Characterizing Multiphase Flow Behavior for Residual Trapping of CO2 in Rock Fractures using a Versatile Fracture Flow Cell

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Abstract

While research on multiphase flow in porous media has been very extensive in the last 40 years, at both the pore and continuum scales, comprehensive understanding of how the phenomenology of two-phase flow in geological fractures is impacted by both the flow conditions (capillary number Ca and viscosity ratio M) and the geometry (fracture closure), remains elu- sive. We investigate residual trapping of CO2 in fractured reservoirs at the fracture scale, explor- ing the complex interplay between fracture surface roughness and the displacement of fluid-fluid interfaces. Our systematic approach explores the phenomenology of two-phase flow in fractures, taking into meticulous consideration the fluid properties, flow conditions, and fracture geometry. To this aim, we have developed a transparent fracture flow cell with self-affine rough-walled sur- faces and precisely-controlled mean aperture, which can be varied. The fracture wall geometry is generated from numerical models that are consistent with the well-known stochastic geometric properties of geological fractures. A camera allows recording the dynamics of the fluid phases' spatial distribution within the fracture plane. The displacement patterns are characterized as functions of Ca, M , the density difference of the fluids, and the fracture's geometrical parameters. We thus aim to characterize the amount of supercritical CO2 trapped in fractured aquifers as a function of those controlling parameters.

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