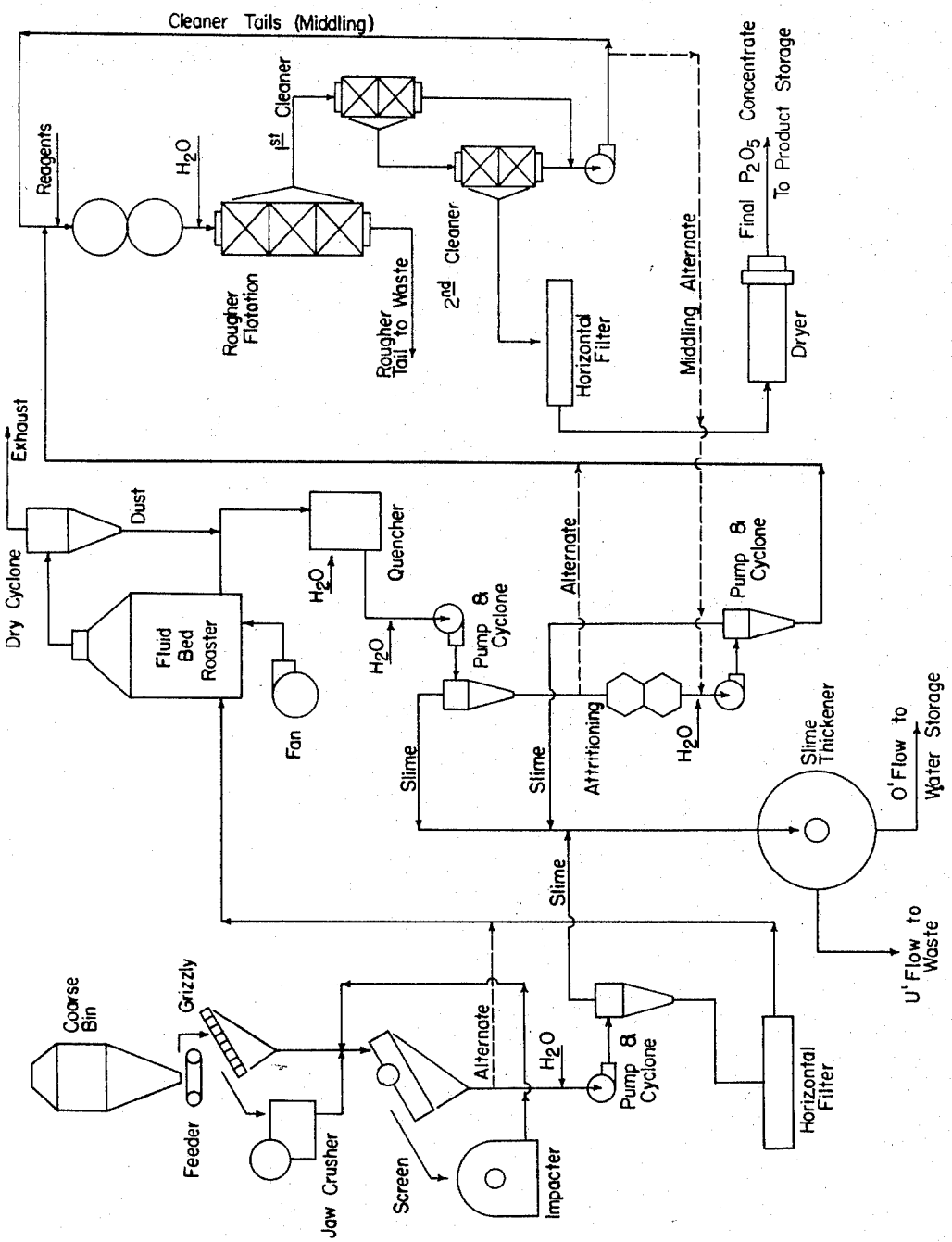
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BENEFICIATION OF CERTAIN PHOSPHATE ROCK ORES BY FROTH FLOTATION

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BENEFICIATION OF CERTAIN PHOSPHATE ROCK ORES BY FROTH FLOTATION

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ABSTRACT OF THE DISCLOSURE

A process of beneficiating Idaho and Tennessee muck types of phosphate rock ores, which contain considerable quantities of slime-forming, hydrated clays, by combined treatment procedures including roasting the ore at a temperature in the range of 200° to 800° C. and subjecting the roasted ore to froth flotation, either with or without previous scrubbing and desliming, for the recovery of a froth concentrate containing at least 30% by weight P_2O_5.

