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Formation and Elimination of Transform Faults on the Reykjanes Ridge

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The Reykjanes Ridge is a type-setting for examining processes that form and eliminate transform faults because it has undergone these events systematically within the Iceland gradient in hot-spot influence. A Paleogene change in plate motion led to the abrupt segmentation of the originally linear axis into a stair-step ridge-transform configuration. Its subsequent evolution diachronously and systematically eliminated the just-formed offsets re-establishing the original linear geometry of the ridge over the mantle, although now spreading obliquely. During segmented stages accreted crust was thinner and during unsegmented stages southward pointing V-shaped crustal ridges formed. Although mantle plume effects have been invoked to explain the changes in segmentation and crustal features, we propose that plate boundary processes can account for these changes [Martinez & Hey, EPSL, 2017].

Fragmentation of the axis was a mechanical effect of an abrupt change in plate opening direction, as observed in other areas, and did not require mantle plume temperature changes. Reassembly of the fragmented axis to its original linear configuration was controlled by a deep damp melting regime that persisted in a linear configuration following the abrupt change in opening direction. Whereas the shallow and stronger mantle of the dry melting regime broke up into a segmented plate boundary, the persistent deep linear damp melting regime guided reassembly of the ridge axis back to its original configuration by inducing asymmetric spreading of individual ridge segments.

Effects of segmentation on mantle upwelling explain crustal thickness changes between segmented and unsegmented phases of spreading without mantle temperature changes.

Buoyant upwelling instabilities propagate along the long linear deep melting regime driven by regional gradients in mantle properties away from Iceland. Once segmentation is eliminated, these propagating upwelling instabilities lead to crustal thickness variations forming the V-shaped ridges on the Reykjanes Ridge flanks, without requiring actual rapid radial mantle plume flow or temperature variations.

Our study indicates that the Reykjanes Ridge can be used to study how plate boundary processes within a regional gradient in mantle properties lead to a range of effects on lithospheric segmentation, melt production and crustal accretion.