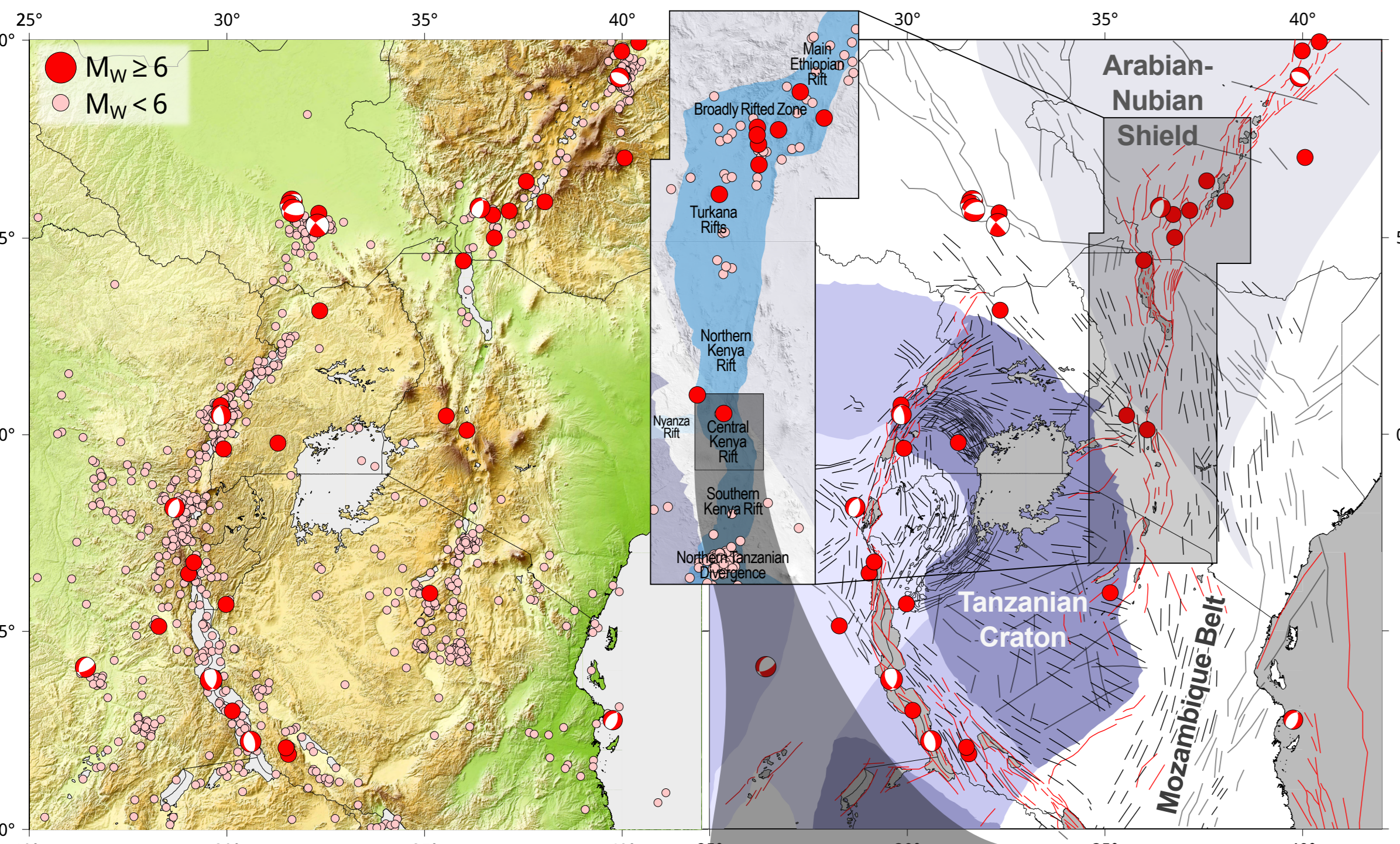


# Inhibited rift evolution at structural kinks: Insights from high-resolution fault mapping in the Central Kenya Rift

Daniel Botha<sup>1</sup>(bthdan019@myuct.ac.za), Alastair Sloan<sup>1</sup>, Beth Kahle<sup>1,2</sup>, Simon Kübler<sup>2</sup> 1 Department of Geological Sciences, University of Cape Town, South Africa  
2 Department of Earth & Environmental Sciences, Ludwig Maximilian University, Germany

## Motivation

**Figure 1** Overview of the basement geology<sup>[1]</sup> and earthquakes of the Eastern Africa Rift System (EARS)<sup>[2][3]</sup>; simplified geology of the study area<sup>[4]</sup>.

