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The determination of the best treatment for a certain Mexican silver ore

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THE DETERMINATION OF THE BEST TREATMENT FOR A CERTAIN MEXICAN SILVER ORE.

by

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A

THESIS

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Approved by Durward Copeland

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Description of the Ore.

The ore is brownish red in color due to iron stain. Being somewhat decomposed, it readily crushed fine.

Mineralogical Composition.

The ore is a porphyry, consisting chiefly of silica and hematite and containing a small amount of pyrite. From qualitative tests, the silver seems to exist chiefly as chloride.

Chemical Composition.

Iron	5.80 %		
Insolubles	72.60 %		
Aluminium oxide	0.10 %		
Calcium oxide	8.40 %		
Magnesium oxide	5.60 %		
Sulphur	0.10 %		
Silver	2.06 %	...	604.80 ozs. per ton.
Gold	0.0004%	...	0.12 ozs. per ton.
Total	94.66 %		

The remaining 5.40% is mostly carbon dioxide which was not determined.

Acidity.

The total acid soluble in water in the ore is equal to 1.27 pounds of lime per ton of ore.

The gold and silver values throughout are reported in ounces troy per avoirdupois ton of 2000 pounds.

The assay of the original ore:

Silver---604.80.

Gold--- 0.12.

The gold value is so small in amount as compared to the value in silver that in some of the work the effect of the process on the gold has been neglected.

SCREEN ANALYSIS.

Object:

The object of this series of experiments is to find whether, on crushing, the gold and silver values enter the particles remaining relatively coarse, or those crushing relatively fine. This information would have much bearing on the mechanical preparation of the ore for any solution process.

Method:

A sample of 250 grams of ore was crushed until it passed a 20 mesh (1.20 m.m.) screen. Then the ore was placed on a nest of screens consisting of 40, 80, 100, and 200 mesh. The material remaining on each screen was weighed and assayed.

The results of this series of experiments are given in table 1.

Table 1.

Material	W't	Assay oz. per ton.		% Total		
	grams.	gold	silver	w't	gold	silver
Raw Ore	250.0	0.12	604.8	—	—	—
Through 20 on 40 mesh " 1.2 m.m. " 0.6 m.m.	85.20	0.04	838.6	34.00	11.30	47.10
Through 40 on 80 mesh " 0.6 m.m. " 0.3 m.m.	65.50	0.04	768.2	26.60	8.87	33.70
Through 80 on 100 mesh " 0.3 m.m. on 0.25 m.m.	14.05	0.10	640.4	5.72	47.50	6.05
Through 100 on 200 mesh " 0.25 m.m. on .15 m.m.	45.52	0.04	430.2	18.20	6.07	12.90
Through 200 mesh " 0.15 m.m.	33.65	0.12	225.1	13.50	13.50	5.02
Loss by Difference	5.10	—	—	2.00	12.80	5.0 #

gain.

According to these experiments the silver is mostly in the ore which breaks into relatively coarse particles, 81% of the total silver value remaining on an 80 mesh screen. This experiment indicates that fine crushing is a necessity for the efficient action of the solution upon the ore. Since solution is a surface effect, and the speed of solution is proportional to the surface exposed; the fact that the valuable mineral does not break fine, when the ore is crushed through a relatively coarse screen, indicates that for the solution process on this ore, fine grinding should be used.

The fact that the valuable mineral does not make fines or slimes should be an important factor if it be desired to concentrate this ore, since it is the fine values which are difficult to save in milling.

CONCENTRATION TEST.

Object:

The object of this series of experiments is to determine whether concentration will prepare the ore for more efficient extraction or for less cyanide consumption, or will in any way lessen the grinding expense.

