Organic geochemical proxies

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Informed predictions of future climate and the Earth's resulting ecology increasingly rely on our ability to assess paleoclimatic conditions tens or hundreds of millions of years in the past, including episodes in which preservation of biominerals is sub-optimal. Organic geochemical proxies, including those for sea surface temperature (SST) and atmospheric pCO_2, provide important paleoclimate reconstructions for these episodes as well as for more recent times. Among the most widely employed are the TEX_{86} SST proxy, the $U^{k'}_{37}$ SST proxy, and the alkenone-pCO_2 proxy. The first is based on lipids of Archaea; while the second and third are based, respectively, on lipid distributions and carbon isotope ($\delta^{13}C$) ratios of haptophyte algae.

Measuring all three of these proxies in a given sample suite greatly enhances the ability to interpet not just paleoclimate, but also ocean biogeochemistry – for example, assessing the depth of the nutricline and the resulting carbon export flux, illuminating variations in upwelling regimes. Largely missing from these multi-proxy records, however, is a complementary set of $\delta^{13}C$ measurements for the lipids used in the TEX_{86} proxy. Such data could be compared to $\delta^{13}C$ data for alkenones (and when available, foraminifera) taken from the same cores. Because Archaea are predicted to have no sensitivity to pCO_2, their lipids should allow better constraint of the local DIC system and should improve the resulting alkenone-pCO_2 reconstructions.

However, as for all biological proxies, understanding the physiology and biochemistry of the responsible organisms is essential to understanding how the proxies work. Here I will discuss what is known about the production and export of the lipids used in the TEX_{86} proxy and propose isotope-motivated ($\delta^{13}C$ and $\Delta^{14}C$) approaches to gain further information. From this perspective, the TEX_{86} proxy is uniquely perplexing: The Archaea believed to be the major source of the TEX_{86} lipids are the ocean's dominant nitrifiers, with maximum activity near and below the base of the photic zone. Analysis of lipid structural distributions and carbon isotopes also establish that the dominant flux to sediments is not from the sea surface, yet multiple approaches to calibration show good correlation between TEX_{86} and SSTs. Reconciling these observations will be critical for future interpretation of the DIC-pCO_2 system and for confident assessment of paleotemperatures.