

April 13, 1971

G. D. ORTLOFF ET AL

3,574,599

MINERAL RECOVERY

Filed June 25, 1968

FIG. 1

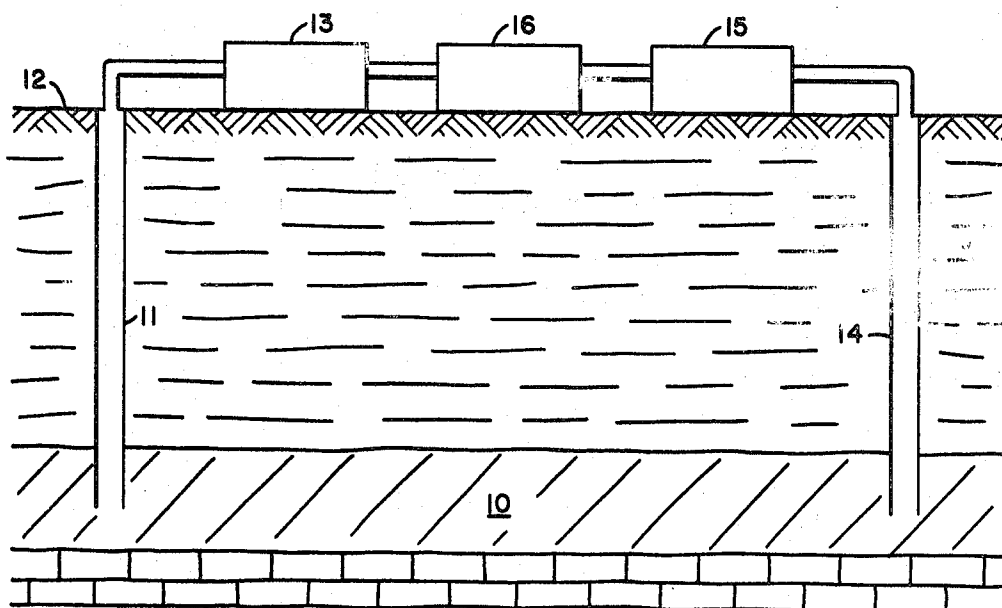
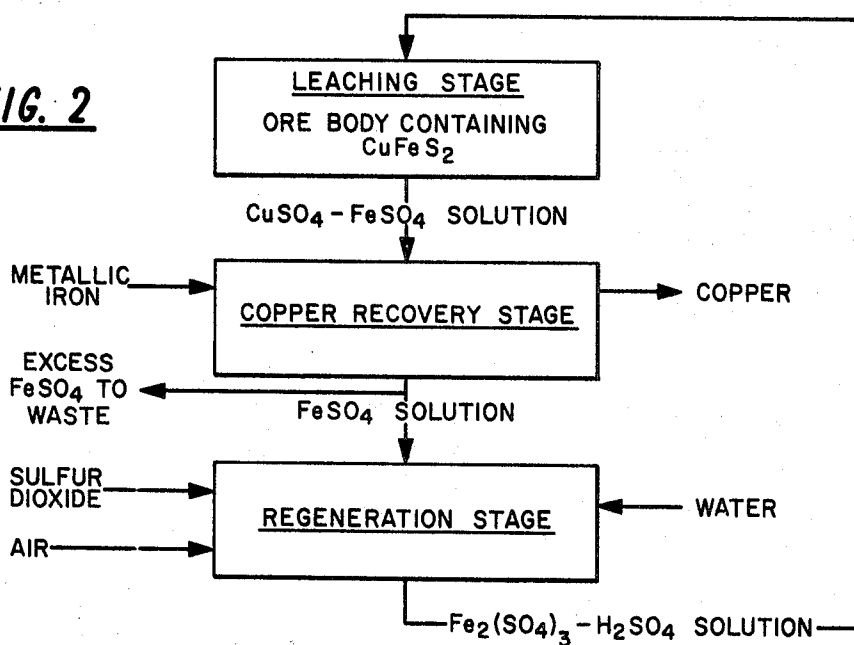


FIG. 2



Gerald D. Ortloff INVENTORS
Claude E. Cooke, Jr.
Donald K. Atwood
BY

Lewis H. Easterton
ATTORNEY

1

2

3,574,599

MINERAL RECOVERY

Gerald D. Ortloff and Claude E. Cooke, Jr., Houston,
and Donald K. Atwood, Bellaire, Tex., assignors to Esso
Production Research Company