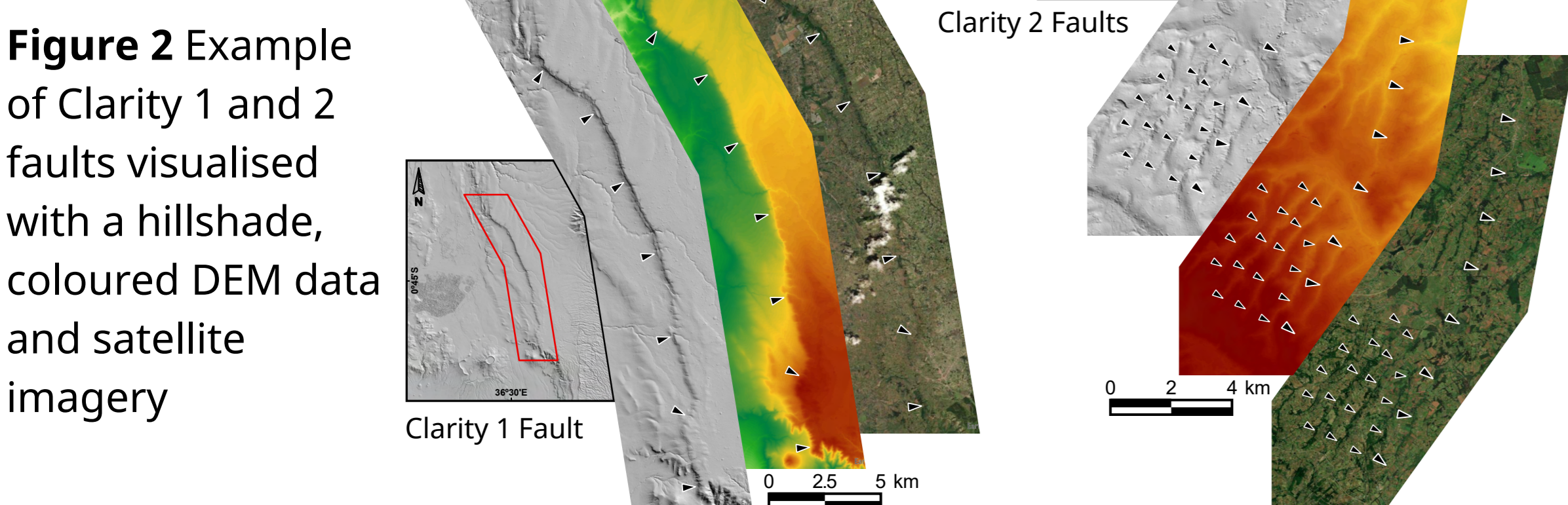


- The EARS kinks at the CKR - how does this affect the modern rifting?
- Despite abundant faulting, major seismicity is generally absent in the Central Kenya Rift (CKR) except for an anomalous  $M_w > 6$  earthquake & aftershock pair in 1928 at the Bogoria kink<sup>[5]</sup>.
- Faulting in the CKR has not been mapped in great detail relative to adjacent rift segments.

