Geophysical Research Abstracts
Vol. 14, EGU2012-12830, 2012
EGU General Assembly 2012

The role of length scales in bridging the gap between rock CPO and seismic signals of crustal anisotropy

D. Okaya (1), S. E. Johnson (2), S. S. Vel (3), W. J. Song (2), N. I. Christensen (4,5)

(1) Dept. Earth Sciences, Univ. Southern California, Los Angeles, CA, USA (okaya@usc.edu), (2) Dept. Earth Sciences, Univ. Maine, Orono, ME, USA (johnsons@maine.edu, wonjoon.song@maine.edu), (3) Dept. Mechanical Engineering, Univ. Maine, Orono, ME, USA (enthil.vel@maine.edu), (4) Dept. Geology, Univ. Wisconsin, Madison, WI, USA (chris@geology.wisc.edu), (5) Dept. Earth and Ocean Sciences, Univ. British Columbia, Vancouver, Canada

Recent studies based on laboratory petrophysics and in particular EBSD-based calculations indicate material rock anisotropy for crustal rocks can possess significant low orders of symmetry. These symmetries based on elastic tensor calculations can range from hexagonal and orthorhombic down to monoclinic and triclinic. On the other hand, interpretation of field seismic data yield crustal anisotropy of fast- or slow-axis transverse isotropy (hexagonal) symmetry at best; identification of orthorhombic symmetry is barely possible. Seismic results are often limited to simple orientations of the symmetry axes, such as vertical (radial anisotropy) or horizontal (azimuthal anisotropy).

The physical scales of earth anisotropic fabrics and of seismic waves affect the types of information that may be extracted from seismic signals. A seismic wave has inherent limits to resolving capabilities, usually measured as some percentage of its wavelength, λ. This wave will accumulate anisotropic signal in two ways based on its path through anisotropic media of physical size, L: (1) When the wave is much smaller than the anisotropic material ($\lambda \ll L$), the seismic signal will be produced integrating along its path. (2) When the wave is much larger than the material ($\lambda \gg L$), the wave will not see details of the material but will respond to just the bulk average of the material. In the first case, the wave will be sensitive to large scale earth changes such as limbs of an antiformal mountain range. The accumulating anisotropic seismic signal can get complicated (e.g., shear wave splits of splits). In the second case, the wave is too large to see any fine detail, and the material can be represented by an equivalent "effective media" that produces the same seismic response.

Geometrical structure is a factor that helps bridge the scales of rock CPO to lower resolution seismic signals. Local rock CPO can fill or be mapped into a structure that is large enough for a seismic wave to respond to. We use tensor representation of anisotropic elasticity to formulate a way to separate structural effects from local rock CPO in order to calculate the effective media associated with a structure (see W.J. Song et al., this session).

Frontier issues exist to improve the connection between rock CPO and seismic signals. For quantitative analyses of anisotropic elastic tensors: *Improved averaging methods of rock CPO tensors beyond modal or volume averaging, such as asymptotic expansion homogenization (AEH). *Updated series of single-crystal elasticity measurements using modern technologies. For structural geology/tectonics and geodynamics: *Catalogue mapping functions or impulse responses associated with 3D structure. *Identify geometries of anisotropy tensors associated with different tectonic regimes. *Geodynamical modeling of crustal tectonics in order to quantify patterns of metamorphic/deformational fabrics. For seismology: *Two-layer and multi-layer seismic anisotropy methods. *Robust anisotropy tomography methods with improved resolution. *Field experiment methods designed specifically for crustal anisotropy (multi-azimuth, multi-incidence, multi-wavelength using active/passive source types).

We discuss the dimensional scales of common seismic waves and earth structures. We illustrate tensor structural operators, effective media, and resulting seismic signals using anisotropic synthetic wave propagation.