REPORT
of the
ORE DRESSING AND METALLURGICAL LABORATORIES
Report No. 326

The Recovery of Gold and Silver from the Ore of the Gem Lake Mine, East Central Manitoba.

By A. K. Anderson

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Shipments: 65 bags of ore, gross weight 5700 lb. were received at the Ore Testing Laboratories on April 11, 1929, from the Gem Lake Mine, East Central Manitoba, near the Manitoba-Ontario Boundary. The shipment was submitted by the Gem Lake Mines Ltd., 252 Fort Street, Winnipeg, Manitoba. Dr. Victor James of Wright, Boydell, James and Associates, 310 McKinnon Bldg., Toronto, is Consulting Engineer.

Characteristics of the Ore: The ore consisted of white and blue quartz carrying a low percentage of iron sulphides. Fine free gold was visible. Approximately 15% of the shipment was barren schist wall-rock.

Purpose of Experimental Tests: The shipment was made for the purpose of determing the assay value of the ore in gold and silver; whether any refractory minerals were present, and by test work, to find the most suitable metallurgical process to apply for the recovery of contained values.

Sampling & Analysis: The ore as received was crushed by Jaw Breakers and Rolls until all was reduced to 1/8". One-tenth of the total weight was cut out by an automatic sampler. This portion was then crushed to pass 10 mesh and passed through a Jones Riffle Sampler. The half portions were again cut. The quarter lots were then crushto -35 mesh and cut in half, then crushed to -65 mesh and cut twice. The resulting samples were then ground to -100 mesh, and samples prepared for the assay laboratory.

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The duplicate samples gave the following values:

Gold - 3.23 ozs per ton; 3.26 ozs/ton
Silver 0.35 " " " ; 0.35 " "

Arsenic, antimony, bismith and copper are absent.

Experimental Tests: Four classes of test work were undertaken. First, grinding in water and amalgamating with mercury: Second, grinding in cyanide solution and amalgamating, followed by cyanidation of the residues: Third, concentration by flotation followed by cyanidation of the residues, and Fourth, straight cyaniding at different sizes of grinding.

Amalgamation

Test No. 1

1000 grams of ore was ground to pass 48 mesh and amalgamated with 10% by weight of mercury.

	Assay Oz/ton	
+	Au	Ag
Heads	3.24	0.35
Amalgamation Tailing	1.22	0.19
% Recoveries	62.3%	45.7%

This shows that at 48 mesh, a high recovery of the gold and silver is not obtained.

Amalgamation and Cyanidation

Test No 2.

1000 grams of ore was ground in a porcelain mill containing iron balls with 1000 grams of Sodium cyanide solution equivalent in strength to 2.0 lb KCN per ton. Lime was added at the rate of 5.0 lb. per ton of ore. After grinding, the pulp was filtered and the solution retained for following cyanide agitation. The ore was then amalgamated and after removal of the amalgam was agitated for 48 hours in 2:1 dilution with the original cyanide solution retained after grinding. The strength of this was brought to 2.0 lb. KCN per ton by the addition of fresh sodium cyanide.

	Assay Oz/ton	
	Au	Ag
Heads	3.24	0.35
Tailing from Amalgamation	0.49	0.12

Recovery - Gold 84.9%; Silver 65.7%

Screen analysis of residue after grinding in cyanide solution and amalgamating.

Product	% Wt.	Assay Oz/ton		% Values	
		Au	Ag	Au	Ag
Tailing +150 mesh	4.9	0.68	0.12	6.8	4.9
" +200 mesh	15.8	0.56	0.12	18.2	15.8
-200 mesh	79.3	0.46	0.12	75.0	79.3
	100.0			100.0	100.0

Cyanidation of Amalgamation Tailing

	24 hr. Agitation				48 hr. Agitation			
	Assay Oz/t		% Recovery		Assay Oz/t		% Recovery	
	Au	Ag	Au		Au	Ag	Au	Ag
Heads = Amalgamation Tailing	0.49	0.12			0.49	0.12		
Cyanide Tailing	0.11	0.05	77.6	58.3	0.05	0.01	90.0	92.0
Recovery on original Feed							13.6	31.6

Strength of Solution at start of grinding KCN = 2.0 lb / ton
" " " " finish " " KCN = 1.5 " "
" " " " start of agitation KCN = 2.0 " "
" " " " finish KCN = 1.55 " "
CaO 1.2

Total Consumption KCN = 1.4 lb/ton ore
CaO 7.0 " " "

The tailing from the 48 hour cyanide test showed the following:

	% Wt.	Assay Oz/ ton	
		Au	Ag
+ 200 mesh	20.5	0.12	0.03
- 200 mesh	79.5	0.03	trace

	Au.	Ag.
Recovery by grinding in cyanide solution & Amalgamating	84.9%	65.7%
Recovery by cyaniding amalgamation tailing	13.6	31.6
Total Recovery	98.5%	97.3%

An examination of this test shows that grinding to 79% minus 200 mesh in cyanide solution and amalgamating, leaves a

residue containing 0.49 oz. gold and 0.12 oz. silver per ton. The 150 mesh portion of this assays 0.68 oz. and the -150+200 mesh part, 0.56 oz. gold.

