Scientists detect deep Earth pulses beneath Africa

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Fresh basaltic lava flows in the region of Afar, Ethiopia. Credit: Dr. Derek Keir, University of Southampton/ University of Florence

Research led by Earth scientists at the University of Southampton has uncovered evidence of rhythmic surges of molten mantle rock rising

from deep within the Earth beneath Africa. These pulses are gradually tearing the continent apart and forming a new ocean.

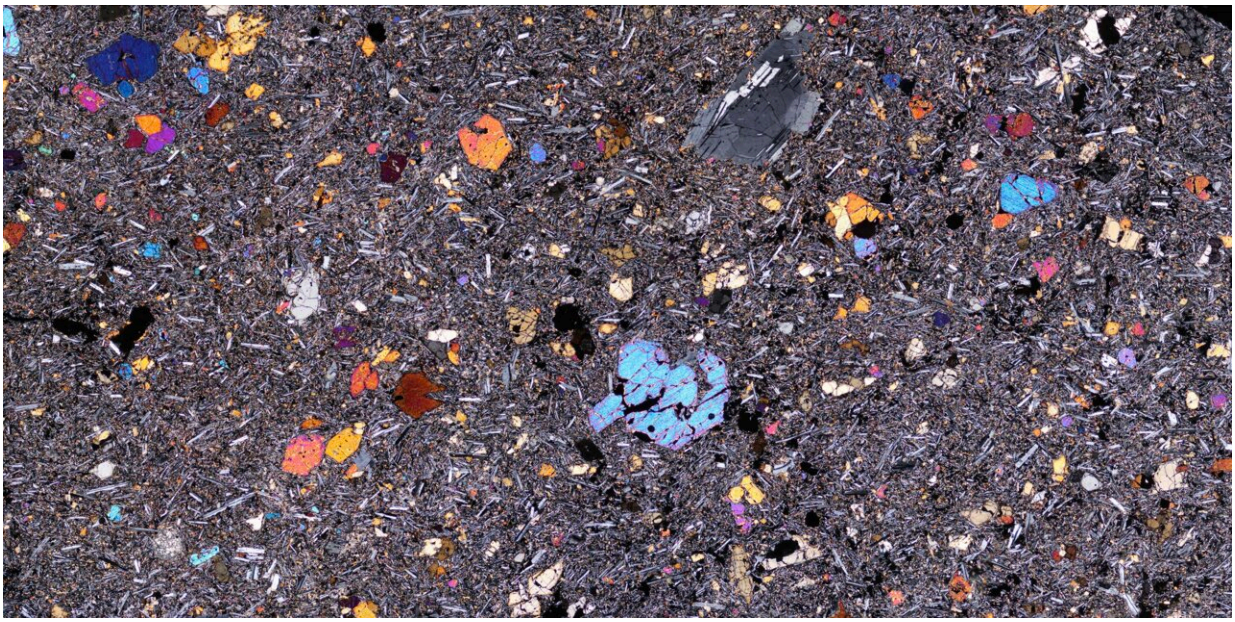
The findings, published in *Nature Geoscience*, reveal that the Afar region in Ethiopia is underlain by a plume of hot mantle that pulses upward like a beating heart.

The team's discovery reveals how the upward flow of hot material from the deep mantle is strongly influenced by the tectonic plates—the massive solid slabs of Earth's crust—that ride above it.

Over millions of years, as tectonic plates are pulled apart at rift zones like Afar, they stretch and thin—almost like soft plasticine—until they rupture. This rupturing marks the birth of a new ocean basin.

Lead author Dr. Emma Watts, who conducted the research at the University of Southampton and is now based at Swansea University, said, "We found that the mantle beneath Afar is not uniform or stationary—it pulses, and these pulses carry distinct chemical signatures. These ascending pulses of partially molten mantle are channeled by the rifting plates above. That's important for how we think about the interaction between Earth's interior and its surface."

The project involved experts from 10 institutions, including the University of Southampton, Swansea University, Lancaster University, the Universities of Florence and Pisa, GEOMAR in Germany, the Dublin Institute for Advanced Studies, Addis Ababa University, and the GFZ German Research Center for Geosciences.



Microscope image of a thin sliver of one of the volcanic rocks from Afar, Ethiopia. Credit: Dr. Emma Watts, University of Southampton/ Swansea University

A window into Earth's interior

The Afar region is a rare place on Earth where three tectonic rifts converge: the Main Ethiopian Rift, the Red Sea Rift, and the Gulf of Aden Rift.

Geologists have long suspected that a hot upwelling of the mantle, sometimes referred to as a plume, lies beneath the region, helping to drive the extension of the crust and the birth of a future ocean basin. But until now, little was known about the structure of this upwelling, or how it behaves beneath rifting plates.

The team collected more than 130 volcanic rock samples from across the Afar region and the Main Ethiopian Rift.

They used these, plus existing data and advanced statistical modeling, to investigate the structure of the crust and mantle, as well as the melts that it contains.

Their results show that underneath the Afar region is a single, asymmetric plume, with distinct chemical bands that repeat across the rift system, like geological barcodes. These patterns vary in spacing depending on the tectonic conditions in each rift arm.

Tom Gernon, Professor of Earth Science at the University of Southampton and co-author of the study, said, "The chemical striping suggests the plume is pulsing, like a heartbeat. These pulses appear to behave differently depending on the thickness of the plate, and how fast it's pulling apart. In faster-spreading rifts like the Red Sea, the pulses travel more efficiently and regularly like a pulse through a narrow artery."

Active lava flows spilling out of the Erta Ale volcano in Afar, Ethiopia. Credit: Dr. Derek Keir, University of Southampton/ University of Florence

Professor Tom Gernon sampling volcanic deposits at Boset Volcano in the Main Ethiopian Rift. Credit: Prof Thomas Gernon, University of Southampton

Looking out into the Main Ethiopian Rift, taken at Boset Volcano in Ethiopia. Credit: Prof Thomas Gernon, University of Southampton

Fresh basaltic lava flows in the region of Afar, Ethiopia. Credit: Dr. Derek Keir, University of Southampton/ University of Florence

A succession of volcanic deposits at Boset Volcano in the Main Ethiopian Rift. Credit: Prof Thomas Gernon, University of Southampton

Links to volcanism and earthquakes

This new research shows that the mantle plume beneath the Afar region is not static, but dynamic and responsive to the tectonic plate above it.

Dr. Derek Keir, Associate Professor of Earth Science at the University of Southampton and the University of Florence, and co-author of the study, said, "We have found that the evolution of deep mantle upwellings is intimately tied to the motion of the plates above. This has profound

implications for how we interpret surface volcanism, earthquake activity, and the process of continental breakup."

"The work shows that deep mantle upwellings can flow beneath the base of tectonic plates and help to focus volcanic activity to where the tectonic plate is thinnest. Follow-on research includes understanding how and at what rate mantle flow occurs beneath plates," added Keir.

Dr. Watts added, "Working with researchers with different expertise across institutions, as we did for this project, is essential to unraveling the processes that happen under Earth's surface and relate it to recent volcanism. Without using a variety of techniques, it is hard to see the full picture, like putting a puzzle together when you don't have all the pieces."

More information: Mantle upwelling at Afar triple junction shaped by overriding plate dynamics, *Nature Geoscience* (2025). DOI: 10.1038/s41561-025-01717-0

Provided by University of Southampton