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Transportation and Transformation of Dissolved Organic Matter from Overlying to Bottom Waters of Cold Seeps in the South China Sea: Insights at the Molecular Level

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Cold seeps are critical hotspots in marine ecosystems, where the biogeochemical processes of dissolved organic matter (DOM) significantly impact regional carbon reservoirs and the global ocean carbon cycle. To clarify the impact of cold seep activity on the production, transportation and transformation of DOM, we employed Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) to analyze DOM from the water column and sediment overlying water collected from cold seep and non-cold seep regions in the northern South China Sea. Our results showed that the overlying water in cold seeps contained a greater diversity of unique molecules, with a larger proportion of sulfur-containing compounds compared to the non-cold seep area. Approximately half of these unique molecules, characterized by lower H/C ratios, higher molecular weights, and a predominance of highly unsaturated compounds (82.3%), were transferred to the corresponding bottom water during the bubbling process. In contrast, molecules with higher H/C ratios, lower molecular weights, and a larger proportion of aliphatics compounds (40.8%) were lost. Additionally, the bottom water of the active cold seep exhibited the formation of some labile molecules (H/C > 1.5) with lower aromaticity (AI_{mod} < 0.25) and the decomposition of nitrogen-containing carboxyl-rich alicyclic molecules (CRAMs) with higher aromaticity, driven by the positive priming effect. These findings highlight the profound influence of cold seep activity on DOM properties and dynamics, providing deeper insights into the complex biogeochemical processes in cold seep ecosystems and their critical implications for marine carbon cycling.