EGU25-6181, updated on 21 May 2025
https://doi.org/10.5194/egusphere-egu25-6181
EGU General Assembly 2025

Afar triple junction fed by single asymmetric mantle upwelling

Emma J. Watts[1,2], Rhiannon Rees[2], Philip Jonathan[3,4], Derek Keir[2,5], Rex N. Taylor[2], Melanie Siegburg[6], Emma L. Chambers[7], Carolina Pagli[8], Matthew J. Cooper[2], Agnes Michalik[2], J. Andrew Milton[2], Thea K. Hinks[2], Ermias F. Gebru[9,10], Atalay Ayele[10], Bekele Abebe[10], and Thomas M. Gernon[2]

[1]Geography Department, Swansea University, Singleton Park, Sketty, Swansea SA2 8PP
[2]School of Ocean and Earth Science, University of Southampton, National Oceanography Centre, European Way, Southampton, SO14 3ZH, UK
[3]Department of Mathematics and Statistics, Lancaster University, Lancaster, UK
[4]Shell Research Limited, London, UK
[5]Dipartimento di Scienze della Terra, Università degli Studi di Firenze, Firenze 50121, Italy
[6]Landesamt für Geologie und Bergwesen Sachsen-Anhalt, Halle (Saale), Germany
[7]School of Cosmic Physics, Geophysics Section, Dublin Institute for Advanced Studies, Dublin, Ireland
[8]Dipartimento di Scienze della Terra, Università di Pisa, Pisa 56126, Italy
[9]Department of Geosciences, University of Fribourg, Fribourg, Switzerland
[10]School of Earth Sciences, Addis Ababa University, Addis Ababa, Ethiopia

The arrival of upwellings within the mantle from Earths deep interior are commonly observed worldwide, but their role in driving volcanism during continental breakup has long been debated. Given that only a small fraction of Earth's upwellings are situated under continents and a limited number of them are associated with active continental rifting, our understanding of these processes remains incomplete.

Here, we investigate the interplay between continental breakup and mantle upwellings using the classic magma-rich continental rifting case study of the Afar triple junction in East Africa. Some studies previously proposed that the region is underlain by mantle upwelling(s), yet others argue for limited involvement of mantle plumes. Several discrete segments of the rift have been studied in terms of magma petrogenesis. However, until now, a paucity of high-precision geochemical data across the broader region has hampered our ability to test the models and evaluate the spatial characteristics and structure of this upwelling in the recent geologic past.

Within this study, we present extensive new geochemical and isotopic data spanning the region and integrate these with existing geochemical and geophysical datasets shedding light on the spatial characteristics of the mantle beneath Afar. By combining geophysics and geochemistry using statistical approaches, our multi-disciplinary approach shows that Afar is underlain by a single, asymmetric heterogeneous mantle upwelling. Our findings not only validate the heterogeneous characteristics of mantle upwellings, but demonstrates their susceptibility to the dynamics of the overriding plates. This integrated approach yields valuable insights into the spatial

complexity of mantle upwellings.