Frictional properties of opal gouge at low-temperature hydrothermal conditions and their implications for seismogenic faulting along subduction-zone megathrusts

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We conducted a series of triaxial friction experiments on opal gouge at low-temperature (≦200°C) hydrothermal conditions, in order to address the change in frictional stability along subduction-zone megathrusts. The results revealed frictional properties of opal gouge dependent on temperature (T), displacement (V) or pore water presure (P_p), as described below.

When fitted by the rate- and state-friction constitutive law, friction parameter a does not change much with T, V or P_p, while friction parameter b increases, and resultantly ($a-b$) value decreases with increasing T, decreasing V or increasing P_p. Microstructural observations revealed that densification and coalescence of gouge particles occurred at higher T, suggesting the operation of pressure solution. Thus increasing activity of thermally activated pressure solution with increasing T, decreasing V or increasing P_p promotes gouge lithification to increase frictional strength, by which ($a-b$) value decreases to <0, and thereby the transition from aseismic faulting to seismic faulting along subduction-zone megathrusts. Our results also imply that increasing P_p at that transition region where ($a-b$) ≈0 would decrease ($a-b$) value to <0, and hence promote slow seismic faulting with small negative ($a-b$) values, which is consistent with high V_P/V_S ratios observed in the regions of slow earthquakes.

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