

O T T A W A

November 30th, 1940.

R E P O R T


of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 921.

Roasting and Cyanidation of Flotation
Concentrate from the Cochenour Willans Gold
Mines, Limited, McKenzie Island, Ontario.

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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Concentrate from the Cochenour Willans Gold
Mines, Limited, McKenzie Island, Ontario.

Shipments:

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A shipment of 20 pounds of Cochenour Willans
flotation concentrate was received on August 9th, 1940,
from Shoemaker and Burnham, Consulting Engineers, 45 Richmond
Street West, Toronto. A 17-pound shipment was received on
the same date from O. Matthews, Mill Superintendent,

Cochencour Willans Gold Mines, Limited, McKenzie Island, Ontario. The analyses and screen tests of these two shipments indicate that they represent the same product. In the work reported here, the two shipments were regarded as one product.

Purpose of Investigation:

The investigation was made to obtain information on a method of roasting which would result in a calcine amenable to cyanidation.

Analysis of the Concentrates:

The concentrates as received gave the following screen tests:

<u>Mesh</u>	<u>Weight, per cent</u>	
	<u>Shipment No. 1.</u>	<u>Shipment No. 2.</u>
+100	0.7	0.7
+150	2.2	2.3
+200	4.7	4.7
+325	6.4	5.3
-325	86.0	87.0
	<u>100.0</u>	<u>100.0</u>

and gave the following analyses:

	<u>Sample No. 1</u>	<u>Sample No. 2.</u>
Gold	3.64 oz./ton	3.62 oz./ton
Iron	20.20 per cent	
Sulphur	15.10 "	15.10 per cent
Arsenic	9.94 "	9.95 "
Insoluble	10.77 "	10.84 "
CaO	10.90 (CaCO ₃ , 19.45)	
MgO	6.74 (MgCO ₃ , 14.10)	

Shipment No. 1 - From Shoemaker and Burnham.
" No. 2 - " O. Matthews, Supt.

The material as received was too finely ground

(Continued on next page)

(Analysis of the Concentrates, cont'd) -

to be suitable for microscopic examination. The $\text{CaCO}_3\text{-MgCO}_3$ ratio of the carbonate fraction of the gangue indicates that it consists of dolomite.

Roasting Practice:

Two different methods of roasting were used:

(a) A slow roast lasting 6 to 8 hours. These roasts were made in a Globar electric furnace with automatic temperature control. Air was admitted through the front of the furnace, the gases were drawn off at the back of the furnace by an exhaust pipe connected with a controlled suction. By this arrangement a current of air replaced the gases above the roasting material more or less completely and provided an oxidizing condition during the entire time of the roast. The suction and amount of air admitted were so regulated as to be just sufficient to sweep the fume out by the exhaust pipe. The temperatures given are those indicated by a thermocouple placed $5\frac{1}{2}$ inches above the floor of the furnace.

In these roasts the temperature was kept below 400°C . for at least two hours during which time most of the arsenic and much of sulphur was eliminated. The temperature was then gradually increased to 500, 600 or 700°C . in 50° or 100°C . jumps and held at the finishing temperature one or two hours.

(b) A rapid roast completed in 75 to 115 minutes. These

(Continued on next page)

(Roasting Practice, cont'd) -

roasts were made in an electric furnace in which the temperature was controlled by a combination of switches operated manually. The hood and suction draft were so arranged that when the furnace door was raised air passed in over the roasting material and diluted the gases given off during roasting. These diluted gases then passed out of the furnace under the raised door as an upper layer and were drawn off through the exhaust pipe. There was no outlet for the gases at the back of the furnace. The temperatures given are those indicated by a thermocouple placed about $2\frac{1}{2}$ inches above the charge. For laboratory-scale work, the roasting may be considered as taking place in three continuous steps: (1) Heating period. During this period the temperature was brought quickly to 450-480° C. The furnace door was closed to restrict the air supply. A concentration of SO₂ was built up, thus preventing the oxidation of the arsenic at this stage. (2) Arsenic and sulphur elimination period. When the 450-480° C. range was reached a regulated amount of air and suction draft was provided. The arsenic was oxidized to As₂O₃ and drawn off. Sufficient air was admitted to dilute the SO₂ to form an SO₂-O atmosphere suitable for active roasting without flashing. During this period the temperature was kept at 450-480° C. (3) Oxidizing period. When no As₂O₃ fume was detected coming from the material the temperature was brought up quickly to finishing temperature. During this period the air was admitted freely and the remaining sulphides decomposed. The heat was then turned off and the charge allowed to cool. During the entire time of roasting the

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(Roasting Practice, cont'd) -

charge was rabbled practically continuously.

