OTTAWA January 16th, 1941.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 945.

Concentration and Cyanidation of a Gold Ore
from the Missanabie Property of the
Macassa Mines, Limited, in Northwestern Ontario.

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:

Sixteen bags of sample rejects, consisting of Lot B from Claims Nos. S34314-S34318 (weight 694 pounds), Lot C from Claim No. 34794 (weight 832 pounds), and Lot BC, a composite sample weighing 272 pounds, were received on November 19th, 1940, from Mr. C. C. Huston, field engineer for Macassa Mines, Limited, 85 Richmond St. W., Toronto, Ontario.

Location of the Property:

The property from which these samples originated is located at the mutual corner of Rennie, Leeson, Stover and Bracken townships in the Sudbury mining division, about 228 miles west of Sudbury along the Canadian Pacific Railway, then approximately 14 miles northeast to the property.

Characteristics of the Ore:

Six polished sections, two from each sample, were prepared and examined under the reflecting microscope for the purpose of determining the character of the ore. Metallic mineralization is very sparse in all three samples and gangue forms the major portion of the polished sections.

B Head Sample:

The gangue is composed essentially of translucent white quartz which contains small streaks and patches of a soft white mineral and a very small quantity of finely disseminated carbonate. It bears local, light brown stains of iron oxides and is transected by narrow sinuous fractures along some of which are very thin films of a black material which may be graphitic in character.

Pyrite is the predominant metallic mineral. It occurs as irregular, disseminated grains coarse to fine in size. The margins of many grains show attack and replacement by "limonite". In some places this replacement has proceeded so far that only a tiny residual remnant of pyrite is left in the centre of a grain of "limonite". Some of the pyrite particles are dense, others contain rather numerous small inclusions of gangue. As already mentioned, "limonite" is prevalent as stains in gangue as well as rims around

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grains of pyrite. A practically negligible amount of chalcopyrite is visible as rare tiny irregular particles in gangue.

C Head Sample:

As exhibited by the polished sections two types of material form the gangue. The major portion consists of soft, dark grey, schistose rock, which carries rather abundant finely disseminated carbonate. A minor portion is composed of translucent white quartz.

Pyrite, "limonite", and chalcopyrite occur as in the B head sample, but the "limonite" is somewhat less abundant. Besides these metallic minerals magnetite, with a small amount of intergrown hematite, is present as moderately coarse to fine irregular grains sporadically disseminated in gangue and in pyrite. Some of the larger particles contain inclusions of gangue and tiny grains of pyrite as well as hematite.

BC Head Sample:

This appears to be a composite of the two samples already described. The gangue material is a mixture of quartz and rock in approximately equal proportions.

The metallic minerals are the same as those described in Head Sample C above, except that no chalcopyrite is visible and the others are very sparingly distributed.

Conclusion from Microscopic Examination:

Since neither native gold nor gold minerals were observed in the sections nothing was learned as to this metal's mode of occurrence.

Sampling and Analysis:

After crushing, cutting and grinding by standard methods, representative portions of each lot were obtained which assayed as follows:

	Lot B	Lot C	Lot BC
Gold, oz./ton	0.23	0.11	0.145
Silver, oz./ton	0.10	0.08	0.10
Iron, per cent	1.55	2.03	1.75
Sulphur, per cent	0.23	0.34	0.24
Copper, "	Trace.	Trace.	Trace.
Arsenic, "	Trace.	Trace.	Trace.
Acid insoluble, per cent	96.00	--	--

Investigative Work:

The work performed, as suggested by Mr. Huston, consisted of tests on the different lots separately and also composite tests using equal quantities of each lot.

By Straight Cyanidation -

On Lot B a cyanide residue of 0.02 ounce gold per ton was obtained in 48 hours' agitation at a grind of 67 per cent minus 200 mesh, and a similar residue of 0.02 ounce per ton was also obtained at a grind of 86.0 per cent minus 200 mesh in 24 hours' agitation. On Lot C a residue of 0.01 ounce gold per ton was obtained in 48 hours' agitation at a grind of 74.0 per cent minus 200 mesh. By taking equal amounts of Lots B, C and BC, a residue of 0.01 was obtained at a grind of 84 per cent minus 200 mesh in 24 hours' agitation.

