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A novel method for thermo-hydro-chemical models for Aquifer Thermal Energy Storage

Rubén Vidal[1] and Maarten W Saaltink[1,2]
[1]Universitat Politècnica de Catalunya, Civil and Environmental Engineering, Spain (ruben.vidal.montes@upc.edu)
[2]Associated Unit: Hydrogeology Group (UPC-CSIC), Barcelona, Spain

Aquifer Thermal Energy Storage (ATES) is a technology that injects heat into aquifers during low energy demand and extracts it during high demand. ATES generates variation of temperature in the underground that can lead to chemical reactions. These reactions can affect the efficiency of ATES and modify the groundwater chemistry and the properties of soils and rocks. We present a novel method that allows calculation of complex numerical models and understanding the thermo-hydro-chemical processes in ATES in a simple way. Aqueous and mineral reactions must be assumed in equilibrium. The method decouples the chemistry from the thermo-hydraulic processes. The chemical part of the method consists of chemical batch calculations in which minerals dissolve/precipitate and water chemistry varies as a result of changing temperature. The thermo-hydraulic part consists of calculating temperature and spatial and temporal derivatives of temperature. From this, chemical composition of groundwater and precipitation/dissolution rates of minerals can be calculated straightforwardly.

We have applied the method to a HEATSTORE benchmark case, which is inspired by an ATES pilot project located in Bern, Switzerland. We used PHREEQC for the chemical calculations and for the thermo-hydraulic modelling we used the finite element code CODE_BRIGHT. The results permit us to understand better the reactive transport processes in the aquifer (which we divided into mixing, heat retardation and heat conduction), changes in the porosity of the rocks and the precipitation and dissolution of minerals.

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