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O T T A W A December 14th, 1940.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 937.

Cyanidation of a Gold Ore from
the West Malartic Mines, Limited,
Heva, Quebec.

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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Shipment:

Eight sacks of ore, total weight 560 pounds, were received on October 12th, 1940, from the West Malartic Mines, Limited, Heva, Quebec. Four of the sacks were from the No. 1 vein on the property and the remaining four from the No. 4 vein. Mr. L. E. Djingheuzian, Siscoe Gold Mines, Limited, Siscoe, Quebec, consulting engineer for the West Malartic Mines, Limited, forwarded the shipment.

Location of the Property:

The property of the West Malartic Mines, Limited, from which the present shipment was received is situated in Cadillac township, Quebec. The claims were formerly known as the Pan-Canadian No. 1 property.

Sampling and Analysis:

After crushing, cutting and grinding by standard methods, samples of the ores were obtained which assayed as follows:

	No. 1 Vein	No. 4 Vein
Gold, oz./ton -	0.79	0.26
Silver, oz./ton -	0.08	0.05
Copper, per cent -	0.01	0.03
Iron, " -	4.38	10.03
Sulphur, " -	0.19	2.58
Arsenic, " -	Nil.	Nil.
SiO_2, per cent -	65.93	40.52
Al_2O_3, " -	5.12	13.32
CaO, " -	4.37	6.17
MgO, " -	9.01	8.09
CO_2, "	5.65	9.60
Pyrrhotite, per cent: -		3.24

Characteristics of the Ore:

Twelve polished sections, six from each sample, were prepared and examined microscopically for the purpose of determining the character of the ore. Since the two samples were somewhat different in character they will be described separately below:

Vein No. 1.

Gangue -

Two types of gangue are present in the polished

(Continued on next page)

(Characteristics of the Ore, cont'd) -

sections: (a) fine-textured white quartz, and (b) soft, highly schistose, dark grey to black rock material. In hand specimens the latter appears to be a dark greenish-grey, talcose schist.

Metallic minerals -

The metallic mineral content of the sections is very small and is represented chiefly by sparsely disseminated grains of pyrite medium to fine in size. A small quantity of magnetite, with a little admixed hematite, is present as coarse to fine irregular grains sporadically scattered through gangue. Chalcopyrite occurs in practically negligible amount as rare tiny grains in gangue and in pyrite.

Nineteen grains of native gold are visible in the sections. They range from 60 microns down to 12 microns in size, and all occur alone (free) in gangue.

Vein No. 4.

Gangue -

The gangue is composed of siliceous, dark grey to black, slightly schistose rock material, which encloses irregular stringers and patches of white quartz and carbonate.

Metallic minerals -

Metallic mineralization is much heavier in these sections than in those from Vein No. 1, but it does not form the greater portion of their content.

Pyrrhotite and pyrite, in almost equal proportions,

(Continued on next page)

(Characteristics of the Ore, cont'd) -

are the predominant metallic minerals. They occur as small masses and coarse to fine irregular grains disseminated through gangue. Both minerals contain inclusions of gangue, and, in places, are slightly fractured and healed with gangue. Ilmenite(?) appears to have taken the place of magnetite in this sample. It is present as small fine-textured masses and tiny irregular grains disseminated in gangue. A very small amount of hematite is intergrown with it. Chalcopyrite is somewhat more prevalent than in the previous sample but its total quantity is very small. It occurs as occasional small grains in gangue and in pyrite.

One grain of native gold, 30 microns in size, is visible in gangue against pyrite.

Results of Investigative Work:

The test work included concentration, amalgamation, and cyanidation.

On the No. 1 vein, straight cyanidation of the ore at a grind of 77 per cent minus 200 mesh gave a cyanide residue of 0.005 ounce gold per ton in 24 hours' agitation. Sixty-two (62) per cent of the gold in the ore was extracted by amalgamation of jig and blanket concentrates.

On the No. 4 vein, straight cyanidation of the ore at a grind of 72 per cent minus 200 mesh gave a cyanide residue of 0.01 ounce gold per ton in 48 hours' agitation when a lead salt was added to the grind in order

(Continued on next page)

(Results of Investigative Work, cont'd) -

to prevent the pyrrhotite in the ore from fouling the solution. This ore gave a recovery of 27 per cent of the gold by amalgamation.

Primary flotation concentration was also tried on both ores but was not successful owing to the large amounts of talc in both shipments.

Details of Test Work:

The test work is divided into two parts, the ore from the No. 1 vein being covered in Part I and the ore from the No. 4 vein being covered in Part II.

