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METHOD AND MEANS FOR BENEFICIATING ORES

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The present invention is a continuation-in-part application of my application bearing Serial No. 12,249, dated March 2, 1960, now abandoned.

This invention relates as indictaed to the beneficiation of ores and has more particular reference to reagents used in the froth flotation of various types of ores.

It has long been the desire of ore refiners to economically separate desirable minerals from ores by froth flotation, and to obtain a final product having a particle size on the order of from 6 to 8 mesh and of a purity which meets the specifications of the industry. Effective froth flotation techniques and reagents for recovering minus 16 mesh particles of the desired minerals from their respective ores have been known. However, these prior art techniques and reagents have been ineffective in the recovery of plus 14 mesh particles and the ore refiners have had to resort to the use of additional operations and equipment in order to obtain particles 14 mesh or larger. This has resulted therefore in processes which are costly and inefficient.

It is, therefore, the principal object of this invention to provide an economical method and means for the froth flotation of ores, which will result in a final product having a particle size on the order of at least 8 mesh and of a desired purity.

Another object of this invention is to provide new, economical and efficient froth flotation reagents which will eliminate the use of additional costly equipment.

Other objects will appear as the description proceeds.

To the accompaniment of the foregoing and related ends, the invention then comprises the features hereinafter fully described and particularly pointed out in the claim, the following description setting forth in detail certain illustrative embodiments of the invention, these being indicative, however, of but a few of the many ways in which the principle of the invention may be employed.

Broadly stated, the present invention comprises the method of obtaining desired mineral values from ores by froth flotation, which comprises pulping said ore, conditioning the resultant ore pulp with a flotation reagent comprising an admixture of a long chain aliphatic amine and a material selected from the group consisting of alkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, chloroalkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, hydrogenated alkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, hydrogenated chloroalkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, alkylmercaptans, the alkyl portion of which contains from 4 to 18 carbon atoms, aryl substituted alkylmercaptans, the alkyl portion of which contains from 2 to 8 carbon atoms, dialkyl sulfides, the alkyl portion of which contains from 4 to 18 carbon atoms, aryl substituted dialkyl sulfides, the alkyl portion of which contains from 2 to 8 carbon atoms, dialkyl disulfides, the alkyl portion of which contains from 4 to 18 carbon atoms, and dialkyl polysulfides, the alkyl portion of which contains from 4 to 18 carbon atoms, subjecting said conditioned ore pulp to a froth flotation cell and recovering said mineral values from said cell.

From the foregoing broadly stated paragraph it will be seen that the present invention uses a combination of flotation reagents to condition the pulped ore so as to obtain the desired mineral values. The present admixture comprises as one component, long chain aliphatic amine collectors which are well known to those skilled in the flotation art. These collector reagents, which selectively coat the desired mineral values in the ore pulp, do not impart sufficient hydrophobic characteristics to the desired mineral values, and consequently, are not able to float particles larger than about 16 mesh. However, by the addition of the above substituted naphthalene and organosulfide auxiliary reagents it is now possible, for the first time, to float by froth flotation particles as large as 6 or 8 mesh.

It is my theory that the amine collector reagents attract the auxiliary reagents which in turn impart a much greater hydrophobic characteristic to the desired mineral values and bring about the flotation of particles as large as 6 or 8 mesh. However, regardless of whether my theory is correct or not, the fact remains that by combining any of the well-known amine collectors with the above-defined substituted naphthalene and organosulfide compounds, it is now possible to efficiently and economically float particles, by froth flotation, as large as 6 or 8 mesh.

As stated above, the amine collector reagents used in the present invention are the same as those used by ore refiners in prior flotation processes. These collector reagents are long chain aliphatic amines consisting of from 7 to 18 or more carbon atoms and are most commonly prepared from beef tallow. They are usually prepared as the salts of the amines, the most commonly used salt being the acetate, and they are purchased commercially as mixed aliphatic amine acetates.

The auxiliary reagents applicable to the present invention are the alkylnaphthalenes, the chloroalkylnaphthalenes, the hydrogenated alkylnaphthalenes, the hydrogenated chloroalkylnaphthalenes, the alkylmercaptans, the dialkyl sulfides, the dialkyl disulfides, the dialkyl polysulfides, the aryl substituted alkylmercaptans and the aryl substituted dialkyl sulfides. The following list is illustrative of the auxiliary reagents which are useful in the present invention:

Methyl naphthalene
Ethyl naphthalene
Propyl naphthalene
Amyl naphthalene
Octyl naphthalene
Chloromethyl methylnaphthalene
Methyltetralin
Ethyltetralin
Methyldecalin
β-Chloroethyltetralin
Ethyldecalin
t-Butylmercaptan
t-Hexylmercaptan
t-Octylmercaptan
n-Dodecylmercaptan
t-Tetradecylmercaptan
t-Hexadecylmercaptan
Phenylethylmercaptan
Phenylpropylmercaptan
Di-n-butyl sulfide
Di-t-heptyl sulfide
Diphenylethyl sulfide
Di-t-amyl disulfide
Di-t-heptyl disulfide
Di-t-tetradecyl disulfide
Di-t-butyl polysulfide
Di-t-octyl polysulfide
Di-t-dodecyl polysulfide

It is to be clearly understood that the foregoing list is only a partial enumeration of the auxiliary reagents applicable to the present invention and is not intended to limit the invention.

