

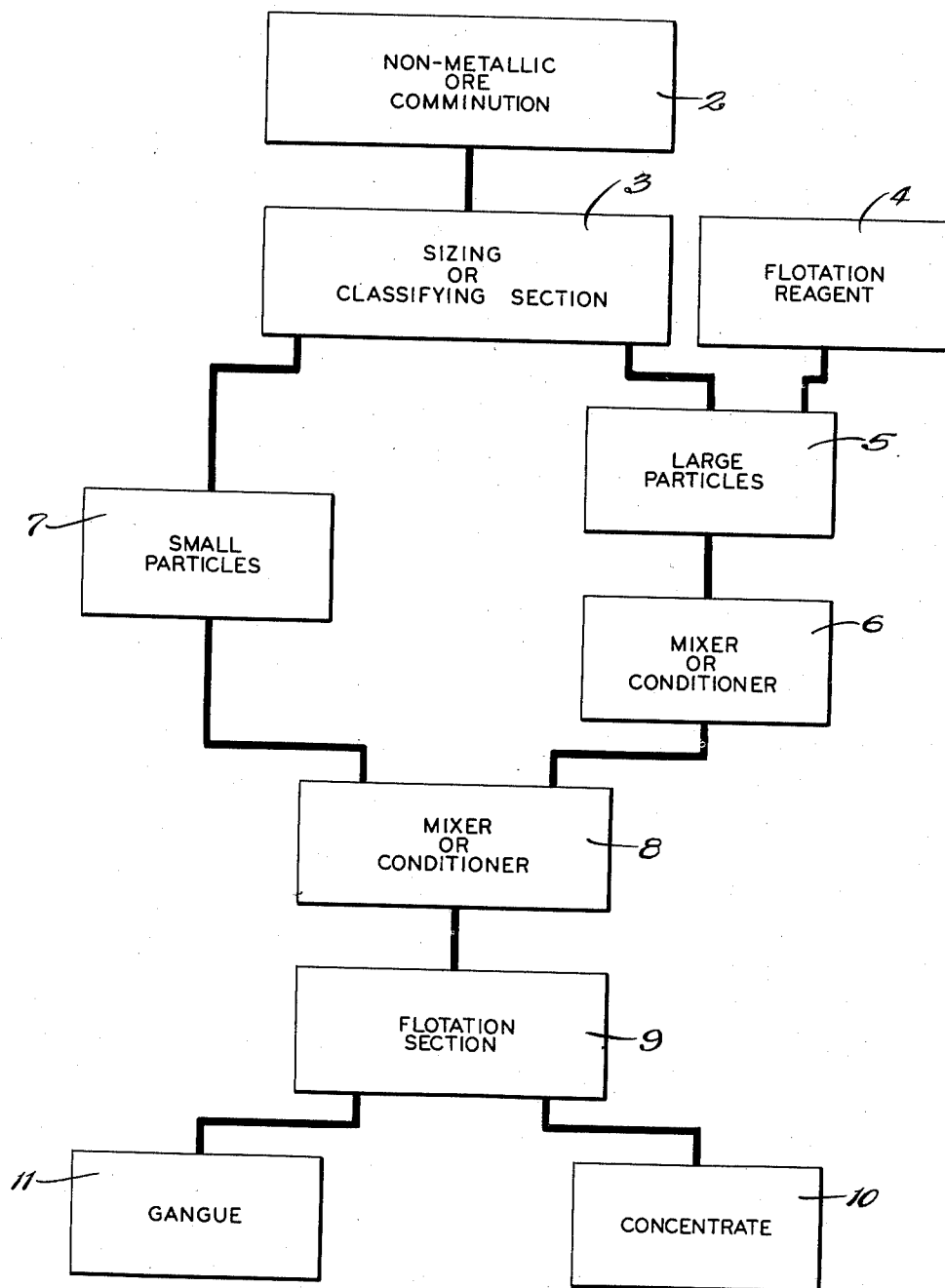
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CONCENTRATION OF NONMETALLIC MINERALS BY FLOTATION

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CONCENTRATION OF NONMETALLIC
MINERALS BY FLOTATION

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This invention relates to an improved process for the recovery of nonmetallic minerals from ores containing the same. More particularly, the invention relates to an improved process for the recovery, by flotation methods, of so-called nonmetallic minerals such as sylvite, tricalcium phosphate, and like values, from ores containing the same.

