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O T T A W A June 28th, 1940.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 862.

Gold Ore from the Santa Fe Gold Mines Limited,
Mine Centre, Rainy River Area,
Northwestern Ontario.

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Shipment:

A shipment of 3 bags of gold ore, gross weight 270 pounds, was received on May 29th, 1940, from George Stager, Mine Centre, Ontario. The shipment was submitted at the instructions of F. M. Little, Santa Fe Gold Mines Limited, 38 King Street West, Toronto, Ontario.

Location of the Property:

The property of the Santa Fe Mines Limited is located six miles south of Mine Centre, in the Rainy river area of northwestern Ontario. Part of the property formerly was owned by the British Canadian Mines Limited.

Purpose of the Investigation:

The shipment was made to determine a method of milling the ore.

Characteristics of the Ore:

Six polished sections were prepared and examined microscopically for the purpose of determining the character of the ore.

Gangue -

The gangue consists essentially of translucent white quartz which is crossed by narrow sinuous cracks and bears local light-brown stains of iron oxides, especially along fractures.

Metallic Minerals -

Sulphides form more than 50 per cent of the mineral content of the sections and are very intimately admixed. In their approximate order of abundance, the metallic minerals present are: pyrite, pyrrhotite, sphalerite, galena, chalcopyrite, native gold, bornite, chalcocite, and covellite.

Pyrite preponderates largely as small masses and coarse disseminated grains; both forms contain veinlets and inclusions of gangue, chalcopyrite, sphalerite and galena. The bulk of the pyrrhotite occurs in one

section as a medium coarse granular mass, which encloses grains of pyrite, chalcopyrite, sphalerite, galena and gangue. A small percentage of this mineral is present also as disseminated grains mixed with the other sulphides. Sphalerite and galena, which are often associated, are visible largely as small masses and irregular grains unevenly disseminated throughout gangue; a small proportion of these two minerals occurs also as discontinuous stringers along sinuous cracks in quartz as well as veinlets and inclusions in pyrite and pyrrhotite. Most of the chalcopyrite is distributed with the other metallics as coarse to fine irregular grains in gangue. As already mentioned, however, some of this mineral occurs as tiny inclusions in other sulphides, particularly within sphalerite. Practically negligible amounts of bornite, chalcocite and covellite are visible as rare tiny scales and narrow margins in and around chalcopyrite.

Ten grains of native gold, ranging from 400 microns down to 24 microns in size, were observed in the sections. These were well scattered but were definitely associated with the sulphides, particularly with sphalerite and galena. It must be remembered, however, that this information is deduced from the small number of grains cut by the sections and may not be truly representative of the ore as a whole.

Sampling and Analysis:

The shipment was crushed and sampled by standard methods and was found to contain:

Gold	- 0.44	oz./ton
Silver	- 0.75	"
Copper	- 0.16	per cent
Lead	- 0.35	"
Zinc	- 1.27	"
Iron	- 3.96	"
Sulphur	- 3.28	"
Arsenic	- 0.02	"
Insoluble	- 88.46	"

Investigative Procedure and Results:

The ore was treated by concentration by jigs and flotation followed by amalgamation of the jig concentrate and cyanidation of the jig tailings. A jig tailing was cyanided for different periods of time.

58.6 per cent of the gold was recovered by jigging and amalgamating the jig concentrate, and an additional 40 per cent recovery was obtained by cyaniding the jig tailing. The overall recovery was 98.6 per cent of the gold within 72 hours' agitation, with a final tailing of 0.005 ounce gold per ton.

Due to the presence of copper in the ore the consumption of cyanide was high, the solution containing copper and nickel.

Straight flotation recovered 81 per cent of the gold. Coarse free gold was found in the tailing. An additional 16.9 per cent was recovered by jigging this flotation tailing.

Jigging followed by flotation gave a tailing of 0.01 ounce gold per ton at a grind of 70 per cent minus 200 mesh. The ratio of concentration of the

combined concentrates was 9.5:1. The combined concentrate contained 4.15 ounces gold per ton.

DETAILS OF THE TESTS:

Test No. 1. - Concentration by Jig followed by Cyanidation of the Jig Tailing and Amalgamated Residue.

A sample of the ore was ground in water at a dilution of 4 parts solids to 3 parts of water to give a product 73 per cent minus 200 mesh. The ground pulp was then jigged in a Denver Laboratory Mineral Jig. The jig concentrate was barrel-amalgamated. The mercury and amalgam was separated and assayed. The amalgamated residue was returned to the jig tailing which was then filtered and sampled.

Samples of the jig tailings were then repulped in cyanide solution at a dilution of 1 part solids to 2 parts of solution containing 1.0 pound NaCN per ton and agitated for periods of 24, 48, and 72 hours. The cyanide tailings were sampled and assayed.

