Probing one-dimensional electrical anisotropy in the oceanic upper mantle from seafloor magnetotelluric array data

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Electrical anisotropy in the oceanic upper mantle provides important clues on mantle structure and dynamics if it is confirmed from seafloor magnetotelluric (MT) data. Here we try to probe electrical (azimuthal) anisotropy in the oceanic upper mantle by analyzing recent seafloor MT array data from the northwestern Pacific at 130-145 Ma seafloor. We propose a method, in which an isotropic 1-D model is first obtained from seafloor MT data through iterative correction for topographic distortion, then anisotropic properties are inferred as deviations from the isotropic 1-D model. We investigate the performance of this method through synthetic forward modeling and inversion, using plausible anisotropic 1-D models and actual 3-D bathymetry and topography for the target area. Synthetic tests reveal that the method can detect the electrical anisotropy in the conductive upper mantle or the electrical asthenosphere. We also compare the performance by using two rotational invariant impedances and two topographic correction equations. An application of the method to two seafloor MT array data in the northwestern Pacific reveal anisotropic inversion models, showing the possible presence of electrical anisotropy in two layers in a conductive mantle of <100 Ω-m at 50-250 km depth. Anisotropic signals are larger in shallower layers for both array areas, while anisotropic azimuths (or most conductive directions) and depths to the two layers are different for two array areas even at similar seafloor ages with the horizontal distance of ~1,000 km. Most conductive directions mostly align rather to directions of past seafloor spreading or their perpendicular directions, than a direction of current plate motion and are inconsistent with fastest directions of seismic azimuthal anisotropy. The electrical anisotropic signals may dominantly result from mantle dynamics in array-scale (~500 km or over), like small-scale convection and the formation of seafloor in the past, over in Pacific basin scale.

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