of this test are shown in Table 8.

TABLE 8

Results of Test 4

Product	Weight %	Assays		Distribution %	
		oz/ton Au	% Fe	Au	Fe
Pyrrhotite cl conc	1.2	0.125	52.6	0.6	9.7
Pyrrhotite cl tail	1.7	0.290	8.34	1.9	2.2
Tailing	97.1	0.255	5.92	97.5	88.1
Feed (calcd)	100.0	0.254	6.52	100.0	100.0

Test 5

A 5,000 g sample was treated on a Jones magnetic separator using the same procedure as in Test 2, except that the pyrrhotite cleaner tailing was added to the tailing. Table 9 summarizes the results of this test.

TABLE 9

Results of Magnetic Separation Test 6

Product	Weight %	Assays		Distribution %	
		oz/ton Au	% Fe	Au	Fe
Pyrrhotite	1.3	0.185	53.9	1.0	10.6
Tailing	98.7	0.230	5.97	99.0	89.4
Feed (calcd)	100.0	0.229	6.59	100.0	100.0

A 1,000 g sample was cut from the tailing in Test 5 and cyanided for 48 hrs. The NaCN and CaO concentration were both kept at 1 lb/ton of solution and the dilution was 2:1. The results of the cyanidation test are shown in Table 10.

TABLE 10

Results of Cyanidation Test 5

Temp °F	pH	Consumption lb/ton of feed		Reducing Power cc $\frac{N}{10}$ $KMnO_4$/1	Residue Assays oz/ton	Extraction %
		NaCN	CaO		Au	Au
74	12.4	1.4	4.4	92	0.015	93.5

The overall gold recovery in Test 5 was 92.6%.

Test 6

A 2,000 g sample of mill feed was floated using the conditions described in Table 11.

TABLE 11

Reagents and Conditions of Flotation Test 6

Operation	Reagents lb/ton of feed		Time min	pH
Conditioning	$CuSO_4$	1.0	5	8.4
	R-208	0.1		
	R-301	0.1		
Flotation	Pine oil	0.04	10	

The flotation results are shown in Table 12.

TABLE 12

Results of Flotation Test 6

Product	Weight %	Assays oz/ton Au	Distribution % Au
Flot conc	4.1	3.63	68.0
Flot tail	95.9	0.073	32.0
Feed (calcd)	100.0	0.219	100.0

The flotation concentrate was ground for 30 min to 99.5% -325m. A 41 g sample cut from the flotation concentrate was mixed with a 959 g sample cut from the flotation tailing. The combined product, which represented the original feed, was cyanided for 48 hrs at a dilution of 2:1 with solution strength maintained at 1 lb of NaCN/ton and 1 lb CaO/ton. Table 13 summarizes the results of this cyanidation test.

TABLE 13

Results of Cyanidation Test 6

Temp °F	pH	Consumption lb/ton of feed		Reducing Power cc N/10 $KMnO_4$/1	Residue Assays oz/ton Au	Extraction % Au
		NaCN	CaO			
73	12.3	1.5	4.6	104	0.018	91.8

The purpose of this test was to liberate the gold contained in the sulphides by regrinding the flotation concentrate which contained 68% of the gold present in the material.

Test 7

Cyanidation tests were made on four 1,000 g samples of the Madsen mill feed. Each sample was agitated for 48 hrs in a solution maintained at 1 lb of NaCN/ton and 1 lb of CaO/ton. The dilution was 2:1. The cyanide tailings were combined for assay. Table 14 summarizes the results of this cyanidation test.

TABLE 14

Results of Cyanidation Test 7

Temp °F	pH	Consumption lb/ton of feed		Reducing Power cc N/10 $KMnO_4$/1	Residue Assays oz/ton Au	Extraction* % Au
		NaCN	CaO			
76	12.3	1.1	4.6	116	0.020	91.3

* calculated by difference

The combined cyanide tailings were cut into two portions for flotation tests. Two similar flotation tests were carried out on each portion and their products were combined for assays. The flotation tests were made using the procedure described in Table 11. Table 15 shows the results of this test.

TABLE 15

Results of Flotation Test 7

Product	Weight %	Assays oz/ton Au	Distribution % Au
Flot conc	4.9	0.076	17.0
Flot tail	95.1	0.019	83.0
Feed (calcd)	100.0	0.022	100.0

Three 50 g samples were cut from the flotation concentrate and ground for 20 min to 99% -325m. Each sample was cyanided in a solution maintained at 1 lb of NaCN/ton and 1 lb of CaO/ton, and at a dilution of 10:1.

The results of these cyanidation tests are shown in Table 16.

