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FLOTATION OF ORES.

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This invention relates to the concentration of ores by flotation, and, more particularly, to the differential flotation of mixed sulfide ores. The invention has for its object the provision of an improved method of concentrating mixed or complex sulfide ores by differential flotation. More particularly, the invention aims to provide an improved method of concentrating by differential flotation a mixed or complex sulfide ore containing either, or both lead or copper sulfides associated with either, or both zinc or iron sulfides.

Our present invention involves treating the mixed or complex sulfide ore, reduced to a flotable size, with a halogen, such as chlorine, bromine, or iodine, either in neutral (that is, non-acid) solution, or in conjunction with an alkaline agent such as an alkali, alkaline salt, an alkali earth salt or hydroxide, and the like. The lead or copper, or both, may be floated as a primary product and the zinc as a secondary product. The iron is inhibited from floating and remains with the tailing. If desired, a iron concentrate may be secured by subjecting the tailing to a flotation operation in the presence of suitable oils or other flotation agents. For example, the thus treated ore is subjected to a flotation operation and the lead or copper, or both, may be recovered in the flotation concentrate, while flotation of the zinc or iron sulfides, or both, is inhibited and remains with the tailing. The tailing is then subjected to another flotation operation and the zinc sulfide recovered in the flotation concentrate while flotation of the iron sulfide is inhibited.

In general, the ore is ground to the desired size in a ball mill in the presence of a halogen alone or together with an appropriate alkaline agent. In many instances, improved results are obtained by the addition of zinc sulfate. The thus treated ore is thereafter subjected to a flotation operation in the presence of an oil, or other appropriate flotation agent, whereby a froth is formed containing most of the lead or copper, or both. The oil, or other appropriate flotation agent, may be added at the ball mill, or at the flotation machine, or at an intermediate point, according to the characteristics of the ore and flotation agent. After removal of the lead or copper, or both, an appropriate amount of an alkaline agent, or a halogen, or a halogen and an alkaline agent, is added. In certain instances, improved results may be obtained by the addition of copper sulfate with one or more of the other reagents. The remaining ore is then subjected to another flotation operation to form a froth containing most of the zinc sulfide. The iron is inhibited from floating and remains with the tailing.

If the ore is already of such fineness that the grains of the component sulfides are free from one another, the ore pulp is subjected to a time treatment in the presence of a halogen alone, or in conjunction with an alkaline agent, with or without zinc sulfate, in a tank or other container large enough and so constructed as to give the pulp the necessary treatment. The pulp is now in readiness for differential separation, and is passed to a flotation machine of a suitable type, where, after the addition of oil or other appropriate flotation agent, a froth containing the lead or copper, or both, is produced; the flotation of the zinc and iron is inhibited. The further treatment of the pulp and subsequent flotation of the zinc is conducted as previously described, although the reagents may be added to the pulp at any point preceding the flotation of the zinc, provided that the pulp and reagents have sufficient time to interact.

Our investigations indicate that any member of the halogen group may be employed in accordance with the invention; that is, in practice, either bromine, chlorine, or iodine may be employed with equally good results. In conjunction with a halogen, we may employ an alkaline agent, such as an alkali, an alkaline salt, an alkali earth salt or hydroxide, and the like. The particular alkaline agent employed is determined by the nature of the ore, as will be readily understood by the art. In treating some ores, it is advantageous to employ zinc sulfate in combination with the other reagents, as it aids in securing a lead product low in zinc.

The practice of the invention will be further illustrated by the following examples:

1. 1000 grams of ore (through 10 mesh) to which was added 500 cc. of water, bromine— 1.0 lb. per ton, sodium bicarbonate—3.0 lbs. per ton, and zinc sulfate—0.5 lb. per ton of ore, were ground until the ore minerals (sul-

fides) were free and of a size suitable for flotation. The pulp was then diluted to about 4 parts of water to 1 part of ore by weight and transferred to a laboratory flotation machine, 0.3 lb. of Barrett No. 4 oil added, and the resultant froth, containing the lead (galena) removed; 1.0 lb. of caustic soda and 1.0 lb. of copper sulfate were added to the pulp, and allowed to mix and react with the pulp for two minutes. A froth containing the zinc formed upon the addition of 0.8 lb. of a coal tar creosote and 0.1 lb. of a steam distilled pine oil, and was removed. This froth was given one cleaning in the same machine, but without further addition of oil or other reagents, resulting in a zinc concentrate and a zinc cleaner tailing or middling product. The results of this run are indicated in the following tabulation:

