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3D X-Ray Visualization of Rayleigh-Bénard Instability in a Porous Medium

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In geological storage of carbon dioxide (CO2), CO2 captured from large emission sources, such as thermal power plants, is injected into the brine-saturated reservoir under a supercritical condition with a density of 600-700 kg/m3. One of the primary concerns in geological storage is the leakage of CO2 due to buoyancy force. The dissolution of CO2 into formation brine improves CO2 storage security. Because natural convection between CO2-saturated and CO2-free brines governs the dissolution processes, many works have been reported on the onset of natural convection and its mass transfer using Rayleigh-Bénard convection. In this work, we report a three-dimensional (3D) experimental investigation on the onset of Rayleigh-Bénard convection in a porous medium and its mass transfer. A packed bed with plastic particles saturated with water was used as a 3D porous medium. In contrast, alkaline acid soap containing sodium iodide (NaI) was used for the top boundary to model the dissolution from a rigid solid surface. The dissolution of alkaline acid soap into water forms an unstable density profile, triggering Rayleigh-Bénard instability in a porous medium. The fingering structures of Rayleigh-Bénard convection were visualized by using the X-Ray micro-computed tomography scanner (X-Ray CT). The experimental conditions cover the Rayleigh number (Ra) range between 2700 and 8100. Because the critical wavelength decreases with an increase in Ra, the finer fingers appear on the top boundary for the higher Ra. The fingers merged into the large fingers, which extended vertically downward with time. The onset time of convection reduces with Ra, and the mass transfer increases with it. These results are compared with the previous numerical works. Finally, we discuss the appropriate modeling of natural convection in geological storage.

Keywords: 3D X-Ray Visualization, Fingering Structures, Rayleigh-Bénard Instability, Rayleigh number (Ra), Natural Convection.

* Corresponding authors: sin.s.ab@m.titech.ac.jp, suekane.t.aa@m.titech.ac.jp

Participation

In-Person

References

[1] Y. Nakanishi, A. Hyodo, L. Wang, T. Suekane, Experimental study of 3D Rayleigh-Taylor convection between miscible fluids in a porous medium, Advances in Water Resources., 97 (2016) 224-232.
[2] L. Wang, Y. Nakanishi, A. Hyodo, T. Suekane, Three-dimensional structure of natural convection in a porous medium: Effect of dispersion on finger structure, International Journal of Greenhouse Gas Control., 53 (2016) 274-283.
[3] G. S. H. Pau, J. B. Bell, K. Pruess, A. S. Almgren, M. J. Lijewski, K. Zhang., High-resolution simulation and characterization of density-driven flow in CO2 storage in saline aquifers, Advances in Water Resources., 33 (2010) 443-455.
[4] J. A. Neufeld, M. A. Hesse, A. Riaz, M. A. Hallworth, H. A. Tchelepi, and Herbert E. Herbert, Convection dissolution of carbon dioxide in saline aquifers., Geophysical Research Letters., 37 (2010) L22404
[5] T. Suekane, T. Nobuso, S. Hirai, M. Kiyota, Geological storage of carbon dioxide by residual gas and solubility trapping, International Journal of Greenhouse Gas Control., 2 (2008) 58-64.

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Primary author: Mr SIN, Sotheavuth (Department of Mechanical Engineering, Tokyo Institute of Technology)

Co-authors: Mr IMAI, Shun (Department of Mechanical Engineering, Tokyo Institute of Technology); Dr MATSUSHITA, Shintaro (Department of Mechanical Engineering, Tokyo Institute of Technology); Prof. SUEKANE, Tetsuya (Department of Mechanical Engineering, Tokyo Institute of Technology)

Presenter: Prof. SUEKANE, Tetsuya (Department of Mechanical Engineering, Tokyo Institute of Technology)

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