A Physically-based Interpretation of Postseismic Relaxation and Slip

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Most large earthquakes are followed by significant postseismic deformation and by an increase in seismicity activity, which can last for several years to decades. This transient slip is generally thought to result from the stress perturbation from coseismic slip. Various mechanical origins have been proposed, ranging from poroelastic rebound, rate-strengthening afterslip, to distributed or localized creep. Distinguishing between different mechanisms is difficult on the basis of available data and there is a lack of understanding of the underlying physics.

In this study, we apply a microphysically-based friction model (Chen and Spiers, 2016; Niemeijer and Spiers, 2007; referred to as the CNS model) to study the postseismic fault behavior.

Numerical simulations of a spring-slider fault model show that the postseismic fault deformation is initially controlled by frictional slip followed by plastic flow. At shallow depth, the postseismic slip can be fully attributed to intergranular slip of the fault in-filling material (i.e. fault gouge), which shows velocity strengthening behavior (Figure 1a). In contrast, the postseismic slip below the seismogenic zone can be activated to become a subseismic (slow) slip, depending on the size of the perturbation of the earthquake, which generally occurs in three phases, i.e. initial acceleration, rate-strengthening frictional slip and pure plastic flow (Figure 1b). These results are further verified by quasi-static earthquake cycle simulations.

Our study demonstrates that postseismic slip is a combination of intergranular slip and plastic creep, which can be unified by a microphysical model. Since the model is physically based, we believe that our approach can provide an improved framework for understanding natural afterslip and seismicity.

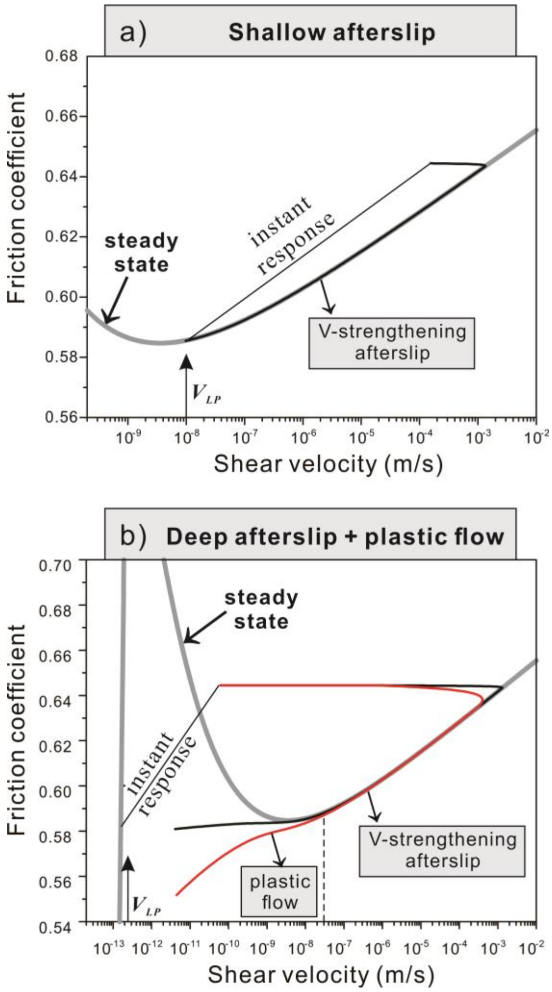

Figure 1. Friction-velocity phase diagram predicted by a microphysical model, showing the postseismic relaxation and slip activated by stress perturbation from an earthquake. The thick grey lines are the steady state profiles.