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NEW CONSTRAINTS ON QUATERNARY CLIMATE AND LANDSCAPE EVOLUTION IN THE EASTERN ALPS FROM CAVE DEPOSITS

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Data of environmental change in the Alps are confined largely to the Late Glacial and Postglacial, because repeated glacial advances effectively obliterated most older surface sedimentary records. Cave calcites (speleothem) hold a high promise of providing critically needed paleoenvironmental information that can complement the record from lacustrine and glacial deposits and extend it back in time up to several hundreds of thousands of years. The reasons for this high expectation are twofold. First, caves are natural shelters that are much less affected by large-scale erosion processes than sedimentary deposits on the Earth's surface. This is particularly true for mountainous regions such as the Alps. Second, calcite can be precisely dated using the uranium-series disequilibrium technique, provided that the material has a sufficiently high uranium concentration coupled with a low abundance of detrital thorium, and has not been diagenetically altered. The typical dating limit of the mass spectrometric Th-U method is approximately 400 ka, but may be extended back to c. 600 ka in the case of excellent sample material.

Results from some 140 Th-U determinations performed on approximately 52 individual samples show that Alpine caves host both Holocene (and in many cases still active) and older, mostly inactive speleothems, some of which are older than the limit of the method. These results underscore the potential of the speleothem "archive" given the fact that there is no "absolute" chronology for the vast majority of the Quaternary surface sediments in the Alps prior to isotope stage 3 (i.e. older than the radiocarbon dating limit).

Our results suggest that many Alpine speleothems are useful recorders of major environmental change simply because calcite deposition ceases under fully glacial conditions. This "on/off switch" provides new constraints on major climatic changes, e.g., the onset of speleothem accretion at 131 ka BP at approximately 2300 m a.s.l. in the Zillertal Alps, requiring essentially ice-free conditions in the accumulation area of the former stage 6 ("Riss") glacier network during Termination II. Likewise, a stalagmite from the same area in the Central Alps grew between 57 ka and 47 ka BP, i.e. during the early part of stage 3 at some 2200 m a.s.l. This places constraints on the extent of alpine glaciers during this long time interval of the Würm glaciation and strongly argues against the presence of a significant ice cover during stage 3. A third example pertains to calcitic flowstone present as fracture-lining deposit in the famous Hötting Breccia near Innsbruck. A sample from this locality yielded a Th-U age of 73 ka and for the first time allows us to state that the central Inn valley was ice-free during the critical stage 5/4 transition.

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