Impact of the biological carbon pump on atmospheric pCO_2 over the past 800,000 years

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Atmospheric CO_2 concentration (pCO_2) varied in a cyclic pattern over recent glacial–interglacial cycles, a phenomenon that is mainly related to carbon uptake and release in the ocean. One important hypothesis invokes the role of marine productivity, namely the biological carbon pump (BCP), where the production and downward export of phytoplanktonic and planktonic organic and inorganic carbon act as a sink and a source of CO_2 for the atmosphere, respectively. Evidence points toward the BCP having an important role in modulating pCO_2 over the last glacial cycle, but its evolution and impacts on the climate system beyond that period remain elusive.

For this study, micropaleontological, geochemical, and scanning electron microscope analyses of sediment core MD04-2718 (48°53.31'S, 65°57.42'E), which was retrieved in the Indian sector of the Subantarctic zone (SAZ), were combined with data from published papers. With this information, we were able to reconstruct millennial changes in the BCP strength over the last 800 kyr and integrate these changes within a coherent glacial–interglacial climate scenario that includes variations in pCO_2. In detail, we show that the carbonate ($CaCO_3$%) and organic (TOC%, $\delta^{13}C_{org}$, C/N) fractions of the studied core reflect coccolith, planktonic foraminifera, and organic matter export productivity, respectively, and that the TOC/$CaCO_3$ may be used as a powerful tool to reflect changes in the BCP. An increased BCP during glacial periods is related to increased phytoplanktonic organic carbon export production and is probably due to the fertilization effect of enhanced iron-rich dust supply. A decreased BCP during interglacial periods reflects enhanced coccolith and planktonic foraminifera export production, probably due to increased sea surface temperatures and the reinvigoration of Southern Ocean upwelling that brought nutrient-rich water to surface waters. Overall, our results show that a strengthened BCP during glacials might help sequester CO_2 into the deep ocean at the expense of the atmosphere, whereas a weakened BCP during interglacials might enhance ocean CO_2 leakage.