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Rayleigh Wave Azimuthal Anisotropy beneath the Hawaiian Swell - Evidence for plume-related mantle flow

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During the two-stage Hawaiian PLUME (Plume-Lithosphere Undersea Melt Experiment) deployment, we collected continuous seismic data at ten land stations and nearly 70 ocean bottom sites from 2005 through mid-2007. Both the usage broad-band seismometers as well as the central location of Hawaii with good azimuthal seismicity coverage allows us to conduct a comprehensive analysis of surface wave azimuthal anisotropy at periods between 20 and 100 s. Using a triangle method that we developed for earlier studies, we fit propagating spherical wave fronts to the phases at three stations simultaneously to determine the frequency-dependent average phase velocity within these triangles. We use the standard Smith-and-Dahlen parameterization to express azimuthal variations. A systematic comparison between results obtained for different truncation levels in the trigonometric expansion allows us to assess stability of the results and assign error bars.

We observe a marked shift in the overall geometry of fast directions. At periods shorter than about 30 s, the fast direction aligns coherently with the fossil spreading direction across the entire PLUME network. This result supports the idea that flow-aligned asthenospheric material is added to the cooling plate as it thickens. This is also consistent with published PLUME shear-wave splitting observations. However, at longer periods, that sense the asthenosphere below the fast direction rotates incoherently, indicating that flow in the asthenosphere is significantly perturbed from the direction of current plate motion. We present results from forward modeling as well as initial inversions that suggest that plume-related mantle flow does not reach into the upper lithosphere, at the scales imposed by both the PLUME station spacing and the surface waves used in this study.