To Split or to Lump? The Importance of Facies Analysis for Interpreting Stable Isotope Paleoclimate Proxies from Lacustrine and Palustrine Carbonates

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Abstract

Stable isotope geochemistry of terrestrial carbonates provides important opportunities to answer questions about climates, environments, and ecosystems both in the present day and the geologic past. Here we present a case study from the Cretaceous Newark Canyon Formation (NCF) type section (~98–113 Ma), where we explore how climate and depositional settings influence the stable isotope record in highly variable lacustrine and palustrine carbonates. The NCF was deposited within the hinterland of the Sevier orogenic belt and allows us to examine how North American terrestrial climate changed during the mid-Cretaceous, a time of potentially significant regional surface uplift and increasing global temperatures related to the Cretaceous Thermal Maximum (Di Fiori et al., 2020; Huber et al., 2018). In this study, we find substantial inter- and intra-facies heterogeneity, despite having formed in the same overall climate setting, highlighting the differences between lacustrine and palustrine environments. Stable carbon, oxygen, and clumped isotopes ($\delta^{13}C$, $\delta^{18}O_{carbonate}$, and Δ_{47}) paired with optical and cathodoluminescence petrography from along-strike lateral and vertical stratigraphic sections show significant isotopic variability between and within seven carbonate facies (Fetrow et al., 2020). Palustrine deposition is interpreted to have occurred along a spectrum of shallow water depths preserved in two key palustrine sub-facies endmembers – shallower mottled micrite and deeper pebbly, peloid-rich micrite. These record mean Δ_{47} temperatures of 51ºC and 44°C, respectively. The mottled micrite has heavier calculated $\delta^{18}O$ of formation water ($\delta^{18}O_{water}$) values indicating increased evaporative enrichment, which suggests more intense desiccation during deposition. Lacustrine sediments preserved in laminated biomicrite to massive micrite have mean Δ_{47} temperatures of 50ºC and 37°C, respectively. Elevated temperatures and $\delta^{13}C$, $\delta^{18}O_{carb}$, and $\delta^{18}O_{water}$ values more similar to values from NCF secondary spar veins indicate that the biomicrite sub-facies underwent diagenetic alteration. We will discuss the implications of these results for the NCF and the Cretaceous western USA paleoclimate record, as well as general lessons learned for interpreting mixed terrestrial carbonate facies records.

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To split or to lump? The importance of facies analysis for interpreting stable isotope paleoclimate proxies from lacustrine and palustrine carbonates

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Plain language summary:

Limestones that form in lakes and wetland environments on land record important signals about the environment and climate in which they form. Here we examine how the environment that carbonate forms in, such as a lake vs. a wetland, influences the stable isotope geochemistry that is encoded into the limestone. Stable isotope geochemistry is an ideal tool to help us better understand variability on a landscape because it can give us vital clues about processes occurring at the same time as deposition. Without properly accounting for how depositional environment influences these records, it is possible to mis-interpret how climates and environments in the past changed through time. We look at terrestrial carbonates from central Nevada from ~100 million years ago to explore these important questions.

References:

[1] Di Fiori, R. V., Long, S. P., Fetrow, A. C., Snell, K. E., Bonde, J. W., & Vervoort, J. D. (2020). Syn-Contractional Deposition of the Cretaceous Newark Canyon Formation, Diamond Mountains, Nevada: Implications for Strain Partitioning Within the North American Cordillera. *Geosphere*, *16*, 1–21. https://doi.org/10.1130/abs/2019am-335173

[2] Huber, B. T., MacLeod, K. G., Watkins, D. K., & Coffin, M. F. (2018). The rise and fall of the Cretaceous Hot Greenhouse climate. *Global and Planetary Change*, *167*, 1–23. https://doi.org/10.1016/j.gloplacha.2018.04.004

[3] Fetrow, A. C., Snell, K. E., DI Fiori, R. V, Long, S. P., & Bonde, J. W. (2020). Early Sevier Orogenic Deformation Exerted Principal Control on Changes in Depositional Environment Recorded by the Cretaceous Newark Canyon Formation. Journal of Sedimentary Research, 90(September), 1–22. https://doi.org/10.2110/jsr.2020.52