The art of recovering nonmetallic minerals such as tricalcium phosphate, sylvite (or potassium chloride), halite (or sodium chloride), and similar materials, from ores containing the same, has been highly developed; and the recovery of such minerals by flotation methods is now generally employed throughout the mining industry. In the United States of America, the major sources of mineral potassium chloride are those occurring in mineral deposits in the Permian Basin—particularly in the vicinity of Carlsbad, New Mexico—and those which result from solar evaporation of saline deposits; for example, those in the vicinity of Trona, California, and Bonneville, Utah. It is common practice to recover the potassium chloride values from such ores or deposits by either crystallization or flotation procedures. Flotation procedures for the recovery of potassium chloride values are particularly employed in the recovery of such values from sylvite-containing deposits such as occur in sylvinite in the Carlsbad area. It is the usual procedure to mine the sylvinite ore from geological strata containing the same, and then subject the ore to a preliminary crushing or grinding operation, thereby obtaining a material of -5 mesh. This operation liberates substantially all of the sylvite, or potassium chloride, which is present in the sylvinite ore. Occasionally it is the practice to split this material into two fractions, one fraction containing -5 to +10 mesh material, the remaining -10 mesh material being processed by froth-flotation methods. The coarser fraction may be pulped with water which is saturated with respect to sylvinite, and the pulp reagentized with a reagent which has an affinity for potassium chloride particles. Suitable reagents are those which are described in Patent No. 2,088,325, issued to Kirby, and in Patent No. 2,132,902, issued to Lenher. The reagentized mixture is then subjected to a tabling operation, which is preferably conducted with riffled shaking tables such as those manufactured by the Deister Concentrator Company. By this means, the sylvite particles are concentrated by skin flotation, and the halite or sodium chloride fraction of the sylvinite is concentrated in the

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tailings. The -10 mesh material is also pulped in water which is saturated with respect to sylvinite, and is then reagentized with an appropriate amount of reagent such as that described in the Kirby and Lenher patents. The resultant reagentized mixture is then subjected to either one or a series of froth-flotation operations in a suitable flotation cell; for example, of the type designated as Fagergren cells. The flotation concentrate contains the majority of the sylvite particles, the percent recovery being dependent upon the type of reagent employed and the efficiency of the flotation operation. The halite or sodium chloride fraction of the sylvinite is concentrated in the tailings. This fraction may be either re-floated in a second operation or discarded. Alternatively, sylvinite ore may be ground to -5 mesh and then pulped with a saturated solution of sylvinite ore. A preliminary classification operation produces a major portion of -14 mesh material which is subjected to froth-flotation in order to remove either the sylvite or halite particles therefrom. Phosphate values present in raw phosphate rock of the type found in the Florida and Tennessee areas may be concentrated by somewhat similar methods which are familiar to those skilled in the art. It is generally recognized that the capacity of the shaking tables is quite low, and it has been proposed to increase the production of sylvite in a plant which is recovering sylvite from sylvinite ore by further grinding the coarse fraction and subjecting the ground material to flotation operations similar to those employed in beneficiating the finer material. This type of process involves additional grinding equipment in plant operations. An attempt has been made to subject the coarse fraction to flotation directly, without further grinding. An extension of this type of operation is described by Greene et al., in Patent No. 2,420,476, whereby a ground sylvinite ore is classified in order to obtain a relatively coarse fraction, the latter then being floated with a fatty amine type reagent in combination with a water-immiscible oil; for example, fuel oil. Greene et al. also describe the sequential flotation of coarse and fine fractions of sylvinite, and subsequently combine the separate flotation froths so produced. This results in a final sylvite concentrate containing both coarse and fine particled material. When operating in accordance with such procedures, a considerable amount of reagent is required in order to froth-float each of the separate fractions, and it is apparently necessary to employ a water-immiscible oil in order to obtain good re-

covery of sylvite or potassium chloride values when floating the coarse particled sylvinite.

It is an object of the invention to provide an improved process for the flotation, from their ores, of so-called nonmetallic minerals containing coarse particles.

It is a further object of the invention to provide an improved process for the flotation concentration of phosphate values from ores containing the same.

It is a further object of the invention to provide an improved process for the flotation concentration of phosphate values from phosphate rock, whereby both coarse and fine particled phosphatic ores are floated in one operation.

It is a further object of the invention to provide an improved process for the flotation, from sylvinite ore, of sylvite containing coarse particles.

It is a further object of the invention to provide an improved process for the recovery of sylvite from sylvinite ore by flotation methods whereby both coarse and fine particled sylvinite may be floated in one operation.

It is still a further object of the invention to provide an improved process for the recovery of sylvite from sylvinite ore by flotation methods whereby the amount of reagent required is substantially reduced in comparison with the methods which have previously been employed.

