



Trace elements in coastal South African speleothems as proxies for sea level change and distance to the coast

Kerstin Braun^{1,2}, Yuval Burstyn^{3,4}, Nathaniel Miller⁵, Lawrence Edwards⁶, and Xianglei Li⁶

¹Arizona State University, Institute of Human Origins, Tempe, United States of America (kerstin.braun@asu.edu)

²African Centre for Coastal Paleoscience, Nelson Mandela University, Gqeberha, South Africa

³Department of Earth and Planetary Science, University of California, Davis, USA

⁴Institute of the Environment, University of California, Davis, USA

⁵Jackson School of Geosciences, University of Texas, Austin, USA

⁶N. H. Winchell School of Earth and Environmental Sciences, University of Minnesota, Minneapolis, USA

The South African south coast is noteworthy for its rich record of archaeological sites. Cave deposits from the region record the first known evidence of hunter-gatherers using marine food resources ~165 ka ago. Between ~110 and 65ka the archaeological record also preserves worn seashells, complex stone and bone tools, shell beads and decorated ochre and ostrich eggshell. Such complex tools and decorated objects may be early examples of items that required the accumulation and dissemination of knowledge over several generations and culture. But our understanding of the environmental and climatic background of the evolution of such milestones in human history is still limited.

Here we present Mg/Ca, Sr/Ca, Ba/Ca and U/Ca records of speleothems from Pinnacle Point on the South African south coast. The records were measured by laser-ablation ICP-MS and cover the time interval between 88 and 58 ka. We compared our new records to a range of global and regional proxies using gaussian-kernel based cross correlation analyses. To understand larger scale patterns of correlation we included several proxies of global and regional temperature change as well as proxies of weathering and river runoff/rainfall amount, coastal upwelling, and orbital parameters/insolation. Our Mg/Ca and Ba/Ca records show a steep decrease at the transition from interglacial MIS 5 into glacial MIS 4 and a general positive relation with global and regional temperature proxies and sea level. We therefore interpret them in terms of changing contributions of sea spray to the caves trace element budget. Such changes are especially pronounced in this area due to the wide and gently sloping continental shelf. Sea level variations during the deposition of our speleothem samples meant that the coast was between ~500m and 30 km distant from the caves.

The Sr/Ca and U/Ca records of Pinnacle Point speleothems show only a short decrease near the MIS 5-4 transition followed by higher values in MIS 4. This also leads to negative correlation with most global and regional temperature proxies whereas correlation with proxies of rainfall/weathering and river runoff is varied. We therefore interpret the Sr/Ca and U/Ca records in

terms of in-cave processes related to water availability, such as Prior carbonate precipitation and CO₂ degassing and redox in the overlying soils, respectively. Higher values of Sr/Ca and U/Ca therefore would be associated with drier conditions and oxidizing conditions in the soil. Following this interpretation, the Sr/Ca and U/Ca records indicate drier conditions at Pinnacle Point in MIS 5 b and early a, wetter conditions at the MIS 5-4 transition and a shift towards drier conditions within MIS 4.

The changing distance to the coast means that hunter-gatherers in the region had variable access to its rich marine resources over time. Variable climate and soil oxidation would also indicate changing water availability and vegetation composition. The consistent use of archaeological sites at Pinnacle Point by hunter-gatherers, however, means that people were able to adapt to these changes.