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Sediment organic matter dynamics: interactions among degradation, secondary production, priming and the actors involved

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Sedimentary organic matter is a mixture of recently deposited (labile) organic matter and extensively transformed organic matter. This heterogenous pool is subject to (preferential) degradation and fuels secondary production by a diverse community of heterotrophs with consequences for the composition of the material eventually buried. By incubating shelf sediments with ^{13}C-labeled algal substrates (lipid and proteins) for 400 days, we quantified mineralization, compositional changes, secondary production and priming (acceleration of background organic matter mineralization due to addition of substrate) using compound-specific isotope analysis, and identified the microbes involved through RNA stable isotope probing analysis.

Our results showed that ~65% of the lipids and ~20% of the proteins were mineralized irrespective of the biogeochemical environment (with or without sulfate) and confirmed that the quantity and quality of the substrate are the single most important factors governing OM mineralization (the rationale underlying the one-G model). Up to 11% of carbon from the algal lipids was transformed into the biomass of secondary producers as indicated by ^{13}C incorporation in amino acids. This biomass turned over throughout the experiment, corresponding to dynamic microbial shifts. RNA isotope probing revealed that numerically minor heterotrophic bacteria dominated mineralization. Archaea played a minor role in processing algal lipids and protein based on the low ^{13}C incorporation into archaeal lipids and RNA.

The priming effect was quantified as the difference in DI^{12}C production in treatments with and without substrate addition. Algal lipid addition accelerated indigenous organic matter degradation by 2.5 to 6 times. ^{12}C-enrichment of RNA revealed that this priming was driven by diverse heterotrophic bacteria and sulfur- and iron-cycling bacteria. Moreover, priming resulted in extra secondary production, which exceeded that stimulated by added substrates. These interactions between degradation, secondary production, and priming govern the eventual fate of OM in marine sediments.