Geophysical Research Abstracts
Vol. 16, EGU2014-8467, 2014
EGU General Assembly 2014

Three-Dimensional (3D) Structure of the Malawi Rift from Remote Sensing and Geophysics Data

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The Malawi rift is a Cenozoic aged rift representing the southernmost segment of the Western Branch of the East African Rift System (EARS). This rift extends over 900 km from the Rungwe volcanic province (Tanzania) in the north to the Urema graben (Mozambique) to the south, with an average width of 50km. It traverses a complex array of Proterozoic orogenic belts of different ages and Permo-Triassic (Karoo) and cretaceous graben systems. The rift's depth is between 3 to 5km partitioned between the topographic escarpment and the sediments fill. The basin's subsidence reflects accumulation of sediments and rift flank uplift. Regardless of its importance in understanding rift tectonics, especially in Africa, the three-dimensional (3D) geometry of the rift is not fully understood. This research presents results from detailed analysis of Digital Elevation Model (DEM) extracted from the Shuttle Radar Topography Mission (SRTM) data to map surface morphological expressions of the entire basin. These results are compared with available seismic data to provide along-strike and at depth variation of the geometry of the border fault systems, nature of rift segmentation and alternation of the polarity of half-grabens, and the partitioning of displacement between exposed and sub-surface border faults. Our results show the following: (1) Surface expression of border faults show that, unlike the typical half-graben en-echelon rift model, where half-graben segments with opposite polarity are linked together through accommodation zones indicative of soft linkage, the Malawi rift shows along-strike segmentation by changing geometry from half-graben to full graben geometry. A half-graben with specific polarity passes through a full-graben geometry before giving place to a half-graben with the opposite polarity. The length of half-gaben and graben segments becomes shorter as the rift progresses from north to south, and this is accompanied by a decrease in displacement within border faults. This geometry is indicative of the propagation of border faults through hard linkage. (2) The continuation of border faults at the subsurface show patterns consistent with those observed at the surface. At the sub-surface, the general trend of rift segmentation, formation of full grabens at the end of each segment, and the decreases in the length of the segments from north to south is consistent with observations at the surface. This suggests the homogeneity of strain accommodation throughout the depth of border faults. (3) Zones of segmentation of the Malawi rift coincide with regions where the pre-existing structures (both the Proterozoic basement and the Karoo grabens) are at high angle to the trend of the rift whereas well-developed border faults of the basin coincides with N-trending pre-existing structures sub-parallel to the rift.