Geophysical Research Abstracts
Vol. 17, EGU2015-3640-1, 2015
EGU General Assembly 2015

The role of mechanical heterogeneities during continental breakup: a 3D lithospheric-scale modelling approach

Guillaume Duclaux (1), Ritske S. Huismans (1), and Dave May (2)

(1) Department of Earth Science, University of Bergen, Bergen, Norway, (2) Department of Earth Sciences, ETH Zürich, Zürich, Switzerland

How and why do continents break? More than two decades of analogue and 2D plane-strain numerical experiments have shown that despite the origin of the forces driving extension, the geometry of continental rifts falls into three categories - or modes: narrow rift, wide rift, or core complex. The mode of extension itself is strongly influenced by the rheology (and rheological behaviour) of the modelled layered system. In every model, an initial thermal or mechanical heterogeneity, such as a weak seed or a notch, is imposed to help localise the deformation and avoid uniform stretching of the lithosphere by pure shear. While it is widely accepted that structural inheritance is a key parameter for controlling rift localisation - as implied by the Wilson Cycle - modelling the effect of lithospheric heterogeneities on the long-term tectonic evolution of an extending plate in full 3D remains challenging.

Recent progress in finite-element methods applied to computational tectonics along with the improved accessibility to high performance computers, now enable to switch from plane strain thermo-mechanical experiments to full 3D high-resolution experiments. Here we investigate the role of mechanical heterogeneities on rift opening, linkage and propagation during extension of a layered lithospheric systems with pTatin3d, a geodynamics modeling package utilising the material-point-method for tracking material composition, combined with a multigrid finite-element method to solve heterogeneous, incompressible visco-plastic Stokes problems.

The initial model setup consists in a box of 1200 km horizontally by 250 km deep. It includes a 35 km layer of continental crust, underlaid by 85 km of sub-continental lithospheric mantle, and an asthenospheric mantle. Crust and mantle have visco-plastic rheologies with a pressure dependent yielding, which includes strain weakening, and a temperature, stress, strain-rate-dependent viscosity based on wet quartzite rheology for the crust, and wet olivine for the mantle. A constant extension rate is imposed on two opposite walls in the horizontal direction; the model' surface evolves freely; an isostatic boundary condition is imposed on the bottom wall. We explore a range of weak notches geometries, as well as the presence of random noise across a central region of the model. We compare the evolution of the geometry of the surface rift segments, their linkage and faults propagation during ongoing extension.

These models allow us to assess the importance of mechanical heterogeneities for controlling passive margin geometries, and to precise the underlying physics governing continental breakup.