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Reactive transport modelling of ore formation in sedimentary basins: non-isothermal compressible fluid flow

Sediment-hosted ore deposits are major resources for base metals like Zn, Pb and Cu. These deposits form by basin-scale flow of hydrothermal fluids through permeable aquifers and fault structures, incorporating metals from source rocks and transporting them to a deposition site where metals precipitate as sulfide minerals due to fluid reduction and/or fluid mixing. Metal enrichment in hydrothermal systems requires favorable combinations of chemical and physical processes on different temporal and spatial scales. Numerical models can help to identify first-order controls on ore formation and quantify the potential to generate world-class deposits. The aim of this project is to further develop and apply a reactive transport model for the formation of Zn-Pb deposits in sedimentary basins, using fluid flow modelling (CSMP++) coupled with geochemical modelling (GEMS3). The fully coupled numerical model will be able to 1) capture the interplay between the chemical and physical processes relevant for metal mobilization, transport and precipitation, and 2) constrain the temporal and spatial scales required for metal enrichment to economic grades. Geodynamic modeling results of continental rifting and basin formation (Glerum et al., 2024) will eventually inform the model setup to incorporate larger-scale geodynamic controls as well.

The subproject presented here focusses on the numerical representation of non-isothermal compressible fluid flow with CSMP++ within the coupled reactive transport model. In a first step, we developed simplified hydrothermal systems as 1D- and 2D-simulations with basin-scale heat flux and fluid flow based on idealized benchmark simulations (Weis et al., 2014). First tests used existing proxies for the temperature- and salinity-dependent solubility of Cu, Pb and Zn in the ore fluid from Stoltnow et al. (2023). In a second step, we added the full chemistry calculations by coupling with GEMS3 (Yapparova et al., 2017). We will present preliminary simulations capturing non-isothermal compressible fluid flow and fluid-rock interactions.

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Yapparova, A., Gabellone, T., Whitaker, F., Kulik, D. A., and Matthäi, S. K. (2017): Reactive Transport Modelling of Dolomitisation Using the New CSMP++GEM Coupled Code: Governing Equations, Solution Method and Benchmarking Results. Transport in Porous Media, 117(3).

Author: Ms PIMENTA, Julia (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany and Institute of Geosciences, University of Potsdam, Germany)

Co-authors: Dr GLERUM, Anne (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany); Dr WEIS, Philipp (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany and Institute of Geosciences, University of Potsdam, Germany)

Presenter: Ms PIMENTA, Julia (GFZ Helmholtz Centre for Geosciences, Potsdam, Germany and Institute of Geosciences, University of Potsdam, Germany)