The above objects, as well as others which will become apparent upon a more complete understanding of the invention which is subsequently herein described, are accomplished by subjecting a comminuted nonmetallic mineral ore to a sizing or classifying operation whereby said ore is divided into at least two fractions of relatively large and small particle size. The relatively large particled material is then suspended in an aqueous solution or in water, depending upon the particular mineral desired to be concentrated, employing a sufficient amount of suspended material to form a high density pulp; that is, a pulp with a high solids content. The pulp is then conditioned with reagent having an affinity for the mineral values which are desired to be removed from the pulp by flotation methods; for example, by employing reagents of the type described in Patents Nos. 2,088,325 and 2,420,476 previously mentioned herein. Cationic or positive ion reagents will be employed in the concentration, from sylvinite ore, of nonmetallic minerals such as sylvite whenever such reagents are found to have an affinity for a particular mineral constituent in any nonmetallic mineral. Alternatively, anionic or negative ion reagent will be employed for the concentration of certain mineral values having an affinity for same; for example, in the concentration of the phosphate values present in phosphatic ores. A particular reagent or combination thereof is added directly to the aqueous pulp either as such, or together with certain water-immiscible oils such as fuel oil, kerosene, or pine oil, which act as frothing or co-operating agents in combination with the flotation agent. In some instances it is expedient to employ certain inorganic reagents such as dilute acids or alkalis, in order to adjust the pH of the reagentized pulp to an appropriate value for optimum concentration of any particular mineral. To the reagentized pulp is then added the relatively small particled material produced in the previously described classifying or sizing operation; and the resultant mixture is further conditioned, without the further addition of re-

agents, and subjected to flotation for the concentration of the desired mineral values. It has been found that not only is a considerable saving in reagent accomplished in comparison with methods which have been heretofore employed, but that only one flotation operation is required to obtain excellent recoveries, thereby eliminating the extensive series of flotation cells which have been heretofore required.

The instant process is applicable to the flotation concentration of nonmetallic minerals by froth-flotation methods. Therefore, in the event that a nonmetallic mineral has a widely varying particle size, it may be subjected to a preliminary classifying or sizing operation; followed by the aforedescribed reagentizing, conditioning, and flotation procedures. Froth-flotation concentration may be accomplished by employing flotation cells of the type currently designated as Denver cells, Turbo-cells, Minerals Separation cells, and others. It will be obvious to those skilled in the art that it is the usual practice to concentrate relatively large particled material (for example, between about -1 mm. to +14 mesh) on tabling devices; whereas relatively fine particled material (for example, -14 mesh) is usually subjected to froth-flotation. Variations are, of course, innumerable.

While the instant process is particularly applicable to the concentration of sylvite or potassium chloride values in sylvinite ore, and will be herein described and illustrated by a process of beneficiating an ore of this type, it is to be understood that the process is also applicable to any similar potassium chloride-containing mineral or natural deposit which may be beneficiated by froth-flotation methods. For example, the sodium chloride-potassium chloride mixtures produced by solar evaporation and/or crystallization from brine deposits in the vicinity of Trona, California, and Bonneville, Utah, may be beneficiated by recovering either sodium chloride or potassium chloride values therefrom in accordance with the instant process. Furthermore, any nonmetallic mineral-containing ore which is amenable to concentration by flotation methods—such as phosphate rock of the type found in the phosphate fields in Florida and Tennessee, iron oxide, lead and zinc carbonates, bauxite, and similar ores—may be beneficiated in accordance with the instant process.

A diagrammatic flow sheet of the process is as follows: Nonmetallic ore is subjected to size reduction in a comminutor indicated by the numeral 2. The comminuted ore is transferred to sizing or classification section 3 where the ore is divided into a fraction of relatively small particled material 7 and a fraction of relatively large particled material 5. Flotation reagent 4 is mixed with the large particled fraction 5, and the reagentized large particled ore is conditioned in mixer 6 for a suitable length of time. The resulting conditioned mixture is then transferred to mixer or conditioner 8, and the unreagentized small particled material 7 is added to mixer 8. The resulting mixture is conditioned for a suitable length of time. The resulting conditioned mixture containing both large and small particled ore is then transferred to flotation section 9 where a concentrate 10 is separated from a gangue 11.

More particularly, and as applied to the concentration of sylvite from sylvinite ore, the invention involves the preliminary comminution of sylvinite ore to liberate sylvite and halite particles

contained therein. This may be accomplished by any suitable and conventional type of grinding or milling apparatus which is currently used in the potash industry—for example, a Jeffrey Flex Tooth Crusher; followed by either hammermills or redmills. The crushing or grinding operation may be carried out either with substantially dry material, or by suspending the ore in a saturated solution of the same and subjecting it to a wet-grinding operation. The ground material is then subjected to a classifying or sizing operation in order to divide the ore into relatively coarse and fine fractions or feeds. The ground ore may be separated into two or more fractions by passing it through a screen, preferably through a screen having a mesh size between about 20 and about 50. In some instances it is beneficial to classify or separate the original ground material into a plurality of fractions, and then treat the individual fractions in accordance with the procedures subsequently herein described.

