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Impact of wettability on supercritical CO2 transport and local capillary trapping in deep saline aquifers

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Given its immense storage capacity, geological CO2 storage in saline aquifers is regarded as a promising and practical strategy for mitigating anthropogenic CO2 emissions into the atmosphere. During the post-injection phase, where CO2 migration is primarily influenced by buoyant force, local capillary trapping emerges as a crucial mechanism for effective storage. In practical scenarios, saline aquifers may exhibit varying degree of wettability, leading to variation in two-phase flow of CO2 and brine, as well as capillary pressure. However, the previse understanding of how wettability influences the local capillary trapping of CO2 during buoyancy dominated flow in saline aquifer remains unclear. In this study, we firstly construct typical heterogeneous aquifer models using geostatistical modeling. Subsequently, we develop relative permeability curves and capillary pressure curves for CO2-brine in rocks with different wettability characteristics, such as water-wet, intermediate-wet, and CO2-wet. The transport and local capillary trapping of supercritical CO2 in aquifers featuring various wettability are then investigated through high-resolution two-phase flow simulations. The spatial and temporal evolution of CO2 plume is analyzed and the contribution of different trapping mechanisms, namely local capillary trapping, residual trapping, and dissolution trapping, are compared. The advantageous wettability characteristics conducive to local capillary trapping of CO2 in saline aquifers are unveiled. The findings of this study offer valuable insights into the transport and trapping mechanism of supercritical CO2 in deep saline aquifers with different wettability characteristics.

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