Geophysical Research Abstracts
Vol. 20, EGU2018-717, 2018
EGU General Assembly 2018

Effects of sedimentation on rift tectonics: Insights from 4D analogue models

Frank Zwaan (1), Guido Schreurs (1), and Jürgen Adam (2)

(1) University of Bern, Institute for Geological Sciences, Tectonics Research Group, Bern, Switzerland (frank.zwaan@geo.unibe.ch), (2) Royal Holloway, University of London, Department of Earth Sciences, Egham, UK

Surface processes are known to affect tectonics. In rift systems for instance, syn-tectonic erosion and sedimentation may prolong fault activity and increase rift subsidence (Burov & Poliakov, 2001), while suppressing salt diapirism (Brun & Fort 2008) and causing rifting to shift to a narrow rifting mode (Bialas & Buck 2009). These insights come mostly from modelling studies, which have predominantly been based on 2D simulations. Here, we present a 3D assessment of the influence of sedimentation on rift tectonics by means of analogue models, analysed with state-of-the-art 4D X-ray computed tomography (CT) methods and digital volume correlation (DVC) techniques.

Our set-up involves a foam/plexiglass base that causes distributed extension in the overlying model materials: a sand layer for the brittle upper crust and a viscous sand/silicone mixture for the ductile lower crust. Pre-described weaknesses serve as inherited structures, controlling the location of graben structures. We apply syn-rift sediments by filling in the developing rift basins with sand at fixed time steps. Models are run either with sedimentation or without to allow a comparison.

Top view results suggest that large-scale structures are quite similar with or without sedimentation. However, CT-data reveals that rift-internal structures undergo a quite different evolution when sedimentation is applied. The extra sediment loading in the rift basin prevents the viscous sand/silicone layer from isostatic rising and the rift wedge actually sinks into the viscous seed below, causing important amounts of deformation there. Sedimentation significantly affects the type of faulting as well, by localizing deformation along large fault structures, in contrast to the distributed faulting style when sediments are absent. The DVC analysis reveals out-of-plane motion of material, as well as distinct differences between brittle and viscous behaviour, and allows a unique quantification of internal deformation. Finally, our models suggest that syn-rift sedimentation may even postpone continental break-up.

References:

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