A multistep approach for joint modeling of surface wave dispersion and teleseismic receiver functions: Implications for lithospheric structure of the Arabian Peninsula

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Abstract

We present a multiple step procedure for joint modeling of surface wave group velocity dispersion curves and teleseismic receiver functions for lithospheric velocity structure. The method relies on an initial grid search for a simple crustal structure, followed by a formal iterative inversion, an additional grid search for shear wave velocity in the mantle, and finally, forward modeling of transverse isotropy to resolve Love-Rayleigh surface wave dispersion discrepancy. It considers longer-period surface wave group velocity (SWGV) dispersion, allowing for the resolution of deeper structure compared to previous joint inversions. The grid search for simple crustal structure is facilitated using a library of precomputed receiver functions and SWGV dispersion curves. The iterative inversion improves fit to the data by increasing the number of layers in the crust when necessary. In order to fit the SWGV for periods greater than about 50 s, we perform a grid search over mantle velocities including the mantle lid and low-velocity zone, keeping the crustal structure fixed to the values from the previous step. In some cases a clear Love-Rayleigh discrepancy prevents a simultaneous fit of the group velocities with an isotropic model. The Love-Rayleigh discrepancy can be resolved by allowing shear wave transverse isotropy with a vertical symmetry axis (v_{SH} _ v_{SV} differences) in the uppermost mantle. The method is applied to 10 stations in the Arabian Peninsula sampling various tectonic environments including active continental rifting and stable regions. The resulting shear velocity models confirm rapid crustal thinning of the Arabian Shield toward the Red Sea; however, we do not find strong evidence for crustal thickening toward the Arabian Platform. Our results suggest that the mantle
lithosphere thickness varies regionally but that the mantle shear velocities beneath the Arabian Shield and Red Sea coast are generally anomalously low. Furthermore, our results indicate the presence of strong polarization anisotropy (up to about 10%) in the lithospheric upper mantle, in the vicinity of, as well as farther away from, the Red Sea.
Our modeling yields $v_{SV} > v_{SH}$ in the southwestern part of the Arabian Peninsula, consistent with vertical flow, and $v_{SH} > v_{SV}$ in the northwestern part of the Arabian Peninsula and the continental interior, consistent with horizontal flow, indicating that the mantle flow pattern is not uniform along the axis of the Red Sea.

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