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Thermal diffusivity of oriented serpentinite at elevated pressures and temperatures by X-radiography

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Using our recently developed X-radiographic Ångström method (Dobson et al., 2008, 2010, Hunt et al., 2011, 2012) we have measured the thermal diffusivity of serpentinite both with and without a strong lattice preferred orientation.

The Ångström method for measuring thermal diffusivity at high pressure uses a stationary thermal wave, which is induced in the sample by varying the power sinusoidally in the surrounding cylindrical furnace. The thermal diffusivity (κ) is determined from the phase lag, Φ_0 - Φ_R, or amplitude difference, θ_0/θ_R, of the thermal wave between points at the axis of the sample and radius, R (e.g. Khedari et al., 1995). Our implementation differs from previous multi-anvil implementations of the Ångström method in that instead of using thermocouples to monitor the temperature variation we use thin strips of metal foil, which are placed at discrete intervals along the sample length and imaged X-radiographically. The metal strips monitor the thermal expansion of a slice across the sample in response to the sinusoidal temperature profile. This represents an improvement over previous methods since (i) the change in temperature is averaged along the sample length, (ii) we measure the phase of the thermal wave at all radii and (iii) since the expansion of the sample is observed as a proxy for the change in temperature there are no problems associated with contact thermal resistance at the thermocouples. To date we have measured the thermal diffusivity of NaCl, olivine, majorite, mantle pyroxenes and a selection of other phases. The measurements we have made are all in agreement with previously published data, where available, and extend them to high pressures.

In this study, we measured the thermal diffusivity of an isotropic and an oriented natural serpentinite sample. The thermal diffusivity of the isotropic sample is found to be smaller than that of olivine at low temperatures and does not change significantly with pressure. These results are in agreement with the measurements of Osako et al. (2010). The anisotropic sample with significant lattice preferred orientation shows that the thermal diffusivity perpendicular to the average orientation of the tri-octahedral sheets is significantly smaller than the thermal diffusivity of the isotropic sample. Given recent interpretations of seismic anisotropy around subducting slabs as crystallographic preferred orientation in serpentine, the significant anisotropy in thermal diffusivity and the contrast with the surrounding olivine dominated mantle will potentially have a significant effect on the heat flux around subducting slabs.

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