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Advanced Digital-SCAL measurements of gas trapping in sandstone

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As a key parameter, trapped gas saturation (Sgr) plays an important role in subsurface processes involving gasses such as carbon capture and storage, H2 storage efficiency and also the production of natural gas. However, the gas compressibility, partitioning/solubility and diffusion effects can be important impact factors for the spatial evolution of fluid and gas phases and directly contribute to the overall mobility. Thus, Sgr is difficult and challenging to measure in the laboratory or field. We have indications that the conventional method of measurement- low-rate unsteady-state core flooding - is often impacted by gas dissolution effects, resulting in large uncertainties of the measured Sgr. Moreover, it is not understood why this effect occurs even for brines pre-equilibrated with gas. The hypothesis is that it is related to the effective thermodynamic behavior inside the porous medium which due to the geometric confinement could be different than the phase behavior of bulk fluids.

Therefore, in this study, we used high resolution X-ray CT imaging techniques to be able to investigate such effects at the pore scale. We conducted in-situ experiments in Bentheimer sandstone using X-ray computed micro tomography which allowed direct visualization of the snap-off of gas phase and the shrinkage of the gas ganglia inside of the pore. Gas saturated brine was injected at very low rate (0.495 µL/min) using high pressure syringe pumps (Quizix), while applying with a back pressure of 5 bar to ensure that the pressure drop over sample is low enough to prevent experimental artefacts. The gas and water distributions in the pore space were scanned using a Zeiss Versa 520 micro-CT scanner with the voxel size of 4 µm at regular time intervals after injection of every PV. After injecting a total of 6 PV, 7 more images were taken every 24 hours to check the gas distribution in the rock sample after stopping l the injection.

One of the key findings is that for pre-equilibrated brine, the remaining gas saturation was continually decreasing with more brine injected and even after the brine injection was stopped, resulting in very low Sgr values (possibly even zero) At the pore scale level, we were able to clearly observe the snap-off effect followed by a further shrinkage of the gas in each pore. This points to the hypothesis that indeed the gas dissolution plays a role during the experiment. The effect is likely linked to ripening dynamics which involves a coupling between phase equilibrium and dissolution/partitioning of components on the one hand and capillarity in the geometric confinement of the pore space on the other hand.

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References

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Participation

Unsure

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