

Investigation of Active Crustal Deformation Across the Incipient Mweru-Wantipa Rift, NW Zambia, East Africa

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Active incipient rift basins provide critical information on how brittle deformation is accommodated in Earth's crust at the earliest phases of continental divergent plate boundary development. The Mweru-Wantipa Rift, NW Zambia, is a poorly understood magma-poor incipient rift zone in the SW Branch of the East African Rift System. The rift exhibits a NE-trending orientation, branching SW from the southern end of the NW-trending Tanganyika Rift. It is arranged en echelon with the Mweru Rift situated farther south. Focal mechanisms in the basin show normal and strike-slip faulting. The region has excellent topographical expression, allowing for thorough mapping and quantitative analysis of active faults and their attributes. We use high-resolution (30m) satellite data and optical satellite imagery to build a new robust active fault database for the rift zone. From here, we analyze 3-D fault geometries, spatial clustering, segmentation, length-scaling, and displacement characteristics. Furthermore, we evaluate the along- and across-rift variability in the broad geomorphic structure of the basin, gaining insight into how tectonic deformation modulates the rift basin's depositional environment. We manually mapped 165 faults, revealing a multi-modal strike distribution of a prominent NE-SW set, as well as less prominent N-S and E-W sets. The rift progressively widens toward the NE and narrows toward the SW, exhibiting the greatest density and intensity of fault clustering in the SE margin zone, less intense faulting in the NW margin zone, and minor faulting (short, sparse faults) in the synformal rift axis. Moreover, our results show the SE margin zone hosts faults with the greatest throws: the Chipasense Fault (ca. 400 m), Chilambwe-Lukwesa Fault (ca. 300 m), and Chisi-Nsama Fault (ca. 200 m). The rift lacks a major rift-bounding border fault, but these three conjugate faults act as border fault candidates. Further, the two margin zones exhibit contrasting models of fault length-scaling: an exponential distribution in the NW, and a power-law distribution in the SE. Overall, our results show the most strain in the incipient rift basin is accommodated within the 41-km wide SE margin zone, which is yet to fully transition into the stretching phase of rifting. This provides insights into crustal deformation patterns during the initiation of border faulting.