Science and Technology Group Annual Report FY2021

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1 Introduction

Cave formation near past glacial margins

Cave formation (i.e., speleogenesis) in the proximity of the ice sheets is strongly influenced by the glacial advances and retreats (Panno et al., 2004). During the warm interglacials, the chemically aggressive melt waters flood the cave, shaping its morphology and filling it with coarse sediment. By contrast, during the glacial episodes, the water table lowers, allowing for formation of speleothems (if the cave temperature stays above freezing). Thus, major shifts in the past climate can leave their distinctive marks on speleogenesis. In this project, we seek to provide a conceptual model of the formation of Donnehue's cave (Indiana, USA) and its relationship with major glacial episodes.

Records of climatic conditions during the last two glacial-interglacial cycles in Donnehue's Cave in Midwestern USA

In this project, we focus on the last two glacial-interglacial cycles, spanning the periods of MIS 5 (~70,000 yr – ~130,000 yr B.P.), MIS 6 (~130,000 yr – ~190,000 yr B.P.), MIS 7 (~190,000 yr – ~240,000 yr B.P.), and MIS 8 (~250,000 yr – ~280,000 yr B.P.). During these periods of significant climate changes, there is a notable lack of well-constrained deglaciation chronologies from the Midwestern USA. Seeking such data, we analyze three stalagmites from different parts of Donnehue's Cave (Indiana, USA). These stalagmites offer a unique opportunity to better understand both the cave system and the overall climate conditions, starting with water availability during the transition from glacial to interglacial conditions.

2 Activities and Findings

Cave formation near past glacial margins

Donnehue's Cave is located a few kms south of the Illinois and Wisconsin glacial maxima. It has two passages, vertically stacked, each approximately 1.5-km long. The upper passage is currently inactive and dry; the lower passage is currently active and carries a small stream. We carried out multiple surveys of Donnehue's Cave in which we documented its major geomorphological features and collected samples of stalagmites, flowstones, and sediments from both passages of the cave. We dated the stalagmites and flowstones using Uranium-Thorium (U-Th) disequilibrium dating and the sediments using Optically Stimulated Luminescence (OSL) dating. The preliminary analysis of all the colected data indicates that the the past three glaciations the the Midwest (Pre-Illinois Glacial Episode, the Illinois Glacial Episode, and the Wisconsin Glacial Episode) have each left a clear record in Donnehue's Cave. The conceptual model of Donnehue's Cave formation is work in progress.

Records of climatic conditions during the last two glacial-interglacial cycles in Donnehue's Cave in 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 ($\delta^{18}O$ and $\delta^{13}C$,

respectively) and the standard suite of trace element data.

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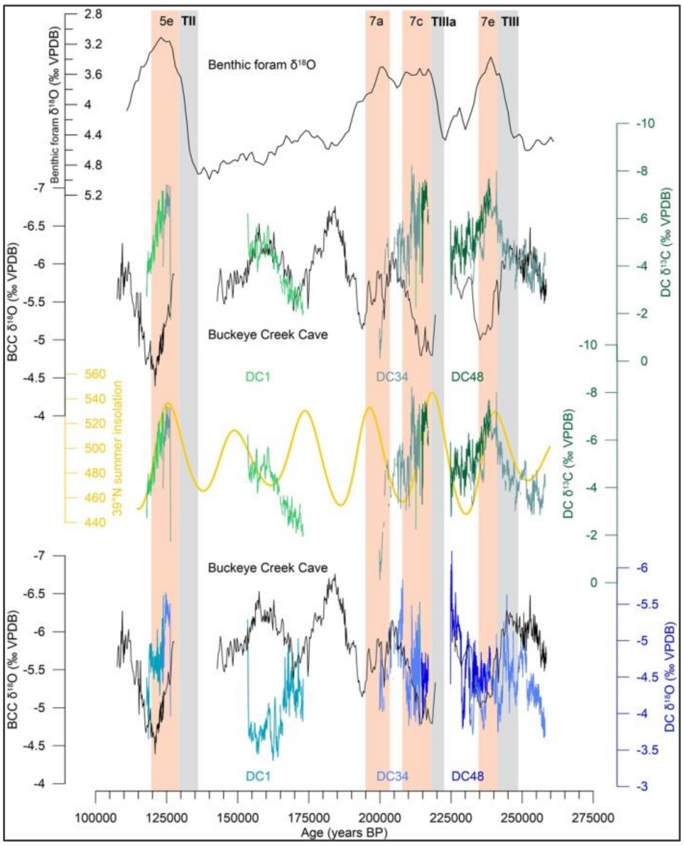

We have carried out analysis of $\delta^{18}O$, $\delta^{13}C$, and Mg records in all 3 stalagmites. In Fig. 1, I plot the $\delta^{18}O$ and $\delta^{13}C$ records, where, for a broader perspective, I also plot $\delta^{18}O$ record from Buckeye Creek Cave, West Virginia, USA (Cheng *et al.*, 2019) and the 39°N summer insolation. I have highlighted regions where correlations amongst different proxies are noteworthy; the analysis of the data is ongoing.

Figure 1: Placing the multi-proxy records from the stalagmites DC 1, DC 34, and DC 48 in a broader context. From top down: North Atlantic benthic foraminifera $\delta^{18}O$ (black; Lisiecki and Raymo, 2005); Buckeye Creek Cave $\delta^{18}O$ (BCC; black; Cheng et al., 2019); Donnehue's Cave $\delta^{13}C$ (green); 39°N summer insolation (yellow; Laskar et al., 2004); $\delta^{18}O$ (blue); gray shading indicates the timing of the Ice Age Terminations according to Cheng et al. (2016), peach shading indicates the timing of warm MIS5e (Lisiecki and Raymo, 2005), MIS7a, MIS7c and MIS7e (Railsback et al., 2015). The composite DC records were constructed by averaging the data from all speleothems for 100-year periods. The same was done for BCC $\delta^{18}O$ to create equal resolution data. Those 100-year periods where no data is available were not interpolated and left blank.

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 Invited talks

Chirienco, M.I.: *Abrupt Climate Changes during the Last Glacial Period in the USA and the Northern Hemisphere.* 2021 OIST-RIKEN joint symposium, Climate Change and Geoscience workshop
Chirienco, M.I.: *Carbonate Rocks and Karst Landscapes in Okinawa.* OIST Research Apprecciation Month series