Imaging the Pacific Lithosphere Discontinuities at ~60 km using SS Precursors and Constraints on Defining Mechanism

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Oceanic lithosphere provides an ideal location to decipher the nature of the lithosphere –asthenosphere system which is vital to our understanding of plate tectonics. Although a thermally defined plate explains many first order observations such as bathymetry and heat flow. Observations of sharp mantle discontinuities are not well-understood. Here we use SS precursors to image the discontinuity structure across the Pacific Ocean using 24 years of teleseismic data. We image a sharp velocity discontinuity (3 –15% drop over < 21 km) at 30 –59 km that increases in depth with age from the ridge to at least ~36 ±9 My according to conductive cooling along the 1100 ˚C isotherm. The discontinuity is imaged at a depth of 35 –80 km for seafloor > 36 My. The shallow discontinuity at ~60 km is laterally continuous across most of the Pacific. It has recently been suggested that discontinuities in this depth range may be explained by an increase in radial anisotropy with depth. We evaluate the potential for an anisotropic variation to explain the discontinuities. We test surface wave depth resolution of radial anisotropy and estimate the apparent isotropic seismic discontinuities that could be caused by a change in radial anisotropy scattered wave imaging using synthetic seismograms. We find strong surface wave azimuthal anisotropy at 0 –50 km depth at an example case near the East Pacific Rise (EPR) implies a strong shallow radial anisotropy if caused by aligned olivine. An additional strong increase in anisotropic strength with depth from 50 –100 km is not supported. We find that neither an increase in radial anisotropy with depth caused by aligned olivine or frozen-in compositional layering can easily explain the observations from scattered waves. Another mechanism such as melt or composition may be required. The strength and pervasiveness of the boundary suggests that it is likely related to the lithosphere –asthenosphere boundary.

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