DIVISION OF
ORE DRESSING AND
METALLURGY

DEPARTMENT OF MINES
CANADA

MINES BRANCH

O T T A W A December 28th, 1931.

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REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES

Report No.

Experimental Tests on Two Samples of Gold Ores from The Reno Gold Mines Ltd., Salmo, Nelson Mining Division, B. C.

By

J. S. Godard.

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Shipment:

A shipment weighing 85 pounds and consisting of equal weights of sulphide and oxidized ores was received December 2, 1931, from Mr. T. J. Mateer, Superintendent for The Reno Gold Mines Ltd.

Characteristics and Analyses of the Ores:

Both samples were high-grade gold ores.

In the sulphide ore about 58 percent of the gold is free and amalgamable at minus 65 mesh. The remainder is associated with the sulphides which constitute about 37 percent of the ore. The sulphides present in their quantitative order are pyrite, zincblende, galena, pyrrhotite, chalcopyrite and arsenopyrite. The gangue material is mainly quartz.

In the oxidized ore there is a considerable quantity of free gold in a coarser state than in the sulphide ore. Much of this free gold is of a rusty nature, which does not lend itself readily to plate amalgamation. The remainder of the gold appears to be associated with deeply oxidized sulphides, which resemble limonite in appearance. The gangue is a hard rusty-colored quartz.

The analyses of the two ores are as follows:

Ore	Au oz./t	Cu %	Pb %	Zn %	Fe %	S %	Insol %
Sulphide	3.25	0.06	3.30	6.05	11.64	13.47	58.16
Oxidized	5.58	0.15	0.48	0.84	6.83	0.41	86.02

Purpose of Experimental Tests:

During the present year a number of experimental tests were made on a sample of sulphide ore from The Reno Mine. Mr. Mateer, the present superintendent, requested that an additional test be made on this ore, as well as a series of tests on a composite sample consisting of 50:50 mixture of sulphide and oxidized ore. The present mill feed consists of ore in the proportion of 3 oxidized to 1 sulphide. As the proportion of oxidized to sulphide ore is gradually decreasing it was thought that with the information gained from two years'

milling of oxidized ore, the previous and present tests on sulphide ore and the present work on the composite sample that the field would be fairly well covered and that mill changes of a permanent nature might be undertaken.

-- Experimental Tests on Sulphide Ore --

Summary of Tests.

Amalgamation at -65 mesh, flotation of the amalgamation tailing and cyanidation of the flotation tailing gave a recovery of 97.6% of the gold. The total recovery was made up as follows: By amalgamation 55.1%; by flotation 40.3%; by cyanidation 2.2%.

Tests 1 - 2

Amalgamation, Flotation and Cyanidation of the Flotation Tailing.

Two tests of the above type were made on the sulphide ore. The ore in each test was dry crushed to -65 mesh before amalgamation. The amalgamation tailing was floated and the flotation tailing sampled and cyanided. In test #1 a smaller quantity of flotation concentrate was purposely removed than in test #2, where as much of the sulphides were floated as was possible.

Results -

Test #1 -

Concentration.

Product	Wt. %	Assays Au oz/t	% Value Au
Conc.	9.1	8.64	63.2
Tail.	90.9	0.503	36.8

Amalgamation tailing - Au 1.24 oz. ton.

The flotation concentrate assayed Ag 26.68 oz. ton,

Pb 37.34%, Zn 18.17%, Cu 0.36%.

A sample of the flotation tailing screened on 100 and 200 meshes:

Product	Wt. %	Assays Au oz/t	% Values Au
+ 100	28.0	0.58	52.0
+ 200	37.1	0.51	37.6
- 200	34.9	0.15	10.4

Average flotation tailing Au 0.503 oz/ton

Cyanidation of the Flotation Tailing.

The flotation tailing was cyanided for 30 hours in 2:1 pulp, KCN maximum 0.05%.

The cyanide tailing was screened on 100 and 200 meshes:

Product	Wt. %	Assays Au oz/t	% Values Au
+ 100	29.2	0.77	61.8
+ 200	34.4	0.30	28.3
- 200	36.4	0.10	9.9

Average cyanide tailing Au 0.364 oz/ton

Heads to cyanidation, flotation tailing Au 0.503 oz/ton

Extraction 27.6%

Test No. 2

Results:

Concentration

Product	Wt. %	Assays Au oz/t	% Value Au
Conc.	35.9	3.64	89.8
Tail	64.1	0.233	10.2

Amalgamation tailing Au 1.46 oz/ton

The flotation concentrate assayed Pb 8.74%, Zn 30.57%, Fe 19.23%.

A sample of the flotation tailing was screened on 100 and 200 meshes.

