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Caught in the Act: Crustal Manifestations of a Hot Transient Pulse Beneath the Mid-Atlantic Ridge at 60°N

Ross Parnell-Turner (1), Nicky White (1), Tim Henstock (2), Bramley Murton (2), Stephen Jones (3), and John Maclennan (1)

(1) Department of Earth Sciences, University of Cambridge, Cambridge, UK (rep52@cam.ac.uk), (2) National Oceanography Centre, University of Southampton, Southampton, UK, (3) School of Geography, Earth and Environmental Sciences, University of Birmingham, Edgbaston, UK

Since its inception, mantle convective upwelling beneath Iceland has had a significant influence on the history of vertical motion, magmatism and paleoceanography in the North Atlantic Ocean. Crucially, intersection of the Reykjanes Ridge with the Icelandic plume provides us with an important window into the transient activity of the plume. The spreading ridge acts as a linear sampler of plume activity, which is recorded as a series of time-transgressive V-shaped ridges and troughs. Here, we present the results of a detailed study along the spreading ridge close to 60°N, where the youngest V-shaped ridge of thickened oceanic crust, is forming today. A combination of multibeam bathymetry and seismic reflection profiles, acquired along and across the ridge axis, is used to map the detailed pattern of volcanism and normal faulting. Along the ridge axis, the density of volcanic seamounts varies markedly, increasing by a factor of two between 59° and 62°N. Within this area, seismic imaging shows that there is enhanced acoustic scattering at the seabed. These observations are accompanied by a decrease in mean fault length from ∼12 km to ∼6 km. A 1960–2009 catalog of relocated teleseismic earthquake hypocenters shows that there is a pronounced gap in seismicity between 59° and 62°N where the cumulative moment release is two orders of magnitude smaller than that along adjacent ridge segments. A steady-state thermal model is used to show that a combination of increased melt generation and decreased hydrothermal circulation accounts for this suite of observations. Our results suggest that the thickness of the brittle seismogenic layer is smaller where the youngest V-shaped ridge intersects the ridge axis. This decrease is consistent with geochemical modeling of dredged basaltic samples, which require horizontal flow of hotter asthenospheric material within a channel beneath the spreading axis. Thus, along-axis variation in melt supply arising from the passage of a pulse of hot material directly affects crustal accretion processes and rheological properties.