Filed June 25, 1968, Ser. No. 739,702

Int. Cl. C22b 3/00, 3/02

U.S. Cl. 75-104

11 Claims

ABSTRACT OF THE DISCLOSURE

A method for the situ recovery of copper values from copper ores. In the process of this invention, the subterranean formation containing the copper ore is penetrated by a well extending from the earth surface to the deposit. A strong leach solution having a high ferric iron content is injected by way of the well into the copper ore deposit. Sufficient mineral acid is included in the leach solution to satisfy the acid requirements of unproductive side reactions. The period during which the leach solution remains in the ore body is regulated to approach the optimum residence time.

BACKGROUND OF THE INVENTION

(1) Field of the invention

This invention relates to a method for the in situ disintegration of a solid material comprising an in situ conversion of the solid material to a fluid solution by chemical reaction.

(2) Description of the prior art

The search for copper is as old as civilization. Neolithic men found in about 8,000 B.C. that the metal from native copper deposits could be shaped into implements which were better than those fashioned from stone. The discovery that a superior metal could be made from an alloy of copper and tin advanced civilization from the Stone Age to the Bronze Age and intensified the quest for copper. Modern technology has developed such a profusion of uses for this versatile metal that the demand for and consumption of copper are ever increasing. Copper deposits which previously would have been by-passed because of low quality for inaccessibility are now sought after and exploited.

Relatively pure deposits of elemental copper are known as native copper. These deposits are rare in occurrence and many of them have become exhausted by mining through the centuries. The present search for copper is primarily directed and toward mineral ores containing compounds of copper and other elements.

The ores of copper are generally classified as native copper, the copper oxides, and the copper sulfides. The sulfidic copper ores are of primary concern in the process of this application and include chalcocite, Cu_2S ; covellite, CuS ; chalcopyrite, CuFeS_2 ; bornite, Cu_5FeS_4 ; enargite, Cu_3AsS_4 ; tetrahedrite, Cu_3SbS_3 ; and tennantite



One method for recovering copper values from copper sulfide ores is hydrometallurgy. This process involves treatment of the ore with a suitable solvent which will take the copper into solution and leave all or a major part of the undesired material in the ore body. Typical solvents employed in this process include ammonia with oxygen, nitrogen tetroxide, cyanide, ferric chloride, and ferric sulfate in aqueous solutions.

In a typical hydrometallurgical process for the recovery of copper, the ore is mined, crushed, and then placed in a manner suitable for leaching. Generally, the crushed ore is placed in large piles on the ground surface and then

contacted with a dilute ferric sulfate solution. The ferric sulfate reacts with copper-bearing compounds to produce a solution which contains copper ions. Sulfuric acid may be added to the ferric sulfate solution to prevent precipitation of basic ferric sulfates. The pregnant solution containing the copper ions is then conducted to a cementation stage where the copper is removed by contacting scrap iron. The spent leach solution is then passed to a regeneration stage where the solution is oxidized to reproduce a dilute ferric sulfate solution. This regenerated leach solution is then passed to the crushed ore for further leaching.

No economically successful method for the in situ leaching of copper ores has been previously suggested. The methods of the prior art are unsuitable for in situ leaching. These methods are employed for the leaching of deposits which are shallow enough to be worked by conventional mining techniques, and the prior art specifically teaches that the concentration of ferric sulfate in the leach solution should be very dilute, i.e. less than 10 grams per liter. The quantity of copper which could be recovered using such dilute solutions would be insufficient to economically operate an in situ recovery process. The cost of drilling and completing input and withdrawal wells, of pumping the leaching fluid through the ore body, and of lifting the pregnant fluid to the surface from great depths makes it imperative that high quantities of copper be recovered in the leach solution.

