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Fault Gouge Velocity Characteristics During Slow-Slip and Stick-Slip Under Laboratory Conditions

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Abstract:
Tectonic faults slip with velocities that range from very slow (slow-slip) to very fast, including dynamic stick-slip and earthquakes. We have reproduced slow and fast slip in the laboratory to gain insight into physical differences that may aid in our interpretation of these phenomena in the Earth. Here we present results for slow and fast slip on simulated faults in the laboratory under static normal stresses of 1-8 MPa and shearing rates of 0.1-100 μm/second. We apply shear to a central block bounded by two gouge layers, held in place by the static load. Simultaneous to shearing we measure acoustical time-of-flight across the gouge layers to quantify the evolution of gouge wavespeed preceding, during and following slip events. At the fixed static stresses studied, we find that stick-slip may occur over a spectrum of grain sizes ranging from order 5-150 micron at least (Mimusil or glass beads of varying dimension); in contrast slow-slip only occurs for fine grain materials such as Minusil (fine-grained white crystalline silica of order 5 micron in diameter). In both cases the gouge compacts at the time of slip associated with a gouge material increase in velocity. Following slip, the gouge material progressively dilates and the material velocity progressively decreases up to slip time, when the process repeats. Numerical simulation will help us understand the fast (stick-slip) and slow (slow-slip) processes. It is plausible that grain sizes influence slow and fast slip in faults in the earth, and the velocity changes observed in the laboratory fault gouge may also exist in fault zones.

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