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Modeling of DNAPL spreading in heterogeneous variable aperture fractures

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The design of effective remediation schemes for dense non-aqueous phase liquids (DNAPLs) in fractured rocks requires a fundamental understanding of their multiphase spreading and dissolution processes in these highly heterogeneous systems. Stochastic heterogeneity is present both at the level of individual fractures and at the level of fracture networks, and the processes of DNAPL spreading in these systems are not well understood. This work investigates the multiphase spreading and immobilization of chlorinated solvents in variable aperture single fractures by means of numerical modeling. Multiphase simulation code iTOUGH2/T2VOC is used. Log-normally distributed and spatially correlated aperture fields are generated and locally valid cubic law is assumed to relate the variable aperture to the variable permeability. Hysteretic Brooks-Corey-Burdine type of capillary pressure-saturation-relative permeability relationships obtained by experimental study of Reitsma and Kueper (Water Resources Research, 30 (1998): 865-878) are adopted and scaled with regard to interfacial tensions and local permeability according to Leverett J function. The effect of fracture aperture characteristics and correlation length as well as fracture dipping angle on DNAPL spreading pathway and residual distribution is examined. Implications for upscaling the observed behavior to fracture network systems are discussed.