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CO_2 Capillary-Trapping Processes in Deep Saline Aquifers

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The idea of reducing the Earth's greenhouse effect by sequestration of CO_2 into the Earth's crust has been discussed and evaluated for more than two decades. Deep saline aquifers are the primary candidate formations for realization of this idea. Evaluation of reservoir capacity and the risk of CO_2 leakage require a detailed modeling of the migration and distribution of CO_2 in the subsurface structure. There is a finite risk that structural (or hydrodynamic) trapping by caprock may be compromised (e.g. by improperly abandoned wells, stratigraphic discontinuities, faults, etc.). Therefore, other trapping mechanisms (capillary trapping, dissolution, and mineralization) must be considered. Capillary trapping may be very important in providing a "secondary-seal", and is the focus of our investigation.

The physical mechanism of CO_2 trapping in porous media by capillary trapping incorporates three related processes, i.e. residual trapping, trapping due to hysteresis of the relative permeability, and trapping due to hysteresis of the capillary pressure. Additionally CO_2 may be trapped in heterogeneous media due to difference in capillary pressure entry points for different materials. The amount of CO_2 trapped by these processes is a complicated nonlinear function of the spatial distribution of permeability, permeability anisotropy, capillary pressure, relative permeability of brine and CO_2, permeability hysteresis and residual gas saturation (as well as the rate, total amount and placement of injected CO_2).

Geological heterogeneities essentially affect the dynamics of a CO_2 plume in subsurface environments. Recent studies have led to new conceptual and quantitative models for sedimentary architecture in fluvial deposits over a range of scales that are relevant to the performance of some deep saline reservoirs [1, 2]. We investigated how the dynamics of a CO_2 plume, during and after injection, is influenced by the hierarchical and multi-scale stratal architecture in such reservoirs. The results strongly suggest that representing these small scales features, and representing how they are organized within a hierarchy of larger-scale features, is critical to understanding capillary trapping processes.

References

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