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Reconstructing permafrost thaw events from alpine cave systems

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Understanding the long-term dynamics of mountain permafrost is fundamental to quantify processes affecting the alpine landscape evolution. Unfortunately, potential archives of past permafrost are rare, not the least because of erosion processes affecting surface sediments. Achieving a robust reconstruction of permafrost evolution through time is nonetheless critical to assess the long-term response of alpine environments to changing climate conditions and thus to delineate potential hazards associated with instable debris slopes and rock walls.

Cryogenic cave carbonates (CCCcoarse) recently emerged as one of the most promising archive for past water circulation in frozen karst systems [Žák et al., 2012]. These secondary calcites precipitate from the segregation of solutes during the progressive freezing of water pools at the surface of cave ice deposits. Accordingly, the occurrence of CCCcoarse reflects both, the local presence of permafrost and suitable conditions for sporadic water infiltration through the karst conduit network, most likely associated with extreme climate events.

Based on geomorphological criteria, 45 caves from seven high-altitude karst areas were selected as suitable for hosting Holocene cryogenic cave carbonates. Field investigations allowed identification of CCCcoarse at six sites located in a narrow altitudinal band ranging from 2500 to 2850 m a.s.l. Scanning electron microscopy suggests that the newly identified CCCcoarse belong to three distinct morphologic types:

1. polycrystalline aggregates;
2. fibrous-radial spherulites and
3. dendritic crystals.

Crystal fabrics suggest that supersaturation state with respect to calcite was variable as well as the Mg concentration, which, in the case of spherulites is high. Mg concentration appears to be crucial in determining the wide range of observed morphologies, in conjunction with microbially mediated nucleation and growth. Preliminary U-series ages indicate that CCCcoarse formation occurred during warm episodes in the Late Holocene [Luetscher et al., 2013]. Our data suggest that ages of CCCcoarse in alpine settings help constraining the onset and duration of warm phases in the Northern Hemisphere, thus contributing to a better understanding of the impact of climate forcing on the spatial and temporal distribution of past permafrost.

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