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O T T A W A

December 4th, 1941.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1121.

Amalgamation and Flotation Concentration
of a Gold-Copper Ore from the
Siscoe Gold Mines Limited,
Siscoe, Quebec.

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:

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Six boxes of ore, weighing 400 pounds, were received on September 22nd, 1941, from Mr. A. H. Robinson, Mine Manager, Siscoe Gold Mines Limited, Siscoe, Quebec. Two of these boxes, weighing 130 pounds, were marked "Cyanide Ore" and the remaining four boxes were labelled "Cupriferous Ore".

Location of the Property:

The property of the Siscoe Gold Mines Limited from which the present shipment was received is situated in Dubuisson and Varsan townships, Abitibi county, Quebec.

Sampling and Analysis:

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

	<u>"Cyanide Ore"</u>	<u>"Cupriferous Ore"</u>
Gold, oz./ton.	0.27	0.16
Silver, oz./ton.	0.07	0.23
Copper, per cent	0.03	0.51
Sulphur, "	0.12	0.80
Iron, "	2.17	7.36
Arsenic, "	None detected	Trace
CaO, "	2.93	3.46
MgO, "	1.73	6.15
Pyrrhotite, per cent	=	0.31
Acid insol., "	86.92	64.16

Characteristics of the Ore:

Six polished sections, three from each type, were prepared and examined under the reflecting microscope for the purpose of determining the character of the ore.

"Cyanide Ore" -

Metallic mineralization is almost completely absent from the polished surfaces, which exhibit only one or two tiny grains of pyrite embedded in gangue. The latter is a mixture of fine-textured, white quartz and siliceous, dark grey to almost black rock. Both constituents carry abundant carbonate as rather finely disseminated grains which give a moderately strong microchemical reaction for iron.

"Cupriferous Ore" -

Metallic minerals are much more abundant in these sections than in those of the first type. Chalcopyrite predominates as small masses and coarse to fine irregular grains

("Cupriferous Ore", cont'd) -

disseminated in gangue. It contains numerous inclusions of gangue and occasional grains of the other metallics. Pyrite is prevalent, largely as medium to coarse isolated grains and granular aggregates scattered through gangue. Magnetite is present in small amount as occasional small masses and irregular grains in gangue, pyrite, and chalcopyrite. A very small quantity of sphalerite is visible as occasional small irregular grains associated with chalcopyrite.

Three irregular particles of native gold were observed and measured. They range from 72 microns (-200+280 Tyler mesh) down to 30 microns (-400+560 Tyler mesh) in size and all occur alone in quartz.

Flotation Concentrates -

Polished sections of four flotation concentrates (Nos. 4-B, 4-C, 4-D and 4-E) assaying 17.7, 19.5, 21.1 and 22.5 per cent copper were obtained from mill tests of the ore samples and were prepared and examined microscopically to determine, if possible, the association of the gold.

The ore had been ground to 60 per cent minus 200 mesh and the sections are composed of mineral particles of this size. These particles consist largely of chalcopyrite, pyrite, magnetite, and gangue, and only rarely are they combined. Chalcopyrite and pyrite are the only minerals which are abundant. Magnetite is fairly common and particles of gangue are occasional to rare.

Gold was observed only in the sections from concentrate 4-B where three small grains of native metal are visible. These range from 18 microns (-800+1100 Tyler mesh) down to 12 microns (-1100+1600 Tyler mesh) in size, and each is free and unassociated.

(Continued on next page)

(Characteristics of the Ore, cont'd) -

Trap Concentrates -

In addition to these microscopic examinations of the polished sections, separate portions of the "cyanide ore" and the "cupriferous ore" were ground in a ball mill to pass 60 per cent minus 200 mesh and the pulp passed through a hydraulic trap. The resulting trap concentrates were examined under a powerful binocular microscope.

In the "cyanide ore" concentrate 12 pieces of free gold were visible. The largest-sized particle was 400-microns in diameter and the average 100 microns. Associated minerals consisted of pyrite and magnetite.

In the "cupriferous ore" concentrate 10 pieces of free gold were observed. The largest size particle was 250 microns in diameter and the average size was 60 microns. Associated minerals were pyrite, chalcopyrite, and magnetite.

Investigative Work:

In his letter of September 8th, 1941, Mr. Robertson stated:

"A very considerable amount of the ore at Siscoe mines contains too much copper, in the shape of chalcopyrite, to allow of its treatment by cyanidation.

We are considering the possibility of grinding in water with traps and possibly blankets in the grinding circuit, followed by flotation of the blanket tails.

We are sending you samples of the easily cyanided ore and of the coppery ore, and we would ask you to be so kind as to carry out tests along the lines we have indicated and also along lines which will occur to your good selves.

