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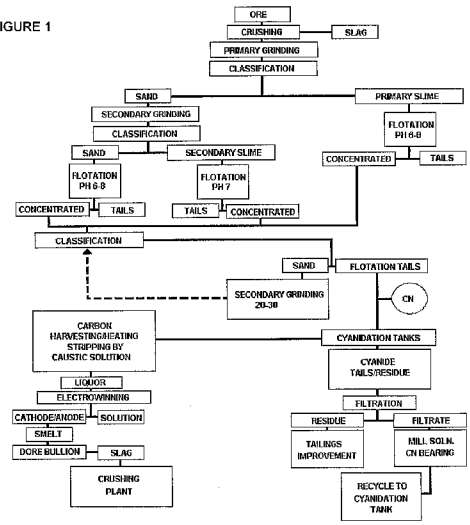
(54) Title: GOLD RECOVERY SYSTEM AND PROCESS THEREFOR

FIGURE 1



(57) Abstract: A system of gold recovery whereby the bulk waste component of a gold ore is removed by froth flotation and the resultant concentrate is then treated by conventional cyanide leaching procedures, characterized in that 96 - 98 % of gold from the ore is finally recovered whereby the system includes the steps of: a) Crushing and grinding of the ore; b) Separating the sand from the primary slime; c) Treating said primary slime with sulfhydric collector; d) Secondary grinding of said sand, and separating the secondary slime from the sand; e) Treating said secondary slime with sulfhydric - fatty acid collector; f) Treating said sand with sulfhydric- fatty acid collector; g) Collecting the concentrates from (3), (5) and (6), and separating sand there from (at 20 -30 μ); h) Treating said concentrate with cyanide; i) Passing activated carbon countercurrent to the flow of the concentrate; j) Separating the tails and residue from the loaded carbon; k) Treating the loaded carbon with hot cyanide and caustic solution; and I) Electrowinning the liquor and smelting gold into bullions

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GOLD RECOVERY SYSTEM AND PROCESS THEREFOR

Field of the Invention

The present invention relates to an improved system of gold recovery whereby the bulk waste component of a gold ore is removed by a pre-concentration process and the resultant concentrate is then treated by conventional methods. More specifically, the present invention relates to a system of gold recovery whereby the bulk waste component of a gold ore is removed by froth flotation and the resultant concentrate is then treated by conventional cyanide leaching procedures.

Background Art

Generally, to recover gold from an ore, using conventional cyanide leaching operations, as currently accepted in the mining industry, the practice is to put the whole ore stream in contact with the cyanide solution to be able to achieve an acceptable level of extraction. For example, in the Carbon in Pulp (CIP) process, the gold bearing ore is crushed, then finely ground as a slurry to around 75 microns. The slurry or pulp is treated with cyanide through a series of tanks. Granulated carbon is passed through the tanks countercurrent to the flow of the pulp, allowing said carbon to adsorb increasing quantities of gold from the pulp. The loaded carbon is then separated from the pulp and treated with hot cyanide and caustic solution to remove gold from carbon. The Carbon in Leach (CIL) process is a variation of CIP.

Gold ores are at present becoming leaner in grade, and more and more are being classified as “unclean ores”. The valuable metal component is only a small percentage of the original bulk. Thus, only a small amount of gold is present in the slurry or pulp treated with cyanide, in the above-mentioned processes. In order to increase the efficiency of cyanidation, the bulk of the

waste component of the ore, has to be removed prior to cyanidation by a pre-concentration process so that said waste, comprising mainly of rock components, is out of the process stream before the latter comes into contact with the cyanide solution. The pre-concentration process may be selected from gold recovery processes known in the art.

For example, U.S. Patent No. 4,710,361 discloses the use of sulfhydric fatty acid collector applied to typical gold tailings material containing 0.6 to 1.0 gram Au/MT, which resulted in a gold recovery of 95%. The same patent disclosed that subsequent cleaner (upgrading) operation produced a final concentrate with a grade of 4.8 gram to 7.2 Au/MT at a substantial gold recovery of 89%.

