OTTAWA July 28th, 1942.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1220.

Gold Ore from the Elmos Property of the Tombill Gold Mines Limited at Geraldton, Ontario.

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(Copy No. 13.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

O T T A W A July 28th, 1942.

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Gold Ore from the Elmos Property of the Tombill
Gold Mines Limited at Geraldton, Ontario.

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Shipment:

A shipment of 500 pounds of crushed ore was received on February 10th, 1942. The ore was taken from the Elmos property of the Tombill Gold Mines Limited, Geraldton, Ontario, and was submitted by A. C. Anderson, Mill Superintendent, Tombill Gold Mines Limited. This property is located some 3 miles from the town of Geraldton, Ontario.

Purpose of the Investigation:

The shipment was made to determine the recovery of gold when milled as indicated below by the company's proposed flow-sheet:

Proposed Flow-Sheet.

> The ore is to be crushed to 40 mesh in stamp batteries and then amalgamated. After classifying, it is to be reground to minus 200 mesh and then floated. The concentrates are to be cyanided at another property.

Tests to determine whether the flotation concentrate would give a higher extraction by roasting prior to cyanidation also were requested.

Character of the Ore:

Selected specimens of the ore were taken and subjected to microscopic examination of polished sections.

Gangue -

Gangue material is a mixture of olive-green rock and milky-white quartz. It contains rather abundant finely disseminated carbonate which gives a moderately strong micro-chemical reaction for iron.

Metallic Minerals:

The metallic minerals present in the polished sections are: pyrite, arsenopyrite, ilmenite(?), chalcopyrite, pyrrhotite, sphalerite, and native gold. The first two named, that is, pyrite and arsenopyrite, are the only ones which are abundant. These two minerals, often in close association with each other, occur as irregular grains and subhedral crystals, coarse to fine in size, disseminated throughout gangue. The pyrite contains inclusions of gangue, ilmenite(?), chalcopyrite, pyrrhotite, and rare, tiny grains of gold; the arsenopyrite is more dense than the pyrite and encloses fewer inclusions.

A small quantity of grey, anisotropic mineral is visible in two or three sections as occasional, tiny, irregular

(Character of the Ore, cont'd) -

grains in gangue and in pyrite. The particles are too small to identify with certainty but resemble ilmenite, probably with some admixed magnetite. Chalcopyrite and pyrrhotite, each in very small amount, are included in pyrite and, more rarely, in arsenopyrite. The former mineral is also disseminated in gangue as rare, small grains, and a practically negligible amount of sphalerite occurs in the same manner.

Four grains of native gold, ranging from 28 microns (-400+560 Tyler mesh) down to 8 microns (-1600+2300 Tyler mesh) in size, were observed and measured. All occur in pyrite, three alone and one associated with inclusions of chalcopyrite and gangue.

Investigative Procedure:

The ore, ground minus 40 mesh, was plate-amalgamated and the plate tailings were reground and floated. The flotation concentrate then was cyanided both raw and after roasting.

Results of Tests:

65.8 per cent of the gold was recovered by amalgamation.

91.9 per cent of the gold in the amalgamation tailings can be recovered as a concentrate assaying 4.3 ounces of gold per ton with a ratio of concentration of 24:1.

This gave a 92.3 per cent recovery by amalgamation and cyanidation of the raw concentrate, while 89 to 93.5 per cent was recovered by amalgamation, roasting, and cyanidation.

Gold losses during roasting varied directly with the gold content of the concentrates. These ranged from 1.8 to 6.3 per cent. The highest loss recorded, 6.3 per cent, resulted in an overall recovery of 89 per cent of the gold by amalgamation and cyanidation.

Sampling and Analysis:

The ore when received had been crushed to approximately minus ½ inch and was quite damp.

After air-drying for a few days it was crushed and sampled by standard methods and was found to contain:

Gold (Au)	-	0.41 oz./ton.
Silver (Ag)	-	0.07 "
Arsenic (As)	-	0.38 per cent.
Iron (Fe)	-	4.69 "
Sulphur (S)	-	1.34 "
Zinc (Zn)	-	0.06 "
Copper (Cu)	-	None detected.
Lead (Pb)	-	" "
Tungsten trioxide (WO_3)	-	None detected.

DETAILS OF TESTS:

PART I. - AMALGAMATION AND FLOTATION.

Test No. 1.

Samples of the ore ground wet in a ball mill (4 parts solids to 3 parts water) to pass 40 mesh were run over an amalgamated plate.

