

O T T A W A

August 22nd, 1941.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1076.

Amalgamation and Cyanidation of
a Gold Ore from Negus Mines Limited,
Yellowknife, N. W. T.

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Report of the Ore Dressing and Metallurgical
Laboratories.

Report No. 1.

Amalgamation and Cyanidation of a Gold Ore from
Negus Mines Ltd.,
Yellowknife, N. W. T.

Shipments:- Four lots of ore were received in July and August, 1941. No. 1 Lot of 10 lbs. No. 2 @ 19 lbs. No. 3 - $6\frac{1}{2}$ lbs. No. 4 - $6\frac{1}{2}$ lbs. The shipments were from Mr. J. G. McNiven, Manager, Negus Mines, Ltd., and were consigned to Mr. W. H. A. Timm, Mill Supt., Negus Mines, who superintended the test work in the Ore Dressing Laboratories. Previously, two shipments of ore had been received from the Negus Mine and the test work is covered in Investigations Nos. 742 and the Report dated May 29, 1940 of the Department.

Location of the Property:- The property of Negus Mines Limited from which the present shipment was received is situated on the West shore of Yellowknife Bay, Yellowknife Area, N. W. T.

Sampling and Analysis:- After crushing, cutting and grinding by standard methods, representative samples of the shipments were obtained which assayed as follows:-

	<u>Lot No. 1</u>	<u># 2</u>	<u>#3</u>	<u>#4</u>
Au oz/ton	1.53	1.11	1.00	0.16
Ag oz/ton	0.54	0.48	0.59	0.32
As %	0.52	0.41	0.58	0.89
Sb %	-	0.05	0.03	0.03
S %	-	2.13	2.03	3.22
Fe %	-	4.81	4.34	6.90
Cu %	-	0.02	0.08	0.05
Graphitic C %	-	-	0.02	0.02

Characteristics of the Ore:- Engineers' Report No. 817-~~8~~.

Sample - The sample of gold ore from Negus Mines Limited, Yellowknife, N. W. T., was received by the Division of Metallic Minerals on July 29, 1941. Six polished sections were prepared and examined microscopically for the purpose of providing a short description of the character of the ore.

Gangue - The gangue consists of rather fine-textured gray quartz with stringers of carbonate (calcite).

Metallic Minerals -

The metallic minerals present in the sections are, in their order of abundance, pyrite, arsenopyrite, sphalerite, chalcopyrite, stibnite, and native gold.

Pyrite is disseminated in the quartz as rather small grains which locally are sufficiently abundant to form irregular stringers of the mineral. Arsenopyrite occurs in considerably less quantity but is common; it is usually present as small grains in the quartz but is often associated with pyrite. Occasional grains of sphalerite and rather rare grains of chalcopyrite occur in the quartz associated with carbonate, as do comparatively rare small grains of a mineral regarded as stibnite.

Native gold is present as small irregular grains in quartz, and as grains against the pyrite crystals. No gold was seen to occur within the sulphides.

Conclusion -

In view of the refractory nature of part of the gold contained in this sample (as proved by test work) it would seem almost certain that the gold seen in the sections represents only that which is comparatively easily extractible. No tiny gold grains which might cause difficulty in treatment were observed in the pyrite or arsenopyrite. It is therefore probable that the refractory portion of the gold in this sample is present in either or both of the sulphides in submicroscopic form.

Investigative Work:-

This procedure generally followed the flow-sheet of the Negus Mill as far as was practicable in the small scale test work. The ore was ground in cyanide and the pulp passed through a Denver gold jig and the jig overflow over the blankets. The combined concentrates were reground and amalgamated and the amalgam residue added to the blanket tailings. This product was agitated in the cyanide grinding solution for 24 hours. The work showed that part of the gold was refractory to cyanidation, the cyanide residue assaying from 0.06 Au oz/ton to 0.24 Au oz/ton generally depending on the fineness of the grinding used. Superpanning and Infrasizing tests on this residue gave results showing that this refractory gold generally was contained in the sulphides.

Results of the test work follow:-

Test No. 1 on Lot No. 2.

In this test the procedure followed the Negus flow-sheet. The ore was ground in cyanide to pass 87.4 % minus 200 mesh. The pulp was then passed over a jig and blankets and the combined concentrates reground and amalgamated. The amalgam residue was added to the blanket tailings and agitated in cyanide solution for 24 and 48 hours.

