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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 pre-vious 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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