Geophysical Research Abstracts
Vol. 14, EGU2012-7219, 2012
EGU General Assembly 2012

Analogue models of oblique rifting in a pre-structured lithosphere

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The geometry and kinematics of rifts are strongly controlled by pre-existing structures in the lithosphere. Such features may be present in both the crust and the lithospheric mantle. In the Gulf of Aden oblique rift, the inherited Mesozoic Jiza-Qamar-Gardafui Basin is orthogonal to the direction of the Oligo-miocene extension. This basin has been cut by an oceanic transform and thus divided into the Jiza-Qamar Basin in the northern margin, West of the Alula-Fartak Fracture Zone (AFFZ), and the Gardafui Basin in the southern margin, East of the AFFZ.
It is noteworthy that the AFFZ is the largest fracture zone of the Gulf, i.e. there is a large shift of the oceanic ridges (Aden and Sheba ridges). This configuration suggests that the inherited basin may play a major role in the present-day geometry of Gulf of Aden and in particular in the formation of the major fracture zone.
The analogue models presented in this contribution are brittle-ductile multilayer models and reproduce oblique rifts. The obliquity is modelled with or without an inherited oblique weakness in the lithospheric mantle. We added an elongated thicker brittle mantle, orthogonal to the extension direction, representing the Jiza-Qamar-Gardafui Basin in the Gulf of Aden. The models mainly show en-echelon patterns with orthogonal faults and few rift-parallel faults, suggesting that the influence of the inherited crustal structure is greater than the deeper one.
The final geometry of the inherited basin is sigmoid and experienced, in the centre of the rift, a rotation of 40°. Nevertheless, the location and geometry of the intense thinning of the brittle mantle suggests that breakup would be strongly influenced by the presence of an inherited oblique weakness in the lithospheric mantle. In the "heterogeneous model" (i.e. with an oblique inheritance) the zone of intense thinning is quite straight while in the "homogeneous model" (i.e. without oblique inheritance) it is rather sigmoid.
These results suggest that the presence in the crust of an inherited basin can constitute a barrier for the initiation of the spreading, which would lead in several shifted accretion centres. However, the reconstructed Gulf of Aden (at Ocean-Continent Transition time) displays a very large left-lateral shift of the ridges, which suggests that the AFFZ is probably inherited.