Incipient Tectonic Reactivation of a ‘Failed’ Rift, Luama Basin, DRC

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Continental rifts commonly undergo multiple cycles of ‘failure’ and reactivation prior to breakup. However, there remains limited understanding of the sources of stress perturbations and strain distribution patterns that fingerprint the incipient phases of rift reactivation. We explore the NW-trending Luama Basin, DRC, East Africa, a ‘failed’ Mesozoic (Karoo) rift basin that is commonly characterized to be inactive in literature, but in which we found >100-km long fault scarps that deform the eroding Holocene surface, earthquakes, hot springs, and geomorphic indicators of active but incipient subsidence on the fault hanging walls. Here, we map faults from published geologic maps, 30-m resolution Shuttle Radar Topography Mission data, and distinguish the traces of the active segments by their anomalous steepness, footwall channel incision patterns, and triangular facets. We then measure the along-fault distribution of vertical displacement of the modern surface (footwall relief of fault scarp) at 1 km intervals along the two most prominent surface ruptures in the basin: the northeastern border fault (Busindi Fault) and a major intra-rift fault (Main Kataki Fault). Further, we analyze the reactivation tendency of the mapped active fault segments within the contemporary East African Rift System (EARS) stress field of the adjacent Tanganyika Rift, following standard Mohr-Coulomb framework. Our results show that the active fault segments exhibit a narrow unimodal (140° – 160°) range of strike, unlike the inactive segments that exhibit a wider range and multimodal distribution in strike (30° – 40°, 80° - 90°, & 140° - 160°). The Busindi Fault exhibits a greater intensity of segmentation and maximum throw than the Main Kataki Fault, but both show a clear southward increase in throw magnitude towards the intersection of the basin with the Tanganyika Rift. Furthermore, we find that the reactivated faults are optimally oriented for failure in the East African Rift stress field with a 0.55 fault rock friction coefficient and <20 MPa cohesion. Altogether, our findings demonstrate that the Luama Rift is undergoing incipient extensional reactivation, driven by the tectonic forces of the EARS, it's frictionally weak fault zones, and potentially hydrothermal weakening at depth.