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Flotation applied to a Mexican silver ore

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FLOTATION APPLIED TO A MEXICAN SILVER ORE

BY

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A

THESIS

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Introduction.

The object of this thesis is to determine the advisability of treating this Mexican Silver ore by flotation. To do this it was necessary to determine the degree of crushing, the kind and amount of oil, the amount of acid, the time of agitation, and the dilution of pulp, which would give the best results. From the following tests a suitable conclusion of the best conditions of this ore was determined.

Description of Ore.

The ore is gray in color and very hard . It is of igneous origin lithologically known as quartz porphyry, and containing a small percentage of sulphides. The sulphides which carry the silver occur in small particles disseminated through the porphyry.

A mineralogical determination showed that the ore contained the following minerals in order of their importance:-

Feldspar
Quartz
Calcite
Pyrite
Chalcopyrite
Galena.
Tetrahedrite
Augitite

A chemical analysis showed that it contained

Zinc	2.61%
Lead	0.48%
Silver	0.32% - 91.62 oz.
Gold	Trace

The remainder of the ore consisted of gangue which is of little importance in the Flotation Process and therefore was not determined.

In this thesis all the silver results are reported in ounces troy per ton of two thousand pounds avoirdupois and the assay of the original ore is as follows:

Silver..... 91.62 oz.

Gold..... Trace.

Inasmuch as the gold content is so small, it has been disregarded entirely.

Screen Analysis.

Microscopical examinations were made on the ore to determine how fine it must be crushed to free the sulphides. At 90 mesh most of the sulphides are free and the particles are suitable in size for successful treatment by flotation.

A partial screen analysis on the ore which has passed through 90 mesh is as follows:-

Mesh. Thru	Mesh. On.	Average diameter of particles.	Weight in Grams.	Percentage.	Assay results oz. per ton.	
90	100	.0059 in.	45.2	22.6	36.00	= 813.6
100	150	.0055 In.	22.5	11.25	69.20	= 778.5
150	200	.0041 in.	46.0	23.00	82.20	= 1890.6
200	240	.0029 in.	19.8	9.90	84.50	= 836.5
240		.0026 in.	66.0	33.00	92.50	= 3075.6
				99.75		7394.8

Test No. 1.

Object - To determine the most suitable oil.

Having several different oils, a number of preliminary tests to determine which oils were suitable for this ore were made. These tests were made in an ordinary 8-inch test tube. The charge was put in, shaken for about thirty seconds, and allowed to settle for several minutes. The amount of float, color of float, and color of gangue were noted.

Charge - Ore..... 5 - 8 grams.
Water..... 30 - 35 cc.
Temperature..... 60 - 80° C.
Oil..... 1 - 2 drops.

(See Page 4-a for Results of Test No. 1.)

Results.

Name of Oil.	Grade of Float. (This was determined by the color and amount of float, the color of gangue.)
Hard Engine	Poor.
S. F. Cylinder	Poor.
Tar	Poor.
Sun Black	Poor.
Black Mineral	Poor.
Gas Engine	Poor.
Rust Proof.	Poor.
Air Compressor	Poor.
Fuel	Poor.
Black	Poor.
Diamond Refined	Fair.
Ruddy Harvester	Fair.
Lard	Fair.
Red Engine	Fair.
Cylinder	Fair.
Special Pine Tar.	Fair-Good.
Oleic Acid.	Good.
Eucalyptus	Good.
Pure Pine	Good.
Refined Pine Tar	Good.
Distilled Pine	Good.

Conclusion:- By this test it can be seen that the heavy oils gave poor results, the medium grade gave fair results, and the light grade gave the best results.

Test No. 2.

Object:- In this test I selected a number of oils used in the previous test, and verified results of test No. 1 on a larger scale.

In this test a 350 cc Erlymire flask was used. The charge was agitated by hand for about thirty seconds and then settled for a few minutes.

