東北沖沈み込みプレート境界物質の摩擦挙動と地震発生
Frictional properties of materials along Tohoku subduction plate boundaries and implications for fault motion

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The 2011 Tohoku-oki earthquake (Mw 9.0) nucleated at 24 km depth along the plate boundary. Moreover, episodic tremor and slow slip events occurred just before the 2011 Tohoku-oki earthquake on a shallow portion (less than 20 km depth) in the Tohoku subduction zone (e.g., Ito et al., 2013). The frictional properties of rocks composed of a subducting oceanic plate exert important controls on the various slip behavior from aseismic to seismogenic slip. However, frictional properties of the rocks to model such subduction earthquakes are poorly understood. We thus conducted friction experiments using a rotary shear apparatus on powders of blueschist (probably distributed at the Tohoku seismogenic zone) and smectite-rich pelagic sediments (present along the shallow portion of the Tohoku plate boundary (Chester et al 2013)). Experiments were performed at temperatures of 20-400°C, effective normal stresses of 25-200 MPa and pore fluid pressures of 25-200 MPa. We investigated the effects of temperature, effective normal stress and slip rate on the rate and state friction parameter (*a-b*) by conducting velocity-stepping experiments with velocity range from 0.1 to 100μm/s.

Blueschist gouges show a positive (*a-b*) values at 22°C which decrease to become negative with increasing temperature. At 200°C, the behavior is velocity weakening and shows negative (*a-b*) values. At 300ºC, the gouges show neutral to positive values of (*a-b*), showing larger (*a-b*) values than at 200ºC. (*a-b*) values slightly decrease again at 400°C. There is also effective normal stress dependence. The gouges exhibit a transition from velocity-strengthening to velocity-weakening with decreasing effective normal stress. Observed (*a-b*) values decrease with decreasing effective normal stress because of an increase in *b* with decreasing effective normal stress. Our results suggest that increasing pore pressure is a key factor for nucleating slip leading to both megathrust and slow earthquakes.

In the case of Smectite-rich pelagic sediments, the simulated gouges show negative values of (*a-b*) at low temperatures of 20-50°C, except at the highest slip rate of 0.1 mm/s, and neutral or slightly negative values of (*a-b*) at temperatures of 50-100°C. However, at temperature of >150°C the gouges show positive values of (*a-b*) under almost all velocity conditions tested. The trend of (*a-b*) seems to be identical with that of *a*, and *b* shows an inverse relationship with (*a-b*). Slow slip events are considered to be able to nucleate under conditions where (*a-b*) value is negative but close to zero. These conditions are met at temperatures of 50-100°C in our experiments, which is consistent with temperature conditions under which slow slip events occur along the plate boundary at the Japan Trench. The frictional properties of the pelagic sediments explain well the observed distributions of slow slip events in Tohoku subduction zone.

