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Instabilities and pattern formation on the pore scale¹ ANNE JUEL, University of Manchester

What links a babys first breath to adhesive debonding, enhanced oil recovery, or even drop-on-demand devices? All these processes involve moving or expanding bubbles displacing fluid in a confined space, bounded by either rigid or elastic walls. In this talk, we show how spatial confinement may either induce or suppress interfacial instabilities and pattern formation in such flows. We demonstrate that a simple change in the bounding geometry can radically alter the behaviour of a fluid-displacing air finger both in rigid and elastic vessels. A rich array of propagation modes, including steady and oscillatory fingers, is uncovered when air displaces oil from axially uniform tubes that have local variations in flow resistance within their cross-sections. Moreover, we show that the experimentally observed states can all be captured by a two-dimensional depth-averaged model for bubble propagation through wide channels. Viscous fingering in Hele-Shaw cells is a classical and widely studied fluid-mechanical instability: when air is injected into the narrow, liquid-filled gap between parallel rigid plates, the axisymmetrically expanding air-liquid interface tends to be unstable to non-axisymmetric disturbances. We show how the introduction of wall elasticity (via the replacement of the upper bounding plate by an elastic membrane) can weaken or even suppress the fingering instability by allowing changes in cell confinement through the flow-induced deflection of the boundary. The presence of a deformable boundary also makes the system prone to additional solid-mechanical instabilities, and these wrinkling instabilities can in turn enhance viscous fingering.

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