This stalagmite from the Cave of Bells in the Santa Rita Mountains near Tucson may be the key to unlocking a 55,000-year record of climate change. (Photo: Courtesy of J.Wagner/J.Cole)

UA Geoscientists Use Cave Stalagmite to Reconstruct Southwestern Climate Back 55,000 Years

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Kara Nyberg

Living in the American Southwest often presents days on end of over-100-degree temperatures and not a drop of moisture in sight. But has the climate here always been so hot and parched? University of Arizona geoscientists are trying to answer this question using an unlikely tool: a cave stalagmite.

By analyzing the concentration of a rare form of oxygen, oxygen 18, within the layers that compose a stalagmite, graduate

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student Jennifer Wagner and her advisor, Professor Julia Cole, can reconstruct the climate history for this region of the southwest. To date, this climate record far exceeds any now in existence for the southwestern U.S.

They presented their findings recently in a poster session at the 2002 American Geophysical Union meeting in San Francisco. Co-authors on the research are UA geoscientists Warren Beck and Jonathan Patchett, and William Peachey, a cave scientist at Colossal Cave State Park.

Wagner and Cole hope that understanding past climate history for the southwest will help predict what the future may hold.

“The past is the key to the present and the future. If we can understand the forcings behind climate changes and how rapidly they occurred, then we are better able to predict how current forcings may effect climate change,” Wagner says. (A "forcing" is something that causes climate change - like increased greenhouse gases or changes in the sun's irradiance.)

Previous climate records for the southwest only extend back a couple thousand years. These accounts are based largely on tree ring data and packrat nest analysis, both of which have shortcomings. Trees from the southwest may be from high altitude sites that might not reflect desert climatology and are only available from the relatively recent past. While plants collected in packrat nests provide detailed information about the type of vegetation present during a particular period of time that, in turn, lends clues to climate history, such records represent only a snapshot of the past.

“The nice thing about the record we are trying to generate is that it will be a continuous record of climate variables over a long period of time. It will eventually be well-dated, and the lengthiness of it will help us to see long-term changes in climate, as opposed to a snapshot here and a snapshot there,” Wagner remarks.

The stalagmite they analyzed grew up from the floor of the Cave of Bells located on the eastern side of the Santa Rita Mountains just north of Mexico. It formed over tens of thousands of years, growing about 1 to 7 millimeters (about four-hundredths of an inch to a quarter inch) every thousand years. As rainfall seeped through the ground and dripped from the roof of the underground cave, minerals trapped in the water built up over time to produce the formation.

Wagner explains that rainfall contains a trace of carbon dioxide, which makes the rain slightly acidic. As this acidic rain percolates down through the soil and rock, it leaches minerals from the Earth, including calcium and carbonate. When the water drips from the cave ceiling onto the stalagmite below, the water evaporates, leaving behind minerals that can be analyzed for insight into the climate that existed when they were deposited.

"The oxygen-18 content of cave formations reflects the oxygen-18 content in the water that's coming through the cave roof. And that oxygen-18 content depends of the amount of rainfall and the temperature at which the rain forms and actually falls out of the clouds," Cole explains.

"In our particular cave, when the oxygen-18 content is high, that indicates warm and dry conditions. When it's low, then it was cold and wet," she adds.

With permission from the U.S. Forest Service, Wagner and Cole removed a stalagmite from the cave floor, and took a one-inch diameter core from its center for sampling. They will replace the stalagmite once their studies are complete in an effort to preserve the cave environment.

Wielding a computer-controlled microdrill, Wagner shaves off minuscule layers of the stalagmite for oxygen-18 sampling. In addition, Wagner establishes a time scale for the formation of the structure by using two different dating techiques, based on radiocarbon and uranium-thorium, on larger samples taken all along the length of the core.

The usable portion of the stalagmite core – a little over 5 inches long – represents a climate history from 9,000 years ago to 55,000 years ago. This period happens to straddle the time when the last ice age ended, about 13,000 to 15,000 years ago in the north Atlantic. Much to their surprise, Wagner and Cole found that the oxygen isotopic record in the stalagmite reflects the deglaciation changes.

"Because weather here is largely influenced by El Nino, we weren't sure if we would see north Atlantic climate patterns replicated here in the southwest. We thought we would see something that told us more about Pacific influences. But maybe what this is telling us is that the Pacific is engaged in this whole climate process as well," Cole says.

Data on glacial melting from Greenland show that deglaciation occurred in a couple of steps. There was a period of warming, followed by cooling, and then the Earth warmed again to temperatures found today. Oxygen-18 data from the stalagmite mirror these steps. According to Wagner's analysis, the transition from fully glacial to a significantly warmer climate took about 200-300 years, very fast by standards of dramatic climate change. And the second warming period occurred even faster – in less than 100 years.

"These rapid changes suggest to us that the climate here is really sensitive to these large-scale patterns. Deglaciation wasn't something that happened just up in the north Atlantic, it it caused worldwide effects. The southwest was no different in responding rapidly to these changes," Cole says.

"This has a corollary for the future in that response to large-scale changes can be very fast. And because they are fast and abrupt, they may be somewhat unpredictable, and society may have trouble adapting rapidly," she adds.

"What this means is that we should be taking precautions now about how we use our climatically vulnerable resources, like groundwater, for instance," she says.

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