Hollinger Milling Practice -

An application of the Hollinger milling practice of concentrating the sulphides by means of a Wilfley table

(Continued on next page)

(Investigative Work results, cont'd) -

and regrinding them prior to agitation gave the following results:

On Lot B a residue of 0.0125 ounce gold per ton was obtained in 24 hours' agitation from an overall grind of 88 per cent minus 200 mesh. On Lot C a residue of 0.01 ounce gold per ton resulted from 24 hours' agitation at a grind of 78 per cent minus 200 mesh. By taking equal quantities of Lots B, C and BC, a residue of 0.01 ounce per ton was also obtained in 24 hours' agitation at a grind of 86.0 per cent minus 200 mesh.

Flotation -

A number of primary flotation concentration tests were made on the different lots but it was not found possible to produce a flotation tailing that could be discarded.

Details of Test Work:

Test No. 1. - Straight Cyanidation.

Portions of the different lots at minus 14 mesh were ground in a ball mill in cyanide solutions of 1.0 pound NaCN per ton strength to different degrees of fineness. The pulps were then bottle-agitated for 24- or 48-hour periods. Sufficient lime was added during the grinding and agitation periods to maintain protective alkalinity. The cyanide residues were assayed for gold.

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(Test No. 1, cont'd) -

Results:

Lot No.	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
B	24	45.6	0.23	0.035	84.8	1.00	0.15	0.3	7.7
B	24	54.6	0.23	0.03	87.0	0.90	0.15	0.4	7.7
B	24	63.8	0.23	0.03	87.0	0.90	0.20	0.4	7.8
B	24	76.6	0.23	0.03	87.0	1.00	0.25	0.5	9.0
B	24	86.0	0.23	0.02	91.3	1.00	0.20	0.5	9.2
B	48	67.0	0.23	0.0175	92.4	0.96	0.20	0.6	9.7
C	24	49.4	0.11	0.015	86.4	1.00	0.15	0.3	7.7
C	24	58.6	0.11	0.015	86.4	0.90	0.15	0.3	7.7
C	24	73.4	0.11	0.015	86.4	0.90	0.15	0.4	7.8
C	24	86.0	0.11	0.015	86.4	1.00	0.25	0.4	8.9
C	24	92.8	0.11	0.01	90.9	1.00	0.25	0.4	9.0
C	48	73.8	0.11	0.01	90.9	0.96	0.20	0.5	9.5
B, C, BC	24	76.0	0.16	0.015	90.6	1.00	0.30	0.5	8.6
B, C, BC	48	76.0	0.16	0.01	93.6	0.96	0.20	0.6	9.6

In the last two cyanidations, equal quantities of Lots B, C, and BC were taken.

The above tests on the different lots indicate that either a fine grind and 24 hours' agitation or a medium grind and 48 hours' agitation is necessary to produce the minimum cyanide residue obtainable.

In all these cyanidation tests no fouling of the solutions was discernible. Determinations of reducing powers on the final solution ran from 15 ml. N/10 $KMnO_4$ per litre to 25 ml. N/10 $KMnO_4$ per litre, indicating no appreciable fouling.

Test No. 2. - Hydraulic Concentration and Microscopic Examination.

This test was made in order to indicate whether any free gold was present and, if so, to determine the size of the individual particles.

The ore of the "B" sample at minus 14 mesh was ground in a ball mill to pass 68 per cent minus 200 mesh and the pulp passed through a hydraulic classifier or trap. The resulting trap concentrate was then panned down to the sulphides and this product examined under a powerful binocular microscope.

Results -

The weight of the final concentrate was 0.050 per cent of the weight of the feed, or a ratio of concentration of 2000:1.

Under microscopic examination, three grains of native gold were observed. They measured respectively 200, 150 and 50 microns in size.

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Test No. 3 (X and Y). - Concentration, Amalgamation, and Cyanidation.

Following the information obtained in Test No. 2, it was decided to amalgamate prior to agitation in cyanide solution in order to see if the amount of gold in the final residue could be reduced.

The ore at minus 14 mesh was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength and the pulp passed through a Denver jig and the jig tailing over a corduroy blanket. The combined jig and blanket

(Continued on next page)

(Test No. 3, cont'd) -

concentrates were then reground and amalgamated with mercury. The amalgam residue was added to the blanket tailing and the combined product agitated in the cyanide grinding solution for 24- and 48-hour periods. Test No. 3-X was performed on Lot B and Test No. 3-Y on Lot C.

