

Five years of the Normal Oceanic Mantle (NOMan) Project

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The Normal Oceanic Mantle (NOMan) project was carried out for 5 years from 2010, aiming to solve two fundamental questions on the normal oceanic mantle from observational approach, which are: (a) Cause of asthenosphere lubrication, and (b) Amount of water in the mantle transition zone. We selected two study areas (A and B) of similar seafloor age (about 130 and 140 Ma, respectively) in the northwestern Pacific Ocean where the mantle below is supposed to be normal. This presentation will give an overview of five years of the NOMan project, especially of its observational activities and a summary of preliminary results so far obtained.

In June 2010, we deployed a small array consisting of 5 (both seismic and EM) sites and started data acquisition from area A, which we call the NOMan pilot experiment. The main observation by long-term seafloor arrays in areas A and B was started by two installation cruises carried out in November 2011 and in August 2012, deploying state-of-the-art ocean bottom seismic and electromagnetic instruments (BBOBS-NXs and EFOSs) in area A that are handled by ROV for installation and recovery. Conventional instruments (BBOBS and OBEM of free-fall/self-pop-up type) were also deployed both in areas A and B. Most of instruments of the pilot experiment were recovered by the cruise in August 2012. So-called advanced instruments (BBOBS-NXs and EFOSs) were equipped with batteries sufficient for 2 years of deployment, but conventional instruments (BBOBSs and OBEMs) only for one year or so. Therefore, we conducted a cruise by W/V Kaiyu in August 2013 to maintain the observation array by retrieving and re-deploying respective instruments. In June 2014, we conducted another W/V Kaiyu cruise, in which we recovered most of conventional instruments in area A after conducting a controlled source seismic experiment by using explosive sources. In September 2014, we completed a recovery cruise by R/V Kairei with ROV Kaiko-7000II. By these two cruises conducted in 2014, we have recovered instruments from all sites except only one site (NM03) where a few EM instruments were left and are to be retrieved in September, 2015.

The seafloor age difference between study areas A and B is only about 10 Ma, which was thought small enough for the temperature difference between two areas to be ignored at the first order approximation. So we originally expected that corresponding results in area B show close similarity to those in area A. However, a result of 1-D array analysis of the surface waves indicated significant difference in the lithosphere-asthenosphere structure between areas A and B. 1-D inversion results of multi-station seafloor magnetotelluric (MT) data also show a certain difference between these two areas. Furthermore, MT results in surrounding areas obtained by previous projects imply the presence of further significant heterogeneity in the old oceanic mantle in the northwestern Pacific toward the subduction zone. For the moment, we are trying to invert each of NOMan geophysical dataset as accurately as possible so as to characterize the mantle structure and its lateral variation. Later we try to clarify the cause for these lateral variabilities, as it can be one of the key issues to understand the lithosphere-asthenosphere system in the old oceanic mantle.

For the key question (b), high-quality data obtained by the long-term seafloor observations are used to investigate the MTZ structure. In particular, electric field data obtained by EFOS (with 2 km electrode separation) provide longer period MT responses sensitive to the MTZ. Resulting MT and GDS (Geomagnetic Deep sounding) responses are almost consistent with the NW Pacific semi-global 1-D model (Shimizu et al., 2010). This indicates that the MTZ conductivity below the study region has weak lateral variation (well approximated by a 1-D model) and is also consistent with the conductivity of MTZ minerals containing at most 0.1-0.5 wt.% water.