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Synthetic receiver function profiles through the upper mantle and the transition zone for upwelling scenarios

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We investigate the signature relevant mantle lithologies leave in the receiver function record for different adiabatic thermal gradients down to 800 kilometers depth. The parameter space is chosen to target the visibility of upwelling mantle (a plume). Seismic velocities for depleted mantle, primitive mantle, and three pyroxenites are extracted from thermodynamically calculated phases diagrams, which also provide the adiabatic decompression paths. Results suggest that compositional variations, i.e. the presence or absence of considerable amounts of pyroxenites in primitive mantle should produce a clear footprint while horizontal differences in thermal gradients for similar compositions might be more subtle. Peridotites best record the classic discontinuities at around 410 and 650 kilometers depth, which are associated with the olivin-wadsleyite and ringwoodite-perovskite transitions, respectively. Pyroxenites, instead, show the garnet-perovskite transition below 700 kilometers depth and SiO_2-supersaturated compositions like MORB display the coesite-stishovite transition between 300 and 340 kilometers depth. The latter shows the strongest temperature-depth dependency of all significant transitions potentially allowing to infer information about the thermal state if the mantle contains a sufficient fraction of MORB-like compositions. For primitive and depleted mantle compositions, the olivin-wadsleyite transition shows a certain temperature-depth dependency reflected in slightly larger delay times for higher thermal gradients. The lower-upper-mantle discontinuity, however, is predicted to display larger delay times for higher thermal gradients although the associated assemblage transition occurs at shallower depths thus requiring a very careful depth migration if a thermal anomaly should be recognized. This counterintuitive behavior results from the downward replacement of the assemblage wadsleyite+garnet with the assemblage garnet+periclase at high temperatures. This transition causes even lower seismic velocities with greater depth (following an adiabatic gradient), the highly continuous nature of the reaction, however, should produce only a smooth negative conversion. In contrast, a small positive conversion is expected at normal thermal gradients in the same depth range between 500 and 550 kilometers because of the wadsleyite-ringwoodite-transition. Hence, the polarity of the 520 discontinuity also offers a possibility to recognize the thermal state of the upper mantle.