Magnitude of the marine carbon isotope excursion during the Paleocene-Eocene Thermal Maximum constrained through archaeal biomarkers

FELIX J. ELLING[1], KATIANA DOEANA[2], STEPHANIE KUSCH[1,3], ANN PEARSON[1]

[1]Dept. of Earth and Planetary Sciences, Harvard University (felix_elling@fas.harvard.edu, apearson@eps.harvard.edu)
[2]Department of Geosciences, University of Bremen (kdoeana@uni-bremen.de)
[3]Institute of Geology and Mineralogy, University of Cologne (skusch@uni-koeln.de)

A negative carbon isotope excursion (CIE) recorded in terrestrial and marine systems corroborates massive organic carbon emissions associated with increased atmospheric CO_2 levels and surface warming during the Paleocene-Eocene Thermal Maximum (PETM). The magnitude of the CIE is a function of the source type and scale of these emissions but remains poorly constrained, varying from ~ -2‰ in the marine carbonate record to -7‰ in the bulk and compound-specific organic carbon records. This heterogeneity may be due to sedimentary overprints (*e.g.*, carbonate dissolution) and/or organism vital effects (*e.g.*, variable fractionation due to changing atmospheric CO_2 concentration). Here we show that $\delta^{13}C$ values of crenarchaeol, an organic compound produced by marine planktonic archaea that fix dissolved inorganic carbon, can be measured using a novel approach (spooling-wire microcombustion IRMS) and can be used to reliably reconstruct the PETM carbon isotope excursion. Our new proxy is not affected by mineral dissolution and also appears to be minimally influenced by biological factors, demonstrating major advantages over previously used proxies. Crenarchaeol $\delta^{13}C$ profiles in three globally distributed marine sediment cores (Arctic, North Atlantic, South Pacific) reveal a consistent magnitude of -3.5‰ for the CIE. The consistency between sampling sites suggests that potential confounding factors such as changes in archaeal ecology are negligible. The constrained magnitude confirms estimates of PETM carbon emissions of ~10,000 Pg from a mixed source of ~ -22‰ $\delta^{13}C$, based on surface ocean pH reconstructions; this would be consistent with atmospheric CO_2 concentrations of ~2000-3000 ppm, based on carbon isotope fractionation observed in higher plants. Crenarchaeol $\delta^{13}C$ appears promising particularly for reconstructing CIEs that exhibit poor carbonate preservation, such as Mesozoic Oceanic Anoxic Events.