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Three-dimensional Rayleigh-Taylor convection of miscible fluids in a porous medium. TETSUYA SUEKANE, YUJI NAKANISHI, LEI WANG, Tokyo Insitute of Technology — Natural convection of miscible fluids in a porous medium is relevant for fields, such as geoscience and geoengineering, and for the geological storage of CO2. In this study, we use X-ray computer tomography to visualize 3D fingering structures associated with the Rayleigh–Taylor instability between miscible fluids in a porous medium. In the early stages of the onset of the Rayleigh–Taylor instability, a fine crinkling pattern gradually appears at the interface. As the wavelength and amplitude increase, descending fingers form on the interface and extend vertically downward; moreover, ascending and highly symmetric fingers form. The adjacent fingers are cylindrical in shape and coalesce to form large fingers. Fingers appearing on the interface tend to become finer with increasing Rayleigh number, which is consistent with linear perturbation theory. If the Pclet number exceeds 10, the transverse dispersion increases the finger diameter and enhances finger coalescence, strongly impacting the decay in finger number density. When mechanical dispersion is negligible, the finger-extension velocity, the mass-transfer rate, and the onset time scale with Rayleigh number. Mechanical dispersion not only reduces the onset time but also enhances mass transport, which indicates that mechanical dispersion influences the long-term dissolution process of CO2 injected into aquifers.

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