O T T A W A January 16th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1149.

Concentration and Amalgamation of a Gold Ore
from the Orelia Property of the Goldorel
Mining Company Limited,
Mine Centre, Ontario.

(Copy No. 23.)

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:

Six bags of ore, total weight 388 pounds, were received on October 24th, 1941, from Mr. W. McG. Brown, President, Goldorel Mining Company Limited, 21 King Street East, Toronto, Ontario.

Previous shipments of mill tailing and ore from this property had been received on June 7th, 1937, March 8th, 1938, and June 27th, 1938, and were reported on in those years.

Location of the Property:

The Orelia property of the Goldorel Mining Company Limited, from which the present shipment was received, is located on the south shore of Vermillion Lake, Rainy River district, Fort Frances mining division, northwestern Ontario, and is 2½ miles from Mine Centre station.

Sampling and Analysis:

After crushing, cutting and grinding by standard methods, a representative sample of the shipment was obtained which assayed as follows:

Gold	-	2.50 oz./ton.
Silver	-	1.53 "
Sulphur	-	0.59 per cent.
Iron	-	3.02 "
Copper	-	0.43 "
Lead	-	0.50 "
Arsenic	-	Trace.
Acid insoluble	-	88.8 per cent.

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 of milky-white vein quartz with small, sparse patches of fine-grained carbonate. It is transected by narrow sinuous fractures and bears numerous, local, brown, green and blue stains of iron and copper, evidence that the sample has undergone rather severe weathering.

Metallic Minerals -

Metallic minerals are only moderately abundant and many of them appear to be of supergene origin. Chalcocite predominates, largely as small, fine-textured masses containing numerous inclusions of gangue and most of the other metallics. Chalcopyrite, the next most abundant metallic mineral, occurs as small masses and coarse to fine grains, usually in

(Characteristics of the Ore, cont'd) -

chalcocite but also in gangue. Pyrite is locally common as medium to small scattered grains in gangue, some of which show signs of replacement by chalcocite and "limonite" around edges and along fractures. The latter mineral is also prevalent as small grains and irregular veinlets in the other sulphides and as stains in gangue. Covellite is common in one section as small grains in chalcocite, and a negligible amount of bornite is present in the same manner. As already suggested under "Gangue", malachite and azurite are visible as deep green and blue stains in gangue.

Despite careful inspection of the six polished surfaces under both low and high powers of magnificiation, only two small particles of native gold were observed in the sections. Each is 16 microns (-800+1100 Tyler mesh) in size and occurs alone in quartz.

Characteristics of the Mill Products:

The flotation and table concentrates from Test No. 2 were submitted to determine, if possible, the association of the gold. For this purpose two polished sections were prepared and examined under the reflecting microscope.

General Description -

The sections consist of irregular particles of pyrite, chalcocite, chalcopyrite, covellite, "limonite", gangue, galena, bornite, pyrrhotite, and native gold embedded in the mounting medium (bakelite). These particles range from about 200 microns (-65+100 Tyler mesh) down to a few microns (-2300 Tyler mesh) in size and most of them are free and unattached. Some grains, however, are combined

(Characteristics of the Mill Products, cont'd) -

with each other, as for example chalcocite and covellite, and some are attached to or enclosed in particles of gangue. As named above the minerals are arranged in their approximate order of abundance.

It is to be noted in passing that galena and pyrrhotite, two minerals not observed in the sections made from the ore, are both visible in the concentrate. The total quantity of pyrrhotite is practically negligible but particles of galena are fairly common and the mineral is present in appreciable amount.

Eleven grains of native gold, ranging from 108 microns (-100+150 Tyler mesh) down to 6 microns (230C Tyler mesh) in size, were observed and measured. Seven grains are free and four are associated with particles of gangue. In the latter case, however, none is entirely enclosed within gangue.