Summary of the Invention

The object of the present invention is to provide a system of gold recovery whereby the bulk waste component of a gold ore is removed by froth flotation and the resultant concentrate is then treated by conventional cyanide leaching procedures.

Another object of the invention is to provide a system of gold recovery, which utilizes a sulfhydric – fatty acid reagent combination as a collector or promoter of the gold present in the "unclean" ore material, as a pre-concentration means applied prior to conventional cyanide leaching procedures.

Another object of the invention is to provide a system of gold recovery, which is inexpensive and more efficient in attaining higher recovery from the "ore" or gold-bearing material by cyanidation using conventional CIP/CIL operations.

Another object of the invention is to provide a system of gold recovery that can be applied to ores containing gold to as low as 0.5% gm/MT concentrations.

Another object of the invention is to provide a system of gold recovery that can be effective even with recalcitrant ores, i.e, sulfidic ores or refractory gold ores.

Yet another object of the invention is to provide a system of gold recovery wherein a pre-concentrate may be stored, or transported, such as to a metal smelter, if cyanidation is not permissible or is impractical after the pre-concentration process, and thus the CIP/CIL plant can be located far from the deposit, allowing a substantial amount of economic benefits to the user. In this way, refining of the gold concentrate can take place in an area of improved security and safety, such as in more urban areas.

The above features and advantages of the present invention will be better understood with reference to the accompanying figures, detailed description and examples. It should also be understood that the particular process illustrating the present invention is exemplary only and not to be regarded as a limitation of the invention.

Brief Description of the Drawings

Reference is now made to the accompanying figures in which certain figures illustrate embodiment of the present invention from which its novel features and advantages will be apparent:

Fig. A shows a schematic representation of a system of gold recovery according to the present invention.

Detailed Description of the Invention

The present invention relates to a system of gold recovery whereby the bulk waste component of a gold ore is removed by froth flotation and the resultant concentrate is then treated by conventional cyanide leaching procedures.

As the waste component comprises about 95% in "unclean" ores, with only about 5% of gold, conventional cyanidation processes are inefficient in that the cyanide solution is in contact with a large amount of non- gold material. With the system according to the present invention, the volume of waste component drops by a factor of 10, and in some instances, it drops by as high as a factor of 20. Consequently, the size of cyanidation plants may be reduced to one- tenth of that required for conventional CIP/CIL processes.

Figure A shows a schematic representation of the present system of gold recovery, comprising the sulfhydric fatty acid flotation pre-concentration process and conventional CIP/CIL processes.

Conventional CIP/CIL processes comprise the following steps:

1. Crushing the gold-bearing ore to around 75 microns, then adding water thereto to form a slurry or pulp;
2. Treating the slurry with cyanide;
3. Passing granulated carbon countercurrent to the flow of the pulp; and
4. Separating the loaded carbon from the pulp and treating the same with hot cyanide and caustic solution to remove the gold from the carbon.

The gold recovery system according to the present invention comprises of the following steps:

1. Crushing and grinding of the ore;

2. Separating the sand from the primary slime;
3. Treating said primary slime with sulfhydric collector (at pH = 6 – 8);
4. Secondary grinding of said sand, and separating the secondary slime from the sand;
5. Treating said secondary slime with sulfhydric – fatty acid collector (at pH =7);
6. Treating said sand with sulfhydric- fatty acid collector (at pH = 6-8);
7. Collecting the concentrates from (3), (5) and (6), and grinding the concentrates to 20 –30 μ;
8. Treating said concentrate with cyanide;
9. Passing activated carbon countercurrent to the flow of the concentrate;
10. Separating the tails and residue from the loaded carbon;
11. Treating the loaded carbon with hot cyanide and caustic solution;
12. Electrowinning the liquor and smelting gold into bullion.

With the system of gold recovery according to the present invention (Figure A), the level of gold recovered increased from 92 % of the conventional CIP/CIL process to 96-98 %.