We would ask you to test the ores separately, and also as mixtures of the two, using charges containing 20, 30 and 40 per cent of the coppery ore with 80, 70 and 60

(Investigative Work, cont'd) -

"per cent, respectively, of the easily treated ore."

These suggestions were followed in the test work on these shipments. Portions of the two ores, in mixtures as outlined above, were ground in water and the pulp passed through a hydraulic classifier or trap and the trap tailing passed over a blanket. The combined trap and blanket concentrates were reground slightly and amalgamated and the amalgam residue added to the blanket tailings. This product was then conditioned and a copper concentrate obtained by flotation concentration. By this method, on the "cupriferous ore" some 75 per cent of the gold was recovered by amalgamation and 17 per cent by flotation, the flotation tailing assaying 0.01 ounce gold per ton. Ninety per cent of the copper was recovered. The flotation concentrates assayed up to 25 per cent copper and 1.1 ounces gold per ton.

On the "cyanide ore" and the mixtures of the two shipments, some difficulties were encountered in the flotation owing to the amount of the talc tending to report in the flotation concentrate. This was largely overcome by the addition of caustic starch as a conditioner. In a test using 70 per cent "cyanide ore" and 30 per cent of "cupriferous ore" 80.8 per cent of the gold was recovered by amalgamation and 10.7 per cent by flotation. The flotation tailing assayed 0.01 ounce gold per ton. Ninety-two per cent of the copper was recovered. The flotation concentrate assayed 19.5 per cent copper and 2.6 ounces gold per ton.

In these tests the ball mill grinds were from 60 to 70 per cent minus 200 mesh. The concentrates were ground to 45 per cent minus 200 and 20 per cent minus 325 mesh during the amalgamation.

(Continued on next page)

(Investigative Work, cont'd) -

In addition to these amalgamation and flotation tests a number of amalgamation and cyanidation tests were made. These tests showed that a final residue of 0.005 ounce gold per ton was readily obtainable and that the addition of a soluble lead salt to the cyanide grind and a decrease in the strength of the cyanide solution used showed a reduction in the amount of cyanide consumed.

DETAILS OF TEST WORK:

In Tests Nos. 1, 2, 3, and 4 five separate portions of the two shipments were taken:

A.	-	100	per cent cyanide ore		
B.	-	80	" " "	20	per cent cupriferous ore.
C.	-	70	" " "	30	" " "
D.	-	60	" " "	40	" " "
E.	-	100	" cupriferous ore.		

These designations (A, B, C, D and E) of the different proportions of the "cyanide" and "cupriferous" ores used are adhered to in the test work.

The different pulps were ground in water in a ball mill to pass 60 to 70 per cent minus 200 mesh and the grind passed through a hydraulic classifier or trap and the trap overflow over blankets. The combined trap and blanket concentrates were reground slightly to pass 45 per cent minus 200 mesh and 20 per cent minus 325 mesh and amalgamated. The amalgam residue was added to the blanket tailing, conditioned, and a rougher flotation concentrate obtained in a Denver flotation cell. This primary concentrate was cleaned in a smaller machine. The different products were assayed for gold and copper.

(Continued on next page)

(Details of Test Work, cont'd) -

Test No. 1 (A to E), - Amalgamation and Flotation.

In this test soda ash was used as a conditioner in the amounts as shown.

Results:

- Gravity Concentration -

Mix- tures: used :	Product	Weight, per cent :	Assays, Au :oz./ton :	Distribution of gold, per cent :	Ratio of concen- tration :
<u>A</u>	Trap and blanket conc.	: 3.30	-	78.5	30:1.
	Blanket tailing	: 96.70	0.06	21.5	
<u>B</u>	Trap and blanket conc.	: 3.20	-	78.7	31:1.
	Blanket tailing	: 96.80	0.06	21.3	
<u>C</u>	Trap and blanket conc.	: 3.65	-	77.4	27:1.
	Blanket tailing	: 96.35	0.055	22.6	
<u>D</u>	Trap and blanket conc.	: 3.00	-	74.1	33:1.
	Blanket tailing	: 97.00	0.06	25.9	
<u>E</u>	Trap and blanket conc.	: 3.00	-	75.7	33:1.
	Blanket tailing	: 97.00	0.04	24.3	

Amalgamation of Trap and Blanket Concentrates.

	Assays, Au oz./ton	Extraction of gold by amalgamation, per cent
	:Amal. tailing and blanket tailing:	
<u>A</u>	:0.27	74.1
<u>B</u>	:0.25	76.0
<u>C</u>	:0.235	74.5
<u>D</u>	:0.225	71.1
<u>E</u>	:0.16	81.3

The following flotations of the amalgam residue and blanket tailing show that the use of soda ash as a conditioner tends to lower the grade of concentrate produced on account of the large amount of talcose material in the "cyanide ore". In the "cupriferous ore" (E), however, a concentrate assaying 20 per cent copper was obtained.