Investigative Work:

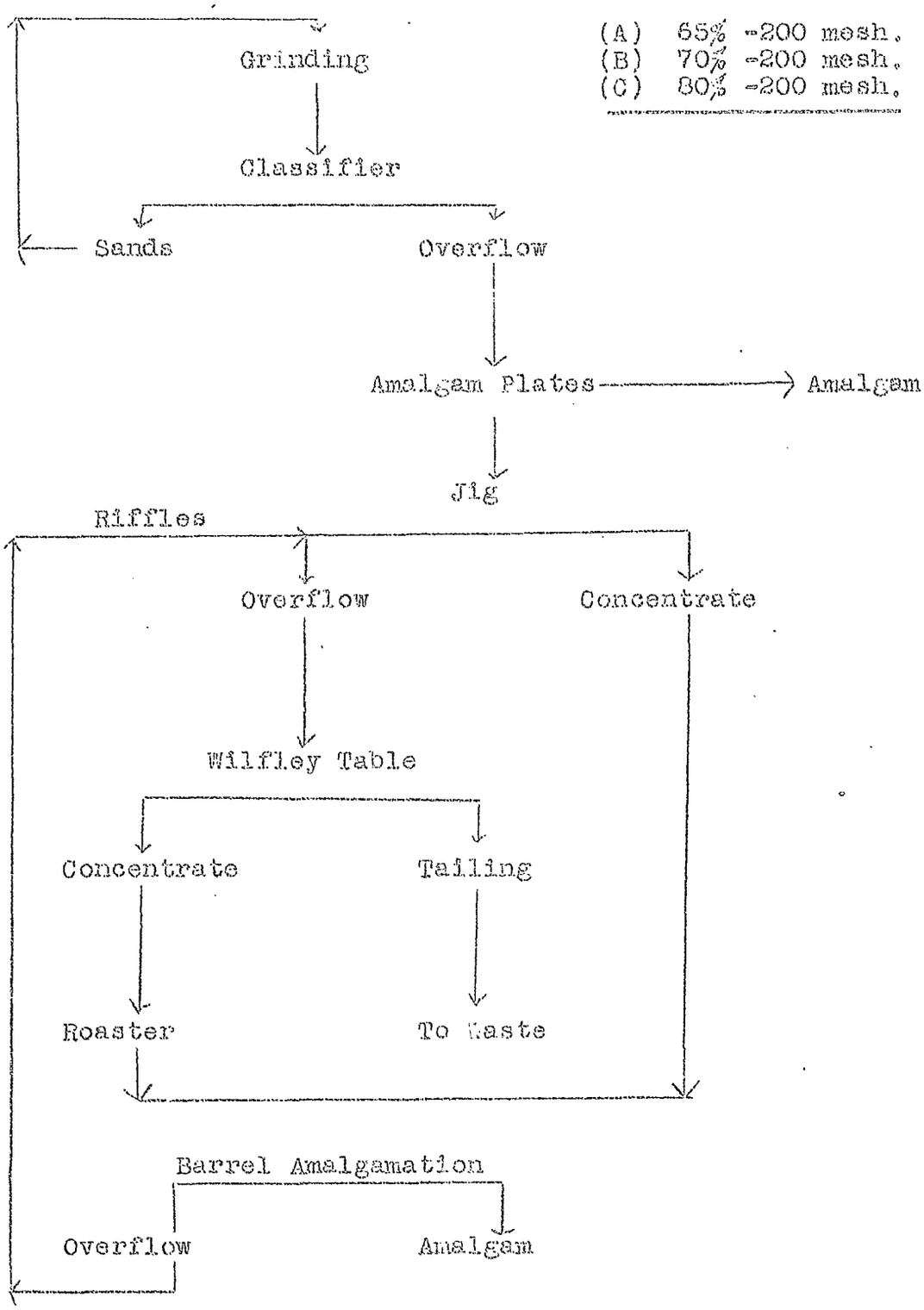
Mr. W. McG. Brown advised in his letter of December 3rd, 1941, that the sample was not representative of the general run of the ore at the mine but was representative of some 300 to 500 tons of ore which had been overlooked in the mining operations of 40-odd years ago.

The engineer for the Goldorel Mining Company Limited, forwarded the following Flow-Sheets Nos. 1 and 2 to be followed in the test work on the ore sample:

(Investigative Work, cont'd) -

Flow-Sheet No. 1.

