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Anisotropic Seismology (Beno Gutenberg Medal Lecture)

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Seismic anisotropy, in spite of its inherent complexity is becoming an important ingredient for explaining various kinds of seismic data. For example, 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 anisotropy (radial anisotropy and then general slight anisotropy) and anelasticity.

The imaging of seismic anisotropy renews our vision of upper mantle dynamics because different physical processes (cracks or fluid inclusions, lattice preferred orientation of crystals, fine layering) related to stress field and/or strain field give rise to observable seismic anisotropy (S-wave splitting, surface wave radial and azimuthal anisotropies).

Surface waves provide an almost uniform lateral and azimuthal coverages, particularly below oceanic areas and are used to image large scale ($>$1000km) lateral heterogeneities of velocity and anisotropy in the upper mantle (0-660km depth). 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. Usually, several different processes create a complex stratification of anisotropy which can be unraveled by simultaneously taking account of effects of anisotropy on body waves and surface waves. The example of stratification of anisotropy beneath the Horn of Africa will be presented.

Another promising application regards the temporal variations of anisotropy before and after an earthquake. Some evidence of such changes will be presented for the Parkfield 2004 earthquake, from continuous seismic noise.

In conclusion, anisotropic seismology covers a wide range of applications for structural geologists and geodynamicists for understanding the dynamics of the crust and the mantle. Its interpretation makes it possible to relate surface geology, crustal deformation and plate tectonics to underlying mantle convection processes.