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# Merging single-well and inter-well tracer tests into one forced-gradient dipole test, at the Heletz site within the MUSTANG project

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The Heletz site[1] in Israel was chosen for conducting a $CO_2$ transport experiment within the MUSTANG project[2], whose aim is to demonstrate and validate leading-edge techniques for CCS site characterization, process monitoring and risk assessment.

The major $CO_2$ injection experiment at Heletz was supposed to be preceded and accompanied by a sequence of single-well 'push-then-pull' (SW) and inter-well (IW) tracer tests, aimed at characterizing transport properties of the storage formation, in accordance to a number of general and specific principles[3],[4]. – Instead of the rather luxurious {SW1, IW1, SW2, IW2} test sequence described in our previous work[5], we now propose a drastically economized tracer test concept, which lets the sampling stages of SW and IW tests merge into a single fluid production stage, and relies on a forced-gradient dipole flow field at any time of the overall test. Besides cost reduction, this economized design also improves on operational aspects, as well as on issues of parameter ambiguity and of scale disparity between SW and IW flow fields:

(i) the new design renders SW test results more representative for the aquifer sector ('angle') actually interrogated by the IW dipole test;

(ii) the new design saves time and costs on the SW test (fluid sampling for SW 'pull' now being conducted simultaneously with IW-related sampling and monitoring), while allowing for a considerably longer duration of SW 'pull' signals than had originally been intended, whose late-time tailings help improve the quantification of non-advective processes and parameters, which are of great relevance to mid- and long-term trapping mechanisms ('residual trapping', 'mineral trapping');

(iii) the quasi-simultaneous execution of fluid injection/production for the IW and SW tests considerably reduces the overall hydraulic imbalance that was originally associated with the SW test, thus preventing formation damage and supporting hydrogeomechanical stability;

(iv) the new design reduces the imbalance between injected and produced fluid volumes at any time to a minimum, thus eliminating the need for large-capacity tanks (and water supply) to provide 'push' fluid for injection and to store 'pull' fluid during production within the SW test (saving on costs again).

Advantages and drawbacks of this modified tracer test concept w. r. to parameter sensitivity and scale representativity are further analyzed by means of numerical simulations of tracer transport in the layered Heletz aquifer (using FEFLOW) alongside with closed-form approximations to tracer signals.

**References:**

[1] www.co2mustang.eu/Heletz.aspx

[2] www.co2mustang.eu/

[3] Behrens H, Ghergut I, Sauter M (2010) Tracer properties, and tracer test results, part 3: modification to Shook's flow-storage diagram. *Stanford Geothermal Prog Tech Reports*, SGP-TR-**188**

[4] Ghergut I, Behrens H, Maier F, Karmakar S, Sauter M (2011) A note on 'heat exchange areas' as a target parameter for tracer SWIW tests. *Stanford Geothermal Prog Tech Reports*, SGP-TR-**191**

[5] presentations.copernicus.org/EGU2012-13549_presentation.pdf
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