After grinding in cyanide of 1 lb. NaCN per ton strength the pulp was filtered, washed and sampled. The residue assayed 0.91 Au oz/ton giving an extraction of 18.0 % of the Au in the cyanide grind.

Jig + Blanket Concentration.

Product	Weight per cent	Assay Au oz/ton	Distribution Au %	Ratio Conc.
Feed	100.00	0.91	100.00	
Jig + Blk. Con.	7.64	7.87	66.1	13.1:1
Blk. Tailing	92.36	0.33	33.9	

After amalgamation of the combined concs. the amalgam residue was added to the blanket tailings. This product assayed 0.43 Au oz/ton giving 43.3 % of the gold recovered by amalgamation.

Cyanidation of Amalgam Residue + Blanket Tailings.

Agitation Hours	Assays Au oz/ton Feed	Au oz/ton Tailings	Extraction Au %	Reagents consumed lbs/ton ore solution.		Titration lbs/ton solution.	
				NaCN	CaO		
24	0.43	0.10	76.75	1.2	5.4	1.0	0.15
48	0.43	0.095	77.90	1.3	5.6	0.9	0.20

Summary Test No. 1.

- Au extraction in cyanide grind - 18.0 %.
 - Au " by amalgamation - 43.3 %.
 - Au " by agitation (48 hrs) 30.1 %.
- Overall extraction - 91.4 %.

Results of the test were as follows:-

A portion of the cyanide residue was concentrated on the Haultain Superpanner with the following results:

Product	Weight per cent	Assays		Distribution Au %.
		Au oz/ton	As %	
Feed	100.00	0.10	-	100.0
Conc.	3.03	1.325	-	40.5
Sands + 200	23.10	0.093	0.11	21.7
Sands - 200	50.59	0.06	0.26	30.7
Slimes	23.28	0.03	0.26	7.1

Test No. 2 on No. 2 Head.

This test was similar to test No. 1 with the exception that the amalgam residue from the jig and blanket concentrates was not added to the blanket tails prior to agitation.

Results.

- Jig + Blanket Concentration -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration
Jig + Blk.	100.00	0.91	100.0	
Conc.	8.04	7.43	65.6	13:1
Blk. Tails	91.96	0.34	34.4	

- Amalgamation of Combined Concs. -

Feed → 7.43 Au oz/ton.
Amalgam Tails → 1.36 Au oz/ton = 43.95 %
recovery by amalgamation.

- Cyanidation of Blanket Tailing -

Agitation Hours	Assays Feed	Au oz/ton Tailing	Extraction Au %	Reagents consumed lbs/ton ore		Titration lbs/ton solution.	
				NaCN	CaO	NaCN	CaO
24	0.34	0.095	72.1	1.2	5.4	1.0	.10
48	0.34	0.09	73.5	1.4	5.5	0.9	.15

Summary Test No. 2.

Au extracted by cyanide grind	-	18.0 %
Au " by amalgamation	-	43.95%
Au " by agitation (48hrs)	-	20.70%
Overall extraction	-	82.65%
Au retained in Amalgam residue	-	9.8 %

A spectrographic analysis of the cyanide solution from 48 hours agitation resulted as follows:

Samples: Two samples of residues from cyanide solutions from Negus Sample No. 2.

Submitted by: J. McCree, Chemical Laboratory.

Requested: Determination of presence of Sb, and other elements.

Ref: Plate No. 387-H.

Agitation Hours	Assay Feed	Au oz/ton Tailing	Extraction Au %	Reagents Consumed		Titration lbs/ton solution	
				lbs/ton ore NaCN	CaO	NaCN	CaO
24	0.64	0.153	76.1	0.90	4.0	1.0	0.20

- Summary Test No. 3. -

Au extraction in cyanide grind	- 17.65 %.
Au " by amalgamation	- 40.55 %.
Au " by agitation	- 31.80 %.
Overall extraction of gold	- 90.00 %.

