Electrical structure of the upper mantle in the Mariana subduction system II: Simulations for an upcoming seafloor MT experiment

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Studies of the electrical conductivity structure of the upper mantle beneath the central Mariana region have been conducted since 2001 in order to construct a standard electrical model for back arc - island arc - subduction systems. The electrical conductivity of the mantle is primarily dependent on temperature, although partial melt and water dissolved in olivine can enhance conductivity. Both melting and mantle hydration are important parameters to constrain in a back-arc setting suggesting that the study of conductivity structure will be useful to furthering our understanding of these regions.

We have collected seafloor magnetotelluric (MT) data and analyzed them as part of this project. The resultant two-dimensional (2D) model revealed some key features of the subduction - island arc - back arc basin (See coupled presentation in the oral session for detail). However, the model cannot resolve the source region of magma supply to the Maraiana Trough back arc spreading, nor the mantle wedge over the subducting slab, both of which are important to understanding the dynamics of the back arc mantle. The reason for this poor resolution is mainly because of the limited number of seafloor stations collected to date. In order to constrain these parts of the mantle a new experiment is being planned, in collaboration with institutions in the world, in which we plan to deploy a dense array with about 40 stations. This will be the largest seafloor MT experiment ever undertaken.

In this study, we have carried out numerical simulations to investigate the ideal array design for this next experiment. We compare the patterns of the MT responses calculated by several distinct forward models. To this end, we first prepare a 2D background structure which consists of a layered structure with a subducting slab. The geometry of the slab is based on the tomographic image by Obayashi and Fukao (2000). Then, conductive zones representing the partial melt zone beneath the Mariana trough axis, the source region of island arc volcanoes, conductive crust, and the dehydration zone above the slab are superimposed on the background model one by one. The effects of these features on synthetic MT responses are tested. MT responses for the period range between 250 and 100,000 seconds are calculated every 5 km along the 1000 km long 2D profile. The results show that shallower conductive zones, such as the melt zone and the source for volcanoes, cause significant changes in the response. Deeper conductive zones, such as the dehydration zone, also change the trend of the response but in this case the effect is less strong. However, the impact of these features depends heavily on our choice of background resistivity. If the background mantle is more resistive, the effect of the conductive regions in further enhanced.

Synthetic inversion studies have also been carried out. We added 3% Gaussian noise to the calculated responses for the model incorporating all conductive zones and inverted three subsets of the synthetic data each containing 35 stations. In addition, we calculated the effect of seafloor topography on the response by forward modeling, incorporating a fine (1 km mesh) three-dimensional topography. This exercise allows us to find the optimal locations for instrument deployment.