Controls on early-stage, magma-poor rifting from top-to-bottom seismic imaging of the Malawi (Nyasa) Rift

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The Malawi (Nyasa) Rift in the southern East Africa Rift System exemplifies an active, magma-poor, weakly extended continental rift. Here we synthesize multi-resolution seismic imaging datasets to examine rift structure and evolution, which allows us to constrain variations in extension with depth and along-strike in this early-stage continental rift system and evaluate the factors that may control these variations.

As a part of the SEGMeNT (Studies of Extension and maGmatism in Malawi aNd Tanzania) project, a team of US, Malawian and Tanzanian scientists collected and analyzed a multi-faceted, amphibious, active- and passive-source seismic dataset across the northern Malawi Rift. Together, analysis and integration of seismic imaging datasets from this study provide a comprehensive portrait of the style and amount of stretching throughout the lithosphere and along strike. Broadband scattered-wave imaging and wide-angle seismic reflection/refraction data reveal substantial variations in extension with depth, with much more thinning of the lithospheric mantle than the crust. The modest observed reduction in velocity below the rift from both broadband surface- and body-wave imaging can be explained with small thermal perturbations and without melt. Lower velocities and complex patterns of anisotropy underlie the Rungwe Volcanic Province to the north of the Malawi Rift, suggesting focused lithospheric modification, melting and complex mantle flow below this localized volcanic province. Active-source seismic refraction and multi-channel seismic (MCS) reflection data quantify cumulative extension accommodated by the border faults and intrarift faults. Border faults have throws over 8 km and bound half graben basins. Intrarift faults are also relatively large (throws up to 2.5 km) and active, and they are estimated to account for ~20-25% of cumulative upper crustal extension. Along-strike variations are observed in faulting and in crustal and lithospheric stretching.

In January-February 2024 as a part of the MWERA (MalaWi Examination of Rifting and Active surface processes) project, we acquired high-resolution seismic imaging and multibeam bathymetry data that constrain spatial and temporal patterns of recent deformation on intrarift faults. Preliminary results from this recent high-resolution imaging project will be synthesized with existing deep imaging results to examine rifting processes.