

Experimental analysis of stress impact on the geochemical interactions of CO₂ with sedimentary rocks

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Geologic CO₂ storage triggers a series of fluid-rock interactions. Importantly, mineral dissolution and precipitation due to the acidic nature of dissolved CO₂ in water may alter the hydraulic and mechanical properties of the rock. Understanding these geochemical interactions under representative subsurface conditions is of utmost importance to reduce uncertainties around CO₂ flow and storage performance underground. We here perform laboratory experiments of CO₂-saturated water injection into two specimens from the Rotliegend Sandstone to resolve the impact of stress state on the chemical reactions of CO₂. The rock is composed of 80 wt% quartz, 10 wt% clays, 6 wt% K-feldspar and 3 wt% dolomite, and has an average, initial bulk porosity and permeability of 0.14 and 2×10^{-17} m², respectively. Experiments are performed under two different stress conditions: (1) hydrostatic stress of 15 MPa and (2) confining stress of 8 MPa and axial stress of 29 MPa, representing the same mean effective stress as in the first scenario but with an elevated deviatoric stress of 21 MPa. A total of 70 nominal pore volumes of CO₂-saturated water with a pH of 3.13 are injected at constant rates in a way resulting in identical initial differential pressures across the specimens subject to 5 MPa backpressure. Preliminary results show that the dissolution of carbonate minerals slightly increases the rock porosity and permeability. Despite the decreasing trend of the injection pressure, the rock continuously undergoes expansion, interestingly implying pore stiffness degradation. Although the observed trends are generally similar in both specimens, some meaningful differences including more pronounced, anisotropic expansion under deviatoric loading is evident. The observed trends have important implications for reactive transport phenomena in the subsurface because macroscopic stresses applied to the rock mass could grow by several folds at grain contacts and intergranular cementing material where chemical reactions with fluid take place, augmenting stress impacts on fluid-rock interactions.