Results:

Jig Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.44	100.0	
Jig concentrate	0.22	131.97	66.0	455:1.
Jig tailing	99.78	0.15	34.0	

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(Test No. 1, cont'd) -

Amalgamation of Jig Concentrate.

Gold recovered in jig concentrate - 131.97 oz./ton
" " " amalgam - 117.19 "
" left in amalgamated residue - 14.78 "

Extraction of gold = $\frac{117.19}{131.97}$ X 100 = 88.8 per cent.

Gold remaining in the amalgamated residue = 11.2 per cent.

Gold extracted from the jig concentrate,
66.0 X 0.8880 = 58.6 per cent
Gold remaining in the jig concentrate,
66.0 X 0.1120 = 7.4 "
66.0 per cent.

Cyanidation of the Jig Tailing and Amalgamated Residue.

Test No.	Agitation, hours	Assays, Au oz./ton: Feed	Tailing	Extraction of gold, per cent	Final titration, lb./ton solution: NaCN	CaO	Reagents consumed, lb./ton ore: NaCN	CaO	Reducing power of sol'n, ml. N/10 $KMnO_4$ per litre
1-A	24	0.15	0.015	90.0	0.7	0.3	3.6	4.5	416.0
1-B	48	0.15	0.01	93.3	0.9	0.3	4.3	4.6	490.0
1-C	72	0.15	0.005	96.7	0.9	0.25	4.9	4.7	475.0

Summary of Test No. 1:

	Per cent
Recovery by amalgamation -	58.6
Gold remaining in cyanide feed, 34 + 7.4 -	41.4

The maximum extraction was obtained within 72 hours and was 96.7 X 0.414 = 40.0 + 58.6 = 98.6 per cent.

The solutions from the three tests were combined and show the following analysis:

Reducing power - 487 ml. N/10 $KMnO_4$ per litre.
NaCNS - 0.56 gram per litre.
Copper in solution - 0.19 " " "
Nickel " " - 0.003 " " "

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Test No. 2. - Straight Flotation followed by Jigging the Flotation Tailing and Cyaniding the Jig Tailing.

A sample of ore was ground to 60 per cent minus 200 mesh with 2.0 pounds soda ash per ton. The pulp was transferred to a flotation machine and conditioned for 10 minutes with 0.2 pound of potassium amyl xanthate per ton, and after adding 0.05 pound of pine oil per ton and removing the resulting concentrate a further addition of reagents was made. The pulp was conditioned with 1.0 pound of copper sulphate and 0.1 pound of amyl xanthate per ton. After adding 0.05 pound of pine oil per ton, an additional amount of concentrate was removed.

The flotation tailing was examined for free gold by passing it through a Denver Laboratory Mineral Jig and examining the jig concentrate. This concentrate contained coarse particles of gold and was assayed.

The jig tailing was further treated by repulping a sample of it in cyanide solution, dilution 1 to 1.5, in a 1.0 pound NaCN per ton solution and agitating it for 24 hours.

Results:

Flotation.

Product	Weight, per cent	Assays, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.44	100.0	
Concentrate	9.77	3.55	81.1	1:10.2
Tailing	90.23	0.09	18.9	

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(Test No. 2, cont'd) -

Results, cont'd -

Jig Concentration of the Flotation Tailing.

Product	Weight, per cent In test	Weight, per cent In feed	Assays, Au oz./ton	Distribution of gold, per cent In test	Distribution of gold, per cent In feed	Ratio of concentration
Feed	100.00	90.23	0.09	100.0	18.9	
Concentrate	0.29	0.26	29.17	89.4	16.9	1:347.
Tailing	99.71	89.97	0.01	10.6	2.0	

Cyanidation of the Jig Tailing.

Agitation, hours	Assays, Au oz./ton Feed	Assays, Au oz./ton Tailing	Extraction of gold, per cent	Final titration; lb./ton solution NaCN	Final titration; lb./ton solution CaO	Reagents consumed, lb./ton ore NaCN	Reagents consumed, lb./ton ore CaO	Reducing power of solution, ml. N/10 $KMnO_4$ per litre
24	0.01	0.005	50.0	0.72	0.08	1.20	3.6	94.0

Summary of Test No. 2:

	Per cent
Gold recovered in the flotation concentrate -	81.1
" " " " jig concentrate -	16.9
" " " cyanidation of jig tailing -	1.0
	99.0
Gold remaining in cyanide tailing -	1.0
Total --	100.0

Analysis of the flotation concentrate:

Gold	- 3.55 oz./ton
Silver	- 8.50 "
Copper	- 1.59 per cent
Lead	- 4.79 "
Zinc	- 15.56 "
Arsenic	- 0.15 "

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Test No. 3. - Jigging followed by Flotation.

A sample of ore was ground 70 per cent minus 200 mesh and jigged in a Denver Laboratory Mineral Jig. The jig concentrate was barrel-amalgamated. The amalgamated residue was added to the flotation concentrate.

