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Non-linear growth of fingers during two-phase flow in porous media

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Invasion of a fluid in a porous medium filled with another fluid immiscible to the injected one produces a wide variety of displacement patterns depending on the fluids'viscosity contrast and the capillary number of the flow. In the case of a low-viscosity fluid advancing through a high-viscosity immiscible fluid, a viscous instability occurs, leading to viscous fingers which have long been assumed to exhibit a linear Laplacian growth behavior. This means that the interface velocities of the advancing fronts depend linearly on the local pressure gradient. This (linear) Laplacian growth behavior is also observed for viscously-unstable fingers observed in continuum Hele-Shaw cells by Saffman and Taylor [1], as well as for diffusion limited aggregates (DLA). However, an experimental study of drainage in a porous Hele-Shaw cell around 20 years ago [2] demonstrated that drainage fingers in porous media can also exhibit non-linearity in the growth in a certain regime. Recently we further investigated this configuration of drainage displacement with a dynamic pore-network model [3] and measured the local growth rate of the fingers as a function of the local pressure drop. We showed that there exists a regime where the two quantities relate nonlinearly with a power-law, which then crosses over to a linear Laplacian growth regime at higher capillary numbers [4]. The origin of this nonlinearity is the disorder in the capillary barriers at the pores [2, 4], and the pore-size distribution, through the distribution of capillary thresholds, controls this non-linearity. In our recent study [4], the pores size distribution was uniform. Here in this talk we will present our further investigations on the sensitivity of these results on the distribution of pore sizes, and how the exponent related to the fingers'growth law depends on the functional form of that distribution.

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