These results confirm the conclusion arrived at from Test No. 1, a high recovery by amalgamation alone is not to be expected.

Cyanidation of the residue shows that high recovery can be obtained by this method.

Concentration and Cyanidation

Test No. 3.

1000 grams of the ore was ground in 1:1 pulp with water and soda ash equal to 6.0 lb. per ton of ore. Flotation was performed in a Ruth mechanically agitated machine. 0.2 lb. per ton Amyl Xanthate and Pine oil sufficient to froth were added to the cell. After removing a pyrite concentrate, the flotation tailing was passed over a small Wilfley table. A complete recovery of the sulphides by flotation was indicated, as no concentrate was secured by tabling.

The tabling from the table was cyanided for 24 and 48 hours. 2:1 dilution with cyanide solution equivalent in strength to 2.0 lb. KCN per ton. Lime was added at the rate of 5.0 lb. per ton of ore.

Flotation

Product	Wt.	Assay oz/ton: Au	Assay oz/ton: Ag	% Values: Au	% Values: Ag
Flotation Conc.	1.28	192.06	19.82	86.2	68.2
" Tailing	98.72	0.40	0.12	13.8	31.8

Cyanidation of Flotation Tailing

	24 hr. agitation				48 hr. agitation			
	Assay oz/t		% Recov'y		Assay oz/t		% Recovery	
	Au	Ag	Au	Ag	Au	Ag	Au	Ag
Heads = Flotation Tailing	0.40	0.12			0.40	0.12		
Cyanide Tailing	0.19	0.09	52.5	25.0	0.05	0.04	87.5	66.7
Recovery on Original Feed							12.1	21.2

	Au.	Ag.
Recovery by Flotation	86.2%	68.2%
Recovery by Cyanidation	12.1%	21.2%
Total Recovery	98.3%	89.4%

An analysis of the tailing from the 48 hr. cyanide test shows:

	% Wt.	Assay Oz/ton	
Tailing +200	18.5	0.11	0.08
Tailing -200	81.5	0.04	0.03

A high recovery of the values can be secured by this method. No tests were made on the very high grade concentrate which assays 192.06 oz. per ton. The residue after cyaniding the tailing from flotation again shows a marked difference between the +200 and -200 mesh portions. Fine grinding to secure maximum recoveries is indicated.

Cyanidation

Test No. 4

Ore ground to pass 48 mesh with 43% through 150 mesh was agitated with sodium cyanide solution (2.0 lb/ton KCN), 1:2 dilution for 24 and 48 hours. Lime was added at the rate of 5.0 lb. per ton of ore.

	24 hr. agitation					48 hr. agitation				
	% Wt.	Assay Oz/tn Au	Assay Oz/tn Ag	% Recov'y Au	% Recov'y Ag	% Wt.	Assay Oz/tn Au	Assay Oz/tn Ag	% Recovery Au	% Recovery Ag
Heads		3.24	0.35				3.24	0.35		
Tailing + 150 mesh	56.6	0.49	0.14			53.6	0.38	0.09		
Tailing - 150 mesh	43.4	0.15	0.03			46.4	0.11	0.02		
Average Tailing		0.34	0.09	89.5	74.3		0.25	0.06	92.3	82.8

	24 hrs.		48 hrs.	
	KCN	CaO	KCN	CaO
Solution at start lb/ton	2.0	-	2.0	-
" " finish " "	1.90	0.95	1.90	0.85
Consumption lb/ton ore	0.20	3.1	0.20	3.3

This test shows that with coarse grinding, 48 mesh, 92.3% of the gold and 82.5% of the silver is extracted in 48 hours agitation, with a cyanide consumption of 0.20 lb. per ton of ore.

Test No. 5.

The same procedure was followed in this test as in Test No.4, with the exception that the ore was ground to pass 100 mesh instead of 48 mesh.

