TIME, MONEY, AND MELTING ICE: PROPOSAL FOR A COOPERATIVE STUDY OF THE WORLD’S CAVE ICE IN A RACE AGAINST CLIMATE CHANGE

**Abstract**

Climate change is a global phenomenon that is melting and threatening to melt ice deposits in many of the world’s ice caves. The National Cave and Karst Research Institute of the USA is concerned that major and important paleoclimate and paleoenvironmental records stored in cave ice will soon be lost, and is proposing an international collaborative effort to overcome funding and logistical challenges to sample and analyze at least a representative collection of ice from several regions before further melting occurs.

**The Problem**

“Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased” (WGI Technical Support Unit, 2014).

This recent announcement by the Intergovernmental Panel on Climate Change (IPCC) has vast implications for all aspects of humanity. For the cave ice community, the IPCC’s observations that “Over the last two decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent” reflect what is now being observed with cave ice deposits worldwide. Even during the time from when this 6th International Workshop on Ice Caves was proposed for Idaho Falls, decreases in ice have been seen in caves in the area as part of the continued warming trend.

The final report of the 5th assessment by the IPCC won’t be available until the end of 2014, but the technical summary predicts a mean annual temperature increase of 1.25-2.00°C by 2100, relative to temperatures from 1850-1900, for the world’s high latitude and high elevation regions where most known ice caves occur (Stoker et al., 2013). IPCC predicts warming will continue beyond 2100, that it is “very likely that the Arctic sea ice cover will continue to shrink and thin and that Northern Hemisphere spring snow cover will decrease during the 21st century,” “global glacier volume will further decrease,” and that “most aspects of climate change will persist for many centuries even if emissions of CO2 are stopped” (WGI Technical Support Unit, 2014).

No climate simulations have been developed to predict the impacts of climate change on cave ice. Based on losses observed to date and the loss of snow and ice deposits on the surface, it is reasonable to assume that many of the world’s cave ice deposits will soon be gone. Many have already been lost.

Perennial deposits of stratified ice form by the successive accumulation of annual layers of ice interlaminated with organic and inorganic sediment and cryogenic carbonates, similar to varves in lakes. They often preserve a large variety of candidate proxies for past climate and environmental changes, including stable isotopes, pollen, ice stratigraphy, and chemical properties of the ice and contained sediment. Ice caves are thus valuable repositories for various forms of paleoclimatic and paleoenvironmental information that has been protected from destructive processes acting on the surface. Moreover, due to the peculiar combination of cave morphology and external climate required for their presence, these types of ice deposits are usually present in areas where surface glaciation is absent. This is especially important because perennial ice deposits, in the form of polar ice and mountain glaciers, offer some of the best sources of paleoclimatic information, thus making ice caves a preferential target for paleoclimate studies.

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Previous research has demonstrated that the isotopic composition of cave ice, in-situ formed calcite trapped in the ice, and pollen are reliable proxies for past climatic and environmental changes (e.g. Perşoiu et al., 2011). By combining the age of ice at various depths with high-resolution stable isotope, hydrochemical and palynologic analyses, a detailed record of climate and environmental changes can be derived. These paleoclimatic records are in danger of being permanently lost as cave ice deposits begin to melt due to the effects of climate change.

The Plan
The National Cave and Karst Research Institute (NCKRI) of the USA is proposing to conduct a study to identify and sample cave ice deposits that are at risk of melting from as broad a range of geographic settings as possible. The purpose of the study would be to salvage a wide and representative sampling of cave ice for paleoclimatic and paleoenvironmental analysis. The proposed broad range of climatic regimes for sampling would allow examination of various modes of climate variability, climate forcing, and strength of anthropogenic impacts.

The research would be conducted in three phases. Phase one would involve monitoring and collection of baseline data from selected caves for a period of one year to cover a full climatic cycle. The monitoring program will require monthly visits to measure several climatic parameters and rates of ice accumulation, and to collect water and cryogenic calcite samples for stable isotope analyses. These baseline data are crucial for accurate interpretation of ice cores collected during a subsequent phase of the research.

The second phase of research, which would be concurrent with the ice cave monitoring program, involves construction of a facility for storage of ice cores, or expansion of an existing facility. In addition to providing space for storage of cave ice cores collected for this project, this facility would also be used for long-term archiving of ice cores for future research. The ice core storage unit would include a cold room for archiving, a lab area where ice cores could be slabbed and sampled, and an airlock between the lab and archive space. Back-up diesel power would be established in the event of a failure of the main power source.

The third phase of this investigation would involve collecting cores of cave ice from those caves that have been identified as having the most potential for preservation of an extensive and continuous paleoclimate record. The cores would be analyzed for stable isotopes of oxygen, hydrogen and carbon, carbon-14, tritium, organic and inorganic chemistry of the ice and contained sediment, and fossil pollen. Sites with existing year-long monitoring records that were not monitored by this study could also be incorporated into this third phase of investigation.

The Challenges
While the urgency of climate change is well known in scientific circles, NCKRI has encountered some difficulties in starting this project.

Presently, the sites under consideration are only in the Northern Hemisphere. The intent of this project is for a global sampling of cave ice, but a review of the literature and international calls for information have yet to yield any Southern Hemisphere cave ice localities.

NCKRI’s initial plan was to store the cave ice in an existing facility. We have contacted several ice storage centers and discovered, with the exception of one offer for short-term storage, this is not generally possible. Many lack the storage space for additional samples from outside of their projects. Others are incompatible for cave ice, storing ice only from continental glaciers to avoid sample contamination from sediments in cave and mountain glacier ice. Consequently, developing a facility dedicated to cave ice seems necessary.

Funding is critical. Travel is extensive. Many of the sites are remote. Teams are needed during the first phase to sample the caves monthly. Coring of ice could require helicopter transportation. Special shipping is needed for the cores from the caves to the ice storage and lab facility, which needs to be built, equipped, and maintained.

Despite attempts to minimize costs, no funds have been acquired to date for this project. Six years ago, a worldwide economic crisis developed and many countries have not yet fully recovered. Governmental and private funding sources have greatly diminished. Competition for the remaining lesser funds has increased. NCKRI’s experience and sources suggest no more than 3-4% of grant proposals in the USA are currently funded. Some traditional major sources of support for scientific research, like the US National Science Foundation,
will not fund the first phase of the project because they incorrectly see it as scientific uncertainty instead of data collection critical to the analysis and interpretation of the third phase results. As a result, this project remains a proposal while the ice continues to melt.

**The Hope**

When NCKRI began this project, it included primarily the three authors of this paper. Some discussions were held with other scientists, and if the project was funded there would be a broad, international outreach for participation commensurate with the funds available. However, the combined economic and logistical difficulties encountered now require a new approach.

Through this paper, we propose a broad and open discussion to create a partnership among ice cave scientists whereby we can exchange information and mutually support each other to sample and study as much of the world’s ice as possible before it disappears. NCKRI would serve as a clearinghouse for information and communication. The goal isn’t for NCKRI or any organization to do this research, but to make it as easy possible for any knowledgeable and responsible scientist to do the work in a cooperative fashion that minimizes unnecessary duplication of effort and maximizes efficient use of knowledge and resources. This is an urgent scientific crisis. We seek your cooperation and support, and look forward to working with you.

**References**


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