A relatively coarse fraction which is produced by the classifying or screening operations described above is suspended in an aqueous solution that is saturated with respect to sylvinitic. This solution may be prepared by dissolving sylvinitic in water until the saturation point with respect to sylvinitic is reached. Alternatively, recycle liquor or brine produced in plant operations for the recovery of sylvite from sylvinitic ore may be employed in this operation. It is to be understood that the liquor which is employed for pulping the coarse particled sylvinitic ore may also contain substances other than dissolved sylvinitic; for example, small amounts of water-soluble compounds of calcium, iron, etc. In any event, the solution should be substantially saturated with respect to sylvite or potassium chloride. A sufficient amount of coarse particled sylvinitic ore is suspended in the liquor in order to produce a high solids pulp. By the term "high solids pulp" is meant a pulp which contains more than about 40% by weight of suspended solids, and preferably contains between about 50% and about 80% by weight of suspended solids. It has been found that the solids density of this order in the first conditioning give the best balance between reagent adsorbed on the coarse particles and reagent left unadsorbed and interadsorbed by the finer particles; but solids densities outside of this range may be employed if desired. It has been found that if the suspended solids content of the pulp initially reagentized falls below about 50% by weight, the beneficial features which are inherent in the instant novel process are not fully realized. The resulting sylvinitic pulp is then conditioned with a cationic flotation reagent which has an affinity for sylvite particles. As previously described herein, the reagents described in Patents Nos. 2,088,325 and 2,420,476 are suitable for reagentizing a sylvinitic pulp. It has been found that straight-chain aliphatic amines containing at least one alkyl group having 7-18 carbon atoms are particularly useful as a flotation reagent for this operation; for example, aliphatic amines such as n-heptylamine, n-dodecylamine, n-heptadecylamine, and the like. The higher members of the aliphatic series of amines—for example, those which contain from 16-18 carbon atoms—are much less soluble in the sylvinitic pulp and ore and are more conveniently employed in the form of their water-soluble acid addition salts. For example, a mixture of aliphatic amines comprising about 25% by weight of hexadecylamine and about 75% by weight of octadecylamine is par-

ticularly useful for conducting flotation operations herein described, when employed in the form of their acetic acid addition salts. Other acids which may be employed to form salts of the amine reagents are sulfuric acid, hydrochloric acid, phosphoric acid, etc. It has now been found that these reagents successfully float the relatively coarse sylvite particles under the conditions obtaining, without the need for additional reagents such as fuel oil, pine oil, or other similar froth promoters which have heretofore been employed. In many instances it has been found that the use of such reagents is actually harmful and reduces the percent recovery obtained in the flotation concentrates. The reagentized coarse particled sylvinitic ore is conditioned by agitating the pulp and reagent mixture for a suitable period of time. Usually about 20 seconds to two minutes will be sufficient for this purpose, depending upon the thoroughness of the mixing. To the conditioned mixture is then added a relatively fine particled fraction of sylvinitic ore obtained in the preliminary classifying or screening process. Fine particled material may be added to the reagentized pulp containing coarse particled material, either in the solid form or in the form of an aqueous pulp which has been prepared by suspending fine particled sylvinitic in a saturated aqueous solution of sylvinitic or other liquor saturated with respect to potassium chloride. It is not necessary to add fine particled sylvinitic in the form of a high density pulp, but this may be convenient in some instances. It has been found that a fine particled sylvinitic ore pulp, containing between about 20% and about 75% by weight of solids, may be added to the reagentized pulp containing coarse particled material, while still obtaining the beneficial effects which are inherent in the instant novel process. In the event that fine particled sylvinitic ore, which is substantially dry, is added to the reagentized pulp containing coarse particled material, the density of the resultant mixture is conveniently regulated for purposes of conditioning with reagent by adding thereto a saturated aqueous solution of sylvinitic ore or, in place thereof, a recycle liquor or brine which is saturated with respect to potassium chloride and which is obtained in subsequent sylvite recovery plant operations. The resultant pulp containing both coarse particled and fine particled sylvinitic ore is then conditioned for a suitable length of time—for example, between about 20 seconds and about three minutes—and is then subjected to a flotation operation for the recovery of the sylvite or potassium chloride values which are suspended in the pulp material.

As applied to the treatment of phosphate rock for the recovery of phosphate values contained therein, the instant process involves a preliminary classification or sizing operation which is usually, but not necessarily, conducted by hydraulic means whereby relatively large particled phosphate rock is segregated from the relatively fine particles. For example, a suitable classification will result in a product having a mesh size of -28 to +60 mesh, and a second product having a -60 to about +200 mesh size. The fraction of large particled material may be conditioned by suspending the same in water, employing a sufficient amount of said fraction to form a pulp having a suspended solids content of between about 40% and about 80%. The resultant pulp is then conditioned with negative ion or anionic reagents such as high molecular weight fatty acids (oleic,

