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SEYMOUR POWER WARREN, OF GOLDEN, COLORADO

FLOTATION PROCESS

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This invention relates to flotation processes and it deals with improvements in the general type of flotation processes known as "selective" flotation processes in which different values contained in an ore are separated from each other in a sequence of succeeding steps, whereby the various minerals containing the values are floated off from the gangue and thereby concentrated and recovered one after the other in a predetermined succession.

Specifically, the present process is particularly adapted to the treatment of complex sulphide ore containing the sulphides of lead, copper, zinc and iron, together with some silver and gold, as well as gangue, and, as indicated above, it seeks to concentrate the values through a series of successive flotations, as will be hereinafter described. It will be understood, however, that the process is not restricted to complex sulphide ores, but is also applicable in the separation of oxide minerals and sulphides other than thoss specifically mentioned above. It may be here mentioned also, that the separation of metallic minerals from non-metallic minerals, herein referred to as "gangue" does not necessarily imply the use of selective flotation, since this term is intended to mean the separation of the values from each other in a succession of predetermined steps.

In the present process, use is made of reagents which are, in themselves, well known in the flotation art, but which are herein employed in various combinations to facilitate the separation of, for example, lead minerals from zinc minerals, and zinc minerals from iron minerals. Among the reagents found to be most convenient and satisfactory are sodium carbonate, sodium cyanide, sodium and potassium xanthate, thiocarbanilide, phosphocresylic acid and lime. Combined with these well known reagents this process provides for the addition of small quantities of copper salts of strong acids, or larger quantities of copper salts of weak acids, with or without the addition of ammonia or ammonium compounds.

It will be seen, therefore, that one object of the present invention is the accomplishment of the separation and concentration of mineral values one from another in a succession of predetermined stages, such as, for example, the separation of copper, copper minerals, silver, silver minerals, and gold, from other minerals commonly associated with these values, such as lead, iron, zinc, and various gangue minerals.

A still further specific object is to separate zinc minerals from lead, copper, iron and gangue minerals.

A still further object is to provide a reagent, or one or more combinations of reagents, which will effect the desired separation in a series of selected and predetermined steps or stages as above pointed out.

It is found that the combination of reagents employed is essential to the succesful practice of the present process; and the reagents so employed have the property of accelerating the flotability of the copper, silver and gold values, whether these values are in the native state, or whether they are in the form of compounds, as for example, sulphides or oxides.

The object of the reagents cited above is to increase or accelerate the flotability of the copper values as well as the silver and gold values. With the aid of other agents such as sodium carbonate, calcium oxide, potassium, xanthate, cresylic acid, phosphocresylic acid, orthotoluidine, thiocarbanilide, sodium cyanide and pine oil, it is possible to effect a separation of the copper, silver and gold values from the lead, iron, zinc, and gangue minerals.

The invention will be more clearly understood from a consideration of a specific illustrative example, it being understood that it is to be regarded as illustrative only, and that variations in the quantities of the reagents employed, the combinations of reagents, and the steps of the procedure may be varied in practice as determined by the composition of the given ore, without departing from the inventive concept.

A sulphide ore containing lead, copper, zinc, silver and gold was ground to 100 mesh, and passed to a flotation machine. There were then placed in the machine with the ore pulp sodium carbonate in quantities of three pounds per ton of ore, potassium xanthate

about 0.1 pound per ton of ore, sodium cyanide, 0.4 pound per ton and pine oil, about .05 pound per ton, and the whole thoroughly mixed. The air supply to the machine was turned on, and there was produced a froth, which resulted in a separation of values indicated below as assay No. 2, which will be found to contain a majority of the lead content. After taking off the lead product, a small quantity of sodium cyanide, about 0.1 pound per ton was added to the pulp, and allowed to mix with it for a short time. This was followed by the addition of a solution of copper ammonium acetate in a quantity of about 0.6 pound per ton of ore. A small quantity of potassium xanthate and pine oil was then added, as above, and the mixture again subjected to flotation, producing a separation of values indicated below as assay No. 3. After separation of this fraction, rich in gold, silver and copper values, lime was introduced into the machine in quantities about two pounds per ton of ore, and the pulp agitated for a short time. At the end of this agitation period a quantity of copper sulphate, about 1 pound per ton of ore was added, and the pulp again allowed to agitate for a short period. At the end of this second agitation period a small and variable amount of potassium xanthate and pine oil was added and the froth designated below as assay No. 4 was produced. The ore itself is designated below as assay No. 1.

These assays gave the following results—

Assay	No. 1	Ore
Au	0.14	Oz. per ton.
Ag	10.5	Ozs. per ton.
Pb	2.4	Percent.
Cu	0.4	Percent.
Zn	8.5	Percent.
Fe	5.0	Percent.
Insol.	36.8	Percent.

Assay	No. 2	Lead concentrate
Au	0.1	Oz. per ton.
Ag	58.4	Ozs. per ton.
Pb	66.3	Percent.
Cu	0.16	Percent.
Zn	1.8	Percent.
Fe	1.6	Percent.
Insol.	9.1	Percent.

