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Electrical conductivity of old oceanic mantle beneath the northwestern Pacific revealed from seafloor magnetotelluric observations

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Electrical conductivity of the oceanic upper mantle is typically imaged as highly conductive zone overlaid with resistive layer by seafloor magnetotelluric (MT) data. They are generally interpreted as hotter asthenospheric mantle and cooler lithosphere and their variation is frequently discussed in terms of the cooling history with seafloor age, according to the strong dependency of the conductivity on temperature. Water content and partial melting also control electrical conductivity, which are keys to constrain the state of the lithosphere and asthenosphere as well as temperature. However, quantitative evaluation of the relation between conductivity structure and these parameters is not fully understood yet. In this study, we discuss it from the conductivity structure models of very old (>130 Ma) upper mantle, which were obtained from two seafloor MT experiments conducted in northwestern Pacific Ocean. The first data set was obtained in off-Japan Trench, as a part of the petit-spot multidisciplinary observation project (Baba et al., 2007). Petit-spot is young tiny volcanic activities in superficially normal ocean basins, which are not associated with any volcanic activities of plate boundaries or hot spots (Hirano et al., 2006). The second data set was collected in off-Ogasawara Trench, as a part of Stagnant Slab Project (Shiobara et al., 2009; Baba et al., 2010). The data were analyzed and representative one-dimensional (1-D) conductivity models were obtained for the mantle beneath each region. The effect of the surface heterogeneity structure on the data was carefully corrected, and the corrected data were inverted. The obtained 1-D models indicate that the thickness of the resistive layer is more than 200 km for both regions. If conductivity is converted into temperature under dry condition, this feature is fit better to the half space cooling model with small bias rather than the plate cooling model which explains bathymetric subsidence for old (>80) seafloor. This disharmony should be studied more in the future. The temperature converted from the conductivity is much lower than the dry solidus of mantle peridotite. If the thermal structure is represented by the half space cooling model, the small bias may be attributed to mantle hydration. The maximum water content estimated from the conductivity is about 0.02 wt% which is not enough to reduce the solidus as low as the assumed temperature. These results suggest that basaltic melt is not necessary in the asthenospheric mantle. However, it is not acceptable at least in the petit-spot region because the analysis of the basalt samples obtained from the petit-spot volcanoes suggests that the source magma originates in the asthenospheric mantle. This discrepancy may be explained by the contribution of a material such as eclogite, the solidus of which is much lower than that of peridotite. The lateral distribution of the petit-spot melt is still unclear. To dispose of the discussion on partial melting in the asthenosphere, further data experiments are necessary, which cover the northwestern Pacific region more densely and widely.