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The Role of Convective and Diffusive Mixing in Porous Media
SHYAM SUNDER GOPALAKRISHNAN, Fluid and Plasma Dynamics Unit, Universite Libre de Bruxelles, JORGE CARBALLIDO-LANDEIRA, ANNE DE WIT, Nonlinear Physical Chemistry Unit, Universite Libre de Bruxelles, BERNARD KNAEPEN, Fluid and Plasma Dynamics Unit, Universite Libre de Bruxelles —
The classical Rayleigh–Taylor (RT) instability that triggers convective and diffusive mixing when a denser fluid lies on top of a less dense one is characterised both numerically and experimentally in an ideal two-dimensional porous media. The universal nature of the flow dynamics starting with a stable diffusive regime, that is followed by a linearly unstable regime, and eventually to a nonlinear regime is presented. Though the fundamental behaviour has been studied extensively, the roles of convective and diffusive mixing on the flow features are not yet explored. It has been a long held view that diffusive mixing is significant only during the initial stages, and once the transition has occurred, the dynamics are governed by convection. We show that this is not the case, and both convection and diffusion play an important role even during the nonlinear regime, albeit at different regions of the flow with convection dominant locally at the tip of the fingers, and balanced by diffusion in the rest of the mixing zone. This also provides a quantitative measure for the evolution of the width of the fingers. The computational findings are well supported using our experimental observations, where an excellent agreement on the flow dynamics are obtained.

Bernard Knaepen
Fluid and Plasma Dynamics Unit, Universite Libre de Bruxelles

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