Constraints on mantle anisotropy from the NoMELT magnetotelluric data set

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The formation of lithosphere at a mid-ocean ridge and the subsequent movement of that lithosphere across the underlying convecting asthenosphere result in deformation through shearing. This deformation can result in anisotropy in measureable physical properties such as the lattice preferred orientation of olivine, with the a-axis aligned in the direction of mantle flow. Patterns of anisotropy and the depths over which anisotropy occurs can, in turn, constrain models of lithospheric formation and evolution. Seismic results from the NoMELT data at 70 Ma Pacific seafloor reveal strong anisotropy through the lithosphere, with fabric aligned parallel to the fossil spreading direction. There is a decrease in anisotropy through the lithosphere-asthenosphere boundary and almost no anisotropy in the asthenosphere (Lin et al., submitted). Despite the strong patterns of anisotropy seen in the seismic data set from the NoMELT experiment, a previous analysis of coincident magnetotelluric (MT) data showed no evidence for anisotropy in the electrical conductivity structure of either lithosphere or asthenosphere (Sarafian et al., 2015). This apparent discrepancy raises two questions: 1) Could the MT data detect the seismic anisotropy layer in the lithosphere if it existed? 2) Is such a layer compatible with observations from the NoMELT region and, if so, what are the constraints on the properties of such a layer? To answer these questions, we revisit the MT data and use 1-D anisotropic models to demonstrate the limits of acceptable anisotropy within the data. We construct 1-D anisotropic models by varying the thickness of the anisotropic layer and the degree of anisotropy in the lithosphere, based on the results of Sarafian et al. (2015), and carry out a series of forward modeling to generate a suite of MT responses. We compare the values of the calculated splits in the off-diagonal elements of the MT responses with those seen in the NoMELT data, which allows us to place some constraints on the permissible anisotropic models. We discuss several topics including consistency with the seismic anisotropy, consistency with the electrical anisotropy model by shearing (Pommier et al., 2015), and whether our result is helpful to discriminate between water and melt models of upper asthenosphere.

