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Effect of obliquity and structural inheritance on the dynamics of passive margins

Laetitia Le Pourhiet (1), Leila Mezri (1), Dave May (2), and Sylvie Leroy (1)
(1) UPMC, ISTEP, PARIS, France (laetitia.le_pourhiet@upmc.fr), (2) ETH, geophysics,GFD,ZURICH,Switzerland

In order to better understand the formation of oblique margins, we have made use of top of the art 3D thermo-mechanical numerical models. The model set up is based on the well-known offset weak notch model. We impose two offset weak-zones which consist of damaged material, in order to ensure the nucleation of two offset continental rift segments and test how the spacing of the notch influence the structures. This set up is well establish and understood for two layers mechanical models resembling sand box.
Contrarily to previously published studies, we have ensured that the model are large enough (600 km by 1200 km by 200 km) in order to capture the length scale of oblique passive margin. We have made use of massively parallel architecture of pTatin 3D and its efficient non linear solver in order to achieve a 2km cube resolution on the whole mesh and also to run the models for sufficient number of time step to capture the rifting and the effect of the onset of spreading in both the normal and oblique segments.
In order to study the impact of tectonic inheritance on the dynamic of the oblique margins, two different type of crust have been tested. One regular crust which is homogeneous in composition and one post-orogenic crust, in which the lower crust is made of less mafic material, in order to simulate the presence of upper crustal material underplated during a previous orogenic event. This post orogenic crust was previously showed to amplified strain localisation on strike slip segment in 3D and to favour the occurrence of asymmetric detachment structure in extension.
In 2D models, the necking of the mantle is forced to occur in similar direction as the necking of the crust. In 3D, the decoupling between the upper crust and the upper mantle leads to an obliquity between the different level of necking and results without any change in the other all kinematics in the boundary in three main faulting direction with time which reflects jumps of the strength of the lithosphere from one necking level to the other. The time scale and the apparition of different orientation of faults are controlled mainly by the stratification of the lithosphere. Another interesting finding of the model is the systematic asymmetry of spreading at the onset of the oblique margin, its relationship with post-rift deformation in the continental deep offshore and its impact on initial heat flow.
We detail our finding with interpretative cross-sections of models which are compared to natural dataset from the Gulf of Aden and other published section from the Central Atlantic. We discuss in detail the relationship between fault orientation and length of the margin as well as the timing, location and intensity of heat pulse affecting the margin just after the continental break-up.