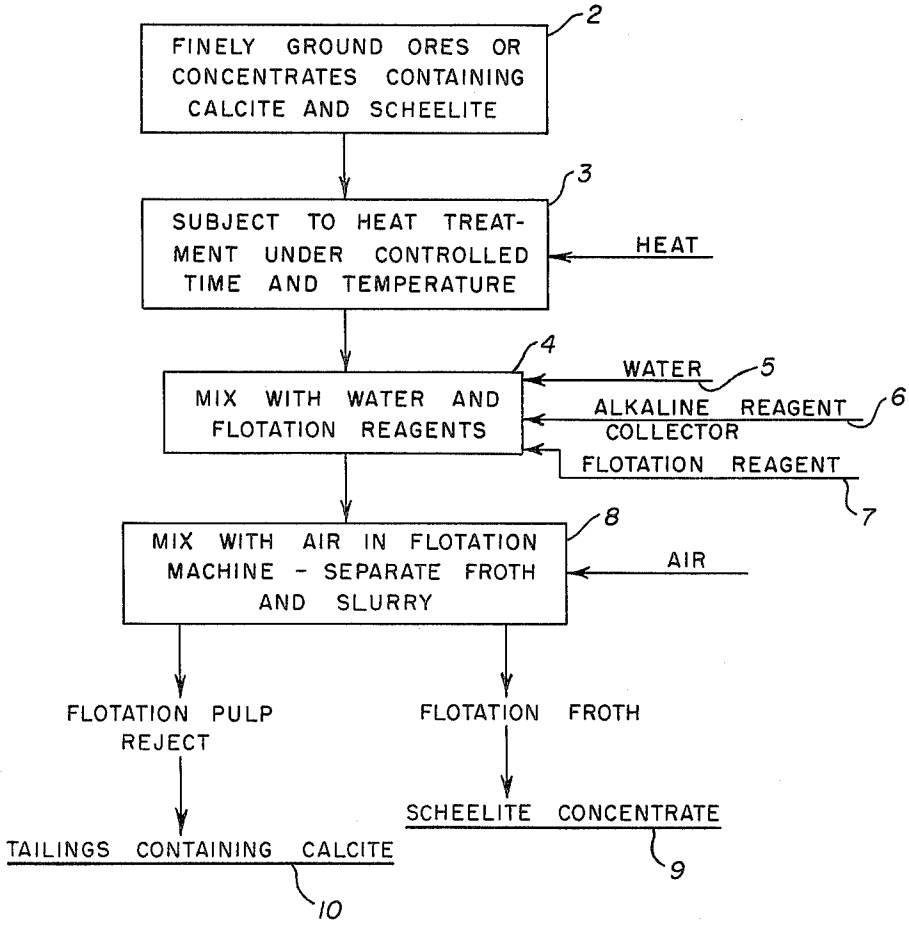
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FLOTATION CONCENTRATION OF NON-METALLIC MINERALS CONTAINING CALCITE

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FLOTATION CONCENTRATION OF NON-METALLIC MINERALS CONTAINING CALCITE

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This invention relates to the concentration of ores by flotation, and more particularly to a differential or selective flotation of ores, or other products of concentration, having calcite as a gangue constituent.

In the concentration of ores by flotation for the recovery of so-called "non-metallic minerals" such as scheelite, wolframite, powellite, apatite, fluorite, rhodochrosite, or the like, it is the custom of the industry to employ collector reagents such as soaps, fatty acids, amines or similar compounds which selectively film or react upon the surfaces of these minerals and promote their separation from worthless gangue minerals such as silica by selective flotation. A problem exists in this field when the ores contain substantial amounts of calcite, or calcium carbonate, because calcite in the presence of such reagents tends to float and also is recovered in the concentrate with the valuable minerals. This decreases the grade or mineral value of the concentrate and often prevents the making of a marketable product without further expensive upgrading or purification steps.