The auxiliary reagents may be used individually, or in any combination, with the amine collector reagents; however, the fact remains that at least one auxiliary reagent must be used with an amine collector reagent in order to float material having a particle size greater than about 16 mesh.

Froth flotation is used in two ways for the beneficiation of ores. In one instance the desired mineral value is recovered from the froth, such as in the flotation of:

(*a*) Potassium values from potassium bearing ores;
(*b*) Spodumene from silica and mica feldspar;
(*c*) Mica and silica from cement rock;

while in the other instance the impurities are floated and discarded and the desired mineral values are recovered from the flotation cell, such as in the flotation of:

(*a*) Silica from ilmenite;
(*b*) Silica from lepidolite;
(*c*) Calcite and silica from fluorspar;
(*d*) Silica from phosphate bearing ores;
(*e*) Silica from iron bearing ores.

In any froth flotation process, where amine collector reagents are used, the addition of the defined auxiliary reagents permits the efficient flotation of particles as large as 6 or 8 mesh. This brings about substantial savings in the cost of grinding, screening and flotation equipment and material of desired purity is recovered in higher than normal yields.

So that the present invention is more clearly understood, the following examples are given for illustrative purposes:

I

Sylvinite ore was ground to a minus 8 mesh size and was slurried in a saturated brine composed of the soluble constituents of the ore. The slurry was then deslimed through a 100 mesh screen to remove the fines and insoluble matter. The ore pulp was then conditioned with an admixture of auxiliary reagent and amine collector reagent, and the conditioned ore pulp was added to a "Fag" flotation cell along with some clear saturated brine. The slurry was then aerated from the bottom of the cell and as froth formed at the surface it was removed carrying with it substantially all of the potash.

The following table shows results of tests performed following the above procedure. The rate of addition of reagents is measured in pounds of reagent per ton of crushed ore and the percent potassium chloride recovered is based on the percent potassium chloride in the ore pulp after desliming.

Table I

Auxiliary Reagent	Auxiliary Reagent, lb./ton	Collector Reagent, lb./ton	Percent KCl Recovered
Substituted Naphthalenes:			
Methyl naphthalene	0.38	0.38	94.65
Ethyl naphthalene	0.35	0.38	95.21
Amyl naphthalene	0.38	0.38	95.96
Octyl naphthalene	0.35	0.38	95.14
Chloromethyl methylnaphthalene	0.35	0.38	94.87
Methyldecalin	0.35	0.38	95.22
β-Chloroethyltetralin	0.35	0.38	95.14
Organosulfides:			
t-Octylmercaptan	0.35	0.38	94.96
n-Dodecylmercaptan	0.35	0.38	95.47
t-Dodecylmercaptan	0.38	0.38	95.29
t-Tetradecylmercaptan	0.35	0.38	95.50
t-Hexadecylmercaptan	0.35	0.38	94.98
Phenylethylmercaptan	0.35	0.38	94.89
Diphenylethylmercaptan	0.35	0.38	95.02
Di-t-amylsulfide	0.35	0.38	95.36
Di-n-butylsulfide	0.38	0.38	95.28
Di-t-dodecyldisulfide	0.35	0.38	96.20
Di-t-octyldisulfide	0.35	0.38	95.81
Di-t-dodecylpolysulfide	0.35	0.38	95.13
Di-t-amylpolysulfide	0.35	0.38	95.04
Mixed:			
t-Dodecylmercaptan	0.18	0.38	95.62
Amyl naphthalene	0.17		
t-Hexadecylmercaptan	0.18	0.38	95.38
Ethyl naphthalene	0.17		
None	0	0.75	82.46

II

Sylvinite ore was ground to a minus 8 mesh size and was slurried with brine comprised of the soluble constituents of the ore. The slurry was then deslimed through a 100 mesh screen to remove the fines and insoluble matter, and the deslimed ore was wet screened and divided into two fractions, one fraction containing the plus 16 mesh particles, the other fraction containing the minus 16 mesh particles. The plus 16 mesh fraction was conditioned with an admixture of auxiliary reagent and the minus 16 mesh fraction was conditioned with only amine collector reagent. After conditioning, the two fractions were added to a "Fag" flotation cell along with some clear saturated brine. The slurry was then aerated from the bottom of the cell and as the froth formed at the surface it was removed carrying with it substantially all of the potash.

