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National Cave and Karst Research Institute

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# A PRELIMINARY ASSESSMENT OF SPELEOTHEM SAMPLING METHODS FOR PALEOCLIMATE RESEARCH

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## Abstract

Speleothems are incomparable archives of paleoclimate information. However, most methods to extract past climate information from speleothems are destructive, because sampling must occur along the growth axis. Development of sustainable methods for sampling these nonrenewable resources, whereby the needs of science and cave conservation are balanced, ought to be a priority of the paleoclimate community. Ergo, I am studying currently practiced field methods in speleothem paleoclimatology. Part 1 of this two-part study entails surveying paleoclimatology labs working on speleothems nationally and internationally. The results of this portion of the survey were converted to an anonymous list of current methods. These data will be written into a second survey in which stakeholders, including cave managers, will be asked which method(s) aligns best with their cave use and goals. The final output will be a peer-reviewed assessment of methodology, including “best practice” guidelines, which will improve sampling and field methodology in the community as a whole. Additional outputs (e.g., interpretive educational products, brochures, or a speleothem sample archive, etc.) could be produced through collaboration with speleothem paleoclimate labs and cave and karst managers worldwide.

## Introduction & Background

Cave formations (speleothems), in addition to being aesthetically pleasing, are also sources of past climate (paleoclimate) information. The mineral and chemical structure of speleothems record changes in past climate because as meteoric water falls above a cave, infiltrates into the ground, and drips onto stalagmites, the original isotopic composition of the rainfall is maintained. Because speleothems can be dated absolutely using small quantities of uranium and thorium in their mineral structure, paleoclimate records from caves can be related to other climate changes anywhere worldwide.

Speleothems can be particularly useful in arid areas, where few other sources of paleoclimate information preserve well (e.g., Wagner et al. 2010). Understanding past climate variability will allow us to comprehend how the climate system functions and better prepare us to address future climate change.

Sampling speleothems in the lab for paleoclimate research is somewhat destructive; sampling must occur along the growth axis (generally down the center of the stalagmite) to be meaningful. For this reason, many scientists prefer to remove stalagmites entirely, so they have access to the most material possible and can produce robust science (for more information on this see Gregory Springer’s publications in the January and June 2012 issues of the *NSS News*). Others prefer coring of stalagmites as a less invasive technique (Spotl and Matthey 2012), but this method is not yet commonly used. Development and adoption of new methods to sample speleothems for paleoclimate research is necessary to improve both cave conservation and sampling efficiency.

Some scientists have paid attention to conservation when sampling and have published on the topic. For example, it is not uncommon to see phrases such as “it must also be emphasized that great care must be paid to sampling strategy and to other conservation issues so that vandalism is avoided” (Lauritzen and Lundberg 1999). A few researchers have actively discussed sampling efficiency and conservation, by outlining a strategy to select stalagmites that are directly responsive to a relevant climate variable (Frappier 2008). Similarly, some scientists have outlined other approaches, including careful site selection using prescreening approaches, cautious sample removal, and creative replacement using replicas (Truebe et al. 2011). Other researchers suggest treating speleothems more like archeological materials rather than simply as rocks – Fairchild and Baker (2012) point out “Most geologists have regarded speleothems

simply as a type of rock sample and have been slow to grasp the necessity for conservation through archiving.” However, it is equally common to see mention of multiple (sometimes more than 10) stalagmites taken out of a cave for a paleoclimate reconstruction. Clearly the dialogue must deepen between cave managers and cave paleoclimate scientists about cave conservation.

To facilitate this dialogue, I am developing a two-part cave stakeholder survey, which includes one survey of current cave paleoclimate scientists and a second survey of other cave stakeholders such as cave managers, cave conservancies, recreational cavers, etc. (hereafter: “cave managers”). The objective of this project is to develop mutually agreeable “best practice” guidelines for speleothem sampling for paleoclimate research.

## Methods

“Best practice” guidelines will be developed using a suite of methods currently in practice by paleoclimate scientists and opinions/feedback collected from cave managers. Scientists were asked the following questions via email:

### (1) Field methodology

- (a) How do you select a cave to sample in?  
*For example: ease of access, size of cave, remoteness of site, etc.*
- (b) How do you select a speleothem within that cave?  
*For example: site characteristics, speleothem size/shape, distance from entrance, pre-damaged, etc.*
- (c) Describe how you sample a speleothem from the cave you have selected:  
*For example: removal, removal/reassembly/replacement, coring, etc.*
  - (i) Is this your ideal sampling strategy? (Yes/No)
  - (ii) If yes, why do you prefer this method? If no, please describe how you would ideally sample and why you cannot sample that way.