To illustrate, the ore obtained from the Balatoc mine comprises 6.0 g/MT of gold. After the flotation process, 94- 97 % of gold was recovered and the resultant concentrate comprises of 50 g/MT gold. The concentrate was then treated with cyanide according to conventional CIP/CIL process. The gold recovered amounted to 98 % of the gold present in the concentrate.

The table below shows the recovery of gold from different ores that are representative of Philippines gold-bearing ores or materials at different stages of the gold recovery system according to the present invention, including the overall recovery.

Ore grade, g/T	Flotation Tails	Flotation Recovery	CIP/CIL Extraction	Overall Recovery
6	0.2	97.0	99.6	96.6
4	0.15	96.6	99.6	96.2
2	0.10	95.5	99.5	95.0
0.7	0.05	93.6	98.9	92.1

Gold recovery from the Balatoc ore using conventional CIP/CIL alone is only about 85- 92 %. The above test clearly shows an improvement in gold recovery with the system of gold recovery according to the present invention (Figure A). Said improvement in gold recovery is readily achieved even at coarser grinds. For the refractory ore, gold recovery is about 35%.

In the Balatoc test, the customary milling product size of P80 of 74 microns (or 80% passing 200 mesh) dropped to P80 of 110 microns, when the system according to the present invention is used, thus providing a 15% drop in energy spent for grinding.

The present invention utilizes a sulfhydric – fatty acid reagent combination as a collector or promoter of the gold present in the "unclean" ore material, as a pre-concentration means.

Suitable sulfhydric collectors may be xanthate and may be sodium ethyl xanthate or sodium isobutyl xanthate, which are available commercially.

Suitable fatty acid collectors may be selected from commercially available mixtures containing oleic and linoleic acids along with rosin acids, among others.

As has been determined experimentally, the percentage range of reagent combination used in the flotation process applied to tailings (US Patent 4,710,361) is from 5% to 20% of sulfhydric collector and 80% to 95% of fatty acid collector depending among other things on the alkalinity – acidity of the floatation pulp. The total amount of collector dosage is from 0.5 to 3

lbs./MT of material. The pH range in which the sulfhydric-fatty acid collector is effective, based on the material treated is from pH 5 to pH 8.

For the primary slime obtained from the Balatoc ore, tested with the present invention, 100% sulfhydric collector may be used. For the secondary slime, the percentage range of reagent used in the flotation process is from 60 to 80 % sulfhydric collector and 20 to 40 % fatty acid collector. For sand, 20 – 30 % of sulfhydric collector and 70-80 % of fatty acid collector was found to be most efficient.

In the present invention, with the much reduced volume of ore material in the pre-concentrate, it now becomes inexpensive and more efficient to attain higher recovery on said concentrate rather than on the original ore material, well below the average mill grade of conventional CIP/CIL operations.

The present invention has been proven effective for various ore materials containing gold as low as 0.5 gm/MT concentrations and has also been found to be effective even with recalcitrant ores, i.e, sulfidic ores or refractory gold ores.

As an alternative embodiment, the pre-concentrate may be stored, or transported, such as to a metal smelter, if cyanidation is not permissible or is impractical after the pre-concentration process under the conditions obtaining. The CIP/CIL plant can, therefore, be located far from the deposit, allowing a substantial amount of economic benefits to its user.

The gold recovery system of the present invention will now be further illustrated with reference to the following examples.

Example 1

3,000 tons of Balatoc ore was crushed and ground, with a milling product size of P80 of 65 microns. Sand was then separated from the primary

