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Why does Victoria rotate? The controls of preexisting lithospheric heterogeneities on microplate rotation, tectonic regime and the stress field in the East African Rift System.

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The Victoria plate in the East African Rift System (EARS) is one of the largest continental microplates on Earth. Victoria is encompassed by the partly overlapping eastern and western EARS branches that follow inherited weaknesses of Proterozoic mobile belts. Multiple lines of evidence unequivocally show that Victoria rotates counterclockwise with respect to Nubia, in striking contrast to its neighboring plates. However, the cause of this distinctive rotation has remained speculative so far.

Using 3D upper-mantle scale numerical models of extension, we investigate the role of preexisting strength heterogeneities in the rotation of a continental microplate. We find that the amount of rotation is primarily controlled by the distribution of (i) stronger zones that transmit the drag of the major plates along the edges of the block and (ii) weaker regions that facilitate the rotation. For right-lateral step-overs, this ‘edge-driven’ mechanism (suggested by Schouten et al. 1993 for oceanic microplates) produces a counterclockwise rotation of the microplate, inducing a clockwise shift of the local extension direction along the overlapping rift branches.

The counterclockwise rotation of Victoria, its rotation pole and its angular velocity are best reproduced in our models if we include preexisting weaknesses that follow the distribution of the mobile belts surrounding the Victoria plate as well as the stronger regions of the Tanzania craton and Turkana depression. Our models show that under regional, north-to-south decreasing E-W extension this rotation results in local extension directions that strike more WNW-ESE. Together with the oblique orientation of the preexisting weaknesses, this leads to predominantly normal faulting oblique to the regional and local extension direction. In the most oblique (45°) section of the western branch, the Tanganyika-Rukwa-Malawi segment, this can produce transient strike-slip faulting, although comparison to stress observations suggests a local stress reorientation, possibly due to smaller-scale inherited mechanical anisotropy (e.g. Morley 2010).

Schouten, H., Klitgord, K. D. and Gallo, D. G. (1993), Edge-driven microplate kinematics. Journal of Geophysical Research 98, B4, 6689–6701.

Morley, C. K. (2010), Stress re-orientation along zones of weak fabrics in rifts: An explanation for pure extension in ‘oblique’ rift segments? Earth and Planetary Science Letters 297, 3–4, 667–673.