**What does the geomorphology of the rift reveal about the tectonics of rift evolution?**

## Data Collection

- Fault scarps were mapped using 12m TanDEM-X Digital Elevation Model<sup>[6]</sup> - fault density, orientations and lengths were analysed
- Cross-sections of the rift reveal rift morphology
• Quaternary extension rates calculated in the intra-rift using lithological ages

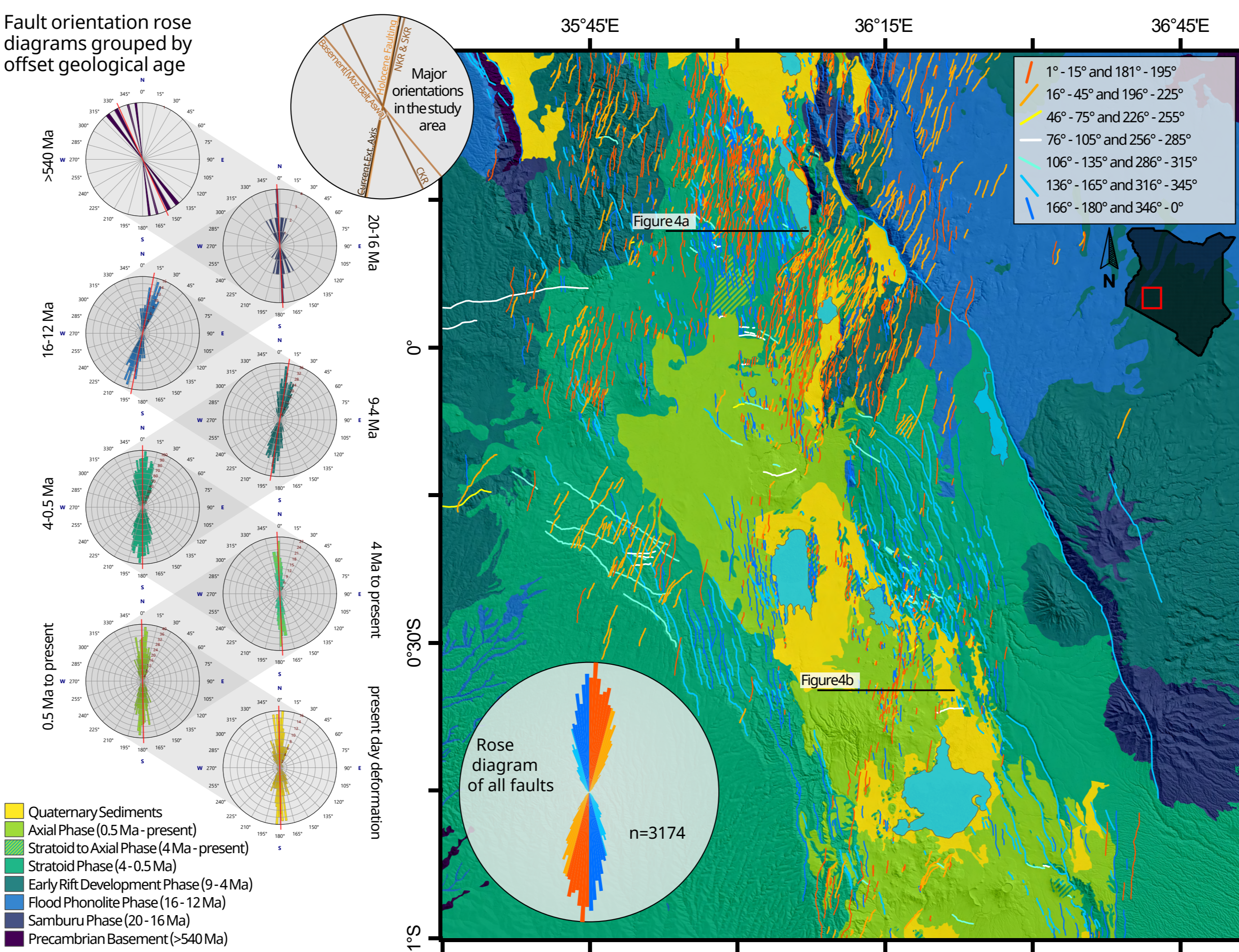


[1] Van Hinsbergen, D. J. J., Butler, S. J. H., Torsvik, T. H., Gains, C. and Webb, S. J. (2011). The Formation and Evolution of Africa: A Synopsis of 3.8 Ga of Earth History. *Geological Society, London, Special Publications*, 357, pp. 1-8. doi: 10.1144/SP357.1 0305-8719/11/357.001  
[2] U.S. Geological Survey Earthquake Catalogue, accessed 27 March 2020, at <https://earthquake.usgs.gov/earthquakes/search/>  
[3] Dziewonski, A. M., T. A. Chou and J. H. Woodhouse (1981). Determination of earthquake source parameters from waveform data for studies of global and regional seismicity. *J. Geophys. Res.*, 86, pp. 2825-2852. doi:10.1029/J086iB04p02825 | Ekström, G., M. Nettles, and A. M. Dziewonski (2012). The global CMT project 2010: Centroid-moment tensors for 13,017 earthquakes. *Phys. Earth Planet. Inter.*, 200-201, pp. 1-9. doi:10.1016/j.pepi.2012.04.002

