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## A study to determine the best method of treatment for a certain gold-silver ore

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A STUDY TO DETERMINE THE BEST METHOD OF  
TREATMENT FOR A CERTAIN GOLD-  
SILVER ORE.

by  
Deane Dwight Harris  
and  
Duane Montgomery Kline.

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A  
T H E S I S  
submitted to the faculty of the  
MISSOURI SCHOOL OF MINES AND METALLURGY  
in partial fulfillment of the work  
required for the degree of  
MINING ENGINEERING

Rolla, Mo.

1912.

Approved by Harward Copeland  
Professor of Metallurgy.

## **C O N T E N T S .**

**Purpose.**

**Description of the Ore.**

**Analysis.**

**Acidity.**

**Physical Conditions.**

**Experiments.**

**Summary.**

**PURPOSE:**

The purpose of this thesis is to find a suitable method for extracting the gold and the silver from an amalgamation tailing.

**DESCRIPTION OF THE ORE:**

This ore is exceedingly complex in composition but consists chiefly of limestone, quartz, pyrite, limonite, a little slag, a small amount of galena, some leaves, twigs and decayed wood, a small amount of copper minerals, both oxide and sulphide, some grease and a great deal of clay. The tailing has remained out of doors for some years and has been contaminated with many substances.

**ANALYSIS:**

Percentage of elements present that are important in the study of this ore.

SiO <sub>2</sub>	41.4 %
Cu	0.61%
Fe	3.00%
Hg	trace
Pb	trace
Au	0.20 oz. per Ton.
Ag	7.34 oz. per Ton.

#### ACIDITY:

The soluble acid in this ore requires for neutralization twelve pounds of Cao per ton of ore. This large amount of Cao is needed because of the fact that the ore, exposed to the weather, and being alternately wet and dry, has had excellent opportunity to oxidize.

#### PHYSICAL CONDITIONS:

The ore consists of broken fragments of limestone, silicates, and clayey material, all of which will pass a four mesh screen, except pieces of wood which are from small fibers to pieces four or five inches in length. The clayey nature of the material makes it difficult to filter and difficult to concentrate.

#### EXPERIMENTS.

##### EXPERIMENT NO. I.

The object of this experiment is to determine whether the gold and the silver values are chiefly in the coarse part or in the fine portions of the ore, and also to show the physical nature of the ore. The results of the experiment are given in Table No. I.

TABLE NO. I.

Mesh of Screen.	Wt. in Gr.	Oz. per Au.	Ton Ag.	Percentage of total Au.	Percentage of Ag.	Percentage weight.
Thru 30	500	0.20	7.34			
On 40	20	0.22	2.40	4.4	1.3	4.4
" 60	33	0.36	3.20	12.1	3.0	6.6
" 80	52	0.32	3.90	16.5	5.1	10.4
" 100	26	0.19	9.60	4.0	7.1	8.8
" 150	62	0.20	5.52	12.4	9.2	12.4
Thru 150	297	0.19	8.40	56.4	74.1	59.4

EXPERIMENT II.

The object of this experiment is to determine if there is a possibility of putting a large portion of the values of this ore into a small amount of concentrate. It may be that the concentrate will require other treatment than cyaniding, or it may be that the concentrate will require a more expensive treatment than that necessary for the tailing portion of the ore. The results of this experiment are given in Table NO. II.

TABLE NO. II.

Material.	Wt. in Gr.	Oz. per Au.	Ton. Ag.
Ore	760	0.20	7.34
Concen- trate	342	0.20	7.21
Tailing	418	0.20	7.41

Ore Mesh 30.

Ratio of Concentration, 1.3 Tons into  
1 Ton.

From the results shown in Table No. II., it seems that concentration as a means of putting the values from a number of tons of raw ore into one ton of concentrate is out of the question. The values are evenly distributed in the heavy and light minerals.

It must be born in mind, however, that even tho the values seem evenly distributed, the heavy and light minerals may not give up their values equally well to similar treatment. There is, therefore, a possibility that the concentration idea or some similar notion may be of use.

#### EXPERIMENT III.

##### Classification.

A classification was attempted in a spitzlucen classifier with the following results.

TABLE NO. III.

Material.	Wt. In Gr.	Assay oz. Au.	per Ton. Ag.
Raw Ore	1000	0.20	7.35
Spigot	210	0.20	7.35
Overflow	787	0.20	7.90

Ore Mesh 30.

It seems that the gold and silver values are intimately associated with the ore particles and a partial separation cannot be effected by classification. This of course was expected from the results of the concentration tests. Looking back at the screen analysis, however, one might think that it would possible to separate from the ore a part richer than the average of the whole.

EXPERIMENT NO. IV.

It was next desired to determine if it is possible to economically cyanide the ore. The first experiment on cyaniding was performed to show the effect on extraction caused by varying the strength of cyanide solution. In all of our cyaniding work, the cyanide consumption is determined in each case. The results on the extraction and consumption of cyanide in this experiment is shown in Table No. IV.



TABLE NO. IV.