The amalgamation tailings were then reground to 84.8 per cent minus 200 mesh and floated for 7 minutes with the following reagents:

To the ball mill		Lb./ton
Soda ash	-	2.0
No. 208	-	0.2
To flotation cell		
No. 301	-	0.2
Pine oil	-	0.1

Results:

Amalgamation:

Feed	-	0.41 oz./ton gold.
Tailing	-	0.18 " "
Recovery	-	56.1 per cent.

(Continued on next page)

(Test No. 1, cont'd) -

Flotation:

Products	Weight, per cent	Assays Au, oz./ton	Assays As, per cent	Distribution, per cent Au In test	Distribution, per cent Au In orig. feed	Distribution, per cent As	Ratio of concentration
Feed	100.0	0.18	0.38	100.0	43.9	100.0	
Concentrate	5.5	2.86	5.78	87.0	38.2	82.8	18:1.
Tailing	94.5	0.025	0.07	13.0	5.7	17.2	

The concentrate contained 0.34 per cent pyrrhotite.

Screen Test of Flotation Tailing.

Mesh	Weight, per cent	Assays Au, oz./ton	Assays As, per cent
+200	15.2	0.04	Nil
-200	84.8	0.02	0.07

56.1 per cent of the gold was recovered by amalgamation and 38.2 per cent was contained in the flotation concentrate, a combined recovery of 94.3 per cent.

Test No. 2.

This test is similar to the preceding one, with the exceptions as noted:

Grind, 92.8 per cent minus 200 mesh.

Increased reagent additions:

Soda ash, to 4.0 lb./ton.
No. 301 , to 0.3 "

Results:

		Per cent
Recovery by amalgamation	-	53.7
" " flotation	-	40.8
Total recovery	-	94.5
Ratio of concentration	-	13.1.

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(Test No. 2, cont'd) -

The same tailing loss was obtained as in Test No. 1. A screen analysis of the flotation tailing showed that the +200 mesh portion assayed 0.03 and the -200 mesh portion assayed 0.025 ounce gold per ton. This indicates that grinding to pass 200 mesh is advisable.

Test No. 3.

To determine the lowest tailing obtainable, a number of tests were made following the same procedure as above. The flotation practice differed slightly as after 7 minutes of flotation, reagents were added and flotation was continued for 7 minutes to remove as much of the arsenopyrite as was possible. From assays of the various tests, a grind of 97 per cent minus 200 mesh was found to give the lowest tailing, i.e. 0.01 oz./ton. The concentrates from this series of tests were combined and reserved for cyanidation tests.

Reagents:

To the ball mill -		Lb./ton
Soda ash	-	3.0
Potassium amyl xanthate	-	0.2
To flotation -		
Pine oil	-	0.15

pH, 9.7.

Pulp density, 22 per cent solids.
Flotation time, about 7 minutes.

A concentrate obtained appeared to be mostly pyrite.

Flotation of arsenopyrite -

Additional reagents to flotation:

Copper sulphate	-	1.0
Potassium amyl xanthate	-	0.1
Pine oil	-	0.05

Flotation time, about 7 minutes.

The resulting concentrates were combined for treatment to extract gold.

The concentrates were not recleaned.

Results:

Amalgamation (-40 mesh grind):

Feed	=	0.41 oz./ton.
Tailing	=	0.14 "
Recovery	=	65.8 per cent.

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(Test No. 3, cont'd) -

Flotation:

Products	Weight, per cent	Assays, Au, oz./ton	Distribution of gold, per cent: In test	Distribution of gold, per cent: In orig. feed	Ratio of concentration
Feed	100.0	0.14	100.0	34.2	
Concentrate	12.6	1.00	91.3	31.2	8:1.
Tailing	87.4	0.0137*	8.7	3.0	

* Combined tailing from series.

		Per cent
Recovered by amalgamation	-	65.8
" " flotation	-	31.2
		97.0

It is to be noted that the recovery by amalgamation in this test is higher than in previous tests.

Test No. 4.

A series of batch flotation tests was made from amalgamation tailing to obtain a higher grade of concentrate than that produced in Test No. 3. In this series the concentrate was cleaned without additional reagents and was saved for subsequent cyanidation tests.

Results:

Amalgamation

Feed	-	0.41 oz./ton.
Tailing	-	0.17 "
Recovery	-	58.5 per cent.

