How Fault Friction Affects Earthquake Slip and Surface Deformation: Velocity-Dependent Friction and Its Role in the Evolution of Surface Deformation and Topography

project subtitle

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Project description

Friction controls how a tectonic fault resists or allows sliding. On a fault, some areas are velocity-weakening (VW, seismogenic), meaning friction decreases as the fault slips faster. This promotes sudden energy release, which is how earthquakes are generated. Other areas are velocity-strengthening (VS, non-seismogenic), where friction increases with sliding speed, leading to slow, stable motion without generating large earthquakes. By studying VW and VS in the laboratory, we can see how these frictional properties affect the deformation of the surface above a fault over time.

Understanding how different frictional behaviors on the fault influence surface deformation is essential for linking laboratory fault mechanics to natural fault evolution. This project will investigate how VW and VS frictional regimes generate distinct patterns of surface deformation and long-term topography in a strike-slip fault. The experiment will reproduce repeated slip events while simultaneously measuring shear force, acoustic emissions, and high-speed surface displacement. By adjusting boundary conditions and fault material properties to achieve VW and VS behaviors, the study will directly relate the frictional stability to evolving fault surface structures.

High-speed imaging will be employed to quantify surface displacement fields and shear localization patterns during each slip event. In parallel, photogrammetry will capture the evolving surface topography over multiple slip cycles. Force and acoustic data will provide complementary insights into the energy release and micro-failure activity associated with each regime.

The project aims to develop a mechanical and morphological framework connecting the frictional behavior of the active fault to surface deformation. Results will contribute to our understanding of how seismogenic and aseismic (non-seismogenic) fault zones mature and leave distinct surface signatures, bridging laboratory observations with nature.

The project will provide hands-on experience in experimental design and data analysis related to earthquake fault mechanics. The student will conduct laboratory experiments and collect measurements of force, acoustic emissions, and surface motion. The student will analyze how laboratory earthquakes deform the surface and evolve over repeated cycles. Additionally, the student will read relevant papers to collect observations from nature.

Job requirements

- Highly motivated to perform laboratory work. Manual tasks such as sieving sand/rubber powder into the setup will be part of the work.
- Ability to search for and read relevant literature (e.g., research papers).
- Good/Very good programming skills in Python and/or MATLAB.
- Good oral (for discussion and presentation) and written English skills are required.