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Anisotropic Lithospheric layering in the North American craton, revealed by Bayesian inversion of short and long period data

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Competing hypotheses for the formation and evolution of continents are highly under debate, including the theory of underplating by hot plumes or accretion by shallow subduction in continental or arc settings. In order to support these hypotheses, documenting structural layering in the cratonic lithosphere becomes especially important.

Recent studies of seismic-wave receiver function data have detected a structural boundary under continental cratons at 100–140 km depths, which is too shallow to be consistent with the lithosphere–asthenosphere boundary, as inferred from seismic tomography and other geophysical studies. This leads to the conclusion that 1) the cratonic lithosphere may be thinner than expected, contradicting tomographic and other geophysical or geochemical inferences, or 2) that the receiver function studies detect a mid-lithospheric discontinuity rather than the LAB.

On the other hand, several recent studies documented significant changes in the direction of azimuthal anisotropy with depth that suggest layering in the anisotropic structure of the stable part of the North American continent. In particular, Yuan and Romanowicz (2010) combined long period surface wave and overtone data with core refracted shear wave (SKS) splitting measurements in a joint tomographic inversion.

A question that arises is whether the anisotropic layering observed coincides with that obtained from receiver function studies.

To address this question, we use a trans-dimensional Markov-chain Monte Carlo (MCMC) algorithm to generate probabilistic 1D radially and azimuthal anisotropic shear wave velocity profiles for selected stations in North America. In the algorithm we jointly invert short period (Ps Receiver Functions, surface wave dispersion for Love and Rayleigh waves) and long period data (SKS waveforms).

By including three different data types, which sample different volumes of the Earth and have different sensitivities to

structure, we overcome the problem of incompatible interpretations of models provided by only one data set.

The resulting 1D profiles include both isotropic and anisotropic discontinuities in the upper mantle (above 350 km depth). The huge advantage of our procedure is the avoidance of any intermediate processing steps such as numerical deconvolution or the calculation of splitting parameters, which can be very sensitive to noise.

Additionally, the number of layers, as well as the data noise and the presence of anisotropy are treated as unknowns in the transdimensional Monte Carlo Markov chain algorithm. We recently demonstrated the power of this approach in the case of two stations located in different tectonic settings (Bodin et al., 2015, submitted). Here we extend this approach to a broader range of settings within the north American continent.