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Experimental investigation of the Heletz shale caprocks sealing capacity: implication for CO_2 geological storage integrity

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Using a combination of core flooding experiments and wettability measurements, we evaluate the sealing efficiency of Heletz caprock under CO_2 sequestration conditions. The flow through experiments consisted of flowing CO_2 enriched fluid into two micro-fractured cylindrical cores (15 mm length - 9 mm diameter, with hydraulic aperture: 2.7 μm for the sample named H18A and 13 μm for sample named H18B) and monitoring the permeability changes, the evolution of the chemistry from the inlet and outlet fluid. The changes in microstructures and mineralogy were also studied using an environmental scanning electrons microscope (ESEM) and X-ray micro-tomography (XRMT) images.

The fracture permeability was found to decrease significantly in the two experiments from 14.1×10-12 m2 to 5.0×10-12 m2 for experiment H18B and from 6.5×10-13 m2 to 2.8×10-13 m2 for experiment H18A. Calcite dissolution and reconversion of k-feldspar to illite and kaolinite were the main reaction on sample H18B while "calcite precipitation" in batch condition was the dominant reaction on sample H18A. Accordingly, the decrease in permeability was induced by the dispersion of dissolution products and the re-organization of clay particles within the fracture for sample H18B as shown by micro-tomography and ESEM images. The fracture healing due to the calcite and clay mineral precipitation along the fracture was attested by ESEM image for sample H18A.

The results of capillary pressure breakthrough calculated by applying the Washburn equation and the reservoir scaling method from intrusion of mercury are approximately 380 kPa and 310 kPa for H18B and H18A respectively. Although, these values are sensibly different but close to each other and in good agreement to indicate the weak storage capacity of the heletz caprock. Subsequently less than 90 m of CO_2 column height can be efficiently stored in the Heletz reservoir. Thus the self-mitigation of the CO_2 leakage is expected only when few quantity of CO_2 will be injected.