Shear wave splitting around hotspots: Evidence for upwelling-related mantle flow?

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ABSTRACT

We review evidence for plumelike upwellings beneath the Eifel, Great Basin, Hawaii, Afar, and Iceland hotspots by using teleseismic shear wave splitting to resolve the anisotropy associated with mantle flow. An approximately parabolic pattern of fast polarization azimuths (f) is consistent with splitting observations around the Eifel, Great Basin, and Hawaii hotspots, and this pattern may be explained by a model of upwelling material that is being horizontally deflected or sheared in the direction of absolute plate motion (parabolic asthenospheric flow, PAF). The source of splitting beneath Iceland and the Afar is not clear, but the data are not inconsistent with a plumelike upwelling. The success of the upwelling model in explaining the splitting data for the Eifel and the Great Basin, regions far from plate boundaries, suggests that a mantle anisotropy pattern exists for at least some hotspots driven by plumelike upwellings and that splitting can be a useful diagnostic to differentiate between plumelike and alternative sources (e.g., propagating cracks, leaky transform faults) for mantle hotspots. Furthermore, the PAF pattern provides two useful tectonic and geodynamic parameters: the direction of relative motion between the lithosphere and asthenosphere and the stagnation distance, which is proportional to the strength of the upwelling and the speed of the moving plate. When this pattern is used with other types of geophysical data such as seismic velocity tomographic images, one can estimate the plate speed, upwelling volumetric flow rate, buoyancy flux, asthenospheric thickness, excess temperature, and viscosity.