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Thermal and compositional constrains on the upper mantle beneath the northwestern Pacific imposed by marine magnetotellurics

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Oceanic upper mantle beneath the northwestern Pacific has large-scale lateral heterogeneity that is impossible to attribute to just an age-dependency of the thermal structure based on a cooling of homogeneous mantle with age. This surprising fact was revealed from seafloor magnetotelluric (MT) data collected in three areas, northwest (Area A) and southeast (Area B) of the Shatsky Rise, and off the Bonin Trench (Area C), through the Normal Oceanic Mantle Project and the Stagnant Slab Project. One-dimensional structures of electrical conductivity representing each area show significant difference in the thickness of the upper resistive layer that may be interpreted as cool lithosphere. The thickness of the layer that is more resistive than 0.01 S m^{-1} is $\sim$90 km for Area A, $\sim$100 km for Area B, and $\sim$180 km for Area C. The conductivity below the resistive layer is similar to $\sim$0.03 S m^{-1} for all areas. The thermal structures for the lithospheric age representing the areas (130, 140, and 147 Ma for Areas A, B, and C, respectively) predicted from a simple plate cooling model are almost identical and thus cannot reproduce such variations in electrical conductivity. Then, in this study, thermal and compositional states of the mantle beneath the three areas were investigated to discuss the cause of the variations. Combination of five model parameters, electrical conductivity of crust, mantle potential temperature, thickness of thermally conductive plate, and H_2O and CO_2 contents in the asthenospheric mantle were searched by forward modeling and the χ^2 misfit between the MT responses observed and predicted were assessed with 95% acceptable level. The possibility of partial melting was taken into account by a self-consistent manner comparing to the solidus of peridotite that is reduced by H_2O and CO_2. We assumed that the mantle conductivity may be represented by the mixture of hydrous olivine and hydrous carbonated melt. This procedure enables us to discuss how water, carbon, and/or melt can contribute the electrical conductivity in a range accepted by the observed data and gives hints to the nature of lithosphere and asthenosphere boundary.