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Intra-plate Magmatism Related to Short Wavelength Convective Instabilities in the Upper Mantle – a Case Study from the Massif Central, France

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Tertiary-Quaternary magmatism 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 short wavelength, finger-like, convective instabilities from the base of the upper mantle [Granet et al., 1995; Wilson & Patterson, 2000]. Evidence for this model comes from the French Massif Central, where both local and global seismic tomographic studies indicate a zone of upwelling from the Transition Zone, 100-300 km across and 100-200 ºC hotter than ambient mantle [Granet et al., 1995; Sobolev et al, 1996, 1997]. Magmatism is predominantly alkaline, involving a spectrum of sodic primitive mafic magmas ranging from melilite nephelinites and melilititites, through to basanites and alkali basalts and their differentiates. This primitive magma spectrum is considered to represent variable degrees of partial melting of a HIMU-like reservoir, the European Asthenospheric Reservoir or EAR, which appears to provides a common source component to the magmatism throughout Europe [Wilson & Bianchini, 1999]. Widespread "pollution" of the upper mantle beneath Europe with the EAR component could be a consequence of complex outflow of anomalous mantle from the Iceland plume, which impacted beneath Greenland in the Latest Cretaceous and is almost certainly sourced from the core-mantle boundary [Bijwaard & Spakman, 1999]. The EAR is isotopically distinct, with characteristics intermediate between those of the Depleted Mantle and the HIMU reservoir, widely considered to reflect ancient recycled oceanic crust. Rare potassic mafic magmas also occur within the Massif Central, inferred to originate by partial melting of enriched domains within the mantle lithosphere. Spinel peridotite mantle xenoliths exhumed by the Tertiary-Quaternary magmas provide important constraints on the nature of the lithosphere, which comprises at least two isotopically distinct basement terranes.

Variations in the trace element and Sr-Nd-Pb isotopic characteristics of the most primitive mafic magmas within the Massif Central are consistent with mixing of partial melts of both lithospheric and asthenospheric mantle sources. However, within the mafic magma spectrum we have also been able to recognise a distinct magma type generated by partial melting of mantle material within the base of the lithosphere which has been metasomatically enriched by earlier plume-derived melts/fluids. We use the temporal and spatial distribution of the different mafic magma types within the Massif Central to provide important constraints for tracking partial melting processes within the ascending mantle diapir.

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