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**Prediction of gravity-driven fingering in porous media** ABDELAZIZ BELJADID, Massachusetts Institute of Technology, LUIS CUETO-FELGUEROSO, Massachusetts Institute of Technology and Technical University of Madrid, RUBEN JUANES, Massachusetts Institute of Technology — Gravity-driven displacement of one fluid by another in porous media is often subject to a hydrodynamic instability, whereby fluid invasion takes the form of preferential flow paths—examples include secondary oil migration in reservoir rocks, and infiltration of rainfall water in dry soil. Here, we develop a continuum model of gravity-driven two-phase flow in porous media within the phase-field framework (Cueto-Felgueroso and Juanes, 2008). We employ pore-scale physics arguments to design the free energy of the system, which notably includes a nonlinear formulation of the high-order (square-gradient) term based on equilibrium considerations in the direction orthogonal to gravity. This nonlocal term plays the role of a macroscopic surface tension, which exhibits a strong link with capillary pressure. Our theoretical analysis shows that the proposed model enforces that fluid saturations are bounded between 0 and 1 by construction, therefore overcoming a serious limitation of previous models. Our numerical simulations show that the proposed model also resolves the pinning behavior at the base of the infiltration front, and the asymmetric behavior of the fingers at material interfaces observed experimentally.

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