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A NUMERICAL STUDY OF ION/FLUID FLOW IN CHALCOPYRITE WITH APPLICATION TO ELECTROKINETIC IN SITU RECOVERY

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ABSTRACT

Alternative modern approaches to conventional mining are driven by the need for more sustainable exploitation schemes with the aim of increasing the recovery of metals and reducing the environmental footprint. In-situ recovery (ISR) represents an unconventional mining technique, where a lixiviant is injected sub-surface to recover valuable minerals without mining the ore body. However, fluid transport is limited to a few preferential flow paths due to the low permeability of the ore deposits, which results in limited mineral–lixiviant interactions.

Electrokinetic in-situ recovery (EK-ISR) presents the application of an electric field to enhance the flow of ions. The key transport processes for EK-ISR are fluid/ion flow and mineral reaction in fractured ore. Previous studies of EK-ISR techniques have been limited to experimental studies and numerical simulations in 1D. Here we present a 3D image-based numerical model to characterize the fundamental ion/fluid transfer behaviour and its interaction with a charged mineral surface. A Lattice–Boltzmann–Poisson Method (LBPM) solver was utilised to simulate the electrical field distribution of the electrical double layer and the electroosmotic flow in porous media. COMSOL Multiphysics was used to validate our model in a charged micro-channel. X-ray micro-computed tomography scanning (micro-CT) was applied to image a copper-bearing synthetic sample, which was then segmented into chalcopyrite, quartz, and pores. LBPM was used to model EK transport in the reconstructed geometry. Good agreement was obtained for a range of parameters (surface charge density, external voltage, distance between two plates) for validation against the COMSOL results.

Because LBPM is built for simulation on image-based porous systems, its application is more advantageous than COMSOL, where a simplification of the rock geometry is required. Simulation results on a 3D copper-bearing synthetic sample showed that, with an external electrical field and charged minerals, ions and fluid move through the pores and anions/cations are attracted to the mineral surface, which is beneficial to the reaction process. The ion concentration is a key factor that controls the electroosmotic flow due to its relationship with the Debye length of the electrical double layer and the pH of the domain. This process suggests the feasible application of this new mining approach for the recovery of metals from minerals.

Keywords: Electrokinetic in-situ recovery, Ion transfer, Electrical field, Micro-CT imaging, Digital imaging processing