Seismic Images of Slabs in the Mid and Lowermost Mantle

Justin Revenaugh[1]; Anna Courtier[2]; Alexander Hutko[3]

[1] none; [2] Geophys., Univ. Minnesota; [3] Earth Sciences, Univ. California, Santa Cruz

Seismic tomography demonstrates occasionally continuous high velocity anomalies reaching great depths in the lower mantle that connect to strong velocities highs coincident with upper mantle Wadati-Benioff zones. Phase conversions and reflections from slabs in are frequently observed originating in the upper mantle, but sightings from greater depths are quite rare. In this talk, we present evidence of coherent slab reflections and slab-induced scattering in the mid and lowermost mantle. The study examines three distinct data sets. Two sets of multiple ScS reverberation data, one covering the Gulf of Mexico and continental US, the other sampling the region bounded by the Tonga-Fiji subduction complex on the east, the New Hebrides, Solomon Islands, Papua-New Guinea trend to the north, Australia to the west and Tasmania to the south. And a third data set consisting of long-period SH displacement seismograms sampling the lowermost mantle beneath the Caribbean.

Multiple ScS reverberations sampling the eastern continental US find clear evidence of mid-mantle SH reflectors with impedance contrasts of a few percent. The depths of these correspond well with tomographic images of the Farallon slab. The fact that the slab at ˜1000 km depth is capable of producing large reflections is unexpected. Multiple ScS reverberations do extensive path averaging and are most sensitive to near horizontal reflectors. The tomographically imaged slab occupies only a small portion of the volume sampled by the reverberations and appears inclined. This suggests some localized phenomenon is acting to enhance the impedance contrast of the slab, such as crust ponding or partial melting.

Multiple ScS reverberations sampling the mid-mantle beneath the Coral Sea show similar reflections likely tied to the Pacific plate subducted to depths well beneath the transition zone. Any tomographic signature of the slab in the lower mantle is notably absent in most work to date.

Lastly, we use Kirchhoff migration methods to image the post-perovskite transition in the deepest portions of the Farallon slab beneath the Caribbean. Slab folding produces stacked phase transitions in this location, requiring the use of full 3D imaging methods. This result explains inconsistencies between 1D stacks and individual waveform measurements of the depth of the so-called D” reflector; because neither method considers out-of-plane propagation or non-geometric paths, they introduce considerable errors in depth estimation. Lastly, evidence of an ultra-low velocity zone outlining the folded slab agrees with predictions of impinging-slab-induced plume instability.