(See table on next page)

FLOTATION CONCENTRATION OF AMALGAM RESIDUE + BLANKET TAILING.

Mix- ture used	Product	Weight: per cent	Assays		Distribution, per cent		Ratio of: concen- tration	Grind, % -200 mesh	Reagents added, lb./ton feed	
			Au, oz./ton	Cu, %	Au	Cu			To primary cell	To cleaner cell
A	Conc.	3.52	1.45	0.41	70.4	52.2	29.4:1.		2.0 Soda ash	-
A	Midd.	4.56	0.27	0.09	17.0	14.9			0.1 Butyl Z-8	-
A	Tailing	91.92	0.01	0.01	12.6	32.9		66.4	0.03 pine oil	-
B	Conc.	2.30	1.77	3.60	64.1	74.9	43.5:1.		1.2 Soda ash	-
B	Midd.	4.72	0.285	0.39	21.3	16.6			0.1 Butyl Z-8	-
B	Tailing	92.98	0.01	0.01	14.6	8.5		68.2	0.03 pine oil	-
C	Conc.	2.45	1.46	4.67	60.5	74.6	41:1.		1.2 Soda ash	-
C	Midd.	4.71	0.30	0.63	23.8	19.4			0.1 Butyl Z-8	-
C	Tailing	92.84	0.01	0.01	15.7	6.0		69.4	0.03 pine oil	-
D	Conc.	2.73	1.70	7.61	71.5	90.8	36.6:1.		1.5 Soda ash	-
D	Midd.	4.02	0.25	0.58	14.2	1.0			0.1 Butyl Z-8	-
D	Tailing	93.25	0.01	0.02	14.3	8.2		61.8	0.03 pine oil	-
E	Conc.	1.98	0.92	20.17	56.9	85.5	50.5:1.		1.0 Soda ash	-
E	Midd.	2.40	0.18	1.22	13.4	6.3			0.1 Butyl Z-8	-
E	Tailing	95.62	0.01	0.04	29.7	8.2		64.4	0.03 pine oil	-

(Details of Tests, cont'd) -

Summary Test No. 1.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Gold recovered by amalgamation, per cent -	74.1	76.0	74.5	71.1	81.3
" " by flotation, "	21.3	18.6	19.1	23.6	12.0
Overall recovery of gold, "	95.4	94.6	93.6	94.7	93.3
Assay tailing loss of gold, oz./ton -	0.01	0.01	0.01	0.01	0.01
Copper recovered by flotation, per cent -	60.0	87.3	89.1	91.7	90.9
Assay tailing loss of copper, "	0.01	0.01	0.01	0.02	0.04

Test No. 2 (A to E).

This test was conducted similarly to Test No. 1, with the exception that "Quebracho" was used as a conditioner in place of soda ash. The results of the trap and blanket concentration were approximately the same as in the previous test, the method used being identical.

The amalgamation of the different trap and blanket concentrates resulted as follows:

	: Assays, Au oz./ton	: Amal. tailing and blanket tailing:	: Extraction of gold by amalgamation, per cent
<u>A</u>	:0.27	0.06	77.8
<u>B</u>	:0.25	0.06	75.5
<u>C</u>	:0.235	0.06	74.5
<u>D</u>	:0.225	0.055	75.6
<u>E</u>	:0.16	0.05	68.8

In the following flotation tests it is apparent that the use of quebracho is not suitable to this type of ore, the sulphides tending to be depressed along with the gangue.

(See table on next page)

FLOTATION CONCENTRATION OF AMALGAM RESIDUE + BLANKET TAILING.

