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Fracture characterization in a deep geothermal reservoir

Wolfram Rühaak, Vera Hehn, Alireza Hassanzadegan, and Torsten Tischner
Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany (wolfram.ruehaak@bgr.de)

At the geothermal research drilling Horstberg in North West Germany studies for the characterization of a vertical fracture are performed. The fracture was created by a massive hydraulic stimulation in 2003 in approx. 3700 m depth within rocks of the middle Buntsandstein. The fracture surface is in the order of 100,000 m^2, depending on the flow rate at which water is injected. Besides hydraulic characterization, multiple tracer tests are planned. At the depth of interest the reservoir temperature is around 150 °C, pressure is around 600 bar (60 MPa) and due to salinity the water density is around 1200 kg/m^3.
Knowledge of tracer stability and behavior at these reservoir conditions is limited. Additionally, the planned tracer tests will be performed within one single borehole. In a closed cycle water is injected into the inner pipe of the well (tubing), which is separated by a permanent packer from the outer pipe (annulus). The water is produced back from the annulus approximately 150 m above the injection point. Thus, the circulation of thermal water between two sandstone layers via an artificial fracture can be achieved. Tests will be carried out with different flow rates and accordingly with different pressures, resulting in different fracture areas. Due to this test setup tracer signals will be stacked and will remain for a longer time in the fracture – which is the reason why different tracers are required. For an optimal characterization both conservative and reactive tracers will be used and different injection methods (continuous, instantaneous and pulsed) will be applied.
For a proper setup of the tracer test numerical modelling studies are performed in advance. The relevant thermal, hydraulic and chemical processes (mainly adsorption and degredation) are coupled, resulting in a THC model; additionally the dependence of fracture aperture and area on fluid pressure has to be considered. Instead of applying a mechanically coupled model (THMC) a simplified approach is applied which takes the pressure dependence of the fracture permeability into account by using constitutive relations.
Results of this modeling study will be presented together with details of the planned field study.