The Effect of Microscale Heterogeneity on the Transport of Carbon Dioxide in Geologic Carbon Sequestration

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ABSTRACT

Carbon capture and storage utilizing geological carbon sequestration is a proven technology option for carbon mitigation for certain carbon emissions sources by injecting large volumes of carbon dioxide into the subsurface. The lack of existing field data in this burgeoning field requires conceptual models instead. Predicting the effectiveness of a storage project and retention of injected carbon dioxide underground is heavily reliant on leveraging predictive fluid dynamics models of the migration of injected carbon dioxide in the subsurface. Due to the heterogeneity of reservoir geology, the multiphase nature of the system, and buoyancy limiting capillary effects, microscale features can significantly influence CO_2 transport through storage formations. This can present itself through multiphase capillary pressure barriers of varying sand grain sizes, and therefore pore sizes, which impact CO_2 residual and dissolution trapping mechanisms. To study these effects, microfluidic devices are fabricated using precise microfabrication techniques to create rock-based pore-structure flow cells. Fluid flow tests of CO_2 and brine are performed on these devices as a means to inform flow behavior through microscale heterogeneity and validate computational fluid dynamics models. Validated computational models can then be transferred to larger representative volumes and cases. Large-scale models rely on assumptions of a number of input parameters and the importance of certain effects which can be more accurately represented when informed by a pore-scale understanding and quantitative analysis. When risk and uncertainty of a carbon sequestration model are reduced, the storage project becomes more predictable, insurable, and safer.

I would like to acknowledge the Jackson School of Geoscience and the Gulf Coast Carbon Center at The University of Texas at Austin, The Department of Energy, Los Alamos National Laboratory, and Chevron. I would also like to thank my advisor, Dr. Sahar Bakhshian, for her patience and support.

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