Copper Mining and Extraction: Oxide Ores

Copper is refined from ores in the ground, either through underground or open-pit mines. Most of the copper ores mined today are oxide or sulfide ores. Extraction of sulfide ores is covered in more detail in Copper Mining and Extraction: Sulfide Ores (11–14), but is introduced here because an important by-product of this process is used for the extraction of oxide ores. Below are different sections of this e-source, for quick navigation.

Click here for extension material on copper reserves

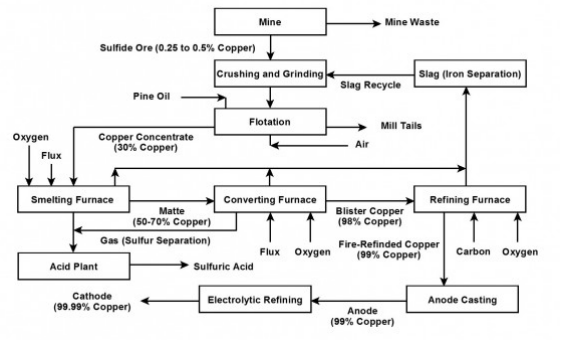
Did You Know?

Of the 550 million tonnes of copper produced since 1900, it is estimated that two-thirds is still in productive use.

Pyroprocessing Sulfide Ores Provides Acid for Leaching

The process used to treat sulfide copper ores begins at the mine site, where the copper-bearing minerals are physically separated from the rest of the rock. The flow diagram below shows how the percentage of copper increases as the ore is refined, first physically by froth flotation, then chemically by smelting and finally electrolytic refining. The smelting stage gives the name pyroprocessing: processing by fire.

A by-product of the smelting and converting furnaces is sulfuric acid. In what looks like a lucky coincidence, sulfuric acid is needed to treat oxide ores in processes called leaching and SX-EW (Solvent Extraction - Electrowinning). The acid would have to be made anyway as it would be environmentally unacceptable to release sulfur dioxide gas into the atmosphere.



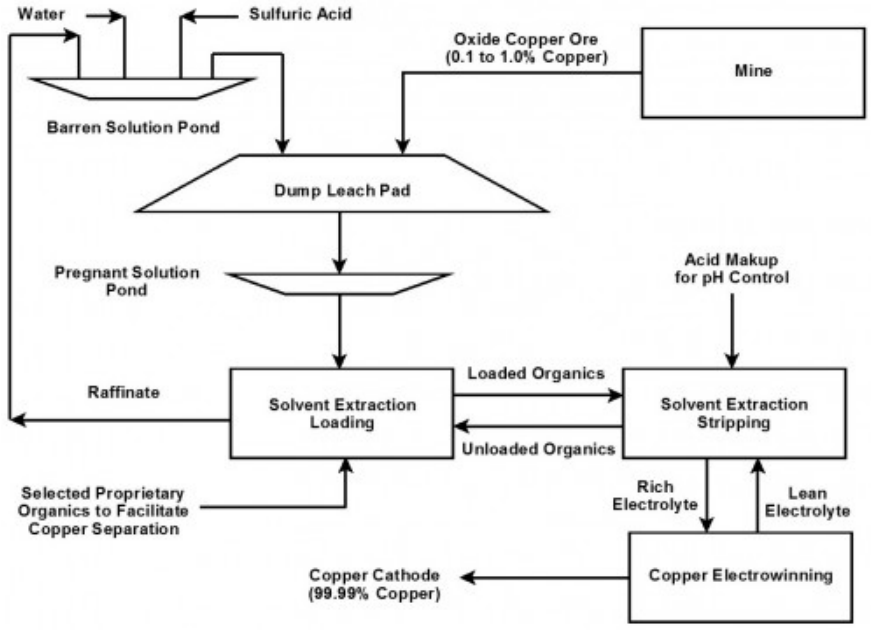
Click here to enlarge

The smelter for sulfide ores produces sulfur dioxide gas. This is scrubbed from the flue gases to make sulfuric acid for leaching copper from oxide ores. Scrubbing sulfur dioxide also protects the environment. (Courtesy of Xstrata.)

Leaching Oxide Ores with Sulfuric Acid

The flowchart above shows how the smelting process of sulfide ores produces sulfur dioxide, which is converted to sulfuric acid.

The chart below shows how acid is used to leach out copper ions creating lakes of blue copper sulfate solution from which copper is recovered in a solvent and then electrolytically refined in a process called solvent extraction and electrowinning (SX-EW).



This chart shows how sulfuric acid is used to extract copper. The main difference between this and the 'pyroprocessing' of sulfide ores is that no heat is used.

The pictures on the right show the process sequence.

