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Manual and Automated In Situ Contact Angle Measurements of scCO2 and Brine in Sandstone Cores Using Micro-CT Imaging - A Correlation to Pore Connectivity

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Geologic Carbon Storage is one method available to mitigate excess carbon dioxide produced at point sources. X-Ray micro-computed tomography provides the resolution requirements necessary to image in situ contact angles (θ) at representative conditions; however, experimental data is limited and varies among materials and temperature settings used in literature (Andrew et al., 2014, Lv et al., 2017, Tudek et al., 2017). To further expand the practice of X-ray tomography, experiments were done on Mt. Simon and Nugget sandstone, adding more contact angles to the library of data obtained with this technique. The Mt. Simon core was subject to one imbibition cycle. The Nugget sandstone contained a preferential pathway spanning the length of the core and was further analyzed to correlate the effect of connectivity to the resultant θ measurements. Two separate experiments were completed using the same Nugget core: (1) drainage and two imbibition cycles and (2) drainage and one imbibition cycle. In the first Nugget test, scCO2 remobilized and became trapped in new pores along the flow path after the second imbibition cycle. Detailed analyses were completed for the Nugget sandstone: θ were measured and remeasured after the second imbibition cycle on scCO2 ganglia that remained trapped between brine floods and θ within a pore were measured after each imbibition cycle to determine variation. For comparison with the Mt. Simon core, the sessile drop method was completed on additional Mt. Simon samples.

The θ range was reviewed for both the Nugget and Mt. Simon where θ were measured manually in three different planes throughout each core and summed to an average value. The results were compared to determine any variation between sandstones. An automated algorithm designed to measure θ was developed to verify the sessile drop method results, to check the average θ values for both Nugget and Mt. Simon, and to measure more θ throughout the cores for more representative data. From manual measurements, Mt. Simon sandstone resulted in an average θ of 35° and a range from 5° to 120° while the Nugget sandstone resulted in an average θ of 56° and a range of 5° to 145°. The average contact angles for each classify both cores as weakly water-wet systems while the ranges suggest an intermediate-wet system within some pores. The Nugget average θ was 20° higher than the Mt. Simon sandstone and had a broader θ range by 25°. Different contact angles in two sandstone cores exposed to similar conditions indicate additional factors need to be considered.

References

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