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O T T A W A December 11th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1759.

Concentration Tests for Recovery of Gold from a Radium Residue submitted by the Radium Luminous Industries Limited, Toronto, Ontario.

(Copy No. 14.)

Bureau of Mines
Division of Metallic
Minerals.
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Ore Dressing
and Metallurgical
Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch
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Shipment:

A shipment of ore residue, weighing 162 pounds, was received on September 23rd, 1944. This shipment was submitted by the Radium Luminous Industries Limited, 103 Church Street, Toronto, Ontario, per Scott Stockwell, General Manager,

The shipment was said to have been taken from the Port Hope radium refinery's dump, which consists of several hundred tons of material remaining after complete chemical extraction of radium and uranium from a high-grade pitchblende concentrate. The pitchblende concentrate originally contained gold and silver and the chemical refining has reduced the original weight to about 15 per cent in the form of these residues. The bulk of the precious metals must have been concentrated proportionally in the residues. The radium left in the residues is less than 10 milligrams per dry ton.

Purpose of the Investigation:

The investigation was requested to determine whether the residue can be concentrated to reduce the bulk and increase the gold content of the concentrated product.

Sampling and Analysis:

The shipment was sampled by standard methods. A head sample assayed for gold and silver was found to contain:

Gold	-	1.70 oz./ton.
Silver	-	15.91 "
Iron	-	5.92 per cent.
Silica (SiO_2)	-	79.28 "

A spectrographic analysis indicated the presence of numerous elements, including copper, lead, nickel, cobalt, bismuth, vanadium, molybdenum, titanium, silicon and zinc.

A screen analysis was made to determine the distribution of gold in the residue.

Product	Weight, per cent	Assay, Au, oz./ton	Distribution of gold, per cent
Feed	100.0	1.71	100.0
+ 48 mesh	3.6	0.31	0.64
- 48+ 65 "	2.7	0.29	0.46
- 65+100 "	4.1	0.41	0.98
-100+150 "	9.9	0.69	4.00
-150+200 "	10.7	0.80	4.98
-200 "	69.0	2.21	88.94

Results of the Investigation:

It is possible to decrease the bulk of this material 30 per cent by screening through 200 mesh. Approximately 89 per cent of the contained gold is in the very fine material passing through the screen. This is not a very practical method as 11 per cent of the gold would be lost in the plus 200 mesh portion. The grade is raised from 1.71 ounces to 2.21 ounces of gold per ton.

Concentration tests by tabling, jigging traps or blankets were not successful; little, if any, concentration was obtained.

Barrel and plate amalgamation was also tried, but

(Results of the Investigation, cont'd) -

no recovery was obtained and the mercury floured badly.

Cyanidation extracted 88 per cent of the gold and 92 per cent of the silver. Cyanide consumption was 3.4 pounds per ton of residue. The solution fouled badly, so that it will be necessary to waste a large amount of cyanide, thus raising the cyanide consumption to probably double the figure indicated. The presence of other metals in the material would probably cause precipitation troubles.

Flotation recovers approximately 90 per cent of the gold as a concentrate assaying 3.47 ounces per ton and constituting 44.9 per cent of the weight of feed. The froth obtained was troublesome to handle.

The results of the tests indicate that there is no simple or inexpensive method to recover the gold from this material.

Investigative Procedure;

The tests included concentration of jigs, blankets, Wilfley table, amalgamation, and flotation.

Cyanidation tests included straight cyanidation, cyanidation of blanket tailings, and a cyanide cycle test.

Screen analyses and infrasizer tests on various products were included in some tests.

DETAILS OF INVESTIGATIVE TESTS:

Test No. 1. - Jig Concentration.

A sample of the residue was ground 10 minutes in a jar mill at a dilution of 4 parts residue to 3 parts water. The ground pulp was passed through a Denver laboratory jig. The jig concentrate was recleaned. The products of the jig were assayed. A screen test shows 86.7 per cent of the feed passed a 200-mesh screen.

Results:

Jig Concentration.

Product	Weight, per cent	Assays, oz./ton		Distribution, per cent		Ratio of concentration
		Au	Ag	Au	Ag	
Feed	100.0	1.70	15.91	100.0		
Concentrate	0.8	6.42	12.07	3.1		125:1.
Middling	3.6	0.36	-	0.8		
Tailing	95.6	1.71	-	96.1		

Test No. 2. - Jig and Blanket Concentration.

In this test the jig tailing was run over corduroy blankets sloping 1½ inches in 12 inches.

