Contribution ID: **896** Type: **Oral 20 Minutes**

Morphological Evolution of Invading Fluids under Homogeneous and Heterogeneous Wetting Conditions

Monday, 14 May 2018 11:54 (15 minutes)

Wettability is a major factor that controls the evolution of interfaces during immiscible fluid displacement from a permeable medium. Three dimensional imaging by ultrafast X-ray tomography allows us to investigate the morphology at different wetting conditions and relate it to the prevalent pore-scale process. In this study we focus on the evolution of the fluid interfaces in random piles of spherical beads with a narrow radius distribution. The contact angle of the invading fluid is varied through surface functionalization and by using different combinations of invading and defending fluids. Three methods are proposed to quantify the morphology of the invading interface from the acquired X-ray images. As governed by the contact angle, two qualitatively different classes of displacement pattern are observed in homogeneous bead packs of uniform wettability [1]. The same contact angle for the cross-over between the two distinct displacement regimes is obtained applying three independent methods to quantify the morphology of the invading fluid. Samples consisting of wettable and non-wettable beads indicate that the displacement pattern is the result of a mixture of different local advancing modes of the interface. These modes lead to either capillary fingering or stable front invasion [1]. The influence of wettability is further delineated by varying the ratio between wettable and non-wettable beads in the packing. Our results demonstrate the strong influence of mixed wet conditions on the displacement process, and provide further insights to the factors that control the formation of the macroscopic fluid flow pattern.
Reference:
[1] K. Singh, H. Scholl, M. Brinkmann, M. Di Michiel, M. Scheel, S. Herminghaus, and R. Seemann. Sci. Rep. 7: 444 (2017).

References

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Session Classification: Parallel 1-D

Track Classification: GS 3: Experimental achievements