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Geochemical Analysis of Diachronous V-Shaped Ridges and Troughs that Flank the Reykjanes Ridge South of Iceland

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It is increasingly recognized that mantle plumes play a direct role in generating regional uplift and producing immense volumes of basaltic magmatism, both of which can influence paleoclimate in different ways. The Icelandic Plume, beneath the North Atlantic Ocean, is of particular importance due to its size and position at a significant paleoceanographic gateway. It is transected by a mid-oceanic ridge system, which has generated a series of V-shaped ridges and troughs that flank the Reykjanes Ridge south of Iceland. The origin of these diachronous features is debated—do they reflect temperature fluctuations within the plume head or have they formed as a result of compositional variations within the buoyant convecting mantle? To address these and other hypotheses, the International Ocean Discovery Program (IODP) carried out three drilling expeditions which recovered basalt core from a sequence of V-shaped ridges and troughs. Here, we show that the petrology and geochemistry of fifty samples taken from boreholes that penetrate different ridges and troughs reveal systematic differences in major, trace and rare earth element concentrations. By combining forward and inverse modeling based upon polybaric fractional melting, we argue that these geochemical variations are successfully fitted by varying melt fraction as a function of depth for plausible mantle source compositions. Our results suggest that average mantle temperature increases of 25 to 30 °C between ridges and troughs play a dominant role. A significant part of our analysis is comparison with, and calibration with respect to, the geochemistry of dredged basaltic glasses and rocks along the active Reykjanes Ridge. We conclude that the drilled basaltic rocks reveal a chronology of resolvable temperature perturbations that should enable the fluid dynamics of flow within a major convective plume to be better understood.