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Effective description of the interaction between viscous fingers in a pore network micromodel

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We report the results of viscous fingering experiments in a rectangular network of microfluidic channels, an analogue system for porous media. Depending on the geometry of the grid, we observe different types of dendrite-like structures spontaneously forming in the system: either wide dendrites, spanning many pore diameters or thin, pore-wide, needle-like fingers. As they grow, the dendrites interact with each other, competing for the available flow. Next, we develop an upscaled description of this system in which only the dendrites are tracked and the effective interactions between them are introduced, mediated through the evolving pressure field. Due to the quasi-2d geometry of the system, this is conveniently accomplished using conformal mapping techniques. A complex two-phase flow problem is thus reduced to a much simpler task of tracking evolving shapes in a 2d complex plane. This description, although simplified, turns out to capture all the key features of the system's dynamics and allows for the effective prediction of the resulting growth patterns.