Is the Median Tectonic Line hot?

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The Median Tectonic Line (MTL) is the longest fault system running through southwestern Japan along the geologic border that divides the Sanbagawa belt which crops high-pressure metamorphic rocks and the Ryoke granitite belt. Displacement velocity at the active fault segments in Shikoku and the western Kii Peninsula exceeds 1m/1000years (Oakda, 1992). A right-lateral steady slip of 5mm/year was detected by GPS observation (Tabei et al., 2002) and effects of the westward movement of the forearc sliver were found to appear in the crustal deformation in Kyushu (Takayama and Yoshida, 2007). These movements are considered to be related to oblique subduction of the Philippine Sea plate.

In this paper we investigate tectonic implications of our finding which the seismogenic layer along the MTL is exceptionally shallow. We especially look at its relevance to the thermal structure of the crust.

The depth of the seismogenic layer is considered to depend on the thermal structure in the crust. The temperature at the bottom of the layer is estimated at around 300-450 degree (e.g., Sibson, 1982; Ito, 1990). The fact that the depth of the seismogenic layer is regulated by the temperature is indicated by the observation that the geothermal flux and the depth of the Curie point are related to the lower limit of the depth of the seismogenic layer (Ito, 1999, Tanaka, 2004). It is pointed out that the seismogenic layer is especially shallow in volcanic areas (Ito, 1992). Using the JMA hypocenter data in recent years, we found that the seismogenic layer is actually shallow in the zone along the Volcanic Front in northeast Japan and in the Bepp-Shimabara graben where many volcanoes are distributed. We also found unexpectedly that the seismogenic layer is exceptionally shallow on the southern side of the MTL in Shikoku and the Kii Peninsula where no volcano exists. The shallowness of the seismic activity in the Wakayama plain (the mean depth of earthquakes in the Wakayama swarm activity is 6km) is especially remarkable because we found out that seismogenic layer in low lands is relatively deep compared to that in mountainous areas (the higher the topographic altitude, the shallower the depth).

Geothermal flux is relatively larger on the backarc side in northeast Japan and it is considered that the crust there is thinner and more fragile compared to the forearc side (Shimamoto, 1989). In contrast to that the spatial change in the depth of the seismogenic layer indicates that the temperature in the crust is higher on the forearc side in southwestern Japan. This difference casts a doubt whether the MTL has the same tectonic meaning as the Volcanic Front in northeast Japan.

The Philippine Sea plate subducting beneath Shikoku and the Kii Peninsula is relatively young and hot compared to the Pacific plate under northeast Japan. However, that does not explain the fact that the seismogenic layer is shallow only in the zone of the width of several tens km on the southern side of the MTL. It should be noted that the shallow seismic zone almost coincides with the metamorphic belt. Many geophysical evidences suggest that mantle wedge materials are serpentinized by a plenty of water that are transported to the depth with subducting oceanic plate (e.g., Hyndman and Peacock, 2003). Seno and Kirby (2006) proposed a model which the water provided by dehydrated slab plays an essential roll in the exhumation process of the high-pressure metamorphic rocks. Although it is improbable that the exhumation process of the metamorphic rocks in the Sanbagawa belt that occurred ca 60 Ma is still going on, we think it is possible that hot serpentine and water began to uprise again due to subduction of the hot young Phislippine Sea plate. The anomalously shallow seismic activity in the metamorphic belt along the MTL seems to suggest the possibility.