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Modeling of single-well CO2 injection-withdrawal experiment to be carried out at the Heletz site

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Single-well injection-withdrawal (push-pull) test with alternating injections of water, CO2 and CO2 saturated water and withdrawal of formation fluid at selected stages of the experiment, will be part of the experimental test suite at the Heletz site, Israel, the main CO2 injection site of the EU FP7 MUSTANG project. A single-well push-pull experiment is an attractive alternative and support to two-well injection-monitoring tests as uncertainties due to CO2 transport and associated parameters in the heterogeneous media between the wells are greatly eliminated in the interpretation of this test. Taking this approach Zhang et al. (in print) presented a test sequence for determining the residual phase trapping using thermal, hydraulic and noble gases tracer tests. A similar basic approach is implemented in this study

The present study presents the results of model simulations with the TOUGH2/ECO2N model aiming to aid the design of the experiment to be carried out at Heletz and to find an optimal test sequence, based on the data presently available. The site has previously been extensively explored for oil exploration purposes - but the injection will take place in the saline part of the formation - and is therefore relatively well understood. The target layer where the injection will take place is about 10 m thick sandstone layer (composed of three conductive layers) at the depth of 1600 m. Model simulations are carried out to simulate different alternative injection/withdrawal scenarios, to test the incorporation of heating as part of the test sequence and to carry out sensitivity studies concerning parameters where uncertainties exist. Simulations with different assumed residual gas saturations, heater effects and amount of injected CO2 are carried out. The results are interpreted in terms of how the properties of interest in the target layer, in particular the residual CO2 gas saturation, is seen in the monitored, measurable response quantities of temperature, pressure and mass fraction of CO2 in the aqueous phase and how this observability is changing with different test conditions and in-situ properties. The results show that a reduction in pressure could be seen between the hydraulic test responses at the different CO2 saturation conditions and that the temperature response depend on in-situ CO2 gas saturations as well as the heating effect (20, 30 and 50 W/m), where the choice of effect is crucial to be able to observe a response. Simulation results also indicate that the amount of injected CO2 impacts the distribution between the phases.

Future studies will include (i) a more detailed description of the system as more in-situ data from the particular well becomes available, (ii) more comprehensive modeling approach, including e.g. the effect of hysteresis and (iii) finally also incorporation of specific tracers into the modeling scenario.

Reference:
Zhang Y., Freifeld B., Finsterle S., Leahy M., Ennis-King J., Paterson L., Dance T. Single-well Experimental Design for Studying Residual Trapping of Supercritical Carbon Dioxide. Journal of Greenhouse Gas Control. In print.