Global imaging of the lithosphere-asthenosphere system

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Massive surface wave datasets constrain upper mantle seismic heterogeneities with horizontal wavelengths larger than 1000 km, allowing us to investigate the large-scale properties and alignment of olivine crystals in the lithosphere and asthenosphere. The azimuthal anisotropy projected onto the direction of present plate motion shows a very specific relation with the plate velocity. Plate-scale present-day deformation is remarkably well and uniformly recorded beneath plates moving faster than ∼4 cm/yr. Recent geodynamic models suggest that cold sinking instabilities tilted in the direction opposite to plate motion below fast plates could produce a pattern of large-scale azimuthal anisotropy consistent with our observations. Beneath slower plates, plate-motion aligned anisotropy is only observed locally, which suggests that the lithospheric motion does not control mantle flow below these plates.

Radial anisotropy extends deeper beneath continents than beneath oceans, but we find no such difference for azimuthal anisotropy, suggesting that beneath most continents, the alignment of olivine crystal is preferentially horizontal and azimuthally random at large scale. As most continents are located on slow moving plates, this supports the idea that azimuthal anisotropy aligns at large scale with the present plate motion only for plates moving faster than ∼4 cm/yr.

The same inversion also provides 3D models of seismic velocity and attenuation. The simultaneous interpretation of global 3D shear attenuation and velocity models has a great potential to decipher the effect of temperature, melt and composition on seismic observables. We will discuss our findings from the simultaneous interpretation of our latest models.