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Quantifying the multiphase CO2-brine transport in basaltic rocks

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Amid intensified global efforts to mitigate climate change, carbon mineralization in basaltic formations has emerged as a more prominent, secure, and permanent storage solution for anthropogenic CO2. When CO2 is injected into basaltic rocks, displacing the in-situ pore fluid, the volume of displaced fluid and, consequently, the injected gas depends on the interplay between relative permeability, capillary pressure, and fluid saturation. However, characteristic flow curves specific to basaltic rocks are limited, emphasizing the need for a deep understanding of this multiphase transport behavior to design effective carbon storage systems. Hence, this study addresses this critical aspect by employing the Lattice Boltzmann Method (LBM) on X-ray computed tomography (XRCT) scans of select basaltic rock samples, capturing the complex internal structures of the basalt. These acquired images are reconstructed into digital models that represent the physical characteristics of the basaltic rocks. We utilized these digital models and LBM, based on the sophisticated Shan-Chen framework to compute key transport properties, including permeability, relative permeability, and capillary pressure. This model enables us to accurately simulate the intricate interactions and dynamics of CO2 transport within basalt under varying temperature and pressure conditions. The comparison of the LBM computational results with the limited experimental data revealed a high degree of correlation, thereby validating the accuracy of our simulations. The strong agreement not only attests to the reliability of LBM in the simulation of geological processes but also reinforces our capability to accurately predict CO2 storage in basalt, further affirming its feasibility as an effective carbon sequestration strategy. Overall, our findings provide valuable insights into the dynamics of CO2 storage in basaltic formations, offering a robust foundation for ongoing efforts and future research that will enhance our ability to combat climate change.

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