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Sediment structure, ages and unconformities under different rifting styles from numerical modelling

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Sediments record the history of rifting that leads to the formation of passive margins. However, age control on sedimentary layers is often sparse and the interpretation of the geometrical relationships between syn- and post-kinematic sediments and the underlying deformation, uplift and subsidence is ambiguous. We have developed a 2D visco-elasto-plastic numerical model of extension coupled with a diffusive landscape evolution model. Our landscape evolution model simulates both subaerial and submarine environments.

Here, we show results of margins developed by extending lithospheres of different strengths. The extension of a strong lithosphere proceeds by rapid migration of deformation form both proximal margins into the rift center resulting in symmetric conjugate margins. As deformation migrates, an unconformity, the Rift Migration Unconformity, RMU, forms separating syn-tectonic from sag sequences, whose age predates break-up. The RMU has an erosive character at the crest of the large proximal faulted blocks. Towards the distal margin the syn-tectonic sediments become younger. The edge of both continental margins is characterized by basement highs which are rotated blocks formed by the antithetic faults leading to break-up. Mantle upwelling during break-up leads to back-rotation of the continental basement and syn-tectonic sediments deposited within this phase. This back-rotation imparts a sediment geometry akin to that of seaward dipping reflectors. We call this sedimentary unit, the break-up sequence, BS. The top of the BS is formed by an erosional surface, the break-up unconformity, BU, which separates them from the overlying post-rift sequences. The postrift sequences gently onlap onto this surface and have a typical sag geometry. Towards the continent, the BU laterally joints with the RMU.

In weaker lithosphere scenarios, rift migration typically occurs along a single direction, dragging crustal blocks of the future narrow margin into the future wide margin leading to asymmetric conjugated margins. This mechanism allows for the incorporation of old sediments of the narrow margin into the distal and deep sectors of the wide margin. Thus, the wide margin is characterized by syn-tectonic sediment whose age spans the whole rifting period and generally youngs oceanward. Still, old and shallowly deposited sediment derived from the narrow margin, can be found in the distal sectors above highly thinned crust. Here also an RMU separates syn-kinematic from post-kinematic sag sediments and laterally turns into a BU, but thick breakup sequences are not observed. Conversely, the narrow margin showcases younger syn-kinematic sediments, as older sediments have been cannibalized by the wider margin during rift migration. These syn-kinematic sequences are also thicker as the distal areas are closer to the coast than in the wide margin. Finally, an unconformity separates thick syn-kinematic breakup sequences from post-rift sediments, dating the breakup. In summary, models show that rift migration may play an important role on the sediment age distribution along margins, and on the generation of regional unconformities. These unconformities form previous to breakup. We find that the unconformities only date breakup near its locus and, consequently, we suggest that the term breakup unconformity needs to be revisited.