SUMMARY OF THE INVENTION

It has been found that deeply buried deposits of copper sulfide ore can be leached employing strong solutions of ferric iron (0.2 to 2.0 molar, expressed as gram-moles of ferric iron per liter of solution) and sufficient mineral acid to satisfy the requirements of unproductive side reactions with the ore body. The residence time or the period during which the leach solution remains in contact with the ore body is controlled so that the ferric iron concentration is essentially depleted by the time the solution is withdrawn.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a vertical section taken through the earth showing a subsurface deposit containing a mineral deposit to be subjected to the steps of the present methods, and

FIG. 2 is a flow sheet illustrating an application of the process to such a subsurface deposit.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Applicants' technique has primary utility in porphyry copper sulfide deposits which are too deep for conventional mining. The term porphyry is generally applied to a type of disseminated copper deposit which is igneous in origin and is characterized by a large proportion of the minerals being rather uniformly distributed throughout thin fractures.

Many of the known porphyry copper sulfide deposits are too deep for conventional mining. Mineralogists speculate that the copper ore deposits were originally precipitated from magnetic waters as sulfides of copper. The deposits which were shallow enough to be contacted with oxygen-bearing ground water were oxidized over geologic times from sulfides to oxides of copper. This is borne out by the known facts that many deposits have a cap of copper oxide and that the more deeply buried portion of the same deposit is generally a copper sulfide ore. Whether this speculation is correct or not, it is known that many deposits of sulfidic copper are located at extreme depths and are too deeply buried to be exploited from mining shafts created by conventional methods.

Referring to FIG. 1, a porphyry copper sulfide deposit is shown generally at 10. For purposes of illustration, it is assumed that the primary copper bearing mineral in the deposit is chalcopyrite, CuFeS_2 , with minor amounts of other copper sulfides.

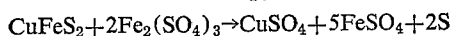
An injection well 11 is drilled from the surface of the earth 12 into the chalcopyrite deposit 10. The leaching solution containing from 0.1 molar to 1.0 molar ferric sulfate is pumped from the storage vessel 13 and into the ore deposit 10. A withdrawal well 14 is also drilled from the surface of the earth into the ore deposit. The ferric sulfate leach solution passes through the fractures within the porphyry ore deposit 10 and to the withdrawal well 14. It should be understood that, while it is preferred to employ a ferric sulfate-sulfuric acid leach solution, alternative compositions of the leach solution are contemplated. Any other suitable source of ferric iron may be employed, e.g. ferric chloride or ferric nitrate. Any other suitable mineral acid may be employed as a source of hydronium ion, e.g. hydrochloric acid or nitric acid.

If the natural fracture system has insufficient permeability to permit reasonable rates of fluid flow at reasonable pressure levels, it may be necessary to increase the permeability by means known to those skilled in the art of fracturing subterranean formations. When fluid permeability has been established in the deposit, the residence time of the leach solution in the deposit can be controlled by the rates of injection and withdrawal of the solution.

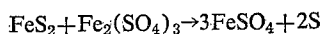
The pregnant leach solution then passes into cementation stage 15 where the copper is removed from solution and deposited upon scrap or sponge iron in the cementation vessel. The spent leach solution containing a high proportion of ferrous sulfate is withdrawn from the cementation vessel 15 and passes to the regeneration vessel 16. In the regeneration vessel, the ferrous sulfate is oxidized to ferric sulfate. Following oxidation, the ferric sulfate solution is then passed to the leach solution storage vessel 13.

The chemistry of the various reactions can be more clearly understood by reference to FIG. 2. This flow sheet illustrates the various stages of the process and the solutions flowing from stage to stage.

A leach solution containing ferric sulfate and sulfuric acid is injected into the chalcopyrite ore body. The leach solution reacts with the chalcopyrite in accordance with:

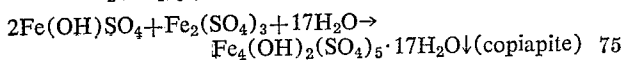
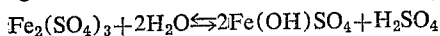


Laboratory analysis of core samples will show the amount of ferric sulfate which may be consumed in reaction with other compounds in the order, such as iron pyrite. Such a reaction would be:



Sufficient ferric iron must be supplied to satisfy these competing reactions as well as the reaction with the copper ore.

