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Reconciling Seismology and Mineral Physics in the Mantle

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The Earth is a complex 3-D mineral assemblage whose gradients are dominantly with depth. As a result much effort has been expended on trying to tie estimates of mineral properties at depth to indirect inferences about radial structure, e.g., from Seismology. At the scale of sampling of seismic waves most of the mantle appears isotropic, but the constituent minerals are not. There are therefore two issues to be resolved when making comparisons between information derived from equations of state and seismology: firstly, the quality of the estimators for individual minerals and secondly, the way that these mineral specific estimates are combined. The standard procedures work quite well, but if we are to be able to pin down effects such as those due to spin transition in iron atoms we need to improve the representations. In particular it is highly desirable that determinations of equations of state include information at the highest pressures (e.g., shock wave or ab initio) so that any estimate of properties is based on interpolants, rather than extrapolation from the pressure range of regular experiment.

It is likely that most current estimates of seismic wavespeed variability in the mantle represent underestimates, yet such variability lies well outside the range of applicability of derivatives from a single adiabat, if indeed this is a suitable reference. Insight into the class of information required is available from mantle convection simulations at Earth-like conditions, and indicates that the equilibrium mineral state must itself be taken into consideration with mantle profiles that can be far from adiabatic. Simulations also allow insight into the way that the imperfect sampling of the Earth can affect apparent seismological properties.