Charge:- Ore.....50 grams.
Water.....100 cc.
Temperature...60-80° C.
Oil.....2 - 4 drops.

Results.

1. Hard Engine Oil.

Here there was very little float. The oil seemed to form into clots that could not be broken up. There was no coagulation of the sulphides,and tailings carried many sulphides.

2. Air Compressor Oil.

This oil acted in a manner very similar to Hard Engine Oil. The float was extremely small and no coagulation took place.

3. Diamond Refined Oil.

In this test there was a small float which was very black in color. There seemed to be some coagulation, but the tailings carried many sulphides.

4. Ruddy Harvester Oil.

This gave very little float and no coagulation could be seen.

5. Red Engine Oil.

The float here was fair in quantity, dark in color, and carried some gangue.

6. Special Pine Tar Oil.

A good black float was found here, but it was small in bulk. The coagulation seemed better than in any of the above cases.

7. Oleic Acid.

Large quantities of float were obtained in this case. It was light gray in color, showing therefore the presence of much gangue.

8. Oil of Eucalyptus.

Here the float was very good. There was not a very great quantity, but it was extremely black and much coagulation was noted.

9. Distilled Pine Oil.

With this oil the best results were attained. The float carried little gangue, good in bulk, and coagulation was very pronounced.

10. Refined Pine Tar Oil.

This also seemed an excellent oil for this ore. Although the float was not as large in bulk as in the case of Distilled Pine Oil, it was darker in color.

11. Pure Pine Oil.

The results here were very similar to the two above.

Conclusions: - Again, as in No. 1, the light oils gave the better results.

Test No. 3.

Object. Here the results of Tests Nos. 1 and 2 were verified, using a Flotation machine.

From the previous tests the eight best oils were chosen, and then tested in an experimental Flotation machine. This machine was modeled after one Hoover suggests in his text book, "Text on Flotation".

Charge. Ore..... 500 grams.
Water..... 1500 cc.
Temperature..... 60° - 70° C.
Oil..... 5 cc.
Time Agitated ..... 3 Minutes.
Time Settled..... 3 Minutes.

Name of Oil.	Assay of Tailings. Oz. of Silver per ton.
Oleic Acid	57.76
Red Engine	56.20
Diamond Refined	43.32
Eucalyptus	30.40
Distilled Pine	20.70
Refined Pine Tar	40.16
Pure Pine Oil	18.40.
Special Pine Tar	40.14

Conclusion:- Distilled Pine and Pure Pine were the two oils that gave the best results.

Test No. IV.

Object - To determine the action of acid when used in the charge.

A similar charge as that used in Test No. 3, except one cubic centimeter of Sulphuric acid was added in each case.

Name of Oil.	Assay - Oz. of Silver per Ton.	
	Tails.	Concentrates.
Oleic Acid	61.00	226.44
Red Engine	41.20	
Eucalyptus	37.90	259.56
Distilled Pine	18.80	316.16
Diamond Refined	52.60	
Refined Pine Tar	48.88	319.00
Pure Pine	18.20	372.04
Special Pine Tar	20.82	369.12

Conclusion:-

Oil aided materially in the concentration as shown by the fact that the tailings carried less silver.

Test No. 5.

Object:- To determine the correct amount of oil to be used.

Charge:- Ore..... 500 grams.
Water..... 1500 cc.
Temperature..... 60-70° C.
Oil..... Varying.
Time Agitated..... 3 Minutes.
Time Settled.....3 Minutes.
Acid (H_2SO_4)..... 1 cc.

