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Rheology profile across the Northeastern Japan

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Recent seismological and geodetic observations have shown the current lithospheric deformation of the northeastern Japan arc (e.g., Hasegawa et al., 2005). These observations have shown a significant localization of GPS strains and concentration of shallow microseismicity along the Ou Backbone Range by the presence of hot upwelling flow including partial melts and water from mantle wedge beneath the volcanic front. Furthermore, the number of reverse slip earthquakes have been generated along steep-dipping reverse faults implies the reactivation of pre-existing faults under the presence of overpressured fluids (Sibson, 2009). However, despite close distributions between the presence of fluids (water and melt) and reactivated fault systems on recent earthquakes, the effects of fluids and pre-existing fault systems on the present-day lithospheric deformation and earthquake generation have not been quantitatively evaluated yet.

In order to predict the present-day lithospheric strengths across the NE Japan, I construct two dimensional strength profiles using the petrological model and geophysical observations for NE Japan combined with recent development in rock mechanics. The calculated strength profiles are compared with the distribution of microseismicity and geodetic strain field in the NE Japan. Based on the profile, I discuss the possible roles of fluids and pre-existing fault systems on fault reactivation.

The lithospheric strengths are calculated using frictional and ductile constitutive laws as a function of temperature, pressure and strain rates of the lithosphere. A petrological model of the NE Japan based on the laboratory measurement of seismic velocity by Nishimoto et al (2005) was adopted: granite for the upper crust, hornblende gabbro for the lower crust, and spinel lherzolite for the upper mantle. The geodetically determined horizontal east-west strain rate of about 10^{-7}/yr (Miura et al., 2004) was used to calculate the lithospheric strengths along the seismic profile across the Northen Honshu, Japan by Iwasaki et al. (2001).

The calculated strength profiles explain patterns of present-day geodetic strain accumulation and shallow seismicity along the Ou Backbone Range. Laboratory derived flow laws also reproduce the presence of weak zones by mechanisms likely operated in the lithosphere (e.g., partial melting and shear zone development). The strain localization into weak zones efficiently accumulates elastic strains at the base of upper seismogenic faults locked during interseismic periods (e.g. Ando and Okuyama, 2010). This may result in the reactivation of pre-existing fault systems in the NE Japan.

Keywords: Northeastern Japan, rheology, strength profile, earthquake, rock mechanics