Product	Per cent of total weight	Assay			Per cent recovery		
		Per cent Fe	Per cent Zn	Per cent Pb	Fe	Zn	Pb
Head	100.0	6.6	15.2	8.6	100.0	100.0	100.0
Pb R. conc	10.9	3.6	10.6	55.0	5.9	7.6	69.3
Zn conc	24.9	4.7	49.1	7.9	17.7	80.5	22.9
Zn middling	9.3	9.1	13.4	2.0	12.9	8.2	2.2
Talling	54.9	7.6	1.0	0.8	63.2	3.6	5.1
Total	100.0				99.7	99.9	99.5

2. The same procedure as in Example No. 1, but in which 1.0 lb. of iodine per ton of ore is substituted for bromine:

Product	Per cent of total weight	Assay			Per cent recovery		
		Per cent Fe	Per cent Zn	Per cent Pb	Fe	Zn	Pb
Head	100.0	6.7	14.3	7.9	100.0	100.0	100.0
Pb R. conc	12.4	5.5	16.2	50.6	6.4	14.1	79.4
Zn conc	19.7	5.0	50.8	6.0	14.8	70.0	14.9
Zn middling	7.8	13.1	23.0	3.2	15.2	12.5	3.2
Tailing	60.1	7.1	0.8	0.3	63.7	3.3	2.2
Total	100.0				100.1	99.9	99.7

3. The same procedure as in Example No. 1, but in which 1.0 lb. of chlorine is substituted for the bromine, and 3.0 lbs. of sodium carbonate for the bicarbonate:

Product	Per cent of total weight	Assay			Per cent recovery		
		Per cent Fe	Per cent Zn	Per cent Pb	Fe	Zn	Pb
Head	100.0	7.7	11.2	5.7	100.0	100.0	100.0
Pb R. conc	8.4	6.2	14.0	50.6	6.8	10.5	74.6
Zn conc	14.5	6.9	48.7	6.0	13.0	63.0	15.2
Zn middling	9.0	14.0	24.0	3.0	16.4	19.3	4.7
Tailing	68.1	7.2	1.2	0.5	63.6	7.3	6.0
Total	100.0				99.8	100.1	100.5

4. The same mechanical procedure as in Example No. 1. The reagents used are 3.0 lbs. of sodium bicarbonate, and 1.0 lb. of bromine, but zinc sulfate omitted.

Product	Per cent total weight	Assay				Per cent recovery			
		Oz. Ag.	Per cent Fe	Per cent Zn	Per cent Pb	Ag.	Fe	Zn	Pb
Head	100.0	8.35	6.53	15.15	7.78	100.0	100.0	100.0	100.0
Pb Conc	13.1	43.8	4.0	15.5	47.5	68.8	8.1	13.4	80.0
Pb tailing	86.9	3.0	6.9	15.1	1.8	31.2	91.9	86.6	20.0
Total	100.0					100.0	100.0	100.0	100.0

5. 1000 grams of ore were ground to the required fineness with 500 cc. of water, 1.0 lb. of chlorine, and 1.2 lbs. of sodium hydroxide per ton of ore. The pulp was then diluted to about 4 parts of water to 1 part of ore by weight and placed in a laboratory flotation machine. After the addition of 0.3 lb. of Barrett No. 4 oil (per ton of ore), a froth was produced which contained the lead (galena); then 1.0 lb. of sodium hydroxide per ton of ore was placed in the pulp, and after a time interval of two minutes, 0.8 lb. of coal tar creosote and 0.1 lb. of pine oil were added, and a froth containing the zinc (sphalerite) produced. The iron remained in the tailing.