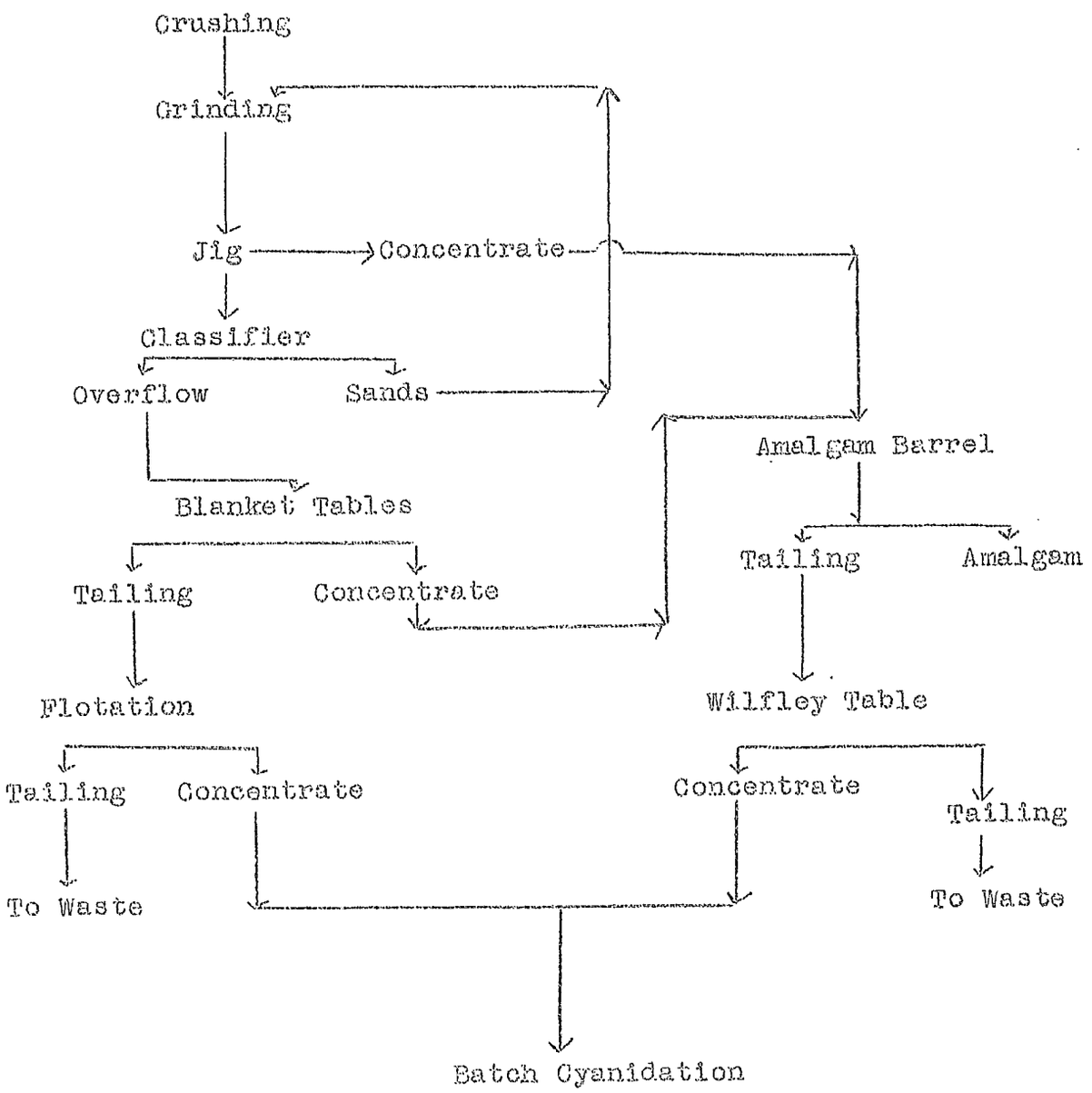
Crushing -3/16" Product.



(A) 65% -200 mesh.
(B) 70% -200 mesh.
(C) 80% -200 mesh.

