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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 64-52

INVESTIGATION OF A GOLD ORE FROM THE LA FORMA PROPERTY OF ORMSBY MINES LIMITED, CARMACKS, Y. T.

by

G. I. MATHIEU

MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The investigation showed that processing ore from this property, assaying approximately 1.0 oz Au/ton, by jigging, amalgamation and cyanidation gave a gold recovery of over 98%.

About 70% of the gold was free milling which was recovered at a relatively coarse grind by jigging and amalgamation. The remaining gold was extracted by cyanidation of the jig and amalgamation tailing reground to about 70% -200 mesh.

The ore contained appreciable slimy clay material which was said to be from a seam of gouge and fine clay following the ore vein. This material resulted in extremely slow settling and filtration rates. Desliming and the use of a suitable flocculant increased these rates by 50 times. Tests showed that desliming could reject up to 25% of the weight of the cyanidation feed with a loss of less than 3% of the gold.

A flowsheet incorporating desliming before cyanidation gave an overall gold recovery of 96.4% on an original mill feed assaying 1.0 oz Au/ton.

Flotation of the deslimed ore before cyanidation reduced the feed to cyanidation by 97% with a loss of about 5% of the gold in the flotation tailing. Treating the ore by jigging, amalgamation and desliming followed by cyanidation of a flotation concentrate gave an overall gold recovery of 91.7%.

*Scientific Officer, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

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INTRODUCTION

Ormsby Mines Limited hold the former La Forma Mine property consisting of 32 claims in Mount Freegold area, northwest of Carmacks, Yukon Territory.

Exploration during the past year on the La Forma property resulted in the discovery of high grade ore for a continuous length of 372 feet. Mine development operations are scheduled to resume in April and a production decision is expected by mid-summer of this year.

Shipment

Three samples, identified as Sample No. 1 (Rejects), Sample No. 2 (Central Face) and Sample No. 3 (North Face) and weighing 100, 40 and 40 lb, respectively, were received at the Mines Branch on January 9, 1964. The ore samples were shipped by Mr. C.H. Macdonald, Mine Manager, at the request of Mr. J.C. Byrne, President of Ormsby Mines Limited, Suite 1011, 2200 Yonge Street, Toronto 12, Ontario.

Purpose of Investigation

Mr. F.B. Brien, P. Eng., 6358 - 43rd Avenue, Seattle 15, Washington, U.S.A., consultant for the company, requested an investigation on the processing of this ore for the recovery of the contained gold. It was stated that the company would like to treat the ore by a jigging-cyanidation process.

After learning that the settling and filtration rates of the cyanidation pulp were extremely low due to the presence of clay, Mr. Brien requested further studies on desliming and flocculation to outline a process for overcoming these difficulties.

Sampling and Analysis

The three samples of ore were crushed to minus 10 m and a head sample was riffled out by conventional methods from each sample. A fourth composite sample, consisting of equal parts of Samples No. 2 and No. 3, was prepared for testing at the request of Mr. Brien and was identified as Sample No. 4.

A spectrographic analysis of a portion of the head samples indicated the elements were present in the following approximate order of decreasing abundance:

TABLE 1

Spectrographic Analysis* of Head Samples

I	-	Si, Ca, Al, Fe	(> 1%)
II	-	Cu, Mo, Pb	(1% - 0.1%)
III	-	Nb, B, Sr	(0.1% - 0.01%)
IV	-	Ni, Zr, V	(< 0.01%)

*From Internal Report MS-AC-64-58.

Chemical analysis of the head samples gave the following results:

TABLE 2

Chemical Analysis* of Head Samples

Element	Sample No. 1 (Rejects)	Sample No. 2 (Central Face)	Sample No. 3 (North Face)	Sample No. 4** (Mixed)
Gold (Au)	0.76 oz/ton	1.59 oz/ton	0.39 oz/ton	0.99 oz/ton
Silver (Ag)	0.30 "	0.29 "	0.14 "	0.22 "
Iron (Fe)	3.10 %	2.16 %	2.38 %	2.27 %
Arsenic (As)	0.17 "	0.42 "	0.13 "	0.28 "
Sulphur (S)	1.73 "	0.57 "	0.60 "	0.58 "
Insoluble	80.76 "	89.69 "	81.66 "	85.68 "

*From Internal Report MS-AC-64-334.
**Calculated average figures.

MINERALOGICAL EXAMINATION*

A portion of each head sample was submitted to the Mineralogy Section of the Mineral Sciences Division for examination.

Each sample was sized and the -65+ 200 mesh fractions were separated into sub-fractions by means of heavy liquids. Polished sections were prepared from some of the sub-fractions and the minerals were identified by means of microscopy and X-ray diffraction.

Minerals identified were native gold, pyrite, arsenopyrite, sphalerite, chalcopyrite, tetrahedrite, hematite, covellite, ilmenite, rutile, goethite, quartz, feldspar, tourmaline and chlorite. The native gold occurred as free grains in the gravity sub-fractions and as inclusions in pyrite, goethite and gangue minerals. Typical occurrence of gold in the ore is illustrated by Figures 1 and 2.

