Late Paleocene sea surface cooling in Southeast New Zealand

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A particularly intriguing aspect of the Paleocene is the apparent dramatic enrichment of ^{13}C in the carbon isotopic composition of the ocean-atmosphere reservoir at c. 60-57 Ma, which is associated with isotopic evidence for cooling [1]. Increases in organic content and siliceous microfossil abundance offshore New Zealand suggest an associated increase in oceanic productivity [2]. However, it is uncertain if these signals are a local response to global cooling or are due to other factors, such as regional oceanographic changes or sea level changes. To address this uncertainty, we have developed sea surface temperature records (SST) to evaluate the magnitude of cooling across a range of sites, with particular focus in the southwest Pacific region.

Here we construct SSTs from mid-Waipara River, NZ (c. 55°S) and the eastern margin of the Campbell Plateau (ODP site 1121, 62°S) across the Paleocene using TEX_{86}. We find a general cooling trend of c. 3°C correlated to the onset of the Paleocene Carbon Isotope Maximum (PCIM) from 60.5 to 58 Ma. A similar trend is also apparent in preliminary data from Paleocene strata at Bass River, New Jersey, USA (c. 27°N). Moreover, we reveal a more pronouced cooling interval in the uppermost 13 m of the 83 m thick Paleocene strata at Mid-Waipara coincident with elevated TOC and isotopically heavy organic carbon ($\delta^{13}C > -25‰$), indicating an enhanced local response to climate changes. We reconstruct biomarker records to investigate ecological changes associated with cooling at Mid-Waipara, and use compound specific carbon isotope analysis of higher plant biomarkers to interrogate carbon cycle dynamics.

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Mycorrhizal weathering through space and time: Implications for the long-term carbon cycle

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Several recent hypotheses strongly link plants and their fungal symbionts to the long-term carbon cyle via their impact on the release of calcium and magnesium from silicate minerals: (a). Primary productivity controls the nature, extent and rate of biological weathering [1]; (b). Mycorrhizal fungi direct this weathering activity toward nutrient-rich minerals more effectively than roots [2]; (c). The evolution of ectomycorrhizal fungi could have contributed to CO_2 drawdown in the Cretaceous [3]. In contrast to the ancestral arbuscular-mycorrhizal fungi, ectomycorrhizal fungi can exude copious amounts of organic acids and they prevent most of the host root system from interacting directly with the soil [2]. In models of the long-term carbon cycle [4], plant weathering and response to changes in atmospheric CO_2 are usually represented by empirical functions. We have previously integrated simple yet rigorous rate laws into such a model to test the third hypothesis (c), but we used global mean temperatures along with a simplistic empirical function to represent net primary productivity [3]. We now continue to explore the effects of weathering by plants and mycorrhizal fungi through geological time, linking our weathering model to the Hadley Centre general circulation model [5] and the Sheffield Dynamic Global Vegetation Model [6] to produce weathering and primary productivity maps for the modern day and for several Mesozoic and Cenozoic timeslices. Comparison of our results with published observations provides support for hypotheses (a) and (b).

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