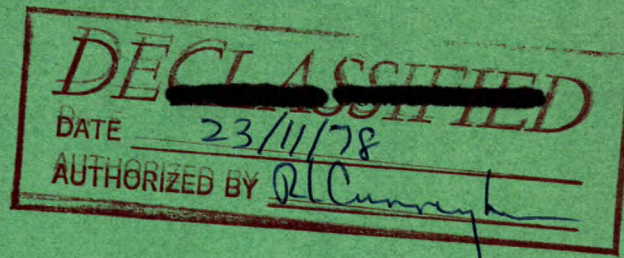


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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

OTTAWA

MINES BRANCH INVESTIGATION REPORT IR 62-56

**FLOTATION AND CYANIDATION TESTS ON
A SAMPLE OF GOLD-BEARING SULPHIDE
CONCENTRATE, SUBMITTED BY
PRECAMBRIAN MINING SERVICES LIMITED,
YELLOWKNIFE, N. W. T.**

by

G. I. MATHIEU & R. W. BRUCE

MINERAL PROCESSING DIVISION

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AUGUST 16, 1962

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SUMMARY OF RESULTS

The Precambrian sample consists of a pyrite and arsenopyrite concentrate containing a small amount of antimony. Gold is the only important mineral in the concentrate.

It was not possible to concentrate the gold bearing minerals by flotation (Tests 1 to 4).

Roasting of the Precambrian concentrate and cyanidation of the calcine gave overall gold recoveries varying from 62.0% to 88.1% (Tests 4 to 19).

Selective flotation of antimony minerals removed 41.2% of the antimony and 4.0% of the gold present in the Precambrian concentrate (Test 20). Roasting of the flotation tailing and cyanidation of the calcine recovered 88.4% of the gold contained in the flotation tailing.

The "Bromocyanide Process" did not extract any additional gold from a straight cyanidation tailing.

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INTRODUCTION

Shipment and Instructions

A sample of the Precambrian concentrate for this investigation was received from the Extraction Metallurgy Division of the Mines Branch on February 6, 1962. This material, weighing 120 lb, represented about one half of the original sample shipped to the Mines Branch by Mr. Norman Byrne, President of Precambrian Mining Services Limited, Yellowknife, N.W.T., in September 1960.

In correspondence with Dr. Frederick Brien, P. Eng., Consulting Metallurgist, 2552 Roanoke, Seattle 2, Wash., U.S.A., a testing program was arranged for the Precambrian concentrate.

This included flotation of the gold bearing minerals; roasting and cyanidation of the calcine; removal of antimony minerals by flotation followed by roasting of the flotation tailing and cyanidation of the calcine; application of the "Bromocyanide Process".

Location of Property

The property from which the sample originated is the Negus Mine, near Yellowknife in Northwest Territories. Dr. Brien described the sample as a bulk sulphide concentrate floated from cyanidation tailing and stock-piled for at least twelve years.

Sampling and Analysis

A one pound head sample was riffled out by conventional methods for chemical analyses.

The following determinations were made:

Gold	(Au)	1.21	oz/ton
Silver	(Ag)	2.08	oz/ton
Iron	(Total Fe)	26.3	%
Iron	(Soluble Fe)	26.3	%
Arsenic	(As)	12.10	%
Antimony	(Sb)	0.21	%
Sulphur	(S)	24.24	%
Insoluble		18.35	%

DETAILS OF INVESTIGATION

The first part of the investigation was an attempt to float the gold bearing minerals (Tests 1 to 4).

In the second part, a series of roasting and cyanidation tests were carried out under different conditions (Tests 5 to 19).

The third part of the investigation was concerned with the removal of the antimony minerals, prior to roasting and cyanidation, to determine the effect on the gold recovery (Test 20).

In the fourth part, the possible application of the "Bromocyanide Process" to the Precambrian concentrate was investigated (Test 21).

Flotation of Gold Bearing Minerals

Test 1

A 2000 g sample was cut from the concentrate and floated as indicated in Table 1.

TABLE 1

Reagents and Conditions

Operation	Reagents	lb/ton	Time	min	pH
Conditioning	R-301	- 0.1	5		6.0
	Cu SO ₄	- 1.0			
Flotation	Pine Oil	- 0.04	12		

The results of Test 1 are shown in Table 2.