(Investigative Work, cont'd) -

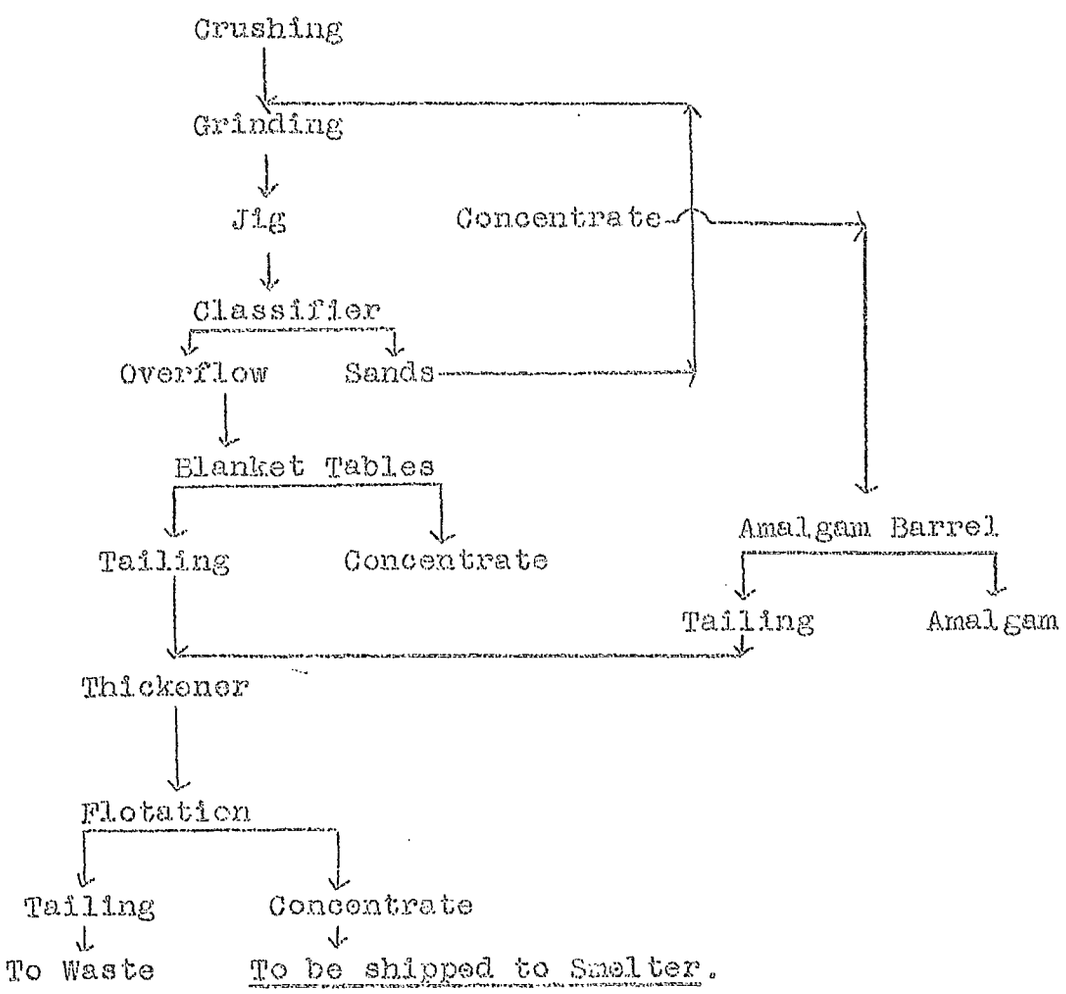
Flow-Sheet No. 2.



(Investigative Work, cont'd) -

Flow-Sheet No. 3.

This flow-sheet was designed in the Bureau of Mines laboratories.



If it is found necessary, the flotation tailing can be passed over an additional blanket table prior to final disposal.

(Investigative Work, cont'd) -

An additional test was made, as shown in Flow-Sheet No. 3, in which the ore was ground in a ball mill, concentrated by means of a jig and blanket; the combined concentrates barrel-amalgamated, and the amalgam residue added to the blanket tailing. A flotation concentrate was then obtained from this product.

The results of the test work showed that by using Flow-Sheet No. 1 a recovery of 90.7 per cent of the gold was obtained by amalgamation at 66.2 per cent minus 200 mesh grind. 88.5 per cent of the gold was recovered using a 71.5 per cent minus 200 mesh grind, and 89.4 per cent using the finer grind of 82.0 per cent minus 200.

In Flow-Sheet No. 2, where the use of batch cyanidation is included, it was not found possible to follow this method owing to the amount of copper in the flotation concentrate precluding the use of cyanide.

