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How does hydrothermal heating alter the bioavailability of sedimentary organic matter?

SAMUEL MCNICHOL[1], LELAND WOOD[2], ANDREAS TESKE[3], SUNITA R SHAH WALTER[2] AND NAGISSA MAHMOUDI[4]

[1]McGill University
[2]University of Delaware
[3]University of North Carolina at Chapel Hill
[4]Department of Earth & Planetary Sciences, McGill University

Marine sediments cover more than two thirds of the Earth's surface and store vast amounts of organic matter that are continually transformed by diverse microbial communities. While much of our understanding of these processes comes from low-temperature environments, a substantial portion of sediments experience elevated temperatures due to burial or hydrothermal activity. Such conditions can reshape both microbial activity and the chemical nature of organic matter. Thermal alteration promotes the generation of small organic compounds, such as acetate, that can support microbial communities. While laboratory incubations have demonstrated that moderate heating of marine sediments can lead to the production of labile organic compounds, it remains unclear whether hydrothermal activity alters the bioavailability of the remaining organic matter pool. To examine how elevated temperatures affect the bioavailability of sedimentary organic matter, we conducted a series of bioreactor experiments using Guaymas Basin sediments. This study used sediments collected during International Ocean Discovery Program (IODP) Expedition 385, from site 1547, above a shallow, recently emplaced hot sill and site 1545, adjacent to a large, thermally equilibrated sill. We incubated a model marine bacterium with sterilized Guaymas Basin sediment that was heated (70°C for 7 days) in the laboratory and tracked respired CO_2 and its associated ^{13}C and ^{14}C signatures. This allowed us to assess organic matter pools supporting microbial respiration and the age of organic matter being respired. Our results revealed that sediment depth and hydrothermal history strongly control abiotic acetate production, with higher yields in shallower sediments. Total respiration and respiration rates in control and heated sediment incubations were nearly identical, indicating that heating does not measurably alter the bioavailability of the bulk sedimentary organic matter. The $\delta^{13}C$ values of respired CO_2 were indistinguishable between control and heated incubations while $\Delta^{14}C$ values were more depleted early in heated incubations. This transient offset indicates that low-temperature heating briefly mobilizes a small pool of older organic matter, without substantially altering overall organic matter bioavailability. Our findings shed light on the role of hydrothermal activity in shaping carbon cycling in marine sediments by influencing how organic matter is transformed and made available to microbes.