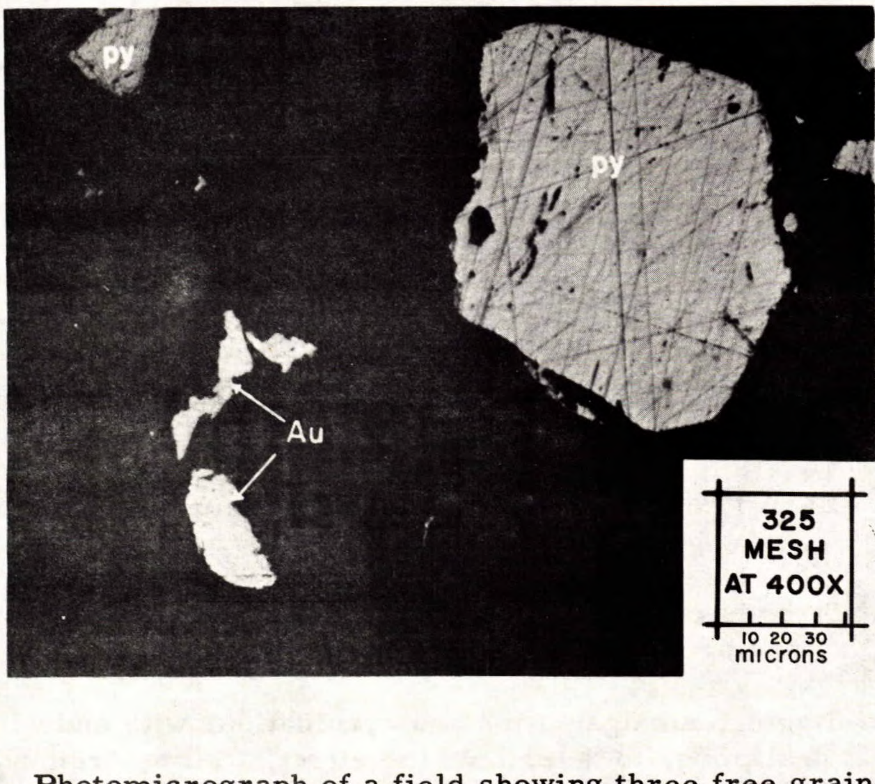

Figure 1. Photomicrograph of a field showing three free grains of gold and one of pyrite.

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*From Internal Report MS-64-4 by W. Petruk, February 6, 1964.

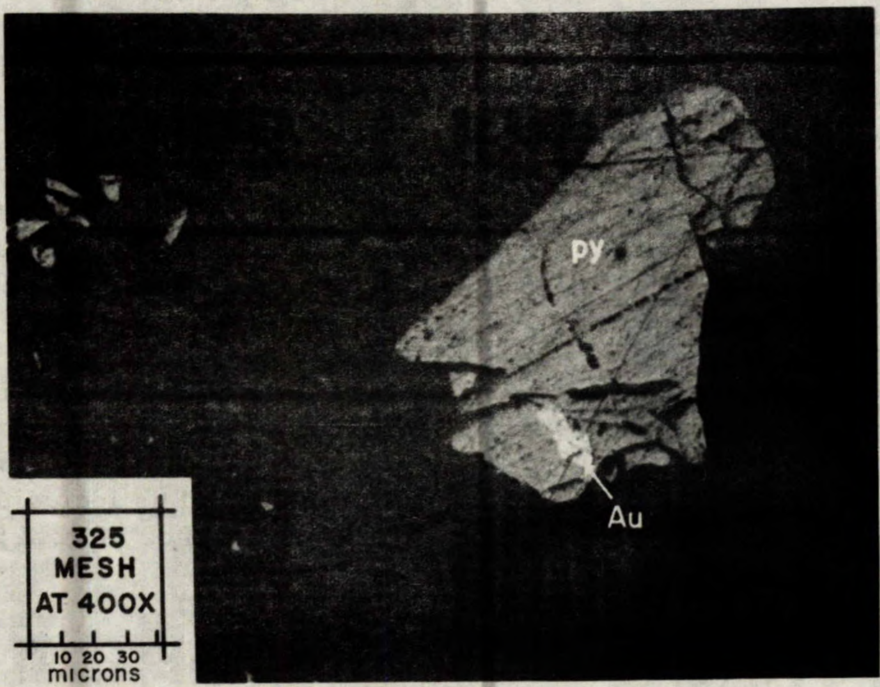

Figure 2. Photomicrograph of a field showing an inclusion of gold in pyrite.

OUTLINE OF PROCEDURE

The investigation on the Ormsby gold ore was carried out under five main procedures as follows:

1. Barrel amalgamation to determine the quantity of free milling gold.

2. Straight cyanidation at different grinds to find the minimum grinding necessary to liberate the gold.

3. Jigging, amalgamation and cyanidation, with and without desliming, to determine the effect of slimes removal either after crushing or after grinding, on settling and filtration rate.

4. Jigging, amalgamation, flotation and cyanidation to assess the effectiveness of this procedure.

5. Settling and filtration tests with the addition of flocculants to increase the settling and filtration rate of the cyanidation tailings.

DETAILS OF INVESTIGATION

Amalgamation, Tests 1 to 4

In these tests, 1000 g lots of ore from each sample were separately ground for 10 minutes and amalgamated for 1 hour with 10 ml of new mercury and 1 g of lime.

TABLE 3

Results of Amalgamation

Sample	Fineness of Grind % -200 mesh	Assays* oz Au/ton		Extraction % Au
		Amalgam**	Residue	
No. 1	42	0.49	0.33	59.8
No. 2	40	1.23	0.31	79.9
No. 3	45	0.29	0.15	65.9
No. 4	41	0.78	0.23	77.2

*From Internal Report MS-AC-64-277.

**Amalgam assays expressed in terms of amalgamation feed.

Straight Cyanidation, Tests 5 to 16

This series of tests consisted of grinding 1000 g lots of ore from each sample for 10, 20 and 30 minutes, and cyanidation for 48 hours at solution strengths of 1.0 lb NaCN/ton and 0.5 lb CaO/ton. The following results were obtained.

