Skewed mantle melt delivery induces segment-scale variations in mid-ocean ridge magmatic and hydrothermal processes

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Using seismic tomography, we image the isotropic and anisotropic *P*-wave velocity structure of the topmost mantle and crust, as well as crustal thickness, beneath the intermediate-spreading Endeavour segment of the Juan de Fuca Ridge. Our tomographic results constrain for the first time the segment-scale, three-dimensional structure of a mid-ocean ridge magmatic system. At crustal depths, results reveal a low-velocity volume (LVV)—inferred to be the magmatic system—that is continuous along the entire Endeavour segment at depths of 2-3 km below seafloor and closely follows the axis of spreading. The ridge-tracking trend of the mid-crustal LVV is in contrast to the mantle LVV, which is skewed with respect to both the ridge axis and mid-crustal magmatic system and connects two overlapping spreading centers bounding the segment. From the seismic results, we estimate the thermal structure and melt distribution beneath the Endeavour segment. The thermal structure shows that the transition between the asthenospheric and lithospheric magmatic systems is abrupt, suggesting they are thermally decoupled and governed by different regimes. We infer that the asthenospheric magmatic system is governed by a regional, north-south trending thermal structure at the base of the lithosphere, whereas the lithospheric magmatic system is controlled by a thermal structure shaped by rifting, magma injection, and hydrothermal processes. Along-axis variations in crustal melt content correlate with the cross-axis offset in mantle melt delivery. Axis-centered mantle melt delivery coincides with the most robust portion of the crustal magmatic system and vigorous hydrothermal activity, whereas sites of off-axis mantle melt delivery correlate with crustal melt volume minima and the absence of a lower crustal magmatic system. We propose that the degree of skew in mantle melt delivery influences the efficiency of melt transport, thus resulting in segment-scale variations in mid-ocean ridge magmatic and hydrothermal processes.