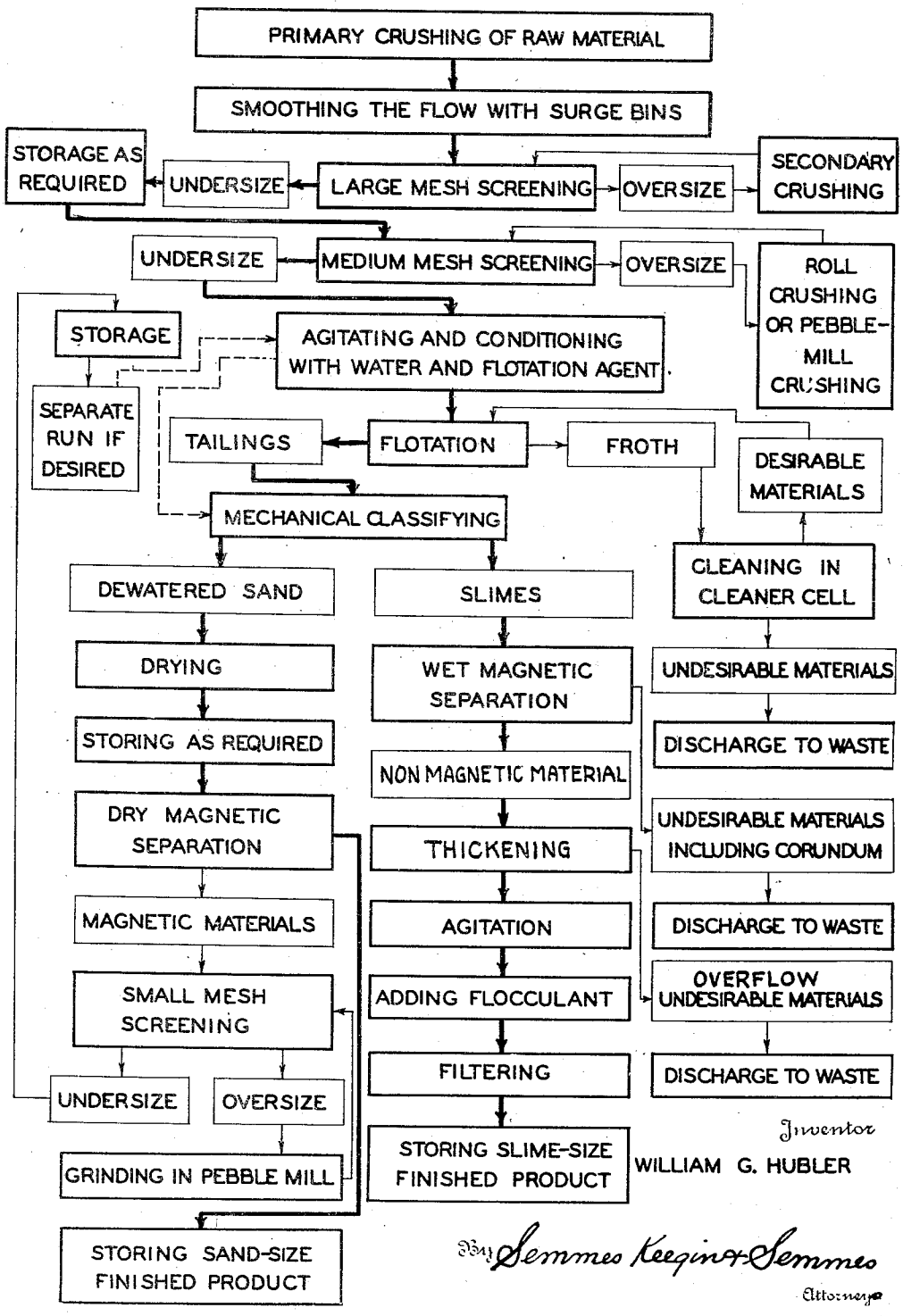
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BENEFICIATION OF FELDSPATHIC AND SIMILAR ORES

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BENEFICIATION OF FELDSPATHIC AND SIMILAR ORES

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My invention relates to the beneficiation of ores, and more particularly to the purification of certain non-metallic minerals, chiefly minerals of the feldspathic group. While I shall described the process as applied to the treatment of feldspathic ores, it will, of course, be appreciated that such process, and especially certain of the individual steps in it, will be of value in the treatment of other materials.

