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The wettability of organic rich shales and its effect on transport properties in fractures as realized with the Lattice Boltzmann method

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The geologic sequestration of CO2 is a potential solution for decreasing anthropogenic atmospheric CO2 emissions by trapping it underground. A primary mechanism for storage is structural trapping where low permeability and high capillary entry pressure caprock materials hold back the buoyant CO2 from rising to the surface. The wettability (or contact angle) of reservoir and caprock materials in relation to CO2 and formation brine partly determines the efficiency of structural trapping. Current practice applies the results of individual reservoir-comprising minerals recorded under laboratory conditions, to rocks under in-situ reservoir conditions. However, the wide variety of measured contact angles reported in the literature calls this practice into question. Moreover, organic shales have not been the focus of systematic studies. Here we analyzed the wettability of CO2 at reservoir conditions on organic shales (Barnett Shale) at various organic matter concentrations and thermal maturities. We found that bulk organic shale remains highly water wet with respect to CO2 despite changes to the maturity or concentration of organics. This finding is in contrast to recent molecular dynamic simulations and our initial expectations from previous pore-scale analyses in which organic matter was shown to be hydrophobic. The results are likely due to the remaining mineralogy of the rock dominating the wetting behavior despite concentrations of organics up to 7.9%. Due to the high porosity of organic matter in shales these bulk, or effective, contact angles may not adequately characterize the wettability of the pore network. To explore this idea further, Lattice Boltzmann simulations on shale fractures with heterogeneous wetting characteristics are presented. The effect of organic matter connectivity on transport properties such as percolation threshold and permeability are explored.

References

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