Multi-proxy analysis and growth modelling of Late Cretaceous fossil bivalves: Disentangling seasonal parameters

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The Late Cretaceous greenhouse world is characterized by high atmospheric pCO_2 values and serves as an ideal analogue for future climate change due to anthropogenic CO_2 emissions (IPCC, 2014). While the Late Cretaceous is often studied on a long timescale, it also is important that the short-term seasonal-resolution climate of this system is understood. Trace element and stable isotope proxies in incrementally growing bivalve shells have been used to reconstruct palaeoseasonality (STEUBER et al., 2005). However, internal parameters, such as growth and metabolic rate also control the recording of palaeoenvironmental proxies in bivalve calcite (e.g. LORRAIN et al., 2005; SCHÖNE et al., 2011). Culture experiments with extant bivalves can be used to constrain some of these vital effects, but these are not available for extinct bivalve species such as the extremely common Cretaceous rudistid bivalves.

In the present work, a multi-proxy, multi-species approach is used in an attempt to disentangle the effects of species-specific vital effects on palaeoenvironmental proxies. High-resolution micro-X-Ray Fluorescence (microXRF) and Laser Ablation-Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) trace element profiles are combined with stable oxygen and carbon isotope profiles. The relative expression of palaeoenvironmental proxies (e.g. $\delta^{13}C$, $\delta^{18}O$, Mg/Ca, Sr/Ca, S/Ca, Zn/Ca) in fossil bivalves is compared. Furthermore, a new numerical modelling routine based on growth increments in cross sections of fossil bivalve shells is used to reconstruct growth rates through the lifetime of the organisms. This model is combined with microXRF mapping and phase analysis of shell cross-sections to trace accumulation rates of trace elements and stable isotopes through time in an attempt to trace the role of growth on these proxy records. Application of this growth model in combination with multi-proxy records through the shells sheds light on the respective roles of internal and external parameters that control incorporation of proxies in bivalve shells. This multi-proxy modelling approach critically assesses the application of calcite palaeoenvironmental proxies and their relationship with Cretaceous climate and sea water chemistry without the use of species-specific culture experiments. As a result, a more detailed reconstruction is made of Late Cretaceous environments, and seasonal fluctuations are interpreted.

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