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Mantle Flow Contributions to Shear Wave Splitting Beneath Continental Roots

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Our objective is to investigate patterns of flow, strain, and anisotropy around thick continental roots that develop due to root motion through the surrounding mantle. This study is motivated by shear wave splitting observed in SKS and other teleseismic core phases that sample the mantle beneath eastern North America. We have estimated shear wave splitting in phases recorded by the Missouri to Massachusetts Broadband Seismometer Deployment, an IRIS/PASSCAL experiment that extended from western Massachusetts to eastern Missouri. At stations located above the thick (200-300 km) high-velocity root imaged beneath interior North America, fast directions are roughly parallel to absolute plate motion. However, fast directions measured at stations in the northeastern U.S. near the root margin are more variable. In addition, shear wave splitting measurements from other stations to the southeast of the root boundary indicate fast directions that appear to wrap around the lateral margin of the root [Silver, Barroul, and co-workers]. Our goal is to evaluate the amount of observed splitting that can be explained by flow around the mantle root, and the amount that must be attributed to anisotropy and deformation within the continental root and overlying lithosphere.

We have calculated 3D mantle flow using finite-difference models in which a continental root translates through the mantle, generating a combination of root-induced return flow and plate-driven flow. Initial calculations reveal flow lines that bend smoothly around and beneath the root margins. We will use the calculated velocity flow fields to determine the distribution of strain, which will allow us to estimate the development of lattice-preferred orientation (LPO) in a peridotite mantle. In one scenario assuming that dynamic recrystallization does not significantly alter LPO due to dislocation creep, olivine a -axes will align in the direction of maximum finite extension, which will be roughly parallel to flow lines. Calculated preferred orientations will be used to predict seismic anisotropy and shear wave splitting for paths that correspond to splitting observations. Comparisons of predicted and observed splitting parameters should help constrain the partitioning of anisotropy and strain between the lithosphere, asthenosphere, and deeper upper mantle, and ultimately the degree of coupling between deep continental roots and the surrounding mantle.