Elucidating microbial species-specific effects on organic matter transformation in marine sediments

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Abstract

Microbial transformation and decomposition of organic matter in sediments constitutes one of the largest fluxes of carbon in marine environments. Mineralization of sedimentary organic matter by microorganisms results in selective degradation such that bioavailable or accessible compounds are rapidly metabolized while more recalcitrant, complex compounds are preserved and buried in sediment (Mahmoudi et al., 2017). Recent studies have found that the ability to use different carbon sources appears to vary among microorganisms, suggesting that the availability of certain pools of carbon can be specific to the taxa that utilize the pool. This implies that organic matter mineralization in marine environments may depend on the metabolic potential of the microbial populations that are present and active. The goal of our study was to investigate the extent to which organic matter availability and transformation may be species-specific using sediment from Guaymas Basin (Gulf of California). We carried out time-series incubations using bacterial isolates and sterilized sediment in the IsoCaRB system (Beaupre et al., 2016) which allowed us to measure the production rates and natural isotopic signatures (δ¹³C and Δ¹⁴C) of microbially-respired CO₂. Separate incubations using two different marine bacterial isolates (Vibrio sp. and Pseudoalteromonas sp.) and sterilized Guaymas Basin sediment under oxic conditions showed that the rate and total quantity of organic matter metabolized by these two species differs. Approximately twice as much CO₂ was collected during the Vibrio sp. incubation compared to the Pseudoalteromonas sp. incubation. Moreover, the rate at which organic matter was metabolized by the Vibrio sp. was much higher than the Pseudoalteromonas sp. indicating the intrinsic availability of organic matter in sediments may depend on the species that is present and active. Isotopic analyses of microbially respired CO₂ will be used to constrain the type and age of organic matter that is accessible to each species. Moreover, molecular analysis of subsamples collected from each incubation will link carbon utilization with the underlying gene expression. Our study sheds light on the degree to which the metabolic capacities of microorganisms affect carbon transformation in sedimentary environments.
Microbial transformation and decomposition of organic matter in sediments constitutes one of the largest fluxes of carbon in marine environments. Recent studies have found that the ability to use different carbon sources appears to vary among microorganisms1-3, suggesting that the availability of certain pools of carbon can be specific to the taxa that utilize the pool. This implies that organic matter mineralization in marine environments may depend on the metabolic potential of the microbial populations that are present and active. The goal of our study was to investigate the extent to which organic matter availability and transformation may be species-specific using sediment from Guaymas Basin (Gulf of California). We carried out time-series incubations using bacterial isolates and sterilized sediment in the IsoCaRB system which allowed us to measure the production rates and natural isotopic signatures of microbially-respired CO2. Separate incubations using two different marine bacterial isolates (Vibrio sp. and Pseudoalteromonas sp.) and sterilized Guaymas Basin sediment under oxic conditions showed that the rate and total quantity of organic matter metabolized by these two species differs. Isotopic analyses of microbially respired CO2 will be used to constrain the type and age of organic matter that is accessible to each species. Moreover, molecular analysis of subsamples collected from each incubation will link carbon utilization with the underlying gene expression. Our studies shed light on the degree to which the metabolic capacities of microorganisms affect carbon transformation in sedimentary environments.

Experimental Approach

**Incubate sterilized sediment with model organisms in the IsoCaRB system to evaluate the potential species-specific effect on organic carbon degradation.**

**Guaymas Basin** is an an ideal study site—its wide range of potential microbial carbon sources with a large spectrum in radiocarbon ages.

Various marine isolates were incubated with sterilized sediment to identify organisms that could potentially degrade sedimentary organic matter.

Two different bacterial isolates were selected (**Vibrio splendidus** and **Pseudoalteromonas sp.** 3D05) and subsequently used for IsoCaRB incubations. Incubation in the IsoCaRB system consisted of:

1. (1) 22g of decarbonated sterilized sediment.
2. (2) 2L of minimal media.
3. (3) 50M log phase cells washed with carbon free media (cell density = 5 x 10^7 cells/mL).

**Results**

The rate and total quantity of organic matter metabolized by these two species differs, indicating the intrinsic availability of organic matter in sediments may depend on the species that are present and active. **Figure 2.** Microbial CO2 production rates (gray line) of respired CO2 collected during incubation of 22g of Guaymas Basin sediment (0.9 cm; cores TRT1-6, 7, 810-10.) by (A)Pseudoalteromonas sp. and (B)Vibrio sp. The width of each box spans the time interval during which each CO2 fraction was collected for isotopic analysis to constrain the type and age of organic matter that is accessible to each species. For cell densities (green squares), subsamples were serially diluted in minimal media and plated on marine broth plates for CFU counts.

Although organic matter transformation appears to be species-specific, intrinsic sediment properties are still an important control on organic matter degradation.

When incubated with a different series of cores, an opposite pattern was observed such that **Vibrio sp.** metabolized substantially more organic matter than **Pseudoalteromonas sp.**

Significantly less organic matter was metabolized by **Vibrio sp.** when incubated with sediment from deeper depths. **Figure 3.** Microbial CO2 production rates (gray line) of respired CO2 released during incubation of 22g of Guaymas Basin sediment (0.9 cm; cores 4490-25, 4490-26) by (A) Vibrio sp. and (B) Pseudoalteromonas sp. Approximately 2.1 mg of carbon was collected during the **Pseudoalteromonas sp.** incubation and 3.6 mg was collected during the **Vibrio sp.** incubation. **Figure 4.** Microbial CO2 production rates (gray line) of respired CO2 released during incubation of 25g of Guaymas Basin sediment (0.14 cm; cores 4490-25, 4490-26) with V. splendidus. Approximately 0.9 mg of carbon was collected during the incubation.

**References**