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A process for the separation of barite and sphalerite

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A PROCESS FOR THE SEPARATION

OF

BARITE AND SPHALERITE

by

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NOTE: An ABSTRACT of a thesis done at the Missouri School of Mines and Metallurgy, Rolla, Mo. for the Degree of Bachelor of Science. 1912.

A process wherein the Barite-Sphalerite concentrate from the ordinary water concentration is given a bath of very weak neutral sulfate solution at a cost of 10¢ or less per ton, previous to electrostatic separation.

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The present high price of zinc has stimulated a greater interest in Sphalerite Barite separations than has been manifested for some time. A great many processes have been worked on and have failed for any reasons, the main one being that the physical characteristics of the ore varied so much. The process that is sucessful must be independent of these variations. The following process is one that depends on a chemical phenomenon and is adapted to any sphalerite-barite separation.

This series of experiments was performed by the authors at the Missouri School of Mines and Metallurgy, Rolla, Mo. and was embodied in a thesis.

An Unusual Separating Problem.

Ordinarily, sphalerite is a nonconductor of electricity and because of this is easily separated from copper sulfide minerals by electrostatic means as the latter are very good conductors. A test on some weathered table middlings of these minerals showed the sphalerite to be a good conductor and it could not be separated from the copper minerals. The sphalerite was darker than it was originally . The fresh middling was very easily separated, the sphalerite being in this case a non conductor as usual. The differ nce in conductivity of the sphalerite in the two cases was due to a dark film deposited on its surface by the weathering of the copper minerals. As copper sulfate is the principal decomposition product of copper sulfides by weathering, it occurred that it might be possible to make the sphalerite, in any case, a good conductor artificially by leaching with dilute copper sulfate solutions.

Application to Sphalerite-Barite Separation.

Barite is a nonconductor and is unaffected by copper sulfate solutions. Hence by giving the sphalerite mixture a copper sulfate treatment, the sphalerite can be made a good conductor and can be separated electrostatically from the barite.

Preliminary tests showed this to be possible and hastily drawn conclusions stated that " the sphalerite was made a good conductor by the electro-chemical deposition of a minute film of copper on its surface by the sulfating action."

The product treated was a hand jig concentrate consisting chiefly of barite and sphalerite with no pyrite or galena, from a mine in Central Missouri and had not been sucessfully treated by any process.

The Separator.

The Apparatus used in these tests was a small one roller separator made to resemble the Huff Roller Type Electrostatic Separator. Electrification was supplied by an ordinary Holtz Electrostatic machine. The separator is shown in Fig.1 It consists of a V shaped hopper suitably mounted to lead the ore properly to the roller, which is a two inch brass tube four inches long. The hopper is capable of being moved forward or backward and is held in place by screws in slots "A" The rate of feed is regulated by a lip on the front of the hopper which may be raised or lowered by a bolt in the slot "B" . A tight flexible joint between the hopper and the roll is maintained by pieces of felt attached to the hopper. The roller is mounted on a shaft below the hopper and is driven by a motor.

At the bottom of the roller , set well back , is a metal scraper, held against the roller by springing it a small amount. This scraper serves a double purpose;to scrape off any nonconductors that cling to the rollwhen it is charged,and also to form an electrical connection to the roll.Just in front of the roll is the electrode,which consists of a copper tube enclosed in a glass tube,supported by iron hooks, which are supported by the framework of the machine. The hooks are threaded the greater portion of their length and slide in horizontal slots.Small nuts clamp both sides of the sopport,making it possible to firmly fix the electrode in any position desired. About two inches below the machine roller and extending out in front of the machine are two supports for the concentrates pan.The pan is a wooden box with an inclined sharp edge to facilitate cutting in at the desired place. Below this pan is a tailing pan. The machine is about 15 inches high.The other dimensions can be estimated by eye.

The ore must be dried before separating and is fed into the hopper. The roll can be grounded or charged oppositely to the charge on the electrode. In all the tests,however,the roll was grounded,as in practice,for mechanical reasons,the machines are operated that way.The speed of the roll is about 200 R.P.M. The entire aparatus set up for work is shown in Fig22. and consists of a small motor,the electrostatic generator,and the separator.

First Experiments.

To determine the effect of various strengths of copper sulfate solutions, time of treatment, sizing of feed, temperature of the bath, washing out of the solution after treatment, and the effect of no treatment,tests 3 to 9 were made.In all of these tests,the manner of treatment in the separator was precisely the same,special care being taken to make all the variables constant but the one under observation during the whole of each test.

Test Number	3	4	5	6	7	8	9
Size of ore	20-40 mesh thruput except in #9						12-0
Copper sulfate sol.	1% crystals		5%	1%	1%	none	1%
C.c. of solution	500	500	500	500	500	"	500
Minutes on ore	10	10	10	60	10	"	10
Temperature Cent.	100	28	100	100	100	"	100
Times washed	2	2	3	2	None	"	2
C.c. wash water	300	300	300	300	"	"	300
R.P.M. Roller	136	136	136	136	136	136	136
Times thru Separator	4	4	4	4	4	4	4
Weight ore in grams	500	500	500	500	500	500	500
Percent Zinc	19.80	19.80	19.80	19.80	19.80	19.80	19.80
Weight tailing (gm)	347	354	345	349	378	454	----
Percent Zinc	1.08	2.12	1.22	1.38	5.30	15.06	----
Weight Concentrate	153	146	155	151	122	46	-----
Percent Zinc	62.20	63.20	61.80	62.30	64.51	66.40	----
Percent Recovery	96.3	93.5	96.8	95.0	79.5	30.9	----

Conclusions from tests 3-9.

