The three-dimensional conductivity structure in the upper mantle beneath the Philippine Sea and the western Pacific Ocean

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The Philippine Sea Plate consists of several small basins, ridges, and troughs with various seafloor ages, and has complex history which has been closely linked to evolution of the Izu-Bonin-Mariana arc system. The upper mantle electrical conductivity distribution should reflect the complex evolutionary history, and we have determined the 3-D electrical conductivity distribution in the upper mantle beneath and vicinity of the Philippine Sea by using marine 3-D MT inversion Techniques.

The MT impedance tensors used in this study were obtained from seafloor EM observations using OBEMs at 25 sites in the Philippine Sea and the western margin of the Pacific Ocean. 24 sites of them were already reported in Baba et al. (2010). We acquired an additional EM data set obtained at T08 in the western Shikoku Basin. At this additional site, three orthogonal components of magnetic field and two horizontal components of electric field were collected every 60 seconds from November 2008 to August 2009.

In order to obtain reliable model, both regional large-scale topography and local small-scale topography around each site are taken into account in the inversion (Tada et al., 2012; Baba et al., 2013). The distortion tensor due to the local small-scale topography was estimated for each site by forward calculation with fine scale bathymetric data, assuming regional 1-D structure below and incorporated in the inversion. After the inversion, the distortion tensors were estimated again using the 3-D inverted model. The second inversion incorporating the new distortion tensors constructed a model that fits better the data especially at the sites on relatively more complex bathymetry, suggesting the recalculation of the distortion tensor is important in this study.

Selection of initial and prior models also influences obtained 3-D images. We tested 9 different inversions with different initial and prior models, which are combination of the PHS, PAC, and PHS&PAC models. We call a 1-D conductivity model of Philippine Sea mantle beneath 3-D bathymetry structure as the PHS model and that of Pacific mantle as the PAC model, respectively. The PHS&PAC model is a 3-D model in which the PHS model and PAC model are combined along the major plate boundary. The smallest RMS data misfit was obtained the case using the PHS&PAC model and the PHS model as the initial and prior models, respectively, which means that a clear boundary between the Philippine Sea and the Pacific is not required by the data.

One of the biggest issues for 3-D inversion is the treatment of error floors. We tested two cases, the one-phase method and the two-phase method. In the one-phase method, the error floors were set to be constant values through the whole iteration steps, while in the two-phase method the error floor of the off-diagonal elements were changed to be smaller value after a few inversion steps. Both the RMS data misfit and the RMS model misfit for the two-phase method are smaller than those of the one-phase method by using the checkerboard tests. Thus we applied the two-phase method to the data. The checkerboard tests also indicated degree of model recovery. The checkerboard patterns are recovered well especially around the sites and the shallower than the depth of about 410 km.

The main features of the 3-D electrical conductivity are: 1) a conductive anomaly is located between 55 km and 95 km depths along the northern part of the Kyusyu Palau ridge. 2) Another conductive anomaly is located at depths deeper than about 80 km at the northwestern part of the Parece Vela Basin. 3) Two conductive anomalies are located at shallower than about 100 km depth at the northern part of the Izu-Bonin Arc and at the northern part of the Mariana Trough. 4) The conductivity of the Pacific mantle is significantly lower than that of Philippine Sea mantle at shallower than 200 km depth.