Mix- ture used	Product	Weight, per cent	Assays		Distribution, per cent		Ratio of Au : Cu	Grind, % -200 mesh	Reagents added, lb./ton feed	
			Au, oz./ton	Cu, per cent	Au	Cu			To primary cell	To cleaner cell
A	Conc.	0.39	0.875	0.39	5.6	5.1	256:1.		0.42 Quebracho	0.48 Quebracho
A	Midd.	7.09	0.68	0.13	79.3	31.5			0.10 Butyl Z-8	0.02 Butyl Z-8
A	Tailing	92.52	0.01	0.02	15.1	63.4		67.4	0.05 pine oil	0.01 pine oil
B	Conc.	6.02	0.79	1.88	62.5	61.9	16.6:1.		0.15 Quebracho	-
B	Midd.	3.98	0.38	0.13	19.8	28.3			0.10 Amyl xan- thate	-
B	Tailing	90.00	0.015	0.02	17.7	9.8		64.2	0.05 pine oil	-
C	Conc.	4.15	1.05	3.84	64.9	75.5	24:1.		0.20 Quebracho	-
C	Midd.	5.70	0.26	0.38	14.4	6.9			0.10 Amyl xan- thate	-
C	Tailing	92.15	0.015	0.04	20.7	17.5		59.0	0.05 pine oil	-
D	Conc.	3.49	1.02	6.25	64.5	79.3	28.6:1.		0.20 Quebracho	-
D	Midd.	3.97	0.26	0.50	18.6	7.2			0.05 No. 301	-
D	Tailing	92.54	0.01	0.04	16.9	13.5		60.6	0.05 Amyl xan- thate	-
									0.05 pine oil	-
E	Conc.	2.63	1.05	16.79	56.1	85.1	38:1.		0.20 Quebracho	0.20 Quebracho
E	Midd.	1.67	0.44	2.35	14.8	7.5			0.10 Butyl Z-8	0.02 Butyl Z-8
E	Tailing	95.70	0.015	0.04	29.1	7.4		68.4	0.03 pine oil	0.01 pine oil

FLOTATION CONCENTRATION OF AMALGAM RESIDUE + BLANKET TAILING.

Mixture used	Product	Weight, per cent	Assays		Distribution, per cent		Ratio of Au : Cu	Grind, % -200 mesh	Reagents added, lb./ton feed	
			Au, oz./ton	Cu, per cent	Au	Cu			To primary cell	To cleaner cell
A	Conc.	2.50	1.86	0.65	64.6	30.0	40:1.		2.5 lime	1.0 lime
A	Midd.	7.23	0.23	0.46	22.9	61.5			0.10 Butyl Z-8	-
A	Tailing	90.27	0.01	0.005	12.5	8.5		70.2	0.05 pine oil	-
B	Conc.	1.75	2.32	4.95	57.3	72.6	57:1.		2.5 lime	1.0 lime
B	Midd.	6.04	0.35	0.39	29.7	19.7			0.10 Butyl Z-8	-
B	Tailing	92.21	0.01	0.01	13.0	7.7		69.0	0.03 pine oil	-
C	Conc.	2.20	1.90	6.54	56.6	74.1	45.5:1.		3.5 lime	0.5 lime
C	Midd.	4.89	0.37	0.27	24.5	6.8			0.10 Butyl Z-8	-
C	Tailing	92.91	0.015	0.04	18.9	19.1		67.4	0.03 pine oil	-
D	Conc.	1.31	2.60	13.16	52.5	77.8	76:1.		3.5 lime	1.0 lime
D	Midd.	4.91	0.44	0.62	33.2	13.7			0.10 Butyl Z-8	0.01 Butyl Z-8
D	Tailing	93.78	0.01	0.02	14.3	8.5		65.1	0.03 pine oil	0.01 pine oil
E	Conc.	2.17	0.80	21.93	60.3	84.8	46:1.		2.5 lime	1.0 lime
E	Midd.	2.57	0.08	1.84	7.2	8.4			0.05 butyl xanthate	-
E	Tailing	95.26	0.01	0.04	32.5	6.8		70.1	0.02 cresilic acid	-
									0.02 pine oil	-

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(Test No. 3, cont'd) -

Summary of Test No. 3.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Gold recovered by amalgamation, per cent	- 74.1	72.0	70.0	71.1	81.2
Gold recovered by flotation, per cent	- 20.6	20.8	21.1	20.2	12.1
Overall recovery of gold, per cent	- 94.7	92.8	91.1	91.3	93.3
Assay tailing loss gold, oz./ton	- 0.01	0.01	0.015	0.01	0.01
Copper recovered by flotation, per cent	- 43.5	86.9	79.1	88.4	91.9
Assay tailing loss of copper, per cent	- 0.005	0.01	0.04	0.02	0.04

Test No. 4 (A to E).

In this test caustic soda was used as a conditioner in the flotation concentration. The trap and blanket concentration, followed by amalgamation of the resulting concentrates, was similar to the previous tests.

Results of Amalgamation.

	<u>Assays, Au oz./ton</u>	<u>Amal. tailing</u>	<u>Head</u>	<u>Extraction of gold by amalgamation, per cent</u>
		<u>and</u>	<u>blanket tailing:</u>	
<u>A</u>	: 0.27	0.06		77.8
<u>B</u>	: 0.25	0.065		74.0
<u>C</u>	: 0.235	0.055		76.6
<u>D</u>	: 0.225	0.06		73.3
<u>E</u>	: 0.16	0.04		75.0

The following flotation results, using caustic starch as a conditioner, are satisfactory except in No. "A" where the amount of sulphides in the ore (0.12 per cent sulphur) was not sufficient to permit a clean concentrate being produced.

