Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37898

Competing influences of volcanic carbon emissions, ocean alkalinity, and insolation on the Miocene Climate Optimum

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While the Miocene Climate Optimum (MCO) is viewed as an analogue for near-future conditions resulting from anthropogenic warming, improved understanding of this event requires proxy records developed within a well-calibrated temporal framework. Large igneous province emplacement in the Columbia River Basalt Group (CRBG) has been suggested to cause elevated global temperatures and CO_2 during the MCO, but assessing this connection requires robust timelines for records of these events. Although we have developed a new age model for CRBG volcanism based on high-precision U-Pb geochronology (Kasbohm et al., 2023) and a U-Pb age model for the MCO that reinforces the validity of astronomical tuning of this event (Kasbohm et al., 2024), only a small number of MCO proxy records have astronomical calibrations. Existing boron isotope CO_2 proxy records from the MCO were age-calibrated through biostratigraphy alone, hindering correlation to known intervals of CRBG volcanism. These records showed high-amplitude CO_2 variability, calling into question the stability of the Miocene climate system.

Here, we present a new foraminiferal boron isotope record from IODP Site U1490 (Western Pacific Warm Pool), which has an astronomically tuned age model concordant with our radiometric ages for the MCO (Holbourn et al., 2024). This new record targets the onset of the MCO through the end of main-phase CRBG volcanism (17.1-16 Ma) at ~15 kyr resolution, with lower resolution across the entire MCO (17.8-13 Ma). We find well-resolved and relatively stable pH values across the MCO marked by orbital pacing. Our reconstructed CO_2 estimates show less variability than prior records, though we note somewhat variable correlation with changes in benthic $\delta^{18}O$ values, which may reflect the development of a thick oligotrophic layer at this site during the warmest conditions of the MCO. We observe little change in CO_2 resulting from CRBG surface volcanism, and no strong correlation between CO_2 changes and the tempo of eruptions. A transient uptick in CO_2 prior to surface eruptions, as well as sustained somewhat higher values afterwards, may be explained by cryptic degassing of large amounts of CRBG magma trapped in the crust, but the magnitude of this CO_2 change was small.