Geologists publish new details about evolution of East African Rift Valley

December 21 2016

A view of the Malawi coast in Eastern Africa. Credit: Christopher Scholz

Researchers in the College of Arts and Sciences have published new details about the evolution of the East African Rift (EAR) Valley, one of the world's largest continental rift zones.

Christopher Scholz, professor of Earth sciences, and a team of students and research staff, have spent the past year processing and analyzing data acquired in 2015 from Lake Malawi, the result of a multinational research effort sponsored by the National Science Foundation (NSF). By studying the interplay of sedimentation and tectonics, they have confirmed that rifting—the process by which the Earth's tectonic plates move apart—has occurred slowly in the lake's central basin over the past 1.3 million years, utilizing a series of faults many millions of years older.

Scholz says the nature of the tectonic activity is attributed to a strong, cold lithosphere and to strain localization on faults that occurred millions of years earlier, when the basin formed. The Earth's lithosphere includes the crust and uppermost mantle.

The team's findings are the subject of an article in the *Journal of Structural Geology* (Elsevier, 2016), which Scholz co-authored with lead author and Ph.D. candidate Tannis McCartney G'17.

"We collected data during a month-long research cruise aboard a converted container ship on Lake Malawi," says Scholz, a leader in sedimentary basin analysis of extensional systems. "For the first time, a crustal-scale seismic source was deployed on an African lake, revealing tantalizing, new details about the stratigraphic and structural evolution of the East African Rift System."

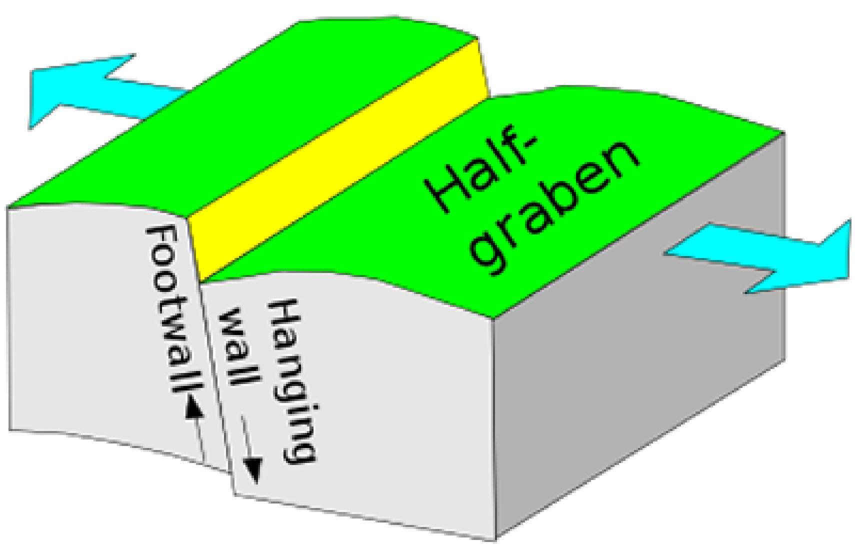
Tectonic plates are huge slabs of crust and mantle that are constantly in motion, often crashing into, grinding against or falling beneath one another, causing earthquakes in the process. When this happens, the plates tear apart to form a lowland region known as a rift valley.

One of the world's largest rift valleys is the EAR, approximately 3,700 miles long and 30-40 miles wide. The rift valley is so big that it is slowly splitting Africa in two. The larger Nubian tectonic plate encompasses most of the continent, whereas the smaller Somali plate carries the Horn of Africa.

"The EAR is considered the cradle of humanity," Scholz says. "During its formation more than 25 million years ago, the region underwent considerable rifting, altering its rivers, lakes and climate, and setting the stage for the evolution of primates and humans."

Within the EAR are two valley systems, one of which is the Western Rift. This system is home to a chain of enormous lakes and wetlands, including Lake Malawi. Bordered by Malawi, Tanzania and Mozambique, Lake Malawi has a surface area of more than 11,400 square miles, making it the ninth-largest freshwater body of water in the world. It also is Africa's third-largest lake, and, at 2,300 feet, its second deepest.

Lake Malawi is known for its more than one thousand species of cichlid fish—diversification likely triggered by shifting environmental forces. Scholz recently made headlines when he confirmed that water levels in Lake Malawi have ebbed and flowed approximately two-dozen times, sometimes by as much as 600 feet, over the past million years.



Credit: Syracuse University

Scholz explains that a rift is a fracture in the Earth's surface that widens over time. "In East Africa, rifting has created a series of narrow, deep rift valleys that contains some of the world's largest freshwater lakes," he says. Although these lakes stem from millions of years of tectonic stretching and thinning, Lake Malawi is relatively young. Based on analyses carried out by McCartney, the lake's rift basin probably was formed about 8 million years ago. "Deep-water conditions didn't persist until around 4 million years later, when freshwater flooded the rift valley," Scholz adds.

In 2015, Scholz and a team of colleagues imaged geologic structures and recorded earthquakes beneath Lake Malawi. They did this using a supply of "air guns," generating soundwaves that were recorded by pressure sensors within a 5,000-foot-long cable towed behind their converted research vessel. (The erstwhile container ship boasted a lab, generators, compressors and heavy equipment for towing the seismic source.) Data collected by the cable's sensors were compared to that collected by dozens of seismometers onshore and on the bottom of the lake.

The team returned to Syracuse with loads of geophysical, geological and geochemical data. Little did they know how much of it was truly groundbreaking. McCartney, in fact, based her doctoral dissertation on it. "The data are helping us answer key questions about the origin and role of magma during early rifting, the formation and evolution of rift segmentation and its manifestation in the crust and upper mantle," she says.

Much of the team's work has focused on understanding the shapes and the extent of the rift-forming faults, which produce topographic depressions called half-grabens. When the Earth's crust pulls apart, the lithosphere extends—in the case of Lake Malawi, less than an inch per year—and creates a rift. "We now have conclusive evidence of fault migration away from the border fault of the half-graben," McCartney adds. "We also know that faults in the hangingwall [the section of the rift under the lake, itself], have lengthened over the past million years."

Scholz hopes the findings will provide a unified geologic framework for anyone exploring the EAR system, and will shed light on other continental rift systems—even ancient ones, such as rift basins along the eastern coast of North America.

The Malawi government is interested in the rift's potential for commercial quantities of oil and natural gas.

"The presence of working hydrocarbon systems in young rift-lake basins—those a few million years in age—has spurred extensive exploration interest in the Great Rift Valley," Scholz says. "The scientific discoveries emerging from the NSF study are purely academic in nature, but governments in the region are using the findings to help identify energy resources for some of the world's poorest people."

Many researchers consider the EAR—and, by extension, Lake Malawi—one of the best-expressed examples of a continent in the early stages of break-up. "East Africa always has been a hotbed of evolution," Scholz concludes. "Plate tectonics and climate variability have not only transformed its landscape, but also dictated our ancestors' development and dispersal from Africa to the rest of the world. We're witnessing evolution, in every respect of the word."

More information: Tannis McCartney et al. A 1.3 million year record of synchronous faulting in the hangingwall and border fault of a half-graben in the Malawi (Nyasa) Rift, *Journal of Structural Geology* (2016). DOI: 10.1016/j.jsg.2016.08.012

Provided by Syracuse University