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Active rifting along the Zambian African Rift System - evidence from $^3He/^4He$ across the Kafue, Luangwa and Luano rifts

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The southwestern section of the African Rift System, incorporating the Luangwa, Luano, and Kafue Rifts, was once thought to be inactive. Recent work, focusing on plate modelling and identifying active faults [1-3], shows an active rift system. Active rift systems are often associated with magmatic degassing and geothermal springs. The Zambian rift segments are no different [4]. Geothermal springs occur along major fault zones within the Zambian rift. However, there are also geothermal springs located in proximal apparent quiescent areas of the crust [4].

We build on the study by Karolytė et al.,[5] which used helium and carbon isotope data from geothermal springs to identify evidence of mantle melting and degassing along the Kafue Rift. We collected samples from a further 17 geothermal springs both within and proximal to the rifts. We show that a mantle helium signal is only found within the rift systems proximal to deep faults. Plotting $^3He/^4He$ against $^4He/^{20}Ne$ corrects for air helium additions and identifies a common maximum $^3He/^4He$ ratio of 0.14Ra (Ra in air = $1.4x10^{-6}$). Geothermal springs proximal but external to the rift have a crustal end-member helium isotopic composition of 0.02Ra. Percent level helium concentrations are found both within and external to the rift.

Our results reveal variations in degassing in-rift and off-rift and confirm that the Karolytė et al.,[5] observations of mantle signatures in the Kafue rift can be extended to the Luangwa and Luano rift segments. The entire Zambian rift, which extends for over 1000 kilometres, appears to be producing heat and degassing volatiles that contain a significant mantle component, best explained by mantle melting during active extension. The diversity of springs sampled allows the comparison of geochemical signatures between the rift and proximal settings to develop an understanding of what drives such consistent $^3He/^4He$ input over such a large geographical area, and the source of heat driving proximal geothermal springs that contain no mantle signature.

[1]Daly et al.,(2020). *Geochemistry, Geophysics, Geosystems*, 21(6).

[2]Wedmore et al.,(2021). *Geophysical Research Letters*, 48(17).

[3]Wedmore et al.,(2022). *Solid Earth*, 13(11).

[4]Legg, C.(1974). *Economic Report of the Geologic Survey No. 50*

[5]Karolytė et al.,(submitted)