PART I. (No. 1 Vein)

Test No. 1. - Concentration, Amalgamation, and Cyanidation.

A portion of the ore at minus 14 mesh was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength to pass 73.2 per cent minus 200 mesh. The pulp was then concentrated in a Denver jig and the jig tailings passed over a corduroy blanket. The combined jig and blanket concentrates were then reground and amalgamated and the amalgam residue added to the blanket tailing. This product was then agitated in cyanide solution of 1 pound NaCN per ton strength for 24- and 48-hour periods.

After grinding in cyanide and prior to jig concentration the pulp assayed 0.66 ounce gold per ton.

(Continued on next page)

(Test No. 1, cont'd) -

Results:

Jig and Blanket Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.66	100.0	
Jig and blanket conc.	1.24	40.48⊕	76.1	80:1.
Blanket tailing	98.76	0.16	23.9	

⊕ Calculated.

After amalgamation of jig and blanket concentrates, the amalgam residue was added to the blanket tailing. This product assayed 0.17 ounce gold per ton.

Cyanidation of Blanket Tailing + Amalgam Residue.

Agitation, hours	Grind, % -200 mesh	Assays, Au oz./ton Feed	Assays, Au oz./ton Tailing	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
24	73.2	0.17	0.015	91.2	1.00	0.25	0.40	3.5
48	73.2	0.17	0.005	97.1	0.96	0.20	0.50	3.6

The primary grinding solution was used in the above agitation.

Summary of Test No. 1:

	Per cent
Gold extracted in cyanide grind	16.5
Gold recovered by amalgamation	62.0
Gold extracted by agitation (48 hours)	20.9
Overall recovery of gold	99.4 per cent.

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Test No. 2. - Flotation Concentration.

A portion of the ore at minus 14 mesh was ground in a ball mill with 2 pounds of soda ash, 0.08 pound of

(Continued on next page)

(Test No. 2, cont'd) -

amyl xanthate and 0.04 pound of Barrett No. 4 oil per ton. The pulp was then transferred to a flotation machine, conditioned with 0.6 pound of sodium silicate per ton, and floated with 0.05 pound pine oil and 0.05 pound amyl xanthate per ton. The initial grind was 78.8 per cent minus 200 mesh and the pH of the pulp prior to flotation concentration was 9.4.

Results of Flotation:

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.79	100.0	
Flot. conc.	25.98	2.73⊕	89.7	3.8:1.
Flot. tailing	74.02	0.11	10.3	

⊕ Calculated.

Owing to the large amount of talc in the ore the ratio of concentration and subsequent grade of concentrate were both low.

A portion of the flotation tailing was panned and the panner concentrate showed several small pieces of free gold under the microscope. The remainder of the concentrate consisted of magnetite with a very small amount of pyrite.

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Test No. 3 (A to D). - Straight Cyanidation.

Portions of the ore at minus 14 mesh were ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength to different degrees of fineness. The pulps

(Continued on next page)

(Test No. 3, cont'd) -

were then bottle agitated for 24- or 48-hour periods. Sufficient lime was added during the grinding and agitation to maintain protective alkalinity. The cyanide residues were assayed for gold.

Results of Cyanidation: (Feed = Au, 0.79 oz./ton).

Test No.	Agitation, hours	Grind, % -200 mesh	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
3-A	24	61.2	0.01	98.7	0.90	0.30	0.50	5.4
3-B	48	61.2	0.01	98.7	1.00	0.20	0.60	5.6
3-C	24	76.8	0.005	99.4	1.00	0.32	0.60	5.5
3-D	48	76.8	0.005	99.4	0.96	0.26	0.60	5.8

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Test No. 4 (A and B). - Settling Tests.

The ore at minus 14 mesh was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength to pass 80.1 per cent minus 200 mesh. Three pounds of lime per ton of ore was added to the grind. The pulp was then transferred to a cylindrical glass tube of 1 inch diameter at a 2:1 or 2.5:1 ratio of concentration. The level of solids in decimals of feet was read for a 1-hour period. At the end of the test the solution was titrated for alkalinity.

Results:

		TEST NO. 4-A	TEST NO. 4-B
Ratio of liquid to solid	--	2:1.	2.5:1.
Lime added per ton solid, pounds	--	3.0	3.0
Alkalinity of solution at end of test, lb./ton		0.10	0.08
Overflow -- (S.C. = slightly cloudy)	--	S.C.	S.C.
Rate of settling, ft./hour	--	1.08	1.47

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(Test No. 4, cont'd) -

The rate of settling is faster than normal.

