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Kinematic model of the East African rift based on stress inversion of geological and seismological data

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The kinematics of rifting and the associated opening direction for the East African rift system have been the focus of much attention since the first kinematic models have been proposed in 1980. They were based on the interpretation of the first satellite images available at time, as a result of the emergence of the remote sensing technology. The new satellite images gave for the first time the opportunity to get a regional picture of the entire East African rift. These models stated the importance of continental transfer and transform fault zones as controlling features during the development of the rift. They relied in particular on the interpretation of the rectilinear portion of the western rift branch within the Ubendian shear belt as a large continental transform fault zone formed by the southern half of the Tanganyika basin, the Rukwa basin and the northern extremity of the Nyasa (Malawi) rift basin (the TRM zone). Arguments were developed initially on the basis of satellite image interpretation, and were confronted later by field structural analysis along the major rift border faults and paleostress inversion of fault slip data.

For the last 15 years, this TRM zone was the focus of several research projects on the dynamics of rift development and basement reactivations since the first rifting period in the Karoo Time (Permian-Triassic). Field observations confirm the idea that important strike-slip movements occurred along the major rift border faults at some time of their evolution, but probably related to the Permo-Triassic tectonic crisis. They also show that most of the rift border faults are presently characterised by dip-slip movements and that those are associated with the Late Cenozoic (Mid-Miocene – Quaternary) rift phase, the one corresponding to the East African rift System. The focal mechanisms of earthquakes which are now much more numerous than the ones available in 1980, also confirm that the dominant faulting in the East African rift is normal faulting.

The newly available field structural and focal mechanism data as well as seismic and borehole data in the rift basins show that certain portions of the East African rift are indeed characterized by recent (and still active) strike-slip faulting. These portions seem to be restricted to relatively small areas, generally in the transfer zones between large rift segments characterized by pure normal faulting and orthogonal opening. One such area is the Mbeya triple junction between the Rukwa, Nyasa and Usangu rift basins at the junction between the western and the eastern rift branches in SW Tanzania. It can be interpreted as being as an evolution of the triple junction into an incipient transform fault zone, transferring extensional strain from the northern extremity of the Nyasa (Malawi) basin to the southern extremity of the Tanganyika basin, in order to accommodate the lateral offset of the western rift branch between these two rift segments. Other similar areas affected by strike-slip faulting have been documented in the Albertine graben in Uganda, in the Turkana rift in North Kenya, and in coastal Tanzania. The locations of such areas of recent strike-slip faulting mechanism are often characterized by strong basement discontinuities.