Flotation:

Products	Weight, per cent	Assays, Au, oz./ton	Distribution of gold, per cent: In test	Distribution of gold, per cent: In orig. feed	Ratio of concentration
Feed	100.0	0.17	100.0	41.5	
Concentrate	5.2	2.89	88.0	36.5	19.3:1.
Cleaner tailing	3.9	0.17	4.0	1.7	25.2:1.
Flot. tailing	90.9	0.015	8.0	3.3	

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(Test No. 4, cont'd) -

The rougher concentrate had a calculated assay of 1.71 oz. gold per ton with a ratio of concentration of 10.9:1.

The cleaner concentrate contained 7.70 per cent arsenic and 24.73 per cent sulphur.

Test No. 5.

A test similar to Test No. 4 was carried out to obtain a further quantity of concentrate for subsequent testing. The results check those of the above or show a slight improvement.

Results:

Amalgamation -

Feed	-	0.41 oz./ton.
Tailing	-	0.16 "
Recovery	-	61.0 per cent.

Flotation:

Products	Weight, per cent	Assays, Au, oz./ton	Distribution of gold, per cent: In test	Distribution of gold, per cent: In orig. feed	Ratio of concentration
Feed	100.0	0.16	100.0	39.0	
Concentrate	4.1	3.62	90.2	35.2	24.3:1.
Cleaner tailing	4.2	0.06	1.5	0.6	24.2:1.
Flot. tailing	91.7	0.015	8.3	3.2	

This test shows a recovery of 96.2 per cent by amalgamation and flotation.

Test No. 6.

A third series of batch tests similar to the preceding was carried out. In this series the cleaner tailing from each test was ground and added to the next batch for flotation. Butyl xanthate was used in place of amyl xanthate.

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(Test No. 6, cont'd) -

Results:

Amalgamation -

Feed - 0.41 oz./ton.
Tailing - 0.19 "

Recovery - 53.7 per cent.

Flotation:

Products	Weight, per cent	Assays, Au, oz./ton	Distribution of gold, per cent: In test	Distribution of gold, per cent: In orig. feed	Ratio of concentration
Feed	100.00	0.19	100.0	46.3	
Concentrate	4.10	4.30	91.9	42.6	24.4:1.
Cleaner tailing	0.65	0.18	0.6	0.3	153.8:1.
Flot. tailing	95.25	0.015	7.5	3.4	

Infrasizing.

To determine the distribution of gold in the residues, a sample of the flotation tailing was infrasized.

Infrasizer data:

Drops per minute, 63.
Differential pressure, 18 inches water.
Standard golf balls.
Weight of charge, 400 grams.
Time, 6 hours.

Results:

Products, size in nominal microns	Weight, per cent	Assays, Au, oz./ton	Assays, S, per cent	Distribution per cent, Au	Distribution per cent, S
Feed	100.00	0.015	0.13	100.0	100.0
+56 microns	5.22	0.03	0.07	10.0	2.8
-56+40 "	10.87	0.03	0.05	20.8	4.2
-40+28 "	12.65	0.015	0.04	12.1	3.9
-28+20 "	13.05	0.01	0.05	8.3	5.0
-20+14 "	11.25	0.01	0.07	7.2	6.1
-14+10 "	10.88	0.01	0.10	7.0	8.4
-10 "	36.08	0.015	0.25	34.6	69.6

These results indicate that a tailing of 0.015 ounce gold per ton is the lowest that can be expected with an economic grind.

PART II. - CYANIDATION AND ROASTING OF FLOTATION CONCENTRATES.

Cyanidation of Flotation Concentrates.

Samples of rougher and cleaner concentrates were cyanided in a 3.0 pound NaCN per ton solution at a dilution of 1 part solids to 3 parts of solution.

Some portions were reground in cyanide solution prior to agitation. The period of agitation was 48 hours. Lime was used to give protective alkalinity to the solutions.

Roasting Procedure.

The concentrates were roasted by the method (known as the Short Roast) which was developed by research chemist F. R. Archibald (and associates), of Beattie Gold Mines (Quebec) Limited, and was reported in the Bulletin of the Canadian Institute of Mining and Metallurgy, Transactions, Volume XLII, 1939, pp. 608-631.

