Geophysical Research Abstracts
Vol. 20, EGU2018-6530-2, 2018
EGU General Assembly 2018

P-wave velocity structure of the upper mantle and 410-km discontinuity below the Mid-Atlantic Ridge from ocean-bottom-seismometer data

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Upper mantle seismic velocity structure provides key information about plate tectonics and mantle dynamics processes. The upper mantle includes the lithosphere, i.e. Earth's outermost rigid layer, and seismic discontinuities, like the 410-km discontinuity. Properties of the mantle and its discontinuities include the mantle velocity as a function of depth, discontinuity depth (and topography), size of velocity increase across boundaries and sharpness of boundaries. However, poor seismic coverage of the ocean basins leads to poor constrains on the mantle structure of young lithosphere below spreading centers, especially under slow spreading ridges. Global seismology data provide an initial assessment of mantle structure. Thus, surface waves have been inverted for S-wave velocity structure and precursors of global phases – like SS - provide underside reflections to derive the depth of major discontinuities. However, under the oceans, upper mantle P-wave velocity and its vertical structure remain elusive. Here, we report results from an 1100 km long ocean-bottom-seismometer (OBS) array deployed in the equatorial Atlantic to record seismic airgun shots. The OBS spacing along the profile was between 10 and 20 km. During a month long deployment, the array captured a moment magnitude Mw=6.5 earthquake at the Romanche transform fault, providing refracted and reflected phases at a source-received distances of 11° to 20° and consequently excellent coverage of the 410-km discontinuity. The 410-km boundary marks the depth where olivine is transformed by increasing pressure and temperature to modified spinel (ringwoodity) and hence its structure is of global interest. We use hydrophone data in the frequency range of ∼0.1 to 1 Hz. Detailed analysis of the wavefield suggests that maximum depth of ray turning points increase from ∼120 km depth to 460 km across the array. Further, results from 1-D travel time analysis suggests that global seismic models, like PREM or AK135, provide a poor fit to the data. Preliminary results suggest that P-wave velocity in the lithospheric mantle is in the order of 8.1-8.2 km/s. Below of the asthenospheric inversion zone, velocity increase linearly from ∼8.0 km/s at 120 km depth to ∼8.4 km/s at 370 km depth. The 410-km discontinuity is clearly defined by a triplication consisting of seismic refraction branch and a retrograde reflection and can be fitted best introducing a transition zone with velocities increasing from 8.4 km/s to ∼9.5 km/s at 410 km depth. Below, velocities agree well with global P-wave models.