This roasting procedure was originated and investigated by Archibald, Martin and Koenen, of the staff of the Beattie Gold Mines Limited. (See C. I. M. M. Trans., vol. XLII, 1939, pp. 608-631).

Treatment of the Calcines:

After roasting by either of these methods the calcines were ground to 98-99 per cent minus 325 mesh, diluted 1:4, bottle agitated 4 hours, filtered, and washed. The filter cake was then repulped 1:2 and agitated in cyanide solution containing 2 pounds NaCN per ton calcine. In most cases little or no CaO was added as the calcine gave an alkaline reaction.

Six roasts were made by the method described under (a) and 12 by the method described under (b) or variations of this method. In each of the eighteen tests the temperature of the furnace was brought to 200° C. before putting in the charge and beginning the temperature readings.

A summary of the results obtained in the 18 roasts is given in Table I.

Tests Nos. 1, 2, 3, 4, 5 and 18 were made according to method (a); Tests Nos. 6 to 17, inclusive, were made by method (b).

(See Table I, on next page)

(Treatment of the Calcines, cont'd) -

Table I.

Test No.	: ROASTING :		: Assays, :		: Extrac- tion of: gold, : p.c. :	: Agita- tion, : hours :	: Final sol'n :		: Reagents	
	: Total time, : min. :	: Final temp., : ° C. :	: Cal- cine: tailings :	: Au oz./ ton : Cyanide :			: strength, : lb./ton soln. :	: CaO :	: NaCN :	: lb./ton calc. :
1	420	600	4.48	0.63	85.94	24	1.76	1.0	6.48	Nil
				0.55	87.72	48	2.08	1.2	8.08	Nil
2	480	700	4.86	1.25	74.28	48	2.0	3.4 [⊗]	7.2	Nil
3	360	500	4.28	0.71	83.41	48	2.2	Nil	11.6	3.0
4	420	600	4.17	0.47	89.73	24	2.1	0.2	4.8	Nil
5	360	400	3.94	0.80	79.70	24	1.9	Nil	7.4	2.0
18	140	550	3.96	0.41	89.65	24	2.2	0.7	7.6	Nil
6	110	650	4.37	0.40	90.85	24	1.6	0.2	8.0	0.4
				0.42	90.39	48	2.1	0.2	9.2	0.6
7	105	650	4.70	0.40	91.49	24	1.6	0.5	8.0	0.7
8	90	550	4.48	0.53	88.17	24	2.0	0.5	6.6	0.6
9	103	650	4.66	0.62	86.70	24	1.5	0.2	7.7	1.1
10	106	550	4.48	0.56	87.50	24	1.8	0.1	7.0	0.9
11	114	650	4.60	0.58	87.39	24	2.0	0.4	6.5	Nil
12	115	650	4.10	0.44	89.27	24	2.0	0.04	4.0	Nil
13	225	650	4.54	0.88	80.62	24	1.8	0.4	6.0	Nil
14	107	650	4.78	0.75	84.31	24	2.3	2.2	4.8	Nil
15	105	650	4.78	0.48	89.96	24	2.3	1.7	4.8	Nil
16	90	550	4.40	0.33	92.50	24	1.8	0.1	10.6	Nil
17	75	550	4.23	0.36	91.49	24	1.5	0.2	9.0	Nil

[⊗] Total protective alkalinity reported as CaO, partly due to NaOH formed from the NaCN.

Roasting Details:

Test No. 1.

Two charges of 750 gm. each. Temperature held 1 hour at 300°, 30 min. at 350, 400, 450, 500, 550 and 1 hour at 600° C. Loss in weight, 20.5 per cent. As₂O₃ fume began to come off at 310° C., came off freely for 20 minutes, then decreased gradually; at the end of 40 minutes practically no fume could

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(Treatment of the Calcines, cont'd) -

be detected.

Test No. 2.

Two charges of 750 gm. each. Temp. held 1 hour at 300, 30 min. at 350, 400, 450, 500, 550, 600 and 1 hour at 700° C. Loss in weight, 26.7 per cent.

Test No. 3.

Two charges of 750 gm. each. Temp. held 1 hour at 300, 30 min. at 350, 400, 450 and 2 hours at 500° C. Loss in weight, 16.9 per cent.

Test No. 4.

One charge of 750 gm. 5 per cent NaCl added. Roasted the same as No. 1.

Test No. 5.

One charge of 750 gm. Temp. held 1 hour at 300, 350 and 3 hours at 400° C.

Test No. 18.

One charge of 500 gm. Temp. raised to 350° C. with door up $3\frac{1}{2}$ inches and held at 350° until no As_2O_3 fume could be seen - 45 min. Sufficient suction was used to carry away the fume. The temperature was brought to 550°, the power was then turned off.

