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FROTH FLOTATION OF MONAZITE FROM HEAVY GRAVITY MINERALS

Robert E. Cuthbertson, Denver, Colo., assignor to Climax Molybdenum Company, New York, N. Y., a corporation of Delaware

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The present invention relates to a froth flotation treatment of ores or ore products containing phosphorus bearing minerals and heavy gravity minerals.

Objects and advantages of the invention will be set forth in part hereinafter and in part will be obvious herefrom, or may be learned by practice with the invention, the same being realized and attained by means of the processes and steps pointed out in the appended claims.

An object of this invention is to obtain heavy gravity minerals free of any phosphorus containing minerals by a froth flotation treatment of an ore containing said heavy gravity minerals and phosphorus containing minerals whereby the phosphorus containing minerals go into a froth and the heavy gravity minerals remain in the froth tailing.

A further object of this invention is to provide a process for froth flotation treatment of ores in which valuable phosphorus bearing minerals may be concentrated in a flotation froth so that they may ultimately be removed in a substantially free state.

The invention consists in the novel steps, processes, combinations and improvements herein shown and described.

The invention in general is directed to forming a froth whereby the phosphorus bearing minerals go into a flotation froth and valuable heavy gravity minerals remain in the froth tailing. In this way, substantially pure heavy gravity minerals are obtained without the use of costly chemical methods in order to produce readily saleable products. This is accomplished by adding a cationic reagent of the amine type and starch or equivalent starchy material to an acid pulp of an ore containing phosphorus bearing minerals and heavy gravity minerals, said acid pulp having been placed in a cell of a conventional flotator. A froth is formed when air is agitated through the mixture with the phosphorus bearing materials going into the froth and the heavy gravity minerals remaining in the froth tailing. The phosphorus bearing materials are skimmed off at the top by skimmers or the like.

More specifically, the invention is directed to separating a phosphorus bearing material such as monazite from heavy gravity minerals such as wolframite, rutile and cassiterite. This is accomplished in the manner described above, that

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is, a cationic agent of the amine type and starch or equivalent starchy material are added to an acid pulp of an ore containing monozite and a heavy gravity metal such as wolframite, rutile and cassiterite, said acid pulp having been placed in a cell of a conventional flotator. The acid pulp is formed by adding water to an ore concentrate to form a pulp and then adding the acid. There is nothing critical as to the amount of water added in forming the pulp. High dilution favors selectivity in the separation of the phosphate minerals from the non-phosphate minerals, whereas high percent of solids in the flotation pulp favors recovery of phosphate minerals and economy of reagents. A suitable range of dilutions would be from 15% solids to 35% solids. A froth is formed when air is agitated through the mixture with the monazite going into the froth and skimmed off at the top of the cell and the wolframite, rutile or cassiterite remaining in the froth tailing.

The cationic amine acts both as a frothing agent and a flotation agent or collection promoter. An additional fortifying frothing agent such as pine oil is usually added to obtain a more desirable froth than when the cationic amine is the sole frothing agent. When the cationic amine is added without any starch, the phosphate minerals, such as monazite, separate from the heavy minerals in the froth but the separation is incomplete and difficult to control. The addition of a boiled starch or starchy product to the amine flotation agent in an acid circuit makes the separation of the phosphate minerals, such as monazite, from wolframite, rutile, cassiterite and the like, highly selective and constitutes a discovery of considerable economic value.

Illustrative examples of the cationic amine flotation agents are higher aliphatic amines, such as lauryl amine, hexadecyl amine, dodecyl amine, short chain amines such as triethanol amine; amine salts which may be used include lauryl amine hydrochloride, hexadecyl amine hydrochloride, and dodecyl amine hydrochloride; quaternary ammonium salts of the higher aliphatic series may be used such as cetyl trimethyl ammonium bromide, lauryl triethyl ammonium chloride, octadecyl trimethyl ammonium chloride; amine-fatty acid condensation products may be used such as Armac C (Coco Amine Acetate) and Armac S (Soy Amine Acetate) made by Armour &

Co. For practical use on a commercial scale, the amine used must be in salt form such as the acetate or hydrochloride salts since the amine itself is too sparingly soluble in water. The amines derived from fatty acids with a high concentration of C–10 to C–14 fatty acids are most favorable.

In addition to using ordinary starch, other starch products may be used such as causticized starch, dextrim, Amijel (a dried gelatinized starch made by Corn Products Company), and Stayco M (a chlorinated starch) Stayco S (a chlorinated starch of the fluidity type) and Eclipse F (a fluidity type starch), all made by the A. E. Staley Mfg. Company.

In order to illustrate the invention more clearly, the following examples are given.

EXAMPLE I

A 500 gram sample tungsten concentrate obtained in the Climax Molybdenum Company mill by gravity concentration followed by additional refining on a cross belt type separator and made up of the following minerals:

	Percent
Wolframite	90.00
Monazite	2.50
Xenotime [1]	0.20
Cassiterite	0.15
Rutile	3.00
Metallic Iron	1.50
Miscellaneous [2]	2.65
Total	100.00

[1] Xenotime is a complex phosphate of rare earths somewhat similar in composition to monazite.
[2] Miscellaneous includes topaz, quartz, feldspar, and a number of unidentified minerals.

is placed in a Fagergren laboratory flotation cell and 2500 ml. of water are added until a pulp containing a consistency of 17% solids is obtained. To this pulp is added:

10 pounds sulfuric acid per ton of flotation feed (tungsten plup).
4.0 pounds of boiled starch (E. F. Staley Company—Eclipse F) per ton of flotation feed.
2.0 pounds Armac C (Coco Amine Acetate—Armour & Co.) per ton of flotation feed.
1.0 pound of pine oil per ton of flotation feed.