(See table on next page)

FLOTATION CONCENTRATION OF AMALGAM RESIDUE + BLANKET TAILING.

Mix- ture used	Product	Weight, per cent	Assays		Distribution, per cent		Ratio of: concen- tration:	Grind, % -200: mesh	Reagents added, lb./ton feed	
			Au, oz./ton	Cu, per cent	Au	Cu			To primary cell	To cleaner cell
A	Conc.	0.17	8.46	4.57	21.6	33.5	588:1.		0.20 starch	0.10 starch
A	Midd.	4.32	0.74	0.15	54.2	28.3			0.10 Butyl Z-8	0.02 Butyl Z-8
A	Tailing	95.51	0.015	0.01	24.2	41.2		61.0	0.03 pine oil	0.01 pine oil
B	Conc.	0.58	5.50	17.71	49.5	87.6	172:1.		0.20 starch	0.10 starch
B	Midd.	4.27	0.54	0.23	35.7	8.4			0.10 Butyl Z-8	0.02 Butyl Z-8
B	Tailing	95.15	0.01	0.005	14.3	4.0		59.4	0.03 pine oil	0.01 pine oil
C	Conc.	0.63	2.66	19.54	39.8	82.7	147:1.		0.16 starch	0.10 starch
C	Midd.	5.66	0.32	0.33	39.8	11.6			0.10 Butyl Z-8	0.02 Butyl Z-8
C	Tailing	93.68	0.01	0.01	30.4	5.7		60.4	0.03 pine oil	0.01 pine oil
D	Conc.	1.03	3.56	21.11	60.6	92.7	97:1.		0.16 starch	0.10 starch
D	Midd.	5.01	0.29	0.25	23.9	5.3			0.10 Butyl Z-8	0.02 Butyl Z-8
D	Tailing	93.96	0.01	0.005	15.5	2.0		57.6	0.03 pine oil	0.01 pine oil
E	Conc.	2.02	1.14	22.30	59.4	84.4	49.5:1		0.12 starch	0.10 starch
E	Midd.	3.14	0.20	1.74	16.0	10.2			0.10 Butyl Z-8	0.02 Butyl Z-8
E	Tailing	94.84	0.01	0.03	24.6	5.4		67.0	0.03 pine oil	0.01 pine oil

(Test No. 4, cont'd) -

Summary of Test No. 4.

	<u>A</u>	<u>B</u>	<u>C</u>	<u>D</u>	<u>E</u>
Gold recovered by amalgamation, per cent	- 77.8	74.0	76.6	73.3	75.0
Gold recovered by flotation, per cent	- 7.4	17.5	13.0	20.0	17.2
Overall recovery of gold, per cent	- 85.2	91.5	89.6	93.3	92.2
Assay tailing loss, gold, oz./ton	- 0.015	0.01	0.01	0.01	0.01
Copper recovered by flotation, per cent	- 43.0	94.9	92.3	97.6	93.0
Assay tailing loss of copper, per cent	- 0.01	0.005	0.01	0.005	0.03

Test No. 5. (A and E). - Amalgamation and
 Flotation Concentration.

In this test, portions of the "cyanide ore" A and the "cupriferous ore" E were ground in water in a ball mill and the pulps passed over traps and blankets as in the previous tests. The combined trap and blanket concentrates were reground and amalgamated and the blanket tailings were concentrated by flotation. The amalgam residue was not added to the blanket tailings prior to flotation as in the previous tests.

- Trap and Blanket Concentration -

Test No. 5-A.

Product	:Weight, : per : cent	: Assays		: Distribution,		: Ratio of : concen- : tration
		: Au, : oz./ton	: Cu, : per cent	: Au	: Cu	
Feed	:100.00	0.27	0.03	100.0	-	
Trap + blanket: concentrate	: 2.57	8.04	-	76.5	-	39:1.
Blanket tailing	: 97.43	0.065	-	23.5	-	

Test No. 5-E.

Feed	:100.00	0.16	0.51	100.0	100.0	
Trap + blanket: concentrate	: 3.02	4.01	2.31	75.7	13.7	33:1.
Blanket tailing	: 96.98	0.04	0.45	24.3	86.3	

(Test No. 5, cont'd) -

- Amalgamation of Trap + Blanket Concentrates -

Test No.	Assays, Au oz./ton:	Extraction :	Overall extraction	
	Feed :	Tailing :	of gold, :	of gold,
			per cent :	per cent
5-A	8.04	0.13	98.39	75.3
5-E	4.01	0.12	97.0	73.4

The grinding, accompanying amalgamation, was 45 per cent minus 200 mesh in Test No. 5-A and 43 per cent minus 200 mesh in Test No. 5-E.

