

THE JOURNAL
OF THE
Canadian Mining Institute
1901

CONTAINING THE
PAPERS AND PROCEEDINGS OF THE MEETINGS
AND EXCURSIONS OF THE INSTITUTE

Held in Cape Breton and Newfoundland
in August, 1900

AND THE
ANNUAL GENERAL MEETINGS

Held at Montreal in March, 1901



VOLUME IV.

EDITED BY THE SECRETARY AND
PUBLISHED BY AUTHORITY OF THE COUNCIL

OTTAWA, JUNE, 1901

*complete desc of
Delors Bromo cyanide
process*

The Treatment of Auriferous Mispickel Ores at Deloro, Ontario.

By SIDNEY B. WRIGHT, F.I.C., Deloro, Ont.

Before proceeding with particulars as to the actual treatment of the concentrates mentioned by Mr. Kirkegaard, a few words on the chemistry of the process adopted will the writer thinks, be in order although already fully gone into by Messrs. Sulman and Teed in papers communicated to the Society of Chemical Industry.

Briefly the process consists in :

(1). The "Extraction" of the Gold by the leaching of the finely ground ore with a dilute solution of Potassium Cyanide, to which is added a small quantity of a solution of a "haloid" salt of Cyanogen—Cyanogen Bromide.

(2). The "Precipitation" of the precious metal from this Bromo-Cyanide "liquor" by means of metallic Zinc.

(3). The "Clean-up" of the Zinc-Gold Slimes thus obtained.

In comparing the equation representing the solution of metallic Gold by the Bromo-Cyanide solution, viz: $3 \text{ K Cy} + \text{Au}_2 + \text{Cy Br} = 2 (\text{K Au Cy}_2) + \text{K Br}$, with Elsner's well-known equation for the solution by Potassium Cyanide, $4 \text{ K Cy} + \text{Au}_2 + \text{H}_2 \text{ O} + \text{O} = 2 (\text{K Au Cy}_2) + 2 \text{ K O H}$, it will be readily seen that whereas in the former case the reaction is one of "Cyanidation" only, the latter, as is now generally admitted, involves oxidation, a reaction, the disadvantages of which in the treatment of ores rich in Sulphur, Arsenic, etc., are apparent.

—On this point and on the extreme activity of the Bromo-Cyanide solvent on the precious metals together with the method of application of the process, depends largely the successful treatment of these dense concentrates.

Plant.—The plant now in use, and which is placed in a two-story building below the Mill, consists of :—

Four Leaching Vats fitted with sand and pebble filter bottoms, and bottom discharge-gates.

Four Solution or "Liquor" tanks—on the floor above the leaching vats.

Three small Northey Duplex Steam Pumps for pumping liquors.

Three small "sump tanks," 40 gallon barrels, over which the steam pumps are so placed that by means of a float connected by a rod to a lever on a special type of throttle-valve the speed of the pumps is regulated automatically by the rise and fall in level of the liquors flowing into the sumps. Two 50 gallon barrels holding the Stock Solution of Cyanogen Bromide.

Precipitation.—One Sulman's patent "Cone" for the use of Zinc Fume or "Dust" as the precipitant.

One Settling-box connected with same.

One Zinc-box through which all drainings only from the vat charges are run.

Pipe Systems.—The pipe systems employed are so arranged that the liquor from each tank may be run to any leaching vat independently; similarly the systems fitted to the bottoms of the leaching vats run to the small sumps from which the liquors having percolated through the charge of ore, may be pumped to any of the liquor tanks desired.

In this connection it may be mentioned that each pipe-line run is painted with a different colour in order to obviate any chance of a mistake being made in opening or closing the cocks, for any particular run. Asbestos-packed cocks are used in all these pipe systems and have proved a great advance on the old iron "plug" cock for this work.

Clean-up.—The clean-up plant in which the Zinc-Gold Slimes, obtained in the precipitation of the Gold from the liquors by means of metallic Zinc, are treated, consists of:—

One "Acid-Treatment" Tank fitted with a hood and stack by which the obnoxious gases evolved during the acid-treatment are carried immediately out of the building. A small steam jet is used in the stack in order to ensure a good draught.

One Settling-Tank, and *One* Filter-Tub into which the Slimes are run after acid-treatment and washing.

This, briefly comprises the whole of the plant used in the "Extraction" building and since the final smelting of the "Slimes" is carried out in the Bullion-Room attached to the Laboratory, the furnaces employed there will be described further on.

