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Multi-phase fluid behaviors with various capillary numbers, viscosity and wettability: Insight into effective and safe CO2 storage

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The behavior of CO2 inside a reservoir (i.e., two-phase flow in CCS, or three-phase flow in CCUS) is influenced by interfacial tension, pore structure, wettability and other reservoir parameters (e.g., pressure gradient), which vary significantly from one reservoir to the next. Therefore, understanding multi-phase flow under various reservoir conditions is crucial to estimating CO2 storage capacity, leakage risk, and storage efficiency. In this study, we calculated two-phase or three-phase fluid displacements in natural digital rocks using lattice Boltzmann (LB) simulation, and characterized the influence of reservoir conditions (e.g., interfacial tension, pressure gradient, and wettability) upon CO2 behavior. By mapping the CO2 saturation on the diagram of capillary number and viscosity ratio of the two fluids, we could identify the suitable environments for effective CO2 storage. We further calculated two-phase and three-phase relative permeability of digital rocks under various conditions. Porous flow simulation also contributes to geophysical monitoring of CO2 behavior in reservoirs. For example, we calculated geophysical properties (e.g., seismic velocity) of the digital rocks with injected CO2 under various reservoir conditions. Using the relationship between seismic velocity and CO2 saturation parameterized by reservoir conditions, we could quantify in situ CO2 saturation in reservoir from geophysical monitoring data (seismic velocity). In this presentation, we would like to show how porous flow simulations practically contribute to the safe and effective CO2 storage.

References

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