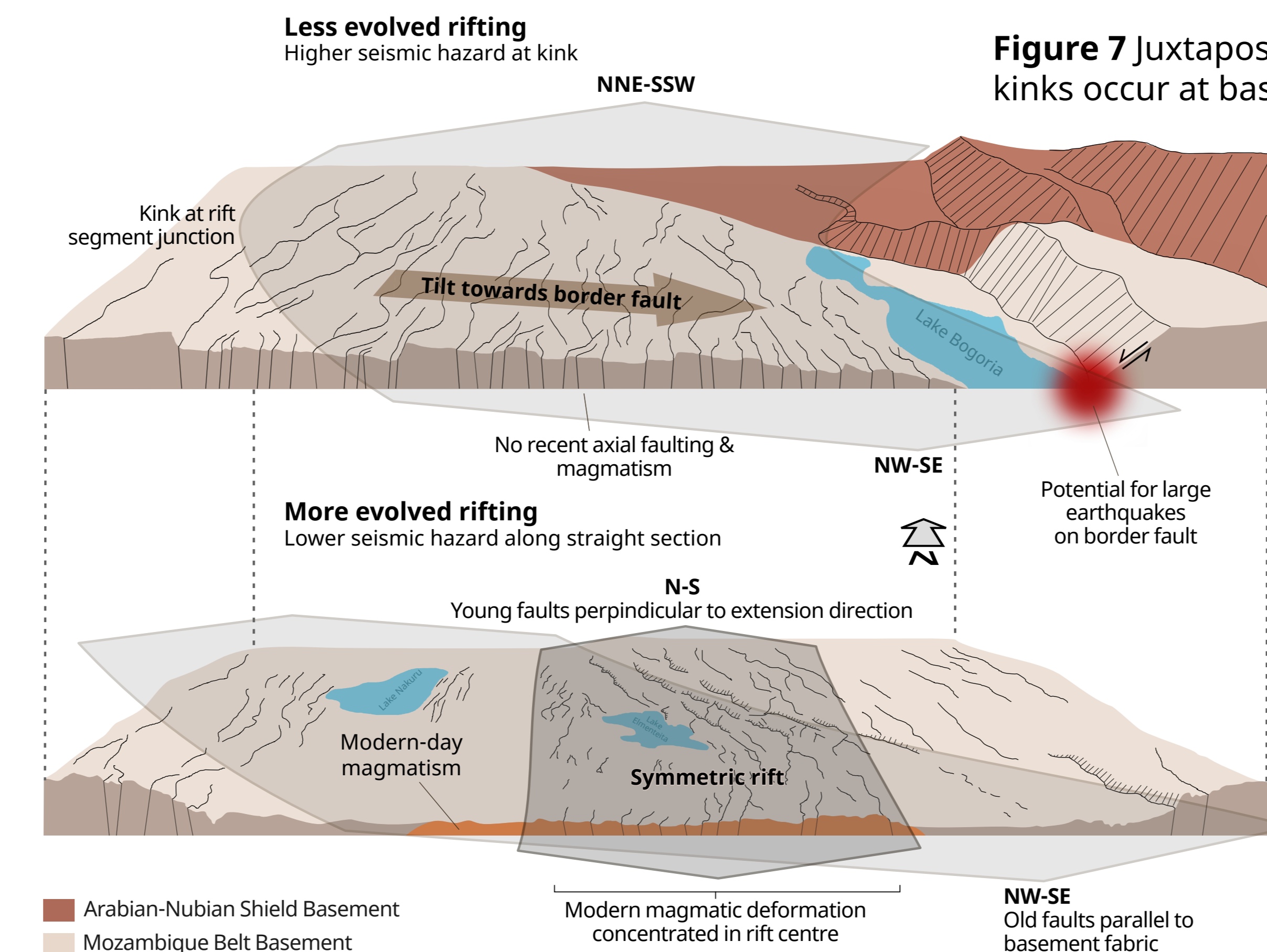
## Results

### 1) Fault Mapping & Rift Orientations

**Figure 3** Faults mapped in the study area coloured according to their orientation. Rose diagrams of fault orientations grouped according to geological ages.



