Geophysical Research Abstracts
Vol. 16, EGU2014-620, 2014
EGU General Assembly 2014

What controls the shallow structure of divergent plate boundaries? Insights from field and modelling data

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The interest in the role of magma in splitting plates at divergent plate boundaries through discrete rifting episodes has been re-invigorated. However, despite the renewed enthusiasm for this topic, the precise mechanism by which the magma affects the geometry, the kinematics, and the temporal evolution of a rift is still poorly understood.
Here we address several of the related issues, focusing on the surface deformation along plate boundaries, and then comparing the observed deformation with the results of analogue models on dike intrusion. We investigated surface deformation at divergent plate boundaries via field surveys in the Neovolcanic Zone of Iceland and the Main Ethiopian Rift, with focus on: 1) single eruptive fissures (Laki and Eldgjá, South Iceland), 2) mature rifts where several diking events have occurred comparatively recently (i.e. Sveinagjá and Krafla in North Iceland and Fantale in Ethiopia) and 3) on fissure swarms where strike-slip component is also present (Vogar and Þingvellir swarms, Southwest Iceland). Systematic measurements of fault and extension-fracture geometries and kinematics were carried out, including the analysis of the morphology of the fault terminations as possible indicators of the propagation direction of the faults. In addition, we conducted measurements across the fossil Álftafjörður dyke swarm, of late Tertiary age, in East Iceland, exposed at a depth of about 1.2 km below the original surface of the rift zone within which the dikes were emplaced. We use this dataset to calculate the crustal dilation due to diking and faulting at depth at 1-2 km. Analogue models are used as a complementary tools to aid understanding of the geometry and the kinematics of dike-induced structures, under systematically varied boundary conditions (intrusion depth, number of dikes per unit length of profile, etc). Laser-scanner and Particle Image Velocimetry (PIV) techniques were used to quantify the surface deformation in the analogue models and to reconstruct the time evolution of the rift-zone development. The field and analogue results make it possible to provide a general model which considers the role of tectonics and magma (diking) in the development of the axial part of divergent plate boundaries.