Triggering dynamic failure on a fault with heterogeneous structure

Ostapchuk A., Pavlov D., Morozova K.

Institute of Geosphere Dynamics of Russian Academy of Sciences, Moscow, Russia

e-mail: ostapchuk@idg.chph.ras.ru

Studying catastrophic events, which include both large earthquakes and landslides, is one of the priorities in the Earth Sciences. Making decisions aimed at mitigation of damages from natural disasters requires clarity in understanding their physical mechanisms. The increase of number and energy of seismic events induced by technogenic changes in the stress-strain state of a rock massif determines the importance of solving the problem.

It is well known that mechanical vibrations cause short-term fluctuations of the stress state. These fluctuations can have a significant impact on the deformation mode and properties of a local area of the Earth's crust. In this paper, we focused on identifying the conditions of triggering dynamic failures of a model fault with a heterogeneous structure by weak impacts.

The study was carried out at the Geomechanical test bench of the Laboratory of deformation processes in the Earth's crust of the IDG RAS. All the experiments were performed in the classical statement of the slider model. The model fault was a contact of a granite block with a granite rod, the contact gap was filled with a multicomponent filler. Under the action of normal and shear forces, the fault exhibited the stick-slip deformation mode. During the laboratory seismic cycle, elastic oscillations were excited in the system by impacts of steel balls, and the acoustic emission (AE) response to this effect was controlled.

In the course of experiments, the parameters of the AE response (response delay, laws of AE activity growth and decrease, wave index of induced pulses) to an external impact were investigated. Depending on the amplitude and the period of perturbation at the interseismic stage of the cycle, a separate burst of AE activity can be initiated, and the formation of dynamic "micro-breaks"can occur, and at the final stage of the seismic cycle a dynamic failure can be triggered.

The obtained results indicate that (i) analyzing the AE response parameters allows to estimate the stress state of the local fault and (ii) on the basis of the results of analysis of AE activity at the inter-seismic stage, it is possible to determine the parameters of perturbation suitable for triggering a dynamic failure of maximum intensity.

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