Geophysical Research Abstracts
Vol. 21, EGU2019-2684, 2019
EGU General Assembly 2019

Heterogeneous velocity-dependency structures of lithospheres as inferred from a friction to flow law

Toshihiko Shimamoto (1) and Hiroyuki Noda (2)

(1) China Earthquake Administration, Institute of Geology, Beijing, China (shima_kyoto@yahoo.co.jp), (2) Disaster Prevention Research Institute, Kyoto University, Uji, Kyoto, Japan

Behaviours of large-scale faults across lithospheres and plate boundaries are characterized by a change in frictional slip at shallow depths to high-temperature shearing deformation at depths. Friction to flow law (Shimamoto and Noda, 2014, JGR) can describe a transition from friction to flow using only frictional and flow parameters, and shear zone width w. Friction and flow laws are described in terms of velocity and displacement, and shear strain rate and shear strain, respectively, and w is needed to relate velocity and shear strain rate and to merge the two laws. No other parameters are required probably because no new deformation mechanisms operate in the transitional regime. This law is bound by friction law at shallow depths and by flow law at great depths, and it smoothly connect the two laws. Thus, the friction to flow law is a mixing law of frictional slip and high-temperature shearing deformation. Velocity dependency of shear resistance has vital effects on the stability of fault motion. Velocity dependency of steady-state friction is generally quite small and is described by (a – b) parameter. Whereas the velocity dependency increases with increasing flow stress in the flow regime, i.e. towards shallow depths. Thus the velocity dependency increases very sharply in the intermediate regime, and this is consistent with experimental results by Blanpied et al. (1995, JGR). The peak velocity dependency exists in the intermediate regime.
This presentation explores heterogenous velocity-dependency structures of lithospheres as inferred from the friction to flow law, and how the heterogeneity can affect the seismic fault motion, using flow parameters of representative rocks. Locations and magnitude of peak velocity dependency depends largely on temperature for the onset of high-temperature flow. Quartz-containing rocks undergo plastic flow at lower temperatures than quartz-free rocks containing feldspar, amphiboles and pyroxene. Thus the largest heterogeneity in the velocity dependency is expected in the core of lithosphere and in the overall transitional regimes from friction to flow. If different rocks of various sizes having different flow properties coexist, rocks still keeping frictional properties can coexist with rocks having very high velocity dependency in the intermediate and even in the flow regime. This heterogeneity in the velocity dependency is far larger than the heterogeneity arising from different frictional and flow properties. Pelitic rocks are abundant in subduction zones, but unfortunately its flow law is not established yet. However, it is likely to be the weakest rocks, and hence subducting plate boundary near the bottom of seismic zone is probably characterized by frictional patches surrounded by matrix with very high velocity dependency. This is quite similar case as assumed in the modelling of episodic tremor and slip (ETS) by Ando et al. (2012, JGR). Such a matrix will suppress growth of rupture to grow into a large earthquake and may promote slow slip and ETS. It would be of great interest to conduct earthquake modelling incorporating heterogeneous velocity dependency across lithospheres, as expected from the friction to flow law.