Mechanism controlling the frictional strength of quartz rocks at intermediate slip rates

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Frictional strength of quartz rocks is known to be extraordinary low at subseismic slip rates ranging from 1 mm/s to 10 cm/s, which has been ascribed to the hydration of comminuted amorphous silica, i.e., silica gel. In order to testify this hypothesis, we conducted rotary-shear friction experiments on intact agate or silica gel gouge at a normal stress of 1.5 MPa and slip rates (V) ranging from 1 mm/s to 10 cm/s. We also measured temperature (T) adjacent to the slip surface or the gouge layer during the experiments.

Steady-state friction coefficient of agate μ_{ss} was ≈0.6 at V = 1 mm/s, ≈0.5 at V = 7 mm/s, and ≦0.1 at V = 10 cm/s. T was ≈25°C at V = 1 mm/s, ≈30°C at V = 7 mm/s, and up to 85°C at V = 10 cm/s, but the actual temperature along the slip surface must have been much higher. μ_{ss} of silica gel gouge was ≈0.7 at V = 1 mm/s, 0.4–0.5 at V = 7 mm/s, and ≦0.2 at V = 10 cm/s. T was 25–28°C at V = 1 mm/s, 30–37°C at V = 7 mm/s, and 80–100°C at V = 10 cm/s, but again, the actual temperature in the gouge layer must have been much higher.

Thus our results show that agate or silica gel exhibits weakening with increasing T, and that the presence of silica gel does not reduce the frictional strength when T is not high enough. Shear strength of quartz rocks is high so that significant amount of frictional heat would be produced at asperity contacts even at V ≈1 cm/s, which must be responsible for weakening of quartz rocks at intermediate slip rates.

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