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Reconstructing Holocene glacier fluctuations from alpine speleothems

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Alpine glaciers are known to be sensitive markers of climate changes responsive both to temperature and hydrological cycles. Glacio-morphological reconstructions based on ^{14}C or dendrological dating of organic material found in glacier forefields established a chronology of glacier fluctuations throughout the Holocene (e.g. Joerin et al. 2006) but little is known about their magnitude. To investigate these fluctuations in more detail 4 coeval stalagmites, between 28 and 232 mm long, were sampled from Milchbach cave, an extensive multilevel karst system developing along the flank of the Upper Grindelwald glacier (Switzerland). Historic surveys (1870) confirm that the cave was until recently covered by ice. During the present major glacier recession several of the cave entrances are open to the atmosphere, allowing forced convection (Q_{air} >1 m^{3}s^{-1}) and a high degree of cave ventilation. This results in both diurnal and seasonal changes in temperature and humidity. Given the absence of soil and vegetation above the cave, speleothem deposition is probably driven by the presence of sulfides (e.g. Spoetl and Magini 2007). This suggestion is confirmed by the observation of gypsum deposits on the cave walls.

MC-ICPMS U/Th dating indicates speleothem growth commenced some 8500 years ago and continued until the present day; mean speleothem growth rates averages $\sim$35 μm/a. All four samples consist of clear, dense carbonate free of detritus, but distinct textural changes are observed along the growth axis documenting periodic changes in the hydrological regime. Stable isotopes were analysed along the main growth axes at a 1mm resolution and along 8 individual growth layers (Hendy Tests). Results show

changing rates of isotopic fractionation with time. Extreme δ^{13}C enrichments are also measured on aragonitic coralloids incorporated in two of the samples from well ventilated sites. The mineralogical and isotopic records are interpreted to indicate changes in the dynamic ventilation of the cave, which may be associated with progressive opening of the cave entrances associated with the glacier retreats documented by Joerin et al. (2006). Milchbach cave represents therefore an ideal study site both for development of improved understanding of the role of forced ventilation on the speleothem record and for recording Holocene variations in Upper Grindelwald glacier extent.

References

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