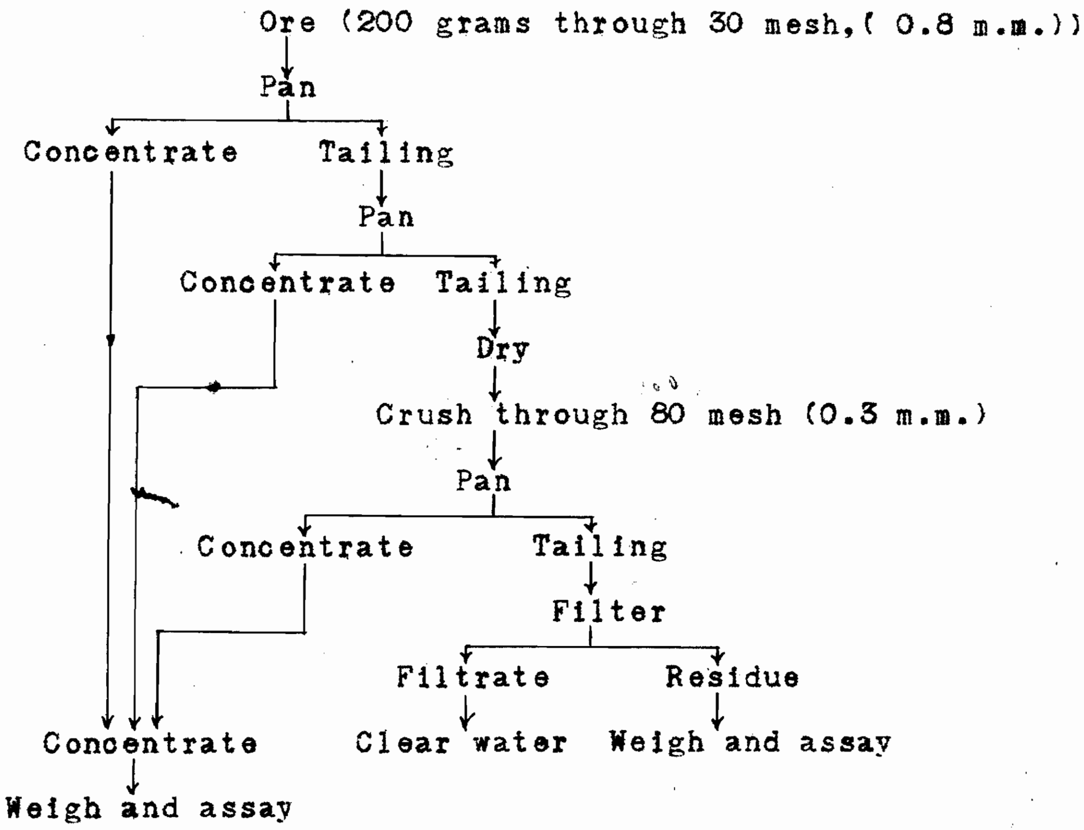
(1) A part of the ore may be better treated by some other process than that to which the bulk of the ore is subjected. The heavy mineral, if rich, and freight charges are not too great, may be shipped to the smelter and the tailing treated by cyanide.

(2) Some constituent detrimental to the cyanide process may be removed by concentration.

(3) It may be that all of the constituents of the ore are amenable to the cyanide process, but that the heavy minerals may be more efficiently treated by a special treatment, such as finer grinding than is required by the non-concentrate portion. This might save expense by regrinding only the concentrate if that portion was to be the only part of the ore actually needing much finer grinding.

Method:

The method is given in the following flow-sheet:



The results of this experiment are shown in table 2.

Table 2

Material	Weight in A. Tons	Assay oz. per ton.		Total oz.		Percent Loss		
		gold	silver	gold	silver	wt.	gold	silver
Raw Ore	6.84	0.12	604.8	0.82	4136.8	—	—	—
Concentrate	1.20	0.26	2907.2	0.31	3488.6	—	—	—
Tailing.	5.55	trace	100.6		558.3	—	—	—
Loss by Difference	.09	—	—	0.51	89.9	1.32	38.0	2.1

The ratio of concentration is 5 into 1. The ore produced a very rich concentrate and a relatively low value in the tailing. The concentrate consisted chiefly of hematite, silver chloride and silica. Little pyrite existed in with the heavy mineral.

The loss due to sliming was very small. There is an actual gain in silver of 2%. This must be due to a combination of small errors in sampling and in assaying such rich material. The great gold loss was due to the same causes. The gold, existing in such relatively small amounts, no particular care was used in taking sufficient ore to properly account for the gold. This experiment has not been completed. There is, however, a promising field here in special treatment of the concentrate by cyaniding, giving to it the relatively finer grinding suggested in the introduction to this series of experiments.

