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Towards a bettter understanding of foam flow patterns in porous media

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Liquid foams are a proposed solution to overcoming conformance issues while increasing apparent viscosity over gas/water only injections in petroleum reservoirs. However due to the diversity of flow behaviour foam flow in porous media providing a sufficiently accurate and low uncertainty model for industrial use can represent a significant challenge. Understanding the specifics of foam flow dynamics in terms of elements of the porous media microstructure could alleviate some of the task involved with describing foam displacements.

In our study we make use of a microfluidic experimental setup including a high speed camera (800 fps obtained in one configuration), and precise fluid injection rates and measured pressure drop over a 2D micromodels of varying structure through which we observe foam flow. A significant increase in viscosity is observed as the pressure drop rises until obtaining a smooth pressure profile interpreted as the steady state. To obtain quantified data regarding foam bubble population and transport, an image processing workflow was developed that involves binarizing the images through a thresholding method based around the foam films, then successively eliminating the objects representing the solid grains impeding flow. The final step of the workflow involves tracking individual bubbles through the image series, and averaging the results over multiple image series. The dynamic tracking of a high number of objects (approx. 5 000 000 velocity data points per model heatmap) allows us to establish of steady state velocity and flux fields within the medium. This data is furthermore combined with the bubble sizes. In this way the flow behaviour can be observed in terms of either flow velocity per bubble size or inversely.

Initial results of velocity and flux fields demonstrate that significant differences exist between flow of differing bubble sizes. Whether it be through self-segregation or bubble size adaptation, the flow of largest bubbles is exclusively found in a few paths that are seen to be on average wider and oriented in parallel to the flow. These paths are also more likely to carry higher velocities. On the contrary, the smallest bubbles populate transverse small pathways perpendicular to the flow direction. For a means of comparison, we perform 2D Lattice Boltzmann simulations of simple Stokes flow on a digitized template of the micromodel, and compare the obtained foam fluxes with the monophasic numerical analogue. When compared to the monophasic flow simulations, the amount of transverse flux in paths perpendicular to the flow direction is much smaller in all the foam examples.

Through a more quantitative analysis flow in terms of microstructural parameters we explore relationships (or lack thereof) between foam flow and local porous media properties such as pore/constriction sizes, coordination and immediate neighbourhood properties. Foam flow is only weakly correlated to pore scale properties as in a steady state situation the entirety of a flow path over the medium has to be taken into account as a single flowing object and flow preference needs to be evaluated in terms of the complete path properties.

References

Ettinger, R. A.; Radke, C. J. (1992): Influence of Texture on Steady Foam Flow in Berea Sandstone. In SPE Reservoir Engineering 7 (01), pp. 83–90. DOI: 10.2118/19688-PA.
Géraud, Baudouin; Jones, Siân A.; Cantat, Isabelle; Dollet, Benjamin; Méheust, Yves (2016): The flow of a foam in a two-dimensional porous medium. In Water Resour. Res. 52 (2), pp. 773–790. DOI: 10.1002/2015WR017936.

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