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Exploration of dynamic fluid regimes during steady-state multiphase flow in a sandstone with using synchrotron imaging

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The Diamond Lightsource Pink Beam was used to image dynamic fluid flow in Bentheimer sandstone at steady state, at a resolution of 5.2 μm during the co-injection of oil and water together. We present a novel method that uses fast synchrotron tomography to examine flow mechanisms underground by observing oil and water distribution through time.
Bentheimer is a homogeneous sandstone with a pore size from 8 to 11 μm, whose connected porosity resides in the macro-porosity with very little micro-porosity. A non-wetting phase, decane, and a wetting phase, 15 wt% KI brine, were co-injected at equal flow rates into a micro-core 5 mm across. Both fluids were injected simultaneously into the core and were collected at the outlet with a back pressure regulator. Tomographic scans were taken successively with a 6.7 mm by 5.6 mm field of view. Total acquisition time was ~ 1 min per scan.
The total flow rate increased from 0.02 mL/min (Ca ~ 2.5×10-7) to 2 mL/min (Ca ~ 2.5×10-5) step by step. We found that when Ca is lower than 10-6, oil and water reside their own pore space even when there is a sudden increase in flow rate. However, when Ca is higher than 10-6, an increase rate will alter the fluid distribution. The higher the flow rate, the greater the fluid rearrangement. Eventually a steady-state is reached, but even here some pore-space configurations continue to fluctuate.

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