Constraints on mantle flow in the oceanic upper mantle from a high-resolution estimate of seismic velocities in the central Pacific

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Observations of seismic anisotropy in ocean basins are important for constraining deformation and melting processes in the upper mantle. The NoMelt OBS array was deployed on relatively pristine, 70-Ma seafloor in the central Pacific with the aim of constraining upper-mantle circulation and the evolution of the lithosphere-asthenosphere system. Azimuthal variations in Rayleigh-wave velocity suggest strong anisotropic fabric both in the lithosphere and deep in the asthenosphere, with the asthenospheric flow driven by either small-scale convection or large-scale lateral pressure-gradients, and little deformation related to plate motion. To further evaluate these mechanisms, we combine Love waves derived from high-frequency ambient noise (5-10 s period) and earthquakes (20-100 s period) with body-wave travel times to further constrain fabric and flow in the oceanic mantle. High-frequency Love waves require positive radial anisotropy (Vsh > Vsv) and azimuthal anisotropy with a strong 4-theta azimuthal signal in the upper 30 km of the mantle, consistent with the high-resolution Rayleigh-wave anisotropy, but inconsistent with estimates from global models. Forward modeling of multi-mode Love waves traversing the array from three strong earthquake sources suggests that the positive radial anisotropy (Vsh > Vsv) extends through the asthenosphere. Taken together, the Love- and Rayleigh-wave anisotropy suggests that olivine fabric can explain the anisotropic signature of the lithosphere-asthenosphere system, and melt or other exotic mechanisms are not required. To further evaluate the processes producing asthenospheric fabric, we measure teleseismic P- and S-wave multi-channel delay times to constrain lateral velocity variations beneath the array. Finite-frequency sensitivity kernels provide the mapping of the delay times to velocity variations in the asthenosphere. We will specifically test for the presence of lateral velocity variations within the asthenosphere that are consistent with small-scale convection. At minimum, we will place bounds on the maximum plausible temperature variations allowed by the data. Taken together, the surface- and body-wave modeling will provide a unique, high-resolution picture of seismic structure and mantle flow within the oceanic lithosphere-asthenosphere system.

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