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Shallow Calcium Carbonate Cycling in the Ocean Driven by Organic Matter Respiration

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The cycling of biologically produced calcium carbonate ($CaCO_3$) in the ocean is a fundamental component of the global carbon cycle. Through a dedicated research expedition to the North Pacific Ocean, we demonstrate here a coupling of the calcium carbonate and organic carbon cycles, stemming from the fact that all organisms that produce $CaCO_3$ also produce intimately associated organic carbon. Highly constrained biogenic $CaCO_3$ dissolution rates, driven by a combination of ambient saturation state and CO_2 produced through oxic respiration, simultaneously explain solid-phase $CaCO_3$ flux profiles and patterns of alkalinity regeneration across the entire N. Pacific basin. The resulting shallow $CaCO_3$ dissolution cycle is not driven by $CaCO_3$ phases with large solubilities, but instead by the production and subsequent respiration-driven dissolution of primarily coccolithophore calcite. Biomineralization and particle aggregation dynamics together drive the coupled shallow remineralization of C_{org} and $CaCO_3$ by generating the acid (CO_2) in immediate proximity to the base ($CaCO_3$) within the same particles, resulting in the storage of respiratory CO_2 as bicarbonate. We suggest that the mechanisms responsible for particulate $CaCO_3$ export are likely tightly coupled to those controlling the formation and sinking of particulate organic carbon. This respiration-driven shallow $CaCO_3$ cycle acts as a major filter on the export of both organic and inorganic carbon to the deep ocean.