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ENTRAPMENT OF CO_2 AS RESIDUAL GAS DURING COUNTER-CURRENT FLOW IN SALINE AQUIFERS

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Summary. A key challenge in CO_2 sequestration projects is to ensure long-term storage of CO_2 without significant leakage. For sequestration projects in saline aquifers, substantial evidence must be provided that any injected CO_2 will remain in the target formation. However, the counter-current flow dynamics that control a portion of the immobilization of CO_2 in an aquifer are not yet fully understood. Currently available models of residual entrapment are based on observations from sequential displacements experiments whereas any CO_2 that is injected into an aquifer will migrate upwards due to buoyancy in a counter-current flow setting. In this paper, we examine the accuracy of the physical models that are currently implemented in state-of-the-art simulation tools. Numerical calculations of residual trapping of CO_2 due to hysteresis in capillary pressure are compared to experimental observations.

Experimental observations are presented from counter-current flow experiments in glass bead packs with the analog fluids isooctane and brine. Resistivity measurements are used to monitor the dynamics of the gravity segregation process and form the basis for a comparison with available physical models. We use numerical calculations to study the impact of popular hysteresis models on the predicted evolution of a well-defined CO_2 plume in an aquifer and compare the calculated results with our experimental observations. Our comparison of experimental observations with detailed numerical calculations indicates that some hysteresis models clearly fail to reproduce the experimental observations.

The results of our investigation apply directly to the planning of CO_2 sequestration projects in saline aquifers that commonly involves detailed simulations to delineate the potential migration patterns. In summary, our combined numerical and experimental analysis provides new insight into the dynamics of CO_2 entrapment during counter-current flow in the context of geological carbon sequestration.