Test No.	%K <sub>2</sub> CN <sub>2</sub>	A. T. Ore.	A. T. Sol.	Lb. Kcn consumed.	% Recovery	
					Ag/	Au/
1	1.0	2	4	14	67.7	85
2	1.0	2	4	11	62.5	80
3	0.5	2	4	13	40.0	60
4	0.5	2	4	16	64.0	75
5	0.25	2	4	6	6.0	70
6	0.25	2	4	5	8.0	80
7	0.1	2	4	3	6.0	40
8	0.1	2	4	3	6.0	50

Time constant, 12 hours.

Ore mesh, 98% thru 100.

The best extraction under the above condition was obtained by the use of 1% solution cyanide, but, however, the highest consumption of cyanide took place here. Agitation and relatively fine grinding were used in the above experiment because the previous experiments on this same material by percolation with relatively coarse grinding were always failures.

In no case was the extraction satisfactory, this being particularly true of the silver values. The agitation time, however, was relatively short and the

next series of experiments were performed to show the effect of increased length of agitation. The results of varying the length of time of agitation with ore of the same fineness and with the same strength of solution is shown in Table No. V.

TABLE NO. V.

No. of Experiment.	A. T. Ore.	A. T. Sol.	Time of Agitation, Hrs.	Lbs. Kcn Consumed per ton ore.	% Extraction Ag.
1	2	6	1	7	18.1
2	2	6	2	10	25.6
3	2	6	12	13	50.6
4	2	6	24	21	75.6

Strength solution = 1 %.

Mess ore = 98% thru 100.

From this experiment it seems that the longer the agitation, the greater the consumption of cyanide. At least, the consumption of cyanide increased with the time as long as twenty-four hours. From twelve hours on to twenty-four hours, the cyanide consumed seemed to be about one pound of cyanide per hour per ton of ore. But the AV and Ag extraction increased with the time.

The consumption of Kcn is far too great, which is thought to be due to the presence of copper and perhaps organic matter, so a previous treatment was tried in an attempt to remove as much of these two as possible.

The raw ore contains 0.61 % Cu.

(a). A dilute sulphuric acid wash was given the ore after which there was 0.42 % Cu. left. The copper dissolved was probably chiefly oxidized copper, that remaining chiefly sulphide.

(b). Some ore was leached with  $NH_4OH$ , which also left in the residue 0.43 % Cu.

If one-third of the Cu is present as the oxide, it might consume at the most eight pounds of cyanide per pound of copper. The organic matter also being present might account for some of the cyanide consumed.

#### EXPERIMENT NO.VI.

Cyanide tests were tried on a batch of ore which had been given a preliminary wash with dilute sulphuric acid, followed by a water wash.

Tables No. VI. and VII. show the results of these tests.

TABLE NO. VI.

No. Of Experiment.	A. T. Ore.	H <sub>2</sub> SO <sub>4</sub> conc. of strong.	Time of contact Hr.	H <sub>2</sub> SO <sub>4</sub> consumed C.C.strong.	Percentage Cu. Raw Ore.	Tail-ing.
1	2	5	1/2	3.0	0.61	0.43
2	2	5	2	3.5	0.61	0.426
3	2	5	4	2.7	0.61	0.47
4	2	5	8	3.1	0.61	0.49

Mesh Ore 98% thru 100.

The above table shows the effect on the copper solution by varying the length of time of contact of acid and ore. The acid seemingly acts as efficiently in one-half hour as in eight hours.

TABLE NO. VII.

No. of Experiment.	A. T. Ore.	Gr.Cao used.	A. T. Sol.	Time of contact Hrs.	Percentage extraction. Ag.	Au.
1	2	5	10	24	74	83
2	2	5	10	24	78	86
3	2	5	10	24	80	85
4	2	5	10	24	82	93

Strength of cyanide sol. = 1 %.  
 Mesh Ore = 98% thru 100.

The number of experiment refers to the same material under the same number in Table No. VI.

From the Table No. VII. it seems that copper oxide is a factor in the excess consumption of cyanide per ounce of gold and silver values extracted. Also that a preliminary wash with dilute ( $H_2SO_4$ ) by removing the copper is effective in reducing the consumption of KCN. It may be true, too, that  $H_2SO_4$  wash has played a part in destroying to a certain degree the bad effects of the organic matter on the process.

It appears from Tables VI. and VII. that where the copper is least in the tailing, even by a few hundredths of one per cent., there is the least consumption of cyanide, an indication that a thorough removal of copper oxide is essential to small cyanide consumption.

#### SUMMARY:

It is impracticable to concentrate or classify the ore, because the Au and Ag values are intimately associated with the ore particles, and equally in the heavy and low gravity portions.

The copper and organic matter have a great power to consume cyanide before the Au and Ag is taken into solution. For this reason it is necessary to remove as much of the copper and organic matter as possible before cyaniding.

A dilute solution of sulphuric acid is effective in taking in solution these injurious substances, copper and organic matter. Therefore, it is advisable to give the ore a wash before cyaniding, which of course greatly increases the expense. There is here a chance for regeneration of cyanide in the sump solution by acid, or other suitable means.

#### CONCLUSIONS:

After considering in detail the results of the foregoing experiments, we suggest the use of a dilute solution of cyanide, strength of which should not be greater than 0.1%

Give the ore a preliminary acid wash and follow with a longer agitation in contact with the cyanide.

Regenerate the cyanide from the sump solution by the use of sulphuric acid.

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