Single-well and inter-well tracer test design for CCS pilot site assessment

MUSTANG EC FP7, Collaborative Large Scale Integrating Project

I. Ghergut1, J. Bensabat2, A. Niemi3, T. Licha1, M. Nottebohm1, M. Schaffer1, M. Sauter1
1University of Göttingen, 2EWRE Haifa, 3Uppsala University

**AIM of tracer tests**: quantify single-phase and two-phase transport properties of storage formation

**PRINCIPLES of tracer tests**:
- **Inter-well** tracings can be used to determine fluid residence time distributions (RTD).
- ‘Statistical’ moments of RTDs provide important information about the reservoir:
  - the zeroth-order RTD moment can tell something about reservoir boundaries;
  - the first-order RTD moment (MRT) represents a measure of reservoir size;
  - higher-order RTD moments provide information about reservoir heterogeneity.

**Single-well push-pull** tracings can be used to quantify non-advective processes.

**THEIR APPLICATION within CCS-MMV program at R&D pilot site**:
- At the Heletz site in Israel (former oil exploration field), three tracer tests will be conducted:
  1. prior to CO2 injection: dual-tracer single-well push-pull test (monopole divergent followed by convergent flow field), using tracers with contrasting sorption and diffusion properties, aimed at characterizing fluid-rock interfaces and estimating fluid-rock interface densities;
  2. prior to CO2 injection: brine-phase dual-tracer inter-well circulation test (forced-gradient, divergent-convergent dipole flow field), aimed at estimating storage reservoir size, determining brine RTD and FSR, characterizing reservoir-scale heterogeneity;
  3. during CO2 injection: dual-tracer, inter-well injection-extraction test (forced-gradient, divergent-convergent dipole flow field), using single-phase and phase-partitioning tracers, aimed at quantifying the storage capacity, characterizing brine displacement processes, and determining RTD and FSR under two-phase flow conditions.

Unlike the brine-phase spiking conducted at the Ketzin site in Germany (www.co2sink.org), where only passive sampling was possible (yielding so-called ‘resident’ values of tracer concentration, inconsistent with the reservoir-scale transport equations), the Heletz experiment offers the advantage of fluid extraction at well-defined rates, rendering measured values of tracer concentrations (actually, tracer fluxes) consistent with the transport equations from which parameter inversion is endeavored. Forced-gradient extraction of fluid is not meant to be representative of how a CCS site would be operated in reality, but it ensures the meaningfulness of measured experiment quantities.

The research leading to these results has received funding from Baker Hughes (Celle) and from the Lower-Saxonian Science and Culture Ministry (MWK Niedersachsen) within the GEBO G6 project, and from the European Community’s 7th Framework Programme FP7/2007-2013 under grant agreement n° 227286.