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Application of P- and S-receiver functions to investigate crustal and upper mantle structures beneath the Albertine branch of the East African Rift System

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The Rwenzori region at the border between Uganda and the Democratic Republic of Congo is part of the western (Albertine) branch of the East African Rift System (EARS). The region is characterized by a horst structure, the Rwenzori Mountains, reaching elevations of more than 5 km and covering an area of about 120 km by 50 km. The unusual location of the mountain range, between two segments of the Albertine rift, suggests complex structures of the crust and the upper mantle below.

In our study, we employ P- and S-receiver functions in order to investigate the corresponding discontinuities of the lithosphere-asthenosphere system. The analyses are based on recordings from a dense network of 33 seismic broadband stations operating in the region for a period of nearly two years, from September 2009 until August 2011. The crustal thickness is analysed by using P-receiver functions and the grid search method of Zhu & Kanamori (2000) which involves the stacking of amplitudes of direct converted (Ps) and multiple phases (PpPs and PpSs) originating from the Moho. The method of S-receiver functions is more effective in analysing deeper discontinuities of the upper mantle, such as the lithosphere-asthenosphere boundary (LAB). The latter method also has the advantage that the interfering influence of multiple phases from shallower discontinuities is avoided. To simplify the analysis of the S-receiver functions, we use an automatic procedure to determine incidence angles used in the rotation from the ZNE system to the ray-centered LQT system.

We apply this approach to confirm and significantly extend results from the study of Wölbern et al. (2012), which provided evidence for an intra-lithospheric discontinuity at depths between 54 km and 104 km and the LAB between 135 km and 210 km. Our results provide evidence for significant variations of crustal thickness beneath the region. The Moho depth varies between 20 km beneath the rift valley and 39 km beneath the adjacent rift shoulders. We also consider influences of sediment layers and of a low-velocity intra-crustal zone on the thickness estimates. The comparison of the Moho topography with the hypocentral depth distribution of local earthquakes indicates that the seismicity extends from the surface down to the base of the crust. From our investigation, there is no evidence for a crustal root beneath the Rwenzori mountain range. This observation provides support for rift-induced delamination, as recently proposed by Wallner and Schmeling (2010), to explain the unusual uplift of the Rwenzori Mountains between two rift segments.