palmitic, stearic, and others), resin acids, rosin, talloil, naphthenic acids, and the alkali metal soaps of such materials—for example, the sodium soap of talloil. In some instances it will be beneficial to incorporate into the reagentized pulp a similar amount of a water-immiscible oil such as fuel oil or kerosene. The reagentized pulp is conditioned for a suitable period of time by agitating the same, either mechanically or by means of a current of air or gases that are inert to the reagentized mixture. Usually about 20 seconds to two minutes will be sufficient for this purpose. To the conditioned mixture is then added the fine particled fraction of phosphate ore obtained in the aforementioned classifying or screening process. This fraction may be added to the reagentized pulp containing coarse particled material, either in the solid form or in the form of an aqueous pulp prepared by suspending fine particled phosphate rock in water. The resultant pulp containing both coarse and fine particled phosphate rock is conditioned for a suitable period of time and then subjected to a froth-flotation operation for the recovery of the phosphate values contained therein.

In a preferred embodiment of the invention, ground sylvinitic ore is classified into at least three fractions, preferably by passing a previously comminuted material through a 50 mesh screen and then passing the +50 mesh product through a 25 mesh screen. The +25 mesh product is suspended in a saturated aqueous solution of sylvinitic ore to form a pulp containing between about 50% and about 70% by weight of suspended solids. To this pulp is added about 0.1 lb. of a water-soluble acid addition salt of a mixture of aliphatic amines comprising about 25% by weight of hexadecylamine and about 75% by weight of octadecylamine. Usually this reagent is added in the form of its acetic acid addition salt. The resultant mixture is then conditioned by agitation for about 30 seconds, and the -25 to +50 mesh sylvinitic ore fraction is added thereto in the form of a pulp which is prepared by suspending said fraction in a saturated aqueous solution of sylvinitic ore. The resultant mixture is further conditioned for a similar period of time, after which the -50 mesh fraction is added to the conditioned pulp in the form of a pulp prepared by suspending said fraction in a saturated aqueous solution of sylvinitic ore. The resultant mixture is then subjected to a froth-flotation operation and the sylvite particles are concentrated in the float, while the halite particles are concentrated in the tailings. Not only is an excellent recovery of sylvite from the sylvinitic ore obtained by such an operation, but the reagent economy is considerable when compared to methods which have been heretofore employed. Furthermore, the need for reagents which cooperate with flotation reagents such as fuel oil, pine oil, etc. is obviated, and the number of flotation operations is reduced to one; thereby greatly increasing the capacity and productivity of any sylvite recovery plant employing froth-flotation. These advantages will be further illustrated in the examples which will be subsequently herein set forth.

The amount of cationic flotation reagent which is required in recovering sylvite from sylvinitic ore in accordance with the instant novel process is usually about 0.1 lb. per ton of feed, based upon the solids content of the pulp which is to be reagentized, and in many instances is considerably less than this amount. Excellent results have been obtained by employing as little as 0.03

lb. of long-chain aliphatic amine reagent per ton of feed. This is in sharp contrast with the quantities of reagent necessarily heretofore employed; i. e., between about 0.2 and about 1.0 lb. per ton of flotation feed. The amounts of reagent required may be varied widely over that heretofore mentioned, depending upon the degree of coarseness or fineness of the particular feed reagentized.

In order to further illustrate the nature and character of the invention, but with no intention of being limited thereby, the following examples are recited:

Example I

A sample of sylvinitic ore of the type common to the Carlsbad, New Mexico, area and analyzing about 18.6% K_2O , was ground to a point where about 33% of the material was +28 mesh. The +28 mesh material was suspended in a saturated water solution of sylvinitic ore at about 24° C., the resultant pulp containing about 70% by weight of suspended solids. To about 750 g. of this pulp was added about 0.027 lb. per ton of total ground ore of an amine reagent comprising about 25% of mono-octadecylamine acetate, about 25% of monohexadecylamine acetate, and about 50% of octadecylamine acetate. The resultant mixture was conditioned for about 30 seconds. To the conditioned pulp was added an equal weight of unreagentized pulp consisting of -28 mesh sylvinitic ore suspended in an aqueous solution which was saturated with respect to sylvinitic ore; this second pulp containing about 70% by weight of suspended solids. The resultant mixture was conditioned by agitation for about 30 seconds and was then subjected to froth-flotation in a Fagergren flotation machine and a sylvite concentrate was recovered. The tailings analyzed about 1.42% K_2O , and the over-all recovery of sylvite or potassium chloride values was about 94.8%.

The above described process indicates the excellent results which may be obtained with a minimum of reagent while accomplishing the froth-flotation of both coarse and fine particled sylvinitic ore, yet employing only one flotation operation.

In another run identical to that of Example I as to feed material, reagents used, flotation conditions, etc., (except that all of the feed was reagentized with 0.081 lb. of reagent per ton of solids, and then conditioned, as single steps) the concentrate analyzed 58% K_2O —the same as in Example I—the tailings being 1.07% K_2O , with the recovery being about 96%. However, three times as much reagent was required as in the case of Example I.

