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Effect of permeability heterogeneity on CO_2 sweep efficiency and implication for storage capacity

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To investigate the effect of heterogeneity on CO_2 sweep efficiency (volume percentage swept by the displacing phase), we study CO_2 injection into a heterogeneous formation where the statistical properties of the permeability field represented by standard deviation and correlation length are systematically varied. A wide range of injection pressures as well as injection rates has been simulated using the TOUGH2/ECO_2N simulator. We focus on the primary drainage process which occurs during the CO_2 injection period where supercritical CO_2 is injected through a vertical well fully perforated to the target layer and the spreading is followed until the plume reaches a spill point, representing a fracture or other leaking features. For each set of parameter values of standard deviation and correlation length, a large number of realizations are run to allow convergence of the output statistics.

The preliminary results indicate that for the cases with larger correlation lengths, increasing in the standard deviation decreases the sweep efficiency. For cases with smaller correlation lengths, increasing standard deviation leads to a higher sweep efficiency when a low injection pressure is applied, but leads to a decreased sweep efficiency when a high injection pressure is applied. In other words, the sweep efficiency shows a great dependence on the injection pressure when the correlation length is small. However, regardless of the injection pressure applied, a greater amount of CO_2 enters the domain with larger correlation lengths and smaller standard deviations at the breakthrough time. The sweep efficiency, therefore, is in favor of permeability fields with greater correlation lengths and smaller standard deviations for heterogeneity cases studied here.