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岩塩ガウジのスティック・スリップ挙動に対する塑性の効果
Effects of plasticity on stick-slip behaviors of halite gouge

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Non-volcanic tremors in subduction zones and San Andreas are known to be located near the bottom edge of the seismogenic zone. Assuming that the occurrence of ordinary earthquakes is inhibited by the onset of crystal plasticity in rock-forming minerals (e.g., quartz and feldspar), this implies that tremor activity occurs at the depth of a transition between brittle and ductile deformation. Previous studies of rock friction (Shimamoto, 1986, *Science*; Noda and Shimamoto, 2010, *GRL*) have already indicated that halite is a good candidate to explore the effects of plasticity on frictional behavior in laboratory, because with increasing normal stress (σ_n), the deformation mechanism of halite changes from frictional sliding to dislocation creep even at room temperature. However, it remains unclear how plasticity affects stick-slip behaviors of halite, including stress-drop magnitude, recurrence interval, frictional velocity dependence (a-b), and rupture propagation process.

To explore the effects of plasticity on stick-slip behavior, we conducted friction experiments on halite gouges at room temperature, constant normal stresses of 10 to 120 MPa, and sliding velocities of 1 or 10 μm/s, using a large biaxial testing machine installed at Tohoku University. Seven strain gauges were mounted on a forcing block at 23 mm intervals along the fault. For each experiment, we recorded more than 50 stick-slip events in total. At sliding velocity of 1 μm/s, the magnitude of stress drop increased from 1 MPa at σ_n = 10 MPa to 3 MPa at σ_n = 30 MPa, while decreasing to 0.5 MPa at σ_n = 120 MPa. The stick-slip recurrence interval at the same sliding velocity decreased from 20 s at σ_n = 10 MPa to 4 s at σ_n = 120 MPa. (a-b) values decreased from -0.005 at σ_n = 10 MPa to -0.025 at σ_n = 40 MPa, while remarkably increasing to 0.015 at σ_n = 120 MPa. Critical length (L_c) at which unstable, fast rupture propagation (>10% V_s) starts seems to increase with increasing σ_n.

Our experimental results indicate that the stick-slip behavior of halite fault gouges dramatically changes with increasing degree of plasticity, i.e., sharp, large stick-slip events in brittle regime evolve to smooth, small oscillations in semi-ductile (plastic) regime. Source characteristics of the small oscillations with sustained slow rupture may be linked to those of slow earthquakes such as non-volcanic tremors. It is well known that extremely low effective normal stress on the fault is the primary control on the occurrence of slow earthquakes. Furthermore, we suggest that the onset of plasticity in minerals, leading to an increase in (a-b), also facilitates the emergence of such slow transient creep events.

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