The leaching solution also contains a quantity of sulfuric acid. This sulfuric acid is added to satisfy the acid requirements of unprofitable side reactions which may occur within the ore body. If there are feldspars or other minerals in the ore which could react with sulfuric acid, the added sulfuric acid will satisfy the requirements of these reactions without unfavorably affecting the concentration of the ferric iron in the solution. The amount of sulfuric acid which must be added to the leaching solution can be readily determined from laboratory tests on core samples obtained in drilling the ore body. If the acid were not added to the ferric sulfate solution, the ferric iron might be withdrawn from the solution by hydrolysis of the ferric sulfate to form insoluble basic ferric sulfates, such as copiapite. Such a substance could be produced according to:



It can be seen that sulfuric acid is produced in the first step of this hydrolysis, and that if this acid is consumed in side reactions with feldspars or other minerals, the hydrolysis reaction cannot maintain equilibrium and will proceed to the right. Thus, ferric sulfate would be withdrawn from the solution and precipitated as copiapite or other of the many possible basic ferric sulfates. These substances will precipitate when their concentration reaches a certain minimum level and consequently less ferric iron will be present to react with the chalcopyrite.

After the leach solution has passed through the ore body and remain in contact with the ore body for suitable residence time, the pregnant leach solution is withdrawn. This solution will contain cupric sulfate and ferrous sulfate. This solution is then passed to a next stage for the removal of the copper from the solution.

It is important to the practice of applicants' invention that the residence time of the leach solution in the ore body be controlled. If the leach solution is withdrawn too rapidly, the ferric sulfate will not sufficiently react with the copper bearing ore. If the solution is withdrawn too slowly, essentially all of the ferric sulfate will have reacted and valuable time will be lost as the pregnant leach solution remains unrecovered in the ore body. The optimum residence time will be the time period necessary for essentially all of the ferric iron to react. A shorter or longer period will be less than optimum.

It is difficult to predict precisely the optimum residence time. However, the optimum residence time can be reasonably approximated from known characteristics of the ore body such as the extent of the fracture system, the average permeability of the system, and the amount of recoverable copper sulfides present in the fractures. These characteristics can be determined from laboratory analysis of core samples. The operating conditions for the process should also be taken into consideration. These conditions include the spacing between the input and withdrawal wells, the pressure drop between the wells and the strength of the leaching solution.

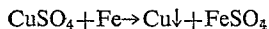
The residence time as determined by these factors can be adjusted as experience dictates. Qualitative and quantitative analysis of samples takes from the pregnant leach solution for ferric iron can be made to determine if change in residence time is necessary. If excessive amounts of ferric iron are present, the injection of withdrawal rate should be reduced to increase the residence time. If no ferric iron is present, the injection or withdrawal rate should be increased until a small but measurable amount of ferric iron is present in the pregnant leach solution.

In some instances, the concentration of recoverable copper in the fracture system will be so high that the optimum residence time will be reached and the ferric iron will be depleted from the leach solution long before the pregnant solution can be withdrawn. Such a condition will be more likely during the early life of the project when larger amounts of unrecovered copper ore are present in the fracture system. In such a situation, operating conditions such as well spacing, fracture permeability, and reasonable injection-withdrawal rates will be the governing factors on residence time. However, even when physical and operating conditions prevent the optimum residence time from being realized, the process can be improved by adjusting the factors which are controllable to shorten the residence time as much as possible. The optimum may not be attainable, but the process can be adjusted to approach the optimum.

For economic recovery of copper values from most deeply buried copper sulfide deposits, a leach solution containing a concentration of ferric iron of from 0.2 molar to 2.0 molar will be satisfactory. Where a ferric iron concentration is at the lower end of the scale, the optimum residence time will be shorter. Where a stronger solution is employed, the optimum residence time will increase.

In the practice of applicants' method it is preferred to employ conventional cementation stage for removal of copper from the solution. Other extraction processes such as electrowinning, ion exchange, or liquid-liquid extraction may also be employed if desired.

In the cementation method, the pregnant leach solution passes over a bed of metallic iron in any suitable manner to accomplish replacement of metallic iron by metallic copper yielding a copper precipitate which is the desired product. Either scrap iron or sponge iron is a suitable source of metallic iron from the cementation stage. Since iron lies above copper in the electromotive series, it will displace copper from a solution of its salts according to:

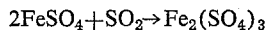


The metallic iron consumed in the cementation process must be replaced. Theoretically, .88 pound of iron must be added for every one pound of copper removed from the leach solution. However, competing side reactions, such as atmospheric oxidation of and acid reaction with the metallic iron, are also occurring during the cementation process and sufficient iron must be added to the cementation stage to satisfy these reactions as well. Experience has shown that approximately 1.3 to 2 pounds of iron per pound of copper will satisfy the copper replacement reaction as well as unfavorable side reactions which occur during this stage of the process.