A portion of the cyanide residue was infrasized on the Haultain Infrasizer with the following results:-
The +200 mesh portion of the residue assayed 0.17 Au oz/ton and 1.66 % S.
The -200 mesh portion infrasized as follows:-

Size in Microns	Weight %	Assays		Distribution %	
		Au oz/ton	S %	Au	S
+56	2.53	0.58	22.65	10.3	19.6
56 to 40	19.20	0.17	3.24	22.8	21.2
40 to 28	15.51	0.19	4.40	20.6	23.3
28 to 20	11.24	0.185	2.89	14.5	11.1
20 to 14	9.70	0.145	2.41	9.8	8.0
14 to 10	8.05	0.14	1.68	7.9	4.6
- 10	<u>33.77</u>	<u>0.06</u>	<u>1.06</u>	<u>14.1</u>	<u>12.2</u>
Totals	100.00	0.143	2.92	100.00	100.00

Test No. 4.

on No. 2 Head .

In this test a Wilfley table was inserted in the grinding circuit. The pulp from the amalgam tails and blk. tails was passed over a Wilfley table and the table concentrate reground in cyanide to pass 99 % - 325 mesh. It was then added to the table tailings and divided into three portions prior to agitation. In #A 0.03 lbs of fuel oil was added. In #B the product was aerated in a lime pulp for 4 hours prior to agitation. In #C straight cyanidation was used. Otherwise the test followed the Negus flow-sheet. The primary grind was 62.0% - 200 mesh.

- Jig + Blanket Concentration -

Agitation Assay Au oz/ton Extraction Reagents Consumed lbs/ton solution
 Hours Feed Tailings Page 7. NaCN CaO NaOH CaO

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration.
Feed	100.00	0.91	100.00	0.20
Jig +Blk. Conc.	9.83	5.13	55.4	10:1
Blk. Tails	90.17	0.45	44.6	

After regrinding and amalgamating the combined concentrates an extraction of 34.3 % of the gold was shown by amalgamation.

- Table Concentration of Amalgam Tails + Blk. Tails -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration.
Feed	100.00	0.53	100.0	
Table Conc.	7.46	3.01	42.4	13.4:1
" Tails	92.54	0.33	57.6	

After regrinding the table concentrate in cyanide the residue was added to the table tailings. This product assayed 0.40 Au oz/ton.

- Cyanidation of Table Conc. + Table Tails.-

Test No.	Agitation Hours	Assays Au oz/ton		Extraction Au %	Reagents consumed lbs/ton ore		Remarks
		Feed	Tailing		NaCN	CaO	
A	24	0.40	0.08	80.0	1.2	6.8	0.03 lbs/ton Fuel oil added.
B	24	0.40	0.07	82.5	1.2	6.8	Aerated prior to agitation.
C	24	0.40	0.08	80.0	1.2	6.8	Straight cyanidation.

Summary
 Test No. 4

Au extraction in cyanide grind	-	18.0 %
Au " by amalgamation	-	34.3 %
Au " by secondary grind	-	11.7 %
Au " by agitation (C)	-	29.7 %
Overall extraction	-	93.7 %

Test No. 5

on No. 2 Head.

In this test the Negus flow-sheet was followed and in addition the cyanide tailings were concentrated by flotation and the flotation concentrate reground and agitated in cyanide solution. The primary grind was 69.6 % - 200. After amalgamation the amalgam residue was added to the blanket tailings. This product assayed 0.49 Au oz/ton giving an extraction of 55.9 % of the gold in the primary grind and amalgamation.

- Cyanidation of Amal. Tails + Blk. Tails -

Agitation Hours	Assays Feed	Au oz/ton Tailing	Extraction Au %	Reagents consumed	
				lbs/ton ore NaCN	CaO
24	0.49	0.12	75.8	0.9	5.8

- Flotation of Cyanide Residue -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration.
Feed	100.00	0.12	100.0	
Flot. Conc.	9.30	0.71	54.8	10.7:1
" Tailing	90.70	0.06	45.2	

Prior to flotation the pulp was conditioned for 15 minutes with 5 lbs of soda ash, 1.5 lbs of CuSO_4 and 0.04 lbs of Barrett #4 Oil per ton. A concentrate was obtained by the further addition of 0.10 lbs pine Oil per ton.

The flotation concentrate was washed and re-ground in cyanide solution of 3 lbs/ton strength to pass 99 % - 325 mesh.

- Agitation of reground Flotation Conc. -

Agitation Hours	Assays Feed	Au oz/ton Tailing	Extraction Au %	Reagents consumed		Titration	
				lbs/ton conc. NaCN	CaO	lbs/ton solution NaCN	CaO
24	0.71	0.26	63.4	8.0	14.6	2.7	0.15

Summary

Au extraction in primary Grind + Amalgamation - 55.9 %.
 Au " by agitation - 33.4 %.