The actual treatment of the Vat charges may now be taken.

Treatment.—The wet concentrates, as received from the Mill, consist principally of Mispickel, some Iron Pyrites carrying small but varying quantities of Copper, and 15 per cent. to 20 per cent. of Quartz-sands. The latter is taken over purposely on the Concentrators and plays an important part in rendering these dense concentrates leachable. In this connection it may be mentioned that experiments were made by the writer on the separate treatment of *three* grades of the "sized" concentrates but the results obtained were inferior to those which the mixed products gave.

The wet mass of concentrates, mixed to some extent in the concentrator room and transferred in side-dumping cars to the leaching vats, is therefore dumped direct into the latter and a small quantity of Caustic-Lime added.

Here a further slight mixing is given by shovelling and spreading occasionally until the vat contains a charge about three feet deep, or approximately 40 tons of concentrates.

The surface is now levelled off and the charge sampled.

The sample obtained by the usual method, viz., that of withdrawing a small quantity from each car-load by means of a pipe was soon found to be unreliable and was therefore abandoned. The method now adopted consists in taking drillings by means of a 2 inch auger—3 feet long—the entire depth of the vat charge.

The pulp thus obtained from twenty to thirty drill-holes is then well mixed, quartered down in the usual way, and is found to constitute a very accurate sample.

The charge is now submitted to a short Water Wash in order to get rid of the soluble "cyanicides" formed by the exposure of the moist

concentrates to the action of the air during the filling of the vats, and this is the only preliminary treatment given.

After partial draining, or as soon as the water has disappeared below the surface of the ore, the cyanide solution or "liquor" is run on together with the requisite quantity of Cyanogen Bromide Solution. The original quantity of solution or "liquor," which for convenience may be called the "Strong" liquor, run on is, in all, approximately one third of the weight of the ore-charge—or thirteen tons. Formerly a Weak Cyanide Solution was run on previous to the above-mentioned liquor with the idea of reducing cyanide consumption. This weak liquor, however, was found to exert practically no influence in the latter respect and at the same time dissolved only a very small quantity of Gold. It was therefore abandoned and the length of treatment materially reduced in consequence.

The first mentioned liquor having been run on to the charge the water remaining from the preliminary wash, and now being replaced by the Bromo-Cyanide Solution, is run out through the Zinc boxes.

At this stage a somewhat radical departure from ordinary practice is made, and one which has proved a necessity in treating this refractory material.

It being the fact as in nearly all leaching operations that the first portion of the liquor to pass through the ore charge is extremely rich, comparatively, in the dissolved metal, a rapid and easy means of ascertaining the correct point at which to "switch" to the liquor tanks becomes necessary.

The usual "Silver Nitrate" test, though applicable in the treatment of most ores was found unsatisfactory in this case even in skilled hands, and since it frequently happens that such tests must be made by the workman in charge of the vats it will be readily understood that a simple and decisive test is an absolute necessity. It was found on examination that the very dilute solution first appearing through the charge, although extremely weak in free K Cy, contained an appreciable quantity of soluble "Ferrocyanides."

Advantage was therefore taken of this fact to apply the delicate "Prussian Blue" test, by adding "Ferric Chloride" solution to running

samples drawn from the liquor tanks.

The dry place.

It consists of the *Weak* liquor between the practice it is used, without until it is desired.

The *Weak* cyanide solution of the

In the "Strong" liquor limits on the Cyanogen Bromide

The *Weak* solution is run on to the tank and is required

Caution to render the percolation to Strong and with the

to get the *Weak* solution in the

samples drawn from the Zinc boxes. By this means on the first appearance of Gold-bearing solution a distinct Prussian Blue coloration is obtained and the operator knows at once when to switch to the liquor tanks.

The departure from ordinary practice mentioned above now takes place.

It consists in switching this very dilute (in K Cy) solution *not* to the *Weak* but to the *Strong* tank and as a further distinguishing point between Bromo-Cyanide treatment generally and ordinary Cyanide practice it may here be mentioned that this "Strong" liquor may be used, without any precipitation of the Gold by Zinc or other means, until it contains as much as 6 to 7 ozs. of Gold per ton of liquor if desired.

This practice although considered unsafe in many cases in ordinary cyanide work is perfectly free from danger in the Bromo-Cyanide treatment of this ore.