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This concluded the test work on the No. 1 Vein shipment. The gold in the ore is mostly free, amalgamates readily, and is easily amenable to cyanidation.

PART II. (No. 4 Vein)

Test No. 1. - Concentration, Amalgamation, and Cyanidation.

A portion of the ore at minus 14 mesh was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength to pass 75.2 per cent minus 200 mesh. The pulp was then concentrated in a Denver jig and the jig tailings passed over a corduroy blanket. The combined jig and blanket concentrates were then reground and amalgamated and the amalgam residue added to the blanket tailings. This product was then agitated in cyanide solution of 1 pound NaCN per ton strength for 24- and 48-hour periods.

After grinding in cyanide and prior to jig concentration the pulp assayed 0.24 ounce gold per ton.

Results:

Jig and Blanket Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.24	100.0	
Jig and blanket conc.	2.76	3.06⊕	35.2	36.2:1.
Blanket tailing	97.24	0.16	64.8	

⊕ Calculated.

(Continued on next page)

(Test No. 1, cont'd) -

(Results, cont'd) -

After amalgamation of jig and blanket concentrates, the amalgam residue was added to the blanket tailing. This product assayed 0.17 ounce gold per ton.

Cyanidation of Amalgam Residue + Blanket Tailing.

Agitation, hours	Grind, % -200 mesh	Assays, Au oz./ton Feed	Assays, Au oz./ton Tailing	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
24	75.2	0.17	0.015	91.2	0.96	0.25	0.40	3.50
48	75.2	0.17	0.01	94.1	0.90	0.20	0.50	3.60

In the cyanide grind 3 pounds of lime and 0.25 pound of lead nitrate per ton were added. The grinding solution was used in the agitation of the amalgam residue and blanket tailing.

Summary of Test No. 1:

	Per cent
Gold extracted in cyanide grind -	7.7
Gold recovered by amalgamation -	26.9
Gold extracted by agitation (48 hours) -	61.5
Overall recovery of gold -	96.1 per cent.

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Test No. 2. - Concentration and Cyanidation.

The ore at minus 14 mesh was ground in cyanide solution of 1 pound NaCN per ton strength to pass 71.6 per cent minus 200 mesh. The sulphides in the pulp were then concentrated on a Wilfley table. The table concentrate was reground in cyanide solution of 3 pounds NaCN per ton strength to pass 98.0 per cent minus 325 mesh and agitated for 48 hours. The table tailings were agitated in cyanide

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(Test No. 2, cont'd) -

solution of 1 pound NaCN per ton strength for 48 hours. In the initial cyanide grind 3 pounds of lime and 0.25 pound of $PbNO_3$ were added to the grind. The grinding solution was used in the agitation of the table concentrates and tailing.

After grinding in cyanide the pulp assayed 0.24 ounce gold per ton and was concentrated on a Wilfley table as follows:

Table Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.24	100.0	
Table conc.	8.38	1.61⊕	56.1	11.9:1.
Table tailing	91.62	0.115	43.9	

⊕ Calculated.

Cyanidation of Reground Table Concentrate and Table Tailing.

Product	Grind, % -200 mesh	Agitation, hours	Assays, Au oz./ton Feed	Assays, Au oz./ton Tailing	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
Table conc.	98.0⊕	48	1.61	0.015	99.1	2.80	0.15	4.00	9.2
Table tailing	71.6	48	0.115	0.01	91.3	0.96	0.20	0.30	3.0

⊕ Minus 325 mesh.

Summary of Test No. 2:

		Per cent
Gold extracted by cyanide grind	-	7.7
Gold extracted from table concentrate	-	51.3
Gold extracted from table tailing	-	37.0

Overall extraction of gold - 96.0 per cent.

Overall tailing loss - 0.011 ounce gold per ton.

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Test No. 3. - Flotation Concentration.

The ore at minus 14 mesh was ground in a ball mill to pass 76.2 per cent minus 200 mesh. Two pounds of soda ash, 0.04 pound of Barrett No. 4 oil and 0.05 pound of amyl xanthate per ton were added to the grind. The pulp was then transferred to a flotation machine, conditioned with 0.5 pound of sodium silicate per ton, and a concentrate obtained by the further additions of 0.05 pound amyl xanthate and 0.05 pound pine oil per ton.

Results of Flotation:

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.26	100.0	
Flot. conc.	16.02	1.41⊕	87.1	6.2:1.
Flot. tailing	83.98	0.04	12.9	

⊕ Calculated.

