Estimation of Surrogate Fluid Constitutive Relationships for Modeling of Tank Test Results to Develop Strategies for Geological Carbon Sequestration

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Abstract. To develop effective strategies for safely storing supercritical CO_2 ($scCO_2$), it is necessary to understand the fundamental processes that contribute to stable entrapment. However, controlled experiments to generate data at all scales of interest are not feasible and it is challenging to use $scCO_2$ at laboratory conditions. Therefore, models contribute to the ability to properly characterize the capillary trapping of $scCO_2$ in saline aquifers and improve the understanding of complex processes of the multiphase flow of $scCO_2$ and saline water.
The constitutive relationships, such as the capillary pressure (P_c) – saturation (S_w) and the relative permeability (k_r) – saturation (S_w), are important factors to simulate multiphase flow. Prediction methods for these constitutive relationships are popular due to their advantages compared to experimental estimation, although the evaluation of the adequacy of the prediction method is often challenging.
The objective of this study is to measure $P_c - S_w$ and $k_r - S_w$ relationships using surrogate fluids and identify and model the constitutive relationships of theses fluids. Results demonstrate that the soil water retention relationship fitted using three different methods have similar scaling factor. However, the scaling factor shifts the retention curve in vertical direction; therefore, the residual and irreducible saturation has to be measured experimentally. The $k_r - S_w$ results indicate that commonly used Mualem model does not represent the test sands and fluids. The differences in behaviour of $scCO_2$ are investigated by contrasting the data from the actual intermediate tank experiment and simulation using TOUGH 2 model of this tank experiment which simulates both the prediction and the experimental method. Accomplishment of this research will play a significant role in understanding the processes of multiphase flow of $scCO_2$ and saline water and effective trapping mechanisms of $scCO_2$ in saline aquifers.

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