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Small-scale convective Instabilities in the upper Mantle – a generic Class of Hotspots linked to recent continental Collision in Europe and the circum-Mediterranean Region

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Many intra-plate hotspots (both continental and oceanic) appear to be associated with short-wavelength convective instabilities (diapirs) within the upper mantle, originating from Transition Zone (410-660 km) depths. We investigate the dynamics of such instabilities and, develop a model for a generic class of hotspots which form in regions of the upper mantle which have experienced recent subduction and continental collision.

Paleocene-Recent volcanism within western and central Europe, which is spatially and temporally linked to the development of a major intra-continental rift system and to domal uplift of Variscan basement massifs, has been attributed to the diapiric upwelling of small-scale, finger-like, convective instabilities from the base of the upper mantle. Evidence for this model comes from the French Massif Central, the Eifel province of northern Germany and the Bohemian Massif (Czech Republic) where both local and global seismic tomographic studies indicate the existence of localised zones of mantle upwelling extending to the base of the upper mantle, several hundred km across and up to 100-150 degrees Centigrade hotter than ambient mantle. Short-wavelength uplift of the lithosphere, without associated volcanism, also occurs further north in the UK, Scandinavia and Brittany; this may also be a sign of mantle upwelling.

A fundamental question concerns the relationship between this distinctive (short-

wavelength) mode of mantle convection and the development of the Alpine orogenic belt. Beneath Europe and the Mediterranean region the Transition Zone is seismically fast and may, therefore, be cooler than the overlying mantle and also compositionally distinct (containing, for example, a significant component of subducted oceanic crust). It has been argued that the Transition Zone is in fact a “slab graveyard” containing the remnants of subducted Tethyan (or older) oceanic lithosphere. If this is the case, then the upwelling mantle diapirs are unlikely to be driven by either thermal or compositional buoyancy. So what process or processes does drive the mantle upwelling which triggers partial melting?

We evaluate a range of mantle convection models in the context of the regional plate tectonic setting of Europe and constraints provided by both local and seismic tomographic studies. We explore the role of discontinuities in the base of the lithosphere (e.g. Variscan terrane boundaries) and Tertiary lithospheric extension in nucleating diapiric instabilities which may subsequently propagate downwards, producing, “top downwards”, small-scale structures which look like plume stems but which may have a totally different origin.