

Fluid-matrix interactions during high-temperature aquifer storage - lab experiments and modelling

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High-temperature aquifer storage is a promising extension to combined heat and power plants because it allows to store excess heat during the summer months and to recuperate the heat in winter when the heat demand exceeds the production. Within a research project funded by the Bavarian State Ministry for Economic Affairs and Media, Energy and Technology and the BMW Group, a pilot scale test was run at the Dingolfing site (Bavaria, Germany) in 2014. Field data and an a priori numerical model suggest dissolution and precipitation of the processes in the calcareous aquifer. In order to quantify the reaction kinetics, lab experiments were run in an autoclave. The experimental results were used to setup and calibrate a numerical hydrogeochemical model based on PhreeqC.

Laboratory experiments were performed in a closed system with respect to CO₂ and under pre-defined conditions using a high temperature autoclave. Within the dissolution test series original core samples of different depth were heated up with ultrapure water in defined heating cycles up to 110 °C and at defined pressure. For combined dissolution and precipitation processes, tap water from Munich was used. The gas phase was equilibrated with CO₂ regarding the pCO₂ of tap water. Five water samples were taken for each heating cycle and analyzed by ion chromatography to quantify the calcium/magnesium concentrations and ratio. Additionally the sorption properties of the core materials were tested with respect to the fluorescent dyes used in the field tests.

The starting point to model the fluid matrix interactions was literature data of dolomite and calcite rates, which were integrated in the conceptional model. While the model results matched the experimentally determined concentrations nicely, there was a discrepancy with respect to the effective surface areas, which is likely due to impurities of the natural rock materials. The model was able to describe the minor precipitation of calcite during the dissolution of dolomite, which was observed in the experiments qualitatively.