Product	Wt. %	Assays Au oz/ton	% Value Au
+ 100	21.9	0.52	48.9
+ 200	41.7	0.18	32.2
- 200	36.4	0.12	18.9

Average flotation tailing Au 0.233 oz/ton

Cyanidation of the Flotation Tailing

The details of this part of the test were similar to those in the corresponding part in test No. 1.

The cyanide tailing was screened on 100 and 200 meshes.

Product	Wt. %	Assays Au oz/ton	% Value Au
+ 100	30.6	0.26	65.0
+ 200	37.9	0.08	24.4
- 200	31.5	0.04	10.6

Average cyanide tailing Au 0.123 oz/ton

Heads to cyanidation, flotation tailing - Au 0.233 oz/ton

Extraction 47.2%.

Summary - Tests I and 2.

No	Tails - Au oz/ton			Recovery % Total Au				Ratio of Conc.	Reagents Cons'd	
	Amal.	Flot.	Cyan.	Amal.	Flot.	Cyan.	Total		KCN	CaO
1	1.24	0.503	0.364	61.9	24.1	3.9	89.9	11.0:1	4.06	8.04
2	1.46	0.233	0.123	55.1	40.3	2.2	97.6	2.8:1	2.67	6.90

Conclusions:

I Sulphide Ore:

The test-work on this ore may be considered as complementary to that done previously during the present year and these tests are chiefly concerned with the cyani-

dation of the flotation tailing.

The results of the test work, test 2, show that 3.9% of the total gold in the head sample was recovered by cyanidation of the flotation tailing. On a head sample assaying gold 3.25 oz/ton such a step would prove profitable as the operation could be carried out well within the economic limit of 3.9% of 3.25 ounces of gold per ton of ore, roughly $2.50, but we are not in a position to state just where the line of profitable operation would be.

Under the circumstances it is almost essential that the flotation concentrates be treated at the property and that cyanidation appears to be the most practical method of treatment. As it is proposed to cyanide both the flotation concentrates and the tailings we are under the impression the injection of flotation into the flowsheet would be superfluous, or that the introduction of flotation should only be attempted if it alone or followed by table concentration be sufficient to reduce the gold content of the ore to such a point as to permit the discarding of a final tailing at the same time securing a ratio of concentration of at least 2.5:1.

Experimental Tests on Composite Sample:

For the following tests the sulphide and oxidized ores were mixed in equal proportions to make the composite sample which assayed, gold 4.52 oz/ton.

Summary of Results:

By amalgamation and cyanidation of the amalgamation tailing a recovery of 96.9% of the gold was obtained.

By amalgamation, flotation and tabling the flotation tailing 97% of the gold was recovered. The ratio of concentration was 2.5:1.

By amalgamation, flotation and cyanidation of the flotation tailing a total recovery of 96.6% of the gold was made.

Cyanidation of the reground flotation concentrate extracted 98.3% of the gold.

Amalgamation - Cyanidation of the Amalgamation Tailing:

In this test the ore was dry crushed -65 mesh before amalgamation. The amalgamation tailing was sampled and then cyanided in two parts, A - B. In part A, the amalgamation tailing was cyanided direct. In part B, the amalgamation tailing was reground before agitation.

Results:

The amalgamation tailing was screened on 100 and 200 meshes.

Mesh	Wt. %	Assays Au oz/ton	% Values Au
+ 100	25.5	2.76	43.8
+ 200	29.6	1.61	29.7
- 200	44.9	0.95	26.5

Amalgamation tailing Au 1.61 oz/ton

In addition to the gold in the amalgamation tailing there was rusty gold equivalent to 0.42 oz/ton that would not amalgamate. This brings the amalgamation tailing to 2.03 oz/ton.

Recovery by amalgamation 55.1%.

Cyanidation of the Amalgamation Tailing:

Part A. The amalgamation tailing was cyanided for 46 hours in 2.5:1 pulp, KCN maximum 0.075%. The cyanide tailing was screened on 100 and 200 meshes.

Mesh	Wt. %	Assays Au oz/ton	% Value Au
+100	27.2	0.23	34.2
+200	29.7	0.16	25.9
- 200	43.1	0.17	39.9

Average cyanide tailing - Au 0.183 oz/ton

Head sample to cyanidation, amalgamation tailing, Au 1.61 oz/ton. Extraction 88.7%.

Part B.

The amalgamation tailing was reground in cyanide solution, KCN 0.05%, then diluted to 2.5:1 before agitation, KCN strength maximum during agitation was 0.075% and the time was 45 hours.

The cyanide tailing was screened on 200 mesh.

Mesh	Wt. %	Assays Au oz/ton	% Value Au
+200	18.6	0.14	24.2
- 200	81.4	0.10	75.8

Average cyanide tailing Au 0.11 oz/ton

Head sample to cyanidation, amalgamation tailing Au 1.61 oz/ton. Extraction 93.2%.

