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The interaction between viscous fingering and wrinkling in elastic-walled Hele-Shaw cells DRAGA PIHLER-PUZOVIC, ANNE JUEL, MATTHIAS HEIL, University of Manchester — The development of viscous fingers in circular Hele-Shaw cells is a classical and widely-studied fluid mechanical problem. The introduction of wall elasticity (via the replacement of one of the bounding plates by an elastic membrane) can weaken or even suppress the fingering instability, but it also makes the system susceptible to additional solid-mechanical instabilities. We show that in elastic-walled Hele-Shaw cells that are bounded by sufficiently thin elastic sheets the (fluid-based) viscous fingering instability can arise concurrently with a (solid-based) wrinkling instability. We study the interaction between these distinct instabilities, using a theoretical model that couples the depth-averaged lubrication equations for the fluid flow to the Föppl–von Kármán equations which describe the deformation of the thin elastic sheet. By using a combination of a linear stability analysis and direct numerical simulations, we show that system's behaviour may be characterised by a non-dimensional parameter that indicates the strength of the fluid-structure interaction. For small [large] values of this parameter the system's behaviour is dominated by viscous fingering [wrinkling], with strong interactions between the two instabilities arising in an intermediate regime.

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