TABLE 2

Results of Flotation Test 1

Products	Weight %	Assays				Distribution			
		%			oz/ton	%			
		As	Sb	S	Au	As	Sb	S	Au
Flotn conc	20.1	9.1	0.66	24.7	1.12	15.3	54.3	20.4	18.5
Flotn tail	79.9	12.7	0.14	24.2	1.24	84.7	45.7	79.6	81.5
Feed (calcd)	100.0	12.0	0.24	24.3	1.22	100.0	100.0	100.0	100.0

Test 2

Test 2 was similar to Test 1, except that 3.0 lb of Na₂CO₃ per ton of ore was added to the conditioning, increasing the pH to 7.1. The results of this test are summarized in Table 3.

TABLE 3
Results of Flotation Test 2

Products	Weight %	Assays				Distribution			
		%			oz/ton	%			
		As	Sb	S	Au	As	Sb	S	Au
Flotn conc	14.4	9.1	0.99	21.8	1.21	11.1	54.3	12.9	14.3
Flotn tail	85.6	12.3	0.14	24.8	1.22	88.9	45.7	87.1	85.7
Feed (calcd)	100.0	11.8	0.26	24.4	1.22	100.0	100.0	100.0	100.0

Test 3

This test was similar to Test 1, except that 0.2 lb of Reagent 610 per ton of ore was added to the conditioning. Table 4 shows the results of Test 3.

TABLE 4
Results of Flotation Test 3

Products	Weight %	Assays				Distribution			
		%			oz/ton	%			
		As	Sb	S	Au	As	Sb	S	Au
Flotn conc	22.3	8.8	0.69	29.9	1.04	15.9	58.6	27.4	19.4
Flotn tail	77.7	13.4	0.14	22.7	1.24	84.1	41.4	72.6	80.6
Feed (calcd)	100.0	12.4	0.26	24.3	1.20	100.0	100.0	100.0	100.0

Test 4

This test was similar to Test 1, except that the ore was ground for 10 min before flotation. Table 5 summarizes the results of Test 4.

TABLE 5

Results of Flotation Test 4

Products	Weight %	Assays				Distribution			
		%			oz/ton	%			
		As	Sb	S	Au	As	Sb	S	Au
Flotn conc	17.4	10.8	1.04	23.4	1.34	15.1	68.7	16.5	19.0
Flotn tail	82.6	12.8	0.10	25.0	1.20	84.9	31.3	83.5	81.0
Feed (calcd)	100.0	12.4	0.26	24.7	1.22	100.0	100.0	100.0	100.0

Roasting of Precambrian Concentrate and Cyanidation of Calcine

Test 5 (Standard Test)

A 500 g sample of Precambrian concentrate was mixed with 50 g of NaCl and roasted for 90 min at 450°C, until all arsenic fumes were evolved. The temperature was then raised to 650°C and held for 15 min.

A 200 g sample from the calcine was ground for 30 min to 85% - 20 microns and cyanided for 72 hours at a dilution of 5:1, with solution containing 1.0 to 1.5 lb of NaCN and 0.05 to 0.1 lb of CaO per ton.

Using the pattern of Test 5, a series of tests was made to investigate different factors as follows:

Test 6-7: Grinding

Test 6 was done on unground calcine, and in Test 7, calcine was ground for 60 min. Size analyses showed 39% and 93%, respectively, minus 20 microns.

Tests 8-9: Cyanidation Time

In Tests 8 and 9, the cyanidation time was 48 and 96 hours respectively.

Test 10: Cyanide Concentration

The sodium cyanide concentration was increased and maintained at 2.0 to 2.5 lb/ton in this test.

Test 11: Addition of Lead Nitrate

This test was carried out with an initial PbNO₃ addition of 2.0 lb/ton of solution.

Test 12: Preaeration

A 6 hours aeration with CaO preceded the cyanidation in this test.

Tests 13-14: Final Roasting Temperature

In Test 13, the material was roasted for 105 min at 450°C while, in Test 14, it was roasted for 90 min at 450°C and then the temperature was raised to 900°C for 15 min.

Tests 15-16: Salt Addition

The NaCl addition was decreased to 25 g in Test 15 and Test 16 was made without NaCl addition.

Test 17

This test was similar to the Standard test, except that no salt was added to the roasting stage and the final roasting temperature was 900°C.

Tests 18-19: Lime Concentration

Tests 18 and 19 were similar to Test 17, except that no CaO was added to the solution in Test 18 and the CaO strength was maintained at 0.2 lb/ton of solution in Test 19.

The results of the roasting and cyanidation tests are shown in Table 6 and 7 respectively.

