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Probing the use of coccolith geochemistry as a proxy for past carbon dioxide concentrations - Insights from Termination II in the Northern Atlantic Ocean

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Despite their omnipresence in pelagic carbonate sediments, the coccoliths, the calcite biominerals produced by the coccolithophores, have historically been under-exploited in palaeoenvironmental studies. This is due, in part, to their small size (2-20 microns), which makes them difficult to isolate from other particles, and to the large differences in isotopic composition existing between coccolith calcite and equilibrium conditions. This so-called "vital effect" complicates the use of coccolith geochemistry to derive paleoclimatic signals with confidence. Recent studies from cultured and fossil coccoliths have shown that the oxygen and carbon isotopic compositions of the coccoliths are particularly sensitive to the availability of CO_2 in the environment, upon which the coccolithophores rely for their photosynthetic activity. Therefore, our approach here is to test whether the coccolith geochemistry can be used as a novel proxy for surface ocean and atmospheric CO_2 concentrations.

In this study, different size fractions of coccoliths were extracted from carbonate sediments of site MD95-2037 in the Northern Atlantic Ocean and run for isotopic analysis. Using calibrations between coccolith vital effects and seawater [CO_2] from culture studies, we present a seawater [CO_2] curve for site MD95-2037 across Termination II (130 kyrs). The curve was in turn translated into atmospheric pCO_2 estimates taking into account changes in ancillary parameters (such as temperature). Coccolith-derived CO_2 concentrations yield comparable values, both for the absolute numbers and trends, to the record from Vostok ice cores. This coherency is confirmed by a 80 ppm-shift in pCO_2 concentrations in the North Atlantic between glacial and interglacial times reconstructed from the coccolith record.

Altogether, these datasets confirms that coccolith geochemistry can indeed be used to reconstruct past changes in $[CO_2]_{sw}$. Perspectives for this study include providing the scientific community with a new record of pCO_2 for periods extending beyond the Vostok record, in particular the Mid-Pleistocene Transition, where a decrease in global pCO_2 has been put forward to explain the shift from 41 kyr- to 100 kyr-cycles in glacial-interglacial cycles.