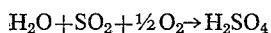
The spent liquid which is withdrawn from the cementation stage is essentially an aqueous solution of ferrous sulfate. In many instances, more ferrous sulfate may be present in the spent liquid than is needed in the regeneration stage of the process. This excess ferrous iron may be due to iron pyrite present in the ore body, the iron contained in the chalcopryite, or the iron taken into solution in the cementation stage. It is desirable to remove that portion of the ferrous sulfate solution which is not needed in the regeneration cycle. In the process illustrated in FIG. 2, a portion of the ferrous sulfate along with its associated water is discharged to waste following the cementation stage. The remaining ferrous sulfate solution is passed to the regeneration stage.

In the process of this application, it is preferred to employ sulfur dioxide-air regeneration as the method for regenerating ferric sulfate. If desired, other regeneration methods may be employed, such as bacterial oxidation of the solution using *Thiobacillus ferrooxidans* or other bacteria which have the ability to oxidize ferrous sulfate to ferric sulfate. It is also possible to regenerate the leach solution by prolonged contact with the atmosphere.

In the regeneration stage of applicants' process, the ferrous sulfate solution is passed to a suitable regeneration vessel. The ferrous sulfate solution is contacted with sulfur dioxide and air to produce ferric sulfate in accordance with:



The regeneration process can be conveniently carried out in the storage vessels employing gas spargers as means for introducing a gaseous SO_2 into the system. At the same time the needed sulfuric acid may be produced in this stage. The sulfuric acid which is needed in the leach solution for undesirable side reactions within the ore body may be produced by:



This reaction will not proceed until all of the ferrous ion has been converted to the ferric state. The quantity of sulfuric acid produced can therefore be easily controlled by adjusting the period of time during which the solution is contacted by the sulfur dioxide and air. The regenerated leach solution should have sufficient acid to lower the pH to less than 1.0 and preferably to less than 0.6. If insufficient ferric sulfate is produced, some of the ferrous sulfate which was previously passed to waste may be cycled into the regeneration stage. Alternatively, pure

ferric sulfate may be added to the leach solution following the regeneration stage. The regenerated ferric sulfate sulfuric acid leach solution is then returned to the input well for injection into the ore body.

For any given ore body, the concentration of ferric iron must be in excess of 0.2 molar to recover sufficient quantities of copper in an in situ recovery process. Additional quantities of ferric iron must also be added to the leach solution to react with non-copper producing side reactions such as reaction with iron pyrite. The amount of excess ferric iron necessary to satisfy these side reactions can be determined by a laboratory analysis of the ore. Such an analysis of the ore will also determine the amount of mineral acid which should be added to the leach solution to satisfy the acid requirements of the ore rock. Analysis of core data will determine the extent of fracturing in the porphyry, the width of the fractures, the ease with which fluids may flow in the fractures, and the amount of recoverable copper disseminated within the fractures. Fluid injectivity tests, before and after treatments to increase permeability, at the wells within the ore body can give a direct measure of the transmissibility of fluids. These factors can be used by one of ordinary skill in the art to determine the optimum residence time for a given strength of leaching solution. Continued monitoring of the withdrawn pregnant leach solution for the presence of ferric iron will indicate the necessity for adjustments of the flow rate of the leach solution to more closely approach an optimum residence time. Such an adjustment of flow rate may be necessitated by a change in conditions, such as depletion of available copper ore in the fracture system during the life of the process.

The following is an example of the application of this process to a specific subterranean ore body. It should be obvious to one skilled in the art that the quantities expressed in this example are illustrative of the process under given conditions and that the process will vary from the example given as these conditions change.

