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Unstable slip behavior in sediments from the Costa Rica convergent margin

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At convergent margins, which host the world's largest magnitude earthquakes, seismogenic behavior on subduction megathrusts is thought to be controlled by the properties of the sediments approaching the trench. Previous work has documented that the mineralogic composition of the shearing fault material exerts a first order control on frictional stability. The majority of sediments approaching subduction zones are typically rich in clay minerals, which tend to exhibit stable-sliding behavior which is not conducive to earthquake nucleation. However, drilling offshore Costa Rica has documented a package of carbonate-rich sediment entering the subduction zone. We conducted laboratory experiments in a rotary-shear device to measure the frictional behavior of sediments sampled during ODP Legs 170 and 205 to the Middle America Trench offshore Costa Rica. We compare the behavior of a carbonate-rich sample (66% carbonate) with that of a clay-rich sample (74% phyllosilicates) sheared at effective normal stresses up to 90 MPa, pore fluid pressures up to 60 MPa (simulating a pore pressure ratio [U+F06C] = 0.4), and temperatures up to 210°C. In the carbonate sample, we observe consistent velocity-weakening behavior and the appearance of unstable stick-slip behavior at higher pressures, suggesting that these sediments could slip coseismically in nature. At elevated temperatures, the onset of stick-slip behavior occurs at lower pressures. Stick-slip is not observed in the clay-rich sample, however in a few cases velocity-weakening is observed. The carbonate-rich unit is located at the bottom of the sedimentary section, and therefore may not be appropriately positioned to drive seismogenesis because Costa Rica is thought to be an erosive margin. However, in areas of high bathymetry (e.g. seamounts) seaward of the trench, the carbonate section is exposed at the seafloor. These areas could act as nucleation points for earthquakes ("asperities"), and propagation of coseismic slip could be aided by surrounding sediments that may be velocity-weakening under specific conditions despite their clay-rich lithology.