

Global Mantle Flow and the Development of Seismic Anisotropy

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Viscous shear in the asthenosphere accommodates relative motion between Earth's surface plates and underlying mantle, generating lattice-preferred orientation (LPO) in olivine aggregates and a seismically anisotropic fabric. Because this fabric develops with the evolving mantle flow field, observations of seismic anisotropy can constrain asthenospheric flow patterns if the contribution of fossil lithospheric anisotropy is small. We use global viscous mantle flow models (developed using the CIG-supported *CitcomS* spherical convection code) to characterize the relationship between asthenospheric deformation and LPO, and compare the predicted pattern of anisotropy to a global compilation of observed shear-wave splitting measurements. For asthenosphere >500 km from plate boundaries, simple shear rotates the LPO toward the infinite strain axis (ISA, the LPO after infinite deformation) faster than the ISA changes along flow lines. Thus, we expect the ISA to approximate LPO throughout most of the asthenosphere, greatly simplifying LPO predictions because strain integration along flow lines is unnecessary. Approximating LPO with the ISA and assuming A-type fabric (olivine *a*-axis parallel to ISA), we find that mantle flow driven by both plate motions and mantle density heterogeneity successfully predicts oceanic anisotropy (avg. misfit = 13°). Continental anisotropy is less well fit (avg. misfit = 41°), but lateral variations in lithospheric thickness improve the fit in some continental areas. This suggests that asthenospheric anisotropy contributes to shear-wave splitting for both continents and oceans, but is overlain by a stronger layer of lithospheric anisotropy for continents. The contribution of the oceanic lithosphere is likely smaller because it is thinner, younger and less deformed than its continental counterpart.

Combined Plate- & Density-Driven Flow ($\beta = 0.5$), Laterally-Varying Viscosity

A) Planform at 225 km

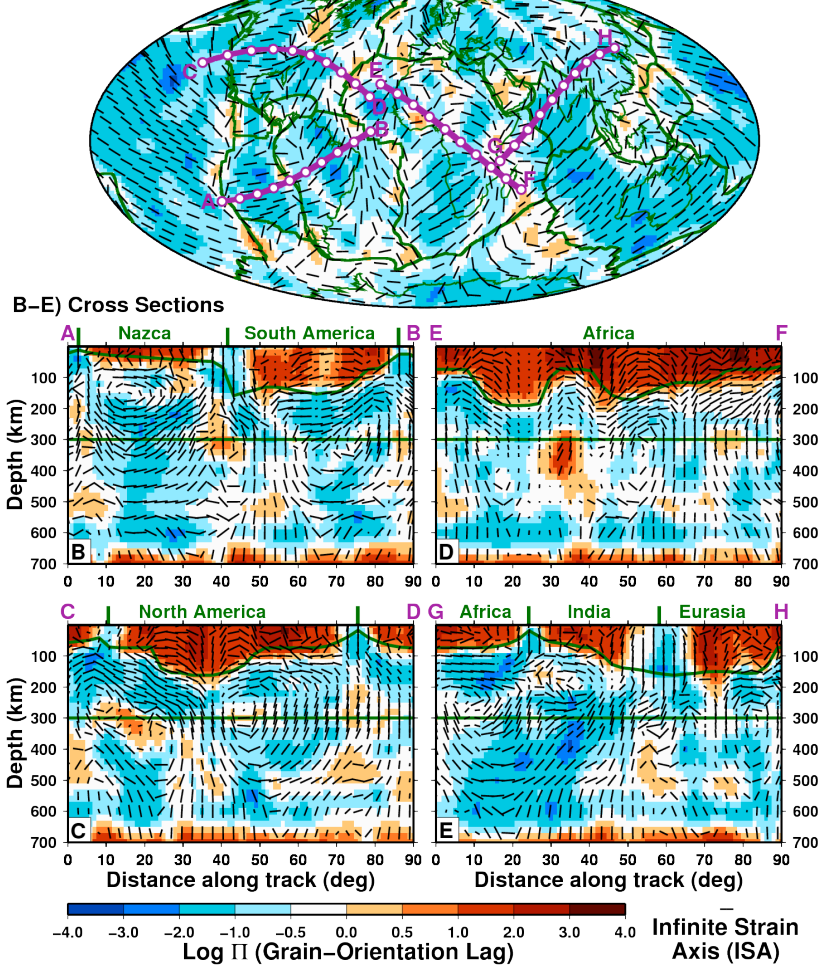


Figure 1. Map (a) and cross sections (b-d) of anisotropic fabric in the upper mantle, as predicted by the infinite strain axis (ISA, bars), which we computed using a global mantle flow model (*CitcomS*). Colors show the grain orientation lag parameter (Π), which compares the rate of LPO rotation away from the ISA direction to the rate of ISA formation. Wherever $\Pi < 0.5$, the ISA is a good approximation for LPO. This is true throughout most of asthenosphere, greatly simplifying the estimation of anisotropic fabric from a mantle flow model.

Note: our code for estimating ISA and Π is available:

<http://www.soest.hawaii.edu/GG/FACULTY/conrad/mantleflow/mantleflow.html>

Reference

Conrad, C.P., M.D. Behn, and P.G. Silver, Global mantle flow and the development of seismic anisotropy: Differences between the oceanic and continental upper mantle, *Journal of Geophysical Research*, 112, B07317, doi:10.1029/2006JB004608, 2007.