Fish otolith stable isotope paleothermometry in the early Paleogene: limitations and future directions

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The climate of the early Paleogene is characterized by short-scale temperature variations which are superimposed on a general trend of rising temperatures culminating during the late early Eocene (early Eocene climatic optimum, EECO). These include several transient periods of abrupt climate warming or 'hyperthermals', such as the PETM (~55 Ma). Profound proxy development is needed to successfully extract shorter-scale variability from suitable records and unravel its underlying mechanisms. This study assesses and extends the use of fossil fish otolith O and C stable isotopes as a paleotemperature and seasonality proxy for early Paleogene marginal marine sedimentary environments. Well-known limitations include the lack of accurate estimates for the oxygen isotope composition of ambient water, and potential bias when applying paleotemperature equations. Moreover, taxon inconsistencies for both O and C were observed, complicating data interpretation (Vanhove *et al.*, 2011).

A single locality test case in the southern North Sea Basin has been performed to address this observation (Egem, Belgium, coastal sands). In each of four fossiliferous levels sampled, the same three demersal otolith species were analyzed (*Platycephalus janeti*, *Paraconger papointi* and "genus Neobythitinorum" *subregularis*). Cross-plots of $\delta^{18}O$ and $\delta^{13}C$ isotopes show three statistically different data clouds, corresponding to the three taxa. Several processes can cause such discrepancies. The most likely option is the influence of freshwater influx. According to this interpretation, *Paraconger sp.* and *Platycephalus janeti* lived in coastal areas prone to freshwater influx, while *"genus Neobythitinorum" subregularis* inhabited more distal realms. This is confirmed by similar analyses on *Callista* sp. and *Venericardia* sp. bivalves of the same locality, because these were deposited relatively in situ compared with otoliths, which predominantly arrive in the sediment after post-mortem predation-related transport. Taxon-sensitive differential diagenesis is disproved by SEM, cold cathodoluminescence and X-ray diffraction investigations, revealing the presence of pristine aragonite in all cases. Bias resulting from variability in the amount of summer or winter carbonate deposition is contradicted by visual inspection of growth ring thicknesses, and cyclical incremental stable isotope patterns of individual growth bands.

Taxon inconsistencies were not described previously by authors working on the same taxa and in the same area, hence the paleoecological interpretation of this data could indicate enhanced runoff and freshwater influx during the EECO relative to later time intervals, or the presence of a large river mound close the investigated location. Temperature calculations based on *"genus Neobythitinorum" subregularis* reveal mean annual temperatures around 27.5 °C and a seasonality of 9 °C for the EECO interval. Given the mentioned assumptions, future directions should include other quantitative, preferably salinity-independent paleotemperature proxies to test these data interpretations.

Vanhove D., Stassen P., Speijer R. P., Steurbaut E. (2011). *Assessing paleotemperature and seasonality during the early Eocene climatic optimum (EECO) in the Belgian Basin by means of fish otolith stable O and C isotopes*. Geologica Belgica, Volume 14, n°3-4, pp. 143-158.