Test No. 7

on No. 3 Head.

This test followed the Negus flow-sheet with the exception that the combined jig + blanket concentrates were not reground prior to amalgamation. After grinding in cyanide to 63.0 % minus 200 mesh the residue assayed 0.68 Au oz/ton, giving an extraction of 32.0 % of the gold in the primary grind.

- Jig + Blanket Concentration -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.00	0.68	100.0	
Jig + Blk. Conc.	8.63	3.75	47.6	11.6:1
Blk. Tails	91.37	0.39	52.4	

The combined Jig + Blanket Concentrates were amalgamated without regrinding. The amalgam residue + Blanket Tailings assayed 0.43 Au oz/ton = 85.0 % of amalgamation.

- Cyanidation of Amal. Tails + Blk. Tails -

Agitation Hours	Assays Au oz/ton Feed	Assays Au oz/ton Tailing	Extraction Au %	Reagents consumed		Titration lbs/ton solution	
				lbs/ton ore NaCN	CaO	NaCN	CaO
24	0.43	0.175	59.3	0.60	5.8	0.9	0.10

The pregnant solutions assayed 0.05 Cu and 0.00095 Ni gms/litre.

- Flotation of Cyanide Residue -

Product	Weight %	Assays Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.00	0.175	100.00	
Flot. Conc.	6.89	1.08	42.4	14.5:1
" Midds.	7.47	0.32	13.6	
" Tails.	85.64	0.09	44.0	

The reagents used were similar to test No. 6. The rougher flat conc. was cleaner in a smaller cell. The pH of the pulp was 9.6.

The flotation tails were passed over a blanket with the following results:-

Page 11.

- Blanket Concentration of Flot. Tails. -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.00	0.10*	100.0	
Blk.Conc.	4.01	0.80	32.4	25:1
Blk.Tailing	95.99	0.07	67.6	

* Calculated.

Summary Test No. 7

Au extracted in cyanide grind	-	32.0 %.
Au " by amalgamation	-	25.0 %.
Au " by agitation	-	25.5 %.
Overall extraction of gold	-	82.5 %.
Au recovered in Flotation + Blk. Concentrates.	-	11.3 %.

Test No. 8

on No. 4 Head.

In this test the flow-sheet of the Negus Mill was followed. The combined concentrates were re-ground prior to amalgamation. After grinding in cyanide to 76 % minus 200 mesh the residue assayed 0.12 Au oz/ton giving an extraction of 25.0 % of the gold in the primary grind.

- Jig + Table Concentration -

Product	Weight %	Assays Au oz/ton	Distribution Au %	Ratio Concentration.
Feed	100.00	0.12	100.0	
Jig + Blk. Conc.	9.45	0.36	28.3	10.5:1
Blk.Tails	90.55	0.095	71.7	

After regrinding and amalgamation, the combined concentrates + blanket tails. assayed 0.095 Au oz/ton = 34.4 % of Amalgamation.

-Cyanidation of Amal. Tails + Blk. Tails.-

Agitation Hours	Assays Au oz/ton Feed	Tailings	Extraction Au %	Reagents		Titration solution.	
				NaCN lbs/ton ore	CaO lbs/ton	NaCN	CaO
24	0.095	0.06	37.0	0.7	5.7	0.9	0.15

The pregnant solution assayed 0.03 Cu and 0.0065 Ni grms./litre.

Flotation of Cyanide Residue -

Product	Weight %	Assays Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.0	0.06	100.0	
Flot. Conc.	14.37	0.24	57.2	7:1
" Tailing	85.63	0.03	42.8	

The pulp was conditioned with 5 lbs of soda ash, 2.0 lbs of CuSO_4 and 0.07 lbs of Aerofloat # 25 per ton and floated with 0.05 lbs. # 301 reagent, 0.05 lbs of 208 reagent, and 0.10 lbs pine oil per ton. The pH of the pulp was 9.6.

- Blanket Concentration of Flotation Tails -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.00	0.034*		
Blk. Conc.	3.35	0.15	14.8	30:1
" Tails.	96.65	0.03	85.2	

*Calculated.

Summary Test No. 8

Au extracted by cyanide grind	- 25.0 %.
Au " by amalgamation	- 34.4 %.
Au " by agitation	- 22.0 %.
Overall extraction	- 81.4 %.