This invention relates to processes of upgrading phosphate rock ores by froth flotation, particularly certain types of ores not heretofore capable of being successfully treated by froth flotation because they contain organic matter and a considerable quantity of slime-forming, hydrated clays.

The certain ores concerned are those of the type found in Idaho and known as "furnace shales" and "waste shales" and those of the type found in the flatland areas of Tennessee and known as "Tennessee muck."

Phosphate rock for the manufacture of fertilizer by acidulation should have a P_2O_5 content of 33% or more to be considered high grade and should have a minimum P_2O_5 content of 30% to be considered low grade. In Idaho, rock concentrates are produced by calcining ore of 28% to 31% P_2O_5. Lower grade ore (24% P_2O_5) is used for the manufacture of phosphorus in an electric furnace.

Some Idaho ores of 24% to 28% P_2O_5 can be upgraded to minimum commercial standard rock (30% P_2O_5) by washing. Grades of 18% or lower apparently have no commercial value. In most cases, Idaho main bed ores have a P_2O_5 content of 30% to 31% and need no beneficiation to provide low grade rock for acidulation. High grade rock for acidulation can be produced from this ore by calcining.

Some of the lower grade Idaho ores can be upgraded to minimum commercial standards for acidulation (30% P_2O_5) by washing, but most of this material under present practice must be used in the electric furnace. Washed Tennessee muck is also used for furnace feed, but can be used as furnace feed without prior washing if mixed with higher grade Florida rock.

Inasmuch as low grade ore is normally interbedded with high grade ore in most phosphate deposits of the types concerned, much of the phosphate ore that is mined cannot be converted successfully to high value rock under present methods.

Idaho ores of the type concerned contain organic matter in the form of carbonaceous inclusions in pellets of phosphorite mineral. This inhibits coating of such pellets with collector reagents, as required for flotation. Tennessee muck contains organic matter in the form of humic acids that cause undesirable frothing and otherwise interfere with effective recovery by froth flotation procedures. Both types of ore contain considerable quantities of slime-forming, hydrated clay-like material, which adheres to the valuable mineral particles.

This invention has for its purpose the provision of a process by which such phosphate ores can be successfully upgraded by froth flotation.

In the accomplishment of this purpose, a principal feature of the invention is the application, to the ore as mined or following crushing and washing, of a roasting step preliminary to flotation by customary techniques. This apparently prepares the surfaces of the phosphorite mineral particles for acceptance of flotation collector reagents.

Such preliminary roasting oxidizes and volatilizes the organic matter associated with the phosphorite mineral and renders the hydrated, clay-like particles of slime-forming material easily removable from the surfaces of the phosphorite mineral particles and freely dispersible in the flotation pulp, improves their settling characteristics for desliming procedure which is preferably carried out prior to flotation, and otherwise contributes to sharp separation thereof from the valuable mineral particles.

It has been found advantageous to utilize an alkaline reagent, such as soda ash or sodium silicate during the roasting. This has been found to result in a stronger bonding of the collector reagents to the phosphorite particles during flotation and to effect greater dispersion of the slime-forming particles.

Preliminary roasts for some types of high slime ores have been advocated heretofore, but so far as we are aware none have been for the same purpose. Thus, for example, in Grothe U.S. Patent No. 2,363,315, lateritic ores are ground fine and subjected to a reducing roast at about 900° C. or above for chemically converting limonite slimes to magnetite. Again, in Atwod U.S. Patent No. 2,772,775, sylvanite (KCl) ores containing large amounts of slime-forming, clay-like materials are roasted at a temperature between about 400° and 550° C. for effecting comminution of the larger sylvanite particles and for coincidentally "inactivating" the slime-forming material for subsequent flotation. It is said that the inactivated, slime-forming material is rendered non-dispersible.

In accordance with the invention, not only is the organic matter eliminated by the roasting step, but the slime-forming, hydrate, clay-like material of the particular phosphate rock ore concerned is dehydrated and rendered dispersible. Ordinarily, the ore is crushed, roasted, scrubbed, deslimed, and subjected to flotation with appropriate reagents for floating the phosphorite mineral particles and thereby producing a phosphorite froth concentrate, which is filtered or otherwise dewatered and dried to yield a final P_2O_5 concentrate of commercial grade.

