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Extension by dyke intrusion and faulting in Ethiopian Rift magmatic segments

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The opening direction of the Main Ethiopian Rift is now about 15deg counterclockwise from the direction recorded in the Miocene rift border faults. This rotation has resulted in the development of right stepping magmatic segments and Quaternary volcanic chains. The magmatic segments have a variety of structures: fissures, dykes, segmented normal faults, parallel lines of cones and volcanoes which appear to be extended in the current opening direction. The deformation in the area could be used as an example of the transition from continental rifting to sea-floor spreading. Consequently we have undertaken remote sensing studies backed up by fieldwork to understand the structures better and to elucidate the processes operative in the transition to sea-floor spreading.

The segmentation of the faulting was studied from high resolution images

and digital elevation models. A set of faults can be related to the recent opening direction by their orientation and the fact that they cut Quaternary lavas. The segmentation of the younger faults is cleaner than that of the older, rift-border, faults. Additionally the ratios of maximum displacement to segment length are different for the two fault populations. This is an indication that the faults are the result of different mechanics as well as of different kinematics. The segmentation of the younger faults is attributed to faults propagating from depth into a slightly rotated stress field near the surface.

The fissures, dykes and lines of cinder cones are oriented perpendicular to the Quaternary extension direction and indicate that magma intrusion is an important mechanism of extension. The cinder cones, often occurring in parallel lines, are interpreted to be the result of segmentation in the same manner as proposed for the younger faults. The volcanoes all show elliptical shapes of their edifices, craters or calderas. The long

axes of the ellipses are parallel to the recent opening direction of the rift. The elliptical shapes can be regarded as strain indicators and the amounts of finite strain are consistent with opening rates determined from GPS studies and the estimated duration of the younger opening direction. The number of young faults and the accumulated throw on them is insufficient to account for the amount of deformation. It is concluded that dyke intrusion is the dominant process of extension in the Quaternary.