Results:

After grinding in cyanide the jig feed assayed 0.20 ounce gold per ton in Test No. 3-X and 0.085 ounce per ton in Test No. 3-Y.

Jig and Blanket Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution: of gold, per cent	Ratio of concentration
Test No. 3-X (Lot B).				
Feed	100.00	0.20	100.0	
Jig and blanket conc.	2.01	5.32	53.4	50:1.
Blanket tailing	97.99	0.095	46.6	
Test No. 3-Y (Lot C).				
Feed	100.00	0.085	100.0	
Jig and blanket conc.	1.84	1.68	36.5	54:1.
Blanket tailing	98.16	0.055	63.5	

After amalgamation the amalgam residue was added to the blanket tailings. This product assayed 0.105 ounce gold per ton in Test No. 3-X and 0.07 ounce per ton in Test No. 3-Y.

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(Test No. 3, Results, cont'd) -

Agitation of Amalgam Residue + Blanket Tailing.

Test No.	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
3-X	24	80.8	0.105	0.0175	83.3	0.90	0.25	0.5	8.6
3-X	48	80.8	0.105	0.015	85.7	0.90	0.20	0.7	9.8
3-Y	24	78.6	0.07	0.01	85.7	1.00	0.25	0.4	8.1
3-Y	48	78.6	0.07	0.01	85.7	0.90	0.20	0.5	9.4

Summary of Test No. 3:

	Per cent: Test No. 3-X	Per cent: Test No. 3-Y
Gold extracted in cyanide grind	13.1	22.7
" " by amalgamation	41.3	13.7
" " " agitation (24-hour)	38.0	54.5
" " " " (48-hour)	39.1	54.5
Overall extraction of gold =	93.5 per cent.	90.9 per cent.

The results of this test show that a slightly higher overall extraction of the gold can be expected when amalgamation is included in the flow-sheet. It is doubtful, however, whether this small increase should supersede straight cyanidation of the ore when the additional costs are considered.

Test No. 4. - Infrasizing.

In order to determine the relationship between the gold and the sulphides and also to show the quantities of gold in the smaller-sized particles, a portion of the cyanide residue from Test No. 3-X, of 48 hours' agitation, was run through the Haultain infrasizer.

The residue, assaying 0.015 ounce gold per ton, was passed through a 200-mesh screen. The +200 mesh part assayed 0.01 ounce gold per ton and 0.175 per cent sulphur. The -200 mesh portion, which was 80.8 per cent by weight, was passed through the Haultain infrasizer with the following results:

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	4.84	0.056	1.44	19.2	25.5
-56 +40	33.97	0.015	0.21	36.0	26.1
-40 +28	21.72	0.010	0.19	15.4	15.1
-28 +20	13.59	0.010	0.23	9.6	11.4
-20 +14	7.50	0.0075	0.23	4.0	6.3
-14 +10	5.47	0.01	0.23	3.9	4.6
-10	12.91	0.013	0.23	11.0	11.0
Totals	100.00	0.014	0.27	100.0	100.0

Conditions:

Length of time for test - 6 hours 27 minutes.
Number of drops per minute - 63.
Differential pressure - 19 inches of water.
Height of drop - 5/16 inch.
Standard golf balls used.

It can be seen from the infrasizer test on the cyanide residue that extremely fine grinding of the ore fails to improve the extraction of the gold in cyanide solution, the -10 micron particles assaying 0.013 ounce gold

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(Test No. 4, cont'd) -

per ton, after 48 hours' agitation. The results in the smaller-sized particles also show a rather close relationship between the gold and the sulphides. The higher values in the +56 micron size are probably due to some concentration of the gold and sulphides in this size of particle.

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Test No. 5 (X and Y). - Table Concentration and Cyanidation.

Following the results of the infrasizer test it was decided to concentrate and regrind the sulphides prior to agitation in cyanide solution.

Two portions of ore were taken in this test. In the tests numbered 5-X a portion of Lot B was used. In those numbered 5-Y, equal portions of Lots B, C and BC were taken.

