

Scientists detect deep carbon emissions associated with continental rifting

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Lake Magadi, an alkaline lake that contains soda, is located in southern Kenya.

Scientists at the University of New Mexico conducted research to effectively study carbon emissions through fault systems in the East African Rift (EAR) in an effort to understand carbon emissions from the Earth's interior and how it affects the atmosphere.

Carbon dioxide (CO₂) from Earth's interior is thought to be released into the atmosphere mostly via degassing from active volcanoes. CO₂

can also escape along faults away from active volcanic centers. However, such tectonic degassing is poorly constrained, and to date has been largely unmeasured.

The research, funded by the National Science Foundation (NSF) Tectonics Program, is directed by UNM Professor Tobias Fischer and is part of a continued effort to better quantify global emissions of CO₂ from the Earth's interior.

Led by UNM Ph.D. student Hyunwoo Lee, the lead author of the paper titled "Massive and prolonged deep [carbon emissions](#) associated with continental rifting" published in *Nature Geoscience*, the scientists set out to measure diffuse CO₂ flux from the Magadi-Natron basin in the East African Rift (EAR) between Kenya and Tanzania.

"CO₂ is the main source of the greenhouse effect," said Lee. "Natural carbon emissions come from volcanoes and are derived from magma. Mostly, people have thought the major sources of magmatic emissions have come through active volcanic events. Our research is the first attempt to quantify magmatic CO₂ gases from non-volcanic and continental rift regions."

The EAR is the world's largest active continental rift and is comprised through distinct western and eastern sectors. Several active volcanoes emit large volumes of CO₂ including Nyiragongo in the Congo and Oldoinyo Lengai in Tanzania. Additionally, significant amounts of CO₂ are stored in large anoxic lakes in this region.

"To measure diffuse CO₂ flux, we used an EGM-4 CO₂ gas analyzer with a cylindrical accumulation chamber," Lee said. "The gas samples were then diverted from the chamber into pre-evacuated glass vials in order to carry out gas chemistry and carbon isotope analyses in our laboratories at UNM."



Lead author Hyunwoo Lee gathers samples at the East African Rift with some of the native wildlife in the background.

Additional gas samples collected along fault zones in the Magadi-Natron basin showed an elevated CO₂ flux and provided further evidence that faults act as permeable pathways facilitating the ascent of deeply-derived CO₂. This particular study area represented a conservative 10 percent of the entire Natron-Magadi region.

The data from all samples were then compared to gas data from the active volcano Oldoinyo Lengai and found to have carbon isotope compositions that indicated a strong magmatic contribution to the observed CO₂.

James Muirhead, a doctoral student at the University of Idaho, focused on the relationship between the structure of the faults and the gas they

released, including what controls carbon dioxide flow from depth and what volumes of gas the faults release.

Combing the CO₂ flux data and fault structures with carbon isotopic analyses, conducted at UNM's Center for Stable Isotopes (CSI), the research generated interesting data allowing the scientists to quantify the massive and prolonged deep carbon emissions through faults.

"We found that about 4 megatonnes per year of mantle-derived CO₂ is released in the Magadi-Natron Basin, at the border between Kenya and Tanzania," Lee said. "Seismicity at depths of 15 to 30 kilometers detected during our project implies that extensional faults in this region may penetrate the lower crust." Thus, the ultimate source of the CO₂ is the lower crust or the mantle, consistent with the carbon isotopes measured in the gas.

The findings suggest that CO₂ is transferred from upper mantle or lower crustal magma bodies along these deep faults. Extrapolation of the measurements to the entire Eastern branch of the rift system implies a huge CO₂ flux 71 megatonnes per year, comparable to emissions from the entire global mid-ocean ridge system of 53 to 97 megatonnes per year.

"It is often argued that large volcanic eruptions instantly transfer significant amounts of CO₂ and other gases into the atmosphere where they affect the global climate over a few years," Fischer said. "On human time-scales, continental rifting is extremely slow at spreading rates of mm's per year but on geologic time-scales, rifting can be considered a catastrophic continental break-up event."

"Widespread continental rifting and super-continent breakup could produce massive, long-term CO₂ emissions and contribute to prolonged greenhouse conditions like those of the Cretaceous," Lee added.

Large-scale rifting events could play a previously unrecognized role in heating up the atmosphere and perhaps ending global ice ages.

"It is important to note, however, even when including the newly quantified CO₂ emissions from the EAR in the global CO₂ budget, natural emissions are dwarfed by emissions from fossil fuel use, which were 36 giga tons of CO₂ in 2013," Fischer said. "This comparison shows that humanity is currently emitting the equivalent of 500 East African Rifts in CO₂ to the atmosphere per year."

Cindy Ebinger, a professor of earth and environmental sciences at the University of Rochester, coordinated field activities near the Kenya-Tanzania border and analyzed earthquake patterns within the rift zone.

"The unique coupling of gas chemistry and earthquake studies made it possible to discover the escape of gas along permeable fault zones that serve as conduits to the surface," said Ebinger. "The work also allowed us to document the process of crustal growth through the formation of igneous rocks from magma in early-stage continental rift zones."

Lee says the scientists plan to measure diffuse CO₂ flux and collect gas samples from other areas in the EAR to better constrain how much it releases deep carbon to try to better constrain how much deeply derived CO₂ comes from natural systems.

"Because some geological settings, for example fault zones, have never been paid attention to, global CO₂ flux from natural systems are obviously underestimated," he said. "Although there are still many ongoing studies to find better ways to quantify CO₂ flux from [active volcanoes](#), we expect this study to trigger more research on CO₂ output from non-volcanic areas."

More information: Hyunwoo Lee et al. Massive and prolonged deep

carbon emissions associated with continental rifting, *Nature Geoscience* (2016). [DOI: 10.1038/ngeo2622](https://doi.org/10.1038/ngeo2622)

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