Global Anisotropy and the Thickness of Continents

Yuancheng Gung, Mark Panning, Barbara Romanowicz • Berkeley Seismological Laboratory

Since the concept of “tectosphere” was first proposed, there have been vigorous debates about the depth extent of continental roots. The analysis of heat flow, mantle xenoliths, gravity and glacial rebound data indicate that the coherent, conductive part of continental roots is not much thicker than 200-250 km. Some global seismic tomographic models agree with this estimate but others indicate much thicker lithosphere under old continents, reaching at least 400 km in depth.

Although global Vs models differ from each other significantly in the depth range 200-400 km under the main continental shields, these differences are consistent when they are classified into three categories, depending on the type of data used to derive them: ‘SV’ (mostly vertical or longitudinal component data, dominated by Rayleigh waves in the upper mantle), ‘SH’ (mostly transverse component data, dominated by Love waves), and ‘hybrid’ (3 component data). ‘SH’ and ‘hybrid’ models are better correlated with each other than with ‘SV’ models, and this difference is accentuated when the correlation is computed only across continental areas. Also, ‘SH’ (and ‘hybrid’) models exhibit continental roots that exceed those of ‘SV’ models by 100 km or more. These disagreements can be reconciled when taking into account anisotropy.

We have developed a radially anisotropic model of the upper mantle, based on the inversion of waveforms of fundamental and higher mode surface waves, in the framework of Non-Linear Asymptotic Coupling Theory (Li and Romanowicz, 1995), and including truly anisotropic kernels. Significant radial anisotropy with $V_{SH}>V_{SV}$ is present under most cratons in the depth range 250-400 km, similar to that reported earlier at shallower depths (80-250 km) under ocean basins. We propose that in both cases, this anisotropy is related to shear in the asthenospheric channel, located at different depths under continents and oceans. The seismically defined lithosphere is then at most 200-250 km thick under continents. The Lehmann discontinuity, observed mostly under continents around 200-240 km, and the Gutenberg discontinuity, observed under oceans at shallower depths (~ 60-80 km), may both be associated with the bottom of the lithosphere, marking a transition to flow-induced asthenospheric anisotropy (Gung et al., 2003).


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