Geophysical Research Abstracts
Vol. 15, EGU2013-5997, 2013
EGU General Assembly 2013

3D numerical models on lithospheric scale: Crustal stress and fault patterns during formation of the Gulf of Aden

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The Gulf of Aden constitutes an ideal natural laboratory to study oblique rifting since numerous structural data are available both onshore and offshore, down to the ocean-continent transition where exhumed mantle is identified. We investigate deformation processes in terms of crustal fault geometries and stress patterns using a 3D numerical thermo-mechanical model. We thereby adopt a novel post-processing method that allows to infer preferred crustal fault orientation from the surface stress tensor. This study is among the first to address oblique extension on lithospheric scale from initial deformation to final break-up.

The Gulf formed under a supposedly N25° trending far field extension with a N165° rift-normal azimuth. Our study suggests a fault evolution in three phases: (1) Large scale intermediate faulting (N95°) occurs during the initial rift phase. (2) Rift-parallel normal faulting takes place at the rift flanks, while simultaneous strike-slip faulting in the central part of the rift system indicates strain partitioning. (3) During continental break-up, displacement-orthogonal as well as intermediate faults occur. We compare our results to previous analogue experiments of oblique rifting on lithospheric scale as well as to the structural evolution of the Gulf. The spatio-temporal fault patterns of the numerical model corroborate and extend conclusions of the analogue experiments and allow further interpretation of the distal margin evolution of the Gulf of Aden.