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Coupled phytoplankton and climate evolution during the late Miocene

Clara Bolton, *Bioindicators & Paleoenvironmental Tracers, CNRS, CEREGE, France (bolton@cerege.fr)*
Maria-Teresa Hernandez-Sanchez, Oviedo University, Spain; Heather Stoll, Oviedo University, Spain; Miguel-Angel Fuertes, Salamanca University, Spain; Saúl González-Lemos, Oviedo University, Spain; Lorena Abreveya, Oviedo University, Spain; Ana Mendez-Vicente, Oviedo University, Spain; José-Abel Flores, Salamanca University, Spain; Ian Probert, Station Biologique de Roscoff, France; Liviu Giosan, Woods Hole Oceanographic Institution, USA; Joel Johnson, University of New Hampshire, USA; Laura Perrin, LOCEAN, France; Giovanni Aloisi, LOCEAN, France.

Calcifying marine phytoplankton (coccolithophores) respond to environmental forcing on multiple timescales and in a variety of measurable ways. Understanding the mechanisms and drivers behind these responses is important because coccolithophores play a dual role in the ocean carbon cycle via photosynthesis and calcification. How ocean acidification might influence coccolithophore calcification is strongly debated, and the effects of carbonate chemistry changes in the geological past are poorly understood. Recent research combining coccolithophore geochemistry and morphometry suggests long-term adaptation of coccolithophores to evolving climate and ocean chemistry. During the late Miocene, inter-specific coccolith oxygen and carbon stable isotope vital effects emerged, accompanied by a decrease in cellular calcification state inferred from coccolith thickness in the dominant coccolithophore family. Results suggest that these long-term trends in coccolithophore interspecific vital effects and calcification represent cellular-level responses to reduced carbon dioxide concentrations in the ocean on evolutionary timescales. The hypothesis that ocean CO2 concentration decreased during the late Miocene is in agreement with new alkenone δ13C -based estimates that additionally account for inferred changes in carbon allocation to photosynthesis versus calcification, and is supported by emerging sea surface temperature records that show considerable cooling over this interval. New results investigating coccolith vital effects in culture also shed new light on the parameters affecting isotopic fractionation under constant CO2, with implications for the use of coccolith isotopes in paleoceanography.