TABLE 16

Results of Cyanidation Tests 7A, 7B, 7C

Test	Time hrs	Temp °F	pH	Consumption lb/ton conc		Reducing Power cc N/10 $KMnO_4$/l	Residue Assay oz/ton Au	Extraction % Au
				NaCN	CaO			
A	24	70	12.4	4.7	15.9	62	0.033	56.6
B	48	70	12.5	5.5	17.5	68	0.030	60.5
C	96	70	12.4	6.3	19.1	76	0.030	60.5

The overall gold recoveries were 92.1% for Test 7A and 92.2 for Tests 7B and 7C.

Primary DorrClones Overflow (Tailing O'flow)

Test 8

A screen and infrasizer analysis was done on a 500 g sample of the Tailing O'flow. Table 17 shows the results of this test with the gold values in each fraction also calculated in dollars on the basis of gold at $35.00 per oz.

TABLE 17

Results of Test 8

Size	Weight %	Assays		Distribution	
		oz Au/ton	$/ton	%	$
-200 +325m	8.8	0.013	0.46	9.9	0.04
-325m+20 microns	56.3	0.011	0.38	53.4	0.22
-20 +10 microns	14.4	0.011	0.38	13.7	0.06
-10 microns	20.5	0.012	0.46	23.0	0.10
Feed (calcd)	100.0	0.012	0.42	100.0	0.42

Test 9

To determine the association of the gold in the Tailing O'flow, a 1,000 g sample was given the following treatment:

The sample was cyanided for 24 hrs, using the same procedure as in Test 7. A sample was cut from the cyanide tailing for assay. The remaining portion was treated with 10% hydrochloric acid until all the carbonates were decomposed. The acid leach residue was washed thoroughly, dried, weighed, and then cyanided for 24 hrs. A sample was cut from this residue and assayed. A second 5-assay ton sample was cut from this residue and was treated with hot aqua regia for 6 hours, and then assayed. The last two assays were corrected for loss of weight due to dilute hydrochloric acid treatment. The results of this test are summarized in Table 18.

TABLE 18

Results of Test 9

Product	Assays oz/ton Au	Distribution % Au
Feed	0.012	100.0
1st cyanide residue	0.010	83.3
2nd " "	0.0076	63.3
Aqua regia residue	0.0018	15.0

The following distribution of gold was calculated from these results:

Exposed gold	16.7 %
Gold enclosed in carbonates	20.0 %
Gold enclosed in sulphides	48.3 %
Gold enclosed in insoluble gangue	15.0 %

Secondary DorrClones Underflow (Tailing U'flow)

Test 10

A screen and infrasizer analysis was done on an 800 g sample of the Tailing U'flow. Table 17 shows the results of this analysis with the values also shown in dollars.

TABLE 19

Results of Test 10

Size	Weight %	Assays		Distribution	
		oz Au/ton	$/ton	% Au	$
+150m	14.9	0.048	1.68	16.8	0.25
-150 +200m	21.2	0.032	1.12	15.9	0.24
-200 +325m	28.1	0.036	1.26	23.8	0.36
-325m +20 microns	32.8	0.047	1.65	36.2	0.55
-20 +10 "	2.0	0.12	4.20	5.6	0.08
-10 "	1.0	0.07	2.45	1.7	0.03
Feed (calcd)	100.0	0.043	1.51	100.0	1.51

Test 11

In this test, the cyanidation and acid treatment described in Test 9 was repeated on a 1,000 g sample of the Tailing U'flow. The results of this test are shown in Table 20.

TABLE 20

Results of Test 11

Product	Assays oz/ton Au	Distribution % Au
Feed	0.043	100.0
1st cyanide residue	0.037	86.0
2nd " "	0.031	72.0
Aqua regia residue	0.0048	11.2

From these results, the following distribution of gold was calculated:

Exposed gold	14.0 %
Gold enclosed in carbonates	14.0 %
Gold enclosed in sulphides	60.8 %
Gold enclosed in insoluble gangue	11.2 %

Tests 12 to 20

The following flotation tests were carried out on 2,000 g samples of the Tailing U'flow. The flotation conditions are described in Table 21 and the results are shown in Table 22.

