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Plume and plate controlled hotspot trails in the South Atlantic

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Discovering if hotspots observed on the Earth's surface are explained by underlying plumes rising from the deep mantle or by shallow plate-driven processes continues to be an essential goal in Earth Science. Key evidence underpinning the mantle plume concept is the existence of age-progressive volcanic trails recording past plate motion relative to surface hotspots and their causal plumes. Using the icebreaker RV Polarstern, we sampled scattered hotspot trails on the 2,000 km-wide southeast Atlantic hotspot swell, which projects down to one of the Earth's two largest and deepest regions of slower-than-average seismic wave speed – the Africa Low Shear Wave Velocity Province – caused by a massive thermo-chemical 'pile' on the core-mantle boundary. We showed recently using Ar/Ar isotopic ages – and crustal structure and seafloor ages – that these hotspot trails are age progressive and formed synchronously across the swell, consistent with African plate motion over plumes rising from the stable edge of a Low Shear Wave Velocity Province (LLSVP) (O'Connor et al., 2012). We showed furthermore that hotspot trails formed initially only at spreading boundaries at the outer edges of the swell until roughly 44 million years ago, when they started forming across the swell, far from spreading boundaries in lithosphere that was sufficiently weak (young) for plume melts to reach the surface. We concluded that if plume melts formed synchronous age progressive hotspot trails whenever they could penetrate the lithosphere, then hotspot trails in the South Atlantic are controlled by the interplay between deep plumes and the shallow motion and structure of the African plate. If the distribution of hotspot trails reflects where plume melts could or could not penetrate the continental or oceanic lithosphere then plumes could have been active for significantly longer than indicated by their volcanic chains. This provides a mechanism for extended late stage interplay between deep mantle processes and the passive margin and adjacent continents that might explain extensive magmatism, lithospheric thinning and phases of post-rift uplift on continental margins and nearby continents.

O'Connor, J. M., Jokat, W., le Roex, A. P., Class, C., Wijbrans, J. R., Kessling, S., Kuiper, K. F. & Nebel, O. Hotspot trails in the South Atlantic controlled by plume and plate tectonic processes. Nature Geoscience, DOI:10:1038/NGEO1583 (2012). http://www.nature.com/ngeo/journal/v5/n10/full/ngeo1583.html