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A Continuous History of Plume-Influenced Rifting in the North Atlantic Ocean

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Evolution of the North Atlantic Ocean has been dominated the Iceland mantle plume. Here we present an unbroken record of variable mantle plume activity stretching back 55 Ma, through analysis of regional seismic reflection images. Residual depth anomalies of oceanic lithosphere, long wavelength gravity anomalies and seismic tomographic models show that this convective upwelling reaches from Baffin Bay to Western Norway, and from offshore Newfoundland to Spitzbergen. At fringing passive margins, there is strong evidence for present-day dynamic support of the crust (e.g. Scotland, Western Norway). The Iceland plume is bisected by a mid-oceanic ridge, which provides a record of the temporal evolution of the plume. Transient behavior of the plume is indirectly recorded within the fabric of oceanic floor south of Iceland. We exploit regional seismic reflection profiles that traverse the oceanic basin between northwest Europe and Greenland. A diachronous pattern of V-shaped ridges is imaged beneath a thickening blanket of sediment, revealing a complete record of transient periodicity that can be traced continuously. This periodicity increases from $\sim$3 to $\sim$8 Myr with clear evidence for minor, but systematic, asymmetric crustal accretion. V-shaped ridges grow with time and reflect small (e.g. 5–30°C) changes in mantle temperature, consistent with quasi-periodic generation of hot solitary waves triggered by growth of thermal boundary layer instabilities within the mantle. Our continuous record of convective activity suggests that the otherwise uniform thermal subsidence of sedimentary basins, which fringe the North Atlantic Ocean, has been periodically interrupted by transient uplift events. These elevation changes can explain a suite of diverse observations from the geologic record. Regional Paleogene erosion surfaces in the Faroe-Shetland Basin, the punctuated deposition of contourite drifts, and the history of denudation on the UK continental shelf can all be explained by transient mantle plume behaviour. These manifestations of convective activity should lead to improved insights into the fluid dynamics of the mantle, with implications for the subsidence history of sedimentary elsewhere.