Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31214

Constraining early Eocene and middle Miocene upper ocean latitudinal temperature gradients using coccolith clumped isotope thermometry

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The early Eocene and middle Miocene are characterised by generally warmer conditions and higher CO_2 levels relative to today. Both periods are marked by a reduced latitudinal temperature gradient relative to today, shown in both model simulations and proxy data [1,2]. However, inter-proxy offsets in reconstructed absolute temperatures — of up to 10°C — result in large uncertainties in the strength of these latitudinal gradients. These inter-proxy discrepancies suggest that regional factors, seasonal temperature variability, and/or the depth habitat of proxy-related organisms may bias the proxy-based reconstructions of annual mean surface temperatures. To that end, we apply coccolith clumped isotope thermometry, following the recent well-constrained calibration from coccolithophore cultures [3], to a suite of globally distributed sediment cores. We use a “snapshot” approach to target two key past warm intervals, constraining our samples through integrated bio-, magneto-, and chemostratigraphy to a set time interval, and obtain a global overview without deep-time variability.. We compare our reconstructed ocean temperatures to previously generated climate model simulations conducted under multiple CO_2 levels for both periods [1,2]. This comparison enables a direct estimation of coccolithophore calcification depths. Our coccolith clumped isotope-derived temperature data reveals the seasonal, regional, and calcification depth biases, as well as trends in the global latitudinal gradients during both the early Eocene and middle Miocene. We highlight the potential of coccolith clumped isotopes as a useful tool to reveal upper ocean paleotemperatures and through combination with models to reveal paleo-ocean temperature structures and reduce the uncertainties on the upper ocean latitudinal temperature gradients.

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