Background

- The mantle transition zone (MTZ), bounded by 410 and 660 discontinuities, is a key region to understand the thermal, chemical, and dynamical evolution of the mantle.
- Mantle dynamics is primarily thermally driven and the topography of 410 and 660 has been widely used to infer the temperature of the MTZ. However, in a number of recent studies we have found that properties of transition-zone discontinuities may also provide insight in the distribution of compositional heterogeneity.

Thermal and Chemical Properties of the Mantle Transition Zone from Seismic Observations

Saskia Goes\textsuperscript{1}, Chunquan Yu\textsuperscript{2}, Ross Maguire\textsuperscript{3}, Elizabeth Day\textsuperscript{1}, Rob van der Hilst\textsuperscript{4}, Jeroen Ritsema\textsuperscript{5}, and Jing Jian\textsuperscript{1},

**Fig. 1**

Systematic variations of discontinuity strengths and depths are expected as a function of composition (expressed as the fraction of basalt, \( f \), in a mechanical mixture of basalt and harzburgite in A-B) and temperature (expressed as potential temperature of mantle adiabats, C-D) (from Maguire et al., 2018).

**Fig. 2**

Preliminary results from a global study of PP and SS precursors using a curvelet-based seismic array processing technique (Yu et al., IGR 2018), where we successfully extract \( p+pp \) signals.

**Fig. 3**

Global trends of SS/SS and PP/PP amplitude ratios are consistent with predictions from a pyrolytic mantle transition zone. Effects of geometrical spreading, attenuation and incoherent stacking are not considered in these calculations. The results can not distinguish between cooler (1300°C) or hotter (1400°C) potential mantle temperature.

**Fig. 4**

Travel time difference across the MTZ (after moveout correction to 130°) is positively correlated with velocity anomalies within the MTZ (from S40RTS, Ritsema et al., 2011). Both of them are likely controlled by thermal anomalies. Mean: \( \Delta T = 0.7 \) s (relative to ak135) => MTZ thickness = 248 km => ~1350°C adiabat

**Fig. 5**

S660/SS amplitude ratios from curvelet filtering, after correction for geometric spreading, intrinsic attenuation and incoherent stacking for two regions with high data density, NW (A) and SE (B) of Hawaii. Red curves shows how predicted reflection coefficients for our best fitting models are clearly different for the two regions. Comparison with corresponding density and velocity jumps around 660 km from models as in Fig. 1 are shown in panel C (Yu et al. 2018).

**Fig. 6**

Longitudinal cross section through P-to-S receiver-function CCP volume below the US. Background tomography from Schmandt and Lin (2014). Regional high-amplitude discontinuities around 520 and 730 km depth could be due to enhanced hydration and concentrations of basaltic material, respectively. Both signatures might be a record of recent Farallon subduction (Maguire et al., 2018).

**Fig. 7**

Longitudinal and transverse profiles of ak135 and ak135/ak130 for a hotspot corner (Hawaii) shown in panel A. Global average of ak135 is 0.73, whereas for PP the average is 0.80 (for PP global average 0.77, for PKP 0.68). A small gradient from 400°E to 100°W and a larger gradient from 50°W to 140°W. For SS the gradient is larger than for PP, which is consistent with the analysis of other studies (e.g., Ritsema et al., 2011).

**Fig. 8**

SS-S660-S410 global anomalies. Both of them are positively correlated with velocity anomalies within the MTZ, consistent with the analysis of other tomographic images below a few other hotspots.

**Fig. 9**

SS-S660-S410 global anomalies. Both of them are positively correlated with velocity anomalies within the MTZ, consistent with the analysis of other tomographic images below a few other hotspots.

**Fig. 10**

SS-S660-S410 global anomalies. Both of them are positively correlated with velocity anomalies within the MTZ, consistent with the analysis of other tomographic images below a few other hotspots.

Key Points

- Comparison of \( pp+pp \) amplitude-distance trends with thermodynamic models suggests that on a global scale, amplitude trends of SS and PP precursors from both 410 and 660 are consistent with predictions from a pyrolytic mantle transition zone.
- Global variation in MTZ thickness: has a positive correlation with velocity anomalies within the MTZ, consistent with a control by variable transition zone temperatures.
- In an application of this method to data from Hawaii, we however found evidence of compositional variations, consistent with the analysis of tomographic images below a few other hotspots.
- Further compositional heterogeneity linked to recent subduction has been found from a receiver-function study below the US.
- Results thus indicate a quite well mixed background mantle with more heterogeneity in areas of recent up and downwelling.

\footnotesize{(1) Imperial College London UK, (2) Southern University of Science and Technology, Shenzhen, China, (3) University of New Mexico, USA, (4) Massachusetts Institute of Technology, USA, (5) University of Michigan, Ann Arbor, USA.}
