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Crustal architecture and deep structure of the Namibian passive continental margin around Walvis Ridge from wide-angle seismic data

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The opening of the South Atlantic ocean basin was accompanied by voluminous magmatism on the conjugate continental margins of Africa and South America, including the formation of the Parana and Entendeka large igneous provinces (LIP), the build-up of up to 100 km wide volcanic wedges characterized by seaward dipping reflector sequences (SDR), as well as the formation of paired hotspot tracks on the rifted African and South American plates, the Walvis Ridge and the Rio Grande Rise. The area is considered as type example for hotspot or plume-related continental break-up. However, SDR, and LIP-related features on land are concentrated south of the hotspot tracks. The segmentation of the margins offers a prime opportunity to study the magmatic signal in space and time, and investigate the interrelation with rift-related deformation. A globally significant question we address here is whether magmatism drives continental break-up, or whether even rifting accompanied by abundant magmatism is in response to crustal and lithospheric stretching governed by large-scale plate kinematics.

In 2010/11, an amphibious set of wide-angle seismic data was acquired around the landfall of Walvis Ridge at the Namibian passive continental margin. The experiments were designed to provide crustal velocity information and to investigate the structure of the upper mantle. In particular, we aimed at identifying deep fault zones and variations in Moho depth, constrain the velocity signature of SDR sequences, as well as the extent of magmatic addition to the lower crust near the continent-ocean transition. Sediment cover down to the igneous basement was additionally constrained by reflection seismic data.

Here, we present tomographic analysis of the seismic data of one long NNW oriented profile parallel to the continental margin across Walvis Ridge, and a second amphibious profile from the Angola Basin across Walvis Ridge and into the continental interior, crossing the area of the Etendeka Plateau basalts. The most striking feature is the sharp transition in crustal structure and thickness across the northern boundary of Walvis Ridge. Thin oceanic crust (6.5 km) of the Angola Basin lies next to the up to 35 km thick igneous crustal root founding the highest elevated northern portions of Walvis Ridge. Both structures are separated by a very large transform fault zone. The velocity structure of Walvis Ridge lower crust is indicative of gabbro, and, in the lowest parts, of cumulate sequences. On the southern side of Walvis Ridge there is a smooth gradation into the adjacent 25-30 km thick crust underlying the ocean-continent boundary, with a velocity structure resembling that of Walvis Ridge The second profile shows a sharp transition from oceanic to rifted continental crust. The transition zone may be underlain by hydrated uppermost mantle. Below the Etendeka Plateau, an extensive high-velocity body, likely representing gabbros and their cumulates at the base of the crust, indicates magmatic underplating. We summarize by stating that rift-related lithospheric stretching and associated transform faulting play an overriding role in locating magmatism, dividing the margin in a magmatic-dominated segment to the south, and an amagmatic segment north of Walvis Ridge.