Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS29-07 Room:A05 Time:May 24 15:15-15:30

Experimental study on frictional properties of biogenic sediments entering the Costa Rica subduction zone

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Various seismic behaviors such as large earthquakes, episodic slow slip events, or silent earthquakes are observed in subduction zones. This variation likely reflects spatial variations in frictional properties along the seismogenic portion of plate-boundary megathrusts (e.g., Bilek and Lay 1998). A number of studies have been performed to reveal the frictional properties of subduction-zone material. However, available experimental data have thus far been limited mostly to clayey materials (e.g., Brown 2003). Recently, Namiki et al. (2014) have reported that the frictional properties of silicic to calcareous ooze collected from the Costa Rica subduction zone were different from those of clay as the following: (1) the steady-state μ values of the silicic to calcareous ooze are high, measuring 0.6 to 0.8; and (2) the steady-state μ values of the silicic to calcareous ooze samples show negative dependence on velocity at velocities of 0.0028 to 0.28 mm/s and positive dependence at velocities of 0.28 to 2.8 mm/s. The second property is important because velocity-weakening behavior implies potentially unstable fault motion. In this study, to understand the mechanism of generating such characteristic frictional properties of the silicic to calcareous ooze, a series of friction experiments was performed on biogenic amorphous silica, a possible end-member component of the silicic to calcareous ooze.

We dissolved calcite by acid treatment to extract amorphous silica from the ooze, whose particle size and shape are expected to be similar to natural sediments. The extracted biogenic amorphous silica shows the following frictional properties: (1) the steady-state μ value is high, measuring ˜0.6; (2) the steady-srtate μ value of the biogenic amorphous silica shows negative dependence on velocity at velocities of 0.0028 to 2.8 mm/s; and (3) as slip velocities increase, the values of D_c become larger.

The experimental results suggest that the frictional velocity dependence of the biogenic amorphous silica is intrinsically negative at a range of velocities tested in this study. The observed negative velocity dependence of the amorphous silica suggests that mixing of a second phase material such as calcite to amorphous silica probably influences the bulk frictional properties of the ooze, of which friction showed positive dependence on velocity at velocity of several mm/s.

Homogeneously sheared deformation texture was observed in the silicic to calcareous ooze sample after it showed positive friction velocity dependence. The homogeneous deformation textures are consistent to the previously reported diagnostic textures of positive frictional velocity dependence (e.g., Ikari et al., 2011).

Keywords: subduction zone, frictional experiment, CRISP