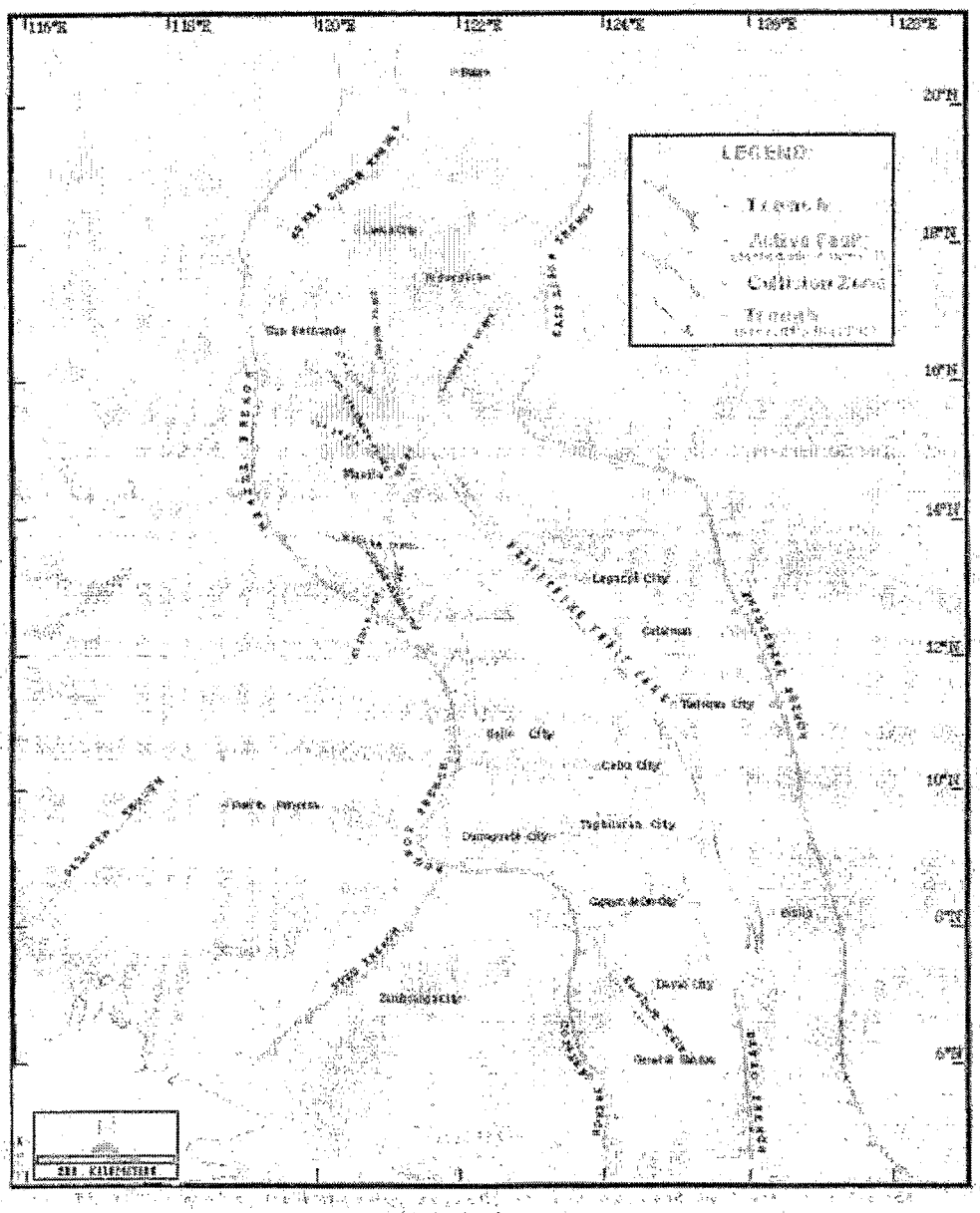
slime by a D20 hydrocyclone. Said primary slime was then treated with sulfhydric collector, at a pH of 6. The separated sand was then made to undergo a secondary grinding using a D15 and thereafter reclassified using a D15 hydrocyclone, separating sand from the secondary slime. Said secondary slime was then treated with sulfhydric – fatty acid collector at pH =7. The separated sand was then treated with sulfhydric- fatty acid collector at pH 8. The concentrates from the treatment of the primary and secondary slimes and sand were then collected and further classified, separating sand therefrom and grinding the coarse fraction to a product, all essentially passing 20 –30 microns. The concentrate was then treated with cyanide. Activated carbon was then passed countercurrent to the flow of the concentrate. Thereafter, cyanidation tails and residue were separated from the loaded carbon, and said loaded carbon was treated with hot cyanide and caustic solution. The resultant liquor underwent Electrowinning and the recovered gold was smelted into bullions.

