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A numerical and analogue study of dike ascent in asymmetric continental rift zones

Jana Schierjott (1,2), Francesco Maccaferri (1), Derek Keir (3), Andreas Kemna (2), and Eleonora Rivalta (1)

(1) Deutsches GeoForschungsZentrum Potsdam, Potsdam, Germany , (2) Steinmann-Institut, Rheinische Friedrich-Wilhelms-Universtität Bonn, Bonn, Germany, (3) National Oceanography Centre, University of Southampton, Southampton, United Kingdom

In continental rift zones, tectonic extension is responsible for the creation of deep topographic depressions bordered by large border faults. Volcanism may be distributed within, at the border and outside of the depressions, and the mechanisms controlling this distribution are debated. Recently, Maccaferri et al. (2014) proposed that the reorientation of the principal stresses linked to crustal thinning and overall crustal mass redistribution in rift zones modifies the expected trajectory of ascending magma pockets and plays a fundamental role in the distribution of volcanism at the surface. However, the model does not explain why volcanism is asymmetric in most continental rift zones. The goal of this study is to investigate the relation between the characteristic distribution of volcanism at the surface, the distribution and geometry of magma storage at depth, and the observed geometric asymmetry of the grabens at most rift zones. By using a boundary element model for dike propagation and analogue laboratory experiments we evaluate the ascent path of magmatic dikes in asymmetric continental rifts. We find that introducing asymmetry of various degrees into the models has a huge impact on the modeled location of the surface volcanic activity. In particular, varying model parameters such as the half-graben width and depth and the degree of asymmetry leads to numerous different scenarios, including one-sided volcanic activity when the degree of asymmetry is very high and the half-graben is not too deep. For wider or deeper half-grabens and moderate asymmetry a larger proportion of the magma tends to become arrested as horizontal intrusions at depth.