

# Science and Technology Group Annual Report FY2022

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## 1 Introduction

In FY2022, I focused on two projects:

- (1) Cave formation near past glacial margins.
- (2) Climate variability during the late Marine Isotope Stage 3 (MIS3) recorded by speleothems from the Midwestern USA.

## 2 Activities and Findings

### Cave formation near past glacial margins

Cave morphology and cave deposits embody crucial information for paleoclimate studies. This information assumes heightened importance in regions affected by glaciation because glacial processes can render surficial records unreliable for paleoclimate analysis. In this project, we studied how glacial episodes and interglacial periods left their signatures on the speleogenesis of a cave located in proximity of glacial margins from the Illinois glacial episode and Wisconsin glacial episode: Donnehue's Cave in Indiana, USA. We carried out an analysis of geomorphological features of the cave passages (upper passage and lower passage). The key features include phreatic tubes, vadose canyons, flowstones, and paragenetic features (such as lateral corrosion, half tubes, and cave ceiling anastomoses). Additionally, we conducted geochemical dating of the cave deposits (speleothems and sediments). For speleothems, we used the technique of Uranium-Thorium (U-Th) dating and for sediments, we used the technique of Optically Stimulated Luminescence (OSL) dating. Based on the results from the geomorphological and geochemical analysis, we formulated a conceptual model for speleogenesis of Donnehue's Cave.



A photograph showing sediment remnant next to the ceiling of the lower passage. (The passage height at this location was about 3 m)

### Climate variability during the late MIS3 recorded by speleothems from the Midwestern USA

The Marine Isotope Stage 3 (MIS 3) spanned the time period between ~60,000 yr B.P.

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and ~27,000 yr B.P. during the last glacial cycle. MIS3 is characterized by the high frequency of the abrupt millennial-scale oscillations in the climate conditions, known as the Dansgaard-Oeschger (DO) events. The DO events consisted of several millennial-scale cycles of abrupt temperature rises followed by a slow return to colder conditions. The trigger mechanism(s), as well as the impact of these DO events on temperature and rainfall amounts in continental regions are still poorly understood. One major factor that limits our understanding of these events is the paucity of paleoclimate data. In particular, the paleoclimate data available from Midwestern USA is insufficient for reconstructing the main paleoclimate events that affected North America and for correlating these events with similar events across the Northern Hemisphere.

Seeking to provide such data, in this project we analyze two partially coeval stalagmites from Donnehue's Cave (Midwestern USA). We dated the stalagmites by means of Uranium-Thorium (U-Th) disequilibrium dating. Further, we measured the oxygen and carbon stable isotope data ( $\delta^{18}\text{O}$  and  $\delta^{13}\text{C}$ , respectively) and the standard suite of trace element data. Our analysis of the data suggests that the record in the Donnehue's Cave stalagmites corresponds not just to regional oscillations, but to millennial-scale and orbital-scale variations seen in different proxies from various parts of the Northern Hemisphere.

### 3 Collaborations

Samuel Panno, Senior Geochemist, Illinois State Geological Survey, USA  
Prof. Christoph Spötl, University of Innsbruck, Austria  
Prof. Hai Cheng, Institute of Global Environmental Change Xi'an, Jiaotong University, China  
Dr. Klaus Peter Jochum, Max Planck Institute for Chemistry, Germany  
Brigitte Stoll, Max Planck Institute for Chemistry, Germany  
Ulrike Weis, Max Planck Institute for Chemistry, Germany  
Dr. Jasper Wassenburg, IBS Center for Climate Physics, South Korea

### 4 Publications and other output

Chirienco, M.I., Wassenburg, J.A., Cheng, H., and Spötl, C., "Climate variability during the late MIS3 recorded by speleothems from the Midwestern USA", Session on Advancing Speleothem Paleoclimate Research: Geochemical Toolkits, Proxy-Climatic Quantification, and Isotope-Enabled Climate Models I, American Geophysical Union Fall Meeting 2022 (December 12-16 2022) (Online Poster)

Chirienco, M.I., Panno, S., Lundstorm, C., and Cheng, H., "How the past climate formed and shaped a cave", Seminar at the Annual Science and Technology Group Forum (STG Forum), OIST (March 28, 2023)