Comparison of long- and short-term terrestrial carbon isotopic records of the Palaeogene

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The Paleocene-Eocene Thermal Maximum (PETM) is a key time interval for interrogating Earth's response to greenhouse gas-induced climatic forcing, and has been the subject of intense palaeoclimate modelling efforts. Crucial to such efforts are estimates of how much carbon was injected into the ocean-atmosphere system. This can be constrained by the magnitude of the associated carbon isotope excursion (CIE), assuming knowledge of end-member carbon isotopic compositions; unfortunately, studies of different sedimentary materials are yielding increasingly diverse estimates for the CIE, with larger values associated with terrestrial organic matter (e.g *n*-alkanes). However, the terrestrial records lack a long-term context, which could prove useful in constraining the impact of other factors, e.g. vegetation change and climate, on the recorded carbon isotopic compositions.

Onshore drilling expeditions in Tanzania have yielded sediments that span much of the Late Cretaceous and Palaeogene and provide the opportunity to develop both long- and short-term records. The PETM was recovered at Tanzania Drilling Project Site 14; planktonic foraminifera (*Subbotina*) show a negative CIE of 4.5 permil, and *n*-alkanes show a negative CIE of 6.5 permil. However, the PETM is also associated with changes in *n*-alkane distributions, increased *n*-alkane concentrations and elevated abundances of soil bacterial biomarkers; collectively, these suggest dramatically increased runoff and possibly changes in the predominant vegetation. Here, we examine these records in the context of our long-term Tanzanian dataset. From 60 to 30 Ma, *n*-alkane distibutions vary significantly more than that observed at the PETM, but changes in their isotopic compositions are less than 2 permil. This suggests that vegetation shifts can account for part but not all of the difference between the CIE recorded by Tanzanian *n*-alkanes and deep sea foraminifera.

Lipid biomarkers in geothermal microbialites: Occurrences, implications and applications

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Lipids are preserved in a range of environments and across vast timescales; crucially, analyses of geothermal sinters and cold seep carbonates reveal that lipids are also encapsulated and preserved in mineral deposits, often at higher concentrations than surrounding sediments. Although this suggests that such materials will be ideal targets in the quest for extraterrestrial and early Earth organic biosignatures, little is known about the diversity of compounds, the degree to which they reflect the microbial population, the heterogeneity of their encapsulation during mineral precipitation and their long-term preservation.

Here, we have examined ca. 50 modern and ancient sinters from five geothermal systems of the Taupo Volcanic Zone, NZ North Island. We find that lipid signatures in modern sinters reflect the microbial population and are conserved across multiple samples from a single site. For example, at Champagne Pool (CP), lipid distributions, reflected by ratios of bacterial and archaeal diethers and fatty acid chain lengths, are relatively constant, with similar biomarkers occurring in seven different samples representing three different facies. Although distributions generally match CP's microbiology, the lack of monoether lipids was inconsistent with abundant Aquificales species. This could reflect poor preservation of those organisms or, more likely, incomplete knowledge of thermophile lipid biochemistry.

Although the lipid distributions are conserved, concentrations are not, varying by over an order of magnitude over the seven CP samples and displaying similar variability at other sites. This was despite the proximity of the samples (< 1m) and the large sample sizes (>20g). Presumably, sampling over a wider area and using smaller samples would reveal even more profound heterogeneity. Thus, lipids do appear to record microbiological input with some fidelility, but understanding lipid abundance variability will be a crucial component for constraining analytical sensitivity and sampling protocols, e.g. for future Mars missions.