A typical example is found in the recovery of the tungsten mineral scheelite, or calcium tungstate, from its ores, in a treatment in which it is desired to produce a mineral concentrate containing at least 60 percent WO_3 as a saleable product. As the usual ores contain from .5 to 2 percent WO_3 and often from 3 to 25 percent calcite, flotation by the use of fatty acids is employed to concentrate the scheelite mineral. However, the usual concentrate will contain from 10 to 20 percent WO_3 due to the inclusion of calcite which also is concentrated. This low grade concentrate must be subjected to further mechanical or chemical processing to remove the calcite, such as leaching with hydrochloric acid, pressure digestion with sodium carbonate or other expensive steps to meet grade standards.

It is an object of my invention to provide a simple, economical and efficient process for concentrating non-metallic ores containing calcite in a flotation separation in which the calcite is depressed and does not tend to collect in the concentrate.

Another object of my invention is to provide a surface alteration of the calcite content of non-metallic ores as a preparation for flotation concentration which renders the calcite substantially inert to the action of the collector reagent of the flotation treatment.

A further object of this invention is to provide a simple, efficient and economical process for obtaining a high grade scheelite concentrate in a froth flotation treatment of scheelite ores.

Still another object of my invention is to provide an improved method of flotation separation of calcite from associated minerals, whether present in ores, flotation concentrates, middlings, or products of other types of concentration by a surface alteration of the calcite without impairing the other mineral surfaces so as to depress the calcite in the flotation separation stage.

My invention is based upon the discovery that the flotation of calcite by non-metallic flotation collector reagents can be inhibited by subjecting the ore or concentrates to a carefully controlled roasting step under proper time and temperature conditions whereby through surface alteration a non-reacting film is formed on the calcite surface which prevents its flotation, while other mineral surfaces such as scheelite are unaffected. By exercising proper control of this step, in combination with

suitable control of conditioning, reagent addition and flotation, the calcite content of the tungsten-bearing material can be selectively rejected and a tungsten concentrate of a grade in excess of 60 percent can be produced with a high recovery of the tungsten content of the ore.

The practice of my invention will be described with reference to the accompanying flow sheet drawing FIG. 1, which depicts a typical circuiting arrangement. In such a circuit, a non-metallic ore containing calcite, such as scheelite, wolframite, powellite, apatite, fluoride or rhodochrosite is delivered from a suitable source of supply, such as an ore bin **2** to a heating stage **3**. In preferred practice, the heating stage will involve two steps, namely, drying or moisture removal followed by controlled roasting. Whenever the feed material is already dry, the moisture removal step is omitted.

The roasting preferably is performed in a hearth furnace provided with mechanical rabbles and subjected to controlled indirect heat. The type and purpose of the roasting controls will be set forth in detail in a following portion of the description.

The hot calcine from roasting is delivered to a mixing stage **4** which may include sizing, pulping, conditioning and reagent introduction. As shown in the flow sheet, water is introduced at **5**, an alkaline reagent at **6** and the flotation collector reagent at **7**. The details of the mixing and conditioning practices and controls will be explained in a following portion of the description.

The conditioned pulp discharging from stage **4** is delivered to one or a plurality of flotation machines or cells at stage **8** and subjected to agitation and aeration for collection of a valuable mineral as a froth concentrate. Preferably a rougher-cleaner circuit is employed, the features of which will be described hereinafter. In such concentration, the flotation froth, such as scheelite concentrate, is removed at **9** as a final product of such separation while the tailings containing the calcite are discharged at **10** as a reject material of the treatment.

In carrying out my invention in accordance with approved practice as in the above described circuit, the ores, concentrates or other products of concentration are subjected to four steps or treatments as follows:

(1) DRYING

The material, in finely divided condition, is transported to a drier to expel moisture to a point not exceeding 1% to 1½% water. The air temperature of the drier should not exceed 550° F., and the temperature of the drier discharge should be in the range of 212° F. to 230° F., although greater temperatures may sometimes be permitted. No open flame should be allowed in the drier because of the probability of decomposing calcite by excess temperatures from radiant heat. If the material is already dry, this step can be omitted.

