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Shear-wave velocity structure of young Atlantic Lithosphere from dispersion analysis and waveform modelling of Rayleigh waves

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The lithosphere is the outermost solid layer of the Earth and includes the brittle curst and brittle uppermost mantle. It is underlain by the asthenosphere, the weaker and hotter portion of the mantle. The boundary between the brittle lithosphere and the asthenosphere is call the lithosphere-asthenosphere boundary, or LAB. The oceanic lithosphere is created at spreading ridges and cools and thickens with age. Seismologists define the LAB by the presence of a low shear wave velocity zone beneath a high velocity lid. Surface waves from earthquakes occurring in young oceanic lithosphere should sample lithospheric structure when being recorded in the vicinity of a mid-ocean ridge. Here, we study group velocity and dispersion of Rayleigh waves caused by earthquakes occurring at transform faults in the Central Atlantic Ocean. Earthquakes were recorded either by a network of wide-band (up to 60 s) ocean-bottom seismometers (OBS) deployed at the Mid-Atlantic Ridge near 15°N or at the Global Seismic Network (GSN) Station ASCN on Ascension Island.

Surface waves sampling young Atlantic lithosphere indicate systematic age-dependent changes of group velocities and dispersion of Rayleigh waves. With increasing plate age maximum group velocity increases (as a function of period), indicating cooling and thickening of the lithosphere. Shear wave velocity is derived inverting the observed dispersion of Rayleigh waves. Further, models derived from the OBS records were refined using waveform modelling of vertical component broadband data at periods of 15 to 40 seconds, constraining the velocity structure of the uppermost 100 km and hence in the depth interval of the mantle where lithospheric cooling is most evident. Waveform modelling supports that the thickness of lithosphere increases with age and that velocities in the lithosphere increase, too.