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Numerical modeling of slip processes at the deeper part of the inland seismogenic fault (I)

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The fault zone consists of three different regions from the top to bottom, brittle region, brittle-ductile transition, and ductile region. This fault zone structure controls the earthquake generation processes significantly. First, stationary localized deformation proceeds at the plastic region, which results in stress concentration along the brittle-ductile transition. Then, due to the stress concentration, slip is accelerated widely along the brittle-ductile transition. Finally, slip acceleration is localized into the narrow zone to create a nucleation zone of the main rupture. The deeper part of the seismogenic zone non-linear flow is thought to coexist with frictional slip. Previous studies have not considered realistic non-linear rheology. In this study, we develop a numerical model for inland large earthquakes in which friction and non-linear flow process are considered. Our model consists of two parts: (1) analysis of non-linear flow processes and (2) slip acceleration at the deeper part of the seismogenic zone.

(1) Analysis of non-linear flow processes: We analyze shear localization in and below the seismogenic zone. There exist two modes of shear localization: stationary shear localization and unstationary shear localization. Stationary shear localization in the lower crust is very important since this process results in stress concentration at the deeper part of the seismogenic zone. Non-stationary shear localization such as plastic instability and ductile fracture relates to slip acceleration of the deeper part of the fault zone. To investigate the mode of shear localization, Garatani et al. (2003) developed non-linear visco-elastic simulation software on the GeoFEM platform. We report some numerical results considering the temperature and the water fugacity dependent flow laws.

(2) Slip acceleration at the deeper part of the seismogenic zone: For efficient modeling of the accelerating slip processes, the boundary integral equation method is effective in which fault constitutive law is given on the fault plane. We plan to use the constitutive law obtained by experiments (Masuda et al., 2003). There is only a theoretical model for ductile friction by Estrin and Brechet (1996). In this model, steady state friction behaves as velocity weakening at low slip velocity and velocity strengthening at high slip velocity. Using this kind of friction law we can confirm the occurrence of acceleration slip at the deeper part of the seismogenic zone.

The final goal of this study is to apply our numerical model which consists of two parts to the northern part of the Itoigawa-Shizuoka tectonic line. Assuming the geometry of the fault zone inferred from seismic prospecting and geodetic observation, we will simulate the deformation and slip processes around this area. By comparison between numerical results and observations, we will be able to determine an appropriate model for this region.