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Are Extensional Faults Active at Low or High Angles? The Iberia Rifted Margin Example

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During the formation of magma-poor rifted margins, upper lithosphere thinning and stretching is achieved by extensional faulting. To study the kinematic and geometric evolution of these extensional structures either seismic data or field observations are used. These present-day datasets provide the post-kinematic structural configuration, however these do not directly indicate the initial and active fault geometry. This uncertainty has led to an ongoing debate about how faults form and evolve especially within the distal part of rifted margins. To address this problem, it is essential to also consider the physical response of the lithosphere due to fault displacement, in particular the flexural isostatic response, as it strongly controls the architecture of faults and syn-rift sediment deposition as observed on seismic data.

We use the distal part of the Iberia rifted margin as a case-study to investigate whether extensional faults were active at low or high angles and how they may have evolved to their present-day position. The distal part of the Iberia margin shows a present-day sub-horizontal seismic structure referred to as the S reflector, the origin of which has been strongly debated.
To achieve our aim, we use a kinematic forward model (RIFTER), which incorporates the flexural isostatic response to extensional faulting, crustal thinning, lithosphere thermal loads, sedimentation and erosion. Inputs for RIFTER are derived from seismic reflection interpretation and outputs of RIFTER are the prediction of the structural and stratigraphic consequences of recursive sequential faulting and sedimentation.

Using RIFTER we model the tectonic development of Iberia margin along the TGS seismic line. We test and calibrate the model against quantitative target data (top basement and Moho) restored to breakup time.

Modelling results demonstrate that the active geometry of extensional faults in both proximal and distal parts of rifted margins is steep ($\sim$ 50-60°). We show that steep active extensional faults produce present-day inactive sub-horizontal fault surfaces such as the S reflector due to flexural isostatic rotation (i.e. the rolling hinge model). Our modelling results calibrate well against the quantitative target data and reproduce the present-day fault geometry observations of the distal part of Iberia rifted margin.