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応力降下量の臨界すべり量依存性
Dependence of earthquake stress drop on critical slip-weakening distance

加藤 尚之 [1]*
Naoyuki Kato[1]*

[1] 東京大学地震研究所
[1]ERI, Univ. Tokyo

Earthquake stress drop is one of the most fundamental parameters that characterize earthquake sources. It is known that there is a large variation of estimated stress drop, and its origin is unknown. Numerical simulations are carried out in order to examine factors that control stress drop of earthquakes. A straight fault, on which friction obeys a rate- and state-dependent friction law, is embedded in a 2D uniform elastic medium, and the fault is shear loaded at a constant rate. Velocity-weakening friction is assumed on the central part of the fault, which is sandwiched between regions of velocity-strengthening friction. Stable sliding at the velocity-strengthening regions generates stress concentration at the edges of the velocity-weakening region, which results in earthquake occurrence. Stress drop is measured by the ratio of average slip on the fault to the fault rupture length, using a plane-strain shear crack model. Many simulations are done for various values of applied normal stress to the fault and characteristic slip distance L. Simulation results indicate that the average stress drop increases with the normal stress and L. By definition, the stress drop is proportional to the average seismic slip at the velocity-weakening region of the model fault, and therefore to accumulated slip deficit during an interseismic period approximately. Rupture occurs when the stress concentration at an edge of the locked zone becomes large enough to overcome fracture energy Gc, which is approximately proportional to the normal stress and L. Critical slip-weakening distance Dc and Gc are estimated from relations between shear stress and slip obtained for simulated data, and it is found that stress drop increases with Gc and Dc. Stress drop does not linearly increase with normal stress, which may be related to relatively small depth dependence of observed stress drop. Note that the above results hold when seismic coupling is high and rupture starts near an edge of the locked region of the fault. When seismic coupling is low because of low normal stress or large L, stress drop is simply proportional to the normal stress and is not dependent on L or Dc. It is known that stress drop is little dependent on L and is proportional to normal stress for a single-degree-of-freedom spring-block model. This is because stress concentration at an edge of a locked zone cannot be realized in the spring-block model.
Keywords: earthquake mechanics, earthquake parameters, friction, numerical simulation