

# Carbon Dioxide Plume in Bespoke 2D Porous Micromodels

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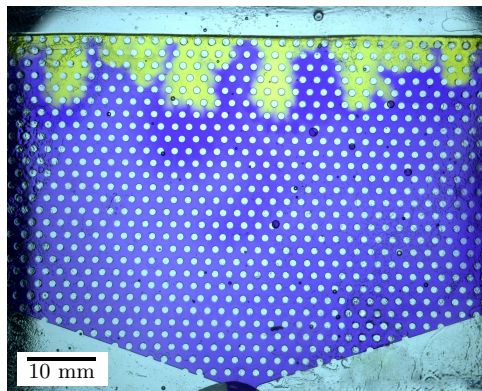


Fig. 1 – Snapshot of a gravitational fingering instability in a porous micromodel. The diameter of the cylindrical pillars is  $400\mu\text{m}$ , and the edge-to-edge distance is  $800\mu\text{m}$ .

In the current context of global warming, the short-term mitigation of greenhouse gas emission is of utmost importance. In this context, geological storage of carbon dioxide ( $\text{CO}_2$ ) appears a promising solution. Upon injection, supercritical  $\text{CO}_2$  rises up to the top caprock and immediately starts dissolving at the water/brine interface, leading to a  $\text{CO}_2$ -enriched layer of brine that happens to be heavier than the underlying pure brine. After a diffusion stage, this unstable configuration triggers a gravitational instability where convective plumes are generated and pour downwards to the bottom of the aquifer. In such a convective regime, the dissolution rate of  $\text{CO}_2$  - that is the efficiency of the  $\text{CO}_2$ -trapping - is greatly enhanced. However, the trapping efficiency is drastically affected by dispersion and mixing effects occurring at the porous scale [1, 2, 3].

In this work, experiments are performed to study the  $\text{CO}_2$  plume migration by means of in-house built microfluidic micromodels (pseudo Hele-Shaw cells). The micromodel core is made of NOA-63, a UV curable photo resin which is impermeable to gases. We developed a soft-lithography repeatable protocol to make symmetric regular patterns of cylindrical pillars sandwiched between two vertical plane walls separated from each other by a  $300\mu\text{m}$  gap. Pillars diameters ranging from  $R = 200$  to  $400\mu\text{m}$ , and edge-to-edge distances (between pillars) ranging from  $R$  to  $4R$  have been tested.

The water-filled micromodel was placed vertically in a  $\text{CO}_2$ -pressurized chamber, and plumes were visualized using pH-sensitive colour indicators - since  $\text{CO}_2$ -dissolution increases the acidity of aqueous solutions. We have used Bromocresol Purple (BP) whose color change region lies between 6.8 and 4.8 units of pH. The partial pressure of  $\text{CO}_2$  ranging from 1 to 8 bar have been explored. We observed that lateral growth of the gravitational fingers is enhanced by porous dispersion, which in turn reduces transverse concentration gradients in the system. This leads to decreases the growth rate of the instability (for a given value of the permeability) and mitigates the dissolution rate of carbon dioxide - i.e. the quantity of  $\text{CO}_2$  dissolved in the liquid per unit time (Sherwood number).

## References

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