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PHASE-FIELD MODELING OF MULTIPHASE FLOW THROUGH ROUGH FRACTURES

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Multiphase flow through fractured geologic media controls key processes in energy resources and the environment, from enhanced oil recovery from fractured carbonate reservoirs and natural gas production from deep shale formations, to enhanced geothermal energy systems and nuclear waste repositories. Important questions include the role of the viscosity contrast between fluids, heterogeneity in fracture apertures, the wetting state of the system, and how to upscale relative permeabilities from the fracture scale to the reservoir scale [1,2].

Here, we present a continuum model of two-phase flow through fractures that accounts for the viscous coupling between fluids in the gap and the wetting properties of the system. We adopt a Darcy formulation of the fluid fluxes, and propose to derive the capillary potentials from a free energy functional [3,4]. We simulate two-phase flow through fractures with strong heterogeneity in aperture distributions. We vary the viscosity contrast between fluids and capillary numbers, and determine effective relative permeabilities that can be used in reservoir-scale models. We compare the flow patterns and relative permeabilities in drainage in imbibition, varying the wetting properties of the fluid-fluid-solid system.

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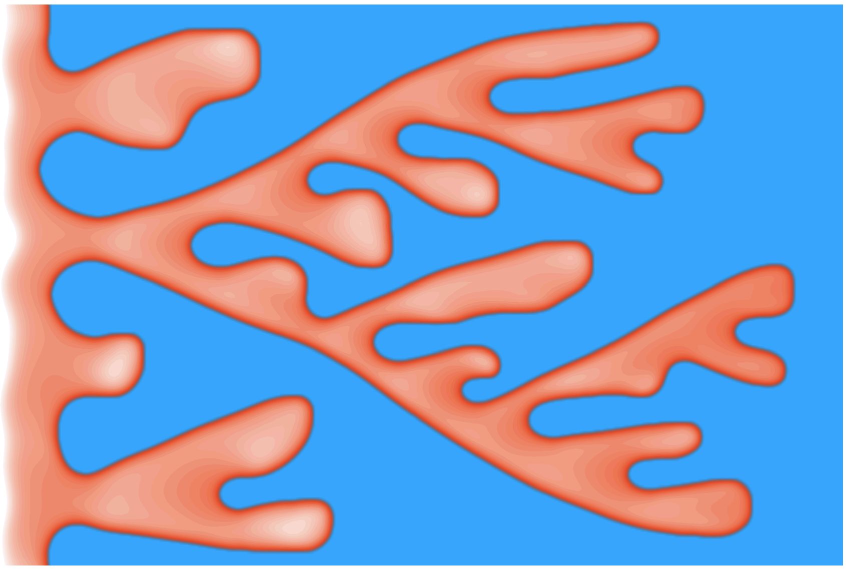

Fig. 1. Numerical simulation of a viscously-unstable two-phase displacement in a constant-width fracture. We plot the gas saturation field.