Geophysical Research Abstracts
Vol. 19, EGU2017-481, 2017
EGU General Assembly 2017

Analogue modelling of microcontinent formation: a case study from the Danakil Block, southern Red Sea

Nicolas Molnar, Alexander Cruden, and Peter Betts
School of Earth, Atmosphere and Environment, Monash University, Melbourne, Australia (nicolas.molnar@monash.edu)

The kinematic evolution of the Danakil Block is well constrained but the processes responsible for the formation of an isolated continental segment around 13 Ma ago with an independent pole of rotation are still matter of debate.
We performed three-dimensional analogue experiments of rotational continental extension containing a pre-existing linear weakness zones in the lithospheric mantle to investigate the formation of the Red Sea, including the Danakil Block. We imposed a rotational extensional boundary condition that simulates the progressive anticlockwise rotation of the Arabian Plate with respect to the Nubia Plate over the last 13-15 Ma and we simulated the presence of a narrow thermal anomaly related to the northward channelling of Afar plume by varying the viscosity of the model lithospheric mantle.
The results from experiments containing a linear zone of weakness oriented at low angles with respect to the rift axis show that early stages of deformation are characterised by the development of two rift sub-parallel compartments that delimit an intra-rift block in the vicinity of the weak lithosphere boundary zone, which are analogous to the two rift branches that confine the Danakil Block in the southern Red Sea. The imposed rotational boundary condition creates a displacement gradient along the intra-rift block and prevents the nucleation of the early rift compartments to the north of the block, enhancing the formation of an independently rotating intra-rift segment. Comparison with geodetic data supports our modelling results, which are also in agreement with the "crank-arm" model of Sichler (1980. La biellette Danakile: un modèle pour l'évolution géodynamique de l'Afar. Bull. la Société Géologique Fr. 22, 925–933).
Additional analogue models of i) orthogonal extension with an identical lithospheric mantle weakness and, ii) rotational extension with a homogeneous lithosphere (i.e. no lithospheric mantle weakness) show no evidence of developing rotating intra-rift segments and therefore suggest that if these processes had acted diachronously, the Danakil Block would not have formed. Based on the modelling results, we hypothesize that the Danakil Block formed as a result of the interaction between northward rift propagation and a north-northeast-trending mantle weakness zone, associated with anticlockwise rotation of the Arabian Plate and simultaneous northward channelling of the Afar plume.