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Electrical conductivity of hydrous Ca-free aluminous pyroxene: Implications for the electrical structure in the upper ma

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It was reported that the top of the asthenosphere shows high conductivity anomaly (Evans et al., 2005). Although this kinds of anomaly has been often explained by olivine hydration, it is reported that hydrous olivine is unable to account for this conductivity anomaly (Yoshino et al. 2006). Orthopyroxene is thought to be one of the main constituents of the upper mantle. Although it is less abundant than olivine, Mierdel et al. (2007) observes aluminous pyroxenes can contain strikingly high amount of water, hence, it can be the most important host of water in the shallow part of the upper mantle. It is necessary to measure electrical conductivity of hydrous aluminous orthopyroxene.

The electrical conductivity of Ca-free aluminous enstatite with various water contents has been determined at a pressure of 3 GPa in a Kawai-type multi-anvil apparatus. Impedance spectroscopy was performed for both hydrogen-doped and -undoped samples in a frequency range from 0.1 Hz to 1 MHz to examine the effect of water on conductivity. Two conduction mechanisms were identified for hydrogen-undoped samples at temperature of 1000-1723 K and for hydrogen-doped samples at relatively lower temperature range of 500-900 K to minimize dehydration of samples. For the hydrogen-undoped samples, the activation enthalpy is around 1.9 eV at the higher temperatures range ($>$ 1300 K) suggesting that the dominant charge transfer mechanism is Fe^{2+}-Fe^{3+} hopping (small polaron) conduction. For the hydrogen-doped samples measured below 900 K, the activation enthalpy decreases from 1.11 to 0.70 eV, and the conductivity values systematically increase with increasing water content, suggesting that proton conduction is the dominant conduction mechanism. Using the present results, a laboratory-based conductivity-depth profile in the upper mantle has been constructed as a function of water content. Comparison of our model with the currently available geophysical observations beneath the Eastern Pacific Rise indicates that hydrous aluminous enstatite cannot account for the high conductivity anomaly at the top of the asthenosphere as well as olivine.

References:

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