The pH of the pulp was 9.3.

Owing to the large amount of talc included in the concentrate, both the grade and the ratio of concentration were low.

A microscopic examination of the panned concentrate from the flotation tailings showed one small piece of gold and some magnetite. Practically no sulphides were visible.

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Test No. 4 (A to H). - Cyanidation.

In Tests A and B the ore was ground in cyanide solution of 1 pound NaCN per ton strength to pass 84.6 per cent minus 200 mesh and the pulp agitated for 24 and 48 hours. Four pounds of lime per ton was added to the grind.

In Tests C, D, E, and F the ore was ground in

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(Test No. 4, cont'd) -

cyanide solution of 1 pound NaCN per ton strength and 0.25 pound lead nitrate and 5 pounds of lime per ton were added to the grind.

In Tests G and H, the ore was ground in a lime pulp and aerated for 16 hours prior to cyanidation. 0.25 pound of lead nitrate per ton of ore was added during agitation in cyanide solution of 1 pound NaCN per ton strength.

Results: (Feed = Au, 0.26 oz./ton)

Test No.	Grind, % -200 mesh	Agitation, hours	Tailing assay, Au oz./ton	Extraction of gold, per cent	Reagents consumed, lb./ton solution: NaCN	Reagents consumed, lb./ton solution: CaO	Reducing power, ml. N/10 $KMnO_4$ per litre	Remarks
4-A	84.6	24	0.05	80.8	0.3	4.3	110	
4-B	84.6	48	0.02	92.3	0.4	4.5	190	
4-C	82.4	24	0.02	92.3	0.3	5.4	40	$PbNO_3$ added.
4-D	82.4	48	0.01	96.2	0.4	5.5	60	" "
4-E	72.2	24	0.02	92.3	0.4	6.7	26	" "
4-F	72.2	48	0.01	96.2	0.5	7.7	56	" "
4-G	76.4	24	0.02	92.3	0.3	4.6*	24	Aeration + $PbNO_3$
4-H	76.4	48	0.01	96.2	0.3	5.6*	44	" + "

* 3 pounds of lime per ton were also used in aeration.

This test shows the beneficial effects of the addition of the lead salt during the grinding and agitation periods, the extraction of the gold being increased to 96.2 per cent and the fouling of the cyanide solution noticeably decreased, as evidenced by the reducing powers.

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Test No. 5 (A and B). - Settling Tests.

These tests were performed similarly to Test No. 4 in Part I. The ore was ground in cyanide to a fineness of 80.4 per cent minus 200 mesh. The results obtained on the settling of the pulp were as follows:

	Test No.	
	5-A	5-B
Ratio of liquid to solid	2:1.	2.5:1.
Lime added per ton solid, pounds	4.0	4.0
Alkalinity of solution at end of test, lb./ton	0.10	0.08
Overflow	Clear.	Slightly cloudy.
Rate of settling, ft. per hour	1.00	1.30

The rate of settling is faster than normal.

Summary and Conclusions:

The test work indicated that the ore from the No. 1 vein is easily amenable to either amalgamation or cyanidation. At a grind of 73 per cent minus 200 mesh, 62 per cent of the gold was recovered by amalgamation and 37.4 per cent by cyanidation. The final cyanide residue assayed 0.005 ounce gold per ton. By straight cyanidation, a cyanide residue of 0.005 ounce gold per ton was obtained in 24 hours' agitation at a grind of 76.8 per cent minus 200 mesh.

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(Summary and Conclusions, cont'd) -

On the No. 4 Vein shipment a cyanide residue of 0.01 ounce gold per ton was obtained in 48 hours' agitation at a grind of 72.2 per cent minus 200 mesh. Owing to the amount of pyrrhotite in this ore body it was necessary to add a lead salt to the grind in order to prevent undue fouling of the cyanide solutions.
By a combination of amalgamation and cyanidation as shown in Test No. 1, 26.9 per cent of the gold was recovered by amalgamation and 69.2 per cent by cyanidation, giving a final cyanide residue of 0.01 ounce gold per ton.

Flotation concentration was tried on both of these ores but owing to the large amount of talc present it was not successful.

Settling tests on the pulps gave results which showed that no difficulties should be expected in this regard from either ore.

From the results of the test work on the ores, as outlined above, it is apparent that cyanidation of the ores, with some provision for catching the free gold in traps, jigs or blankets, should prove to be the most acceptable method of recovery. The pyrrhotite in the No. 4 vein would be counteracted by the use of a lead salt in the grind.

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