Product	Per cent of total weight	Assay			Per cent recovery		
		Per cent Fe	Per cent Zn	Per cent Pb	Fe	Zn	Pb
Head	100.0	8.2	12.8	8.7	100.0	100.0	100.0
Pb R. conc	14.6	4.0	18.4	45.3	7.2	21.0	75.8
Zn conc	16.2	5.2	48.6	7.7	10.3	61.5	14.4
Zn middling	9.7	8.9	1.3	1.0	64.5	6.0	6.9
Total	40.5				82.0	88.5	97.1

6. 1000 grams of ore (through 10 mesh) were ground to the required fineness with 500 cc. of water, and bromine equivalent to 1.0 lb. per ton of ore. The pulp was diluted as before and then passed to a flotation machine. Upon the addition of 0.4 lb. of Barrett No. 4 oil (per ton of ore), a froth containing the lead was produced, the zinc and iron remaining in the tailing. A zinc concentrate is not shown, but may be made in the same manner as in preceding tests.

Product	Per cent of total weight	Assay			Per cent recovery		
		Per cent Fe	Per cent Zn	Per cent Pb	Fe	Zn	Pb
Head	100.0	6.32	14.07	6.61	100.0	100.0	100.0
Pb R. conc	9.1	3.5	9.6	52.6	5.1	6.9	72.5
Pb tailing	90.9	6.6	14.4	2.0	94.9	93.1	27.5
Total	100.0				100.0	100.0	100.0

7. 1000 grams of an ore were ground to the desired fineness in a ball mill with 3.0 lbs. of sodium carbonate, 1.0 lb. of zinc sul-

fate, and 1.0 lb. of chlorine per ton of ore, and 500 cc. of water. The pulp was diluted as before and then placed in a flotation machine of a suitable type, oil added, and the froth containing the lead removed. To the pulp in the flotation machine, 2.0 lbs. of chlorine per ton of ore was added. A froth rich in zinc (blende) formed immediately, and resulted in the removal of a considerable portion of the zinc without the use of oil. The remainder of the zinc was floated and removed by the addition of 0.5 lb. of Barrett No. 4 oil. The greater portion of the iron remained in the tailing. The zinc rougher concentrate was cleaned once, forming a zinc concentrate and a zinc middling.

Product	Per cent of total weight	Assay			Per cent recovery		
		Per cent Fe	Per cent Zn	Per cent Pb	Fe	Zn	Pb
Head	100.0	7.60	11.46	5.67	100.0	100.0	100.0
Pb R. conc	10.2	6.8	15.8	41.4	9.1	14.1	74.4
Zn conc	14.1	6.3	50.0	6.0	11.7	61.5	15.0
Zn middling	8.7	13.8	23.0	3.0	15.8	17.4	4.6
Tailing	67.0	7.2	1.2	0.5	63.4	7.0	6.0
Total	100.0				100.0	100.0	100.0

8. 1000 grams of ore were ground to the desired fineness in a ball mill with 1.0 lb. of chlorine, 0.5 lb. of zinc sulfate, and 3.0 lbs. of sodium bicarbonate per ton of ore, together with 500 cc. of water. The pulp was diluted as before and passed to a flotation machine, oil added, and the froth containing the copper removed; to the pulp in the machine, 1.0 lb. of caustic soda was added, allowing a time treatment of two minutes (equivalent to passage through launders and elevator in practical operation), and upon the addition of 0.4 lb. of Barrett No. 4 oil and 0.05 of steam distilled pine oil, a froth formed, which contained the zinc.

Product	Per cent of total weight	Assay		Per cent recovery	
		Per cent Cu	Per cent Zn	Cu	Zn
Head	100.0	2.93	11.99	100.0	100.0
Cu R. conc	12.8	17.20	21.3	75.1	22.8
Zn R. conc	19.2	2.96	46.5	19.6	74.4
Tailing	68.0	0.23	0.5	5.3	2.8
Total	100.0			100.0	100.0

This separation may be made by any of the methods specified in the separation of lead and zinc, subject, of course, to the same restriction; i. e., the nature of the ore and condition of the ore pulp.