Summary Test I

Head Sample Au 4.52 oz/ton

Test No.	Recovery % Total Au			Reagents cons'd #/ton	
	Amal	Cyan	Total	KCN	CaO
1 - A	55.1	39.8	94.9	3.39	8.3
1 - B	55.1	41.8	96.9	3.87	10.7

Test 2.

Amalgamation, Flotation, Tabling the Flotation Tailing:

A sample of the ore, dry crushed to pass 65 mesh was amalgamated. The amalgamation tailing was floated and the flotation tailing tabled. The rusty gold that did not amalgamate was united with the table concentrate. The table tailing was screened on 100 and 200 meshes.

Results:

Product	Wt. %	Assays Au oz/ton	% Value Au
Flotation Conc.	24.8	4.08	52.7
Table Concentrate	15.5	4.96	40.1
Table Tail + 100	15.1	0.30	2.4
" " + 200	16.7	0.19	1.6
" " - 200	13.9	0.17	1.2
" Slimes	14.0	0.27	2.0

The flotation concentrate assayed Ag 7.36 oz/ton, and the table concentrate assayed Ag 2.48 oz/ton.

The amalgamation tailing assayed Au 1.92 oz/ton.

Summary of Test:

Head sample Au 4.52 oz/ton
Recovery by amalgamation 57.6%
Recovery by concentration = 92.8 X 42.4 = 39.4%
Total Recovery Au = 97.0%

Test No. 3

Amalgamation, Flotation and Cyanidation of the Flotation Tailing:

A sample of the ore, dry crushed to pass 65 mesh, was amalgamated, the amalgamation tailing was floated and the flotation tailing was sampled. The remainder of the flotation tailing divided into two parts and each part was cyanided. In part A the flotation tailing was cyanided without regrinding. In part B the flotation tailing was reground before agitation.

Results:

Flotation of the Amalgamation Tailing:

Product	Wt. %	Assays Au oz/ton	% Value Au
Conc.	20.6	7.28	71.8
Tail.	79.4	0.74	28.2

Amalgamation tailing from products Au 2.09 oz/ton

Recovery by amalgamation 53.7%.

Rusty gold amounting to 0.44 oz/ton that did not amalgamate was removed at this stage. When this is added to the amalgamation tailing, the assay value is Au 2.53 oz/ton, and the recovery is 44.1%.

A sample of the flotation tailing was screened on 100 and 200 meshes.

Results:

Mesh	Wt. %	Assays Au oz/ton	% Value Au
+ 100	22.0	1.84	54.4
+ 200	32.8	0.51	22.5
- 200	45.2	0.38	23.1

Average assay of flotation tailing Au 0.74 oz/ton

The recovery of the gold to this stage is:

By amalgamation	44.1%
By flotation 71.8 X 55.9 =	40.1%
Total	84.2%

Cyanidation of the Flotation Tailing:

In parts A and B the dilution during agitation was 2:1 and the cyanide strength was KCN, maximum, 0.05% and the time was 29 hours in part A, 42 hours in part B.

Results - Part A.

The cyanide tailing was screened on 100 - 200 meshes:

Mesh	Wt. %	Assays Au oz/ton	% Value Au
+ 100	31.8	0.54	64.4
+ 200	31.0	0.15	17.4
- 200	37.2	0.13	18.2

Average assay of cyanide tailing - Au 0.27 oz/ton

Part B.

The flotation tailing was reground in cyanide solution KCN 0.050% before agitation.

The cyanide tailing was screened on 200 mesh.

Product	Wt. %	Assays Au oz/ton	% Value Au
+ 200	25.1	0.40	64.1
- 200	74.9	0.075	35.9

Average assay of cyanide tailing Au 0.157 oz/ton

Summary Test No. 3:

Head sample	Au oz/t	4.52	4.52
Recovery amalgamation and flotation	%	84.1	84.1
Head to cyanidation	Au oz/t	0.74	0.74
Cyanidation tails	" " "	0.27	0.157
Extraction % of gold in flotation tailing		63.5	78.7
Extraction % of total gold		10.1	12.5
Total recovery		94.2	96.6
KCN consumed #/ton		1.37	1.89
CaO consumed #/ton		4.7	8.3

Test No. 4:

Amalgamation, Flotation of the Amalgamation Tailing and Cyanidation of the Flotation Concentrates:

Because of the high freight and smelter charges, amounting to $22. - $26. per ton of concentrates it is almost essential, that any concentrates that may be obtained either by flotation or tabling, be treated at the mine.

This test was made at the request of Mr. Mateer, for the purpose of obtaining some information on the behaviour of the flotation concentrates from the amalgamation tailing, when subjected to cyanidation.

A quantity of the composite sample was dry crushed to -65 mesh, then amalgamated. The amalgamation tailing was floated in batch lots and the flotation concentrates were combined. Two samples of the concentrate were cyanided. In part A the concentrate was cyanided direct, in part B, it was reground in cyanide solution before agitation.