(Continued on next page)

FLOTATION OF BLANKET TAILING.

Mix- ture Used	Product	Weight, per cent	Assays		Distribution, per cent		Ratio of concen- tration	Grind, % -200 mesh	Reagents added, lb./ton feed	
			Au, oz./ton	Cu, per cent	Au	Cu			To primary cell	To cleaner cell
A	: Conc.	: 0.33	4.60	2.71	24.7	38.4	303:1.		0.20 starch	0.10 starch
A	: Midd.	: 4.96	0.65	0.10	52.3	21.1			0.10 Butyl Z-8	0.02 Butyl Z-8
A	: Tailing	: 94.71	0.015	0.01	23.0	40.5		63.0	0.03 pine oil	0.01 pine oil
E	: Conc.	: 1.04	1.67	27.73	58.8	77.5	96:1.		0.10 starch	0.05 starch
E	: Midd.	: 4.71	0.06	1.58	9.5	20.0			0.10 Butyl Z-8	0.02 Butyl Z-8
E	: Tailing	: 94.25	0.01	0.01	31.7	2.5		69.0	0.03 pine oil	0.01 pine oil

(Test No. 5, cont'd) -

Summary of Test No. 5.

	<u>A</u>	<u>E</u>
Gold recovered by amalgamation, per cent	- 76.4	73.4
Gold recovered by flotation, per cent	- 8.8	15.6
Gold remaining in amalgam residue, per cent	- 1.2	2.3
Assay tailing loss, gold, oz./ton	- 0.01	0.01
Copper recovered by flotation, per cent	- 46.5	80.2

Owing to the small amount of mineralization in the "cyanide ore" A, the flotation recovery was low in both the gold and copper. On the "cupriferous ore" E, however, the recovery in both gold and copper was fairly satisfactory.

Test No. 6 (E). - Amalgamation and Flotation Concentration.

In this test three portions of the "cupriferous ore" E were ground in water to pass 68.7 per cent minus 200 mesh. The pulps were then passed through traps and blankets and the combined concentrates amalgamated as in the previous tests. The amalgam residues were then added to the blanket tailings.

In the flotation concentration of these pulps an attempt was made to duplicate actual milling flotation procedure in the small scale test work. After conditioning the first product with caustic starch and floating with butyl xanthate and pine oil, the resulting concentrate was cleaned in a smaller flotation machine and the cleaner middlings were returned to the primary cell and refloated along with the second product. This procedure was repeated for the third product. The assay results of the three flotation tailings showed whether the gold or copper tended to build up in successive tailings and thus reduce the overall recovery.

(Continued on next page)

(Test No. 6, cont'd) -

Results of Amalgamation.			
Product	Assays, Au oz./ton	Amal. tailing and blanket tailing	Extraction of gold by amalgamation, per cent
1	0.16	0.03	81.2
2	0.16	0.03	81.2
3	0.16	0.03	81.2

Overall Extraction by Amalgamation (Three Products).			
1, 2, 3	0.16	0.03	81.2

Flotation of Amalgam Residue + Blanket Tailing.

Product	Weight, per cent	Assays		Distribution, per cent	Grind, % -200 mesh	Ratio of concentration
		Au, oz./ton	Cu, per cent			
Feed	100.00	0.033 [Ⓢ]	0.47 [Ⓢ]	100.0	100.0	
Flot. conc.	1.52	1.43	25.74	64.8	83.7	65.8:1.
Final midd.	1.51	0.14	1.82	6.3	5.9	
1st F. tailing	31.89	0.01	0.04	9.6	2.7	68.5
2nd F. tailing	32.69	0.01	0.06	9.7	4.2	67.2
Final F. "	32.39	0.01	0.05	9.6	3.5	70.3

[Ⓢ] Calculated.

During the primary flotations and cleaning of the flotation concentrates the following reagents were added:

Product Number	Reagents added, lb./ton feed	
	To primary cell	To cleaner cell
1	0.20 starch	0.10 starch
1	0.10 Butyl Z-8	0.01 Butyl Z-8
1	0.03 pine oil	0.01 pine oil
2	0.20 starch	0.10 starch
2	0.05 Butyl Z-8	0.01 Butyl Z-8
2	0.02 pine oil	0.01 pine oil
3	0.10 starch	0.05 starch
3	0.05 Butyl Z-8	-
3	0.01 pine oil	-

(Continued on next page)

(Test No. 6, cont'd) -

Summary of Test No. 6 (E).

	<u>Per cent</u>
Gold recovered by amalgamation	- 81.2
Gold recovered by flotation	- 12.3
Overall recovery of gold	- 93.5
Copper recovered by flotation	- 85.3

The results of this test show no appreciable build-up of the flotation tailings. The assays of the tailings are approximately the same for all three products.

