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The deep structure of the South Atlantic rifted margins and the implications of the magmatic processes for the break-up

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The high velocity lower crust HVLC (Vp > 7km/s) together with seaward dipping reflectors (SDRs) and continental flood basalts are specific characteristics of volcanic rifted margins. The nature and origin of the HVLC is still under discussion. Here we provide a comprehensive study of the deep crustal structure of the South Atlantic rifted margins in which we focus on variations in the distribution and size of HVLC bodies along and across the margins.

Two new and five existing refraction lines complemented by gravity models cover the area between the Rio Grande Rise - Walvis Ridge to the Falkland Agulhas Fracture Zone. Three seismic lines on the South American margin outline the change from a non-magmatic margin (lacking seaward dipping reflectors) in the south to a well-developed volcanic rifted margin off Uruguay in the north. While the HVLC exhibit a consistent increase in the cross-sectional area along both margins from South to North, we observe a major asymmetry across the margins. The African margin has about two-three times thicker and four times more voluminous HVLC than the South American margin. Importantly, the erupted lavas in the Etendeka-Paraná Provinces show the opposite asymmetry. Also the spatial position of the HVLC with regard to the inner SDRs varies consistently along both margins. Close to the Falkland Agulhas Fracture zone a small body of HVLC is not accompanied by seaward dipping reflectors. In the central segment, HVLC is centered under the SDRs inner wedge but in the north, HVLC also extends further seawards. These observations question a simple extrusive/intrusive relationship between SDRs and HVLC, and they imply differences in the timing of the HVLC formation during the rifting and break-up process.

We conclude that the HVLC is predominantly a magmatic feature related mantle melting during break-up. Melt generation models suggest that the greater thickness of HVLC on the African margin is due to active upwelling combined with elevated temperatures whereas the model predicts passive upwelling and a thick lithospheric lid for the South American HVLC. The contrast in upwelling rate and lithospheric thickness can be explained by a model of asymmetric rifting with a simple shear extension. Combining our estimates for the total HVLC volumes with the SDRs and flood basalts implies a total magma production about 6 x 10^6km^{3}on the rifted margins of the South Atlantic.