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Stochastic inversion of P-to-S converted waves for Earth's thermal and compositional structure: synthetic and data examples

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P-to-S waves converted at the 410- and 660-km discontinuities have been widely used to map variations in velocity gradients associated with the mantle transition zone. These gradients reflect phase transitions of major mantle minerals providing valuable insight on mantle thermo-chemical state. We present a methodology for stochastic inversion of P-to-S converted waves to directly infer variations in mantle temperature and composition. Based on a self-consistent thermodynamic calculation of mineral phase equilibria, we compute elastic properties as a function of pressure, temperature, and composition (parameterized in terms of the basalt fraction in a basalt-harzburgite mixture). The resulting velocity profiles are subsequently used to compute P-to-S converted waves in the form of receiver functions (RF).

We first analyzed the dependency of RFs on thermal and compositional variations. The former significantly influence arrival times, whereas the latter affect the amplitude of waves converted at the discontinuities bounding the transition zone. After testing the robustness of our inverse scheme by a series of synthetic inversions, we applied the proposed methodology to data from Obninsk (Volgo-Uralia) and Kongsberg (Baltic Shield) seismic stations. Preliminary results suggest normal mantle conditions ($\sim$1350 °C at the bottom of a 95 km thick lithosphere) beneath Obninsk, relatively high temperature as well as large lithospheric thickness ($\sim$1470 °C at 200 km depth) underneath Kongsberg, and harzburgite-enriched mantle composition beneath both stations.