Feldspathic materials are widely used in the ceramic arts but, as found in nature, the feldspathic ores frequently carry products which are objectionable for the intended use. For instance, some of the feldspathic ores contain corundum, mica, and various iron bearing products such as magnetite, hematite, and pyrites. These, and other impurities, are objectionable in the feldspathic product that is for use in ceramic ware. For instance, corundum, being relatively infusible, develops "seeds" in the finished ware which are not fused into the whole article. Likewise, iron in the finished product is to be avoided inasmuch as it discolors the ware and also tends to weaken the finished product. In general, the presence of impurities alter the fluxing properties of the feldspathic material, and therefore are to be avoided, or at least kept at a minimum.

Heretofore, feldspathic material free from impurities has been obtained by restricting mining operations to only the better grade of ore, by hand picking, and by subjecting the ore to magnetic separation. Such expedients have resulted in only a limited measure of success, and with the depletion of the high grade deposits, the problem of successfully treating feldspathic ores has become more acute.

It will, of course, be appreciated that a process, in order to be practicable, must not only effectively remove the impurities, but, in so doing, it must not impair the properties of the ore for use in the ceramic art. In other words, such treatment should not introduce other impurities while removing the above mentioned ones.

An object of my invention is to produce a higher yield of utilizable material from an ore.

Another object is to enable the more complete removal from an ore of deleterious substances which are either magnetic, or non-magnetic.

A further object of my invention is to accomplish the beneficiation of feldspathic ores.

Yet a further object is to remove certain non-magnetic or weakly magnetic impurities by conditioning them for a magnetic separation step.

Yet another object is to provide a flotation process for the removal of certain impurities from an ore.

A still further object is to add to the raw material only those reagents which are not objectionable in the finished product or which may be readily removed from it.

Another object is to utilize the same agent both for flotation and for conditioning the ore for magnetic separation.

Still another object is to beneficiate feldspathic ores by multiple-stage grinding, flotation, mechanical classification, both wet and dry magnetic separation, and by thickening.

With these and other objects in view, I have included in the appended drawing a flow sheet for better presenting the invention. This flow sheet shows an embodiment of my invention, the specific process there illustrated being designed for the beneficiation of feldspathic material, in particular, nepheline syenite. But it will be understood that this process may be adapted for the purification and beneficiation of other ores, such as granites, particularly where it is desired to remove iron-bearing impurities and certain other impurities such, for instance, as corundum.

In order to facilitate the disclosure of my invention and the statement of what I claim as new, certain definitions of terms are now given.

"Feldspathic materials" as used herein includes all those minerals in the feldspar and the feldspathoid groups.

"Magnetic" is used in this specification in a practical sense and means that magnetic separation can be achieved commercially.

Briefly, my invention includes the following steps:

(1) Crushing raw material with supplementary crushing and grinding steps for materials screened out.

(2) Special conditioning with water and certain agents, preferably fatty acids or their derivatives.

(3) Froth flotation of undesirable material, including corundum and mica.

(4) Classifying the flotation tailings into sand and slimes.

(5) Magnetically separating the sands and slimes.

(6) Grinding the magnetic sands and recirculating them to the flotation stage of the process, preferably as a separate run.

(7) Magnetically separating the magnetic material and corundum from slime.

(8) Thickening the magnetic slimes to remove

organic matter including the flotation reagent and the smallest slimes.

(9) Addition of a flocculation agent, preferably alum.

(10) Filtering flocculated material to give a finished product of fines.

In carrying out my process, I first take the raw material which may be stored in a bin and subjected to a primary crushing process. This crushed material is passed through a surge bin to smooth out the flow, and then fed to a mechanical or electrical vibrating screen having a large mesh. The oversize is crushed and recirculated onto the large mesh screen. The material passing through the large mesh screen is carried into storage as required. Then this undersize is fed to a medium-size vibrating screen of approximately 20 mesh.

The oversize from this medium mesh screen is fed to a roll crusher or a pebble mill and the ground material is fed back onto the medium mesh screen. The undersize from this medium mesh screen is fed to an agitator and conditioner, which forms a pulp of the material to be treated, water and the conditioning reagent. The conditioning reagent, as will be described in more detail, serves a dual function. It serves to float certain of the undesirable constituents of the ore, such as corundum, magnetite, hematite and mica. Likewise, it renders certain of the non-magnetic or only weakly magnetic undesirable constituents amenable to magnetic separation.

