Geophysical Research Abstracts
Vol. 12, EGU2010-8918-1, 2010
EGU General Assembly 2010

A lattice Boltzmann approach to non-pure invasion of immiscible two-phase flow in porous media

Ying Wang, Benjamin Ahrenholz, and Manfred Krafczyk

TU Braunschweig, Institute for Computational Modeling in Civil Engineering, Braunschweig, Germany (Email: {yingwang, ahrenholz, kraft}@irmb.tu-bs.de, Fax: +49 (0531) 391 7518)

In contrast to pure invasion, i.e., drainage or imbibition, we focus on the non-pure invasion process in porous media that recently attracts increased attention in experimental research. Transport is usually dominated by the interaction and competition between drainage and imbibition. Experimentally non-pure invasion can be designed by simultaneous injection of two-phase fluids from alternating inlet points, and two flow regimes are therefore generated in the model allowing a seamless conversion from a transient process to a statistical equilibrium state. The constant inlet flow rate can be utilized as the sole external force to drive the model into a statistical equilibrium. In addition the inlet flow rate determines explicitly the capillary number, which is used for establishing various relations between flow properties and scaling laws of non-wetting cluster size distributions in steady state.

The numerical study based on a lattice Boltzmann model at the pore scale will be performed to reveal the flow dynamics of both states, especially the steady state, for which pressure difference, relative permeability, saturations and cluster distribution are invariant in time. To generate a geometry numerically for fitting the experimental configuration of [1,2], a random sphere packing algorithm is used to obtain the desired porosity allowing a small overlap between the spheres. The numerical geometry demonstrates a monolayer of spheres with the uniform diameter $a = 0.01$. The porosity 0.63 implies the total number of the spheres with the model dimensions $8.5 \times 4.2 \times 0.01$ and the uniform volume of sphere 5.236×10^{-7}, namely 252274 spheres are contained in the model.

The contribution of the lattice Boltzmann method to dimensionless analysis for the non-pure invasion model will be explored on the background of the quantitative derivation and experimental interpretation of the relations in the steady state, which are reported by Tallakstad et al. in [1,2]. The results of this numerical approach, i.e., the important power-laws with respect to the capillary number Ca, will be plotted on the context of experimental data, e.g., the averaged steady-state pressure difference ΔP_{ss}, the non-wetting saturation S_{nw}, the numerical breakthrough time t_b and the time t_{ss} reaching the steady state. In addition we will conduct an analysis of the cluster size distribution for both phases which will allow a derivation of the quantity β for the relationship $\Delta P_{ss} \propto Ca^{\beta}$, which has been postulated to be 0.54 ± 0.08 in [1,2].

In this work, we have compared the simulated non-pure invasion model to experimental data without consideration of gravity, for which the Capillary number plays a key role to perform the dimensionless analysis. The numerical influence of gravity on the model will be subject of future studies.

References

[1] Ken Tore Tallakstad, Henning Arendt Knudsen, Thomas Ramstad, Grunde Løvoll, Knut Jørgen Måløy, Renaud Toussaint, and Eirik Grude Flekkøy. Steady-state two-phase flow in porous media: Statistics and transport properties. *Phys. Rev. Lett.*, 102(7):074502, Feb 2009.

[2] Ken Tore Tallakstad, Grunde Løvoll, Henning Arendt Knudsen, Thomas Ramstad, Eirik Grude Flekkøy, and Knut Jørgen Måløy. Steady-state, simultaneous two-phase flow in porous media: An experimental study. *Phys. Rev. E*, 80(3):036308, Sep 2009.