The jig and blanket concentrates were assayed. The blanket tailing was held for and treated by cyanidation in Test No. 9.

Results:

Jig Concentration.

Product	Weight, per cent	Assays, oz./ton		Distribution, per cent		Ratio of concentration
		Au	Ag	Au	Ag	
Feed	100.0	1.71	16.55	100.00	100.00	
Jig conc.	1.66	4.22	11.10	4.09	1.11	60.2:1.
Jig tailing	98.34	1.67	16.64	95.91	98.89	

Blanket Concentration.

Blanket feed	98.34	1.67	16.64	95.91	98.89	
" conc.	1.19	3.71	10.18	2.57	0.73	82.6:1.
" tailing	97.15	1.65	16.22	93.34	98.16	

(Details of Investigative Tests, cont'd) -

Test No. 3. - Plate Amalgamation.

A sample of the residue as received was repulped in water and amalgamated by plate amalgamation.

The feed for this test was resampled and the head sample cut out assayed:

Gold - 1.665 oz./ton
Silver - 14.65 "

The amalgamated tailing was assayed and a screen analysis was also made.

Results:

Plate Amalgamation.

Assays, oz./ton				Recovery, oz./ton		Recovery, per cent	
Feed		Tailing					
Au	Ag	Au	Ag	Au	Ag	Au	Ag
1.665	14.65	1.650	14.43	0.015	0.22	0.90	1.50

Screen Analysis on Amalgamation Tailing.

Product	Weight, per cent	Assays, oz./ton		Distribution, per cent	
		Au	Ag	Au	Ag
Feed*	100.0	1.67	14.73	100.0	100.0
+100 mesh	10.8	0.59	5.27	3.8	3.9
-100+150 "	13.2	0.94	7.51	7.4	6.7
-150+200 "	14.0	0.96	7.41	8.1	7.1
-200 "	62.0	2.18	19.58	80.7	82.3

* Calculated value from the products of the test.

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Test No. 4. - Barrel Amalgamation.

A sample of the residue was barrel-amalgamated with mercury added at the rate of 10 per cent of the dry weight of the residue and lime at the rate of 20 pounds per ton.

After separating the mercury and amalgam, the amalgamated tailing was assayed.

Results:

Barrel Amalgamation.

Assays, oz./ton				Recovery, oz./ton		Recovery, per cent	
Feed		Tailing					
Au	Ag	Au	Ag	Au	Ag	Au	Ag
1.665	14.65	1.58	14.57	0.085	0.08	5.11	0.5

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(Details of Investigative Tests, cont'd) -

Test No. 5. - Table Concentration.

A sample of the residue as received was concentrated on a Wilfley table, making a concentrate, middling and tailing. A portion of the tailing was used to make a screen analysis, to show the distribution of gold and silver in the tailing.

Results:

Table Concentration.

Product	Weight, per cent	Assays, oz./ton Au	Assays, oz./ton Ag	Distribution, per cent Au	Distribution, per cent Ag	Ratio of concentration
Feed*	100.0	1.62	15.00	100.00	100.00	
Concentrate	1.1	1.89	7.07	1.29	0.52	90.1:1.
Middling	0.8	0.73	4.51	0.35	0.23	128.2:1.
Tailing	98.1	1.62	15.16	98.36	99.25	

Screen Analysis of Table Tailing.

Product	Weight, per cent	Assays, oz./ton Au	Assays, oz./ton Ag	Distribution, per cent Au	Distribution, per cent Ag
Feed*	100.0	1.65	15.08	100.00	100.00
+ 48 mesh	4.6	0.76	4.825	2.13	1.48
- 48+ 65 "	1.8	0.396	5.502	0.44	0.67
- 65+100 "	4.4	0.824	6.976	2.20	2.04
-100+150 "	12.9	0.870	7.980	6.79	6.82
-150+200 "	10.5	0.780	6.390	5.01	4.44
-200 "	65.8	2.095	19.385	83.43	84.55

* Calculated values from the products.

Test No. 6. - Table Concentration and Amalgamation of Concentrate.

This test was made on a sized feed. A portion of the residue was screened on the following screens: 20, 35, 48, and 65 mesh. The plus 20 mesh residue was crushed to pass 20 mesh. The following products were obtained: -20+35 mesh, -35+48 mesh, -48+65 mesh, and -65 mesh.

The plus 65 mesh products were concentrated on a Wilfley table, producing a concentrate and a tailing from each. The concentrates were combined and assayed. The table tailing was reground to pass 65 mesh and combined with the original

(Test No. 6, cont'd) -

minus 65 mesh residue. This product was then concentrated on the Wilfley table. The concentrate was recleaned on a Haultain superpanner. The concentrate was amalgamated by barrel amalgamation.