The reagent which I usually find preferable is oleic acid, although other of the fatty acids or their derivatives may be used under certain circumstances. When oleic acid is used, I find that not over two pounds of the acid per ton of ore is sufficient, and I prefer to add water to give a fifty percent pulp. While a fifty percent pulp is the most desirable when made of 20 mesh material, satisfactory results can be obtained with a more dilute or a thicker pulp. With more dilute pulp, a greater proportion of flotation reagent is required. With thicker pulp, agitation becomes difficult. The agitation and conditioning should preferably be done at a temperature between 60 and 70° F. It will be noted that fatty acid alone suffices for the flotation step, and the use of other reagents should be avoided inasmuch as they may serve to upset the flotation equilibrium (i. e., float some of the constituents that should not be floated, or interfere with the flotation of the desired constituents), and they may interfere with the subsequent magnetic separation step or contaminate the finished product for its intended use.

After the conditioning, this pulp is fed to a flotation machine. The froth from this flotation machine is passed to a cleaner cell. The cleaner cell recovers a portion of the material desired, which material is fed back to the flotation machine. The cleaner froth is discharged to waste. This discharge includes nearly all of the corundum, ninety percent of the magnetite and hematite, and practically all of the biotite mica.

The tailings from the primary flotation step are passed to a mechanical classifier of any standard kind which gives a sand product and a slime overflow product.

Reference has been made above to the fact that the conditioning agent, not only serves to float certain constituents of the ore, but also renders magnetic certain of the non-magnetic or only slightly magnetic constituents which it is desired to remove from the ore. This is an important feature of my invention. While I do not wish to be bound by any theory, it is my belief that the conditioning agent effects a coating of the non-magnetic or only slightly magnetic particles with finely divided magnetite, thereby rendering such particles amenable to magnetic separation. I have found that weakly magnetic material such, for instance, as biotite mica, which formerly required a high intensity separator can, by my process, now be separated by a low intensity separator; and that corundum, which formerly was non-magnetic, may be rendered sufficiently magnetic to be removed from the pulp by a high intensity separator. It should also be noted that this coating step facilitates generally magnetic separation in that it tends to increase the size of the particles and to remove the excessive fines.

The overflow from the mechanical classifier is passed to a wet magnetic separation machine, which may be either of the high or low intensity type. The material passing through this machine is approximately 200 mesh or smaller. This magnetic separation removes the corundum, magnetite, and other coated and undesirable materials which remain after the flotation step.

The magnetic material removed by wet magnetic separation is sent to waste. The non-magnetic material which has passed through the magnetic separator is sent to a thickener. In operating the thickener no flocculating agents are used and the thickener is operated with the pulp having a high enough specific gravity to overflow organic matter, including the flotation reagent, and any finely divided hematite and other objectionable discoloring matter. The thickener overflow is discharged to waste.

The thickened product is agitated in a combined agitator and storage tank. During the storage a flocculent, preferably alum, is added in order to insure the proper filtration, of the fines.

The optimum amount of alum to be added varies with certain factors, such as fineness of grind, pulp temperature and the nature of the material to be flocculated. In the case of aluminum sulfate alum, the amount added varies between 0.2 pound per ton of solids to 2.0 pounds per ton of solids, depending upon the above mentioned factors.

From an operating standpoint, the thickener underflow cannot be successfully filtered without the addition of such flocculating agents. While any number of flocculating agents may be used, such as lime, sulphuric acid, zinc sulfate, and other electrolytes, these reagents would not be satisfactory in the ceramic art because of the objectionable material they would add to the products. The presence of alum, on the contrary, is actually an improvement in the finished product.

The flocculated fines are then taken from the storage and filtered in order to produce a filter cake which may be stored wet or dried and then sold as the trade may demand.

Another branch of my process, starting from the classifying step is the final purification of the sand-size particles coming from the classifier. This de-watered sand has been thoroughly freed from slimes, not only by the washing of the classifier but also by the previous flotation step. Consequently the dry magnetic separation which is to follow is made more efficient, the sand particles being free from any slime.

The sand from the classifier is dried in any suitable dryer, a rotary dryer lined with silica brick and fired with gas or coke being preferred. How-

ever, any suitable dryer that will not contaminate the material is satisfactory.

