Estimating Absolute Effective Normal Stress During Slow Slip Events From Slip Velocities and Shear Stress Variations

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Slow slip events (SSEs) are quasi-static phenomena in which slip accelerates very slowly and which do not radiate seismic energy. Because SSEs are a newly understood mechanism of stress release along plate boundaries, it is important to investigate their behavior to further our understanding of plate boundary tectonics. One of possible causes of the SSEs is the existence of fluid in the plate boundary.

A theoretical analysis using a rate- and state-dependent friction law has shown quasi-static and stable slip behaviors following velocity weakening (Rice and Tse, JGR, 1986). In their paper, trajectories of shear stress variations vs. slip velocity imply that the quasi-static slip accelerates slowly along a line parallel to the steady state friction line, then decelerates. The gradient of the steady state friction line is $(a-b)\ \sigma_n'$, where a and b are the friction coefficients, and σ_n' is the effective normal stress on the slip surface.

We estimated spatiotemporal slip distributions for six slow slip events (SSEs) off the Boso Peninsula, Japan, from GNSS data and plotted their shear stress variations vs. slip velocity. Most trajectories are similar to theoretical quasi-static trajectories, implying that the Boso SSEs represent a quasi-static and stable process, and that the gradient of the trajectories during slip acceleration is equal to $(a-b)\ \sigma_n'$. Taking $(a-b) = -0.003$, we estimate that the absolute effective normal stresses during the SSEs were 10–50 MPa at 12.5–20.5 km depth. These values are much smaller than the lithostatic pressures at those depths, implying high pore pressures on the slow slip interface.

(For details, please see Kobayashi and Sato, GRL, 48, e2021GL095690.
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