A sample of minus 65 mesh table tailing was used for a screen analysis to show the distribution of gold and silver in this product.

Results of Wilfley Table Concentration of Sized Feed: Plus 65 Mesh Concentration.

Product	Weight, per cent	Assays, oz./ton Au	Assays, oz./ton Ag	Distribution, per cent Au	Distribution, per cent Ag	Ratio of concentration
Feed*	100.00	1.54	14.88	100.00	100.00	
Concentrate	0.26	3.23	29.19	0.54	0.51	384.6:1.
Tailing	99.74	1.54	14.84	99.46	99.49	

Minus 65 Mesh Concentration.

Product	Weight, per cent	Assays, oz./ton Au	Assays, oz./ton Ag	Distribution, per cent Au	Distribution, per cent Ag	Distribution, in per cent of original feed: Au	Distribution, in per cent of original feed: Ag	Ratio of concentration
Feed*	99.74	1.54	14.84	100.00	100.00	99.46	99.49	
Pan conc.	2.91	2.21	8.10	4.20	1.59	4.18	1.58	34.2:1.
Pan middling	1.43	1.26	5.80	1.17	0.56	1.16	0.56	70:1.
Pan tailing	2.97	0.30	2.38	0.58	0.48	0.58	0.48	33.6:1.
Table tailing	92.43	1.56	15.59	94.05	97.37	93.54	96.87	-

* Calculated values.

Amalgamation of the Table Concentrate from the Minus 65 Mesh Feed.

The recleaned table concentrate was amalgamated by barrel amalgamation.

After separating the mercury and amalgam from the amalgamated concentrate, each product was assayed for gold.

(Continued on next page)

(Test No. 6, cont'd) -

Results:

Gold in concentrate - 2.21 oz./ton.
" " amalgamated conc. - 1.28 "

Gold recovered in mercury - 0.93 "

Recovery of gold, $\frac{0.93}{2.21} \times 100$ = 42.08 per cent of gold in concentrate.

Gold in concentrate, in terms of feed = 4.18 per cent.

Recovery by amalgamation of concentrate =

42.08 x 4.18 = 1.76 per cent of the gold in original feed.

Screen Analysis of Minus 65 Mesh Wilfley Table Tailings.

Product	Weight, per cent	Assays, oz./ton Au	Assays, oz./ton Ag	Distribution, per cent Au	Distribution, per cent Ag
Feed*	100.00	1.56	14.95	100.00	100.00
- 65+100 mesh	2.87	0.31	2.92	0.57	0.56
-100+150 "	9.75	0.59	4.78	3.68	3.12
-150+200 "	11.53	0.60	5.22	4.43	4.03
-200 "	75.85	1.88	18.19	91.32	92.29

* Calculated value.

Test No. 7. - Straight Cyanidation.

A sample of the residue was ground in cyanide solution containing 1.0 pound NaCN per ton. Lime was added to give protective alkalinity to the pulp. The ratio of dilution during the grind was 4 parts solids to 3 parts of solution. The degree of grinding was 96 per cent through 200 mesh.

The ground pulp was agitated for 24 hours at a dilution of 1½ parts of solution to 1 part solids which was held at approximately 1.0 pound NaCN per ton of solution. Frequent additions of reagents, NaCN and lime, were required to hold the strength of the solution.

After 24 hours' agitation the pulp was filtered, the

(Test No. 7, cont'd) -

cyanide tailings were assayed for gold and silver, and the solution was tested for reducing power and KCNS.

Results:

Agitation period, hours	Assays, oz./ton Feed Au	Feed Ag	Tailing Au	Tailing Ag	Extraction, per cent Au	Extraction, per cent Ag	Final titration, lb./ton solution NaCN	Final titration, lb./ton solution CaO	Reagents consumed, lb./ton ore NaCN	Reagents consumed, lb./ton ore CaO
24	1.70	15.91	0.28	1.31	83.53	91.77	1.0	0.1	3.4	22.85

Reducing power of the cyanide solution: 347.8 c.c. N/10 $KMnO_4$ per litre.

KCNS, 0.31 gram per litre.

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Test No. 8. - Straight Cyanidation.

The sample of the residue was ground 96 per cent minus 200 mesh in water, filtered, and washed with water.

The residue was then repulped in cyanide solution and agitated for 48 hours.

