Betancourt in camp at Sierra Domeyko, Chile. Quade (below) checks desert subsoil for carbon dioxide from living organisms.

Ancient rodent middens record past tropical rain in "absolute" desert

Thursday, 06 January 2000

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Where does one go to find information about tropical rainfall patterns since the last major glaciation? Try the driest desert of South America.

That's the approach taken by University of Arizona geoscientists Julio Betancourt and Jay Quade. With assistance from several UA students, they are combing the Atacama Desert in northern Chile for clues on regional climate changes over the past 40,000 years.
Their findings may force the scientific community to rethink the accepted views on the timing of wet and dry periods in the region -- and the importance of the tropics during times of climate change. Their research is funded by the InterAmerican Institute, the National Geographic Society and the National Science Foundation.

Why look in the desert for signs of past rainfall?

"The Atacama is an obvious place to do it because it's so conspicuous. It's not like the Amazon where you have to hack your way through and the outcrops are covered with vegetation," explained Quade. Outcrops are surface geological

exposures.

At the same time, summer rainfall in the northern Atacama Desert flows from the same atmospheric circulation patterns that define climate in the Amazon, as Betancourt pointed out.

Still, the region bears small resemblance to the tropical rain forests -- or even the relatively lush Sonoran Desert here. The researchers use the phrase "absolute desert" to describe the barrenness they find once they move down from the mountains into the Atacama Desert.

"Below about 3,000 meters in altitude, plants become so widely spaced that they disappear from the landscape, depending on where you're standing," Betancourt observed. "But if you increased precipitation in this area, you would get the expansion of plants into this absolute desert, along with the animals who follow the vegetation."

These animals include rodents, many of whom have a peculiar habit of urinating in their nests. The end result is a hardened deposit, known as a midden, that can persist for 40,000 years or more.

Scientists can analyze the materials in these ancient rodent middens -- leaves, twigs, seeds, bones and insects -- to reconstruct vegetation zones for the area, which in turn reveal climatic trends at the time of the middens' creation. Researchers then use radiocarbon techniques to date the midden material and thereby put the climate on a timeline.

Betancourt and other UA researchers have led the North American midden research effort, collecting and analyzing more than 2,000 packrat middens from western North America over the years. So he expected to find interesting information on climate by expanding this data base into South American deserts, where at least four different rodent species use similar nest-building techniques.

He didn't expect his findings to challenge the current thinking on the timing of climate change in the region, however.

Other researchers had concluded earlier that regional lakes were drying up

about 11,600 calendar years ago. Yet radiocarbon dates showed many of the 400 Atacama middens collected by Betancourt and team were constructed between 10,500 and 11,800 calendar years ago and are full of summer-flowering grasses, indicating a stronger monsoon at the end of the period geologists call the Younger Dryas.

The Younger Dryas -- named after a flower, not a moisture condition, incidentally -- is generally recognized as the time when ice sheets briefly readvanced over North America and Europe.

Betancourt called in Quade, a colleague also working at the UA Desert Lab on Tumamoc Hill, whose expertise includes interpreting vegetation signals from soil carbonates and reconstructing water table heights from spring deposits.

Upon joining the Atacama effort, Quade and some of his students headed for ancient spring deposits left high and dry along mountain fronts in the Atacama Desert.

"Think of them as bathtub rings," Quade said of the spring deposits. "When the water table was high, it left a ring on the canyon wall. It's the same stuff you get on your pipes or the bottom of your water cooler."

The dates returned for the spring deposits support Betancourt's interpretation of climate.

"We're seeing higher water tables between 14,000 and 9,100 years ago, and 2,000 to 7,000 years ago, right when everybody else says it's dry," Quade said.

The UA researchers maintain that their own radiocarbon dates will stand the test of time better than the information gleaned earlier from lake deposits.

"In lakes, there's the 'hard water effect,' which means aquatic organisms are actually taking up old water," Betancourt noted. They incorporate carbon from the older water into their tissue and shells, which are later dated by geologists. "So the dates are not very trustworthy."

Although the debate may sound academic at first glance, it could influence modern interpretations of climate change.

"The climate changes at the end of the Younger Dryas might have been happening, basically, in a few decades," Betancourt explained. "This question has bearing on our future. Is it possible within the current regime to get such rapid changes in climate?"

Also, the findings support an emerging line of thinking that the tropics play an important role in large-scale climate change. For the past several decades, many scientists have viewed the tropics as climatically stagnant and the polar regions as the driving force behind global climatic shifts.

Quade agrees that their work could have bearing on modern thinking, as international leaders depend on scientists to use knowledge of past climate along with Global Circulation Models to predict how climate could change in the future.

As he asked rhetorically: "How can you build a model if you don't have the dates right?"