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Quantitative interpretation of electrical conductivity structure of the mantle

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Studies on electrical conductivity of the mantle based on magnetotelluric (MT) survey frequently discuss the water distribution in the mantle because the conductivity of the mantle minerals is thought to be highly sensitive to only small amount of water dissolved in minerals. The electrical conductivity is also strongly dependent on the temperature and the fraction and connectivity of the melt if the mantle is partially molten. Thus, it is impossible to distinguish the impacts of these parameters from the electrical conductivity alone and use of other independent information is indispensable to distinguish the impacts of each parameter.

In this presentation, I introduce my recent work on quantitative interpretation of electrical conductivity of oceanic upper mantle estimated from seafloor MT data. The keys are 1) selection of possible scenarios to reduce the model space to be searched, 2) self-consistency between temperature and existence of melt. For oceanic upper mantle, it is reasonable to test a thermal model like plate cooling or half-space cooling because these models explain the bathymetry subsidence and heat flow variation with the lithospheric age well. I here chose the model space of one-dimensional electrical conductivity associated with a thermal structure which is described as the function of lithospheric age, thickness of thermally conductive plate, and potential temperature. The effect of partial melting is taken into account by a self-consistent manner. I use the information about solidus temperature of the mantle rock and incipient melting process with the solidus reduction due to dissolved water and carbon to check if the melt is stable and how much melt is stable if so for given temperature and contents of water and carbon. The electrical conductivity can be calculated applying laboratory experiment models for hydrous olivine and hydrous carbonated melt. The MT response is produced from the conductivity structure by forward modeling and compared with the observed MT response in statistical sense. This procedure enables me to detect possible range of the parameters to explain the data and the trade-off relation of each parameter quantitatively. I show an example of application to real data obtained in the northwestern Pacific Ocean.

The future work must be a joint analysis with other observation, for example, seismic data to constrain each parameter more strictly reducing the trade-off relation.

Keywords: oceanic upper mantle, magnetotellurics, electrical conductivity structure, H2O, CO2, partial melt