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Flotation applied to basic ores

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FLOTATION APPLIED TO BASIC ORES.

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A

THESIS

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FLOTATION APPLIED TO BASIC ORES.

Concentration, by flotation, as used in to-day is limited to the ores containing an acid gangue. Although, it is probable, that in a few instances flotation schemes are being used on certain ores containing basic gangue, the processes are carefully guarded as trade secrets.

It was with ores containing basic gangue that the experiments embodied in this thesis were made, in an effort to determine some means of concentration and also to determine the best conditions for some of the varying factors.

Before considering the experiments and results it might be best to note some of the phenoma and factors generally known and taken advantage of in flotation schemes.

"The film of gas that is attracted to the surface of solid particles adhere strongly in some instances, and are displaced therefrom by a liquid, with considerable difficulty. This quality of adhesion varies remarkably with different substances.

With some substances the gas adhesion is strong and the liquid adhesion is weak; in other words they are wetted with difficulty.

In this class is the metallic sulphides, which, altho they have a natural tendency not to adhere strongly to water, do fortunately have a strong natural tendency to adhere to oil. And further, oil has an even stronger tendency to adhere to its gas film so that a sulphide particle covered with an oil film has an already strong tendency not to adhere to water considerably increased. Quartz and gangue minerals, on the other hand have preference in directly the opposite direction. They have a comparatively feeble adhesiveness to water, and this already strong adhesiveness for water is greatly increased by a slight acidulation of the water. There has been no satisfactory theory yet propounded as to why acid does promote the preferential adhesion to gangue particles and probably also at the same time the preferential adhesion of oil to sulphides.

It has been established that there are:

(1) Forces acting at the surface of a liquid, the resultant of which tends to prevent rupture of the surface.

(2) Forces acting at the surface of all substances, especially at the surface of sulphide particles, that cause films of gases resisting displacement to adhere to their surface.

(3) Forces acting at the surface of sulphides that cause these surfaces to show preferential adhesion to oil.

(4) Forces acting at the surfaces of gangue minerals that cause these surfaces to show a preferential adhesion to water, and especially acidified water."

(Hoover's Flotation)

With these principles in mind an investigation was made, the result of which follows:

Since natural occuring basic ores were not at hand various types of ores were made up by mixing sulphides such as galena, chalcocite, and sphalerite with basic gangues as calcite and hematate. This of course, would not give an ore corresponding in composition and texture to the natural occuring ores but it would furnish the main factor, viz., the basic gangue.

At first experiments of a preliminary nature were made in order to determine with what oils the best results were obtained.

In these experiments it was found that, when a calcite ore was agitated and sulphuric acid was added, the carbon dioxide liberated lifted the sulphides to the surface. But, as soon as they reached the surface the gas bubbles broke loose from them and they immediately sank. The problem, then was to find an agent that would give sufficient froth or bubbles to hold these sulphides on the surface when they were once lifted by the air and carbon dioxide. With this end in view the following substances were tried: soap, oleic acid, heavy cylinder oil, crude petroleum, pine tar and various other oils.

Soap was found to give a froth but it also held up large quantities of gangue. The selective action of the acid in lifting to sulphides seemed to be lost. The various oils acted similarly and gave very little froth. Finally the best results were obtained with pine tar and it was with this, that the remainder of the work was done in order to determine the best conditions for separation and to see if these conditions were suitable for different ores.

EXPERIMENTS.

Ore - Calcite 50 gms.

Galena 10 gms.

Thru 40 on 80 mesh

Water- 1000 cc

Temp 60 - 70 °C

Time of agitation 2 - 3 minutes.

Test.	Skim No.	Acid.	Pine tar.	Wt. Conc.	Wt. Pbs in Conc.	%Conc.	%Recovery.
I	1	2cc	2 drops	16 gms.	5.2 gms.	32 %	
	2	3 "	2 "	48 "	1.2 "	25 "	
	3	3 "	2 "	42 "	.7 "	16 "	
			Total	25.0	7.1 "	24.4	71 %
II	1	4 "	3 "	17.5	6.3 "	36 "	
	2	4 "	3 "	4.5	1.0 "	22 "	
	3	4 "	3 "	4.1	.8 "	19.5"	
			Total	26.1	8.1	31 "	81 %
III	1	6"	3 "	11 "	7.1	64.5	
	2	6	3	5	.6	12.	
	3	6	2	3	.2	6.2	
			Total	19	7.9	41.5	79 %
IV	1	8"	3 "	15. "	6.8 "	45."	
	2	9	2	9	.9	10.	
	3		Total	24.	7.7	32.1	77 %

Using conditions in Test III ore thru 80 mesh was substituted for ore thru 40 on 80 mesh with the following results.

