

Small scale convection under the island arc?

Satoru Honda[1]

[1] E.R.I., Univ. Tokyo

Recently Billen and colleagues (e.g. Billen et al. (2003)) extensively studied the subduction zones based on the dynamic modeling of subduction zones and proposed the existence of the low viscosity wedge (LVW), which may be produced by the water dehydrated from subducting slabs. Meanwhile, in northeast Japan, Tamura et al.(2002) found along-arc variations of distribution of volcanoes, low velocity anomalies and Bouger anomalies. They can be grouped 10 lineaments with a wavelength of ~80 km, which are perpendicular to the trend of trench. They called these Hot Fingers, since those features are suggestive of high temperature in the upper mantle. The morphology akin to this has previously been expected for small-scale convection beneath moving oceanic plates. We might expect such a small-scale convection under the back-arc, if the wedge mantle viscosity is low enough. This small-scale convection may be a possible origin of Hot Fingers. We explore this possibility using both 2-D and 3-D modeling with/without pressure and temperature dependent viscosity of wedge mantle. 2-D models without pressure and temperature dependence of viscosity show that, with a reasonable geometry of the LVW and subduction speed, the small-scale convection is likely to occur, when the viscosity of the LVW is less than 10^{19} Pa sec. Corresponding 3-D model studies reveal that the wavelength of rolls depend on the depth of the LVW. An inclusion of temperature dependent viscosity requires an existence of further low viscosity in the LVW, since temperature dependence suppresses the instability of cold thermal boundary layer. A pressure (i.e. depth) dependence combined with a temperature dependence of the viscosity produces a low-viscosity zone, and, thus, it promotes short wavelength instabilities. The model, which shows a relatively moderate viscosity decrease in the LVW (Most of the LVW viscosity is $10^{18} \sim 10^{19}$ Pa sec) and the wavelength of roll ~80 km, has a rather small activation energy and volume (~130 kJ/mol and ~4 cm³/mol) of the viscosity. This small activation energy and volume may be possible, if we regard them as an effective viscosity of non-linear rheology.