Linking marine carbonate preservation to past climate through the filter of the biological pump

SARAH E. GREENE[1*], SANDRA ARNDT[1], SANDRA KIRTLAND TURNER[12] AND ANDY RIDGWELL[12]

[1]School of Geographical Sciences, University of Bristol, Bristol BS8 1SS, UK
*correspondence: sarah.greene@bristol.ac.uk
[2]Department of Earth Sciences, University of California, Riverside, Riverside, CA 92521, USA

The preservation of marine calcium carbonate can be used as a paleoclimate proxy because of the requirement that terrestrial weathering and carbonate burial remain balanced over long timescales. However, changes in deep sea carbonate preservation (e.g. the carbonate compensation depth) are challgenging to interpret because of the complex interplay of processes governing marine carbonate chemistry.

The recycling of organic matter plays an important role in the preservation of calcium carbonate because aerobic respiration and secondary redox reactions decrease the stability of calcium carbonate minerals in the water column and in sediment pore waters. Thus to interpret changing temporal or spatial patterns in carbonate burial requires a holistic understanding of the ways in which organic carbon cycling, both in the water column (the biological pump) and in marine sediments, affects marine carbonate preservation. This is especially critical for warm greenhouse climates, because a) the strength and operation of the biological pump may have been quite different from today and b) greenhouse climates are more prone to anoxic events, meaning that anaerobic respiratory pathways, which have markedly different effects on carbonate chemistry than aerobic respiration, must be considered.

Using an Earth system model of intermediate complexity (cGENIE) we explore the role of the biological pump (including export productivity, organic matter reactivity, and the rain ratio) on the preservation of deep sea calcium carbonate. In conjunction with these experiments, we use a 1D reaction transport sediment model (BRNS) to quantitatively explore the role of organic matter depositional fluxes (quantity and quality) and the resulting benthic redox dynamics (including the role of anoxia/anaerobic pathways) on the preservation of calcium carbonate. Our results show that deep sea carbonate burial patterns can be surprisingly resistant to changes in the recycling of organic matter, highlighting that the carbonate system is rife with feedbacks and balances brought about by carbonate buffering.