Gold recovered in Flotation + Blanket Concentrates - 11.7 %.

Test No. 9 on No. 3 Head.

In this test, the regular Negus flow-sheet was followed. In addition the cyanide residue was concentrated by flotation:

The cyanide grind was 70.2 % minus 200 mesh. After grinding the assay was 0.74 Au oz/ton giving an extraction of 36 % of the gold, in the grind.

- Jig + Blanket Concentration -

Product	Weight %	Assay Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.00	0.74	100.00	
Jig + Blk. Conc.	7.34	-	51.2	13.6:1
Blk. Tails	92.66	0.39	48.8	

The combined Jig + Blk. Conc. were reground and amalgamated. The amalgam residue + Blk. Tails assayed 0.43 Au oz/ton = 21.0 % extraction by amalgamation.

-Cyanidation of Amalgam residue + Blk. Tails -

This product was divided into two parts. In Part A 0.10 lbs Fuel Oil per ton were added. In Part B straight cyanidation.

Test No.	Agitation Hours	Assay Feed	Au oz/ton Tailing	Extraction Au %	Reagents consumed lbs/ton ore	Reducing power cc N/10KMnO ₄ / Litre.
A	24	0.43	0.14	67.4	1.1 NaCN 5.3 CaO	50
B	24	0.43	0.14	67.4	1.1 NaCN 5.3 CaO	50.

The cyanide residues from A and B were washed sampled and combined. The pulp was then transferred to a flotation machine and conditioned for 15 minutes with 5 lbs of Soda Ash, 1.5 lbs copper sulphate and 0.10 lbs of Aeroflot No 25 per ton. Further additions of 0.05 lbs of Reagent # 301, 0.05 lbs reagent # 208 and 0.10 lbs of pine oil per ton were added during flotation, which consumed 15 minutes. The resulting concentrate was cleaned in a smaller machine. The p. h. of the pulp was 9.1

-Flotation of Cyanide Residues -

Product	Weight %	Assays Au oz/ton	Distribution Au %	Ratio Concentration
Feed	100.00	0.16 *	100.0	
Flot. Conc.	5.03	1.14	36.1	19.9:1
" Midds	7.64	0.30	14.4	
" Tails	87.33	0.09	49.5	

Au extracted in cyanide grind	- 36.0 %.
Au " by amalgamation	- 21.0 %.
Au " by agitation	- 29.0 %.
Overall extraction	- 86.0 %.
Gold recovered in Flotation Conc.	- 5.8 %.

- Summary and Conclusions -

The test work on the present ore shipments generally followed quite closely the flow-sheet of the present Negus Mill. The ore was ground in cyanide, to different degrees of fineness and the pulp passed through a Denver gold jig with the jig overflow passing over blankets. The combined jig and blanket concentrates were reground and amalgamated. The amalgam residue was added to the blanket tailings and agitated in the cyanide grinding solution. In addition, flotation concentrations were made on several of the cyanide residues.

By this method cyanide residues of 0.10, 0.15, 0.14 and 0.95 Au oz/ton from sample lot Nos. 1, 2, 3, and 4 were obtained. The grinds were 87.4 %, 86.2 %, 70.2 % and 76 % minus 200 mesh.

On sample No. 2, when a Wilfley table was included in the grinding circuit and the resulting table concentrate reground in cyanide to 99 % - 325 mesh, and added to the table tailings prior to agitation, cyanide residues of 0.08 Au oz/ton were obtained as shown in test No. 4. Flotation concentration of the cyanide residue followed by regrinding and cyanidation of the resulting concentrates gave an additional extraction of 0.04 Au oz/ton in test No. 5 on Sample No. 2.

In the Infrasizer test on the cyanide residue it was only in the very finest particles, that there was any appreciable reduction in the residual gold. This result was confirmed by a superpanner test on the residue from No. 2 sample.

Assays of the pregnant solution disclosed that a comparatively large amount of Ni salt was present. The reducing power of the solutions was low and showed no fouling.

The test work on the present shipments showed no appreciable difference in the refractory character of ore from that of the previous report dated May 1940. The increase in the value of the cyanide residues and the consequent lowering of the Au extractions indicated that a larger percentage of the gold is in refractory sulphides. Concentration of these sulphides and fine grinding will reduce this amount somewhat, but a portion of the gold is so refractory that only concentration of the residue followed by roasting and cyanidation of the calcine will extract this remaining gold.