Establishing past firn accumulation records from ice caves of the European Alps
Tanguy Racine¹, Christoph Spötl², Paula Reimer²

¹Institute of Geology, University of Innsbruck, ²Centre for Climate, the Environment and Chronology, Queen’s University, Belfast.

Background

Ice caves are rock-hosted caves containing perennial ice. In many sag-type caves, winter snow accumulations accounting for several 100 m³ are preserved underground in the form of firn. Ice in such caves is a proven climate archive (Stoffel et al., 2009; Munroe et al., 2018; Sancho et al., 2018) which can provide complementary insights in climate of the last 2 ka.

Objective

Establish radiometrically dated records of ice accumulation in alpine caves

Materials & Methods

→ Woody macrofossils (e.g. twigs) were sampled from the ice stratigraphy. Detailed stratigraphic logs, supplemented by annotated ice age estimates, were constructed to reconstruct the age model and the age framework of firn deposition. Site age distributions were calibrated using IntCal13 and Marine13 Radiocarbon Calibration Curves (Reimer et al., 2015). Radiocarbon dates were calibrated to calendar years using OxCal v4.3.1 (Ramsey, 2011).

Study Sites

<table>
<thead>
<tr>
<th>Site</th>
<th>Region</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Großer Natsrchacht (GN)</td>
<td>Carnithia, Dobratsch</td>
<td>1985 m</td>
</tr>
<tr>
<td>Eisgruben ice cave (EE)</td>
<td>Upper Austria, Saurstein</td>
<td>1720 m</td>
</tr>
<tr>
<td>Guffert ice cave (IG)</td>
<td>Tyrol, Reifen</td>
<td>1805 m</td>
</tr>
</tbody>
</table>

Key Results

Three broad ice accumulation periods in the past 2 ka are discerned in the ice cave record.

1. 250BC-500AD, with apparent accumulation rates < 1 cm a⁻¹
2. 700-1000AD only seen at Eisgruben (this study), between unconformities II and III. and Hundalm Eishöhle (Spötl et al., 2014).
3. 1150-1850 AD exhibited in all three caves, with relatively high rates of accumulation generally > 3 cm a⁻¹, and up to 13 cm a⁻¹ at Großer Natsrchacht. Ice deposited during period 3 (broadly coincident with the Little Ice Age) constitutes the greater portion of ice in alpine caves. At Eisgruben and Guffert, no ice deposited post 1600-1700 is preserved. This is likely due to (1) the lack of accommodation space as well as (2) widespread ice loss.

Perspectives

This study highlights the potential of sag-type ice caves as archives of past winter precipitation. Major hiatuses will need to be replicated in other alpine caves and the established ice-cave records will be compared to and contrasted with constituents of the cryosphere.