

Flotation of Oxidized Lead-Silver Ores

BY A. W. HAHN,* SALT LAKE CITY, UTAH

(Presented before Utah Section, A. I. M. E., May 12, 1927)

ALTHOUGH enormous tonnages of sulfide lead and lead-silver ores are treated by flotation, the products of flotation mills treating oxidized ores of lead and silver are almost negligible. However, each year there is a slight tonnage increase, and it is possible, should a sizeable oxidized lead ore tonnage be developed, the field will become an important one.

In 1918, the Shattuck-Arizona Copper Co. erected a plant at Warren, Ariz., for the treatment of oxidized gold-silver-lead ores. Glenn L. Allen worked out the metallurgy for this plant, employing tabling, followed by flotation concentration. The Shattuck-Denn Mining Co., successors to the Shattuck-Arizona Co., now employs straight flotation in the same mill, treating about 200 tons daily.

In 1922, the San Diego mill of the American Smelting & Refining Co., in the Parral district, Chihuahua, Mexico, started operating a 600-ton mill on a mixed sulfide-oxide gold-silver-lead ore. Tables and flotation are used here, and about 200 tons of oxidized slime treated by flotation. In 1923, the Eureka Holly Mining Co. started operating a 90-ton mill at Eureka, Nev., using tables and flotation, on an oxidized lead-silver ore. In 1924, the American Smelting & Refining Co. started a 250-ton mill in northern Peru, to treat a high grade oxidized gold-silver ore with very low lead values. In 1924, the Grand Central Mining Co. started a 200-ton flotation mill on old oxidized gold-silver-lead tailings at Fairbank, Ariz.

In 1926, the Compania Internacional Minera, a subsidiary of the Union Corporation of London, started a 250-ton flotation mill on oxidized lead-silver ores, and during April of this year, the Phelps-Dodge Corp. will probably start a 250-ton mill at Warren, Ariz., on oxidized lead-silver ores, similar to those being treated in the Shattuck-Denn mill.

METHODS

All of these mills use sodium sulfide for filming the oxide minerals, with the possible exception of the North Peru mill, and all use oily reagents. The total tonnage of strictly oxidized lead-silver ores concentrated by flotation is probably less than 2500 tons daily. The following figures give the various types of ores being treated:

* General manager, Eureka Metallurgical Co.

Mills	Heads			Concentrates			Tailings		
	Gold, Oz.	Silver, Oz.	Lead, Per Cent.	Gold, Oz.	Silver, Oz.	Lead, Per Cent.	Gold, Oz.	Silver, Oz.	Lead, Per Cent.
Shattuck-Denn.....	0.10	6.8	6.1	0.82	40.2	39.0	0.02	1.6	0.55
Eureka-Holly.....	0.01	2.5	10.0	0.15	25.0	55.0	Tr.	1.2	2.2
San Diego.....	0.03	4.5	4.0				0.01	2.5	2.0
American Smelting & Refining Co.—Peru	0.40	55.0	1.0				0.03	3.0	Tr.
Grand Central.....	0.09	4.5	5.8	0.25	14.0	33.0	0.03	3.3	2.8

Where mixed sulfide and oxidized minerals are present, the sulfides are recovered first either by table concentration, as at the San Diego mill, and the table slime tails sulfidized with sodium sulfide and floated, or by primary flotation, as at the Shattuck-Denn mill, the primary flotation tails are then sulfidized and floated. In the northern Peru operation, a single flotation operation gives good results.

At the Grand Central mill, straight flotation is employed, but the temperature of the pulp during sulfide filming is maintained above 130°. This method was patented by Hendrickson. The quantities of sodium sulfide vary from 2 to 6 lb. per ton. Sodium silicate is also added at the Shattuck-Denn mill. Small amounts of xanthate, P. & E. oil, Barrett No. 4, Lewis tar, Eureka Metallurgical Co. No. 70, Yarmor pine and wood creosote are also used at the various plants. Mechanical agitation flotation machines are used at each of these mills.

RELATIVE FLOATABILITY

Each sample is an individual problem. Our experience shows the relative flotability of the lead minerals to be: (1) cerusite (lead carbonate), (2) anglesite (lead sulfate), (3) wulfenite (lead molybdate), (4) pyromorphite (lead phosphate), (5) mimetite (lead arsenate).

If these minerals can be filmed with a soluble sulfide, they can be floated. The time required for filming varies with the type of lead mineral, in about the above order, and when the phosphate and arsenate minerals are present, the addition of caustic soda aids in sulfidizing.

The principal difficulties encountered when attempting to float oxidized ores of any type are the presence of: (1) soluble salts, (2) colloidal slimes, (3) large amounts of oxides of iron and manganese.

Soluble salts of the heavy metals, such as iron and manganese sulfates, consume large quantities of sodium sulfide, while all soluble salts, except those of the alkaline group, tend to flocculate the pulp, which is extremely detrimental to successful oxidized ore flotation. Dispersing or peptonizing agents, such as sodium silicate, will eliminate this difficulty providing the amounts of soluble salts present are not excessive.

EFFECT OF SLIMES ON RECOVERIES

Colloidal slimes have a profound effect on recoveries. By colloidal slimes are meant that portion of a 2-to-1 pulp remaining in suspension on standing 3 min. after the ore has been ground with sodium sulfide, sodium silicate and other reagents and poured into a pan 4 in. high. These slimes consume sodium sulfide and other reagents, probably by adsorption and what is more detrimental, occlude values which as far as we know are not recoverable by any other method than leaching.

