Extracting copper from its ore

"Low-grade" ore is carefully poured on specially treated impermeable ground for ease, all in affect to later drain away the copper ion solution. Afterwards, the bacteria can then be sprayed, requiring acidic conditions involving a supply of Fe^{2+}/S^{2-} ions, carbon dioxide, oxygen, nitrogen and phosphorous containing nutrients. Furthermore, thiobacillius ferro-oxidans and thiobacillius thio-oxidans obtain the energy to survive/live by oxidising Fe^{2+}/S^{2-} ions; as a result they release the required metal ions into solution.[1]

The copper ion solution can then be drained, allowing the copper ions to be removed using the aid of another solvent in a ligand exchange reaction. The term "ligand" refers to a specific compound with a lone pair of electrons that binds with the metal compounds to form a complex.[2]
The ligand can be dissolved in an organic solvent such as kerosene, which is immiscible in water:

$$Cu^{2+}_{(aq)} + 2LH_{(organic)} \rightleftharpoons CuL_{2\,(organic)} + 2H^{+}_{(aq)}$$

Note: the "L" represents the ligand.

The copper can be removed from a low concentration in water to a high concentration in the organic solvent. By applying concentrated acid to the organic solvent, the process can be reversed; the Cu^{2+} ions return into the aqueous solution, thus increasing the concentration of the Cu^{2+} ions.

Passing an electric current through the copper ion solution enables the copper to be extracted in sheets; pure copper can be collected on the negative electrodes.

Extracting gold from its ore

Firstly, the gold is crushed and grinded to reduce the large particles to finer grains. Secondly, a cyanide solution is then mixed with the grains. The solution is then mixed with water, where air is circulated through; this engages the lighter particles to float to the top of the solution, this process is known as flotation. (The lighter particles are the gold containing particles – this is the metal that needs to be extracted). The water is then removed and recycled, where it forms thick slurry; bacterial oxidation only occurs once the slurry is mixed with water.
Note: the slurry contains the gold particles, which are maintained within a matrix of minerals. E.g. arsenopyrites.

The minerals are oxidised and made water soluble, leaving behind the insoluble gold particles. The oxidation reaction is carried out by sulpholobus acidocalderius in the presence of oxygen and water at a low pH.
Firstly, sulpholobus acidocalderius catalyses the formation of iron, arsenic and sulphur compounds:

$$FeAsS \longrightarrow Fe\,(II) + As\,(III) + S\,(VI)$$

Note: the arsenic and sulphur have been oxidised in this reaction.
Further oxidation of Fe (II) and As (III) then occurs:

$$Fe\,(II) \longrightarrow Fe\,(III)$$

$$\text{As (III)} \longrightarrow \text{As (V)}$$

Note: all products are water-soluble:

$$2FeAsS + 7O_2 + 4H^+ + 2H_2O \longrightarrow 2Fe^{3+} + 2H_3AsO_4 + 2HSO_4^-$$

Lastly, the gold remains solid after the separation from liquid and the pH is raised with the aid of lime; using the method of cyanidation, the gold can be extracted.[3]

Advantages and disadvantages of bacterial leaching

Bacterial leaching is environmentally friendly; bacterial-leaching solutions can be recycled. The water pollution problems that may result from acid mine drainage are difficult to clean up. Another advantage is that underground mining means that there are no environmental "eyesores", keeping the environment both clean and attractive.

Biologically, bacterial leaching is cheaper. However, due to the slow process, this suggests that it can be very expensive. The traditional method involved smelting ores at high temperatures and is a much faster process. However, the traditional method is an extensively polluting and energy demanding process.

Bacterial leaching is used only as a secondary extraction process for copper simply for the fact that it is not yet possible to be performed on a large scale. Other reasons suggest that it is an extremely slow process. Leaching is used as a primary extraction process for gold because it proved to be a cost-effective method, as it recovers almost all the gold.

The developments of a new process

Firstly, it must be considered where the particular ore is situated; the ore must be within reasonable grounds for access to by workers or other people with authority. Also, a healthy supply of transport will need to be required. E. g. by train, road or rail links.

Secondly, the demand for the product must be fairly high, otherwise there would be no point in extracting the ore and therefore no profit would be made, thus this would probably lead towards debt. Referring back to the initial location of the ore, the site of the plant must be in within a reasonable range to a specific market. If however, the plant were not near to a market, the cost of transporting the goods would be very expensive; again less profit would be made.

Lastly, the effect of setting up a plant will increase employment and may attract people to the site. However, this can also have its disadvantages; if the plant were to be set up near a quiet country-side village, conflict will be made as some of the local residents may complain of noise discomfort, pollution etc…

Summary of development stages that a new mining process must pass before commercially operating

A chemist must first discover and invent a new process in the lab. After which, a test scheme can be set up to see how successful the idea actually is. Then, the cost of the operation must be taken into account; only then will the procedure commence once all the targets are met.

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