TABLE 21

Reagents and Conditions of Flotation Tests 12 to 20

Operation	Test								
	12	13	14	15	16	17	18	19	20
Grinding Time (min)	Nil	nil	nil	nil	nil	10	20	20	20
Fineness of grind (% -200m)	64	64	64	64	64	73	84	84	84
1st conditioning: 5 min									
Reagents (lb/ton): R-301	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05
R-208	0.10	0.10	0.10	0.10	0.05	0.05	0.05	0.05	0.05
$CuSO_4$		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
H_2SO_4			2.0						
Na_2CO_3				1.0	1.0	1.0	1.0	1.0	1.0
pH	8.7	8.8	6.4	8.9	8.8	9.0	9.1	8.8	9.0
1st flotation: 15 min									
Reagent (lb/ton): pine oil	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

TABLE 21 (contd)

Reagents and Conditions of Flotation Tests 12 to 20

Operation	Test								
	12	13	14	15	16	17	18	19	20
2nd conditioning: 5 min									
Reagents (lb/ton): R-301					0.05	0.05	0.05	0.05	0.05
R-208					0.05	0.05	0.05	0.05	0.05
H_2SO_4					2.0	2.0	2.0	2.0	2.0
pH					6.9	7.0	6.9	6.9	6.9
2nd flotation: 10 min									
Reagent (lb/ton): pine oil					0.02	0.02	0.02	0.02	0.02
3rd conditioning: 5 min									
Reagents (lb/ton): oleic acid								0.25	0.25
NaCl*								35.0*	
Na_2SiO_3									1.0
pH								5.9	8.2
3rd flotation: 5 min									
Reagent (lb/ton): nil									

* This addition was made to give a 4% brine pulp.

TABLE 22

Results of Flotation Tests 12 to 20

Test	Product	Weight %	Assays				Distribution %			
			oz/ton Au	%						
				As	Fe	S	Au	As	Fe	S
12	Sulphide conc	3.6	0.145	2.07	38.4	40.5	12.2	16.5	20.2	52.7
	Flot tail	96.4	0.039	0.39	5.67	1.36	87.8	83.5	79.8	47.3
	Feed (calcd)	100.0	0.043	0.45	6.85	2.77	100.0	100.0	100.0	100.0
13	Sulphide conc	4.9	0.16	3.52	30.0	30.3	19.1	36.2	21.5	53.4
	Flot tail	95.1	0.035	0.32	5.63	1.36	80.9	63.8	78.5	46.6
	Feed (calcd)	100.0	0.041	0.48	6.82	2.78	100.0	100.0	100.0	100.0
14	Sulphide conc	4.7	0.20	4.98	32.2	32.5	22.5	51.6	22.5	54.8
	Flot tail	95.3	0.034	0.23	5.48	1.32	77.5	48.4	77.5	45.2
	Feed (calcd)	100.0	0.042	0.45	6.74	2.78	100.0	100.0	100.0	100.0
15	Sulphide conc	5.8	0.22	4.97	30.3	28.0	29.7	67.1	25.6	60.2
	Flot tail	94.2	0.032	0.15	5.42	1.14	70.3	32.9	74.4	39.8
	Feed (calcd)	100.0	0.043	0.43	6.86	2.70	100.0	100.0	100.0	100.0
16	Sulphide conc	6.2	0.24	4.91	28.9	26.5	34.6	67.0	26.3	59.6
	Flot tail	93.8	0.030	0.16	5.35	1.19	65.4	33.0	73.7	40.4
	Feed (calcd)	100.0	0.043	0.45	6.81	2.76	100.0	100.0	100.0	100.0
17	Sulphide conc	9.7	0.22	3.60	26.4	19.1	48.6	79.5	34.0	74.3
	Flot tail	90.3	0.025	0.10	5.50	0.71	51.4	20.5	66.0	25.7
	Feed (calcd)	100.0	0.044	0.44	7.52	2.49	100.0	100.0	100.0	100.0
18	Sulphide conc	9.4	0.265	4.16	28.1	20.8	55.6	84.4	34.2	75.8
	Flot tail	90.6	0.022	0.08	5.62	0.69	44.4	15.6	65.8	24.2
	Feed (calcd)	100.0	0.045	0.46	7.73	2.58	100.0	100.0	100.0	100.0
19	Sulphide conc	9.7	0.23	3.40	23.2	18.2	52.7	80.7	33.5	69.3
	Calcite conc*	6.5	0.025	0.18	10.3	3.94	3.8	2.9	10.0	10.0
	Flot tail	83.8	0.022	0.08	4.52	0.63	43.5	16.4	56.5	20.7
	Feed (calcd)	100.0	0.042	0.41	6.71	2.55	100.0	100.0	100.0	100.0
20	Sulphide conc	11.4	0.22	3.37	27.0	17.3	56.4	79.7	44.6	86.0
	Calcite conc**	3.4	0.02	0.12	6.60	1.12	1.5	0.9	3.3	1.7
	Flot tail	85.2	0.022	0.11	4.21	0.33	42.1	19.4	52.1	12.3
	Feed (calcd)	100.0	0.044	0.48	6.89	2.29	100.0	100.0	100.0	100.0

* This calcite concentrate assayed 15.8% CaO and recovered 55.5% of the calcite.

