EGU24-14277, updated on 20 May 2024
https://doi.org/10.5194/egusphere-egu24-14277
EGU General Assembly 2024

Hydroclimate Response to the 8.2ka Event Across California: Insights from A Southern Sierra Nevada Stalagmite

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Climate simulations project an increasing “whiplash climate” or rapid oscillations of wet and dry extremes, for 21st century California, prompting the need for research into the Holocene climate volatility periods. Paleoclimate records from California (CA) suggest that the 8.2 ka event is experienced as a whiplash climate. A coastal stalagmite record from central CA indicates variable infiltration and overall wetter conditions above the cave. Fire biomarkers from the stalagmite support a link between whiplash climate and fire activity in Western North America, a similar relationship is also observed in tree rings and lake deposits. However, the spatial heterogeneity characterizing Mediterranean climates and the observed shifts of the north-to-south climate dipole in response to global climate change presents a challenge in forming a cohesive regional image of paleoclimate CA.

Crystal 67 Cave (C67) is situated in the Southern Sierra Nevada at an elevation of ~2000 meters amsl. Our study includes a geochemical monitoring campaign from soil to deposition site and a high resolution (30y to 5y) stalagmite proxy record covering the early to mid-Holocene. In 2020, a significant fire complex rampaged through the forest above the cave, followed by an exceptionally rainy winter season in 2022-2023, making C67 a prime candidate for studying the response of both extreme “whiplash” climate years (this study) and post-fire signal transport through the karst system (Hren et al., EGU 2024).

The 2022-2024 monitoring of C67 shows that drip rate data is inversely correlated with the cave CO_2, suggesting seasonal ventilation and potential winter and spring bias in speleothem growth. Drip rate is also well synchronized with the high precipitation events and snowpack in the winter and early spring indicating high hydrologic connectivity between the cave and the surface. Drip water $\delta^{18}O$ and δD values fall along the Local Meteoric Water Line in three distinct clusters: spring water, associated with summer drip water, and water sourced from sub-tropic and north-pacific storm tracks, associated with winter and early spring drip water, respectively. Trace Elements (TEs) highlight a rapid infiltration end-member dominant in winter and spring, and a second seepage end-member feeding the cave drips throughout the dry season.

The stalagmite geochemical data supports alternating wet and dry conditions during the 8.2 ka event. However, while the $\delta^{18}O$ profile of C67 mimics that of the coastal cave, its $\delta^{13}C$ values suggest that C67 experiences a shift from mean to drought conditions, supported by coinciding high TE/Ca. Additionally, P/Ca ratios increase during and after 8.2 ka, indicating increased colloidal influx into the cave, previously associated with enhanced fire activity.

Our results show that the C67 cave and stalagmites present a unique opportunity for a high-resolution investigation of the position of the CA climate dipole and whiplash seasonality.