(2) HEAT TREATMENT INCLUDING SURFACE ALTERATION

The dry material is fed at a uniform rate to a roasting furnace (preferably a hearth furnace) provided with mechanical rabbles and subjected to controlled, indirect heat; for open flames result in excessive temperatures from radiant heat. Temperatures must be held within definite limits; for the furnace atmosphere above the bed, the range may be from 580° F. to 930° F., depending upon the product, residence time in the furnace, and thickness of bed; for the hearth discharge, herein called calcine, its temperature may range from 580° F. to 850° F., depending upon the factors enumerated above.

The maximum air temperature limit is set at 930° F., because the decomposition temperature of calcite is 932° F. Very fine calcite particles begin to decompose somewhat below this temperature. We find that if the furnace

is heated with an open flame above the ore bed, decomposition of part of the calcite occurs (especially if dusting) giving abnormally high pulp alkalinity to the subsequent flotation operation; and destroying, partially or wholly, the differential flotation separation.

Residence time of the material in the hearth may vary from 10 minutes to 3 hours, according to the moisture content, fineness, and temperature. It may be said here that the drying step may be dispensed with and the hearth used for drying as well as heat treatment; but greatly increased hearth area is required for such a treatment and the heat treatment is difficult to control and less efficient.

It is most important that the furance feed enter at a uniform rate and with a maximum moisture content of 1% to 1½%; for, when the furnace feed is damp, it is almost impossible to maintain uniform feed rate, and a part of the hearth area must be used to remove excess moisture, thus reducing normal residence time and upsetting the heat balance.

The alkalinity of the hot calcine upon discharging may range from pH-7.0 to pH-9.2, more or less. If the pH of the calcine is less than 8.0, presence of an acid constituent is indicated, possibly arising from the oxidation of sulphides. If the alkalinity of the calcine be substantially greater than 9.2, decomposition of the calcite has occurred, and subsequent flotation products will be progressively and adversely effected with the incerasing rise of alkalinity above pH-9.2.

Should temperatures for discharging calcine be substantially less tahn 580° F., and those of the furnace atmosphere be substantially less than 600° F., the calcite is not inhibited from floating; and in the case of treatment of a flotation product, the soap, or fatty acid film on particles is not destroyed, calcite mineral surfaces are not sufficiently altered, and no selective flotation separation of scheelite from calcite occurs. Should the temperatures for discharging calcine substantially exceed 930° F., then same decomposition of calcite particles takes place, giving abnormally great alkalinities (in excess of pH-10.5) to pulps in subsequent flotation operation; which adversely affects flotation separations of scheelite and calcite.

(3) CONDITIONING

The hot calcine from the hearth is discharged into a mixer, or conditioning tank, with water supplied, to form a pulp having 20% to 50% solids, more or less. Under normal conditions, a mixture of hot calcine and cold water would assume a temperature of approximately 110° F. to 130° F. Steam may be added to bring pulp temperature to 170° F. to 195° F., more or less, depending upon the product. Reagents are added to the pulp in the conditioning tank; soda ash to maintain pulp alkalinity at the desired point; fatty acid sulphonate or similar product, for collection and flotation of tungsten minerals, and quebracho or a similar reagent as a retarder for gangue constituents.

Pulp densities in the conditioner are not too important and may be held between 20% and 50% solids, more or less, except that greater percentages of solids require less additional heat if such be employed.

The period of contact between reagents and pulp in the conditioner varies with the pulp temperature and tonnage rate. If the temperature be near or under the boiling point (say 190° F. to 200° F.) 5 minutes is sufficient; if the pulp temperature is about 130° F. to 150° F., a 10-minute period is required; and if for any reason the temperature drops to 70° F., 15 to 20 minutes of contact is needed. In the practice of my invention, I prefer to hold the pulp temperature at the conditioner stage between 170° F. and 190° F., which, of course, requires additional steam introduction.

