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In Earth’s upper mantle the deformation of olivine crystals should lead to directional dependence of seismic wave speed, offering a way to map patterns of mantle flow through the study of anisotropy indicators in seismic waves. For example, the birefringence in core-refracted teleseismic shear waves (SKS) in two regions of the northwestern Pacific were studied using data from GSN stations ADK and PET, and a PASSCAL deployment on Kamchatka (1998-1999 SEKS campaign).

At Adak island in the central Aleutians the fast polarization of shear waves is closely aligned with oblique convergence between Pacific and North American plates (right plot). In Kamchatka, areas underlain by the subducting Pacific plate show fast polarization direction orthogonal to the near-normal convergence between North America and Pacific plates. In both cases the anisotropic signal is strong enough to require upper mantle involvement. The dramatic difference in the relationship between the geodynamic regime and the pattern of anisotropy indicators suggests that the “mapping” of the latter into the former involves extra complexity that we do not fully understand at the moment.

On the plots below red bars denote individual estimates of shear wave birefringence parameters, plotted at map positions of 200 km piercing points for corresponding rays. In the right plot red crosses show measurement with delays < 0.1 s, white arrows show relative North America - Pacific plate motion, and the yellow arrow shows fast shear wave polarization in the best-fitting one-layer anisotropic model found by matching synthetic seismograms to observed waveforms. In the left plot the open arrow shows relative plate motion, and thin purple lines show depth contours of the subducting plate beneath Kamchatka.