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Frictional properties of simulated anhydrite/dolomite fault gouge: implications for seismogenic potential

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The frictional properties of anhydrite-dolomite fault gouges, and the effects of CO_2 upon them, are of key importance in a) assessing the risks associated with CO_2 storage in reservoir formations capped by anhydrite-dolomite evaporite sequences, and b) understanding seismicity occurring in such formations in tectonically active regions. To explore these properties, we performed velocity-stepping direct-shear experiments on simulated dolomite, anhydrite and 50:50 anhydrite/dolomite gouges, at representative in-situ conditions of 120°C and an effective normal stress of 25 MPa. The experiments were conducted dry, with the pore fluid system under vacuum, or else using water or CO_2-saturated water as pore fluid at 15 MPa pressure. All samples displayed a friction coefficient of 0.55 to 0.7. The mixed gouges showed a strength similar to dolomite, which tended to be a little weaker than anhydrite when dry, and a little stronger than anhydrite when wet. Dry gouges were slightly stronger than samples tested wet, which in turn were slightly stronger than those tested with CO_2-saturated water. All dry samples showed velocity-weakening behavior, whereas wet samples showed velocity-strengthening behavior, without or with CO_2. The observed behavior is consistent with trends previously reported for anhydrite, dolomite, calcite and anhydrite/dolomite gouges, all of which show a transition from velocity-strengthening at temperatures below 80-120°C when dry, and below 100-150°C when wet, to velocity-weakening at higher temperatures. Since we found only velocity-strengthening behavior in wet samples, tested without and with CO_2 at the investigated temperature (120°C), we infer little seismogenic potential for wet dolomite, anhydrite and mixed gouges under CO_2 storage conditions. Seismic slip in the Italian Apennines at depths of $\sim$6 km and beyond may be explained in terms of the velocity-weakening behavior expected in anhydrite and especially dolomite at temperatures above 150°C, but for shallower earthquakes in the Apennines other explanations are needed.