Compositional heterogeneities and flat slabs in the mid to lower mantle revealed by seismic reflected waves

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The mantle transition-zone discontinuities are usually attributed to isochemical phase transformations of olivine and its high-pressure polymorphs. However, recent seismic observations have shown complexities in these discontinuities that cannot be explained by conventional models of thermal variations. Here we analyze *SS* precursor stacking results to investigate global mantle transition-zone properties. The precursor waveforms provide information on the seismic velocity and density profiles across and near the major mantle discontinuities.

A sporadic low-velocity layer immediately above the 410-km discontinuity is observed worldwide, including East Asia, western North America, eastern South America, and 33-50% of the resolved Pacific Ocean [1]. The 520-km discontinuity exhibits significant variations in its sharpness and depth, and occasionally appears to be split. A sub-discontinuity beneath 660 km is detected in some regions, possibly suggesting enrichment of garnet. All of these lateral variations show no geographical correlation with discontinuity topography or tomographic models of seismic velocity, suggesting that they are not caused by regional thermal anomalies. Alternatively, our observations can be explained by compositional heterogeneities in the mid-mantle, including major minerals and volatile content, which may result in additional phase transformations and partial melting.

In addition, flat slabs that extend horizontally for at least a few thousand kilometers are imaged beneath several subduction zones at various depths in the lower mantle. This suggests a variety of slab sinking at different stages. A slab morphology in the lower mantle seems to be controlled by its individual evolution rather than specific changes in mantle rheology.

[1] Wei and Shearer (2017) *J. Geophys. Res.* **122**, 5144-5159.