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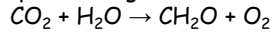
# BIOGEOCHEMICAL CARBON CYCLE IN A COCCOLITHOPHORID BLOOM

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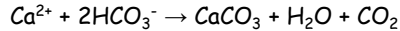


## Introduction

Coccolithophores, among which *Emiliana huxleyi* (*E. huxleyi*) (figure 1) is the most abundant and widespread species, are considered to be the most productive calcifying organism on earth. *E. huxleyi* often forms massive blooms in temperate and sub-polar oceans, and in particular at continental margins and shelf seas. The intrinsic coupling of organic matter production and calcification in coccolithophorid blooms underlines their biogeochemical importance in the marine carbon cycle. Primary production via photosynthesis in the photic zone and vertical export of organic matter to deep waters draws down  $CO_2$ :



this is the so-called "organic carbon pump". In contrast, calcification and thus formation of biogenic calcium carbonate ( $CaCO_3$ ), consumes total and carbonate alkalinity and releases  $CO_2$ :



this is often named the "carbonate counter-pump" because it counter-acts the effect on  $CO_2$  fluxes. This intimate coupling of the two pumps in coccolithophores, together with other calcifying organisms (mainly planktonic foraminifera), has been considered to be responsible for generating and maintaining the ocean's vertical distribution of total alkalinity (TA) in seawater and for regulating the atmospheric  $pCO_2$  since the Mesozoic era.

## Results & discussion

The biogeochemical properties of an extensive bloom of the coccolithophore, *E. huxleyi*, at the shelf break in the northern Gulf of Biscay (figure 2) was investigated in June 2006. Total Alkalinity (TA) values in the water column showed strong non-conservative behaviour indicative of the impact of calcification, with the highest TA anomalies (up to  $26 \mu mol kg^{-1}$ ) in the high reflectance coccolith patch (figure 3 and 4). Partial pressure of  $CO_2$  ( $pCO_2$ ) values ranged from 250 to  $338 \mu atm$  and the area was found to act as a sink for atmospheric  $CO_2$ . Overall,  $pCO_2@13^\circ C$  ( $pCO_2$  normalized at a constant temperature of  $13^\circ C$ ) in the water column was negatively related to TA anomalies (figure 7) in agreement with an overall production of  $CO_2$  related to calcification. Hence, the calcifying phase of the *E. huxleyi* bloom decreased the sink of atmospheric  $pCO_2$ , but did not reverse the direction of the flux. Rates of pelagic respiration up to  $5.5 mmol O_2 m^{-3} d^{-1}$  (figure 5 and 6) suggested a close coupling between primary production and respiration and/or between organic carbon content and respiration. Benthic respiration rates were quite low and varied between 2 and  $9 mmol O_2 m^{-3} d^{-1}$ , in agreement with the fact that the study area consists of sandy sediments with low organic matter content. Benthic respiration was well correlated to the chlorophyll a content of the top 1 cm of the sediment cores (figure 8). Based on the co-variance of TA fluxes and  $O_2$  consumption, evidence was found for dissolution of  $CaCO_3$  due to the acidification of superficial sediments in relation to the production of  $CO_2$  and the oxidation of  $H_2S$  in the oxic layers (figure 9).

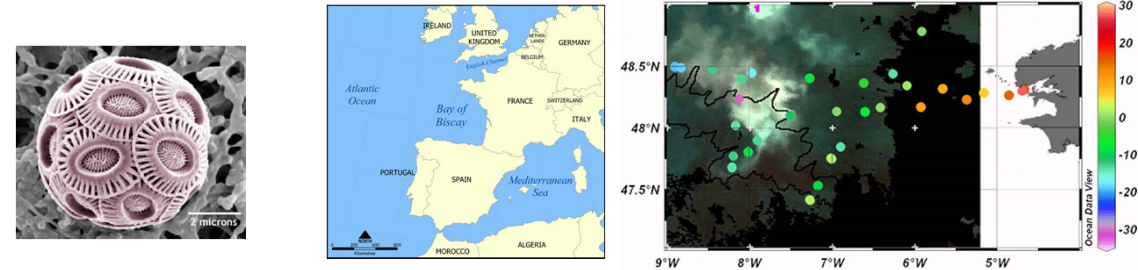


Figure 1 (left): Coccolithophorid *Emiliana huxleyi*. Figure 2 (middle): Gulf of Biscay. Figure 3 (right): TA anomalies ( $\mu mol kg^{-1}$ ) on a satellite image of the 1st of June 2006 (provided by Steve Groom, Remote Sensing Group, Plymouth Marine Laboratory, Plymouth, UK)

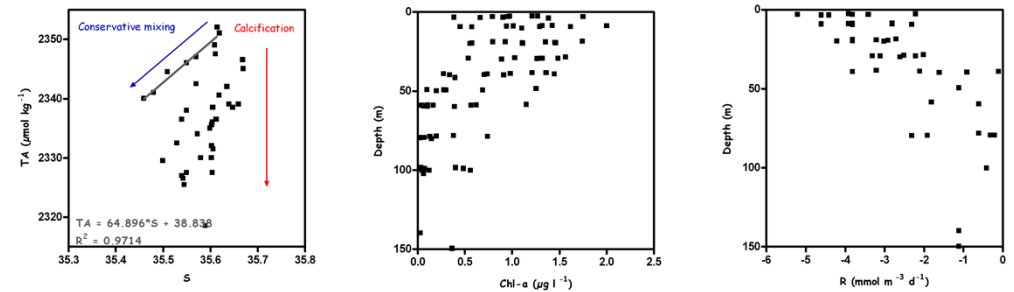


Figure 4 (left): TA ( $\mu mol kg^{-1}$ ) versus salinity to calculate the TA anomalies. Figure 5 (middle): Chl a content ( $\mu g l^{-1}$ ) versus depth. Figure 6 (right): respiration ( $mmol m^{-3} d^{-1}$ ) with depth in the water column.

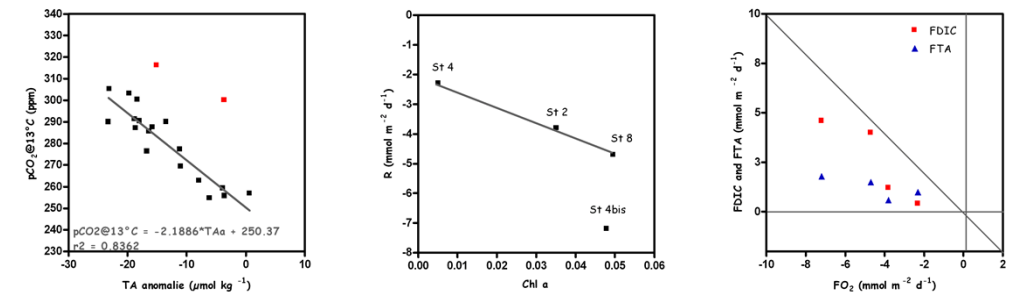


Figure 7 (left):  $pCO_2@13^\circ C$  (ppm) versus TA anomaly ( $\mu mol kg^{-1}$ ) over the top 50 m of the water column. Figure 8 (middle): Benthic respiration versus Chl a content ( $\mu g l^{-1}$ ) of the top 1 cm of the sediment cores. Figure 9 (right): Dissolved inorganic carbon (DIC) flux and TA flux versus respiration flux ( $mmol m^{-2} d^{-1}$ ).