The following table shows results of tests performed as per the above procedure. The rate of addition of reagents and the percent potassium chloride recovered are measured on the same basis as in Example I.

Table II

Auxiliary Reagent	+16 Mesh Fraction		−16 Mesh Fraction	
	Auxiliary Reagent, lb./ton	Collector Reagent, lb./ton	Collector Reagent, lb./ton	Percent KCl Recovered
Substituted Naphthalenes:				
Methyl naphthalene	0.18	0.20	0.12	94.97
Ethyl naphthalene	0.18	0.20	0.12	95.57
Amyl naphthalene	0.18	0.20	0.12	95.92
Octyl naphthalene	0.15	0.20	0.12	95.02
Chloromethyl methylnaphthalene	0.15	0.20	0.12	95.44
Methyldecalin	0.15	0.20	0.12	95.40
β-Chloroethyltetralin	0.15	0.20	0.12	94.89
Organosulfides:				
t-Octylmercaptan	0.15	0.20	0.12	94.91
n-Dodecylmercaptan	0.15	0.20	0.12	95.67
t-Dodecylmercaptan	0.18	0.17	0.15	95.49
t-Tetradecylmercaptan	0.18	0.20	0.12	95.46
t-Hexadecylmercaptan	0.15	0.20	0.12	95.96
Phenylethylmercaptan	0.18	0.20	0.12	95.34
Diphenylethylmercaptan	0.18	0.20	0.12	95.18
Di-t-amylsulfide	0.15	0.20	0.12	95.53
Di-n-butylsulfide	0.15	0.20	0.12	95.64
Di-t-dodecyldisulfide	0.15	0.20	0.12	95.59
Di-t-octyldisulfide	0.15	0.20	0.12	95.44
Di-t-amylpolysulfide	0.15	0.20	0.12	95.57
Di-t-dodecylpolysulfide	0.15	0.20	0.12	96.06
Mixed:				
t-Dodecylmercaptan	0.075	0.20	0.12	95.92
Amyl naphthalene	0.075			
t-Hexadecylmercaptan	0.075	0.20	0.12	96.02
Ethyl naphthalene	0.075			
None	0	0.38	0.12	69.14

The concentrates recovered, as per the examples given, ranged in grade from about 95.2% to about 97.7% potassium chloride, which exceeds the minimum standard of purity, 95%, as set by the potash industry.

Although there are numerous variations which can be used in performing a froth flotation process, such as conditioning the ore pulp first with the amine collector reagent and then with the defined auxiliary reagents, in the preferred embodiment of the invention, I use the method as described above in Example II. I have found this method to be the most economically desirable process, as it requires a minimum of reagents with a minimum of equipment and handling.

It is important to note that the tables from the preceding examples indicate that the addition of auxiliary reagent and amine collector reagent provides an efficient flotation process where amine collector reagent alone does not. Although the examples shown are only for the beneficiation of sylvinite ore, the combination of auxiliary reagent and amine collector reagent works equally well in any of the prior art froth flotation processes which employed only amine collector reagent, and for the first time, provides the efficient recovery of particles as large as 6 or 8 mesh.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features in the following claim or the equivalent of such be employed.

I, therefore, particularly point out and distinctly claim as my invention:

The method of obtaining sylvite from sylvinite ore by froth flotation, which comprises pulping said sylvinite ore to a particle size of at least about 8 mesh, conditioning the resultant ore pulp with a flotation reagent comprising an admixture of a long chain aliphatic amine and a material selected from the group consisting of alkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, chloroalkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, hydrogenated alkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, hydrogenated chloroalkylnaphthalenes, the alkyl portion of which contains from 1 to 8 carbon atoms, alkylmercaptans, the alkyl portion of which contains from 4 to 18 carbon atoms, aryl substituted alkylmercaptans, the alkyl portion of which contains from 2 to 8 carbon atoms, dialkyl sulfides, the alkyl portion of which contains from 4 to 18 carbon atoms, aryl substituted dialkyl sulfides, the alkyl portion of which contains from 2 to 8 carbon atoms, dialkyl disulfides, the alkyl portion of which contains from 4 to 18 carbon atoms, and dialkyl polysulfides, the alkyl portion of which contains from 4 to 18 carbon atoms, subjecting said conditioned sylvinite ore pulp to a froth flotation cell and recovering substantially all of the sylvite from the resultant froth.

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