海底電磁気機動観測でスタグナントスラブを診る - 上部マントル１次元電気伝導度構造モデル -

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Investigation of the stagnant slab by maneuver seafloor electromagnetic surveys: A reference 1-D conductivity of the upper mantle

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We ran a three-year-long seafloor electromagnetic (EM) survey project in the Philippine Sea in order to image electrical feature of deep mantle slab stagnating in the transition zone and surrounding mantle in three dimensions (3-D). The electrical conductivity of the mantle minerals depends strongly on temperature composition (including the degree of mantle hydration), and the fraction and connectivity of melt, all of which are important parameters in understanding the mantle dynamics. The project iterated one-year-long deployment of ocean bottom electromagnetometers (OBEMs), involving total of 37 instruments installed at 18 sites. The data obtained by each phase have been analyzed in turn based on magnetotelluric (MT) method.

As the first step toward the 3-D analysis, we have attempted to obtain one-dimensional (1-D) model which can be used as a reference model for the Philippine Sea mantle. To have a good representative model is critical for subsequent 3-D inversion analysis with quick and stable convergence. We have so far analyzed 20 seafloor data collected through the first observation phase and past experiments and obtained MT response for each site. The seafloor MT responses are severely affected by surface heterogeneity because of high contrast in the conductivity between crustal rocks and seawater. Thus, the effect of the surface heterogeneity is stripped from the observed responses by 3-D forward modeling analysis. Then, the corrected responses are averaged over the sites and the mean response is inverted in a 1-D space. After a few iterations of this procedure, we obtain a 1-D conductivity model that is free from the effect of the surface heterogeneity.

The resultant 1-D model shows that the mantle in 100 - 400 km depth is relatively homogeneous with about 0.03 S/m. In the mantle transition zone, the conductivity increases by 0.2 - 1.0 S/m. Both the upper mantle and the transition zone are much more conductive than the 1-D reference models for northern Pacific obtained by semi-global analysis (Utada et al. 2003, Kuvshinov et al. 2005 and Shimizu et al. 2009). The conductivity of the asthenospheric mantle can be interpreted by using laboratory models (e.g., Constable, 2006; Wang et al., 2006; Yoshino et al., 2006). Temperature and water content in olivine are obtained from the conductivity model under some assumptions. The obtained temperature under dry condition at 40 - 85 km depths is higher than dry solidus of garnet pyrolite, suggesting that the mantle may be partially molten beneath some areas of the Philippine Sea.