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# Trapping Behavior of Gases from 4D Pore Scale Imaging

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The trapping behavior of gases in porous rock plays an important role in many subsurface processes such as underground storage of carbon dioxide and hydrogen, and the production of hydrocarbons. Over the last decade several laboratory studies have demonstrated that the trapping behavior of gas can be different than that of an immiscible liquid [1-7]. It is challenging to experimentally measure the trapped gas saturation (Sgr) in the laboratory, as the gas compressibility, partitioning/solubility and diffusion effects largely impact the spatial evolution of fluid and gas phases. The uncertainty in Sgr is often so large that it could have significant impact on field development decisions. Experiments with 3D pore scale imaging have already revealed details of physicochemical processes. In the particular case of trapped gas saturation, it is furthermore important to develop a more general understanding of gas dynamics at the pore scale, i.e. an understanding of dynamic processes, which requires then 4D imaging (3D + time).

The pre-equilibration of liquids e.g. brine with gas is necessary to measure Sgr [6]. However, it has been observed that trapped gas still dissolves over time –the mechanism of which is not fully understood yet [1, 6]. Here, we present a 4D high resolution X-ray CT imaging technique in a study covering the effective in-situ behavior of a range of gases, including compressed air, CH4 and H2, inside the porous media. Using a novel laboratory-based micro-CT scanner it was possible to acquire dynamic 3D images with high time resolution, which allows us to capture the intrinsic time scales of the gas dynamics.

The experiments confirmed the previous findings of a continuously decreasing gas saturation with more equilibrated brine injected, which even continued after the brine injection was stopped, resulting in very low (near zero) Sgr values [1]. We find systematic differences between the gases studied. We divided the observed dynamics in two different regimes, the capillary trapping regime where the gas pathways from inlet to outlet are disconnected by snap-off, and the dissolution regime. We found more capillary trapping and also faster dissolution for CH4 and H2 than for compressed air.

From previous studies, based on pore scale occupancy and the relevance of diffusive transport [4, 5], Ostwald ripening is playing an important role, impacting the gas dynamic behavior. In this work, we found more supporting evidence for this interpretation. The dissolution time scale follows a trend that can be captured in the product of diffusion coefficient and gas solubility in the liquid measured by Henry law constant.

## Participation

In-Person

## References

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