Assessing the use of fish otolith stable O and C isotope geochemistry as a paleotemperature and seasonality proxy: results from the early Eocene climatic optimum (EECO) in Belgium

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Evidence for a highly variable climate superimposed on global trends during the early Paleogene is rapidly accumulating. This variability is mainly known from high-resolution deep-sea sedimentological and stable isotope records. However, focusing on marginal marine sections reveals indispensible insight in the nature of this variability, as they represent areas were local and global climate and biota are linked in many ways. These include faunal shifts in space and time and variable oxygen isotope signatures of biominerals secreted by many benthic and planktic organisms. Also, by studying adjacent basins, local expressions of latitudinal climatic gradients can be obtained. In our study, paleotemperature data of the early Eocene climatic optimum (EECO) from the mid-latitude marginal marine Belgian Basin are discussed. The Belgian Basin, part of the southern North Sea bight, comprises a fairly continuous early Eocene sedimentary record. It is dominated by fossiliferous sands and clays, which have suffered only minor deformation.

Paleotemperatures are derived from fish otolith $\delta^{18}O$ compositions of four non-migratory benthic species belonging to the families Congridae and Ophidiidae. Well-preserved otoliths from several levels and localities within the middle to late Ypresian were selected. After manual polishing, bulk and incremental microsamples (along concentric growth bands) were drilled and analyzed by a mass spectrometer. A cross-plot of bulk otolith $\delta^{18}O$ vs. $\delta^{13}C$ results shows a discrepancy between both families used. Ophidiid data probably represent true bottom water temperatures of the Belgian Basin. The mean annual temperature (MAT) of the EECO is calculated at 27.5°C, which is in line with other proxy results. However, variations in MAT up to 6°C occur, suggesting a more pronounced expression of climate variability in mid-latitude marginal basins than in tropical areas. Incremental analyses revealed a ~9.5°C mean annual range of temperatures, similar to present-day seasonality. These results show that marginal marine environments such as the Belgian Basin are well suited to infer paleoclimate variability.

During the past decade, the use of fish otoliths as (paleo)environmental indicators has increased, leading to recognition and improved understanding of their various applications. However, some difficulties remain, such as detecting possible influence of freshwater influx affecting paleotemperatures, the sensitivity of calculated paleotemperatures to a certain paleotemperature equation, and pursuing non-biased microsampling of aragonite powder within a single otolith. Future directions of our research include comparison of otolith stable isotope data with those from other sclerochronological proxies such as bivalves and foraminifera, constraining variations in aragonite accumulation rate and correcting for averaging errors during otolith carbonate microsampling.