TABLE 4

Results of Cyanidation

Sample	Test	Grinding Time min	Grinding % -200 m	Reagents Consumed lb/ton of ore NaCN	Reagents Consumed lb/ton of ore CaO	Reducing Power cc $\frac{N}{10}$ $KMnO_4$/l	Residue Assays* oz/ton Au	Extraction** % Au
No. 1	5	10	42	1.2	5.0	80	0.023	97.0
	6	20	69	1.4	5.1	84	0.015	98.0
	7	30	86	1.8	4.9	80	0.017	97.8
No. 2	8	10	40	1.1	5.0	60	0.045	97.2
	9	20	64	1.5	5.1	64	0.015	99.1
	10	30	81	1.6	5.1	60	0.015	99.1
No. 3	11	10	45	1.7	5.0	120	0.014	96.4
	12	20	75	2.1	5.1	100	0.008	98.0
	13	30	89	2.4	5.1	112	0.010	97.4
No. 4	14	10	41	1.6	5.0	80	0.022	97.8
	15	20	65	1.7	5.1	85	0.020	98.0
	16	30	82	1.7	5.1	80	0.019	98.1

* From Internal Reports MS-AC-64-277 and 367.

**Calculated by difference.

The results of these tests showed that a 20 minute grinding period was sufficient to liberate most of the gold contained in each sample. It was also noted that all the residues from the above tests filtered very slowly.

Jigging, Amalgamation and Cyanidation, Tests 17 to 20

Lots of 6000 g of ore cut from each sample were ground for 10 minutes and fed to a laboratory jig to recover the free milling gold. Each concentrate produced was ground for 10 minutes and amalgamated for 1 hour with 10 ml of mercury and 1 g of lime. The jigging and amalgamation tailings were combined, ground for an additional 10 minutes, and cyanided for 48 hours at solution strengths of 1.0 lb NaCN/ton and 0.5 lb CaO/ton. The results of Tests 17 to 20 are shown in Tables 5 to 8. In these tables, the amalgam assays are expressed in terms of amalgamation feed and the solution assays are expressed in terms of cyanidation feed.

TABLE 5

Results of Jigging, Amalgamation and Cyanidation (Sample No. 1)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.8	21.06	50.4	50.4
	Tailing	98.2	0.38	49.6	
	Feed (calcd)	100.0	0.75	100.0	
Amalgamation	Amalgam	-	20.22	96.0	48.4
	Tailing	-	0.84	4.0	
	Feed (calcd)	-	21.06	100.0	
Cyanidation	Solution	-	0.366	96.3	49.7
	Residue	-	0.014	3.7	
	Feed (calcd)		0.38	100.0	
Amalgamation and cyanidation (overall)					98.1

*From Internal Reports MS-AC-64-302 and 321.

TABLE 6

Results of Jigging, Amalgamation and Cyanidation (Sample No. 2)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.6	68.16	75.5	75.5
	Tailing	98.4	0.36	24.5	
	Feed (calcd)	100.0	1.44	100.0	
Amalgamation	Amalgam	-	67.81	99.5	75.1
	Tailing	-	0.35	0.5	
	Feed (calcd)	-	68.16	100.0	
Cyanidation	Solution	-	0.345	95.8	23.9
	Residue	-	0.015	4.2	
	Feed (calcd)	-	0.36	100.0	
Amalgamation and cyanidation (overall)					99.0

*From Internal Reports MS-AC-64-302 and 359.

TABLE 7

Results of Jigging, Amalgamation and Cyanidation (Sample No. 3)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.2	19.12	57.7	57.7
	Tailing	90.8	0.17	42.3	
	Feed (calcd)	100.0	0.40	100.0	
Amalgamation	Amalgam	-	18.76	98.1	56.6
	Tailing	-	0.36	1.9	
	Feed (calcd)	-	19.12	100.0	
Cyanidation	Solution	-	0.162	95.3	41.4
	Residue	-	0.008	4.7	
	Feed (calcd)	-	0.17	100.0	
Amalgamation and cyanidation (overall)					98.0

*From Internal Reports MS-AC-64-302 and 367.

TABLE 8

Results of Jigging, Amalgamation and Cyanidation (Sample No. 4)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.2	62.70	76.0	76.0
	Tailing	98.8	0.24	24.0	
	Feed (calcd)	100.0	0.99	100.0	
Amalgamation	Amalgam	-	62.12	99.1	75.3
	Tailing	-	0.58	0.9	
	Feed (calcd)	-	62.70	100.0	
Cyanidation	Solution	-	0.228	95.0	23.5
	Residue	-	0.012	5.0	
	Feed (calcd)	-	0.24	100.0	
Amalgamation and cyanidation (overall)					98.8

*From Internal Reports MS-AC-64-398 and 428.

The amounts of sodium cyanide and lime consumed during these cyanidation tests, and the reducing power of the cyanidation pulps are shown in the following table.

TABLE 9

Reagent Consumption in Cyanidation

Sample	Test	Reagent Consumption lb/ton of ore		Reducing Power cc $\frac{N}{10}$ $KMnO_4$/1
		NaCN	CaO	
No. 1	17	1.8	4.0	60
No. 2	18	1.3	4.0	60
No. 3	19	2.2	4.2	76
No. 4	20	1.7	4.2	72

The cyanide pulp from each test was divided into several fractions to carry out settling rate tests using the Coe and Clevenger method(1) and filtration rate tests using the standard leaf method(2). The settling rates were measured at 4:1, 3:1 and 2:1 dilution. The filtration rates were all determined at a dilution of 1.2:1.

After a few preliminary determinations using different quantities of flocculation reagents to find their effect on the settling and filtration rates, a series of tests was run with adequate quantities of caustic starch, Aerofloc 550 and Separan NP-10. The results obtained with and without flocculants are shown in Table 10.

