Advancing Models for Multiphase Flow and Transport in Porous Medium Systems

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Multiphase porous medium systems arise routinely in the subsurface. Relevant applications include carbon sequestration, contaminant transport, hydraulic fracturing and the recovery of oil and gas. Recent advances in three-dimensional imaging provide a window into the microstructure of these systems. Technologies such as computed micro-tomography rely on a synchrotron or other high energy light source to generate high-resolution images that show the position of fluids within micrometer-sized void spaces inside a sample of rock or soil. These approaches can be used to quantify the geometry and topology of fluid phases within real geologic materials. However, in order to connect the information generated experimentally to continuum-scale models, additional information must be supplemented by large-scale computation. Simulation provides a mechanism to determine microscale quantities that cannot be measured experimentally, such as fluid densities, pressures, and velocities. Simulations performed on Titan are used to fill in this missing information to fully leverage the results of experiment. We show that this approach can be used to accurately predict the microscale behavior of multiphase systems and describe how it can be used used to inform improved models to describe multiphase flow and transport at larger spatial scales.