In the additional test on the ore, following the Flow-Sheet No. 3, designed in these Laboratories, 82.8 per cent of the gold was recovered by amalgamation and a shipping flotation concentrate was obtained assaying 20.5 ounces gold per ton, 9.90 ounces silver per ton, 11.85 per cent copper, and 9.82 per cent lead. The overall recovery of the gold was 98.1 per cent.

Details of Tests:

Test No. 1 (A, B, and C).

This test follows the procedure of Flow-Sheet No. 1 as given under "Investigative Work."

Test No. 1-A.

The ore was ground in a ball mill to pass 66.2 per cent minus 200 mesh and the pulp passed over an amalgamation plate, with the following results:

Plate Amalgamation.

Assays, Au oz./ton		Recovery of gold,
Feed	Tailing	per cent
2.50	0.96	61.6

The plate tailing was passed through a Denver gold jig, with results as follows:

Jig Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.96	100.0	
Jig concentrate	2.49	32.00	72.6	40:1.
Jig tailing	97.51	0.27	27.4	

The jig tailings were passed over a Wilfley table.

Table Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.27	100.0	
Table concentrate	2.40	2.72	24.2	41.7:1.
" middling	4.22	0.76	11.9	
" tailing	93.38	0.185	63.9	

The foregoing table concentrate was roasted at a temperature of 500° C. and the calcine added to the jig concentrate. This combined product was then barrel-amalgamated,

(Test No. 1-A, cont'd) -

with the following results:

Barrel Amalgamation.

Assays, Au oz./ton		Recovery of gold,
Feed	Tailing	per cent
18.22	8.99	50.7

The amalgam residue, assaying 8.99 ounces gold per ton, was then passed over a Wilfley table:

Table Concentration of Amalgam Residue.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	8.99	100.00	
Table concentrate	23.30	35.28	92.5	4.3:1.
Table tailing	76.70	0.875	7.5	

The table concentrate, assaying 35.28 ounces gold per ton, was roasted at 500° C. and the calcine was barrel-amalgamated.

2nd Barrel Amalgamation.

Assays, Au oz./ton		Recovery of gold,
Feed	Tailing	per cent
35.28	2.32	93.5

Summary of Test No. 1-A:

	Per cent
Gold recovered by plate amalgamation -	61.6
" " by 1st barrel amalgamation -	15.6
" " by 2nd " " -	13.5
Overall recovery of gold by amalgamation -	90.7 per cent

(Details of Tests, cont'd) -

Test No. 1-B.

This test follows the procedure of Flow-Sheet No. 1 and was similar to Test No. 1-A with the exception that the grind was 71.3 per cent minus 200 mesh.

Results:

Plate Amalgamation.

Assays, Au oz./ton		:Extraction of gold,
Feed	Tailing	per cent
2.50	0.88	64.8

Jig Concentration of Amalgam Tailing.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.88	100.0	
Jig concentrate	1.44	30.65	50.2	69.4:1.
Jig tailing	98.56	0.445	49.8	

Table Concentration of Jig Tailing.

Feed	100.00	0.445	100.0	
Table concentrate	0.89	21.11	42.2	112:1.
Table middling	1.53	2.42	7.2	
Table tailing	97.78	0.23	50.6	

Barrel Amalgamation of Roasted Table Concentrate + Jig Concentrate.

Assays, Au oz./ton		:Extraction of gold,
Feed	Tailing	per cent
27.2	12.21	55.11

Table Concentration of Amalgam Residue.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	12.21	100.0	
Table concentrate	16.0	65.76	86.2	6.25:1.
Table tailing	84.0	2.01	13.8	

(Continued on next page)

(Test No. 1-B, cont'd) -

Barrel Amalgamation of Roasted Table Concentrate.

Assays, Au oz./ton		Extraction of gold,
Feed	Tailing	per cent
65.76	1.69	97.4

Summary of Test No. 1-B:

	Per cent
Gold recovered by plate amalgamation	- 64.8
" " " 1st barrel amalgamation	- 14.1
" " " 2nd " "	- 9.6
Overall recovery of gold by amalgamation	- 88.5 per cent

Test No. 1-C.

This test followed the procedure of Flow-Sheet No. 1 and was similar to Tests Nos. 1-A and 1-B, with the exception of the grind which was 82.0 per cent minus 200 mesh.

Results:

Plate Amalgamation.

Assays, Au oz./ton		Extraction of gold,
Feed	Tailing	per cent
2.50	0.72	71.1

Jig Concentration of Amalgam Tailing.

