EGU24-557, updated on 10 Dec 2024
https://doi.org/10.5194/egusphere-egu24-557
EGU General Assembly 2024

Temporal Record of Plume-Ridge Interaction in the North Atlantic: Interdisciplinary Insights from IODP Expedition 395C

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The Icelandic mantle plume is regarded as one of the most significant mantle upwellings on Earth, however the dynamics of its interaction with the surrounding asthenosphere and mid-oceanic ridge systems in the North Atlantic are poorly understood. The clearest manifestation of this plume-ridge interaction are the Reykjanes V-shaped ridges and V-shaped troughs (VSRs and VSTs) that straddle the Reykjanes Ridge axis south of Iceland. These time-transgressive linear features are particularly well exposed by short-wavelength gravity data and are thought to represent the progressive sampling of thermal asthenospheric pulses that horizontally advect away from the Icelandic mantle plume conduit. The Reykjanes Ridge therefore acts as a 'window-sampler' into the temporal and spatial dynamics of plume outflow. International Ocean Discovery Program (IODP) Expedition 395C drilled into two VSR and VST pairs along a plate-spreading flow line approximately 600 km south of Iceland in summer 2021. Over 400 m of basalt was recovered, which represents a magmatic record over 15 Ma of plate spreading at a fixed distance from the mantle plume conduit. We present Nd isotopic analysis of recovered whole-rock that reveals a linear isotopic evolution from Nd of 7.5 to 10.5 over 14 Ma (n = 50), which implies that the 'plume-like' enriched component of the mantle source has been progressively diluted by mixing with depleted upper mantle material. This evolution occurred synchronously with the entire timeframe of VSR formation as defined by free-air gravity anomalies, and a long-wavelength increase in crustal thickness implied by wide-angle seismic experiments. It is therefore apparent that the dynamics of plume-ridge interaction are directly interlinked with changes in magmatism, structural tectonics and crustal production. Furthermore, major and trace elements of both whole-rock and glass samples have been measured, by multiple analytical techniques, revealing distinct compositions between and within boreholes. These observations can be understood in terms of temporal changes in the depth and degree of melting. In summary, petrological, petrophysical and geochemical analysis of this rock core in conjunction with consideration and modelling of wide-angle seismic surveys, gravity and bathymetric data can be used to develop a quantitative understanding of the dynamics of plume-ridge interaction, test hypotheses for the formation of VSRs, and constrain the temporal evolution of the North Atlantic mantle domain.

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