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PREDICTION OF RESIDUAL OIL SATURATION IN MIXED-WET NETWORKS USING ACCURATE PORE SHAPE DESCRIPTORS

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Summary. Immobilization of non-aqueous phase liquids (NAPL) is similar to oil trapping during waterflooding in oil reservoirs. Proper two-phase flow simulation, including trapped or residual oil saturation, requires accurate capillary pressure and relative permeabilities curves. Pore-scale network modelling can be used to estimate these flow parameters.

The present two-phase pore network modelling tool takes as input geometrically and topologically representative networks from digital pore space reconstructions to generate the corresponding flow curves. Recently, Ryazanov at el. (Transp. Porous Med. 80(1): 79-99, 2009) have included the thermodynamic oil layers collapse criterion (van Dijke and Sorbie, J. Coll. Int. Sci. 293:455-463, 2006) in this network model. In this work, a new n-cornered star shape characterization technique (Star) (Helland et al., Proc. ECMOR XI, 2008) has been implemented in addition to the commonly used Circle-arbitrary Triangle-Square (CTS) shape representation. The star shape needs one more parameter to describe the pore shape, i.e. the normalized hydraulic radius, which can easily be obtained from the digital pore space.

The improved network model has been used to predict experimental water-wet relative permeabilities and oil residuals for the network extracted from a Berea sandstone reconstruction. Simulations for CTS only and when also including the star shape have been performed. It has been shown that star shapes give a significantly better match for relative permeabilities and residual oil saturation. A number of oil-wet simulations also showed substantial differences between star shape and CTS simulations. For a fractionally wet model with star shapes the sensitivity of residual oil to the fraction of oil-wet pores and to different contact angle intervals has been investigated. As a result the residual oil saturation reduces with increasing oil wetness. Additionally, relative permeabilties have been calculated.

Furthermore, comparison of network simulations with a range of mixed-wet core waterflooding experiments (Jadhunandan and Morrow, SPEJ.10:40-46,1995) showed good agreement between predicted and experimental residual oil. Secondary drainage has been simulated to reproduce experimental Amott-Harvey wettability indices.