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Neutron imaging of hydrogen diffusion in polycrystalline forsterite aggregates

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An understanding of hydrogen diffusion in nominally anhydrous minerals (NAMs) is an essential context of correct interpretation of conductivity dissimilarity in Earth mantle. The mechanism of hydrogen diffusion in dominant mantle minerals was described by Demouchy (2010) and Demouchy and Casanova (2016) using a defect model in crystalline materials. This concept is well-known and well documented in the material science community (Nowick 2012) where the effects of in-grain and grain boundary (gb) diffusion are separated using the bricklayer model and other associated derivatives of this model (Tuller 2000). Separation of the two components of the proton conductivity in olivine will substantially improve current proton conduction model for Earth mantle. Finally, it will help to interpret magnetotelluric conductivity data and will give prospects to find new mineral sources and explain other sub-surface geological phenomena such as volcanism and plate tectonics. (Demouchy and Bolfan-Casanova 2016)

A recent insight is that the high conductivities determined from proton conduction measurements at low temperatures are mainly due to conduction along grain boundaries (Demouchy 2010). Demouchy (2010) was the first, and to date only experimental work on hydrogen grain-boundary diffusion in olivine, the dominant upper mantle mineral phase. We have repeated Demouche's experiment with neutron imaging which a most promising in-situ technique to image hydrogen diffusion profile. Neutrons can penetrate through the capsule while providing information about contents and they are highly sensitive to hydrogen in the sample. Therefore, neutron imaging allows measuring time and temperature dependent gb hydrogen diffusion rates in mantle minerals.

We carried out a series of experiments where we diffused water (H) through a forsterite polycrystalline matrix at high-pressure and temperature. The capsules and their contents were imaged using the DINGO neutron tomography instrument at the Australian Centre for Neutron Scattering. The results indicate hydrogen transport inside the forsterite polycrystalline matrix as changing neutron attenuation along the diffusion direction of the polycrystalline block and it correlates with temperature dependent hydrogen diffusion in this mineral. This study revealed the ability of neutron imaging technique to find the proton diffusion coefficient of NAMs. We are sharing these results in this conference.

References

Demouchy, S. (2010). "Diffusion of hydrogen in olivine grain boundaries and implications for the survival of water-rich zones in the Earth's mantle." Earth and Planetary Science Letters 295(1): 305-313.
Demouchy, S. and N. Bolfan-Casanova (2016). "Distribution and transport of hydrogen in the lithospheric mantle: A review." Lithos 240: 402-425.
Nowick, A. S. (2012). Diffusion in solids: recent developments, Elsevier.
Tuller, H. L. (2000). "Ionic conduction in nanocrystalline materials." Solid State Ionics 131(1): 143-157.

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