The present process is distinguished from standard commercial processes in that (1) under standard calcining practice, the calcining is the final step in beneficiation, (2) the roasting step of the present process is generally at a lower temperature than is used in standard calcining operation, (3) the present process incorporates flotation as a beneficiation procedure.

There is shown in the accompanying drawing what is presently regarded as the best mode of carrying out the invention in practice. The single figure is a flowsheet showing typical procedures.

Referring to the drawing:

As indicated, the particular ore concerned, either the Idaho type or the Tennessee muck type is crushed and screened in customary manner to a size suitable for flotation. As an optional procedure, the resulting finely-divided ore may be subjected to a preliminary desliming procedure by washing, cycloning, and filtering.

The resulting finely-divided ore is then roasted in any suitable apparatus, e.g., the fluid bed roaster indicated, at a temperature in the range of about 200° to 800° C. for about one hour. Desired dehydration of the hydrated, clay-like slime-forming material present in the ore takes

place at the lower temperatures, so it is not necessary to go to the higher temperatures unless the presence and desired elimination of organic components in the ore require it. Above 800° C., calcium carbonate in the ore begins to calcine, which has an undesirable influence on subsequent flotation procedures. The organic matter in Tennessee muck is usually eliminated at lower temperature than is that in the Idaho ore.

The roasted ore is passed to washing and scrubbing apparatus, where the slime-forming material is largely removed from adherence to the phosphorite mineral particles. The resulting slurry is subjected to a desliming operation in any suitable apparatus, e.g., one or more cyclones, as indicated.

The deslimed pulp is then subjected to froth flotation in any suitable flotation circuit, here shown as comprising a conditioning stage, a rougher stage, and two cleaner stages, the reagents employed being customary for the minerals concerned, e.g., fuel oil and a fatty acid.

The final froth concentrate is dewatered, as by filtration, and dried to yield a final P_2O_5 product of commercial grade.

Numerous laboratory tests have indicated usefulness of the process.

EXAMPLE 1

A sample of Idaho Georgetown ore from Simplot's Gay mine near Pocatello, Idaho, was crushed and screened to minus 28 mesh. It analyzed 19.9% by weight P_2O_5. The finely divided ore was roasted in a muffle furnace at 732° C. for one hour to eliminate organic matter and to dehydrate the hydrated, clay-like, slime-forming material present. Following attrition washing (scrubbing) and desliming by dilution and decantation, the resulting deslimed pulp was run into a laboratory flotation machine and subjected to froth flotation treatment in the presence of fatty acid and fuel oil as flotation reagents in accordance with standard practice. The product obtained by filtering the final froth concentrate analyzed 37.43% P_2O_5 with a total recovery of about 57%.

EXAMPLE 2

Following a generally similar procedure with a sample of an Idaho Georgetown ore obtained from Central Farmers Fertilizer Company, Georgetown, Idaho, analyzing 22% by weight P_2O_5 and size reduced by a special explosive procedure to minus 28 mesh, the roast being conducted at 340° C. for one hour and fatty acid, kerosene, and petroleum sulfonate being used as reagents, the final concentrate analyzed 36.75% P_2O_5 with a total recovery of about 60%.

EXAMPLE 3

A minus quarter inch sample of another Idaho Georgetown ore containing 23.71% P_2O_5 was roasted at 800° C. for one hour with eight pounds per ton of sodium carbonate and was then wet ground to a size of minus 28 mesh, scrubbed, deslimed, conditioned with 3 lbs./ton Actinol FA–2 (fatty acid), 5 lbs./ton kerosene, and 2 lbs./ton ammonia, and subjected to flotation, yielding a froth concentrate analyzing 33.68% P_2O_5 with a total recovery of about 60%.

EXAMPLE 4

A sample of the same Idaho Georgetown as in Example 3 containing 23.66% P_2O_5 was treated in the same manner as in that example except that no sodium carbonate was used. The concentrate analyzed 34.40% P_2O_5 with a total recovery of about 56%.

EXAMPLE 5

This test corresponded to that of Example 4 except that the sample contained 24.69% P_2O_5 and roasting was carried out at 600° C. The concentrate analyzed 33.94% P_2O_5 with a total recovery of about 54%.