Test No. 7 (A to E). - Amalgamation and Cyanidation.

Portions of the "cyanide ore" and the "cupriferous ore" were taken, in the proportions as given below, and ground in cyanide solutions of 1 pound NaCN per ton strength to pass 60 per cent minus 200 mesh. 0.50 pound of lead nitrate and 2.0 pounds of lime per ton of feed were added to the grind. The pulps were then filtered and the grinding solutions saved for the agitation periods. After repulping the filter cake, it was passed through a hydraulic trap and the trap overflow over blankets. The combined trap and blanket concentrates were reground and amalgamated and the amalgam residue added to the blanket tailings. This product was agitated in the cyanide solution, saved from the grind, for 24 hours. Enough sodium cyanide was added to keep the strength of solution at 1.0 pound NaCN per ton, and enough lime to maintain protective alkalinity.

Results:

After grinding in cyanide, passing the repulped filter cake through traps and blankets and regrinding and amalgamating the combined concentrates, the amalgam residues

(Test No. 7, cont'd) -

were added to the blanket tailings. These products assayed as follows:

Mixture used	Assays, Au oz./ton	Extraction of gold by amalgamation + cyanide grind, per cent
A	0.27	70.0
B	0.25	83.7
C	0.235	83.0
D	0.225	82.2
E	0.16	75.0

Agitation of Amalgam Residue + Blanket Tailing

Mixture used	Assays, Au oz./ton	Feed Tailing per cent	Extraction of gold, %	Reagents consumed, lb./ton feed	Reducing power, ml. N/10	Grind, mesh
A	0.08	0.005	93.75	0.53	5.0	14
B	0.04	0.005	87.50	0.53	5.0	50
C	0.04	0.005	87.50	0.60	5.0	60
D	0.04	0.005	87.50	0.61	5.0	60
E	0.04	0.005	87.50	0.83	5.1	120

The cyanide solution assayed 0.08 gram copper per litre.

The agitation period was 24 hours in all cases.

The cyanide solutions were kept at a strength of 1.0 pound NaCN and 0.15 pound CaO per ton.

Summary of Test No. 7.

	A	B	C	D	E
Gold recovered by cyanide grind + amalgamation, per cent	70.0	83.7	83.0	82.0	75.0
Gold recovered by agitation, per cent	28.1	14.3	14.9	15.6	21.9
Overall recovery of gold, per cent	98.1	98.0	97.9	97.8	96.9
Overall tailing loss, Au oz./ton	0.005	0.005	0.005	0.005	0.005

Test No. 8 (E). - Amalgamation, Cyanidation and Flotation.

In this test a portion of the "cupriferous ore" E was ground in a ball mill in a cyanide solution of 0.5 pound NaCN per ton strength. Three pounds of lime and 0.5 pound of lead nitrate per ton of feed were added to the grind. The pulp was then treated by concentration and amalgamation as in Test No. 7. The amalgam residue and blanket tailings were then divided into two parts and agitated in the cyanide grinding solution of 0.5 pound NaCN per ton strength. In part A sufficient lime was added to give a strength of solution of 0.10 to 0.15 pound per ton and in part B, 0.40 to 0.50 pound per ton. Enough cyanide was added to maintain a strength of solution of 0.5 pound NaCN per ton. After agitating for 24 hours the residue was filtered, washed, and the cakes were sampled separately. The cakes were then repulped together and conditioned in a Denver flotation machine with 0.10 pound of caustic starch per ton and a rougher copper concentrate obtained by the addition of Butyl Z-8 and pine oil. This concentrate was cleaned in a smaller machine. The different products were assayed for gold and copper.

The amalgam residue and blanket tailing assayed 0.02 ounce gold per ton, showing a recovery of 87.5 per cent of the gold by grinding in cyanide plus amalgamation of combined trap and blanket concentrates.

Agitation of Amalgam Residue + Blanket Tailing.

Feed - 0.02 ounce gold per ton.							
Grind, % -200 mesh	Tailing assay, Au : oz./ton	Extraction of gold, per cent	Titrations, lb./ton solution		Reagents consumed, lb./ton ore		Reducing power, ml. N/10 KMnO ₄ /L
			NaCN	CaO	NaCN	CaO	
67.4	0.005	75.0	0.50	0.10	0.60	4.80	90
67.4	0.005	75.0	0.50	0.40	0.60	7.70	100

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(Test No. 8, cont'd) -

The cyanide solutions assayed 0.054 and 0.057 gram copper per litre. The agitation period was 24 hours.

The cyanide solutions were kept at a strength of 0.50 pound per ton NaCN and 0.10 to 0.15 pound CaO in the first agitation and 0.50 pound NaCN and 0.40 pound CaO in the second.