Preferred reagents added to the pulp in the conditioner are: soda ash in quantities sufficient to hold the flotation feed at an alkalinity of not more than 10, and the amount may vary from 5 to 12 pounds, or more, per ton of calcine; quebracho in the amount of approximately 1 pound per ton of calcine is employed as a retardant; a combined frother and collector may be a fatty acid sulphonate or an allied product introduced at the rate of from 0.4 to 0.7 pound per ton of calcine, more or less. Other combinations of usual reagent combinations may be employed at the desire of the operator.

(4) FLOTATION

The conditioner discharge is pumped to flotation cells, diluting the pulp en route to 10% or 30% solids, more or less; which also controls pulp temperatures. In the preferred method of operation, the flotation rougher pulps are held within a temperature range of 90° F. to 110° F., although the average temperatures may vary somewhat. Usually, the rougher concentrates are cleaned twice; the second cleaner tailings returning to the first cleaner cells; and the first cleaner tailings being sent to the rougher cells. Cleaner cell pulps may range from 70° F. to 90° F., more or less. The final froth concentrate from cleaner cells contains the tungsten minerals, or other floatable minerals whose recoveries are sought, while the calcite, in large part, is rejected in the flotation tailings.

To summarize, my process comprises the heat treatment of ores containing substantial quantities of calcite within certain temperature ranges and for varying time periods according to the temperatures; conditioning the hot calcine with reagents; and subjecting the so-treated plup to a flotation operation whereby tungsten minerals, or other floatable minerals are recovered in the froth and the calcite, in large part, is rejected to the tailings.

If the period of heat treatment be too short under the indicated temperature ranges, i.e., substantially less than 10 minutes for a dry hearth feed, the calcite mineral surfaces will remain unaltered; and if products from an earlier flotation separation are being treated, the soap or fatty acid films on mineral particles are not destroyed; and no flotation separation of tungsten minerals and calcite occurs in the subsequent flotation step. Conversely, if the period of heat treatment be too great, particularly if air temperature above the hearth is substantially above 930° F., then flotation concentrate grades and recoveries of tungsten minerals are adversely affected.

The most important factor in the rejection of calcite is the heat treatment given to the ore or product in a hearth furnace, prior to flotation. I have found that a cloudy, dull film, or coating is formed on calcite surfaces during the heat treatment; but scheelite mineral surfaces are unaffected. I believe the coating on the surface of calcite to be $CaOCO_3$, although I do not wish to be bound by this hypothesis. Also, it is believed that the calcite coatings undergo further transformation in the mixer, becoming hydrated calcium oxycarbonate

$$(2CaO.OH)CO_3$$

In the application of my invention to low grade ores, particularly tungsten-bearing ores, it is usually advantageous to first separate the tungsten mineral by conventional soap flotation methods in a low grade concentrate with the objective of recovery of the largest part of the tungsten, in excess of 90 percent, in this preliminary concentrate, and then applying the present invention to the low grade material to produce a high recovery in a high grade product. In this manner, the initial flotation operation can be conducted to effect the maximum recovery of tungsten and reject a tailing very low in mineral values, and the application of the invention can then be applied to a small tonnage of enriched material with maximum efficiency and economy. When the conventional methods of recovery are used in the treatment of low grade ores and a high grade product is desired, this can only be done at the sacrifice of recovery.

Milling test

The working of the invention is illustrated in the following large scale milling tests:

One hundred tons of tungsten-bearing ore containing scheelite and assaying .95 percent WO_3, .10 percent Mo and 10 percent $CaCO_3$, were ground to −60 mesh and concentrated by soap flotation using 6 pounds of Na_2CO_3, .5 pound of fatty acid compound and 1 pound of quebracho per ton of ore. The pH of the pulp was 9 and the pulp density was 30 percent solids. 6.1 tons, dry weight of flotation concentrates were recovered containing 11 percent WO_3 and 1.0 percent Mo or approximately 95.9 percent of the tungsten contained in the ore. The tailings contained .03% WO_3 of the head ore. The low grade concentrates contained 62 percent $CaCO_3$.

