Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SEM33-08 Room:102A Time:May 26 11:15-11:30

Electromagnetic investigation into the mantle transition zone in the Normal Oceanic Mantle project

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We report a preliminary analysis of marine electromagnetic field data that were obtained under the Normal Oceanic Mantle project for elucidating an electrical conductivity structure of the mantle transition zone in the northwest Pacific. A primary aim of this study is to answer one of fundamental questions in the solid earth science “Is the mantle transition zone a major water reservoir of the Earth?” from observations for the electrical conductivity structure with our new and latest instruments. To elucidate the electrical conductivity structure of the mantle transition zone, periods of electromagnetic response functions should be long as more than 10^5 s (approximately 1 day) due to the response sensitivity to plausible electrical conductivities of the mantle [Fukao et al., 2004]. The electric field observation system (EFOS) has achieved better signal-to-noise ratio at the target long period range than the ocean bottom electromagnetometer (OBEM) in measurement of voltage difference variation with its long electrodes separation of almost 2 km [Utada et al., 2013]. In addition to utilizing the EFOS, multi-year observations with EFOSs and OBEMs were conducted (up to 2 years for EFOS and up to 4 years for OBEM) to obtain data for estimation of electromagnetic response functions at the long period range with high accuracy.

Three EFOSs were deployed in September 2012 and were recovered in September 2014. One EFOS recorded excellent data for full two years, and the other two EFOSs recorded good data for one year in total. The sampling rate of the EFOSs was 1 s, and clock drift of each EFOS, which was less than 120 s, was corrected for the subsequent data analysis. MT response functions were estimated by using the processed EFOS electric field data and OBEM magnetic field data obtained at the same site, and GDS response functions were estimated by using OBEM magnetic field data (Baba et al. in the same session will present details on OBEM data). These response functions were estimated mainly at the period range of 10^5 - 10^6 s. MT responses were estimated at 3 sites in Area A (northwest of the Shatsky Rise), and GDS responses were estimated at 15 sites in Area A and at 7 sites in Area B (southeast of the Shatsky Rise).

The estimated response functions were compared with predictions from a known semi-global 1-D electrical conductivity model of the north Pacific with land-ocean conductance distribution in a surface layer [Shimizu et al., 2010]. The comparison done so far suggests that the mantle transition zone may be more resistive than the reference 1-D model and a north-south variation in electrical conductivity of the mantle transition zone may be none or weak under Area A. A further data analysis is ongoing, and the result of the analysis and an interpretation of the result on the thermal and geochemical state of the mantle transition zone will be presented.

Keywords: mantle transition zone, electrical conductivity structure, northwestern Pacific