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Screening of EOR Potential on the Pore Scale - Application of Microfluidics to Alkaline Flooding

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Complex chemical EOR processes, such as in alkaline or surfactant flooding, are typically optimized on their phase behavior and by core flood experiments. However, the information from classical experiments are rather limited, because they do not directly give insight the details of oil mobilization and displacements – in core floods, typically oil production and differential pressure are measured, which are both 1D data sets. The phase behavior is typically measured in test tubes and not under realistic flow (mixing) conditions in porous media flow. Chemical EOR is changing interactions between fluids and the porous medium and is therefore manifested on the pore scale, where fluids are actually displaced. However, pore scale observations are typically suffering from a limited field of view especially for multiphase flow effects, which may not be representative for the overall system or the displacement.

In the frame of this study, we investigate displacements of crude oil by water and alkali solutions in order to optimize injection-water compositions for tertiary recovery. The study takes advantage of the high spatial and temporal resolution of microfluidics in order to observe fluid phases in the pore space, their distribution and displacements. Changes of the wetting state, breaking of oil clusters and the formation of emulsion phases as characteristic for the displacements have been observed. In order to overcome the limitation of the relatively small field of view, oil clusters have been analyzed by statistical and topological means showing a systematic change form water flooding to EOR.

The study shows that (a) cluster analysis can be used for EOR screening and – in the present case – is more indicative with respect to EOR performance than production data from the same experiment. The study might be a first step towards statistical fingerprinting for optimizing EOR processes. (b) classical phase behavior experiments do not reflect (or just partly) the phase behavior in the porous medium under flow conditions. (c) the formation of (micro) emulsions in the pore space leads to pinning effects and is therefore of disadvantage for the displacement.