Quantification of Relative Permeability Induced Uncertainty in CO_2 Trapping Predictions

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Injecting anthropogenic carbon dioxide into the subsurface is considered as a viable option for climate change mitigation. CO_2 injection is also used as a tool in commercial geological operations (e.g. CO_2-enhanced oil recovery, CO_2-enhanced geothermal systems, etc.) for process efficiency enhancement. In any of these applications, it is critical to understand and predict the behavior, migration and long-term fate of the injected CO_2. We investigated the impact of and the uncertainty caused by relative permeability (RP) parameters on the predictions of physical and chemical trapping of CO_2. Our hypothesis was that the choice of RP parameters would cause substantial uncertainty in the predictions of CO_2 migration and trapping. It is difficult to acquire lab-tested RP data specific to the formations being modeled. Moreover, even applying lab-derived RP in the models can lead to significant uncertainty due to unforeseen heterogeneity in the reservoir. In most cases, generic RP parameters from literature are employed in reactive transport models. We investigated 18 lab-measured RP data calibrated to either van Genuchten or Corey models as applied in most multiphase flow models, while keeping all other model parameters unchanged throughout the suite of simulations. Results are presented in comparison to those obtained from "standard" van Genuchten parameters used frequently in literature. Significant differences in CO_2 plume migration and dissolution were found in the post-injection phase (>200 years), with varying ratios predicted of trapping through different mechanisms. The uncertainty caused by these relative permeability parameters and formulations was estimated using statistical techniques like density estimation and resampling strategies. This analysis can be critically useful to the field of risk assessment and management of CO_2 Capture Utilization and Sequestration. This project was conducted with the support of the National Energy Technology Laboratory and its Southwest Regional Partnership on Carbon Sequestration.

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