Global distribution of seismic heterogeneities and azimuthal anisotropy in the upper mantle

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Surface wave tomography is the only approach to provide constraints on the upper mantle structure at global scale, including regions where there are no seismic stations. We discuss a global upper-mantle tomographic model of Sv-wave heterogeneities and azimuthal anisotropy as a function of depth, constrained from the analysis of over 100,000 fundamental and higher mode Rayleigh waveforms. The selected waveforms are mostly associated with epicenter-station paths shorter than 6000 km. Compared to the longer R1 and R2 paths classically used in global tomography, these short paths are associated with thinner Fresnel zones and are less likely to be affected by spurious effects such as multipathing or focusing/defocusing. Our original dataset provides a global coverage of the Earth that allows us to resolve horizontal structure with wavelengths smaller than 1000 km, comparable to what is usually achieved at regional scale.

A good overall agreement is found at long wavelengths and at asthenospheric depths between fast anisotropic directions and present day plate motion for the fast-moving plates.

In oceanic regions this is especially clear beneath the Pacific although upwelling seems able to locally disturb this simple long wavelength pattern. We observe that azimuthal anisotropy does not correlate with plate driven flow over small anomalous regions of the northern Pacific that are systematically located westward of the hotspots associated with mantle plumes by Montelli et al. (2004). A broader anomalous anisotropic region is also observed in the vicinity of the Pacific Superswell, where seismic heterogeneities suggest a thinner lithosphere.

In continental regions, the fast-moving Australian plate appears to be the only continent for which basal drag on the lithosphere is sufficient to cause azimuthal anisotropy aligned with plate motion. Beneath other continents, azimuthal anisotropy vanishes near 150 km depth and supports a frozen-in origin within the lithosphere with no evidence for a deeper layer. This is compatible with a delay time of about 1 s, as typically observed in SKS studies. The weak azimuthal anisotropy observed at depth greater than 150 km for continents other than Australia is compatible with simple shear leading to anisotropy with a plunging axis of symmetry.

References:

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