Behavior of Non-Aqueous Phase Liquids in Fractured Porous Media under Two-Phase Flow Conditions

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Abstract

After Dense Non-Aqueous Phase Liquids (DNAPLs) travel downward through the subsurface, they typically come to rest on fractured bedrock or tight clay layers, which become additional pathways for DNAPL migration. DNAPLs trapped in fractures are continuous sources of groundwater contamination. To decide whether they can be left in place to dissolve or volatilize, or must be removed with active treatment, the movement of DNAPLs in fractured media must be understood at a fundamental level. This work presents numerical simulations of the movements of DNAPLs in naturally fractured media under two-phase flow conditions. The flow is modeled using a multiphase network flow model, used to develop predictive capabilities for DNAPL flow in fractures. Capillary Pressure-Saturation-Relative Permeability curves are developed for two-phase flow in fractures. Comparisons are made between the behavior in crystalline, almost impermeable rocks (e.g. granite) and more permeable rocks like sandstone, to understand the effects of the rock matrix on the displacement of the DNAPLs in the fracture. For capillary-dominated flow, displacements occur as a sequence of jumps, as the invading phase overcomes the capillary pressure at downgradient apertures. Preferential channels for the displacement of non-aqueous phase are formed due to high fracture aperture in some regions.