Amount of oil.	Distilled Pine Oil			Pure Pine Oil		
	Weight of float grams	Assay Concentrate	Tailings.	Weight of Float.	Assay Concen.	Tails.
0.1 cc.	34.0		59.02	53.0	279.00	36.00
0.2 cc.	20.0	339.40	29.20	31.0	265.50	45.20
0.3 cc.	36.0	454.80	20.96	51.0	310.20	22.28
0.4 cc.	36.0	340.60		50.0	330.00	20.20
0.5 cc.	29.0	453.50	16.84	50.0	348.00	
0.6 cc.	35.0	578.70	14.52	51.0	356.10	17.72
0.7 cc.	37.0	461.00	13.76	51.0	328.10	18.50
0.8 cc.	37.0	348.20	14.04	46.0		17.40
0.9 cc.	36.0	431.00	16.10	46.0	317.00	16.40
1.0 cc.	37.0	494.20	24.70	45.0	340.00	15.60

Conclusion: - Consider the tailings and concentrates, and it can be readily seen that the amount of oil that gives the best results was:

Distilled Pine Oil - 0.6 cc.
Pure Pine Oil - 0.6 cc.

Test No. 6.

Object:- To determine the required amount of acid to give the best results:

Charge:- Ore..... 500 grams.
Water..... 1500 cc.
Temperature..... 60-70° C.
Oil..... .6 cc.
Time Agitated..... 3 minutes.
Time Settled..... 3 minutes.
Acid H_2SO_4..... Varying.

Amount of Acid	Distilled Pine Oil.			Pure Pine Oil.		
	Weight of float grams	Assay Concent's.	Tails.	Weight of float grams	Assay Concent's.	Tails.
0.25 cc.	40	360.00	16.82	40	340.50	17.30
0.50 cc.	45	350.00	12.00	38	420.00	16.84
0.75 cc.	32	483.00	17.00	35	419.80	12.20
1.00 cc.	10	780.00	44.30	31	468.00	12.16
1.50 cc.	8	849.00	47.60	10	713.00	31.30
2.00 cc.	17	375.00	45.80	10	590.00	54.00
2.50 cc.	15	356.00	50.20			

Conclusion:- The amount of acid that seems to give the better results:-

Distilled Pine Oil - 0.5 cc.
Pure Pine Oil - 1.0 cc.

Test No. VII.

Object - The determination of the best temperature to be used.

Charge. Ore..... 500 grams.
Water..... 1500 cc.
Temperature..... Varying.
Oil..... 6 cc.
Time Agitated..... 3 minutes.
Time Settled..... 3 minutes.
Acid H_2SO_4..... 0.5 - 1.0 cc.

Temperature Degree Centigrade	Distilled Pine Oil			Pure Pine Oil		
	Weight of float. grams.	Assay Concent's.	Tails.	Weight of float. grams.	Assay Conc.	Tails.
20°	35.0	406.0	44.00	15.0	670.50	49.80
50°	32.0	460.0	14.90	18.0	660.00	42.20
80°	40.0	481.0	14.00	20.0	675.00	14.50

Conclusion:- At a temperature of about 80° centigrade in the case of both oils the best extraction was obtained.

Test No. VIII.

Object:- The determination of the amount of agitation necessary to give the best extraction.

Charge: - Ore..... 500 grams.

Water..... 1500 cc.

Temperature..... 80° C.

Oil..... 0.6 cc.

Time Agitated..... Varying

Time Settled..... 3 minutes.

Acid (H_2SO_4)..... .5 cc - .6 cc.

Time Agitated Seconds.	Distilled Pine Oil.			Pure Pine Oil		
	% Weight of float. grams.	Assay Concent's.	Tails.	% Weight of float grams.	Assay Conc's.	Tails.
15	25.0	622.00	23.50	10.0	782.00	50.30
30	32.0	522.10	18.40	25.0	422.10	32.24
45	35.0	508.50	17.50	30.0	483.50	14.24
60	35.0	532.00	14.40	30.0	712.00	16.64
90	35.0	471.00	16.70	30.0	1310.00	16.04
120	40.0	440.00	16.00	20.0	409.00	18.00

Conclusion:-

In the case of Distilled Pine Oil 60 seconds of agitation was sufficient while in the case of Pure Pine Oil agitating, 90 seconds was required.

Test No. IX.

