

## Diffusion in the deep Earth: Is it all about grain boundaries?

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We can consider two mechanisms by which diffusion can occur in Earth's deep interior: 1) through mineral lattices: lattice diffusion or 2) along the boundaries between grains: grain boundary diffusion. To date very little work has been conducted on grain boundary diffusion of volatiles under mantle conditions. Here we present recently acquired experimental data obtained using a novel method to determine grain boundary diffusion rates under mantle conditions, initially looking at hydrogen. The data is considered in terms of the mobility of hydrogen in the mantle and how an understanding of this can help to constrain the influence it has on bulk mantle properties. Preliminary results suggest that grain boundary diffusion rates may be of similar magnitude to diffusion through crystal structures, suggesting that very small diffusing species are indiscriminate towards their surroundings/host (mineral lattice versus grain boundary).

Further data is presented on a complimentary study of diffusion of titanium in quartz. Single crystal diffusion rates for Ti in quartz are very slow, potentially acting as a limiting factor for Ti abundance in crystallising quartz – with implications for the applicability of Ti in quartz thermometry.

## Tuning the interactions of PNIPAM Gel Nanoparticles

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The presence of a lower critical solution temperature (LCST) at 33C in PNIPAM gels is well known. Above the LCST the gel in water collapses from a solvent swollen state. Previously, we synthesized and studied the properties of 5 nm PNIPAM gel nanoparticles [1]. The size of these particles allowed us to characterize the temperature-dependent changes in the particle interactions using light scattering and small-angle neutron scattering (SANS) with the unanticipated result that the interactions go from highly repulsive to attractive as the temperature is increased above the LCST. The magnitude of the repulsive interaction was larger than that anticipated for hard sphere excluded volume effects.

With the aim of understanding the interaction potential of these PNIPAM gel nanoparticles and the relation to the LCST, we studied the concentration and temperature-dependent phase map, using SANS to probe the structures of the fluid, crystalline and glassy phases. Concentration is used to explore the distance dependency of the interaction potential, while temperature is used to tune this potential through the repulsive to attractive states. The overall goal of this work is to understand the underlying physics of these and like materials for the development of environmentally responsive systems.

[1] Arleth, L., Xia, X., Hjelm, R.P. Hu, Z. and Wu, J. (2005) *J. Polym. Sci. B: Polym. Phys.*, **43**, 849-860.