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Laboratory study of fault slip modes and earthquake radiation efficiency

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It is well known that the part of the energy of an earthquake, which is spent to radiation, varies so strongly that seismic source efficiency may differ at least by three orders of magnitude. If one takes into account the low frequency earthquakes (LFE) and slow slip events (SSE), the range becomes much wider. Variations of rock strength and stressed conditions at one and the same locality can't explain such a difference. Described are the results of laboratory and numerical experiments, which simulated different modes of inter-block sliding. The regularities of gradual transition from stick-slip to aseismic creep on an interface between granite blocks separated by a thin layer of granular material were investigated. Small variations of material composition of the fault principal slip zone may lead to the change of the slip mode and to a huge variation of seismic energy radiated during fault dynamic rupture, whereas differences in fault strength and shear stress drop remain relatively small. In contrast to the experiments of other authors, we observed only the velocity weakening during the transition from the stick-slip to the stable slip.

The Rate-and-State friction law in the conventional form allows to reach good agreement of numerical calculations with experimental data for dynamic failures in the stick-slip regime, but it fails to reproduce the characteristics of motion for transitional sliding regimes such as laboratory LFE or SSE. In order to model "slow slip events" numerically it is proposed to add a viscous term to the Rate-and-State law. The modified model allows to describe the full range of laboratory slip modes.

The obtained results led to the conclusion that the sliding mode and the earthquake radiation efficiency are governed by the ratio of two parameters – fault weakening rate (or fault local shear stiffness) and shear stiffness of the enclosing rock mass, and this ratio can essentially change due to small variations of the material composition of the fault principal slip zone.

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