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Effective Wettability Measurements of CO_2-Brine-Sandstone System at Different Reservoir Conditions

Ali Al-Menhali and Samuel Krevor

Department of Earth Science & Engineering, Qatar Carbonates and Carbon Storage Research Center, Imperial College London

The wetting properties of CO_2-brine-rock systems will have a major impact on the management of CO_2 injection processes. The wettability of a system controls the flow and trapping efficiency during the storage of CO_2 in geological formations as well as the efficiency of enhanced oil recovery operations. Despite its utility in EOR and the continued development of CCS, little is currently known about the wetting properties of the CO_2-brine system on reservoir rocks, and no investigations have been performed assessing the impact of these properties on CO_2 flooding for CO_2 storage or EOR. The wetting properties of multiphase fluid systems in porous media have major impacts on the multiphase flow properties such as the capillary pressure and relative permeability. While recent studies have shown CO_2 to generally act as a non-wetting phase in siliciclastic rocks, some observations report that the contact angle varies with pressure, temperature and water salinity. Additionally, there is a wide range of reported contact angles for this system, from strongly to weakly water-wet. In the case of some minerals, intermediate wet contact angles have been observed. Uncertainty with regard to the wetting properties of CO_2-brine systems is currently one of the remaining major unresolved issues with regards to reservoir management of CO_2 storage. In this study, we make semi-dynamic capillary pressure measurements of supercritical CO_2 and brine at reservoir conditions to observe shifts in the wetting properties. We utilize a novel core analysis technique recently developed by Pini et al in 2012 to evaluate a core-scale effective contact angle. Carbon dioxide is injected at constant flow rate into a core that is initially fully saturated with water, while maintaining a constant outlet pressure. In this scenario, the pressure drop across the core corresponds to the capillary pressure at the inlet face of the core. When compared with mercury intrusion capillary pressure measurements, core-scale effective contact angle can be determined. In addition to providing a quantitative measure of the core-averaged wetting properties, the technique allows for the observation of shifts in contact angle with changing conditions. We examine the wettability changes of the CO_2-brine system in Berea sandstone with variations in reservoir conditions including supercritical, gaseous and liquid CO_2injection. We evaluate wettability variation within a single rock with temperature, pressure, and salinity across a range of conditions relevant to subsurface CO_2 storage. This study will include results of measurements in a Berea sandstone sample across a wide range of conditions representative of subsurface reservoirs suitable for CO_2 storage (5-20 MPa, 25-90 ^oC, 0-5 mol kg^{-1}). The measurement uses X-ray CT imaging in a state of the art core flooding laboratory designed to operate at high temperature, pressure, and concentrated brines.