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Anomalous Azimuthal Anisotropy near Hawaii - Plume-perturbed Mantle Flow?

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Hawaii's isolated location far from any plate boundaries allows the study of most basic ideas how a deep–rooted mantle plume should work. For the 2005-2007 Hawaiian PLUME (Plume-Lithosphere Undersea Melt Experiment) deployment, we collected continuous broadband seismic data at ten land stations and nearly 70 ocean bottom sites. Hawaii's central location in the Pacific ocean provided ideal azimuthal seismicity coverage to investigate both shear-wave splitting behaviors as well as to conduct a comprehensive analysis of Rayleigh wave azimuthal anisotropy at periods between 20 and 100 s. A published shear-wave splitting study (Collins et al., 2012) found no compelling evidence for anomalous mantle flow near Hawaii.

For the Rayleigh-wave study, we use a sub-array approach to obtain 'in-situ' estimates of azimuthal variations in the attempt to minimize imaging trade-offs and cross-mapping with lateral heterogeneity. We apply the standard Smith-and-Dahlen trigonometric expansion 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. At short periods, our results agree with those of the shear-wave splitting study, confirming that fossil plate-motion is imprinted on the fabric of the lithosphere. However, at long periods, azimuthal anisotropy is increasingly disturbed close to the islands while, away from the islands, 'fast' directions broadly align with the current absolute plate-motion direction.

We perform grid-search forward modeling to find simple best-fitting models that contain anisotropic mantle material with hexagonal symmetry. Finding the optimal orientation of the symmetry axis and the corresponding thickness of anisotropic layers are some of the focus aspects in the grid search. Results suggest that ascending mantle plume material penetrates the asthenosphere to the southwest of Hawaii but does not reach into the upper lithosphere.