EXAMPLE 6

This test corresponded to that of Example 5, except that the sample contained 23.99% P_2O_5 and roasting was carried out with 8 lbs./ton of sodium carbonate added to the ore. The concentrate analyzed 34.60% P_2O_5 with a total recovery of about 57%.

EXAMPLE 7

This test corresponded to that of Example 6, except that the sample contained 22.86% P_2O_5 and sodium silicate was used instead of sodium carbonate. The concentrate analyzed 33.43% with a total recovery of about 59%.

EXAMPLE 8

In this test, a sample of Idaho Georgetown ore containing 21.6% P_2O_5 and ground to minus 28 mesh was subjected to scrubbing and desliming, to raise the grade to 29.69% P_2O_5. It was then conditioned as in Example 3, without prior roasting. There was no coating of the phosphorite minerals with the reagents. The quantity of reagents was doubled for an additional period of conditioning, resulting in parital coating. Flotation yielded a froth concentrate analyzing only 31.03% P_2O_5 with a total recovery of about 46%. The meager rise in grade with poor recovery and uneconomical quantities of reagents used showed flotation to be impractical.

EXAMPLE 9

A sample of Tennessee muck analyzing 15.2% P_2O_5 was ground to 65×325 mesh, washed, roasted under an infrared heat lamp for one hour at 200° C., scrubbed, deslimed by decantation, conditioned for 7 minutes with 4.0 lbs./ton Actinol FA–2, 4.0 lbs./ton kerosene, 3.0 lbs./ton turpentine, and 2 lbs./ton ammonia, and subjected to flotation. The final concentrate analyzed 30.72% P_2O_5 with a total recovery of about 75%.

EXAMPLE 10

A portion of the same Tennessee muck ore used for Example 9 was treated in the same way, except that the roasting was carried out in a muffle furnace with temperature maintained at 600° C. The final concentrate analyzed 30.78% P_2O_5 with a total recovery of about 75%.

EXAMPLE 11

A portion of the same Tennessee muck ore used for Examples 9 and 10 was treated in the same way, except without prior roasting and with the conditioning reagents being 4.0 lbs./ton Actinol FA–2, 10.0 lbs./ton kerosene, and 5.0 lbs./ton sodium hydroxide. The final concentrate analyzed only 28.63% P_2O_5 (noncommercial) with a total recovery of about 80%. This shows the impracticality of attempting to upgrade this ore by froth flotation without preliminary roasting.

Whereas a particular procedure and various examples of the invention are presented herein as representing the best mode presently known of carrying out the process of this invention, it should be understood that various changes can be made without departing from the inventive subject matter particularly pointed out and claimed herebelow.

We claim:

1. A froth flotation process for the beneficiation of phosphate rock ores in the form of phosphorite mineral containing such quantities of slime-forming hydrated clays as to be normally non-amenable to flotation and such quantities of organic matter as to interfere with effective recovery by flotation methods, comprising roasting such an ore at a temperature in the range of 200° to 800° C. to volatilize organic matter therefrom, to render slime forming materials therein dispersible in a flotation pulp, and to condition the surfaces of phosphate mineral values for the acceptance of collector reagents; and subjecting the roasted ore to froth flotation in the presence

of a fatty acid flotation reagent for the recovery of a froth concentrate containing at least 30% by weight P_2O_5.

2. The process of claim 1, wherein the roasting is carried out in the presence of an alkaline reagent mixed with the ore.

3. The process of claim 2, wherein the alkaline reagent is at least one of the members of the group consisting of sodium carbonate and sodium silicate.

4. A froth flotation process for the beneficiation of phosphate rock ores in the form of phosphorite mineral containing such quantities of slime-forming hydrated clays as to be normally non-amenable to flotation and such quantities of organic matter as to interfere with effective recovery by flotation methods, comprising roasting such an ore at a temperature in the range of 200° to 800° C. to volatilize organic matter therefrom, to render slime forming materials therein dispersible in a flotation pulp, and to condition the surfaces of phosphate mineral values for the acceptance of collector reagents; scrubbing and desliming the roasted ore; and subjecting the roasted ore to froth flotation in the presence of a fatty acid flotation reagent for the recovery of a froth concentrate containing at least 30% by weight P_2O_5.

5. The process of claim 4, wherein the roasting is carried out in the presence of an alkaline reagent mixed with the ore.

6. The process of claim 5, wherein the alkaline reagent is at least one of the members of the group consisting of sodium carbonate and sodium silicate.

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