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Pressure tomography for exploring CO_2 plume evolution in a deep saline homogeneous aquifer

Linwei Hu (1), Peter Bayer (1), Peter Alt-Epping (2), Alexandru Tatomir (3), Martin Sauter (3), and Ralf Brauchler (4)

(1) Geological Institute, Swiss Federal Institute of Technology, Zurich, Switzerland (linwei.hu@erdw.ethz.ch, peter.bayer@erdw.ethz.ch) , (2) Institute of Geological Sciences, University of Bern, Bern, Switzerland (alt-epping@geo.unibe.ch), (3) Geosciences Center, University of Göttingen, Göttingen, Germany (atatomi@gwdg.de, martin.sauter@geo.uni-goettingen.de), (4) AF-Consult Switzerland Ltd, Baden, Switzerland (ralf.brauchler@afconsult.com)

Deep saline aquifers serve as the potential CO_2 storage formations due to their often large storage capacity. For characterizing and monitoring CO_2 migration in deep saline aquifers, cost-efficient and expressive field methods are required to provide direct insight into the prevailing physical conditions of the subsurface. In our study, we propose an innovative pressure tomography approach to characterize the initial flow properties of the aquifer and the development of CO_2 plume based on a virtual homogeneous saline aquifer. Deep CO_2 injection has an impact on the flow properties of the CO_2 and brine mixture depending on the saturation. Variations of the flow properties, such as hydraulic diffusivity, are considered as indicators for tracking the plume, which can roughly be approximated by a single-phase model. Comparable to seismic tomography experiments, pressure tomography generates streamline patterns by either injecting brine at variable depths (sources) prior to full-scale CO_2 injection, or by injecting small amounts of CO_2 into the CO_2-brine system during later stages of storage. The streamlines are derived by recording the introduced pressure responses at given observation locations (receivers). An eikonal-based pressure tomographical framework allows the quantification of the apparent single-phase or mixed-phase diffusivity of the formation. By applying the inversion at different times and by comparison of the inverted diffusivity tomograms, the evolution of the CO_2 plume shape can be monitored temporally in a time-lapse strategy.