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Knocke et al.

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[54] **FLOTATION OF ALUMINOSILICATE, PHOSPHATE AND FLUORIDE ORES**

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[51] **Int. Cl.** **B03d 1/02**

[58] **Field of Search** 209/166, 167

[56] **References Cited**

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[57] **ABSTRACT**

Mineral concentrates are obtained from aluminosilicate and alkali and alkaline earth aluminosilicate, phosphate and fluoride ores in a beneficiation process in which the ore is conditioned prior to flotation with a C_{20} to C_{22} saturated or unsaturated fatty acid or a mixture of C_{20} to C_{22} saturated or unsaturated fatty acids and C_{18} or lower fatty acids and an alicyclic or aromatic hydrocarbon oil.

9 Claims, No Drawings

FLOTATION OF ALUMINOSILICATE, PHOSPHATE AND FLUORIDE ORES

BACKGROUND OF THE INVENTION

This invention relates to a beneficiation process in which minerals are concentrated by froth flotation utilizing a C_{20} to C_{22} saturated or unsaturated fatty acid or a mixture of C_{20} to C_{22} saturated or unsaturated fatty acids and C_{18} or lower fatty acids and an alicyclic or aromatic hydrocarbon oil to condition the ore prior to flotation.

It is widely recognized that saturated and unsaturated fatty acids may be utilized in beneficiation processes to condition an ore pulp prior to flotation. For example, U.S. Pat. No. 3,028,008 describes a beneficiation process in which spodumene is isolated from mineral mixtures containing spodumene and beryllium. This process includes a flotation step which utilizes multicomponent collecting aids consisting of magnesium based lignin sulfonate, sodium fluoride and a fatty acid such as oleic acid to condition the mineral mixture prior to flotation. U.S. Pat. No. 3,329,265 describes a process for the beneficiation of mica ores by flotation which utilizes a combination of a cationic and an anionic reagent as flotation collecting aids, suitable anionic reagents being described as saturated or unsaturated fatty acids containing 8 to 20 carbon atoms or salts thereof. U.S. Pat. No. 3,278,028 also describes a beneficiation process utilizing saturated and unsaturated fatty acids containing 8 to 20 carbon atoms or salts thereof as collecting aids for the flotation of mica ores. U.S. Pat. No. 2,974,884 describes a beneficiation process for recovering lithium from lithium aluminosilicate ores utilizing tall oil fatty acids and methyl isobutylcarbinol to condition the ore prior to flotation.

U.S. Pat. No. 1,902,839 discloses a froth flotation process in which a mixture of a fatty acid, such as oleic acid and a hydrocarbonaceous thiophosphoric acid compound is utilized as a collecting aid. U.S. Pat. No. 3,061,097 describes a flotation process for separating carbonaceous materials such as kerogen and paraffin from oil shales which utilizes monocyclic hydrocarbons as collecting aids.

It is the object of this invention to provide collecting aids useful in conditioning ores prior to froth flotation in a beneficiation process which produces mineral concentrates from aluminosilicate and alkali and alkaline earth metal aluminosilicate, phosphate and fluoride ores.

DETAILED DESCRIPTION OF THE INVENTION

This invention relates to a beneficiation process which utilizes a froth flotation procedure in which an ore is conditioned prior to flotation with from about 0.25 to about 4 lbs. per ton of ore of a fatty acid collecting aid, said fatty acid being selected from the group consisting of a fatty acid containing 20 to 22 carbon atoms and a mixture of fatty acids containing from about 15 to about 75% of a fatty acid containing 20 to 22 carbon atoms, the balance C_{18} or lower fatty acids, said percentages being by weight, based on the weight of the fatty acid mixture and from about 0.05 to about 1 lb. per ton of ore of an alicyclic or aromatic hydrocarbon oil selected from the group consisting of turpentine, pinene, mesitylene, cedrene and 1,3-dicyclopentadiene to provide a mineral concentrate from an ore selected from the group consisting of aluminosilicate and alkali and alkaline earth metal aluminosilicate, phosphate and fluoride ores.

It has now been found that a combination of fatty acids having 20 to 22 carbon atoms per molecule or mixtures of C_{20} to C_{22} fatty acids with C_{18} or lower fatty acids and an alicyclic or aromatic hydrocarbon oil acts as an extremely efficient collecting aid when utilized to condition aluminosilicate, and alkali and alkaline earth metal aluminosilicate, phosphate and fluoride ores prior to froth flotation. The C_{20} to C_{22} fatty acids utilized as the fatty acid component of the collecting aid in this process include both saturated and unsaturated fatty acids such as erucic, arachidic, n-heneicosoic, behenic, gadoleic, cetoleic and brassidic acids, erucic acid being especially preferred. As will be recognized, mixtures of two or more of these acids in any proportions may be utilized in the collecting aids in this invention, although, commonly a single acid will be utilized.

