# Effects of ambient temperature on the frictional strength and frictional heating of dolerite

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Frictional properties at intermediate to high slip velocities are essential to understand the earthquake propagation and slip. Coseismic weakening has been observed experimentally at seismic slip velocities for many types of rocks (e.g., Tsutsumi and Shimamoto, 1997; Di Toro et al., 2011). Weakening mechanisms has been controlled by temperature rise including flash heating, melt lubrication or thermal pressurization (e.g., Rice, 2006; Hirose and Shimamoto, 2005). Although the importance of temperature during fault motion are widely recognized, the effects of temperature on frictional properties at intermediate to high velocities remain unknown. We therefore conducted friction experiments at a wide range of temperatures and investigated the effects of temperature on the friction coefficient ($\mu$) and frictional heating.

Experiments were performed on dolerite (Belfast, Northern Ireland) using a rotary shear deformation apparatus at Chiba University. Samples were displaced up to about 20 m at a normal stress of 1 MPa, slip velocities V of 3–300 mm/s, and ambient temperatures $T_a$ of ~20–500°C in an argon atmosphere with an oxygen concentration of 0.3 %. Temperature adjacent to the slip surface $T_s$ was also measured by a thermocouple placed near the slip surface.

At V = 3–30 mm/s, dolerite showed steady-state friction coefficients $\mu_{ss}$ of 0.46–0.54 at $T_a$ = 20–100°C. Whereas at $T_a$ = 200–500°C, $\mu_{ss}$ increased to 0.64–0.71. At V = 100 mm/s, dolerite showed clear velocity-strengthening with $\mu_{ss}$ up to 0.58–0.64 at $T_a$ = 20–100°C, almost constant values with $\mu_{ss}$ = 0.65–0.69 at $T_a$ = 200°C and 300°C, and clear velocity-weakening with $\mu_{ss}$ = 0.45–0.46 at $T_a$ = 400°C and 500°C. At V = 300 mm/s, dolerite showed strong velocity-weakening at all $T_a$ investigated. In addition, slip-weakening distance ($D_c$) at V = 100 mm/s and 300 mm/s was smaller at higher $T_a$. $T_s$ increased with increasing V. The amount of $T_s$ increase ($\Delta T_s$) due to frictional heating was almost the same at all $T_a$ tested at V = 3–30 mm/s ($\Delta T_s$ was ~1°C at V = 3 mm/s and ~30°C at V = 30 mm/s). At V = 100 mm/s and 300mm/s, on the other hand, $\Delta T_s$ was notably smaller at higher $T_a$. Thus, the frictional properties and frictional heating of dolerite are affected not only by V but also by $T_a$. Estimations of temperature distribution during experiments based on three-dimensional finite element modeling are also in progress.

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