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Frictional behavior of Juan de Fuca sediments approaching the Cascadia subduction zone

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Geological evidence of past megathrust earthquakes on the Cascadia subduction zone, such as turbidite and tsunami deposits, is a valid reason to assume that another event will occur in the future. Earthquakes that propagate from seismogenic depths along the décollement all the way to the trench can result in exceptionally large tsunamis, posing an enormous socio-economic hazard for the coastal areas of western North America. One factor controlling the propagation of an earthquake is the frictional slip behavior of geologic material in a fault system. However, there are very few laboratory friction studies for the Cascadia subduction zone.

Here, we report on friction experiments testing sediments on the Juan de Fuca plate being input to the Cascadia subduction zone. The material was obtained from cores recovered during IODP Expedition 301 at Site U1301. All major lithologies including hemipelagic clay, silt turbidites, and sand turbidites from depths of 65 to 260 mbsf were tested. Using a direct shear device, both intact and powdered samples were sheared under in-situ effective normal stress, at room temperature, and saturated with simulated seawater. In our experiments, we measured the steady-state frictional strength, cohesion, and the rate-dependent friction parameter a-b. Values of a-b are derived from velocity step tests ranging from nearly plate convergence rates of 0.0017 μm/s (5.3 cm/yr) up to 30 μm/s. We observed a significant decrease in friction coefficient from 0.75 to 0.19 as well as an overall increase in bulk phyllosilicate content from 19 to 44 % with increasing depth. The most clay-rich unit at 260 mbsf is the frictionally weakest and is therefore expected to host the décollement upon subduction. Values of a-b for this horizon show predominantly velocity-strengthening frictional behavior, a condition that is expected to inhibit earthquake propagation. Although these results suggest that the frictionally weak clay-rich strata on the Juan de Fuca plate do not favour earthquake propagation under seafloor conditions, steady-state frictional sliding of these strata occurs at very low friction coefficients and hence, may show little resistance to a propagating large earthquake rupture.

Ongoing work includes microstructural analysis of the sheared samples as well as conducting slide-hold-slide tests on the clay-rich unit to explore the mechanisms of the observed frictional behavior of Juan de Fuca plate sediments.