The cyanide tailing was assayed and a portion was screened on a 200-mesh screen. The minus 200 mesh fraction was sized on the Haultain infrasizer. Each of the fractions was assayed for gold and silver to show the distribution of values in the cyanide tailing.

Results:

Cyanidation.

Agitation period, hours	Assays, oz./ton Feed Au	Feed Ag	Tailing Au	Tailing Ag	Extraction, per cent Au	Extraction, per cent Ag	Final titration, lb./ton solution NaCN	Final titration, lb./ton solution CaO	Reagents consumed, lb./ton ore NaCN	Reagents consumed, lb./ton ore CaO
48	1.70	15.91	0.20	1.28	88.2	92.0	1.0	0.12	4.5	17.8

Reducing power of the cyanide solution: 257.0 c.c. N/10 $KMnO_4$ per litre.

KCNS, 0.37 gram per litre.

(Continued on next page)

(Test No. 8, cont'd) -

Infrasizer Test on the Cyanide Tailing.

Product	Weight, per cent	Assays, oz./ton Au	Assays, oz./ton Ag	Distribution, per cent Au	Distribution, per cent Ag
Feed*	100.00	0.22	1.44	100.0	100.0
+200 mesh	4.30	0.29	1.07	5.7	3.2
-200+56 mesh microns	1.03	0.486	1.18	2.3	0.8
- 56+40 "	14.90	0.08	0.81	5.5	8.4
- 40+28 "	19.72	0.14	1.01	12.7	13.8
- 28+20 "	15.52	0.15	0.98	10.8	10.5
- 20+14 "	9.40	0.14	1.02	6.1	6.6
- 14+10 "	7.48	0.17	1.15	5.9	6.0
- 10 "	27.65	0.40	2.65	51.0	50.7

* Calculated value.

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Test No. 9. - Cyanidation of Blanket Tailing

A sample of the blanket tailing from Test No. 2 was repulped, at a dilution of 1½:1, in cyanide solution containing 1.0 pound NaCN per ton of solution. Lime was added for protective alkalinity. The agitation was discontinued after 24 hours.

Results:

Agitation period, hours	Assays, oz./ton Feed Au	Assays, oz./ton Feed Ag	Assays, oz./ton Tailing Au	Assays, oz./ton Tailing Ag	Extraction per cent Au	Extraction per cent Ag	Final titration, lb./ton solution NaCN	Final titration, lb./ton solution CaO	Reagents consumed, lb./ton ore NaCN	Reagents consumed, lb./ton ore CaO
24	1.65	16.22	0.25	1.49	84.85	90.8	1.0	0.16	3.1	16.9

Washing of pulp prior to cyanidation reduces the amount of reagents consumed.

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Test No. 10. - Straight Cyanidation Cycle Tests.

This test was made to determine the amount of fouling of the solutions and the extraction to be expected in treating the residue by cyanidation.

The first cycle: The residue was ground 96 per cent minus 200 mesh and agitated, at a dilution of 1½:1,

(Test No. 10, cont'd) -

in a 1.0 pound NaCN per ton solution for 48 hours.

The pulp was filtered and the cyanide tailing was sampled for assay.

The second cycle: A fresh sample of the residue was ground in solution from the first cycle, with additions of cyanide and lime as required. The pulp was diluted, as in Cycle No. 1, to 1½:1 with the remaining solution which had been previously subjected to clarification, de-aeration, precipitation, and filtration (to remove gold precipitate).

The third cycle was made similarly to the second cycle. The period of agitation was 48 hours for each cycle.

At the end of the third cycle the solution was tested for reducing power and KCNS.

The extraction of gold decreased in the third cycle.

The results indicate considerable fouling of the solution during cyanidation.

Results:

Cycle Test

Cycle No.	Agitation period, hours	Assays, oz./ton Feed Au	Feed Ag	Tailing Au	Tailing Ag	Extraction, per cent Au	Extraction, per cent Ag	Final titration, lb./ton solution NaCN	Final titration, lb./ton solution CaO	Reagents consumed, lb./ton ore NaCN	Reagents consumed, lb./ton ore CaO
1	48	1.665	14.65	0.205	1.14	87.7	92.2	0.88	0.16	4.9	14.8
2	48	1.665	14.65	0.19	0.97	88.6	93.4	0.80	0.10	4.9	14.9
3	48	1.665	14.65	0.30	1.44	82.0	90.2	0.80	0.15	4.9	14.9

Reducing power solution, third cycle, 780 c.c. N/10 $KMnO_4$ per litre.

KCNS, 0.78 gram per litre.

Test No. 11 - Flotation.

