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Tracking the degradation of organic carbon in Arctic Rivers: Insights from RPO-^{14}C analyses in the Canning River, Alaska

MARISA N REPASCH[1], VALIER GALY[2], SUZANNE P ANDERSON[1], IRINA OVEREEM[1], JOSHUA C. KOCH[3], JOSIE ARCURI[1] AND ROBERT S. ANDERSON[1]

[1]University of Colorado Boulder

[2]Woods Hole Oceanographic Institution

[3]U.S. Geological Survey

Presenting Author: marisa.repasch@colorado.edu

Arctic permafrost is a large terrestrial carbon reservoir, storing ~1300 PgC in just the uppermost 3 m of frozen soil and sediment. Global climate change is accelerating the rate of permafrost thaw, making this long-lived carbon reservoir vulnerable to erosion and oxidation to CO_2. Thawed permafrost organic carbon (OC) may be eroded into rivers and transported down fluvial corridors to the oceans. OC may survive fluvial transport and be buried in marine sediments, or it may be oxidized to CO_2. To predict future change in atmospheric CO_2 concentrations, we must understand how quickly thawed OC is oxidized and mobilized at Earth's surface. While some studies have measured OC export fluxes to the Arctic ocean, we lack the data needed to quantify OC transformation to CO_2 within Arctic river systems.

It is challenging to predict CO_2 release in river systems because OC transported in rivers consists of diverse organic molecules with different reactivities. Although radiocarbon has frequently been employed to distinguish between OC pools in river sediment samples and to estimate their turnover times, bulk OC ^{14}C measurements limit our ability to measure the relative abundances of different OC pools with different decomposition rates. To tackle this problem, we use ramped pyrolysis oxidation-^{14}C (RPO-^{14}C), a powerful, yet underutilized tool for separating particulate organic carbon (POC) pools in soil and sediment based on OC thermal stability and ^{14}C content. We present RPO thermograms and ^{14}C measurements of distinct OC pools in river suspended sediment samples from the Canning River, Alaska, which traverses continuous permafrost terrain. Using this method, we determine the relative contributions of POC from modern biomass, ancient permafrost soils, and eroded bedrock. We use samples collected at different distances along the source-to-sink pathway to show how permafrost-derived POC is transformed during fluvial transit. Based on these ^{14}C measurements, we then estimate the decomposition rates of POC in the Canning River, calculate CO_2 release over the duration of fluvial transit, and predict future POC oxidation under changing climate scenarios. This analysis will help elucidate the fate of OC mobilized from the Arctic landscape.