Example I, while illustrating the invention, is not strictly on a comparable basis with the following examples because of slight variations in grinding of the feed, degree of saturation of the brine, and other operating factors. The following examples were all carried out on the same feed, and at about the same time, so that these variable factors were minimized.

Example II

A wet-ground sylvinitic flotation feed containing about 26.4% KCl was classified in order to obtain two fractions, the coarse fraction being +35 mesh. The type reagent employed in this flotation operation and in the following examples was the acetates of a mixture of about 25 weight percent of hexadecylamine and about 75% of octadecylamine.

The coarse particled material was conditioned with about 0.1 lb. of reagent per ton of total ground ore in a pulp consisting of a saturated aqueous solution of sylvinitic ore containing about 70% by weight of suspended coarse particled material. The pulp was conditioned for about 30 seconds and was then combined with the fine particled material which was suspended in a saturated aqueous sylvinitic ore solution, the resultant mixture having a solids content of about 40%. This admixture was conditioned for about 30 seconds and subjected to froth-flotation, with the resulting concentrate analyzing about 58% K_2O and the tailings analyzing about 4.0% K_2O . The percent recovery of potassium chloride was about 82%.

Example III

A wet-ground sylvinitic ore of the type employed in Examples I and II, one-third of which will be retained on a 35 mesh screen, was subjected to the following type of beneficiation: The recovery of sylvite or potassium chloride values was effected by conditioning the +35 mesh fraction for about 30 seconds in a saturated aqueous solution of sylvinitic ore with the same amount and type of reagent as described in Example II; but, in addition, about 0.5 lb. of kerosene per ton of solid feed was added during the conditioning of the coarse particled fraction. To the conditioned pulp was added a suspension of the unreagentized fine particled material (-35 mesh) in a saturated aqueous solution of sylvinitic ore as described in Example II. The resultant mixture of about 40% solids, after 30-second conditioning, was then subjected to froth-flotation, and a concentrate containing about 59% by weight of K_2O was recovered. The tailings analyzed about 13.7% K_2O . The recovery of potassium chloride values in this particular modification of the instant novel process was only about 25%.

This last example illustrates the detrimental effect which may be caused by adding conventional froth-promoting reagents such as kerosene, which type of operation has heretofore been deemed necessary in order to achieve the efficient froth-flotation of coarse particled sylvite in a comminuted sylvinitic ore. It illustrates the distinct advantages which are realized by employing a cationic nitrogenous reagent in the absence of other cooperating reagents for the froth-flotation beneficiation of sylvinitic ore, which is one of the distinguishing features of the instant novel process.

While the above examples illustrate the use of particular long-chain aliphatic amine reagents within specified amounts, it is to be understood that any cationic type reagent which has an affinity for sylvite or potassium chloride particles, such as those described in the patents hereinbefore mentioned, may be employed to advantage in producing a high recovery of potassium chloride values from sylvinitic ore. Furthermore, it is not intended to limit the invention to the particular type of flotation operations herein described for purposes of illustration; but, on the contrary, any type of froth-flotation operation which is familiar to those skilled in the art may be employed without departing from the spirit and scope of the invention.

It is further to be understood that comminuted sylvinitic ore or other nonmetallic ore may be subjected to a sequential series of screening or classifying operations, and that the coarsest fraction is first conditioned with reagent, followed by

sequentially adding to the conditioned pulp fractions containing progressively finer particled material; the addition being in the order of decreasing particle size of the several fractions. Therefore, in some instances as many as six or more different fractions may be subjected to conditioning in this manner, followed by a single froth-flotation operation after the addition of the final small particled fraction to the reagentized pulp. Illustrative of the practice of this novel process when applied to the froth-flotation of phosphate ores, the following example dealing with the beneficiation of Florida pebble phosphate ore is given:

Example IV

A deslimed, Florida pebble phosphate, from which the +1 mm. particles had been previously removed and about 95.5% of the remaining material had a mesh size of -28 to +200, was employed as the feed material in this run. About 936 g. of this material was pulped with water and had admixed therewith, at a solids density of about 70-72%, caustic soda at the rate of about 0.5 lb. per ton of solids, fuel oil, and fatty acid. The caustic was added first, fuel oil at the rate of about 3 lb. per ton of solids feed, and fatty acid (crude talloil) at the rate of about 0.76 lb. per ton of solids feed were admixed and added to the feed pulp. The feed, however, prior to the addition of any of the reagents, was split into a fraction, -28 to +60 mesh, and a smaller-sized fraction of -60 to +200 mesh. All of the reagents were added to the -28 to +60 mesh material, and this was conditioned at the heretofore specified solids density for about one minute. The smaller-sized particle fraction in unreagentized condition was then added at about the same solids density to the first and reagentized fraction. The entire mixture was then conditioned for about one minute, after which sufficient water was added to give a pulp density of about 25 weight percent solids. This material was then subjected to froth-flotation in a conventional froth-flotation cell for about 45 seconds, during which time the phosphate concentrate float was collected. The dried concentrate analyzed about 57.31% B. P. L. and the tailings analyzed about 6.03% B. P. L. The over-all recovery of phosphate values in the concentrate was about 92.46%.

