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The CO_2 sealing efficiency of caprocks

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Shale lithotypes of various compositions occur abundantly in sedimentary basins and act as natural seals for petroleum and natural gas reservoirs over extended geologic periods. Based on to their mechanical, petrophysical and chemical/mineralogical properties shales are encountering increasing interest in the context of long-term deposition of anthropogenic (e.g. radioactive) waste and subsurface storage of fluids. The efficiency and long-term integrity of seal formations (caprocks) is also one of the central issues for CO_2 storage in saline aquifers, depleted oil and gas reservoirs and coals. Due to its chemical reactivity and physico-chemical properties; CO_2 is expected to differ substantially from other natural gas components in terms of transport behaviour and interaction with the mineral/water system.

In the German national GEOTECHNOLOGIEN Programme the sealing efficiency of caprocks is currently under investigation at RWTH Aachen University. The main goal of this study is the characterisation of various caprocks with a wide geographical distribution.

In order to quantify the capillary sealing properties of various tight lithologies, CO_2 gas breakthrough experiments have been conducted on initially fully water-saturated samples of 10–20 mm thickness. Single-phase (water) flow tests prior to the breakthrough experiments yielded absolute permeability coefficients in the range from 10^{18} to 10^{22} m^2. An experimental procedure has been developed to measure molecular diffusion of CO_2 in water-saturated shales. This non-steady state method provides information on the effective diffusion coefficients and the CO_2 storage capacity of the shales. Effective diffusion coefficients for CO_2 were found to range between 10^{-9} and 10^{-11} m^2/s.

Volumetric sorption experiments with CO_2 at pressures up to 20 MPa have been performed on dry and moist shale samples. The results of these experiments revealed unexpectedly high storage potentials ranging from 13 to as much as 49 kg CO_2/t. The CO_2 storage capacities are apparently not related to the organic carbon contents and could not yet be attributed to a specific mineralogical feature. Comparison of x-ray diffraction patterns of post-experiment samples and original samples did not reveal any detectable mineralogical differences.

These findings may provide a new view on the issue of caprock integrity: In addition to their sealing properties, natural shale sequences could represent a significant sink for carbon dioxide deposited in the subsurface by fixing and immobilising it, and hence reduce the risk of leakage to the surface.