The effect of injection rate on fluid invasion patterns: Immiscible two-phase fluid displacement in 2D laser-manufactured micromodels

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The Effect of Injection Rate on Fluid Invasion Patterns: Immiscible Two-Phase Fluid Displacement in 2D Laser-Manufactured Micromodels

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The physical process whereby an immiscible fluid phase replaces a second resident fluid in a porous medium is characteristic of many subsurface processes that include remediation of non-aqueous phase liquids, enhanced oil recovery, and CO2 storage(1). Therefore, understanding of fluid displacement mechanisms at the pore level is essential to improve existing technologies in the petroleum and hydrology industries. The aim of this study is to enhance our understanding of invasion processes of immiscible fluids at the pore scale. To do so, we use laser-manufactured micromodels that are made of transparent, borosilicate glass substrates(2). Micromodels are simplified, two-dimensional (2D) representations of natural porous media that enable direct visualization of processes within patterned microstructures(3). An experimental visualization setup is used to vary injection rates and observe fluid invasion patterns in immiscible two-phase fluid displacement experiments in laser-machined micromodels. The components of the set-up include a syringe pump for fluid injection, a uniform light source, and a camera mounted on a translation stage for image acquisition. To imitate reservoir conditions, fluid displacement experiments are conducted at capillary numbers ranging from 9.5×10-6 to 1.9×10-5. Direct numerical simulations are a useful tool to improve our ability to predict the dynamics of immiscible two-phase flow in porous media. Accordingly, in this work the micromodel visualization studies are complimented with simulations and results from the experiments are used to validate the numerical models. The Cahn–Hilliard phase-field method is applied for direct numerical simulation of the two-phase flow experiments.

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