Water content estimates of the upper mantle and the transition zone beneath the northwest Pacific basin

Tsutomu Motobayashi[1]; # Hiroaki TOH[1]

[1] Dept Earth Sciences, Univ. Toyama

http://www3.u-toyama.ac.jp/toh/

Since August, 2001, we have been conducting seafloor electromagnetic (EM) observation at a site called NWP on the North-West Pacific basin (Toh et al., 2004; Toh et al., 2006). The objectives of the long-term seafloor observation are not only to establish a seafloor geomagnetic observatory in a region of scarce data, but also to reveal the electrical conductivity structure beneath NWP where the age of the seafloor is as old as 129Ma (Nakanishi et al., 1999). We applied the magnetotelluric (MT) and geomagnetic depth sounding (GDS) methods to the observed 5-component EM field of approximately 1300-day long with a sampling interval of one minute. The one-dimensional (1D) conductivity structure was then estimated by Occam inversion (Constable et al., 1987) using both the static shift corrected MT responses and the scalar MT responses converted from the observed GDS responses. The characteristics of the derived 1D model are summarized as follows:

1) The resistivity-thickness product of the uppermost lithosphere estimated by two-dimensional forward modeling with a conductive path to the upper mantle is of the order of 10^{10} ohm.m, which is one order of magnitude larger than those reported in the northeast Pacific basin (e.g., Cox et al., 1986). This means a very cold lithosphere beneath NWP depleted in volatile elements including water.

2) A conductive asthenosphere centred at a depth of 200 km has been detected, which is, in turn, consistent with the result beneath the northeast Pacific basin (Lizarralde et al., 1995). The cause of the conductive asthenosphere may be attributed to the presence of small amount of water (~0.06 wt %), which is less than the amount of water necessary for the onset of hydrous melting. The conductive asthenosphere, therefore, does not necessarily require the presence of partial melts in order to explain its high electrical conductivity.

3) Discontinuous jumps of electrical conductivity at depths of 410 km and 660 km are within factors of approximately 10 and 2, respectively. By comparing our 1D model (about 0.2 S/m at 410 km and 0.5 S/m at 660 km) with recent laboratory experiments with respect to the influence of water (or hydrogen) content on electrical conductivity in wadsleyite and ringwoodite (Huang et al., 2005), we conclude that the water content in the mantle transition zone is approximately 0.13 wt %, which may support the transition-zone water filter hypothesis (Bercovici and Karato, 2003).

References

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