AMALGAMATION TEST.

Object:

The object of this experiment is to determine the effect on extraction attainable by amalgamation, followed by solution treatment of the amalgamation tailing.

Method:

The ore, crushed through 100 mesh (0.25 m.m.), was mixed with water until a pulp of the consistency of thick paint was formed. To this pulp was added 50 grams of mercury and the whole was triturated in a Wedge-wood mortar, the temperature being kept close to 100°C.

The results of these experiments are shown in table 3.

Table 3.

Material.	W't. in A. tons	Assay		% of the total.	
		gold	silver	gold	silver
Raw Ore	1.0	0.12	604.8	——	——
Tailing	1.0	0.07	228.4	41.7	62.2
Amalgam	1.7	0.03	221.4	58.3	37.8

It will be noted that although a 62% recovery of the silver is obtained, the tailing still contains 228 ounces of silver.

This treatment might be used economically as a preliminary step in securing the values. If, however, the ultimate extraction be not greatly increased thereby, amalgamation should not be recommended. Amalgamation on this ore, since pans would be needed, should be fairly expensive.
It is doubtful, also, if the expense for following solution treatment, would be lessened by a preliminary amalgamation.

CYANIDE TEST.

Object:

The object of this experiment is to determine the effect of fine crushing on the percentage of extraction.

Method:

The ore, crushed through the mesh as given in table 4, was put into an agitator with varying amounts of solution and agitated for a period of 48 hours, the volume of pulp being kept constant in each agitator to account for the water evaporation.

The results are tabulated in table 4.

Table 4.

Wt. ore A. tons	Mesh thru.	Wt. Solution Assay tons.	Strength Solution		KCN Consumption		Extraction Silver	
			lbs per ton KCN	% KCN	% total KCN	lbs per ton ore	oz. per ton	%
3.0	30	9.0	20.0	1.0	96.3	57.7	502.0	83.1
3.0	100	9.0	20.0	1.0	98.3	58.9	530.4	87.7
3.0	200	9.0	20.0	1.0	98.5	59.1	540.0	89.3
3.0	200	20.0	20.0	1.0	78.6	104.8	593.1	98.1
3.0	200+ 1. hrs. tube	20.0	20.0	1.0	79.4	105.8	597.9	98.9
3.0	200+ 10. hrs. tube	20.0	20.0	1.0	76.2	101.6	596.4	98.7
3.0	200+ 20. hrs. tube	20.0	20.0	1.0	78.0	104.0	598.1	98.9

When the solution and ore were used in the ratio of 3 to 1 there was no great increase in the percentage of extraction caused by extra crushing beyond 100 mesh. The amount of solution, as compared to ore by weight, being increased to 6 2/3 to 1 gave a much greater extraction. This was due to increasing the available cyanide, which had been lacking when using the smaller amount of one strength solution. There is an enormous consumption of cyanide shown by these figures, but it must be remembered that the silver mineral itself will theoretically consume many pounds of cyanide per ton of ore treated.

$$2\ KCN + AgCl = KAg(CN)_2 + KCl$$

$$4\ KCN + 2\ Ag + H_2O + O = 2\ KAg(CN)_2 + 2\ KOH$$

There is in the ore per ton 604.8 x 480 grains or $\frac{604.8 \times 480}{7000}$ avoirdupois pounds of silver. This would require as per above reactions $\frac{2 \times 65 \times 604.8 \times 480}{108 \times 7000}$ = lbs of cyanide. = 50 pounds of KCN per ton of raw ore to dissolve the silver.

The cyanide consumption is still very large, being as high as 50 pounds of cyanide per ton of ore, which would amount to $10.00 additional cost per ton of ore for theoretically unnecessary cyanide consumption.

CYANIDE TEST.

Object:

The object of this series of experiments is to determine the most efficient strength of solution.

Method:

The ore, through 200 mesh (0.15 m.m.), was treated with different strengths of solution and agitated for 48 hours, the volume being kept constant in each case.

