GLOBAL ANISOTROPY AND THE THICKNESS OF CONTINENTS

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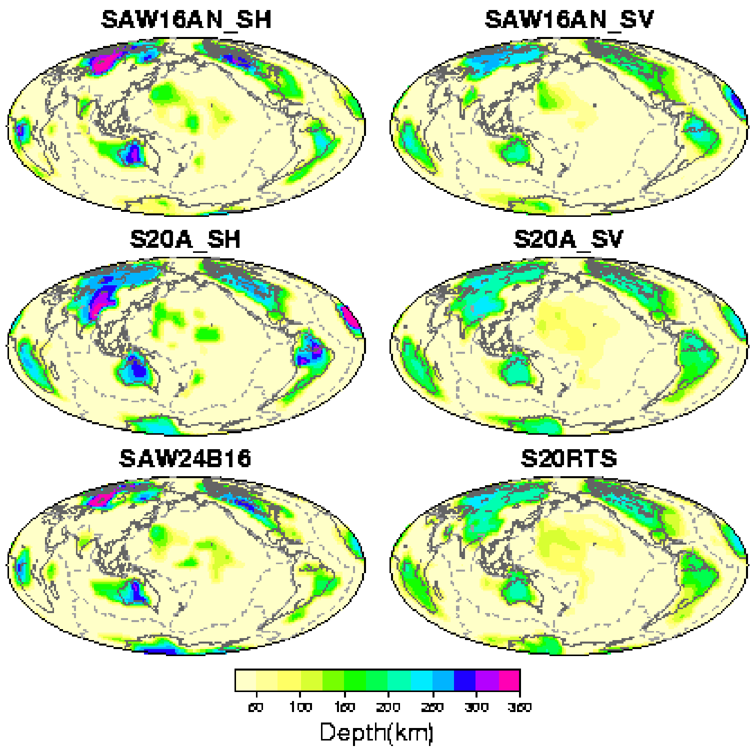

Maximum depth for which the velocity anomaly with respect to the reference model PREM (Dziewonski and Anderson, 1981) is greater than 2%, for different S velocity models. Left: "SH" type models; right: "SV" type models. Bottom: Vsh model SAW24B16 (Mégnin and Romanowicz, 2000) compared to Vsv model S20RTS (Ritsema et al., 1999); middle: SH and SV parts of model S20A (Ekström and Dziewonski, 1998) obtained by inverting T component data and Z,L component data separately; top: SH and SV parts of anisotropic model SAW16AN discussed here. While the roots of continents generally extend to depths greater than 300-350 km in SH models, they do not exceed 200-250km in SV models.

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 400km in depth.

Although global Vs models differ from each other significantly in the depth range 200-400km 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, as illustrated in Figure 1. These disagreements can be reconciled when taking into account anisotropy.

Global tomographic studies that account for seismic anisotropy have documented significant lateral variations in the anisotropic parameter ξ=(Vsh/Vsv)2 on the global scale. Until now, attention has primarily focused on the significant anisotropy observed in the oceans in the depth range 80-200 km (Ekström and Dziewonski, 1998). Deeper anisotropy was not well resolved in these studies, either because the dataset was limited to fundamental mode surface waves,, or because of the use of inaccurate depth sensitivity kernels. While coupling effects between SH and SV are relatively minor for fundamental mode surface waves, they are non-negligible for higher modes.

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 Vsh>Vsv is present under most cratons in the depth range 250-400 km, similar to that reported earlier at shallower depths (80-250km) 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 (~ 60-80km), may both be associated with the bottom of the lithosphere, marking a transition to flow-induced asthenospheric anisotropy (Gung et al., 2003).

Ekström, G. and A. M. Dziewonski (1998) The unique anisotropy of the Pacific upper mantle, Nature, 394, 168-172, 1998.

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Li, X.D. and B. Romanowicz, Comparison of global waveform inversions with and without considering cross-branch modal coupling, Geophys. J. Int., 121, 695-709, 1995.

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