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Deep magmatism alters and erodes lithosphere and facilitates decoupling of Rwenzori crustal block

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The title is the answer to the initiating question "Why are the Rwenzori Mountains so high?" posed at the EGU 2008. Our motivation origins in the extreme topography of the Rwenzori Mountains. The strong, cold proterozoic crustal horst is situated between rift segments of the western branch of the East African Rift System. Ideas of rift induced delamination (RID) and melt induced weakening (MIW) have been tested with one- and two-phase flow physics.

Numerical model parameter variations and new observations lead to a favoured model with simple and plausible definitions. Results coincide in the scope of their comparability with different observations or vice versa reduce ambiguity and uncertainties in model input.

Principle laws of the thermo-mechanical physics are the equations of conservation of mass, momentum, energy and composition for a two-phase (matrix-melt) system with nonlinear rheology. A simple solid solution model determines melting and solidification under consideration of depletion and enrichment. The Finite Difference Method with markers is applied to visco-plastic flow using the streamfunction in an Eulerian formulation in 2D. The Compaction Boussinesq and the high Prandtl number Approximation are employed.

Lateral kinematic boundary conditions provide long-wavelength asthenospheric upwelling and extensional stress conditions. Partial melts are generated in the asthenosphere, extracted above a critical fraction, and emplaced into a given intrusion level. Temperature anomalies positioned beneath the future rifts, the sole specialization to the Rwenzori situation, localize melts which are very effective in weakening the lithosphere.

Convection patterns tend to generate dripping instabilities at the lithospheric base; multiple slabs detach and distort uprising asthenosphere; plumes migrate, join and split. In spite of appearing chaotic flow behaviour a characteristic recurrence time of high velocity events (drips, plumes) emerges. Chimneys of increased enrichment develop above the anomalies and evolve to narrow low viscous mechanical decoupling zones. Deep rooting dynamic forces then affect the surface, showing a vigorous topography.

A geodynamic model, linking magmatism. mantle dynamics and lithospheric extension, qualitatively explains most of observed phenomena. Depending on physical model parameters we cover the whole spectrum from dripping lithospheric base instabilities to the full break off of the mantle lithosphere block below the Rwenzoris.