## Conclusions

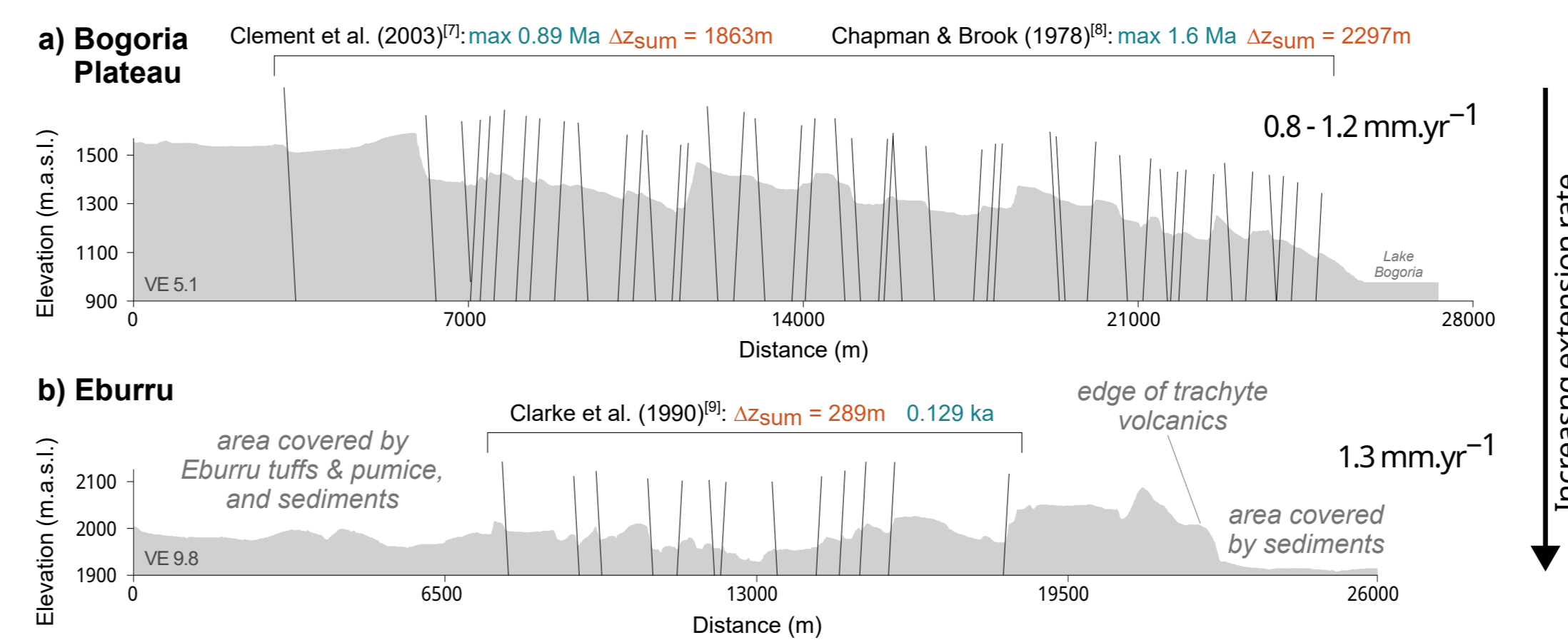


**Figure 7** Juxtaposing rift maturity at rift kinks and along straight segments. Rift kinks occur at basement geology heterogeneities and increase seismic hazard.

