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Seasonal Controls on the ecological and geochemical Planktic Foraminifera Proxy Systematics in the Gulf of Aqaba

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Planktic foraminifera (PF) are widely used paleoceanographic archives because their shell chemistry record environmental conditions such as temperature and salinity. However, in highly saline, oligotrophic basins, PF ecology and proxy systematics remain insufficiently constrained which limits robust paleoenvironmental reconstructions. To address this, we investigate the trace element/Ca of individual chambers (TE/Ca; measured using LA-ICP-MS), the $\delta^{18}O$ and $\delta^{13}C$, and morphology (using SEM and NanoSIMS) of two flux-dominant species, *Turborotalita clarkei* and *Globigerinoides ruber* (albus), in the Gulf of Aqaba (northern Red Sea) using monthly sediment-traps (June 2014–June 2015) from five water column depth horizons (120–570 m), complemented by concurrent water measurements.

While some TE/Ca's appear to robustly record the water column conditions (e.g., Mg/Ca for temperature in *G. ruber*) others reveal complex trends which we investigated further using redundancy analysis (RDA). For example, in *T. clarkei* the TE/Ca of whole-shells and chambers of numerous elements (e.g., Mg/Ca, Na/Ca) peak in variability during late winter-spring (March–April 2015) and RDA links the TE/Ca variations to shifting mixed-layer depth. In both species, chamber-specific TE/Ca analyses show systematic offsets in the youngest final (F0) chamber relative to older chambers, suggesting that F0 may be excluded from the pooled mean chamber values for more robust proxy reconstructions. Shell $\delta^{18}O$ values and trends compared to predicted surface and deep layer $\delta^{18}O$, reveal that *G. ruber* predominantly records shallow calcification (above the thermocline), while *T. clarkei*, characterized by more negative $\delta^{18}O$ values, may have rapidly calcified. Additionally, *T. clarkei* appears as two distinct phenotypes (big and encrusted) with increasing abundance ratio (encrusted/big) in winter and decreasing in summer, supporting its potential as an indicator of changing seasonal hydrological and ecological conditions. Together, these results refine PF proxy interpretation in stratified, high-salinity settings and provide a framework transferable to other oligotrophic basins.