High-Resolution Isotopic Monitoring of Cave Air CO_2

Paul Töchterle* (1), Yuri Dublyansky (1), Magda Mandic (2), Samuel Barrett (1), Nils Stöbener (2), HJ Jost (2) and Christoph Spötl (1)

(1) University of Innsbruck, Institute of Geology, Innsbruck, Austria
(2) Thermo Scientific, Bremen, Germany

* Corresponding Author: paul.toechterle@student.uibk.ac.at

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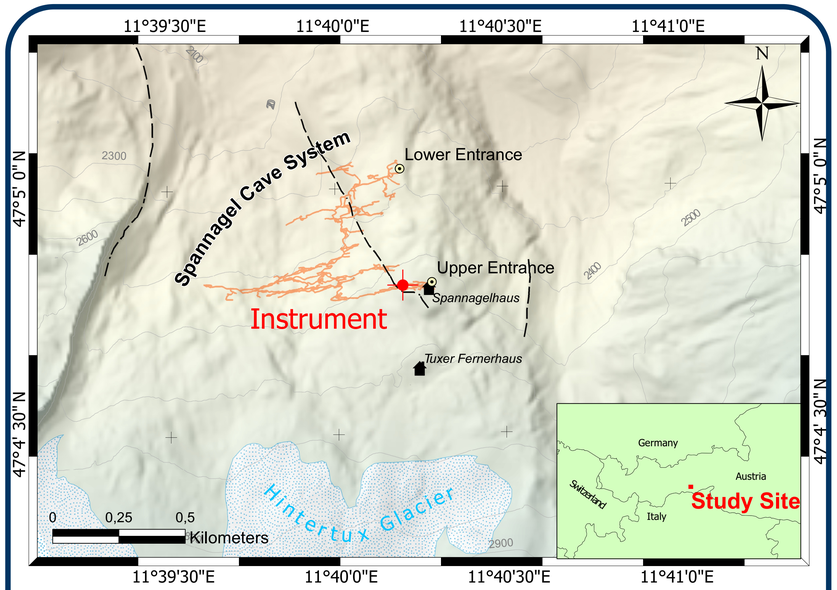
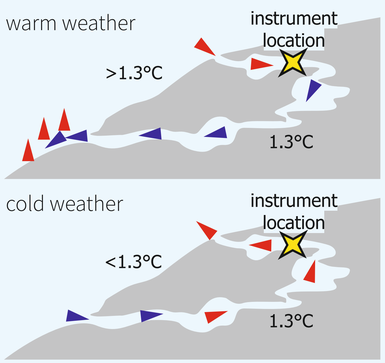
Introduction



Caves provide excellent climate records through calcium carbonate precipitates, commonly known as speleothems. These chemical deposits result from the interaction between groundwater, CO_2 and limestone, whereas the availability of CO_2 determines whether carbonate precipitation or dissolution occurs. Within any given cave system, ventilation regulates the spatial and temporal distribution of CO_2 and consequently also effects speleothem formation. When using speleothems as climate archives, a profound understanding of cave ventilation is therefore a necessity[1].

Spannagel Cave is a high-alpine cave system, situated in the Zillertal region of the Austrian Alps. This system has been studied extensively[2,3,4] and the hydrological, geochemical and atmospheric processes, that govern its speleothem formation are comparably well understood. However, previous monitoring efforts of characterizing the ventilation patterns relied on temperature data whereas the relationship between cave ventilation and CO_2 is not well known[5]. This study aims at characterizing the ventilation patterns of Spannagel Cave (Box 1) with respect to CO_2 by employing a novel approach facilitating a **Thermo Scientific Delta Ray ISIS** unit.



Box 1 - Chimney Effects in Caves

Caves like Spannagel Cave with multiple entrances at different altitudes usually show advective air movement. Flow may be induced by pressure or temperature gradients[6]. In most cases a **chimney-type ventilation** is found. Inside a cave the air transfers heat to the rock. Thermal equilibrium with the host rock is usually reached within a short distance from the entrance[4]. As the temperature outside of the cave fluctuates around this equilibrium temperature, cave air becomes either denser or lighter than the outside air and thus changes its direction of flow.

