Sub-axial asthenospheric flow revealed by a plume-spiked mantle

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Interaction between actively upwelling deep mantle plumes and mid-ocean ridges usually result in excess melting, thickened oceanic crust and unusually shallow ridge depths. The Foundation plume, in contrast, is characterised by only a weak temperature anomaly (<20K) and a small plume volume flux (~1.0 km³ a⁻¹) [1], thus limiting the plume’s physical impact on the adjacent Pacific-Antarctic Ridge (PAR). However, the Foundation plume delivers material compositionally distinct to the PAR mantle source and provides thus a unique opportunity to study the dispersal of the ‘plume-spiked’ mantle along a single, 550 km-long ridge segment.

Radiogenic Sr-Nd-Pb isotope data indicate the involvement of at least three distinct mantle components in the Foundation-PAR system. One corresponds to the ambient MORB mantle source but the two others are likely to be entrained in the Foundation plume conduit. One of these components has lower 206Pb/204Pb but slightly higher 87Sr/86Sr relative to the ambient MORB mantle and the enriched plume component is similar to PREMA (FOZO).

Radiogenic isotopes as well as incompatible trace element ratios (e.g., Nb/Zr, La/Sm) indicate an asymmetric dispersal of plume material along the adjacent ridge axis. Close to the plume-ridge intersection, all three components are present and the enriched component vanishes with increasing distance from the plume centre. Further to the south, off-axis volcanism traps a source that contains lower proportions of the enriched plume component than the respective on-axis ridge section. This indicates that, in the Foundation-PAR case, plume material is dispersed along the ridge axis exclusively by a shallow sub-axial asthenospheric transport mechanism. An overlapping spreading centre in the north of the Foundation-PAR intersection and the asymmetric geochemical anomaly along the PAR indicate a preferred southward transport direction, consistent with models of the sub-axial asthenospheric flow [2,3] and regional geodynamics.