Assay	No. 3	Copper concentrate
Au	4.36	Ozs. per ton.
Ag	276.5	Ozs. per ton.
Pb	7.1	Percent.
Cu	14.4	Percent.
Zn	13.2	Percent.
Fe	16.5	Percent.
Insol.	10.8	Percent.

Assay	No. 4	Zinc concentrate
Au	0.09	Oz. per ton.
Ag	7.3	Ozs. per ton.
Pb	0.01	Percent.
Cu	0.8	Percent.
Zn	50.4	Percent.
Fe	10.5	Percent.
Insol.	0.7	Percent.

It will be seen from the above assays, which are listed in the order in which they were produced, that the copper, gold, and silver had an opportunity to float with the lead froth, as indicated in assay No. 2, but the concentration of gold, silver and copper in the froth is very small compared with the concentration of lead. On the other hand, there is to be noted the large concentration of gold, silver and copper in froth designated as assay No. 3, which froth was produced after the introduction of the reagents containing small quantities of copper salts of strong acids, or larger quantities of copper salts of weak acids, with or without the addition of ammonia or ammonium compounds. The above example shows that the above mentioned reagents have a selective preference for the gold, silver and copper minerals in comparison with the zinc, iron and gangue minerals.

As illustrative of the use of the reagents of another combination, the following assays are given, these assays being the result of a procedure entirely analogous to the example given above, with the exception of the fact that a solution of copper tartrate was used in place of copper ammonium acetate, as shown in the preceding example. The results obtained by the use of these reagents were as follows:

Assay	No. 1	Ore
Au	0.11	Oz. per ton.
Ag	4.8	Ozs. per ton.
Pb	3.4	Percent.
Cu	1.16	Percent.
Zn	16.9	Percent.

Assay	No. 2	Lead concentrate
Au	0.03	Oz. per ton.
Ag	33.0	Ozs. per ton.
Pb	59.8	Percent.
Cu	0.76	Percent.
Zn	6.3	Percent.

Assay	No. 3	Copper concentrate
Au	1.64	Ozs. per ton.
Ag	29.2	Ozs. per ton.
Pb	4.1	Percent.
Cu	21.9	Percent.
Zn	17.4	Percent.

Assay	No. 4	Zinc concentrate
Au	0.01	Oz. per ton.
Ag	2.5	Ozs. per ton.
Pb	0.01	Percent.
Cu	0.8	Percent.
Zn	57.2	Percent.

It has been found that no matter how much the flotability of copper and copper minerals, silver and silver minerals, and gold, has been hampered or retarded by the use of cyanide, these minerals can be caused to rise by the addition of small quantities of copper salts of strong acids, or larger quantities of copper

salts of weak acids, with or without the addition of ammonia or ammonium compound.

It is understood that while in the above illustration only copper ammonium acetate and copper tartrate have been used the same effects can be obtained by various combinations of copper salts of organic or inorganic acids with or without ammonia or ammonium compounds.

It is further understood that it is desired and intended to comprehend within the scope of this invention such changes as may be necessary to adapt it to varying conditions and uses.

What I claim, is:—

1. The process of concentrating values in complex sulphide ores, which comprises subjecting the ore to a series of froth flotation operations in successive stages in the presence of a reagent comprising ammonium compounds and copper salts of weak acids, the said salts having the property of accelerating the selective concentration of the copper, gold and silver values in a series of predetermined fractions.

2. The process of concentrating by froth flotation the values of complex ores containing as values copper, lead, gold, silver and zinc which comprises comminuting the ores and forming a pulp thereof subjecting the pulp to a series of froth flotation operations in successive stages, in the presence of a reagent comprising salts of copper-ammonium compounds the said salts having the property of accelerating the selective froth flotation concentration of the copper, gold and silver values in a series of predetermined fractions.

3. A process of concentrating by froth flotation the values of complex ores which comprises forming a pulp of the ores, adding sodium carbonate, sodium cyanide, potassium xanthate, and pine oil to accelerate the froth flotation of the lead minerals; then adding an additional quantity of sodium cyanide, a small quantity of a copper salt, more potassium xanthate and pine oil to accelerate the froth flotation of gold, silver and copper minerals, and finally the addition of a small quantity of lime, a small quantity of copper sulphate, and more potassium xanthate and pine oil to accelerate the froth flotability of the zinc.

4. The process of concentrating the values in complex sulphide ores containing, among other values, copper and precious metals, which comprises subjecting the said ores to froth flotation in the presence of reagents containing copper and ammonium compounds having the property of accelerating the flotability of the copper and precious metal values, while retarding the flotability of remaining values in the said reagents.

5. The process of concentrating by froth flotation the values in complex sulphide ores which comprises subjecting the ore to froth flotation in the presence of copper salts and ammonia to accelerate the froth flotability of selected values, while retarding the froth flotability of remaining values in the said ores.

In testimony whereof, I affix my signature.

SEYMOUR POWER WARREN.