The results are given in table 5.

Table 5.

Wt ore A. tons.	Mesh	Wt. solution A. tons	Strength Solution		Cyanide Consumption		Extraction Silver	
			%	lbs. KCN per ton.	% total KCN	lbs. per ton ore	oz. per ton ore	%
3.0	200	10.0	2.0	4.0	94.3	119.0	568.2	93.9
3.0	200	10.0	3.0	60	67.2	134.4	581.0	96.6
3.0	200	10.0	5.0	100	48.2	160.6	585.0	96.7

The most efficient strength of solution seems to be 1%. Only 3% greater extraction is derived by using a 2% solution and this is obtained at the expense of more cyanide consumed. The 3% and 5% solutions are too strong as they give too great a consumption of cyanide and with no greater extraction.

ROASTING TESTS.

Object:

The object of this series of experiments is to determine the effect of an oxydizing or a chloridizing roast on the extraction attainable.

Method:

In the oxydizing roast, the weighed raw ore,being previously assayed, was roasted and, after roasting, was reweighed and assayed.

In the chloridizing roast two schemes were followed:

(1) The weighed raw ore was mixed with 10% by weight of salt and assayed before and after roast.

(2) The weighed raw ore was mixed with 10% salt and 5% pyrite by weight and assayed before and after roast. The purpose of adding pyrite was to insure the formation of enough iron sulphate to decompose the salt.

See table 6 on page 16, which gives tabulated results of this series of experiments.

In the oxydizing roast the sulphur content being so small, there would be little sulphur liberated. However, most of the sulphur may be in the form of silver sulphide. By roasting, the sulphur is driven off, thereby eliminating one of the possibly detrimental elements from solution treatment.

In the chloridizing roast, the principle is to change the silver sulphide to silver chloride.
Roasting this ore is impracticable as silver chloride is volatile at a good roasting temperature, and much silver is lost during this treatment on an ore as rich as is this one.

Table VI.

Material	Wt. in A.T.		Assay Silver		Total Silver		Loss Silver		Time Roast	Highest	Solution			KCN Consumed		Assay	
	Before Roast	After Roast	Before Roast	After Roast	Before Roast	After Roast	oz. per ton raw ore	%	hrs.	temp	%	tons sol.	lbs KCN total	lbs	lbs per ton roasted ore	Tailing	% Extract.
Raw Ore Oxidizing Roast.	4.11	4.00	604.8	5.48	2485.7	2192.0	56.8	9.3	0.3	650°C	1.0	12.	240.	142.	37.3	129.7	69.1
Raw Ore + 10% salt. chloridizing Roast	4.52	4.34	550.3	504.9	2485.7	2075.5	45.4	7.5	0.5	650°C	1.0	12.	240.	101.6	23.4	78.4	70.5
Raw Ore +10% salt +5% pyrite chloridizing Roast	4.73	4.39	526.1	468.3	2485.7	2056.7	57.8	9.5	0.5	650°C	1.0	12.	240.	96.2	21.9	72.3	65.4

REGENERATION OF CYANIDE.

Object:

The object of this experiment is to determine the amount of cyanide which may be regenerated from the solution after precipitation.

Method:

The solution used was the 2% solution in table 5. The method of proceedure may be clearly followed by the flow-sheet.

Ore
↓
Solution
↓
Agitate
↓
Filter

Residue → Wash ↓
Filtrate ↓

Precipitate with Zinc dust
↓
Filter

Residue
Solution
↓
Sample 20 c.c.
↓
H_2SO_4 (5 c.c. solution)

Solution
↓
Made alkaline with KOH
↓
KCN determined

Fume
↓ Pass thro
(KOH solution containing 8 grams KOH to 20 c.c. H_2O)
↓
KCN determined

The results are shown in table 7.