### (2) Cave ownership

- (a) Of the caves you have worked in at any point in the past 10 years, how many are on public lands?
- (b) Of the caves you have worked in at any point in the past 10 years, how many are on private lands?
- (c) Who controls access to the caves you work in (or recently worked in)?

### (3) Other

- (a) Is there anything else you would like to add?
- (b) Is there anyone else I should contact for information on field methods in speleothem paleoclimatology?
- (c) May I follow up with you if I have further questions? (Yes/No)

Their answers have been collated into a survey for cave managers. The second survey will be online, allowing cave managers worldwide to participate. Results of both surveys will be presented in a peer-reviewed format and made available to cave managers and scientists around the world. This publication will include “best practice” guidelines for speleothem sampling, which will improve sampling efficiency and cave conservation in the paleoclimate community as a whole.

## Preliminary Results & Discussion

Some preliminary data have already been compiled from part 1 of the survey. The data show that paleoclimate scientists use a variety of metrics for selecting a cave to sample from: whether a cave is in a scientifically valuable location for their specific research question, is easy to access, and contains many speleothems. Selection of a speleothem within that cave depends on: speleothem morphology, distance into the cave, whether the speleothem is out of sight or otherwise visually uninteresting, whether the sample is already broken or damaged, and the mineralogy of the speleothem. When selecting caves and sampling locations, scientists point out the usefulness of having “pre-screened” the site using dripwater analysis, microclimate monitoring, or preliminary uranium-thorium dates. Many scientists recognize that such strategies increase their own sampling efficiency while conserving nonrenewable cave resources. Some scientists are even developing new methods, including using MRI-scanning (Magnetic Resonance Imaging – a tool from the medical industry) to identify the best speleothems to sample for their research. Finally, a number of scientists have identified the need to archive samples in one location, rather than at individual labs, making those materials available for future researchers. This procedure will minimize future impact on caves because it means scientists can work directly from samples in the archive rather than from new speleothems from new caves.

Although the responses to the survey are likely from the subgroup of paleoclimate scientists who are already

thinking about cave conservation issues, this study holds great promise to produce a “best practice” set of guidelines for paleoclimate sampling in caves.

## Recommendations for Cave Managers

As the study progresses, cave managers can help in a number of ways. Initially, they can fill out the survey (the second part of the methods assessment for speleothem paleoclimatology), and send it to their contacts and constituents to complete. Secondly, when approached by paleoclimate scientists, cave managers could proactively recommend “best practice” methods and/or work with scientists to develop interpretive educational products for explaining to the public why paleoclimate research from caves is useful. Additionally, cave managers can provide creative new suggestions about how best to sample for paleoclimate research while protecting cave resources; sharing that information with scientists will be critical to advancing new sampling methods.

## Conclusions

Speleothems are a good source of paleoclimate information, and are often the only source of such critical information in some areas of the world. Paleoclimate information from speleothems is increasingly useful to understanding our climate system and preparing for modern and future climate change. This paper outlines a project to develop more sustainable methods to sample speleothems for paleoclimate studies by surveying speleothem paleoclimate labs and cave managers, cave conservancies, recreational cavers, and other cave stakeholders.

Many cave paleoclimate scientists are actively working to reduce the impacts of their research. Others know that cave conservation is an important issue, but also recognize that there is little funding or community support for developing and publishing low-impact methods. This project aims to overcome that barrier by increasing transparency of the methods that are currently in use, as well as producing guidelines for how to sample speleothems more sustainably. The goal of this research is to encourage responsible sampling that reconciles cave conservation with paleoclimate science. It is an opportunity for cave managers and cave paleoclimate scientists to work together to improve sampling, while maximizing the scientific and cave aesthetic benefits to society.

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## Biography

Sarah Truebe (NSS #61563) is a PhD Candidate at the University of Arizona. Sarah grew up caving under southern Arizona, but since becoming an adult, she has also caved in more than seven states and six foreign countries. She spent a brief period in California, at Stanford University, to obtain Bachelor's and Master's degrees in Earth Systems, an interdisciplinary program

in earth and environmental science and policy. As a PhD student, Sarah is reconstructing past rainfall variability in southern Arizona using speleothems, understanding drip water geochemistry and calcite precipitation in a modern cave monitoring project, and working on an assessment of current speleothem climatology methods. She hopes to find a cavey post-doc or job after she finishes her PhD next year. In her spare time, Sarah volunteers with the Southern Arizona Rescue Association and plays piccolo with the University of Arizona Wind Ensemble.