Optimizing pCO_2 reconstructions from marine phytoplankton

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The carbon isotopic fractionation of marine phytoplankton during photosynthesis (e_p) has been widely applied to reconstruct past atmospheric CO_2. We describe recent approaches which may improve confidence in pCO_2 estimates based on alkenone (e_p) reconstructions, and the emergence of new pCO_2 estimates based on (e_p) reconstructions from diatoms.

Temporal changes the significance of active carbon uptake for photosynthesis may affect e_p and therefore the reliability of pCO_2 records. The significance of active carbon uptake in coccolithophorid cultures shows a logarithmic scaling with CO_2 aq, suggesting that its effect on past ep-CO_2 relationships could be modeled effectively using the ACTI-CO cellular model. In addition, measurements of isotopic fractionation in fossil coccolith calcite, together with estimates of changing cellular calcification of coccoliths derived from coccolith thickness measurements, constrain the timing of cellular reallocation of HCO3- from calcification to photosynthesis. These data can provide independent evidence for past changes in the significance of active uptake on e_p. Because light limits reliance on active uptake, the significance of active carbon uptake to e_p is likely exaggerated in laboratory culture experiments and some shallow photic zone materials where irradiance is much higher than in the deep chlorophyll maximum (DCM) where production of alkenones occur in the oligotrophic gyres.

Recent work suggests that e_p may also be reliably determined on organic compounds entrapped in the opaline frustules produced by diatoms, for which specific cell geometeries can be isolated my microfiltering techniques. Our new calibrations of physiological effects on diatom e_p across a core top transect in the Southern Ocean allow us to relate the "b" slope to indicators readily measured in sediments, such as opal accumulation rate and frustule Zn content. Diatom e_p from the eastern equatorial Pacific indicates a strong decline in CO_2 over the last 12 Ma, in agreement with new alkenone pCO_2 records.