Imperial College London

Natural Environment Research Council

2023_35_ESE_Jackson: Electrokinetic enhanced in-situ resource utilisation (EK-ISRU) for green copper production

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Copper is an essential raw material for the energy transition, with demand predicted to increase by 7% per annum. Historically, copper has been extracted by mining the ore and then separating it from the gangue material. This creates large volumes of geological waste with attendant environmental and safety risks, as well as massive energy requirements.

In-situ resource utilisation (ISRU) is an alternative to mining and involves pumping a solvent (a lixiviant) through the ore body to leach and extract the metals via boreholes. ISRU can significantly reduce the environmental impacts and energy demands of mining. However, major challenges remain to widespread uptake of ISRU for copper, including the identification of suitable lixiviants, presence of flowpaths (permeability) within the ore-body, control of lixiviant flow in the subsurface, avoidance of leakage and associated contamination of the surrounding environment, and reduction or elimination of mineral passivation (deposition of new minerals that isolate the ore minerals from the lixiviant).

Electrokinetic-enhanced in-situ resource utilisation (EK-ISRU) has recently been proposed for copper production. EK is the application of an electrical field to mobilize charged species in the lixiviant and is widely used in remediation of contaminated soils and rocks. EK promotes the transport of charged species, including metals, even through low permeability ore bodies, and offers control of lixiviant flow. However, 'proof-of-concept' results have only recently been reported and numerous questions remain concerning the choice of lixiviant for a given ore type, the optimum application of EK, the environmental impacts of this emerging technology, and scaling from laboratory experiments to practical deployment.

The broad aim of this project is to address these key research questions through a combination of laboratory experiments and numerical modelling. The results will support significant expansion of EK-ISRU for green mining of copper. Experiments will leverage our extensive experience of EK in the NORMS Laboratory for Reservoir Physics, and of the Advanced Mineral Processing Research Group (AMPRG)'s experience in XMT based tracking of mineral grain dissolution for studying heap leaching. Numerical modelling will leverage existing code for simulating coupled flow and EK, implemented in the open-source Imperial College Finite Element Reservoir Simulator (IC-FERST). This will be complemented by the mineral dissolution and mass and heat transport models developed for heap leach simulation by the AMPRG. In addition, EK-ISRU will be screened for environmental hotspots by performing a prospective life cycle assessment.

Applicants should hold a degree in an appropriate subject (e.g. earth science, physics, mathematics or engineering). The project will involve interactions with other research groups within and beyond ESE, including key mining industry partners. We anticipate additional financial support and a 3 month internship with an industry partner . Skills developed during this project will include advanced experimental and numerical modelling methods, with extensive training provided.