Object: - To determine the best ratio of dry ore to water by weight.

Charge:- Ore..... Varying

Water..... Varying.

Temperature..... 80° C.

Oil..... .6 cc.

Time Agitated..... 60 - 90 sec.

Time Settled..... 3 minutes.

Acid (H_2SO_4)..... .5 cc. - 1.0 cc.

Ratio of dry ore to water by weight.	Distilled Pine Oil			Pure Pine Oil		
	Weight of float. grams	Assay. Conc's.	Tails.	Weight of float. grams.	Assay. Conc's.	Tails.
1 to 1	40	488.50	12.90	72	584.50	18.00
1 to 4	30	742.10	13.50	25	580.00	27.24
1 to 8	10	1016.80	12.50	10	691.00	15.24
1 to 12	5	827.50	35.40	4	701.00	29.70

Conclusion;- The best ratio seem to be one part dry ore to eight parts water in the case of both oils.

Summary:-

In summing up the condition that will give the extraction:-

a. Distilled Pine Oil.

Amount of Oil..... 0.6 cc.

Amount of Acid (H_2SO_4).....0.5 cc.

Temperature..... 80° C.

Amount of Agitation..... 60 sec.

Dilution of Pulp..... 1:8 by wt.

b. Pure Pine Oil.

Amount of Oil..... 0.6 cc.

Amount of Acid (H_2SO_4)... 1.0 cc.

Temperature..... 80° C.

Amount of Agitation..... 90 sec.

Dilution of Pulp..... 1:8 by wt.

Test No. 10.

Object:- To determine whether or not soap aided in the concentration.

In this test the change that gave the best results with Distilled Pine Oil was used. In the first test 1 cc. of liquid soap was added and in the second 1 cc. of shaving cream.

In both cases there were large quantities of float. But the float was very light in color, showing that it carried a large percentage of gangue. The assay results were as follows:-

	Concentrate.	Tailings.
(1)	350.00	25.80
(2)	295.20	35.75

Test No. XI.

Object: - To determine results that could be obtained by retreating the concentrate and tailings.

Concentrates were used which were obtained from a series of runs in which the best conditions, as stated on page 16, were used. After this concentrate was dried and screened through a 90 mesh, it was used in place of the regular ore in a charge. The first skim assayed 2588.00 ounces. After agitating these tailings for sixty seconds, they assayed sixty ounces, and the resulting skim assayed 740 ounces. Repeating this experiment without adding oil the resulting skim assayed 2198.90 ounces.

Some of the tailings were dried and screened in the same manner as the above concentrate. By retreating once without oil, the tailings assayed 6.72 ounces agai against an assay of 6.60 ounces obtained by retreating with oil. In two retreatments with the addition of a little soap the tailings were reduced to 4.20 ounces.

Several different methods of lowering the grade of tailings were tried, but in none of the experiments could the content be lowered below 4.20 ounces of silver.

Conclusions:-

(1) Character of the Oil.

The oils that gave the best results were the light oils. Distilled Pine Oil, the oil with which the best results were obtained, is light yellow in color, very thin and liquid, specific gravity 0.93, and the viscosity 63 seconds at 80° Fahrenheit.

(2) Acid:-

Acid aided in concentration and as such small quantities were required, the additional cost would be comparatively small.

(3) Pulp dilution.

The dilution of pulp which was found suitable in the experiment can easily be carried out in a mill where wet crushing is maintained without additional expense.

(4) Soap.

Such substances as soap, which in many cases are very valuable in forming a strong scum, were unsuccessful in this case.

(5) Temperature and Agitation.

The temperature and amount of agitation necessary is about the same as that in general use in the flotation process.

(6) It must be borne in mind that this work was carried out in the laboratory on a small scale and the results secured are not necessarily conclusive. It is thought, however, they are sufficiently conclusive to justify further investigation upon a larger scale.

I would suggest the following flow-sheet as a means of treatment in the case of this ore.