In this roast the air was drawn over the roasting material according to the method outlined in (a) but the temperature was controlled according to the method outlined in (b) in so far as the nature of the furnace allowed.

(Continued on next page)

(Treatment of the Calcines, cont'd) -

Test No. 6.

A single charge of 750 gm. The procedure outlined in (b) was followed.

Heating period - Temp. raised to 480° C. in 30 min.

Elimination period - As₂O₃ fume came off for 40 min.

Oxidizing period - Temp. raised to 650° C. in 40 min.

Test No. 7.

A single charge of 500 gm. Same as No. 6.

Test No. 8.

A single charge of 500 gm.

Heating period - Temp. raised to 480° C. in 30 min.

Elimination period - As₂O₃ fume comes off for 25 min.

Oxidizing period - Temp. raised to 550° C. in 35 min.

Flamed for 5 min. after door was raised.

Test No. 9.

A single charge of 500 gm.

Heating period - Temp. raised to 450° C. in 26 min.

Elimination period - As₂O₃ fume comes off for 36 min.

Oxidizing period - Temp. raised to 650° C. in 41 min.

Test No. 10.

A single charge of 500 gm.

Heating period - Temp. raised to 450° C. in 22 min.

Elimination period - As₂O₃ fume comes off for 38 min.

Oxidizing period - Temp. raised to 550° C. in 16 min.
Temp. held at 550° C. for 30 min.

Test No. 11.

A single charge of 600 gm. Same as No. 6.

Flamed for 10 minutes after door was raised.

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(Treatment of the Calcines, cont'd) -

Test No. 12.

A single charge of 500 gm. concentrate to which was added 50 gm. common salt.

Same procedure as No. 6.

Test No. 13.

A single charge of 500 gm. concentrate to which was added 50 gm. charcoal.

Same procedure as No. 6 for first part of roast. The charge was then roasted 2 hours at 550° C. to completely burn out charcoal and oxidize iron. Flamed for a short time during elimination period.

Test No. 14.

A single charge of 500 gm. Same procedure as No. 6. Flamed for 10 minutes after door was raised.

Test No. 15.

A single charge of 500 gm. Same procedure as No. 6.

Test No. 16.

A single charge of 500 gm.

Heating period - Temp. raised to 450° C. in 34 min.

Elimination period - As₂O₃ fume came off for 31 min.

Oxidizing period - Temp. raised to 550° C. in 25 min.

Test No. 17.

A single charge of 500 gm. Same procedure as No. 16 except that temperature was raised more rapidly in first period.

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(Treatment of the Calcines, cont'd) -

Partial Analysis of Calcines.						
Cal- cine No.:	Au, oz./ton:	Fe, %	Total S, %	Sulphur present as sulphate: (%)	Total As, %	
1	4.48		4.07	3.87	1.64	Total CaO, 16.24%; Ferrous Fe, 1.11%.
2	4.86		4.39	4.20	1.56	Free CaO, 1.75%.
3	4.28		3.70	3.70	1.96	" " , 0.63%.
4	4.02		7.09	6.94	2.07	
5	4.17		3.40	3.40	2.03	
6	4.37	24.95	3.78	3.68	1.43	
7	4.70	26.18	4.17	4.05	1.13	(Total CaO, 16.82%; Free " , 1.23%; Ferrous Fe, 0.59%.
8	4.60	25.16	6.74	6.53	1.17	
9	4.66	25.78	5.00	4.84	1.24	
10	4.48	24.74	5.16	5.02	1.43	
11	4.60		6.93	6.68	0.94	
12	4.10		6.41	6.39	0.91	
13	4.54		8.10	7.10	1.43	
14	4.78	26.65	5.71	5.51	0.72	
15	4.78	26.44	5.40	5.24	0.72	(Total CaO, 15.64%; Free " , 0.63%; Ferrous Fe, 2.18%.
16	4.40	24.50	2.58	2.48	0.72	
17	4.23		3.20	2.88	1.25	Free CaO, 0.75%.
18	3.96		2.48	2.46	0.94	" " , 0.63%.

Analysis of Representative Solutions -

Cyanide Solutions

	Test No. 2	Test No. 6
Reducing power, ml. N/10 KMnO ₄ per litre of solution	-- 12	12
KCNS	-- Trace.	Trace.
K ₄ Fe(CN) ₆	-- Trace.	Trace.

Examination of Cyanide Residues:

The residues from Test No. 1 and Test No. 16 were each concentrated on the Haultain superpanner to about 150:1. A microscopic examination of the concentrate showed small amounts of magnetic iron oxide, pyrite, and very small amounts of arsenopyrite, but no visible gold.

