Mesoscale Priority Research Direction

Fluid, Mass, and Energy Transport in Porous and Quasi-Porous Media

Opportunity

Fluid, mass, and energy transport phenomena in porous and quasi-porous materials are generally characterized by a myriad of microscale physical, chemical, and thermodynamic processes whose collective interactions and aggregate mesoscale behavior is relevant across a spectrum of needs in the earth and energy sciences, mechanical, biomedical, and environmental engineering fields, and related applied technology disciplines.

Meso Challenge

- How can complex and coupled pore (or micro) scale processes be better observed, characterized, and quantified?
- What is the most effective way to translate, abstract, and simplify their collective behavior to achieve predictive continuum models?

Approach

Our approach will advance an evolving paradigm of three necessary and interacting components: (1) Mathematical (mesoscale) model developments based upon thermodynamically-constrained porous media averaging and closure theory techniques; (2) Microscale physical and computational experiments to support the identification, quantification, and visualization of pore scale phenomena; (3) Corresponding experiments to support mesoscale model parameterization and simplification.

Impact

Although general and widely applicable, our proposed approach will provide more consistent and defensible continuum (meso) scale model formulations for increasingly important applications, especially in the earth, energy, and related sciences.

References: **W. G. Gray et al.** (2002), *Transport in Porous Media*, 47, 29-–65; **K. A. Culligan et al.** (2004) *Water Resources Research*, 40(12):W12413, doi:10.1029/2004WR003278; **M. L. Porter et al.** (2009) *Advances in Water Resources* 32, 1632–1640

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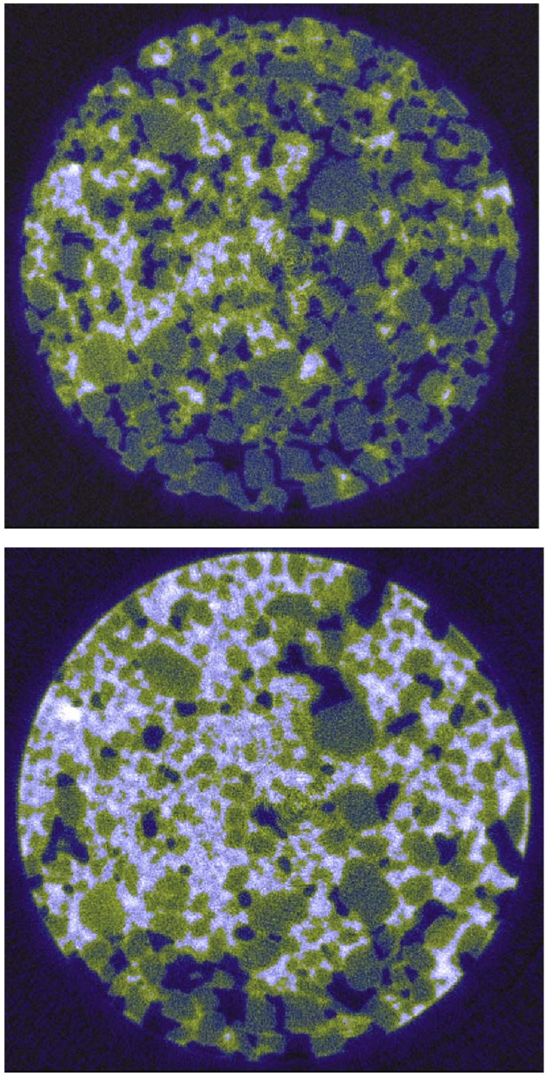
Example: On the Significance of Interfacial Area in the Macroscale Equations of Multiphase Flow



May equations of state, typically posed at one scale, be directly applied at another scale?

The range of reported values for capillary pressure suggests that macroscopic water pressure must take on large negative values at low saturations. Is this realistic or representative of other physics that are not explicitly represented?

Is a theory that does not formally take into account the evolution and distribution ~~of~~ specific interfacial areas necessarily complete?