Certain mixtures of the C_{20} to C_{22} fatty acids with C_{18} or lower fatty acids, particularly those mixtures containing from about 15 to about 75% of a fatty acid containing 20 to 22 carbon atoms, balance C_{18} or lower fatty acids, said percentages being by weight, based on the weight of the fatty acid mixture have also been found useful as collecting aids when combined with an alicyclic or aromatic hydrocarbon oil. Useful C_{18} or lower fatty acids which may be utilized in forming the collecting aids include tall oil fatty acids, oleic acid, stearic acid, palmitic acid and the like. When desirous of using a mixture of C_{20} to C_{22} fatty acids with C_{18} or lower fatty acids, the fatty acids may be combined in any conventional manner such as by mixing until a uniform product is obtained.

In addition to the fatty acid component, the collecting aid of this invention includes an alicyclic or aromatic hydrocarbon oil. Useful alicyclic or aromatic hydrocarbon oils which are to be combined with the fatty acid component of the collecting aid include turpentine, pinene, mesitylene, cedrene and 1,3-dicyclopentadiene.

In general, the beneficiation process of this invention includes a conventional froth flotation procedure in which an ore is first ground to a reduced particle size and introduced into a flotation cell where the collecting aids of this invention are added to treat the ore prior to introduction of air into the flotation cell. While not always required, certain ores may be deslimed after the grinding procedure, the pulp recovered from the desliming operation being passed to the flotation cell for treatment with the collecting aid.

The ground ore is introduced into the flotation cell in the form of a slurry, the slurry containing the ore particles at levels ranging from about 5 to about 40% solids. The collecting aid is combined with the ore slurry in the flotation cell in a proportion of from about 0.25 to about 4 lbs. per ton of ore (based on the ore in the slurry) of the fatty acid components and from about 0.05 to about 1 lb. per ton of ore (based on the ore in the slurry) of the alicyclic or aromatic hydrocarbon oil component of the collecting aid. The fatty acid component and the hydrocarbon oil component of the collecting aid may be added to the flotation cell simultaneously, or they may be added individually in any sequence desired so long as both components are present in the flotation cell and are allowed to condition the ore prior to introduction of air into the cell.

The ore is conditioned with the collecting aid for a period of time ranging from a few minutes up to as long as an hour. No special conditions are required for the conditioning, however, should it be desired, the ore and collecting aid may be heated to temperatures up to as high as 100°C. during the conditioning period. Optimum quantities of the collecting aid, length of conditioning and other parameters of the conditioning process are best determined empirically and will vary considerably depending on the type and amount of ore treated as well as the type of mineral concentrate desired. Combination fatty acid — alicyclic or aromatic hydrocarbon oil collecting aids have been found to be especially useful in a beneficiation process designed to recover ceramic grade spodumene, spodumene containing not less than 6.6% Li_2O and less than 0.9% Fe_2O_3 from lithium aluminosilicate ores. In this process, the lithium aluminosilicate ore is ground, deslimed and transferred in a slurry containing from 5 to 40%, by weight, solids, to a flotation cell and treated with the collecting aid. The collecting aid is combined with the ore pulp in a proportion of from about 0.25 to about 4 lbs. per ton of ore (based on the ore in the slurry) of fatty acid and from about 0.05 to about 1 lb. per ton of ore (based on the ore in the slurry) of hydrocarbon oil, followed by introduction of air into the cell which causes the particles of the desired spodumene to float to the surface of the cell in the form of a froth which is collected and further treated to recover the desired ceramic grade spodumene.

Beneficiation process including a flotation procedure which utilizes the collecting aids described herein have been found to be particularly desirable, resulting in the recovery of a spodumene concentrate in which the predominant portion at least 75%, or more, by weight, based on the weight of the concentrate recovered, is ceramic grade spodumene containing not less than about 6.6% Li_2O and less than about 0.9% Fe_2O_3. The collecting aids of this invention have been found to promote the flotation of relatively large, 28 to 48 mesh, mineral particles, a significant factor contributing to the enhanced recovery of ceramic grade spodumene just described.

The invention will be illustrated by the following example.

EXAMPLE 1

A series of lithium aluminosilicate ore samples were ground to a particle size of 28 mesh by down, deslimed in a hydrocyclone, conditioned with a collection aid for 30 minutes and fed in the form of a slurry of about 35% solids into a flotation cell where the desired components of the ore were isolated and recovered in the froth formed with the introduction of air into the flotation cell. In Table I which follows below, the ore samples subjected to froth flotation are characterized by the particle size and the Li_2O content of the ore, this characterization being found in the columns headed "Feed" in Table I. The collecting aid utilized to treat the ore slurry prior to flotation, is a mixture of erucic acid and tall oil fatty acid with various alicyclic or aromatic hydrocarbon oils, the flotation collecting aid being combined with the ore in a proportion of 0.45 lbs. of erucic acid per ton of ore, 0.33 lbs. of tall oil per ton of ore and 0.11 lbs. of oil per ton of ore, all based on the ore in the feed slurry. The spodumene recovered in this manner is characterized in Table I in the columns enumerating the weight (%) recovery of spodumene, the weight (%) of spodumene recovered in terms of Li_2O, the purity of the spodumene recovered expressed in terms of Li_2O and the weight recovery of spodumene expressed as percent recovery of available +50 mesh spodumene. For sake of comparison, one test was run containing no oil in the collecting aid.