Test 9 was not run to completion as it was too inferior to be regarded.

From the foregoing results,it is evident that the ore must be treated to affect a separation; that it must be reasonably closely sized; that the temperature,strength, and time of treatment are not important items to consider; and that the remaining solution hinders the separation. The reason test 8 gave a partial separation is accounted for by the fact that some copper minerals have been observed in the vicinity of the deposit and the weathering of these had partially coated some of the sphalerite.

Rapidity of Deposition.

To show the rapidity of deposition of the conductive film on the sphalerite, and the time for maximum deposition, the following tests were made. 20-40 mesh sphalerite was treated with copper sulphate solution(1% crystals) at room temperature for varying lengths of time. 25 grams was treated with 25 c.c. of the above solution in each case. AT the desired time, the solution was quickly filtered off and was analyzed by the "Iodide" method. 8c.c. were taken for analysis each time. From these results, copper used up per 100 gm. Sphalerite in each case was calculated and the following curve was plotted.

This curve shows that the deposition of the film is very rapid, the maximum, under these conditions being reached within three hours.

Minimum time of Sulfating.

To get more of a notion of the minimum time of treatment that would give the desired separation, a batch of ore was treated for one minute with 1% coppersulfate solution at room temperature, washed immediately, dried and separated. The results were entirely satisfactory. The time of treatment, then, is not an important factor.

From the curve showing the rapidity of deposition, the copper used up was calculated and five kilograms of ore , thru 12 mesh, was given the same amount of copper sulfate per gm. as was used up in the preceeding experiment in a very dilute solution. This was to show whether deposition would would go on to completion in dilute solution. If it would, the copper sulfate used up per ton of concentrate would be much smaller as none would be left in the ore or solution unused and also the expense of washing would be eliminated.

The 5 Kilos. of ore was put in a tube 6 feet long, held in a vertical position, and 1200 c.c. of copper sulfate solution at 28 C and of 0.111% Cu. were poured on to the top of the ore. The resulting solution was drawn off at the bottom. This was to resemble treatment in ordinary bins by pouring the solution over the surface of the ore and letting it drain off thru openings in the bottom as waste water. It took 30 minutes for500 c.c. to drain off, the remainder being held as moisture.

The ore was then dried, screened into four sizes--12-20mesh, 20-40 mesh, 40-80 mesh, and thru 80 mesh. Separation of the 12-20 mesh product gave the following results.

Feed	2727 grams	19.38%	Zinc.
Concentrate	771 "	63.75%	" 0.52% Fe.0.14%Pb., 0.08%Cu.
Middling	114 "	24.04%	" .
Tailing	[illegible] "	0.61%	" .

Percent recovery(counting middling lost)----92.8

Percent " (" " recoverable)--97.8

The middling was not run to tailing and concentrate as it was too small in bulk. Its behavior, however indicated that it would separate as well as the rest did.

Separations of the other sizes gave equally as good results, the dust separating nearly as well as the coarser sizes.

Analyses of the solution used in the foregoing experiment are as follows.

Original solution--	0.111% Cu.	No Fe.	No Zn.
Resulting "	0.006% "	0.164% Fe.	0.056% Zn.

Treatment charges.

The copper used up in this experiment was at the rate of 2.1 pounds of crystallized copper sulfate per ton of ore. This gives about 10 cents per ton treatment charges above those incurred in the electrostatic separation.

It took 25 minutes to make this separation on the single roll machine. Hence the capacity of an electrostatic separator working on this ore ought to be as high as or higher than those in use now on other separations.

Conclusions.

Thus ~~from~~ all data at hand indicates that sphalerite and barite can be separated by this method, which consists of pouring over the ordinary water concentrate, a very dilute copper sulfate solution, drying, screening and separating by electrostatic means.

The effect of abrasion on the conductive film has not yet been studied. Abrasion in drying, screening and handling after sulfating may effect the practical application of the process. It is not believed to be of much importance, however, as the film is psuedomorphous and would resist wear as well as the original sphalerite. It is not probable that more abrasion would result in practice than did in these tests.

The Conductive Film.

The conductive film deposited on the surface of the sphalerite by the sulfating begins to deposit as soon as the solution touches it and ~~colors~~ darkens the crystals from a grey to a jet black according to the thickness of the deposit. The rapidity if the action is increased by heat and by strengthening the solution. This film appears as lustrous as, or more lustrous than the original sphalerite, indicating that the film in pseudomorphous, not amorphous.. It was first thot by those that first observed the phenomenon, that it must be copper because it altered the conductivity of the blende so markedly. Chemistry does not corroborate this hastily drawn conclusion as the following experiment shows.

About 50 grams of sphalerite was ground in an agate mortar to an inpalpable powder in order to expose the maximum surface to the action of the solution. It was leached continuously for three days with a strong neutral copper sulafte solution at 100 C. The resulting mineral was jet black. ~~and was of the following composition~~ After washing and drying, it was of the following composition.

Zn.	50.85 %
Cu.	16.82 %
S.	32.75 %
Fe.	trace
Total	100.00%

Figuring the percent ZnS that remained unaltered from the Zn., shows the following composition.

ZnS	75.88 %
S	7.72 %
Cu	16.82 %

The ratio of copper to sulphur remaining is seen to be 2.18 / 1 .
The ratio of copper to sulphur in CuS is 1.98 / 1 .
These ratios check closely enough to say that the copper exists as CuS.

Hence, the conductive film deposited on sphalerite by treatment with neutral copper sulfate solution, is CuS, not Cu or Cu_2S . The equation expressing the reaction is,

$$CuSO_4 + ZnS = CuS + ZnSO_4$$