The low grade concentrate was dried in a rotary furnace drier with gas temperatures at 400° to reduce the moisture content to 1 percent or less and then was charged to an indirect fired single hearth furnace where it was given 15 minutes of contact with furnace air at 840° F. and quenched in water at a temperature of 190°. The pH of the calcine in water was 8.1. Flotation reagents were added in the conditioner stage to the amount of 0.4 pound of fatty acid, 1 pound of quebracho and 5 pounds of soda ash per ton, or approximately the same reagents used in the initial float. The pulp was mixed for 5 minutes, pumped to flotation cells and subjected to two stages of flotation with temperatures adjusted to 94° F. The final concentrate analyzed 63.4% WO_3 and 13.4% $CaCO_3$, with a recovery of 81 percent of the tungsten contained in the crude ore. The rougher tailing from the flotation contained 1.5 percent WO_3 and was returned to the next crude or charge where an additional recovery was effected. In a cyclic mill operation in this manner, 91 percent of all the tungsten contained in the crude ore was recovered in a final product containing in excess of 63 percent WO_3.

Time and temperature tests

To further illustrate the application of the invention and the effect of temperature and time on the elimination of calcite, three portions of low grade tungsten concentrates were treated by roasting at different times and temperatures and subjected to the same sequence of conditioning and flotation as in the large scale mill test.

In Test No. 1, using 500 grams, the low grade concentrate containing 7.81% WO_3 was subjected to heat treatment for 3 hours at a furnace air temperature of 580° F. and conditioned and floated. 97 percent of the tungsten contained in the low grade concentrate was recovered in a final concentrate containing 47.17% WO_3.

In Test No. 2, a low grade concentrate containing 12.9% WO_3 and 66.7% $CaCO_3$ was given a heat treatment of 30 minutes with furnace air temperatures of 700° F., and subjected to the preferred conditioning and flotation procedure. Only 61 percent of the tungsten in the low grade material was recovered in a product containing 55.2 percent WO_3.

In Test No. 3, a low grade concentrate containing 12.27% WO_3 was given a heat treatment of 10 minutes at a gas temperature of 840° F. and subjected to the same flotation procedure as Test No. 2. 87.5 percent of the tungsten contained in the feed material was recovered in a concentrate containing 60.34% WO_3.

The foregoing tests show the importance of temperature in the heat treatment step. While some rejection of calcite is effected by prolonged temperature contact below 600° F., the objective of a product above 60% WO_3 was not obtained in No. 1. The second test shows no finished product at 700° F. and a low recovery. The third test shows a desired concentration and reasonable recovery.

Conditioning contact time tests

While the temperature and time of heat treatment are essential in the application of the invention, the time of contact between the hot calcine and reagents in the conditioner is also important in obtaining the best results. This is shown in a series of three tests with a range of conditioner temperatures from cold to hot with varying time periods.

The calcines used in these illustrative tests resulted from the heat treatment of low grade flotation concentrates at a temperature of 840° F. and 10 minutes of hearth time with a pH of hot calcines of 8.1. The flotation reagents added consisted of 6 pounds of soda ash, 1 lb. of quebracho and .5 lbs. of fatty acid sulphonate per ton of calcine. 500 gram charges were used in each test.

	Test 1	Test 2	Test 3
Tungsten Content-Calcine, Percent	15.71	15.62	16.10
$CaCO_3$ Content, Calcine, Percent	62.60	63.3	61.90
Conditioning Time, Minutes	15	10	5
Temperature of Pulp, Degrees F	68	140	190
Final Concentrate, Percent WO_3	62.09	58.67	63.10
Final Concentrate, Percent $CaCO_3$	75.0	19.0	13.4
Recovery of WO_3 in Concentrate, Percent	66.8	76.2	87.8
Tailings from Tests, Percent WO_3	3.83	2.35	1.50

These tests indicate the range of effectiveness in heat treatment and conditioning temperatures and enable the operator to select the proper operating procedure to effect the intent of the invention.

