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Crustal and Upper-Mantle Shear-Velocity Structure of Saudi Arabia from Joint Inversion of P-/S-Wave Receiver Functions and Rayleigh-Wave Group-Velocities

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We investigate the crustal and upper-mantle shear-velocity structure of Saudi Arabia by jointly inverting teleseismic P- and S-wave receiver functions and fundamental-mode Rayleigh-wave group-velocities at 156 broadband seismic stations operated by the Saudi Geological Survey (SGS). The Arabian Plate is geologically divided into two distinct terrains: the western Arabian shield and the eastern Arabian platform. Extensive Precambrian Proterozoic basement rocks are exposed on the Arabian shield, although they underlie the entire Arabian Peninsula. Cenozoic volcanic rocks, known as “harrats”, are mainly overlying the western part. The Arabian platform is covered by predominant Paleozoic, Mesozoic and Cenozoic sedimentary rocks whose thicknesses generally increase towards the East..

P-wave receiver functions (PRFs) are sensitive to shear-velocity contrasts across rock discontinuities, and the S-P traveltimes between the free surface and the discontinuities. Surface-wave dispersion velocities constrain absolute velocity with depth within frequency-dependent averages. Therefore, the combination of the two datasets into a joint inversion reduces the nonuniqueness of the inverse problem and helps to resolve fine velocity variations..In addition, S-wave receiver functions (SRFs) provide robust constraints on lithospheric and sub-lithospheric depths to improve the estimates of lithospheric structure.

For our study, we chose over 300 teleseismic events, with epicentral distances between 30° and 90° and mb > 5.5 for a four-year period of 2012 - 2015, to calculate PRFs. Additionally, a subset of ∼170 events, with epicentral distances 60° - 85° and mb > 5.7 between 2012 and 2015, are selected to compute SRFs. The Rayleigh-wave group-velocities are extracted from previous tomographic results at periods of 8 - 133 s. Using these data, we obtain a series of 1-D inverted models that we interpolate to construct a 3-D shear-velocity model for Saudi Arabia that reveals significant lateral variations in crustal, lithospheric thickness, and shear-velocity under the Arabian plate. In particular, we identify small-scale low shear-velocity features at crustal levels beneath the Cenozoic volcanic fields in the Arabian shield that we interpret as potential indicators for local magma reservoirs and/or possible channels for melts from deeper sources. Our study also reveals the upper-mantle low velocity zone (LVZ) below the Arabian shield, supporting the model of lateral mantle material transportation from the Afar hotspot.