What controls the generation of alkalinity in marine sediments?

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One of the key processes in sedimentary diagenesis is the microbially-mediated oxidation of organic carbon in marine sediments, often in the absence of oxygen. This oxidation of organic carbon generates subsurface alkalinity, largely in the form of carbonate alkalinity. The anaerobic oxidation of organic carbon also consumes protons, and can drive the precipitation of sedimentary carbonate phases such as calcite, dolomite, and siderite. The amount of alkalinity in marine sediments can reach nearly 1.5 orders-of-magnitude higher than the alkalinity at the sediment-water interface, and the return flux of alkalinity from marine sediments into the ocean has been suggested to be as much as 25% of the riverine flux of alkalinity to the ocean. Key to quantifying the amount and type of authigenic carbonate burial is understanding what controls the rate and total amount of alkalinity generated through microbial oxidation of organic matter.

We use a combination of pore fluid analyses from a range of drilling sites, with laboratory cultures, to explore the controls on the generation of alkalinity in marine sediments. We observe a strong correlation between alkalinity generation and sulfate consumption in marine sediments, but less correlation between alkalinity generation and calcium consumption suggesting a more nuanced link between alkalinity production and authigenic carbonate precipitation. The consumption of calcium and sulfate in global marine pore fluids are tightly correlated, hinting at a direct role of sulfate-reducing bacteria in nucleating sedimentary carbonate precipitation. In laboratory cultures and in natural sediments, we observe a difference in the amount of alkalinity generated when there are carbonate minerals present versus when a combination of carbonate and clay minerals are present, where the generation of alkalinity is lower in the absence of clay minerals. This presentation will explore these results and offer ideas about the controls on sedimentary alkalinity generation; how this may have differed in the geological past and how this impacts the overall amount of authigenic carbonate precpitated over time.