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# Campanile gastropods as recorders of Eocene hothouse climate: A multi-proxy study with comparison with modern relatives

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The Eocene Epoch is characterized by high global temperatures compared to present-day climate, elevated atmospheric $CO_2$ concentrations and a lack of polar ice caps (Pearson and Palmer, 2000). This period is therefore of wide interest for the paleoclimate community as a potential analogue for future climate (IPCC, 2013). While many studies provide reconstructions of long-term climate change or geologically rapid hyperthermal events during the Eocene, there is little knowledge of environmental changes at an annual to sub-annual timescale. However, such records are indispensable if the effects of climate transitions on the occurrence of extreme weather events and changes in seasonality are to be understood. The chemical composition of well-preserved mollusc shells records valuable information about these short-term changes in climate and can be used to reconstruct paleoclimate and –environment down to a seasonal scale (Andreasson & Schmitz 1996). In this study, we investigate the use of large (up to ±40 cm long) exceptionally well-preserved fossil Campanile giganteum gastropod shells from the Lutetian (±45 Ma) Paris Basin as high-resolution recorders of Eocene hothouse conditions.

Trace element (Mg/Ca, Sr/Ca, Mg/Li, Sr/Li), stable isotope ($\delta$13C, $\delta$18O) and clumped isotope ([U+F044]47) analyses were combined on the same shells in a multi-proxy approach as the large size of these gastropods permits sampling at sub-annual resolution. This study design can therefore reveal species-specific vital effects and/or biases in all proxies, which are known to complicate reconstructions based on fossil mollusc genera without modern representatives.

As these vital effects can complicate reconstructions, similar sampling strategy was carried out on the shell of a close extant relative (Campanile symbolicum) which grew under known recent conditions in Telegraph Bay in Australia. In the modern specimen, all three proxies record a clear seasonal cyclicity that can be linked to known changes in temperature, productivity and salinity. Seasonal patterns in these very long gastropod shells reveal exceptionally high growth rates of both C. symbolicum and C. giganteum during the warm season as well as nearly year-round growth. Therefore, Campanile shells can be used for paleoenvironmental reconstructions at a very high temporal resolutions, up to weekly or even sub-daily resolution. [U+F044]47 values in the modern specimen are biased to colder temperatures, and we explore the possibility for vital effects in this species.

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