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Viscosity and surface tension effects during multiphase flow in propped fractures

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Geological sequestration of CO_2 was proposed as an important mechanism to reduce its emission into atmosphere. CO_2 exhibits a higher affinity to organic matter than methane molecules and, potentially, it could be pumped and stored in shale reservoirs while enhancing late stage shale gas production. A successful analysis of CO_2 sequestration in low matrix permeability rocks such as shales requires a thorough understanding of multiphase flow in stimulated rock fractures, which provide most significant pathways for fluids in such systems. Multiphase fracture flows are also of great relevance to brine, oil and gas migration in petroleum systems, water and stream circulation in geothermal reservoirs, and chemical transport of non-aqueous phase liquids in shallow hydrogeological systems, particularly in partially saturated zones.

There are various physical models that describe phenomena taking place during multiphase flow through porous media. One of key aspects that need to be considered are pore-scale effects related to capillarity. Unfortunately, detailed models that describe motion and evolution of phase or component boundary require direct numerical simulations and spatial resolutions that are hard to reach when considering industrial relevant systems. Main aim of the presented work was the development of reduced 2.5D models based on Brinkman approximation of thin domain flow that would be able to capture local scale phenomena without expensive 3D simulations. Presented approach was designed specifically to tackle incompressible and immiscible systems and is based on Continuous Surface Force approach presented by Brackbill et al., implemented using Lattice Boltzmann Method.

Presented approach where firstly validated against standard test cases with known classical solution and known experimental data. In the second part, we present and discuss two component, immiscible permeability data for rough and propped fracture obtained with our code for a rage of proppants fraction, apertures and flow conditions.