Title: IMPROVED HEAP LEACH

Abstract: An improved heap leach process for the bacterial heap leaching of base metal sulphide ores, the process characterised by the addition of elemental sulphur to the ore, whereby sulphur oxidising bacteria indigenous to, or added to, the ore may oxidise the elemental sulphur and generate heat within the ore heap.
“Improved Heap Leach”

Field of the Invention

The present invention relates to an improved heap leach. More particularly, the improved heap leach of the present invention is directed to the bacterial heap leaching of base metal sulphide ores.

Background Art

The extraction of metals from sulphide ores by use of bacteriologically assisted heap leaching has been demonstrated previously. The majority of the prior art processes involve the use of mesophilic bacteria, including Thiobacillus and Leptospirillum species. Such bacterial species generally operate in a temperature range of 20°C to 45°C (Peterson and Dickson, Thermophillic Heap Leaching of a Chalcopryite Concentrate, Minerals Engineering, 15 (2002), pages 777 to 785). However, the use of bacteriologically assisted heap leaching in the extraction of copper from chalcopryte ores is an exception. In such circumstances higher temperatures are required in order to achieve commercially acceptable leach kinetics. In either case, the success of the heap leaching operation is largely dependent upon the oxidation of sulphide minerals to elevate the temperature within the heap above ambient levels and to keep the temperature at those levels.

If the sulphide mineralisation of an ore is below a particular level, the amount of heat generated will be relatively small. Consequently, only a small elevation of the internal heap temperature would be achieved during leaching of that ore, this elevation possibly not being sufficient to result in an economically acceptable leach rate. One apparent remedy for any such short fall in heat generation is to supply heat to the heap from an external source. Such an external source might be the leach liquor that is conventionally applied to the top of the heap, or the air supply, which in some operations is blown into the base of the heap in order to promote the oxidation of sulphide minerals. Further, International Patent
Application PCT/ZA/00154 (WO 02/029124) discloses a means for supplying heat to a heap leach, the heat being generated externally of the heap in a bioreactor.

It should be apparent that if an ore contains a sulphide mineral that requires a temperature in excess of 45°C before it will begin to leach, such as chalcopyrite, then the above circumstance is exacerbated. Irrespective of the quantity of chalcopyrite present, if there is no other sulphide mineral present that will begin to oxidise at lower temperatures, the heap cannot autogenously be brought up to the required operating temperature. As a result, the heap will remain at ambient temperature without the addition of a significant quantity of heat to start the chalcopyrite oxidation reaction. After the injection of the necessary additional heat, if there is sufficient sulphide mineral present the reaction may become self-sustaining. In International Patent Application PCT/US99/28962 (WO 00/36168) there is disclosed a heap leach process in which the process liquor may be added to the top of the heap, requiring an external source of heat. Also, the heap is described as being heated by way of the pumping of steam or hot air through supply lines into the heap, again requiring an external source of heat. Still further, a complicated method for stacking heaps on top of an existing heat generating heap is also described, a process that may extend over several generations of heap.

It is one object of the present invention to overcome the abovementioned problems associated with the prior art, or to at least provide a useful alternative thereto.

The preceding discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was part of the common general knowledge in Australia or any country, region or territory as at the priority date of the application.

Throughout the specification, unless the context requires otherwise, the word “comprise” or variations such as “comprises” or “comprising”, will be understood
to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

**Disclosure of the Invention**

In accordance with the present invention there is provided an improved heap leach process for the bacterial heap leaching of base metal sulphide ores, the process characterised by the addition of elemental sulphur to the ore, whereby sulphur oxidising bacteria indigenous to, or added to, the ore may oxidise the elemental sulphur and generate heat within the ore heap.

Preferably, the elemental sulphur is either blended with the ore during agglomeration or added to the ore at another point prior to or during stacking of the heap. Further, the sulphur may also be added to the top of the ore heap subsequent to stacking, such that the leach liquor is heated as it passes through the layer or level of the heap that is actively oxidising sulphur.

Still preferably, the blending or addition of elemental sulphur to the ore provides between about 2 to 20% elemental sulphur to ore (w/w).

In accordance with the present invention there is further provided an improved heap leach process for the bacterial heap leaching of base metal sulphide ores containing a mineral or an assemblage of minerals that require temperatures of greater than 45°C for efficient oxidation of the or each mineral, the process characterised by the addition of elemental sulphur to the ore, whereby the elemental sulphur is oxidised at temperatures lower than about 45°C by mesophilic bacteria present in the ore heap, this oxidation of elemental sulphur generating heat and raising the internal temperature of the heap upwardly such that thermophilic bacteria can operate.

In one form of the present invention chalcopyrite comprises the predominant sulphide mineral in the ore.
Preferably, the blending or addition of elemental sulphur to the ore provides between about 2 to 20% elemental sulphur to ore (w/w).

Still preferably, the addition of elemental sulphur to a process for the bacterial heap leaching of base metal sulphide ores generates sulphuric acid through the oxidation of elemental sulphur, in addition to the generation of heat.

**Brief Description of the Drawings**

The improved heap leach process of the present invention will now be described, by way of example only, with reference to one embodiment thereof and the accompanying drawing, in which:-

Figure 1 is a schematic representation of a process for the bacterial heap leaching of base metal sulphide ores in accordance with the present invention.