EXAMPLE

An ore body 100 acres in area and averaging 100 feet in thickness lies at an average depth of 3,000 feet below the surface of the earth. Samples of the ore shows that it is composed primarily of granitic igneous rock and that it contains chalcopryite as the principal copper mineral. The ore samples also show that it contains approximately 1.4 weight percent chalcopryite and that the total copper content of the ore averages 0.5 percent. The volume of ore in the deposit is, therefore, 10^4 acre-feet, or 4.356×10^8 cubic feet. The specific gravity of the granitic ore is 2.6. Therefore, the total weight of the ore in the deposit is 3.54×10^7 tons, and the copper content of the ore body is 3.54×10^8 pounds.

Wells are drilled into the ore body in an array such that the well density is one per acre, and the wells are completed such that fluids may be either injected or produced from individual wells. By measurements on core samples and by injection and production tests on individual wells, it is determined that the void volume within the randomly-oriented fracture system is equivalent to 2 percent of the bulk ore volume, that the fracture spacing averages 6 inches, and that the permeability of the ore body to liquid averages about 25 millidarcys.

Petrographic examination of core samples taken from the ore body shows that about 2 percent of the rock surface area exposed by the fractures is covered by the chalcopryite mineral and that the rock matrix bounded by the fracture system is substantially cubical in configuration.

Thus, the surface-to-volume ratio of the ore blocks bounded by the fractures is approximately equal to that for cubically shaped blocks and the surface area to volume ratio for the ore blocks is equal to $6/L$, where L is the length of the side of a cube. In this case $L=0.5$ feet,

and the surface area to volume ratio is equal to 12 square feet/cubic foot.

The total surface area of ore exposed by the fracture network is equal to $12 \times 4.356 \times 10^8$, or 5.227×10^9 square feet. The surface area of the chalcopryite mineral exposed by the fracture system is equal to 2 percent of the total surface area, or 1.045×10^8 square feet.

Laboratory tests with the ore samples showed that ferric sulfate solutions will dissolve copper from the chalcopryite of the ore body at a rate equal to 0.002 pound of copper per square foot of chalcopryite surface area per day. The initial maximum rate of copper production attainable from the ore body by in situ leaching with ferric sulfate would be $0.002 \times 1.045 \times 10^8 = 209,000$ pounds of copper per day. The laboratory tests also showed that by allowing a 0.4 molar solution of ferric sulfate to react completely with the chalcopryite and other minerals in the ore, a pregnant leach solution containing 3.0 pounds of copper per barrel (42 gallons) could be obtained. Therefore, in order to supply 0.4 molar ferric sulfate solution to the ore body at the optimum rate, i.e., at the rate sufficient to produce the maximum amount of copper and at the same time allow total reaction of the ferric iron, the 0.4 molar ferric sulfate solution must be injected initially at a rate equal to

$$\frac{209,000 \text{ lbs. cu./day}}{3 \text{ lbs. cu./barrel}}$$

or 69,700 barrels/day. The required average residence time for the solution within the ore body is fixed by the injection rate and the void volume of the ore body:

$$\text{Average Residence Time} = \frac{\text{void volume}}{\text{injection rate}} = \frac{(0.02) (4.34 \times 10^9) \text{ cubic feet}}{(69,700 \text{ bbl./day}) (5.615 \text{ cu. ft./bbl.})} = 22.2 \text{ days}$$

The injection and withdrawal rates of the wells is thus regulated to permit the ferric sulfate solution to remain in the ore body for approximately 22 days.

This average residence time, or the average time required for the fluid to traverse the ore body between injection and production wells must be increased as the chalcopryite mineral is depleted and the surface area of chalcopryite exposed to the leaching solution diminishes. Over the useful life of the in situ leaching operation the optimum average residence time for the 0.4 molar ferric sulfate solution will be continuously increasing and may be substantially greater than the 22.2 days calculated as the optimum average residence time at the start of the operation.

In most cases, the injection and production rates should be approximately equal in order to minimize migration of fluids into or away from the ore body being subjected to the solution mining process. In this example, if half of the wells are used as injection wells and the other half of the wells are used as production wells, the average injection and production rates will be initially:

$$\frac{69,700 \text{ barrels/day}}{50 \text{ wells}} = 1394 \text{ barrels/(day) (well)}$$

The injection and production rates at individual wells may be varied as necessary to maintain an approximate overall balance between total injection and total production, and to maintain the residence time required for essentially complete reaction of the ferric iron in the leaching solution with the ore minerals.

