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A Two-Equation Model For Mixing in Viscous-Fingering Displacements BIRENDRA JHA, LUIS CUETO-FELGUEROSO, RUBEN JUANES, MIT — We study, by means of numerical simulation, the mixing of two fluids of different viscosities in advection-dominated flows in a porous medium. It is well known that when a less viscous fluid displaces a more viscous fluid, the displacement front is unstable and leads to the formation of a pattern known as viscous fingering. We present a high-resolution simulation approach that is stable for arbitrary viscosity ratios, and study mixing under different configurations with viscosity contrasts up to M = 400. We observe, in agreement with lab experiments, that for high-M displacements, the growth of new fingers follows the trace of previous ones. This channeling effect, which is a result of the nonlocal coupling through the pressure field, greatly reduces mixing. A two-equation mixing model using the scalar variance and its dissipation rate is derived from the advection-diffusion equation. It provides a measure of effective diffusivity due to convective and diffusive mixing processes. Our analysis predicts the optimum range of viscosity contrast and Peclet number that maximizes the interfacial area by balancing the number of fingers with their length before diffusive mixing across the sharp interface takes over. Interesting fingering patterns such as channeling and tip-splitting play an important role in this balancing act which makes degree of mixing a non-monotonic function of the viscosity contrast and the Peclet number.

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