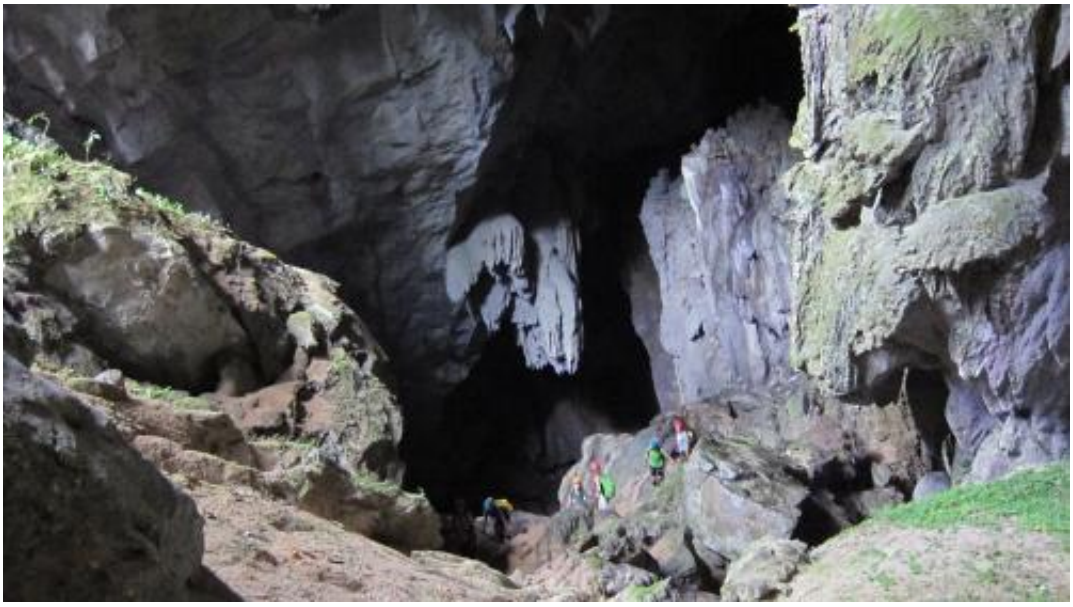
Borneo stalagmites provide new view of abrupt climate events over 100,000 years

June 6 2013



Georgia Tech researchers Stacy Carolin (Ph.D. candidate), Jessica Moerman (Ph.D. candidate), Eleanor Middlemas (undergraduate), Danja Mewes (undergraduate) and two caving guides (Syria Lejau, Jenny Malang) climb out from Cobweb Cave in Gunung Mulu National Park after a day of rock and water sample collection during the Fall 2012 field trip. Credit: Kim Cobb

A new set of long-term climate records based on cave stalagmites collected from tropical Borneo shows that the western tropical Pacific responded very differently than other regions of the globe to abrupt climate change events. The 100,000-year climate record adds to data on past climate events, and may help scientists assess models designed to

predict how the Earth's climate will respond in the future.

The new record resulted from oxygen isotope analysis of more than 1,700 calcium carbonate samples taken from four stalagmites found in three different northern Borneo caves. The results suggest that climate feedbacks within the tropical regions may amplify and prolong abrupt climate change events that were first discovered in the North Atlantic.

The results were scheduled to be published June 6 in *Science Express*, the electronic advance online publication of the journal *Science*, and will appear later in an issue of printed publication.

Today, relatively subtle changes in the tropical Pacific's ocean and atmosphere have profound effects on global climate. However, there are few records of past climate changes in this key region that have the length, resolution and age controls needed to reveal the area's response to abrupt climate change events.

"This is a new record from a very important area of the world," said Kim Cobb, an associate professor in the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. "This record will provide a new piece of the puzzle from the tropical Pacific showing us how that climate system has responded to forcing events over the past 100,000 years."

Among the findings were some surprises that show just how complicated the Earth's climate system can be. While the stalagmite record reflected responses to abrupt changes known as Heinrich events, another major type of event – known as Dansgaard-Oeschger excursions – left no evidence in the Borneo stalagmites. Both types of abrupt climate change events are prominently featured in a previously-published stalagmite climate record from China – which is only slightly north of Borneo.

This image shows The Secret Chamber inside of Clearwater Connection cave in Gunung Mulu National Park in northern Borneo. Credit: Syria Lejau