TABLE 6

Results of Roasting Tests 5 to 19

Test	Loss Weight %	Calcine Assays					Recovery*	
		%			oz/ton		%	
		Sb	As	S	Au	Ag	Au	Ag
5	22.4	0.04	1.82	6.55	1.22	-	86.1	-
6	22.9	0.04	1.68	6.67	1.24	-	87.0	-
7	24.0	0.06	1.68	6.36	1.23	-	85.0	-
8	20.8	0.10	2.24	7.15	1.22	-	87.8	-
9	23.0	0.07	1.72	6.42	1.22	-	85.4	-
10	23.1	0.05	1.63	6.68	1.23	-	86.0	-
11	23.5	0.06	1.26	6.75	1.22	-	84.9	-
12	22.2	0.04	1.91	6.94	1.24	-	87.7	-
13	22.9	0.04	1.57	6.35	1.23	-	89.7	-
14	24.2	0.05	1.60	5.78	1.26	-	86.8	-
15	25.1	0.09	1.99	5.93	1.42	-	92.2	-
16	27.6	0.15	2.41	3.50	1.62	-	96.9	-
17	29.4	0.18	2.28	2.18	1.70	3.02	99.2	100.0
18	29.4	0.19	2.33	2.21	1.70	2.94	99.2	99.8
19	29.4	0.20	2.37	2.24	1.69	2.87	98.6	97.4

*Calculated percentage of gold and silver remaining in the calcine after roasting.

TABLE 7

Results of Cyanidation Tests 5 to 19

Test	Reagent Consumption		R.P. cc N KMnO ₄ /1 10	Cyanide Residue		*Extraction		Overall Recovery	
	lb/ton ore			oz/ton		%		%	
	NaCN	CaO		Au	Ag	Au	Ag	Au	Ag
5	37.2	36.1	40	0.26	-	78.7	-	67.8	-
6	16.9	49.2	36	0.31	-	75.0	-	65.3	-
7	13.7	49.7	32	0.27	-	78.0	-	66.3	-
8	32.2	37.3	52	0.30	-	75.4	-	66.2	-
9	17.4	54.1	24	0.28	-	78.7	-	67.2	-
10	27.4	54.4	24	0.32	-	74.0	-	63.6	-
11	27.6	48.4	44	0.33	-	73.0	-	62.0	-
12	15.2	55.3	20	0.32	-	74.2	-	65.1	-
13	33.1	35.3	28	0.30	-	76.6	-	68.7	-
14	10.3	30.6	20	0.17	-	86.5	-	75.1	-
15	28.3	34.7	60	0.30	-	78.9	-	72.7	-
16	15.2	27.5	120	0.41	-	74.7	-	72.4	-
17	4.2	0.6	16	0.20	2.75	88.2	8.9	87.5	8.9
18	4.2	0.0	16	0.19	2.73	88.8	7.2	88.1	7.2
19	3.2	3.0	16	0.19	2.64	88.8	8.0	87.6	7.8

* Calculated by difference.

Flotation of Antimony Minerals, Roasting of
Flotation Tailings and Cyanidation of Calcine

Test 20

A 2000 g sample of Precambrian concentrate was conditioned for 20 min in a flotation cell with 2.0 lb/ton of NaCN per ton of solids and floated for 4 min with 0.02 lb of pine oil per ton. Table 8 summarizes the results of this test.

TABLE 8

Results of Flotation Test 20

Products	Weight %	Assays					Distribution				
		%			oz/ton		%				
		Sb	Cu	As	Au	Ag	Sb	Cu	As	Au	Ag
Sb conc	3.1	3.06	2.53	10.3	1.53	32.94	41.2	53.6	2.5	4.0	46.8
Flotn tail	96.9	0.14	0.07	12.7	1.16	1.20	58.8	46.4	97.5	96.0	53.2
Feed (calcd)	100.0	0.23	0.15	12.6	1.17	2.18	100.0	100.0	100.0	100.0	100.0

A 500 g sample, cut from the flotation tailing, was roasted and cyanided using the same procedure as Test 17. The roasting and cyanidation results are shown in Table 9 and 10 respectively.

