



Contribution ID: 288

Type: Oral Presentation

Copper leaching in low-grade ore: A reactive-transport modelling study revealing controls on local reactions on mineral surfaces

Thursday, 2 June 2022 09:25 (15 minutes)

The global copper demand is rapidly increasing with the electrification of the energy sector, requiring new ore deposit discoveries and more efficient copper recovery. Copper leaching occurs in piles of low-grade ore aggregate also known as heaps, which typically contain 2-5% copper mostly associated with the mineral chalcopyrite (CuFeS_2). The reagent for the dissolution of chalcopyrite is sulfuric acid with variable and complex ionic composition. Predicting and optimising the rate of chalcopyrite dissolution in heaps is complex because of a number of conditions including the following:

- Two competing reactions lead to the dissolution of chalcopyrite (Kimball et al., 2010): proton-promoted dissolution and ferric iron-promoted dissolution, where the latter requires iron oxidation in solution to maintain high ferric iron concentrations.
- Chalcopyrite is mostly surrounded by microporous gangue minerals such as quartz and not directly exposed to the reagent.
- Chalcopyrite is mostly surrounded by microporous gangue minerals such as quartz and not directly exposed to the reagent.
- Secondary minerals, mainly jarosite ($(\text{K,Na})\text{Fe}_3(\text{SO}_4)_2(\text{OH})_6$), can form on the chalcopyrite surface leading to surface passivation.

In order to better understand the controls on copper dissolution at the surface of chalcopyrite, we developed a combined pore- and continuum-scale reactive-transport model for a single grain of chalcopyrite surrounded by gangue mineral (quartz). The model was developed in iCP, where COMSOL is coupled to PhreeqC (Jyoti and Haese, 2021). Micro-porosity was assigned to the gangue mineral layer, while the chalcopyrite surface layer was resolved at pore-scale allowing us to determine local reaction rates of chalcopyrite dissolution and potential jarosite precipitation and associated changes in the solid phase at the mineral surface. Ferrous iron oxidation by oxygen in the aqueous phase was enabled. All reactions were kinetically controlled. The inflow composition, flow velocity, porosity of the gangue mineral and the thickness of the gangue mineral layer were varied in simulations to constrain the main controls on reactions at the mineral surface. We wanted to understand which dissolution reaction mechanism dominates under given conditions, whether the dissolution reaction is rate- or transport-limited and what conditions lead to surface passivation. The dissolution was simulated using injection fluids with a pH 1 and 2 and with $\text{Fe}^{3+}(\text{aq})$ concentrations between 0.1M and 0.01M. To understand the role of physical effects, the radius ratio of the chalcopyrite to quartz grains were varied between 1:2 to 1:4 and the flow velocity varied between $1.2\text{e-}6$ and $1.2\text{e-}4 \text{ m s}^{-1}$.

Initial results indicate an increase in copper recovery with increasing ferric iron concentration and decreasing pH. The dominant chalcopyrite dissolution mechanism is the ferric iron promoted reaction, except for a case with a pH of 1 and a very low (0.01 M) $\text{Fe}^{3+}(\text{aq})$ concentration where proton promoted dissolution dominates. The copper recovery increased by about 50% for a radius ratio of 1:4 relative to a 1:2 ratio. Finally, the highest copper recovery was attained with the slowest injection fluid velocity of $1.2\text{e-}6 \text{ m s}^{-1}$, with concentrations measuring two orders of magnitude higher than with the fastest fluid velocity of $1.2\text{e-}4 \text{ m s}^{-1}$.

Acceptance of the Terms & Conditions

[Click here to agree](#)

MDPI Energies Student Poster Award

No, do not submit my presentation for the student posters award.

Country

Australia

References

Kimball, B.E., Rimstidt, J.D., Brantley, S.L., 2010. Chalcopyrite dissolution rate laws. Appl. Geochemistry 25, 972–983, doi.org/10.1016/j.apgeochem.2010.03.010

Jyoti A. and Haese R.R., 2021, Validation of a multi-component reactive-transport model at pore scale based on the coupling of COMSOL and PhreeqC. Computers and Geosciences 156, doi.org/10.1016/j.cageo.2021.104870.

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Unsure

Primary authors: Prof. HAESE, Ralf R. (School of Geography, Earth and Atmospheric Sciences, The University of Melbourne); Mr ANSAH, Eric O. (School of Geography, Earth and Atmospheric Sciences, The University of Melbourne); Dr JAY R., Black (School of Geography, Earth and Atmospheric Sciences, The University of Melbourne); Dr JYOTI, Apoorv (School of Geography, Earth and Atmospheric Sciences, The University of Melbourne)

Presenter: Prof. HAESE, Ralf R. (School of Geography, Earth and Atmospheric Sciences, The University of Melbourne)

Session Classification: MS09

Track Classification: (MS09) Pore-scale modelling