TABLE 10

Settling and Filtration Rates

Sample	Test	Settling: Reagents lb/ton of ore		Settling: Rate, ft/hr, Dilution 4:1	3:1	2:1	Final Density Water/Solids	Filtration: Reagents lb/ton of ore		Filtration: Rate lb/ft²/hr
No. 1	17	nil	-	0.6	0.4	0.2	1.0:1	nil	-	2
		Caustic Starch	0.45	2.9	0.5	0.2	1.0:1	Caustic Starch	0.20	4
		Aerofloc 550	0.40	2.6	0.6	0.2	0.9:1	Aerofloc 550	0.20	22
		Separan NP-10	0.20	11.0	1.5	0.3	0.9:1	Separan NP-10	0.10	35
No. 2	18	nil	-	1.0	0.6	0.3	0.9:1	nil	-	2
		Caustic Starch	0.40	3.8	1.4	0.2	0.9:1	Caustic Starch	0.20	6
		Aerofloc 550	0.30	3.9	1.6	0.3	0.8:1	Aerofloc 550	0.20	27
		Separan NP-10	0.15	19.8	4.2	1.1	0.8:1	Separan NP-10	0.10	48
No. 3	19	nil	-	0.4	0.2	0.1	1.0:1	nil	-	1
		Caustic Starch	0.50	2.1	0.3	0.1	1.0:1	Caustic Starch	0.20	3
		Aerofloc 550	0.45	1.8	0.3	0.1	1.1:1	Aerofloc 550	0.20	7
		Separan NP-10	0.25	6.8	1.4	0.3	1.1:1	Separan NP-10	0.10	28
No. 4	20	nil	-	0.6	0.4	0.3	1.0:1	nil	-	2
		Caustic Starch	0.45	1.6	0.3	0.1	1.0:1	Caustic Starch	0.20	6
		Aerofloc 550	0.40	1.6	0.6	0.2	1.0:1	Aerofloc 550	0.20	15
		Separan NP-10	0.20	8.1	1.1	0.3	0.9:1	Separan NP-10	0.10	32

The results show that Separan NP-10 was the most effective settling and filtration aid. In addition, it produced the clearest overflow and the clearest filtrate.

Desliming Ground Ore, Tests 21 to 24

In this series of tests, three 1500 g samples were cut from each combined jigging and amalgamation tailing produced in Tests 17 to 20. Each sample was ground for 10 minutes and deslimed in a V-trough counter-current desliming apparatus with water added at flow rates of 1.0, 1.5 and 2.0 litres per minute. In each case, samples of the underflow and slimes fractions were taken for assays and for screen and infrasizer analyses. The results of the desliming tests are shown in Table 11.

TABLE 11

Results of Desliming Ground Ore

Sample	Test	Product	Flow Rates								
			1.0 l/min			1.5 l/min			2.0 l/min		
			Weight %	Assays* oz/ton Au	Distn % Au	Weight %	Assays* oz/ton Au	Distn % Au	Weight %	Assays* oz/ton Au	Distn % Au
No. 1	21	U'flow	78.3	0.45	92.6	68.4	0.47	84.3	66.6	0.46	81.4
		Slimes	21.7	0.13	7.4	31.6	0.19	15.7	33.4	0.21	18.6
		Feed (calcd)	100.0	0.38	100.0	100.0	0.38	100.0	100.0	0.38	100.0
No. 2	22	U'flow	82.0	0.41	92.6	75.4	0.43	89.2	72.5	0.43	87.1
		Slimes	18.0	0.15	7.4	24.6	0.16	10.8	27.5	0.17	12.9
		Feed (calcd)	100.0	0.36	100.0	100.0	0.36	100.0	100.0	0.36	100.0
No. 3	23	U'flow	69.9	0.22	89.5	61.2	0.23	83.8	56.1	0.24	79.3
		Slimes	30.1	0.06	10.5	38.8	0.07	16.2	43.9	0.08	20.7
		Feed (calcd)	100.0	0.17	100.0	100.0	0.17	100.0	100.0	0.17	100.0
No. 4	24	U'flow	74.0	0.29	89.2	70.1	0.30	86.5	65.2	0.30	82.4
		Slimes	26.0	0.10	10.8	29.9	0.11	13.5	34.8	0.12	17.6
		Feed (calcd)	100.0	0.24	100.0	100.0	0.24	100.0	100.0	0.24	100.0

*From Internal Reports MS-AC-64, 321, 359, 367 and 398.

The size distributions shown by the screen and infrasizer analyses of both the underflow and slimes fractions were practically identical for each sample tested. Therefore, in the following table, only calculated composite figures for the four ore samples are shown to facilitate comparison of the three flow rates investigated.

TABLE 12

Screen and Infrasizer Analyses of Underflow and Slimes

Size	U'flow	Weight, g		
		Slimes		
		1.0 l/min	1.5 l/min	2.0 l/min
+ 100 m	12.9	-	-	-
-100 + 150 m	16.5	-	-	-
-150 + 200 m	20.4	-	-	-
-200 m + 40 µ	28.3	-	-	2.2
-40 + 28 µ	14.7	-	2.9	13.2
-28 + 20 µ	4.3	3.0	6.6	10.6
-20 + 14 µ	2.4	11.8	18.8	12.4
-14 + 10 µ	0.3	22.8	17.6	17.3
-10 µ	0.2	62.4	54.1	44.3
Feed	100.0	100.0	100.0	100.0

A few desliming tests run in an elutriation column and a cyclone gave results approaching those obtained in the V-trough apparatus.

The underflow fractions from each sample deslimed at the flow rate of 1.0 l/min were cyanided for 48 hours at solution strengths of 1.0 lb NaCN/ton and 0.5 lb CaO/ton. Pertinent results of previous jigging, amalgamation and desliming tests are summarized in Tables 13 to 16 along with results of cyaniding the deslimed product. In these tables, the amalgam assays are expressed in terms of amalgamation feed and the solution assays are expressed in terms of cyanidation feed.

