Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.29713

Coccolith clumped isotope insights into Miocene climate transitions: Reconstructing temperature and carbon cycling in the South Atlantic

MADELEINE SANTOS[1], MADALINA JAGGI[1], STEFANO M BERNASCONI[1], CLARA BOLTON[2], ALFREDO MARTINEZ-GARCIA[3] AND HEATHER STOLL[1]

[1]ETH Zürich
[2]Aix Marseille University, CNRS, IRD, INRAE, CEREGE
[3]Max Planck Institute for Chemistry

The Oligocene-Miocene Transition (OMT, ~23 Ma) and Late Miocene Cooling (LMC, (~7–5.7 Ma) were key intervals of climate evolution, marked by major shifts in global temperature, ocean circulation, and partial pressures of atmospheric CO_2 (pCO_2). Existing proxy records show discrepancies in the magnitude and timing of temperature and pCO_2 changes, particularly in the southern hemisphere. To address these gaps, we generate new coccolith clumped isotope (Δ_{47}) temperature reconstructions from the South Atlantic at Ocean Drilling Program Sites 1090 (OMT) and 1088 (LMC). At Site 1090, coccolith size and calcification records indicate major changes in ocean carbonate chemistry during the OMT linked to a long-term decline in pCO_2 (Guitián et al., 2022). At Site 1088, previous studies suggest a twofold to threefold decline in pCO_2 during the LMC (Tanner et al., 2020), coinciding with sea surface temperature (SST) cooling and shifts in Southern Ocean frontal positions.

In this study, we compare coccolith Δ_{47}-based temperature estimates with alkenone-derived surface temperature reconstructions to identify potential proxy offsets in temperature magnitude and timing. We also investigate coccolith size and calcification patterns to explore their relationship with reconstructed pCO_2 and ocean carbonate chemistry. Using empirical relationships between coccolith dimensions and calcite mass, we estimate particulate inorganic carbon and particulate organic carbon production, enabling us to reconstruct changes in coccolithophore carbon allocation strategies in response to changing pCO_2.

By integrating multiple proxies, we provide new insights into SST-CO_2 interactions, coccolithophore calcification strategies, and biological carbon cycling during these two major climate transitions. These findings contribute to a better understanding of how past climates associated with higher pCO_2 evolved and can inform future projections of ocean-climate feedbacks.

References

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