ABSTRACT

The Magadi rift in southern Kenya formed at ~7 Ma within Proterozoic rocks of the Mozambique orogenic belt, parallel to its contact with the Archean Tanzania craton. The rift is bounded to the west by the ~1600-m-high Nguruman border fault. The rift center is intensely dissected by normal faults, most of which offset ~1.4-0.8 Ma lavas. Current E-W extensional velocities are ~2-4 mm/yr. Published crustal tomography models from the rift center show narrow high velocity zones in the upper crust, interpreted as cooled magma intrusions. Local, surface-wave, and SKS-splitting measurements show a rift-parallel anisotropy interpreted to be the result of aligned melt zones in the lithosphere. Our field observations suggest that recent fault activity is concentrated at the rift center, consistent with the location of the 1998 seismic swarm that was associated with an inferred diking event. Fault zones are pervasively mineralized by calcite, likely from CO_2-rich fluids. A system of fault-fed springs provides the sole fluid input for Lake Magadi in the deepest part of the basin. Many of these springs emanate from the Kordjya fault, a 50-km-long, NW-SE striking, transverse structure connecting a portion of the border fault system (the NW-oriented Lengitoto fault) to the current locus of strain and magmatism at the rift center. Sampled springs are warm (44.4°C) and alkaline (pH=10). Dissolved gas data (mainly N_2-Ar-He) suggests two-component mixing (mantle and air), possibly indicating that fluids are delivered into the fault zone from deep sources, consistent with a dominant role of magmatism to the focusing of strain at the rift center. The Kordjya fault has developed prominent fault scarps (~150 m high) despite being oblique to the dominant ~N-S fault fabric, and has utilized an en echelon alignment of N-S faults to accommodate its motion. These N-S faults show evidence of sinistral-oblique motion and imply a bookshelf style of faulting to accommodate dextral-oblique motion along the Kordjya fault. Fault relationships imply that the NW-SE transverse structures represent recent activity in the rift, and have locally tilted Late Pleistocene sediments. Given the abundance of N-S striking faults in the rift, the tendency for fault activity along transverse features suggests a change in the rifting driving forces that are likely the result of an interplay between strain localization at the rift center, inherited crustal fabric (NW structures in the Mozambique belt), a possible counterclockwise rotation of stress related to interacting rift segments in southern Kenya, and an active hydrothermal fluid regime that facilitates faulting. By connecting the Lengitoto fault to the rift center, the Kordjya fault has effectively caused the Magadi rift to bypass the Nguruman border fault, which has been rendered inactive and thus no longer a contributor to the rifting process