

Determination of proton conduction in olivine and hydrogarnet

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An understanding of proton conduction in mantle minerals is essential for the correct geophysical interpretation of magnetotelluric (MT) data. Unfortunately, full interpretation of this data is not straightforward. To convert MT derived conductivity maps of the inner Earth into geological maps requires knowledge of rock conductivities measured in laboratory experiments. It is well known that the conductivity mechanism of these minerals are dominated by proton conduction in the upper mantle physiochemical environment due to fast diffusion rate and low activation energy of hydrogen compared to other mechanisms. Current proton conduction models disagree by many orders of magnitude. For this reason, there has been a large international experimental effort aimed at determining upper mantle rock conductivities. Our aim is to separately measure in-grain and grain-boundary proton diffusion in order to reconcile proton conduction in mantle minerals. Attempts to determine proton conductivity in mantle minerals (especially olivine) have mainly taken two experimental approaches: measurement of proton conduction and measurement of proton diffusion [1]. Quasielastic neutron scattering (QENS) can potentially tell us in-grain proton diffusion rates because, is typically associated with diffusive motion, whereas inelastic peaks are usually associated with lattice or localized excitations [2]. The proton diffusion coefficient can be calculated at a range of temperatures from the Lorentzian half-width of the QENS from the protons in a solid via the Einstein equation for three dimensional random motion. An Arrhenius plot can then be used to determine the diffusion constant and activation energy[3]. We have carried out trial measurements on the PELICAN time of flight neutron spectrometer and the EMU backscattering neutron spectrometer in Australian Centre for Neutron Scattering using two minerals, olivine and hydrogarnet. Well characterized synthetic hydrated olivine (Forsterite) and synthetic hydrogarnet were used to take measurement on these instruments. The results from PELICAN demonstrated that a signal can be measured but that the diffusivities are faster than directly measurable on PELICAN. The new EMU instrument should have the necessary resolution to allow us to determine these diffusivities. We are presenting this results in this conference.

1. Padrón-Navarta, J.A., J. Hermann, and H.S.C. O'Neill, Site-specific hydrogen diffusion rates in forsterite. *Earth and Planetary Science Letters*, 2014. 392: p. 100-112.
2. Bée, M., Quasielastic neutron scattering. 1988.
3. Heuser, B.J., et al., Direct Measurement of Hydrogen Dislocation Pipe Diffusion in Deformed Polycrystalline Pd Using Quasielastic Neutron Scattering. *Physical review letters*, 2014. 113(2): p. 025504.

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