The present invention may, of course, be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the present invention. The present embodiments are, therefore, to be considered in all respects as an illustration and not restrictive. Therefore, any changes coming within the meaning and equivalency range of the appended claims are to be embraced therein.

The gold recovery system according to the present invention was found to be similarly efficient with different kinds of ores found at three other mine sites along the Philippine fault, from north to south, namely, Bicol (Camarines Norte), Agusan del Norte and Davao, as shown by the map below. The samples from said mine sites, including that of Balatoc, are found to be representative of the different gold ores found throughout the Philippine archipelago, and thus, the gold recovery system of the present invention is applicable to said gold ores found throughout the Philippines, and by

inference, to most ores whose origin is identified with the tectonic belt called the Ring of Fire.

Naturally, since gold ores are produced by common geological processes, the foregoing will not be considered a limitation upon this invention. It is applicable to gold ores and gold-bearing materials wherever they may be found. The foregoing are merely cited as exemplars.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Cebu
Iloilo
Bacolod
Legazpi
Tabaco
Lucena
Manila
Baguio
Vigan
Tuguegarao
Dagupan
Olongapo
Angeles

We claim:

1. A system of gold recovery whereby the bulk waste component of a gold ore is removed by froth flotation and the resultant concentrate is then treated by conventional cyanide leaching procedures, characterized in that 96 – 98 % of gold from the ore is finally recovered.

2. The gold recovery system according to claim 1 comprising of the steps of:

a) Crushing and grinding of the ore;

b) Separating the sand from the primary slime;

c) Treating said primary slime with sulfhydric collector;

d) Secondary grinding of said sand, and separating the secondary slime from the sand;

e) Treating said secondary slime with sulfhydric – fatty acid collector;

f) Treating said sand with sulfhydric- fatty acid collector;

g) Collecting the concentrates from (3), (5) and (6), and separating sand therefrom (at 20 –30 μ);

h) Treating said concentrate with cyanide;

i) Passing activated carbon countercurrent to the flow of the concentrate;

j) Separating the tails and residue from the loaded carbon;

k) Treating the loaded carbon with hot cyanide and caustic solution; and

l) Electrowinning the liquor and smelting gold into bullions.

3. The gold recovery system according to claim 1 wherein the treatment of said primary slime with sulfhydric collector is at a pH of 6 – 8.

