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Late Cretaceous seawater variability recorded in bivalve rudist shells from northern and southern Mexico

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Cretaceous greenhouse oceans were characterized by dynamic carbonate production, evolving seawater chemistry, and complex biotic-environmental interactions across tropical platforms. However, high-resolution, well-screened archives from low-latitude carbonate systems remain comparatively scarce, limiting our understanding of environmental variability and chemical gradients within the western Tethyan realm. Rudists (Order Hippuritida), dominant carbonate-producing bivalves of the Cretaceous, produced a thick low-Mg calcitic shells capable of preserving primary geochemical signatures at subannual resolution. Here we present a multi-proxy dataset from 19 well-preserved specimens representing 8 taxa collected from the Cárdenas and Ocozocoautla formations (north-central and southeastern Mexico, respectively). These Upper Cretaceous carbonate units preserve abundant rudist assemblages, yet their paleoenvironmental interpretations remain debated. Element/Ca ratios (Mg/Ca, Sr/Ca) measured along growth transects display pronounced cyclicity, reflecting short-term environmental fluctuations during shell accretion. Rare earth elements and yttrium (REY) systematics exhibit seawater-like PAAS-normalized signatures, including slight heavy REE enrichment, negative Ce anomalies, positive La and Y anomalies, and superchondritic Y/Ho ratios (>40), supporting predominantly oxic marine conditions and minimal diagenetic overprint. Oxygen isotope-derived sea-surface temperature estimates range from 16.0 to 42.8 °C, with most specimen averages clustering between ~25 and 35 °C, consistent with tropical greenhouse marine settings for the Late Cretaceous. By integrating high-resolution trace-element transects, REY systematics, stable isotopes, and quantitative spectral analysis, this study confirms that shells from northern and southern Mexico preserve seasonally records of seawater chemistry. These findings refine reconstructions of Late Cretaceous tropical platform dynamics and contribute to broader understanding of chemical evolution and environmental variability in greenhouse oceans.