In the latter case it is also advantageous to precipitate the "Strong" liquor as seldom as possible, within the above-mentioned limits on account of the fact that by contact with metallic Zinc the Cyanogen Bromide is decomposed and the liquor thus rendered much less active.

To revert to the actual treatment of the charge—the "blue" coloration having been obtained and all the liquor having been run on, the solution now percolating through the charge is run to the "Strong" tank and is brought up to correct strength by the addition of the requisite quantity of K Cy.

Constant slow percolation of the liquor through the ore is found to render the solution of the Gold much more rapid than if soaking and percolation be adopted and for this reason the liquor is run back to the Strong tank, as stated previously, and is run on to the charge at intervals with the requisite quantity of Cy Br solution.

After twenty four hours' leaching it is found that 60 per cent. to 70 per cent. of the gold contents have been extracted and at this point it is advantageous to drain the charge, and turn the mass by shoveling in order to break up and mix any clots of fine mispickel which may be

present, and thus expose fresh surfaces to the action of the Bromo-Cyanide liquor. The latter is now again run on and the leaching continued until assays of samples of the liquor show that the extraction is completed.

A weak "Wash" liquor is now run on to replace the "Strong" solution, the latter being run off at full bore of the pipe. As soon as the original 13 tons of Strong liquor have been collected the stream is switched to the "Weak" tank and a water wash run on to the ore.

The original quantity of "Weak" liquor used is collected and this collection is continued until a running sample of the washings shows on testing that the stream may be run out through the Zinc boxes. In this way it will be noticed, the quantity of Strong liquor in use is retained at the original 13 tons, while the Weak or Wash liquor is allowed to increase in bulk with each leach.

By this method the Strong liquor is refreshed with clean solution in each charge treated, and on the great activity of the Bromo-Cyanide solvent in conjunction with this retaining of the working solution in a clean condition depends largely, in the writer's opinion, the successful treatment of these concentrates.

The Weak Wash liquor, accumulated as above-mentioned, is used to wash several charges and is always precipitated ahead of the Strong solution so that when the latter is rich the former is practically free from Gold.

Precipitation of the Gold.—For this purpose Zinc Fume or "Dust" a bye-product obtained during the operation of Zinc smelting, is employed.

The Plant consists of an inverted cone of sheet-iron 4 feet 6 inches in diameter and of the same depth. This is fitted at its apex with a three-way cock and a small perforated cone or *rose*, which serves to distribute the stream uniformly, thus ensuring thorough admixture of the liquor with the Zinc Fume which is run in at intervals through a central funnel and pipe.

The latter is expanded at its lower end into an inverted funnel and by deflecting the stream of liquor helps to mix the "fume" and liquor still more thoroughly.

The li
40 gallon la
order to dis

This la

by a pipe a
tain a

the cone and
the upward

particles de
decrease in

small quantity
surface of the

the Gold from

The gas
the cone and

flows in, the
taining two

is in the gas

There
ready for inv

It can be
replaced by a

will be used
suspended in

for the times
precipitation

The 2-3
and, it can be

(2) A fine
from the tank

regular pump

(1) The
(2) For
(3) The
into material

(4) The

The liquor to be precipitated is run from the storage tanks into a 40 gallon harrel the delivery into which is fitted with a ball-cock in order to obviate any chance of overflow.

This barrel is connected with the three-way at the apex of the cone by a pipe and, being placed above the top rim of cone, serves to maintain a constant head. The liquor thus runs direct into the bottom of the cone and meets the Zinc fume just above the distributing rose. In the upward travel, however, of the solution the Zinc and Zinc-Gold particles descend again into the precipitation "Zone" by reason of the decrease in velocity of the currents with the increasing area; thus a *small* quantity of the "Fume", exposing, in proportion, an enormous surface of metallic Zinc to contact with the liquors serves to precipitate the Gold from a large quantity of liquor.

The precipitated liquor which, by the time it reaches the rim of the cone carries only a small quantity of suspended matter, now overflows into a peripheral gutter and thence to a wooden settling-box containing two compartments in which a number of glass plates 24 in. x 18 in. are placed at an angle of 45°.

Thence the perfectly clear liquor flows to the sumps and is again ready for use on the ore charge.

It may here be mentioned that the "settling-box" will shortly be replaced by a small filter-press or other convenient form of filter which will be used firstly, as a means of separating the small quantity of suspended slimes from the flowing liquors and secondly as a receptacle for the slimes withdrawn from the bottom of the "cone" when the precipitation "run" is completed.