Skim.	Acid.	Pine tar.	Wt. Conc.	Wt.Pbs in Conc.	% Conc.	Total % Recovery.
1	6cc	2dr.	12.3 gms.	7.6 gms.	62 %	
2	6	3	4.1	1.1	27	
3	5	2	3.1	.6	19.3	
	Total		19.5	9.3	47	93 %

It is to be noted in experiments of this nature that the conditions seem to be just as important factors as the proportions in which the substance are present. For example, after many tests, it was found out that if the agitation were continued for any length of time after the acid was added there would be little concentration for the continued agitation seemed to cause the sulphides to again settle.

So in each of the above tests the water, ore and tar were agitated from two to three minutes before the acid was added and as soon as it was added the agitation was immediately stopped.

In the above data the only variable mentioned is the acid. Other, previous experiments were made by varying the thickness of the pulp, temp of the water, and the amount of pine tar added with the results used in the above tests.

Water at a temperature of about 60 - 70 $^{\circ}C$ was found to give better results than cold water or water near boiling. Two to four drops of tar were found to be sufficient. Any more than this was found to be of little value and in some cases detrimental, and caused trouble in the assay of the concentrates.

On the first skimming there was a good separation of the gangue from the froth. This, however, was not true on the second and third skimmings, as there was a tendency for the gangue to stay in suspension thereby making a good skimming almost impossible. This accounts for the second and third skimmings in each test running low in concentrates. This was partially overcome by giving the gangue time to settle and by adding fresh amounts of calcite each time. A more perfect skimming devise might also overcome this.

It was found necessary to add fresh amounts of tar before each agitation or else there would be in-sufficient froth to hold the concentrates on top.

Sulphuric acid was found to be better than hydrochloric.

It was also found that it was better to dilute the acid before adding than to add the concentrated acid.

Several experiments, the data on one, which is given above, established the fact that better results could be obtained with ore thru 80 mesh than with that thru 40 mesh. As a rule it was always the heavier particles that first broke loose from the froth and sank.

Tests similar to the above were tried with pyrite and chalcocite. Although the concentrates were not assayed the results, from appearances, corresponded closely to the above results with galena.

Thirty-seven grams of concentrates, running 31.27 were agitated with more pure tar and water. It was necessary to add some fresh calcite in order to furnish the necessary CO_2 as most of the calcite had been changed over to calsium sulphate.

Skim.	Acid.	Pine tar.	Wt.Conc.	Wt.Pbs in Conc.	% Conc.	% Recovery.
1	6cc	3 dr.	14.0	8.3 gm.	59.37	
2	6	3	3.3	1.7	55.1	
3	5	2	2.1	.6	28.6	
		Total	19.4	10.6	54.67	92.1 %

Tests using galena with hematite and hematite mixed with calcite.

Ore- thru 80 mesh - 10 gms. galena- 50 gms. gangue

Acid- 6 - 7cc   Tar- 2 - 3 drops

Water - 1000cc   Temp 60 - 70 $^{\circ}$C

		Gangue						
Test No.	Skim. No.	Parts Hematite.		Parts Calcite.	Wt. Conc.	Wt. Pbs in Conc.	% Conc.	% Recovery.
I	1	5		0				
II	1	4		1	10.3	2.5	24.2	6
	2	4		1	8.5	1.7	20.0	
			Total		18.8	4.2	22.3	42 %
III	1	3		2	14.1	3.8	27.1	
	2	3		2	6.2	1.9	30.6	
			Total		20.3	5.7	28.8	57 %
IV	1	2		3	13.6	4.1	30.1	
	2	2		3	7.5	2.1	28.0	
			Total		21.1	6.2	29.4	62 %
V	1	1		4	17.4	8.2	48.2	
	2	1		4	4.2	.4	9.5	
			Total		21.6	8.6	39.8	86 %

There was no concentration and very little froth when no calcite was added.

The percent of concentration seemed to be proportioned to the calcite added.

Test using sphalerite with hematite and hematite mixed with calcite.

Ore - thru 80 mesh - 10 gms. Sphalerite - 50 gms. Gangue

Acid - 7 - 8 cc Tar 2 - 3 drops

Water 1000cc - Temp 60 - 70 ^{o}C

Test No.	Skim. No.	Gangue: Parts Hematite.	Gangue: Parts Calcite.	Wt. Conc.	Wt. Zns in Conc.	% Conc.	% Recovery.
I	1	3	0				
II	1	2	1	13 gms.	3.3	25.4 %	
	2	2	1	8	2.4	30.0	
			Total	21	5.7	27.1	57 %
III	1	1	2	16	5.6	35 %	
	2	1	2	8.5	2.9	34.1	
				24.5	8.5	34.7	85 %

CONCLUSION.

It must be borne in mind that the experiments were on a small scale and the apparatus used was not the best possible, but nevertheless it was pretty well established that the concentration of certain basic ores by flotation schemes is not impossible.

It was also found that:

(1) Calcite was necessary to give off carbon dioxide.

(2) A frothing agent was necessary to hold this carbon dioxide.

(3) Pine tar was a good frothing agent.

(4) With a calcite - hematite gangue the percentage concentration was almost directly proportional to the percentage calcite in the gangue.

(5) That the sulphides, pyrite, galena, chalcocite and sphalerite acted similarily.