A record of Northern Hemisphere climate variability during the Penultimate Glacial from high resolution speleothem data

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Numerous paleoclimate records have contributed to our understanding climate change during the Last Glacial. Data for previous glacial cycles are rare however, due to the lack of absolutely dated continuous records. Here we present stable and elemental data of an absolutely dated stalagmite (FS-TR3) from Fort Stanton Cave, New Mexico, that reveal the character and timing of Northern Hemisphere (NH) climate variability during the Penultimate Glacial (MIS 6). These data show links to summer insolation, rapid North Atlantic cold/warm anomalies and lack thereof, and climatic oscillations resembling the 1500-year cycle.

Previous results from the study area showed that δ18O values from stalagmite FS2 mimic the δ18O record of the Greenland Ice Core in both general trends and higher frequency variations such as the Dansgaard-Oeschger (DO) and Heinrich events (HEs) (Asmerom et al., 2010 ref 1). The new FS-TR3 stalagmite extends our record to the Penultimate Glaciacion. Stalagmite FS-TR3, based on high-resolution U-series chronology, grew continuously from 165 to 130 ka. At the orbital scale, the trend is dominated by insolation, rapid North Atlantic cold/warm anomalies or lack thereof, and climatic oscillations resembling the 1500-year cycle.

Stable isotope tracing of ZnO nanoparticles in complex systems

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Whilst nanomaterials are employed in an increasing range of commercial and industrial products, analytical difficulties obstruct the scientific understanding of their toxicological properties and environmental fate. ZnO nanomaterials (NMs) are of particular interest as these are used in sunscreens and cosmetics as a UV filter, and reach the biosphere through a variety of routes. Due to the high natural background levels of Zn, the detection of ZnO NMs in ecotoxicologically relevant exposures cannot be attained through concentration data alone. However, highly sensitive detection can be achieved using purpose-made ZnO nanoparticles (NPs) labelled with a stable Zn isotope [1]. This approach also negates handling difficulties and time restrictions associated with radioactive tracing. Even with relatively inexpensive 68Zn as the isotope label, ZnO nanoparticle concentrations as low as 5 ng/g can be precisely quantified against a background of 100 μg/g Zn when measured using MC-ICP-MS.

ZnO NPs (30 nm, TEM) labelled with 68Zn were synthesized by hydrolysis from an acetate precursor [2]. Parallel 10-day exposures of Corophium volutator to labelled 68ZnO NPs, bulk 65ZnO and soluble 65ZnCl2 were performed in artificial seawater in the presence of sediment [3]. Dialysis experiments were used to determine the rate and extent of dissolution for both bulk and nanoparticulate 65ZnO in the test medium. The subsequent analyses of organisms, sediment and water samples for Zn isotope compositions and concentrations were carried out by MC-ICP-MS following preconcentration of Zn by anion exchange chromatography [4].

For all exposures, including those utilizing dissolved 65ZnCl2, the sediments accumulated the largest pool of the 68Zn label. This finding and the low final 68Zn contents of the aqueous media are indicative of significant Zn transfer from the water column to sediments, presumably as a result of Zn sorption [5]. The observations that (i) the 68Zn levels determined for the organisms were approximately scaled in proportion to the dissolved 68Zn concentrations that are expected based on the dialysis experiments and (ii) the organisms featured 68Zn/66Zn isotope ratios lower than those measured for the corresponding water samples, suggest that the uptake of 68Zn by the organisms from 68ZnO NPs occurred through the dissolved state.