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CO_2-Brine Displacement and Reactive Transport in Limestone

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The process of displacement and mass transfer between CO_2 and brine is of high importance for the prediction of plume migration and pore-space utilization during CO_2 injection in saline aquifers. CO_2/brine displacement in carbonates was studied by conducting unsteady-state core flood experiments in two different types of limestone. Mutually saturated and unsaturated CO_2 and brine phases were injected in the rock under realistic sequestration conditions. Relative permeability and capillary pressure curves were extracted by history matching the unsteady state experiments conducted with mutually saturated CO_2 and brine. Aspects of the mass transfer between the CO_2 and the brine phase during the displacement process were studied by drainage and imbibition with unsaturated fluid phases. As a reference and for comparison, decane–brine primary drainage was conducted on the same samples. The data is presented in comparison to CO_2/brine data recorded earlier from Berea sandstone (SCA2011-05) and to literature data on sandstone and carbonate rocks.

Ideally, such studies are performed with the fluid phases being in equilibrium with the rock matrix, however, CO_2 injection is subject to reactive transport, and especially calcite based rock interacts strongly with the resulting low-pH brine. Calcite dissolution is usually very fast resulting in a generally high Peclet-Damkoehler number (PeDa) and hence it is a transport limited system. Resulting dissolution patterns such as wormholes are discussed on basis of single phase reactive flow experiments (injection of CO_2 saturated brine). Major questions such as the growth rate and density of wormholes and the relationship, if any, between porosity (dissolved volume) and permeability are still for discussion, as well as the influence of a wormhole pattern on two- (or multi-) phase flow, and the question under what conditions do wormhole form in two-phase flow.