Some idea of how these slimes effect recoveries, can be gained from the following tests:

	Weight, Per Cent.	Silver		Lead	
		Oz.	Per Cent.	Per Cent.	Per Cent.
Heads.....	100.0	39.9	100.0	1.20	100.0
Sand tails.....	54.8	2.95	4.1	0.10	4.6
Slime tails.....	10.0	25.3	6.3	1.10	9.2
Heads.....	100.0			15.5	100.0
Sand tails.....	17.0			0.90	3.1
Slime tails.....	20.2			6.48	5.5
Heads.....	100.0	14.3	100.0	2.60	100.0
Sand tails.....	37.6	3.0	7.9	0.6	8.7
Slime tails.....	3.8	11.4	3.0	2.9	4.0

All our efforts to recover the values in these slime tails, by any method other than leaching, have been failures, and leaching methods are too costly. Our tests have shown conclusively that when slimes are present, the pulp must be in a "dispersed" condition, in order successfully to float the values, and sodium silicate is the best addition agent for this purpose. These slimes also lower the grade of the concentrates.

Oxidized iron and manganese minerals, especially when in the form of slimes, consume excessive quantities of sodium sulfide, and can exist in an ore to such an extent as to consume 20 or 30 lb. of sulfide per ton of ore, which, of course, are prohibitive amounts.

IDEAL ORE FOR FLOTATION

The ideal oxidized lead-silver ore for a flotation operation, providing economic factors, such as water supply, power and accessibility are normal, is one having the following composition: Silver, 5 oz. and up; lead 5 per cent. and up, in the form of carbonate; combined iron and manganese not over 12 per cent.; lime not over 10 per cent., and insoluble above 50 per cent. This type of ore usually contains only a small amount of

colloidal slimes; is easily sulfidized and floats about as readily as a galena ore. The reason for placing a limit on the lime is that we have found that some types of lime carbonates, especially aragonite, float quite readily which lowers the grade of the concentrate.

A combination of table concentration and flotation on this type of ore will usually cut down the amount of sodium sulfide required and often increase extraction to some extent. The following is an example of combined tabling and flotation, on an ore from California:

[Ratio of Concentration—Six tons into one of Combined Concentrate]

	Assay						Percentage Contained		
	Gold, Oz.	Silver, Oz.	Lead, Per Cent.	Iron, Per Cent.	CaO, Per Cent.	Insoluble, Per Cent.	Gold	Silver	Lead
Heads.....	0.05	2.6	6.5				100.0	100.0	100.0
Table concentrate.....	0.32	18.0	39.7	10.2		3.1	62.3	61.9	54.0
Flotation concentrate....	0.25	14.0	32.3	5.8	14.2	5.8	37.7	38.1	35.0
Combined concentrate....	0.29	16.2	36.3	8.2	8.0	3.6	100.0	100.0	89.0
Tails.....	Tr.	Tr.	0.8						10.0

REAGENTS USED ON TABLE TAILS

The laboratory reagents used on the table tails were: sodium sulphide 5 lb.; sodium silicate, 6 lb.; P. & E. oil, 3 lb., and reconstructed Yarmou pine oil, 1 lb. per ton of table tails. Without table concentration, but a straight flotation operation, the recoveries were the same on the gold and silver, but 5 per cent. lower on the lead. The consumption of sodium sulfide was double in amount. This test is also an example of the flotability of calcium carbonate, viz., 14.2 per cent. CaO in the flotation concentrate.

As an example of straight flotation on a siliceous oxidized silver-lead ore, I have selected a 90-ton test-mill run on ore from the Victoria Mine of the Bingham Mines Co. The gold and silver in the ores from the

	Assay					Percentage Contained		
	Gold, Oz.	Silver, Oz.	Lead, Per Cent.	Iron, Per Cent.	Insoluble, Per Cent.	Gold	Silver	Lead
Heads.....	0.03	11.4	6.5			100.0	100.0	100.0
Flotation concentrate.....	0.10	91.5	53.1	5.0	14.6	67.4	78.6	87.0
Tails.....	0.01	2.7	0.9			32.6	21.4	12.0

Tintic district appear to be occluded to some extent in the gangue material, so that the tailings are relatively high in these two metals. This characteristic is particularly true of some ores from the Chief Consolidated orebodies.

Finer grinding does not improve the recoveries of gold and silver. The lead mineral is quite distinct from the occluded silver, as shown by the fact that only 6 min. in the flotation machine is necessary to recover the lead in a rougher concentrate running 57 per cent., the silver lagging behind.

SUMMARY

The governing factors determined, up to the present, for successful oxidized lead ore flotation, and this applies to some extent to oxidized copper ores, may be summarized as follows.

1. If the valuable oxidized minerals can be sulfidized and these sulfidized minerals, when treated with flotation reagents and agitated with air, gather into flocculated aggregates of the valuable minerals and air, and the gangue material remains in a dispersed condition, then a commercial recovery of the valuable minerals can be obtained.

2. The pulp must be, and remain in, a dispersed condition during the flotation period.

3. The percentage of so-called colloidal slimes in the pulp should not exceed 15 per cent.

4. The amounts of oxidized iron and manganese in the ore should not exceed 15 per cent.

5. If the ore contains both sulfide and oxidized minerals, the sulfides should be removed by either tabling or primary flotation before attempting to sulfidize and float the oxidized minerals.

ACKNOWLEDGEMENT

All the laboratory experimental work was performed by C. M. Nokes, a graduate of the University of Utah, and I am greatly indebted to him for his timely suggestions and keen sense of observation: which were of the greatest value during the progress of this work.