Coupled Greenhouse Warming and Deep Sea Acidification in the Middle Eocene

Steven M. Bohaty[1,4*], James C. Zachos[1], Fabio Florindo[2], Margaret L. Delaney[3]

1) Earth and Planetary Sciences Department/ Institute of Marine Sciences, University of California, Santa Cruz, 1156 High Street, Santa Cruz, CA 95064, USA
2) Istituto Nazionale di Geofisica e Vulcanologia, Via di Vigna Murata 605, 00143-Roma, Italy
3) Ocean Sciences Department/ Institute of Marine Sciences, University of California, Santa Cruz, 1156 High St., Santa Cruz, CA 95064, USA
4) *Now at*: School of Ocean and Earth Science, National Oceanography Centre, Southampton, European Way, Southampton. SO14 3ZH, United Kingdom

*Corresponding author email address: S.Bohaty@noc.soton.ac.uk

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Abstract:

The Middle Eocene Climatic Optimum (MECO) is an enigmatic warming event that represents an abrupt reversal in long-term cooling through the Eocene. In order to further assess the timing and nature of this event, we have assembled stable isotope and calcium carbonate concentration records from multiple Deep Sea Drilling Project and Ocean Drilling Program sites for the time interval between ~43 and 38 Ma. Revised stratigraphy at several sites and compilation of $\delta^{18}O$ records place peak warming during the MECO event at 40.0 Ma (Chron C18n.2n). The identification of the $\delta^{18}O$ excursion at sites in different geographic regions indicates that the climatic effects of this event were globally extensive. The total duration of the MECO event is estimated at ~500 kyr, with peak warming lasting <100 kyr. Assuming minimal glaciation in the late middle Eocene, ~4 to 6ºC total warming of both surface and deep waters is estimated during the MECO at the study sites. Maximum warming at ~40.0 Ma also coincided with a world-wide decline in carbonate accumulation at sites below 3000 m depth, reflecting a temporary shoaling of the calcite compensation depth. The synchroneity of deep-water acidification and globally extensive warming makes a persuasive argument that the MECO event was linked to a transient increase in atmospheric pCO_2. The results of this study confirm previous reports of significant climatic instability during the middle Eocene. Furthermore, the direct link between warming and changes in the carbonate chemistry of the deep ocean provides strong evidence that changes in greenhouse gas concentrations exerted a primary control on short-term climate variability during this critical period of Eocene climate evolution.