Geophysical Research Abstracts
Vol. 14, EGU2012-5381, 2012
EGU General Assembly 2012

Stress and slip partitioning during oblique rifting: comparison between data from the Main Ethiopian Rift and laboratory experiments

G. Corti (1), M. Philippon (2), F. Sani (3), and D. Keir (4)

(1) Consiglio Nazionale delle Ricerche, Istituto di Geoscienze e Georisorse, Firenze, Italy (cortigi@geo.unifi.it), (2) VU-University Amsterdam, Faculty of Earth and Life Sciences, Amsterdam, The Netherlands, now at: Faculty of Geosciences, University of Utrecht, Utrecht, The Netherlands, , (3) Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Firenze, Italy, (4) National Oceanographic Centre, Southampton, United Kingdom

Oblique rifting in the central and northern Main Ethiopian Rift (MER) has resulted in a complex structural pattern characterized by two differently oriented fault systems: a set of NE-SW-trending boundary faults and a system of roughly NNE-SSW-oriented fault swarms affecting the rift floor (Wonji faults). Boundary faults formed oblique to the regional extension vector, likely as a result of the oblique reactivation of a pre-existing deep-seated rheological anisotropy, whereas internal Wonji faults developed sub-orthogonal to the stretching direction. Previous works have successfully reconciled this rift architecture and fault distribution with the long-term plate kinematics; however, at a more local scale, fault-slip and earthquake data reveal significant variations in the orientation the minimum principal stress and related fault-slip direction across the rift valley. Whereas fault measurements indicate a roughly N95°E extension on the axial Wonji faults, a N105°E to N110°E directed minimum principal stress is observed along boundary faults. Both fault-slip data and analysis of seismicity indicate a roughly pure dip-slip motion on the boundary faults, despite their orientation (oblique to the regional extension vector) should result in an oblique displacement.

To shed light on the process driving the variability of data derived from fault-slip (and seismicity) analysis we present crustal-scale analogue models of oblique rifting, deformed in a large-capacity centrifuge by using materials and boundary conditions described in several previous modeling works. As in these previous works, the experiments show the diachronous activation of two fault systems, boundary and internal, whose pattern strikingly resemble that observed in previous lithospheric-scale modeling, as well as that described in the MER. Internal faults arrange in two different, en-echelon segments connected by a transfer zone where strike-slip displacement dominates. Whereas internal faults develop roughly orthogonal to the extension direction, boundary faults form oblique to the imposed stretching vector: as a group, the faults follow the rift trend, controlled by a pre-existing weak anisotropy, but individually they form oblique to both the rift margin and the extension vector. Detailed analysis of fault displacements suggest that whereas the average displacement on single internal faults is consistent with the imposed direction of extension, slip on boundary faults does not parallel this direction; the average motion on these faults is orthogonal to the faults, resulting in a roughly pure dip-slip motion. This gives rise to a marked difference in fault-slip direction between internal faults (where slip orientation follow the regional extension) and boundary faults (where displacement is oblique to the "regional" extension). A similar scenario is observed for the reconstructed direction of the minimum principal stress that follows the regional stress field within the rift and is re-oriented at rift margins. Minor counterclockwise block rotations accommodate the different slip along the different fault systems.

The model-to-nature striking is striking in terms of fault orientation, stress and slip orientation and its across-axis variations. The analogue models thus allows explaining the across-axis variability observed in natural fault-slip and earthquake data. Modeling results support that boundary faults form in response to a local stress re-orientation imposed by a deep seated anisotropy: their displacement trajectories deviate from those imposed by the regional extension, resulting in a pure dip-slip motion in an overall oblique rifting kinematics, as observed in other sectors of the East African Rift. Conversely, internal faults -which form later and affect a weaker, more uniform lithosphere- respond directly to the regional extension direction resulting in a fault slip sub-parallel to the Nubia-Somalia motion. Minor counterclockwise block rotations are required to accommodate the difference in slip along the different fault systems.