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Characterization of Fluid-Fluid Interactions in Heterogeneous Porous Media

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The two-phase flow of water and oil is accompanied by the emulsification process at the interface between the fluids. The compositions and rate of formation of these emulsions can strongly affect the predicted oil recovery. However, it is a scientific challenge to study and characterise the emulsions formed during the flow in porous media since their properties are not reproducible in ex-situ conditions.

In this work, we have conducted a pore-scale investigation on the formation of in-situ emulsions in heterogeneous carbonate rocks. In addition, the effect of injected water chemistry on the composition and volume of formed emulsions was studied. To achieve that, three experimental sets were completed. In each set, a micro-plug sample was first injected with seawater to model the secondary oil recovery. After that, a brine with modified ionic composition was injected in tertiary mode. A high-resolution μCT image was captured after each recovery step. Next, we have applied a novel methodology for precise identification of the mixed-phase on images by combining images of a sample saturated with pure fluids (100% water and 100% oil) with rock matrix histogram fitting. At last, we applied the compositional gradient technique to analyse the fraction of oil in the identified emulsion clusters.

The results show that the composition of emulsion is dependent on both rock geometry as well as the initial wetting state. Specifically, in an initially oil-wet sample emulsion is mostly of oil content, while for the mixed-wet sample the composition distribution is more evenly spread between water and oil fractions. Emulsion cluster size has shown a log bimodal distribution both before and after modified water injection. Noteworthy, in each case, injection of brine with modified ionic composition caused the growth of emulsion clusters, which led to improved sweep efficiency and oil recovery. The composition of the emulsion generated during tertiary injection was skewed towards the water content in every case. However, the efficiency of oil recovery improvement was observed to be dependent on the type of brine modification. In particular, the brine with depleted Ca2+ content was shown to be the most effective, while a brine enriched with SO42- has shown to be the least effective.

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References

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

In person

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