Spatiotemporal variation in frictional behavior within the Nankai accretionary prism

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Nankai Trough is one of the most active earthquake zones on the planet and has been focused for many years. Samples were collected from many drilling sites of the International Ocean Drilling Project drilled as a part of the Nankai Trough Seismogenic Zone Experiment project to explore the earthquake mechanisms within the Nankai Trough subduction zone system. We report the experimental results of frictional behavior for samples recovered at different locations in the Nankai subduction zone. Our findings will help to describe (1) the spatiotemporal variation in frictional behavior during the accretion process, (2) the potential for seismic activities along the décollement and splay faults, and (3) the evolution of the accretionary prism.

In this study, three drilling sites were selected which are located in sediments approaching subduction seaward of the trench (Site C0011), in young accreted sediments in the prism toe (Site C0006), and in older accreted sediments in the inner prism (Site C0002). We selected the samples based on the comparability of lithology and clay content. All samples from Site C0011 were Shikoku Basin sediments and samples from Site C0006 included both accreted trench deposits and accreted Shikoku Basin sediments. Laboratory shear experiments on intact samples were performed in a single-direct shear device at in-situ effective normal stresses, calculated assuming a hydrostatic pore fluid pressure, with samples saturated with 3.5% simulated salt water as pore fluid. Intact samples were trimmed from core samples into cylindrical shapes to fit the experimental cell (~20 mm height, ~25 mm diameter). Shear velocities were set to be 10 μm/s for a displacement of 5 mm as a “run-in” process before the velocity was stepped from 0.01 –0.03 –0.1 –0.3 –1 –3 –10 –30 μm/s for 700 μm displacement at each velocity. Friction data obtained from the measured shear stress normalized to the normal stress at each velocity step was fit to a rate- and state-dependent friction law to quantitatively investigate the potential for frictional instability.

Measured steady-state friction coefficients showed inverse correlations with clay content, but no clear relation with smectite content. Because this trend was observed at all three sites, frictional strengths could be primarily controlled by lithological composition: sandy trench deposits exhibit high friction coefficients whereas lower values are seen for clayey hemipelagic sediments. Samples from the prism toe generally showed higher friction coefficients than those from both other sites for the entire range of clay content. This could be because these currently overthrusted sediments at the prism toe may be highly overconsolidated due to lateral compression near the frontal thrust. Negative friction-velocity dependence, a prerequisite of unstable slip, was observed for the input and inner prism sediments even when the samples showed low friction coefficients. Prism toe material had both a negative and positive velocity dependence on friction.

Our measurements of friction velocity-dependence suggest that input sediment and old accreted sediment could be frictionally unstable and therefore favorable for seismic slip, whereas young accreted sediment may resist earthquake slip. Ongoing work on the sample from the deep part of old accreted

sediments is expected to provide further information on the slip partitioning between décollement and megasplay fault near the seismogenic zone, as well as fault activities and structural evolution within the Nankai accretionary prism.

Keywords: Nankai Accretionary Prism, Friction Experiment

