Berner lecture: How will anthropogenic CO_2 affect shallow water calcium carbonate sediment dissolution?

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Oceanic uptake of anthropogenic CO_2 and the subsequent decline in seawater pH and saturation state with respect to calcium carbonate ($CaCO_3$) are likely to alter the cycling and preservation of $CaCO_3$ substrates. As a result of reduced biogenic calcification and increasing chemical and biological $CaCO_3$ dissolution, it has been hypothesized that carbonate dominated ecosystems such as coral reefs could transition from net calcifying to net dissolving during this or the next century. Some experimental evidences even suggest that $CaCO_3$ dissolution may be an order of magnitude more sensitive to changes in seawater pH than biogenic calcification. In spite of this, shallow water $CaCO_3$ dissolution has received relatively little attention in the context of the ongoing anthropogenic CO_2 perturbation.

Robert Berner dedicated significant efforts throughout his career to better understand the early diagenesis of $CaCO_3$ substrates and sediments. This included work on their solubilities, dissolution kinetics, the effect of Mg incorporation, and numerous other aspects that are relevant to our understanding of the potential responses of these minerals to increasing anthropogenic CO_2. In this Berner lecture, I will discuss the effects of a contemporary high-CO_2 world on shallow water $CaCO_3$ substrates and sediments. In keeping with Berner's broad spectrum of research approaches, I will present results from a combination of numerical models, laboratory experiments, and field observations. I will highlight that microbial decomposition of organic matter under oxic conditions is the ultimate driver of shallow water $CaCO_3$ sediment dissolution, but that the extent of dissolution is highly influenced by the offset in $CaCO_3$ saturation state between the overlying seawater and the porewater and also affected by the apparent solubility of the most soluble bulk mineral phase present in the sediments. Fundamentally, as seawater $CaCO_3$ saturation decreases in response to rising anthropogenic CO_2, carbonate sediment dissolution will increase because increasing proportions of organic matter decomposition will be available to fuel additional dissolution.