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How oblique extension and structural inheritance control rift segment linkage: Insights from 4D analogue models

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INTRODUCTION

During the early stages of rifting, rift segments may form along non-continuous and/or offset pre-existing weaknesses. It is important to understand how these initial rift segments interact and connect to form a continuous rift system. A previous study of ours (Zwaan et al., in prep) investigated the influence of dextral oblique extension and rift offset on rift interaction. Here we elaborate upon our previous work by using analogue models to assess the added effects of 1) sinistral oblique extension as observed along the East African Rift and 2) the geometry of linked and non-linked inherited structures.

METHODS

Our set-up involves a base of foam and plexiglass that forces distributed extension in the overlying model materials: a sand layer for the brittle upper crust and a viscous sand/silicone mixture for ductile lower crust. A mobile base plate allows lateral motion for oblique extension. We create inherited structures, along which rift segments develop, with right-stepping offset lines of silicone (seeds) on top of the basal viscous layer. These seeds can be connected by an additional weak seed that represents a secondary inherited structural grain (model series 1) or disconnected and laterally discontinuous (over/underlap, model series 2). Selected models are run in an X-ray computer topographer (CT) to reveal the 3D evolution of internal structures with time that can be quantified with particle image velocitmetry (PIV) techniques.

RESULTS

Models in both series show that rift segments initially form along the main seeds and then generally propagate approximately perpendicular to the extension direction: with orthogonal extension they propagate in a parallel fashion, dextral oblique extension causes them to grow towards each other and connect, while with sinistral oblique extension they grow away from each other. However, sinistral oblique extension can also promote rift linkage through an oblique- or strike-slip zone oriented almost parallel to the extension direction. This occurs when rifts are laterally sufficiently far apart and local effects probably overrule the far-field stresses. Our CT- and PIV-analyses will reveal this surprising effect in more detail.

The influence of rift-connecting seeds (model series 1) on rift interaction is limited. Only when they are oriented some 30° or more oblique to the extension direction, can they be activated. In most of these cases oblique-slip fault zones (transfer zones) form along the rift-connecting weak zone, linking the rift segments. Transfer zone structures depend on the angle between the seed orientation and extension direction: the higher the angle, the wider the fault zone. However, these observations are only valid under dextral oblique extension conditions; none of our rift-connecting weak zones (connecting right-stepping rift segments) are activated when sinistral oblique extension is applied. Still our models show how structural inheritance can control the orientation and structuration of transfer zones between rift segments that later on might evolve into oceanic transform faults.

REFERENCE

Zwaan, F., Schreurs, G., Naliboff, J., Buiter, S.J.H. (in revision) Insights into the effects of oblique extension on continental rift interaction from 3D analogue and numerical models.