Simplified CO_2 plume dynamics for a certification framework for geologic sequestration projects

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Abstract:
A framework for certifying and decommissioning CO_2 geologic sequestration sites is a critical requirement for large-scale deployment of CO_2 sequestration in brine formations. The certification process should account for the sequestration efficiency of a given volume of a saline aquifer. The sequestration efficiency is determined by maximizing CO_2 trapping while minimizing the leakage risk. As part of the development of the Certification Framework, we carried out a large number of compositional simulations to quantify the effect of various reservoir and operating parameters. Porosity, horizontal permeability, permeability anisotropy, formation thickness and dip, pressure, and temperature were systematically varied. Operating parameters such as injection rate, vertical vs. horizontal well and perforation interval were investigated. We then developed several simplified models of CO_2 plume behaviour and verified them against sophisticated reservoir simulations.

The simple models captured the following trends: leakage potential increases (1) as the time for the CO_2 plume to reach the top seal of the aquifer decreases; (2) as the lateral distance travelled by the plume increases, and (3) as total mobile CO_2 increases. We studied one risk parameter in detail, the time for the CO_2 plume to reach the aquifer top seal, and showed that it varies systematically with gravity number, defined as the ratio of gravity forces to viscous forces. Likely behaviour of an actual saline aquifer relative to that one risk parameter is easily captured by interpolation within the catalogue of detailed simulations for different reservoir and operational parameters. We illustrate the application of these simplified models to assess risks of leakage for a hypothetical sequestration project in a gas storage reservoir for which extensive characterization is available.