

Lecture Abstract:

“Processes – From the ocean to the cave (O isotopes)”

By Matthew S. Lachniet¹

Variations in speleothem oxygen-isotope values ($\delta^{18}\text{O}$) result from a complicated interplay of environmental controls and processes in the ocean, atmosphere, soil zone, epikarst, and cave system. As such, the controls on speleothem $\delta^{18}\text{O}$ values may be complex. An understanding of the processes that control equilibrium and kinetic fractionation of oxygen isotopes in water and carbonate species is essential for the proper interpretation of speleothem $\delta^{18}\text{O}$ as paleoclimate and paleoenvironmental proxies, and is best complemented by study of site-specific cave processes such as infiltration, flow routing, drip seasonality and saturation state, and cave microclimate, among others. This talk will provide a process-based summary of the multiple controls on $\delta^{18}\text{O}$ in the atmosphere, soil, epikarst, and speleothem calcite, illustrated with case studies. Primary controls of $\delta^{18}\text{O}$ in the atmosphere include temperature and relative humidity through their role in the multiple isotope “effects”. Variability and modifications of water $\delta^{18}\text{O}$ values in the soil and epikarst zones are dominated by evaporation, mixing, and infiltration of source waters. The isotopically effective recharge into a cave system consists of those waters that participate in precipitation of CaCO_3 , resulting in calcite deposition rates, which may be biased to time periods with optimal dripwater saturation state. Recent modelling, experimental, and observational data yield insight into the significance of kinetic fractionation between dissolved carbonate phases and solid CaCO_3 , and have implications for “Hendy” test. To assist interpretation of speleothem $\delta^{18}\text{O}$ time series, quantitative and semi-quantitative $\delta^{18}\text{O}$ -climate calibrations are discussed with an emphasis on some of the difficulties inherent in using modern spatial and temporal isotope gradients to interpret speleothems as paleoclimate proxy records. An “equilibrium” test should be done for each speleothem based on known cave temperatures, drip water $\delta^{18}\text{O}$ values, and established equilibrium water-carbonate fractionation factors, to assess whether the stalagmite was precipitated near equilibrium; some of the uncertainties of the equilibrium test will also be discussed. Lastly, some considerations of the use of aragonite speleothems for oxygen isotope analysis and palaeoclimate reconstruction will be considered.

¹ Department of Geoscience, University of Nevada Las Vegas, USA