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Analysis of alternative push-pull-test-designs for determining in-situ trapping of CO_2

M. Rasmusson (1), K. Rasmusson (1), F. Fagerlund (1), A. Niemi (1), J. Bensabat (2), and V. Shtivelman (3)

(1) Department of Earth Sciences, Uppsala University, Uppsala, Sweden (maria.rasmusson@geo.uu.se, kristina.rasmusson@geo.uu.se, fritjof.fagerlund@geo.uu.se, auli.niemi@geo.uu.se), (2) Environmental & Water Resources Engineering (EWRE) Ltd, Haifa, Israel (jbensabat@ewre.com), (3) Geophysical Institute Israel, Lod, Israel (vladi@gii.co.il)

Modeling results of different single-well push-pull (injection-withdrawal) test designs have been analyzed for their ability to determine residual and dissolution trapping of CO_2 in-situ. The modeling aims to improve the design of a CO_2 push-pull test that will be part of the field experiment conducted at the Heletz site, Israel, within the EU FP7 MUSTANG project. The injection will take place in a saline formation, where the target layer, an about 10 m thick sandstone layer composed of three layers, is located at a depth of 1600 m. Single-well experiments complement two-well injection-monitoring tests in that they offer a way of reducing heterogeneity effects on CO_2 transport in comparison to two-well tests. The test scenarios simulated combine thermal, hydraulic and tracer tests in line with the work by Zhang et al (2011), where the test sequences have three main stages divided into (i) reference tests, (ii) creation of a zone of residual gas saturation and (iii) testing during residual gas saturation conditions. One of the main interests is to compare different ways of creating the residual zone, the two principal approaches being to push the mobile CO_2 away by injecting CO_2 saturated water, thus leaving the residual zone behind or by pumping the mobile CO_2 back. Implications of the different designs on optimal use of tracers are also analyzed.
Inverse modeling with the iTOUGH2/EOS17 and EOS7c simulators is used to analyze the ability of the competing test designs to accurately determine parameters of main interest during CO_2 sequestration, in particular the residual gas saturation and dissolution. The inverse modeling approach uses results from e.g. sensitivity analysis and uncertainty propagation analysis to make design decisions leading to improvements in the test scenarios, choosing the optimum pumping and injection rates, heating effects, amount of CO_2 used, tracer and method to create the zone of residual CO_2 trapping, leading to a test design that will give the least uncertainty in the estimated parameters of interest.

The residual gas saturation and dissolution can be derived from measurable responses in temperature, pressure, mass fraction of CO_2 in the aqueous phase or tracer breakthrough curves during the test. Longer test sequences with combination of temperature, pressure and tracer measurements help determining the parameters of interest more accurately. Future studies will incorporate a more detailed description of the system when new in-situ data becomes available.

Reference:

Zhang Y., Freifeld B., Finsterle S., Leahy M., Ennis-King J., Paterson L., Dance T. Single-well Experimental Design for Studing Residual Trapping of Supercritical Carbon Dioxide. 2011, International J. of Greenhouse Gas Control 5, 88-98.