Clumped isotope sea surface temperature estimates: Analysis of paleoclimate and diagenesis

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Greenhouse climates are characterized by warm global temperatures and shallow latitudinal temperature gradients. Previous studies have used a variety of temperature proxies to reconstruct these gradients, including Mg/Ca and $\delta^{18}O$ in carbonate materials and organic proxies such as TEX_{86} and U^{K}_{37} (e.g., [1]). All temperature proxies have inherent uncertainties and it is critical to understand their underlying assumptions and test existing temperature records with novel, emerging methodologies. For example, the carbonate clumped isotope proxy (Δ_{47}) is appealing in reconstructing sea surface temperatures (SSTs) and testing existing estimates because it requires fewer assumptions. Like other proxies, Δ_{47} is sentitive to diagenetic alterations during recrystallyzation. Also, when exposed to high burial temperatures Δ_{47} may be altered by solid-state diffusion, which is hard to diagnose and can produce temperature estimates between environmental and burial temperatures. This highlights the importance of multi-proxy studies for reconstructing greenhouse temperatures. Δ_{47} can provide information (e.g., temperature and $\delta^{18}O$ of carbonate) to estimate other parameters such as $\delta^{18}O$ and Mg/Ca of seawater, and salinity. We use the Δ_{47} of mollusk fossils (*Exogyra cancellata)* from the Late Campanian in the Gulf Coast (~28 °N to 40 °N paleolatitude) to estimate sea surface temperatures and paleoceanography. SST estimates agree with previous studies based on TEX_{86} in this locality [2]. These temperatures, combined with shell $\delta^{18}O$, predict very high $\delta^{18}O$ of seawater suggesting highly evaporative Tethys water. These fossil shells show clear seasonalitly through microsampling, and trace metal concentrations suggest they did not experience diagenetic recrystallization, yet the southern most samples give SST estimates ~40 °C, higher than previous studies [2] and unfavorable for life, implying unrecognized alterations associated with solid-state diffusion.

[1] Bijl et al. (2009) *Nature* **461**, 776–779. [2] Linnert et al. (2013) *Nature Communications* **5**:4194.