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The importance of magnesite precipitation on the frictional strength and stability of CO_2 storage reservoir fault zones

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Long-term sequestration of CO_2, harvested from point sources such as coal burning power plants and cement manufactories, in depleted oil and gas reservoirs is considered to be one of the most attractive options for short- to medium-term mitigation of anthropogenic forcing of climate change. Many such reservoirs are laterally bounded by low-permeability fault zones which could potentially be reactivated either by changes in stress state during and after the injection process, and also by alterations in the frictional strength of fault gouge material. Of additional concern is how the stability of the fault zones will change as a result of the influence of supercritical CO_2, specifically whether the rate and state frictional constitutive parameters (*a*, *b*, D_C) of the fault zone will be altered in such a way as to enhance the likelihood of seismic activity on the fault zone. Earlier work on the mineralogic alteration of simulated fault zones using kinetic geochemical modeling, indicated that the mineral phases muscovite, montmorillonite, microcline, and magnesite would be likely alteration products of a fault gouge with the simple starting mineralogy, 1/3 quartz, 1/3 dolomite, and 1/3 illite that was allowed to reach chemical equilibrium under conditions relevant to a planned CO_2 sequestration reservoir pilot site in the Netherlands sector of North Sea (P_{CO2}= $15MPa, T = 115°$C). Based on the modeling predictions of the evolution of fault zone mineralogy through time, velocity stepping direct shear experiments were conducted on simulated fault gouges, and indicated only slight changes in frictional strength and stability through time, insufficient to suggest increased seismic activity due to the presence of CO_2 over thousands of years. However, when the individual secondary minerals were sheared, it was found that while a 100% magnesite fault gouge is relatively frictionally strong, with a coefficient of friction of 0.68, it has some tendency towards velocity weakening behavior at the experimental conditions used (σ'=35 MPa, *T*=115 °C), which could lead to enhanced seismicity if magnesite were precipitated along the principal slip surfaces of CO_2 storage reservoir fault zones in sufficient amounts. The present study aims to experimentally measure *a*, *b*, and D_C in simulated fault gouges with a variable percentage of magnesite, from 0 to 100