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Cryogenic cave carbonates suggest changing winter conditions in the European Alps during the mid-Younger Dryas

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Coarsely crystalline cryogenic cave carbonates (CCC_{coarse}) are secondary carbonate deposits that form via slow freezing-induced supersaturation of small water bodies in cave ice at temperatures very close to 0°C. CCC_{coarse} are also receiving increasing attention as a quantitative indicator of palaeo-permafrost thawing, because they can be precisely dated using U-series disequilibrium methods.

CCC_{coarse} formed during the Younger Dryas (GS-1) cold period were found in two caves in the Eastern Alps that are located approximately 170 km apart from each other. The entrance of Cioccherloch cave is located at 2245 m a.s.l. in the Dolomites; the second cave (Großes Almbergloch) is situated in Totes Gebirge at an elevation of 1475 m a.s.l. Both caves act as cold traps, i.e. their microclimate is mainly governed by dense cold air incursions in winter, while being insulated from the outside atmosphere during summer. Modern cave air temperatures at the CCC_{coarse} sites are 2.5°C and 1.9°C in Cioccherloch and Großes Almbergloch, respectively.

²³⁰Th dating of fourteen samples from Cioccherloch and four from Großes Almbergloch indicates a mid-Younger Dryas age for CCC_{coarse} formation with a weighted mean of 12.20 ±0.09 and 12.32±0.09 ka BP, respectively. These data demonstrate that perennial (thawing) ice due was present in these caves during the mid-Younger Dryas, whereby cave temperatures were very close to the melting point.

As the thermal regime of these caves is controlled by the outside air temperature during winter only, the transient warming in these subsurface environments at 12.3 ±0.1 ka BP recorded a shift from very cold and dry to milder and more humid winter conditions in the Alps. The timing of this change agrees with proxy data from other terrestrial archives in Europe (e.g., Meerfelder Maar, El Soplao cave) and corroborates the hypothesis of a northward shift of the polar front during the mid-Younger Dryas in central and northern Europe.