In this specification, the expression "nonmetallic minerals containing calcite" is intended to apply to ores, flotation concentrates, middlings or similar products of other types of concentration containing such minerals and associated calcite, including scheelite, wolframite, powellite, apatite, fluorite and rhodochrosite ores and products derived therefrom. The valuable constituent of all such minerals is rendered floatable by the action of the fatty acid and amine collector reagents previously described and collects in the froth while the calcite treated in accordance with this invention does not respond to such reagents and remains depressed during the flotation separation. These differences in floatability produce a high grade concentrate, and all such materials are amenable to the practices of this invention.

"Surface alteration" as used in this specification is intended to designate a physical change in the surfaces of the calcite particles rather than a chemical change by which the surface or exterior of the particle may assume new properties or characteristics due to the application of the film. Surface alteration as utilized in the practice of this invention produces a more or less permanent change which cannot be modified by wetting, aeration or abrasion resulting from the movement of such material through the plant equipment.

I claim:

1. A process for recovering a high grade concentrate in the treatment of a non-metallic mineral containing calcite said mineral being selected from the group consisting of scheelite, wolframite, powellite, apatite, fluorite and rhodochrosite, which comprises subjecting a pulp of such a mineral in a flotation size range to a froth flotation treatment in the presence of a collector reagent for said mineral so as to collect most of said mineral and some of the calcite as a bulk concentrate product, drying said concentrate product, heating the dry concentrate in a flame-free atmosphere to temperatures above 500° F. but not exceeding 930° F. during which the calcite surfaces are altered without calcite decomposition and the mineral surfaces remain unaltered so as to render the calcite inert to collector reagents for the mineral, pulping the hot concentrate with an aqueous solution, conditioning the aqueous pulp for flotation by introducing a collector reagent for the mineral, an alkaline reagent and a retarder for mixing with the pulp, and subjecting the conditioned pulp to a froth flotation treatment so

as to concentrate the mineral in a froth substantially free of calcite contaminants.

2. A process for recovering a high grade concentrate in the treatment of a non-metallic mineral containing calcite said mineral being selected from the group consisting of scheelite, walframite, powellite, apatite, fluorite and rhodochrosite, which comprises subjecting a pulp of such a mineral in a flotation size range to a froth flotation treatment in the presence of a collector reagent for said mineral so as to collect most of said mineral and some of the calcite as a bulk concentrate product, drying said concentrate product to a moisture content not exceeding 2%, heating the dry concentrate in a flame-free atmosphere to temperatures above 500° F. but not exceeding 930° F. during which the calcite surfaces are altered without calcite decomposition and the mineral surfaces remain unaltered so as to render the calcite inert to collector reagents for the mineral, pulping the hot concentrate with an aqueous solution, conditioning for flotation by introducing a collector reagent for the mineral, an alkaline reagent and a retarder for mixing with the pulp, and subjecting the conditioned pulp to a froth flotation treatment so as to concentrate the mineral in a froth substantially free of calcite contaminants.

3. A process for the recovery of a high grade concentrate in the treatment of scheelite which comprises drying scheelite in a flotation size range to a moisture limit of from 1%–1½%, roasting the dry scheelite in a hearth furnace without an open flame at temperatures above 500° F. but not exceeding 930° F. during which no calcite decomposition occurs and scheelite surfaces remain unaltered whereby the calcite surfaces are glazed and rendered inert to scheelite collector reagents, pulping the hot concentrate with an aqueous solution while maintaining pulp temperatures within the range of 60° F. to 190° F., conditioning said pulp for a flotation separation by introducing a scheelite collector, an alkaline reagent, and a retarder for mixing with said pulp, and subjecting the conditioned pulp to a selective froth flotation treatment so as to concentrate the scheelite in a froth substantially free of calcite contaminants.