- Detailed morphological fault mapping over large areas reveals new tectonic insights.
- All parts of the rift don't evolve equally - rift maturation is slowed at structural kinks.
- Basement structure has a significant effect on the rift evolution rate.
- There is a clear evolution from basement-orientation dominant to extension-direction perpendicular fault orientation over time.
- The delay of rift development at kinks increases seismic hazard by limiting lithospheric thinning, magma input and preventing aseismic spreading. This leads to greater strain concentration on the border fault.

### 2) Quaternary Extension Rates

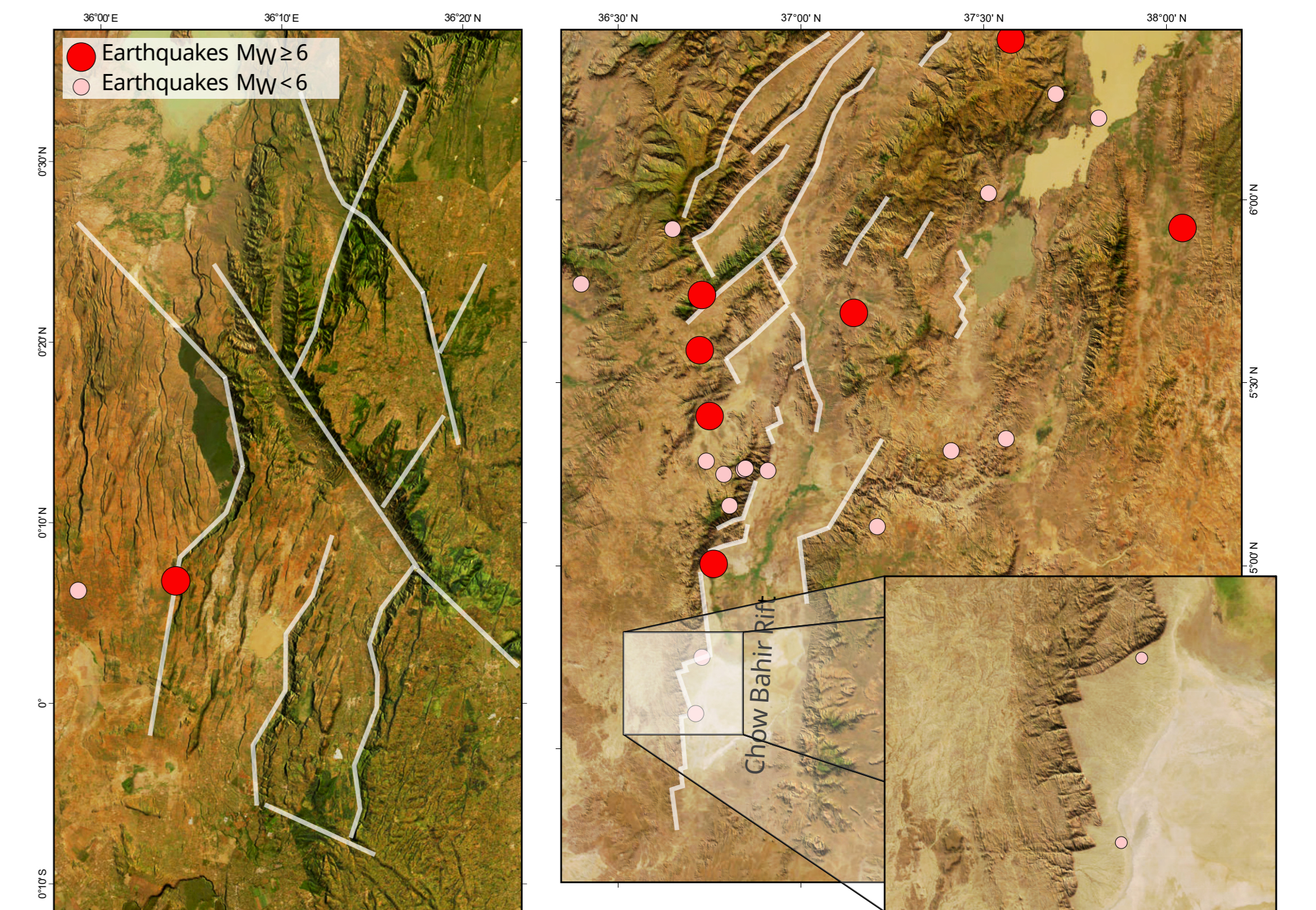
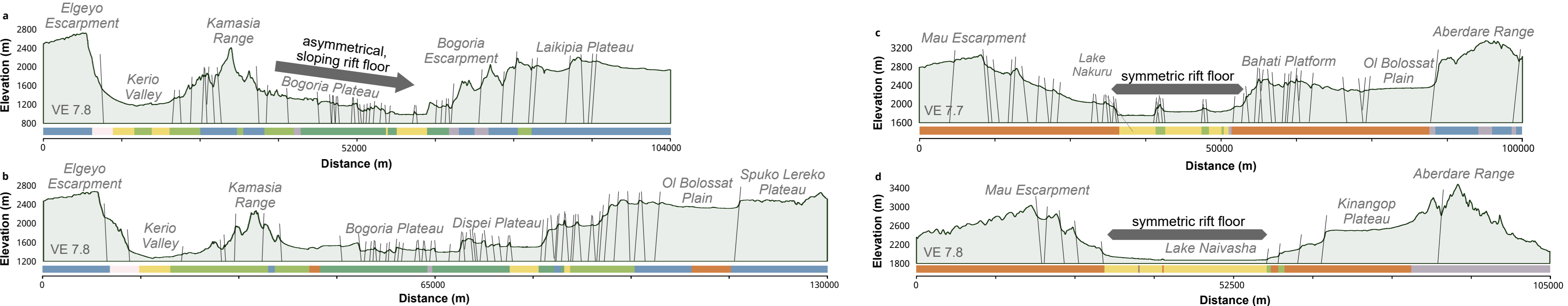
**Figure 4** Rift floor cross-sections of the Bogoria kink and Eburru Volcano (central CKR) for which short-term extension rates were calculated.