The ores at minus 14 mesh were ground in a ball mill in cyanide solutions and the sulphides in the pulps concentrated on a Wilfley table. The table concentrates were then reground in cyanide solution of 2 pounds NaCN per ton strength to pass 99 per cent minus 325 mesh. The reground concentrate was then mixed with the table tailings and this product agitated for 24- and 48-hour periods. The ratio of concentration was approximately 30:1 in each test. The cyanide solutions used in the grinding were also used in the agitations.

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(Test No. 5, cont'd) -

Results of Agitations of Reground Table Concentrates and Table Tailings.

Test No.	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
5-X	66.2	24	0.23	0.015	93.5	1.00	0.35	0.5	8.7
5-X	66.2	48	0.23	0.010	95.7	0.96	0.25	0.6	9.2
5-X	80.2	24	0.23	0.015	93.5	1.00	0.35	0.5	8.8
5-X	80.2	48	0.23	0.010	95.7	0.90	0.25	0.6	9.5
5-X	88.2	24	0.23	0.012	94.7	0.96	0.30	0.7	9.0
5-X	88.2	48	0.23	0.010	95.7	0.90	0.30	0.8	10.3
5-Y	63.2	24	0.16⊕	0.010	93.8	1.00	0.35	0.4	8.3
5-Y	63.2	48	0.16⊕	0.010	93.8	0.96	0.20	0.6	8.9
5-Y	78.8	24	0.16⊕	0.010	93.8	1.00	0.35	0.5	8.6
5-Y	78.8	48	0.16⊕	0.010	93.8	0.96	0.25	0.6	9.2
5-Y	86.0	24	0.16⊕	0.010	93.8	0.96	0.32	0.6	9.0
5-Y	86.0	48	0.16⊕	0.0075	95.3	0.90	0.30	0.8	9.7

⊕ Calculated.

Some samples of the table tailings were obtained, which assayed as follows:

Test No.	Grind, % -200 mesh	Assays Au, oz./ton	Assays S, per cent
5-X	66.2	0.07	0.10
5-X	80.2	0.075	0.12
5-Y	63.2	0.055	0.09
5-Y	78.8	0.055	0.13

The test shows that concentration and regrinding of the sulphides, prior to agitation, give an improved extraction of the gold over straight cyanidation.

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Test No. 6 (X, Y, and Z). - Flotation Concentration.

Three portions of ore at minus 14 mesh were taken, Test No. 6-X being from Lot B, Test No. 6-Y from Lot C, and Test No. 6-Z from Lot BC.

The ores were ground in a ball mill with 0.75 part of water to 1.0 part of ore with the following reagents being added to the grinds: (The figures are in pounds per ton of ore)

Test No.	Soda ash	Reagent No. 301	Barrett No. 4 oil	Aerofloat No. 31	Grind, % -200 mesh
6-X	3.0	0.07	0.085	-	64.0
6-Y	3.0	0.07	0.085	-	73.0
6-Z	2.5	0.05	-	0.04	76.2

The following reagents were added to the cells:

Test No.	Reagents, lb./ton ore			pH of pulp
	Potassium amyl xanthate	Pine oil	Copper sulphate	
6-X	0.07	0.075	-	9.4
6-Y	0.07	0.075	-	9.4
6-Z	0.10	0.075	1.0	9.1

After grinding, as specified, the pulp was placed in a Denver flotation machine and a bulk concentrate obtained by the additions of the above flotation reagents. This concentrate was then cleaned in a smaller machine.

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(Test No. 6, cont'd) -

The results of the different flotation concentrations were as follows:

Test No. 6-X (Lot B).

Product	Weight, per cent	Assay, Au, oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.20⊕	100.0	
Flot. conc.	0.23	35.82	40.4	435:1.
Flot. middling	1.52	3.46	25.8	
Flot. tailing	98.25	0.07	33.8	

Test No. 6-Y (Lot C).

Product	Weight, per cent	Assay, Au, oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.11⊕	100.0	
Flot. conc.	0.54	8.86	43.1	185:1.
Flot. middling	2.29	1.06	21.9	
Flot. tailing	97.17	0.04	35.0	

Test No. 6-Z (Lot BC).

