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Methane seep fluids enhance carbon transformations in the deep-sea

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Best known for emitting gas from the seafloor, methane seeps are also conduits to export dissolved organic carbon (DOC), dissolved inorganic carbon (DIC), nutrients, and reduced chemical species into the deep ocean. In seep sediments, microbial metabolisms transform carbon from methane into DIC and DOC, facilitating the entrance of methane-carbon to the water column in multiple forms. Quantifying the extent that seep fluids serve as a source of bioavailable carbon and energy for deep-sea microbial communities and/or contribute recalcitrant DOC to the deep ocean is critical for assessing the influence of methane-carbon from seeps on the ocean carbon cycle.

In this study, we conducted a series of mesocosm incubations that simulated the mixing of seep and non-seep porewater with deep seawater to investigate (1) the autotrophic and/or heterotrophic response of deep-sea microbes to seep fluids, and (2) microbially-mediated molecular changes to DOC that is expelled from seeps into the deep ocean. We monitored changes to the carbon pools over 100 days by quantifying DOC and DIC concentrations and $\delta^{13}C$ values, headspace CO_2 concentrations, and cell counts. We also used high resolution mass spectrometry (FT-ICR MS) to probe the types of compounds that were formed and consumed over the course of the experiment. Production of DOC, increased cellular biomass, decreased DIC, and enrichment of $\delta^{13}C$-DIC are consistent with enhanced chemoautotrophy in seep porewater + seawater mesocosms. Additionally, the consumption of DOC compounds with relatively high nominal oxidation state of carbon (NOSC) and production of compounds with relatively low NOSC supports enhanced heterotrophy in seep porewater + seawater mesocosms, compared to non-seep porewater + seawater mesocosms where consumed and produced compounds have similar average NOSC values. These results suggest that seep fluids deliver bioavailable organic substrates and reduced chemical species capable of fueling diverse autotrophic and heterotrophic metabolic pathways and enhancing microbial activity that both produces and consumes DOC in the deep ocean.