Berner lecture: How will anthropogenic CO$_2$ affect shallow water calcium carbonate sediment dissolution?

ANDREAS J. ANDERSSON$^1$

$^1$Scripps Institution of Oceanography, University of California San Diego, La Jolla CA 92093-0244, USA

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.