Shear strain concentration mechanism in the lower crust below an intraplate strike slip fault based on rheological laws of rocks

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The existence of the shear zone in the lower crust under an intraplate strike slip faults has been suggested by many studies. To understand the structural characteristics of the shear zone in the lower crust under an intraplate strike slip fault (slip rate of 1mm/yr) and its temporal evolution in a geological time scale, we have been conducting 2-D numerical experiments. In our previous study (Zhang and Sagiya, 2015), stress singularity appears at the bottom of the upper crustal fault where stepwise velocity was assigned as a boundary condition. To avoid the stress singularity, we introduce a yield threshold in the brittle-ductile transition. We also add the fault fictional heating to better evaluate the amount of heat generation due to fault activity.
Calculation with wet anorthite rheology show that the viscosity of the brittle ductile transition is about 10^{22} Pa*s. The brittle-ductile transition is located approximately at 19 km depth, consistent with the cut-off depth of seismicity in the continental crust. On the other hand, for dry anorthite, the depth of the brittle ductile transition exceeds 25km. Therefore water is of importance in making the lower crust weak. Calculated temperature rise for 3Myrs is 15 K for wet anorthite and 22 K for dry anorthite, much smaller than a case of interplate fault (e.g. 30 mm/yr slip rate). Frictional as well as shear heating has very limited effects on shear localization under an intraplate strike slip fault. Grain size is another factor that controls the rheology of the lower crustal rock. While grain size determines the effective viscosity of diffusion creep, grain size varies both in time and space as a result of dynamic recrystallization and dislocation creep. In our calculation, grain size obtained from a stress dependent constitutive law ranges from several micrometers to several millimeters. On the other hand, grain size determined by balancing the shear strain rate of diffusion and dislocation creep ranges from several tens of millimeters to several centimeters. These results provide constraints on the physical mechanism of ductile flow in the lower crust through comparison with the rock sample originated from the lower crust. Our model suggests that for intraplate strike slip fault, lower crustal shear zone is produced by the stress dependent nonlinear rheology and shear and frictional heating has negligible effect on the deformation of the shear zone.

Keywords: Lower crust, shear zone

