Problems with 1D seismic model fitting

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Tests of lower mantle composition models often compare mineral physics data bearing on the elasticity and density of lower mantle phases to the average seismic velocity profile determined by seismology, such a PREM or ak135. Here we demonstrate why such comparisons between mineralogy and seismology are an inadequate method for definitive discrimination between different scenarios. One issue is that the seismic velocity is more sensitive to temperature than composition for most lower mantle minerals. In practice, this allows one the freedom to choose the geotherm that brings the predicted seismic and density data into agreement with observations. It is commonly assumed that the temperature profile should be adiabatic, however, such a profile presupposes a particular state of the mantle and is only applicable in the absence of layering, buoyancy fluctuations, compositional segregation, and rheological complexities. The mantle temperature should depend on the composition since the latter influences the viscosity of rocks. However, the precise relation between composition, viscosity, and heat transfer would need to be specified, but unfortunately remains highly uncertain. If the mantle contains a mixture of domains with multiple bulk compositions, then the 1D seismic profile comparison is inherently non-unique. For example, while Wang et al.\cite{Wang2015} show a good match to PREM for a pyrolite model composition, they could also fit PREM just as easily by averaging domains of olivine-rich and bridgmanite rich rocks (i.e., harzburgitic and solar/chondritic, respectively). Rocks with different bulk composition likely have different isotopic abundances, and can exhibit differing degrees of internal heating and therefore distinct temperatures. Different composition domains can also exhibit variable densities, and tend to congregate at different depths in ways that also affect their thermal evolution and temperature. Therefore, we urge the deep Earth community to progress beyond fitting a 1D seismic model for evaluating lower mantle composition.

Keywords: mantle composition, mantle mineralogy, mantle seismology