**Best Mode(s) for Carrying Out the Invention**

In Figure 1 there is shown an improved heap leach process for the bacterial heap leaching of base metal sulphide ores in accordance with the present invention. A blending facility 10 is provided for the blending of a base metal sulphide ore containing chalcopyrite as the predominant sulphide mineral and an elemental sulphur. The amount of elemental sulphur to be added to the blend is calculated prior to blending so as to be sufficient to satisfy at least part of the heap requirement and/or the acid demand of the ore. Such decisions are typically made by those responsible for management of the heap leaching process.

It is to be understood that water, acid, bacteria, raffinate and other liquor streams associated with the metal recovery portion of an operating hydrometallurgical base metals recovery plant may also be utilised in the process of the present invention, as may additional reagents or chemicals.
The blended ore and elemental sulphur are then stacked to form a heap 20. The heap 20 is fitted with pipes to supply air and/or other gasses to the heap 20. Further, an irrigation system (not shown) is provided in or on the heap to allow liquor from a liquor pond 30 to be circulated therebetween.

A bacteria breeding facility 40, separate to the ore heap 20, is provided such that bacteria can be added to the ore. It is envisaged that the bacteria may be added to the ore prior to, during, or after blending with the elemental sulphur. Alternately, the bacteria may be added to the heap 20, before or after irrigation of the heap 20 has commenced.

During the process of the present invention mesophilic bacteria ("mesophiles") indigenous to the ore heap 20, or added to the ore heap 20 from the bacteria breeding facility 40, will begin the oxidation of elemental sulphur at temperatures of about 20°C, and possibly as low as 10°C. The oxidation reaction of elemental sulphur to form sulphate is exothermic, thereby releasing heat into the ore heap 20 and raising the temperature thereof. The increased temperature within the heap 20 resulting from the action of the mesophiles on the elemental sulphur increases the temperature within the heap 20 such that thermophilic bacteria begin to operate efficiently and oxidise the chalcopyrite within the ore heap 20. This provides a more efficient bacterial heap leach process with greater recoveries of base metal than might otherwise have been achieved without the addition of elemental sulphur to the ore heap 20.

Savings compared to processes of the prior art are also achieved with the process of the present invention with respect to the generation of sulphuric acid through the oxidation of elemental sulphur. This is particularly the case if the ore to be leached is an overall consumer of acid during the leaching process.

It is envisaged that blending of the elemental sulphur with the ore may be adequately achieved during agglomeration of the ore or might be added to the ore at another point prior to, or during stacking of the ore heap 20. In addition, the elemental sulphur might also be added directly to the top of the ore heap 20 subsequent to stacking, whereby the leach liquor would be heated as it passes
downwardly thorough the layer of the heap containing the elemental sulphur undergoing oxidation.

It is envisaged that the blending or addition of elemental sulphur to ore provides between about 2 to 20% elemental sulphur to ore (w/w).

The improved process of the present invention can be seen from the above description to embody several advantages when compared with prior art processes requiring heat generation externally of the ore heap, after which the heat is required to be passed to the heap, or the heating of the ore prior to stacking.

Modifications and variations such as would be apparent to the skilled addressee are considered to fall within the scope of the present invention.
Claims

1. An improved heap leach process for the bacterial heap leaching of base metal sulphide ores, the process characterised by the addition of elemental sulphur to the ore, whereby sulphur oxidising bacteria indigenous to, or added to, the ore may oxidise the elemental sulphur and generate heat within the ore heap.

2. A process according to claim 1, wherein the elemental sulphur is either blended with the ore during agglomeration or added to the ore at another point prior to or during stacking of the heap.

3. A process according to claim 1, wherein the sulphur is added to the top of the ore heap subsequent to stacking, such that the leach liquor is heated as it passes through the layer or level of the heap that is actively oxidising sulphur.

4. A process according to any one of claims 1 to 3, wherein the blending or addition of elemental sulphur to ore provides between about 2 to 20% elemental sulphur to ore (w/w).

5. An improved heap leach process for the bacterial heap leaching of base metal sulphide ores containing a mineral or an assemblage of minerals that require temperatures of greater than 45°C for efficient oxidation of the or each mineral, the process characterised by the addition of elemental sulphur to the ore, whereby the elemental sulphur is oxidised at temperatures lower than about 45°C by mesophilic bacteria present in the ore heap, this oxidation of elemental sulphur generating heat and raising the internal temperature of the heap upwardly such that thermophilic bacteria can operate.

6. A process according to claim 5, wherein chalcopyrite comprises the predominant sulphide mineral in the ore.
7. A process according to claim 5 or 6, wherein the blending or addition of elemental sulphur to ore provides between about 2 to 20% elemental sulphur to ore (w/w).

8. A process according to any one of the preceding claims, wherein the addition of elemental sulphur to a process for the bacterial heap leaching of base metal sulphide ores generates sulphuric acid through the oxidation of elemental sulphur, in addition to the generation of heat.

9. An improved heap leach process for the bacterial heap leaching of base metal sulphide ores substantially as hereinbefore described with reference to Figure 1.
Figure 1

- Sulphur
- Crushed Ore

Blending facility

Heap

Liquor Pond

Bacteria Breeding Facility

(10) (20) (30) (40)
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.?: C22B 3/18.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC?: C22B 3/18 WITH KEY WORDS INDICATED BELOW

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

DWPI: IPC C22B 3/18 with key words sulfur or sulphur

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>Page 4, lines 9-12; page 5, lines 12-20; page 8, lines 8-11; page 9, line 22- page 10, line 2; page 14, lines 3-12; page 15, lines 2-9; claims 5, 32, 33</td>
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Further documents are listed in the continuation of Box C

See patent family annex

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Form PCT/ISA/210 (second sheet) (January 2004)
This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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