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From pore- to field-scale modelling of kinetic interface sensitive tracers for monitoring CO_2 plume migration in deep saline aquifers

Alexandru Bogdan A.C. Tatomir (1), Matthias Halisch (2), Aaron Peche (3), Friedrich Maier (1), Apoorv Jyoti (1), Tobias Licha (1), Jacob Bensabat (4), Auli Niemi (5), and Martin Sauter (1)

(1) Department of Applied Geology, University of Goettingen, Goettingen, Germany (alexandru.tatomir@geo.uni-goettingen.de, +49 551 39-19700), (2) LIAG, Leibniz-Institute for Applied Geophysics, Hannover, Germany, (3) Leibniz University Hannover, Hannover, Germany, (4) EWRE Ltd., Environmental & Water Resources Engineering Ltd., Haifa, Israel, (5) Department of Earth Sciences, Uppsala University, Uppsala, Sweden

We describe a workflow of modeling kinetic interface sensitive (KIS) tracers for monitoring CO_2 plume migration in deep saline aquifers.

Existing CO_2 injection and storage sites and a large number of enhanced oil and gas recovery projects have shown that the geological storage of CO_2 is a feasible and viable technology. KIS tracers are intended to characterize the CO_2-brine interfacial area during the supercritical injection of CO_2 into the deep saline aquifers. Based on high resolution micro-CT images representing the complex geometrical characteristics of reservoir samples from Heletz, Israel, a complex high resolution modeling domain is obtained. First, we present an FEM numerical pore-scale two-phase flow model solving Navier-Stokes equations (including the surface tension) to track and quantify the propagating fluid-fluid interfacial area within a porous media REV. Further, the pore-scale modeling results are used to quantify system's specific capillary pressure-wetting phase saturation - interfacial area relationship (pc-Sw-awn). Additionally, the model is used to determine several essential flow and transport parameters (porosity, permeability, dispersivity, etc.) which are compared to the ones from laboratory and field experiments. The workflow includes a procedure to reduce the geometrical degree of complexity based on REV-analysis.

Consequently, the KIS tracer migration and reaction across the interface at the field scale is considered in a second FVM numerical model which is a non-isothermal multiphase multicomponent one. It is determined that the constitutive relationship pc-Sw-awn together with the kinetic rate are the two key parameters for the KIS tracer experiments.

Taken in total, this work provides a realistic way to model KIS tracers in CO_2-brine systems by addressing to the pore-and field-scales, and demonstrates that the KIS tracers represent a potential accurate monitoring technique.