A-129

Numerical Simulation of Bio-Geo-Reactive Transport during UHS - A Modelling Approach

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The increased share of renewable energy sources leads to larger fluctuations of energy availability but also increases the significance of energy storage. Large scale hydrogen storage in the subsurface may hence become a vital element of a future sustainable energy system because stored hydrogen is an energy carrier that will be available on demand. Large capacities of hydrogen can be stored in porous formations such as former gas fields or gas storages, while caverns will contribute with high deliverability. However, the storage of hydrogen induces unique processes on fluid-fluid and rock-fluid interactions (for example, bio- and geochemical reactions), which may affect the efficiency of the storage.
In the present study, a numerical model describing the two-phase multi-component flow in porous media, including bio- and geochemical reactions, is developed. The proposed model extends an existing model in the open-source simulator DuMu^x describing the bio-reactive transport process considering methanogenesis and sulfate-reduction by geochemical reactions. Based on the kinetical formulation, the hydrogen-driven reduction of pyrite to pyrrhotite with the production of harmful hydrogen sulfide is modelled. Due to limited literature data, a simplified model describing the conversion process is used, and artificial rates are defined. Preliminary simulations on a semiartificial geological model show the potential hydrogen consumption and consequently lead to a reduced withdrawal of stored hydrogen. Furthermore, changes in mineral composition can be observed, though with a minor impact on the petrophysical parameters.
Within the scope of the study, the established numerical model is validated and improved by accompanying laboratory experiments to assess the risk of hydrogen conversion during UHS. Finally, field scale simulations with actual field data are planned to be conducted.