OTTAWA July 15th, 1940.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 874.

Amalgamation and Cyanidation of a Gold Ore
from the Albany River Gold Mines Limited,
Pickle Crow, Ontario.

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BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Amalgamation and Cyanidation of a Gold Ore
from the Albany River Gold Mines Limited,
Pickle Crow, Ontario.

Shipment:

Six sacks of gold ore, total weight 750 pounds, were received on April 15th, 1940, from George S. Gilbert, Manager, Albany River Gold Mines Limited, Pickle Crow, Ontario.

Location of the Property:

The property of the Albany River Gold Mines Limited from which the present shipment was received is situated in the Pickle Crow area, Patricia district, northwestern Ontario, and adjoins the Pickle Crow mine.

Sampling and Analysis:

After crushing, cutting and grinding by standard methods, a representative sample of the shipment was obtained which assayed as follows:

Gold	-	0.22 oz./ton
Silver	-	0.06 "
Copper	-	0.045 per cent
Arsenic	-	0.11 "
Sulphur	-	3.53 "
Iron	-	23.68 "
Pyrrhotite	-	5.85 "

Characteristics of the Ore:

Six polished sections were prepared and examined under the reflecting microscope for the purpose of determining the character of the ore.

Gangue -

The gangue consists of translucent white quartz and fine-textured dark-grey rock with rather abundant finely disseminated carbonate. The rock shows a distinct schistosity in one section, and the carbonate gives a slight microchemical reaction for iron.

Metallic Minerals -

Metallic mineralization in the polished sections is heavy and the minerals are very intimately admixed. In their approximate order of decreasing abundance, those observed are: pyrite, pyrrhotite, arsenopyrite, magnetite, chalcopyrite, and native gold.

Pyrite and pyrrhotite are abundant as small masses and coarse to fine irregular grains disseminated throughout gangue. These two minerals are often associated with each other and occur in almost equal proportions. Both contain numerous inclusions of gangue and small grains of the other metallics. A considerable quantity of arsenopyrite is present, largely as disseminated subhedral crystals medium to fine in size; these are usually very closely associated with pyrite and pyrrhotite. Magnetite is locally abundant as streaks and clouds of small irregular grains in gangue as well as tiny inclusions in the sulphides. A small amount of chalcopyrite is visible as small irregular grains in gangue, pyrite, and pyrrhotite.

Ten small grains of native gold were observed in the sections. Their sizes and modes of occurrence are summarized in the table given below. It should be remembered, however, that this analysis represents only the small number of grains cut by the sections and serves merely as an indication of how the gold occurs.

Grain Sizes and Modes of Occurrence of Native Gold.

Mesh	GOLD IN GANGUE: Associated with pyrrhotite, per cent	GOLD IN GANGUE: Associated with chalcopyrite, per cent	GOLD IN PYRITE: Alone, per cent	GOLD IN PYRITE: Associated with chalcopyrite, per cent	TOTALS, per cent
+ 560	20.0				20.0
- 560 + 800	13.3				13.3
- 800 +1100	42.7			9.4	52.1
-1100 +1600					
-1600	4.0	5.3	5.3		14.6
	80.0	5.3	5.3	9.4	100.0
	85.3		14.7		

Investigative Work:

The work comprised straight cyanidation, under different conditions of grinding, aeration, and amounts of reagents used. Also, the flow-sheet of the Pickle Crow mill was followed as far as was practicable in the small-scale test work.

The results indicated that an extraction of 95 per cent of the gold and a cyanide residue of 0.01 ounce gold per ton can be obtained at a grind of 85 to 90 per cent minus 200 mesh when amalgamation and cyanidation are used, and that a cyanide residue of 0.015 ounce gold per ton can be secured by straight cyanidation. The fouling of the cyanide solutions, due to the large amount of pyrrhotite in the ore, was corrected to a large extent by aeration of the solutions and the addition of a soluble lead salt to the grind.

Details of Tests:

Test No. 1 (A to K). - Straight Cyanidation.

