A Th/U dated record of the penultimate deglaciation, Spannagel Cave, Austrian Alps

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Speleothems can provide a precise chronology of environmental change of land and we have studied a complex flowstone sample from Spannagel Cave in the Central Alps of Austria. This site is exceptional, because it hosts both active and fossil speleothems despite its high altitude of 2500 m and a constant internal air temperature of only +1° to +2°C. Being located close to a modern glacier, the cave system is highly sensitive to climate change, inasmuch as the area above the cave gets glaciated and/or covered by permafrost and speleothem deposition ceases once mean annual air temperatures drop. During the Last Glacial Maximum the cave system was well within the glacier accumulation area and covered by up to a few hundred meters of ice.

A detailed study of flowstone SPA 52, currently probably the best Th/U-dated speleothem record from the Alps, thanks to a very high U content of up to 100 ppm, reveals a warm climatic episode during marine isotope stage 7a. Flowstone formation ceased after 180 kyr, i.e. during the penultimate glaciation, and renewed calcite deposition started at 135 ± 1.2 kyr, suggesting that this high-Alpine site was ice-free shortly after beginning of marine isotope stage 5e. ^{18}O-depleted and ^{13}C-enriched calcite isotope values indicate flushing of the karst fissure network by glacier meltwater and the lack of a soil cover, respectively. This first episode of growth is overlain by an unconformity between 127 and 122 kyr ago. The subsequent growth phase, representing relatively rapid accretion of speleothem calcite with low $\delta^{13}C$ and relatively high $\delta^{18}O$ values diagnostic of fully interglacial conditions at this site, ceased 115 kyr ago.

The timing of the onset of flowstone deposition at 135 kyr requires ice-free conditions in the high Central Alps by that time. This new dataset not only provides the first isotopically dated age constraint on the penultimate deglaciation in the former accumulation area of isotope stage 6 Alpine glaciers, but also adds evidence against Northern Hemisphere forcing of climate change during Termination II.

Deducing oxygen evolution history from iron and manganese retention in Late Archean to Paleoproterozoic paleosols

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Knowledge of the timing, pattern, and causes of oxygenation of the Precambrian atmosphere is of fundamental importance because it held a critical threshold on the evolution of biosphere. The compositions of paleosols emerged as useful semi-quantitative indicators of P_{O_2} of the past atmosphere (Rye and Holland, 1998). Despite a large number of studies on Precambrian paleosols, there is no consensus either on effective usage of their compositions or on the timing and pattern of oxygen evolution. The difference in Fe content between the parent material and the highly weathered horizon of the paleosol has been used to constrain the P_{O_2} of the atmosphere, which suggests a drastic rise at ~ 2100 Ma. However, citing the problem of alkali metasomatism that has affected many Precambrian paleosols Ohmoto (1996) suggested usage of Fe^{2+}/Ti and Fe^{3+}/Ti ratios and concluded that oxic environments prevailed during the Archean itself. Obviously this discrepancy has arisen due to different approaches in processing the paleosol data to achieve information regarding atmospheric oxygen content. Ideally isovolumetric changes in redox sensitive elements such as iron and manganese in paleosols can yield vital information regarding the atmospheric oxygen evolution. In this work, using immobile Al and Ti contents a method is proposed to estimate the compaction of paleosols for unraveling the effect of burial to comprehend the secular variation in fraction of iron and manganese retained (Fe_R and Mn_R) during the Late Archean to Paleoproterozoic weathering. The results indicate a gradual rise in Fe_R and Mn_R between 2750 and 1850 Ma. Both Fe and Mn retained completely in paleosol of ~ 1850 Ma age, being consistent with other lines of evidence of the oxygenation event. A large rise in Fe_R and Mn_R is observed in pre-Huronian paleosols of ~ 2450 Ma coinciding probably with the mantle overturn event, contradicting the existing views of either early oxygen evolution during Archean or a drastic rise in oxygen level during post-2100 Ma period. Mantle and surficial events at 2500 and 2100 Ma, respectively appears to have constrained the Precambrian oxygen evolution.

References

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