As in all previous tests on the composite sample, a quantity of rusty gold that would not amalgamate was removed before flotation.

The flotation concentrate, head sample to cyanidation, assayed - Au 4.92 oz/t, Ag 8.00 oz/ton, Pb 6.55%, Zn 22.83%, Fe 19.38%, and Cu 0.21%.

The ratio of concentration was 46:1.

Cyanidation of Flotation Concentrate.

Part A.

The concentrates were agitated for 48 hours in 3:1 pulp, KCN maximum 0.20%. The cyanide tailing was repulped and screened on 100 and 200 meshes.

Results:

Cyanide tailing screened on 100 - 200 meshes:

Mesh	Wt. %	Assays Au oz/ton	% Value Au
+ 100	14.2	*6.66	69.9
+ 200	25.0	0.92	17.0
- 200	60.8	0.29	13.1

* Evidently free gold.

Average cyanide tailing - Au 1.35 oz/ton.

Part B.

The concentrates were reground in 1:1 pulp, KCN 0.10%, then diluted to 3:1 before agitation. The KCN strength (max) was 0.10%, and the time was 67 hours.

Results:

Cyanide tailing screened on 200 mesh:

Mesh	Wt. %	Assays Au oz/ton	% Value Au
+ 200	3.9	0.09	4.4
- 200	96.1	0.08	95.6

Average cyanide tailing - Au 0.08 oz/ton

Summary Test No. 4.

Head sample to cyanidation - Au 4.92 oz/ton

Test No.	Tail Au oz/ton	Extrac'n %	Reagents consumed in #/ton of Conc. KCN	CaO	#/ton of ore KCN	CaO
4 - A	1.35	72.4	9.5	19.3	2.06	4.2
4 - B	0.08	98.3	13.0	28.2	2.82	6.1

Composite Sample:

Conclusions:

Grinding: We are under the impression that for good metallurgical results on this sample the ore should be ground to minus 100 mesh with 70 percent minus 200 mesh, and that two stage grinding with classification should be practised.

Amalgamation: Due to uneven distribution of the rusty gold liberated from the oxidized ore portion of the sample some difficulty was experienced in getting good check results. The average of those obtained should closely approximate those obtainable at the size indicated in actual practise using plate amalgamation.

Plate amalgamation using a number of short plates is suggested rather than blanket amalgamation because of the quantity of sulphides present which would tend to fill the pores with sulphides. A fairly steepslope to the plates would keep the sulphides in motion.

Flotation: Flotation tests on the amalgamation tailings showed the ore to divide itself into two natural selections. For the first part of the flotation the following

reagents were used: Na_2CO_3 2.0 oz/ton, water gas tar A 0.20 lb/ton, Na_2S 0.40 lb/ton, amyl xanthate 0.03 lb/ton and Risor pine oil 0.08 lb/ton. On the completion of this float, the addition of $CuSO_4$ 0.30 lb/ton and amyl xanthate 0.06 lb/ton raised additional sulphides which were mainly zincblende, pyrite and pyrrhotite. The addition of $CuSO_4$ in the presence of xanthate made the cell more difficult to froth, requiring an additional 0.12 lb/ton of Risor pine oil. Should flotation be introduced on this ore and air cells be chosen it is suggested that the flotation be done in two stages with a contact tank between stages for the mixing of the second group of reagents. While the quantity of sulphides removed in the second stage is less than in the first, the sulphides are slower to respond and hence the stages should be of equal capacity. With mechanical cells a 25 - 50% over capacity for the tonnages and quantity of sulphides is suggested. In this type of machine the second group of reagents could be added about half way down the series.

Cyanidation: Cyanidation is effective one the free coarser gold is removed. The concentrates cyanide quite readily after regrinding. The reagents consumption is fairly high but might possibly be cut down by shortening the time. Agitation using a plentiful supply of air would probably save cyanide at the expense of lime, by oxidizing some of the soluable sulphides to the sulphate state.

Generally there appears to be two methods of treating such an ore as this one, namely; two stage grinding in cyanide solution with blanket amalgamation and cyanidation of

the amalgamation tailing. If single stage grinding should be practised it is suggested that an agitation period of 12 hours should precede the thickening operation. The second method is plate amalgamation followed by flotation and tabling the flotation tailing. This latter operation will catch the rusty gold and the oxidized gold bearing sulphides. The table concentrate could be treated in a pan amalgamator with mercury and cyanide. The cyanide solution and the sulphide-oxide material could then be passed to the cyanide circuit for treatment with the flotation concentrates.

The extremely high gold content of the composite sample and the great differences in the nature of the two ores that constitute the sample makes the metallurgy, at best, somewhat complicated.