Product	Weight, per cent	Assays, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.72	100.0	
Jig concentrate	1.59	16.81	37.1	63:1.
Jig Tailing	98.41	0.46	62.9	

(Continued on next page)

(Test No. 1-C, cont'd) -

Table Concentration of Jig Tailing.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.46	100.0	
Table concentrate	1.12	19.70	48.0	89:1.
Table middling	1.16	1.26	3.2	
Table tailing	97.72	0.23	48.8	

Barrel Amalgamation of Roasted Table Concentrate + Jig Concentrate.

Assays, Au oz./ton		Extraction of gold,
Feed	Tailing	per cent
17.94	1.84	89.8

Table Concentration of Amalgam Residue.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	1.84	100.0	
Table concentrate	12.52	6.47	44.4	8:1.
Table tailing	87.48	1.17	55.6	

Barrel Amalgamation of Roasted Table Concentrate.

Assays, Au oz./ton		Extraction of gold,
Feed	Tailing	per cent
6.47	2.00	69.17

Summary of Test No. 1-C:

	Per cent
Gold recovered by plate amalgamation	= 71.1
" " " 1st barrel amalgamation	= 17.7
" " " 2nd " "	= 0.6
Overall recovery of gold by amalgamation	= 89.4 per cent

(Details of Tests, cont'd) -

Test No. 2. - Concentration, Amalgamation and Cyanidation.

In this test the procedure followed Flow-Sheet No. 2. The ore was ground in a ball mill to pass 60.2 per cent minus 200 mesh and the pulp passed through a Denver gold jig. The jig overflow was classified and the sands reground and passed through the jig. The combined jig overflows were concentrated on a blanket table and the blanket tailings conditioned and concentrated by flotation. The combined jig and blanket concentrates were barrel-amalgamated. The amalgam residue was concentrated on a Wilfley table and the resulting table concentrate combined with the flotation concentrate and agitated in cyanide solution for 24 hours.

Results:

Jig Concentration.

Product	Weight, per cent	Assays, Au oz./ton	Distribution of gold per cent	Ratio of concentration
Feed	100.00	2.50	100.0	
Jig concentrate	3.37	50.38	67.9	29.7:1.
Jig tailing	96.63	0.83	32.1	

Blanket Concentration of Jig Overflow.

Feed	100.00	0.83		
Blanket concentrate	1.09	39.45	51.8	92:1.
Blanket tailing	98.91	0.405	48.2	

Flotation of Blanket Tailing.

Feed	100.00	0.405	100.0	
Flotation concentrate	1.74	16.48	70.8	57.5:1.
Flotation middling	1.14	2.70	7.6	
Flotation tailing	97.12	0.09	21.6	

In the flotation of the blanket tailing the pulp was conditioned for 10 minutes with 3 pounds of soda ash per ton and a concentrate obtained by the addition of 0.07 pound Z-8, 0.09 pound Barrett No. 4 Oil and 0.10 pound of pine oil per

(Test No. 2, cont'd) -

ton. This concentrate was cleaned in a smaller machine.

The jig and blanket concentrates were barrel-amalgamated with the following results:

Assays, Au oz./ton: Feed	Tailing	Recovery of gold, per cent
47.90	0.40	99.2

The amalgam residue was concentrated on a Wilfley table with results as follows:

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	0.40	100.0	
Table concentrate	20.17	0.64	32.3	5:1.
Table middling	25.94	0.42	27.3	
Table tailing	53.89	0.30	40.4	

The table concentrate and the flotation concentrates were combined and assayed 10.51 ounces gold per ton, 8.90 per cent copper, and 10.30 per cent lead.

This product was agitated in cyanide solution of 1 pound per ton strength for 24 hours.

No appreciable extraction of the gold was indicated in the assay of the resulting cyanide residue. The consumption of cyanide was extremely high (60 lb./ton) and it was not found possible to maintain the strength of solution, this result, of course, being due to the large percentage of copper (8.9 per cent) in the concentrate.

(Continued on next page)

(Test No. 2, cont'd) -

Summary of Results, Test No. 2:

		Per cent
Gold recovered by barrel amalgamation of jig + blanket concentrates	-	83.8
Gold recovered by flotation	-	4.0
Overall recovery of gold		87.8 per cent

Test No. 3. - Concentration and Amalgamation.