Product	Weight, per cent	Assay, Au, oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.22⊕	100.0	
Flot. conc.	0.35	28.28	44.7	286:1.
Flot. middling	2.07	3.56	33.3	
Flot. tailing	97.58	0.05	22.0	

⊕ Calculated.

The flotation tailing from Test No. 6-X (Lot B) was concentrated on the Haultain superpanning machine with the following results. The tailing assayed 0.07 ounce gold per ton and 0.09 per cent sulphur.

Superpanner Results.

Product	Weight, per cent	Assays: Au, oz./ton	Assays: S, per cent	Distribution, per cent: Au	Distribution, per cent: S
Feed	100.00	0.07	0.09	100.0	100.0
Concentrate	0.47	7.57⊕	15.06⊕	50.8	78.7
Sands	88.02	0.03	0.014	37.7	13.6
Slimes	11.51	0.07	0.06	11.5	7.7

⊕ Calculated.

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(Test No. 6, concluded) -

On microscopic examination of the panner concentrate, one small piece of gold, 30 to 40 microns in size, was visible. The concentrate consisted mainly of coarse pyrite and quartz particles. The superpanning test indicates that a portion of the gold is in the gangue, as evidenced by the assay of the panner sand.

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Test No. 7 (X and Y). - Settling Test (Lot BC).

This test was made in order to determine the rate of settling of the pulp at different densities. The ore from Lot BC, at minus 14 mesh, was ground in a ball mill in cyanide solution of 1 pound NaCN per ton strength to pass 81.3 per cent minus 200 mesh. Six pounds of lime per ton of ore was added to the grind. After grinding, the pulp was made up to the required dilution and transferred to a tall glass cylinder of 2-inch diameter. The rate of settling of the pulp in decimals of feet was read for a 1-hour period. The clear solution was titrated for alkalinity.

A screen test showed the grinding as follows:

Mesh	Weight, per cent
- 65 +100	1.0
-100 +150	6.7
-150 +200	11.0
-200	81.3
	100.0

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(Test No. 7, cont'd) -

Results of Settling:

	Test No. 7-X.	Test No. 7-Y.
Ratio of solid to liquid	1.5:1.	2:1.
Lime added, pounds per ton of ore	6.0	6.0
Alkalinity of solution at end of test, pounds per ton of solution	0.36	0.30
Overflow solution	Slightly cloudy.	Slightly cloudy.
Rate of settling, in feet per hour	0.68	1.21

The pulp settles more rapidly than normal.

Summary and Conclusions:

Straight cyanidation of the ores showed that fine grinding, of over 80 per cent minus 200 mesh, and long agitation are necessary in order to obtain cyanide residues of 0.02 ounce gold per ton in Lot B and 0.01 ounce per ton in Lot C.

When concentration of the sulphides by jigs and blankets was followed by amalgamation, and the amalgam residue was cyanided with the blanket tailings, cyanide residues of 0.015 ounce and 0.01 ounce gold per ton were obtained from Lots B and C respectively.

Table concentration and regrinding of the sulphides, prior to agitation, gave a cyanide residue of 0.015 ounce gold per ton in 24 hours' agitation for Lot B at an

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(Summary and Conclusions, cont'd) -

overall grind of 66.2 per cent minus 200 mesh and a residue of 0.01 ounce per ton in 48 hours' agitation at the same grind. By taking equal quantities of Lots B, C and BC, a cyanide residue of 0.01 ounce gold per ton was obtained in 24 hours' agitation at an overall grind of 63.2 per cent minus 200 mesh.

Primary flotation concentration was not successful in producing a tailing which could be discarded.

The infrasizing test on the cyanide residue went to show that a tailing of 0.01 ounce gold per ton was the lowest that could be expected at an economic grind. The superpanning test on the flotation tailing indicated that a portion of the gold was in the gangue.

While no free gold was visible in the microscopic slides, a number of small particles were observed under the binocular microscope in a trap concentrate.

The pulp settles normally and no difficulties should be expected in this regard. Cyanide consumption was normal and no signs of fouling of the solutions were discernible. Lime consumption was high, probably in part due to the somewhat oxidized condition of the shipments as shown in the microscopic examination.

The test work indicates that an application of the Hollinger milling practice of concentrating the sulphides by means of a Wilfley table and regrinding them, prior to agitation with the main body of the pulp, is the best metallurgical procedure for this type of ore.

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