Evidence for methane cycling in Paleogene terrestrial and marginal marine sediments

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Earth system modeling indicates that terrestrial methane cycling may have played a more prominent role as a feedback on climate during previous hothouse climatic states than in the present day. The influence of terrestrial methane cycling derives from its sensitivity to both temperature and hydrological regime. However, Paleogene methane cycling remains poorly constrained due to the lack of proxy data.

One potential window into relative changes in methane cycling derives from the carbon isotopic compositions ($\delta^{13}C$) of hopanoid lipids. Hopanoids, preserved on geological timescales as hopanes, derive from diverse bacteria including methanotrophs. Assimilation of biogenic methane-derived carbon results in hopanoids substantially depleted in $\delta^{13}C$, as observed in cold-seep mats and carbonates and in some methane-rich lakes. The $\delta^{13}C$ of sedimentary hopanoids may thus become depleted when methanotrophs contribute a large proportion of hopanoids.

Within this context, hopanes with substantially $\delta^{13}C$-depleted compositions (< -60 ‰) in the Cobham Lignite (England) are interpreted to reflect increased methanotrophy, and hence methanogenesis, at the onset of the Paleocene-Eocene Thermal Maximum (PETM). To assess whether lipid biomarker evidence for enhanced methane cycling in Paleogene wetlands is unique to the Cobham Lignite, we examined the $\delta^{13}C$ of hopanes in PETM-age marginal marine sediments exposed in Otaio River Gorge, New Zealand, and in a suite of Eocene-age lignites from India and Germany. We find that $\delta^{13}C$-depleted hopanoids in Paleogene lignites are widespread, both regionally and temporally, though not ubiquitous. Our findings are consistent with models indicating enhanced methane cycling in Paleogene wetlands, but also emphasize the importance of local hydrological and geochemical conditions.