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Comparison of long-term numerical simulations at the Ketzin pilot site using the Schlumberger ECLIPSE and LBNL TOUGH2 simulators

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Geological modelling and dynamic flow simulations were conducted at the Ketzin pilot site showing a good agreement of history matched geological models with CO_2 arrival times in both observation wells and timely development of reservoir pressure determined in the injection well.

Recently, a re-evaluation of the seismic 3D data enabled a refinement of the structural site model and the implementation of the fault system present at the top of the Ketzin anticline. The updated geological model (model size: 5 km x 5 km) shows a horizontal discretization of 5 x 5 m and consists of three vertical zones, with the finest discretization at the top (0.5 m). According to the revised seismic analysis, the facies modelling to simulate the channel and floodplain facies distribution at Ketzin was updated. Using a sequential Gaussian simulator for the distribution of total and effective porosities and an empiric porosity-permeability relationship based on site and literature data available, the structural model was parameterized.

Based on this revised reservoir model of the Stuttgart formation, numerical simulations using the TOUGH2-MP/ECO$_2$N and Schlumberger Information Services (SIS) ECLIPSE 100 black-oil simulators were undertaken in order to evaluate the long-term (up to 10,000 years) migration of the injected CO_2 (about 57,000 t at the end of 2011) and the development of reservoir pressure over time. The simulation results enabled us to quantitatively compare both reservoir simulators based on current operational data considering the long-term effects of CO_2 storage including CO_2 dissolution in the formation fluid.

While the integration of the static geological model developed in the SIS Petrel modelling package into the ECLIPSE simulator is relatively flawless, a work-flow allowing for the export of Petrel models into the TOUGH2-MP input file format had to be implemented within the scope of this study. The challenge in this task was mainly determined by the presence of a complex faulted system in the revised reservoir model demanding for an integrated concept to deal with connections between the elements aligned to faults in the TOUGH2-MP simulator. Furthermore, we developed a methodology to visualize and compare the TOUGH2-MP simulation results with those of the Eclipse simulator using the Petrel software package.

The long-term simulation results of both simulators are generally in good agreement. Spatial and timely migration of the CO_2 plume as well as residual gas saturation are almost identical for both simulators, even though a time-dependent approach of CO_2 dissolution in the formation fluid was chosen in the ECLIPSE simulator. Our results confirmed that a scientific open-source simulator as the TOUGH2-MP software package is capable to provide the same accuracy as the industrial standard simulator ECLIPSE 100. However, the computational time and additional efforts to implement a suitable workflow for using the TOUGH2-MP simulator are significantly higher, while the open-source concept of TOUGH2 provides more flexibility regarding process adaptation.