9. 1000 grams of ore (through 10 mesh) were ground to the necessary fineness in a ball mill with 2.0 lbs. of caustic soda, 1.0 lb. of chlorine per ton of ore, and 500 cc. of water. The pulp was diluted as before and passed to a flotation machine, and upon the addition of a suitable oil, a froth containing the copper was formed and removed, the iron, for the most part, remaining in the tailing.

Product	Per cent of total weight	Assay		Per cent recovery	
		Per cent Cu	Per cent Fe	Cu	Fe
Head	100.0	4.91	15.6	100.0	100.0
Cu R. conc	23.8	17.57	23.9	85.1	36.5
Tailing	76.2	0.96	13.0	14.9	63.5
Total	100.0			100.0	100.0

That part of the iron which is chemically combined with the copper, as in chalcopyrite and bornite, cannot be separated from the copper. The high percentage of iron in the copper concentrate is due to this fact.

In the practice of the invention as illustrated by the specific examples, the halogen used will vary, but it must be borne in mind that any member of this group—bromine, chlorine, or iodine—may be substituted for the one used, and substantially the same result obtained.

The particular alkaline agent employed is determined by the nature of the ore—in some ores a certain alkaline agent will give better results than another, and vice-versa. In treating some ores, it is advantageous to use zinc sulfate in combination with the other reagents as it aids greatly in making a lead product low in zinc.

After an ore has been treated with a sufficient amount of a halogen and the separation of lead sulfide or copper sulfide from zinc sulfide is obtained, we have found that a further addition of a halogen (the quantity varying with the ore and pulp condition) to the pulp, either with or without an alkali, will cause the immediate formation of a froth high in zinc, and leave the iron in the tailing; i. e., inhibit the iron from floating. In some cases a clean tailing may be made without the further use of oil; in others an oil is required.

It will be noted, however, that the separation of lead sulfide or copper sulfide, or both, from zinc sulfide may be made in any of the ways previously mentioned, and that the separation of zinc sulfide from iron sulfide may be accomplished by the use of a halogen alone, or in conjunction with an alkaline agent such as an alkali, alkaline salt, alkali earth salt or hydroxide. The amount of the halogen used is dependent upon the particular ore or metallurgical product to be treated—a certain amount being necessary for the separation of lead or copper sulfide from zinc sulfide, and a certain further amount for the separation of zinc sulfide from iron sulfide.

Our invention is applicable to ores, concentrates, tailings, and other metallurgical

products containing lead, copper, zinc, or iron sulfides in any combination, for which the term ore is used throughout this sepcification and the appended claims.

The addition of the halogens to ore pulps may be made in several ways; bromine, a liquid, and iodine, a solid, may be added directly to pulp in a ball mill, or in a tank at any desired point; chlorine, a gas, may be added as chlorine water, or the pulp may be chlorinated at any point in the flow.

It is sometimes desirable to secure an iron concentrate, since in many ores gold and silver occur with the iron, and may be recovered in this way. In floating the iron after removal of zinc, heavy oils, such as an acid sludge, coal tar creosote, or pine tar, either alone or in combination, are effective. It is understood, of course, that other oils or oil combinations may be used advantageously in this connection.

While it seems probable from our investigations that fluorine behaves like the other halogens with respect to its differential action on sulfide minerals, the practical difficulties in using fluorine in a flotation mill are so great that we now consider fluorine impracticable in the commercial practice of the invention and on this account and to this extent we exclude fluorine.

We claim:

1. The process of concentrating by froth-flotation an ore containing sulfides of lead, copper, zinc, and iron, which comprises treating the ore with a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the lead and copper sulfides are in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

2. The process of concentrating by froth-flotation an ore containing sulfides of lead, zinc, and iron, which comprises treating the ore with a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the lead sulfide is in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

3. The process of concentrating by froth-flotation an ore containing sulfides of lead and zinc, which comprises treating the ore with a halogen in such amount as will substantially inhibit the flotation of zinc sulfide, and subjecting the so treated ore to a flotation operation in which the lead sulfide is in large part recovered in the resulting froth and the flotation of the zinc sulfide is in large part inhibited.

