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東北沖プレート境界物質の摩擦特性からみるスロー・スリップ・イベント
Frictional properties of materials along the plate boundary of Tohoku subduction zone: implications for slow slip events

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Episodic tremor and slip occurred just before the 2011 Tohoku-oki earthquake on a shallow portion (less than 20 km depth) in the Tohoku subduction zone (Ito et al., 2013). The area where slow slip occurred overlapped with the seismogenic zone. To understand such diverse slip behaviour around the Japan Trench, not only the major earthquakes but also the slow slip events, it is essential to reveal the frictional properties of rocks distributed at the Tohoku subduction zone. We thus conducted friction experiments using a rotary shear apparatus on powders of blueschist (probably distributed at hypocenters at major Tohoku earthquakes) and smectite-rich pelagic sediments (distributed along the shallow portion of the Tohoku plate boundary (Chester., et al 2013)). Simulated gouges were sheared at temperatures of 20-400^{o}C, and effective normal stresses of 25-200 MPa and pore fluid pressures of 25-200 MPa. We conducted velocity-stepping sequences (0.1 to 100 micron/s) to determine the rate and state parameter (a-b) and investigated the effects of temperature, effective pressure and slip rate on slip stability.

Blueschist gouges show a friction coefficient of about 0.75 and positive (a-b) values which decrease to become negative with increasing temperature. At 200oC, the behavior is velocity weakening and shows negative (a-b) values with a background friction of ˜0.75. At 300oC, friction is ˜0.65 and the gouges show neutral to positive values of (a-b), showing larger (a-b) values than at 200 oC. (a-b) values slightly decrease at 400oC with a background friction of ˜0.7. There is also effective normal stress dependence: even at temperature conditions where (a-b) tends to be positive, (a-b) values are negative at low effective pressure and increase to positive with increasing effective normal stress. This suggests that increasing pore pressure is a possible factor causing unstable slip, leading to slow slip events.

Smectite-rich pelagic sediments show that at low temperatures of 20 and 50oC, the simulated gouges exhibit negative values of (a-b) with a background friction coefficient of 0.38, except at the highest slip rate of 0.1 mm/s. However, the gouges show neutral to positive values of (a-b) at temperatures of $>$100oC with the same background friction coefficient as at lower temperatures. In addition, the value of parameter (a-b) depends significantly on slip rates: at temperatures of 20 and 50^{o}C it increases from negative to neutral (or slightly positive at 20^{o}C) with increasing slip rates to 0.1 mm/s, whereas it tends to decrease with increasing slip rate at temperatures higher than 100^{o}C. The downdip temperature limit of the slow slip events at Japan Trench (Ito et al., 2013) seems to be in the range between 100 to 150^{o}C. The transition in (a-b) value from neutral to positive, particularly at lower slip rates, occurs at the same temperature range. Hence, this could correspond to the observed downdip limit of the slow slip events.