In this test the ore at minus 14 mesh was ground in cyanide solution of 1 pound NaCN per ton strength to different degrees of fineness and bottle-agitated for 24- or 48-hour periods. The requisite amount of lime to maintain alkalinity was added to the grind. Different reagents were also added to the grind, as noted.

(Continued on next page)

(Test No. 1, cont'd) -

Results of Straight Cyanidation: (Feed, Au 0.22 oz./ton).

Test No.	Agitation, hours	Grind, % -200 mesh	Tailing assay, Au oz./ton	Extraction of gold, per cent	Reagents consumed, lb./ton ore: NaCN	Reagents consumed, lb./ton ore: CaO	Reducing power of solution, ml. N/10 $KMnO_4$ per litre	Additional reagents added, lb./ton ore
1-A	24	92.5	0.06	72.7	0.92	6.7		
1-B	48	92.5	0.03	86.4	1.45	9.7	420	
1-C	24	97.0	0.03	86.4	1.40	7.8		
1-D	48	97.0	0.015	93.2	1.55	9.7	510	
1-E	24	98.4	0.02	90.9	1.60	7.8		
1-F	48	98.4	0.01	95.5	1.76	9.7	540	
1-G	24	87.0	0.08	63.6	0.80	9.0	240	Lime saturated.
1-H	24	87.0	0.07	68.2	0.80	10.0	260	" ", + 1.0 NH_4SO_4.
1-I	24	87.0	0.03	86.4	0.80	10.0	90	" ", +0.5 $PbNO_3$.
1-J	24	85.0	0.02	90.9	0.70	6.8	66	0.5 $PbNO_3$.
1-K	48	85.0	0.015	93.2	0.80	8.6	86	0.5 $PbNO_3$.

The titration of the cyanide solution was kept between 0.9 to 1.0 pound of NaCN per ton and the lime at 0.15 to 0.20 pound per ton, except in Tests Nos. 1-G, 1-H and 1-I, where the lime was 0.5 to 0.6 pound per ton.

From the above tests it can be seen that the use of lead nitrate in the grind is effective in curtailing the foulness of the solutions and thus permitting a cyanide residue of lower gold content.

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Test No. 2. - Cycle Cyanidation.

This test was run in order to determine whether the use of $PbNO_3$ would prevent the fouling of the cyanide solution when the same solution was used in grinding and agitating successive batches of the ore.

The ore at minus 14 mesh was ground in cyanide

(Test No. 2, cont'd) -

solution of 1 pound NaCN per ton strength to pass 90.0 per cent minus 200 mesh. Four pounds of lime and 0.5 pound of $PbNO_3$ were added to the grind. The pulp was then bottle-agitated for 24 hours. The solution was then filtered off and used for a fresh batch of ore for the same grind and agitation period. This procedure was applied to five successive batches of ore. The different cyanide residues were assayed for gold and at the conclusion of each cycle the reducing power and the cyanide and lime titrations were determined. Enough lime was added to maintain alkalinity at 0.15 to 0.20 pound per ton.

Results of Cycle Cyanidation: (Feed, Au 0.22 oz./ton).

Cycle No.	Agitation, hours	Tailing assay, Au oz./ton	Extraction of gold, per cent	Titration, lb./ton solution: NaCN	Titration, lb./ton solution: CaO	Reagents consumed, lb./ton ore: NaCN	Reagents consumed, lb./ton ore: CaO	Reducing power, ml. N/10 $KMnO_4$ per litre
1	24	0.015	93.2	1.00	0.20	0.50	5.6	100
2	24	0.015	93.2	1.00	0.15	0.80	6.7	160
3	24	0.015	93.2	1.00	0.15	1.00	5.6	170
4	24	0.015	93.2	1.00	0.20	0.80	5.6	270
5	24	0.015	93.2	1.00	0.15	0.80	6.7	310

The grind was 89.8 per cent minus 200 mesh in all cycles.

As can be seen from the above test, the tailing assay remained constant at 0.015 ounce gold per ton through the five cycles of cyanidation. From the results of the reducing power it is evident that some fouling of the cyanide solutions is taking place.

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Test No. 3. - Cyanidation and Aeration.