TABLE 13

Results of Jigging, Amalgamation, Desliming and Cyanidation
(Sample No. 1)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.8	21.06	50.4	50.4
	Tailing	98.2	0.38	49.6	
	Feed (calcd)	100.0	0.75	100.0	
Amalgamation	Amalgam	-	20.22	96.0	48.4
	Tailing	-	0.84	4.0	
	Feed (calcd)	-	21.06	100.0	
Desliming	U'flow	78.3	0.45	92.6	47.8
	Slimes	21.7	0.13	7.4	
	Feed (calcd)	100.0	0.38	100.0	
Cyanidation	Solution	-	0.438	97.3	46.5
	Residue	-	0.012	2.7	
	Feed (calcd)	-	0.45	100.0	
Amalgamation and cyanidation (overall)					94.9

*From Internal Reports MS-AC-64-302 and 321.

TABLE 14

Results of Jigging, Amalgamation, Desliming and Cyanidation
(Sample No. 2)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.6	68.16	75.5	75.5
	Tailing	98.4	0.36	24.5	
	Feed (calcd)	100.0	1.44	100.0	
Amalgamation	Amalgam	-	67.81	99.5	75.1
	Tailing	-	0.35	0.5	
	Feed (calcd)	-	68.16	100.0	
Desliming	U'flow	82.0	0.41	92.6	23.1
	Slimes	18.0	0.15	7.4	
	Feed (calcd)	100.0	0.36	100.0	
Cyanidation	Solution	-	0.393	95.9	22.1
	Residue	-	0.017	4.1	
	Feed (calcd)	-	0.41	100.0	
Amalgamation and cyanidation (overall)					97.2

*From Internal Reports MS-AC-64-302 and 359.

TABLE 15

Results of Jigging, Amalgamation, Desliming and Cyanidation
(Sample No. 3)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.2	19.12	57.7	57.7
	Tailing	98.2	0.17	42.3	
	Feed (calcd)	100.0	0.40	100.0	
Amalgamation	Concentrate	-	18.76	98.1	56.6
	Tailing	-	0.36	1.9	
	Feed (calcd)	-	19.12	100.0	
Desliming	U'flow	69.9	0.22	89.5	48.8
	Slimes	30.1	0.06	10.5	
	Feed (calcd)	100.0	0.17	100.0	
Cyanidation	Solution	-	0.212	96.4	47.4
	Residue	-	0.008	3.6	
	Feed (calcd)	-	0.22	100.0	
Amalgamation and cyanidation (overall)					94.0

*From Internal Reports MS-AC-64-302 and 367.

TABLE 16

Results of Jigging, Amalgamation, Desliming and Cyanidation
(Sample No. 4)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Jigging	Concentrate	1.2	62.70	76.0	76.0
	Tailing	98.8	0.24	24.0	
	Feed (calcd)	100.0	0.99	100.0	
Amalgamation	Amalgam	-	62.12	99.1	75.3
	Tailing	-	0.58	0.9	
	Feed (calcd)	-	62.70	100.0	
Desliming	U'flow	74.0	0.29	89.2	22.0
	Slimes	26.0	0.10	10.8	
	Feed (calcd)	100.0	0.24	100.0	
Cyanidation	Solution	-	0.278	95.9	21.1
	Residue	-	0.012	4.1	
	Feed (calcd)	-	0.29	100.0	
Amalgamation and cyanidation (overall)					96.4

*From Internal Reports MS-AC-64-398 and 428.

The amounts of sodium cyanide and lime consumed in these cyanidation tests, and the reducing power of the pulps are shown in Table 17.

TABLE 17

Reagent Consumption in Cyanidation after Desliming Ground Ore

Sample	Test	Reagent Consumption lb/ton of ore		Reducing Power cc $\frac{N}{10}$ $KMnO_4$/1
		NaCN	CaO	
No. 1	21	0.6	1.9	40
No. 2	22	0.5	2.1	40
No. 3	23	0.9	1.6	80
No. 4	24	0.8	1.9	60

The cyanidation pulp from each test was split into fractions for settling and filtration rate determinations with and without Separan NP-10 added.

TABLE 18

Settling and Filtration Rates after Desliming Ground Ore

Sample No.	Test	Settling: Separan NP-10 lb/ton of ore	Settling: Rate, ft/hr, Dilution 4:1	3:1	2:1	Final Density Water/Solids	Filtration: Separan NP-10 lb/ton of ore	Filtration: Rate lb/ft^2/hr
1	21	nil	2.9	2.6	2.1	0.6:1	nil	11
		0.04	28.0	13.0	7.1	0.6:1	0.02	168
2	22	nil	4.8	4.0	3.0	0.6:1	nil	22
		0.03	36.0	16.0	9.2	0.6:1	0.02	173
3	23	nil	3.0	2.1	1.5	0.7:1	nil	5
		0.06	25.0	11.0	6.1	0.6:1	0.03	86
4	24	nil	3.3	2.3	1.8	0.6:1	nil	7
		0.04	27.0	12.0	6.9	0.6:1	0.02	139

To determine if removal of greater amounts of slimes would increase the settling and filtration rate of the cyanidation pulp, a few tests were done on the ground ore deslimed at flow rates of 1.5 l/min and 2.0 l/min. The results showed only a slight increase in the rates which did not compensate for the higher gold losses.

Desliming Crushed Ore, Tests 25 to 28

At the request of Mr. Brien, a few desliming tests were done on the crushed ore before grinding. Lots of 1500 g of ore from each sample were deslimed by counter-current washing at a flow rate of 1.5 l/min. The slimes removed were substantially minus 28 microns. Samples of 1000 g, cut from the deslimed ore, were ground, jigged, amalgamated and cyanided as in previous tests. The results are shown in Tables 19 to 22. The amalgam and solution assays are expressed in terms of amalgamation feed and cyanidation feed respectively.