4. The process of concentrating by froth-flotation an ore containing sulfides of copper, zinc, and iron, which comprises treating the ore with a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the copper sulfide is in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

5. The process of concentrating by froth-flotation an ore containing sulfides of copper and zinc, which comprises treating the ore with a halogen in such amount as will substantially inhibit the flotation of zinc sulfide, and subjecting the so treated ore to a flotation operation in which the copper sulfide is in large part recovered in the resulting froth and the flotation of the zinc sulfide is in large part inhibited.

6. The process of concentrating by froth-flotation an ore containing sulfides of copper and iron, which comprises treating the ore with a halogen in amount approximating one pound per ton of ore, and subjecting the so treated ore to a flotation operation in which the copper sulfide is in large part recovered in the resulting froth and the flotation of the iron sulfide is in large part inhibited.

7. The process of concentrating by froth-flotation an ore containing sulfides of zinc and iron, which comprises treating the ore with a halogen in amount approximating one pound per ton of ore, and subjecting the so treated ore to a flotation operation in which the zinc sulfide is in large part recovered in the resulting froth and the flotation of the iron sulfide is in large part inhibited.

8. The process of concentrating by froth-flotation an ore containing sulfides of lead, copper, zinc, and iron, which comprises treating the ore in a non-acid pulp with a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the sulfides of lead and copper are in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

9. The process of concentrating by froth-flotation an ore containing sulfides of lead, zinc, and iron, which comprises treating the ore in a non-acid pulp with a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the sulfide of lead is in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

10. The process of concentrating by froth-flotation an ore containing sulfides of lead and zinc, which comprises treating the ore

in a non-acid pulp with a halogen in such amount as will substantially inhibit the flotation of zinc sulfide, and subjecting the so treated ore to a flotation operation in which the sulfide of lead is in large part recovered in the resulting froth and the flotation of the zinc sulfide is in large part inhibited.

11. The process of concentrating by froth-flotation an ore containing sulfides of copper, zinc, and iron, which comprises treating the ore in a non-acid pulp with a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the sulfide of copper is in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

12. The process of concentrating by froth-flotation an ore containing sulfides of copper and zinc, which comprises treating the ore in a non-acid pulp with a halogen in such amount as will substantially inhibit the flotation of zinc sulfide, and subjecting the so treated ore to a flotation operation in which the sulfide of copper is in large part recovered in the resulting froth and the flotation of the zinc sulfide is in large part inhibited.

13. The process of concentrating by froth-flotation an ore containing sulfides of copper and iron, which comprises treating the ore in a non-acid pulp with a halogen in amount approximating one pound per ton of ore, and subjecting the so treated ore to a flotation operation in which the sulfide of copper is in large part recovered in the resulting froth and the flotation of the iron sulfide is in large part inhibited.

14. The process of concentrating by froth-flotation an ore containing sulfides of zinc and iron, which comprises treating the ore in a non-acid pulp with a halogen in amount approximating one pound per ton of ore, and subjecting the so treated ore to a flotation operation in which the sulfide of zinc is in large part recovered in the resulting froth and the flotation of the iron sulfide is in large part inhibited.

15. The process of concentrating by froth flotation an ore containing sulfides of lead, copper, zinc, and iron, which comprises treating the ore with a halogen and an alkaline agent in such amounts as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the lead and copper sulfides are in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

16. The process of concentrating by froth flotation an ore containing sulfides of lead, zinc, and iron, which comprises treating the ore with a halogen and an alkaline agent in such amounts as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the lead sulfide is in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited.

17. The process of concentrating by froth flotation an ore containing sulfides of lead and zinc, which comprises treating the ore with a halogen and an alkaline agent, in such amounts as will substantially inhibit the flotation of zinc sulphide, and subjecting the so treated ore to a flotation operation in which the lead sulfide is in large part recovered in the resulting froth and the flotation of the zinc sulphide is in large part inhibited.

18. The process of concentrating by froth flotation an ore containing sulphides of copper, zinc, and iron, which comprises treating the ore with a halogen and an alkaline agent, in such amounts as will substantially inhibit the flotation of zinc and iron sulfides, and subjecting the so treated ore to a flotation operation in which the copper sulfide is in large part recovered in the resulting froth and the flotation of the zinc and iron sulphides is in large part inhibited.

