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EVOLUTION OF THE LATITUDINAL SEA SURFACE TEMPERATURE GRADIENT DURING THE EOCENE

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The Eocene Climatic Optimum at 52Ma marks what is believed to be a temperature maximum for the Paleogene. Throughout the Paleocene and the initial stages of the Eocene, global temperatures increased gradually, punctuated by more rapid short term events, before starting to slowly decrease. Though debate exists surrounding the timing or even occurrence of an actual climatic optimum, the subsequent global cooling throughout the Eocene is widely recognised[1] and thought to have ultimately culminated in conditions favourable for growth of the Antarctic ice sheet. However, that paradigm is based almost exclusively on deep sea foraminiferal oxygen isotope records and these have been recently questioned[2]. Here, we determine and compare new Eocene SST records from tropical (Tanzania) and high latitude (New Zealand) sites using foraminifera oxygen isotopes and the recently developed TEX_{86} (TetraEther indeX of tetraethers consisting of 86 carbon atoms) SST proxy.

The Tanzanian sediments are noted for their immaculate foraminiferal and organic matter preservation. Critically, although the OM is dominated by terrigenous inputs, pelagic crenarchaeal GDGTs are present and can be used to reconstruct SST. Although both the foraminifera and TEX_{86} values indicate SSTs that range from 30 to 33°C, only slightly elevated relative to modern tropical SSTs, these values are significantly higher than previous estimates (Fig 1). Moreover, both datasets show no long-term Eocene cooling, calling into question this fundamental paradigm of Cenozoic climate evolution.

Situated on the East coast of New Zealand's south island, the Waipara river section contains sediment outcrops that date back to the Cretaceous period. Our analyses focussed on a section that is relatively thermally immature and represents a readily accessible record spanning the latter part of the Eocene. These sediments originate from a coastal marine setting and contain a mixture of abundant marine and terrestrial biomarkers. The acid fraction yielded the most abundant biomarkers, mainly long-chain, predominantly even-carbon number *n*-alkanoic acids. This signature, typical of terrestrial higher plants, was also reflected in the less abundant *n*-alkanes, identified in the saturated hydrocarbon fraction, and *n*-alkanols in the neutral polar fraction. The acid fraction also contained a suite of hopanoic acids, derived from the bacteriohopanoid compounds that comprise bacterial cell walls. The most complex fraction was the polar fraction. This contained a wide variety of compounds ranging from the aforementioned *n*-alkanols to sterols from the cell membranes of algae. Critically, abundant pelagic crenarchaeal GDGTs were also present in the neutral polar fraction. These compounds are present in sufficient abundance to allow the determination of TEX_{86} values and thus the reconstruction of SSTs.

The absolute SST values from Waipara sediments are comparable to those obtained from the tropical Tanzanian sites. Although the local oceanographic regime must be considered, these results indicate a relatively small latitudinal temperature gradient, in marked contrast to the situation today. However, our initial results clearly show a cooling from 50 to 45 Ma, indicating both polar cooling and the development of a latitudinal temperature gradient during the Eocene. This suggests that SSTs at the poles are more susceptible to global variations than waters at lower latitudes. This has important implications for the development of polar ice sheets and the transition from a global greenhouse climate to the icehouse climate of today.

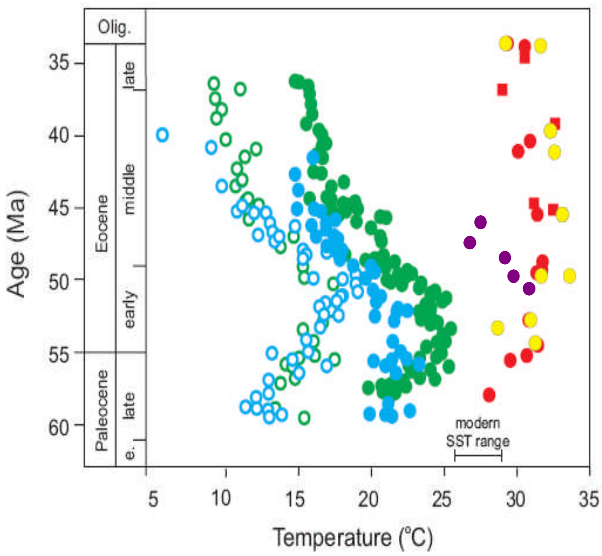

Figure1. Global SST records for the Eocene; blue and green data points were derived from deep sea $\delta^{18}O$ values of foraminifera (open circles denote benthic species and closed circles denote planktic species). In contrast, Tanzanian values yield higher temperatures: the yellow data points were derived from TEX_{86} values and the red data points were derived from foraminifera oxygen isotopes. Purple data points represent NZ (Waipara) SSTs and were derived using the TEX86 proxy.

REFERENCES

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2. Pearson P.N. *et al.* (2001), *Nature*, **413**, 481-487