Effect of Pore Fluid on Permeability and Bulk Modulus in Hydro-Chemo-Mechanical Coupling: An Experimental-Driven Analysis

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Abstract

Porosity, permeability, reactive transport, and rock deformation are key factors in the hydro-chemo-mechanical (HCM) coupling process. In this study, high-pressure high-temperature (HPHT) flow-through experiments with a strain monitoring system on three micro-facies samples from the Pennsylvanian Paradox Formation's Cane Creek clastics were conducted under 75°C and 13.8 MPa to quantify the effect of pore fluid on permeability and bulk modulus. A high salinity brine solution and CO_2 were injected into the sample at a later phase of the experiment to study the effect of reactive transport on the mechanical properties of the reservoir rock. The external variable controls of the experiment are different pore fluids (N_2 vs. CO_2 vs. brine), pore fluid pressures (gas vs. supercritical vs. liquid), and reactivity of the injection fluid (non-reactive vs. reactive). We found that permeability and bulk modulus decrease as pore fluid density increases. We also found that high salinity injection fluid (~3.7 molar) could decrease the dissolved CO_2 and thus lead to less mineral dissolution than expected. Additionally, the salt in Cane Creek clastics with large-size crystals shows a high mechanical property and minimum creep behavior, which can be tied to the overpressured history during compaction. This study contributes to a better understanding of the HCM coupling process, which can significantly affect the reservoir storage capacity and integrity and benefit subsurface energy exploration in many potential unconventional oil plays.