19. The process of concentrating by froth flotation an ore containing sulfides of copper and zinc, which comprises treating the ore with a halogen and an alkaline agent in such amounts as will substantially inhibit the flotation of zinc sulphide, and subjecting the so treated ore to a flotation operation in which the copper sulphide is in large part recovered in the resulting froth and the flotation of the zinc sulphide is in large part inhibited.

20. The process of concentrating by froth flotation an ore containing sulphides of copper and iron, which comprises treating the ore with a halogen and an alkaline agent in such amounts as will substantially inhibit the flotation of iron sulphide, and subjecting the so treated ore to a flotation operation in which the copper sulphide is in large part recovered in the resulting froth and the flotation of the iron sulfide is in large part inhibited.

21. The process of concentrating by froth flotation an ore containing sulfides of zinc and iron, which comprises treating the ore with a halogen and an alkaline agent in such amounts as will substantially inhibit the flotation of iron sulphide, and subjecting the so treated ore to a flotation operation in which the zinc sulphide is in large part recovered in the resulting froth and the flotation of the iron sulphide is in large part inhibited.

22. The process of concentrating by froth flotation an ore containing sulphides of lead and zinc, which comprises treating the ore with a halogen, an alkaline agent, and zinc

sulphate and thereby inhibiting in large part the flotation of zinc sulphide in the following flotation operation, and subjecting the so treated ore to a flotation operation in which the lead sulphide is in large part recovered in the resulting froth and the flotation of the zinc sulfide is in large part inhibited.

23. The process of concentrating by froth flotation an ore containing sulphides of lead, zinc, and iron, which comprises subjecting the ore in the form of an ore pulp to the action of a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, subjecting the so treated ore pulp to a flotation operation and thereby effecting in large part the flotation of the lead sulphide while inhibiting in large part the flotation of the zinc and iron sulfides, treating the remaining ore pulp with a halogen in such amount as will substantially inhibit the flotation of iron sulfide, and subjecting the so treated remaining ore pulp to another flotation operation in which the zinc sulfide is in large part recovered in the resulting froth.

24. The process of concentrating by froth flotation an ore containing sulfides of copper, zinc, and iron, which comprises subjecting the ore in the form of an ore pulp to the action of a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, subjecting the so treated ore pulp to a flotation operation and thereby effecting in large part the flotation of the copper sulphide while inhibiting in large part the flotation of the zinc and iron sulfides, treating the remaining ore pulp with a halogen in such amount as will substantially inhibit the flotation of iron sulfide, and subjecting the so treated remaining ore pulp to another flotation operation in which the zinc sulphide is in large part recovered in the resulting froth.

25. The process of concentrating by froth flotation an ore containing sulfides of lead, zinc, and iron, which comprises subjecting the ore in the form of an ore pulp to the action of a halogen in such amount as will substantially inhibit the flotation of zinc and iron sulfides, subjecting the so treated ore to a flotation operation and thereby effecting in large part the flotation of the lead sulfide while inhibiting in large part the flotation of the zinc and iron sulfides, treating the remaining ore pulp with a halogen and an alkaline agent in such amounts as will substantially inhibit the flotation of iron sulfide, and subjecting the so treated remaining ore pulp to another flotation operation in which the zinc sulfide is in large part recovered in the resulting froth.

26. The process of concentrating by flotation an ore containing sulfides of copper, zinc, and iron, which comprises subjecting the ore in the form of an ore pulp to the action of a halogen in such amount as will inhibit in large part the flotation of the zinc and iron sulfides in the following flotation operation, subjecting the so-treated ore pulp to a flotation operation in which the copper sulfide is in large part recovered in the resulting froth and the flotation of the zinc and iron sulfides is in large part inhibited, treating the remaining ore pulp with a halogen and an alkaline agent and thereby inhibiting in large part the flotation of the iron sulfide in the following flotation operation, and subjecting the so-treated remaining ore pulp to another flotation operation in which the zinc sulfide is in large part recovered in the resulting froth and the flotation of the iron sulfide is in large part inhibited.

In testimony whereof we affix our signatures.

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