Geophysical Research Abstracts
Vol. 20, EGU2018-7421, 2018
EGU General Assembly 2018

Capillary end effects and their impact on pore-scale steady-state relative permeability data

Gaël Raymond Guédon (1), Jeffrey De'Haven Hyman (2), Fabio Inzoli (1), Monica Riva (3), and Alberto Guadagnini (3)

(1) Politecnico di Milano, Energy Department, Milano, Italy (gaelraymond.guedon@polimi.it), (2) Los Alamos National Laboratory, Computational Earth Science Group (EES-16), Earth and Environmental Sciences Division, Los Alamos, USA, (3) Politecnico di Milano, Department of Civil and Environmental Engineering (DICA), Milano, Italy

We analyze the impact of capillary end effects on steady-state relative permeability estimates based on pore-scale numerical simulations of two-phase flows in three-dimensional reconstructed porous media. Understanding and characterizing capillary end effects is of outmost importance to modern characterization of subsurface flows in reservoirs/aquifers, as they can significantly bias relative permeability estimates based on both laboratory-scale multiphase flow experiments and pore-scale numerical simulations. While capillary end effects arise from discontinuities in the solid matrix caused by the inlet and outlet connections during experiments, a phenomenon, which is akin to capillary end effects, can also arise in numerical simulations due to the constraints applied at the boundaries of the computational domain. Here, we profile the relative strength of these capillary end effects on the calculation of steady-state relative permeabilities obtained within randomly generated porous micro-structures using a finite volume-based two-phase flow solver. We mimic steady-state protocols employed for relative permeability laboratory-scale experiments by co-injecting a wetting (i.e. water) phase and a non-wetting (i.e. oil) fluid phase. We consider porous micro-structures characterized by three diverse average pore size and length parallel to mean flow direction and illustrate the results associated with a given porosity (i.e. Phi = 0.48). Our results consistently show the establishment of three regions along the medium: (a) an inlet-disturbed (ID) region characterized by oil saturations which are relatively high and mainly driven by the inlet boundary value; (b) a bulk-undisturbed (BU) region where oil saturation appears to oscillate around a constant value; and (c) an outlet-disturbed (OD) region in which a sudden drop in oil saturation is observed. Capillary end effects drive the system behavior in the disturbed regions. Our results document that varying the length of the porous micro-structures along the mean flow direction does not alter significantly the size of the disturbed regions. Thus, a bulk-undisturbed region is not clearly visible for the smallest pore domains. We propose and illustrate a method for the evaluation of relative permeabilities that excludes the regions of the pore-space affected by boundary conditions. Our approach is based on the analysis of the computed trends of the time and section-averaged fluid pressure and oil saturation distribution. We provide recommendations on the minimum length of pore spaces conducing to relative permeability estimates marginally influenced by capillary end effects. In this sense, our study contributes to the ongoing development of procedures for the determination of pore-scale relative permeabilities.