Another run was carried out under exactly the same conditions, using the same reagents, but with talloil used in the amount of about 1.29 lb. per ton of solids treated; and wherein the feed material was not split as to particle size. The concentrate obtained analyzed about the same as in Example IV. The tailings, however, analyzed 9.53% B. P. L. and the over-all recovery of phosphate values from the feed was only 88.5%. In spite of the fact that about 60% more fatty acid (talloil) was used in the conventional flotation operation, only 88.5% recovery was obtained as compared with about 92.46% recovery in the case of the separate conditioning of the particle fractions; while the concentrates in both instances were almost identical as to their phosphate values. The feed material used in Example IV and in the run carried out using conventional procedure analyzed about 35.64% B. P. L. and about 54.19% insoluble material.

Obviously the invention is not limited to the procedural details herein set forth, but may be modified by employing obvious extensions and modifications which are familiar to those skilled in the art.

Having thus fully described the nature and

character of the invention, what is desired to be secured by Letters Patent is:

1. In a process for the flotation concentration of nonmetallic ore, the improvements comprising dividing said ore into at least two fractions, one of which is of relatively large particles and the other of which is of relatively small particles, preparing an aqueous high solids pulp of large particled material, conditioning the latter with reagent having an affinity for the mineral value in said ore, subsequently adding the unreagentized small particled material to the pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined ore fractions to flotation.

2. In a process for the flotation concentration of potassium chloride from a comminuted composition containing the same, the improvements comprising dividing said composition into at least two fractions, one of which is of relatively large particles and the other of which is of relatively small particles, suspending large particled material in an aqueous solution saturated with respect to potassium chloride to form a high solids pulp, conditioning the latter with reagent having an affinity for potassium chloride particles, subsequently adding the unreagentized small particled material to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined fractions to flotation.

3. A process according to claim 2, wherein the flotation agent employed is selected from the group consisting of aliphatic amines containing at least one alkyl group having 7-18 carbon atoms and their water-soluble acid addition salts.

4. In a process for the concentration by froth-flotation treatment of potassium chloride from a comminuted composition containing the same, the improvements comprising dividing said composition into at least two fractions, one of which is of relatively large particles and the other of which is of relatively small particles, suspending large particled material in an aqueous solution saturated with respect to potassium chloride to form a high solids pulp, conditioning the latter with reagent having an affinity for potassium chloride particles, subsequently adding the unreagentized small particled material to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth flotation.

5. In a process for the concentration of sylvite from sylvinite ore by froth-flotation treatment, the improvements comprising comminuting sylvinite to liberate sylvite and halite particles, dividing the resultant product into a plurality of fractions of progressively decreasing particle size, suspending a fraction of large particled sylvinite in an aqueous solution substantially saturated with respect to sylvinite to form a high solids pulp, conditioning the latter with cationic flotation agent having a selective affinity for sylvite particles, subsequently adding at least one fraction of the unreagentized smaller particled sylvinite to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth flotation.

6. A process according to claim 5, wherein

small particled fraction of sylvinite is added to the conditioned large particled pulp in the form of a pulp made by suspending small particled sylvinite in a saturated aqueous solution of sylvinite.

7. In a process for the concentration of sylvite from sylvinite ore by froth-flotation treatment, the improvements comprising comminuting said sylvinite to liberate sylvite and halite particles, dividing the resultant product into a plurality of fractions of progressively decreasing particle size, suspending a fraction of large particled sylvinite in a saturated aqueous solution of sylvinite to form a pulp containing between about 40% and about 80% by weight of suspended solids, conditioning the pulp with reagent selected from the group consisting of aliphatic amines containing at least one alkyl group having 7-18 carbon atoms and their water-soluble acid addition salts, subsequently adding at least one fraction of the unreagentized smaller particled sylvinite to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth-flotation.

8. In a process for the concentration of sylvite from sylvinite ore by froth-flotation treatment, the improvements comprising comminuting said sylvinite to liberate sylvite and halite particles, dividing the resultant product into a plurality of fractions of progressively decreasing particle size by successively passing the ore through at least one screen having a mesh size between about 20 and about 50, suspending a relatively large particled fraction in a saturated aqueous solution of sylvinite to form a pulp containing between about 40% and about 80% by weight of suspended solids, conditioning the pulp with reagent selected from the group consisting of aliphatic amines containing at least one alkyl group having 7-18 carbon atoms and their water-soluble acid addition salts, subsequently adding at least one fraction of the unreagentized smaller particles in the form of a pulp made by suspending small particled sylvinite in a saturated aqueous solution of sylvinite to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth-flotation.

