Geophysical Research Abstracts
Vol. 16, EGU2014-3757-1, 2014
EGU General Assembly 2014

Constraining crustal anisotropy: The anisotropic H-κ stacking technique

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Measuring anisotropy in the crust and mantle is commonly performed to make inferences on crust/upper mantle deformation, tectonic history or the presence of fluids. However, separating the contribution of the crust and mantle to the anisotropic signature remains a challenge. This is because common seismic techniques to determine anisotropy (e.g., SKS splitting, surface waves) lack the resolution to distinguish between the two, particular in regions where deep crustal earthquakes are lacking. Receiver functions offer the chance to determine anisotropy in the crust alone, offering both the depth resolution that shear-wave splitting lacks and the lateral resolution that surface waves are unable to provide. Here I present a new anisotropic H-κ stacking technique which constrains anisotropy in the crust. I show that in a medium with horizontally transverse isotropy a strong variation in κ (V_P-to-V_S ratio) with back azimuth is present which characterises the anisotropic medium. In a vertically transverse isotropic medium no variation in κ with back azimuth is observed, but κ is increased across all back azimuths. While, these results show that estimates of κ are more difficult to relate to composition than previously thought, they offer the opportunity to constrain anisotropy in the crust. Based on these observations I develop a new anisotropic H-κ stacking technique which inverts H-κ data for anisotropy. I apply these new techniques to data from the Afar Depression, Ethiopia and extend the technique to invert for melt induced anisotropy solving for melt fraction, aspect ratio and orientation of melt inclusions. I show that melt is stored in interconnected stacked sills in the lower crust, which likely supply the recent volcanic eruptions and dike intrusions. The crustal anisotropic signal can explain much of the SKS-splitting results, suggesting minimal influence from the mantle. This results show that it is essential to consider anisotropy when performing H-κ stacking on receiver function data. The new technique presented here can be applied to any anisotropic medium where it can provide constraints on the average crustal anisotropy.