Calcification temperature of surface oceans: a coccolith clumped isotope approach

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Sea surface temperature (SST) proxies based in foraminiferal Mg/Ca and biomarkers show numerous drawbacks, leaving questions on the reliability of currently available SST reconstructions, especially from tropical warm oceans. We have applied clumped isotope thermometry to coccolith calcite to reconstruct calcification temperatures of coccolithophores' environment in the surface ocean, profiting from their ubiquitous geographical and chronological distribution and growth requirement in the photic zone. More reliable SST reconstructions will allow improving predictions of the climate response to anthropogenic CO_2 emissions.

Here we assess how clumped isotope temperatures from the bulk coccolith size fraction (<11 μm) and from highly purified coccoliths (excluding the <2 μm calcite of unidentifiable origin) of sediments of ODP Site 982 (North Atlantic; last ~16 Ma), differ from each other and from coeval alkenone SSTs. We assess the effect of the fraction of small unidentifiable calcite fragments (<2 μm), which may concentrate diagenetic carbonate. We evaluate whether differences in coccolith clumped temperatures and alkenone temperatures may reflect the proportion of alkenone producers among the coccoliths, contrasting seasonal export efficiency of alkenones vs. coccoliths, and vital effects in coccolith clumped isotopes.

Vital effects in carbon isotopes in coccolithophores are produced by carbon limitation. Therefore, CO_2 concentrations may also affect coccolith clumped isotopes. Here we also present preliminary results on the clumped isotope analysis of highly purified coccolith calcite of Holocene sediments from environments with both a range of temperature and CO_2 concentrations, to deconvolve the temperature and potential carbon availability influence. To verify the presence or absence of size-dependent vital effects, we will also measure discrete size-separated coccolith fractions from Site 982 samples and from some Holocene sediments.

We are one of the first studies to investigate whether coccolith clumped isotopes can be used where and when other proxies are not reliable for absolute reconstructions.