** This calcite concentrate assayed 16.6% CaO and recovered 30.5% of the calcite.

NOTE: "Sulphide conc" contains the 1st and 2nd flotation concentrates combined.
"Calcite conc" is the 3rd flotation concentrate.

Tests 17A - 17B

A 150 g sample was cut from the flotation concentrate produced in Test 17 and ground for 20 min to 87% -325m. The sample was fed to a Jones magnetic separator set at 0 amp to remove the pyrrhotite. The results of this test are summarized in Table 23.

TABLE 23

Results of Magnetic Separation

Product	Weight %	Assays		Distribution %	
		oz/ton Au	% Fe	Au	Fe
Pyrrhotite conc	6.7	0.15	47.4	4.9	11.9
Tail	93.3	0.21	25.2	95.1	88.1
Feed (calcd)	100.0	0.206	26.7	100.0	100.0

Two 50 g samples were cut from the magnetic separation tailing and both ground for 5 min to 92% -325m. Each sample was cyanided for 48 hrs in a solution maintained at 1.0 of NaCN/ton. The lime strength of the solution was kept at 1.0 lb of CaO/ton for Test 17A and at 0.2 lb of CaO/ton for Test 17B. The results of these tests are shown in Table 24.

TABLE 24

Results of Cyanidation Tests 17A-17B

Test	Temp °F	pH	Consumption lb/ton of conc		Reducing Power	Residue Assays oz/ton Au	Extraction % Au
			NaCN	CaO	cc N/10 $KMnO_4$/1		
17A	78	12.6	5.6	15.0	380	0.105	49.0
17B	78	11.1	5.6	4.2	400	0.105	49.0

The overall recovery was 23.8% of the gold contained in the Tailing U'flow.

Tests 18A - 18B

Two 50 g samples were cut from the flotation concentrate produced in Test 18 and both ground for 10 min to 92% -325m.

Tests 18A and 18B were cyanidation tests similar to Tests 17A and 17B respectively. Table 25 shows the results of Tests 18A and 18B.

TABLE 25

Results of Cyanidation Tests 18A-18B

Test	Temp °F	pH	Consumption lb/ton of conc		Reducing Power cc N/10 $KMnO_4$/1	Residue Assays oz/ton Au	Extraction % Au
			NaCN	CaO			
18A	78	12.7	4.2	17.0	448	0.125	52.8
18B	78	11.3	5.4	4.6	440	0.125	52.8

The overall recovery was 29.4% of the gold in the Tailing Outflow.

Tests 19A-19B

Tests 19A and 19B were cyanidation tests similar to Test 17B except that the 50 g samples cut from the flotation concentrate produced in Test 19 were ground for 20 min to 94% -325m and for 30 min to 96% -325m respectively. The results of these tests are summarized in Table 26.

TABLE 26

Results of Cyanidation Tests 19A-19B

Test	Temp °F	pH	Consumption lb/ton of conc		Reducing Power cc N/10 $KMnO_4$/1	Residue Assays oz/ton Au	Extraction % Au
			NaCN	CaO			
19A	80	10.6	11.4	6.0	880	0.10	56.5
19B	79	10.4	18.0	10.0	1360	0.08	65.2

The overall gold recoveries were 29.8% and 34.4% respectively.

Tests 20A - 20B

A 150 g sample was cut from the flotation concentrate produced in Test 20 and roasted for 45 min at 500°C. The calcine assayed 0.24 oz Au/ton, 1.03% As, 26.7% Fe and 1.78% S. The loss of weight was 12%. Two 50 g samples were cut from the calcine for cyanidation.

Tests 20A and 20B consisted of 48 hrs cyanidation tests without grinding for Test 20A and with a 10 min grind for Test 20B. A screen test made on both samples gave 65% -200m and 92% -200m respectively. In each test, the cyanide solution was maintained at 1.0 lb of NaCN/ton and 0.2 lb of CaO/ton. Table 27 shows the results of Test 20A and Test 20B.

TABLE 27

Results of Cyanidation Tests 20A-20B

Test	Temp °F	pH	Consumption lb/ton calcine		Reducing Power cc N/10 $KMnO_4$/1	Residue Assays oz/ton Au	Extraction % Au
			NaCN	CaO			
20A	81	11.3	6.0	9.2	72	0.04	81.8
20B	80	11.0	11.0	5.2	160	0.04	81.8

In each test, the overall gold recovery was 46.1%.

