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Electrical conductivity imaging of the upper mantle beneath the Philippine Sea and the western edge of the Pacific Ocean

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We performed a three-year-long seafloor electromagnetic (EM) survey in the Philippine Sea, including the western edge of the Pacific Ocean, to image electrical features of a deep mantle slab stagnating in the transition zone and the surrounding mantle in three dimensions (3-D). The project iterated one-year-long deployment of ocean bottom electromagnetometers (OBEMs), involving a total of 37 instruments installed at 18 sites. The data obtained have been analyzed in the order of their recovery based on a magnetotelluric (MT) method. In this study, we attempt to obtain a one-dimensional (1-D) electrical conductivity model that can be used as a reference model as the first step toward 3-D analysis. The effect of surface heterogeneity is stripped from the observed MT responses. 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 essentially free from the effect of surface heterogeneity. This procedure is applied to the data obtained in the Philippine Sea region and the Pacific region separately. The resultant 1-D models show three main features: 1) Strong contrast in the conductivity for the shallower 200 km of the upper mantle depths is recognized between the two regions, which is qualitatively consistent with the large difference in lithospheric age. 2) The conductivity at 200.30 0 km depth is more or less similar between the two regions at about 0.3 S m^{-1}. 3) The conductivity around 400 km depth is higher for the Philippine Sea mantle than for the Pacific mantle. The conductivity structure can be interpreted in terms of thermal structure, mantle hydration, and the existence of partial melt using experimental results for the conductivity of mantle minerals. If the conductivity is interpreted simply as the effect of temperature, the mantle beneath the Philippine Sea can be hotter than the dry solidus of garnet pyrolite; thus partially molten. However, beneath the Pacific region, the present analysis suggests that partial melting is not required or is at least restrictive even if we consider mantle hydration.

Keywords: Philippine Sea plate, Pacific plate, upper mantle, electrical conductivity, ocean bottom electromagnetometer, magnetotellurics