Geophysical Research Abstracts
Vol. 16, EGU2014-13917-1, 2014
EGU General Assembly 2014

Seismic constraints on the lithosphere-asthenosphere boundary

Catherine A. Rychert
University of Southhampton, UK (c.rychert@soton.ac.uk)

The basic tenet of plate tectonics is that a rigid plate, or lithosphere, moves over a weaker asthenospheric layer. However, the exact location and defining mechanism of the boundary at the base of the plate, the lithosphere-asthenosphere boundary (LAB) is debated. The oceans should represent a simple scenario since the lithosphere is predicted to thicken with seafloor age if it thermally defined, whereas a constant plate thickness might indicate a compositional definition. However, the oceans are remote and difficult to constrain, and studies with different sensitivities and resolutions have come to different conclusions. Hotspot regions lend additional insight, since they are relatively well instrumented with seismic stations, and also since the effect of a thermal plume on the LAB should depend on the defining mechanism of the plate. Here I present new results using S-to-P receiver functions to image upper mantle discontinuity structure beneath volcanically active regions including Hawaii, Iceland, Galapagos, and Afar. In particular I focus on the lithosphere-asthenosphere boundary and discontinuities related to the base of melting, which can be used to highlight plume locations.

I image a lithosphere-asthenosphere boundary in the 50 – 95 km depth range beneath Hawaii, Galapagos, and Iceland. Although LAB depth variations exist within these regions, significant thinning is not observed in the locations of hypothesized plume impingement from receiver functions (see below). Since a purely thermally defined lithosphere is expected to thin significantly in the presence of a thermal plume anomaly, a compositional component in the definition of the LAB is implied. Beneath Afar, an LAB is imaged at 75 km depth on the flank of the rift, but no LAB is imaged beneath the rift itself. The transition from flank of rift is relatively abrupt, again suggesting something other than a purely thermally defined lithosphere.

Melt may also exist in the asthenosphere in these regions of hotpot volcanism. Indeed, S-to-P also images strong velocity increases that are likely related to the base of a melt-rich layer beneath the oceanic LAB. This discontinuity may highlight plume locations since melt is predicted deeper at thermal anomalies. For instance, beneath Hawaii the base of melting increases from 110 km to 155 km depth 100 km west of Hawaii, i.e. the likely location of plume impingement on the lithosphere. Beneath Galapagos the discontinuity is deeper in 3 sectors, all off the island axis, suggesting multiple plume diversions and complex plume-ridge interactions. Beneath Iceland deepening is imaged to the northeast of the island. Beneath the Afar rift a shallow melt discontinuity is imaged at $\sim$75 km, suggesting that the plume is located outside the study region. Overall, the deepest realizations of the discontinuities agree with the slowest velocities from surface waves, but are not located directly beneath surface volcanoes. This suggests that either plumes approach the surface at an angle or that restite roots beneath hotspots divert plumes at shallow depths. In either case, mantle melts are likely guided from the location of impingement on the lithosphere to current day surface volcanoes by pre-existing structures of the lithosphere.