This dried sand is stored as required, and then passed to the dry magnetic separators, preferably of the high intensity type. These separators are able to make a quite complete removal of magnetic material. The purified non-magnetic material is then ready for storage as a sand-size finished product.

The magnetic material removed by the dry magnetic separator is passed through a screen, preferably of 40 mesh, but any size mesh from 35 to 65 could be used. The oversize screened out is passed through a pebble mill. The material so ground is fed back onto the screen. The undersize from this screen is transferred to a storage tank.

It is possible to add the ground rejects from the dry magnetic separator to the conditioner at the same time that the raw material is being conditioned. However, due to the usually smaller amount of desirable material in the ground rejects, it is preferable to add them to the conditioner in a separate run. That is, during a part of the operation period, the flow of raw material to the agitator and conditioner would be stopped and the ground rejects would be treated alone and sent through the steps including and subsequent to the conditioning step. It would, of course, be possible as an alternative procedure to treat the ground rejects in a separate series of units the same as already described, but it is an economy to use the same equipment.

In the re-running of these magnetic rejects, it will, of course, be appreciated that provision must be made in some cases for relieving the system of the dry magnetic particles in order to avoid overloading the system with successive accumulations of magnetic particles. Normally, the dry magnetic rejects from the re-run would be returned to the circuit and any excess of magnetic particles would be removed by the flotation step. Where the magnetic materials are found to be building up in the circuit to the extent of contaminating the finished material, the following modification may be carried out. While not shown in the drawing, by this modification dry magnetic rejects secured during one of the reruns may be removed immediately from the system without further treatment.

While it is usually preferable to include the flotation step in the process, as above described, an alternative treatment would be one in which the flotation step is omitted, as indicated by the dotted lines extending from the conditioning step to the mechanical classifying step. Even in such event, however, the pulp should be conditioned with the fatty acid reagent in order to effect a coating of the non-magnetic and weakly magnetic particles with magnetite. So the reagent should be used regardless of whether flotation is or is not included in the process.

Under certain conditions, and particularly where there is an excess of non-magnetic undesirable constituents or where there is a deficiency in the amount of magnetite present, it might be advisable to add to the pulp a supply of magnetite particles in order to insure a sufficient coating of the other undesirable constituents to thus render such constituents amenable to separation by a magnetic separator.

As another method of supplying fine magnetic material to an ore that would otherwise be deficient in it, my process can be modified to include a step of wet grinding the ore in a ball mill, using highly magnetic balls and liners. In this step, the grinding is done in the presence of the organic flotation reagent. This wet grinding step may take the place of one or more of the crushing steps in the process selected for illustration and previously described. Consequently in this ball mill process, the addition of further flotation reagent during the agitation-conditioning step may become optional.

As illustrative of the superior results produced by my product, I have included the following table of figures showing the recoveries of utilizable feldspathic material from nepheline syenite, by my process as compared with the former practice:

Material	Per cent of crude rock	Per cent of iron (as Fe_2O_3)
Crude rock	100.0	1.5000
Sand-size nepheline syenite produced by my process	80.50	0.029
Slime-size nepheline syenite produced by my process	14.25	0.080
Total recovery of finished product by my process	94.75	
Sand-size nepheline syenite produced by standard practice	70.0	0.0800
Slime-size nepheline syenite produced by standard practice	21.50	1.25
Total recovery of usable product by standard practice (slime-size unusable because too high in Fe_2O_3 content)	70.00	

It will be seen from the foregoing that I have invented a particularly efficacious method of beneficiating ores, which will give a superior product and is more economical to practice than processes heretofore available. Although capable of wide application, my process is particularly desirable in the treatment of ores containing iron-bearing particles which it is desired to have removed from the finished product. It will also be noted that my process removes certain iron-free undesirable constituents, such as iron-free corundum.

While the flotation step in my process is not essential, I find it preferable inasmuch as it serves to remove the load on the magnetic separators and also serves to better condition such ore as is sent to the magnetic separators. It will also be noted in this connection that there is a particular cooperative relationship between the flotation and magnetic separation steps in that a single reagent and conditioning step may be used for both the flotation and magnetic separation. In connection with the reagent it will be noted that a single, and relatively inexpensive, reagent not only suffices, but is actually preferable to avoid using additive reagents.

It is also to be noted that my process contemplates means for maintaining the finished product relatively free of conditioning reagent as well as other undesirable organic material, and in this connection finds particular application in the treatment of ores for use in the ceramic industry.