Flotation of Cyanide Residues.

The two filter cakes were combined, repulped, and transferred to a Denver flotation cell. The pulp was conditioned with caustic starch and a cleaned copper concentrate obtained as follows:

Product	Weight, per cent	Assays		Distribution, per cent		Ratio of concentration
		Au, oz./ton	Cu, per cent	Au	Cu	
Feed	100.00	0.0065 [Ⓢ]	0.52 [Ⓢ]	100.0	100.0	
Copper concentrate	0.93	0.08	30.50	10.8	54.4	107:1.
" middling	2.51	0.04	5.25	15.3	25.3	
" tailing	96.56	0.005	0.11	73.9	20.3	

[Ⓢ] Calculated.

The additions of flotation reagents was as follows:

To primary cell: 0.10 pound starch, 0.10 pound Butyl Z-8, 0.03 pound pine oil per ton.

To cleaner cell: 0.05 pound starch, 0.02 pound Butyl Z-8, 0.01 pound pine oil per ton.

Summary of Test No. 8 (E).

The test was conducted on the sample E of "cupriferous ore".

	Per cent
Gold extracted by cyanide grind and amalgamation	- 87.5
Gold extracted by agitation	- 9.4
Gold recovered in flotation concentrate	- 0.4
Overall recovery of gold	- 97.3
Copper recovered by flotation	- 68.1

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(Test No. 8, cont'd) -

In this test, as in previous tests, the percentage of gold and copper recovered from the middling product was figured as being the same as the percentage recovery of the concentrate.

Summary and Conclusions:

The test work on the ore shipments indicates that the flowsheet as suggested by the mine management, consisting of a water grind followed by concentration by means of traps and blankets, amalgamation of ensuing concentrates and finally flotation of the amalgam residue and blanket tailings, will be successful in the case of the "cupriferous ore" or in a mixture containing at least 30 per cent "cupriferous" and 70 per cent "cyanide ore".

Using this flowsheet some 77 per cent of the gold was recovered by amalgamation and 14 to 15 per cent by flotation concentration. The final flotation tailing loss was 0.01 ounce gold per ton. A recovery of some 85 to 90 per cent of the copper in the ore was obtained with a flotation concentrate assaying 20 to 25 per cent copper, and about 1.5 ounces gold per ton at a ratio of concentration of from 65 to 100:1. The grinds used were from 60 to 70 per cent minus 200 mesh in the ball mill and a coarse grind of 45 per cent minus 200 mesh in the amalgamation of the trap and blanket concentrates.

A test (No. 5) was also made where the amalgam residues were not added to the blanket tailing prior to flotation. This method worked out fairly satisfactorily for the "cupriferous ore" E. On the "cyanide ore" A, however, owing to the small amount of mineralization, the recoveries by

(Summary and Conclusions, cont'd) -

flotation concentration of both the gold and copper were low.

The chief difficulty encountered in the treatment was the tendency of the talcose material in the "cyanide ore" to report in the flotation concentrate. Conditioning was attempted with soda ash, lime, quebracho, and caustic starch. Of these reagents only caustic starch was found to be beneficial in producing a cleaned copper concentrate comparatively free from gangue.

In addition to the amalgamation and flotation tests on the ores, a number of amalgamation and cyanidation tests were made on the different ore mixtures. These tests followed the flowsheet which is at present used in the Siscoe mill. They indicated that the excessive cyanide consumption, due to chalcopyrite in the ore, can be alleviated to some extent by the addition of a soluble salt to the grind and a reduction in the strength of cyanide solution used. By these means a cyanide consumption of 0.50 pound per ton of ore was obtained with an extraction of 97 per cent of the gold and a final cyanide residue of 0.006 ounce gold per ton. On the "cupriferous ore" a flotation copper concentrate was also obtained from the cyanide residue, assaying 30.5 per cent copper with a recovery of about 68 per cent of the copper in the ore.

In the microscopic examination of the polished sections and concentrates all the gold observed was free and no association of the gold with either the pyrite or chalcopyrite was detected.

It is indicated from the test work performed on these shipments that amalgamation and flotation procedure

(Summary and Conclusions, cont'd) -

can be applied with satisfactory results to the "cupriferous ore" or a 30 to 70 per cent mixture of the cupriferous and cyanide ores but that, owing to the sparseness of mineralization in the cyanide ore, flotation concentration would hardly be applicable to this type of ore alone or to a mixture containing less of the "cupriferous ore" than the amount indicated. Owing to the comparatively large amount of free gold in the ore, blanketing of the flotation tailings prior to final shipment might be necessary.

The test work also indicated that some reduction in the amount of cyanide consumed may be effected by the addition of a soluble lead salt to the grind and a decrease in the strength of the cyanide solution used.

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