Two-phase Flow in Porous Media: Power-law Scaling in Steady-state Properties

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ABSTRACT: We study the steady-state properties of two-phase flow in porous media considering a network of disorder tubes transporting two immiscible fluids, one is wetting and another is non-wetting with respect to the pores. Steady-state flow in the simulation is implemented by two different ways, by the bi-periodic boundary conditions in a toroidal topology and by open boundary conditions similar to the experiments reported in literature. We find two regimes of power-law scaling for the steady-state pressure with the capillary number. We then propose through our numerical simulations and a mean field calculation that the two fluids in the system effectively behave as a Bingham viscoplastic fluid which leads to a generalized Darcy equation where the flow rate varies quadratically on an excess pressure drop in the capillary dominated regime. In the high flow rate regime, the flow is Newtonian. Our results are in a great agreement with the recent experimental works.