Effects of Stress Perturbations on Frictional behavior: An Experimental Study

Shengli Ma[1]; Kaiying Wang[1]; Shunyun Chen[1]; Liqiang Liu[1]

[1] State Key Lab. Earthq. Dynamics, Inst. Geology, China Earthq. Admin.

In recent years correlation between sesimicity and transient or periodic loading of the Earth's crust including solid Earth tides, reservoir impoundment, and dynamic and static stress changes caused by large earthquake have been a hot topic in earthquake study. Experimental study on frictional response to loading fluctuation is helpful for understanding the mechanism of triggered seismicity. We have conducted a series of frictional experiments using three-granodiorite block direct shear configuration. The experiments were performed in a biaxial rig with a servo-controlled loading system under normal stress of 5-15 MPa and load point velocity of 0.5 m/s in shear direction. Average load point velocity or average normal stress was modulated by the addition of a short period and small-amplitude sine wave to simulate shear stress perturbation and normal stress perturbation, respectively. Stick-slip events were recorded during the experiments to determine the correlation between the timing of stick-slip events and the imposed periodic loading. The main points are as follows.

(1) Under constant normal stress and loading point velocity, samples always show regular stick-slip. The shear stress perturbation has little effect on interval and stress drop of stick-slip events, meaning that samples still keep regular stick-slip. However, shear stress perturbation may control the timing of stick-slip, and the degree of correlation between the timing of stick-slip events and the imposed periodic loading increases with increasing the amplitude of perturbation.

(2) The normal stress perturbation may not only control the timing of stick-slip but also affect interval and stress drop of stick-slip events, and the effect increases with increasing the average normal stress and the amplitude of perturbation. In statistics, the interval and stress drop of stick-slip events increase with increasing normal stress under constant loading velocity. However, the relation is greatly changed when normal stress perturbation is imposed, and stress drop and interval of stick-slip events are obviously scattered. In particular, the magnitude of stress drop may tremendously increase. Strain measurement indicates that the normal stress perturbation increases the heterogeneity of strain distribution and strain release along the sliding surface, and stick-slip events with large stress drop and that with small stress drop are corresponding to strain release along whole sliding surface and that along parts of sliding surface, respectively.

(3) The important point in our experimental results is that the effect of normal stress perturbation on frictional behavior is more obvious than that of shear stress perturbation. This implies that not only the effect of change in coseismic Coulomb stress on seismicity should be analyzed but the possible effect of change in normal stress on fault should be paid more attention when fault interaction is considered.