Geophysical Research Abstracts, Vol. 9, 04390, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-04390

Mantle Plumes: dynamic Models and seismic Images

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Different theories on the origin of hotspots have been debated for a long time now, by many authors from different fields; global-scale seismic tomography is probably the most effective tool at our disposal to substantiate, or abandon, the mantle-plume hypothesis. Nevertheless, there is a lack of quantitative, comprehensive analyses of the numerous published tomographic images of the Earth's mantle, and their consistency with different ideas on the nature of presumed mantle upwellings. We attempt to identify coherent, approximately vertical slow/hot anomalies in recently published maps of P and S velocity heterogeneity throughout the mantle, combining the following, independent quantitative approaches: (i) development and application of a "plume-detection" algorithm, conducting a systematic search for vertically coherent features throughout each considered model; (ii) calculation of correlations, as a function of depth and maximum harmonic degree, between tomographic images and dynamic models of the shape and size of plume conduits, with and without consideration of plume advection in a convecting mantle; (iii) depth-dependent spectral analysis of the independent patterns of slow vs. fast heterogeneities. Our results favour the idea that only a small subset of known hotspots have a lower-mantle origin. Those that do can be associated geographically with a few, well defined, extensive slow/hot regions in the lowermost mantle, sometimes referred to as "superplumes". In all the seismic images we consider, we find evidence for both secondary plumes originating from superplume domes, and hotspot plumes whose conduits remain narrow all the way to the lowermost mantle. In the latter case, conduits are considerably tilted by advection, in agreement with the dynamics of mantle flow.