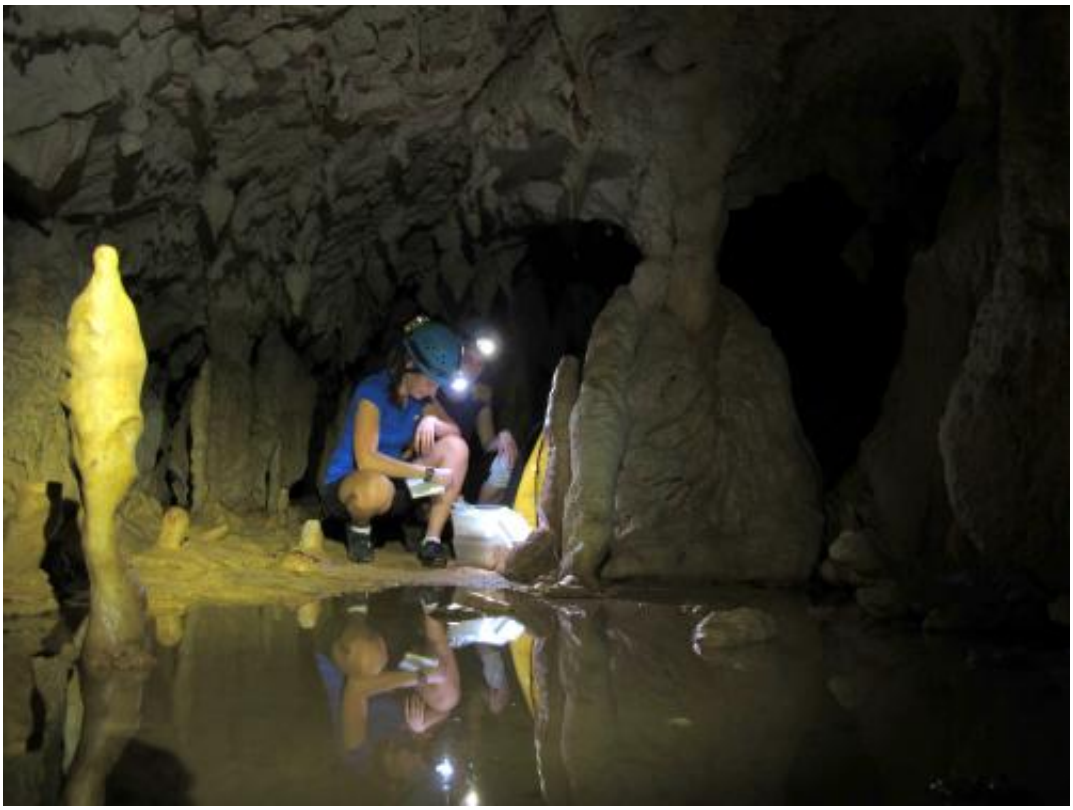
"To my knowledge, this is the first record that so clearly shows sensitivity to one set of major abrupt climate change events and not another," said Cobb. "These two types of abrupt change events appear to have different degrees of tropical Pacific involvement, and because the tropical Pacific speaks with such a loud voice when it does speak, we think this is extremely important for understanding the mechanisms underlying these events."

The researchers were also surprised to discover a very large and abrupt signal in their stalagmite climate records precisely when super-volcano Toba erupted nearby, roughly 74,000 years ago.

The team recovered the stalagmites from caves in Gunung Mulu and Gunung Buda National Parks, in northern Borneo, which is located a few degrees north of the Equator in the western Pacific. Back at their Georgia Tech lab, they analyzed the stalagmites for the ratio of oxygen isotopes contained in samples of calcium carbonate, the material from which the stalagmites were formed. That ratio is set by the oxygen isotopes in rainfall at the site, as the water that seeped into the ground dissolved limestone rock and dripped into the caves to form the stalagmites. The stalagmites accumulate at a rate of roughly one centimeter every thousand years.

"Stalagmites are time capsules of climate signals from thousands of years in the past," said Stacy Carolin, a Georgia Tech Ph.D. candidate who gathered and analyzed the stalagmites. "We have instrumental records of climate only for the past 100 years or so, and if we want to look deeper into the past, we have to find records like these that locked in climate signals we can extract today."

In the laboratory, Carolin sawed each stalagmite in half, opening it like a hot dog bun. She then used a tiny drill bit to take samples of the calcium carbonate down the center at one-millimeter steps. Because the stalagmites grew at varying rates, each sample represented as little as 60 years of time, or as much as 200 years. The precise ages of the samples were determined by measuring uranium and thorium isotope ratios, an analysis done with the help of Jess F. Adkins, a professor at the California Institute of Technology and a co-author of the study.



Georgia Tech Ph.D. candidates Stacy Carolin and Jessica Moerman prepare for sample collection within Lagang Cave in Gunung Mulu National Park during the Fall 2012 field trip. Credit: Syria Lejau

Rainfall oxygen isotopic ratios are good indicators of the amount of rainfall occurring throughout the region, as determined by a modern-day calibration study recently published by another graduate student in Cobb's lab.

Merging data from the four different stalagmites provided a record of precipitation trends in the western Pacific over the past 100,000 years. That information can be compared to stalagmite and ice core climate records obtained elsewhere in the world.

"This record, which spans the entire last glacial period, adds significantly

to the understanding of how various climate forcings are felt by the western tropical Pacific," Carolin added.

Climate scientists are interested in learning more about abrupt climate changes because they indicate that the climate system may have "tipping points." So far, the climate system has responded to rising carbon dioxide levels at a fairly steady rate, but many scientists worry about possible nonlinear effects.

"As a society, we haven't really thought enough about the fact that we are moving Earth's climate system toward a new state very quickly," said Cobb. "It's important to remember that the climate system has important nonlinearities that are most evident in these abrupt climate events. Ultimately, we'd like to be able to reproduce the global signatures of these abrupt climate events with numerical models of the climate system, and investigate the physics that drive such events."

For Carolin, studying the half-meter-long stalagmites brought an awareness that the Earth has not always been as we know it today.

"You have to be impressed with the scope of what you are studying, and recognize that the state our climate is in today is incredibly different from Earth's climate during the last Ice Age," she said. "As we consider how humans may be affecting climate, dissecting what was going on tens of thousands of years ago in all regions of the globe can help scientists better predict how the Earth will respond to modern climate forcings."

More information: Stacy A. Carolin, et al., "Varied response of western Pacific hydrology to climate forcings over the last glacial period," *Science*, 2013.

Provided by Georgia Institute of Technology