BIOMARKERS AND ISOTOPIC RECORDS OF CLIMATE CHANGE ACROSS THE PALEOCENE-EOCENE THERMAL MAXIMUM

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The Paleocene-Eocene Thermal Maximum (PETM), a period of abrupt and significant global warming, is one of the most dramatic climate events in the history of our planet. It is characterised by a rapid negative shift in the $\delta^{13}C$ values of marine and terrestrial carbon, a change attributed to a massive release of methane from gas hydrates. Carbon isotopic records have been obtained from terrestrial settings and used to estimate the magnitude of the shift in atmospheric CO_2 $\delta^{13}C$ values. Unfortunately, such records are limited in number and resolution. In an attempt to address this issue, we have studied two PETM sedimentary sequences dominated by terrestrial organic matter: a Kumara section (New Zealand), deposited in deltaic to nearshore marine sediments and one from Tanzanian continental margin sediments. Analyses of the distribution of higher plant and bacterial biomarkers and their carbon isotopic composition provide direct records of changes in higher plant vegetation, sedimentary redox conditions and atmospheric CO_2.

In the Kumara section, the organic matter is dominated by terrestrial biomarkers derived from either higher plants (e.g. *n*-alkanes with a strong odd-over-even predominance) or bacteria (hopanes), consistent with deposition in a riverine or deltaic setting. *N*-alkane $\delta^{13}C$ values were measured and a 4.5‰ negative shift recorded, suggesting the studied interval spans the PETM. Interestingly, the negative isotope excursion is associated with a remarkable change in biomarker assemblages over this interval. First, pristane and phytane (derived from algal chlorophyll) and low-molecular-weight *n*-alkanes become more abundant, indicating a shift to marine dominated conditions. Second, a variety of biomarker proxies suggest that bottom waters and sediments became more reducing. Third, the abundance of oleananes, angiosperm biomarkers, increases dramatically, possibly reflecting a dramatic change in the higher plant assemblage. These shifts in depositional setting coincide with a lithologic transition and provide direct evidence for sea level rise associated with the PETM.

In the Tanzania section, similar terrestrial biomarkers abound, but in addition to *n*-alkanes and hopanes other functionalised biomolecules were also identified: *n*-alkanols and *n*-alkanoic acids (with an even-over-odd predominance) derived from higher plants and bacterially-derived hopanoids. Hopane and hopanoid abundances and distributions vary through the section, with a significant decrease in the abundances of all hopanoids just below the PETM boundary, whereas the *n*-alkanoic acid distribution switches from a short-over-long-chain predominance to a predominance of long chain components at the PETM and then back again after the event. Lower molecular weight *n*-alkanoic acids are typically derived from bacteria whereas higher plants are the primary source for their higher molecular weight homologues; therefore, these trends suggest a change in the organic matter source during the PETM, possibly driven by an increase in terrestrial runoff. The $\delta^{13}C$ values derived from *n*-alkanes reveal a negative shift of ~6.5‰ over the PETM interval. The magnitude of this shift is much greater than the value of 3‰ quoted in most of the existing literature and based on planktonic foraminifera[1].

Although these large terrestrial shifts could be the result of changes in humidity or plant distribution, it is also possible that these terrestrial records better represent the true magnitude of the carbon isotope excursion. This has implications for the quantity and source of the ^{13}C-depleted carbon, and other sources, besides methane hydrates, should be considered.

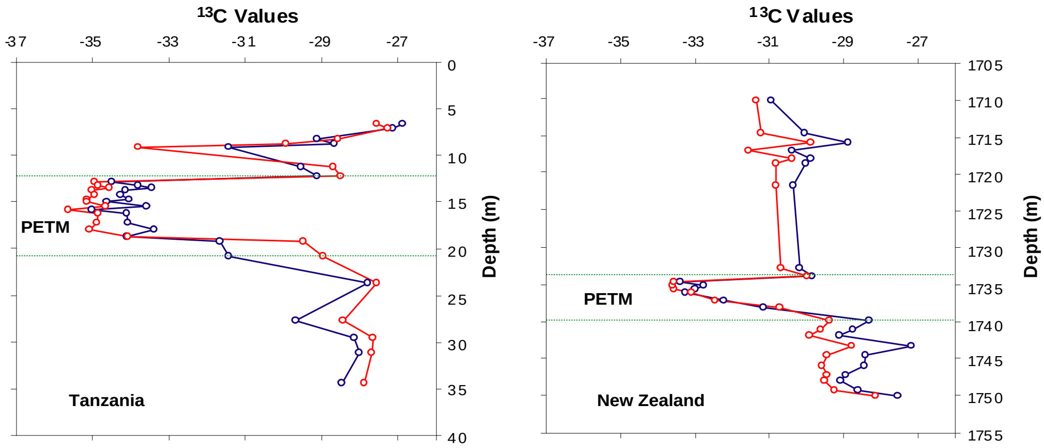

Figure 1. $\delta^{13}C$ values of higher plant derived C_{27} and C_{29} *n*-alkanes through the PETM, blue and red data points respectively. The Tanzanian setting yields a CIE of ~6.5‰, whilst the New Zealand section shows a 4.5‰ negative shift. Both values are larger than the traditional 3‰ marine excursion.

REFERENCE

1. Bowen G.J. *et al.* (2004), *Nature*, **432**, 495-499