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Molecular degradation kinetics and carbonate system responses during permafrost organic carbon remineralization in seawater

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Arctic amplification is accelerating permafrost thaw, enhancing the mobilization of terrestrial organic carbon (OC) from the active layer toward coastal Arctic waters. The transfer into seawater leads to greenhouse gas production and has been linked to acidification of coastal waters. However, the molecular and isotopic evolution of permafrost organic matter during its transition across the land-ocean interface remains poorly understood. In particular, the combination between quantitative carbon loss, alteration of molecular signatures, and feedbacks on seawater carbonate chemistry is not well constrained. To address these questions, we conducted controlled aerobic seawater incubations different active layer samples from Qikiqtarjuaq (Nunavut, Canada) spanning a natural TOC gradient (9.9% - 1.4%) to determine CO_2 and dissolved inorganic carbon (DIC) production, O_2 consumption, total scale pH and total alkalinity (TA) changes, as well as bulk and molecular OC degradation dynamics (changes in % TOC, bulk stable carbon isotope composition, and plant-wax alkyl lipids concentrations). Our data show rapid early-stage remineralization characterized by CO_2 and DIC production, decreasing pH, and changes in O2 concentration, indicating strong microbial processing of OC. We will present corresponding bulk TOC and alkyl lipid degradation rate constants and bulk $\delta^{13}C$ values characterizing the preferential removal of labile pools during mineralization. By integrating molecular degradation kinetics, isotopic tracers, and comprehensive measurements of the carbonate system, this study provides new insights into permafrost OC remineralization dynamics in seawater and their control on ocean carbonate chemistry. These results improve predictions of carbon feedbacks in the Earth system in the face of ongoing climate warming.