The advantages obtained by adopting Zinc Fume as the precipitant, as compared with the older Zinc "Shavings," method are briefly:—

(a). A closer and more uniform precipitation of the precious metal from the solutions, 99 per cent. of the original contents being the regular proportion thus obtained.

(b). The production of rich Zinc-Gold Slimes.

(c). Ease and rapidity of manipulation in clean-up.

(d). The rapid conversion of all the Gold extracted by the liquors into marketable bullion.

(e). The low cost for Zinc consumption.

Clean-up.—The Gold bearing precipitate, whether obtained from the Zinc-boxes or from the "Fume" cone is now treated with Sulphuric Acid in order to get rid of the Zinc present. This is carried out in a room adjacent to the Extraction building, all the precipitate collected during the month being treated in one lot in the Acid tank.

The strength of Acid used is approximately one part in four parts of water.

The moist precipitate is placed in the Acid tank the requisite quantity of water added, the hood which is fitted with a small glass window front and back so that the action may be observed, closed down and the Acid run in through a leaden funnel.

The mass is stirred with a wooden paddle, the handle of which projects through a small opening in the front of the hood, and as soon as the first violent evolution of gas has subsided somewhat, more acid is run in. The stirring and additions of acid are continued until the reaction is seen to be complete. The tank is now filled with cold water, stirred well and allowed to settle. By using cold rather than hot water a more rapid settling of the Gold slimes is effected and after two further decantation washings the slimes are obtained free from Zinc Sulphate. All the washings from this are run into the Settling tank in which they are allowed to stand until thoroughly settled; the clear solution, which on assay shows only traces of Gold, is then run off and the small quantity of fine precipitate on the bottom of the tank collected.

The Gold-slimes in the acid tank are rinsed into the filter-tub as soon as the third "wash" has been run off and, after draining, are transferred to shallow sheet-iron trays. These are placed in a special form of oven-furnace in which the contents are first dried and finally heated to a dull red heat.

The furnace itself consists of a small wind-furnace, which is used for the melting of bullion and which is fitted with a hinged damper so that when required the trays containing precipitate may be heated by the waste heat from the furnace. This is effected by placing the trays on shelves in the oven one above another in such a way that the spaces

between then the stack.

By this using of the slimes dusting is expected the trays.

The road clay crucibles smelt finally.

The Slag accumulate on

Although particular class had opportunity Bromo-Cyanic treating ore with practical results by the

the Bromo-Cyanic cases to convert

The following extraction of by amalgamation

Potass. C

Cyanogen

Zinc For

Total loss

Extraction

An

This last saving of 88 per cent the Milling of will it is the factory and

between them form the flue through which the furnace gases pass to the stack.

By this means the objectionable vapours evolved during the roasting of the slimes are carried away and at the same time no loss by dusting is experienced on account of the large flue area allowed between the trays.

The roasted slimes are now mixed with a suitable flux, smelted in *clay* crucibles which for safety are placed inside graphite pots, and the smelt finally cast in the usual "brick" moulds.

The Slags obtained which are exceptionally clean are allowed to accumulate and are treated at intervals by Caldecott's process.

Although this paper has been confined to the treatment of one particular class of material it may also be mentioned that the writer has had opportunities for making comparative tests of the merits of the Bromo-Cyanide as compared with the ordinary Cyanide process in treating ores and tailings of various descriptions, and has found that with practically all the so-called "refractory" ores treated the best results both as regards cost and extraction have been obtained by using the Bromo-Cyanide process, the difference being sufficient in many cases to convert an uneconomical treatment into a profitable operation.

The following figures representing the chemical consumptions and extraction on the concentrates, in conjunction with the saving effected by amalgamation, speak for themselves:—

Potass. Cyanide per ton of concentrates treated.....	2.0 lb.	✓
Cyanogen Bromide per ton of concentrates treated.....	0.5 lb.	✓
Zinc Fume per ton of concentrates treated.....	0.19 lb.	
Total length of treatment.....	80 to 100 hours.	
Extraction of Gold from Concentrates	87 per cent. to 94 per cent.	
An average of.....	90.5 per cent.	

This latter with the values saved by amalgamation gives a *total* saving of 88 per cent. to 90 per cent. of the original Gold contents of the Milling Ore a result which, as an average of two years' steady work, will it is thought be generally admitted to be exceptional on so refractory an ore.