This invention relates to the recovery of ores by the froth flotation method and is particularly directed to the recovery of sodium tetraborate from borate ores by the flotation of the sodium tetraborate from its gangue.

Flotation methods have heretofore been applied with success in the separation of minerals from each other in cases where such minerals are all insoluble in water or the separation of minerals in cases in which all the minerals are soluble in water, but the present invention is directed to a simple and efficient method of froth flotation as applied to an ore in which the values soluble in water are floated from the insoluble constituents.

Further, it may be said that with regard to the flotation of one mineral as compared with another when using fatty acid or soaps it has been considered by those skilled in the art of flotation of non-metallic minerals that the presence of an element of the heavy metal group or of the alkaline earth group, is usually indicative of floatability of the mineral containing it. In a like manner, a mineral mixture, such as is represented by what is known as the Baker ore, containing sodium tetraborate and certain water-insoluble minerals that have an alkali element in their composition, it would be expected that the water-insoluble portion would float more readily than the water-soluble portion, i.e., the sodium tetraborate. But, as carried out in the present process, it has been discovered that the water-insoluble constituents of the ore do not float so readily as sodium tetraborate does, especially after suitable activation which acts selectively on the borate minerals. In the Baker ore there is a large percentage of sodium tetraborate amounting to approximately eighty (80%) percent or over, the remainder of the ore consisting largely of an insoluble gangue containing Mg, Fe, and Al silicates.

For attaining the results desired, the process of the present invention may be carried out for example as follows, it being understood, however, that the conditions of working may be varied within wide limits.

The first step performed, is that of grinding. This is done in any well known manner and is performed primarily for two purposes. First, to reduce the size of individual ore particles to the floatable size; and second, to liberate the several minerals that are intergrown in the ore so as to be able to more readily separate them.

In the preparation of the Baker ore, it was found that grinding to about fifty mesh was necessary to reduce the ore to the floatable size and liberate the several minerals, as above noted.

In conducting the flotation of an ore such as the Baker ore the process is carried out in aqueous pulp; therefore, in continuous operation the water used to pulp the ore will soon be saturated with sodium tetraborate at the temperature that obtains during flotation. Thus, flotation is conducted on a pulp consisting of two phases: the solid phase which is made up of the water soluble minerals, alkali borates, and of the insoluble minerals; and the aqueous phase, which consists of saturated borate solution. The water soluble minerals remain undissolved in the saturated borate solution.

In conducting the process, the pulp of the ore with the saturated borate solution is prepared ahead of flotation by mixing the ore with the returned saturated borate solution, which is re-cycled by suitable means from the tailings. After the ore is ground, it is suitably diluted with saturated solution, as an example, ten parts of saturated borax solution to one part of solids by weight, and heated somewhat above the temperature that will obtain during the flotation, as an example 3° C. to 7° C. above the flotation temperature. This preheating step is desirable in order to facilitate differential flotation of the borate minerals from the insoluble gangue minerals. The pulp so preheated is forcibly cooled and then floated; or else floated directly after the preheating treatment, which causes cooling to take place naturally inasmuch as the ore is preheated above the temperature that obtains during flotation.

It has been found that if a constant temperature be maintained before and during flotation, the differential separation of sodium tetraborate from the water insoluble gangue is not as marked as when the pulp is preheated previously to flotation in which case the sodium tetraborate crystals are activated more readily and float more easily than otherwise, thus permitting a differential separation of the sodium tetraborate from the water insoluble gangue.

Reagents that are added previous to and during flotation comprise the following: an activator of the alkaline earth group, such as barium chloride, or of the heavy metal group, such as copper sulfate; a promoter such as a fatty acid or a 50 derivative of a fatty acid; if the promoter has frothing properties, such reagent alone may fulfill the functions of a promoter and frother, otherwise a separate frother, such as pine oil or cresylic acid, may be used.
It will be noted from the above description of this method that the activation of the water soluble borate minerals is effected by means of two agencies, to wit, preheating of the pulp previous to flotation and the use of a chemical such as one of the alkaline earth group or of the heavy metal group. Both these agencies are selective in that they enhance the flotation of water soluble borate minerals but do not show any marked tendency towards floating the insoluble gangue minerals, thus permitting a differential separation of the two constituents in the ore.

It is believed that the preheating treatment results in removing the surface film from the sodium tetraborate crystals which is inert (or rendered inert with time) to the activator and promoter reagents. Also, it is believed that after the dissolution of this inert coating the effect of partial cooling results in the formation of a fresh film of mineral on the surface of the particles, which aids in the selective action of the reagents towards the borate mineral surfaces. As an example 100 grams of Baker ore ground to all minus fifty mesh was pulped with 1000 cc. of sodium tetraborate solution saturated at 29° C. and the pulp heated to 36° C. The heated pulp was then charged into a laboratory flotation machine and agitated with external cooling on the machine until the pulp temperature again reached 29° C. Barium chloride and oleic acid were added and the sodium tetraborate minerals floated for 23.5 minutes. The rougher concentrate thus produced was suitably cleaned at constant temperature in the same machine.

Test data

<table>
<thead>
<tr>
<th>Product</th>
<th>Weight percent</th>
<th>Sodium borate (by difference)</th>
<th>Water insoluble percent</th>
<th>Sodium borate insoluble percent</th>
<th>Distribution water insoluble percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heads</td>
<td>100.0</td>
<td>88.00</td>
<td>10.00</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Concentrate</td>
<td>65.3</td>
<td>95.18</td>
<td>4.82</td>
<td>73.1</td>
<td>21.0</td>
</tr>
<tr>
<td>Tailing</td>
<td>25.1</td>
<td>61.10</td>
<td>18.84</td>
<td>12.9</td>
<td>57.2</td>
</tr>
</tbody>
</table>

The above test data is illustrative of the flotation of the borate mineral from the gangue and shows that the water insoluble content of the concentrate is 4.82% as against 15.00% in the ore and that the recovery of the borate minerals as concentrate was 73.1%.

We claim as our invention:
1. The process of treating borate ores containing sodium tetraborate and minerals non-soluble in water which consists in mixing the ore in a finely divided condition with a saturated solution of sodium tetraborate and then subjecting the pulp to a froth flotation treatment in the presence of a reagent having a preferential affinity for the sodium tetraborate, said reagent consisting of barium chloride and a fatty acid.
2. The process of treating ores containing borates and minerals non-soluble in water, which consists in mixing the ore in a finely divided condition with a saturated solution of the borates and then subjecting the pulp to a froth flotation treatment in the presence of a reagent having a preferential affinity for the borates, said reagent consisting of barium chloride, and a fatty acid.
3. The process of treating borate ores which consists in forming a saturated solution of borates, heating the solution above the flotation temperature, adding finely divided borate ore to the heated solution, then subjecting the pulp so formed to froth flotation action in the presence of an activator reagent having an affinity for the borates, whereby the unsoluble soluble material is floated off the mixture.
4. The process of treating borate ores which consists in forming a saturated solution of sodium tetraborate, heating said solution to a temperature above the flotation temperature, mixing said heated solution with finely divided borate ore, permitting the pulp so formed to partially cool, and then subjecting said pulp to a froth flotation action.
5. The process of treating ores containing minerals readily soluble in water of the type having increased solubility with increased temperature of their solution which consists in forming a saturated solution of such mineral, adding to said saturated solution additional finely divided particles of the mineral, heating the pulp so formed, partially cooling the pulp and then subjecting the pulp to froth flotation treatment.

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