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Viscous fingering instabilities: from suppression to disorder

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What links a babys first breath to adhesive debonding, enhanced oil recovery, filtration or multiphase microfluidics? These processes involve two-phase displacement flows in rigid or elastic confined vessels, which are prone to interfacial instabilities. The canonical viscous fingering instability, which occurs when air displaces a viscous fluid in the narrow gap between two parallel plates, provides a versatile test-bed for such phenomena. In this talk, I will use both experiments and numerical simulations of depth-averaged models to explore several aspects of viscous fingering. I will first show how the onset of fingering can be suppressed when replacing the upper plate of the vessel with an elastic sheet. Interfacial flows in narrow gaps can also exhibit considerable disorder, but they are rarely investigated from a dynamical systems perspective. I will show how compliance can promote rich multiplicity of front propagation modes in a channel, including disordered and therefore transient dynamics. I will then turn to exploring how organised transient dynamics of bubbles propagating in a rigid channel are orchestrated by weakly-unstable steady propagation modes, which can appear and disappear as the number of bubbles changes through bubble break-up and coalescence.