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# Experimental and numerical investigation on convective mixing in porous media flows

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We use experiments and simulations to investigate the mixing dynamics of a convection-driven porous media flow. We consider a fully saturated homogenous and isotropic porous medium, in which the follow is driven by density differences induced by the presence of a solute. In particular, the fluid density is a linear function of the solute concentration. The configuration considered is representative of geological applications in which a solute is transported and dissolves as a result of a density-driven flow, such as in carbon sequestration in saline formations or water contamination processes. The mixing mechanism is made complex by the presence of the rocks (solid objects), which represent obstacles in the flow and make the solute to further spread, due to the continue change of the fluid path. Making predictions on the dynamics of this time-dependent system is crucial to provide reliable estimates of the evolution of subsurface flows and in determining the controlling parameters, e.g., the injection rate of a current of carbon dioxide or the spreading of a pollutant in underground formations. To model this process, we consider here an unstable and time-dependent configuration defined as Rayleigh-Taylor instability, where a heavy fluid (saturated with solute) initially sits on top of a lighter one (without solute). The fluids are fully miscible, and the mixing process is characterised by the interplay of diffusion and advection: initially diffusion controls the flow and is responsible for the initial mixing of solute. At a later stage, the action of gravity promotes the formation of instabilities, and efficient fluid mixing takes place over the entire domain. The competition between buoyancy and diffusion is measured by the Rayleigh-Darcy number (Ra), the value of which controls the entire dynamics of the flow. With the aid of experiments in bead packs (optical measurements) and pore-resolved numerical simulations (immersed-boundary method), we analyse the time-dependent evolution of this system at high Ra, and we quantify the effect of the Rayleigh-Darcy number on solute transport and mixing. The results are analysed at two different flow scales: i) at the Darcy, where the buoyancy-driven plumes control the flow dynamics, and ii) at the pore-scale, where diffusion promotes inter-pore solute mixing. Numerical and experimental measurements are used to design simple physical models to describe the mixing state and the mixing length of the system. The results obtained are compared against previous experimental and numerical works.

## Participation

In-Person

## References

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**Primary authors:** DE PAOLI, Marco (Physics of Fluids Group, University of Twente); HOWLAND, Christopher (Physics of Fluids Group, University of Twente); VERZICCO, Roberto (University of Rome "Tor Vergata"); LOHSE, Detlef (Physics of Fluids Group, University of Twente)

**Presenter:** DE PAOLI, Marco (Physics of Fluids Group, University of Twente)

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