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Upscaled model for two-phase flow in porous media

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The formal derivation of the macroscopic mass and momentum balance equations for two-phase, creeping incompressible and Newtonian flow in rigid and homogeneous porous media is proposed in this work, assuming separation of length-scales and the existence of a (periodic) representative elementary volume, both classical for upscaling. The development is performed by making use of elements of the volume averaging method, combined with the adjoint technique and a Green's integral formulation [1, 2]. The macroscopic mass balance equation in each phase is identical to that already reported in the literature [3, 4]. The macroscopic momentum balance equation expresses the seepage velocity in each phase under the form of a pair of Darcy-like terms, involving a dominant and coupling permeability tensor, respectively related to viscous effects in the phase under concern and viscous coupling through the interfaces. Importantly, it includes an additional term resulting from capillary effects. The later has not been obtained so far as a result of a priori assumptions that this term should be negligible, in particular for small capillary numbers [4, 5, 6]. The effective coefficients present in this macroscopic model are all obtained from the solution of two coupled closure problems that coincide with those already reported in the literature [4, 5, 6, 7]. The performance of the model is illustrated with numerical simulations carried out in a model two-dimensional configuration using a boundary element method. Average velocities, resulting from direct numerical simulation, are compared to the predictions of the macroscopic model obtained from the closure problems solution, showing excellent agreement over extended ranges of the capillary number, viscosity ratio and wetting-phase saturation. The additional capillary term present in the average momentum equation is shown to have a very important contribution is some situations. Extensions to other flow situations are briefly discussed.

Participation

In-Person

References

[1] Bottaro, A. 2019 Flow over natural or engineered surfaces: an adjoint homogenization perspective. J. Fluid Mech. 877, P1.

[2] Lasseux, D., Valdés-Parada, F.J. & Bottaro, A. 2021 Upscaled model for unsteady slip flow in porous media. J. Fluid Mech. 923, A37.

[3] Whitaker, S. 1986 Flow in porous media II: the governing equations for immiscible, two-phase flow. Transp. Porous Med. 1 (2), 105–125.

[4] Auriault, J.-L. 1987 Nonsaturated deformable porous media: quasistatics. Transp. Porous Med. 2 (1), 45–64.

[5] Whitaker, S. 1994 The closure problem for two-phase flow in homogeneous porous media. Chem. Engng Sci. 49 (5), 765–780.

[6] Lasseux, D., Quintard, M. & Whitaker, S. 1996 Determination of permeability tensors for two-phase flow in homogeneous porous media: theory. Transp. Porous Med. 24 (2), 107–137.

[7] Picchi, D. & Battiato, I. 2018 The impact of pore-scale flow regimes on upscaling of immiscible two-phase flow in porous media. Water Resour. Res. 54 (9), 6683–6707.

[8] Lasseux, D. & Valdés-Parada, F. J. 2022 A macroscopic model for immiscible two-phase flow in porous media. Journal of Fluid Mechanics 944, A43.

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