4. A process for the recovery of a high grade concentrate in the treatment of scheelite, which comprises roasting dry scheelite in a flotation size range in a flame-free furnace at temperatures above 500° F. but not exceeding 930° F. during which no calcite decomposition occurs and scheelite surfaces remain unaltered thereby glazing the calcite surfaces and rendering the calcite inert to scheelite collector reagents, pulping the hot concentrate with an aqueous solution, conditioning said pulp for flotation by introducing a scheelite collector, an alkaline reagent, and a retarder for mixing with said pulp, and subjecting the conditioned pulp to a selective froth flotation treatment so as to concentrate the scheelite in a froth substantially free of calcite contaminants.

5. A process for the recovery of a high grade concentrate in the treatment of scheelite, which comprises roasting dry scheelite in a flotation size range in a hearth furnace without an open flame at temperatures above 500° F. but not exceeding 930° F. during which no calcite decomposition occurs and scheelite surfaces remain unaltered thereby glazing the calcite surfaces and rendering the calcite inert to scheelite collector reagents, pulping the hot concentrate with an aqueous solution, conditioning said pulp for flotation by introducing a scheelite collector, an alkaline reagent, and a retarder for mixing with said pulp, and subjecting the conditioned pulp to a selective froth flotation treatment so as to concentrate the scheelite in a froth substantially free of calcite contaminants.

6. A process for the recovery of a high grade concentrate in the treatment of scheelite, which comprises roasting dry scheelite in a flotation size range by indirect heat without an open flame at air temperatures above 500° F. but not exceeding 930° F. during which no calcite decomposition occurs and scheelite surfaces remain unaltered thereby glazing the calcite surfaces and rendering the calcite inert to scheelite collector reagents, pulping the hot concentrate with an aqueous solution, conditioning said pulp for flotation by introducing a scheelite collector, an alkaline reagent, and a retarder for mixing with said pump, and subjecting the conditioned pulp to a selective froth flotation treatment so as to concentrate the scheelite in a froth substantially free of calcite contaminants.

7. A process for the recovery of a high grade concentrate in the treatment of scheelite, which comprises roasting dry scheelite in a flotation size range in a flame-free furnace without an open flame at air temperatures above 500° F. but not exceeding 930° F. during which no calcite decomposition occurs and scheelite surfaces remain unaltered thereby glazing the calcite surfaces and rendering the calcite inert to scheelite collector reagents, discharging hot concentrate from the furnace at temperatures ranging from about 580° F. to 850° F., pulping the hot concentrate with an aqueous solution, conditioning said pulp for flotation by introducing a scheelite collector, an alkaline reagent, and a retarder for mixing with said pulp, and subjecting the conditioned pulp to a selective froth flotation treatment so as to concentrate the scheelite in a froth substantially free of calcite contaminants.

8. A process for the recovery of a high grade concentrate in the treatment of scheelite, which comprises roasting dry scheelite in a flotation size range in a hearth furnace without an open flame at temperatures above 500° F. but not exceeding 930° F. during which no calcite decomposition occurs and scheelite surfaces remain unaltered whereby the calcite surfaces are glazed and rendered inert to scheelite collector reagents, discharging the concentrate from the roasting stage at a temperature above 580° F., pulping the hot concentrate with an aqueous solution, conditioning said pulp for flotation by introducing a scheelite collector, an alkaline reagent, and a retarder for mixing with said pulp, and subjecting the conditioned pulp to a selective froth flotation treatment so as to concentrate the scheelite in a froth substantially free of calcite contaminants.