In this test the ore at minus 14 mesh was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength to pass 96 per cent minus 200 mesh. Six pounds of lime and 0.5 pound of $PbNO_3$ per ton were added to the grind. The pulp was then aerated for 16 hours. Bottle-agitation was then conducted for 24- and 48-hour periods on the aerated pulp. The cyanide residues were then assayed for gold.

After aeration, the reducing power of the solution was 170 ml. N/10 $KMnO_4$ per litre.

Results of Cyanidation and Aeration:

(Feed - Au, 0.22 oz./ton)

Agitation, hours	Grind, % -200 mesh	Tailing assay, Au oz./ton	Extraction of gold, per cent	Titration, lb./ton solution		Reagents consumed, lb./ton ore		Reducing power, ml. N/10 $KMnO_4$ per litre
				NaCN	CaO	NaCN	CaO	
24	96.0	0.015	93.2	1.00	0.15	1.00	10.7	190
48	96.0	0.01	95.5	0.96	0.15	1.08	11.2	230

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Test No. 4. - Superpanner Test.

In this test a portion of the cyanide residue from Test No. 2, having a fineness of 90.0 per cent minus 200 mesh, was concentrated on the Haultain superpanner with the following results:

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(Test No. 4, cont'd) -

Results of Superpanner Test: (Feed, Au 0.015 oz./ton).

Product	Weight, per cent	Assays Au oz./ton	Per cent S	Per cent Fe	Distribution of gold, per cent
Feed	100.00	0.017*	3.53	23.68	100.0
Concentrate tip	4.77	0.124	-	-	34.1
Concentrate bulk	19.06	0.02	11.78	56.08	22.0
Sands	60.39	0.01	2.04	13.48	34.7
Slimes	15.78	0.01	0.90	6.84	9.2

* Calculated.

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Test No. 5. - Infrasizer Test.

A portion of the ore was ground in cyanide solution of 1 pound NaCN per ton strength with 0.5 pound of $PbNO_3$ and 6 pounds of lime per ton added to the grind, which was 90.9 per cent minus 200 mesh. The pulp was then bottle-agitated for 24 hours. The cyanide residue was then divided into two portions. The plus 200 mesh portion was assayed for gold and sulphur and the minus 200 mesh portion was passed through the Haultain infrasizer and the different-sized products also assayed for gold and sulphur. The plus 200 mesh product assayed 0.02 ounce gold per ton and 3.07 per cent sulphur.

The minus 200 mesh product was infrasized, with the following results:

(Continued on next page)

(Test No. 5, cont'd) -

Results of Infrasizer Test:

Size, in microns	Weight, per cent	Assays, Au, oz./ton	Assays, S, per cent	Distribution, per cent Au	Distribution, per cent S
+56	2.4	0.04	15.86	7.4	8.5
-56 +40	21.5	0.02	5.10	33.4	30.1
-40 +28	20.5	0.01	4.57	15.9	25.7
-28 +20	18.1	0.01	3.12	14.1	15.5
-20 +14	13.1	0.01	1.72	10.2	6.2
-14 +10	8.9	0.01	1.72	6.9	4.2
-10	15.5	0.01	2.29	12.1	9.8
Totals	100.0	0.013	3.64	100.0	100.0

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In the superpanner test, No. 4, no free gold was visible under the microscope when the tip of the concentrate was examined. Owing to the large amount of magnetite in the ore the concentration of the sulphides was rendered rather difficult.

In the infrasizer test, No. 5, the assay of the minus 10 micron product showed that 0.01 ounce gold per ton was apparently the lowest cyanide residue that could be expected.

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Test No. 6. - Cyanidation and Amalgamation.

This test followed the flow-sheet of the Pickle Crow mill in as far as was feasible.

The ore at minus 14 mesh was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength

(Test No. 6, cont'd) -

to pass 82.6 per cent minus 200 mesh. Six pounds of lime and 0.5 pound of $PbNO_3$ per ton of ore were added to the grind. The pulp was then passed through a Denver mineral jig and the jig overflow passed over a corduroy blanket. The combined concentrates were then amalgamated with mercury and the amalgam residue added to the blanket tailing. This product was then bottle-agitated for 24 and 48 hours.

