Effects of dissolution–precipitation creep on the frictional properties of opal gouge at low-temperature hydrothermal conditions

*Nakanishi Tomoya[2], Kyuichi Kanagawa[1], Michiyo Sawai[1]

1. Graduate School of Science, Chiba University, 2. Faculty of Science, Chiba University

In order to examine the effects of dissolution–precipitation creep on the frictional properties at low-temperature hydrothermal conditions, we conducted triaxial friction experiments on opal gouge at a confining pressure of 150 MPa, a pore water pressure of 50 MPa, and temperatures (T) ranging from room T to 200°C, and at displacement rates (V) changed stepwise among 0.1155, 1.155 and 11.55 μm/s. We then fitted the friction data for each step change in V by the rate- and state-dependent friction constitutive law, and obtained the optimized ($a-b$) value, i.e., an indicator of frictional stability, at each V.

The results show that steady-state friction coefficient μ_{ss} increases with increasing T, from 0.64 at room T to 0.67 at 200°C, which is consistent with slip hardening behavior observed at higher Ts. Microstructural observations reveal that significant grain interlocking and porosity reduction occur in the gouge layer sheared at higher Ts. Thus increasing gouge lithification with increasing T, which is promoted by thermally activated dissolution–precipitation creep, is likely responsible for increasing μ_{ss} with increasing T.

Our results also show that ($a-b$) value tends to decrease with increasing T or decreasing V at $T \geqq 50$°C. Decreasing ($a-b$) value with decreasing V at a given T is likely due to increasing gouge lithification and hence μ_{ss} with decreasing V, which is promoted by dissolution–precipitation creep favored at lower Vs. At a given V, a value does not change much while b value increases with increasing T, which results in decreasing ($a-b$) value with increasing T. Increasing b value with increasing T implies that more strength recovery occurs when V is stepped down, which is also ascribed to increasing activity of dissolution–precipitation creep. Because ($a-b$) value does not change with V at room T, dissolution–precipitation creep was not active at room T.

At a given V, the transition from $a-b > 0$ to $a-b < 0$ occurs with increasing T, but the transition T is also dependent on V, because ($a-b$) value is dependent on both T and V as described above; T <50°C at V = 0.1155 μm/s, 50°C< T <100°C at V = 1.155 μm/s, and T >100°C at V = 11.55 μm/s. Our results suggest that increasing activity of dissolution–precipitation creep with increasing T or decreasing V promotes decreasing ($a-b$) value and hence the transition from stable aseismic faulting with $a-b > 0$ to unstable, possible seismic faulting with $a-b < 0$.

Keywords: frictional properties, opal gouge, low-temperature hydrothermal conditions, dissolution–precipitation creep