Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35336

Southern Ocean temperature and seawater oxygen isotopes from coccolith clumped isotopes during the Oligocene-Miocene Transition and the (pre-)Miocene Climatic Optimum

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The Oligocene-Miocene Transition (OMT) and the Miocene Climatic Optimum (MCO) feature global changes in climate and corresponding changes in the Antarctic Ice Sheet (AIS) response. We measured clumped isotopes in coccolith-dominated fine-fraction (i.e., 5-8 µm) sediments to investigate temperature and the stable isotope composition of surface seawater ($\delta^{18}O_{sw}$) during and prior to the MCO and/or OMT at three locations in the Southern Ocean, encompassing Atlantic, Pacific, and Indian Ocean sectors (ODP Sites 1090, 1168, and 747/751, respectively). Clumped isotope analysis allows for simultaneous estimation of temperature and the change in $\delta^{18}O_{sw}$, leading to robust $\delta^{18}O_{sw}$ values and thereby changes in AIS and surface Southern Ocean water mass response. T-tests performed on the current dataset reveal significant ($p < 0.05$) differences in temperature and $\delta^{18}O_{sw}$ values through time and across sites (Fig. 1).

During the OMT, $\delta^{18}O_{sw}$ values at Site 1168 significantly increase (1.1 ‰) in accordance with early Miocene glaciation. The MCO onset at this site shows a significant decrease in $\delta^{18}O_{sw}$ values (-0.9 ‰), likely due to the decrease in ice volume. Spatially, significantly different $\delta^{18}O_{sw}$ values during the OMT likely indicate different surface water masses at Sites 1090 and 1168. In contrast, the $\delta^{18}O_{sw}$ values do not significantly differ during the pre-MCO and MCO periods, suggesting a more homogenous surface Southern Ocean.

Additional replicates (i.e., where n < 30) and samples from the OMT at Site 747 will provide a further insight into changes in the Southern Ocean surface water masses during the OMT and MCO onset.

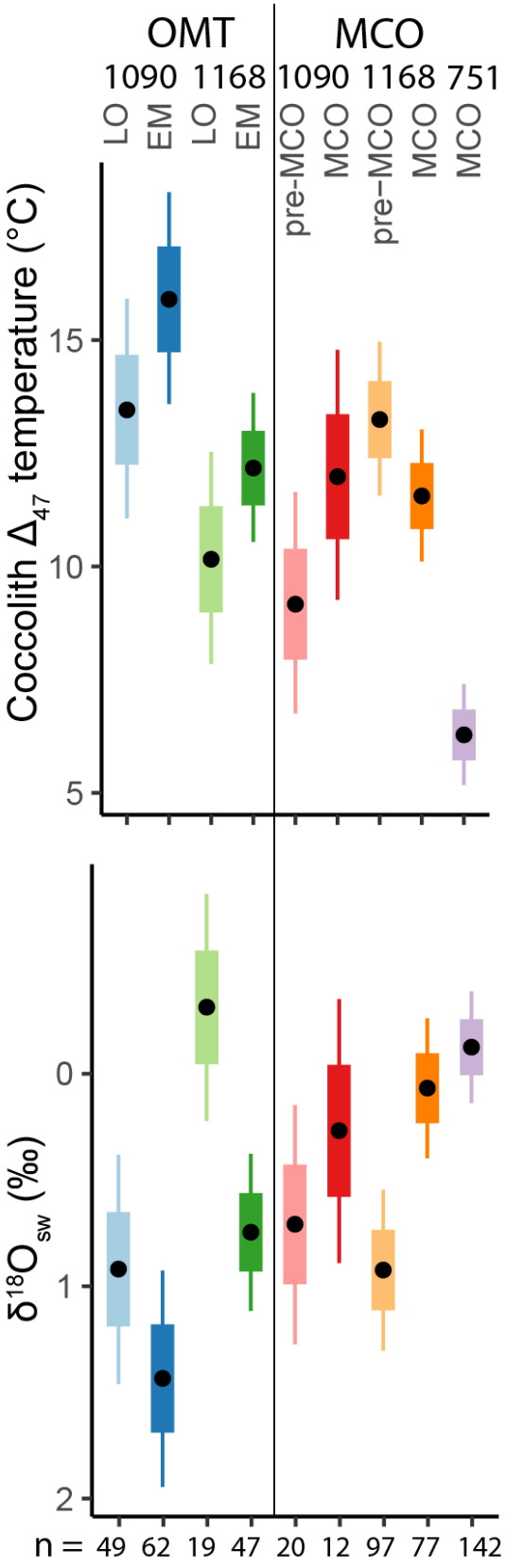


Figure 1. Temperature (top) and $\delta^{18}O_{sw}$ (bottom) estimates from clumped isotopes in fine-fraction sediments from Sites 1090, 1168, and 751 during the OMT (LO = Late Oligocene; EM = Early Miocene) and onset of the MCO. Replicates were pooled from multiple sedimentary intervals.