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Saffman-Taylor instability in a rough fracture: beyond Darcys law AMIR PAHLAVAN, LUIS CUETO-FELGUEROSO, GARETH MCKINLEY, RUBEN JUANES, Massachusetts Inst of Tech-MIT — The interplay between wetting and disorder, as well as the inherent complexity of porous media renders the description of immiscible flows a daunting task. To shed light on this problem, we conduct experiments on rough radial Hele-Shaw cells. We fill the cell with a viscous glycerol, and then inject a less viscous silicone oil at the center of the cell. The surfaces are treated to alter their wettability, allowing us to study both drainage and imbibition regimes. Viscous forces tend to destabilize the interfaces, whereas capillary forces play a stabilizing role; however, the disorder in the medium complicates this balance: 1) it leads to heterogeneities in the permeability field and capillary pressure distribution, and 2) it changes the effective wettability of the medium and leads to contact line pinning and hysteresis. We observe that at high capillary numbers, the disorder only weakly modulates the patterns, whereas at low capillary numbers, it affects the flow pattern significantly; the disorder leads to preferential flow paths in the drainage regime, and pinning and intermittent avalanche-like behavior in the imbibition regime. Inspired by these observations, we construct a phase-field model that takes the chemical potential gradients into account, going beyond Darcy's law.

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