Test 21

A 2,000 g sample of Tailing U'flow was floated using the same procedure as in Test 18. In this test, the first and second flotation concentrates were kept separate. The first flotation concentrate was then cut into two portions, A and B, which were cleaned, as indicated in Table 28, in an attempt to float the pyrite and to depress the arsenopyrite.

TABLE 28

Reagents and Conditions of Cleaner Flotation Test 21

Operation	Portion	
	A	B
Conditioning: 5 min		
Reagents (lb/ton): $KMnO_4$	0.25	0.50
pH	8.5	8.4
Flotation: 5 min		
Reagent (lb/ton): nil		

TABLE 29

Results of Flotation Test 21

Product	Weight %	Assays				Distribution %			
		oz/ton Au	% As	% Fe	% S	Au	As	Fe	S
1st flot cl conc A	1.7	0.40	5.8	36.1	40.1	15.0	25.0	8.6	25.7
1st flot cl tail A	1.4	0.21	1.6	12.1	5.4	6.5	5.8	2.4	2.9
1st flot cl conc B	1.6	0.42	6.5	38.7	40.1	14.8	26.3	8.7	24.2
1st flot cl tail B	1.5	0.22	2.3	14.5	8.1	7.3	8.7	3.0	4.6
2nd flot conc	3.3	0.17	2.17	23.7	12.8	12.4	18.1	11.0	15.9
Flot tail	90.5	0.022	0.07	5.25	0.78	44.0	16.1	66.3	26.7
Feed (calcd)	100.0	0.045	0.39	7.15	2.65	100.0	100.0	100.0	100.0

CONCLUSION

Straight cyanidation of the Madsen mill feed resulted in a 91.3% gold extraction (Test 7). This value is higher than that obtained at the Madsen plant, possibly due to the use of a fresh cyanide solution.

Pyrrhotite can be removed from the mill feed by magnetic concentration with gold losses of less than 1%, but no significant increase in the overall gold recovery was obtained by cyanidation of the ore after removal of pyrrhotite (Tests 2 to 5). However, a magnetic separation to remove pyrrhotite might reduce the build-up of deleterious elements in the cyanide solution at the Madsen cyanidation plant.

No significant increase in the gold recovery was obtained by selective regrinding of the gold-bearing minerals prior to cyanidation (Test 6).

A treatment, consisting of cyanidation of the mill feed, flotation of the cyanide residue, regrinding and cyanidation of the flotation concentrate resulted in a 0.9% increase of the overall gold recovery (Test 7B).

Because the cyanide residue produced from the sample of mill feed was lower in gold than the Madsen mill tailing, a series of flotation tests were run on the cyanide tailing from the Madsen mill. The tailings submitted consisted of samples of the primary DorrClones overflow and the secondary DorrClones underflow, assaying 0.011 oz Au/ton and 0.043 oz Au/ton respectively. The gold content of the primary DorrClones overflow was too low to justify an investigation.

An acid treatment indicated that about 61% of the gold contained in the secondary DorrClones underflow (Tailing U'flow) was associated with sulphide minerals and 14% with carbonate minerals (Test 11). Flotation of bulk sulphide concentrates from the Tailing U'flow recovered over 48% of the gold in Tests 17 to 20. These concentrates were cyanided under different conditions and the results obtained can be summarized as follows:

1. Magnetic separation of the pyrrhotite prior to cyanidation does not increase the gold recovery;

2. Decreasing the lime concentration has no effect on the gold recovery but reduces the lime consumption;

3. Increasing the grinding time results in a marked increase in the gold recovery;

4. Roasting of the flotation concentrate prior to cyanidation gave the highest gold recovery;

5. Regrinding of the calcine before cyanidation has no effect in the gold recovery.

Flotation of a calcite concentrate to improve the gold recovery and separation of pyrite from arsenopyrite by a cleaner flotation of a bulk sulphide concentrate gave disappointing results (Tests 18 to 21).

Briefly, an appreciable decrease of the gold contained in the Madsen cyanidation tailings can be achieved by flotation of a sulphide concentrate from the U'flow fraction and recyanidation of the concentrate. This procedure reduces the U'flow Tailing from 0.043 to .028 oz Au/ton for a straight cyanidation and to 0.023 oz Au/ton for a recyanidation preceded by a roasting stage. These results, based on mill tailing composed of 50%, by weight, of both O'flow and U'flow, correspond to a reduction in the gold content of the final tailing from 0.027 oz/ton to 0.020 or 0.017 oz/ton.

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