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Comparison of Darcy's law and invasion percolation simulations with buoyancy-driven CO_2-brine multiphase flow in a heterogeneous sandstone core

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Abstract

In CO_2 storage scenarios, CO_2 flow is dominated by gravity and capillary forces rather than viscous forces over much of the storage space. It is unclear what is the most efficient and effective method to model CO_2 flow under these conditions – standard continuum Darcy-based flow models or invasion percolation models. We perform experiments using high-pressure liquid CO_2 injection into a vertically-aligned heterogeneous Boise sandstone core (30 cm long, 7 cm diameter). Effluent measurements assure that the flow is gravity dominated, and the resulting invasion pattern is measured using X-ray computed tomography (CT). Before the flow experiment is performed, a porosity map of the core is obtained from the CT data and is used as an input to both an invasion percolation model and a Darcy-based flow model. Each simulation matched different features of the data, but neither produced a comprehensive match. The results highlight the strengths and weaknesses of each type of model. We suggest possibilities of integrating the techniques to improve predictions of buoyancy driven flow in heterogeneous media.