Magmatic centers and rift segmentation: insights from the Late Quaternary Menengai Caldera, Central Kenya Rift

Simon Riedl1, Daniel Melnick1,2, Geoffrey K Mibe3, Lucy Njue3, and Manfred R Strecker1

1University of Potsdam, Institute of Geosciences, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam, Germany (sriedl@uni-potsdam.de)
2Instituto de Ciencias de la Tierra, Universidad Austral de Chile, 5111430 Valdivia, Chile
3Geothermal Development Company, P.O. Box 100746, 00101 Nairobi, Kenya

In magmatically active continental rifts, crustal deformation is often accompanied by caldera volcanism along the rift axis. These caldera volcanoes help to characterize the spatiotemporal relationship between regional tectonic extension, the development of normal faults, and the role of magmatism during the long-term evolution of continental rifts. In the Kenya Rift, magmatic activity has been focused at regularly spaced Quaternary volcanoes, each located within an extensional sub-basin of the rift. We document the structural characteristics of the c. 36-ka-old Menengai Caldera and adjacent regions located within such a young zone of extension, to gain insight into the role of regional-scale structures and volcanism in a rift zone subjected to oblique extension, and discuss the role of magmatic centers in the context of advanced stages of rift-basin differentiation.

Our field mapping and high-resolution digital surface models in the greater Menengai area located in the Central Kenya Rift show that the interior rift sectors are dominated by NNE-striking Holocene normal faults perpendicular to the regional ESE-WNW extension direction. Inside the caldera, these structures continue, but are overprinted by post-collapse doming and faulting of the magmatic center, resulting in obliquely slipping normal faults bounding a resurgence horst. Radiocarbon dating of faulted units as young as 5 ka cal BP and the paleo-shorelines of a lake formed during the African Humid Period in the Nakuru Basin that we use as strain markers indicate that volcanism and faulting inside and in the vicinity of Menengai must have been sustained during the Holocene.

Our analysis confirms that the caldera is located at the center of an extending rift segment that is kinematically linked with adjacent zones of extension; similar volcano-tectonic relationships apply to virtually all larger volcanic centers in the Kenya Rift. These zones of extension in the inner sectors of the rift are arranged in en échelon patterns and are linked by transfer zones. In contrast to punctiform spreading centers in much more advanced extensional regions (e.g., the Red Sea) normal faulting in the Kenya Rift is not focused at these volcanic centers. We suggest that the magmatic centers in the segmented Kenya Rift are precursors of a more evolved rifting stage, where magmatic centers may constitute nucleation points of faulting in future magma-assisted rifting that will ultimately lead to the final stages of continental break-up.