The roasting method was essentially as follows:

The portion of concentrate to be roasted was placed in a roasting dish and put into a muffle furnace at an initial temperature of 200° C. The door was closed and air was excluded during the period of raising the temperature to 480° C., which was about 30 minutes. The door was then opened sufficiently to permit continuous rabbling while white fumes of As_2O_3 were coming off. During this time the temperature was held as closely as possible to 480° C. When no more white fumes were seen the temperature was raised to 650° C., leaving the door open. This takes about 30 minutes. When cool enough to handle, the charge was removed from the furnace.

It is to be noted that the door is the only opening to the muffle and when it is open the air enters and the fumes

(Roasting Procedure, cont'd) -

leave from it. It is necessary that the furnace be fitted with a suitably arranged door and fume-collecting device or hood.

The roasted concentrates were reground in cyanide solution and cyanided similarly as were the raw concentrates.

Screen tests showed that the reground concentrates were over 99 per cent minus 325 mesh.

For ease of comparison, the results of the various tests comprising Part II are now given in tabulation form, as follows:

Roasting Raw Concentrates.

Concentrates from Test No.	Assays of Concentrates			Gold in roasted conc., per cent		Extraction by cyanidation, per cent	
	Au, oz./ton	Per cent As	Per cent S	In test	In orig. feed	In test	In orig. feed
(3) Raw	1.00	2.14	8.46				
(3) Roasted	1.02	0.81	1.82	94.2	29.4	94.1	27.7
(4) Raw*	4.22	8.41	-				
(4) Roasted	5.00	0.58	1.94	88.7	32.4	95.2	30.8
(5) Raw	3.62	-	-				
(5) Roasted	4.00	-	-	85.8	30.2	94.5	28.5
(6) Raw	4.30	1.41	28.20				
(6) Roasted	4.73	0.24	2.50	85.1	36.3	92.8	33.7

* The feed to the roast was made up of a composite sample of concentrate. The assay of the raw concentrate was a calculated value.

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Cyanidation of Raw Concentrates.

Concentrate from Test No.	Assay, Au oz./ton Feed	Assay, Au oz./ton Tailing	Extraction, per cent	Final titration, lb./ton solution NaCN	Final titration, lb./ton solution CaO	Reagents consumed lb./ton conc. NaCN	Reagents consumed lb./ton conc. CaO	Reagents consumed lb./ton ore NaCN	Reagents consumed lb./ton ore CaO	R.P., ml. 1/10 N $KMnO_4$ per litre
(3) Rougher conc.	1.00	0.52	48.0	3.2	0.30	4.6	22.3	0.58	2.8	160.0
(3) Reground rougher conc.	1.00	0.15	85.0	3.5	0.15	11.9	40.2	1.87	6.3	520.0
(4) Cleaner conc.	2.89	1.19	58.8	2.5	0.4	16.4	41.5	0.85	2.15	176.0
(5) Reground cleaner conc.	3.62	0.56	84.5	3.0	0.20	15.0	29.7	0.62	1.22	910.0
(6) Reground cleaner conc.	4.30	0.50	88.4	2.5	0.30	5.5	21.4	0.23	0.88	404.0

Cyanidation of Roasted Concentrate.

Concentrate from Test No.	Assay, Au oz./ton Feed	Assay, Au oz./ton Tailing	Extraction, per cent	Final titration, lb./ton solution NaCN	Final titration, lb./ton solution CaO	Reagents consumed lb./ton conc. NaCN	Reagents consumed lb./ton conc. CaO	Reagents consumed lb./ton ore NaCN	Reagents consumed lb./ton ore CaO	R.P., ml. 1/10 N $KMnO_4$ per litre
(3) Reground	1.02	0.06	94.1	3.2	0.40	7.4	37.8	0.86	4.4	55.0
(4) Reground	5.00	0.24	95.2	2.9	0.5	12.2	42.0	0.47	1.63	40.0
(5) Reground	4.00	0.22	94.5	3.0	0.10	20.[illegible]	58.9	0.65	1.88	56.0
(6) Reground	4.73	0.34	92.8	2.6	0.4	23.3	12[illegible].2	0.95	5.3	200.0

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Overall Recoveries by Amalgamation and Cyanidation of the Raw Concentrates.

Concentrate from Test No.	Recovery, per cent					
	Amalgamation	Flotation		Cyanidation		Total, per cent
	In orig. feed	In test	In orig. feed	In test	In orig. feed	
(3) Rougher conc.	65.8	91.3	31.2	48.0	15.0	80.8
(3) Reground	65.8	91.3	31.2	85.0	26.5	92.3
(4) Cleaner conc.	58.5	88.0	36.5	58.8	21.5	80.0
(5) Reground	61.0	90.2	35.2	84.5	29.8	90.8
(6) Reground	53.7	91.9	42.6	88.4	37.7	91.4

Overall Recoveries by Amalgamation and Cyanidation of the Roasted Concentrates.

