

Seismic Velocity Structure and Depth-dependence of Anisotropy in the Red Sea and Arabian Shield from Surface Wave Analysis

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Abstract

We investigate the lithospheric and upper mantle structure as well as the depth dependence of anisotropy along the Red Sea and beneath the Arabian Peninsula using receiver function constraints and phase velocities of surface waves traversing two transects of stations from the Saudi Arabian National Digital Seismic Network. Frequency-dependent phase delays of fundamental-mode Love and Rayleigh waves, measured using a cross-correlation procedure, require very slow shear velocities and the presence of anisotropy throughout the upper mantle. Linearized inversion of these data produce path-averaged 1D radially anisotropic models with about 4% anisotropy in the lithosphere, increasing to about 4.8% anisotropy across the lithosphere-asthenosphere boundary (LAB). Models with reasonable crustal velocities in which the mantle lithosphere is isotropic cannot satisfy the data. The lithospheric lid, which ranges in thickness from about 70 km near the Red Sea coast to about 90 km beneath the Arabian Shield, is underlain by a pronounced low-velocity zone with shear velocities as low as 4.1 km/s. Forward models, which are constructed from previously determined shear-wave splitting estimates, can reconcile surface and body wave observations of anisotropy. The low shear velocities extend to much greater depth than those observed in other continental rift and oceanic ridge environments. The depth extent of these low velocities combined with the sharp velocity contrast across the LAB may indicate the influence of the Afar hotspot and the presence of partial melt beneath Arabia. The anisotropic signature primarily reflects a combination of plate and density-driven flow associated with active rifting processes in the Red Sea.