TABLE 19

Results of Desliming, Jigging, Amalgamation and Cyanidation
(Sample No. 1)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Desliming	U'flow	87.8	0.84	93.5	93.5
	Slimes	12.2	0.34	5.3	
	Feed (calcd)	100.0	0.79	100.0	
Jigging	Concentrate	4.3	11.54	59.0	55.2
	Tailing	95.7	0.36	41.0	
	Feed (calcd)	100.0	0.84	100.0	
Amalgamation	Amalgam	-	10.93	94.7	52.3
	Tailing	-	0.61	5.3	
	Feed (calcd)	-	11.54	100.0	
Cyanidation	Solution	-	0.357	96.4	39.8
	Residue	-	0.013	3.6	
	Feed (calcd)	-	0.37	100.0	
Amalgamation and cyanidation (overall)					92.1

*From Internal Reports MS-AC-64-321 and 359.

TABLE 20

Results of Desliming, Jigging, Amalgamation and Cyanidation
(Sample No. 2)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Desliming	U'flow	90.0	1.48	97.8	97.8
	Slimes	9.1	0.34	2.2	
	Feed (calcd)	100.0	1.38	100.0	
Jigging	Concentrate	2.8	40.57	77.0	75.3
	Tailing	97.2	0.35	23.0	
	Feed (calcd)	100.0	1.48	100.0	
Amalgamation	Amalgam	-	40.25	99.2	74.7
	Tailing	-	0.32	0.8	
	Feed (calcd)	-	40.57	100.0	
Cyanidation	Solution	-	0.333	95.1	22.0
	Residue	-	0.017	4.9	
	Feed (calcd)	-	0.35	100.0	
Amalgamation and cyanidation (overall)					96.7

*From Internal Reports MS-AC-64-321 and 359.

TABLE 21

Results of Desliming, Jigging, Amalgamation and Cyanidation
(Sample No. 3)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Desliming	U'flow	83.7	0.38	94.2	94.2
	Slimes	16.3	0.12	5.8	
	Feed (calcd)	100.0	0.35	100.0	
Jigging	Concentrate	3.1	6.41	51.9	48.9
	Tailing	96.9	0.19	48.1	
	Feed (calcd)	100.0	0.38	100.0	
Amalgamation	Amalgam	-	6.25	97.5	47.7
	Tailing	-	0.16	2.5	
	Feed (calcd)	-	6.41	100.0	
Cyanidation	Solution	-	0.182	95.8	44.5
	Residue	-	0.008	4.2	
	Feed (calcd)	-	0.19	100.0	
Amalgamation and cyanidation (overall)					92.2

*From Internal Reports MS-AC-64-321 and 359.

TABLE 22

Results of Desliming, Jigging, Amalgamation and Cyanidation
(Sample No. 4)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
Desliming	U'flow	88.4	1.20	98.1	98.1
	Slimes	11.6	0.17	1.9	
	Feed (calcd)	100.0	1.08	100.0	
Jigging	Concentrate	1.6	53.18	70.6	69.3
	Tailing	98.4	0.36	29.4	
	Feed (calcd)	100.0	1.20	100.0	
Amalgamation	Amalgam	-	53.04	99.7	69.1
	Tailing	-	0.14	0.3	
	Feed (calcd)	-	53.18	100.0	
Cyanidation	Solution	-	0.335	95.7	27.8
	Residue	-	0.015	4.3	
	Feed (calcd)	-	0.35	100.0	
Amalgamation and cyanidation (overall)					96.9

*From Internal Report MS-AC-64-398.

The amounts of sodium cyanide and lime consumed in these cyanidation tests, and the reducing power of the cyanidation pulps are shown in the following table.

TABLE 23

Reagent Consumption in Cyanidation after Desliming Crushed Ore

Sample	Test	Reagent Consumption lb/ton of ore		Reducing Power cc $\frac{N}{10}$ $KMnO_4$/1
		NaCN	CaO	
No. 1	25	1.1	2.5	56
No. 2	26	0.8	2.7	48
No. 3	27	1.3	2.3	64
No. 4	28	0.9	2.6	72

The cyanidation pulp from each test was split into fractions for settling and filtration rate tests. These were run with and without Separan NP-10.

TABLE 24

Settling and Filtration Rates after Desliming Crushed Ore

Sample No.	Test	Settling: Separan NP-10 lb/ton of ore	Settling: Rate, ft/hr, Dilution 4:1	3:1	2:1	Settling: Final Density Water/Solids	Filtration: Separan NP-10 lb/ton of ore	Filtration: Rate lb/ft²/hr
1	25	nil	1.1	0.7	0.4	0.8:1	nil	4
		0.10	19.1	5.1	2.2	0.8:1	0.05	42
2	26	nil	2.9	2.1	1.4	0.7:1	nil	5
		0.08	31.0	12.7	4.9	0.7:1	0.04	63
3	27	nil	0.9	0.5	0.3	0.9:1	nil	2
		0.12	10.5	3.8	1.9	0.8:1	0.06	36
4	28	nil	1.3	0.8	0.5	0.8:1	nil	3
		0.10	14.5	4.6	2.1	0.7:1	0.05	49

The settling and filtration rates obtained on ground ore which has been deslimed prior to grinding were considerably slower than those obtained when the ore was deslimed after grinding. This was due to the amount of new slimes formed during the grinding stage.

Jigging, Amalgamation, Flotation and Cyanidation, Tests 29 and 30

This series of tests was carried out only on Sample No. 1 and Sample No. 4 due to the limited quantity of material left. Lots of 3000 g of jigging and amalgamation tailings from Tests 17 and 20 were deslimed using a wash water flow rate of 1.5 l/min. Both underflow fractions were then floated using the following procedure.

