INNOVATIVE ECO-EFFICIENT BIOHYDROMETALLURGICAL PROCESSES FOR THE RECOVERY OF STRATEGIC AND RARE METALS FROM PRIMARY AND SECONDARY RESOURCES

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The conventional pyrometallurgical route for winning of metals is increasingly confronted with a number of challenges which include the necessity to exploit more complex and deeper deposits, arsenic containing deposits, increased demands to protect the environment, and to use less energy. Biohydrometallurgical processes have been shown to be a good alternative for the winning of metals from poor and complex ores. On large scale they are performed mainly for the oxidative dissolution of sulfidic copper ores, but processes have also been developed for winning of zinc or cobalt from sulfidic ores, as well as for the biooxidation of gold ores. Due to the strategic importance of biohydrometallurgical processes TU Bergakademie Freiberg with support by the Dr. Erich Krüger Foundation in 2013 established the Biohydrometallurgical Center Freiberg (BHMZ).

The major focus of the BHMZ is on the winning of indium from sphalerite (ZnS) in regional ores. After initial experiments in batch cultures (shake flaks and bioreactors), currently a continuous leaching in a three-step bioreactor system is established. A moderately thermophlic mixed culture comprising *Leptospirillum ferriphilum*, *Acidithiobacllus caldus* and *Sulfobacillus thermosulfidooxidans* is being used, and efforts are directed at lowering the hydraulic retention times.

At the deposit Pöhla-Hämmerlein a sphalerite associated with chalcopyrite is especially rich in indium. Chalcopyrite so far usually is poorly bioleached, but can be chemically leached by high chloride concentration. Usually chloride is inhibitory for acidophilic iron-oxidizing bacteria. Therefore attempts are made to obtain chloride-tolerating iron-oxidizing bacteria and to use them for bioleaching of chalcopyrite and other ores.

In the longer run the most elegant way of winning metals from poor ores may be *in situ*-bioleaching. To investigate this approach in more detail, an experimental site for *in situ*-bioleaching was established in the research and teaching mine “Reiche Zeche”. Here also, besides zinc, indium despite of its low concentration is the main valuable metal Using several methods, the permeability of the rock is increased by hydraulic stimulation and explosions.

Many ores in the ore omountain region contain arsenic, e.g. as arsenopyrite or tennantite. A special case is represented by the BiCoNi ores which contain cobalt and nickel in the the form of skutterudite ($CoAs_3$ or $NiAs_3$). Experiments are being performed to leach the metals from the BiCoNi ores.

In the “Theisen sludge” project bioleaching is performed on a secondary resource which resulted from dusts of copper smelters processing black-shale ores. This sludge contains a number of valuable metals. While these metals can be leached to a considerable extent, it was so far not possible to establish a selective leaching using set redox potential.

Key words: Indium, Cobalt, Continuous bioreactor leaching, *In situ*-bioleaching, Arsenides, Theisen sludge