The assay of the amalgam residue + blanket tailing was 0.10 ounce gold per ton, giving a recovery of 54 per cent of the gold in the cyanide grind and amalgamation.

The bottle-agitation of the amalgam residue + blanket tailing resulted as follows:

(Feed, Au 0.10 oz./ton).

Agitation, hours	Grind, % -200 mesh	Tailing assay, Au oz./ton	Extraction of gold, per cent	Reagents consumed,* lb./ton ore NaCN	CaO
24	82.6	0.015	85.0	1.0	8.2
48	82.6	0.015	85.0	1.2	9.4

* Including cyanide grind.

Summary of Test No. 6:

		Per cent
Gold extracted by cyanide grind + amalgamation	-	54.6
Gold extracted by agitation	-	38.6
Overall extraction	-	93.2 per cent.
Overall tailing loss	-	0.015 Au oz./ton.

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Test No. 7. - Cyanidation and Amalgamation.

The flow-sheet of this test was similar to that of Test No. 6. The ore was ground in cyanide to pass 90.4 per cent minus 200 mesh and the pulp passed through a jig and blankets. The combined concentrates were then amalgamated and the amalgam residue + blanket tailing bottle-agitated. In this test the different products were assayed after each step in the flow-sheet.

After grinding in cyanide, the pulp, which was 90.4 per cent minus 200 mesh, assayed 0.11 ounce gold per ton, giving an extraction of 50.0 per cent of the gold in the cyanide grind.

The jig and blanket concentration results were:

Product	Weight, per cent	Assay, Au oz./ton	Distribution, gold, per cent	Ratio of concentration
Feed	100.00	0.11	100.0	
Jig and blanket concentrates	3.68	1.42	47.4	27:1.
Blanket tailing	96.32	0.06	52.6	

After amalgamation, the amalgam residue from the jig and blanket concentrates was added to the blanket tailing. This product assayed 0.07 ounce gold per ton, giving a recovery of 18.2 per cent by amalgamation.

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(Test No. 7, cont'd) -

Results of Cyanidation: (Feed, Au 0.07 oz./ton).

Agitation, hours	Grind, % -200 mesh	Tailing assay, Au oz./ton	Extraction of gold, per cent	Reagents consumed,* lb./ton ore	
				NaCN	CaO
24	90.4	0.015	78.6	1.1	8.4
48	90.4	0.01	85.7	1.2	9.7

* Including cyanide grind.

Summary of Test No. 7:

		Per cent
Gold extracted by cyanide grind	-	50.0
" " " amalgamation	-	18.2
" " " agitation	-	27.2
Overall extraction (48-hour agitation)	-	95.4 per cent.

Summary and Conclusions:

Straight cyanidation of the ore gave an 0.015 ounce gold per ton cyanide residue at a grind of 85 per cent minus 200 mesh in 48 hours' agitation. 0.5 pound of lead nitrate per ton was added to the grind. In Test No. 3 a cyanide residue of 0.01 ounce gold per ton was obtained at a grind of 96.0 per cent minus 200 mesh when aeration of the pulp preceded agitation.

Using the Pickle Crow flow-sheet, an overall recovery of 95.4 per cent of the gold and a cyanide residue of 0.01 ounce gold per ton were realized at a grind of 90.4 per cent minus 200 mesh, as shown in Test No. 7.

In the cycle test (No. 2) the cyanide residue remained constant at 0.015 ounce gold per ton through five periods of agitation. Some fouling of the cyanide solution was evident in the increasing reducing power, however.

The infrasizer and superpanner tests showed that a cyanide residue of 0.01 ounce gold per ton is the lowest that can be obtained by cyanidation. Lime titration of the solution should be kept at 0.15 to 0.2 pound per ton and free lime should not be added to the grinding circuit but rather to the settling tanks in quantity just sufficient to promote settling. The use of lead nitrate in the grind, followed by aeration of the pulp prior to agitation, appears necessary to avoid undue fouling of the solutions.

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