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Design of a two-well field test to determine in-situ residual and dissolution trapping of CO_2 in a deep saline aquifer

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CO_2 trapping as immobile residual phase and by dissolution to brine are critical processes for CO_2 storage security and reservoir capacity in many geological settings in consideration for geological CO_2 storage. While laboratory and numerical modelling studies have provided valuable information on the topic, further field testing is critical to improve understanding of how the CO_2 trapping will take place in-situ and to assess the relative importance of the different trapping mechanisms at field sites for geological storage. Given the challenge to measure fluid flow and trapping processes in kilometre-deep reservoirs with few boreholes and limited knowledge of the spatial distribution of geological parameters, the design of field tests that can accurately quantify the CO_2 trapping is also challenging. Using modelling applied to the EU MUSTANG project's field testing site at Heletz, Israel, this study investigates how a two-well dipole test configuration can be used to study migration and trapping of CO_2 in-situ under influence of geological heterogeneity between two boreholes. A two-well dipole test sequence for quantifying both residual and dissolution trapping of CO_2 in situ is presented. The test uses a relatively small amount of injected CO_2 which is monitored by a combination of hydraulic, thermal and tracer measurement techniques. Hydraulic and thermal tests are shown to be sensitive to CO_2 saturation and residual trapping. Furthermore we present a novel tracer technique, employing a non-water-soluble tracer in the CO_2 phase, which is used to quantify the effective in-situ dissolution rate. Our modelling results show that the combination of these measurements in the two-well dipole configuration together with a mass balance of injected and abstracted fluids constitute an effective tool for characterization of in-situ trapping of geologically stored CO_2 at the field scale.