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Verification of geomechanical integrity and prediction of long-term mineral trapping for the Ketzin CO_2 storage pilot site

Thomas Kempka, Marco De Lucia, and Michael Kühn
GFZ German Research Centre for Geosciences, Hydrogeology, Potsdam, Germany (kempka@gfz-potsdam.de)

Static and dynamic numerical modelling generally accompany the entire CO_2 storage site life cycle. Thereto, it is required to match the employed models with field observations on a regular basis in order to predict future site behaviour. We investigated the coupled processes at the Ketzin CO_2 storage pilot site [1] using a model coupling concept focusing on the temporal relevance of processes involved (hydraulic, chemical and mechanical) at given time-scales (site operation, abandonment and long-term stabilization). For that purpose, long-term dynamic multi-phase flow simulations [2], [3] established the basis for all simulations discussed in the following. Hereby, pressure changes resulting in geomechanical effects are largest during site operation, whereas geochemical reactions are governed by slow kinetics resulting in a long-term stabilization.

To account for mechanical integrity, which may be mainly affected during site operation, we incorporated a regional-scale coupled hydro-mechanical model. Our simulation results show maximum ground surface displacements of about 4 mm, whereas shear and tensile failure are not observed. Consequently, the CO_2 storage operation at the Ketzin pilot site does not compromise reservoir, caprock and fault integrity.

Chemical processes responsible for mineral trapping are expected to mainly occur during long-term stabilization at the Ketzin pilot site [4]. Hence, our previous assessment [3] was extended by integrating two long-term mineral trapping scenarios. Thereby, mineral trapping contributes to the trapping mechanisms with 11.7 % after 16,000 years of simulation in our conservative and with 30.9 % in our maximum reactivity scenarios. Dynamic flow simulations indicate that only 0.2 % of the CO_2 injected (about 67,270 t CO_2 in total) is in gaseous state, but structurally trapped after 16,000 years. Depending on the studied long-term scenario, CO_2 dissolution is the dominating trapping mechanism with 68.9 % and 88.1 %, respectively.

We verified the mechanical integrity of the storage system during site operation and predicted the trapping mechanisms for the Ketzin pilot site based on a time-dependent integration of relevant processes for a time period of 16,000 years. Supported by our coupled modelling results, we conclude that CO_2 storage at the Ketzin site is safe and reliable on the pilot scale.

References

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