EGU2020-12049
https://doi.org/10.5194/egusphere-egu2020-12049
EGU General Assembly 2020

Changing winter conditions in the Alps during the Younger Dryas cold period

Gabriella Koltai[1], Christoph Spötl[1], and Hai Cheng[2]
[1]Institute of Geology, University of Innsbruck, Innsbruck, Austria (gabriella.koltai@uibk.ac.at; christoph.spoetl@uibk.ac.at)
[2]Institute of Global Environmental Change, Xi'an Jiaotong University, Xi'an, China (cheng021@mail.xjtu.edu.cn)

The Younger Dryas (YD, GS-1) is the latest of the canonical millennial-scale stadials of the last glacial period. Proxy data from terrestrial archives point to a climate dominated by extreme seasonality and continentality across Europe. YD summers were characterised by large meridional temperature gradients and remained quite warm despite the prominent slowdown of the Atlantic Meridional Overturning Circulation. The few available winter proxy records point to cold and dry winters.

In the Alps, the YD was characterised by the last major glacier advance and the development of rock glaciers. Dating these cryogenic geomorphological features, however, is associated with substantial uncertainties. A new type of secondary carbonate archive (coarsely crystalline cryogenic cave carbonates, or CCC_{coarse}) has received increasing attention as a promising quantitative cryogenic indicator for the shallow subsurface environment. CCC_{coarse} are found in karst caves and their formation is directly linked to thawing of perennial cave ice and U-series disequilibrium methods allow to date these events at high precision.

CCC_{coarse} formed during the YD were found in three caves covering an approximately 170 km-long SW-NE transect. The entrance of Cioccherloch cave is located at 2245 m in the Dolomites; Frauenofen opens in the Tennengebirge at 1635 m, while the third cave, Großes Almbergloch, is situated in Totes Gebirge at an elevation of 1475 m. The thermal regime in Cioccherloch reflects the ambient mean annual air temperature, while the cave microclimate of Frauenofen and Großes Almbergloch is partially influenced by cold air intrusions in winter.

^{230}Th dating of twenty-two CCC_{coarse} samples demonstrates that perennial ice was present in these caves during the first part of the YD, and Großes Almbergloch, Cioccherloch and Frauenofen warmed to 0°C at 12.32 ±0.09, 12.20 ±0.09, and 12.01 ±0.04 ka BP (weighted means), respectively, initiating slow thawing of cave ice bodies. Due to the partial cold trap behaviour of Frauenofen and Großes Almbergloch, a delay in cave ice demise and thus CCC_{coarse} formation is likely. This and the higher elevation could explain the centennial lag observed in CCC_{coarse} deposition in Frauenofen compared to Großes Almbergloch.

The change in the thermal condition of these caves commencing at ~12.3 ±0.1 ka BP is attributed to a change in the winter climate in the Alps, from dry to snow-rich and/or from extremely cold to

milder winters. A snowpack could effectively insulate the shallow subsurface from the YD winter coldness, allowing the subsurface to slowly warm. The timing of this warming of the subsurface coincides with the mid-YD transition recorded in other archives across Europe (e.g., Meerfelder Maar, central Germany; El Soplao cave, northern Spain) and corroborates the hypothesis of a northward movement of the Westerlies during the mid-YD, bringing warmer air and moisture to the Alps. Our study also demonstrates that the interpretation of CCC_{coarse} data requires a sound understanding of the cave geometry and the resulting mode of air exchange, since both the onset of perennial ice build-up and the eventual thawing may lag the atmospheric forcing outside the cave.