9. A process for the concentration of sylvite from sylvinite ore which comprises crushing said sylvinite to produce a product about two-thirds of which will have a particle size less than 30 mesh, dividing the crushed product into two fractions by passing it through a 35 mesh screen, suspending +35 mesh sylvinite in a saturated aqueous solution of sylvinite to form a pulp containing about 70% by weight of suspended solids, conditioning the pulp with reagent consisting of the acetic acid addition salts of a mixture of aliphatic amines comprising about 25% by weight of hexadecylamine and about 75% by weight of octadecylamine, subsequently adding to the pulp conditioned for flotation and prior to subjecting the pulp to any flotation a slurry consisting of -35 mesh sylvinite suspended in a saturated aqueous solution of sylvinite, conditioning the resulting mixture, and then initially subjecting the conditioned pulp of the combined fractions to flotation.

10. A process according to claim 9, wherein the reagent employed for conditioning and froth-floating the sylvite consists of the acetate salts of

a mixture of aliphatic amines comprising about 25% by weight of hexadecylamine, about 25% by weight of octadecylamine, and about 50% by weight of octadecenylamine.

11. In a process for the concentration of sylvite from sylvinitic ore by froth-flotation treatment, the improvements comprising comminuting said sylvinitic ore to liberate sylvite and halite particles, dividing the resultant product into three fractions of progressively decreasing particle size, suspending the fraction containing the largest particles of sylvinitic ore in a saturated aqueous solution of sylvinitic ore to form a pulp containing between about 40% and about 80% by weight of suspended solids, conditioning the pulp with reagent selected from the group consisting of aliphatic amines containing at least one alkyl group having 7-18 carbon atoms and their water-soluble acid addition salts, subsequently adding the fraction of unreacted medium size particles of sylvinitic ore to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, further conditioning the resultant mixture, subsequently adding the fraction of unreacted smallest particle sylvinitic ore to the resulting conditioned pulp, conditioning the mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth flotation.

12. In a process for the concentration of sylvite from sylvinitic ore by froth-flotation treatment, the improvements comprising crushing said sylvinitic ore to liberate sylvite and halite particles, dividing the crushed product into three fractions by passing it through a 25 mesh screen and then passing the -25 mesh product through a 50 mesh screen, suspending +25 mesh sylvinitic ore in a saturated aqueous solution of sylvinitic ore to form a pulp containing between about 50% and about 70% by weight of suspended solids, conditioning the pulp with reagent selected from the group consisting of aliphatic amines containing at least one alkyl group having 7-18 carbon atoms and their water-soluble acid addition salts, subsequently adding the unreacted -25 to +50 mesh fraction in the form of a pulp made by suspending said fraction in a saturated aqueous solution of sylvinitic ore to said pulp conditioned for flotation and prior to subjecting the pulp to any flotation, further conditioning the resultant mixture, subsequently adding the unreacted -50 mesh fraction in the form of a pulp made by suspending said fraction in a saturated aqueous solution of sylvinitic ore to the resulting conditioned pulp, conditioning the resultant mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth-flotation.

13. In a process for the flotation concentration of phosphate values from phosphate ore containing the same in association with silica, the improvements comprising dividing said ore into at

least two fractions, one of which is of relatively large particles and the other of which is of relatively small particles, preparing an aqueous high solids pulp of large particle material, conditioning the latter with reagent having an affinity for phosphate values, subsequently adding the unreacted small particle material to the pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the mixture, and then initially subjecting the conditioned pulp of the combined fractions to flotation.

14. In a process for the froth-flotation concentration of phosphate values from phosphate ore containing the same in association with silica, the improvements comprising dividing said ore into at least two fractions, one of which is of relatively large particles and the other of which is of relatively small particles, preparing an aqueous high solids pulp of large particle material, conditioning the latter with reagent having an affinity for phosphate values, subsequently adding the unreacted small particle material to the pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth flotation.

15. In a process for the concentration of phosphate values from phosphate ore containing the same in association with silica by froth-flotation treatment, the improvements comprising dividing said ore into a plurality of fractions of progressively decreasing particle size, suspending a fraction of large particle ore in water to form a pulp containing between about 40% and about 80% by weight of suspended solids, conditioning the pulp with negative ion agent having an affinity for phosphate values, subsequently adding at least one fraction of the unreacted small particle material to the pulp conditioned for flotation and prior to subjecting the pulp to any flotation, conditioning the mixture, and then initially subjecting the conditioned pulp of the combined fractions to froth flotation.

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