The residues from Tests Nos. 6 and 7 were united, agitated with a weak cyanide solution for a few hours, filtered, and washed. The residue then assayed 0.38 ounce gold per ton. When infrasized it gave the following distribution of the gold:

<u>Particle size</u>	<u>Weight, per cent</u>	<u>Assay, Au oz./ton</u>	<u>Distribution of gold, per cent</u>
+40 microns	4.55	0.46	5.60
+28 "	12.00	0.355	11.40
+20 "	18.17	0.345	16.78
+14 "	17.92	0.32	15.35
+10 "	14.32	0.335	12.84
-10 "	33.04	0.43	38.03

The +40 to +10 micron fractions (inclusive) were united and treated with aqua regia. The -10 micron fraction was similarly treated to find the percentage of the gold locked up in the siliceous part of the residue.

The following distribution was found:

- +40 to +10 micron fractions, 0.31 per cent of the gold in siliceous gangue.
- 10 micron fraction, 0.33 per cent of the gold in siliceous gangue.

When the cyanide residues of Tests Nos. 1 and 2 were filtered and washed in the usual manner they gave unusually high assays. By drying the residues, repulping

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(Examination of Cyanide Residues, cont'd) -

in a very weak NaCN solution, agitating a few hours, filtering, and washing, the assays were reduced to the values shown in the tables. The treatment removed the gold which apparently had been dissolved by the agitation in cyanide solution but was held in the residues by adsorption. The residues from the other tests showed only a slight tendency to retain gold by adsorption.

The most amenable calcines were those made by roasting the concentrate for a comparatively short time, as in Tests Nos. 6, 7, 16 and 18. The only variation of the "Beattie Roast" found to give a better result than No. 6 or No. 7 was that used in No. 16. The very fine grind of these concentrates may account for the fact that the lower temperatures used in this test gave a slightly more amenable calcine.

There is no marked difference between the residual sulphur and arsenic content of Calcine No. 2 which was one of the most refractory calcines and Calcine No. 7 which was one of the least refractory. The method of roasting No. 2 would result in formation of more free CaO and MgO; this may be a factor. A few free CaO determinations were made but the reliability of the method of analysis is not known when applied to material of this nature.

Roasting with 5 per cent common salt as in Test No. 4 gave a better recovery than a roast made at the same temperatures without using the salt. The addition of salt in the short roast did not improve results (Test No. 12). The use of charcoal (Test No. 13) appears to be detrimental.

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(Examination of Cyanide Residues, cont'd) -

In Test No. 18 the roasting time was abnormally short for this type of roast but the calcine was the best obtained by the (a) type of roasting. Flaming occurred in some roasts of the (b) type due to improper air control. Sufficient material was not available to investigate air control further.

A 24-hour agitation period gave as high an extraction as agitation for longer periods except in Test No. 1. In Tests Nos. 14 and 15, 2 pounds Na_2CO_3 per ton solution was used in one set of tests and 2 pounds NH_4Cl per ton solution in another in cyaniding to lessen the activity of the free CaO . The NH_4Cl tests gave the better extractions (reported in the table) but both were below those obtained in similar tests without the use of these reagents. When NH_4Cl was used the NaCN consumption was lessened. The same effect was found with the salt roasts.

When roasted above 550°C . no addition of lime is needed to maintain a protective alkalinity.

A quantity of the concentrate was treated with acid to dissolve out the carbonates prior to roasting. When calcined (in the same way as No. 16) and cyanided, the extraction was 93.7 per cent (Test No. 19). Sufficient material was not available to investigate the effect of the carbonates further.

Summary and Conclusions:

A short controlled-atmosphere roast yields a calcine from which a 92 per cent extraction of the gold can be made.

An examination of the cyanide residue indicated that the refractory gold is extremely fine and can not be released by commercial grinding. Only a trace of gold is locked up in the siliceous gangue.

The concentrate is self-roasting to a considerable extent. This, together with the low temperature at which arsenic elimination is obtained and the short total roasting time required, indicates that the fuel consumption required per ton of concentrate would be comparatively small.

From the standpoint of roasting, a coarser product would probably be more satisfactory; dusting would be reduced and it is known that in some cases a finely ground product gives a more refractory calcine than a coarser one.

Cyaniding the calcine did not present any special difficulty.

The fact that the better extractions were obtained from calcines having a low free CaO content and that when the bulk of the carbonates was removed prior to roasting the extraction increased (Test No. 19) suggests that a concentrate containing a smaller percentage of carbonaceous gangue would be more amenable to cyaniding after calcining.

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