TABLE 9

Results of Roasting Test 20

Loss Weight %	Calcine Assays					Recovery	
	%			oz/ton		%	
	Sb	As	S	Au	Ag	Au	Ag
27.2	0.11	2.25	1.97	1.64	1.68	100.0	100.0

TABLE 10

Results of Cyanidation Test 20

Reagent Consumption lb/ton ore		R.P. cc $\frac{N}{10}$ $KMnO_4$ /l	Cyanide Residue oz/ton		Extraction %		Overall Recovery %	
NaCN	CaO		Au	Ag	Au	Ag	Au	Ag
3.2	3.4	16	0.19	1.58	88.4	6.0	84.9	3.1

Bromocyanide Process

A 1000 g sample of the Precambrian concentrate was aerated for 24 hrs at a dilution of 2:1 with CaO added periodically in small amounts. The pulp was then cyanided for 48 hrs in a solution maintained at 1.0 lb of KCN/ton and 0.2 lb of CaO/ton, filtered and washed thoroughly. A small portion of the cake was cut for assay while the remainder was repulped to a dilution of 2:1 in a solution containing 1.0 lb of KCN/ton and 0.7 lb of bromocyanide/ton, which was prepared as indicated in "Cyanidation and Concentration of Gold and Silver Ores" - Dorr and Bosqui, pps 266-267. The pulp was agitated for 24 hrs, filtered and washed. A portion of the cake was cut for assay while the remainder was submitted to a second bromocyanide treatment similar to the first one.

The results of this test are shown in Table 11.

TABLE 11

Results of Bromocyanide Test 21

Operation	Reagent Consumption lb/ton ore		Reducing Power cc $\frac{N}{10}$ $KMnO_4$ /l	Residue Assays oz/ton Au
	CaO	KCN		
Aeration	43.0	-	-	-
Cyanidation	1.8	5.9	1280	0.99
1st Bromocyanidation	-	-	440	0.98
2nd Bromocyanidation	-	-	440	1.02

These results indicated that no additional dissolution of the gold took place during treatment with bromocyanide.

CONCLUSIONS

The Precambrian material is a bulk pyrite and arsenopyrite concentrate assaying 1.21 oz Au/ton. The silver assaying 2.08 oz/ton is intimately associated with the antimony probably in a tetrahedrite-tenantite mineral.

In Tests 1 to 4, attempts were made to concentrate the gold bearing minerals by flotation. No concentration was achieved by this procedure, probably due to the degree of oxidation of the material.

Tests 5 to 16 involved roasting and cyanidation, while varying conditions to determine their effects on the gold recovery. The results of these tests can be summarized as follows:

- (1) Grinding the calcine before cyanidation resulted in only a slight increase in gold extraction.
- (2) Nearly all the dissolution of the gold took place in the first 48 hours. Extending the cyanidation period to 96 hours results in a very slight increase in recovery.
- (3) A cyanide strength of 1.0 to 1.5 lb per ton of solution gave maximum extraction. No increase in recovery was obtained when the cyanide strength was increased above this amount.
- (4) The addition of lead nitrate during cyanidation gave no increase in gold extraction.
- (5) Preaeration with lime reduced cyanide consumption but gave no increase in gold extraction. In all of the above tests, the overall gold extraction was in the range of 62 to 68%.
- (6) Increasing the final temperature and decreasing the salt addition in the roasting stage resulted in marked increase in overall gold recoveries and decrease in reagent consumption.

The investigation showed that the addition of salt was not necessary during roasting for maximum gold extraction, as long as the roasting was done in two stages. The first stage was at 450°C at which temperature the arsenic is oxidized below the melting point of the stibnite; in the second stage, the roasting temperature was 900°C. This resulted in the best gold extraction from cyanidation of the calcine. Test 17 conducted along these lines gave an overall gold recovery of 87.5% and at the same time greatly reduced cyanide and lime consumption.

Test 18 and 19 showed that although the elimination of lime during cyanidation gave no improvement in gold extraction, it is recommended that lime strength be kept low and in an amount used that is sufficient for good settling.

Flotation of the antimony minerals in Test 20 produced a concentrate assaying 3.06% Sb, 32.94 oz Ag/ton and 1.53 oz Au/ton and contained 41.2% of the antimony, 46.8% of the silver and 4.0% of the gold in the sample.

Roasting of the flotation tailing and cyanidation of the calcine gave an overall gold recovery of 84.9%. It may be assumed from the gold recoveries in this test and previous tests that the antimony is not in sufficient amount to interfere with the cyanidation of the gold provided a two stage roasting technique is used as previously outlined. This test also established the silver-antimony association which explains in part the poor silver extraction by cyanidation.

The "Bromocyanide Process" does not appear applicable for the treatment of the Precambrian concentrate.

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