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Physically-consistent magma pathways in continental rifts

Eleonora Rivalta
GFZ Helmholtz Centre for Geosciences, 2.1, Physics of Earthquakes and Volcanoes, Potsdam, Germany (rivalta@gfz-potsdam.de)

Magmatism and volcanism are fundamental components of all tectonic environments on Earth, and play a particularly crucial role in the evolution of magma-assisted continental rifting. Magmatism alters the rheological behaviour of the lithosphere by building networks of intrusions, thereby modifying how plates accommodate tectonic extension. The geochemical footprint of the eruptive products is affected by both the architecture of magma ascent pathways and by the timescales of magma storage and ascent. Volcanism, the surface manifestation of magmatism, results in the construction of large volcanic edifices or distributed volcanic fields. Volcanism is observed to shift during the lifetime of rift systems, eventually focusing on the rift axis in mature rifts. Surface eruptive vents are fed through complex magma plumbing systems, which we can observe through geophysical imaging.

Geodynamic modelling of the temporal evolution of lithospheric rheology and the magma evolution during ascent and storage demand for physics-based models of ascent pathways that incorporate the time scale of ascent and conditions for arrest. Such physics-based models would help better constrain the parameters of geodynamic codes by providing the tools to compare predicted magma pathways, magma evolution and distribution of volcanism with geological, geophysical and geochemical observations. However, this poses a challenge in linking the ductile deformation of the lithosphere and diking, which occur over vastly different spatial and temporal scales. The stress field has the dominant control on dike pathways and velocity: dikes open perpendicular to the axis of least compression to minimize work against the elastic stress field. Thus, an accurately calibrated stress field is fundamental for physically-consistent magma pathways. The stress field in the lithosphere evolves due to changing far-field stresses, new magmatic intrusions, growing surface loads, formation of basins, erosion and sedimentation; how can these be properly incorporated in geodynamic models? What rules do dikes follow when they propagate in a stressed medium? In this talk, I will present an evaluation of the dominant factors affecting the stress field, and propose guidelines for a physically consistent incorporation of magma pathways in geodynamic models.