As noted above, it will be necessary to adjust the residence time of the leaching solution within the ore body to maintain the optimum residence time as the ore minerals are depleted. The need for such adjustment will be indicated by the appearance of ferric iron in increasing concentrations in the fluids produced from the production wells. When ferric iron is observed in the fluid produced

from a production well, the rate of fluid withdrawal from that well should be adjusted until ferric iron is no longer found in the fluid produced from the well. The injection rates at nearby injection wells should then be correspondingly reduced to maintain an overall balance between injection and production. This operation should be repeated as necessary to maintain the optimum residence time for the leaching fluid.

The process of this application has been described as primarily applicable to the copper sulfide ores. It should be understood, however, that the process is also applicable to ores bearing native copper and also to ores of copper oxides and silicates where the copper is present in the cuprous valence state. When the copper is present in its elemental or lower valence state, it is susceptible to oxidation by ferric iron to form solutions of cupric sulfate.

It should also be understood that while it is preferred to conduct the process in an ore body between an input and withdrawal well, a single well process is also included within the scope of applicants' invention. In a single well process, the leach solution will be injected through a well, permitted to remain in contact with the ore body for a period of time, and then withdrawn through the same well. The pregnant leach solution is then passed to a copper recovery stage, a regeneration stage and ultimately reinjected.

What is claimed is:

1. A method for recovering copper values from a subterranean deposit of copper-bearing ore penetrated by at least one wellbore comprising:

- (a) injecting a solution containing ferric iron at a concentration greater than 0.2 molar into the deposit by way of a wellbore; and
- (b) withdrawing a solution containing copper values from the deposit.

2. A method as defined in claim 1 wherein the solution containing the copper values is not withdrawn until the ferric iron is substantially depleted.

3. A method as defined in claim 1 wherein the subterranean deposit is penetrated by at least one input well through which the solution containing the ferric iron is injected and at least one output well through which the solution containing the copper values is withdrawn.

- 4. A method as defined in claim 1 further comprising:
 - (a) sampling the solution containing the copper values to determine the quantity of ferric iron present in the solution; and
 - (b) regulating the residence time of the ferric iron solution in the deposit to approach an optimum residence time.

5. A method as defined in claim 1 wherein the ferric iron solution contains sufficient mineral acid to satisfy side reactions within the deposit.

6. A method as defined in claim 5 wherein the ferric iron-mineral acid solution has a pH of less than 1.0.

7. A method as defined in claim 6 wherein the ferric iron-mineral acid solution has a pH of less than 0.6.

8. A method as defined in claim 5 wherein the mineral acid is sulfuric acid.

9. A method as defined in claim 1 wherein the solution containing ferric iron comprises an aqueous solution of ferric sulfate.

10. A method as defined in claim 1 wherein the solution containing ferric iron comprises an aqueous solution of ferric chloride.

11. A method for recovering copper values from a subterranean deposit of sulfidic copper ore penetrated by at least one input well and at least one withdrawal well comprising:

- (a) injecting an aqueous leach solution of ferric sulfate and sulfuric acid into the deposit by way of an input well, the concentration of ferric iron being from 0.2 molar to 2.0 molar and the quantity of mineral acid being sufficient to satisfy acid requiring side reactions with the ore body,

9

- (b) withdrawing a pregnant leach solution containing copper values from the deposit by way of a withdrawal well;
- (c) sampling the pregnant leach solution to determine the ferric iron concentration of the pregnant leach solution.
- (d) adjusting the flow rate of the leach solution through the ore deposit to approach an optimum residence time;
- (e) recovering copper values from the pregnant leach solution to produce a spent leach solution;
- (f) regenerating the spent leach solution to produce an aqueous leach solution of ferric sulfate and sulfuric acid; and
- (g) repeating steps a-f.

5

10

15

10

References Cited

UNITED STATES PATENTS

2,563,623	8/1951	Scott	75—104
735,512	8/1903	Hirsching	75—101X
975,106	11/1910	Austin	75—101
3,260,593	7/1966	Zimmerly	75—117
3,330,650	7/1967	Zimmerly	75—117X

L. DEWAYNE RUTLEDGE, Primary Examiner

J. E. LEGRU, Assistant Examiner

U.S. Cl. X.R.

23—97, 125; 75—109, 117; 299—5