In this test Flow-Sheet No. 3 was followed. The ore at minus 14 mesh was ground in a ball mill to pass 60.2 per cent minus 200 mesh, the pulp was then passed through a Denver gold jig. The jig overflow was classified and the sands reground and again passed through the jig. The jig overflows were passed over a blanket table. The combined jig and blanket concentrates were barrel-amalgamated and the amalgam residue added to the blanket tailing. This product was thickened and transferred to a Denver flotation machine. It was then conditioned and a flotation concentrate obtained. The concentrate was cleaned in a smaller flotation machine and a shipping grade of concentrate secured.

Results:

Jig Concentration.

Product	Weight, per cent	Assay, Au oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.00	2.50	100.0	
Jig concentrate	7.00	28.14	78.8	14.3:1.
Jig tailing	93.00	0.57	21.2	

(Continued on next page)

(Test No. 5, cont'd) -

Blanket Concentration of Jig Tailing.

Product	Weight, per cent	Assay, Au oz./ton	Distribution, of gold, per cent	Ratio of concentration
Feed	100.00	0.57	100.0	
Blanket concentrate	1.43	26.07	65.4	70:1.
Blanket tailing	98.57	0.20	34.6	

The jig and blanket concentrates were combined and barrel-amalgamated. The amalgam residue was added to the blanket tailings and assayed 0.43 ounce gold per ton, giving a recovery of 82.8 per cent of the gold in the ore by amalgamation.

Flotation of Amalgam Residue + Blanket Tailing.

The pulp was transferred to a Denver flotation cell and conditioned for 10 minutes with 2 pound of soda ash and 0.07 pound of Aerofloat No. 25 per ton; 0.075 pound of pine oil, 0.05 pound of No. 208 and 0.05 pound of No. 301 promotors per ton were then added, and a rougher flotation concentrate was obtained. This concentrate was cleaned in a smaller flotation cell.

Results:

Product	Weight, per cent	Assay, Au oz./ton	Distribution, of gold, per cent	Ratio of concentration
Feed	100.00	0.45	100.0	
Flotation concentrate	1.77	20.58	84.7	56:1.
Flotation middling	2.30	0.98	5.2	
Flotation tailing	95.93	0.045	10.1	

The flotation concentrate assayed 20.58 ounces gold and 9.90 ounces silver per ton, 11.85 per cent copper, and 9.82 per cent lead.

(Continued on next page)

(Test No. 3, cont'd) -

Summary of Test No. 3:

		Per cent
Gold recovered by amalgamation of jig + blanket concentrates	-	82.8
Gold recovered by flotation of amalgam residue + blanket tailing	-	15.3
Overall recovery of gold	-	98.1 per cent

Barrel Amalgamation.

In the different barrel amalgamations it was found that the addition of about 2 pounds of lime and 0.5 pound of potassium bichromate per ton had a beneficial effect. The shipment was considerably weathered and rather badly oxidized and unless the foregoing reagents were added the mercury fouled considerably during the amalgamation process.

SUMMARY AND CONCLUSIONS:

The different tests show that a recovery of 89 per cent of the gold in the ore by plate and barrel amalgamation resulted from the application of Flow-Sheet No. 1, as laid out by the engineer for the company, and given in detail on Page 5.

Flow-Sheet No. 2, which was also supplied by the company and included cyanidation of the flotation concentrates, was not found to be feasible, owing to the large amount of copper included in the concentrate.

In addition to the above a test was made, using Flow-Sheet No. 3, in which the pulp was passed through a gold jig and over a blanket table. The ensuing concentrates were barrel-amalgamated and the amalgam residue added to the

(Summary and Conclusions, cont'd) -

blanket tailing. A flotation concentrate was then made of this product. By this method 82.8 per cent of the gold was recovered by amalgamation and 15.3 per cent recovered in a flotation concentrate. The ratio of concentration was 56:1. This concentrate assayed 20.5 ounces gold per ton and would constitute a high-grade shipping product.

It is indicated, by the results obtained from the different flow-sheets, that the simplest method would involve the procedure as given in Flow-Sheet No. 3, in which only one amalgamation is necessary and only some 2 per cent of the gold is lost in the tailing after a shipping concentrate is obtained.

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