Simulations of chemical processes during high-temperature aquifer thermal energy storage

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The Forsthaus Heat Storage project aims for an underground thermal energy storage site (UTES) at Bern, Switzerland where waste heat from various surface sources (e.g. municipal waste incinerators) is stored during the summer and recovered and fed into the district heating network during the winter months. The project, which is currently still in the planning stage, is part of the Swiss contribution to the European GEOTHERMICA-Heatstore project.

The target reservoir of the UTES project is the Lower Freshwater Molasse (USM), a stratigraphic sequence of the Swiss Molasse Basin. At Bern the USM is about 350 m thick and overlain by 150 m of Quaternary unconsolidated sediments. The reservoir rock consists of porous, permeable sandstone layers embedded in a low-permeability matrix composed of marl- and mudstone. The permeable sandstone layers constitute the aquifer, i.e. the target for fluid injection and extraction, while heat will be stored within the entire rock sequence.

As part of the planning phase we developed reactive transport models to assess the type of mineral reactions and ensuing porosity and permeability changes of the aquifer material expected to occur after repeated injection and extraction cycles. Furthermore, the models were used to explore the composition and the amount of mineral scales that may form in surface installations. Preliminary results suggest that as the reservoir temperature increases over time, the overall reactivity between the injected fluid and the aquifer rock decreases and chemical processes tend to approach a steady state. Porosity and permeability changes due to mineral dissolution and precipitation reactions are small and do not affect injectivity. Solids precipitating as scales in the surface installation are dependent on the composition of the aquifer rock. In the system at Bern, scales are dominated by carbonate minerals, silica and clay minerals constitute accessories.

As more constraints become available, the model will be updated and used to guide development of the site and to help predict the long-term behaviour of the reservoir.

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