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Global Tomography of Seismic Anisotropy and Interpretations

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Seismic anisotropy, in spite of its inherent complexity is becoming an important ingredient for explaining various kinds of seismic data. Global tomographic models have been improved over years not only by an increase in the number of data but more importantly by using more general parameterizations, now including general anisotropy (both radial and azimuthal anisotropies). Different physical processes (lattice preferred orientation of crystals, cracks or fluid inclusions, fine layering...) related to strain field and/or stress field, give rise to observable seismic anisotropy (S-wave splitting, surface wave radial and azimuthal anisotropies), which makes its interpretation sometimes difficult and non-unique.

Surface waves are well suited for imaging large scale (>1000km) lateral heterogeneities of velocity and anisotropy in the mantle by using fundamental and higher modes, since they provide an almost uniform lateral and azimuthal coverages, particularly below oceanic areas. The interpretation of anisotropy makes it possible to relate surface geology and plate tectonics to underlying mantle convection processes, and to map at depth the origin of geological objects such as continents, mountain ranges, slabs, ridges and plumes. Since different processes creating anisotropy are in play in different layers, a complex stratification of mantle anisotropy is observed and can be unraveled by simultaneously taking account of effects of anisotropy on body waves and surface waves.

We present results of simultaneous inversion of Rayleigh and Love wave overtone data obtained by Beucler et al. (2006) and Visser et al. (2008) down to 1500km depth. New determinations of seismic anisotropy in the upper mantle and the transition zones are obtained from these higher mode phase velocity measurements. We show that seismic anisotropy is small below most of the transition zones except below subduction zones, all around the Pacific Ocean and beneath eastern Eurasia, reflecting complex past slab interactions. Since the presence of anisotropy is due to intense deformation of minerals, it is related to the existence of boundary layers in convective systems. Therefore,the transition zone seems to be a secondary boundary layer within the mantle.

In conclusion, The imaging of seismic anisotropy renews our vision of mantle convection processes covering a wide range of applications for structural geologists and geophysicists.