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Onset of Oil Mobilization and Cluster Size Distribution

Maja Ruecker (1,2), Ryan Armstrong (1), Apostolos Georgiadis (1), Holger Ott (1), Steffen Berg (1), Leon Leu (1,2), Martin Wolf (2), Faisal Khan (2), Frieder Enzmann (2), and Michael Kersten (2)

(1) Shell Global Solutions International B.V., Rijswijk, The Netherlands, (2) Geosciences Institute, Johannes-Gutenberg University, Mainz, Germany

The onset of oil mobilization during imbibition has been imaged under dynamic flow conditions where the visco-capillary balance is maintained by using fast synchrotron-based X-ray computed micro tomography. Oil mobilization under unsteady-state displacement has been studied for sintered glass, sandstone and carbonate rock which show distinctly different behaviour.

For sintered glass, in agreement with a previous study under static conditions [Georgiadis et al., Phys.Rev.E 033002, 2013], the cluster size distribution is power-law like only over limited. Also the saturation stays rather constant during the low-rate imbibitions because the visco-capillary balance did not exceed 1, i.e. the macroscopic capillary number remains smaller than 1 which is not sufficient for oil mobilization [Armstrong et al., GeoPhys.Res.Lett. 41, 1-6. 2014].

The carbonate rock shows a power-law like cluster size distribution over the whole range. It is not fully clear whether this behaviour is caused by a more complex pore morphology in carbonates with a broader pore size distribution overlapping with heterogeneity length scales which creates an apparent larger range scale-free behaviour.

The sandstone rock shows the most interesting behaviour as during imbibitions a significant amount of oil is mobilized during the imbibitions process. The fast tomography now allows to follow this process step by step providing detailed spatially resolved information on the pore scale and also the statistical relevance. The observations can be summarized that during imbibition oil is mobilized by the biggest (percolating) cluster breaking successively apart into fragments and in particular intermediate size clusters grow in size and increase in frequency.