The jig tailing was floated by conditioning the pulp in a flotation machine for 15 minutes with 2.0 pounds of soda ash per ton. Amyl xanthate, 0.2 pound per ton, was then added and given 5 minutes' contact. After adding 0.05 pound of pine oil per ton, a concentrate was removed. The pulp was further conditioned by adding 1.0 pound of copper sulphate and 0.1 pound of amyl xanthate per ton. After adding 0.05 pound of pine oil per ton an additional amount of concentrate was removed and added to the first concentrate obtained.

Results:

Jig Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.44	100.0	
Jig concentrate	0.26	127.03	75.1	1:385
Jig tailing	99.74	0.11	24.9	

Amalgamation of the Jig Concentrate.

Gold recovered in the concentrate = 127.03 oz./ton
" " " " amalgam = 105.22 "
" remaining in the amalgam residue = 21.81 "

Recovery of gold, $\frac{105.22}{127.03} \times 100$ = 82.8 per cent, or 62.2 per cent of jig feed.

Gold remaining in the residue = 17.2 per cent, or 12.9 per cent of jig feed.

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(Test No. 3, cont'd) -

Results, cont'd -

Flotation of the Jig Tailing.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent: In test	In feed	Ratio of concentration
Feed	100.00	0.11	100.00	24.9	
Flot. conc. + amalgamated residue	10.23	1.03	92.14	23.0	1:9.8
Flot. tailing	89.77	0.01	7.86	1.9	

Summary of Test No. 3:

	Per cent
Recovery of gold by jigging - 75.1 per cent.	
Recovery of gold as amalgam	62.2
" " " in amalgam residue in flot. conc.	12.9
" " " in flotation concentrate	23.0
	98.1
Gold remaining in flotation tailing	1.9
Total --	100.0

Analysis of the Flotation Concentrate:

Gold	1.03 oz./ton
Silver	6.74 "
Copper	1.60 per cent
Lead	5.64 "
Zinc	16.66 "
Nickel	Trace.

Shipping Grade of Concentrate, in gold -

From 100 tons of mill feed,

0.26	tons of jig concentrate @	127.03	oz./ton
10.23	" " flot. concentrate @	1.03	"
10.49	" " combined concentrate @	4.15	"

By amalgamation of the jig concentrate ship 0.26 X 127.03 X 0.8283 = 27.36 ounces gold as bullion.

Ship residue, from 100 tons of mill feed,

0.26	tons of jig concentrate amalgamation residue @	21.81	oz./ton
10.23	" " flotation concentrate @	1.03	"
10.49	" " combined concentrate @	1.54	"

Ratio of concentration = 1:9.5.

Summary:

The investigation shows that part of the gold is coarse and that 75 per cent of it can be recovered by jigging at a grind of 70 per cent minus 200 mesh.

Approximately 89 per cent of the gold in the jig concentrate was recovered by barrel-amalgamation.

Cyanidation of the amalgamated residue and jig tailing gave a minimum tailing of 0.005 ounce gold per ton within 72 hours of agitation, with an overall recovery of 98.6 per cent of the gold.

Flotation of a jigged feed gave a tailing of 0.01 ounce of gold per ton. Sixty-two per cent of the gold was recovered as bullion and 92 per cent of the remaining gold reported in a concentrate assaying 1.03 ounces gold per ton and containing 6.74 ounces of silver per ton as well as copper, lead, and zinc. Only a trace of nickel was found in this concentrate.

Conclusions:

The results obtained from these preliminary tests indicate several methods of treatment which are applicable to treatment of the ore as represented by the sample under investigation.

For a small daily tonnage, concentration by jigs, followed by a further concentration by tables or by blanket strakes with barrel amalgamation of the resulting concentrates, will recover a fair quantity

of the gold as bullion. The amalgamation residues could be sold to a smelter.

Jigging followed by flotation effects a high recovery of the values. The installation of flotation cells constitutes a more elaborate flow-sheet than the preceding simpler system. The resulting concentrates could be amalgamated or shipped to a smelter.

The flotation concentrates contain appreciable quantities of copper, lead, and zinc. For this reason, cyanidation of a flotation concentrate would not be practical, due to excessive reagent consumption and fouled solutions.

Cyanidation, with removal of coarse gold by jigs, yields a recovery of over 98 per cent. Cyanide consumption is high and a large part of the solutions would require to be discarded daily.

Removal of a high-grade copper-lead concentrate by flotation followed by cyanidation of the flotation tailing would reduce the consumption of cyanide. This would require an elaborate plant.

The gold in this sample is readily soluble in cyanide and also is readily recovered by concentration.

The choice of methods depends largely on the size of ore body, the daily tonnage to be milled, and the capital expenditure anticipated.

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