The Eocene was Hot

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Global warming induced by anthropogenic perturbation of the carbon cycle is occuring and will continue to occur, regardless of the posturing of some politicians. Using reconstructions of past pCO_2 and temperature, geochemists have been at the forefront of confirming that first order relationship, validating climate models and challenging the limits of our current understanding. Throughout his career, Mark Pagani championed all aspects of that: demanding that we act on the knowledge that during times of elevated pCO_2 our planet was much warmer; but also demanding that we challenge our own assumptions and approaches to better understand these relationships and Earth history.

There is extensive evidence that the early Cenozoic was characterised by exceptional global warmth, especially during transient (Paleocene Eocene Thermal Maximum) or extended hyperthermals (Early Eocene Climatic Optimum). There is, however, considerable debate over the nature and geographical distribution of that warmth. Depending on the choice of proxy and calibration, sea surface temperature (SST) estimates yield either very hot (nearing 40ºC) tropics or very low latitudidanal SST gradients. The latter are hard to simulate with climate models, whereas the former are thought to be difficult to reconcile with temperature limits to life.

Much – but not all – of the proxy data from which particularly high SSTs are derived are based on glycerol dialkyl glycerol tetraether lipids (i.e. the TEX_{86} proxy). This has resulted in numerous efforts to interrorgate the limitations of the proxy. However, both the proxy itself and these efforts proceed from a reductionist view of GDGT distributions and the expression of TEX_{86} as a single numerical value. The four GDGTs used in TEX_{86} contain more nuanced insights, as do the major GDGTs (GDGT-0 and crenarchaeol) excluded from the proxy. These distributions collectively indicate profound warmth during the early Cenozoic. Many Eocene tropical GDGT distributions exist nowhere on Earth today; and high latitude GDGT distributions are nearly identical to tropical ones of today. These patterns are replicated in terrestrial archives by other classes of GDGTs. Crucially, because of the diverse structures and origins of GDGTs, many (but not all) attempts to reconcile these distributions with our preconceptions can be precluded. Issues do remain, but the evidence is strong that during times of eleveated pCO_2, Earth was remarkably hot.