Environmental Change Through the Eyes of Ancient Hopi Lake:

Reconstructing Climate and Topographic History of the Colorado Plateau Using Isotope Geochemistry

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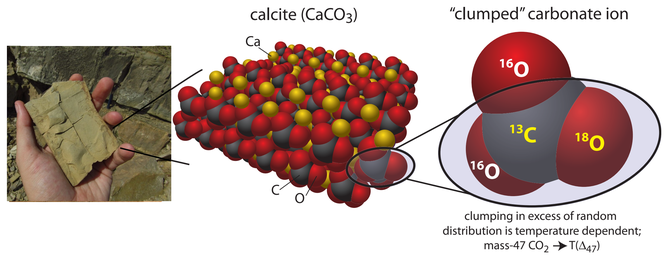
What are causes and consequences of topographic change?

Ancient marine deposits from the Colorado Plateau show that the region was once near sea level (Nations et al., 1991), despite its 2 km elevation today. The uplift of the plateau was likely a consequential change for regional climate and biodiversity, but the causes and timing of this uplift is still not agreed upon (see review by Heitmann et al., 2021).

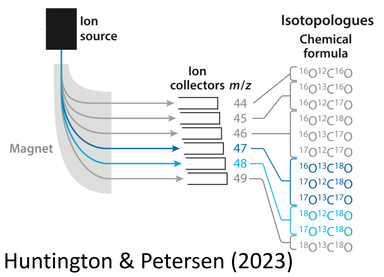
The Bidahochi Formation (pictured above) contains ancient lake deposits spanning 16-6 Ma (Dallegge et al., 2003). The isotope composition of carbonates in these deposits (oxygen ($\delta^{18}O$) and clumped (Δ_{47})) may record global climate change as well as uplift processes that created the Colorado Plateau we know today.

Methods

Heavy isotopes are more likely to bond together in lower temperatures due to thermodynamic favorability, allowing us to use isotope clumping as a *direct temperature proxy*.

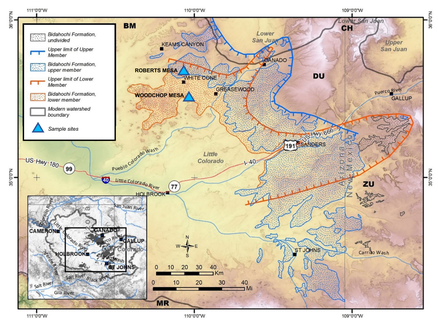


In order to collect both bulk (overall $\delta^{18}O$ and $\delta^{13}C$ composition) isotope data and clumped (Δ_{47}) isotope data (the bonding of heavy ^{18}O and ^{13}C relative to random distribution), a Nu Perspective Stable Isotope Ratio Mass Spectrometer with a Nu Carb Automated Carbonate Device attachment (pictured below) was used for measurements.

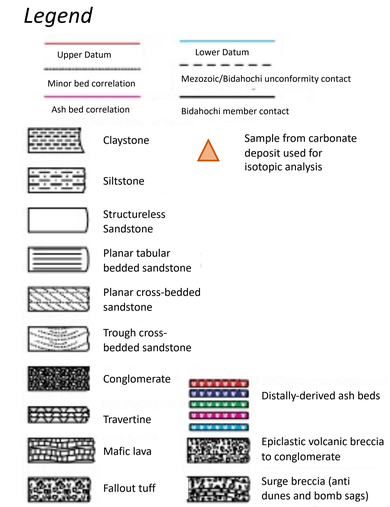


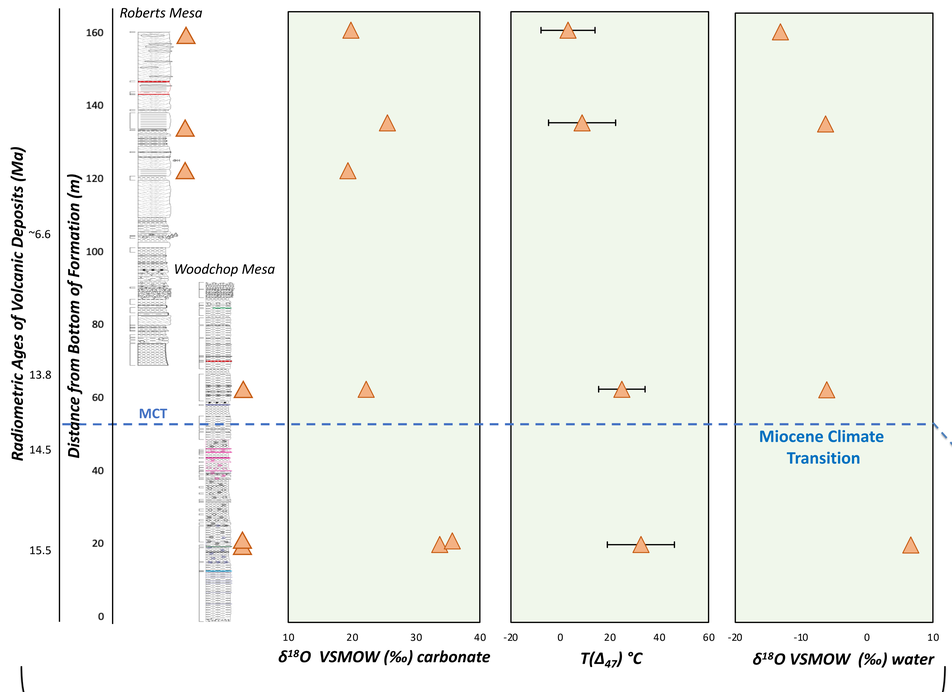
Huntington & Petersen (2023)

Lake carbonate isotope record shows larger temperature shift than global climate record

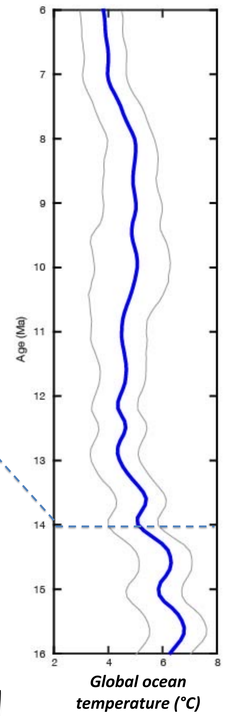


Sample locations and stratigraphic context. Map from Douglass et al. (2020), measured stratigraphic sections from Dallegge (1999).





Sample stratigraphy, approximate ages, measured carbonate $\delta^{18}O$ and temperature (Δ47), and calculated water $\delta^{18}O$.



Temperature estimates from benthic foraminifera Mg/Ca (Cramer et al. 2011)

Climate records suggest 7-10 °C cooling, while lake carbonate records show >20 °C cooling.

Preliminary Conclusions

The isotope composition of carbonates in these deposits record global climate change. However, the temperature change observed is larger than expected, suggesting that the record may record uplift as well. Further work is needed to test this hypothesis.

Future Work

Next steps could include climate modeling to help separate topography and climate trends, adding more samples from different sections of the Bidahochi Formation, perfecting instrumental methods in order to create less error for T(Δ47), and more fieldwork to collect additional samples.

References and Acknowledgements

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