Coccolithophores’ efficiency towards CO₂ buffering in the Western Pacific Ocean during the last 300 kyr

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The biogeochemical and physical processes occurring in the oceans are pivotal in controlling the atmospheric carbon dioxide (CO₂atm) concentration. In particular, the biological pump uptakes CO₂ through photosynthesis, whereas the carbonate pump produces CO₂ during CaCO₃ production. On the other hand, the accumulation of microbiota-derived carbonates into the deep-sea sediments favors the CO₂ surplus buffering during high carbonate dissolution episodes. To unravel the role of calcifying marine microbiota on CO₂atm regulation, we studied the microfossil contents from two sectors of the Western Pacific Ocean with potential different behaviors towards CO₂ buffering: the Ocean Drilling Program Site 1209 (NW Pacific) and the IMAGES Core MD 97-2114 (SW Pacific). The selected time interval covers the last 300 kyr – i.e. the most recent glacial-interglacial cycles, with particular attention to the Last Interglacial (LIG; 129-116 kyr) which is a good modern-analogue within the geological records. Analyses of calcareous nannofossil assemblages provided data on coccolith carbonate production and fluxes, primary productivity, and carbonate dissolution, which are essential to investigate the carbonate and biological pumps’ efficiency on CO₂atm uptake.

Our data confirm that the calcareous nannofossils contributed significantly to the ocean carbon cycle through both the biological and carbonate pumps, constituting up to 50-70% of the carbonate stocked into the sediments of the studied sites. In both the oceanic sectors, we recorded higher coccolith carbonate fluxes mostly during deglaciations, and thus coccolithophores’ production acted as a negative feedback on CO₂atm uptake contributing to the CO₂atm abrupt increase which characterizes the deglacial-interglacial transitions of the last 800 kyr. Instead, higher carbonate dissolution episodes generating positive feedback on CO₂atm occurred during glacial inceptions and interglacials at Site 1209, and during glacial phases at Core MD 97-2114 due to the stronger intensity of the highly corrosive Deep Western Boundary Current (DWBC). Therefore, changes in coccolithophore production influenced the saturation state of deep waters in a time ranging from 10 to 100 kyr at both sites. The comparison between the two oceanic areas allows identifying significant differences in the processes involved in the CO₂ buffering. In the NW Pacific site the biological pump is probably more efficient owing to the high productivity of coccolithophorids together with the presence of diatom blooms during glacial phases. At the southern site the biological pump consists only of coccolithophorids, but the
coccolith carbonate fluxes are almost doubled compared to the northern site testifying a major efficiency of the carbonate pump on CO$_2$ production. On the other hand, the higher amount of CaCO$_3$ stocked into the southern sediments and the higher efficiency of the physical pump related to the DWBC strongly contributed to the CO$_{2atm}$ uptake during glacial periods. Thus, these two oceanic sectors seem to be decoupled and, therefore, it could be possible that their combined effect in a long-term trend can result in a balance.