Geophysical Research Abstracts
Vol. 19, EGU2017-7774-1, 2017
EGU General Assembly 2017

Transformation of fault slip modes in laboratory experiments

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Slip mode of crust fault can vary because of many reasons. It's well known that fault structure, material of fault gouge, pore fluid et al. in many ways determines slip modes from creep and slow slip events to mega-earthquakes [1-3]. Therefore, the possibility of fault slip transformation due to external action is urgent question. There is popular and developing approach of fluid injection into central part of fault. The phenomenon of earthquakes induced due to pumping of water was investigated on small and large scales [4, 5]. In this work the laboratory experiments were conducted to study the evolution of the experimental fault slip when changing the properties of the interstitial fluid.

The scheme of experiments is the classical slider-model set-up, in which the block under the shear force slips along the interface. In our experiments the plexiglas block 8x8x3 cm^3 in size was put on the plexiglas base. The contact of the blocks was filled with a thin layer (about 3 mm thick) of a granular material. The normal load varied from 31 to 156 kPa. The shear load was applied through a spring with stiffness 60 kN/m, and the rate of spring deformation was 20 or 5 mcm/s. Two parameters were recorded during experiments: the shear force acting on the upper block (with an accuracy of 1 N) and its displacement relatively the base (with an accuracy of 0.1 μm). The gouge was composed of quartz sand (97.5%) and clay (2.5%). As a moisturizer were used different fluids with viscosity varying from 1 to 10^3 mPa x s.

Different slip modes were simulated during slider-experiments. In our experiments slip mode is the act of instability manifested in an increase of slip velocity and a drop of shear stress acting on a movable block. The amplitude of a shear stress drop and the peak velocity of the upper block were chosen as the characteristics of the slip mode.

In the laboratory experiments, slip events of one type can be achieved either as regularly recurring (regular mode) or as random stochastic (irregular mode). To investigate regularities of transformation and get statistically correct results we simulated only regular mode. During the experiments, after the establishment of a regular mode, we injected fluid into central part of interblock contact. Varying injecting fluid we were able both to decrease and increase amplitude of events. For example, after injection of 1 mPa x s fluid (water) in gouge, moisturized with 100 mPa x s fluid (ethylene glycol), peak velocity rose by almost an order. But after injection of an aqueous solution of starch (big viscosity and dilatant rheology) amplitude decreased 1.5 times and then slip almost completely stabilized. It's probably connected with the viscosity of solution, which increases with quick shift.

Time of injection also has the significant impact on the possibility of transformation and its efficiency. Thus, it is well known that if the time of injection is in the vicinity of loss of strength moment, any external influence only initiates slip events.

Preliminary results of our laboratory experiments show that the fluid injection can both reduce the part of deformation energy going seismic wave radiation, and to increase it. The most effective action observed in experinemts with injection of dilatant fluid. Findings demonstrate the prospectivity of further research in this direction.

The work was supported by the Russian Science Foundation (Grant No. 16-17-00095)

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