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Static and dynamic modeling for assessment of freshwater salinisation by CO_2 storage

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Present scientific research activities addressing geological CO_2 storage highlight upward brine migration as potential endangerment for freshwater aquifers. The processes at the salt- and freshwater boundary are in general not well understood. Taking into account the pressure elevation resulting from a CO_2 storage operation, the knowledge of these processes becomes even more important.

Within the scope of the present study, we implemented a static geological model of a prospective CO_2 storage site located in the Northeastern German Basin. It was previously explored by a few wells and 2D seismics. Further investigations using 3D seismics as well as additional exploration wells are scheduled. Furthermore, we applied large-scale coupled numerical multi-phase multi-component (CO_2, water and salt) simulations on a high performance computing cluster system to identify the impact of pressure elevation on brine migration for a specific CO_2 storage reservoir.

The prospective CO_2 storage site is characterized by saline aquifers very likely suitable for CO_2 storage. These are located in a classical anticline structure originating from salt tectonic processes. In total, three sand stone formations situated in the Middle Bunter were identified as potential CO_2 storage formations at depths between about 1,050 (reservoir top) and 1,500 m (spill point) with a cumulative thickness of about 60 m. In addition to the 180 m thick Upper Bunter cap rock mainly consisting of anhydrite, salt, clay and silt stones, each of the target storage formations provides a cap rock composed of clay and silt stones with average thicknesses of 30 to 60 m. Potentially endangered freshwater reservoirs are located in the Quarternary and Tertiary, whereas the saline to freshwater boundary is determined at a depth of about 220 m. The area investigated in the numerical simulations has a size of about 41 x 41 km^2 and is confined by fault systems in the southwest and northeast. About 1.7 million metric tonnes of CO_2 per year are scheduled for injection starting in 2015.

Our first numerical simulation studies aimed at the sensitivities of pressure elevation in the target CO_2 storage formations with regard to the conductivity of the adjacent fault systems as well as reservoir properties such as porosity, permeability and relative permeabilities. Furthermore, we investigated the utilization of reservoir pressure management based on brine production from the target storage formations. For this purpose, sensitivities of reservoir pressure development based on different brine production rates applied at two wells situated at the flanks of the anticline (each in a distance of about 6 to 7 km of the injection well) were evaluated. As a result, we determined spatial and time-dependent distributions of the displaced brine as well as reservoir pressure development during the computation of several migration scenarios involving the identification of brine migration paths such as hydraulic conductivities in the cap rocks (crack and fissure systems) as well as hydraulic conductive fault systems.

Further numerical simulations aim at the coupling of our multi-phase multi-component simulations with a geomechanical simulator to evaluate the generation of cracks in the cap rocks as well as the reactivation of faults with regard to the reservoir pressure. Based on these results a sustainable injection strategy will be elaborated.