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海底地形効果の 3 次元海底 MT インバージョンへの組込み
Incorporation of seafloor topographic effects into marine 3-D MT inversion

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In recent years, seafloor magnetotelluric (MT) observation is carried out by using an increasing number of ocean bottom electromagnetometers (OBEMs) not only along a line but also in 2-D array. Thus, imaging electrical conductivity structures under the seafloor in 3-D is now feasible, if we have a capable tool to invert obtained EM responses.

We would like to emphasize that a 3-D treatment is indispensable especially for marine MT, because the electric and magnetic fields observed at the seafloor are heavily distorted by the rugged seafloor topography and the distribution of land and sea which are generally 3-D. It is very important to properly treat the distorted electric and magnetic fields for an accurate estimation of the conductivity structure beneath seafloor that is generally more resistive than seawater by several orders of magnitude. This problem may be solved by making a huge forward calculation covering a sufficiently wide area, but it is not practical simply because of the computational burden. Here we assume that the distorted electric and magnetic fields are separated into long-wavelength (more than a few tens of km) and short-wavelength (less than a few tens of km) components. Then we propose their separate treatment: The long-wavelength parts are incorporated into a 3-D inversion code (WSINV3DMT; Siripunvaraporn et al., 2005), and effects of the short-wavelength topographies are corrected with other 3-D forward code (e.g. FS3D; Baba and Seama, 2002).

The WSINV3DMT is one of 3-D inversion codes that are now of practical use, but the original WSINV3DMT is not applicable to marine MT data because of two reasons. 1) MT responses are calculated only at flat Earth surface. 2) We have to use fine mesh design because an observation site must locate exactly at the center of the top surface of a block, which needs large memory that even a highest performance computer can not handle. We coded an extended version of the WSINV3DMT by solving the two problems shown above so that it can be applied to the marine MT responses. Topographies longer than length of calculation blocks (the long-wavelength topographies) are incorporated into the extended version of the WSINV3DMT by converting the lateral change in volume fraction of seawater and crustal rock in a calculation block into the lateral change in conductivity, conserving horizontal conductance.

For the treatment of the effect for the short-wavelength topographies, we tested two ways through the inversions of synthetic data. In either case, we assume that the effect is expressed as a complex coefficient matrix to the MT impedance tensor for regional structure. The synthetic data is generated based on a real observation array and topography in the Philippine Sea (Shiobara et al., 2009). 1) Correction method: The data is corrected for effect according to Baba and Chave (2005) and then the corrected MT responses are inverted using the extended version of the WSINV3DMT. 2) Incorporation method: We further modified the extended version of the WSINV3DMT to input both MT responses and the topographic effect term which is separately simulated by forward modeling. In the inversion, sensitivity of the full (non-corrected) MT impedance to the conductivity is calculated, neglecting the coupling between the topographic effect term and subsurface structure. Both tests show that the inversions recovered given anomalies (a resistive and a conductive anomalies) beneath the seafloor. However, the second method is found to provide better result than the first one because the second one rather than the first one has good agreements in the amplitude and size of anomalies. In this presentation, results of synthetic test will be presented and the importance of taking into account the topographic effect will be discussed.

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