The influence of iron partitioning on seismic wave velocities in the lower mantle

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Various lines of evidence, such as the super chondritic Mg/Si ratio of the upper mantle, have been used to argue that the lower mantle is chemically distinct from the upper mantle. One of the only approaches that can clarify this would be to use a mineral physical model to calculate seismic wave velocities for a lower mantle of a given bulk composition and compare these estimates with seismic observations. Models for seismic velocity in the lower mantle require elasticity measurements of the dominant mantle minerals as a function of pressure, temperature and composition. A petrological model is also required to describe the compositions of minerals in the lower mantle with depth for a given bulk composition.

A bridgmanite elasticity model has been derived using single crystal Brillouin scattering measurements collected as a function of pressure and composition combined with ultrasonic data on polycrystalline aggregates collected as a function of pressure and temperature. A petrological model is derived using available experimental data, which mainly has to account for the exchange of iron between the dominant mineral phases. This model also accounts for the influence of an iron spin transition in ferropericlase.

If it is assumed that the mantle is isochemical, then calculated seismic velocities match those observed for the lower mantle, at least in the top 1000 km. However, this model also assumes that the oxygen content of the mantle is constant and, therefore, that approximately 1 wt. % iron metal forms in the lower mantle. A lower mantle model that does not account for an isochemical oxygen content predicts velocities that are marginally too low to be in agreement with seismic observations.