Convective Dissolution of CO_2 in Index-Matched Porous Media: A Shadowgraphy Study

Happiness Imuetinyan[a,b], Paul Fruton[a,c], Cedric Giraudet[a,d], and Fabrizio Croccolo[a]

[a]*Universite de Pau et des Pays de l'Adour, E2S UPPA, CNRS, LFCR, Anglet, France*
[b]*Universite de Pau et des Pays de l'Adour, E2S UPPA, CNRS, DMEX, Pau, France*
[c]*Dipartimento di Fisica, Università degli Studi di Milano, Milano, Italy*
[d]*CTS Consulting & Technical Support, Vernon, France*

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Long-term carbon-dioxide (CO_2) storage is a key strategy for achieving the goals of the 2015 Paris Agreement [1]. To improve the efficiency and safety of CO_2 storage in saline aquifers, post-injection processes need to be better understood. One critical process is convective dissolution, where CO_2 first diffuses into brine, triggering buoyancy-driven convection thanks to density mismatch. Despite the physicochemical processes being well-characterised, open questions remain about the 3D convective dissolution of CO_2 in porous rocks. This work aims to make use of an experimental method based on shadowgraphy to study CO_2 convection in a transparent, saturated porous medium.

In a recent study, we reported on our first investigation of convective dissolution by shadowgraphy and with miscible analogue fluids in a saturated transparent porous medium [2]. In this follow-up work, we apply the same methods to study the convective dissolution of CO_2 in a saturated porous medium at high pressure and controlled temperature. We investigate Rayleigh numbers (Ra) ranging from 10^3 to 10^4, by varying the CO_2 injection pressure, thus obtaining various density differences. By investigating the temporal evolution of the image variance, we can detect distinct regimes of the CO_2 dissolution process, pure Fickian diffusion, onset of convection in the form of plumes, and fully developed convective mixing. Additionally, we are able to measure the plume speed (Figure 1) and quantify the convective flux, corroborating the findings from our previous study on miscible analogue fluids.

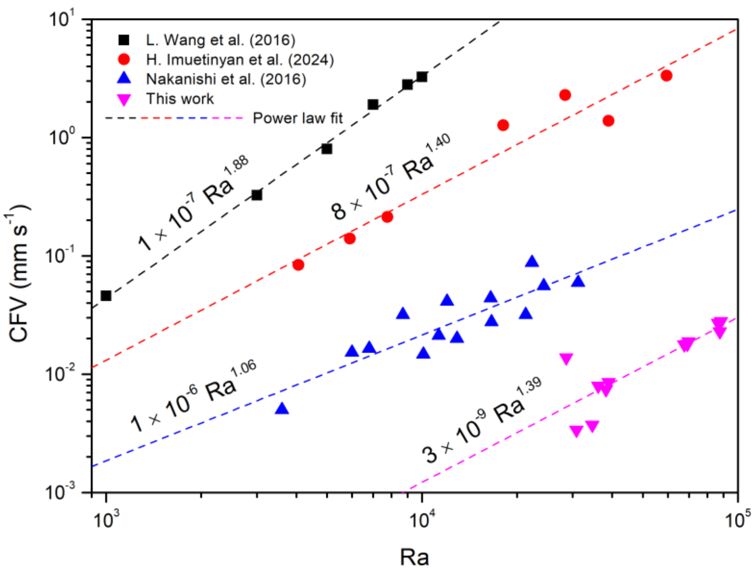

Figure 1: Average convective front velocity (CFV) as a function of Ra for different experiments.

References

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