An advantage inherent in the thickening step is the fact that the removed slime protects the health of the workmen, prevents loss in handling, and removes a major part of any free conditioning reagent and other undesirable organic material.

In general, my process produces a superior product, and achieves this result with little waste of the raw material and in such a way that a minimum of equipment is necessary.

While I have shown, for the purposes of illustration, a specific embodiment of my invention, the purification of nepheline syenite, it will be

understood that other ores can be purified by my process. Also it will be understood that various changes may be made in the treatments, reagent, steps, forms, and proportions without exceeding the scope or spirit of my invention, and that I am to be limited only by the scope of my invention and the appended claims.

I claim:

1. In a process of purifying feldspathic and similar minerals containing magnetic constituents, the steps of comminuting a raw material to particles having a size of minus 20 mesh, agitating said particles with a substantially equal weight of water and an organic compound containing a fatty acid, said organic compound being in the proportion of two pounds per ton of said particles, said agitation taking place in a range of temperature from 60° to 70° F., subjecting the conditioned pulp to a flotation treatment to remove a froth of objectionable materials, discarding the rejected froth, classifying the flotation tailings into slimes and sands, and separately subjecting the slimes and sands to a magnetic separation step.

2. In a process of beneficiating feldspathic and similar ores containing magnetite and other undesirable constituents, the steps of comminuting the ore, agitating and conditioning the comminuted ore with water and a fatty acid compound to form an approximately 50% pulp, classifying said pulp into slimes and sands, treating the sands to a dry magnetic separation step, treating the slimes to a wet magnetic step, thickening the non-magnetic products of the wet magnetic step, and filtering said non-magnetic material.

3. In a process for beneficiating feldspathic and similar ores containing magnetite and other undesirable constituents, the steps of comminuting the ore, agitating and conditioning the ore with water and a fatty acid reagent to form an approximately 50% pulp, said reagent being used at the rate of two pounds per ton of ore, classifying the conditioned ore to form a sand product and slimes, subjecting the sand to a dry magnetic separation step, subjecting the slimes to a wet magnetic separation step, thickening the non-magnetic product of the wet magnetic step, adding a flocculating agent to such thickened material, and then filtering the material.

4. In a process of beneficiating feldspathic ores containing magnetite and other undesirable constituents, the steps of conditioning the comminuted ore with water and a fatty acid reagent to form an approximately 50% pulp, classifying the conditioned pulp to form a sand product and slimes, subjecting the slimes to a wet magnetic step, drying the sand's product, subjecting such dried product to a dry magnetic separation, reconditioning the magnetic product of the dry magnetic separation step, and again subjecting the same to a magnetic separation step.

5. In a process of beneficiating feldspathic ores containing magnetite and other undesirable constituents, the steps of conditioning the comminuted ore with water and a fatty acid reagent to form an approximately 50% pulp, such reagent being added at the rate of two pounds per ton of ore, classifying the conditioned pulp into a sand product and slimes, drying the sand product, subjecting such dried product to a dry magnetic separation step, reconditioning the magnetic product and subjecting it to magnetic separation, subjecting the slimes from the classifying step to a wet magnetic separation step, thickening the non-magnetic material therefrom, adding a flocculating agent to said thickened product, and filtering the said product.

6. In a process of beneficiating a feldspathic ore, the steps of thickening a pulp of said ore in the absence of a flocculating agent, adding alum to said thickened pulp at the rate of 0.2 to 2.0 pounds of alum per ton of ore to effect flocculation of the particles, and filtering said flocculated material to form a de-watered product suitable for shipment.

7. In a process of beneficiating feldspathic ores containing corundum and other undesirable materials which are weakly magnetic, the steps of adding water to the ore, wet grinding the ore in ball mills having strongly magnetic grinding media and liners, whereby finely divided particles from said magnetic grinding media and liners will be added to the ground mixture, conditioning the ore to selectively coat the said undesirable particles with said magnetic particles, and subjecting such conditioned ore to a magnetic separation treatment.

8. In the treatment of feldspathic rock materials containing magnetic and other impurities, the method which comprises grinding the feldspathic material, treating the ground material alone with a conditioning agent consisting of oleic acid to render the magnetic and other impurities more completely separable, and thereafter subjecting the conditioned material to magnetic concentration to remove the magnetic and other impurities.

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