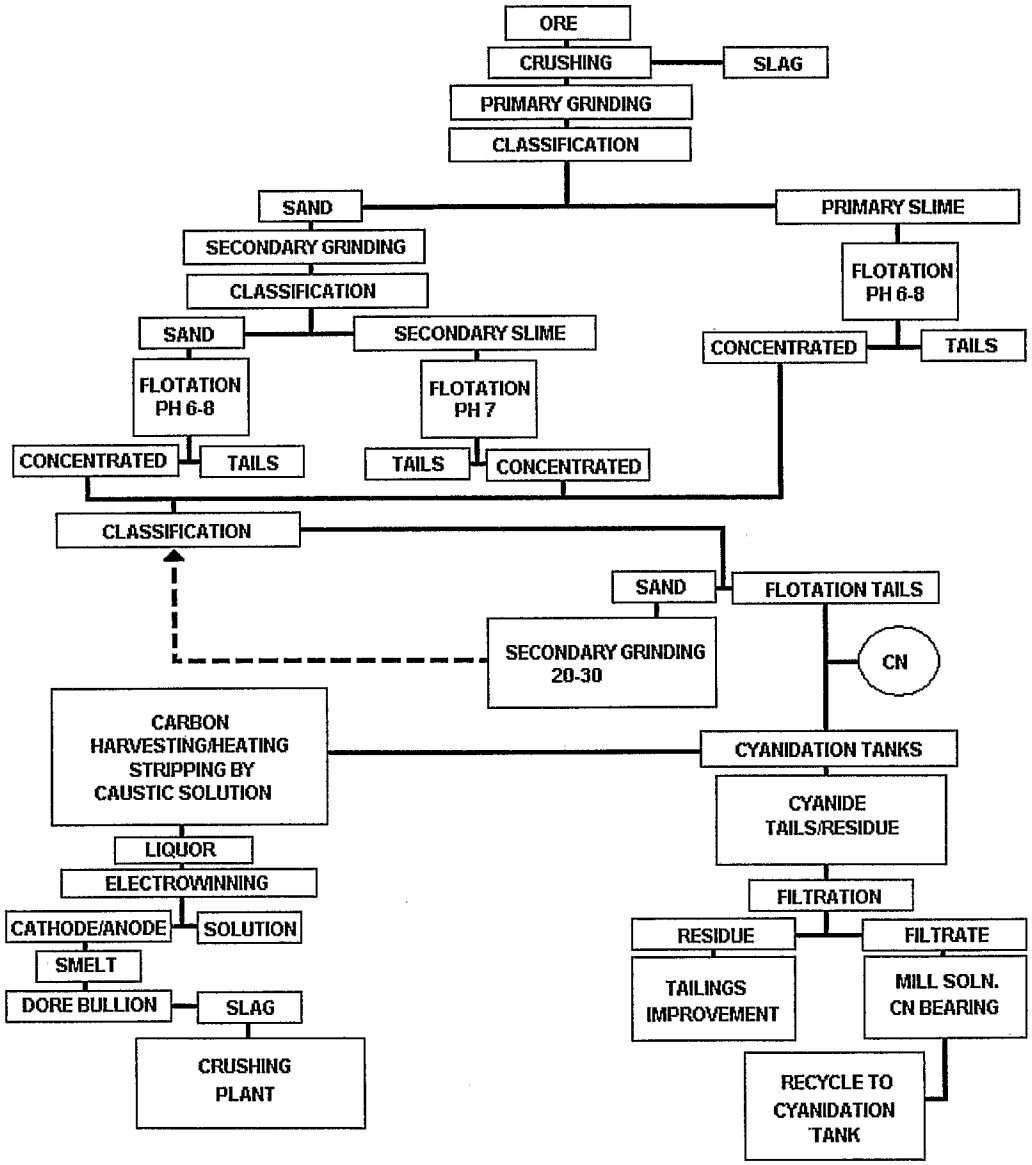
4. The gold recovery system according to claim 1 wherein the treatment of said secondary slime with sulfhydric – fatty acid collector is at a pH of 7.

5. The gold recovery system according to claim 1 wherein the treatment with sulfhydric- fatty acid collector of said sand, recovered after secondary grinding, is at a pH of 6 -8.

6. The gold recovery system according to claim 3 wherein said primary slime is treated with 100 % sulfhydric collector.

7. The gold recovery system according to claim 4 wherein said secondary slime is treated with 60 to 80 % sulfhydric collector and 20 to 40 % fatty acid collector.

8. The gold recovery system according to claim 5 wherein said sand, recovered after secondary grinding, is treated with 20 – 30 % of sulfhydric collector and 70-80 % of fatty acid collector.


ORE
CRUSHING
SLAG
PRIMARY GRINDING
CLASSIFICATION
SAND
PRIMARY SLIME
SECONDARY GRINDING
CLASSIFICATION
FLOTATION PH 6-8
SAND
SECONDARY SLIME
CONCENTRATED
TAILS
FLOTATION PH 6-8
FLOTATION PH 7
CONCENTRATED
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SAND
FLOTATION TAILS
SECONDARY GRINDING 20-30
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CARBON HARVESTING/HEATING STRIPPING BY CAUSTIC SOLUTION
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FILTRATION
CATHODE/ANODE
SOLUTION
RESIDUE
FILTRATE
SMELT
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SLAG
CRUSHING PLANT
RECYCLE TO CYANIDATION TANK