Air is circulated throughout the pulp with the acid and starch being added together at the start of the flotation and the amine acetate being added in five equal amounts during the frothing period at about three minute intervals. The acid, starch and amine may all be added to the water pulp simultaneously, if so desired. If a sequence operation is followed as illustrated above, the only limitation is that the amine should not be added prior to the starch and acid.

Test results of a feed heading which assayed 0.33% P and 69.0% WO_3 are indicated by the following tabulation:

Test No. 1

Product	Weight Grams	Percent Weight	Analyses		Percent Recovery	
			Percent P	Percent WO_3	P	WO_3
Flotation Fr th.	50	10.0	3.02	50.0	91.8	7.2
Flotation Tailing	450	90.0	0.030	71.2	8.2	92.8
Total	500	100.0			100.0	100.0

EXAMPLE II

About 500 grams of crude monazite concentrate ore containing:

	Percent
Monazite	44.0
Xenotime	2.5
Rutile	35.0
Wolframite	12.0
Cassiterite	1.5
Brannerite [1]	2.0
Miscellaneous [2]	3.0
Total	100.0

[1] Brannerite is a uranium titanate. Restrictions on dissemination of information regarding content of uranium in ores or products may preclude the listing of this mineral.
[2] Miscellaneous includes small amounts of columbite and other minerals not yet identified.

is placed in a Fagergren flotation cell. The crude monazite concentrate was obtained in a climax milling operation by high intensity magnetic separation following the removal of wolframite at a somewhat lesser magnetic intensity.

2500 ml. of water are added to the crude monazite until a pulp containing a consistency of 17% solids is obtained. To this pulp is added:

8.0 pounds of sulfuric acid per ton of flotation feed.
2.8 pounds Globe pearl starch (boiled) per ton of flotation feed.
2.5 pounds Armac C (Coco Amine Acetate—Armour & Co.) per ton of flotation feed.
1.0 pound of pine oil per ton of flotation feed.

Air is circulated throughout the pulp and a rough froth is produced which is cleaned once by flotation in the presence of a small additional amount of acid and starch, namely, 4.0 pounds of sulfuric acid and 1.4 pounds of starch per ton of original flotation feed. The period of time for roughing was 10 minutes and 3 minutes for cleaning. The test results are indicated by the following tabulation:

Test No. 2

Product	Weight Grams	Percent Weight	Analyses percent Monazite	Percent Recovery Monazite
Flo. cleaner froth	220	43.8	95.1	89.2
Flo. cleaner tailing	48	9.6	49.7	10.2
Flo. rougher tailing	234	46.6	0.6	0.6
Total	502	100.0		100.0

EXAMPLE III

About 600 grams shaking table middling from tin recovery tables containing:

	Percent
Monazite	10.5
Cassiterite	12.0
Rutile	10.5
Pyrite	3.0
Topaz	50.0
Quartz	11.0
Miscellaneous	3.0
Total	100.0

is placed in a laboratory Fagergren cell. 2500 ml. water are added until a pulp containing a consistency of 20% solids is formed. To this pulp is added:

8.0 pounds sulfuric acid per ton of flotation feed.
4.0 pounds Amijel (modified starch—Corn Products Refining Company) per ton of flotation feed.

3.0 pounds Armac S (Soy Amine Acetate—Armour & Co.) per ton of flotation feed.
1.0 pound pine oil per ton of flotation feed.

Air is circulated throughout the pulp and a froth is obtained. Test results are indicated below after 10 minutes froth removal.

Test No. 3

Product	Weight Grams	Percent Grams	Analyses		Percent Recovery	
			P	Sn	P	Sn
Flotation froth	223	36.1	2.76	1.8	78.7	7.2
Flotation tailing	395	63.9	0.42	13.1	21.3	92.8
Total	618	100.0			100.0	100.0

The tests described in the foregoing clearly demonstrate that a novel combination of reagents has been discovered which permit a high degree of selectivity in the flotation separation of monazite and phosphate minerals of a similar character from wolframite, rutile, cassiterite, and other like heavy gravity minerals.

The process is applicable over a fairly wide range of flotation conditions such as dilution, temperature, type of flotation machine and quantity of reagent.

It should be pointed out that other acids are useful besides sulfuric acid. Sulfuric acid proved to be the most effective of all the acids operable and is favorable from a cost standpoint. The process is operable in the presence of hydrochloric and nitric acids but with reduced efficiency.

The invention in its broader aspects is not limited to the specific processes and steps described but departures may be made therefrom within the scope of the accompanying claims without departing from the principles of the invention and without sacrificing its chief advantages.

I claim:

1. A froth flotation process for separating monazite from heavy gravity minerals selected from the group consisting of wolframite, rutile and cassiterite, which comprises adding to an acid pulp concentrate containing monazite and at least one of the above mentioned heavy gravity minerals a cationic flotation agent of the amine type and a starchy product so that a froth is formed when air is passed through the pulp whereby monazite is collected in the flotation froth and at least one of the heavy gravity minerals selected from the group consisting of wolframite, rutile and cassiterite remain in the flotation tailing.

2. A process as defined in claim 1 in which the cationic amine is coco amine acetate and the starchy product is boiled starch.

3. A process as defined in claim 1 in which the cationic amine is soy amine acetate and the starchy product is a dried gelatinized starch.

4. A process as defined in claim 2 in which the heavy gravity mineral is mainly wolframite.

5. A process as defined in claim 2 in which the heavy gravity mineral is mainly rutile.

6. A process as defined in claim 3 in which the heavy gravity mineral is mainly cassiterite.

7. A process as defined in claim 1 in which the acid pulp is a sulfuric acid pulp.

ROBERT E. CUTHBERTSON.

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