9. In a process of concentrating non-metallic minerals containing calcite by a flotation separation, in which such a non-metallic mineral composition selected from the group consisting of scheelite, wolframite, powellite, apatite, fluorite and rhodochrosite and in a flotation size range is prepared as feed to a flotation separation stage, the steps comprising feeding such a material in the dry state at a substantially uniform rate into a roasting stage, glazing the surface of calcite constituents of such a non-metallic mineral composition by roasting in a flame-free atmosphere within a temperature range between 500° F. and 930° F. in which a surface alteration of calcite is produced and no calcite decomposition occurs, thereby inhibiting the flotation properties of the calcite, conditioning an aqueous pulp of the selected mineral with a collector reagent for said mineral, selectively floating said mineral at the flotation stage with the surface-altered calcite depressed and not responding to the collector reagent due to its surface alteration, and recovering a major portion of the mineral of the feed as a high grade concentrate of the flotation separation.

10. A process as defined in claim 9 in which the non-metallic mineral is a tungsten mineral.

11. A process as defined in claim 9 in which the non-metallic mineral is scheelite.

12. In a process of concentrating non-metallic minerals containing calcite by a flotation separation, in which such a non-metallic mineral composition selected from the group consisting of scheelite, wolframite, powellite, apatite, fluorite and rhodochrosite and in a flotation size range is prepared as feed to a flotation separation stage, the steps comprising feeding such a material in the dry state at a

substantially uniform rate into a roasting stage, glazing the surface of calcite constituents of such a non-metallic mineral composition by roasting in a flame-free atmosphere within a temperature range between 500° F. and 930° F. in which a surface alteration of calcite is produced and no calcite decomposition occurs, thereby inhibiting the flotation properties of the calcite, mixing the hot mineral composition at a temperature above 580° F. with water to form an aqueous pulp, conditioning the aqueous pulp of the selected mineral with a collector reagent for said mineral, selectively floating said mineral at the flotation stage with the surface-altered calcite depressed and not responding to the collector reagent due to its surface alteration, and recovering a major portion of the mineral of the feed as a high grade concentrate of the flotation separation.

13. In a process of concentrating non-metallic minerals containing calcite by a flotation separation, in which such a non-metallic mineral composition selected from the group consisting of scheelite, wolframite, powellite, apatite, fluorite and rhodochrosite and in a flotation size range is prepared as feed to a flotation separation stage, the steps comprising drying such a material to produce a feed to a roasting stage having a moisture content not exceeding 2%, feeding such dry material at a substantially uniform rate into a roasting stage, glazing the surface of calcite constituents of such a non-metallic mineral composition by roasting in a flame-free atmosphere within a temperature range between 500° F. and 930° F. in which a surface alteration of calcite is produced and no calcite decomposition occurs, thereby inhibiting the flotation properties of the calcite, conditioning an aqueous pulp of the selected mineral with a collector reagent for said mineral, selectively floating said mineral at the flotation stage with the surface-altered calcite depressed and not responding to the collector reagent due to its surface alteration, and recovering a major portion of the mineral of the feed as a high grade concentrate of the flotation separation.

14. In a process of concentrating non-metallic minerals containing calcite by a flotation separation, in which such a non-metallic mineral composition selected from the group consisting of scheelite, wolframite, powellite, apatite, fluorite and rhodochrosite and in a flotation size range is prepared as feed to a flotation separation stage, the steps comprising feeding such a material in the dry state at a substantially uniform rate into a roasting stage, glazing the surface of calcite constituents of such a non-metallic mineral composition by roasting the feed in continuous movement in a flame-free atmosphere within a temperature range between 500° F. and 930° F. in which a surface alteration of calcite is produced, the mineral surfaces remain unaltered and no calcite decomposition occurs, thereby inhibiting the flotation properties of the calcite, conditioning an aqueous pulp of the mineral composition with a collector reagent for said mineral while maintaining a pulp temperature above 110° F., selectively floating said mineral at the flotation stage while maintaining a pulp temperature between 70° F. and 110° F. and with the surface-altered calcite depressed and not responding to the collector reagent due to its surface alteration, and recovering a major portion of the mineral of the feed as a high grade concentrate of the flotation separation.

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