Imaging the crust and mantle beneath the equatorial Mid-Atlantic Ridge using the PI-LAB experiment

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The concept of the lithosphere-asthenosphere system is well defined as the rheological boundary between the rigid lithosphere that transfers coherently with the weaker asthenosphere. A better understanding of this transition, the lithosphere-asthenosphere boundary (LAB), is essential as it may have implications for the driving forces of plate tectonics and mantle dynamics. Ocean lithosphere is the ideal place to study this plate transition. The Passive Imaging of the Lithosphere-Asthenosphere Boundary (PI-LAB) was designed to better characterize and understand the lithosphere-asthenosphere boundary of the oceanic plate at a range of resolutions. We deployed 39 broadband ocean bottom seismometers (OBS) and 39 ocean bottom magnetotellurics (OBMT) on 0 –80 My seafloor at the mid-Atlantic Ridge near the Chain fracture zone from March 2016 –March 2017.

Here we present our first imaging results of the crust, mantle, and transition zone from S-to-P receiver functions, P-to-S receiver functions, and surface waves. S-to-P receiver functions image a ˜7 km thick oceanic Moho across our study area. We image a negative discontinuity, likely the lithosphere-asthenosphere boundary, which deepens progressively away from the western ridge segment from 30 to 80 km beneath 0 to 40 My old lithosphere. The depths are consistent with thermally controlled thickening with age. However, the amplitude and sharpness of the phases we observe also suggest melt may be present at the base of the lithosphere. We find Rayleigh wave average phase velocities that range from ˜1.5 km/s at 5 s period to 4.31 km/s at 143 s, and fundamental mode Love waves with average phase velocities of 4.00 km/s at 5 s to 4.51 at 22 s. We invert these phase velocities for 1-D average radially anisotropic shear velocity structure and find a ˜60 km thick fast lid with velocities of 4.62 km/s, and x values up to 1.08 with radial anisotropy in the upper 200 km. 3D shear velocity inversions require a fast lid beneath the ridge, to ˜30 km depth, with a thicker fast lid at greater age. The low velocity zone beneath the ridge has a minimum velocity of 4.1 km/s. With P-to-S receiver functions we image thinning of the transition zone by 5 to 20 km in the western part of our study region consistent with a 200 K thermal anomaly. The result suggests mid-ocean ridges have a signature deep as the transition zone, implying whole mantle convection.

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