This test was made in a natural pulp.

A sample of the residue, from which the plus 20 mesh portion had been screened out, was repulped in a flotation machine with water.

The pulp was conditioned with the following reagents

(Test No. 11, cont'd) -

for 10 minutes:

Reagent No. 208, 0.4 pound per ton.
" " 301, 0.4 " " "

Then 0.1 pound of pine oil was added.

A very voluminous froth resulted which consisted of the slime portion of the pulp. When the froth subsided, further additions of Reagents Nos. 208 and 301, 0.1 pound per ton, were made. The concentrate resulting from this addition was kept separate from the first recovery.

It was noted that the coarser particles of the pulp showed no tendency to float.

Results:

Product	Weight, per cent	Assay, Au, oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.0	1.73	100.0	
Conc. No. 1	44.3	3.48	89.0	2.3:1.
Conc. No. 2	4.7	1.56	4.2	21.4:1.
Combined conc.	49.0	3.30	93.2	2.04:1.
Flot. tailing	51.0	0.23	6.8	-

Test No. 12. - Flotation.

In this test the pulp was made alkaline with soda ash.

The minus 20 mesh residue was repulped in a flotation machine with 8 pounds of Na_2CO_3 per ton (pH, 9.15). A froth formed which carried most of the slimes. This material was removed and designated Concentrate No. 1.

Then 0.45 pound of sodium sulphide per ton was added and the pulp was conditioned for 10 minutes. Amyl xanthate was then added at the rate of 0.1 pound per ton, followed by 0.1 pound of pine oil per ton. A small volume of concentrate

(Test No. 12, cont'd) -

was recovered and this was designated Concentrate No. 2.

Results:

Product	Weight, per cent	Assay, Au, oz./ton	Distribution of gold, per cent	Ratio of concentration
Feed	100.0	1.72	100.0	
Conc. No. 1	39.1	3.66	83.1	2.56:1.
Conc. No. 2	5.8	2.16	7.3	17.3:1.
Combined conc.	44.9	3.47	90.4	2.23:1.
Flot. tailing	55.1	0.30	9.6	

Summary:

A screen analysis of the feed shows that 88.9 per cent of the gold was contained in the minus 200 mesh fraction, 69 per cent of the feed, and assayed 2.21 ounces of gold per ton.

A jig concentrate recovered 3 per cent of the gold, in a concentrate assaying 6.42 ounces of gold per ton, with a ratio of concentration of 125:1.

Blanket concentration of the jig tailing recovered 2.6 per cent of the gold, in a concentrate assaying 3.71 ounces of gold per ton with a ratio of concentration of 82.6:1.

Barrel amalgamation recovered 5.1 per cent of the gold in the residue.

Table concentration resulted in a recovery of 4.2 per cent of the gold in a concentrate assaying 2.21 ounces of gold per ton. The ratio of concentration was 34:1. Amalgamation of the concentrate resulted in a recovery of 1.76 per cent of the gold in terms of original feed.

Straight cyanidation of the residue resulted in an extraction of 83.5 per cent of the gold and 91.8 per cent of the silver within 24 hours and 88.2 per cent of the gold and

(Summary, cont'd) -

92 per cent of the silver within 48 hours.

An infrasizer test on the 48-hour tailing shows that 51 per cent of the gold in the tailing remains in the minus 10 micron fraction of the tailing, which assays 0.40 ounce of gold per ton.

The cyanidation cycle test indicates that after the second cycle the extraction begins to decrease. The solution becomes fouled, with a reducing power of 780 c.c. of 1/10 N $KMnO_4$ per litre and KCNS of 0.78 gram per litre.

Flotation recovers 93.2 per cent of the gold, in a concentrate assaying 3.3 ounces of gold per ton with a ratio of concentration of 2.04:1.

CONCLUSIONS:

The results of the investigation indicate that the minus 200 mesh portion of the feed contains approximately per cent of the gold. The gold and silver could not be concentrated from this fraction of the residue.

It was not amenable to amalgamation.

Flotation resulted in the concentration of the slimes (minus 200 mesh portion) of the feed, at a low ratio of concentration.

Cyanidation extracted 88 per cent of the gold within 48 hours with heavy fouling of the solution. This method gave the highest recovery of values in the tests. It is to be expected that large-scale operation of this process would result in excessive consumption of cyanide caused by the fouling of the solution, due to various cyanicides in the residue and resultant bleeding of solution.

Since concentration methods fail to offer a solution for the treatment of the residue, it may be possible to ship the material to a smelter.

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