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Identification and determination of trapping parameters as key site parameters for CO_2 storage for the active CO_2 storage site in Ketzin (Germany) - Comparison of different experimental approaches and analysis of field data

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Petrophysical properties like porosity and permeability are key parameters for a safe long-term storage of CO_2 but also for the injection operation itself. The accurate quantification of residual trapping is difficult, but very important for both storage containment security and storage capacity; it is also an important parameter for dynamic simulation.

The German CO_2 pilot storage in Ketzin is a Triassic saline aquifer with initial conditions of the target sandstone horizon of 33.5 ˚C/6.1 MPa at 630 m. One injection and two observation wells were drilled in 2007 and nearly 200 m of core material was recovered for site characterization. From June 2008 to September 2013, slightly more than 67 kt food-grade CO_2 has been injected and continuously monitored. A fourth observation well has been drilled after 61 kt injected CO_2 in summer 2012 at only 25 m distance to the injection well and new core material was recovered that allow study CO_2 induced changes in petrophysical properties. The observed only minor differences between pre-injection and post-injection petrophysical parameters of the heterogeneous formation have no severe consequences on reservoir and cap rock integrity or on the injection behavior.

Residual brine saturation for the Ketzin reservoir core material was estimated by different methods. Brine-CO_2 flooding experiments for two reservoir samples resulted in 36% and 55% residual brine saturation (Kiessling, 2011). Centrifuge capillary pressure measurements (p_c = 0.22 MPa) yielded the smallest residual brine saturation values with ~20% for the lower part of the reservoir sandstone and ~28% for the upper part (Fleury, 2010). The method by Cerepi (2002), which calculates the residual mercury saturation after pressure release on the imbibition path as trapped porosity and the retracted mercury volume as free porosity, yielded unrealistic low free porosity values of only a few percent, because over 80% of the penetrated mercury remained in the samples after pressure release to atmospheric pressure. The results from the centrifuge capillary pressure measurements were then used for calibrating the cutoff time of NMR T_2 relaxation (average value 8 ms) to differentiate between the mobile and immobile water fraction (standard for clean sandstone 33 ms). Following Norden (2010) a cutoff time of 10 ms was applied to estimate the residual saturation as Bound Fluid Volume for the Ketzin core materials and to estimate NMR permeability after Timur-Coates. This adapted cutoff value is also consistent with results from RST logging after injection. The maximum measured CO_2 saturation corresponds to the effective porosity for the upper most CO_2 filled sandstone horizon. The directly measured values and the estimated residual brine saturations from NMR measurements with the adapted cutoff time of 10 ms are within the expected range compared to the literature data with a mean residual brine saturation of 53%.

A. Cerepi et al., 2002, Journal of Petroleum Science and Engineering 35.

M. Fleury et al., 2011, SCA2010-06.

D. Kiessling et al., 2010, International Journal of Greenhouse Gas Control 4.

B. Norden et al. 2010, SPE Reservoir Evaluation & Engineering 13.

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