TABLE I

VARIOUS OILS AS FLOTATION COLLECTION AIDS WITH HIGH CHAIN FATTY ACIDS

	Collecting Aid		Feed ***					
Sample No.	Oil Component*	Fatty Acid Component**	% Li_2O	% +50 Mesh	% Wt. Recovered	%Li_2O Recovered	Spodumene Concentrate % Li_2O	% Recovery of Available +50 Mesh Spodumene
1	None		3.11	10	18.9	73.2	6.34	62.1
2	Pinene		3.11	10	22.2	80.7	6.06	88.3
3	Mesitylene		3.11	10	17.4	74.5	6.78	52.8
4	Dicyclopentadiene		3.11	10	22.6	83.7	6.01	84.9
5	Cedrene		3.11	10	29.3	88.3	5.03	81.6

*0.11 lbs. per ton ore feed
**FATTY ACID COMPONENT: a mixture of 0.45 lbs. per ton ore feed of erucic acid and 0.33 lbs. per ton ore feed of tall oil fatty acids
*** 35% solids slurry

Having thus described the invention, What is claimed is:

1. In a beneficiation process including froth flotation of ground ore to provide a mineral concentrate from an ore selected from the group consisting of aluminosilicate and alkali and alkaline earth metal aluminosilicate, phosphate and fluoride ores, the improvement consisting essentially of conditioning the ground ore prior to flotation with from about 0.25 to about 4 lbs. per ton of ore based on the ore being treated, of a fatty acid collecting aid said fatty acid being selected from the group consisting of a fatty acid containing 20 to 22 carbon atoms and a mixture of fatty acids containing from about 15 to about 75% of a fatty acid containing 20 to 22 carbon atoms, balance C_{18} or lower fatty acids, said percentage being by weight, based on the weight of the fatty acid mixture and from about 0.05 to about 1 lb. per ton of ore, based on the ore being treated of an alicyclic or aromatic hydrocarbon oil selected from the group consisting of turpentine, pinene, mesitylene, cedrene and 1,3-dicyclopentadiene.

2. The process of claim **1** wherein said fatty acid component of the collecting aid is a fatty acid containing 20 to 22 carbon atoms said fatty acid being a mem-

ber of the group consisting of saturated fatty acids, unsaturated fatty acids or mixtures of saturated and unsaturated fatty acids in any proportion.

3. The process of claim 2 wherein said fatty acid is erucic acid.

4. The process of claim 1 wherein said fatty acid component of the collecting aid is a mixture of fatty acids containing from about 15% to about 75% of a fatty acid containing 20 to 22 carbon atoms, balance C_{18} or lower fatty acids, said percentage being by weight based on the weight of the fatty acid mixture.

5. In a beneficiation process including froth flotation of ground lithium aluminosilicate ores to provide a lithium aluminosilicate mineral concentrate, the improvement comprising conditioning the ground ore prior to flotation with from about 0.25 to about 4 lbs. per ton of ore based on the ore being treated, of a fatty acid collecting aid said fatty acid being selected from the group consisting of a fatty acid containing 20 to 22 carbon atoms and a mixture of fatty acids containing from about 15 to about 75% of a fatty acid containing 20 to 22 carbon atoms, balance C_{18} or lower fatty acids, said percentage being by weight based on the weight of the fatty acid mixture and from about 0.05 to about 1 lb. per ton of ore, based on the ore being treated, of an alicyclic or aromatic hydrocarbon oil selected from the group consisting of turpentine, pinene, mesitylene, cedrene and 1,3-dicyclopentadiene.

6. The process of claim 5 wherein said fatty acid component of the collecting aid is a fatty acid containing 20 to 22 carbon atoms said fatty acid being a member of the group consisting of saturated fatty acids, unsaturated fatty acids or mixtures of saturated and unsaturated fatty acids in any proportion.

7. The process of claim 5 wherein said fatty acid is erucic acid.

8. The process of claim 5 wherein said fatty acid component of the collecting aid is a mixture of fatty acids containing from about 15% to about 75% of a fatty acid containing 20 to 22 carbon atoms, balance C_{18} or lower fatty acids, said percentages being by weight based on the weight of the fatty acid mixture.

9. The process of claim 5 wherein the lithium aluminosilicate mineral recovered is ceramic grade spodumene.

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