1. Crushed ore is carefully dumped into a leakproof lined valley created in an open pit mine.

2. Dilute sulfuric acid is poured over the crushed ore using an irrigation system.

3. Copper sulfate solution is collected in the pregnant leach pond then pumped to the solvent extraction plant. The solvent extraction phase of treatment occurs in two stages. During the initial phase an organic solvent is used to recover copper ions contained in the pregnant leach solution, exchanging them with hydrogen ions in the acid. The final phase of the solvent extraction process employs a strong acid to strip the copper from

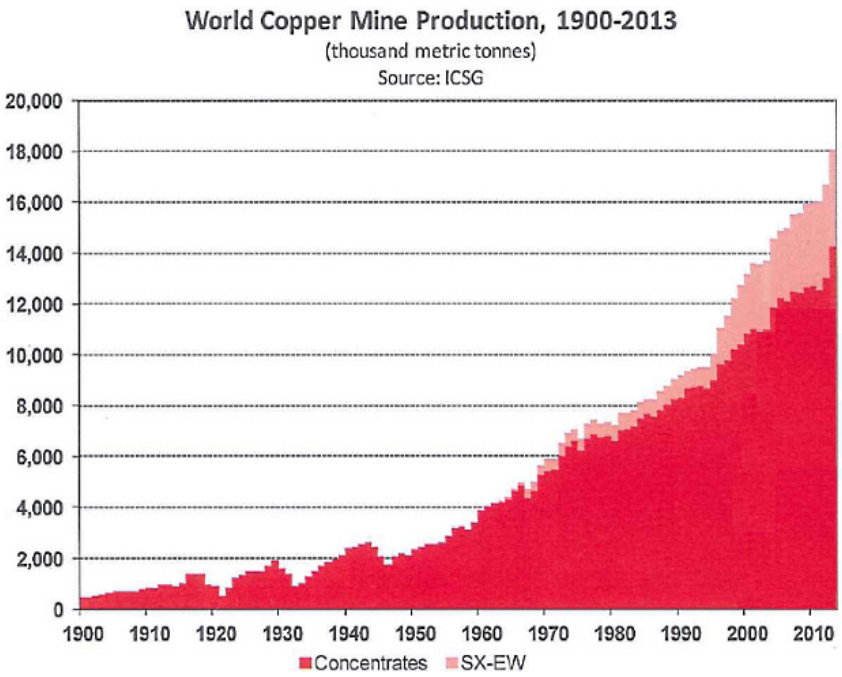
Crushed ore in the leach pad. The pregnant leach pond is in the distance. The crushed ore rests on a leak-proof membrane to protect the underlying ground and prevent the acid and copper ions polluting the local water table.

The pregnant leach pond contains copper ions that give it the blue colour of copper sulfate. The liquid is continually pumped to the SX-EW plant. (Courtesy of Red Tiger Mining Inc.)

After solvent extraction using organic solvents, the copper ions are stripped from the solution with a strong acid and leave a blue solution with a high copper content. This is called the 'rich electrolyte'. (Courtesy of Red Tiger Mining Inc.)

the organic solution, producing a blue, enriched copper-bearing solution that is treated at an electrowinning plant.

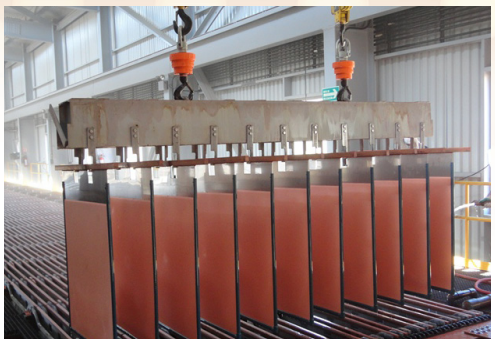
4. The electrowinning plant uses electrolysis to collect copper onto steel cathodes. Inert lead anodes are used. These do not take part in the electrolysis except to complete the electrical circuit.



Solvent Extraction and Electrowinning (SX-EW) production, virtually non-existent before the 1960s, reached nearly 3.8 million tonnes of copper in 2013. (Courtesy of ICSG.)

One of the biggest advantages of using leaching is that low grade ores that would be uneconomic to smelt become economic to leach. This is largely due to the much lower energy costs of leaching and also to the lower capital and employment costs of the process.

It's important to note that the graph above shows total copper production from primary sources. Recycling of scrap components and process scrap (secondary sources) helps to meet 35% of global demand for copper, conserving resources.



Stainless steel cathodes become coated in copper during the electrowinning process.

Copper is stripped from the steel cathode plates when it is thick enough. This cathode copper is 99.99% pure.

Questions

1. **Why can the electrolytic refining (electrowinning) be done without the use of copper anodes?**

2. **In electrolytic refining of anode copper from sulfide ores, small amounts of impurities from the anode form a sludge containing precious metals. In SX-EW there is no sludge. Explain why.**

Click here for answers

Go to extension material on copper reserves

Copper Development Association is a non-profit organisation that provides information on copper's properties and applications, its essentiality for health, quality of life and its role in technology. It supports education through a collection of resources spanning biology, chemistry and physics. These materials have been developed in conjunction with the Association for Science Education, and reviewed by teachers.

For more resources, visit www.copperalliance.org.uk/education.

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