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Electrical conductivity of metasomatized lithology in subcontinental lithosphere

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Abstract

A plausible origin of the seismically observed mid-lithospheric discontinuity (MLD) in the subcontinental lithosphere is mantle metasomatism. The metasomatized mantle is likely to stabilize hydrous phases such as amphiboles. The existing electrical conductivity data on amphiboles vary significantly. The electrical conductivity of hornblendite is much higher than that of tremolite. Thus, if hornblendite truly represents the amphibole varieties in MLD regions, then it is likely that amphibole will cause high electrical conductivity anomalies at MLD depths. However, this is inconsistent with the magnetotelluric observations across MLD depths. Hence, to better understand this discrepancy in electrical conductivity data of amphiboles and to evaluate whether MLD could be caused by metasomatism, we determined the electrical conductivity of a natural metasomatized rock sample. The metasomatized rock sample consists of ~87% diopside pyroxene, ~9% sodium-bearing tremolite amphibole, and ~3% albite feldspar. We collected the electrical conductivity data at ~3.0 GPa, i.e., the depth relevant to MLD. We also spanned a temperature range between 400 to 1000 K. We found that the electrical conductivity of this metasomatized rock sample increases with temperature. The temperature dependence of the electrical conductivity exhibits two distinct regimes. At low temperatures <700 K, the electrical conductivity is dominated by the conduction in the solid state. At temperatures >775 K, the conductivity increases, and it is likely to be dominated by the conduction of aqueous fluids due to partial dehydration. The main distinction between the current study and the prior studies on the electrical conductivity of amphiboles or amphibole-bearing rocks is the sodium (Na) content in amphiboles of the assemblage. Moreover, it is likely that the higher Na content in amphiboles leads to higher electrical conductivity. Pargasite and edenite amphiboles are the most common amphibole varieties in the metasomatized mantle, and our study on Na-bearing tremolite is the closest analog of these amphiboles. Comparison of the electrical conductivity results with the magnetotelluric observations constrains the amphibole abundance at MLD depths to <1.5%. Such a low-modal proportion of amphiboles could only reduce the seismic shear wave velocity by 0.4–0.5%, which is significantly lower than the observed velocity reduction of 2–6%. Thus, it might be challenging to explain both seismic and magnetotelluric observations at MLD simultaneously.

Keywords: Mid-lithospheric discontinuity (MLD), electrical conductivity, metasomatized rock, diopside, amphibole