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コスタリカ沖沈み込み帯に持ち込まれるココスプレート上堆積物の摩擦特性
Frictional properties of sediments on the Cocos Plate entering the Costa Rica Subduction Zone

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Mechanical properties of the incoming sediments to subduction plate boundaries are essential to constrain subduction-related faulting processes. Recently, frictional properties of clay-rich megasplay fault material collected from the Nankai Trough have been explored (Ikari et al., 2009; Ujiie and Tsutsumi, 2010; Tsutsumi et al., 2011). However, knowledge of the frictional properties of pelagic sediments composed of abundant biogenic component, such as spicules, diatoms, and radiolarians are limited. Here we report experimental results on the frictional properties of the input sediments, which include biogenic horizons, on the Cocos Plate entering the erosive Costa Rica subduction zone.

Experimental samples are fine, soft silty clay sediments (lithostratigraphic Unit I) and silicic to calcareous ooze (Unit II), collected at a reference site off shore Osa Peninsula (Site U1381) during the IODP expedition 334 (Vannucchi et al., 2012). To be used in the experiments, the discrete samples was disaggregated, oven dried at 60 degrees centigrade for 24 hours. The experimental fault is composed of a 24.9 mm diameter cylinder of gabbro cut perpendicularly to the cylinder axis in two halves that are ground to obtain rough wall surfaces, and re-assembled with an intervening thin layer (~1.0 mm) disaggregated sample. Frictional experiments have been performed using a rotary-shear friction testing machine, at normal stresses up to 5 MPa, over a range of slip velocities from 0.0026 mm/s to 1.3 m/s, with more than ~150 mm of displacements for water saturated condition.

Experimental results reveal that the steady-state friction values at slow slip velocities (v < ~30 mm/s) are less than ~0.2 for the silty clay sediments and ~0.7 for the silicic to calcareous ooze, respectively. The silty clay always shows velocity-strengthening behavior at velocities v < ~3 mm/s. On the contrary, the silicic to calcareous ooze samples show velocity-weakening at v < 0.3 mm/s and neutral to velocity-strengthening at 0.3 < v < ~3 mm/s. At higher velocities (v > ~30 mm/s), steady state friction decreases dramatically. At a velocity of 260 mm/s, the friction coefficient shows a gradual decrease with a large weakening displacement toward the establishment of a nearly constant level of friction at ~0.1.

The low frictional strength of the uppermost silty clay sedimentary sequence may provide a condition for shear localization to occur within this stratigraphic horizon. The velocity-strengthening behavior observed for the silty clay suggests that faulting along the fault within silty clay horizon would be a stable sliding. On the other hand, velocity weakening behavior of the silicic to calcareous ooze, which is observed at slow velocities, could provide a condition to initiate unstable fault motion at shallow depths if a fault rupture can extend to the silicic to calcareous ooze horizon. The neutral to velocity strengthening behavior observed for intermediate velocities could stabilize the propagation process of earthquake nuclei that emerges in the velocity weakening portion along the fault. It is important to note also that a dramatic slip weakening at velocities of v > ~30 mm/s characterizes the frictional behavior of the silicic to calcareous ooze. Presented frictional properties of the incoming sediments may offer an important constraint for improving models of subduction-related faulting processes within the Costa Rica subduction channel.

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