	24 hr. agitation					48 hr. agitation				
	% Wt.	Assay oz/t Au	Assay oz/t Ag	% Recov'y Au	% Recov'y Ag	% Wt.	Assay oz/t Au	Assay oz/t Ag	% Recovery Au	% Recovery Ag
Heads		3.24	0.35				3.24	0.35		
Tailing +150 mesh	28.0	0.26	0.08			29.9	0.24	0.06		
Tailing -150 mesh	72.0	0.10	0.04			70.1	0.07	0.03		
Average Tailing		0.15	0.05	95.4	85.7		0.12	0.04	96.3	88.6

	24 hr. agita'n		48 hr. agitation	
	KCN	CaO	KCN	CaO
Solution at start lb/ton	2.0	-	2.0	-
" " finish " "	1.85	0.85	1.75	0.76
Consumption lb/ton ore	0.30	3.3	0.50	3.5

This test shows that with grinding minus 100 mesh, with 75% passing through 150 mesh, 96.3% of the gold and 88.6% of the silver is in solution within 42 hours. Cyanide consumption is 0.5 lb. per ton of ore.

Test No. 6.

This test was made with ore ground to pass 150 mesh. Other conditions were the same as in Tests 4 and 5.

	24 hr. agitation					48 hr. agitation				
	% Wt.	Assay oz/ton Au	Assay oz/ton Ag	% Recov'y Au	% Recov'y Ag	% Wt	Assay oz/ton Au	Assay oz/ton Ag	% Recovery Au	% Recovery Ag
Heads										
Tailing +200 mesh	14.0	0.16	0.04			17.2	0.12	0.06		
Tailing -200 mesh	86.0	0.05	0.02			82.8	0.05	0.03		
Average tailing		0.065	0.02	98.0	94.3		0.06	0.04	98.1	88.6

Details of cyanidation

	KCN	CaO
Solution at start	2.0	-
Solution at finish 48 hrs.	1.7	0.60
Consumption lb/ton ore	0.6	3.8

This test indicates that with fine grinding 86% - 200 mesh, an extraction of 98% of the gold and 94% of the silver is obtained within 24 hours. No advantage is gained by prolonging the time of agitation, as the minus 200 mesh portion of the two lots, agitated for 24 and 48 hours respectively show no difference.

The results of fine grinding and cyaniding is shown in a comparison of tests 4, 5 & 6.

Test No.	Mesh Grinding	Tailing Assay: Au	Tailing Assay: Ag	% Recovery: Au	% Recovery: Ag
4	- 48	0.25	0.06	92.3	82.8
5	-100	0.12	0.04	96.3	88.6
6	-150	0.06	0.04	98.1	88.6

The following tabulation shows the results obtained by the four different systems of test work employed.

Test No.		Tailing Assay		% Recovery	
		Au	Ag	Au	Ag
1	Grinding in water and amalgamating	1.22	0.19	62.3	45.7
2	Amalgamation and cyanidation	0.05	0.01	98.5	97.3
3	Concentration and cyanidation	0.05	0.04	98.3	89.4
4	All-cyanidation	0.06	0.04	98.1	88.6

In test 3, concentration by flotation followed by cyanidation of the flotation tailing, the recoveries recorded do not take into consideration the additional treatment necessary to recover the gold in the concentrate. As this product is worth over $1.90 a pound, it would not be practical to recover the gold by cyanidation, and would best be sold to a smelter. This would raise the total milling costs.

Fine grinding in cyanide solution to at least 80% through 200 mesh, followed by amalgamation and agitation gives the highest recovery 98.5% of the gold and 97.3% of the silver as against 98.1% and 88.6% respectively secured by all-cyanidation. Against this would be the extra cost of amalgamation and retorting of the amalgam, and the danger of loss by theft. The all-cyanide plant would have in it's favour a slightly lower operating cost due to the absence of amalgamation plates and of the higher class labour necessary to attend to them. Against this there would be a slight increase in refining charges, due to the greater bulk of precipitate produced.

It is recommended that amalgamation and cyanidation be adopted. Mills grinding the ore in cyanide solution to produce a classifier overflow at least 80% -200 mesh will give a product sufficiently fine. Amalgamation plates placed between the ball mill dischcarge and the classifier will catch much of the fine gold provided the dilution of the pulp is low.

The nature of the grinding circuit to be installed will depend largely on the tonnage treated. If low, single stage grinding would be sufficient. If high, double stage grinding with inter-

mediate classifiers will afford an efficient easily controlled installation.

Over a period of time the benefits, if any, derived from the presence of amalgamation plates can be established, and if found necessary, can be removed without effecting the flow sheet.

The classifier overflow, adjusted to the required fineness of grinding and pulp dilution should be given from 36-40 hours agitation to secure the highest recovery. Sufficient lime should be added to the grinding circuit to ensure operation of the thickeners following the agitation system. No advantage is to be gained by an excess. A cyanide solution of from 1-2 lbs. KCN per ton will be found to yield results.

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