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Seismic velocity and anisotropy of the upper mantle and transition zone at global and regional scales imaged using Surface and S waveform tomography

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The continued development and deployment of large-scale high-resolution seismic arrays (*e.g.*, the Earthscope US Array) are producing massive new datasets that sample the Earth at scales from tectonic units to continent-wide domains and enable resolution of structures and deformation of the lithosphere previously possible only at regional scales. With this resolving power comes new challenges relating to efficient management and processing of such large data volumes. In this study, we have assembled a massive global dataset (with focus on North America) of three-component broadband seismic waveforms collected from more than 2000 stations, and have carried out full waveform inversions resulting in more than 700,000 successfully fit source-receiver paths for vertically polarized shear waves. We augmented available US Array stations with additional stations of the GSN and affiliates, Canadian National Seismograph Network, regional arrays, past PASSCAL experiments, and other stations from Iceland, Greenland, Central and South America, the Caribbean, and several Mid-Atlantic Islands. We exploit the resolving power of this unprecedentedly large dataset using Automated Multimode Inversion of surface- and S-wave forms. Vertically polarized shear waves (Rayleigh waves) are inverted for path-averaged linear constraints on elastic structure along the source-receiver paths. Of these almost three-quarters of a million waveform fits, many provide constraints not only on the fundamental mode, but higher modes as well. These linear equations are then simultaneously solved for a high-resolution 3D upper mantle shear velocity and azimuthal anisotropy model. Embedded multi-resolution grids afford higher model resolution in regions where data sampling (*i.e.*, station distribution) justifies, and permit the exploration of features at both global and regional scales.

We present a global model of upper mantle shear velocity and azimuthally anisotropic structure down to the 660 km discontinuity. In continental domains, clearly identifiable boundaries between different tectonic features such as basins and relic mountain ranges are readily observable, as well as the signature of deep cratonic roots versus juvenile accretionary margins. Both active and fossil subduction zones are marked by clearly discernible slab signatures deep in the upper mantle and extending through the transition zone. In oceanic regions, spreading ridges are clearly visible down to depths of 100-120 km, and the evolution (cooling and thickening) of lithosphere away from the spreading ridges clearly matches with the expected signature from geodynamic and thermal modeling.

The pattern of azimuthal anisotropy in the ocean basins, in particular the Pacific Ocean, aligns with the paleo-spreading orientations at shallow depths within the lithosphere and modern plate motions at greater depths within the asthenosphere. However, there are exceptions, where the observed azimuthal anisotropy does not necessarily follow such a pattern, such as parts of the Atlantic Ocean. Through the computation and ongoing integration of full waveform fits from horizontally polarized Love waves, we are assembling high-resolution constraints on the global distribution of radial anisotropy throughout the upper mantle and transition zone. We discuss preliminary results from this model, including comparisons with the global distribution of azimuthal anisotropy.