Concentrate from Test No.	Recovery, per cent						
	Amalgamation	Flotation		Cyanidation			Total, per cent
	In orig. feed	In test	In orig. feed	In roast	Test	Feed	
(3) Reground	65.8	91.3	31.2	29.4	94.1	27.7	93.5
(4) Reground	58.5	88.0	36.5	32.4	95.2	30.8	89.3
(5) Reground	61.0	90.2	35.2	30.2	94.5	28.5	89.5
(6) Reground	53.7	91.9	42.6	36.3	92.8	33.7	87.4

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Distribution of Gold in the Products of the Tests.

Test No.	RECOVERY, PER CENT Amalga-mation	Cyani-dation	Total	LOSS OF GOLD, PER CENT Cleaner tailing	Flot. tailing	Cyanide tailing	Roast	TOTAL, PER CENT
3	65.8	15.0	80.8	-	3.0	16.2	-	100.0
3	65.8	26.5	92.3	-	3.0	4.7	-	100.0
3	65.8	27.7	93.5	-	3.0	1.7	1.8	100.0
4	58.5	21.5	80.0	1.7	3.3	15.0	-	100.0
4	58.5	30.8	89.3	1.7	3.3	1.6	4.1	100.0
5	61.0	29.8	90.8	0.6	3.2	5.4	-	100.0
5	61.0	28.5	89.5	0.6	3.2	1.7	5.0	100.0
6	53.7	37.7	91.4	0.3	3.4	4.9	-	100.0
6	53.7	33.7	87.4	0.3	3.4	2.6	6.3	100.0

SUMMARY AND CONCLUSIONS:

Plate amalgamation at a minus 40 mesh grind resulted in recoveries of from 53 to 65 per cent of the gold in the feed.

The flotation tailings contain 0.015 ounce gold per ton which cannot be recovered by the method of treatment which has been investigated and is to be used in practice.

Butyl xanthate as a flotation collector is preferred over amyl xanthate as this reagent raised the grade of concentrate recovered and resulted in a higher ratio of concentration without a corresponding lowering of the recovery of gold.

The average flotation tailing assayed 0.015 ounce gold per ton from amalgamation tailings reground 98 per cent minus 200 mesh. This is apparently the minimum tailing to be expected from this ore. Assays of tailings ground 99 per cent minus 200 mesh assayed 0.015 ounce gold per ton in the minus

(Summary and Conclusions, cont'd) -

200 mesh portion of the tailing.

Infrasizing a portion of this tailing shows that gold and sulphur occur in the various fractions from 56 microns to minus 10 microns. The minus 10 micron portion contains 34.6 per cent of the gold and 69 per cent of the sulphur in the tailing.

Cyaniding the raw flotation concentrate without regrinding resulted in a tailing assaying 1.19 ounces gold per ton, with an extraction of 58.8 per cent of the gold. Regrinding and cyaniding increased the extraction to 88.4 per cent of the gold.

Roasting the concentrates resulted in higher extractions of gold with less fouling of the solutions, this, however, apparently caused loss of gold during the roast. It was noted that with a low-grade rougher concentrate a loss of 1.8 per cent of the gold occurred, and that when a high-grade cleaner concentrate was roasted the loss increased from 4 to 6 per cent of the gold in the original feed.

Cyaniding the roasted rougher concentrate resulted in an increase of 1.2 per cent in the overall recovery of gold over that obtained from the raw concentrate; while from cyaniding the roasted cleaner concentrate lower overall recoveries of gold resulted, due to the higher losses in roasting these concentrates.

The results of the investigation indicate that the increase in recoveries resulting from roasting the flotation concentrate would not cover the additional expense of roasting. Only one test indicated a slight increase in overall recovery by roasting the concentrate. The remaining tests showed that, due to gold losses while roasting, a higher overall recovery may be expected by cyaniding the raw concentrate. Due to

(Summary and Conclusions, cont'd) -

increased fouling of the cyanide solutions by these raw concentrates, some loss of cyanide by bleeding barren solution to waste should be expected.

The results obtained apply only to ore similar in grade and character to that submitted in the shipment for this investigation.

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