Flow in Porous Media: Experiments and Simulations with Application to CO_2 Sequestration, Dustin Crandall, Clarkson University, Department of Mechanical and Aeronautical Engineering, Potsdam NY 13669 and National Energy Technology Laboratory, Morgantown, WV 26507, meDustin@gmail.com; Goodarz Ahmadi, Clarkson University, Department of Mechanical and Aeronautical Engineering, Potsdam NY 13669; and Duane H. Smith, National Energy Technology Laboratory, Morgantown WV 26507

The amount of carbon dioxide that can be sequestered in reservoirs is dependent on fluid-fluid-solid interactions within porous rock. Displacement of an in-place fluid by a less viscous invading fluid does not evacuate 100 percent of the defending fluid, due to capillary and viscous fingering. This has been studied over the past decades experimentally and numerically with pore-throat flow cells and pore-level models, respectively. This current work examines immiscible two-phase displacements within a novel flowcell and extends this experimental work with a computational fluid dynamics model within the same random pore-throat geometry using the Volume of Fluid (VOF) method.

A new, experimental flowcell is described and experiments of constant-rate injection of air into the water-saturated cell are shown. The flowcell is weakly water wetting with a static contact angle measured as 76°. The motion of the invading fingers is shown to obey the well defined fingering structures observed in pore level numerical models of drainage; namely, dendritic fingers at high flow rates and a more stable invasion at low rates. An increase in the fractal dimension (D_f) of the interface and a decrease in the final saturation of invading air was noted with increasing flow rate.

VOF modeling within the same flowcell geometry is then discussed. Percent saturation and the D_f of the invading fluid were calculated from the numerical model and shown to be in good agreement with the experimental findings of air invasion into a water saturated domain. The fluid properties (viscosity and density) were than varied and the viscosity ratio (M) between fluids and capillary number (Ca) of the flow are shown to affect the percent of displaced fluid, with lower Ca and higher M displacing a greater amount of the wetting fluid.

Finally, the fluid-fluid-surface conditions of the numerical model were changed to show the effect on the percent saturation and D_f for the case of a weakly water repellent surface, the case of imbibition. The invading fluid is shown to preferentially move into small throats and displace a larger percent of the in-place fluid than observed in the drainage case. The interface was also observed to have a higher D_f, similar to 2.

This study has used porous media analogies and computational fluid dynamics to show the effect that pore-level interactions have on the motion of two fluids within a heterogeneous domain. The results indicate that a greater percent saturation of CO_2 can

be achieved within geological reservoirs when a low injection rate is used to mitigate this greenhouse gas.