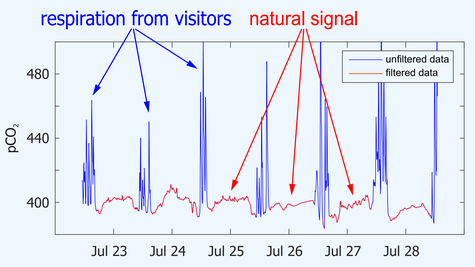
Methods

The isotopic composition and concentration of CO_2 in cave air was monitored using a Thermo Scientific Delta Ray IRIS. Because of the extreme conditions inside the cave a special instrumental setup was developed in close collaboration with a team at Thermo Scientific Bremen, Germany. It employs a 19" plastic rack and two 12V chassis fans for temperature stabilisation and air circulation.

The instrument allows **monitoring of pCO_2, $\delta^{13}C$ and $\delta^{18}O$ of CO_2 in air** at a temporal resolution of up to 1s. For this study, measurements were taken every 10s and compiled into 5-minute mean values. Additionally, temperatures inside the cave were measured with HOBO Temperature Pro V2 loggers and atmospheric temperatures were kindly provided by the Tyrolean Avalanche Warning Service.

Box 2 - Human Impact Filtering

The upper part of Spannagel Cave is visited regularly by guided tours during summer and autumn. Human breath contains CO_2 and is thus picked up by the instrument. To mitigate this data bias, a filter script was developed. The algorithm is based on a 1hr long moving window that detects human imprint based on sudden increases in standard deviation, CO_2 signals and time of the day.



References

1 Fairchild, I. J. and A. Baker 2012. Speleothem Science: From Process to Past Environments, first edition. Wiley-Blackwell.

2 Spötl, C. and A. Mangini 2010. Paleohydrology of a High-Elevation, Glacier Influenced Karst System in the Central Alps (Austria). Austrian Journal of Earth Sciences, 103(2):92–105.

3 Cliff, R. A., C. Spötl, and A. Mangini 2010. U–Pb Dating of Speleothems from Spannagel Cave, Austrian Alps: A High Resolution Comparison with U–Series Ages. Quaternary Geochronology, 5:452–458.

4 Spötl, C. 2002. Das Spannagel Höhlensystem. Höhlenkundliche Mitteilungen des Landesvereins für Höhlenkunde in Tirol, 54:55–73.

5 Spötl, C. and R. Pavuza 2000. Zur Bewetterung der Spannagelhöhle. Höhlenkundliche Mitteilungen des Landesvereins für Höhlenkunde in Tirol, 52.

6 Palmer, A. N. 2007. Cave Geology. Cave Books.

Acknowledgements

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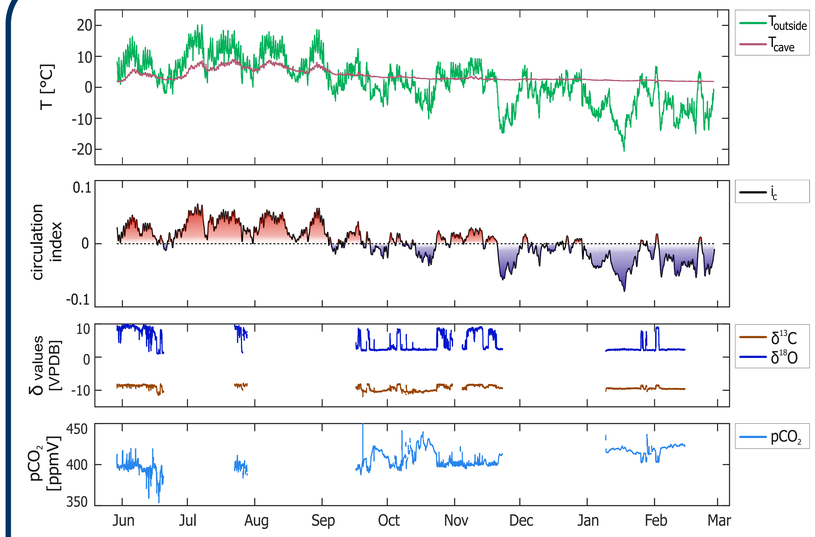
Links

http:// quaternary.uibk.ac.at/
http:// spannagelhoehle.jimdo.com/

Preliminary Results



Results from CO_2 monitoring have been filtered for contamination caused by respiration from cave visitors (Box 2). The filtered data set shows **two trends**:

1) **Low concentrations of isotopically heavy CO_2** resembling atmospheric values that coincide with warm outside temperatures. This suggests a downward airflow, bringing atmospheric air to the instrument, which is situated close to the upper entrance.

2) **High concentrations of isotopically light CO_2** that coincide with low outside temperatures relative to the cave interior. Assuming this trend represents an upward airflow at the sampling site, the CO_2 isotopic data suggests significant input of isotopically light CO_2 from more interiors parts of the cave.