Simple plate cooling model is no longer applicable to the upper mantle beneath the northwestern Pacific: Evidence from marine magnetotellurics

*Kiyoshi Baba[1], Noriko Tada[2,1], Tetsuo Matsuno[3], Pengfei Liang[1], Ruibai Li[1], Luolei Zhang[4], Hisayoshi Shimizu[1], Natsue Abe[5], Naoto Hirano[6], Masahiro Ichiki[7], Hisashi Utada[1]

1. Earthquake Research Institute, University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology, 3. Kobe Ocean Bottom Exploration Center, Kobe University, 4. School of Ocean and Earth Science, Tongji University, 5. Research and Development Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 6. Center for Northeast Asian Studies, Tohoku University, 7. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

The old oceanic lithosphere and asthenosphere beneath the northwestern Pacific Basin cannot be interpreted by the lithospheric age difference under a framework of the simple cooling of thermally conductive homogeneous mantle. This surprising result is now more definitely constrained by the electrical conductivity structure models obtained for four areas: northwest (Area A) and southeast (Area B) of the Shatsky Rise, off the Bonin Trench (Area C) and off the Japan Trench (Area D) where the representative lithospheric ages of these areas are 130, 140, 147, and 135 Ma, respectively. The marine magnetotelluric (MT) data were collected through several projects in the areas during the last decade. The 1-D electrical conductivity structure models of the upper mantle representing the areas were estimated by the state-of-art method that takes account for the effect of coast line and seafloor topography which can distort the electric and magnetic field significantly. The 1-D models show a highly resistive upper layer and a conductive zone, which are typical feature of the oceanic upper mantle and can be interpreted as the cool lithospheric mantle and warmer asthenospheric mantle. The significant difference among the four areas was found in the thickness of the resistive layer. The depth that electrical conductivity increases more than 0.01 S m^{-1} is ~90 km, ~100 km, ~190 km, and ~150 km for Area A, Area B, Area C, and Area D, respectively. The thermal structures for the ages representing the four areas predicted from a lithospheric cooling model are not different from each other very much and therefore such thermal model cannot reproduce the difference in the conductivity structures observed. It is necessary to introduce more dynamic processes such like small-scale convection, melt migration associated with the lithospheric flexure, and influence of plume associated with the Shatsky Rise formation. Observational evidence from the present marine magnetotellurics is one of the key issues for understanding the lithosphere-asthenosphere system (LAS) in the northwestern Pacific.

Keywords: marine magnetotellurics, electrical conductivity, oceanic upper mantle, plate cooling, Northwestern Pacific

