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Complexities of the Upper-Lower Mantle Transition Zone Beneath Hotspots

Y. J. Gu, Y. An

Dept. of Physics, University of Alberta, Edmonton, AB, Canada, T6G2G7.
(jgu@phys.ualberta.ca / Phone : +1 780 492 2292)

Hotspots observed at the Earth's surface are frequently associated with hot thermal plumes within the earth. Over the past few years, improved seismic imaging techniques such as high-resolution tomography and migration have significantly increased the constraints on the existence and dimensions of thermal anomalies beneath hotspots. Still, questions remain regarding the depth extension of hotspots, for example, whether they are continuous across the upper-lower mantle transition zone (350 –1000 km) in the presence of two major mineral phase changes.

In this study we introduce a novel approach to analyze underside reflected waves and determine the shear velocity structure within and below the transition zone at major hotspot locations. Rather than relying on traditional time-domain travel time and amplitude information, we apply Least-squares Radon Transform that simultaneously recovers time shifts and ray parameters. While the time shifts of SdS waves (d for a discontinuity) are sensitive to discontinuity depths, ray parameters directly reflect the seismic structure beneath the discontinuity. We observe a negative relationship between the perturbations of ray parameter and shear velocity within and below the transition zone. The ray parameters are generally greater than their respective reference values, and hence suggest the presence of low-velocity anomalies; the depressed 410-km discontinuity is further evidence for such thermal variations. The topography of the 660-km discontinuity reflects both olivine and majorite-garnet phase transitions, and is therefore much more difficult to interpret. Furthermore, the presence of major thermal perturbations is not evident from global tomographic models, nor is it reflected in the differential times of SdS waves beneath the hotspot locations. Even in the absence of compositional variations, accurate identification of a mantle plume beneath a hotspot is a challenge task that requires the knowledge of ray parameter/velocity, topography of the 410-km discontinuity, as well as the presence/absence of mid-mantle reflectors.