TABLE 25

Flotation Reagents and Conditions

Operation	Time, min	Reagent	lb/ton of ore	pH
Conditioning	5	Copper sulphate	1.0	8.4
		Sodium silicate	0.5	
		Sodium carbonate	0.5	
		Aero Promoter 404	0.07	
		Aerofloat 242	0.04	
Flotation		Pine oil	0.01	8.3

The flotation concentrate from each sample was then cyanided by the previously described procedure. Pertinent results of jigging, amalgamation and desliming tests are summarized in Tables 26 and 27 along with the flotation and cyanidation results. In these tables, the amalgam assays are expressed in terms of amalgamation feed and the solution assays are expressed in terms of cyanidation feed.

TABLE 26

Results of Jigging, Amalgamation, Desliming, Flotation and Cyanidation (Sample No. 1)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
	Concentrate	1.8	21.06	50.4	
Jigging	Tailing	98.1	0.38	49.6	50.4
	Feed (calcd)	100.0	0.75	100.0	
	Amalgam	-	20.22	96.0	
Amalgamation	Tailing	-	0.84	4.0	48.4
	Feed (calcd)	-	21.06	100.0	
	U'flow	68.4	0.47	84.3	
Desliming	Slimes	31.6	0.19	15.7	43.5
	Feed (calcd)	100.0	0.38	100.0	
	Concentrate	4.2	9.83	87.9	
Flotation	Tailing	95.8	0.06	12.1	38.2
	Feed (calcd)	100.0	0.47	100.0	
	Solution	-	9.51	96.7	
Cyanidation	Residue	-	0.32	3.3	36.9
	Feed (calcd)	-	9.83	100.0	
Amalgamation and cyanidation (overall)					85.3

*From Internal Report MS-AC-64-428.

TABLE 27

Results of Jigging, Amalgamation, Desliming, Flotation and Cyanidation (Sample No. 4)

Operation	Product	Weight %	Assays* oz/ton Au	Distribution % Au	Recovery % Au
	Concentrate	1.2	62.70	76.0	
Jigging	Tailing	98.8	0.24	24.0	76.0
	Feed (calcd)	100.0	0.99	100.0	
	Amalgam	-	62.12	99.1	
Amalgamation	Tailing	-	0.58	0.9	75.3
	Feed (calcd)	-	62.70	100.0	
	U'flow	70.1	0.30	86.5	
Desliming	Slimes	29.9	0.11	13.5	21.4
	Feed (calcd)	100.0	0.24	100.0	
	Concentrate	2.5	9.64	80.3	
Flotation	Tailing	97.5	0.06	19.7	17.2
	Feed (calcd)	100.0	0.30	100.0	
	Solution	-	9.22	95.6	
Cyanidation	Residue	-	0.42	4.4	16.4
	Feed (calcd)	-	9.64	100.0	
Amalgamation and cyanidation (overall)					91.7

*From Internal Report MS-AC-64-428.

The amounts of sodium cyanide and lime consumed during the cyanidation of the flotation concentrates, and the reducing power of the cyanidation pulps are shown in the following table.

TABLE 28

Reagent Consumption in Cyaniding Flotation Concentrates

Sample	Test	Reagent Consumption lb/ton of ore		Reducing Power cc $\frac{N}{10}$ $KMnO_4$/1
		NaCN	CaO	
No. 1	29	0.2	0.1	280
No. 4	30	0.2	0.1	420

Settling and filtration rate tests were carried out on the cyanidation pulp from each test and gave the following results.

TABLE 29

Settling and Filtration Rates of Flotation Concentrates

Sample No.	Test	Settling					Filtration	
		Separan NP-10 lb/ton of ore	Rate, ft/hr Dilution			Final Density Water/Solids	Separan NP-10 lb/ton of ore	Rate lb/ft^2/hr
			4:1	3:1	2:1			
1	29	0.002	14.0	6.0	2.5	0.7:1	0.001	23
4	30	0.002	9.1	3.9	1.5	0.9:1	0.001	15

SUMMARY AND CONCLUSIONS

Four slightly different samples of gold ore have been investigated. The first three samples, marked No. 1 (Rejects), No. 2 (Central Face) and No. 3 (North Face) were received from the La Forma property of Ormsby Mines Limited. The Sample No. 4 was a composite prepared from equal parts of Samples No. 2 and No. 3. The gold content of these samples was 0.76, 1.59, 0.39 and 0.99 oz/ton respectively. The ore samples had similar mineralogical characteristics with gold occurring partly as free grains and partly associated with gangue, goethite and pyrite.

At a relatively coarse grind of approximately 41% -200 mesh, barrel amalgamation determined that the four samples contained free milling gold in amounts of 60%, 80%, 66% and 77% respectively. These results indicated that a flowsheet for treating this ore should include a method of recovering this gold as soon as it is liberated. This can be conveniently done by placing a jig in the grinding circuit between the ball mill and the classifier.

Straight cyanidation tests carried out, after grinding to 40%, 70% and 85% minus 200 mesh, showed that most of the gold (98 to 99%) was liberated and extracted at 70% minus 200 mesh. This fineness should be obtained without difficulty in a plant operation considering the soft nature of the ore.

Very slow settling and filtration rate of the cyanidation pulps produced in these tests was noted and attributed to the presence of fine clay mineral. This was particularly evident in Sample No. 3 which contained the largest proportion of clay. Two main methods were investigated to overcome this problem. These consisted of the use of flocculants and desliming either crushed or ground ore. The value of flocculants and slimes removal is illustrated in Table 30. For comparison, the reagent consumed during cyanidation, settling and filtration, and the gold losses in the slimes fractions are summarized in this table which shows the calculated average from the tests on the four samples.