**Figure 5** Kolmogorov-Smirnov Test performed on fault lengths. The Central Axial area of the CKR is more mature relative to the Bogora Area.

### 4) Rift Cross-sectional Morphology

**Figure 6** Cross-sections of the CKR. Rift floor morphology becomes more symmetrical southwards.



**Figure 8** Similarity of Bogoria area to Chow Bahir basin in the Broadly Rifted Zone. This area appears to be experiencing similar stunted maturation with large earthquakes and little intra-rift axial magmatism and faulting.

[4] Guth, A.L., 2013. Spatial and temporal evolution of the volcanics and sediments of the Kenya Rift. PhD thesis, Michigan Technological University.  
[5] Ambraseys, N.N. (1991). Earthquake hazard in the Kenya Rift: the Subukia earthquake 1928. *Geophysical Journal International*, 103(1), pp. 253-269.  
[6] Zink, M., Moreira, A., Bachmann, M., Razzoli, P., Fritz, T., Hajsek, I., ... and Wessell, B. (2017). The global TanDEM-X DEM - A unique data set. In 2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), pp. 906-909. IEEE.  
[7] Clément, J.P., Caroff, M., Hémond, C., Tercelin, J.J., Bollinger, C., Guillou, H. and Cotton, J. (2003). Pleistocene magmatism in a lithospheric transition area: petrogenesis of alkaline and peralkaline lavas from the Baringo-Bogoria Basin, central Kenya Rift. *Canadian Journal of Earth Sciences*, 40(9), pp. 1239-1257.  
[8] Chapman, G.R. and Brook, M. (1978). Chronostratigraphy of the Baringo basin, Kenya. *Geological Society, London, Special Publications*, 6(1), pp. 207-223.  
[9] Clarke, M.C.G., Woodhall, D.G., Allen, D. and Darling, G. (1990). Geological, volcanological and hydrogeological controls on the occurrence of geothermal activity in the area surrounding Lake Naivasha, Kenya. *Ministry of Energy, Kenya*.