GEOLOGY

# Deciphering Ancient Weather Reports, Drip by Drip

**Stalagmites and stalactites are an increasingly valuable trove of high-resolution information on prehistoric climates**

When Dominik Fleitmann dissected a few stalagmites from Oman and Yemen, he was in for a surprise. The University of Bern paleoclimatologist had been examining the cave growths for clues to the Persian Gulf's climate over the past 10,000 years. Instead of confirming a hypothesis that monsoon rains abruptly weakened about 5000 years ago, Fleitmann ruled out such a sudden change, observing that monsoons waxed and waned in intensity over decades. The findings, which appeared in *Quaternary Science Reviews* earlier this year (Vol. 26, pp. 170–188), implicate a temperamental climate in the rise and fall of ancient kingdoms in the Gulf whose survival depended on adequate water resources, Fleitmann says.

Scientists have long examined ice cores and marine sediments for clues to past climates. But such records can't reveal much about continental interiors, apart from Antarctica's, and resolution is blurry for changes that occur rapidly, over decades.

Stalagmites and stalactites—deposits of calcium carbonate known as speleothems that form in caves—are beginning to fill crucial gaps. Speleothems are all the rage because of their dazzling precision: Error bars range from a mere year to decades. "Ice cores and cave formations complement each other nicely. [Just as] ice cores are frozen water, I like to see our stalagmites as petrified water," says Fleitmann.

"Speleothems are producing outstanding insights," adds Richard Alley, a glaciologist at Pennsylvania State University in State College.

Speleothems form in limestone caverns over millennia as water seeps through soil and, upon infiltrating a cave, deposits minerals on the ceiling or floor. Since the late 1980s, researchers have dated speleothems using thermal ionization mass spectrometry, which measures the ratio of uranium-234 to thorium-230 and can pinpoint age as far back as 600,000 years, deep into the Pleistocene epoch. Scientists may soon be able to reach even deeper into antiquity thanks to a method for measuring uranium's decay into lead. This dating technique, which several teams are now refining, could extend speleothem climate records by several million years—far beyond ice core climate reconstructions, says Giovanni Zanchetta, a paleoclimatologist at the University of Pisa, Italy. Meanwhile, measuring the ratio of oxygen-18 to oxygen-16 in calcite tells the climate story, as temperature and rainfall control the ratio.

Illustrating the power of speleothems to unravel intricate climate patterns, geologist Xianfeng Wang and colleagues at the University of Minnesota, Twin Cities, and the Instituto do Carste, Brazil, have strong evidence that abrupt global climate shifts are instigated by conditions in the high latitudes. Speleothems from China and Brazil reveal a tight coupling between rainfall patterns in the Northern and Southern hemispheres over the past 90,000 years. When China was wet, Brazil was dry, and vice versa. In a monograph in press at the American Geophysical Union, Wang argues that rainfall patterns on either side of the equator are linked to North Atlantic sea ice, the extent of which is influenced by alterations in the "conveyor belt" that circulates water from the mid- to North Atlantic. "It is wonderful work," says Alley.

Discerning temperature and precipitation patterns over decades could give insights into droughts and floods—phenomena with huge societal impacts. One high-profile event occurred about 9400 years ago, when a natural dam between the Mediterranean Sea and Black Sea broke, creating the Dardanelles. Some scientists contend that precipitous flooding of settlements on the Black Sea coast gave rise to the legend of Noah's flood.

Fleitmann's group will seek to shed new light on the legend by determining whether the flooding was gradual or sudden, according to how quickly oxygen isotope ratios change in a 45,000-year-old stalagmite from the Black Sea coast in Turkey. The scientists will look for altered oxygen ratios as rain originating from a freshwater Black Sea changes to rain from a Black Sea turned brackish after infusion of salt water from the Mediterranean Sea. Analyses of sea sediments have not settled this question. With the stalagmite, Fleitmann says, "we may achieve a much better temporal resolution" that could unmask a sudden shift in oxygen isotopes.

Extracting the fine-grain details of past climates from stalagmites should also help inform future climate scenarios. "Most of us don't care about climate change that occurs over thousands or more years," says Christopher Poulson, a climate modeler at the University of Michigan, Ann Arbor. "We won't be around, our kids and grandkids won't be around, but for abrupt climate change this is a time scale that matters." Scientists hoping to divine how a warming world will look in the coming decades might wish to go spelunking for answers.

**–JACOPO PASOTTI**

Jacopo Pasotti is a writer in Basel, Switzerland.

**Spelunking for clues.** Speleothems from this cave in northern Oman revealed a dynamic monsoon 5000 years ago, says Dominik Fleitmann (*inset*, emerging from a cave in Turkey).

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