TABLE 30

Comparison of Treatment Methods

Procedure	Gold Loss in Slimes %	Reagent Consumption lb/ton of ore			Settling Rate ft/hr	Filtration Rate lb/ft²/hr
		NaCN	CaO	Separan NP-10		
Cyanidation without Desliming	nil	1.8	4.1	nil 0.30	0.4 5.9	2 35
Cyanidation after Desliming Crushed Ore	4	1.0	2.5	nil 0.15	1.1 9.4	4 45
Cyanidation after Desliming Ground Ore	3	0.7	1.9	nil 0.06	3.2 16.4	9 142

Tests were also run using caustic starch and Aerofloc 550 as flocculants but these were considerably less effective than Separan NP-10.

From the above results, it is seen that desliming ground ore with the use of Separan NP-10 resulted in smaller thickening and filtration requirement and economy in reagents that should more than offset the 3% gold loss in the slimes removed.

From the results of the investigation, a flowsheet has been developed using jigging, amalgamation, and desliming the ground ore followed by cyanidation. Tests conducted along these lines on the four ore samples, resulted in overall gold recoveries of 94.9%, 97.2%, 94.0% and 96.4% respectively.

The final series of tests followed the same basic procedure except that only a flotation concentrate was cyanided. Flotation eliminates 97% of the feed to cyanidation with a gold loss of about 5% in the flotation tailing. This procedure might be considered if the company plan a small operation with a milling plant of low capital cost.

A proposed flowsheet for processing the Ormsby ore is illustrated on page 30. This includes jigging, amalgamation, desliming jig tailing in a cyclone after grinding and cyanidation of the deslimed material. As an alternative procedure to direct cyanidation of the deslimed jig tailing, flotation and cyanidation of the concentrate may be substituted. In order to prevent possible clogging in the secondary crusher by wet clay, a washing step was inserted in the flowsheet to separate and feed the clay particles directly to either the ball mill or the jig depending on the fineness.

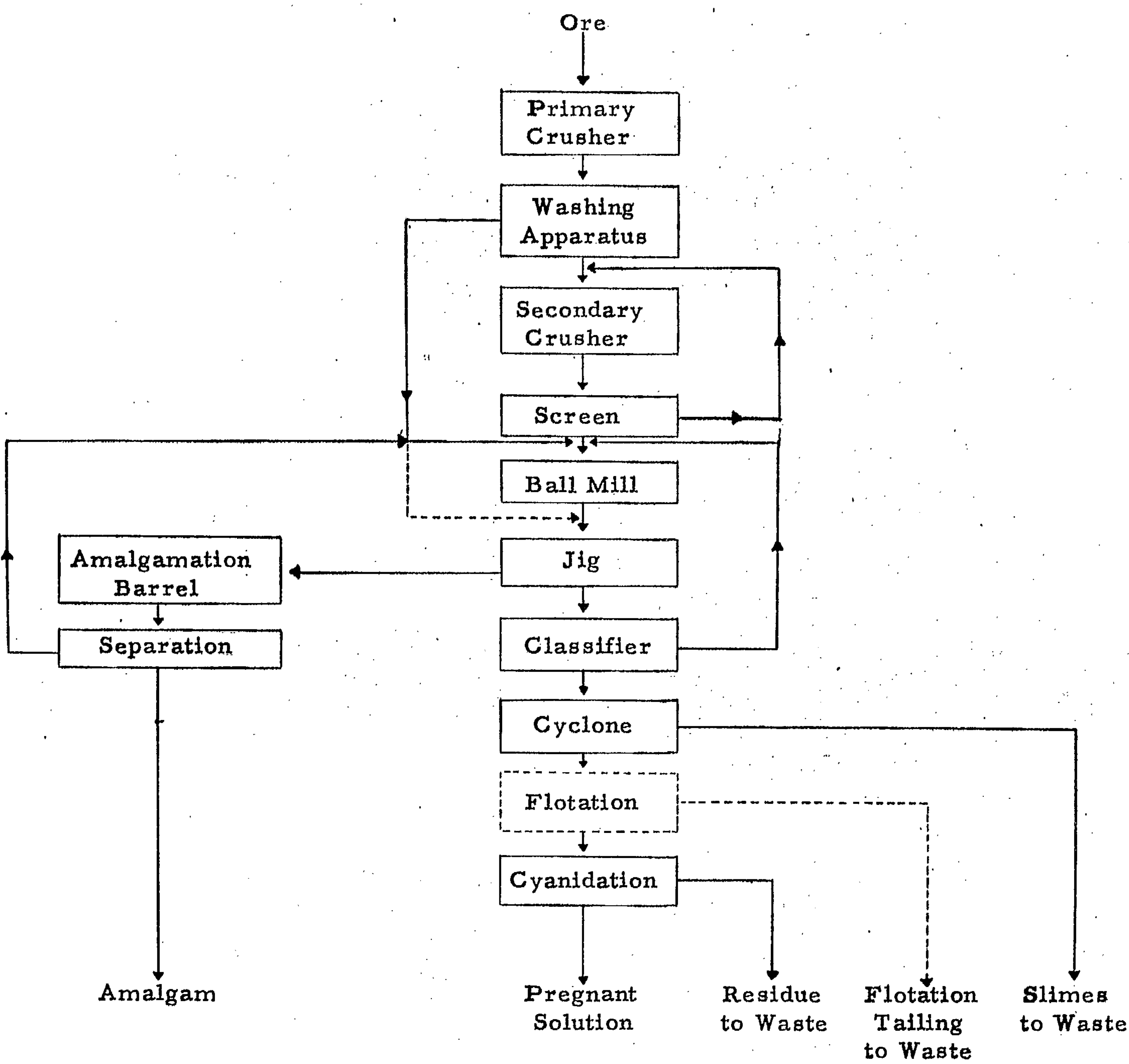

Figure 3. Proposed Flowsheet

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