Frictional properties of pre- and post-subducting oceanic basement rocks

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On the faults in the subduction plate boundary, fault slips when the shear stress exceeds the strength of the rock interface between the hanging and footwall. Seismic slip is associated when the frictional strength decreases with the slip. The up-dip limit of the seismogenic zone coincides with the stepping down of the décollement to the oceanic basement. Seismogenic process is thought to undergo in the upper part of the oceanic crust (Kimura and Ludden, 1995; Bangs et al., 2009). Tectonic mélanges of the Shimanto belt which is formed along the plate boundary fault zone (Kitamura et al., 2005) contains basalts with cataclastic shear zones. To understand the seismogenic process, therefore, basalts are key material and it is essential to know their frictional properties. Here we performed frictional experiment on the basalts from pre-subduction drilled core in the Nankai trough and post-subduction outcrop in the Shimanto belt.
We performed friction experiments using the rotary shear, an intermediate to high velocity frictional testing apparatus in Kyoto University. Basalt samples were taken from IODP Expedition 333 Site C0012 as pre-subduction materials (C12G8R, C12G10R) and from the Mugi tectonic mèlange as postsubduction material (MBN-3). We performed constant low velocity test with normal stress of 2 MPa and rotational speed of 0.012 r.p.m with all three samples, and velocity stepping test to evaluate the velocity dependence with two samples (C12G8R, MBN-3) with normal stresses of 2 MPa and 5 MPa.
Results of the constant low velocity test showed the steady frictional coefficient of C12G8R, C12G10R and MBN-3 ranging from 0.70 to 0.84 (average 0.76), from 0.60 to 0.79 (ave. 0.67) and from 0.50 to 0.63 (ave. 0.57), respectively. On the velocity stepping tests, C12G8R and MBN-3 with normal stress of 2 MPa showed neutral depencence of the friction coefficient to the velocity. But, C12G8R with normal stress of 5 MPa showed velocity strengthening behavior and MBN-3 with normal stress of 5 MPa showed velocity weakening behavior.
The constant low velocity tests revealed that the frictional coefficient of MBN-3 is lower than those of C12G8R/C12G10R. This implies that the post-subduction basalt is essentially weaker. From the results of velocity stepping tests, pre-subducting basalt (C12G8R) without preexisting gouge on the interface (5 MPa, menu 1) showed notable velocity strengthening. Other runs at 5 MPa are velocity neutral or strengthening. On the other hand, post subducting basalt (MBN-3) showed velocity weakening at 5 MPa, menu 1 and 2. These results suggest that the subducting oceanic crust progressively changes its frictional property that enables the rocks to be potent in seismogenesis may leading to the stepping down of the decollement to the oceanic basement at the up-dip limit of seismogenic zone.

Reference

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Keywords: Nankai Trough, Shimanto Belt, Frictional experiment, basalt, velocity weakening

