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Frictional behavior of shallow subduction zone thrusts: Comparison of the Japan Trench and Nankai Trough
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The unusually large coseismic slip generated by the 2011 Mw = 9.0 Tohoku earthquake, which propagated all the way to the trench, raises critical questions regarding mechanical behavior of the shallow reaches of subduction faults. These include: (1) What conditions are favorable for earthquake rupture propagation and large amounts of coseismic slip, and (2) are other areas susceptible to a Tohoku-like event? To address these questions, we compare the results of laboratory experiments conducted in a true-triaxial double-direct shear device measuring the frictional properties of natural samples from the Japan Trench and Nankai Trough. Samples from the Japan Trench were recovered from within the decollement in the region of large coseismic slip in the Tohoku earthquake during Integrated Ocean Drilling Program (IODP) Expedition 343, the Japan Trench Fast Drilling Project (J-FAST). Samples from the Nankai Trough were recovered during IODP Expedition 316 and ODP Leg 190, which respectively sampled a major, out-of-sequence thrust fault (Site C0004), and the main decollement zone near the trench (Site 1174). The samples were tested at effective normal stresses up to 25 MPa as intact wafers when possible (usually wall rock); samples from within the fault zones as brecciated fragments or remolded. Velocity-dependent friction measurements show that the Japan Trench decollement sample is slightly weaker (coefficient of friction = 0.17) compared to the Nankai decollement (0.23-0.28) and megasplay (0.36-0.44). Between 0.001 and 0.3 mm/s, the velocity-dependence of friction for both the Japan Trench and Nankai Trough is consistently velocity-strengthening, and with higher amounts of strengthening correlating with higher sliding velocity. At rates below 0.001 mm/s, however, the Japan Trench exhibits velocity-weakening behavior while the Nankai Trough samples remain velocity strengthening. X-ray diffraction analysis of the $<$ 2 micron size fraction of the Japan Trench decollement sample suggests that smectite may be important, whereas illite and chlorite play a larger role in Nankai. Lower overall strength combined with velocity-weakening behavior at low- to moderate-velocities observed for the Japan Trench indicates that it is more favorable for hosting coseismic slip propagation than either the decollement or the megasplay in the Nankai Trough.

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