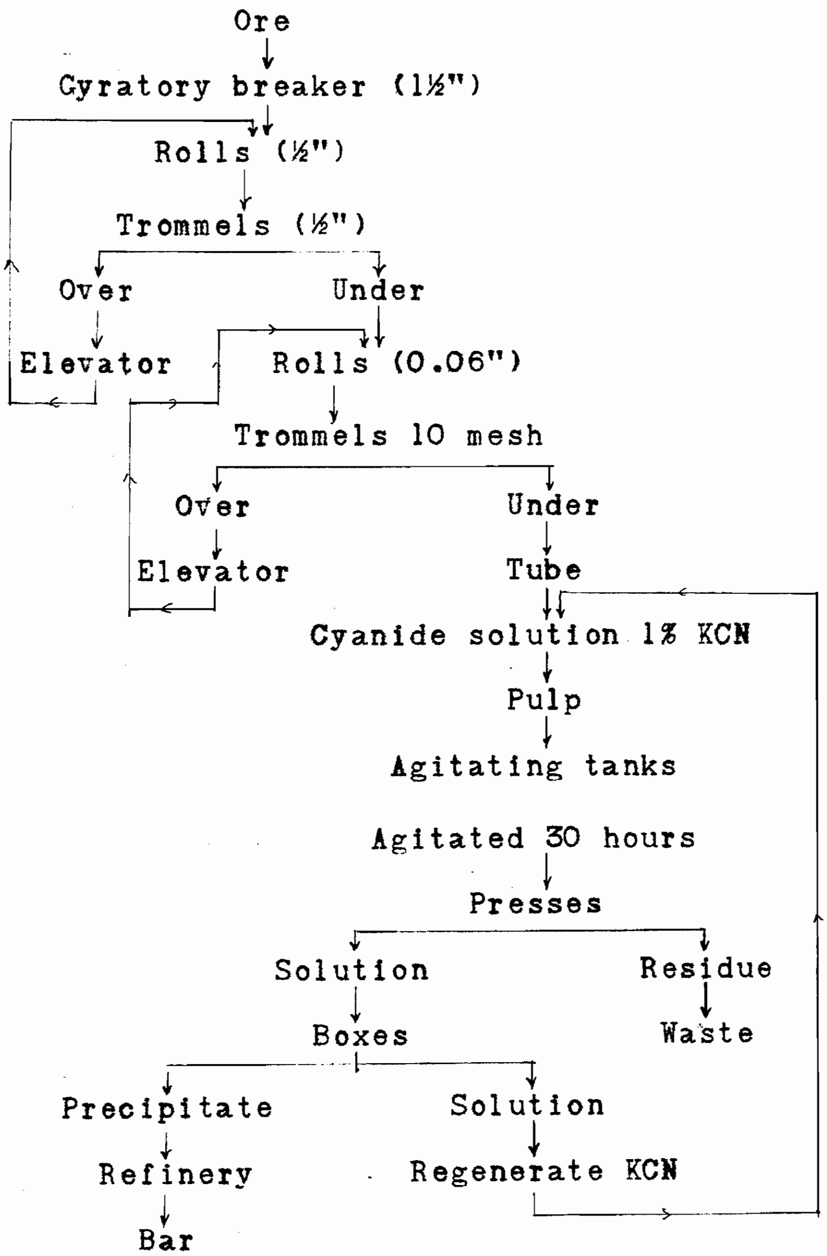
Table 7.

Material	Amount c.c.	H_2SO_4 c.c.	KOH c.c.	Cyanide gms Free.	% Regenerated
Solution after precipitation	20.0	———	———	0.23	———
Solution after adding H_2SO_4	———	5.0	———	0.12	———
KOH. Solution after passing fume	———	———	20.0	0.18	———
KCN Regenerated	———	———	———	0.07	~~17.5~~ 41.1

The theoretical consumption of cyanide is about 48 pounds per ton of ore for the silver values.

This amounts to about 9.50 per ton of ore. With a regeneration of ~~17.5%~~ 41.1 of the KCN used per ton of ore ~~1.75~~ # 3.90 worth of cyanide may be saved for each ton of ore treated.

Based on the preceding experiments, the following treatment is suggested for this ore.



To prevent dust, a 0.5% KCN solution in the proportion of 2 of solution to 1 of ore is added after the ore has passed through the first set of rolls. Before entering the tube mill, the solution is to be increased to 1% KCN and the ratio of solution to ore is increased to 5 to 1.

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